

AIT2018

ITALIAN SOCIETY OF REMOTE SENSING
IX CONFERENCE

FIRENZE

4 - 6 JULY 2018

**FROM SPACE
TO LAND MANAGEMENT**
remote sensing technologies supporting
sustainable development and natural
resource management



UNIVERSITÀ
DEGLI STUDI
FIRENZE

ABSTRACT BOOK

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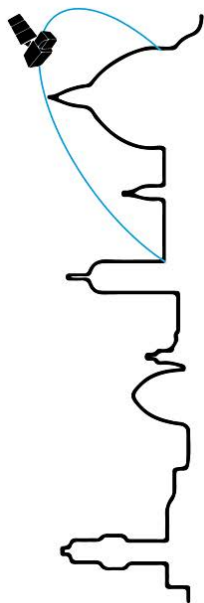
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ITALIAN SOCIETY OF REMOTE SENSING
Firenze 4-6 July 2018

Associazione Italiana di Telerilevamento



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Rooms	
A = Congress Hall	B = Bracco Classroom

4 July

Wednesday		08:00 - 09:30		09:30 - 12:55		14:10		16:15		16:45 - 18:15	
Room A	Registration (Lobby)			LASTOOLS course by Martin Isenburg Registration (Lobby)				PLENARY SESSION1 Chair: G. Chirici		CETEM1 Chair: S. Paloscia, L. Guerniero	
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5 July

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Room A	Registration (Lobby)			move to sessions		CETEM2 Chair: E. Santi, M. Brogioni		GNRAC Chair: E. Pranzini		CETEM3 Chair: N. Pierdicca, Del frate		Lunch		DYNAMICS Chair: M.A. Dessena		Coffee Break		RSAA Chair: M. Boschetti, E. Borgogno Mondino	
	Room B	PLENARY SESSION 2 - Chair: Piero Boccardo			A		SBI Chair: D. Rocchini, C. Ricotta				ECO Chair: G. Vaglio Laurin		UAV Chair: F.G. Tonolo		Coffee Break				

6 July

Friday		08:00		08:30		10:00		10:30		12:00		13:30		15:00		16:30		17:00 - 18:15	
Room A	Registration (Lobby)			GEOHAZ Chair: F. Catani		URBAN Chair: M. Gianinnetto		GECO Chair: G. Tucci, F. Immordino		FRESH Chair: M. Marchetti		Lunch		FLOOD Chair: M.T. Melis		Coffee Break		PLENARY SESSION 3 - Chair: Gherardo Chirici	
	Room B	AGRI Chair: M. Gomarasca			FOREST Chair: E. Borgogno Mondino								BIODIVERSITY Chair: P. Corona						

ORAL SESSIONS

Session Agriculture and forest monitoring
 Wednesday, 4 July 2018 (16:45 - 18:15)
 Congress Hall - Chairman: Simonetta Paloscia, Leila Guerriero

Paolo Ferrazzoli

Active and passive microwave observations of vegetation: Past and recent results

In the last decades, microwave remote sensing of land has used both active and passive instruments, generally with different objectives and approaches. Active observations have been used for applications requiring high resolution, mainly recognition or agricultural monitoring. Passive observations show the benefits of short revisit time and full earth coverage, so that have been mostly dedicated to large scale monitoring of global parameters. More recently, the interest towards a synergic use of both instruments has been increasing, mostly stimulated by the launch of Aquarius and SMAP satellites, carrying both active and passive microwave instruments on board. Aquarius was developed for ocean applications, and was characterized by a coarse resolution of several tens of kilometers. In spite of this limitations, it was used in some studies aimed at characterizing the relations between active and passive signatures over large homogeneous land areas. SMAP was developed for land applications, with the objective to obtain a soil moisture product with better resolution, with respect to passive only products. Unfortunately, the SMAP radar suffered a failure, but the researches in the topic are going on, trying to use other SAR instruments in synergy with the SMAP radiometer.

In general, the synergy between active and passive sensors is investigated with the objective of joining the good performance of radiometric signatures in soil moisture retrieval with the better resolution of radar. To this aim, several techniques have been proposed to downscale the soil moisture retrieval produced by the passive instruments. However, active and passive signatures are influenced by soil and vegetation parameters in different ways. There is need to take this into account in the development of downscaling algorithms, but this complexity can be also employed to achieve a better characterization of the observed surfaces.

This paper reviews some investigations about the combined use of active and passive signatures. First investigations were carried out in the 80's in Italy, specifically in Oltrepo Pavese and Montespertoli sites. Several agricultural fields were observed by airborne radar and radiometric instruments in the framework of Agrisar 86, Agriscatt 87, and Agriscatt 88 campaigns. X band was common to both instruments. These studies allowed us to give a first evaluation of the sensitivities of the two instruments to various land parameters. As expected, the trend of backscattering coefficient versus soil moisture was inverse with respect to the one of emissivity. However, complex effects were produced by variations of soil roughness and vegetation parameters. More recent investigations were carried out in the US, using the active/passive PALS instrument, and in Australia, in the framework of Smapex campaign. In both cases measurements were collected at L band. Main results of these measurements will be summarized, and some simultaneous active/passive signatures collected by Aquarius will be compared with assumptions based on previous studies.

Understanding active and passive signatures of vegetated soils receives an important benefit by the development of radiative transfer models. In particular, the model developed at University of Rome Tor Vergata is based on a unified approach. For a given scenario of soil covered by vegetation, the model computes the bistatic scattering coefficient in all directions, which is subsequently used to estimate both the backscattering coefficient and the emissivity. This paper shows some parametric investigations about the sensitivity of both active and passive signatures to land parameters, and comparisons between model simulations and experimental data collected by airborne and spaceborne instruments.

Session Agriculture and forest monitoring
 Wednesday, 4 July 2018 (16:45 - 18:15)
 Congress Hall - Chairman: Simonetta Paloscia, Leila Guerriero

Giuseppe Satalino¹, Anna Balenzano¹, Francesco P. Lovergine¹, Davide Palmisano¹, Francesco Mattia¹, Michele Rinaldi², Angelo P. De Santis², Salvatore Colecchia², Sergio Ruggieri³, Anna Maria Castrignanò³

Sentinel-1 and Sentinel-2 for agricultural monitoring over the Apulian Tavoliere

Agriculture is one of the sectors that is expected to highly benefit from the new Copernicus Earth monitoring era, where Sentinel radar and multispectral observations are systematically acquired and freely distributed on-line. Indeed, the open access policy will likely speed the development of accurate models capable of predicting the dynamics of crop growth and yield production at large scale and high spatial/temporal resolution based on gridded values of bio-geophysical parameters retrieved from Sentinel missions.

In this study, a suite of multi-temporal products of bio-geophysical parameters, relevant for agricultural monitoring, are derived from time series of Sentinel-1 (S-1) and Sentinel-2 (S-2) data. The investigated parameters include: seasonal crops, vegetation biomass, tillage change and soil moisture content.

It is worth noting that, for instance, maps of tillage change at large scale represent a rather new geophysical product that may improve the modelling of water balance and crop production, especially, in semi-arid regions. Indeed, tillage operations affect a large number of processes taking place at the soil-atmosphere interface, such as soil erosion, surface evaporation, run-off and infiltration, nutrient uptake, carbon sequestration etc. Finally, the monitoring of tillage changes can help to evaluate the application of the minimal soil disturbance (no-tillage) as one of the principles of conservative agriculture, which has been widely promoted by FAO to achieve a sustainable and profitable agriculture.

The assessment of the derived products has been carried out by using in situ data collected over the Apulian Tavoliere site (Apulia region, Italy) in the framework of various campaigns funded by the Italian Space Agency (ASI), the European Space Agency (ESA), and recently, by the European Union through the H2020 "Sensagri" project (i.e. www.sensagri.eu).

The Apulian Tavoliere is the only Joint Experiment of Crop Assessment and Monitoring (JECAM) site in Italy and a crucial agricultural area, particularly for the durum wheat production. The applications of greatest interest for the area concern the control of the conditions of plant water stress, the identification of plant diseases, the evaluation of the use of conservative farming practices, the estimation of the irrigation needs of the various crops and the prediction of their yields. Over the Apulian Tavoliere site, more than 600 hectares of agricultural soils are owned by public research institutes which systematically collect time series of well documented in situ data such as land use, crop biomass, LAI, tillage change, soil moisture measurements.

In particular, soil moisture measurements are recorded by a hydrologic network consisting of 22 stations continuously measuring soil moisture content, soil temperature and precipitation. The stations are distributed with an average spacing of approximately 500 m. For this reason, the network is particularly suited to validate soil moisture products at high resolution. It is also worth mentioning that in 2017, a total of 450 fields have been surveyed collecting ground information including land use, phenology and tillage changes.

The paper will illustrate and discuss the obtained results and will provide recommendations for further work.

Acknowledgements

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Session Agriculture and forest monitoring
Wednesday, 4 July 2018 (16:45 - 18:15)
Congress Hall - Chairman: Simonetta Paloscia, Leila Guerriero

Davide Marchegiani¹, Nazzareno Pierdicca¹, Luca Pulvirenti², Luca Cenci²

Validation of the Bayesian Multitemporal Algorithm Implemented in a Prototype Software Designed to Retrieve Soil Moisture From Sentinel-1 Data

In this work the Validation of a Prototype Software Package for retrieving Soil Moisture content from Sentinel-1 Data is presented. The validated software is based on a Bayesian maximum a posteriori probability statistical criterion, which takes advantage of a multi-temporal approach to the problem of soil moisture retrieval using Synthetic Aperture Radar (SAR) data. The validation is performed by comparing the soil moisture content obtained as the output of the software with the one directly measured by ground stations. Two different sites are taken into account separately: the first one includes 5 stations belonging to a bigger ground network of 12 soil moisture monitoring stations, situated over the Segezia experimental farm (Puglia, Southern Italy); the second one is the International Soil Moisture Network site of Remedhus, which includes 24 monitoring stations. The validation is carried out on a series of Sentinel-1 SAR data, acquired within a time window which goes from 2016-09-22 to 2017-06-30.

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Session Agriculture and forest monitoring
 Wednesday, 4 July 2018 (16:45 - 18:15)
 Congress Hall - Chairman: Simonetta Paloscia, Leila Guerriero

Emanuele Santi¹, Simonetta Paloscia¹, Simone Pettinato¹, Antonio Padovano², Claudia Notarnicola²

Machine learning applications for the retrieval of forest biomass in the framework of ESA BRIX exercise

In this study, two algorithms for estimating the forest biomass (t/ha) from airborne SAR missions managed by ESA have been implemented and tested. The study has been carried out in the framework of the ESA BRIX exercise. BRIX is an international collaborative initiative promoted by the European Space Agency aiming at intercomparing biomass retrieval algorithms for P-band full-polarimetric SAR sensors in view of the incoming BIOMASS mission (a P-band synthetic aperture polarimetric radar), to be launched in 2020 under the ESA's Earth Explorer 7 program (EE-7) (Le Toan et al., 2011). The BRIX retrieval has been addressed by implementing two different machine learning approaches, namely Artificial Neural Network (ANN), and supported Vector Regressions (SVR). ANN can be considered a statistical minimum variance approach for addressing the retrieval problem and they can be trained to represent arbitrary input-output relationships (Hornik, 1989; Linden and Kinderman, 1989). ANNs have been successfully applied to many inverse problems in the remote sensing field (e.g. Del Frate et al. 2003; Paloscia et al. 2008, Santi et al. 2016). An ANN implementation for forest biomass retrieval has been presented in Santi et al. (2017). These works demonstrated the ANN capabilities in offering a good compromise between retrieval accuracy and computational cost. In Paloscia et al. 2013 nevertheless, the importance of a robust and extensive reference dataset for the training was pointed out, in order to obtain a retrieval algorithm able to work at large and global scale with a satisfactory accuracy. SVR is a state-of-the-art regression method, which is becoming popular in the field of geophysical variable retrieval (Evgeniou et al. 2000, Smola et al. 2004) due to its flexibility and its robustness to noisy data. SVR allows the modelling of multi-dimensional non-linear relationships. This can be achieved by mapping the original m -dimensional input domain to a higher dimensionality space, by using a so-called kernel function, in which the function underlying the data is supposed to have an increased flatness. In the transformed space the function can then be approximated linearly. SVR has been successfully applied for retrieval of surface parameters (Pasolli et al., 2011, 2015) where it was also compared to ANN indicating similar performances. In this research, all the data available on BRIX from the Afrisar, Biosar and Tropisar missions have been considered for implementing and testing the algorithms. Several approaches to the retrieval have been exploited, by developing "general" algorithms trained with data derived from the whole dataset and "specific" algorithms for each campaign, trained with data derived from the given campaign dataset (Afrisar/Biosar/Tropisar). In all cases, the algorithms have been trained on a subset of the available data and validated on the remaining. In the case of ANN, the validation of the "general" algorithm resulted in a correlation coefficient $R=0.88$, $RMSE=60$ t/ha and negligible BIAS, while the "specific" ANN for data resulted in R from 0.78 to 0.94 and $RMSE$ between 15 and 50 t/ha, depending on the dataset. The validation of the "general" SVR algorithm resulted in a correlation coefficient $R=0.82$, $RMSE=70$ t/ha and also in this case a negligible BIAS, while the "specific" SVR algorithms show a correlation coefficient of 0.90 for the best case and 0.27 for the worst case and $RMSE$ between 25 and 77 t/ha, depending on the dataset. After validation, both ANN and SVR algorithms have been applied pixel by pixel to the airborne SAR images available in BRIX for generating the corresponding biomass maps. In the prosecution of this research, the possibility of overcoming the intrinsic limitation of experimental driven training, which are in general site dependent and cannot be applied to different areas, will be exploited by merging in the training set the experimental data with data simulated by electromagnetic forward models (e.m.), as proposed in Santi et al. (2017). In detail, the simulated part of the training set will allow training both algorithms for inverting the electromagnetic model, similarly to other physically based algorithms, with less constraints due to the approximations needed for an analytical inversion. The experimental part of the training set will allow adapting the algorithm to the specific features of a given test site.

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Session Agriculture and forest monitoring
 Wednesday, 4 July 2018 (16:45 - 18:15)
 Congress Hall - Chairman: Simonetta Paloscia, Leila Guerriero

Paolo Ferrazzoli¹, Mario Alberto Acuna², Fabio Fascetti³, Nazzareno Pierdicca³, Leila Guerriero¹

L band backscattering of wheat: Modeling and application to soil moisture retrieval

The use of Synthetic Aperture Radar (SAR) for land applications has extensively been investigated in the recent decades. In particular the potential of SAR to retrieve soil moisture (SM) and vegetation properties received great attention. Soil moisture influences hydrological and agricultural processes, and its monitoring is also important to forecast flood or drought extreme events, that produce strong environmental and economic damages. Radar signatures are determined by soil moisture, which controls the permittivity of soil surface, soil roughness, and vegetation cover. A correct characterization of vegetation effects on radar response is important to improve soil moisture retrieval algorithms, and because it can provide information about the biomass of crops, with important applications such as crop yield. Among several crops, wheat receives particular attention, due to its alimentary importance in several countries. Several investigations, based on experimental campaigns and model simulations, have been made in the recent years. Overall, L band is useful for both soil moisture and crop biomass applications. Physical models are useful, since allow us to simulate the radar response of the field under various independent assumptions of soil and vegetation parameters.

Argentinean land can be a suitable area to develop and test monitoring techniques. In particular, the region of Pampas is a wide cropland where remote sensing techniques can be more suitable than traditional in-situ techniques measurements. Investigations about SAR signatures can receive benefit by simulations of a model previously developed at Tor Vergata University, which is based on the radiative transfer theory and a discrete approach, and can be adapted to various crop geometries. The forthcoming availability of SAOCOM satellites can add a significant contribution to the previously indicated applications. SAOCOM is a constellation of two Argentinean satellites, carrying an L band SAR on board.

In this paper, we illustrate and test the model adapted to wheat fields of Pampas region, at L band. Moreover, a soil moisture retrieval algorithm is tested. Polarimetric backscattering coefficients were collected by airborne SARAT in 2010 over agricultural fields at CETT (Centro Espacial Teófilo Tabanera) site, located near the Argentinean city of Cordoba and owned by Comisión Nacional de Actividades Espaciales (CONAE). SARAT is an L band full polarimetric, single mode, airborne SAR. In the framework of the experimental campaign, SARAT observed 20 fields at an incidence angle of 33° and two different azimuth angles (32° and 270°). There were eight winter wheat fields, which can be grouped into early stage and second date, according to the different sowing dates. Moreover, there were two bare soil with higher roughness, two bare soils with lower roughness, and eight fallows of different crops. The SARAT flights took place in seven dates, in which simultaneous measurements of SM, crop height and crop biomass were available.

A simulation work was done for wheat, using the discrete model, which requires detailed dielectric and geometrical variables as input. Although only SM and general vegetation variables were measured at CETT during 2010 SARAT campaign, model inputs were provided on the basis of detailed measurements carried out over a reference wheat field of the same CETT site for 12 dates of 2014. We used soil moisture (SM) and vegetation water content (VWC) measurements taken in 2010 during the flights, while all the other crop inputs were related to VWC with the aid of measurements collected at the reference field, for the same VWC.

A soil moisture retrieval algorithm based on multitemporal techniques was also tested using CETT 2010 data. First, a backscattering analysis over wheat field was carried out in order to take into account the vegetation effects in the inversion process. In particular, the Water Cloud Model (WCM) was used to simulate the canopy backscattering and then, to extract the soil backscattering contributions inverting the derived equation. The canopy backscattering simulated by the discrete model at HH and VV polarizations was tuned through the WCM, using the vegetation water content (VWC) as a proxy of the canopy. Then, the updated version of the WCM was integrated inside the multitemporal retrieval algorithm and the approach was tested over the wheat CETT 2010 plots.

The multitemporal SARAT signatures collected over the eight wheat fields have been compared against model simulations at HH, VV and HV polarizations. The previously mentioned model, calibrated over 2014 measurements

has been used. In general, simulations are close to measurements at all polarizations and dates, except in some cases where the row directions can play an important role, or a very recent rainfall modified the usual geometry or dielectric properties of the plants.

A comparison between the retrieved and measured soil moisture was also made. Overall, we obtained a correlation coefficient of 0.57, with a root mean square differences around $0.07 \text{ m}^3/\text{m}^3$. The highest discrepancies were observed in the first date, in which radar measurements also showed a high spread of values. Analyzing the differences among fields, better results were achieved for fields located in the southern part of the test area. This latter result is interpreted in terms of azimuth angles of incident waves with respect to row directions.

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Session Sentinel-2 applications
Wednesday, 4 July 2018 (16:45 - 18:15)
Bracco Classroom - Chairman: Livio Rossi

Nicola Puletti¹, Martina Pollastrini², Filippo Bussotti², Walter Mattioli¹, Mirko Grotti³

Evaluating the effects of extreme drought events on forest health by multitemporal Sentinel 2 satellite imagery

During summer 2017 central Italy has been hit by an intense drought and heat wave, with unusual mean daily temperatures, in many cases higher than 35°C, for several weeks. Extensive damage and tree mortality were observed on forest ecosystems. The health conditions of forests in Tuscany during and after this extreme climate events were assessed and mapped by means of multispectral and multitemporal Sentinel 2 imagery. A total of 87 observations combining field surveys and Sentinel 2 multi-temporal imagery of both healthy and unhealthy forest stands have been carried out. Beech (*Fagus sylvatica* L.), downy oak (*Quercus pubescens* Willd.), Turkey oak (*Q. cerris* L.), and holm oak (*Q. ilex* L.) forests have been considered as ecosystems with major impacts caused by drought and heat waves. Drought-induced early foliar shedding in deciduous broadleaved tree species and diffuse desiccation of leaves and branches in evergreen broadleaves have been observed. The strongest impacts were detected in sites located at the higher altitudes, south exposed and/or in poor soil conditions (especially on calcareous and serpentine soils). Field surveys have revealed that deciduous trees were affected by strong crown defoliation without mortality, whereas foliar desiccation and large crown dieback characterized evergreen species. Red edge channels and NDVI demonstrated their ability in supporting detection and map of drought effects on forests and can be hopefully considered in future algorithms to estimate GPP from space using Sentinel 2

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Session Sentinel-2 applications
Wednesday, 4 July 2018 (16:45 - 18:15)
Bracco Classroom - Chairman: Livio Rossi

Jaouad Elhachimi¹, Jamal-Eddine Ouzemou¹, Abderrazak El Harti¹, Rachid Lhissou², El Mostafa Bachaoui¹, Abderrahmene El Ghmari¹

Mapping of small agricultural parcels from Single High-Resolution Multispectral Images of Sentinel-2 using SVM classifier

The mapping of agricultural crops in arid and semi-arid regions is an essential application for better agricultural production and optimal management of water resources. Indeed, such an application allows decision-makers and farmers to ensure better agricultural planning (crop rotation, monitoring of crop health, yield estimation) and reasonable management of irrigation water resources by calculating water requirements for each crop. Crop type information is also useful for parameterizing crop growth patterns. In the last decade, space-based remote sensing has become an essential tool for crop mapping. In this sense, the present work demonstrates the feasibility of producing crop type maps using satellite (S-2A). The first objective of this work is the evaluation of the potential of Sentinel-2 data for crop mapping in the Tadla plain. While the second is choosing the most favorable period for the discrimination of different cultures using a single S-2A image. In order to achieve these objectives, we have acquired a set of seven images of the S-2A satellite, which were corrected for atmospheric effects by applying the Sen2Cor algorithm. Maps of crop types were produced at a spatial resolution of 10 m. The Support Vector Machines (SVM) Classifier was applied to each image. The favorable period for mapping was chosen with an overall accuracy of 96.48% and a kappa index of 0.95. The results obtained indicate that a single S-2A image should be sufficient for the discrimination between cereals (wheat and barley), sugar beet, alfalfa, olive, citrus, and arboriculture in an arid to semi-arid climate.

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Session Sentinel-2 applications
 Wednesday, 4 July 2018 (16:45 - 18:15)
 Bracco Classroom - Chairman: Livio Rossi

Luca Angeli¹, Piero Battista², Marta Chiesi², Ramona Magno^{1,2}, Alessandro Materassi², Maurizio Pieri², Bernardo Rapi², Maurizio Romani², Francesco Sabatini², Fabio Maselli²

Use of Sentinel-2 images for growth and water-need monitoring: application on an industrial tomato crop in central Italy

Current climate change projections made by IPCC (Intergovernmental Panel on Climate Change) suggest an increase in frequency and extent of climate extremes. In Mediterranean Basin, and therefore in Tuscany, one of the main challenges is related to minimizing drought and heat wave impacts while increasing environmental resilience (from agricultural production to natural resources conservation, water in particular).

In the last few years the availability of satellite images at high spatial and temporal resolution, joint to improved computation capacity, increased the interest towards the development of integrated systems for monitoring water resources and vegetation growth of different agricultural species.

In this context, IBIMET-CNR and LaMMA Consortium promoted a research activity in a tomato field situated in Roselle (Grosseto), Central Italy.

The objective of the experiment is to set a monitoring system able to support an efficient irrigation management and to monitor the growth and production of tomatoes, integrating remote sensing information and field measurements.

To complete the required local dataset, a fully equipped agrometeorological station was installed in the pilot site, with ten probes, placed at different soil depths, able to measure the soil water content on hourly basis during the whole crop growing season.

Sentinel-2 images (10 m resolution) are routinely downloaded and processed for the computation of vegetation indices, which are used to follow tomato's water requirements and as input into a crop growth and yield model. The effectiveness of the management support assumption was evaluated comparing the performance of the integrated system acting to optimise the watering dose of a single irrigation line, and the rest of the tomato field, managed by with the farmer's traditional methods.

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Session Sentinel-2 applications
 Wednesday, 4 July 2018 (16:45 - 18:15)
 Bracco Classroom - Chairman: Livio Rossi

Monica Pepe¹, Daniela Stroppiana¹, Lorenzo Busetto¹, Gabriele Candiani¹, Luigi Ranghetti¹,
 Daniele Giordan², Tommaso Guarneri³, Mirco Boschetti¹

Analysis of multi-temporal Sentinel 2 data to support loss adjustment

The monitoring of crop dynamics is generally important by both environmental and economic points of view, because of its impacts on ecosystems, food security and markets. There is a lot of literature regarding monitoring of crops by Earth Observation techniques for different applications: ranging from crop season monitoring at continental scale, to optimization of agricultural practices at field level. The use of EO-based monitoring techniques for crop damage assessment is more recent, especially at farm scale. The underpinning concept is that the analysis of EO data could provide evidences, at different temporal and spatial scales, of crop damage occurrence and extent, which are relevant information for different stakeholders and players (i.e. public authorities, insurance companies, consultants, farmers).

In this study the application is committed to the detection and recognition of crop damages hints at within-field level, with the final aim to provide loss adjusters with added-value information to support their decision making, while estimating yield losses as due to crop lodging.

The proposed methodology is configured to automatically detect within-field spatial patterns presenting homogeneous crop dynamics, i.e. characterized by a similar development trend throughout the season; such patterns could likely be associated to the occurrence/absence, or different severity, of weather related damages.

A clustering procedure (fuzzy C-means) was applied to a Sentinel 2 (A and B) time series - from June to August 2017 - covering the crop season of maize in a cereal farm located in Northwest Italy; the modified soil-adjusted vegetation index (MSAVI) was used as the feature for representing crop development over time.

In addition, a UAV survey was performed with a multispectral camera (MicaSense RedEdge) at the end of season, over three parcels affected by severe lodging. During the overflight a field survey (tracked by a GPS) was accomplished together with a loss-adjuster, and reference targets were placed for image correction. The UAV images were ortho-mosaicked, then clustered, and labelled according to the collected ground truth, and the loss-adjuster evaluations.

The case at hand was particularly difficult since lodging was not characterized by the plant stems lying horizontally, as usual; the maize stems were fairly straight and grown, but bended at bottom internodes. This because the damaging wind storm event took place at an early growth stage, and plants kept on their vegetative developing, this causes crop damages to be hardly recognisable, not only within the field, but also from above.

The results of clustering on multi-temporal Sentinel 2 data were compared with the lodging maps obtained from UAV, and the approach proved to be very promising in the perspective of providing added value information to loss adjusters.

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Session Sentinel-2 applications
Wednesday, 4 July 2018 (16:45 - 18:15)
Bracco Classroom - Chairman: Livio Rossi

David Hladnik

Estimation of the leaf-out phenology in temperate floodplain forests using Sentinel-2 satellite-based vegetation indices

Variations in the leafing phenology in temperate forests were used for detection and monitoring of tree species composition. Based on the phenological development of trees, Sentinel-2 satellite derived spectral vegetation indices clearly revealed the differences in species composition of Slovenian floodplain forests, composed predominantly of oak, hornbeam and black alder. Due to high revisit under the same viewing conditions, high spatial and spectral resolution of Sentinel-2 data key phenological periods were detected: leaf flushing until crown closure, period of stable leaf crown cover, period of leaf senescence. The satellite-based vegetation indices used in the last two year period of observation provided reliable estimates of species composition at the stand level and may represent the basis for monitoring the processes related to the vegetation dynamics in temperate forests. A satisfactory compatibility of the multi-temporal data segmentation and forest stand classification methods applied to the floodplain forests was achieved.

Session Sentinel-2 applications
Wednesday, 4 July 2018 (16:45 -18:15)
Bracco Classroom - Chairman: Livio Rossi

Rahul Neware

Satellite Data Analytics in Agriculture Areas

Agriculture is the main source of economy in India and related to agriculture work are the main source of earning to the people of ruler area in India. Nearly 70% of the population in India depends on agriculture for living. If we think about worldwide today total population is 7 billion and it is expected to grow 9.6 billion in 2050. So, for providing food for such huge amount of population we need modern agriculture. Due to the non-availability of temporal data about land used in previous years agricultural productivity is decreasing day by day in India.

Collecting and maintaining temporal data about agriculture area is a very important task to increase productivity. In India State Agriculture Statistics Authorities (SASAs) collect and provide information about crop and land statistics, Crop forecasts, horticulture statistics, land use statistics, Irrigation statistics, land house holding statistics, Agriculture input statistics, Agriculture price statistics etc. SASAs follow traditional field surveying method which has various disadvantages and this method is time consuming, costly and depend on agent or officer for interpretation.

In this research, we finding trend analysis in the agriculture area. Firstly, the field area is selected for study and from Sentinel2 satellite images are downloaded monthly or yearly. To find out agriculture area from satellite image three satellite image classification techniques are used that is NDVI Classification, Supervised Classification and Object-based Classification. Then on classified results grid-wise scenario is created to study agriculture area in the pixel grid of 2X2, 5X5 and 10X10. Each grid contains green pixels and from that knowledge base is created which contains values of weather that grid contains crop area or not and if it contains crop area then the highest NDVI value of that area.

Session Natural disasters, atmosphere and cryosphere
 Thursday, 5 July 2018 (10:10 - 11:40)
 Congress Hall - Chairman: Emanuele Santi, Marco Brogioni

Donato Amitrano¹, Mario Costantini², Domenico Dell'Aglio¹, Antonio Iodice¹, Fabio Malvarosa², Federico Minati², Daniele Riccio², Giuseppe Ruello²

Monitoring the Slumgullion landslide using SAR sub-pixel offset tracking

1. Introduction

Landslides are among the most frequent natural hazards and represent a significant danger for structures and populations. In the last years, time-series of synthetic aperture radar (SAR) acquisitions have widely shown their effectiveness in measuring surface motions and deformations at large scale. The popularity of this methodology is especially due to permanent scatterers (PS) and small baseline (SBAS) interferometry techniques for subsidence monitoring. On the other hand, these methods are subject to some limitations due to the presence of vegetation (causing temporal decorrelation even within very short time intervals), and the 1-D line of sight (LOS) measurement sensitivity, which is also constrained by the adopted wavelength relatively to the maximum measurable displacement gradient.

Actually, there is another class of methods which, working only with the amplitude channel, can provide information complementary to those obtainable from Differential InSAR technique (DInSAR). These techniques, based on sub-pixel offset tracking (SPOT), allow us to measure displacements in the South-North and East-West directions, without any limitation on the observable gradient. In this way, using just a couple of SAR images, movements of several meters can be detected with a good degree of approximation. In fact, SPOT methods are generally less precise than classical DInSAR ones, but they are not sensitive to atmospheric effects and are applicable not only to highly coherent targets, i.e., they can measure displacements, for instance, also in densely vegetated areas.

2. Investigated area and employed data

In this work, we investigate the suitability of a SPOT technique for monitoring the Slumgullion landslide (Colorado, US), using a dataset of three COSMO-SkyMed (CSK) spotlight images with about one meter spatial resolution. The Slumgullion landslide is a fast landslide, which was broadly studied in the past. It consists of two distinct parts: the larger one, extending for about 7 kilometers from the Cannibal Plateau to Lake San Cristobal, is currently inactive; the smaller part, is about 4 kilometers long, and is the active one. It has been moving for about 350 years, with a maximum measured velocity of 6 meters per year.

According to knowledge available in literature, the landslide can be divided into 11 regions. Corresponding displacement velocities, measured in situ in 1985-1990, and by using a ground-based Interferometric SAR in 2010, are reported in the first and second columns of Table 1, respectively.

3. Implemented SPOT technique

In its classic implementation, SPOT exploits cross-correlation measures on several windows extracted from a couple of SAR amplitude images, of which one is assumed as master (i.e. the reference for the calculation of displacements), while the other is known as slave. The cross-correlation between two patches M and S of the master and slave image, respectively, is a function of range and azimuth displacements. The two patches are oversampled by a factor f (which is chosen to be a power of two) to account for sub-pixel movements, so that the minimum detectable displacement (in pixel units) is $1/f$. The peak of the cross-correlation function identifies the amount of the shift to be applied to the slave patch to be superimposed to the master one. The higher (and the sharper) the peak, the more reliable is the estimated shift. Note that the maximum detectable shift is equal to $\pm d/2$, where d is the patch dimension (assumed square).

In order to identify reliable shifts, two quality parameters are considered: the peak value of the cross-correlation matrix and its maximum-to-median ratio. For both of them, a pre-determined user-defined threshold is used to exclude invalid ground control points (GCPs). Retrieved GCPs are then subject to a filtering procedure, in order to minimize noisy displacement patterns.

4. Results and Conclusions

The results of the implemented SPOT technique have been compared with those presented in the literature, see first and second columns of Table 1.

The results obtained by applying the previously described implemented algorithm are reported in the third and fourth columns of Table 1 for the 2011-2012 and 2012-2013 couples of CSK images, respectively.

As we can see, the displacement velocities retrieved through SPOT method are in reasonable agreement with those reported in literature. The most critical regions are those labeled with ID 6, 7, 8, and 9 in the central and in the bottom part of the landslide.

Finally, we implemented a consistency check, in order to verify the reliability of the displacements retrieved using SPOT technique. Being A the displacement map for the period 2011-2012, B the one for the period 2012-2013, and C the one for the period 2011-2013, in the absence of errors we should have $A+B-C=0$. As reported in the sixth column of Table 1, this is not achieved strictly. However, the deviation from zero is (on average) in the order of three centimeters (thus below the resolution of the method, which is $1/8$ of pixel, thus about 10 centimeters), with a maximum of 31 centimeters registered for the area 10, thus confirming the consistency of the obtained results.

Table 1

Region ID	In situ displacement velocity 1985-1990 (m/y)	GBInSAR displacement velocity June-July 2010 (m/y)	SPOT disp. velocity 2011-2012 (m/y)	SPOT disp. velocity 2012-2013 (m/y)	Consistency check (m)
Whole landslide	2.48	1.13	2.48	1.68	0.03
1	0.73	0.15	0.31	0.20	0.29
2	1.20	0.33	0.77	0.31	0.11
3	1.42	0.36	1.01	0.55	-0.09
4	1.60	0.36	1.45	0.72	-0.17
5	1.06	1.06	3.05	2.19	-0.21
6	1.68	1.68	4.30	3.43	0.16
7	2.85	2.85	5.19	3.96	0.18
8	1.64	1.64	3.56	2.43	0.01
9	1.93	1.93	3.93	2.64	-0.14
10	0.91	0.91	1.08	0.81	0.31
11	1.13	1.13	2.64	1.21	-0.13

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Session Natural disasters, atmosphere and cryosphere
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Sentinel data for flood mapping and monitoring: december 2017, flooding along the Enza e Parma rivers

Flood events are one of the main emergencies that European countries have had to face in the last years. The number of devastating floods has more than doubled in Europe since 1980 and flood disasters often have a broad extent and a high frequency.

Earth Observation techniques have become a key tool for flood mitigation and damage assessment.

After the event, satellite remote sensing enables the flood surveying, providing valuable information on the intensity and the progress of flood inundation, spurs and embankments affected/threatened. SAR and optical images are frequently employed for flood mapping and monitoring purposes, being the fastest means of data collection for pre- and post-event disaster analyses.

The Copernicus Earth Observation programme managed by the European Commission has been designed to provide accurate, timely and easily accessible information to improve environmental management and to map a wide range of emergency situations, deriving from natural or man-made disasters. Sentinel satellites, specifically designed for this programme, provide open data in all-weather conditions, day and night images and multispectral and radar data at different spatial resolution.

The present study offers an analysis of the flood event which affected Emilia-Romagna region (Italy) in December 2017. Between the 8th and the 12th of December various meteorological phenomena hit the region. In particular, between the 10th and 11th exceptional rains (300-500 mm recorded in 36 hours) caused the significant increase of the water level in the Po's Emilian tributaries and in the Reno river; in some sections of the Parma, Enza and Secchia rivers, the water level exceeded the historical highs. The flood wave caused severe damages to the embankment resulting in widespread flooding in the built-up area.

The purpose of this study is the detection of the flooded areas caused by this extraordinary event, by means of Sentinel multitemporal data. Both optical and radar images, acquired by the Sentinel 1 and 2 missions, have been processed for mapping and for monitoring the affected area during and after the emergency, in order to produce the flood inundation map.

Firstly, the areas between the Enza and Parma rivers, inundated immediately after the overflows, have been studied by radar imagery, refining the analysis by optical data. In a second phase, the study has been focused on the most affected zone placed along the Enza river, extending the survey to a longer period in order to produce a multitemporal flood map and to evaluate the water retention phenomenon. The extracted flood maps were finally compared with the grading maps produced by the Copernicus Emergency Management Service for the event.

The results are discussed in terms of findings and suitability of images and methods.

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Monitoring areas affected by fires in the Vesuvius National Park with Sentinel data

Wildfires records for 2017 summer season indicate that Italy, in Europe, had the highest number of fire events, while, in terms of burnt area, Portugal was the most affected country. "By early September 2017, wildfires have already burn nearly 700 000 ha of land in the EU; hence this season will most likely be remembered as one of the most devastating wildfire seasons in Europe since records began." (Source: Daniel Calleja Crespo, Director-General of DG for Environment of the European Commission, EUR 28707 EN, PUBSY No. JRC107591).

Southern Italy was particularly affected by last fire season and several fires affected forest areas and, in some cases, threatened the rural-urban interface. In the Campania administrative region, the Vesuvius National Park was struck by multiple simultaneous fires causing a large spatial modification in the continuity of the canopy cover and leading to an alteration of the ecoservices provided by the forest standing the Park.

This study encompasses multi-temporal Sentinel 1 (S-1) and Sentinel 2 (S-2) acquisitions for investigating recently affected fire-disturbed areas in the Vesuvius national park. Time series of SAR backscattering and coherence and optical indices were analysed to investigate changes in vegetation cover and vitality due to a varying fire severity (i.e. the degree of environmental change soon after a fire). Moreover, a fuzzy burned area mapping algorithm was applied to post-fire S-2 images to extract fire perimeters and fuzzy scores which were related to fire severity as extracted from independent datasets. These analyses are preliminary to fine tuning of the fuzzy algorithm for the integration of S-1 and S-2. The integration of SAR and optical data can provide complementary information for mapping burned area extent and severity. A dataset including both ESA (European Space Agency) Copernicus S-1 and S-2 was exploited to monitor the areas affected by fires during and after the 2017 summer events over the Vesuvius National Park. S-1 analysis is based on processing multi-temporal dual-pol (VV+VH) S-1 SAR Single Look Complex (SLC) data (IW mode) acquired over the period from June to September, 2017. SAR data was radiometrically calibrated to obtain relevant backscattering coefficients, also compensating for topography-induced distortions. S-2 images (A&B), covering the period April to September 2017, were downloaded and Spectral Indices (SIs), such as NBR (Normalized Burn Index, S-2 NBR), were computed. To this aim an automatic procedure, which was developed to exploit ESA Sen2Cor processor for generating Level 2A products, was used to perform atmospheric-, terrain and cirrus correction of Top-Of- Atmosphere (TOA) Level 1C Sentinel-2 data and to deliver surface reflectance images. Information on areas at different levels of fire severity were extracted from the fire damage grade dataset of the Copernicus Emergency Management Service (EMSR213: Forest Fire in Southern Italy) service. The dataset provides the damage grade assessment of the Vesuvius area as derived from post-fire visual interpretation of high resolution satellite images. Fire grading provides three damage levels: "Destroyed", "Highly Damaged" and "Negligible to slight damaged". The preliminary analyses presented in this work were carried out within the borders of the National park (Source: DGPNM/ MATTM, vector shape file) and restricted to vegetated areas as provided by the Corine Land Cover 2012 map.

As far as microwave information is concerned, two different processing strategies were carried out to assess the contribution of the full information content of SAR signal (intensity and phase). First, an analysis of multi-temporal backscattering signatures was performed over the area of interest, to investigate fire-induced temporal dynamics and changing backscattering behavior. The S-1 time series was exploited to evaluate the variation of backscattering coefficients between the selected pre- and post-fire dates (Ds_{VH}^0 and Ds_{VV}^0). Indeed, the SLC S-1 images were de-bursting, co-registered, and radiometrically calibrated. Processing was carried out with the ESA SNAP Toolbox. As a matter of fact, the occurrence of a fire event producing changes in the vegetation cover (by direct combustion of the vegetation, delayed mortality of plants and secondary succession), thus a reduction of the volumetric backscattering contribution is associated with the biomass inherent decrease. Therefore, a significant decrease (with respect to pre-fire condition) of the cross-polar (VH) backscattering coefficient can be observed in correspondence of the damaged areas, according to.

Secondly, the phase information was explored. In particular, the temporal variation of the interferometric coherence between couples of SAR images collected during the fire season was examined. The adopted strategy relies on the key observation that the occurrence of a fire event, which induces changes in the vegetation layer, leads to a variation of the coherence. The rate of change is a function of the wavelength, the signal polarization and the level of fire severity. In cases of high fire severity most of the canopy cover is destroyed and, consequently the bare soil remains exposed to direct solar radiation. Therefore, a study of the temporal changes of phase coherence can give additional information on the extension and the characteristics of an area affected by a fire.

Regarding multispectral analysis, first the time series of S-2 VIs were analysed to assess the effect of the occurrence of fires on each index. Second, a fuzzy burned area mapping algorithm was applied to the S-2 time series to extract the perimeter of the area affected by the fires and to highlight spatio-temporal pattern of the fire event. The fuzzy algorithm integrates Spectral Indices (SIs) by applying fuzzy theory and a region-growing algorithm to detect burned areas. The output is a map of fuzzy score (fs) continuous values in the range [0,1]. The higher the fuzzy score the higher the likelihood for the surface/pixel to be burned, as a side product the burn likelihood can be analysed as a proxy of fire severity. Each S-2 image can be processed to compute the fuzzy score for each pixel. Post-fire fuzzy score maps were used to extract fire perimeters, which were compared to the perimeter provided by the EMSR213 dataset used as reference.

Ds_{VH}^0 and Ds_{VV}^0 together with phase coherence and S-2 derived fuzzy score and vegetation indices time series, were analysed to investigate the relationship/correlation between SAR and optical data and changes to the vegetation caused by fire; the analyses were carried out for the three fire severity categories.

Fire perimeters derived with the automated fuzzy algorithm showed agreement with the EMSR213 perimeter produced by expert by visual interpretation. The fuzzy score map derived from S-2 image acquired on 26/08/2017 was correlated to EMSR213 damage grade showing that higher fuzzy scores highlight highly damaged surfaces.

Time series of S-2 vegetation indices well highlight the temporal evolution from pre-fire (unburned) to post-fire (burned) conditions of the vegetated areas affected by the fires. Results reveal that some of the indices are more sensitive to fire severity by highlighting significantly different average values for the low severity vs. the moderate to high severity categories. Atmospheric conditions affect the VIs to a different rate; in particular, NBR and NBR2 show larger standard deviations in the S-2 image acquired during the fire events due to the presence of smoke in the atmosphere.

Concerning the outcome from the analysis of S-1 SAR data, the cross-pol (VH) backscattering coefficient confirmed to be more sensitive to fire occurrence with a significant decrease over burned surfaces. By focusing on the dates close to the fire events and computing the difference of coherence between a pre- and a post-event couple of SAR images, we pointed out that the occurrence of fire induces a significant increase of coherence over burned areas.

S-1 and S-2 multi-temporal data were exploited to analyse the areas affected by fires over the Vesuvius National Park, Italy, during the 2017 summer season. Optical S-2 data were exploited to extract the fire perimeters. Both optical and SAR data were analysed with respect to fire severity showing a relationship with the low to high severity categories provided by the Copernicus Emergency Management Service (EMSR213: Forest Fire in Southern Italy). Future work will focus on the analysis of S-1 SAR coherence maps. Next steps of this research will make use of field surveys during the 2018 spring/summer season to assess in situ fire severity levels.

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Ada Vittoria Bosisio¹, Giovanni Macelloni², Marco Brogioni²

Evaluation of the atmospheric upward thermal emission towards sea surface salinity retrieval at L band

The development of the L-band missions SMOS (ESA) and Aquarius (NASA) occurred in the last decade has offered the opportunity to map the sea surface salinity from satellite-borne sensors with both spatial and temporal accuracy unattained before. Indeed, L-band is the most suitable frequency band available to the remote sensing community for this specific topic. Recent studies showed that the availability of microwave radiometers operating at even lower frequencies (e.g. down to P-band such as UWBRAD) could improve the current performances. As reported in [1], the sensitivity of the brightness temperature T_b to the sea surface salinity has a dynamic range of about 5K; thus every further contribution to the T_b in the observed scenario must be taken into account accurately. Among these contributions, one may recall the cosmic microwave background, the sun-emitted and the moon-reflected radiation, and the self-emission of the atmosphere. Whereas the first three contributions are well assessed and they can be estimated with the required accuracy, the last one is variable in itself as it depends on the continuously changing atmospheric conditions in term of water content, in both vapor or liquid phase, and occurrence of precipitation. A fluctuation of 0.5K due to the atmosphere can have an appreciable impact on the Sea Surface Salinity (SSS) estimations. In order to assess the impact of the atmospheric contamination on the current SSS retrieval and to contribute to the phase 0 studies of the Ultra Wide Band satellite radiometer mission CryoRad, an analysis has been carried out by using experimental data and theoretical models. The atmospheric status is taken from radiosonde profiles collected during 2015 and 2016 on the test site of Lihue airport, Kauai Island, HI-USA (WMO id. 91165 PHLI, 21° 58' N, 159° 20' W, 399m a.s.l.). The profiles database includes 804 dry and 673 with non-precipitating clouds atmospheric scenarios. Integrated Water Vapor content I WV shows an almost Gaussian distribution with average value equal to 30.2 mm and S.D. of about 8 mm; the maximum integrated Liquid Water Path (LWP) in cloudy profiles is 0.5 mm. These data were used as input to the radiative transfer model known as T_b model [6] to estimate the atmospheric contribution to satellite T_b measurements under well-controlled conditions. The database of predicted brightness temperature values computed at 1.4 GHz restitutes an average $\langle T_b \rangle$ value of about 4.7 K with S.D. = 0.02 K as contribution of the atmospheric thermal emission along zenithal path. It should be noticed that the predicted T_b values at this frequency show only a slight variation with the I WV. Details about these simulation results and the comparison against predictions obtained with empirical laws applied to meteorological surface parameters will be shown at the conference.

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Use of Sentinel-1 and Sentinel-3 data to initialize a numerical weather model

High resolution Numerical Weather Prediction (NWP) models are presently able to produce forecasts with a spatial resolution in the order of 1 km (the so-called cloud resolving grid spacing). However, poor knowledge of the initial state of the atmosphere at small scales may imply an inaccurate simulation of the weather phenomena in terms of timing, location and intensity. Moreover, high resolution NWP models need suitable surface information, because the representation of surface-atmosphere interactions in weather forecast models has a strong impact on the Planetary Boundary Layer (PBL) and, in turn, on the forecast. To tackle the problem of the knowledge of the initial and boundary conditions, satellite data can be of great importance, because it is expected that numerical weather modelling uncertainties can be significantly reduced by ingesting EO derived products into models operated at cloud resolving grid spacing. These products may concern soil moisture, land and/or sea surface temperature, wind speed, as well precipitable water vapour contents. In this context, microwave and optical data extracted from the Copernicus Sentinel satellites can be very useful in improving the performances of high-resolution numerical models through a spatially accurate determination of land and sea surface conditions. Additionally, Sentinel-1 data can be used to characterize the atmosphere by applying the SAR interferometry (InSAR) technique. InSAR is able to provide Atmospheric Phase Screen (APS), i.e., maps of the atmospheric delay affecting the SAR signal at the time of the SAR observation relative to the atmospheric delay at the acquisition time of a master image. Atmospheric delays affect also the GNSS observations, which can be used to estimate time series of Zenith Total Delays (ZTDs), representing the delay induced by the troposphere on GNSS signals in the zenith direction above a GNSS receiver. By properly combining InSAR-APS and GNSS-ZTD, it is possible to derive spatial high-resolution maps of ZTDs.

In agreement with the previous considerations, the STEAM (SaTellite Earth observation for Atmospheric Modelling) project, funded by the European Space Agency (ESA), aims at investigating new areas of synergy between high-resolution numerical atmosphere models and data from spaceborne remote sensing sensors, such as the ingestion of high-resolution remote sensing data products in high-resolution NWP models. As numerical model, the Weather Research and Forecasting (WRF) one was chosen because it is well-established, has different physics parameterizations and enables the use of various data assimilation techniques. The ingestion of Sentinel-derived data into WRF will be attempted for a couple of case studies. Possible candidates as STEAM case studies are the extreme events (causing flash floods) that hit Livorno (central Italy) on September 9, 2017 and Silvi Marina (Central Italy) on November 15, 2017.

It must be taken into account that, among the EO data that will be incorporated into WRF, some data, such as sea and land surface temperature, or wind speed are directly available as level-2 products (and can be directly transferred into the model). Conversely, other data, such as high-resolution soil moisture, or the integrated water vapor have to be retrieved (from Sentinel-1 images in this case). For what concerns soil moisture (SM), the retrieval algorithm is based on a multi-temporal maximum likelihood (ML) approach used to invert a direct model of backscattering from a bare soil. The water cloud model is used to discriminate the soil contribution to the radar backscatter in the presence of vegetation.

For the selected case studies, available Sentinel-1 and Sentinel-3 data will be gathered to derive surface soil moisture, land and sea surface temperature, wind speed and APS. Moreover, GNSS data from existing networks of receivers will be used to retrieve point-wise ZTD time series, which will be both directly ingested into WRF and used to produce APS-derived ZTD high resolution maps. The impact of initializing the WRF runs by ingesting one Sentinel-derived variable at a time will be firstly evaluated to verify whether and to what extent the use of a single EO derived product affects the forecasts. Then, the EO products that will prove to mostly influence the model outputs will be jointly ingested to carry out a sort of "optimal" WRF run. The major outcomes of these experiments will be shown at the conference.

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Giovanni Macelloni, Marco Brogioni, Francesco Montomoli, Marion Leduc-Leballeur

Monitoring Antarctic ice sheets characteristics from SMOS data

Because of the sparse coverage of the in situ measurements in Antarctica and due to the limited possibility of operating in such harsh environment, remote sensing data are of paramount importance for the climate study in this continent. Up to recent years, passive microwave sensors were extensively used for the monitoring of ice sheet surface parameters (i.e. snow melting, grains size and density in the first meters) because of the limited penetration depth of the frequency bands available on the satellite sensors. With the launch of L-band microwave radiometers (ESA's SMOS in 2009, and NASA's Aquarius and SMAP in 2011 and 2015 respectively), having a longer wavelength (i.e. 21 cm), the capability to explore deeper portions of the ice sheet increased and opened up new research scenarios. In particular, recent research activities, demonstrate the L- band sensitivities to the temperature gradient of the ice profile (i.e. from the surface to the bottom). It should be mentioned that the internal temperature is a key parameter for the understanding of the ice sheet dynamics which, at present, is available only from glaciological models or in the few boreholes where temperature has been measured. Results demonstrate that, by using an appropriate glaciological and microwave emission model, it is possible to retrieve the ice sheet temperature profile starting from SMOS data. Secondary products are the geothermal heat flux and snow accumulation maps at the same spatial resolution of SMOS. By using a similar approach, it has been demonstrated that it is possible to exploit SMOS data to retrieve the ice thickness. The methodology was tested in region of Antarctica where the ice thickness is well known (i.e. uncertainty lower than 100 m measured by means of radio echo soundings) and provides a maximum difference from the reference of 200m. This result seems to be very promising for those areas of Antarctica where the current estimate have an uncertainty of about 1000m. Snow melting products derived by SMOS are also compared to the same product obtained with higher frequencies (Ku band).

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Bracco Classroom - Chairman: Duccio Rocchini, Carlo Ricotta

Sofia Bajocco¹, Carlotta Ferrara², Alessandro Alivernini², Marco Bascietto³, Carlo Ricotta⁴**Clustering forest types by means of remotely-sensed phenology: Italy as a case study**

Vegetation phenology is an area of ecology concerning seasonal rhythms of plants. Phenology is a responsive indicator of how climatic and physiographic factors affect ecosystems. Long-term phenological observations, such as those provided by satellite remote sensing, are fundamental to understand spatio-temporal dynamics in forests. Satellite Enhanced Vegetation Index (EVI) data represent a well-known proxy suitable for forest productivity monitoring and seasonal variations detecting. The Italian National Forests Inventory and forest Carbon pools (INFC) was considered as a reference dataset of Italian forest types. We used Google Earth Engine for extracting, processing and exporting mean MODIS EVI (2000-2017) profile of each INFC point. Then we applied a multivariate approach for the purpose of (i) deriving clusters of phenologically homogeneous forest stands, (ii) characterizing the seasonality and the forest composition of each cluster and (iii) exploring the role of geographic and physiographic variables on the phenological timing of each cluster. Results identified four macro-clusters encompassing the main phenological forest types in Italy: the Alpine coniferous-like type, the beech-like type, the oaks-like type and the Mediterranean evergreen-like type. The obtained clusters showed to follow a clear elevation gradient, with a distinct separation of the forest phenological groups along the Mediterranean-to-temperate climatic transition of Italy. The discrimination of vegetation phenology types can provide valuable information useful as baseline framework for further studies on forests ecosystem responses to environmental conditions and climate change.

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A multitemporal database of optical and structural data for the validation of radiative transfer models and remotely-sensed information in temperate broadleaved forests

Reflectance models are being used in forest remote sensing, but their effective use has been often hindered by difficulties in model validation. The major challenge in validation is that the needed input parameters are often not measured or are measured with poor precision. Therefore, accurate ground truth data are required to properly validate reflectance model and to calibrate information derived from forest remote sensing. As an example, the RAdiation transfer Model Intercomparison (RAMI) initiative proposes a mechanism to benchmark models designed to simulate the radiative transfer in forest canopies. However, the actual canopies used for running simulations are limited to sparse canopies, which are mainly concentrated in boreal or austral forests. Similar datasets on temperate forests are scarce, but they are particularly relevant considering the high level of complexity of these forests, which in turn can complicate the retrieval of vegetation attributes from remotely sensed data.

In the framework of the Project LIFE FutureForCoppiceS (www.futureforcoppices.eu) an extensive database of optical and structural data has been compiled from nine forest stands, being representative of three most commonly diffused European Forest Types, (mountainous beech forests, thermophilous oak forests and evergreen broadleaved forests), under different management regimes. Forest inventory data have been collected and available since the 1969 and repeated every 5-10 years. Twenty-five years (1992-2016) of annual measurements of leaf area index, litter production and its partitioning were collected using both indirect (LAI-2000 Plant Canopy Analyzer) and direct (Littertraps) methods.

A theoretical gap fraction model was parametrized to illustrate the radiative transfer modelling implementation from the collected data. Other applications include calibrating processed-based models to evaluate the influence of forest management on stand growth and ecological processes within forest stands, modelling tree masting patterns, validating optical measurements from aerial imagery (including unmanned aerial vehicles, airborne and satellite imagery).

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Cristiano Foderi, Giulio Castelli, Elena Bresci, Fabio Salbitano

Back to the future of land cover and sustainability. Historical land cover analysis in remote Bolivian areas with Google Earth Engine

nowadays massive computational capabilities of online cloud-based platforms offer dramatic possibilities in the field of geosciences, including the analysis of remote sensing imageries for earth surface processes observation and modelling. The work presents an application of Google's novel Earth Engine (GEE) platform for the analysis of land cover evolution in the last 30 years for the area of Valles Crucenos, Santa Cruz Department, Bolivia. The region is characterized by the expansion of the neighbouring Santa Cruz de la Sierra, the 2nd fastest growing city in Latin America, that is causing both a migration of rural population to the city and an increase in the fluxes of resources from the peri-urban area, inducing heavy changes in the land cover of the whole department. Land cover maps for the years 1986-87, 1996-97, 2006-07 and 2016-17 were analysed, each one realised with a supervised classification of a composite of two year of Landsat Tier 1 (T1) satellite images. Tier 1 was used to guarantee formal geometric and radiometric quality criteria. All the Landsat T1 scenes used to produce the composite two-years stacks were selected through a cloud score ranking under a threshold of 10% of image cover. The whole process required no data download, with a computational time of 100 seconds on GEE servers for each supervised classification. CART supervised classification process was applied to Landsat T1 spectral bands (from ~0.45 to ~2.3 μm) on over 3600 training points for 7 land use classes: forest, dry forest, agricultural, shrub-bare land, grassland-pasture, grass-shrubland and urban. CART algorithm showed good performance accuracy levels, in a range between 0.86 and 0.90 in term of K. While the prediction made with land cover change models for the area showed an expected deforestation trend, land cover analysis revealed a decrease of agricultural areas and an increase of forest cover in the last 10 years. Results can be explained as an effect of the progressive abandon of agricultural areas, caused by the urbanisation of rural population in Santa Cruz de la Sierra and in minor urban areas of Valles Crucenos. Highlighting these dynamics can provide support to land use planning and future environmental and socio-economic policies for the area. Moreover, the presented methodology can be simply and quickly extended to similar areas of the whole Latin America, especially where land cover change and deforestation data are not present or are available with a scattered coverage.

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Eldar Kurbanov, Oleg Vorobev

Tree species classification with the use of Sentinel-2 data in the Middle Volga Region of Russia

Remote Sensing data and techniques, in combination with GIS and field inventory data, are essential to analyze forest cover and its changes on vast areas. Precise information about tree species distribution is important for forest management, forest inventory and to assess potential impacts of climate change on the biological productivity of forest ecosystems. The study presents the results of iterative process of classification using Maximum Likelihood, Support Vector Machine, and Spectral Angle Mapper algorithms to estimate the potential of single date Sentinel-2 (October 2017) images for mapping tree species in two forestry districts Kirilovskoye and Olshanskoe of Russian Volga Region. Both forest districts are represented by highly fragmented area with heterogeneous land cover pattern and with homogenous structure of forest cover. To validate the newly obtained thematic maps of tree species distribution we used 275 test sites with independent field data, as well Kanopus-V and Resurs-P (satellites) images of high spatial resolution. The authors also analyzed the forest polygons and compared them to the state forest inventory data. Based on the field studies 10 classes of land/vegetation cover (strata) were identified to assess the spatial-temporal structure of the forest areas. In both forest districts tree species were distinguished at 10 m spatial resolution and the Sentinel-2 data confirmed its expected capacity to produce reliable forest cover maps. The use of Sentinel-2 autumn data (October) provided the opportunity to maximize the allocation of forest strata by species that are more difficult to obtain on summer images. The beginning of the change in the phenological condition of the forest stands allowed to distinguish especially deciduous species like *Alnus glutinosa*, *Tilia Cordata*, and *Populus Tremula*. Cross-validated overall accuracies ranged between 68-74% shows high degree of agreement between the thematic tree species maps and the ground truth data. Research results can be applied for the long term forest monitoring and management plan development in the investigated region.

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Bracco Classroom - Chairman: Duccio Rocchini, Carlo Ricotta

Lorenzo Bottai, Lorenzo Arcidiaco, Luca Angeli

Use of 2A and 2B Sentinel images to map forest fire burn scar and estimate forest damage

Every year forest fires cause serious damage to the environment, property, human health and endanger life. Fires can be monitored and analyzed on large areas in a timely and cost-effective manner using satellite sensor images combined with spatial analysis provided by geographic information systems (GIS). In this study the satellite images acquired from the Sentinel 2A and Sentinel 2B satellites were used, for the identification and monitoring of fires that occurred in the regional territory of the Toscana - Italy, in the period from June to September 2017.

Digital image processing methods, such as spectral profile analysis, vegetation indices and multispectral classification, were applied to satellite sensor images acquired before and after the forest fire. For this reason, a simple model algorithm was developed that allowed the automatic identification of the areas covered by fire, using multitemporal NBR (Normalized Burn Ratio) index and an automatic classification. The developed model allowed to estimate the level of forest damage

On the basis of the developed geodatabase local authorities must decide on a range of post-fire measures to mitigate risks quickly since most large fires occur late in summer shortly before the fall-winter rainy season and improve the efficiency of fire management

Session Satellite ecology

Thursday, 5 July 2018 (10:10 - 11:40)

Bracco Classroom - Chairman: Duccio Rocchini, Carlo Ricotta

Michele Zurlo¹, Bruno Bassano², Marco Caccianiga¹

A GIS-based assessment of land cover change in an Alpine protected areas

The European semi-natural landscape was markedly changed by the simultaneous effect of different processes. In this context aerial photos are still a valuable means to detect this change delineating the fine-scale pattern over large areas. Furthermore this remote sensed data are available in decades where other remote sensed data were still not available.

Conversely data availability, software cost, image preparation and data mining affect the effective usability of this supports.

In this case study we used only free and open source geographical software (GFOSS) focusing on image preparation to improve data mining phase.

Aerial images of a mountainous protected area were orthorectified, smoothed and similar group of neighbouring pixels were grouped in meaningful objects through a semi-automatic unsupervised parameter optimization procedure. Pixel groups were manually labeled creating a spatial explicit database.

Using a priori defined minimum mapping unit (MMU), the different landscape configurations were compared showing a change in protected area.

Implemented method ensured a strong repeatability and suitability over different aerial images and represented scene, but there are strong limitation in the use of this remote sensed data as data availability, an enormous amount of work for data pre-process and the need to easily automatize the classification step.

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Session Remote sensing for coastal monitoring and management

Thursday, 5 July 2018 (12:00 - 13:30)

Congress Hall - Chairman: Enzo Pranzini

Francesco Immordino¹, Elena Candigliota¹, Mattia Barsanti², Silvia Cocito², Ivana Delbono², Andrea Peirano²

An application of Sentinel-2 multispectral data for habitat mapping of Pacific islands

The ability to remotely map, measure and monitor the health and status of coral reef systems and associated coastal environments has gained remarkable advances thanks to the application of Earth Observation System (EOS). It represents a valuable habitat management tool to quantify damage and habitat vulnerability in areas of high natural and economic value, particularly in times of climate changes. ESA-European Space Agency is developing a series of next-generation Earth Observation missions (SENTINEL Program) on behalf of the joint ESA/European Commission initiative GMES (Global Monitoring for Environment and Security). Vegetation, soil and coastal areas are among the monitoring objectives of SENTINEL-2 and to provide systematic global acquisitions of high-resolution, multispectral images allied to a high revisit frequency. In this framework, ENEA presents its expertise applied to the marine environment of Palau Republic (western Pacific Ocean) in terms of shoreline assessment and shallow-water benthic habitat mapping. The present work performed by ENEA demonstrated the chance to optimize time and resources also through worldwide collaboration among research teams using shared strategic approaches with the common objective to mitigate effects of climate changes in the Pacific islands. The need to effectively manage coral reef systems and associated coastal environments such as mangroves and seagrass requires the ability to document their present status and monitor changes over time, detecting also those disturbances acting on a small scale that can be averted by local management actions. The ability to remotely map, measure and monitor the health and status of these valuable ecosystems has gained remarkable advances thanks to the application of Earth Observation System (EOS) and represents a habitat management tool to quantify damage and habitat vulnerability in areas of high natural and economic value. Using the Palau Archipelago as testing area, habitat classes were chosen with the objective to achieve a preliminary cartographic map centred on the most ecologically important habitats thriving in the Pacific region, namely coral reefs, seagrasses, mangroves, all sensitive to climate change. Remote Sensing is a powerful tool to classify marine habitats and enable to perform a real time automatic processing of satellite images; in particular, the use of recent Sentinel-2 imagery collection (ESA Copernicus Project) allows a reliable classification of marine habitat and a good identification of shoreline assessment and coastal habitats.

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Session Remote sensing for coastal monitoring and management

Thursday, 5 July 2018 (12:00 - 13:30)

Congress Hall - Chairman: Enzo Pranzini

Francesco Bianco¹, Rocco Dominici², Chiara Lanciano³

Validation Of X-Band Wave Radar Images As A Coastal Monitoring Tool

Italian peninsula and its islands (Sicilia and Sardegna) consist of about 7.480 km of coastal areas; they are hit by three different seas, and together with geological and ecological factors, they create several and peculiar coastal environments, that make Italy one of the most charming place in the world. On the other hand, this fact implies different problems and aspects on the coastal areas management. To make the matters worse, safeguard measures and sea fronts are really habitual and necessary, where some coastal erosion phenomena occurs, or where the economic strategies foresees them. They can often create negative feedbacks to coastal dynamics, and to the whole ecological system. Therefore, in this complex and dynamic system both, geological and sea state components represent two of the environmental matrices involved, but in a modern coastal and urbanized area, anthropogenic structures represent the "modern variable" of which we need to take account of. The aim of this paper is to show how we used an X- Band Wave Radar to detect some crucial information about backshore and foreshore zones in a site where several safeguard structures are still modifying coastal dynamics trends, and for the first time in Italy, as a remote sensing technique for the detection of coastal morpho-dynamics.

One of the main issues in the study of a coastal area is represented by the lack of information about backshore and foreshore; they represent the main occupied zones by the safety structures, and more in general they run from the shoreline to the active profiles lower limit of a beach, that is ranging till a depth of maximum 12 m in the Mediterranean Sea (average depth calculated through buoy data). Moreover, to develop new methodologies in the evaluation of the coastal erosion risk assessment became of primary interest since climate changes are increasing, and sea level is rising in a scenario where the legislative situation about coastal areas management results still inadequate. In addition, several considerations were done through geomorphic evidences in the field, and the using of aerial images, in order to both validate our new method and to infer some general and exhaustive trends of the processes during the last 40 years, and consequently their feedbacks to coastal dynamics.

Bagnara Calabria (RC) represented one of the test sites of the SIGIEC_PON Project (Integrated System for the Integrated Management of Coastal Erosion), which involved the University of Calabria and the National Research Council (CNR-IAMC) of Naples in 2015. In this site some new technological options, such as X-Band Wave Radar and a Sea-Land High-Resolution Seismic configuration were required, and they were experienced from the 24th to the 27th of February 2015. The study area is located in a sector of the "Costa Viola" mountain ridge, between Bagnara Calabria and Scilla, and represents an example of pocket beach, with high and rocky coasts. From a morphological point of view, steep and uneven slopes, cut by deep canyons, characterize the test area in the emerged sector. Cliffs surrounding pocket gravel-sandy beaches are nourished by short high gradient torrents the longest thereof are Favazzina and Sfalassà which drain the western slope of the ridge and flow in the submerged sector, where a discontinuous littoral wedge, extending from coastline to 200m offshore, characterizes the central part of the site. Here, three channels indenting the littoral wedge as result of several coalescing landslide scars (up to 50–100m wide) suggest very recent erosion, although, the test area is characterized by coast-parallel erosion probably related to long shore currents and rip currents, which have formed shelf sand waves and small slope ward erosive channels, respectively.

The X-Band Wave Radar uses electromagnetic waves to detect the distance, the position and the velocity of targets; this entire process works with an antenna (TX) that, at given and regular time intervals, produces a radiofrequency pulse through a transmitter; firstly it hits the targets in the scene, and secondly it is reflected and captured by the antenna (RX) that elaborates the signal through a receiver. Measuring the time that passes from the emission of the pulse and the return of the eco, it is possible to determine the distance (R) between the target and the antenna (TX-RX). The electromagnetic waves emitted by the antenna interact with the water surface through the EM fields reflection, and the backscattering of the EM fields dues by the water surface's roughness. They are mainly produced by the capillary waves caused by the wind action, but moreover, the interaction between EM fields and the sea surface depends on the transmitted radiation, that penetrating the surface highlights the structures with a similar length wave than its. This is the reason why these data are useful for the reconstruction of the meteo-marine climatology of the coastal sector, and also for acquiring the bathymetric features and the

morphologies of the seabed. Although a sequence of 1000 images of the sea state within one mile from the coast were produced, just 32 individual images with an interval of 1.97 s between successive images, were combined in a time integrated image of the reflected electromagnetic energy, that contains the information regarding the wave field and its variation in time on a local scale. The time integrated reflection maps were compared with geomorphic evidences taken both, on the emerged and submerged sides of the beach during a field survey, that was carried out till the depth of about 6 meters seaward, observing also the status of the present breakwaters. On the land side, instead, the upper limit of the active profile of the beach is often fixed by anthropogenic structures like the seafront, in two cases by rocky cliffs, and more often by some secondary roads. In addition, grain size observations and morphological structures on the other hand constituted some very useful factors that led us to justify and better understand the magnitude of the main erosive processes that affect the beach. These processes can be summarized in the cross-shore currents that are described by the sea state parameters, and the strong rip currents detected with X-Band Wave Radar, that both produced the loss of the Fiumara Sfalassà' sediment, respectively through the gap between the reef-type breakwaters and directly to the canyons located at about 200 meters from the shoreline. Furthermore, these erosive structures suggested different trends and origins; some of them are originated by sea storms and incoming waves that very often affect the shore of Bagnara Calabria, producing rough and deep berms and incisions in the direction of the dominant wave front, from SO toward NE. These trends and structures occur in the southern and northern parts of the test site where no breakwaters were built, unlike in the central sector of the beach a series of breakwaters occupies the transition zone, that during the decades were been involved in several dynamics and storms that still produce an intense ringing activity between structures and shore, affecting both the shape of the beach in this sector, and the looseness of sediment through the gaps between the barriers. Rip currents in particular are clearly distinguished in the reflection maps by some plumes of mean amplitude between the values of 2500 and 4000. These values change in relation with the sea conditions, and with rough sea state they become more evident and high. In particular, with very rough state of the sea the mean amplitude values reach their maximum, and it is possible to observe the behavior of the rip currents that after a ringing phase in the back of the barriers run seaward through the gaps, with high velocity firstly, and secondly assuming the same direction of the surface currents. Likewise the mean amplitude values were compared in the field with the outcropping sediments on the beach; at high values correspond rocky cliff and gravelly deposits (red areas in the image), instead of the sandy portions, where yellow patches and lower values of the mean amplitude occur.

Another main aspect of the carried out research was the analysis of aerial images; it was a main supporting point of the study because it led us to investigate processes and forms in a bigger scale. In fact, comparing different aerial images from different periods (1976, 1991, 1998, 2005, 2006, 2010) we observed the coastal dynamic trend assumed in the Bagnara Calabria site in relation with the breakwaters and the others anthropogenic activities, such as small and localized nourishments to contrast some erosive effects in the harbor area, hydraulic and constrained jumps (or orthogonal concrete septa) in the Fiumara Sfalassà, that inhibit the sediment transportation toward the beach, and some shapes (as coves) due to rip currents, during the last 40 years.

Finally, we can assume that X-Wave Band Radar represents one of the best remote sensing techniques in the coastal monitoring field for several reasons. One of the main and very useful aspects is that it has a good operating flexibility resulting in a "plug and play" system situated on a mobile platform, and furthermore if compared to traditional sea state systems monitoring, the X-Band Wave Radar is easier to install, to manage, to maintain, and the configuration in "mobile data acquisition modality" also allows having a great flexibility in the choice of the observation point. In addition it is possible to determine the meteo-marine climatology of particular coastal sectors without having to carry out the transposition of the data acquired through buoys, and in the same time it is possible to infer the behavior trends of the same sites. Hence, the validation methods show how reliable the radar is and how easily scientific and management communities could avail of this useful tool, suggesting enormous enhancements in methodologies and studies used in Calabria since that time. The great contribution offered by new technologies and by new configurations of the old ones in the coastal field, get unexpected evidences and results as the possibility to detect, using the X-Band Waves Radar, both sea state parameters as wave height, wave lengths, wave period and spectra, and to infer coastal dynamics at the same time. This is a huge task in the coastal management and planning in particular for whom that need to design safety structures or for the understanding of their influence on the coastal dynamics, and nonetheless for the projects that need a validation tool, as it happens for several kind of numerical models such as dominant waves and meteo-marine conditions.

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Session Remote sensing for coastal monitoring and management

Thursday, 5 July 2018 (12:00 - 13:30)

Congress Hall - Chairman: Enzo Pranzini

Sara Guida¹, Pierluigi Brandolini¹, Nicola Corradi¹, Antonio Lucarelli²

Laser scanner and multibeam application addressed to geomorphological hazard evaluation of rocky coast

How the application of remote sensing techniques can support and be used in the evaluation of geomorphological hazard has currently a great interest and relevance within land planning and management strategies in coastal areas.

In the framework of rocky coastal environment, where it is necessary to get a large amount of georeferenced data both at sea and inland, we believe that remote sensing techniques, allow the acquisition of the whole information in a single and integrated survey campaign. This is very effective both in term of time and cost.

Within this topical issue, we carried out a survey of rock coast and seabottom of Gallinara Island (Western Liguria, Italy) with the aim to produce a geomorphological map of the emerged and submerged coastal zone particularly addressed to the evaluation of the susceptibility of sea cliffs instability. It is a small island with an extent of 0,11 km² and a maximum elevation of 87 m a.s.l. The integrated survey has been fulfilled using a Laser Scanner RIEGL mod. LMS-Z420i, a MultiBeam (MBES) R2Sonic 2024 and a GPS 5700 TRIMBLE in RTK (Real Time Kinematic) configuration. The coastal survey has been carried out by a boat properly equipped for the simultaneous acquisition of data on the Teledyne Reson PDS2000 platform.

By the implementation with GIS tools, a continuous 3D model reconstruction has been performed both for emerged and submerged coastal zone together with geological and geomorphological data.

MBES and LMS surveys, that were completely aligned thanks to the effectiveness of the configuration adopted during the acquisition, allowed to appreciate the attitude of the layers and the main discontinuities of the bedrock. The obtained data, checked and integrated with field observations and aerialphoto interpretation (orthophotos and stereoscopic images), allowed to produce a geomorphological map following the guidelines of the new legend of the Geomorphological Map of Italy proposed by "Istituto Superiore per la Protezione e la Ricerca Ambientale" (ISPRA) and "Associazione Italiana di Geografia Fisica e Geomorfologia" (AIGeo).

Moreover, the processing of the collected data (e.g. characteristics of the rocks and the joints) allowed the application of the "Sea Cliff Mass Rating" (SCMR) method for the evaluation of the quality and state of stability of sea cliffs (Lucchetti et al., 2013). SCMR partly takes in account the index Slope Mass Rating (SMR) by Romana (1993), introducing some new parameters related to the interaction of sea wave with cliff and seabottom (e.g. slope angle of the cliff; angle between the sea waves direction and the coast line; broken or breaking waves and the sea wave energy).

Finally, a susceptibility map of coastal instability, based on the correlation between SCMR and geomorphological data, has been produced. Five classes of susceptibility of coastal instability (SCI) have been identified according to their quality and state of stability (Lucchetti et al., 2014):

- SCI-4 - very high susceptibility, active landslides and sea cliffs with SCMR = 0-20;
- SCI-3 - high susceptibility, deep seated gravitational slope deformation (D.S.G.S.D.) and sea cliffs with SCMR = 21-40;
- SCI-2 - medium susceptibility, sea cliffs with SCMR = 41-60;
- SCI-1 - low susceptibility, sea cliffs with SCMR = 61-80;
- SCI-0 - very low susceptibility, beaches and sea cliffs with SCMR = 81-100.

In conclusion the application of an integrated survey based on MBES e LMS techniques allowed to detect a large amount of high-accuracy data and significant data in a single survey campaign, even in areas difficult to detect with direct traditional techniques. The results allowed to consistently assess the stability conditions of rocky coast highlighting the most hazardous areas along the southwestern sectors of Gallinara Island, which are exposed to dominant waves.

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Session Remote sensing for coastal monitoring and management

Thursday, 5 July 2018 (12:00 - 13:30)

Congress Hall - Chairman: Enzo Pranzini

Sofia Hakdaoui

Coastal vulnerability mapping using the analytical hierarchical process case of Ad-Dakhla in southwestern Morocco

It is paradoxical that the countries least responsible for global climate change are in fact the most vulnerable to its adverse effects. The Moroccan coast and more particularly, the Saharan coast is characterized by long stretches of beaches with fine sand in the middle of sections in cliffs, the immense bay of Dakhla (37 km long and 12 km wide) and its peninsula constitute a true pool of unlimited beaches which is facing a potentially multi-hazard threat due to climate change. In this paper an analytical hierarchical process (AHP) based approach to coastal vulnerability studies. The process combine socio-economic parameters with the physical parameters to calculate the coastal vulnerability index using AHP derived weights. Eight physical–geomorphological parameters (coastal slope, geomorphology, lithological nature of sediments elevation, shoreline change rate, rate of sea level change, significant wave height and mean tide range) and four socio-economic factors (population, land use/land cover (LU/LC), roads and location of tourist areas) are considered to measure the physical vulnerability index (PVI) as well as the socio-economic vulnerability index (SVI) of the dakhla coast. These variables are integrated through recent geospatial techniques (Sentinel-1 radar coregistration and interferometry, Sentinel 2 optic segmentation by thresholding of ratio bands and pixel classification for each period) and compared to those obtained from old geospatial data (Shuttle Radar Topographic Mission (SRTM)), and then ranked to estimate the degree of coastline vulnerability to sea level rise. The results show that sentinel-1 radar data gives more accurate mapping of coastal vulnerability compared to those obtained by SRTM data.

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Session Remote sensing for coastal monitoring and management

Thursday, 5 July 2018 (12:00 - 13:30)

Congress Hall - Chairman: Enzo Pranzini

Chiara Lapucci¹, Stefano Taddei², Bartolomeo Doronzo¹, Maria Fattorini¹, Samantha Melani¹, Alberto Ortolani¹, Bernardo Gozzini², Carlo Brandin¹

Earth Observation and modelling as an aid to coastal water monitoring and decision support systems

In this work we show the application and perspectives of the combined use of data from satellite, in-situ measurements, and modelling for the monitoring of vulnerable coastal areas, as for instance zones of strong touristic value subject to harmful algal blooms (HAB), as well as areas of outstanding environmental value, like Marine Protected Areas (MPAs). Given the high dynamic variability of marine systems, a comprehensive monitoring system needs to combine multiple sources of information. Indeed, the issues connected to satellite revisiting time and cloud coverage can be dealt with by modelling: hydrodynamic and biogeochemical data from high-resolution models provide dynamic maps of physical and biogeochemical parameters. In addition, variables computed by models are not limited to sea surface parameters. The biogeochemical and physical data derived from different sources are combined and compared to thresholds computed on climatological data and scientific literature regarding the specific area object of the study, in order to detect the conditions under which a potential damaging event for the environment is likely to occur. This study is conducted in selected areas in Ligurian and North Tyrrhenian sea that are known to be particularly vulnerable to specific issues such as HAB, or showing particular care needs, such as MPAs.

Earth Observation (EO) data provide information about biotic and abiotic conditions, as well as data useful to monitor the environmental correlates of biodiversity, also assessing the impact of human threats to biodiversity. Satellite coastal observations undergo many issues, connected for instance with spatial resolution. EO data obtained from new generation satellites with improved characteristics, such as Sentinel 3, are particularly suitable for coastal area studies because of their high spatial resolution and improved atmospheric correction, as for instance concerning coastal aerosols. Until now, waiting for Sentinel 3 and Sentinel 2 biogeochemical algorithms to be implemented in Mediterranean area, MODIS and VIIRS data were used in this study, but the operational chain was implemented for Sentinel 3 OLCI and SLSTR data and the first tests with them are currently being performed. It is known that for coastal observations MODIS and VIIRS spatial resolution is too low, and that there are atmospheric issues connected to coastal atmospheric aerosols, which are going to be managed better with Sentinel 2 and Sentinel 3. In spite of that, thanks to a strict level 2 flag masking applied to the coastal pixels, getting rid of the ones indicating for example clouds, low quality atmospheric correction, bottom reflection saturation of one of the bands, the selected data gave reliable observations, at least in terms of the observed space and time dynamics.

The Earth Observation algorithm is a procedure (written in Python and C shell language) which daily downloads the satellite data, available on the first hours of the day following the satellites overpass. MODIS data are preferred, because VIIRS shows an important striping problem, so VIIRS data are used only when the current MODIS data is not available (because of cloud coverage, etc). When both MODIS and VIIRS data are not available, data of the latest day are taken. Data are cleaned by pixel masking. Pixel average of MPA zone is computed, and the obtained value is compared to a threshold, in order to understand if the single parameter is in a range of ecological safety or alert. The same procedure is applied to Sentinel 3 OLCI data, for a comparison of the performances of the three satellites. The parameters selected for the study are: Chlorophyll a, Sea Surface temperature and Water Clarity (as Kd490). Data from weather stations and marine buoys which are part of LaMMA ocean observing system are also used.

The modelling component is constituted by a chain of very high-resolution nested models, whose boundary and initial conditions are extracted from Copernicus Marine Service ocean and biogeochemical models.

Some of those techniques were formerly applied in the Sympa (Satellite assets Integration for Marine Protected Areas) demonstration project which is co-funded in the framework of ESA Integrated Application Promotion (IAP) programme. The project offers to MPAs a technologically advanced support for MPAs control, developing a set of software applications for protected areas monitoring and conservation also based on EO data and modelling. In the SYMPA system, biogeochemical and physical data derived both from satellites and models are produced daily as an input to the Traffic Light service, a dedicated tool that gives information to MPAs managers about the risk level for the environment, combining those data with sea traffic monitoring data derived from innovative vessel detection algorithms.

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Session Remote sensing for coastal monitoring and management

Thursday, 5 July 2018 (12:00 - 13:30)

Congress Hall - Chairman: Enzo Pranzini

Maria Teresa Melis¹, Antonio Funedda¹, Stefania Da Pelo¹, Giacomo Deiana¹, Giorgio Ghiglieri¹, Mattia Meloni¹, Luca Naitza², Paolo Orrù¹, Andrea Sulis¹

Integrating remote and proximal sensing data for the assessment of coastal cliffs vulnerability: MAREGOT Project

This manuscript focuses on the analysis of coastal cliffs vulnerability to triggering of landslides. This study is part of Project MAREGOT (MAnagement des Risques de l'Erosion cotière et actions de GOuvernance Transfrontalière – "Managing the Risks of Coastal Erosion and Cross-border Governance Actions) funded under the Programme: 2014 - 2020 INTERREG V-A Italy - France (Maritime). MAREGOT is a project aimed at the joint prevention and management of the risks arising from coastal erosion in the cooperation area.

One of the tasks of the project aims to the assessment of cliffs instability to understand the dynamics of erosive phenomena and the dynamics of coastlines, in relation to the geomorphological and hydro-dynamic characteristics of the coast

The erosion (coastal retreat) of cliffs and rocky shores is influenced by the geology, particularly by the structure and lithology of rock formations that outcrop on the coast and their response to local weathering. Geological setting with its complete characterization has to be analysed with different techniques aiming to reconstruct the past evolution and future dynamics.

Five sites have been chosen in to test the proposed methodologies. These sites, located along the Sardinian coast have been selected mainly on the basis of their geological setting. As well known, the geology in Sardinia is very varied and it is possible to observe a large number of lithological, stratigraphic and tectonic features that can be considered representative in order to extend the local observation to a wider scale of application in Mediterranean coasts.

The proposed methodology consists in the characterization of morphological and geological features collecting data from remote and proximal sensing sensors either on the sub-aerial or in the submerged cliff. These data will be integrated by direct observation and surveys of the different geological features and with laboratory analysis of the geotechnical properties of sampled rocks and terrains.

The main aim of this study is to integrate into the same GIS management system data acquired by different sensors as optical and thermal data, Lidar data, side scan sonar and multibeam information.

Acknowledgment

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Session SAR missions and GNSS

Thursday, 5 July 2018 (12:00 - 13:30)

Bracco Classroom - Chairman: Nazzareno Pierdicca, Fabio Del Frate

Maria Libera Battagliere, Luigi Dini, Maria Girolamo Daraio, Maria Virelli, Fabrizio Lenti, Alessandro Coletta

The COSMO-SkyMed Mission of First and Second Generation: evolution and future applications

COSMO-SkyMed (CSK) mission represents the most important Italian space asset in Earth Observation (EO) field designed to satisfy a wide variety of users needs in both civilian and defense domains. The CSK spacecraft constellation was a stepwise deployed from 2007 to 2010, with the launch and commissioning of four satellites hosting on board a Synthetic Aperture Radar (SAR) operating in X-band. In the last decade, thanks to its features, the Italian constellation has provided a significant contribution in several applications domains providing data for scientific, commercial and strategic applications. The operational continuity of CSK mission will be guaranteed by a second generation of satellites and a significant Ground Segment upgrade, known as COSMO Seconda Generazione (CSG) mission, which will join the first one. The CSG program has been taking place since 2010 and it includes two additional satellites which will achieve a generational step ahead in terms of functionality and performances. From the performance point of view, the CSG program aims at improving the quality of the imaging service, providing the End Users with new enhanced capabilities in terms of higher number of equivalent images and of increased image quality with respect to the first generation. Moreover, a smooth transition from CSK to CSG will be ensured through an integrated system accounting of both capabilities (CSK and CSG), meaning that COSMO-SkyMed services provided to users will be granted as if a unique constellation is operating. This paper aims to present the state of the COSMO-SkyMed mission and its evolution in these years, highlighting the functionalities evolution and application domain with an overview of the forthcoming CSG mission.

Session SAR missions and GNSS

Thursday, 5 July 2018 (12:00 - 13:30)

Bracco Classroom - Chairman: Nazzareno Pierdicca, Fabio Del Frate

Fabio Del Frate¹, Luca Fasano², Leonardo De Laurentiis¹, Daniele Latini³, Chiara Clementini¹

Features Extraction Using Auto Associative Neural Networks for SAR Image Processing

In the EO context the capabilities of extracting meaningful information from very large quantities of data is becoming dramatically urgent. This is also true for SAR images where we have both polarimetric missions and new planned missions, such as COSMO-SkyMed Second Generation (CSG), providing data characterized by very large dimensionality. Moreover, the dimensionality can still become larger if fusion with other systems such as Sentinel 1 is considered.

This paper focuses on the objective of extracting information in order to help the users in looking for relevant features using Auto Associative Neural Network (AANN). An AANN is a conventional multi-layer perceptrons (MLP) feedforward neural network. The training of AANN is performed by a backpropagation algorithm. The peculiarity of an AANN relies on a symmetrical network architecture, where the number of nodes in the input layer coincides with the number of nodes in the output layer. Different from the standard NN topology, a nonlinear AANN sees the use of three hidden layers, including an internal bottleneck layer of smaller dimension than either input or output. In particular, the AANN is trained to perform identity mapping (the input has to be equal to the output) in order to minimize the sum-of-squares error. Error minimization in this case represents a form of unsupervised training, since no independent target data is provided. If the training phase finds an acceptable solution, i.e., a solution that gives an error below a predefined threshold, a good compressed representation of the input must exist in the bottleneck layer.

Two applications of the AANN concept in the field of SAR image processing will be presented. A data fusion approach using COSMO-SkyMed and Sentinel-1 data is first described. The input data are joined in a stack of co-registered images (of different sensors, polarization, acquisition time) and the AANN extracts the main features which are then used as inputs for a land cover classification task. It is shown how the classification results obtained considering as input the features extracted by means of the AANN are comparable with those produced with the original images. The second application regards coastline extraction from SAR polarimetric images. In this case the AANN aims at extracting from the original RADARSAT polarimetric data the features that would help the land-sea separation process. The purpose is to use all polarimetric information for a better discrimination of the two types of surfaces. In fact, the AANN is followed by another NN, namely a PCNN (Pulse Couple Neural Network), which has already shown to be very effective for the final segmentation process. The performance analysis highlights an improvement of the accuracy of the final result with respect to more standard procedures.

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Session SAR missions and GNSS

Thursday, 5 July 2018 (12:00 - 13:30)

Bracco Classroom - Chairman: Nazzareno Pierdicca, Fabio Del Frate

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Exploitation of GNSS signals for estimating tree biomass

The measurement of aboveground biomass is commonly recognized of global relevance because of the vegetation role in the carbon cycle. Forest biomass, which is defined as the total amount of aboveground living organic matter in trees expressed as oven-dry tons per unit area, provides an estimate of terrestrial carbon stocks, and the observation of biomass change is a direct measurement of carbon sequestration or loss (Eisfelder et al., 2012). Currently, biomass is estimated either by destructive (harvesting the trees in each area) or indirect methods (measuring the various parts of trees and calculating the biomass by means of the so-called allometric equations), both of which are very demanding in terms of workforce (quality and quantity) and time.

Both active and passive microwave sensors can contribute significantly to this goal because of their high sensitivity to water content and high penetration at lower frequencies (L/P bands). A number of specific satellite missions devoted to vegetation monitoring are planned in the near future. Of special interest are BIOMASS (a P-band synthetic aperture polarimetric radar), to be launched in 2020 under the ESA's Earth Explorer 7 program (EE-7) (Le Toan et al., 2011), and FLEX (equipped with optical and thermal sensors), which is an EE-8 mission approved for launch in 2022 (Mohammed et al., 2014). Global Navigation Satellite Systems (GNSS) are recently receiving increasing interest as illuminating source of opportunity for L-band remote sensing since they could provide portable and low cost sensors for non-destructive forest biomass measurements over large areas. Several studies already dealt with environmental remote sensing applications of the GNSS signals collected by receivers placed on ground or looking down from aboard an airborne or a satellite. Well established techniques are presently exploited for the retrieval of ocean parameters (Gleason et al., 2009) from airborne or spaceborne platforms. Lately, the application of GNSS-Reflectometry (GNSS-R) was proposed as a new technique to overcome the saturation problem of vegetation microwave remote sensing (Ferrazzoli et al., 2011). Indeed, in this last decade, the application of this technique to vegetation monitoring was investigated during several experiments, where the receiver was looking down from a ground based (LEiMON) or an airborne platform (GRASS), respectively (Egido et al., 2012, 2014). During those campaigns, monotonic reduction in the reflectivity was observed with increasing vegetation biomass, showing limited saturation for high biomass, differently to what happens with conventional L-bands radars.

In this paper, a method is proposed to extract biomass information using the Global Navigation Satellite Systems (GNSS) direct signals collected in clear sky and below the vegetation canopy. An experimental campaign, carried out in the framework of an ESA project (GNSSBio), was conducted over three poplar forests with different biomass to verify the feasibility of this technique. The relationships between the GNSS measurements and the tree parameters were first assessed, and then interpreted and supported by statistical analysis and a theoretical model. Both direct line-of-sight propagation and volume scattering play a role in the signal magnitude and its fluctuation in time. An inversion algorithm was also proposed, based on artificial neural networks. Although the experimental dataset is limited in size and environmental conditions, the retrieval performance was encouraging and the proposed concept was reliably demonstrated.

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Session SAR missions and GNSS

Thursday, 5 July 2018 (12:00 - 13:30)

Bracco Classroom - Chairman: Nazzareno Pierdicca, Fabio Del Frate

Gregorio Farolfi, Silvia Bianchini, Nicola Casagli

Space-borne SAR and GNSS: integration for creation of surface movements maps

Nowadays advanced multi-temporal interferometric approaches such as PSI (Persistent Scatterers Interferometry) derived from the processing of space-borne SAR (Synthetic Aperture Radar) images represent an effective tool to detect terrain movements and provide millimetric ground measurements over large scenes thanks to their wide-area coverage, non-invasiveness and high accuracy. Nevertheless, PSI data lack of absolute reference both in time and space, as they are relative estimates measured along the sensors-to-target line of sight and referred to a chosen stable motionless reference point. In this work, a methodology to fix relative InSAR results into conventional geodetic reference systems through calibration with GNSS (Global Navigation Satellite System) data acquired from permanent stations is proposed. In particular, mean yearly velocities of PSI radar benchmarks are corrected with GNSS values by means of procedures commonly used in geodesy for combining crustal and local deformation studies. The operative method is tested in the area of south-eastern alluvial plain of Po river and Northern Apennines (Central Italy), extensively affected by subsidence with strong spatial and temporal variations. The outcomes consist in absolute and accurate vertical surface displacement maps of the study area and reveal high rates of long-term subsidence on the north-western Adriatic coast nearby Po Delta and on Bologna, Modena and Ferrara cities. Such results are in line with lowering terrain motion values presented by previous works carried out at local scale and by geological sources. Overall, the work reveals the usefulness of the presented methodology for generating unique ground deformation maps over wide area using geodesy for aligning PSI data before SAR maps stacking.

Session SAR missions and GNSS

Thursday, 5 July 2018 (12:00 - 13:30)

Bracco Classroom - Chairman: Nazzareno Pierdicca, Fabio Del Frate

Alessio Di Simone¹, Leonardo M. Millefiori², Gerardo Di Martino¹, Antonio Iodice¹, Daniele Riccio¹, Giuseppe Ruello¹, Paolo Braca², Peter Willett³**Toward a ship detection-oriented GNSS-Reflectometry system**

A primary application of Global Navigation Satellite System (GNSS)-Reflectometry is the analysis of the sea surface (sea state, ocean topography, tsunamis and hurricane detection, etc.) using 2-D delay-Doppler maps (DDM) or 1-D delay waveforms. This is best addressed by measuring and processing the Earth-reflected GNSS signal in a forward-scattering acquisition geometry, which represents the conventional configuration adopted in past and current GNSS-R missions. In addition, it is well-established that the sea-reflected GNSS signal is mainly left-hand circularly polarized (LHCP), so that GNSS-R systems are typically equipped with LHCP receivers. Notwithstanding, the exploitation of GNSS-R in the field of maritime surveillance and ship traffic monitoring has been investigated in the recent past. The main conclusion drawn in the related literature is that the conventional forward-scattering configuration is not suitable for ship detection applications due to the very low signal-to-noise-plus-clutter-ratio (SNCR) experienced in conventional GNSS-R systems and data. Moving from these considerations, we investigated the possibility to adopt innovative acquisition geometries in GNSS-R remote sensing, especially the backscattering one. We have conducted a feasibility analysis of the ship detection problem using GNSS-R observables by determining the main parameters (and their role) influencing the detectability of the ship target. In particular, we investigated the impact of the acquisition geometry, radar signal polarization, sea state and ship orientation for the ship detection problem. The study comprised the evaluation of both the signal-to-noise ratio (SNR) and the signal-to-noise-plus-clutter ratio (SNCR) in realistic scenarios and as functions of the above-mentioned parameters. Such an analysis allowed us to 1) identify the main parameters influencing ship detectability; 2) quantitatively assess the role of such parameters; 3) provide useful guidelines for the design of a GNSS-R system suitable for ship detection applications. The analysis is based on a sound theoretical electromagnetic model of the bistatic radar cross section of the ship target derived in the framework of the Kirchhoff Approximation / Geometrical Optics. The analysis clearly shows the benefits of 1) the backscattering configuration with respect to the conventional forward-scattering one, especially in terms of SNCR, due to the much lower sea clutter in the backscattering direction rather than the forward-scattering one; 2) the RHCP receiving channel w.r.t. the conventional LHCP one, used in sea surface analysis. However, the ship orientation and the sea state still play a key role in ship detectability.

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Session Monitoring spatio-temporal dynamics
 Thursday, 5 July 2018 (15:00 - 16:30)
 Congress Hall - Chairman: Maria Antonietta Dessena

Andrea Pomente, Matteo Picchiani, Fabio Del Frate

Unsupervised Deep Learning Approach for Change Detection applied on Sentinel-2 Data

In this study, we address the problem of change detection monitoring using Sentinel-2 data. The proposed method is based on deep features representation obtained by the application of a novel Deep Learning approach.

The continue growth of buildings, roads and infrastructures has raised the attention toward the soil consumption issue occurring often in low density urban areas, particularly at European level, as well in developing country where a rapid urbanization occurs. Knowledge of such detailed changes across time is highly desired since it can be useful to understand the urbanization process and make proper urban planning management.

The recent launch of Sentinel-2 satellites allows us to address several remote sensing problems by use of multi-spectral data with a minimum spatial resolution of 10 m, 13 bands, wide acquisition coverage and short time revisits. The availability of these huge amount of open data allows to propose new earth observation applications.

In this work we seek to address the problem of Change Detection, or rather identify artificial changes altering the natural landscapes, using the Copernicus Sentinel-2 open data.

Recently, Convolutional Neural Networks (CNNs) have become the new state-of-art solution for several computer vision problems, such as image classification, object detection, semantic segmentation, etc.

CNNs can learn hierarchical image representations from the input data by successively abstracting higher-level features from the previous low-level ones. In the last years, this type of neural networks has been used to solve several tasks in different domains. In particular, CNNs have demonstrated excellent performances on different problems in remote sensing field, such as pixel-based classification, target recognition and image pan-sharpening.

CNNs have also shown great capability in the extraction of image's features, the utilization of which for processing remotely sensed imagery is relatively recent. In this work, we exploit the capability of CNNs as feature extractor to represent Sentinel-2 images.

In general, Deep Neural Networks achieve very competitive results with respect to other Machine Learning techniques, but requiring very large amounts of training data.

In practice, it is difficult to have a dataset of sufficient size to train CNN from scratch (with random initialization). This fact is also true for change detection and in particular for Sentinel-2 images, where the creation of a sufficient dataset to perform a supervised approach is very expensive. Instead, it is common to pre-train a CNN on a very large benchmark dataset, such as ImageNet. The latter is one of the most common training dataset developed for image classification purposes and is composed of 1.2 million images labeled with 100 different classes.

In this research, we use aCNN pre-trained on ImageNet to extract features from Sentinel-2 images pairs (i.e. two images acquired on subsequent dates). With the hypothesis that the information of interest for our problem is distributed over all levels of the CNN, we define the, so called, "hypercolumn" feataure map as the outputs of all CNN layers, stacked into one multi-dimensional matrix.

The proposed approach consists of three steps: for each image of the input pair we apply the feature extraction with the pre-trained CNN. After the feature extraction step, the Euclidean distance has been computed between the two multi-dimensional matrices. The output obtained is a new matrix where each pixel value corresponds to the dissimilarity measure, thus indicating the probability that each pixel is changed during time.

The final step of the procedure, is based on the K-Means (KM) algorithm, that can divide the pixels of dissimilarity matrix in changed and not changed ones by fixing the number of clusters equal to two.

To validate the effectiveness of the proposed method, we performed the Sentinel-2 change detection problem on a real dataset. More in particular, we selected two Sentinel-2 data acquired on two different dates, the first one was acquired in 2015 and the second one in 2016. We manually extracted 32 patches composed by 64x64 pixels. This dataset includes both big and small changes. We also extracted patches where no changes occurred and the final bounding boxes for ground truth are manually produced. We compared the approach with the most widely used feature extraction methods, such as HOG and SIFT.

To assess the performance of the different methods we adopted some common criteria, such as False Alarm Rate, Detection Rate and the Intersect over Union. The experiments demonstrate the superiority of the proposed technique, that provides the best results with respect to the considered other methods.

Session Monitoring spatio-temporal dynamics
 Thursday, 5 July 2018 (15:00 - 16:30)
 Congress Hall - Chairman: Maria Antonietta Dessena

Ilenia Fontana¹, Emanuela Molinaroli¹, Federica Rizzetto²

Remote sensing for the evolution of the Venice littoral since 1950s

The present study is aimed at analysing the impact of sea-level rise on the Venice littoral, a low-lying coastal stretch of the Northern Adriatic Sea (Italy) particularly sensitive to sea-level changes, tides, and storm surges and, consequently, prone to be eroded and exposed to serious risk of flooding. In particular, our attention is focused on the eastern Lido coastal zone, i.e. the portion of the narrow sandy barrier that separates the Venice Lagoon from the Adriatic Sea, which extends from the Lido inlet to about 5 km SW. Anthropogenic impacts on the littoral are mainly due to urbanization and tourism. Nevertheless, natural environmental features are locally preserved. Therefore, this area represents an interesting case study in which actions for environmental protection and recreational use have to coexist.

The main purposes of our research consist in understanding how the Lido of Venice will respond to sea-level rise from a morphological point of view and which will be the consequent economic and environmental impacts.

The study of the effects of the natural and anthropogenic processes acting on this coastal stretch so far has been necessary to predict the future of the littoral. Therefore, its morphological evolution and the development of urbanization and tourism infrastructures occurred since the second half of the 20th century have been examined.

The process of modification of a coastal environment is a constantly evolving phenomenon whose description, even at a purely visual level, requires a fairly wide observation period - at least ten years - to allow us to appreciate its differences. In this case, the best method of investigation has consisted in analysing the aerial photographs taken during various reconnaissance flights, both public and private, carried out on the Venice littoral.

The comparison between historical and current aerial photographs has provided us with an essential contribution for the knowledge of the territory and its changes over time. The collected images extend over a period of about 60 years and show the past conditions of the littoral, before the great urban and infrastructural changes evident in the more recent ones.

Images have been digitized (if available in paper format) and georeferenced using a Geographic Information System (GIS) software, a framework for storing, analysing, managing, and displaying geographic and spatial data. Aerial photo interpretation has allowed the realization of thematic maps showing the modifications of both the natural and anthropogenic features occurred in the last 60 years. In particular, the main elements displayed on the maps have been (i) the natural characteristics of the littoral (e.g. dunes and vegetation), (ii) the evolutionary trend of the shore (i.e. erosion, progradation, and stability) and (iii) the presence, type and extent of urban sites, tourism infrastructures and defence measures. The joint interpretation of these outputs and multidisciplinary data from previous studies (including information on local hydrodynamics and meteorological conditions) has allowed identifying the main conditioning factors that act on the littoral and understanding how this coastal stretch has responded to climate change and human pressures over the last decades.

The results have highlighted that:

- except for small scattered zones, the littoral appears levelled, almost completely urbanized or characterized by the presence of touristic structures.
- Overall, in the last 60 years the shoreline has slightly prograded in the NE zone, whereas alternate erosion and accretion have been observed in the SW sector. Erosion, which has mostly occurred in the SW part of the Lido littoral, has been mainly produced by sediment loss due to cross-shore transport.
- The longshore transport is low and scarcely influences the analysed area because the waves produced by the winds blowing on the littorals in opposite directions (from NNE and SSE, respectively) interfere. Only close to the western jetty of the Lido inlet, local hydrodynamics favours sediment accumulation, allowing the preservation of

a wide beach with dunes. In particular, the most significant shoreline progradation took place between 1950 and 1991.

- Since the middle of the last century, beach nourishment has been favoured by the construction of groins, mainly in the periods 1950-1970 and 2009-2013.

- The high subsidence rates occurred from 1930 to 1970 owing to groundwater withdrawal have amplified local sea-level rise during the same period. Groundwater pumping ended a few decades ago; therefore, nowadays subsidence is largely reduced and mostly due to natural process (e.g. tectonics and sedimentological characteristics of the subsoil) except for the areas close to the Lido inlet due to the M.O.S.E. structural pressure (M.O.S.E. is the acronym of Experimental Electromechanical Module, a system of retractable gates built to protect Venice from high tides and not yet completed).

Results have been used to evaluate the evolutionary trend of the littoral until 2100 under different climate change scenarios and, consequently, sea levels and to define the possible effects on the littoral.

Three situations have been proposed considering different values of future relative sea-level rise that have been calculated combining subsidence rate (+9 cm) and three possible eustatic components (i.e. + 28 cm, + 61 cm, + 97 cm, on the basis of the IPCC scenarios). The littoral vulnerability has been evaluated in terms of shoreline retreat and has been calculated using the Bruun Model. Three risk thresholds have been elaborated referring to the minimum shore width.

The comparison of each predicted position of the shoreline with the one detected in 2016 has shown that the SW zone of the littoral could always be at higher risk and more exposed to erosion and flooding events. In the NE sector, the effects of sea-level rise could be mitigated by the large shore surface. However, a sea-level rise higher than 50 cm would be able to produce severe impacts on the whole littoral, which could worsen owing to the negative sediment balance, also depending on local sea and weather conditions as well as sediment availability.

Climate change would cause serious damages to the coastal ecosystem and human activities and heavy environmental and economic loss.

The right choice to minimize these damages should be the implementation and the application of adaptation strategies and planning actions able to effectively hinder the impacts.

Therefore, the present analysis is addressed to local administrators in order to produce correct coastal management plans.

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Session Monitoring spatio-temporal dynamics
 Thursday, 5 July 2018 (15:00 - 16:30)
 Congress Hall - Chairman: Maria Antonietta Dessena

Giuseppe Barbaro¹, Giuseppe Bombino², Vincenzo Fiamma¹, Giandomenico Foti¹, Pierfabrizio Puntorieri¹, Francesca Minniti¹, Carmen Pezzimenti¹

Shoreline changes at Sant'Agata River mouth (Reggio Calabria, Italy)

An analysis and understanding of coastline variability and coastal erosion-accretion trends is important to enable scientists and local decision-makers to make appropriate decisions concerning regulatory and coastal planning.

In territories such as Calabria (Italy), characterized by significant anthropogenic pressures and various eroded coasts, the knowledge of the shoreline changes, and the factors that influence them, is necessary for management and planning of coastal areas. In fact, the shoreline position is one of the most important indicators of coastal dynamics and undergoes both instantaneous and seasonal variations that may have natural or anthropogenic causes. From this point of view recent advances in remote sensing and geographical information system (GIS) techniques allow us to estimate with great precision the changes in the shoreline over the years. The use of any particular method of analysis being influenced by the data sources and resources available.

The paper describes the shoreline changes which occurred near the mouth of the Sant'Agata River over the last 60 years, using end point rate (EPR) and net shoreline movement (NSM) statistics. This area is located in the South of Reggio Calabria, it is heavily anthropized due to the presence of the airport, a sports center and various industrial activities. Not far from Sant'Agata there are three other rivers (from north to south Calopinace, Armo and Valanidi, all within a few kilometers). The diachronic analysis of the shoreline was carried out through the comparison of cartography data of the last 60 years, which consists of aerophotogrammetry (provided by IGM), orthophotos taken from the Open Data section of the National Geoportal and satellite imagery provided by Google Earth Pro.

The paper also analyzed the main factors influencing the coastal dynamics, in particular the deep water wave climate, the longshore sediment transport, and the river sediment contribution, produced by variations of hydraulic structures, rainfall regime, land cover and soil erosion by water (WSE).

From the analysis of the different shoreline it is possible to observe how advancement and erosion phases alternated in the last 60 years and, in terms of NSM, the minimum value was observed in July 2002 while the maximum values was observed in March 2015. In terms of WPR, the maximum negative value (corresponding to erosion) was observed in the period May 2006 - July 2007 while the maximum positive value (corresponding to advancement) was observed in the period January - June 2012.

The methodology for analyzing shoreline changes and related correlations with the factors involved described in the paper is therefore applicable to many contexts which are similar to the Sant'Agata River mouth.

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Session Monitoring spatio-temporal dynamics
 Thursday, 5 July 2018 (15:00 - 16:30)
 Congress Hall - Chairman: Maria Antonietta Dessena

Massimo Perna¹, Giovanni Vitale², Carlo Brandini², Enzo Pranzini³, Bernardo Gozzini¹

Coastal monitoring through field and satellite data

Shoreline position monitoring and analysis of its trends (accretion and erosion) is a crucial information in a wide range of studies related to coastal management and mostly in evaluating coastal erosion. This work addresses the criticalities associated with the monitoring of the shoreline (proxy definition, error evaluation, etc.) with the aim of minimizing the scatter between the ground observations and the EO data. A quantitative validation of this method is presented, and the ways in which the different data (in-situ, satellites, models). Also, by means of the same EO data, coastal dunes have been measured and monitored through multi-temporal analysis, using existing datasets. Many different indicators have been adopted to map shoreline from remote. Some of them are based on identification of specific features in the image while others are related to a specific vertical Datum with respect to a given sea level. Recent Italian National Guidelines ("Linee Guida Nazionali per la difesa della costa dai fenomeni di erosione e dagli effetti dei cambiamenti climatici" - March, 2017) define the DGPS/DGNSS "0" elevation (measured, for example, through RTK field surveys) as the only element, independent from sea conditions during the acquisition, to be used as the reference shoreline proxy. Hence, to compare remote sensing data to this reference, we evaluated that features, observable in the images, able to provide a measurable spatial relation to approximate such reference proxy. In the studied area, we observed that "0" elevation proxy is constantly set between the run up limit (wet/dry sand limit) and the run-down limit (upper side of the beach step), which are clearly visible features in very high resolution remote sensed (RS) data. So we used the strip delimited by these two limits as a proxy for our shoreline, and we defined it as the midline of this strip. In this way we could determine the maximum error committed during the determination of the RS shoreline respect to the "0" elevation DGPS/DGNSS shoreline.

A series of Pleiadés satellite images (spatial resolution 0.5 m for panchromatic band, 2 m for multispectral bands) have been acquired along the coast of Tuscany. The images covered a strip of 1 km seaward from the shore and 4 km inland. Different band combinations have been tested in order to semi-automatically map the described proxy. The near infrared band have been used because of its best capability to discriminate wet and dry sand. Methods include a first smoothing (isoblurring) of the image; then an algorithm of edge detection is applied (canny), and finally the shoreline is mapped through a spline algorithm. Manual digitizing and semi-automatic detection of shoreline have been compared to the DGPS/DGNSS shoreline surveyed at the same time of satellite acquisition. This operation has been repeated in many sandy beaches in Tuscany with different grain-size characteristics and slope to evaluate a spatial correlation between the reference shoreline (DGPS/DGNSS) and the remote sensed proxy strip. Besides satellite images have been also used to map the coastal dunes, and to produce a multi-temporal analysis to evaluate their evolution using old data, where available.

At last, the main uncertainties related to RS shoreline acquisition have been evaluated, such as digitizing errors in the case of manual digitation, pixel errors related to the spatial resolution of images, geometric error due to the orthorectification process, and others. Besides, the correction due to local tide and atmospheric pressure using the average slope of the beach has been applied.

Very high resolution multispectral satellite images (Pleiadés) have been used to map shoreline and coastal dunes of Tuscany. The mapped features have been produced both by semi-automatic extraction and manual digitizing, and their positional accuracy have been evaluated with data derived from field survey. Results show average differences between EO data and survey data far below 1m which is a good result for regional monitoring purpose. Moreover relative position of shoreline respect to the chosen proxy have been spatially correlated to the different geomorphology of the studied beaches.

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Session Monitoring spatio-temporal dynamics
Thursday, 5 July 2018 (15:00 - 16:30)
Congress Hall - Chairman: Maria Antonietta Dessena

Athul K, Ramiya A M

Quantifying land surface dynamics using ICESat data over indian terrain

Digital elevation models (DEMs) of the whole world have been derived through various missions like Space Shuttle Radar Topography Mission (SRTM), Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Mission, Advanced Land Observing Satellite (ALOS) Mission, etc. DEMs find application in all facets of life including hydrological modeling, flight simulation, relief maps, ortho-rectification etc. DEMs which are widely in use include SRTM DEM and ASTER GDEM. For Indian region better resolution and more accurate DEM is made available by Indian Space Research Organization (ISRO) named CartoDEM generated from CartoSat-1 acquisitions carried out since 2005. Errors and discrepancies exist in these DEMs. In this study, the possibility of using ICESat data to generate a better resolution and more accurate DEM was looked upon. The study was carried out in various land cover complexities, i.e. highly urban region and a rural region. Various data products of ICESat were understood and the relevant products were used to generate DEM and digital surface model (DSM). On the course, classification of ICESat data was carried out using a rule-based classification technique and supervised classification technique. The generated DEMs were compared with existing DEMs like SRTM DEM and CartoDEM. ICESat elevation was showing 99% correlation with elevations from CartoDEM in a rural region and 93% correlation in an urban region. The mean difference between ICESat and elevations from CartoDEM is found to be 1.6 m in the rural region and 3.4 m in the highly urban region.

Session Monitoring spatio-temporal dynamics
 Thursday, 5 July 2018 (15:00 - 16:30)
 Congress Hall - Chairman: Maria Antonietta Dessena

Sergei Lezhnin

Creating a map of reforestation on abandoned agricultural lands in republic Mari El using satellite images

The economic situation in Russia and abroad has led in recent years to the fact that in large areas of unprocessed farmland there is a change of ecosystems from agricultural to forest-growing. This process has both negative (reduction of areas for cultivation of crops in the context of the global food problem) and positive aspects (tree species restore water and soil balance in the territory, there is an opportunity for the development of sporadic forest management: gathering mushrooms, berries, hunting).

The study and evaluation of growing agricultural areas is an important task for the national economy of the Russian Federation. The use of satellite information in similar studies is a priority. Modern development of technologies allows to estimate the big areas at the minimum financial and human efforts.

The aim of the study was to find the optimal combination of the Landsat 8 satellite imagery channels for revealing the young trees on the former agricultural lands of the Republic of Mari El, and also to create a map of agricultural lands that are overgrown with tree species.

To achieve this goal, the following tasks were accomplished:

- Cloudless images of the satellite Landsat 8 on the investigated territory were selected for several time periods;
- Several spectral channels of Landsat 8 images were used to identify their optimal combination for research;
- Thematic mapping of selected three-channel images was carried out;
- Conclusions were drawn on the most optimal combination of the spectral channels of Landsat 8 satellite images for revealing tree vegetation in agricultural areas;
- The areas of agricultural lands of the Republic of Mari El, overgrown with tree species, were identified.

The object of the study was the abandoned agricultural lands of the Republic of Mari El.

Materials and methods. The study was based on the analysis of thematic maps obtained by the controlled classification of satellite images Landsat 8 with a spatial resolution of 30 m in various combinations of spectral channels that were obtained from the NASA database. Evaluation of the accuracy of the developed thematic maps allowed to identify the optimal combination of spectral channels of satellite imagery and the time of survey. Satellite images Landsat 8 for three time periods were used for the study: spring snapshots (early May 2017), summer snapshots (July 2017) and autumn snapshots (September 2017).

For thematic mapping using the method of controlled classification (maximum likelihood) and evaluation of the maps obtained, the data collected for the 2007-2016 field season were used. on the deposits of the Republic of Mari El. In the process of thematic mapping, three classes were identified on each survey: agricultural land (including unused ones), young growths of coniferous species, young growths of deciduous species.

Results. During the thematic mapping, 10 maps were obtained for several time periods. The evaluation of the resulting thematic maps was carried out using control points obtained in the test areas, with the Kappa coefficient (k) being determined. The highest accuracy was shown by the thematic map, obtained from the spring image in combination of the 6-5-2 (SWIR2 - NIR - BLUE) spectral channels. This is due to the fact that in spring photographs, the herbaceous vegetation is either covered with snow cover, or differs significantly from tree vegetation in terms of spectral characteristics. In addition, in the spring period there are parts of the deposits where vegetation is absent due to autumn plowing. The Kappa coefficient, which has a value of 0.66-0.67 for spring shots, indicates good consistency of thematic maps and field data.

On the final thematic map of the agricultural lands of the Republic of Mari El for 2017, the areas of the sites of abandoned agricultural lands, overgrown with coniferous and deciduous species, were determined.

Conclusions

- The developed thematic maps testify to a stable process of mass overgrowing of young tree vegetation in the territory of the Republic of Mari El.
- The most accurate was the thematic map obtained by the spring snapshot in combination 6-5-2 (SWIR2 - NIR - BLUE) spectral channels.
- Thematic mapping of young forests on deposits allowed to determine the area of overgrowth for 2017. The total area of agricultural land according to the obtained thematic map reaches 763694.46 hectares, while overgrowing of young growths of deciduous species up to 123776.19 hectares (1.6%), respectively, and overgrowth by young conifers species reaches 52557.12 ha (7%), respectively.
- The created thematic maps of coniferous and deciduous species on the Republic of Mari EL deposits can be used as a basis for their further study and monitoring.

Session Remote sensing of ecosystem properties

Thursday, 5 July 2018 (15:00 - 16:30)

Bracco Classroom - Chairman: Gaia Vaglio Laurin

Cristina Vittucci¹, Paolo Ferrazzoli¹, Gaia Vaglio Laurin², Leila Guerriero²

Soil and vegetation variables retrieved by SMOS microwave radiometer in tropical areas

The ESA SMOS mission uses a microwave radiometer to retrieve soil moisture (SM) over different land covers. The instrument works at L band (1.4 GHz). The measured brightness temperatures are influenced by soil properties, and in particular the selected frequency shows good performances in retrieving soil moisture. Nevertheless vegetation cover also plays an important influence on the measurements. This problem is enhanced in presence of forests, which behave as thick canopies, in which the measured radiometric signal is mostly contributed by wood, and the soil emission is more attenuated with the increase of wood biomass. These effects have been considered in the development of the SMOS Level 2 (L2) retrieval algorithm, composed of a forward model, based on zero order Radiative Transfer Theory, and an iterative inversion procedure. For soils covered by vegetation the L2 product provides retrieval of two parameters: Soil moisture and vegetation optical depth (VOD). Although soil moisture retrieval is the main objective of SMOS, the accuracy of VOD is also important, as several previous studies indicated that it contains information about vegetation water content (kg/m^2) for crops, and biomass (Mg/ha) for forests.

This study is focused on tropical areas where the majority of biomass stock is located. The correlations between SMOS VOD and forest height and forest biomass are evaluated using independent data sets. The same analysis is conducted considering the VOD product retrieved by the AMSR2 radiometer at C band. Finally, the temporal trends of both SM and VOD retrieved by SMOS are compared against environmental variables available from the data base of Climatic Research Unit (CRU).

The latest version (V650) of SMOS L2 data is used. The SMOS maximum revisit time is about 3 days meaning that a defined portion of the Earth surface is seen several times during one month. We exploited this property to compute a monthly average of the VOD values at global scale, in order to filter the noise of VOD estimates, considering that the optical depth of forests is almost constant on limited time ranges under natural condition (i.e. no deforestation processes or fires).

The forest height dataset was obtained by a global map at 1-km resolution, generated by Simard et al, using data collected in 2005 by spaceborne GLAS lidar, and made available to users. The forest height estimations were based on the waveform metric RH100, defined as the distance between signal beginning and the location of the lidar ground peak. For the areas not directly covered by the lidar on the global map, forest height was estimated applying a random forest algorithm, including vegetation information from MODIS, additional elevation data from the Shuttle Radar Topography Mission (SRTM), and climatology information from both the Tropical Rainfall Measuring Mission (TRMM) and the Worldclim database. The forest biomass (Mg/ha) data were taken from the dataset developed by Avitabile et al. This recent biomass dataset was obtained by fusing two existing datasets of Above Ground Biomass (AGB) into a pan-tropical AGB map at 1 km spatial resolution. The fusion was obtained by a bias removal and weighted linear averaging that incorporates the biomass patterns indicated by an extensive dataset of reference data collected at local scale around the world. The independent datasets of forest height and forest biomass were upscaled to the SMOS resolution using a nearest neighbor approach. The analysis was replicated considering level 3 (L3) AMSR2 VOD products for the same timeframe of the SMOS ones. To this aim, the datasets of forest height and biomass were also upscaled to the AMSR2 L3 spatial resolution.

The analysis covered forests of Africa and South America. In order to focus on dense vegetation, SMOS VOD maps were generated for pixels with average forest height higher than 5 m. For both Africa and South America, maps of retrieved VOD are generally consistent with maps of forest height and AGB. Higher values of VOD are obtained in the Congo and Amazonia rainforest. Lower values are observed in the Woody Savannas of Angola and Zambia, and subtropical forest of Bolivia, Paraguay, and North Argentina. A regression analysis based on yearly averages was also carried out. Using SMOS VOD product, the obtained correlation coefficient R^2 is equal to about 0.75 with respect forest height, and 0.68 with respect to AGB. Significantly lower values, such as 0.58 and 0.55, respectively, are obtained using AMSR-2 VOD. This result is interpreted considering that AMSR-2 operates at C band, where the difference of VOD between higher and lower forests is reduced.

Temporal trends of SM and VOD were compared against environmental variables available in version 4.01 Climate Research Unit (CRU) data set, which can be downloaded from the University of East Anglia website (<http://www.cru.uea.ac.uk/about-cru>). This version is provided as a gridded time-series dataset with a coverage extended to land areas at 0.5° resolution. The dataset includes several variables among which we selected the monthly precipitation and the monthly temperature. Since the resolution of the data grid is coarser than the one of SMOS data, an upscaling was applied to re-grid the SMOS variables and make the two data sets comparable from the spatial point of view. We followed a consolidated approach based on nearest neighbor algorithm. For selected sites of Africa and South America the temporal trends (monthly averages) of SM and VOD were compared with trends of temperature and precipitation, obtained by CRU database. The temporal trends of SM follow the rainfall cycle, particularly in subtropical areas characterized by dry winter. The temporal trends of VOD also follow a seasonal trend, but with moderate variations. In fact, the major contribution to VOD at L band is due to forest wood, and is quite stable in time.

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Session Remote sensing of ecosystem properties

Thursday, 5 July 2018 (15:00 -16:30)

Bracco Classroom - Chairman: Gaia Vaglio Laurin

Gianluca Tramontana¹, Gaia Vaglio Laurin², Paolo Ferrazzoli³, Leila Guerriero², Cristina Vittucci³, Paul Bodesheim⁴, Martin Jung⁴, Miguel Mahecha⁴, Dario Papale¹

Ecosystem Functional Properties and links with SMOS data at global level

Traits and functionality of land ecosystems are strictly connected and interrelated; their monitoring at large spatial scale is also a key task in the context of the climate change and global warming. Since the last decades of the previous century, a lot of studies have been carried out for monitoring the functionality of vegetation in natural ecosystems. Consequently, an array of features describing the functionality of photosynthesis has been well defined at leaf level. For example, photosynthesis depends on light, and Light use efficiency (LUE) has been defined in order to describe the capacity with which leaves convert the absorbed photochemical active radiation (APAR) to fixed carbon. Water resource are important too. In fact carbon uptake from atmosphere is accomplished by water loss by transpiration. The capability to convert each unit of water loss by transpiration in fixed carbon is named water use efficiency (WUE). Finally, photosynthesis response to light is generally described as saturated in high APAR conditions.

By the integration of functional properties at the ecosystem level we can define the Ecosystem Functional Properties (EFPs) as the quantities that characterize ecosystem processes and responses in an integrated and comparable manner.

Monitoring EFPs is challenge, for the spatial scale of the analysis and the complexity of natural ecosystems. However, EFPs in which carbon, energy and water fluxes are interrelated can be estimated using Eddy covariance data. Eddy covariance technique provides quantitative estimations of carbon and energy exchanges between land ecosystems and atmosphere in continuous and explicit way. There are more than 800 study sites equipped with eddy covariance instruments that are distributed over the globe (FLUXNET) and covering a wide range of natural and managed ecosystems. Eddy covariance study sites are grouped in regional networks (such as ICOS in Europe or AmeriFlux and NEON in USA), by which acquisition methods and data treatment are defined in standard way.

LUE and WUE can be estimated at ecosystem scale by the use of eddy covariance data, similarly to other important parameters such, for example, the photosynthetic capacity at light saturation (GPPsat), its proxy (e.g. GPPmax, maximum GPP measured during a time interval) or the Bowen ratio (ration between sensible and latent heat fluxes) that is strictly connected with vegetation density and water availability, having high values in bare/dry soils and lower in dense and well watered forests.

Unfortunately, the eddy covariance sites network is not uniformly distributed over the globe but has much higher density in Europe and North America. This point is important in tropical regions, where ecosystems having a key role in the global budget of carbon uptake are not well represented by the current eddy covariance networks. In this conditions the spatial upscaling of fluxes (and derived EFPs) is a key task in order to get a global picture.

Modeling exercise (process based or data driven by machine learning), meteorological data and satellite data are generally involved in spatial upscaling processes. In particular, satellite data are important because they provide spatial explicit measurements over the globe. Multispectral reflectance and vegetation indices resulted highly correlated with key biophysical properties of vegetation (e.g. canopy density, leaf pigments contents, leaf are index) therefore they are widely used as input to models in the spatial upscaling of carbon and energy fluxes.

Conversely, the use of microwave information for fluxes upscaling purposes is less documented and investigated, although key information for photosynthesis can also be carried out at these frequencies. Among potentially useful microwave sensors we use data collected by the Soil Moisture and Ocean Salinity (SMOS) satellite by European Space Agency (ESA) which is equipped with a radiometer acquiring in L-band (~ 1.4 GHz). It can provide soil moisture information as primary product; however a retrieval product named microwaves Vegetation Optical Depth (VOD) has been recently investigated; it describes the attenuation of radiation due to scattering and absorption within the

vegetation layer. There are several studies in which VOD from different sensors have been related with key features of vegetation, such as biomass or vegetation water content. However, features describing the functionality of ecosystems have not been investigated.

In this on-going work we aim at evaluating the feasibility of using VOD derived by SMOS satellite for inferring spatial explicit information on EFPs, with particular attention to the tropical region. For this purpose a correlation analysis between SMOS-VOD and EFPs by carbon and energy fluxes have been carried out. For the limitation in the number of study sites in tropical region, EFPs have been derived by the half hourly globally upscaled fluxes in the context of BACI project. Half hourly fluxes of Gross Primary production (GPP), Latent heat (LE) and sensible heat (H) have been aggregated at month time scale and then used for global estimates the following EFPs: LUE, WUE, Bowen Ratio and GPPmax. While the LUE, WUE and Bowen ratio were directly calculated by the monthly fluxes, GPPmax was estimated aggregating half hour data at daily time step, and then taking the 90th percentile of daily GPP for each month. On its turn, SMOS-VOD has been retrieved by version 650 of the Level 2 Soil Moisture Processor (L2SM) and aggregated at month time scale. Data used for the analysis covered the period between the years 2012-2014. An analysis of correlation between spatial pattern of EFPs and VOD have been carried out in the context of Africa and South America continents. Results confirmed the cross consistency between spatial pattern of modeled EFPs and VOD layer in both continents, in particular in the context of the evergreen broadleaved forest. In general, a positive signed correlation have been obtained between VOD and LUE, WUE and GPPmax (Spearman rank correlation coefficient $R \sim 0.6$), while correlation with opposite sign occurred in the case of Bowen Ratio. Correlation among spatial pattern resulted almost stable across the years, as well as the effect of the sensitivity of VOD to the vegetation structure features. This result is promising for future developments in which a) the cross correlation between VOD and EFPs will be investigated for well defined ecosystem types ad b) the feasibility of VOD for spatial upscaling of fluxes (and EFPs) will be investigated including VOD layers among the model inputs.

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Session Remote sensing of ecosystem properties
 Thursday, 5 July 2018 (15:00 - 16:30)
 Bracco Classroom - Chairman: Gaia Vaglio Laurin

Krzysztof Stereńczak¹, Gaia Vaglio Laurin²

The usefulness of ALS data in forest monitoring: LIFE+ ForBioSensing, H2020 BACI, and the GlobALS initiative

Airborne laser scanner (ALS) data are increasingly used in the monitoring of forest communities. This is mainly due to the fact that they enable the measurement of forest structural variables, which are linked to biomass, biodiversity, and health status. Furthermore, thanks to the penetration of the upper tree layer, it is also possible to obtain topographic information, such as accurate digital terrain models, which is important in ecosystem characterization.

We here present two examples of on-going EU funded projects (LIFE+ ForBioSensing, H2020 BACI) in which ALS data are used to monitoring ecosystem characteristics, their changes, health status, and biodiversity. A new initiative called GlobALS is also introduced, derived from projects collaboration, and aimed at establishing a network of ALS and field data providers, interested in conducting research on a global scale.

The aim of the project "LIFE+ ForBioSensing PL: Comprehensive monitoring of stand dynamics in Białowieża Forest supported with remote sensing techniques" is to develop and apply a monitoring method for a large forested area, with very high conservation value, with the use of innovative techniques and remote sensing data. Using the latest tools in forest ecosystem inventory and monitoring, the project was able to obtain a unique spatial and tree stand dataset for Białowieża Forest. ALS data are possibly among the most important information sources that were collected: data were acquired leaf-on and leaf-off condition in 2015. Using this data, various types of trees and stands based analyzes were carried out. First, an estimate of the GSV in the Polish part of the Białowieża Forest was carried out. The vertical structure of stands, its height and gap detection with the use of data obtained during the leaf-on period were performed. In addition, both ALS datasets and CIR images, with the performed ALS individual tree detection (ITD) results, allowed the development of the classification method for dead and living trees, with the division into the deciduous, pine and spruce groups. The ITD results were also integrated with the outcomes of the processing of other spaceborne and airborne remote sensing (RS) data. With the obtained result, it was possible, among others, to monitor the process of dieback of spruce trees or changes occurring in the structure of forest stands.

The H2020 project "BACI: towards a biosphere-atmosphere change index" aims to tap into the yet-to-be-realized potential of existing and scheduled space-borne Earth observations. In conjunction with ground data, it allows to derive new essential ecosystem variables and to detect changes in ecosystem functioning. Co-interpreting these data can lead to a general "index of change" and essential downstream data products. In the BACI context a specific task was responsible to collect ground and ALS data over a number of sites in EU and Africa, used as additional validation tool for detected changes. In addition, research conducted in selected areas with ALS data, also joined to SAR data, allowed to characterize forest biomass and biodiversity with high accuracy.

The collaboration efforts developed among the two project teams lead to the development of a new international initiative called GlobALS. The aim of the GlobALS network is to establish a worldwide database of providers of ALS data, with often field and other RS data availability. ALS as well other data have already been acquired on a wide range of ecosystems in the world, being collected for different applications and various purposes, even at the country level. Sometimes ALS data are used only once, and archived without been used for other applications; however, these expensive data can be a reliable reference for many applications and to answer different research questions.

The main idea is to create a database of ALS data providers, for networking with the academic world and scientific institutions: this database is not collecting directly ALS data. Instead, specific scientific questions are posed, evaluated by a Scientific Board, and redirected to participants: they can be answered by means of ALS data information. The benefits of such independent network can be resumed in:

- Platform for Worldwide research with the use of ALS data
- Possibility to verify global hypotheses and products using ALS data
- Platform for creation, development, and evaluation of ALS based products

- Integrating data providers and data users
- Providing a platform for calibration and evaluation of global satellite missions
- Possibility to contact and receive feedbacks from vendors
- Documenting plans for upcoming flight campaigns

Here, the current status of the network is presented together with additional information on future developments.

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Session Remote sensing of ecosystem properties
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Bracco Classroom - Chairman: Gaia Vaglio Laurin

Ruben Valbuena

An efficient combination of airborne LIDAR and multispectral sensors improves the estimations and classifications describing structural properties of forests

Studying forest structure and its dynamics is important for understanding forest ecology and for sustainable forest management planning. In this contribution we carried out classifications and estimations of forest attributes useful for giving insights into many forest structural characteristics. We used a combination of airborne LiDAR (light detection and ranging) and multispectral (MS) sensors which efficiently exploited their synergies. The data fusion method progressed beyond the customary use of orthophotos, towards directly back-projecting LiDAR returns onto original MS images, which avoided the co-registration errors that typically affect the use of these sensors in high forests situated in mountainous areas. Canonical Correlation Analysis (CCA) was employed to analyse relationships of forest structural variables against a multivariate dataset including metrics derived from the signal of both LiDAR and MS sensors over the area of sample plots. The inclusion of MS metrics in the typical workflow of LiDAR estimation was carried out by calculations of normalized difference vegetation index (NDVI) metrics at the scale of each back-projected LiDAR return. Then, predictions of those same structural variables were obtained using the most similar neighbour (MSN) estimation method, which is a type of nearest neighbour (k-NN) non-parametric method where distances among neighbours are calculated over the CCA components. The best improvements observed thanks to the inclusion of NDVI metrics were obtained in forest structural variables dependent on the degree of coverage by tree crowns, such as stem density and basal area. We also observed improvements in the estimation of biomass fractions: above ground, below ground, log, needles, and big, medium and small branches. Prediction of indicators describing the vertical heterogeneity of forest canopies, the Gini coefficient and the basal area larger than mean, also benefited from synergies derived from this efficient method for sensor combination. Our results therefore show the potential of metrics derived from MS sensors to complement the information from LiDAR in describing structural properties of forest stands. Nonetheless, variables dependent on tree height, such as dominant height or standing volume, may get little benefit from the combination of sensors, due to the high capacity of LiDAR to accurately estimate these variables and the little explanatory capacity of radiometric information from MS sensors to inform on forest heights. The efficiency demonstrated by the back-projection workflow enables reliable predictions of forest structure and biomass components at finer scales.

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Bracco Classroom - Chairman: Gaia Vaglio Laurin

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Airborne LiDAR versus RPAS (drone) photogrammetry: insights and crucial issues in data analysis for agro-forestry applications

Unstructured point clouds are now a common data product in spatial analysis; they are usually obtained from two approaches: with active sensors – i.e. laser scanners – and with passive digital imaging sensors and photogrammetric methods. Airborne sensor carriers can be piloted aircrafts and remotely piloted aircraft systems (RPAS), providing data at different scales. The final product from both approaches - the point cloud - appears similar, but many important differences must be underlined to correctly use these products. First of all, laser scanning and photogrammetric methods provide a very different error budget. Scientific literature has widely investigated the error budget of aerial laser scanning, providing insights on the expected accuracy of point positions and the spatial correlations with multiple factors such as terrain morphology, scan angle, sensor precision, ground control points accuracy and many others. Photogrammetric methods now include structure from motion (SfM) algorithms that allowing reduced 3D data acquisition time and requiring a lower degree of technical supervision. Dense matching can then provide a point cloud, but the error budget of the photogrammetric process is propagated to this product. These and other characteristics must be kept in mind when using these products, as the consequences of ignorance can lead to gross errors. The objective of this presentation is to bring examples of best-practices in using these two technologies, in particular in surveying for applications in forestry.

When surveying areas covered with vegetation, especially when the target is vegetation analysis, many practical issues have to be considered. First of all these areas often have limited accessibility. It is well known that aerial surveys for geomatic applications must use a network of ground control points (GCPs) for geometric processing and validation of accuracy. In practice, several factors limit the creation of an ideal network of GCPs: (i) an area with low accessibility limits the options for fixing a target at a certain position, i.e. if during planning the target is positioned in a location which is found to be inaccessible in the field, it will be discarded or moved, thus changing, and very likely degrading, the geometry of the network; (ii) vegetation and morphology of terrain can limit significantly the number of GNSS signals, thus a target might not be localized with the necessary accuracy; (iii) obstacles can cause limited visibility of targets from the sensors. RPAS surveys are more sensible to the above-stated issues, because the area that is usually covered in an RPAS survey is smaller than the area that can be covered by an airborne vehicle flying at higher relative altitude; i.e. larger areas provide more options for fixing a robust geometry for a GCPs network.

Another fact related to point (iii) is that photogrammetry, for robust bundle-adjustment, requires GCPs' targets to be visible from multiple images with a baseline, therefore the target must be visible with a large zenith view-angle and morphology and vegetation can limit this. Another key issue, that is often overlooked, is that laser scanners can receive reflected signals from the ground plane under vegetation thus providing very significant data for details of the digital terrain model (DTM). Topographic information of the terrain under vegetation is not present in point clouds from photogrammetric methods. Special care is therefore required to derive DTMs from such methods, because successive products, such as vegetation height models, are degraded by the propagation of the DTM error.

The bottom line in this investigation is a best-practice protocol for using the best of "both worlds", from airborne LiDAR and RPAS photogrammetry, for agro-forestry applications. Some insights are also provided to support policy makers in order to optimize their decision effectiveness. For example, a winning strategy, in particular in light of recent innovations – e.g. photon counting LiDAR – that decreased the cost "per point" in laser scanning, can be to plan LiDAR flights at national scale every N-years, and use lower-cost photogrammetric surveys, using RPAS or piloted aircrafts depending on the scale, to monitor more frequently optical and 3D characteristics of vegetation-covered areas. The rationale is that changes are much more dynamic on features above the ground than on the ground morphology itself. Harvesting and natural disturbances in forestry applications, demolition or creation of infrastructures in urban scenarios all change features above the ground, whereas the majority of

changes of the ground morphology occur over a much longer period. It can be argued that erosion, landslides and other hazards impact the ground morphology with quick changes; it is true, but most of these are on a well-defined and limited area.

In the work presented several case studies are compared providing insights on the issues of the above-mentioned criticalities.

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Session Remote sensing of ecosystem properties
 Thursday, 5 July 2018 (15:00 - 16:30)
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Cristina Gomez

Presence of European beech in its Spanish southernmost limit characterized with Landsat intra-annual time series

The Spanish Central Range host some of the southernmost populations of *Fagus sylvatica* L. (European beech) but there is no detailed local cartography of this species. The character of the European beech in the area as a relict species or as a pioneer expanding species is currently under scientific debate. Furthermore, change in the use of land and short term climate oscillations are the main drivers of European beech populations' recent dynamics in Spain. In this work the current location and distribution of European beech dominated stands was mapped based on intra-annual series of Landsat OLI and ETM+ images captured during the period June 2013 - December 2017 and field verification over 208000 ha of the Spanish Central Range. The spectro-phenological behaviour of six vegetation types present in the area was characterized to get insights of the landscape spectral response, and the most distinct traits of each vegetation type were identified. In particular the distinctive early opening of the European beech leaves, which occurs in this area at the beginning of May, was captured by an ETM+ image acquired on May 11th (Day of Year, DOY 132) in 2015. The highest water content of European beech showed by a strong reflectance on the SWIR (1.566 - 1.651 μm , 2.107 - 2.294 μm) in summery images, being the reflectance of other broadleaved species like *Quercus petraea* (Matt.), Liebl. or *Quercus pyrenaica* Willd. just below on average. Pines showed lower reflectance values on average and a more stable response over the year, whilst shrubs and pastures showed high variations in reflectance over the phenological year.

Four selected images acquired in January (DOY 12), May (DOY 132), June (DOY 172), and September (DOY 268) of year 2015 were input for classification with a Support Vector Machine (SVM) classifier. To obtain full coverage observations without atmospheric obstructions at these key dates a pixel compositing approach was applied employing images from years 2013 and 2014 to complement the 2015 acquisitions. Surface reflectance of the VIS, NIR, and SWIR, and the Tasseled Cap Wetness (TCW) and Tasseled Cap Angle (TCA) vegetation indices were the input variables for classification, making a total of 32 variables. The contribution of texture features from the Grey Level Cooccurrence Matrix (GLCM) was explored but discarded after initial experiments without improvement. To minimize confusion of European beech with other broadleaved species their autumn values of the Normalized Green Red Difference Index (NGRDI), a vegetation index related with yellowing during phenological senescence was explored. However, cloud coverage of images captured during autumn time precluded more accurate discrimination of European beech from ashes (*Fraxinus excelsior* L. and *Fraxinus angustifolia* Vahl.), aspen (*Populus tremula* L.), and birch (*Betula alba* L.). 178 one pixel samples unevenly distributed among vegetation types were selected by a trained interpreter from known European beech locations identified on ancillary cartography and aerial photography contemporaneous with Landsat images. The SVM classifier with Radial Basis Function kernel (Gamma 0.031, penalty 100) yielded best results. Finally to improve results from the image based classification contextual information from a Digital Elevation Model was employed. For structural and ecological characterization of the species in the area we established 116 field plots in a systematic field inventory during 2017. On these plots we measured age of sample trees, evaluated ecological cohorts visually, and estimated stand structural variables through a process based on hemispherical stereo-photography of each plot.

Overall, the spectral classification identified all known European beech locations and spotted some new ones. There was confusion in open pastures with spread narrow-leafed ashes (*F. angustifolia*), straightforwardly amended with the 1200 m height mask. More difficult to discern was the confusion of European beech with European ash (*F. excelsior*), birch, and aspen in small stands next to water streams. An intense field campaign was carried out during spring-summer 2017 and spring 2018 visiting all locations identified by the improved spectral classification. Onsite visual verification or with an UAV recorded video flown in areas of difficult access enabled confirmation of locations where European beech trees are sparse and frequently mixed with broadleaved species (e.g. *Crataegus monogyna* Jacq.). Compared with ancillary cartography (1978) our results demonstrate there has been considerable densification and evident expansion of previously established European beech dominated stands, gaining land to other tree species but mostly to shrub lands, and a few new locations in pine shelters or following water streams.

We are also exploring the recent (1984-2018) dynamics of these European beech populations on the Spanish

Central Range with more than 500 Landsat images from the USGS (222 images) and the ESA (284 images) archives. Automatic routines have been necessary to enable a combined use of images from both archives, which are available with slightly different pre-processing. ESA images have been atmospherically corrected with the Landsat Ecosystem Disturbance Adaptive Processing System (LEDAPS) to surface reflectance values, and USGS images have been geometrically co-registered to ESAs with an automated registration and ortho-rectification package (AROP). Histogram filters and geostatistics supported by three rotations of the National Forest Inventory are being employed to characterize the species dynamics during the last decades, to confirm their gain in dominance over less resilient *Quercus pyrenaica* L. species.

Although slight, the recent expansion of beech populations in the Spanish Central Range indicates the pioneer character of the species. Landsat current data and its historical archive have made an important contribution to obtain insights of *Fagus sylvatica* L. dynamics in a Mediterranean area.

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Session Remote Sensing for Agricultural Applications: from regional to local scale

Thursday, 5 July 2018 (17:00 - 18:30)

Congress Hall - Chairman: Mirko Boschetti, Enrico Borgogno Mondino

Michele Croci, Ferdinando Calegari, Stefano Amaducci, Massimo Vincini

Phenology and yield assessment in maize seed crops using Sentinel 2 VIs' Time Series

The analysis of high-spatial and temporal resolutions data provided by the Sentinel 2 constellations is a powerful tool for crops monitoring. Vegetation indexes (VIs) Time-Series (TS) data can be used to deliver in-season yield forecasts and to extract key phenological metrics. The present work addresses the analysis of time series of different VIs, obtained from Sentinel 2 data for the 2015-17 growing seasons, for yield forecast and for the determination of the beginning of the reproductive stage (silking) in maize seed crops cultivated in the Po plain. Yields (expressed as green ears weight and grain weight) and silking dates (DOY – Day Of Year) were collected for 17 maize seed crops (2 crops for the 2015 growing season, 11 for 2016 and 4 for 2017) and correlated with different temporal parameters extracted from VIs' field average TS by gaussian fitting. A posteriori results (i.e. obtained including data of the whole growing seasons in the TS analysis) showed significant linear correlations of yields with time-integrated EVI (Enhanced Vegetation Index) field average, while the first inflection point DOY of field average TS gaussian fitting showed very strong correlations with silking DOY for most VIs tested. A comparison of correlations obtainable for different temporal parameters in-season (i.e. obtained including in the TS analysis only data collected for vegetative stages for the forecast of silking DOY and reproductive stages before the physiological maturity for yield forecasting) is presented.

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Monitoring sugar beet status in Tadla irrigated perimeter using Sentinel-2A Images

In Morocco, the traditional method of monitoring sugar beet based on random field surveys remains unsuitable and does not give the actual state of all parcels. Sometimes all visited parcels are in good condition. However, there is a considerable area in poor condition. Therefore, it is necessary to use other more advanced methods to deal with this issue. Precision agriculture is a concept of managing agricultural parcels that takes into account the inherent spatial variability of a parcel. It requires the use of new technologies, such as remote sensing, GIS and geolocation tools. In this regard, the present work aims to develop an operational tool for spatiotemporal monitoring of the state of sugar beet crops using free multispectral remote sensing data in the irrigated perimeter of Tadla (Morocco) during the 2015/2016 agricultural year. Our methodology is based on the Sentinel-2A satellite image data and the vegetation spectral indices. The obtained classes of the sugar beet health state were calibrated and validated based on the ground truth observed during the field surveys. This methodology allowed us to detect the parcels in stress condition. The results showed that monitoring has contributed to improving farmers' supervision and the targeted interventions in the field. This resulted in an improvement of average yield compared to the previous agricultural year.

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Session Remote Sensing for Agricultural Applications: from regional to local scale

Thursday, 5 July 2018 (17:00 - 18:30)

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Fabio Volpe, Antonella Catucci, Laura De Vendictis, Pasquale Pistillo, Livio Rossi, Michele Croci, Stefano Amaducci, Ferdinando Calegari, Massimo Vincini

Application of Sentinel-2 and Sentinel-1 data for the assessment of hail damage to processing tomato crops

High-spatial and temporal resolution Optical and SAR satellite data can be used to monitor crops trends and support yield estimation. Starting by this information is possible to provide, following severe meteorological events, information about the damage occurred to crops according to their phenological stage. The present work addresses the application of optical (Sentinel 2) and SAR (Sentinel-1) data for the detection and assessment of hail damage to processing tomato crops due to the hailstorm occurred in the Piacenza province on July 29th 2017. The percent damages paid by the insurers, along with transplanting date and tomato cultivar, have been collected by interviews to farmers for 33 processing tomato crops in the area. Field average and within-field site-specific spectral indexes (Enhanced Vegetation Index - EVI and Normalized Difference Vegetation Index- NDVI) Time Series (TS) were obtained from several Sentinel 2 acquisitions over the affected area in days before and after the event. In order to assess tomato phenology at the event date, extracted TS were compared to those of processing tomato crops in the western Emilia Romagna plain, not affected by the hail event, for which multi-temporal phenology had been characterized and other data collected (e.g. transplanting date, irrigation system, cultivar) during the 2017 growing seasons. Differences in LAI (Leaf Area Index) estimates before and after the event, based on LAI relationships vs. VIs obtained at Sentinel 2 spectral resolution developed by CRAFT, were used, along with time integrated VIs' TS, to assess damage level. SAR Sentinel data, collected before and after the dates of the event over the same reference areas, have been processed in amplitude and coherence and analysed together with optical data. A comparison of hail damage assessments obtained vs. damages paid by the insurers is presented

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Session Remote Sensing for Agricultural Applications: from regional to local scale

Thursday, 5 July 2018 (17:00 - 18:30)

Congress Hall - Chairman: Mirko Boschetti, Enrico Borgogno Mondino

Eslam Farg

Validation of vegetation physiological parameters retrieval using Sentinel-2 data in eastern Nile delta

The vegetation biochemical and biophysical parameters spatial and temporal distribution are essentially important for agricultural decision makers and stockholders in crop management. Recently remote sensing data were used for estimation an important growth indicators during the growing season. The main objective of the current study is retrieving vegetation parameters such as leaf area index LAI, chlorophyll content, and water content from canopy reflectance. In this study 53 sample of potato and wheat crops leaves were collected at in situ chlorophyll measurements and infrared plant canopy thermometer. Moreover synchronized to field data collection sentinel-2 satellite image were acquired and processed using SNAP software to calculate the Top of canopy TOC reflectance. That used for mapping and estimation some crop canopy biophysical parameters such as leaf area index (LAI), chlorophyll a, b content (Chl a, b) and water content (WC). Preliminary statistical analysis was applied on both collected field data and mapped biophysical parameters for identifying data distribution and outliers. Furthermore, advanced correlation statistical analysis showed positive correlation with 0.83 between actual LAI and Mapped LAI using sentinel-2. Moreover MLR using stepwise selection method and NN using Gauss Newton algorithm were used to adapt and estimate the LAI from satellite data to actual LAI. MLR results showed that R2 and Adjusted R2 0.89 and 0.87 respectively. On the other hand NN results showed higher R2 than MLR with 0.94. The chlorophyll index measured in the field and chlorophyll mapped from satellite images showed lack of correlation. The chlorophyll indices calculated from ASD spectroscopy and field measurements statistical analysis showed moderate correlation that need further verification with laboratory analysis and further investigation.

National authority for remote sensing and space sciences NARSS, Egypt

Session Remote Sensing for Agricultural Applications: from regional to local scale

Thursday, 5 July 2018 (17:00 - 18:30)

Congress Hall - Chairman: Mirko Boschetti, Enrico Borgogno Mondino

Francesco Nutini¹, Roberto Confalonieri², Alberto Crema³, Ermes Movedi², Livia Paleari², Dimitris Stavrakoudis⁴, Mirco Boschetti¹

Rice nutritional status assessment based on satellite remote sensing and smart apps

Nitrogen fertilization plays a key role in rice productivity and environmental impact of rice-based cropping systems, as well as on farmers' income, representing one of the main cost items of rice farming. Average nitrogen use efficiency in rice paddies is often very low (about 30%), leading to groundwater and soil contamination, greenhouse gases emission, and economic losses for farmers. The resulting pressure on many actors of the rice production chain is generating a strong request for operational tools and techniques able to increase nitrogen use efficiency. In this context, we present an operational workflow for producing nitrogen nutritional index (NNI) maps at sub-field scale based on the combined use of high-resolution satellite images (RapidEye – RE, and Sentinel 2 - S2) and ground Leaf Area Index (LAI) and plant nitrogen concentration (PNC, %) data collected using smart apps.

The workflow was tested in northern Italy in the framework of the ERMES project (<http://www.ermes-fp7space.eu>). The analysis reveals that vegetation indices are satisfactorily correlated with LAI ($r^2 > 0.77$, $p < 0.01$) and PNC ($r^2 > 0.55$, $p < 0.01$) and most patterns of NNI maps are coherent with the available information on soil texture and performed agro-practices (e.g. cover crop adoption). The study demonstrated also the comparability of S2 data with RE ones, hence this is a promising results supporting operation solution for precision farming. Key features of the proposed approach are i) the exploitation of satellite data to assess within field crop variability to guide smart scouting, ii) the time- and cost-effectiveness acquisition of field data on selected location using smartphones as sensors and iii) the operational production of NNI maps by local calibration of EO based vegetation indices. The developed approach is currently under demonstration in Lomellina rice district in the framework of SATURNO project (<http://www.progettosaturno.it/>, founded by Regione Lombardia - PSR 2014-2020) that aims to fully exploit free of charge Sentinel-2 imagery and smart app for real-time field monitoring and production of NNI maps as a geospatial input to support variable rate fertilization approaches.

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Session Remote Sensing for Agricultural Applications: from regional to local scale

Thursday, 5 July 2018 (17:00 - 18:30)

Congress Hall - Chairman: Mirko Boschetti, Enrico Borgogno Mondino

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Detection and Characterization of Palm Oil Plantations through MODIS EVI time series

1. Introduction

Elaeis guineensis Jacq. is a palm species of the Arecaceae's family commonly called Oil palm; it is planted extensively in South-East Asia, especially in Indonesia, Malaysia, and Thailand. Palm oil is the world highest yielding oil crop. In Indonesia plantations showed an increasing linear trend that brought the 4 million hectares in 2000 up to 11 in 2015. The consumption of palm oil over the world is growing through the years: 50 Million tons in 2012-2013, over 60 Million tons in 2015-2016. According to FAO in 2007 the two largest oil palm producing countries are located in Southeast Asia: Indonesia (4.1 million ha) and Malaysia (3.6 million ha). Oil palm well fits the humid tropical climate with a high precipitation rate, high solar radiation and warm temperature (24–32 °C). Oil palm is a perennial tree. Plantations generally have a triangular pattern (9 m row spacing), to optimize sunlight penetration. The majority of planted oil palms are a small mixture of hybrid clones (i.e. Dura X Pisifera), resulting in a uniform pattern at the ground; this makes oil palms different from other trees or forest in satellite imagery. Cultivation of oil palm in tropical countries, on one hand is an important economic factor, but, on the other hand, it endangers biodiversity and degrades the environment with a global impact. These regions, in fact, represent the 11% of the world's remaining tropical forests, containing numerous endemic or rare species, many of which are restricted to forest habitats. Furthermore, logged-over forests often are seen by governments as degraded habitats, only waiting for farm practices. This fact, has encouraged the conversion of secondary (logged) forests to oil palm plantations in Malaysia and Indonesia. From this point of view remote sensing can support a more efficient plantation management that takes into account their effects over environment. Plantations monitoring by remote sensing well fits requirements of precision farming that many stakeholders are currently approaching. Private owners and local farmers are interested in assessing crop conditions; differently, governmental institutions and environmental associations long for the possibility of continuously monitoring the state of the national natural/crop capital. In this work a time series of EVI maps obtained from the MODIS Vegetation Index products (MOD13Q1) for the period 2000–2018 was processed to automatically detect new oil palm plantations, giving an estimate of both ages and productions.

2. Materials and Methods

2.1 Study Area

The study area is sited in the South of Kalimantan Tengah (Central Kalimantan), a province of Indonesia located on Borneo island (5°00'43.92"S 115°41'04.92"E, WGS-84). Area edges were determined on landscape markers basis (rivers, coast, etc.) resulting in about 2947219 ha. According to Köppen classification, local climate is Tropical rainforest. It is dominated by low-pressure system all over the year generating no thermal and moisture seasonality. According to USDA (United States Department of Agriculture) Soil Taxonomy, local soil is labeled as Oxisol with a high aluminum and low phosphate content that could hinder plant growth. Morphology is generally flat without significant reliefs; even if some existing local microsites conditions could affect vegetative vigour of plantation, edaphic conditions of area can be retained constant at the small scale.

2.2 Available data

An EVI (Enhanced Vegetation Index) image time series, composed of 415 images, and covering a period between 18/02/2000 at 18/02/2018 was generated from the MOD13Q1 (version 5) dataset available from the NASA LPDAAC collection.

A vector map of Indonesian Oil palm concessions was obtained from the Global Forest Watch (GFW) archive. Map was produced by the Indonesia Ministry of Forestry; it is dated 2010 and its nominal scale is not declared. Map reports the boundaries of current (or planned) oil palm plantations in Indonesia. The map is known to be incomplete, but it is currently the only available one. The adopted reference system for all the images is the WGS-84 UTM 49 S. All data were processed by free GIS software (QGIS 2.18.4 and Saga GIS 6.2).

2.3 Mapping Oil Palm Plantations

Starting from the EVI time series a new methodology for oil palm detection and characterization was developed

and implemented in the IDL 8.0 programming language based on temporal profile analysis of each pixel. Pixel EVI temporal profile proved to be effective in describing dynamics of vegetation cover and detecting the moment when an abrupt change occurs along the considered period (18 years).

Candidate pixels possibly representing oil palm fields planted in the analyzed period, were detected with reference to the 1st order polynomial approximating EVI local values in the whole reference period; in particular gain value of the local line was assumed as predictor of new oil palm plantations and saved in a new image layer. The latter was then thresholded to separate potential oil palm pixels from the others. In this work and for the study area authors used a threshold value for line gain of 2.0.

Theoretical assumption is that, in tropical areas palm cover shows a gain higher than natural vegetation, being the EVI values of the new cover significantly higher than the one ordinarily expressed by natural vegetation. In general, can be observed that when natural vegetation is present, yearly EVI trend is slightly varying with no remarkable profile steep trait, determining gain value close to zero. Differently, if a new plantation occurs, EVI temporal profiles suddenly decreases at the moment of forest cut, but after a transitional period, it reaches a new state of vigour corresponding to higher EVI values.

Classification refinement was achieved using the above mentioned Indonesian Oil palm concessions map. It was used to mask out from classification those pixels falling outside the polygons. A further refinement was operated by deleting all those areas smaller than 100 ha, being plantation average size in general higher and higher.

Accuracy assessment was achieved by photo-interpretation of 25 random areas that were selected from those labeled as "oil palm" in the classification step. The 2018 Landsat true color image available from Google Earth website was used as ground truth reference dataset.

2.4 Estimating starting date and age of plantations

Time distribution of changes in the area was analyzed, focusing on the selected pixels from the previous step. Analysis was achieved exploring the local EVI temporal profile with a sliding window (kernel) running along the time and including 11 images preceding and 11 following the middle one. At each position of the window a local linear interpolation (1st order polynomial) was performed and the gain value archived for further investigations. Being 415 the available EVI images, 415 were the gain values archived at each position. It was found that the minimum gain value of the local series was a reasonable indicator of the time of changes for that pixel. According to this minimum value criterion, for each candidate oil palm pixel, an estimate of the year when the new plantation started was computed. Estimated starting date was saved for each pixel and a new image layer generated, finally giving a representation of new plantation trends and spatial distribution in the investigated period.

Accuracy assessment was achieved by photo-interpretation of Landsat true color images available for the period 1984-2016 from Google Earth website. A Landsat image per year was selected focusing on 25 random areas extracted from those labelled as "oil palm" in the previous step, looking for the moment when new palm plantation appears. Estimated and observe dates of changes in vegetation cover were compared and Mean Absolute Error (MAE) computed.

The age of oil palm plantation is an important parameter for crop management: it is a good predictor of yearly yield and conditions the quality and quantity of the fresh fruit bunches (FFB). The age of plantations from available data was computed by comparing (by differencing) the estimated planting year with the present (2018). This operation was performed for the whole "oil palm" class.

2.5 Estimating oil palm production

Oil palms produce FFB that represent the raw material for palm oil mills. Oil is extracted from the pulp of the fruit. Production can be affected by various internal and external factors. Internal factors include age and oil palm breeds/variety; external factors include rainfall, drought, disease, soil fertility and moisture, harvesting efficiency. Thus, to give an estimate of production, all the above mentioned factors would have to be taken into consideration. Nevertheless, a good synthetic predictor of yield is the age of plantation itself.

Palms can be classified in 5 farming classes determining different production: a) "seedling" from 0 to 3 years; b) "young" from 4 to 8 years; c) "teen" from 9 to 14 years; d) "mature" from 15 to 25 years; e) "old" from 25 to 32 years.

Azman et al. (2002) proposed a time dependent unitary production (UP) curve for oil palm, relating FFB yearly yield (tons·ha⁻¹·yr⁻¹) with the age of plantation (annual basis). The curve is not defined by a mathematical formula, but through an empirical table. Consequently, authors used it as a look up table relating the estimated age of plantation to the expected UP in 2018. To give an estimation of local production (LP) UP was multiplied by the area of each MOD13Q1 pixel. A map of expected LP was, therefore, generated for the year 2018. Presented results must be considered purely indicative. In fact, they can be highly moved from the expected value if unknown plant diseases or unfavorable microsite conditions are present in the area.

3. Results and Discussion

Classification showed that in the area about 632585 ha of new oil palm plantations were found in the reference period (21.46% of the whole study area). Classification accuracy (oil palm, not-oil palm), computed referring to the above mentioned 25 check areas, was 92%. The area of new plantations started in each investigated year are respectively: 17695 ha in 2000, 17604 ha in 2001, 70423 ha in 2002, 36480 ha in 2003, 123804 ha in 2004, 25122 ha in 2005, 122739 ha in 2006, 22881 ha in 2007, 13631 ha in 2008, 14203 ha in 2009, 32385 ha in 2010, 11443 ha in 2011, 17816 ha in 2012, 18113 ha in 2013, 23188 ha in 2014, 38817 ha in 2015, 20799 ha in 2016, 5441 ha in 2017.

The estimate of the year when the new plantation started, according was computed with a MAE of 2.27 years corresponding to a percentage error of 11% in respect of the whole period.

Concerning oil palm plantations production in respect of the 5 above mentioned age classes, the proposed methodology found that:

For the whole study area, the total estimate of FFB yield produced only by those plantations started within the investigated period (2000-2018) is, at February 2018, 10 Million tons. Age class contributions to the total are: about 0.093 Million tons·yr⁻¹ for "Seedling" plantations (61436 ha); about 1.36 Million tons·yr⁻¹ for "young" plantations (97493 ha); about 6.58 Million tons·yr⁻¹ for "teen" plantation (363103 ha); about 1.96 Million tons·yr⁻¹ for "mature" plantation (110553 ha). No "old" plantation was detected since the investigated period is shorter than 25 years.

4. Conclusions

MODIS derived EVI time series proved to be effective to map and characterize new oil palm plantations. Detection of new plantations based on local temporal profile analysis revealed to be accurate enough (overall accuracy = 92 %), suggesting that time discriminant is basic in assessing vegetation cover. It also proved to make possible give an approximate estimation of the starting date of new plantations and, consequently, of new productions in the area if a unitary production curve is available.

Many limitations, at the moment, still persist: a) detected changes in vegetation cover can be also related to abiotic or biotic disturbance like wildfire, plant diseases, human clear cut. Auxiliary data from other map or institutional source could help to make result more reliable from this point of view; b) production estimates are based on a literature-derived curve of UP. It is not clear if this curve must be better calibrated according to ground data specifically referring to the explored area; c) production estimates are strictly related to the estimate of the date of beginning of plantations. At the moment, the approximation in this estimate is too large (± 2.27 years) to be reliable enough; d) future experiences trying to apply the same methodology are expected to be based on MOD13Q1 version 6 datasets, since the version 5 is going to be dismissed from LPDAAC.

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Session Application of Unmanned Aerial Vehicules
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Bracco Classroom - Chairman: Fabio Giulio Tonolo

Alessandro Alivernini, Carlotta Ferrara, Silvano Fares

UAV-Based remote sensing techniques for air pollution and vegetation monitoring tasks

Unmanned Aerial Vehicles (UAVs) platforms and sensors technology, imaging techniques, data processing workflows are rapidly emerging as promising tools in air pollution and vegetation modeling. Among the latest technologies in remote sensing, UAVs feature unprecedented potentialities when aiming to obtain fast, cost-efficient and high-resolution mapping and monitoring. The contribution of urban and peri-urban forests in removing air pollutants, ameliorating air quality, is a major concern in modern cities. Therefore, an increasing uptake of UAVs technology can contribute for in-situ air pollution and atmospheric studies. In this regard, the present study proposes the use of a multi-rotor UAV to perform air pollution and emissions monitoring tasks, in urban forest plantations located in the metropolitan area of Rome. The UAV system is equipped with a micro-meteorological station, including atmospheric gas sensors (e.g. ozone, nitrogen oxides and carbon dioxide), and proximal sensors, including a thermal and a multispectral camera, and a micro-lidar sensor. Kriging interpolation method is used to convert UAV-acquired point data to a 3D spatial distribution, providing detailed information on the characteristics of gaseous pollutant distribution and concentration. Throughout the use of the proximal sensors, vegetation vertical and horizontal structure is fully characterized. Results of this study prove the benefits of UAVs to sense atmospheric gases and aerosols and reconstruct their spatial distribution and concentrations to study relationships between air pollutants and forest environment.

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Francesca Giannetti, Martina Cambi, Francesca Bottalico, Gherardo Chirici, Davide Travaglini,
Enrico Marchi

Estimating Soil Displacement from Timber Extraction Trails: application of SfM photogrammetry for a 3D Modelling

The major intervention of the forest management direction was the safety of the areas affected by the crash of forest. In these cases the mechanization constitutes an indispensable requirement, especially for reasons of operators safety forestry. The study area was a silver fir forest situated in Vallombrosa forest (central Italy) damaged by a wind storm in March 2015.

The aim of this study was to evaluate the soil compaction during logging operation with forwarder and skidder. The compaction were analyzed with two different technique: soil physical parameters and 3D model generated by close range photogrammetry system.

The logging operation were last for 10 days and the data were acquired before the start of the building, after 5 days and at the end of the end of the operations to determined the temporal trend of the soil impact.

The 3D model used to quantified are Digital Terrain Model (DTM) the rutting where obtained by a SfM photogrammetry.

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Clara Tattoni¹, Francesco Chianucci², Giada Bertini³, Elena Gottardini⁴, Andrea Cutini³, Duccio Rocchini¹

Multitemporal comparison of in-situ and remotely-sensed vegetation indexes in temperate broadleaved forests

Long term monitoring is crucial for forestry research because it allows to understand the trends in forest coverage and health in response to management and climate changes. Remote sensing provides a unique way to obtain estimates of forest attributes at spatially extensive areas. The availability of standardized vegetation indexes over time allows also to make projections under different management scenarios. However, the analysis and extraction of quantitative information from remotely-sensed data require accurate cross-calibration with in situ forest measurements. This is particularly relevant in temperate broadleaved forests, which are characterized by high level of complexity, which can complicate the retrieval of vegetation attributes from remotely-sensed data. In this work we compare MODIS MOD15A2 products LAI (Leaf Area Index) and F_{par} (Fraction of photosynthetically active radiation) with a series of measure taken on the ground from 2000 to 2016. Ground measurements taken with LAI-2000 Plant Canopy Analyzer were available within the framework of the Project LIFE FutureForCoppiceS (www.futureforcoppices.eu) for seven forest stands, being representative of three most commonly diffused European Forest Types (mountainous beech forests, thermophilous oak forests, evergreen broadleaved forests). Forest inventory data are available since 1969, but we considered only the time frame starting from 2000, according to MODIS data availability. The chlorophyll content was measured in the same stands with a SPAD analyser. LAI showed a good correlation between satellite and ground data for most of the stands, and the pattern in seasonal changes were highly overlapping over the 16 year lag, while for the Clorophylle index results were less clear. We conclude that the remotely sensed LAI data are suitable for modelling and up-scaling indicators from the stands to larger areas.

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Session Remote Sensing for Agricultural Applications: from regional to local scale

Thursday, 5 July 2018 (17:00 - 18:30)

Congress Hall - Chairman: Mirko Boschetti, Enrico Borgogno Mondino

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UAV application for monitoring the annual geomorphic evolution of a coastal dune

UAV (Unmanned Aerial Vehicles) are today a common tool adopted by geomorphologist for monitoring landform evolution in different landscapes. Thanks to commercial market growth and the development of SfM (Structure from Motion) photogrammetry, camera-UAV in few years turned to be low-cost and user friendly, becoming a privileged tool for surveying and monitoring where short term evolution is in place, like in coastal areas. Active coastal dune morphology is constantly changing due to sand transport capability exerted by forcing factors such as wind, waves and tides. In a scenarios of sea level rise and worsening of erosion processes along large portions of coastlines, dune conservation and stability represents an essential condition that has to be maintained by local authorities and citizens. Furthermore, coastal dunes represent a natural defense from flooding induced by sea storms and can protect crucial urban areas and infrastructures located behind them. The results of a short term monitoring (from March 2017 to March 2018), performed at seasonal frequency, are presented, focusing on the geomorphic evolution of a coastal dune system, recently subjected to a preservation scheme by local authorities. The study area is located in the Punta Marina village, on the Northern Adriatic coast, 12 km NE from Ravenna (Emilia-Romagna, Italy). The monitored dune reaches 6 m in elevation, it is ~ 600 m long and 150 m wide and is separated from sea by a 40 to 60 m-wide sandy beach. It represents part of the 28% of preserved dune systems still surviving along the whole regional coast and after decades of occupation by man. The area is an alternation of natural elements and human structures such as tourism facilities and recreational activities. The shore facing the dune is bounded at its southernmost limit by a 70 m long groin that traps sand from the northward-directed littoral drift. The wave climate consists of small waves from E occurring for most of the time (about 90% of significant wave height is below 1.25 m). Main storm directions are from SE ("Scirocco" wind) and ENE ("Bora" wind): the latter is the strongest wind that generates the most energetic storms. The microtidal range is 30-40 cm at neap tide and 80-90 cm at spring tide. Despite the small tidal range the combination of high tides and storm surges can be significant for morphological changes of the dune and beach system. The worsening conservation state experienced by this dune in recent years lead the Ravenna municipality to build a preservation scheme between May and June 2015 to reduce the increasing dune trampling produced by beach users and hold back the geomorphic and vegetation deterioration. The preservation scheme consists of 1-m elevated wooden pathways crossing the dune system throughout its extent. A wooden fence was also built few meters distant from the foredune toe in order to trap sand and stabilize the entire dune ridge in its seaward-most line. Topographic surveys have been performed by means of a RTK-GPS Trimble R6 at the same time of UAV surveys in order to monitor the conservation and geomorphic state of the dune. GPS-RTK data were also used as validation of drone-derived DEMs along four repeated cross-sections. UAV surveys were performed using a commercial DJI Phantom 3 Professional, namely a quadcopter equipped with the standard digital camera of 12 megapixels (4000x3000 resolution, 3.61 mm focal length). The flight parameters used for the surveys were: ~ 80 m flight altitude, 70% sidelap, 70% frontlap, fixed focus and automatic pilot mode. Those parameters were chosen to have a good compromise between the acquisition time and the cell size (ground resolution of 3.3 cm) necessary to detect also the most subtle morphological changing. Four surveys were carried out in March, September, December 2017 and March 2018 and the surveyed area varied between 0.15 and 0.21 km². The photogrammetric restitution (DEM and ortophoto generation) was performed using the Structure-from-Motion (SfM) algorithms of the Agisoft PhotoScan Professional (1.3.3 version) software. During UAV surveys twenty ground control points (GCPs), namely 60 x 60 cm wooden squares with a painted red and white cross, were placed throughout the study area in order to completely cover and include the dune system and the facing subaerial beach. GCPs were then measured by means of a RTK-GPS (range accuracy 3-4 cm) linked to the Comacchio GPS fixed station (27 km North from the study site). The GPS measurements were performed in geographical coordinates with elevations referred to the WGS84 ellipsoid. Then they were projected to the UTM 33N system with elevations based on the ETRF2000 geoid. DEMs produced for every survey were analyzed through the DoD (Dem of Difference) processing to quantify the amount of sand that fed the incipient and active foredune through the monitoring period. Wave and wind data were retrieved for the whole monitoring period from the closest measuring sites provided by the regional environmental agency (ARPAe). Orthomosaics obtained from the photogrammetry processing reached resolutions of 3-4 cm whereas DEMs reached a resolution of 5 cm. Each GCP returned an error on its location below 15 cm for each drone survey with a minimum value of 1.77 cm reached in September 2017. During the monitoring period none of the occurred storms reached the dune, mainly because of

their small energy. Topographic variation was really scarce in the established foredune and small variations were limited to the beach and the active foredune. The most significant result was in fact the generation and growth of a small incipient dune right behind the wooden fence, due to wind action. The incipient dune is clearly visible in the middle and southern portion of the study area, where the foredune, differently from the northern part, remained undisturbed from the construction of any facility building. The largest growth of the incipient dune was registered between March and September 2017 and a qualitative increase of pioneer plant density was observed between September and December 2017 on it. With the occurrence of more energetic storms, especially combined with high level of surge and high tide, the small incipient dune is likely to disappear if not stabilized or if a coincidental growth of the facing beach does not occur. Nevertheless, during the monitoring period, the incipient dune showed to withstand low energy storms and to grow under strong wind action from easterly quadrants. The buffering role acted by the wooden fence resulted important for the generation and growth of this incipient dune. In the near future, this process could provide an enlargement of the active foredune, as already observed between September and March 2017. The incipient dune now represents a small amount of sand ready to feed the facing beach during a sea storm or able to enlarge the backward foredune during intense wind actions from E. In this perspective, we show that with the right methodological approach (acquisition, processing and accuracy) also low cost commercial UAV can be used to establish the rate of growth of incipient dunes and study the volume variation of subaerial beach. This represents a decisive benefit for coastal managers that should take advantage of this low-cost technique applied to storm impact mapping (flood limits, damages on buildings or natural settings, sedimentation and erosion patterns), improve and update risk assessment at local scale and short term monitoring of the conservation state of coastal dunes and beaches.

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Antonino Maltese, Fulvio Capodici, Gino Dardanelli, Mauro Lo Brutto

Digital Surface Model extraction from thermal images acquired by an Unmanned Aerial Vehicle

The use of the thermal imaging camera for Unmanned Aerial Vehicle (UAV) survey is very common especially for environmental analysis. Generally thermal cameras are used for single image analysis or with visual evaluations of video sequences. Some environmental analyses require acquiring the images close to sunrise, to avoid the influence of the incident solar radiation on the surface temperature (e.g., those analyses involving thermal inertia, surface renewal, or the characterization of geothermal fluxes). Optical images acquired with low incident solar radiation contextually to thermal images could be characterized by low signal to noise ratio. In these cases it could be necessary to process thermal images similar to optical images by typical photogrammetric workflows. In this way, a Digital Surface Model (DSM) and an ortho-image could be obtained from thermal data. Low spatial resolution of thermal cameras, optical distortion and quite homogeneous radiant exitance spatial distribution require, however, an adapted workflow.

In this work some first tests were carried out to evaluate the possibility to use thermal images for DSM extraction and for ortho-image production. The study area is within the landfill of Bellolampo (close to Palermo, Italy). Two plots were analyzed within the landfill, a first plot is covered by an impermeable cap, a second is covered with soil and is partially vegetated. Landfill managers are interested in thermal behaviour and actual DSM that undergo temporary storage, consolidation, compactation and transfer of waste materia.

In this operative scenario with seagulls used to live at landfills during daytime in huge numbers, and responding to any intruder flying object on their territory (as an unmanned aerial vehicle), it could not always be allowed to monitor the area during diurnal hours. In these cases it could be necessary to characterize the area during night-time.

The area was flown between the 25th and 30th of January 2018 by a NT-8 Contras optocopter carrying on an Optris PI450 thermal camera and a GoPro HERO Black 4 camera. Images were acquired just before sunrise under no solar radiation and just after sunrise with incoming diffuse solar radiation. Aluminium targets were deployed on the ground as suitable ground control points for the thermal images. Aluminium is indeed characterized by very low emissivity and these results in pixels with very low radiative temperature. The coordinates of the targets were measured by a Network Real Time Kinematic (NRTK) survey using a Topcon Hiper V receiver (both GPS and Glonass). The NRTK positioning was based on the UNIPA GNSS permanent network; it consists of nine CORS located in western Sicily, with an inter-distance ranging between 22-80 kilometers with several correction streams. Thermal images were characterized by a pixel spatial resolution of ≈ 15 cm; about 5 times lower than the optical images (≈ 3 cm). Optical and thermal images were processed using the Agisoft PhotoScan Pro software; the typical photogrammetric/structure-from-motion (SfM) approach was carried out by image alignment and estimation of internal camera parameters, dense point cloud computing, DSM and orto-image production. In this first step only a comparison with the optical images dataset was carried out. Results indicates that the DSM obtained from thermal images matches well the DSM obtained by the optical images ($r2 = 0.98$), although the comparison is given at different spatial resolution. Further analyses have to be carried out to highlight the biases eventually introduced by collecting thermal images under not negligible solar radiation which lead to errors such as thermal shadows due micro-reliefs, thermal imprinting due to evaporation over bare soil, and transpiration of vegetation.

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Session Remote sensing for geohazard assessment

Friday, 6 July 2018 (08:30 - 10:00)

Congress Hall - Chairman: Filippo Catani

Martina Aiello¹, Marco Gianinetto¹, Renata Vezzoli¹, Francesco Rota Nodari¹, Francesco Niccolò Polinelli¹, Federico Frassy¹, Maria Cristina Rulli², Giovanni Ravazzani², Chiara Corbari², Andrea Soncini², Davide Danilo Chiarelli², Corrado Passera², Daniele Bocchiola²

Modelling soil erosion in the Alps with dynamic RUSLE and satellite observations

Soil water erosion is a creeping natural phenomenon, mostly related to weather and climate, and one of the main hydrogeological risk in Europe. It causes nutrients loss and exposes the environment to landslides, with negative impacts on agriculture, ecosystem services and infrastructures. Conversely, several human activities (e.g. land cover changes, agricultural patterns reshaping and intensive grazing) induce environmental modifications which intensify pressure on soils, thus increasing their predisposition to water erosion.

Earth observation data offer a unique mean for a continuous monitoring of land cover and use changes over large areas. That is fundamental for understanding the impacts of human activities on soil erosion processes. This work describes the integration of satellite observations with the Revised Universal Soil Loss Equation (RUSLE) model for estimating soil erosion in the Italian Alps. The study area is located in Val Camonica (about 1,785 km²), northern part of Oglio river basin, where crops and forests cover almost 90% of the landscape. RUSLE is a well-known empirical model that estimates soil erosion as a combination of rainfall, the driving force, topographic parameters, pedology and land cover and land management/support practices. However, the land cover/land use parameter is generally set as a static variable, even when using RUSLE to predict scenarios of future erosion, while the support practice factor, that summarizes all the actions undertaken to reduce the speed of water runoff, is usually set to a constant conservative value equal to 1. Besides, RUSLE is applied at yearly scale neglecting the partitioning between solid (not contributing to erosion) and liquid (active in erosion) precipitation and the sheltering effect of snow cover with respect to soil erosion. Thus, leading to inaccurate estimations of the overall soil water erosion.

With respect to traditional RUSLE, in this study we assigned the cover management factor (C-factor) using a combination of land cover and NDVI values computed from Landsat-7 time series, while we computed the support practice factor (P-factor) based on the DUSAF (*Destinazione d'Uso dei Suoli Agricoli e Forestali*) land cover map of Regione Lombardia. Rainfall erosivity (R-factor) was estimated using a degree-day model to distinguish between liquid (erosive) and solid (not erosive) precipitation from hourly data recorded by several meteorological stations and then spatialized to the whole study area. Soil erodibility was tuned for the study area combining pedological maps with TOC, pH and soil granulometric analysis of soil samples collected on site. Finally, the slope length and steepness factor was derived from a 30 m spatial resolution digital elevation model, as usual.

This approach allows a better quantization of C-factor within vegetated classes that influence erosion. That is particularly important when studying areas where vegetation is the main cover, as the Alps. The estimation of C-factor through NDVI increases the detail from constant values on homogeneous areas derived from land cover classification, to a pixel-by-pixel basis at the image spatial resolution. This is, in turn, reflected on soil loss assessment, as the pixel-based approach could highlight spatial patterns useful to characterize erosion phenomena with respect to spatial dynamics. However, the protective role of vegetation towards soil water erosion is not always directly related to condition of vegetation described by NDVI values. Consequently, with the C-factor estimate approach proposed in this work, the sensitivity of NDVI index to vegetation vitality is restrained by the adoption of DUSAF land cover classes as boundaries for C-factor variations.

Besides, integrating the RUSLE model with spectral indices derived from satellite data allows relating phenological and health variations of vegetation with soil loss severity. Thus, using satellite-derived spectral information opens new ways for modelling the dynamics of soil erosion including both seasonal and long-term land cover changes.

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Session Remote sensing for geohazard assessment

Friday, 6 July 2018 (08:30 - 10:00)

Congress Hall - Chairman: Filippo Catani

Lorenzo Bottai, Massimo Perna, Bernardo Gozzini, Lorenzo Arcidiaco, Davide Pellegrini, Francesco Manetti

Using ALS (Airborn Laser Scanner) data for “Ravaneti” change detection analysis and gravitational process path modeling in Carrara marble basin

We present a method for assessing the modification of the terrain form in quarry landscapes based on a change detection analysis using double-date, pre and post-event airborne laser scanning (ALS) data. ALS data is used for delineating the elevation terrain model and for an initial evaluation of the volume of materials present in the quarry. The total volume of exploited material is then estimated using a change detection analysis based on two acquisition ALS. The proposed method produces maps of the quarry areas in Apuane Mountains in Tuscany Regione and estimates of volume of materials. Between the 5th and 12th of October 2017 a flight was carried out over all the Apuane Mountain using an aircraft equipped with a RIEGL laser scanner and Vexcel Ultracam with RGB and CIR optical instrument. The flying altitude was 1100 m above terrain level. ALS data were registered and discretized to a point density of 5-6 pts/m². Digital orthophotos with 0.2 m spatial resolution were also acquired. Standard pre-processing routines were used to remove noise in the ALS data. ALS echoes were classified as ground/non-ground, and the relative heights above ground for echoes. Carrara Marble Basin in the Apuane Alps (northern Tuscany) is the most productive in the world with 1 billion of tons of white marble per year; the large scale exploitation of Carrara quarries begins in the I century A.C., when the region was dominated by the Romans. This activity, through the years, but mostly since 19th century, produced large areas with quarry dump deposits (locally called ravaneti). The temporal evolution of quarrying techniques determined a typical overlapping along the slopes of two layers with different granulometric and permeability characteristics. The deepest layer, with multi-decimetres blocks and scarce fine matrix, corresponds to the typical ravaneto of the 19th 20 centuries crossing period. The active surface ravaneto, with decimeters blocks and abundant fine matrix, is the consequence of the new diamond wire cutting methods, introduced in the '70s. Nowadays, fine material is added to the ravaneti also by the reject stones sieving, in order to produce CaCO₃. Besides, the morphological complexity of Apuane Alps, combined with the proximity of the Ligurian Sea, makes the area in question particularly rainy, with average annual peaks close to the main massifs up to 3000 mm. The Apuane Alps acts as an orographic obstacle to southern moisture-rich winds, favoring condensation and triggering deep convection processes with intense rainfall events causing new landslides and reactivating quiescent ones. In the lastest years, several debris flows affected the ravaneti. The mobilization occurs with initial soil slip progressively fluidificating and becoming a debris flow. The increased frequency of the events in the last years may be referred to fine material added to the ravaneti that forced the saturation processes. In the Carrara Marble Basins, this situation represents a serious geomorphological hazards for workers and infrastructures, but also for citizens since ravaneti are sometimes located not so far from urban areas. In this work we present a change detection analysis of main ravaneti position and thickness conducted through an airborne Lidar survey which have been compare to existing Lidar datasets. Besides, a gravitational process path model have been applied in different areas, to evaluate possible scenarios in case of debris flow occurrences.

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Session Remote sensing for geohazard assessment
 Friday, 6 July 2018 (08:30 - 10:00)
 Congress Hall - Chairman: Filippo Catani

Giulia Tessari¹, Paolo Riccardi¹, Paola Filippi², Paolo Pasquali¹

Multi-temporal InSAR techniques as a monitoring tool to evaluate dam stability

Monitoring of dams is a crucial and essential practice considering the risk associated with erosion, water load, hydraulic gradients or even external factors. Integration of several techniques could help on verifying the structural health of dams and guarantee the safety of these infrastructures and surrounding areas.

This work is aimed on testing the potential of space-borne Synthetic Aperture Radar (SAR) data and multi-temporal interferometric techniques on supporting the traditional dam monitoring systems, helping on identifying the dam structural health with an adequate spatial and temporal resolution.

The relevance of this process emerges when environmental or logistic conditions do not allow monitoring dams through traditional geodetic and numerical techniques. In such cases, results obtained from SAR data combined with a modelling stage constitute a reliable diagnostic tool of dam structural health to avoid any extraordinary failure that may lead to loss of lives.

Here, we focused in two different cases, the Iraqi Mosul dam and the Turkish Ataturk dam.

Mosul dam is an earth-fill embankment-type with a clay-core. It is the largest Iraqi dam, with its 3.2 km length and 113 m high and a storage capacity of 11.1 billion cubic meters. Since the construction started, in 1981, it was noticed as the bed material was highly water-soluble. Therefore, since it was completed in 1986 up to now, tons of grout have been injected to fill the cavities that form underneath the concrete. Despite the intense remediation activity, Mosul dam suffers of ongoing deformation which are affecting the structure but also the surrounding areas. The analysis of deformation has been developed analyzing several datasets: Envisat-ASAR, Sentinel-1 and COSMO-SkyMed. The multi-temporal processing of the available acquisitions allowed measuring the deformation evolution affecting the area between 2003 and 2017 with small temporal gaps. Moreover, using both ascending and descending, vertical and east-west displacement components have been retrieved. The temporal evolution of deformation showed some localized influence of the fluctuation of the basin water level, suggesting a further analysis aimed on mapping the this effects as an additional information to identify the migration of the groundwater level and the corresponding sensitivity of the subsoil layers.

Ataturk dam was constructed on the mainstream of the Euphrates River, between the 1983 and the 1990. It consists of a rockfill dam with a clay core, having a length of 1.8 km and a height of 169 m and a total storage capacity of 48.7 million m³. Since its completion, the dam was instrumented and systematically monitored through different type of sensor, giving information about the internal states of the structure, but also geodetic measurements. It is estimated that the maximum settlement on the central part of the crest reached 7 m. Interferometric Multi-temporal techniques, both PS and SBAS, have been applied to a stack of 139 Sentinel-1 images between October 2014 and March 2018, acquired with a descending geometry. The results showed a maximum rate of Line-of-Sight deformation of 80 mm affecting the dam crest in the 3.5 years of analysis. The field of deformation constantly decreases moving from the top to the bottom of the dam, showing a general stability of the dam toe. These first results will be integrated considering the ascending geometry in order to identify the vertical and east-west component of the ongoing deformation. Moreover, ERS and Envisat-ASAR data will be analyzed to reconstruct the temporal evolution of the dam deformation, enabling a consistent comparison with the existing geodetic measurements.

Results from both the cases will be analyzed with the final aim of exploiting deformation fields as a starting point to re-create a simplified model, providing preliminary hints about the stress-strain status of the dams.

The obtained results are the first stage of a multidisciplinary project, finalized to assess possible damages affecting a dam through remote sensing techniques and civil engineering investigations.

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Session Remote sensing for geohazard assessment

Friday, 6 July 2018 (08:30 - 10:00)

Congress Hall - Chairman: Filippo Catani

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Is it possible to identify volcanoes submarine slope instability from subaerial ground deformation data?

We demonstrated that Multi-Temporal Interferometric Synthetic Aperture Radar (MT-InSAR) displacement measurements of lava delta can be used to detect submarine slope instability at active volcanoes, testing this methodology at Stromboli volcano (Italy). The Stromboli lava delta formed as consequence of the recent flank eruptions (2002-03, 2007 and 2014), overlying a pre-existing depression produced by a submarine-subaerial tsunamigenic landslide that occurred on 30 December 2002 in the Stromboli NW unstable flank (Sciara del Fuoco depression). MT-INSAR displacement data derived from space-borne X-band COSMO-SkyMED (CSK) and C-band SENTINEL-1A (SNT) SAR imagery, collected between February 2010 and October 2016, and processed using the SqueeSAR algorithm. Differential ground motion of the lava delta was detected in both the datasets, identifying a stable area within the northern sector of the SdF and an unstable area in the part of the lava delta emplaced within the 30 December 2002 landslide depression. The unstable part is characterized by velocity fields on the order of 30 mm/y and 160 mm/y in the CSK and SNT datasets, respectively. The slope stability of the offshore part of the Sciara del Fuoco, evaluated using a 3D Limit Equilibrium Method, highlighted a greater propensity to mass-wasting the sector already involved in the 30 December 2002 landslide, which involved the lava delta and its surrounding areas. While MT-InSAR data provided the post-effusive deformation field after the 2007 and 2014 flank eruptions, stability analysis highlighted that the accumulation of lava flows on the prone-to-failure Sciara del Fuoco submarine slope is the main cause of the detected lava delta deformation. Therefore, the displacement recorded by the InSAR data at the Stromboli lava delta can be considered as a proxy for the deformation of submarine slides within the Sciara del Fuoco.

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Session Remote sensing for geohazard assessment
 Friday, 6 July 2018 (08:30 - 10:00)
 Congress Hall - Chairman: Filippo Catani

Federico Raspini

The continuous monitoring of land surface deformation from space: an example from the Tuscany region

Over the past two decades, techniques and studies demonstrating the applicability of images captured by satellite Synthetic Aperture Radar (SAR) sensors for the detection and mapping of geo-hazard induced deformation have greatly progressed. This is mainly related to i) advances in satellite technology, with an increase of temporal and spatial resolution of the satellite data; ii) flourishing of new, more sophisticated processing chains of SAR images; iii) increase of computer system performance with big-data computing power. However, the reduced revisit capacity of orbiting satellites and the limited access to SAR data were the most serious gaps for the extensive use of radar satellite information as a tool for systematic monitoring of ground deformation. Here we show, for the first time, that the enhanced temporal repetitiveness of the Sentinel-1 constellation can be effectively exploited for a continuous and systematic tracking of ground deformation at regional scale. The results obtained demonstrate how satellite SAR data, acquired with short revisiting times and on a regular basis, contribute to prompt identification of changes in the ground deformation pattern acting as a monitoring system.

In this contribution, we illustrate the capabilities of multi-pass InSAR applied to Sentinel-1 SAR acquisitions for continuous monitoring of ground deformation induced by hydrogeological processes. We exploit Sentinel-1 satellites data to implement an operational service devoted to the generation of advanced interferometric products ideally suited for the management of risk posed by ground deformation. This service relies on the systematic and automatic processing of Sentinel-1 images to create updated ground deformation maps and displacement time series through a multi-interferometric (MT-InSAR) approach. Once a new Sentinel-1 acquisition is available, it is automatically merged to the existing images archive. The new data stack is then processed generating robust and continuously updated deformation time series. Finally, InSAR deformation time series are automatically analysed through a new post-processing method, devoted to the early identification of any anomalous trend and/or acceleration occurring during the monitored period.

We present and discuss this operational service through the case study of the Tuscany Region (Central Italy), specifically selected due to its peculiar geological setting prone to ground instability phenomena. Its territory, mainly hilly (66.5%) with mountainous areas (25.1%) and few plains (8.4%), results to be a very landslide-prone area. Land subsidence has been identified throughout the region, related both to groundwater exploitation and to compaction of soft sediments. Extensive subsiding area has been mapped also in the geothermal district of Central Tuscany.

We demonstrate that advances in satellite radar sensors, processing algorithms, data mining tools and cloud computing allow the design of new monitoring systems, providing an advanced tool for risk mitigation strategies across wide scales. This monitoring system is designed to capture changes in the deformation pattern occurring at regional scale, such as precursor movements that are usually recorded before landslide failures or sinkholes.

Session Remote sensing for geohazard assessment

Friday, 6 July 2018 (08:30 - 10:00)

Congress Hall - Chairman: Filippo Catani

Luca Cicala, Cesario Vincenzo Angelino, Sara Parrilli

A multimission approach to fire monitoring with multispectral imagery

The aim of this research is to show an approach that can improve existing services of fire monitoring by exploiting different satellite constellation with multispectral (MS) sensors provided by the European Space Agency (ESA) and NASA.

Nowadays existing fire monitoring services based on earth observation missions have three main goals: I) fire risk assessment, II) active fire monitoring and III) post-fire damage assessment.

While the risk assessment relies mainly on meteorological observations and prevision models, the active fire monitoring and the post-fire damage assessment are based on spectral measurements performed by satellites equipped with multispectral sensors. Indeed, in order to monitor active fires, the use of SWIR (Short Wavelength Infra-Red) and TIR (Thermal Infra-Red) spectral bands must be taken into account. In fact at such frequencies and at typical wood fire temperature, the thermal emission is energetically prevalent on the reflected sun light. In particular, the SWIR radiation penetrates smoke clouds during active fire phenomena. Therefore, since SWIR bands are more commonly available than TIR, they are of particular interest to generate multi-mission common products.

On the other hand, post-fire damage assessment make use of change detection analyses. The latter can be implemented on data acquired by satellites equipped with instruments operating in NIR (in such case analyses based on the Normalized Difference Vegetation Index can be performed) or both in NIR and SWIR bands (in such case the Normalized Band Ratio can be also considered).

The main findings of this research are:

- 1) A better active fire detection (AFD) using high resolution (HR) images (e.g., Sentinel-2 and Landsat-8) with respect to low resolution (LR) data from MODIS and VIIRS currently employed;
- 2) A more reliable quantification of burned areas for post-fire damage assessment.

For active fire detection, we propose indices that can be calculated both on Sentinel-2 as well as on Landsat-8 data, based on NIR and SWIR spectral bands that are available at both the missions, in order to obtain a common product. They are seen as instances of a Generalized Normalized Difference Index (GNDI). Moreover, a new active fire detection index (AFD3) based on three-bands (instead of two) is proposed. This index has been designed starting from physical and mathematical properties and it produces less false positives as well as more readable results.

A relevant problem in assessing burned area is that vegetation withdraw can be due to many causes, so that is practically impossible to associate vegetation changes to fire damages, especially using poor information as that provided by indices. For this reason, analyses based in indices typically deliver many false positives.

To overtake these limitations, we propose a novel workflow that combines data coming from different ESA and NASA multispectral mission. It is worth to notice that the proposed workflow is based on available or easy computable earth observation products and does not require human supervision.

The basic idea is to compare medium or high spatial resolution imagery (20-30 m), acquired in two different dates, in order to evaluate vegetation changes and then to compare such changes with historical records of active fires detected with low spatial resolution (375-1000 m), belonging to the same time interval. By relating the vegetation regression to the detected fires, it is easy to discriminate changes due to fires from other vegetation change causes. In particular, in our approach, strong variations in the NDVI (Normalized Difference Vegetation Index), over the medium and/or high spatial resolution images are considered, and then such changes are filtered excluding

that not related to hotspots detections. The relations between Landsat-8/Sentinel-2 data and MODIS/VIIRS data are modeled using OBIA, in particular segmenting the Landsat-8/Sentinel-2 data and assigning to the extracted regions spatial features representing the overlaps with and the distance to the footprints of the detected hotspots.

To summarize, in this work an approach to process open data coming from High-resolution and medium-resolution optical multispectral sensors is proposed, both for active fire monitoring as well as for post-fire damage assessment. A set of state-of-the-art and a novel spectral index, all instances of the same Generalized Normalized Difference Index, are proposed, in order to derive the same product both from Landsat-8 and Sentinel-2 images, with the aim at improving the observation frequency of the proposed enhanced resolution monitoring service. For such reason, to be able to compare Landsat-8 and Sentinel-2 products, the proposed indices are based only on NIR and SWIR wavelength, available at both the Earth Observation missions. Moreover, a simple but very effective approach for post-fire damage assessment is proposed. Such an approach is based on a state of the art vegetation index (NDVI) that can be calculated with high reliability both on Landsat-8 and Sentinel-2 imagery, and on already available MODIS and VIIRS hotspot detection products.

The results on the large wildfire occurred on the Vesuvius Volcano near Naples (Southern Italy) on July 2017 showed the effectiveness of such an approach. Indeed, from one hand products can be derived from Landsat-8 and Sentinel-2 data, and on the other hand that both the missions can be used together in order to increase the overall availability of data and to improve the spatial accuracy of the existing fire monitoring services, based on multispectral low resolution missions, like MODIS and VIIRS.

Session Remote sensing application in agriculture
Friday, 6 July 2018 (08:30 - 10:00)
Bracco Classroom - Chairman: Mario Gomarasca

Francesco Chianucci¹, Andrea Lucibelli², Maria Teresa Dell'Abate¹

Estimation of ground canopy cover in agricultural crops using nadir photography

Fast and accurate estimates of canopy cover are central for a wide range of agricultural applications and studies. Visual assessment is a traditionally employed method to estimate canopy cover in the field, but it is limited by the costs, subjectivity and non-reproducibility of the produced estimates. Digital photography is a low-cost alternative method. In this study we tested two automated image classification methods (Rosin and LAB2), which were both previously tested in forest understory, to estimate canopy cover from downward-looking images of agricultural crops. These methods were tested using artificial images with known cover; this allowed exploring the influence of canopy density and object size on canopy cover estimation from photography. The Rosin method provided best estimates of canopy cover in artificial images, whose accuracy was largely unaffected by variation in canopy density and object size. By contrast, LAB2 systematically overestimated canopy cover, because of the sensitivity of the method to small variations of chromaticity in artificial images. The results were replicated in real images of cultivated aromatic crops. The main findings indicate that digital photography is an effective method to obtain rapid, robust and reproducible measures of canopy cover in downward-looking images of agricultural crops.

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Session Remote sensing application in agriculture
 Friday, 6 July 2018 (08:30 - 10:00)
 Bracco Classroom - Chairman: Mario Gomarasca

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Coffea arabica and rust through hyperspectral data, are they really different?

Coffee, mainly *Coffea arabica* L., is a product of global importance and it is part of a significant fraction of the export economy of several countries. In Mexico it is one of the main industrial crops, the second most exported product and a great generator of foreign currency when it is cultivated in 14 states with more than 717 thousand hectares, which makes it an impeller of the regional economy and sustenance for more than half a million families. Chiapas state, the most important producer in Mexico and mostly the Sierra Madre region, has a 200 years history in coffee production, resulting in high quality grains from shaded agroforestry systems.

The under shade coffee crop (a traditional production system) has gained great importance in recent years, because it promotes forest cover and then biodiversity conservation, therefore environmental services too. But since 2013 this activity has presented great losses, in quantity and quality due to rust infestation (*Hemileia vastatrix*), which causes lesions on the coffee leaves trees, affecting the foliage and finally the seed production (coffee grain), which results in monetary losses. In order to reduce this impact, coffee producers have introduced rust resistant coffee varieties that are not compatible with under shade agroforestry systems and hence, forest cover is cut down for corn crop or for livestock. All of these activities put at risk thousands of families and the ecosystem services provided by those agroecosystems.

It is necessary the implementation of mechanisms that allow monitoring the health status of coffee crop because coffee health is usually monitored by work field, but it implies high costs in time and money and different risks for the people in charge. Therefore, new methodologies for crop identification with and without rust should be considered in order to reduce monetary and temporary investment, as well as risk associated with.

Remote sensing has been widely used for vegetation monitoring showing high reliability for homogeneous coverages, but not to identify different species in heterogeneous vegetation cover. The under shade coffee crop is an example of this, because it needs a canopy of trees that protects it from sunlight, and this condition limits coffee plants detection by spatial and aerial commercial sensors and thus, the commonly techniques used for remote sensing have shown poor results for its identification. However, in recent years the effectiveness of advanced methods such as spectral unmixing and the use of hyperspectral data have proven to be effective in identifying species and components found in mixed coverages such as tropical forests and soil minerals, but not in crops such as coffee. In order to bring knowledge in this topic that will help to support research on hyperspectral data usefulness coffee crop identification and therefore its health status monitoring through satellite or aerial data (such as those obtained by drones), the aim of this paper is to test whether there are significant differences between the spectral reflectance of the under shade coffee leaves, coffee leaves with rust and leaves associated with under shade coffee crop.

To achieve this goal, spectral signatures for different varieties of coffee leaves (Arabica, Catimorro, Marago and Bourbon) with and without rust and several species associated with the shade of the coffee crop (shade trees and shrubs), were collected with the high resolution portable FieldSpec 4 spectroradiometer, with a spectral resolution between 350 and 2,500 nanometers. The spectral data were taken on June 8, 2017 in a coffee zone of the Monterrey Ejido located in the buffer zone of the El Triunfo Biosphere Reserve, Municipality of Jaltenango de la Paz, Chiapas. Its altitude is 1,484 meters and the predominant vegetation is cloud forest and coniferous forest. This area was chosen since the main activity is coffee crop, in addition there are different varieties of coffee and the presence and absence of rust, as well as shade vegetation. Five spectral signatures per leaf per variety of coffee (Arabica, Marago, Catimorro and Bourbon) with and without rust (which was only found in Arabica and Marago) and species associated with the crop were taken by the probe, having a total of 59 reflectance signatures. After that, spectral reflectance data were averaged and processed with a derivative analysis using the Savitzky-Golay filtering method, which uses a simplified least-squares convolution for smoothing and computing derivatives of a set of consecutive values to remove noise produced by environment and then make them useful for determine differences between spectral reflectance of coffee leaves varieties with and without rust and also the trees associated with the coffee crops.

Comparing the resulting reflectance spectra obtained from the Savitzky-Golay filtering method, it was found that Arabica variety shows some differences in reflectance at a range of 650 to 680nm of electromagnetic spectrum, compared to the rest (Bourbon, Marago and Catimorro) and from 650 to 730nm where the highest reflectance value is given. Regarding the leaves infested by rust, it was observed that in Marago case the region where the curve has the greatest reflection (around 670-730nm) has a shift to the left (around 650-700 nm) and in both cases Marago and Arabica, it is observed a reduction in reflectance at different regions of the electromagnetic spectrum. Finally, Bonferoni's adjusted t-test showed significant differences at the spectral reflectance range of 650 to 800nm between different varieties of coffee, species associated with the crop and leaves infested by rust.

This work shows that different varieties of coffee, tree species associated with coffee crop, and leaves infested by rust exhibits significant differences in some regions of the electromagnetic spectrum. These differences may be a result of plant-light interaction, which is related to cellular and canopy structure, as well as ecosystem structure, both regulates plants light absorption and photosynthesis process. Hence, it could explain the susceptibility of certain varieties to get infected by rust, since some of them were resistant to infestation and those that were not, had different spectral behaviors. Therefore, it is important to continue the research in this line to improve knowledge about the way coffee plant interacts with light, in order to be able to apply and to develop new methods to measure and support the coffee plant health and coffee agroecosystem.

Session Remote sensing application in agriculture

Friday, 6 July 2018 (08:30 - 10:00)

Bracco Classroom - Chairman: Mario Gomarasca

Camilla Dibari¹, Marco Moriondo², Sergi Costafreda-Aumedes¹, Lorenzo Brilli,² Andrea Triossi³, Marco Bindi¹

A remote sensing analysis to recover abandoned olive grove systems leveraging climate change mitigation

As many rural areas of the Mediterranean, a large abandonment of olive groves in the last decades is occurring in Tuscany (Moriondo et al., 2013; Galli et al., 2010). These systems are mainly managed at familiar level and characterized by extensive production systems, i.e. low nitrogen (N) fertilizer and plant densities, few management practices (i.e. no irrigation) and little incomes (Duarte et al., 2008). Tuscan olive groves are often relegated in marginal and low-productive areas, where most of the labour is done by farmer's family members (Greppi C., 2007). Besides olive production, olive farming systems also provide several ecosystem services such as soil conservation, fire risk reduction, conservation of historic Tuscan agricultural landscape, and atmospheric carbon (C) sequestration; this latter is assuming high relevance due to the need to boost climate change mitigation solutions. In this context, recovering abandoned olive groves may have the potential to support climate change mitigation, recovering and/or restoring abandoned olive groves, while reducing GHG emissions due to agriculture practices. This strategy may be adopted over the hilly area of Montalbano, located across the Provinces of Florence, Prato and Pistoia (Italy), which over decades is experiencing human emigration towards urbanized areas and consequently a large olive orchards are under abandonment and hindered by natural reforestation and shrub encroachment processes leading to a deterioration of the historic Tuscan agricultural landscape (Agnoletti et al., 2015).

On these basis, in this study - carried out within the project CatchCO₂-Live - the mitigation potential of restoration and recover of Montalbano area has been assessed coupling remote sensing with modeling analysis so as to sustain local farmers to adopt strategies for their management under a GHG mitigation perspective and maintaining the historical landscape of rural Tuscany.

The current olive tree distribution of the study area, which extends approximately 19,000 hectares ranging from 23 to 500 m a.s.l., was derived from Corine Land Cover map (2006) updated by Tuscany Region to 2012. Olive groves abandonment over the last 60 years was assessed through a diachronic visual interpretation of historical aerial photos (1954) against the most recent ones (2013) (nominal spatial resolution 0.5m x 0.5 m). A contingency table was thus created so as to map and quantify land use changes as well as areas having the potential to be restored to olive tree cultivation. Current olive groves plant density was assessed through geographically weighted regression approach using NDVI from Landsat 8 OLI multiband scene and local topography (i.e. elevation and slope) as predictor variables. In the specific, current distribution of olive groves (Corine Land Cover, 2012) was converted to a grid fishnet dataset (50 x 50 m spatial resolution) so as to overlay it to Landsat imageries. After, NIR and R values and the relevant elevation and slope were extracted from two Landsat imageries on July (the 12th 2016 and the 26th 2016) and from the digital elevation model, respectively, overlaying each grid cells falling completely inside Corine olive tree distribution. Out of 1,143, 405 grid cells were randomly extracted so as to count, within each cell, the number of olive plants (plant density) through a visual interpretation on aerial photos (2013). Finally, the geographically weighted regression was applied using NDVI value, elevation and slope as predictors of plant density in a leave-one-out scheme to avoid regression overfitting, so as to determine areas having the potential to be restored with additional olive tree plantations. Mitigation potential (in terms of atmospheric C sequestration) of restoration and recover of olive groves was estimated through DayCent biogeochemical model, previously calibrated and validated. The model was applied simulating both olive conventional and organic farming systems considering low (>150 trees/ha), medium (150-300 trees/ha) and high (>300 trees/ha) planting density. Moreover, potential C stock was also simulated on arable lands and shrub/forest systems so as to estimate C sequestration potentials deriving from olive groves restoration in these systems.

Results indicated that about 908 ha of olive orchard out of 4,900 ha have been abandoned from 1954 in Montalbano area, and among them 50 ha turned to low-density olive groves, while 860 ha changed to other land uses (mainly vineyards and fruit tree cultivations, forest and shrublands, urban areas and other cultivations). The weighted multi-regression approach provided optimal performances in predicting olive planting density ($r=0.83^{**}$, RMSE

=41.15 trees/ha) and once applied over the entire study area, large areas (4,785 ha) of olive groves were assumed as semi-abandoned or abandoned due to the very low or low plant density (< 150 trees/ha and 150-300 trees/ha, respectively). Conversely, only 4.3% (215 ha) of current olive groves depicted an economically sustainable plant density (> 300 trees/ha) in the study area, mainly concentrated in Pistoia and Vinci municipalities over plain and more fertile rural lands. According to these results, turning all olive groves into economically sustainable cultivations (plant density > 300 trees/ha) about 890,000 trees should be replanted (Dibari et al. 2017).

DayCent simulations highlighted that, for each plant density, organic farming systems have the potential to sequester a higher amount of atmospheric C (up to 5.3 ton C/ha year) compared to conventional (up to 4.5 ton C/ha year), arable lands (up to 0.5 ton C/ha year) or lands under shrub/forest encroachment (up to 4.2 ton C/ha year). This is because the higher number of trees in high-density olive groves determines a higher total C sequestration, mostly fixed in the woody structure of the plants. On the other hand, mitigation potential of herbaceous vegetation cover in low-density olive orchards, even if playing a significant role in the photosynthetic activity of the entire olive-system, are not able to store the same amount of C with respect to tree systems. Additionally, simulations evidenced differences in mitigation potential in the two farming systems considered: the organic farming system is able to stock higher amount of atmospheric C with respect to conventional. Thus, using organic fertilizer (organic management) maximizes the efficiency of the system during the peak of photosynthetic activity (i.e. spring) and, consequently, expresses a greater ability to fix atmospheric C. Conversion from arable lands to high-density olive groves will result in remarkable benefits in terms of C sequestration (+3.97 ton C/ha year). Even if in a lower magnitude (+0.28 ton C/ha year), these benefits resulted also restoring high-density olive groves from wooded-shrubby system under organic farming systems, since the possibility to add nutrients to the soil immediately available for the system (organic manure) helps the olive tree systems to fix higher amount of atmospheric C with respect to shrub/forest systems. Finally, if all olive groves would be managed under organic farming systems and high-plant density (>300 trees/ha), the atmospheric C sequestration provided by the olive area of Montalbano could reach up to 26,300 ton C/year, thus able to compensate CO₂ emissions of about 31,000 habitants living in the Metropolitan area of Florence.

As conclusion, the study indicated the fundamental role played by olive groves across the hilly area of Montalbano (Tuscany), suggesting as systems characterized by low production and income may offer benefits deriving from their recovering and restoring especially in terms of C sequestration. Given the few number of studies focused on the role that these managed woody systems may play to climate mitigation, further studies should be conducted in order to assess how C sequestration capacity may vary in olive orchards according to different cultivation methods and environmental conditions.

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Session Remote sensing application in agriculture
 Friday, 6 July 2018 (08:30 - 10:00)
 Bracco Classroom - Chairman: Mario Gomarasca

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Monitoring rice agropractices in North Africa: a comparison of MODIS and Sentinel-1 results

Agro-monitoring systems need up-to-date information on where, when and how much a crop is cultivated, in particular in developing countries and for food security reasons. Such information can be derived from remote sensing imagery with fast revisiting cycles. In the past, only time series of optical moderate resolution data such as HVR, SPOT-Vegetation and MODIS provided the necessary high temporal resolution for this kind of applications. These datasets have been successfully used for agro-monitoring activities and to perform retrospective and trend analysis. Due to their moderate to coarse spatial resolution (~ 250 – 1000 m) their applications are limited however to regional to continental scales. In this context, the advent of the Sentinel sensors opens new opportunities, since they provide time series of satellite imagery with decametric spatial resolution and revisit times of 5 days. Studies that fully exploit Sentinel imagery for crop monitoring are therefore needed to assess their potential contribution for i) performing high resolution crop-monitoring activities and, ii) extending time series of information derived from archive coarse resolution imagery with the aim of performing analyses of temporal trends over a reasonably long time span.

This contribution presents a comparison of MODIS or Sentinel1 time series for detection (cultivated area and number of seasons) and seasonal dynamics' analysis (sowing, harvesting and flowering dates) for irrigated rice cultivation in the Senegal River Valley (SRV) for the 2016 dry and wet rice seasons. MODIS time series analysis exploited the PhenoRice algorithm (Boschetti et al., 2017), a rule-based algorithm specifically designed for rice detection and seasonal dynamics monitoring and based on the use of time series of TERRA and AQUA 250 m resolution 16-day Composite Vegetation Indexes (MODIS products MOD13Q1 and MYD13Q1).

SAR data analysis was instead based on Sentinel-1A time series acquired over the study area from January to December 2016. In particular, the RICEScape software was used for analysing the SAR backscatter temporal profiles both in the VV and in the VH polarization, to define a set of rules allowing to properly identify rice cultivated areas. The algorithm mostly exploits SAR data, although cloud free Landsat-8 Optical images were used to crosscheck and complement the information derived from SAR. This approach was applied to generate rice crop area and Start of Season (SOS) maps for both the dry (sowing in February – April) and the wet (sowing in September – November) rice seasons.

Results showed a strong consistency between the thematic maps derived from the two data sources. We observed that, although the rice-classified area is rather different due to the large difference in spatial resolution, the main spatial patterns of estimated sowing dates and crop intensity are quite similar. A comparison between the average values of MODIS and SAR estimated dates after aggregation on a 2x2 km regular grid shows a strong correlation between the sowing dates derived from Sentinel-1 and MODIS data, for both the dry and the wet season of 2016. The comparability of MODIS and Sentinel results is encouraging for the development of innovative services for characterization and monitoring of crop systems. Such systems could in fact exploit both the sufficiently long MODIS time series to characterize the main characteristics of crop systems and their recent evolution, as well as the innovative Sentinel-1 time series for monitoring of present-day and future conditions.

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Session Remote sensing application in agriculture
 Friday, 6 July 2018 (08:30 - 10:00)
 Bracco Classroom - Chairman: Mario Gomarasca

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Mapping irrigated croplands using Sentinel-2 data in Sardinia- Italy

Introduction

This work intends to discuss the results of the research carried out for the monitoring of irrigated areas in an intensively cultivated sector of western Sardinia. Due to the limited availability of water resources in this area, the large amount required by crops need to be necessarily monitored and managed rationally. This issue involves the local administration that has to control water supplies to farmers and verify the effective usage as declared by themselves, where automatic monitoring systems are not completely used. The current availability of mid-resolution multispectral satellite data allows to continuously monitor the observed surfaces, allowing the recognition of irrigated surfaces based on the spectral characteristics.

Therefore, a remote sensed control system seems to be the best operative tool for the management of water resources in agriculture. The ESA (European Space Agency) Sentinel-2 data were used in this work to generate maps of spectral indexes for the detection of irrigated surfaces, in the perspective of a low-cost monitoring system. The study is part of a scientific partnership between the University of Cagliari and the "Consorzio di Bonifica dell'Oristanese" (CBO), and the scientific support of the University of Turin.

Study area, data and methodology

The study area covers the Arborea plain, in central-western Sardinia. This area is characterized by an intensive agriculture and croplands are irrigated during the growing season. These consist in particular of spring-summer crops with a phenological cycle from April to September. In particular the moment when water is required starts in April / May and throughout the summer, depending on the crop.

On the basis of the information provided by CBO, the Sentinel-2 MSI (Multi Spectral Instrument) data were selected as the most suitable for this purpose due to the following features: a) geometric resolution (10 - 20 m) and size of the plots, b) spectral resolution (12 band in the VNIR-SWIR region between 0.429-2.323 μm), with reference to the crop characteristics, c) temporal resolution (5 days), with reference to agronomic calendars of crops, d) the limited cloud cover during the growing season observed. Successively a dataset of 29 Sentinel-2 images from March to November 2017 have then been acquired by the ESA Sentinel-2 Data Hub.

A methodology based on the application of spectral indices has been proposed. In particular, after pre-processing steps, the Normalized Differencing Vegetation Index and the Normalized Differencing Water Index, selected as proxy of vegetation vigour and soil moisture respectively, were generated according to equations [1] and [2]:

$$NDVI = \frac{\rho_{NIR} - \rho_{RED}}{\rho_{NIR} + \rho_{RED}} \quad [1]$$

$$NDWI = \frac{\rho_{GREEN} - \rho_{MIR1}}{\rho_{GREEN} + \rho_{MIR1}} \quad [2]$$

where ρ_{GREEN} , ρ_{RED} , ρ_{NIR} and ρ_{MIR1} are respectively the at-the-ground reflectance in band 3 (0.537–0.583 μm), band 4 (0.645–0.683 μm), band 8 (0.762–0.907 μm) and band 11 (1.541 – 1.685 μm) of Sentinel-2 imagery. The NDVI was initially used to separate vegetated and not-vegetated surfaces by a threshold (0.4). Successively, the NDWI was used to map the different levels of water content. In general, the NDWI assume: a) values below 0 for the vegetated and bare soil surfaces, increasing with the increase of surface water content, b) values above 0 for surfaces with exposed water. Some maps representing vegetated areas with different values of water content, and b) images representing bare soils with different values of soil moisture were then generated for the study area.

Results and conclusions

The results allowed to obtain two classifications of water content values (irrigated areas) both on vegetation-

covered particles and on particles with bare soil.

The validation of the obtained results was discussed with the CBO technicians and was carried out on two levels:

- Verification of existing irrigation questions by the owners.
- Verification on the field of the particles irrigated at the time of acquisition of the satellite data.

The results obtained were extremely interesting:

- the values of presence /absence of water are compatible with field checks;
- anomalies have emerged with respect to what could be expected, and these have been attributed to possible water losses of the pipelines;
- some irrigated particles were not associated with irrigation demand.

Although the test area is strongly fragmented, the geometric resolution of the Sentinel-2 data allows to discriminate the behaviour of the individual plots and to associate them with the surface registry data of the properties.

The availability of a continuous time series allows to provide an effective monitoring tool for the soil moisture status, which can be associated with irrigation management.

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Session Remote sensing application in agriculture
 Friday, 6 July 2018 (08:30 - 10:00)
 Bracco Classroom - Chairman: Mario Gomarasca

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Image Segments Vs Cadastral Maps: Effects in Monitoring Rice by Remote Sensing

Introduction

Nowadays remote sensing techniques are widely used in agricultural applications due to the high availability of free pre-processed dataset, leading to the development of monitoring services (web or standalone).

The management and monitoring of agricultural areas by Regional and European Administration is currently based on a sub-division of territory in cadastral parcels, which however do not necessarily define homogeneous surfaces. In this condition, the spectral signal belonging to the same parcel aggregated to generate a single average temporal profile for the whole parcel, doesn't match the real management of parcels. In fact, many parcels are internally divided in sub-parcels, possibly farmed differently in terms of crop type or timing of operation or both. Signal aggregation, in these situations, generates an unreliable average spectrum inconsistent with real conditions of the sub-parcels.

The focus of this work was to investigate differences between these two approaches, comparing maps of average spectral behaviour generated by aggregation of signal at cadastral level and the one generated by aggregation based on a segmentation algorithm able to identify sub-parcels average behaviour based on NDVI (Normalized Difference Vegetation Index) and NDWI (Normalized Difference Water Index).

Materials and Methods

This work was based on twenty-two optical satellite images representing at-surface reflectances from ESA (European Space Agency) Sentinel-2 Level 2A (S2) and NASA (National Aeronautics and Space Administration) Landsat-8 C1 Level 2 (L8) collections, jointly used. The L8 dataset was resampled at a geometrical resolution of 10 m to be consistent to the S2 one. A study area of 8.7·10³ ha in Piemonte Region, mainly devoted to rice cultivation, has been investigated along the 2016 crop season deriving NDVI [1] and NDWI [2].

$$NDVI = \frac{\rho_{NIR} - \rho_{RED}}{\rho_{NIR} + \rho_{RED}} \quad [1]$$

$$NDWI = \frac{\rho_{GREEN} - \rho_{NIR}}{\rho_{GREEN} + \rho_{NIR}} \quad [2]$$

Where ρ_{NIR} , ρ_{RED} , ρ_{GREEN} are reflectances respectively for Near Infrared, Red and Green bands.

Monitoring of rice managed areas allows to easily identify a typical feature of this crop: the pre-seeding flooding step in which rice fields are submerged. So, as NDVI is suitable for monitoring vegetative vigour of plants, NDWI generated with ρ_{NIR} and ρ_{GREEN} is more suitable detecting water surfaces like the pre-seeding submerged fields. Subsequently to detect homogeneous portions of parcels in terms of vegetative vigor variations during the season, a region-based segmentation method has been performed on the NDVI series into the free software Orfeo ToolBox (OTB). Then, for each index, a single multitemporal profile has been generated for each cadastral parcel and then compared with the segment-based profile one. Using as input a time series of NDVI for the 2016 season, pixel variation in the series has been aggregated in a mean value: if difference between adjacent pixels was under a threshold of 0.1 a homogeneous sub-parcel was created. A mean-shift algorithm with a spatial radius of five pixels and a range radius of 0.1 has been used to generate an homogeneous minimum region size of twenty-five pixels (0.25 ha, minimal area able to be measured with geometric resolution of L8 and S2 ensuring the radiometric homogeneity of the central pixels). Range radius identifies the spectral difference between pixels.

The Mean Absolute Error (MAE) for each index has been aggregated as showed in [3]:

$$MAE = (\sum |SM_i - PM_i|) / n \quad [3]$$

Where SM_i is the generic index mean value for the segmented polygon, PM_i is the generic index mean value for parcel and n is the number of images. To better describe parcels and segmented polygons features, the Shape Index (SI, [4]) has been calculated in SAGA GIS.

$$SI = P / (2 * (P * A)^{0.5}) \quad [4]$$

Where P is the polygon perimeter and A is the area.

Successively, to detect where and when differences between SM_i and the PM_i are located, the signal aggregation maps have been tested with a spatial and temporal investigation for MAE. Spatial investigation lead to the computation for each time level in the series generating an average value of $MAE_{x,y}(t)$. As result, temporal profile for $MAE_{x,y}(t)$ identifies when (which date) maximum differences concentrate. The temporal analysis of $MAE_{x,y}(t)$ along temporal profile of each pixel generate as result a map of $MAE_t(x,y)$ that shows where maximum differences concentrate.

Results and Discussions

Comparison between SM_i and the PM_i maps for the year 2016 proves that this method is more reliable in monitoring and detecting differences between any sub-parcel behavior. In fact, number of homogeneous surface portions increases from 5787 (number of cadastral parcels) to more than 8000 (homogeneous segmented polygons). Moreover, specific features like mean values for area and SI, change respectively from 9594.38 m² and 1.71 for cadastral polygons to 6823.49 m² and 1.84 for segmented ones. It was observed that as the SI increases the shapes change from the perfect plane isotropy to the highest anisotropy in which a dimension is bigger than the other one. Focusing on segmented polygons, mean SI value shows that more anisotropic polygons have been generated identifying parcel edges in which the average index (NDVI or NDWI) behaviour is sensitively different from the central part of the same parcel. Regarding to $MAE_{x,y}(t)$, the maximum differences (0.07 for NDVI and 0.11 for NDWI) are respectively detected on the 19/04/2016 (start of growing season) and 21/05/2016 (first flooding step) underlining that within the same cadastral parcel, farming operations, flooding step and plants development occurred in different times.

Map of $MAE_t(x,y)$, otherwise, makes possible to detect unfarmed surfaces where the value is the highest because SM_i was able to identify terrain features not included in PM_i as headlands and service roads areas where the spectral behaviour is completely different. Moreover, map of $MAE_t(x,y)$ highlighted sub-parcels where differences between many rice cultivars (and related different farming techniques) in the same cadastral parcel are located.

Conclusions

As result of this methodology it is possible to identify homogeneous surfaces usable to obtain unique information related to macro-phenology and water content of crops and fields at single sub-parcel scale. Regarding $MAE_{x,y}(t)$, this was helpful to detect that maximum differences in time are concentrated at the start of growing season (mid-April for NDVI, mid-May for NDWI) underlining differences in sub-parcels management. Moreover this could be helpful, jointly to $MAE_t(x,y)$, to detect sub-parcels involved by dry seeding techniques, characterized by different spectral behaviour. The calculation of SI on the SM_i allowed to identify some terrain infrastructure (headlands, service roads) eventually not mapped by cadastral cartography, permitting their exclusion from the computations directly related to crops phenology.

These steps must be mandatory in a processing workflow oriented to the development of a reliable monitoring service, constantly updated (because based on regularly acquired images) and not based on cadastral data, often obsolete and not related to the real state of the areas, usable by Regional Administrators, farmers, and European agriculture managers.

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Session Remote sensing of urban environments
 Friday, 6 July 2018 (10:30 - 12:00)
 Congress Hall - Chairman: Marco Gianinetta

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Remote sensing and urban metrics: an automatic classification of spatial configurations to support urban policies

1. Introduction

Over time, Italian cities and landscapes have developed through generative processes which have been defined by Tuscany law n° 65/2014 as "invarianti strutturali". The combination of spatial composition rules, that defines specific urban patterns, has governed these generative processes. Urban patterns, in spite of their transformation processes, keep a specific size ratio that makes them always recognizable. Urban patterns have allowed the generation of high quality spaces with which people identify themselves. For these reasons, urban patterns are identifying elements of the region that they belong to and establish the so-called "patrimonio territoriale" (Magnaghi, 2001).

The aim of our research is to find urban patterns of the city of Livorno. This paper proposes an automatized methodology based on urban metrics and remote sensing data, which distinguish homogeneous areas with the same structural characteristics; these areas can then be traced back to urban patterns. To recognize these zones, our method combines sustainability and perceptual indices.

The goal is to determine guidelines useful for urban and landscape planning to regenerate spaces without quality.

2. Materials and Method

2.1 Study area

Livorno is a municipality of Central Italy located on the Tuscan coast and overlooking the Ligurian Sea. The town covers an area of 104.5 square kilometres; it counts 157,052 inhabitants (ISTAT 2011), making it the third largest city in Tuscany by population. The perimeter of the study area only includes the urban territory of the city of Livorno, since this paper is focusing on urban quality. Thus, industrial areas, which lie to the north of the city, and rural districts have been excluded from our study, as well as outlying hamlets that are far from the city centre.

2.2 Data

Our method uses both cartographic information and remote sensing data in order to analyse the relational and perceptual dimension of the city. Height and coverage information about vegetation and buildings derives from multispectral images and LiDAR data.

2.3 Urban metrics

This method is based on automatic unsupervised classification. The urban metrics chosen are included in the landscape index category (Reis, Silva, & Pinho, 2014). This category includes different types of metrics; from simple geometrical measures (e.g. patch area) to more complex indicators based on perimeter-area ratios (e.g. fractal dimension, shape index) to statistical measurements (e.g. Shannon's diversity and evenness indices). These metrics aim at analysing the dimensional, structural and morphological characteristics of urban landscapes in order to highlight their proportions. Based both on this and on several authors' previous classifications, these metrics can be divided into the following three categories:

- 1- built-based metrics (linear blocks and city blocks)
- 2- road-based metrics (road sections and road by toponym)
- 3- normalized difference vegetation index (NDVI).

The metrics used are:

- i) Geometric and volumetric index
- ii) Regular and irregular index
- iii) Fragmentation index
- iv) Density index
- v) Connectivity index

Geometric indices are described by simple geometrical measurements (area, perimeter, volume, etc) and they have been calculated with GIS software; while for the others we used the Fragstats 4.2.1 software.

3. Results and Discussion

The main aim of our research was to create a classification system that would be useful for analysis method urban quality and urban ecology. Indices were analysed by our unsupervised classification, which clustered similar indices in order to identify homogeneous areas in the city . The identified areas defined the different urban patterns of Livorno. Subsequently, we studied which range of indices' values defined high quality patterns. Finally, we created an index urban quality that allowed us to identify the high, medium and low urban quality areas.

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Session Remote sensing of urban environments
 Friday, 6 July 2018 (10:30 - 12:00)
 Congress Hall - Chairman: Marco Gianinetta

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Soaring temperatures triggered by urbanization: a case study of Vijayawada city, India

Urbanization is the process of development or upgradation of an area such that self-sufficiency in terms of social and economic comfort is ensured to its occupants. In the fast growing economy, most of the countries in the world have their cities under metropolitan category meaning a city with densely populated urban core that has the capacity to cater people of all economic background. On account of the increased population density in its city center, there arises the necessity to expand the existing urban area at their periphery. Often this expansion happens by encroaching the surrounding rural areas or sub-urban centers that may be noted with agricultural areas or vegetation. This unplanned growth of a city over time causes unsustainability of the natural resources like vegetation, waterbody, etc. It is observed that the humans and their surrounding environment are interconnected and any human interventions in the path of the natural processes have adverse impact on the entire ecosystem. In this aspect, the unplanned urban growth at the cost of natural resources also paves way to the widely discussed climate change. In view of above cited context, this paper discusses one such growth of city Vijayawada in Andhra Pradesh state of India and analyses how the expansion of the city has impacted the land surface temperature (LST) in and around the city over a period of 25 years.

Temporal analysis involving the Landsat series of satellite imageries from 1990, 2000, 2010 and 2015 have been used to produce the land-use land-cover (LULC) map of the city and extract LST using geospatial techniques. The analysis employed maximum likelihood parametric method of classification to produce the LULC maps and mono-window algorithm to retrieve LST. The LULC of the city is categorized into built-up, vegetation, waterbody and other classes. The spatial indices normalized difference vegetation index, water index and built-up index were also computed and validated for accuracy. Burgess model or the concentric zone model is employed along with spatial metrics to analyze the growth of the city over time. Urban density and the annual urban growth rate were computed at each kilometer from the center of the city to identify the growth of the city during the entire period of study. Change detection and transition of the natural land cover to man-made land use is statistically computed for the city extent. Urban landscape analysis was also performed to evaluate spatial density of built-up areas. This analysis quantifies the urban footprints, urbanized areas and new development areas within the city. The parameters: effective mean atmospheric temperature, ground emissivity and atmospheric transmittance were used to estimate the LST during the summer and winter seasons over Vijayawada. The retrieved temperature was correlated with different LULC classes and identified the intrinsic relationship between them. This enables to identify the contribution of different LULC features towards the varying LST.

Urban growth analysis results showed that the city had been steadily increasing since 1990. The increase in built-up areas has been taking place at the expense of green cover in the area. It is observed that the vegetation including the agricultural lands in and around the urban center has been constantly converted into built-up areas. The overall classification accuracy for the LULC results show 96.33%, 93.07%, 92.0% and 87.0% with their respective Kappa coefficients as 0.9388, 0.8724, 0.8785 and 0.8142 for the years 1990, 2000, 2010 and 2015 respectively. Buffer ring method of analysis shows a steady increase in the urban density throughout the period of study. It is observed that major urbanization happened between 1990 and 2000. The years 2000-2010 witnessed higher densification more than 5% between 1 km and 3 km from the center of the city. The same trend is observed over the years from 2010 and 2015 between 3 km – 7 km from the city center. This trend is an indicator that the city is increasing at a pattern covering the outskirts after densifying the central or core city areas. Directional growth analysis indicate that the built-up areas were up to 5 km in north and 7 km in east and west directions in 1990; with further increase to 11 km, 15 km and beyond particularly in the north-east direction in 2000, 2010 and 2015 respectively. The transition matrix summarizes that the settlement area has increased from 29.77 km² in 1990 to 130.33 km² in 2015. The total built-up area is observed to be steadily increasing every decade during the entire period of study thus forming a linear growth trend.

The LST analysis show that the maximum temperature over Vijayawada has been constantly increasing every decade in both summer and winter. This steady increase in temperature may be attributed to increasing urbanization, population density, vehicular emissions, and decrease in green cover without ensuring sustainability. It is to be

noted that the water body which exhibits minimum temperature in 1990 also shows a gradient rise in temperature over decade. This proves as an evidence for the impact of urbanization on the environment. The trend shows a parabolic increase in the maximum temperatures over every class during both summer and winter. As per the Indian Meteorological norms for any day if temperature remains 40°C or above with a minimum temperature at 5°C or more above the normal may be defined as Hot Day. In this context, the LST trend during summer shows the years after 1995 peak close to 40°C . The years 1996, 2003 and 2008 had the maximum number of hot days as the temperature during these years crossed beyond 40°C and were derived as 40.4°C , 44.3°C and 44.9°C respectively. The class wise temperature analysis shows that the highest temperatures may be observed over the settlements and other classes that include barren lands. Also, unsustainable development of Vijayawada has impacted the LST during the winter as well. This can be proved by the temperature difference over decades. Throughout the study period, there seems no magnificent difference over the winter and summer temperatures. From 1990 through 2015, it is observed that the minimum temperature has been steadily rising especially during winters. Every year winters record an increased minimum temperature than the previous year which again proves unsustainable urbanization of the city. Decrease in the difference between the daily maximum and minimum temperature leads to increased mortality rate and discomfort.

Vijayawada despite being a fast growing city, fails to ensure sustainable development in the phase of micro climate change. This unsustainability will create serious concerns in terms of health risks especially in summers in future. The city is growing in such a rate that apart from converting the existing green areas to the built-ups, the presence of very less natural land covers like vegetation and water bodies in and around the city could not cope up with the increasing temperature contributed by the urban areas. As of climate change is concerned, if no adequate measures are taken in Vijayawada the steadily rising minimum LST may impose regular heat waves especially during summers. To combat this rising temperature, sustainable growth of the city should be ensured by preserving the existing green areas around the city, creation of green parks within the city, proper channeling of the waterways, construction of roof top gardens, selection of construction materials that emit less heat energy. Future scope of this work is to model future urban growth scenarios of the city and predict for LST associated with the growth scenario. This paper will be of use to urban planners, researchers, and city development authorities.

Session Remote sensing of urban environments
Friday, 6 July 2018 (10:30 - 12:00)
Congress Hall - Chairman: Marco Gianinetto

Silvana Cotrufo¹, Constantin Sandu², Fabio Giulio Tonolo¹, Piero Boccardo²

Building damage assessment: damage scale proposal based on vertical imagery

Recent history has shown how the effects of natural catastrophes on unprepared territories and communities can be devastating. Remote Sensing plays an extremely important role in Emergency Mapping, particularly, in Damage Assessment Mapping: the production of maps in a few hours, which can provide an assessment of the damage grade to main assets (e.g. settlements, road network, utilities), by comparing satellite or aerial images acquired before and after the event. To date, different agencies provide emergency mapping products: general guidelines have been proposed by international organisations like the International Working Group on Satellite-based Emergency Mapping, but a common and shared standard to assess building damages using Very High Resolution imagery is still missing. The adoption of an internationally agreed standard would help aid agencies' work, streamlining the use of SEM products generated by different services. Standard damage scale focused on building and tailored to analyses based on VHR vertical imagery was therefore developed and proposed, providing visual interpretation guidelines and relevant examples. The proposal is based on the analysis of the activations of the Copernicus Emergency Management Service (© European Union, 2012-2018) following the earthquake that struck Central Italy on 24/08/2016. In addition to satellite imagery, the analysis has been extended to aerial and UAV imagery interpretation, considering the increasing use of drones in the emergency management domain. Therefore, a level of damage was assigned to each single building by comparing a pre-event satellite image with three post-event images characterized by different resolutions (satellite image GSD = 0.5 m, aerial image GSD = 0.1 m, UAV image GSD = 0.05 m). It has been possible to evaluate accuracy of satellite rapid damage assessment through a confusion matrix based approach. According to the outcomes of the analysis, the standard damage scale is proposed taking 4 classes into account, i.e.: Destroyed, Damaged, Not assessable Damage and No Visible damage. An increase in the thematic accuracy of the Satellite Assessment and a significant reduction of the time required to assess buildings damage have been demonstrated by applying and verifying the damage scale in a specific case study.

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Session Remote sensing of urban environments

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Congress Hall - Chairman: Marco Gianinetto

Stefania Bonafoni¹, Keeratikasikorn Chaiyapon²

Satellite remote sensing for spatial and temporal urban heat island analysis

The urban heat island (UHI) is a well-known anthropogenic thermal modification having implications for human comfort and health, local weather, ecosystem function, air pollution, urban planning and energy management. The UHI phenomenon is due to urban land transformations, especially when vegetated and rural zones are substituted by impervious surfaces trapping and absorbing the solar irradiation in built-up areas. Therefore, a difference in air and surface temperature between urban area and rural surroundings arises, quantified as UHI intensity or magnitude. Many studies estimated the UHI intensity by using ground-based weather stations measuring air temperature in urban and rural sites: however, the sparsely distributed stations do not allow a global analysis over the urban area. Advances in satellite remote sensing and data availability contribute to the great number of studies on surface urban heat island (SUHI) in different cities around the world, exploiting the spatial coverage and the revisit time of spaceborne remote sensing missions. The SUHI mapping and analysis can also satisfy the growing demand for integrating urban planning and landscape ecosystems, providing a scientific support for urban development policies.

In this study, we propose the SUHI analysis of the Bangkok megacity, Thailand, from two standpoints: exploiting satellite thermal data at lower spatial resolution (from MODIS, 1-km pixel size) and at higher spatial resolution (from Landsat 8, 100-m pixel size).

First analysis: Bangkok was monitored during a long-time interval (2003-2016) using 728 MODIS scenes, with daytime and nighttime images. Land surface temperatures (LST) data were directly obtained from free MODIS archives: we selected eight-day LST products with 1-km spatial resolution. Bangkok has experienced significant changes in urban development during the last 20 years. The study provides an extensive spatio-temporal investigation: to analyze the SUHI patterns and its relevance in terms of temporal and spatial trends, a two-dimensional least-square Gaussian fitting technique has been applied to quantify the phenomenon. Such approach represents an efficient quantitative tool to perform comparisons that a visual inspection of several maps would not allow. Specifically, the SUHI pattern insight is performed at three timescales, diurnal, seasonal and multi-year. The diurnal variation is represented by the four MODIS passes (10:00, 14:00, 22:00 and 02:00 local time), with summer and winter images covering a 14-year interval from 2003 to 2016. Results highlight that SUHI does not exhibit significant seasonality differences, with SUHI in the daytime more evident with respect to nighttime, mainly due to the solar forcing and to the intense traffic and human activities. The SUHI maximum intensities are during daytime, with values reaching 6°C; during nighttime they are around 1-2 °C. The SUHI spatial extension is represented by the Gaussian footprint and the results show that it is slightly affected by the urban area growth across the years. Orientation angle and central location of the fitted surface describe the SUHI layout. The daytime footprint orientation is along the NE-SW quarters and follows the urban texture constituted by residential and commercial zones, deployed in the NE-SW quarters. During nighttime, the absence of solar forcing and the reduced working activities clearly mitigate the heating intensity and modify the SUHI shape and orientation. In daytime, the footprint central location moves towards south-east, with a shift of the order of 5-10 km. This central location is positioned in the core of the commercial and high-density residential zone. At nighttime, the footprint displacement is evident in south direction, suggesting the permanence of the SUHI towards the coastal zone.

Second analysis: by means of reflective and thermal data from Landsat 8 imagery in the time interval 2014-2016, the SUHI pattern analysis within the land use categories of Bangkok city plan is performed. As first step, land surface temperature maps were retrieved by using Landsat 8 thermal images, using a pixel size of 30 m resampled from the native 100 m resolution of the thermal bands. Then, the correspondent SUHI maps were derived and compared with the last Bangkok comprehensive land use plan, in order to single out the specific heating pattern in the different urban categories. This monitoring not only describes the current situation, but also provides a perspective insight of the municipal urban plan policy. This study singles out the SUHI behavior in each land use category, describing the heating variability within the different classes in terms of mean, standard deviation, maximum and minimum. We considered the last comprehensive land use zoning plan, effective from 2013, managed by the City Planning Department of the Bangkok Metropolitan Administration (BMA), i.e. the government of the city. The land

use categories of the plan are: Low/Medium/High-density Residential zones, Commercial and Industrial zones, Agricultural and Rural Conservation zones, Public Utilities zone, Military zone, Historical Protection zone. Overall, the analysis shows that the classes in the city center area, i.e. high-density residential, commercial, historical and military categories, exhibit the highest mean SUHI intensities. The vegetated pixels exert a less cool effect with respect to the ones placed far from the city core. Since the insight was performed over the government land use plan, it describes the current situation but also can help to verify if the proposed urban plan requires specific future actions for the SUHI mitigation, or if the maintenance of the current municipal development model is in line with the environmental sustainability.

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Session Remote sensing of urban environments
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Congress Hall - Chairman: Marco Gianinetto

Magdalena Vassileva¹, Fabio Giulio Tonolo¹, Piero Boccardo²

SAR Amplitude Change Detection for Urban Damage Assessment

The paper is focused on urban change detection using multi-temporal SAR acquisitions, aiming to investigate the capabilities of amplitude change detection applied to the specific case of urban damage assessment due to natural disasters and/or conflicts. The relevance of this topic is strongly related to the emergency management and humanitarian assistance domains.

As man-made feature has a strong backscattering response to microwave signal, in case of consistent structural damages this response may be altered and, thus, automatically detected. Many factors, both environmental and technical, may influence the feasibility to assess the damages in urban areas. The last generation SAR missions can acquire SAR data with a corresponding spatial resolution up to 1 m (for civilian applications), allowing the ground target to be investigated with a high level of detail. However, the scope of the research is to focus on free and open data, considering the possible future development of near-real time services.

Specifically, Sentinel-1 imagery has been analysed exploiting the high-performance computing Google Engine platform, developed for Earth science data and analysis. The platform provides also a public catalog of standard Earth science raster dataset, including Sentinel-1 data, enabling a near-real time searching, downloading and processing of the archive data. The proposed approach was tested in several case studies mainly with areas heavily affected by different natural disaster events, e.g. earthquake and hurricane, and regions under armed conflicts.

The analysis of the test outputs shows that group of damaged buildings or larger damaged structures could be detected by means of multi-temporal SAR data, while single damaged buildings in dense urban areas are often omitted.

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Constantin Sandu¹, Sina Ghassemi², Attilio Fiandrotti², Fabio Giulio Tonolo³, Piero Boccardo⁴,
 Gianluca Francini⁵, Enrico Magli²

Building footprint extraction from VHR satellite imagery using a deep learning approach

Updated reference cartographic datasets are one of the main input data sources in several application domain requiring spatial modelling.

The aim of this work is to semi-automatically extract building footprints from very high resolution satellite images in order to update already existing cartographic datasets or generate them if missing over the target area.

The proposed approach for building footprint detection takes advantage of a convolutional neural network for segmenting VHR satellite images. The images from which the building footprints are extracted are different from the images used to train the network. The used architecture enables to generalize the learning features from images that have different statistics from the segmented image.

One application domain where this feature is critical is emergency mapping, since it enables to rapidly extract reference information over the area of interest before the analysed event. Such reference data allows possible damages to infrastructures to be assessed and delineated.

The results indicate that the procedure can be adopted for purposes that range from urban sprawl monitoring to rapid mapping activities using a different approach in comparison to classic image segmentation methods. For example, in emergency mapping activities, if no reference data is available (either from authoritative or open data sources) building footprints have to be manually extracted by means of visual interpretation. The proposed procedure enables a faster reference data extraction, limiting the human intervention.

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Session Remote sensing of urban environments
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Bracco Classroom - Chairman: Enrico Borgogno Mondino

Eleonora Forzini¹, Giulio Castelli¹, Linda Maniezzi², Fabio Salbitano¹, Elena Bresci¹

Fog and forest landscape restoration interactions by testing Google Earth Engine analysis in hyper-arid areas of South Peru

Hyper arid drylands ecosystems are particularly fragile and vulnerable to climate change and human influences due to their dependence on advection fog as main water source for both human activities and the environment. In these so-called 'fogscapes', human-induced fog collection represents a sustainable technology for triggering reforestation, and thus increasing soil fertility and combating desertification. In particular, along Atacama Desert coastal line, the effect of the Humboldt Current favours the formation of stratocumulus, that, moved by eastwards winds, generate large scale fog events, lasting from June to December, on the coastal belt and the vegetation of the first hilly ridges (locally "lomas ecosystems") along the coast may favour of the water content of fog. The University of Florence has set up a long-term research on fog collection associated to reforestation experimental plots in South Peru at the site of the Lomas de Mejia. 20 Large Fog Collectors (LFC) were installed in 1996 to collect water from fog for irrigating two experimental plots (total area of 7.5 ha) by testing both native and exotic tree and shrub species. The irrigation went on for two years and, after that, the grown vegetation was able to collect fog by itself. The paper presents the results of a long term remote sensing monitoring of the area of Lomas de Mejia based on the use of Google Earth Engine platform, able to manage a wide dataset of images. More than 20 years of NDVI time series for both the reforested parcels and portions of external areas, considered as control areas, have been generated and analysed. NDVI time series analysis shows the evolution of the parcel areas from bare soil to vegetated portions and the development of vegetation in time. Results show then the important role of advection fog for inducing the re-vegetation of some areas where forest was previously present, the significant increments of vegetation cover for the reforested parcels in time, encouraging the implementation of fog collection projects for land rehabilitation in the Atacama region.

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Tomáš Klouček, Jan Komárek, Ondřej Lagner, Michal Fogl

Pest outbreaks detectability in non-intervention forest using consumer-grade camera within the aerial survey

Forest disturbances are a necessary part of a forest dynamics and cause changes in the forest ecosystem. An insect outbreak is a sort of biotic disturbance, which can vary seasonality, intensity, and frequency. These types of disturbances can be damaging to the forest, especially for wood. Due to these aspects, outbreaks of insects in forests are quite an important research topic nowadays, not only for ecologists but also for forest managers as well as forest administrations. The outbreaks of bark beetles are extensively studied both in and outside of central Europe. Bark beetles are important for (snag) forest ecology and are plentifully represented, well-specialized, tree-specific species assigned into the Scolytinae subfamily. Bark beetles usually attack weakened trees, nevertheless, healthy trees are sometimes attacked too, especially by this specific species.

The Czech Republic often deals with outbreaks of the European spruce bark beetle species, (*Ips typographus*; [L.]) because of a large number of spruce trees in the forests. Recently, due to the climate changes, the numbers of windstorms and the associated numbers of [L.] outbreaks are highly noticeable. A valuable source for the study of the life cycle of [L.] is non-intervention parts of protected forest areas. The [L.], which is usually only around 5 millimetres long, reproduce in the phloem of living or dead trees and hibernate in the host tree or wood debris until conditions are suitable for reproduction. A few weeks later after the eggs are laid, beetles search for another host and repeat the process. Three ordinary stages of tree infection may be recognized. In green attack stage, the trees are contaminated without any visual demonstration. While in red attack stage, where a visual change in colour is easy to notice, tree needles turn to brown colour and the trees then start to dry. In grey attack stage, trees are completely dry, i.e. dead wood becomes visible. Therefore, early detection of contaminated trees is needed. Unmanned Aerial Vehicles (UAVs) equipped with proper sensors offer a cost-effective solution for early monitoring of local [L.] spreading many times in a season.

The aim of this study is to present a non-invasive methodological approach for monitoring distribution and seasonal dynamics [L.] in detailed scale. This study uses a time series of UAV-borne imagery in very high spatial resolution for the detection of different attack stages in individual trees. The study also provides a description of [L.] dynamic in part of a non-intervention spruce-based area. For the study, we use four orthomosaics acquired within a low altitude aerial survey using a consumer-grade RGB camera and a modified Near-Infrared RGB camera in June, as well as the first and second half of August, and in October. Orthomosaics were assessed using supervised object-based image classification in ENVI software. Results show that even using low-cost (modified) cameras it is possible to detect attack stages of [L.] on an individual tree level and even its seasonal dynamic with sufficient accuracy. The highest accuracy was achieved in the classification of red attack stage and in the grey stages respectively. A UAV equipped with the proper technology is an easily available tool for precise [L.] monitoring, however, further studies using superior multi-spectral sensors are still needed.

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Piotr Wężyk, Pawel Hawryło, Karolina Zięba-Kulawik

Post-hurricane forest mapping in Bory Tucholskie (North Poland) using Random Forest-based up-scaling approach of ALS and photogrammetry based CHM to KOMPSat-3 and PlanetScope images

The global climate changes observed in recent years and decades are more frequent and the effects of their impact are increasingly severe for the natural environment and economy in areas affected by extreme atmospheric phenomena. Natural disasters such as hurricanes can affect very quickly wide forest stands. Assessing the extent of hurricane damage in forest areas is an extremely difficult task if you do it in a traditional way even like GPS-supported inventory. This job is often very risky for foresters in damaged stands, significantly time consuming and limited to quite small areas. In this context, remote sensing technologies are an extremely attractive alternative to fast, inexpensive, and objective mapping of forest damage classes. In addition to open-access NASA and ESA Earth Observation programs (e.g. Sentinel-2; or Landsat 8 LDCM), there are also commercial constellations like PlanetScope (3.1 m GSD; 4 bands, 1-day revisit time) or VHR satellites like KOMPSat-3 (0.7/2.8 m PAN/ MS GSD).

The aim of the study was to determine the suitability of Dove (PlanetScope) and KOMPSat-3 satellite imageries for post-hurricane forest inventory of damage classes in Bory Tucholskie (North Poland) in terms of the economic approach to choosing effective and affordable technology for mapping forested areas after passing hurricanes. The disaster took place on the night of 11/12 August 2017, at the belt with a length of 300 km. Hurricane had negative impact on total 79.700 ha of forest, destroying completely (100% of damage) of 39.200 ha, mostly Scots pine. The Polish State Forests National Holding (PGL LP) assessed the losses in wood biomass to 9.8 million m³ of fallen and broken trees.

The differences in Crown Height Model (CHM; 1.0 m GSD) generated from the 3D point clouds: LiDAR (ALS; 4 pts/m²; GUGiK) and aerial photographs (RGB; 0.15m GSD) - using the image-matching approach (SfM; Photoscan; Agisoft) - have been accepted as reference data. We used ALS point clouds from year 2012 (ISOK project; 5 years before disaster) and the aerial photographs taken in late September 2017 (after disaster) commissioned by PGL LP. The digital aerial orthophotomaps were used as additional reference information for manual photointerpretation in case of doubts of the gathered results. For presented study we used Dove (PlanetScope) imagery captured at Jul. 16, 2016 and Aug. 15, 2017 (after hurricane). The KOMPSat-3 scene was captured at Aug. 30, 2017.

The main analysis was performed for test area consisting of 151 forest stands (sub-compartment). We choose 76 stands for build-up of the Random Forest (RF) regression model. Other 75 sub-compartment were used to validate the accuracy of damage classes assessment. Damage degree has been determined using continuous scale ranging from 0.0 (no damages) to 1.0 (complete damage-100%). Predictive model of damage degree was built for the 20.0x20.0m squared areas. The mean values of KOMPSat-3 as well for Dove (PlanetScope) bands (NIR, Red, Green and Blue) and NDVI were used as predictor variables. Prediction for 75 forest test stands was performed in 20.0x20.0 m squares as well and subsequently the damage degree was averaged for each selected forest sub-compartment. The obtained results showed that RMSE and ME calculated for forest stands based on PlanetScope and KOMPSat-3 imagery amounted to 0.12/0.11 and -0.02 accordingly. The RMSE values close to each other point to similar information potential of the views, differing by ca. 1.0m GSD. With the daily acquisition of Dove satellites, they become a great advantage by allowing you to replace hundreds of expensive aerial photos to assess the extent of the disaster. The possibilities of subscription access to Planets enables their automatic acquisition and processing, i.e. satellite monitoring.

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Classification of forested areas using morphological profiles in dual polarized ALOS/PALSAR data

This study evaluates the impacts of morphological profiles in dual-polarized ALOS/PALSAR data for the classification of forested areas. Morphological profiles have obtained great attention in the fields of image classification and pattern recognition due to providing complementary spatial information for the classes. Morphological profiles were defined by using the opening profile and closing profile with different size of structuring elements. For the classification of the forested areas, four different supervised classification algorithms (support vector machines, random forests, naive bayes and Forest PA :Forest by Penalizing Attributes) were performed. The experimental results were compared in terms of the overall accuracy and kappa coefficient. Our results suggest that morphological profiles have increased the overall classification accuracy by 5.48% and 6.82% for naive bayes and Forest PA, respectively. Furthermore, our results highlighted that highest classification accuracy is obtained from Forest PA by using morphological profiles.

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Jessica Esteban¹, Alfredo Fernández-Landa², Miguel Marchamalo¹

Uncertainty of volume estimates: propagating errors from forest mapping and regression models

In recent decades the ways forest inventories are conducted have changed due to the large amount of remote sensing information available. Airborne LiDAR data has well-documented for inventory purposes, however, this technology presents a handicap since it does not provide information about species composition. In this context, integrating LiDAR and Landsat data could be a good alternative to reach a complete understanding about the structure of the vegetation. Even though, land cover products enhance forest estimates there is a source of uncertainty associated with them which is often ignored giving rise to an underestimation of the variance of the model estimator.

The aim was to estimate the total volume and its uncertainty for a large region taking into account several sources of uncertainty. Wall-to-wall volume estimates were determined fitting a non-parametric model using Spanish National Forest Inventory (SNFI) plots, a set of airborne LiDAR statistics and a Landsat image classification. A model inference approach was followed to obtain the total volume of the population. Test points were used for the accuracy assessment of the forest type following a probabilistic design where the Landsat classification served for stratification. In addition a set of 102 NFI points were used to assess the bias and variance of the estimator using bootstrap procedures. A Monte Carlo approach was applied to propagate the uncertainty from the regression and classification models.

Satisfactory results were obtained for both classification and forest parameters mapping as suggested by errors of 10% and 30% respectively. The average volume over the whole study area was 114.79 m³/ha with 9.16 m³/ha SE and the total volume 19,566,006 m³ with 1,536,900 m³ SE. Estimate of relative standard error when the classification uncertainty was negligible was not higher than 10% while this estimates reached a value of 15% when this source of uncertainty was integrated. Hence, these findings demonstrate the necessity to integrate the uncertainty of maps used as auxiliary information to ensure the viability of forest parameters results.

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Mapping growing stock volume of Italian forests integrating multisource spatial information: a big-data approach

Spatial predictions of forest variables are required for supporting modern national and sub-national forest planning strategies, especially in the framework of a climate change scenario. Nowadays methods for creating wall-to-wall maps and small-area estimations are becoming an essential component of most recent and advanced National Forest Inventory programs. Such methods are based on the assumption that a relationship exists between forest variables to be predicted and predicting variables which are available for the whole forest area. Most commonly such predictors are produced by the application of active or passive remote sensing technologies. Italy has almost 40% of its land area covered by forests, which are very diverse for composition, structure, and management and for climatic, morphological and soil conditions. It is therefore interesting to understand if those methods which were successfully used in more simplified European forests (mainly in boreal areas) may be applied successfully at country level in Italy.

This study presents the results from a preliminary test phase carried out in a study area of more than 65,000 km² in central Italy (38% covered by forest) for the spatially explicit estimation of forest growing stock volume (GSV) measured in the field in 1350 plots during the 2005 Italian NFI. For the same area we collected potential predicting variables which are available across the whole Italy. From cloud free mosaics of multispectral optical satellite imagery (Landsat 7 ETM+, SPOT HRG and IRS WiFS), from a microwave sensor (the JAXA PALSAR) as well as from auxiliary variables (i.e. climate temperatures and precipitation maps, soil maps, digital terrain model).

Several parametric (e.g. Multiple linear regression model, Local linear regression) and non-parametric (e.g. Random Forest, k-NN) prediction methods were tested to find the most accurate approach to create a spatial wall-to-wall prediction of growing stock volume both at 30 meters resolution and a small area estimation at municipality level. The accuracy of all the methods were compared in terms of percent root-mean-square error using a Leave-one-out procedure. We achieved comparable results with those available in other regions of Europe, at least when Airborne Laser Scanning data are not available.

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Session Conservation and cultural heritage application of remote sensing

Friday, 6 July 2018 (12:00 - 13:30)

Congress Hall - Chairman: Grazia Tucci, Francesco Immordino

Branka Cuca, Luigi Barazzetti

Monitoring and risk assessment caused by natural geo-hazards to the archaeological sites: Albenga on the shores of Centa River, Italy

An increasing attention to the effects on cultural heritage in case of emergencies caused by geo-hazards requires innovative solutions based on integration of different disciplines, skills and technologies, including a variety of remote sensing techniques. In Europe for example, Cultural Diplomacy document (European Commission, 2016) states its strong commitment on collaboration with other countries when it comes to protection of cultural heritage, identifying Copernicus Emergency Management Service (EMS) as one that should majorly support this action. This service was in fact activated by the Civil Protection Department (Protezione Civile) during the most recent earthquake in Italy occurring in Amatrice in August 2016. Furthermore, since 2016 an official document issued by MiBACT (Italian Ministry of Cultural Heritage and Activities and of Tourism) has put into place a "Procedure of the Implementing Officer of 21 September 2016: management of activities on the securing of movable and immovable cultural heritage" (ordinanza n. 393 del 13 settembre 2016), nominating a body "Funzione Beni Culturali" as a responsible party with a one member of MiBACT and one member of Civil Protection as main representatives. Such great commitment and attention is currently on heritage affected by extreme earthquake events that shook Italy in the recent years. However, this example could be an excellent best case practice that puts focus on the treats of different geo-hazards endangering cultural assets.

In this framework, authors propose a study of extreme flooding events and their effects on important archaeological site of Albenga located in in Liguria region (Italy). For an effective emergency response, monitoring of a hazardous event immediately after the event but also in the future phases plays a crucial role. In fact, in case of overflowing of rivers and torrents it is important to perform monitoring on the land cover change in the areas bordering the riverbeds and in particular on the effects of flooding on the built environment, for the safety of people but also of the structures themselves. Such actions can be performed shortly after the hazardous event occurs (first rapid mapping) but also over longer periods of time for recovery purposes and risk mapping (e.g. to investigate possible behavior pattern of the water element observed).

The example studies the effects of the extreme flooding event occurred in the town of Albenga situated on the shores of the river Centa. This important archaeological site dating to Roman period is hosted within the boundaries of the Centa riverbed. The church of San Clemente, situated on the right bank of the river is mostly out of water, but it becomes partially or even totally submerged in case of flooding. In occasion of an extreme event in 2016, the wall structures of the site were severely compromised and several portions have collapsed. A repetitive nature of these extreme events exert constant pressure to the integrity of the site, still deprived of any kind ad hoc protection. Experts evaluate that this area is still missing an accurate analysis that take into account its surroundings and the precarious environmental balance of the whole complex.

This study focuses on the use of remote sensing technologies, in particular satellite Earth Observation and integration with other kind of geospatial information. The first operation regarded the estimation of water component of the flooded area using distinctly the indexes NDVI e NDWI. For this purpose a series of satellite images, including freely available Landsat and Sentinel-2 data, was used to analyze the land changes occurring after the last major flooding event that has affected the area in November 2016. The analysis were performed in order to observe and possibly quantify the extension of the flooded area and mood deposit. The results obtained on several "hot-spot" areas were further integrated with information from high resolution orthophotos obtained from several distinct flights carried out with Unmanned Aerial Vehicle (UAV) devices. Such observations were further investigated in integration with freely available geospatial information provided by the Geoportal of Region Liguria and by the Copernicus Land Service, providing some first qualitative and quantitative information. The overall data collected aims to provide a better insight into effects of Centa River behavior on the archaeological site of Albenga during and after flooding events. Authors evaluate that such inputs can be potentially very useful in the future for a more effective emergency management in phases that include rapid mapping but also risk assessment and recovery purposes.

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Session Conservation and cultural heritage application of remote sensing

Friday, 6 July 2018 (12:00 - 13:30)

Congress Hall - Chairman: Grazia Tucci, Francesco Immordino

Vera Costantini¹, Viola Fanciullacci²

Master Planning Consultancy for Mezyad Desert Park

Introduction

Located 20km south of Al Ain, near the border with the sultanate of Oman, the Mezyad Desert Park is one of the most important landscapes and archaeological sites in the United Arab Emirates. The park contains magnificent desert scenery, significant archaeological remains and unique desert plant and animal life.

The area of the assignment is part of the area of "Jebel Hafit Desert Park", one of the World Heritage Sites of Al Ain, and is inscribed in the UNESCO WHL since 2011.

The outstanding significance of Jebel Hafit National Park lies both on natural resources and cultural heritage. The area is a natural geologic "open-air museum", with its unique flora and fauna, magnificent examples of desert alluvial fans, wadis and uplands, dominated by the highest mountain of UAE, the Jebel Hafit massif. At the same time, the history of civilization of this area goes back to the late fourth and early third millennium BC, as testified by the pre-historic Jebel Hafit Tombs, remnants and significant fossil records of the site. There are also historic trade routes and surface remnants dating back over five hundred years.

Although this area is among the most arid sites on earth, its flora and fauna are surprisingly diverse. Jebel Hafit (including the Mezyad Desert Park) is a unique geological and biological area within the Emirate of Abu Dhabi. The geological landmark of Jebel Hafit, of national significance, is a rich repository of:

- cultural and archaeological sites and artifacts dating back to the Neolithic period,
- diverse ecosystem, including 95% of the biodiversity of the Eastern region and over 40% of 390 known plant species in UAE
- numerous wadis
- remnants of abandoned nomadic travel routes, dating back over 5 hundred years, testimonies of the sedentary occupation of a desert region .
- Aflaj systems dating from the Iron Age

Since the last century, certain human activities have been detrimental to the environmental health of the site (i.e. extensive camel and goat farms; illegal building constructions; soil compaction from livestock and off-road vehicle operation) Therefore, the site has been the target of a series of recent developments, aimed at preserving its fauna, flora, archaeology, geology and natural environment.

Aim of the project

The primary duty of the Master Planning Consultant (the "Consultant") is to review the existing information and prepare a Master Plan for the conservation of the Mezyad Desert Park in Al Ain (the "Project") through the restoration, interpretation and presentation of the archaeology and desert landscape according to international standards and best practices.

Part of the activities implemented within this framework have been focused on the review and validation of the existing information in order to prepare a revised Master Plan for the Mezyad Desert Park and produce the following main outputs:

1. Inventory of cultural and natural resources

Collect information on the principal cultural (tangible and intangible) and natural resources, of the Mezyad Desert Park Site in order to create an inventory of resources. Enter and organize all the collect data in a geodatabase.

In the preparation of the inventory a holistic and integrated approach to cultural and natural heritage data management was followed, addressing the diverse resources of the site:

- Cultural heritage such as archaeological, architectural, palaeontological, as well as intangible cultural assets such as place that have special associations or meaning for the community.
- Natural resources such as land forms, geological features and deposits, surface waters, endangered or native species, among others.

Different inventory forms have been prepared for each type of resource identified, and initially completed with information obtained in the assessment of available documentation and completed with information gathered in the field survey and the processing the satellite imageries.

2. Development of a cultural landscape atlas / geodatabase.

In order to understand the Mezyad Desert cultural landscapes in their diachronic evolution it is essential to find an efficient system to store all archaeological and ecological information in a suitable way, so as to examine relations

between different heritage sites and other landscape features (like geomorphologic setting, hydrological assets, soil types, raw materials availability etc.) in time and space, and to analyse how these variables co-varying.

Geographic Information Systems and Remote Sensing have emerged as powerful tools for managing the historic environment. The main objective of this activity was to create a new knowledge-based context for understanding, managing and disseminating data concerning Mezyad Desert Park cultural and natural heritage through the creation of an electronic database.

A "Cultural landscape atlas" is a mapping system that incorporates the complexities of the landscape and the heritage. It is based on the integration of spatial datasets in a GIS environment.

Satellite Image Processing

In order to generate the GeoDatabase and the Cultural Landscape Atlas, ARS progetti took advantage of the consultancy of Sysdeco Italia company for the acquisition and processing of Pléiades Stereo Imagery over the Mezyad Desert Park site (39 sqkm²).

Pléiades is a constellation of two twin satellites, Pléiades 1A and Pléiades 1B. Provider of Pléiades imagery is AIRBUS Defence and Space, whose Sysdeco Italia is an official reseller. The images acquired have a resolution of 50 cm in the panchromatic band and 2 meters in the multispectral bands, which are RGB + NIR. With this kind of data it is possible to appreciate most of the details needed for generation of the geodatabase. Furthermore, the acquisition of a stereo pair is very useful for the aim of geospatial analyses because it allows to extract DEMs in a complete automatic way.

From the stereo couple acquired on July 2016, a 2 meters grid DSM has been extracted using PCI Geomatica software. A DTM has also been generated with manual and automatic editing in Geomatica software using the DEM Editing tool. This is a very user friendly tool that allows to smooth out irregularities and create a more accurate model and in turn, more accurate orthorectified images.

Before orthorectification images were pan sharpened using Geomatica algorithm PANSHARP-2: with this function panchromatic and multispectral bands are fused to create a 50 cm colored image. Thus the pansharpened images have been orthorectified using the DTM and GCPs provided by ARS Progetti. The math model used is RPC, which is more suitable than Toutin rigorous model in case GCPs are not well distributed over the area and are in low number, as in this case.

The 50 cm pansharpened image, the DSM and the DTM were used as input for the object-based classification software eCognition in order to extract the features requested. Trimble's eCognition is an object-oriented image analysis software which perform one or more segmentation steps before classification. In particular, the algorithm for object generation is called Multiresolution Segmentation and allows the sub setting of image in homogenous regions at user defined resolution and scale. eCognition understands images in human-like manner since it takes into account the object and the context.

Thanks to segmentation many attributes can be associated to the objects, like spectral response in all image channels (such as mean, standard deviation, texture, indices), geometry (such as size, shape, length / width ratio) and context (such as proximity to other objects, common border). These objects attributes are then used in the classification process. Furthermore, eCognition provides a high number of algorithms that user can combine in a customized way in order to create his own ruleset.

In this case Sysdeco developed a ruleset that used the mentioned layers (ortho-image, DSM and DTM) together with other information provided by ARS Progetti S.P.A. to extract 15 land cover/land use classes: Enclosures; Tracks; Farms; Buildings; Former farms (Graded areas; Dark gravel; Spoil areas); Debris; Camel dung; Vegetation (4 classes); Alluvial fans; Wadis (existing and proposed).

For some of the classes (i.e. Enclosures, Tracks and Buildings) the ability of eCognition to classify objects based on geometric features was exploited (length/width; compactness; rectangular fit). Vegetation classes were identified mostly on the basis of NDVI index and Ratio NIR (spectral response of NIR band divided by the other bands). Four classes of vegetation were extracted: ACACIA, prosopis jul, prosopis cin and other vegetation.

The result of the classification is exported in shape file format and refined in ArcGIS where needed.

Two additional classes (terraces and powerlines) were digitized in ArcGIS based on previous dataset.

Results

The Cultural Landscape Atlas for Mezyad Desert Park site incorporated the geological and geophysical characteristics of the site, hydrology, soil units, and vegetation surveys; with the cultural heritage information from the inventory. This tool will enable the restitution of the history of the construction of the landscape, and understand landscape dynamics and will also assist management planning by acting as an inventory of all spatial cultural landscape information.

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Session Conservation and cultural heritage application of remote sensing

Friday, 6 July 2018 (12:00 - 13:30)

Congress Hall - Chairman: Grazia Tucci, Francesco Immordino

Annamaria Nassisi

Gender diversity and space sector

The participation of women in employment remains much lower than the one of men and labour markets across EU Member States show persistent and significant gender segregation.

Governments should support more and encourage the presence of women in STEM (Sciences, Technology, Engineering and Mathematics) fields, generating new inputs from a diverse workforce. Space sector is a source of inspiration and opportunities for all generations but it is affected by gender discrimination in the work place in terms of equal pay and career progression. In large firms a campaign to have women in the board has been started, although at a very low rate. In the small firms there is still a low presence of women in high level positions. The situation in the research institutions does not differ consistently from the industrial world: there are only few women in key positions in technological and space research departments, therefore it would be important to find a global approach to sustain the competence and career of women in the space sector.

Women in Aerospace Europe (WIA-E) supports the idea of an inclusive workforce as an invaluable asset to the growth of the European space sector.

THALES ALENIA SPACE, Italy

Session Conservation and cultural heritage application of remote sensing

Friday, 6 July 2018 (12:00 - 13:30)

Congress Hall - Chairman: Grazia Tucci, Francesco Immordino

Luca Benenati¹, Lorenzo Bernardi¹, Nicole Dore¹, Antonio Monteleone¹, Carlo Cacace², Annamaria Giovagnoli², Alessandro Paglialunga³, Rosa Lasaponara⁴, Abdel Aziz Elfadaly⁵

ArTeK - A service dedicated to Cultural Heritage Risk Assessment and Monitoring

The paper presents the methodology and the derived services originated in the frame of ArTeK project, an ARTES 20 IAP programme of the European Space Agency (ESA) dedicated to the cultural properties safeguard, constantly threatened by different types of events, both in the anthropic scenario (e.g. urbanization, pollution) and in the natural one (e.g. landslides, subsidence), compromising their conservation and integrity over time.

After a brief introduction about the evolution of remote sensing for cultural heritage applications in last decades, the Italian critical hydro-geological scenario, constantly threatening the national cultural heritage, is shown. The methodology of the system is, then, presented with the description of ArTeK characteristics and its advantages, as well as the support it provides to the Carta del Rischio methodology for the calculation of monuments vulnerability. The core of the paper is represented by an example of service application activated over two of the project test sites: Villa Adriana (Rome) and Baia (Naples)).

Villa Adriana is the ancient villa made built from roman emperor Adriano between 118 and 138 A.D., and now being part of UNESCO World Heritage List together with Villa d'Este.

Villa Adriana and Tivoli cultural heritage are exposed to several threats related, essentially, to:

- (i) illegal constructions (area of the historic centre, Villa Adriana, Ponte Lucano, Loc. Campolimpido - Favale - Colle Nocello, Loc. Arci);
- (ii) land subsidence given by the phenomenon of water extraction for travertine quarries and thermal baths (500/800 litres per second of sulphurous water).

The archaeological zone of the Baia and the marine park are an important testimony of archaeological remains ascribable to several buildings, pertinent to the imperial period. The remains, still visible and only partially visitable today, are located in part along the slope of the hill which overlooks scenically sea, in part, they are under the sea level because of the bradyseism phenomenon to which the area is subjected. This phenomenon represents a threat for the archaeological remains that are gradually exposed to the action of biotic and abiotic factors.

The analysis carried out include: Persistent Scatterers and Small Baseline interferometric analysis carried out with both COSMO-SkyMed and Sentinel-1 sensors in order to evaluate possible structural alteration on ancient monuments or, in general, detect instable areas threatening monuments; drone images analysis acquired through a 12 channels multispectral camera, aimed at the detection of small structures portion threatened by vegetation or cracks.

Data measured provided information to support site managers and conservation experts in the evaluation of monuments possible displacements.

Innovation and utility of ArTeK services are related not only to tools and techniques used (optical/radar satellites and UAV) nor to the availability of these on a web platform provided also with a GIS tool, but it is based on the support that these technologies can offer to Carta del Rischio methodology for monuments' vulnerability and environmental hazards calculations, thanks to the access granted directly from ArTeK web portal to vulnerability assessment information stored in Carta del Rischio database and made available to experts.

Analysis derived by satellites and drones allow site managers to be constantly updated about monuments and territorial conditions and to request, directly through the web platform, specific types of investigations and assessment

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Session Conservation and cultural heritage application of remote sensing

Friday, 6 July 2018 (12:00 - 13:30)

Congress Hall - Chairman: Grazia Tucci, Francesco Immordino

Grazia Tucci¹, Valentina Bonora², Alessandro Conti², Lidia Fiorini¹, Enzo Santoro², Francesca Panighini¹, Renzo Maseroli³

Multisensorial acquisitions for a critical survey: the Fortezza da Basso in Florence, a project for conservation and enhancement

The Fortezza da Basso is one of the most representative Florentine buildings and a true database of political, military and civic structures: from its construction, ordered by Alessandro de' Medici, to its current use as the main urban exhibition centre, the Fortezza chronicles the history of Florence.

This important historical building has been the subject of new interdisciplinary studies, in view of new uses planned for it by the Comune (the local government) in collaboration with the Soprintendenza (a government body, part of the Ministry of Culture and Tourism). The most accredited scientific institutions in the area have combined their expertise, with impressive results and mutual satisfaction, in order to satisfy the Soprintendenza's request for a thorough knowledge of the conservation of the building as well as its construction techniques.

The Scientific Committee, consisting of the Comune, the University of Florence, the Geographic Military Institute (IGM) and the Institute for the Conservation and Enhancement of Cultural Heritage of the Italian National Research Council (CNR-ICVBC), has contributed to the development of a best-practice protocol for the implementation of a critical survey using advanced methods and the latest technologies.

The working groups followed a very strict timetable to share strategies, methods and results of a research plan that started with three-dimensional metric survey and integrated geophysical tests, samplings and tests on materials, chemical-petrographical analyses and archaeological investigations. Digital photogrammetry, 3D scans, mobile mapping systems (supported by the complex survey network measured by IGM) allowed the researchers of the SCHEMA - UniFi Laboratory to produce a high-resolution virtual model, from which were extracted the initial drawings for the analyses carried out by the other groups.

This three-dimensional model constitutes a very rich database in itself, which in future can be interrogated and integrated. Archaeologists applied a 'light' (non-invasive and economic) approach, identifying both the surviving structures of the construction stage, according to Sangallo's project, and the many construction and demolition works that have interested the building over the centuries. Hypotheses of reconstruction of some parts with re-used bricks, as well as the study of construction materials and their state of preservation, were also supported by mineralogical, petrographic and chemical analyses carried out by the laboratories of ICVBC-CNR and the Chemistry Department of University of Florence.

Inside the Fortezza, state-of-the-art georadar systems inspected the subsoil in a non-invasive way, identifying the buried pipes and thus supporting the design of the new interventions under a plant engineering point of view. The results of the studies are a brilliant example of resource optimization and multidisciplinary integration.

The specific situation which prompted these new research projects was the determination of the Comune of Florence, wisely guided by the Soprintendenza, to reinterpret the spaces of the Fortezza and make them more accessible to the community. The result is the beginning of a new chapter in the history of the Fortezza past and future.

This paper is focused on the design, implementation and documentation of the 3D survey.

It was immediately clear that the features and the extension of the architecture, which extends over 95,000 square meters, would have required the integrated use of many sensors, also mounted on mobile platforms. Special care was paid to the design, measurement and compensation of the control network, built integrating GNSS and classic topographic measurements, whose vertices were permanently materialized. This allowed to reference in the same system the multi-sensor acquisitions made during the whole research, which took place over three years. In addition, it will be possible in future to integrate the survey with new acquisitions and monitor the structures in view of the renovation works planned within the Fortezza itself and the surrounding area. The Fortezza is a significant element in the urban transformations currently in progress, as is close to the main railway station, is surrounded by heavy motor traffic and is affected by the construction of new tram-routes.

The project acquired a special relevance because of the tests conducted with several laser scanner and photogrammetric systems positioned on different platforms in order to optimize the design of the acquisitions and their integration.

The paper will highlight the protocols used because, in order to ensure the quality of what we deliver, we must consider also other additional and indispensable aspects, such as procedural accuracy, adoption of the best techniques and technologies, appropriate documentation of the process, and modalities followed for archiving and dissemination of the results. In other words, continuous improving of practices, finding new solutions when facing special cases, and acquiring more skills and experience, all make a tangible difference even in a virtual world.

The use of multiple technologies with different resolutions was motivated by the need to produce indispensable drawings for the specialized analyses used to investigate the Fortezza through very different scales: from stratigraphic and material analyses to architectural and infrastructural design.

The first stage of the study concerned in particular the documentation of all the external wall coverings of the Fortezza, with a perimeter of about 1500 meters, as well as a more detailed study of the internal coverings and the planimetry of one of the bastions.

This phase was followed by the survey of all the inner spaces of the 16th-century military structure, in order to record the relationship between the historical structures and the internal infrastructures related to its current use as a trade-fair centre. For this phase, mobile mapping systems were used, as were UAV acquisitions to survey both the roofs and the top of the walkways on the walls.

The final section of the paper will cover the testing of some mobile portable acquisition systems, using SLAM technology, at the Fortezza. These systems, like the most widely-used mobile mapping systems (MMS), are designed to acquire three-dimensional, high-resolution point clouds. The new systems can be used both indoors and outdoors for a fast recording of natural, urban and built spaces, even small ones, and can completely dispense with the use of control points. The recent spread of devices on the market based on this technology has given us the idea of testing the functionality and performance of four off-the-shelf survey systems on the same test area, along a close path and an open one. Results were compared with the already available static TLS survey and evaluated in terms of quantity and quality.

The paper will also show the result of using SLAM systems to scan 500 meters of passages running inside the ramparts of the Fortezza. These tunnels are located at the foot of the walls and alternate straight sections and tiny rooms with truncated cone roofs ending at the top of the walls. They had never been surveyed before, as they are hardly accessible and it's not possible to use GPS.

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Session Conservation and cultural heritage application of remote sensing

Friday, 6 July 2018 (12:00 -13:30)

Congress Hall - Chairman: Grazia Tucci, Francesco Immordino

Linda Damiani, Elena Candigliota, Francesco Immordino

An integration of VHR optical and radar multiscale images processing data and Geographical Information System applied to a geo-archaeological reconstruction in the Ferrara area

The present work is proposed as a preliminary tool for the identification of palaeoforms and forms attributable to archaeological emergencies in high hydrogeological risk environmental context; in particular on what is one of the most characteristic phases e representative of the Average Bronze Age (2000- 1550 B.C.) in the Po fluvial plain: the "terramaricola" culture.

The historical reconstruction and the geomorphological structure analysis took place using a methodological approach based on the use of geotechnologies which provide the optical and radar satellite data analysis, in order to better understand the forms and development of the landscape.

Through photointerpretation and image processing try to understand the evolution of the territory with the aim of promoting the preservation and protection of cultural, historical, archaeological heritage. At the same time you want to test an approach methodological that allows to produce useful data from a geo-archaeological reconstruction of the study area, which can assist those that they are the most traditional methods of research, such as archival documentation and cartography (historical and archaeological cartography).

To the scientific interest is added moreover the possibility to favor the communication with the public administrations and the production of "high value-added data" that can assist the land management in terms of monitoring and environmental prevention.

ENEA Bologna, Italy

Session Multiscale remote sensing retrieving forest attributes: results from the FRESH LIFE project

Friday, 6 July 2018 (12:00 - 13:30)

Bracco Classroom - Chairman: Marco Marchetti

Francesca Giannetti, Davide Travaglini, Gherardo Chirici

Use of UAV photogrammetric 3D data to predict forest structure indices

In the past twenty years, three-dimensional (3D) remote sensing (RS) data have become a fundamental source of information for estimating and mapping forest inventory variables. Modern digital photogrammetric data has drawn increasing attention in the last decade. Because of the lower acquisition costs and similar performances compared to alternative 3D remote sensing data (e.g., Airborne Laser Scanning - ALS), photogrammetric data have been increasingly being used to model forest biophysical variables. The present study presents a novel approach to use unmanned aerial vehicle (UAV) photogrammetric 3D data for the prediction of forest biophysical properties. The approach was developed in the framework of the FRESH LIFE project "Demonstrating Remote Sensing integration in sustainable forest management" to increase the potential areas of application of UAVs in forest inventory. The approach was tested in two different mixed forests. The following five forest structure indices were studied: basal area ($m^2 ha^{-1}$); mean DBH (cm); standard deviation of DBH (cm); Diameter Gini coefficient; standard deviation of H (m); dominant height; Lory's height (m) and growing stock volume (V). The models accuracy of UAV 3D photogrammetric data was compared with the ones obtained by models using ALS explanatory variables. Multiple Linear regression models were fitted using as response variable the structure complexity indices of interest and as explanatory the UAV 3D photogrammetric variables and ALS variables. We compared the accuracy of models, in terms of average root mean square errors as percentage of the mean (RMSE%). Our results highlighted that the use of UAV photogrammetric data can be used for forest inventories as an alternative to ALS data.

Session Multiscale remote sensing retrieving forest attributes: results from the FRESH LIFE project

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Bracco Classroom - Chairman: Marco Marchetti

Mirko Grotti¹, Nicola Puletti¹, Piermaria Corona¹, Gherardo Chirici², Diego Giuliarelli³, Rosa Maria Dibiase³, Lorenzo Fattorini⁴

Design-based approaches for the spatial prediction of stand attributes under forest inventory perspectives

The use of remotely sensed data for forest inventory and monitoring of natural resources is ever increasing. Distinctively, remotely sensed data, integrated with ancillary data, can be exploited for the spatialization of biophysical attributes measured by forest inventories or management plans. Such applications are based on the relationships between the considered attributes and the information measured from remotely sensed platforms. As part of the activities of the FRESH LIFE project "Demonstrating Remote Sensing Integration in sustainable forest management", this paper compares some techniques for the quantification of forest resources that exploit the integration of inventoried methods with information layers obtained by remote sensing, with particular reference to Airborne Lidar data. This contribution focuses in particular on the results obtained in the study area located in Rincine, Tuscany. Following a Tessellation Stratified Sampling approach (TSS), which allows a spatially balanced sampling, the area has been sectioned in about 5,500 squares of 23 m in side (529 m²). Subsequently, by One Per Stratum Stratified sampling technique (OPSS), 50 squares were selected: diameter at breast height, total tree height and species of each live tree were measured. For each square, 30 indices (Lidar metrics) derived from the normalized Lidar point cloud were calculated. Four different techniques to estimate growing stock and total biomass volume based on sampling design and integration with Airborne Lidar data are here presented.

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Session Multiscale remote sensing retrieving forest attributes: results from the FRESH LIFE project

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Bracco Classroom - Chairman: Marco Marchetti

Giovanni Santopuoli¹, Mirko Di Febbraro¹, Cesar Ivan Alvites Diaz¹, Marco Balsi², Marco Marchetti¹, Bruno Lasserre¹

ALS data for detecting Habitat Trees in a multi-layered Mediterranean forest

Conservation of biodiversity is one of the most important challenges for forest decision makers and practitioners. Since 1992, several efforts have been made to balance ecological, economic and social aspects of forest resources. Particularly, Criteria and Indicators set for Sustainable Forest Management (SFM) are considered essential tools for assessing the state and trend of both forest resource and its management.

Nevertheless, the availability of inventory data is often limited (e.g. to the public forests only, or for a limited region) due to the costs of inventory activities or as forest management is rarely a priority task for private and public forest owners. In the last decades, several improvements have been made to reduce costs of collecting data and supporting monitoring. Particularly, remote sensing techniques have provided a significant contribution to forest and natural resource management and planning. Nevertheless, most of the studies implement area-based approaches, rather than single-tree detection methods. These studies are mostly focused on estimating and predicting forest variables (e.g. forest area, forest volume, basal area, tree height), while only few studies aim to assess forest biodiversity. Although forest biodiversity is worldwide recognized as fundamental for life on Earth, it embraces multifaceted aspects that need to be evaluated from different points of view. Several constraints still hamper the identification of reliable forest biodiversity indicators (e.g. deadwood and tree species composition). Therefore, efforts are necessary to improve methods and approaches for biodiversity evaluation. Recently, some studies assessing the biodiversity in forests have focused on monitoring the abundance, frequency and type of microhabitats occurring on the trees. Tree microhabitats play a significant role for biodiversity in forests, as they represent important refugia for several organisms, (i.e. saproxylics, birds, mammals, etc.), which are often of conservation concern. LiDAR is becoming a very common tool among forest managers to collect a huge amount of information on forests characteristics. Therefore, it seems useful to test the suitability of Airborne Laser Scanning (ALS) point cloud data to predict Habitat Trees in order to support forest management and planning in the assessment of forest biodiversity. Are ALS data suitable to support the definition of SFM indicators for assessing biodiversity value of forests?

This study aims to demonstrate how ALS data can contribute to assess forest biodiversity through the detection of Habitat Trees. In particular, we selected metrics derived from ALS point cloud data enable to predict the biodiversity value through the abundance of microhabitats in the forest.

The study area is located in the Apennine Mountains in central Italy. It is a mixed multi-layered forest with oak and beech as main tree species. Field data were collected in 35 squared plots. All trees with Diameter at Breast Height (DBH) higher than 2.5 cm were measured recording stem position, species, height, diameter, crown length, crown projection and vitality, using Field-Map technology. In addition, 23 types of tree microhabitats (TreMs) were monitored on the living trees.

The analysis aimed to assess the abundance of Habitat Trees, TreMs, Type of Microhabitats and 23 single microhabitats. Nevertheless, only 3 out 23 microhabitats were possible to estimate, due to the fact that most of them are present in a limited number of plots.

To evaluate the ability of ALS variables to describe forest microhabitat characteristics, we fitted generalized linear models (GLM) with a negative binomial distribution of errors, allowing both linear and quadratic relationships. For each regression, we applied a stepwise variables selection method based on the Akaike's Information Criterion (AIC). The statistics measure used to evaluate the models were the adjusted-R-squared (adjRsqr) and Root Mean Square Error (RMSE).

In detail, the microhabitats that showed a significant correlation with ALS data were M4 (<50% of the crown broken: significant loss of a part or parts of the crown. One or more main branches are lost. The remaining crown seems to be \geq 50% of the former crown), M7 (Broken stem: the crown is totally absent. Underneath the fracture, some very small living twigs have remained) and M12c (Cavities with >5 cm aperture, entrance at hollowed branch forms

cavity in stem).

The study reveals interesting results, particularly for detection of Habitat Trees (adjRs_q 0.66; RMSE 3.29) and TreMs (adjRs_q 0.56; RMSE 6). In addition, the study provide strong support for the detection of TreMs such as M4 (adjRs_q 0.67; RMSE 1.3), M7 (adjRs_q 0.72; RMSE 1.4), M12c (adjRs_q 0.84; RMSE 1.1).

Finally we calculate spatially-explicit predictions of the 5 models in the study area to provide thematic maps showing the abundance of habitat trees in the forest.

Although the methods are already implemented for other forest variables, this study introduce the evaluation of biodiversity value of forest based on the abundance of microhabitats. It also presents some weakness regard the density of plots and the recognition of other microhabitats, that need to be deeper investigated. The integration with data obtained by terrestrial laser scanning (TLS) and by RGB cameras could be very helpful for the improvement of the microhabitat detection. In conclusion, this work highlights that ALS data are useful to detect habitat trees and thus to support forest decision makers and managers in the assessment of forest biodiversity.

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Session Multiscale remote sensing retrieving forest attributes: results from the FRESH LIFE project

Friday, 6 July 2018 (12:00 - 13:30)

Bracco Classroom - Chairman: Marco Marchetti

Marco Balsi¹, Salvatore Esposito², Paolo Fallavollita³, Gherardo Chirici⁴

High-Density Aerial LiDAR Survey for the FRESHLIFE Project

Oben srl, partner of the FRESHLIFE project (<http://freshlifeproject.net>), is responsible for drone-based aerial LiDAR data acquisition.

To this purpose, Oben employs a relatively large octocopter (1.8m diameter, 16kg mass at takeoff) carrying a Yellowscan LiDAR, being one of the first operators worldwide having deployed such instrumentation for scientific and commercial purposes since 2013.

The most interesting characteristic of Airborne Laser Scanning (ALS) in forestry applications is the capability of obtaining relatively high density of returns from ground even under tall and dense vegetation coverage and to derive metrics which are correlated with forest variables (such as growing stock volume or forest structure indicators).

The specific advantage of using Remotely Piloted Aerial Systems (RPAS or drones) for the tasks of the project lies in its capability of flying low and slow. This allows for very high-density point cloud generation (50-100 points/m², about 1 order of magnitude greater than what is normally obtained from manned airborne systems). According to vegetation density, returns from ground amount to 1-10 points/m² in the leaf-on season. Classification of points into ground and non-ground classes allows for production of detailed DTM and DSM, and Canopy Height Models as the difference between them.

Three areas have already been surveyed in the framework of the project, in Molise (bosco Pennataro), in Tuscany (Rincine), and in Latium (Monte Venere, Caprarola). Total area covered is 736 ha, with mean point density of 91 points/m².

The present contribution is aimed at presenting the quality of the data strips obtained by an original methodology that proves that the misalignment error (without trying to remove outliers) is contained in about 1m at 2s over the whole scan, and that local precision is well under 0.5m (as expected from instrument datasheet). In the test area of Rincine a more detailed assessment was carried out comparing ALS data obtained in the framework of the project and with an existing dataset acquired by helicopter.

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Session Multiscale remote sensing retrieving forest attributes: results from the FRESH LIFE project

Friday, 6 July 2018 (12:00 - 13:30)

Bracco Classroom - Chairman: Marco Marchetti

Barbara Del Perugia, Davide Travaglini, Andrea Barzagli, Francesca Giannetti, Susanna Nocentini, Gherardo Chirici

Classification of dominant forest tree species by multi-source very high spatial resolution remote sensing data

Reliable, up-to-date and detailed spatial information on forest tree species composition is required for forest management planning at local scale, but also to assess and monitor Pan-European indicators for Sustainable Forest Management. Forest tree species composition is classified using largely subjective and time consuming methods based upon ground-based, visual observations by a surveyor. Remote sensing platforms equipped with multispectral and/or laser scanning sensors provide very high spatial resolution data useful for forest classification, and small-unmanned aerial vehicle (UAV) is a rapidly evolving technology which offers new opportunities to such end.

In this study we compared the use of multispectral and point cloud based data taken from conventional (helicopter) and unconventional (UAV) remote sensing platforms to classify dominant forest tree species in Mediterranean environments. The study was carried out in the Apennine Mountain, central Italy. The study area was 270 ha large and hosted forest stands dominated by seven tree species, both conifers and broadleaf, plus two mixed formations, for a total of nine classes.

Airborne laser scanning data with a point density of 10 pts/m² and multispectral data (RGB and NIR) with 20 cm spatial resolution were taken using an Eurocopter. RGB and NIR data with 10 cm spatial resolution were also acquired using a fixed wing UAV. 3D point clouds with a point density of 20-40 pts/m² were derived from UAV images. We divided the study area into a grid of quadrats of side 23 m and each quadrat was assigned to a dominant forest tree species class by visual inspection of remote sensing data. For each quadrat, helicopter and UAV's data were used to extract both multispectral features and point cloud-derived metrics. For classification purposes, the quadrats were divided into training sites (35%) and test sites (65%). Two supervised classifiers were tested: Random Forest (RF) and k-NN. Several combinations of data sources were adopted for both helicopter and UAV data: RGB, NIR, NDVI and point cloud alone, and all data sources. The accuracy of the supervised classifications was assessed against the visual one.

Our results show that the best accuracy of dominant forest tree species was obtained with RF using all data sources, achieving an overall accuracy (OA) of 0.705 and a KIA of 0.628. OA and KIA increased by 29% and 50%, respectively, when helicopter instead of UAV data were used. OA and KIA increased up to 0.834 and 0.777, respectively, when forest categories (conifers, broadleaf and mixed) instead of forest tree species were considered. The study was carried out within the project FRESH LIFE14 ENV/IT/000414.

Session Application of remote sensing for floods monitoring and hydraulic risk assessment

Friday, 6 July 2018 (15:00 - 16:30)

Congress Hall - Chairman: Maria Teresa Melis

Anselme Muzirafuti, Giovanni Randazzo, Mustapha Boualoul, Stefania Lanza

Applied geophysics and Remote sensing for water protection in Karst environment, El Hajeb Causse/ Morocco

Deep water aquifers constitute the strategic water reserves for Morocco, these natural resources are used in many activities such as agriculture activities and more importantly they are the source of fresh water for local population. However these resources are vulnerable to anthropogenic and natural phenomenon due to the ongoing climate change and the increasing population growth. To contribute to the recent initiative of the protection of karstic environment of water springs in Tabular Middle Atlas of Morocco, the present research work intend to characterize different karst landforms in Jurassic carbonate rocks of Tabular Middle Atlas in the Causse of El Hajeb which are the origins of pollution identified in water samples of this this region. Using satellite imagery (Copernicus Sentinel2, Landsat, Terra-ASTER, ASTER-GDEM), drone laser scanner and GIS tools, we delineate the extent of carbonate rocks and areas with intense human activities in the aim of enhancing the understanding of karst environment system in order to establish a roadmap of water vulnerability. We also want to explore the feasibility of modern technology combining aerial LiDAR/photogrammetry with satellite images and ground-based field works in karst environment studies. These carbonate rocks have high reflectances in shortwave infrared which make them easily distinguishable from clay rich soil, vegetation and water. Using bands in visible, near infrared and shortwave infrared electromagnetic spectrum portion we computed red, green, blue color composite, Normalized difference vegetation index (NDVI), Normalized difference moisture index (NDMI) and soil adjusted vegetation index (SAVI) to analyze land cover/use of the area. Principle component analysis technique has been used to maximize the information in few bands which helped us compute Sobel operator filter to extract lineaments which can be the groundwater stream flow pathways, pathways for pollutant infiltration or karst landforms location in this karstic environment. Seismic and electrical resistivity tomography and self-potential geophysical methods and based-field works were used to validate pixel-based and object-based image classification with led to identification of new and existent faults system in two major direction Northeast-Southwest and Northwest-Southeast and model of some sinkholes. The first one was identified as pathway for water infiltration which contributed to the chemical erosion of carbonate rocks thus the presence of many circular and elliptic karst landforms, while Northwest-southeast fault system has been identified as one which drain groundwater from the El Hajeb Causse to the Saiss basin this has been vindicated by the presence of numerous water springs. The results of this study show that climatic variations and the increased water use in this region by farmers has contributed to the dramatic change of the landscape and has led to the instability of roof for some sinkholes and in some areas these sinkholes have been collapsing creating cavities. Farmers are unaware of the complexity of this phenomenon and their unintended activities are deteriorating the quality of this precious resource. Locating these sinkholes and following the hydrogeological pathways of this water will help us establish the protection perimeter for these karst landforms and minimize the effect of water pollution in this area.

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Session Application of remote sensing for floods monitoring and hydraulic risk assessment

Friday, 6 July 2018 (15:00 - 16:30)

Congress Hall - Chairman: Maria Teresa Melis

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Applicability of the MultiTemporal Coherence approach to Sentinel-1 time series for the detection and monitoring of flooded areas in the context of Copernicus EMS

The Copernicus Emergency Management Service (EMS) Mapping provides Civil Protection users with accurate and timely geospatial information based on space data combined with other sources during the emergency response cycle. The EMS Validation service aims to the continuous improvement of the service through technical validation of the mapping products, their evaluation based on the user's feedback and the investigation of alternative and innovative technologies.

In this framework, the applicability of the MultiTemporal Coherence (MTC) technique using Sentinel-1 data series and the software made available by the European Space Agency (ESA), Sentinel Application Platform (SNAP) for the detection and monitoring of long lasting floods was investigated. For the purpose, 14 Sentinel-1 images were acquired over a sparsely vegetated area that suffered from a flood that lasted for at least two months, together with Shuttle Radar Topography Mission (SRTM) data, and processed using SNAP followed by an Object-Based Image Analysis (OBIA) to classify water. The resulting water extent was then compared against water extent derived from optical imagery of Very High (VHR) or High Resolution (HR) using OBIA and photo interpretation. Results of the comparison showed the feasibility of using this technique for flood monitoring, with large areas covered by deep water detected. Limitations to the applicability of this technique in other contexts were also studied and are here presented.

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Session Application of remote sensing for floods monitoring and hydraulic risk assessment

Friday, 6 July 2018 (15:00 - 16:30)

Congress Hall - Chairman: Maria Teresa Melis

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The proneness state of Campanian coastal plains to future inundation assessed by InSAR techniques

INTRODUCTION

The low coasts of the Campania Region (southern Italy) are generally located in the main alluvial coastal plains of the region. During the late Holocene these coasts were subjected to progradation thanks to river sediment supplies and locally volcanic inputs. More recently, erosion and episodic flooding expose natural and anthropic assets to permanent damages. In general, these phenomena can be amplified by land subsidence that may enhance marine inundation and irreversible coastal erosion.

The analysis of DInSAR (Differential Interferometry Synthetic Aperture Radar) data related to the low coast of the Campanian Region highlights the presence of wide coastal sectors characterized by subsidence. These phenomena are currently contributing to increase the exposure of these coastal areas to the negative impacts of marine processes, such as inundation and erosion. Several recently studies underline the importance of a detailed estimate of subsidence rate in order to understand its causes and provide a more adequate management of the territory.

Based on both new and published data, this research provides a detailed evaluation of the subsidence rates in several coastal areas located in Campania region, which are considered to be particularly prone to be inundated due to their low topography. This study shows the results of the analysis and interpretation of three SAR datasets of both ascending and descending orbits acquired over the Campania coastal sectors from June 1992 to July 2010. It provides new insights into the spatial variability of vertical ground deformations (subsidence/uplift) and their influence on the future marine inundation related to Relative Sea Level Rise (RSLR) along the Volturno, Sarno, Sele and Alento alluvial coastal plains.

In detail, the Campanian coast is about 450 km long and made of alternating high carbonatic rocky coast (Sorrento peninsula and Cilento promontory), volcanic coast sectors (Phlegrean Fields and Vesuvius) and low sandy coast, including Volturno, Sele, Sarno and Alento rivers alluvial coastal plains. These coastal plains, here investigated, are the terminal point of the major rivers in the region and their catchment areas comprising almost the whole territory of Campania, especially the ones of the Volturno and Sele Rivers. These areas were affected by marine transgression during the Early Holocene caused by post-glacial sea level rise. Then, starting from 6.0 ky BP, and especially during the Greek-Roman and Late Roman periods, the shorelines and the barrier-lagoon systems prograded several hundred meters mainly due to the decrease of the rate of late Holocene sea level rise, the increase of fluvial inputs due to climatic and land-use changes, and the deposition of the pyroclastic sediments of the 79 AD Vesuvius eruption.

The investigated plains have high socio-economical value due to the presence of touristic activities that provide a high employment ratio, especially during the summer season. Moreover, in these areas agricultural and zootechnical activities, which are the main economical activities even associated with PDO (Protected Designation of Origin) dairy production, also take place. Finally, the high environmental value is due to the presence of several wide protected areas, protected also by UNESCO.

METHODS

InSAR Analysis

Based on satellite radar differential interferometry data (DInSAR), Italian national and regional remote sensing projects have reported several PSI-processed datasets referred to a relatively long time period (1992-2010). These datasets have been implemented with different processing techniques, such as Permanent Scatterers (PS-InSAR) and Persistent Scatterers Pairs (PSP), related to interferometric dataset acquired by C-band sensors onboard ERS-1/2, ENVISAT and RADARSAT satellites.

The post-processing and analysis of the available PSI dataset, related to Campania coastal plain sectors, allowed us to obtain a retrospective view on the spatial and temporal distribution of ground deformation for the studied alluvial coastal plains at a decennial scale.

For those areas common to both acquisition satellite geometries (ascending and descending orbits), the availability of coeval datasets from different point of view allows for the evaluation of the vertical components of the

deformation, based on the interpolation of PS point data and some trigonometric calculations.

The obtained 50-m spaced grid maps show the distribution of the vertical components of ground deformation velocity in the coastal plains for the used datasets related to 1992–2000 (ERS-1/2), 2003–2007 (RADARSAT) and 2003–2010 (ENVISAT). In order to obtain a quantitative assessment of the subsidence process referred to the whole analyzed period, the cumulated amount of vertical ground deformation (expressed in millimeters) for the period 1992–2010 was calculated.

Coastal Inundation Analysis

In order to assess the potential coastal inundation, an initial requirement is the development of spatial dataset of the investigated areas. The digital elevation models have been defined by using Lidar data of the Italian Environmental Ministry. LiDAR data have 2 m cell resolution along the coastal stretch (800 m from the shoreline) and 1 m cell resolution within the coastal plain. In this study, both datasets have been taken into account, summing them using the tool Map Algebra in ArcGIS (ESRI®), in order to obtain a complete raster model with a 2 m cell size.

Based on the assumption that the subsidence trend will be kept constant for the near future, the vertical ground displacements values, detected by the PSI-based technique, have been used to obtain the future topography of the investigated coastal plains.

The rate of Vertical Ground Displacement (VGD) in each cell of DInSAR grid was projected to 2065 and 2100, then the grids of the predicted total amount of VGD in 2065 and 2100 have been added to the present day DEM obtaining the raster models of the 2065 and 2100 topographies.

Based on the criteria that the areas along the coast prone to be potentially inundated are those areas lying either below sea level or less elevated above it, the inundation maps for each projected sea level scenario have been defined for the investigated plains. Following previous studies, the inland limit for the inundation analysis has been set at 5 m above sea level, including in this way the most susceptible coastal areas.

RESULTS

The vertical displacement rates derived by PS-InSAR data processing shows that the coastal sector of the Volturno, Sarno, Sele and Alento alluvial plains are characterized by complex vertical velocity patterns during the 1992 to 2010 time interval.

The coastal sector close to the Volturno river mouth is characterized by moderate subsidence values (-50 to -150 mm), whereas the dune ridge system shows low subsidence or stability (0 to -50 mm). Conversely, high subsidence values (-50 to -200 mm) are found in the back-dune depressions, near Lake Patria and Villa Literno. The central part of the Volturno Plain displays subsidence values ranging from -50 to -400 mm with the highest negative values (lower than -200 mm) along the course of the Volturno River around the city of Grazzanise.

The Sarno river coastal plain is characterized by localized moderate subsidence near Castellammare di Stabia (-5 to -20 mm) and high subsidence rates (-20 to -100 mm) near the river mouth. In the strip between 1 to 2 km inland the coastline, the ground shows stability trend (-5 to +5 mm), while along the inner alluvial plain strong subsidence affects the area close to the Sarno River around the cities of Scafati and Sant'Antonio Abate.

The Sele river coastal plain shows different subsidence pattern between northern and southern sectors. In the northern sector of the plain, a continuous coastal strip, up to 18 km long, is characterized by cumulate subsidence values ranging between -50 to -200 mm during 1992–2010; the hilly area towards the east is characterized by stability or discontinuous relative uplift rate of 1–5 mm/year. At the Sele River mouth area, a hot spot of subsidence, developing 5 km inland, is very evident (-50 to -150 mm), while the southern sector to the Sele River shows a general condition of stability with small subsiding areas (-25 to -50 mm).

The Alento rivers coastal plain that runs from Marina di Casal Velino to Marina di Ascea towns, shows a very complex pattern of ground deformation. While the northern sector shows low subsidence (-30 to -5 mm during 1992–2007), the coastal narrow strip among Foce, Velia and Marina di Ascea displays stability or fair uplift (-5 to +10 mm). Along the Alento River course, a hot spot of subsidence, developing 1–2 km inland, is evident (-5 to -50 mm). The results about the potential coastal inundation of the Campanian plains exhibit different degree of susceptibility, due to the different rate of the subsidence coupled with the IPCC sea level rise scenarios predicted for the years 2065 and 2100. The high resolution of the obtained results highlights the importance of the InSAR data for the spatial susceptibility assessment to the inundation of the coastal areas. RSLR scenarios suggest that in the near future natural areas, beaches, human infrastructures, and wide portions of agricultural areas located in the investigated plains will be affected by potential marine inundation, with several zones in high hazard inundation level (between 2% and 21% of the study area for the 2065 and 7% and 35% for the 2100).

DISCUSSION AND CONCLUSION

The overall analysis of the Campanian coastal plains, together with the DInSAR data, highlight that all the investigated areas are characterized by negative vertical ground movements, which present a different areal distribution and

rates ranging from -1 to -25 mm/yr.

The subsidence of the Campanian plains can be considered as a natural process mainly due to the compaction of the alluvial sediments fill under the lithostatic load. Conversely, anthropic influences (e.g., water pumping and urbanization) are considered as an additional factor that locally enhances the subsidence processes. These results confirm the fundamental importance DInSAR data, combined with other coastal trends indicators for hazard coastal inundation assessment.

The hazard inundation maps represent a valuable tool for efficient territorial management aimed to future coastal risk mitigation. To date, the management plans provided by the regional Authorities are drawn up according to the national regulations, which suggest taking into account only the impact of storm surges with different return periods in order to provide coastal flood risk maps. This study highlight the importance of introduce a dynamic component associated with the local VGD and future SLR projections for providing more detailed data on the future RSLR scenarios in terms of both coastal hazard and risk evaluation.

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Session Application of remote sensing for floods monitoring and hydraulic risk assessment
 Friday, 6 July 2018 (15:00 - 16:30)
 Congress Hall - Chairman: Maria Teresa Melis

Paola Mazzoglio¹, Piero Boccardo², Francesco Laio², Simone Balbo¹, Franca Disabato¹

ERDS: a satellite-based approach in the extreme rainfall detection field

Many studies have shown a growing trend, in terms of number, frequency and severity of extreme events. As never before, having tools capable to monitor the amount of rain that reaches the Earth's surface has become a focal point for the identification of areas potentially affected by floods. In order to guarantee an almost global spatial coverage, a precipitation evaluation provided by satellite products proved to be the most appropriate source of information. NASA GPM (Global Precipitation Measurement) mission provides since March 2014 different IMERG (Integrated Multi-satellite Retrievals for GPM) products with a spatial coverage of 60°N - 60°S and a spatial resolution of 0,1° x 0,1°. The first part of our study is aimed to compare at the global scale satellite IMERG early and late data and rain gauge precipitation data, in order to evaluate their relative accuracy. The outcomes demonstrate that satellite data guarantees good result when rainfall aggregation interval is equal or greater than 12 hours. More specifically a 24-hours aggregation interval ensures a probability of detection (defined as the number of hits events divided by the total number of observed events) greater than 80% and a bias of -0,1 mm/h. With an aggregation interval of 72 hours a probability of detection greater than 90% is reached. The outcomes of this analysis supported the development of the updated version of the ITHACA Extreme Rainfall Detection System (ERDS - erds.ithacaweb.org). This system is now able to provide hourly near-real time alerts about extreme rainfall events. ERDS is a strategic tool, capable to provide, during the preparedness and response phases of the emergency cycle, immediate and intuitive information about potential flood events. The information is accessible through a WebGIS application, developed in a complete Open Source environment. Results are published on ERDS website by means of standard WMS services. Specifically, this system automatically downloads the most recent GPM IMERG early run half-hourly data and cumulates it according to specific periods (12hr, 24hr, 48hr, 72hr, 96hr). ERDS generates precipitation alerts where and when the precipitation amount is higher than a specific set of thresholds. This set of thresholds has been calculated for every aggregation interval on the basis of the average annual precipitation values evaluated on a 0,1° x 0,1° grid cell basis.

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Session Application of remote sensing for floods monitoring and hydraulic risk assessment

Friday, 6 July 2018 (15:00 - 16:30)

Congress Hall - Chairman: Maria Teresa Melis

Tommaso Pacetti¹, Enrica Caporali¹, Maria Cristina Rulli²

Remote sensing characterization of crop vulnerability to flood

Introduction

The inner connections among natural disaster and food security are extremely relevant especially in developing countries where the food availability (one of the four pillars food security together with access, utilization and stability) can be highly jeopardized by extreme events that damage the primary access to food, i.e. agriculture.

The objective of this study is to analyze the impact of flood events on food security, taking advantage of remote sensing data to develop a methodology to rapidly determine crop losses due to submergence.

Based on the existing literature related to extreme floods, the events in Bangladesh (2007) and in Pakistan (2010) have been selected. Bangladesh and Pakistan have been chosen as exemplar case studies, because of their vulnerability to floods and the importance of agriculture in their territories. These case studies are characterized by significant differences in their agricultural production (mainly rice in Bangladesh and rice, sugarcane and wheat in Pakistan) allowing us to evaluate the effects of flooding on crops with different resistance to submergence.

The adopted method integrates remote sensing data, agricultural statistics, and water footprint values in order to (i) evaluating the potentially affected agricultural areas; (ii) converting the affected areas into crop loss; (iii) estimating the associated calories and water footprint losses.

Methods and data

Firstly, the evaluation of potentially affected agricultural land is carried out by the intersection of remote sensed flood maps with administrative and land use maps of the area of interest. The classification of the flooded area can be done following one of the many existing algorithms on the base of raw available data or using existing remote sensing product, already classified for flood identification.

The potential agricultural land losses are later converted into effective crop loss taking into consideration the peculiarities of topography, land use and crops characteristics for the selected study area. Additional information, such as specific crop resistance to submergence in terms of time and water depth might be added to refine the crop losses evaluation.

The effects of flood on food availability is then evaluated both converting crop losses into lost calories and Water Footprint (WF). Lost calories are a direct estimation of the crop losses while the WF allows an indirect evaluation of land use management criticalities both for supporting a complete diet and preserving local water resources.

Pakistan: multi crops losses

For the Pakistan case study, the agricultural territories affected by flood are estimated making use of remote sensing derived data that are provided by Suparco and FAO, based on MODIS Aqua Satellite and SPOT VGT data. The flood involved an area with an extension of 58,797 km² with duration of around three months, from the end of July until the end of October.

All the main Pakistan crops have been considered together with wheat stocks. The characteristics of the crops in terms of yield are derived from FAOSTAT database. Using the FAOSTAT, the crops production data for the 10 years before the flood event, it is possible to calculate an average agricultural yield for the main crops lost (i.e. sugarcane and rice), as well as to estimate the actual crop losses (in term of weight). By knowing the energy content in kcal/kg of the different crops, it is then possible to estimate the associated food energy losses, both in terms of vegetal and animal calories

Bangladesh: focus on rice vulnerability

For Bangladesh case study, UNOSAT map of the flooded areas based on MODIS Aqua satellite data were used. It includes 30233 satellite detected water bodies with a spatial extent of 72,972 km² derived from the MODIS-Aqua image acquired on August 2007 and analyzed by a water detection algorithm for rapid flood mapping based on NDVI evaluation.

In the Bangladesh case study, the assumption that in the flooded area identified by the remote sensing all the crops are destroyed is not applicable because floods affect rice production proportionally to flood hydraulic height and length of the submergence period. Therefore, a threshold in time and space has been adopted to take into account the resistance of submergence of rice: 1 meter depth (according to deep water areas defined in literature) and a

period of submergence greater than three weeks have been assumed, as the limiting factors to rice growth. The water depth in the flooded area was estimated integrating MODIS satellite images of 20 August with the remote sensed topography data (SRTM). In order to calculate the area included within the 0-1 meter depth, the slope of the DEM (SRTM) is calculated and used to estimate the average distance from the points where the water depth is 1 meter to the flood area perimeter. The cultivated area not destroyed by the flood is therefore the product of the flood perimeter, times the average distance introduced before. The use of MODIS images from 20 August (six weeks after the beginning of the flood), guarantees that the time constraint is included.

Discussion and Results

In the Bangladesh case study the results depict an average loss of 103 kcal/capita due to flooded rice, representing 5.3% of the potential energy usually provided by this crop. If we consider the effects of flood only on the population of the affected districts, the result increases dramatically to 398 kcal lost. The energy deficit due to the rice production lost, compared to the annual energy provided by the entire food production of Bangladesh in 2006, using the total kcal/cap/day supply of 2006 (i.e. 2417 kcal/cap/day) is 4.3% considering the total population as affected and it raises to 16.5%, if only the population of the affected areas is considered. In order to properly understand the meaning of these percentages, it is important to highlight that the lack of food (and thus energy) caused by the flood is contributing to worsen the already critical situation of food supply in Bangladesh that was already suffering a 19.4% deficit.

Based on the existing statistics on WF in Bangladesh, lost food results have been converted in terms of water footprint to have another measurement of the flood effects on the territory. The results show a total WF of $4.72E+09$ m³ that is equal to 4.4% of the national WF.

In Pakistan, the results show a reduction of production that is about 19% for sugarcane and 40% for rice that is associated to a significant loss of energy available. The sum of crops and stocks destroyed amounts to a total of 205 kcal/cap/day lost, due the flood and it is equal to a loss of 8.5% of the Pakistan average food supply (10.7% if we consider only the energy derived from vegetal products).

As in the previous case study, the food losses results have been converted into WF resulting in total loss of $1.84E+10$ m³ that is equal to 13.5% of the Nation WF.

The results highlight the countries vulnerability to flood, being both countries strongly dependent on local agricultural production. The 2007 flood event reflected badly upon Bangladeshi food security, almost doubling the existing food deficit. The same happened in Pakistan where an already scarce food supply has been worsened by the 2010 flood.

Conclusion

The proposed framework, taking advantage of the integration of remote sensing data and agricultural statistics, provides a rapid assessment of flood effects on food security on the short term. Moreover, if combined with other spatial information (e.g. poverty distribution, as shown in the case studies), it can provide useful information that can be applied to spatially identify the hotspots and support long term planning.

Method results are fully repeatable; whereas, for remote sensed data the sources of data are valid worldwide and the data regarding land use and crops characteristics are strongly site specific, which need to be carefully evaluated. Moreover, the results can be combined with other spatial analysis to provide a broader picture of the flood effects on a territory. An integration of flood extent with population poverty distribution is proposed to identify the hotspots areas where flood strikes the poorest areas This kind of analysis can provide useful information that help the definition of the priorities of intervention to support the poorest areas in case of flood events.

The proposed case studies stress the importance of integrating different analysis approaches to carry out an assessment of the meaningful connections between flood and food security and to enhance the resilience of territories.

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Session Application of remote sensing for floods monitoring and hydraulic risk assessment

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Congress Hall - Chairman: Maria Teresa Melis

Juliana Gueiros Fusato, Maria Cleofé Valverde

Analysis of floods, urbanization and morphometry of watersheds in Santo André-Brazil

The city of Santo André is located in the Metropolitan Region of the State of São Paulo - Brazil and constantly suffers from floods. This research has the aim to study the floods that occur in Santo André focusing on the morphometric analysis of the urban drainage sub-basins of the Tamanduateí river that drain the city: Tamanduateí Médio I and Guarará.

Floods are mainly caused by intense rainfall and are related to the morphometric features of a watershed and can be magnified by inadequate urban infrastructure. It is normal for a river to invade its marginal areas when there is an intense pluviosity and therefore a flood is only considered a natural disaster if it affects the population living nearby.

Because of this, it is important to calculate specific parameters related to the morphometry of the watersheds to comprehend the factors that lead to the occurrence of this type of disaster or if the urbanization played the fundamental role. This helps understand how the land use influences the occurrence of floods and therefore what could be done to improve the urban infrastructure to prevent this type of disaster.

For this purpose the inventory of the flood occurrences in the Santo André city was analyzed from 2001 to 2016 to understand which sub-basins in the city were the most affected, which were Guarará and Tamanduateí Médio I. Both watersheds are located in the north part of the urban area.

There are many parameters that could be used to characterize a watershed. In this study, twelve of them were analyzed, regarding the geometry: form factor and circulation ratio; drainage system: drainage density, first order stream frequency, sinuosity of the main river; and relief: relief ratio, topography factor (circulation ratio + first order stream frequency + relief ratio), amplitude, main stream slope and concentration time. In order to do this, the georeferenced files of the watersheds supplied by the municipality were opened in the Geographic Information System environment. This files include the basin limits, drainage system in scale 1:10.000, the slope maps and contour lines in scale 1:25.000.

Regarding the basin analysis, form factor is defined as the ratio of basin area to square of the basin length and is a dimensionless number varying from 0 to 1. The higher the value, the higher the tendency to floods. The circularity ratio is the relation between the total area of the basin and the area of a circle with the same perimeter. Values over 0,51 indicate a circular shape and higher susceptibility to floods. The relief ratio expresses the relation between the amplitude and the length of the main channel, measuring the global slope of the basin.

The concentration time is an important parameters for basin analysis and represents the time needed for the whole basin to contribute to the surface runoff in a considered area, which is in this case, the river mouth. The lower the value, represented in hours, the faster will be the flood waves.

The analisys of the occurrence of floods events in the city shows that they are more frequent during the summer e more scarce during the winter. The results showed a total of 273 flood events during the 16 years mentioned, 146 only in the Guarará sub-basin, the most affected during the period. The second most affected watershed in Santo André was the Tamanduateí Médio I, with 64 cases.

The guarará sub-basin has an area of 13,46 km² and there are four neighborhoods that were most affected: two of them downstream (Vila America e Vila Pires) and the other two upstream (Jardim Santo André e Jardim Irene). These areas are economically diverse and have different type of land uses, being the one upstream more permeable, with the the level of urbanization lower than the first. If analyzed only the parameters related to the shape of this sub-basin, such as form factor (0.20) and circularity ratio (0.38), it would not be naturally prone to floods.

The Tamanduateí Médio I has an area of 27.76 km², with two neighborhoods most affected: Vila Alzira and Bairro Silveira, both of them upstream and totally urbanized. In fact, this areas are closer to the Guarará river than the Tamanduateí River itself.

This basin has a higher tendency to flooding occurrence in terms of geometry, taking into consideration the circularity ratio, which is 0.47. The value of the form factor is 0.23. The amplitude of the Tamanduateí sub-basin is 98, whereas the Guarará is 202 meters, indicating a steeper relief, since the area of the second is smaller.

The Tamanduteí Médio I subbasin has a lower drainage density: 2,07 m/km². The area is located entirely in the tertiary rocks of the São Paulo Formation and quaternary deposits, supported by a flat relief. Lower drainage densities are often observed in flatter reliefs in sedimentary terrains. The Guarará subbasin has a drainage density

of 3,46 m/km². The slope of the Guarará river is much higher than the Tamanduateí river, being 0.0177 for Guarará and 0.0018 for the second, which demonstrates that Tamanduateí river is not as steep. The higher the slope of the main stream, the higher the flux velocity, which influences the flood hydrograms. This means that the Guarará subbasin has higher energy associated to the water flux of the rain when compared to the Tamanduateí Médio I. The topographic factor, which is directly proportional to the flood potential in the main river mouth, is 11,13 for Tamanduateí Médio I and 30,35 for Guarará, which corroborates the relief ratio: 24 for Guarará and 9 for Tamanduateí. Using the equation to calculate the concentration time which takes into consideration the urbanization and also equivalent slope, the value for the Guarará subbasin was 1,14 hours and 2 hours for the Tamanduateí I. In both drainage areas, the geology and geomorphology is different. In the Guarará sub-basin there are higher slope degrees, especially in the south portion, where metamorphic rocks are found. This leads to a decrease in the concentration time as well as higher rates of erosion and thus the floods events can cause more damage.

If only the geometry parameters for the Guarará subbasin were analyzed, it would be possible to say that the area is not prone to floods, which would be convenient to attribute the causes of flood to urbanization. Although, studying deeper through the relief parameters, it is possible to observe that this drainage area has a higher potential to floods than the other subbasins. This is not true for the Tamanduateí subbasin: according to the geometry parameters, it would be more similar to a circular shape, which indicates propension to floods, but its relief does not classify it as prone to such phenomena. Its amplitude is low as well as the slope of the main river Tamanduateí, which is totally channelized, surrounded by big avenues, with almost no vegetation. This could be also an explanation for the low drainage density: the urbanization tends to lower this parameter, since it is common to find buried rivers in such urban areas. On the other hand, a lower drainage density would make the area less prone to floods since the hydrological response in such areas is slower.

The results found indicate that the flood problems in the urban area of Santo André are not related strictly to the morphometry of the basins, since the two of them that were analyzed have different features, mainly related to the shape, relief and lithology. These natural disasters affect also places with different land uses, shown by the most affected neighborhoods. It is possible to infer that the Guarará subbasin is more susceptible to floods regarding its relief. Besides, the location of the subbasins in the central, totally urbanized portion of Santo André, inadequate drainage projects and structural measures that are not capable to deal with the surface runoff that comes from the rainfall in the summer months, magnifies the occurrence of floods. Therefore, it seems that the anthropization plays the fundamental role in the occurrence of floods in Santo André, since different watersheds, with different features are affected.

Further studies regarding the rainfall upstream and downstream the basins have to be carried out in order to better understand the occurrences of floods in Santo André, as well as the study of the basins nearby.

Session Multiscale application of earth observation for biodiversity monitoring

Friday, 6 July 2018 (15:00 - 16:30)

Bracco Classroom - Chairman: Piermaria Corona

Martin B Bagaram¹, Diego Giuliarelli², Antonio Tomao², Anna Barbati²

UAV remote sensing for biodiversity monitoring: are forest types and canopy gaps good covariates of forest biodiversity?

Tree species composition of forest canopy is an influential component of forest biodiversity. This is why the use of forest types to stratify forest cover into ecologically distinct assemblages of forest dominant species is seen as a way to optimize field-based biodiversity assessment. At the same time, forest canopy gaps are regarded hotspots of conditions for tree recruitment, for maintaining floristic richness in the understory and for increasing the diversity and structural complexity of the forest habitat. Although remote sensing is the best way to detect forest types and forest canopy gaps, their mapping is feasible only by very high-resolution sensors. In this framework, lightweight Unmanned Aerial Vehicles (UAVs) equipped with small digital RGB cameras offer a relatively cheap opportunity to explore links between forest types spatial distribution, canopy gaps, and the occurrence of key forest biodiversity features on small spatial extents. This is attempted in this study carried out in the framework of the FRESHLIFE project in the test site of Caprarola (Central Italy). The site is covered by monolayered and bi-layered forest stands extending over 240 ha on the slopes of Mt. Venere (500-800 m a.s.l.).

A fine scale resolution (pixel size=10 cm) RGB orthomosaic derived from images taken on the test site by the UAV eBee (Sensefly ©) has been used to map forest types according to three classes: beech forest, turkey oak forest and mixed forest of the two species. Canopy gaps have been delineated as well by contrast split segmentation, down to the size of 1 m². Correlation and linear regression techniques have been used to explore relationships between gaps and certain variables describing structure and diversity of canopy trees and of the understory. The sampling units for correlation analysis were 50 corresponding pairs of field-based forest inventory plots (squares of around 530 m²) and 'digital plots' on the eBee RGB orthomosaic. Field measurements provided raw data to process structural and biodiversity-related variables (density, mean dbh, mean height and diversity of the understory; vertical species profile quantified by Pretzch index; density of microhabitat-bearing trees), while gap size and shape patch metrics were processed from the corresponding 'digital plots'.

Canopy gap mapping revealed that shaded canopy gaps can be faithfully extracted from UAV RGB images by contrast split segmentation of the red band. Correlation analysis between canopy gaps and biodiversity variables led to disparate results. Highest correlations were observed in the mixed forest type, while beech forest had the poorest ones and turkey oak forest displayed intermediate results. Moderate to strong linear relationships were found between gap metrics and understory variables in forest oak and mixed forest types, with adjusted R² from linear regression ranging from 0.52 to 0.87. Equally good results were observed for canopy trees (0.52<adjusted R²<0.79) with highest values found for density of trees with microhabitats and vertical species profile.

In conclusion, it is difficult to generalise about the role of UAV derived covariates for mapping biodiversity variables. However, findings from this study help revealing a potential niche of UAVs application to forest biodiversity mapping on small spatial coverage. The use of UAV derived covariates, in some of the examined forest types and stand development stage, seems promising for the spatial estimation of some forest biodiversity variables that are proven particularly costly or time demanding to be assessed by field survey alone.

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Session Multiscale application of earth observation for biodiversity monitoring

Friday, 6 July 2018 (15:00 - 16:30)

Bracco Classroom - Chairman: Piermaria Corona

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Veryhigh-resolution RGB leaf-off imagery for mapping yew and holly understory populations

According to the "Habitat" Directive 92/43/EEC, the conservation status of forest habitats is strictly linked with the occurrence of its typical species. For some forest habitats, typical species do not occur as canopy dominant trees but are found in the understory. This is the case for the priority habitat "Apennine beech forests with *Taxus* and *Ilex*" *9210, where evergreen tree species (*Taxus baccata* L., *Ilex aquifolium* L.) occur, as individual trees or groups, in the understory of beech dominated forests. Accordingly, knowledge of the spatial pattern of populations of typical species is fundamental for habitat monitoring goals.

In this perspective, this study aims to evaluate the potential of very high-resolution RGB leaf-off imagery (pixel size= 11 cm), supplied by Google Earth, for mapping the yew and holly population. This is attempted in a test site extending over 1000 ha in the Cilento National Park (Southern Italy) covered primarily by beech-dominated high forest and, secondly, by coppice forest.

Understory layer detection has been accomplished through an object-oriented approach, based on multiresolution segmentation. The assign class algorithm was used with thresholds based on spectral (vegetation indices) and geometric properties, as well as textural and contextual information.

The proposed methodology allowed to obtain high-quality result on the spatial distribution of the target species, comparable to that achievable through visual interpretation, reaching a minimum mapping unit corresponding to individual trees. The main critical issues are represented by site conditions (i.e. canyons), where shadowing can prevent crown detection.

A field survey is planned in the spring of 2018 in order to quantify map accuracy. The field inventory will be performed by means of unequal probability sampling design. This method allows the intensity of the survey effort to be calibrated on areas where classification provides a higher occurrence of the target species.

The proposed mapping procedure seems promising to support conservation actions for these typical trees species of the priority habitat *9210: identifying priority locations for long-term monitoring; identifying 'mother trees' for future seed collection; identifying suitable habitat types and locations for planting or promoting their natural regeneration through experimental silvicultural treatments.

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Bracco Classroom - Chairman: Piermaria Corona

Salghuna Narayanan Nair, Rama Chandra Prasad, Rama Rao

A surrogate approach of identifying *Artocarpus heterophyllus* species of Attappadi forest, India

The availability of multispectral satellite data showed wide utility in forestry domain with reference to forest area estimations, change detection, pest infestation, tree canopy density, biomass and carbon calculations etc. Further the advancement in remote sensing technology with the development of high spatial and spectral resolution data sets enhanced understanding about vegetation structure and aspects at very fine and local scale. Prominently the advent of hyperspectral remote sensing aided in mapping varied species by discriminating them based on their spectral reflectance patterns, which in turn shaped with respect to their biochemical components, primarily such as chlorophyll, nitrogen, lignin and cellulose.

Hyperspectral data are bulky in nature. The procurement and processing of such data is technically a challenge. Hyperspectral images are data cubes with 'n' number of bands (depending on the sensor) and are noisy. Basically before using the data for any application, user has to remove noise bands, identify suitable bands for analysis, if required compresses image using PCA methods and finally classify the data using any of the available algorithms for better accuracy. As a step for classifying the data pre and post field inventories are required. Pre-field for collection of GCP with reference to species and post-field for assessing the classification accuracy. Once satisfactory accuracy is achieved, user proceeds with the generation of spectral library of species, if the objective of the study is to discriminate species based on their spectral features and finally built spectral library. Further the behavior of the species (intra or inter) is driven by various biochemical components that are present in the leaf. The reflected and absorption peaks of same species vary depending on its growing conditions. So creation of spectral library of species in conjunction with biochemical parameters may be more advantageous in identifying and discriminating the species.

Though the processing of large volume of hyperspectral satellite data can be achieved it is not always feasible to collect field data as well as perform biochemical analysis of leaf components, as both are time consuming and expensive. One constraint that is observed in the use of hyperspectral data by many researchers is thought to be this reason. In this context there is a need for a kind of surrogate approach through which identification of species can be done without extensive and expensive field inventory. Towards this, the current research proposes a method for mapping / identification of species of one area using the spectra generated from other area. Simultaneously biochemical parameters were derived using the formulas (indices) and equations available for different biochemical components.

The test forest site chosen for mapping is Attappadi reserve forest (11°04'05.25"N and 76°33'58.18"E.) of Kerala state, India and the species to be identified is *Artocarpus heterophyllus*, a most common species of the Attappadi forest as well as "state fruit" of Kerala. The master healthy spectrum of *Artocarpus heterophyllus* is collected from Araku forest of Eastern Ghats (at 18°19'38.45"N and 82°52'39.05"E) Visakhapatnam state of Andhra Pradesh, India. It is to be noted that the spectrum of selected species of Araku forest is used to extract spectrum from satellite data of Attappadi forest, ignoring soil, climate and temperature conditions of both the areas.

ASD Fieldspec spectroradiometer was used for collecting the spectrum of *Artocarpus heterophyllus* in the field at Araku forest. The instrument provided full-range detection capacity (350 nm – 2500 nm) that gives uniform Visible/NIR/SWIR data collection across the entire solar irradiance spectrum. Random field surveys were carried out in which 6 plots showed the presence of *Artocarpus heterophyllus*. A bunch of leaves were assumed as single sample and about 5-10 samples of spectra were collected for the species. The average of all the samples was collected and the healthy spectrum of the species was generated and considered for the study. The field collected spectra showed outliers and dropouts which were eliminated by using suitable self-generated statistical algorithm. Thus the created set of spectral library was used for identification of species in Attappadi forest.

Hyperion data is used to for the identification of selected species in Attappadi forest. The data was acquired on 30.1.2010 at 4.55pm and had 25% cloud. The scene does not covered entire forest reserve, hence the study was performed on the forest area that is available in the scene and not on the entire scene downloaded. The Hyperion has a high resolution hyperspectral imager capability of resolving 220 spectral bands (from 0.4 to 2.5 μm) with 30-meter resolution. The image is of 7.5 km by 100 km land area per scene, and provided detailed spectral mapping across all 220 channels with high radiometric accuracy. Pre-Processing was carried out by removing bad pixels

and bands, setting the calibration (gain offset) and then outliers are removed using ENVI 5.1 software. It is always better to perform minimum noise fraction and pixel purity index to get or to know the homogeneity and purity of data. There are many types of classification techniques available but Spectral Angular Mapper (SAM) classification is used to classify the Hyperion data. This approach is used because it uses an n-D angle to match pixels to reference spectra obtained for the species from Araku forest. The algorithm determines the spectral similarity between two spectra by calculating the angle between the spectra. They treat the spectra as vectors in a space with dimensionality equal to the number of bands.

The pixels from the SAM at 0.10 and 0.12 radians were extracted and then 20 random sample points were created from the classified image. The spectrum which was used as reference (spectrum from Araku) spotted only few locations of species in the Attappadi forest when 0.10 radians was chosen for classification. But the ground reality of the Attappadi forest is different. The forest is rich of *Artocarpus heterophyllus*. So the SAM technique was again repeated by widening the angle to 0.12 radians. Almost the species was observed at maximum locations in the image. It was noticed that spectra found during 0.10 radians were healthy and 0.12 are moderate to stressed condition of the species. Every sample point for the species (20 samples) collected from the image were manually checked for their absorptions intensity and position to know whether they represent the selected species or other. These absorptions points were considered as the unique remarks to identify the species. But there were variations in the pattern due to their varied content of biochemical parameters. These variations define the health of the species. To discriminate species based on health conditions by considering their biochemical components, these spectra were converted into ASCII format and biochemical indices such as Chlorophyll index, Nitrogen index, Lig-cel absorption index were calculated.

The reference spectrum used (Araku forest) was a healthy spectrum of the species and it was found that the spectrum under 0.10 radians is good and healthy tree species. Since the angle is less, similar spectrums were matched and their relation with the biochemical parameters derived using indices was also high. This proves that the pixels under 0.10 radians during SAM classification were healthy ones. Whereas the other spectra had moderate to low correlation (values) with the biochemical values. Not necessary that all the four parameters are low but they will not be as high as recorded for healthy species. So these can be considered as stressed trees. There is a possibility that the pixels that fall under 0.12 radians of classification may represent other species. But before carrying out the biochemical indices the absorption points were checked with the reference spectrum. The unmatched random sample is eliminated and another pixel is considered.

Thus the current approach identified species along with their health condition using satellite data and biochemical analysis derived from indices. This study worked as a prototype and by this surrogate approach one can know the presence of species in a particular area using spectral libraries available for same species at other location and without extensive field inventory and expensive lab analysis. Also the study added biochemical parameters to define the behavior of spectra of selected species without direct lab measurements. To conclude, this technique will help the future researchers to avoid the extensive field work and still progress with their analysis in an accurate manner.

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Session Multiscale application of earth observation for biodiversity monitoring

Friday, 6 July 2018 (15:00 - 16:30)

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Simbarashe Sanyaruwa Jombo

Mapping urban alien trees in the City of Johannesburg. The Case of the Randburg region

Urban alien trees are important in energy conservation, reduction of carbon pollution and noise, amongst other roles. In this study, we adopted a multi-temporal World View (WV) 2 satellite image to map urban alien trees in the City of Johannesburg (CoJ), focusing on the Randburg region. Classified maps were produced using the Random Forest (RF) algorithm from both the Pixel-Based Image Analysis (PBIA) and Object-Based Image Analysis (OBIA). Accuracy assessment using field survey was done and results show that both the PBIA and OBIA approaches can be used in mapping urban alien trees. The OBIA was found to be more appropriate with an overall accuracy of 94.7 % compared to 83.6 % for PBIA. This study recommends that mapping of urban alien trees should be done in multiple seasons and also uses ancillary information so as to increase the classification accuracies.

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Krzysztof Stereńczak¹, Gaia Vaglio Laurin², Aneta Modzelewska¹, Rafał Sadkowski¹, Łukasz Kuberski¹, Marcel Urban³, Gherardo Chirici⁴

Biodiversity characterization in Białowieża Forest (Poland) with ALS and Sentinels data

Forest biodiversity monitoring is crucial in a period of intense climate change and increased land use change, with impacts reducing the capacity of forests to store carbon and preserve biodiversity. In addition, there is growing interest in clarifying the links between carbon storage and biodiversity levels. The assessment of biodiversity can be realized using various methods. In the past, and still today for complete assessments, field-based measurements are preferred. Currently, the use of remote sensing from different datastreams and sensors is increasing. On larger scale, satellite data are more useful, but their efficacy in different ecosystems has still to be fully demonstrated due to the availability of multispectral and microwave sensors only. On local scale, airborne data or even UAV equipped with advanced sensors (hyperspectral, lidar etc.), not presently mounted on satellite platforms, are known to provide valuable results even if at high costs. However, airborne remote sensing is unable to provide data describing the full biodiversity of the entire ecosystem and only certain variables can be characterized. In Białowieża Forest in Poland, thanks to the realized airborne campaigns, lidar data were available. We experimented the use of lidar, joined with Sentinels data to provide diversity information on forest stands, such as stand species compositional and structural diversity. The study was carried out in the Polish part of Białowieża Forest. Field data on species, height, DBH, dominance, health status, was collected in 685 geolocated sample plots of 500 square meters size; they were used to understand the diversity distribution in the study area and for satellite and airborne data calibration and validation, during the diversity estimation procedure. ALS data and orthophotos were acquired in summer 2015, in a period coincident with field ground data collection, obtaining a minimum of 6 points per square meter. One year of Sentinel 1 and Sentinel 2 data were acquired and processed over the same study area. Different indices were selected to compute structural and compositional biodiversity. Preliminary results shows that structural biodiversity, intended as diversity in height, DBH, and biomass among plots, is successfully detected using ALS and multitemporal SAR Sentinel 1 data ($R^2 > 0.7$). The addition to these datasets of multispectral Sentinel 2 data, even if from few dates due to cloud cover, allowed to accurately estimate compositional diversity in the studied plots. However, exact species mapping was not possible: for this task hyperspectral data are needed, or possibly longer multispectral time series.

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Duccio Rocchini¹, Matteo Marcantonio², Carlo Ricotta³

Rao's Q diversity as an effective measure of ecosystem heterogeneity from space

Measuring biodiversity is a key issue in ecology to guarantee effective indicators of ecosystem health at different spatial and time scales. However, estimating biodiversity from field observations might present difficulties related to costs and time needed. Moreover, a continuous data update for biodiversity monitoring purposes might be prohibitive. From this point of view, remote sensing represents a powerful tool since it allows to cover wide areas in a relatively low amount of time. One of the most common indicators of biodiversity is Shannon's entropy H , which is strictly related to environmental heterogeneity, and thus to species diversity. However, Shannon's entropy might show drawbacks once applied to remote sensing data, since it considers relative abundances but it does not explicitly account for distances among pixels' numerical values. In this talk we propose the use of Rao's Q applied to remotely sensed data, providing a straightforward R-package function to calculate it in 2D systems. We will introduce the theoretical rationale behind Rao's index and then provide applied examples based on the proposed R function.

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POSTER SESSION

Session General Poster Session
Wednesday, 4 July - Friday, 6 July
Poster Area - Chairman: Gherardo Chirici

Gherardo Chirici, Raffaello Pegna, Francesca Giannetti, Davide Travaglini

Landsat vs Sentinel2 time series analysis for estimating clearcut area in Mediterranean forests

In the last decade the open access availability of the Landsat archive has stimulated the development of methods for the automatic mapping of forest disturbances. Landsat images are preferably used because their availability potentially goes back to the seventies of the past century. In the last three years the new Sentinel2 satellites are able to provide frequent earth observations with unprecedented geometric and spectral geometry.

To map clearcut areas methods are generally based on the multitemporal analysis of multispectral images since the forest loggings determine an abrupt decrease of photosynthetic activity as most or all trees are lodged, followed by an increasing trend due to regeneration.

Most of the applications available in literature are developed in temperate or boreal forests where forest clearcut are carried out over large areas and the regeneration is from seeds or replanting.

In Italy, the vast majority of clearcut is carried out in coppice forests where the vegetative natural regeneration is extremely fast in recovering harvested areas. It is therefore interesting to understand if it is possible to automatically detected clearcut areas in such Mediterranean forest ecosystems. We also noted that in literature most of the contributions present the results without providing a formal statistical calculation of the standard error in the clearcut area estimation.

This study is carried out in Tuscany on the basis of one Landsat scene acquired for a time series of 16 years (between 1999 and 2015), partially covered by a Sentinel2 scene. We first analysed the spectral behavior of coppice forests to highlight specific spectral temporal trends in both the sensors. We then applied a method based on multiple multi-temporal changes in the Normalized Burn Ratio to automatically map forest clearcut area. On the basis of some test areas where the clearcut area was manually acquired without errors, we finally present the achieved results comparing the capabilities of Landsat and Sentinel2 together with an innovative proposal for a formal error estimation of clearcut area.

Session General Poster Session
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Evgeny G Shvetsov, Nadezhda M Tchebakova, Elena I Parfenova

Land cover change detection using Landsat data over South-Central Siberia during 1990–2015

Introduction

Studies of climate change indicate a significant increase in temperature and precipitation in continental Siberia during the 21-st century. The changes in the natural and anthropogenic terrestrial ecosystems caused by global warming include reduction of permafrost coverage and northward shift of forests. In the southern Siberia changes in the areas occupied by forest and agricultural lands could also be expected. The study of such changes could help to develop the land management strategies for the steppe and forest-steppe zones.

Classification and mapping the vegetation cover is an important task in the natural resources management as well as in assessing the consequences of natural and anthropogenic impacts. Currently, remote sensing technologies are widely used to perform such tasks including the classification of vegetation types at global, regional and local scales. Landsat products have been used as one of the main sources of data in vegetation mapping on a regional scale. Since Landsat has a long history of dataset, it is helpful to map long-term vegetation changes.

The main objective of this work is to estimate the changes in areas occupied by forested and agricultural lands in the southern Siberia during the last 30 years.

Methods

To identify the changes between forest and non-forest types of vegetation we used imagery having moderate spatial resolution (30 m) from Landsat 4 – 8 satellites covering southern regions of central and southern Siberia. The study area included the central and southern areas of the Krasnoyarsk region, as well as the Republics of Khakassia and Tuva, covering the territory from 50° to 58° N and from 88° to 99° E. Overall temporal data coverage was from the late 1980-s to 2016 including two time slices: 1988–1992 and 2013–2016. Totally 79 cloud free images obtained between June and September were used in further processing.

Landsat images were subject to radiometric calibration that was achieved by converting raw Digital Numbers (DN) into top of atmosphere reflectance values for different spectral bands. These bands were then used to calculate the tasseled cap transformation for the image. This transformation converts surface reflectance values measured in six spectral bands of Landsat to three principal components: brightness, greenness and wetness. We used supervised classification approach to identify main vegetation classes, such as forest, non-forest (including steppes and agricultural lands), mountain tundra, etc. on the tasseled cap transformed images. The sites used as the training sample for the classification procedure were selected based on high-resolution imagery (Google Earth) and vegetation maps such as GLC (Global Land Cover) 2000 and USSR vegetation map of 1990. Totally about 90 sample sites were selected to perform algorithm training.

Results

Following the methodology described above we derived maps of forest / non-forest lands for two time periods: 1988–1992 and 2013–2016. To validate the obtained classification results we compared our Landsat-based vegetation map to "Landscape map of the Altai-Sayan ecoregion" (2001) which is based on geobotanical data. The geobotanical categories were generalized in three: tundra, forests and steppe (including agricultural lands). The kappa-based comparison of the Landsat image to the vegetation map showed the good degree of similarity (Kappa = 0.65).

We also created the difference map between two vegetation maps showing the areas of reforestation and of the forest loss. The total forest loss area was about 2.6 million hectares or 5% of the study area, while the reforestation area was 1.6 million hectares or 3% of the study area.

Forest loss occurred mainly in the territory of the Tyva Republic (south of the study area) and in the Angara region (north of the study area). A comparison of the derived land cover change map with the locations of forest fires showed that most of the tree cover loss in these areas was caused by fires occurred in 2002 in Tyva Republic and in 2011, 2012 in the Angara region. In addition, logging was another significant reason for tree cover loss in the northern regions of the study area. The largest areas marked as reforestation are located mainly in northern and central regions and can be attributed to the forest regrowth on the old logging sites. At the same time we were not able to detect any significant shifts of the border between agricultural / steppe and forest lands in areas not disturbed by logging or fires.

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Rabia Munsaf Khan

Time Series Analysis of Aerosol Data over Lahore Region

Aerosols are the tiny suspended particles in our atmosphere that can cause climatic changes. Aerosol data can be collected from two major sources: Ground based instrument (AERONET) or the satellite imagery (MODIS etc.). These instruments measure various parameters of aerosols one of which is AOD (Aerosol Optical Depth). A study was carried out to check the variations in the values of AOD for Lahore city. It was at the start intention of this study to carry out time series analysis on 6 years of data but unfortunately due to large data gaps and haphazard data values it could not be achieved. However, auto spectral analysis was carried out on the data for year 2012 and major frequencies were detected. The major objectives were to use Fourier Transform to perform time series analysis, plot the power spectrum, remove the dominant frequency, re calculate the power spectrum and then analyze and discuss the results. Fourier Transform can be used in time series data. This type of data is used in statistics, signal processing, pattern recognition, finance, weather forecasting, earthquake prediction and many more. Time series data can be filtered using the fast Fourier transform. Fourier analysis reveals nothing of the evolution in time, but rather reveals the variance of the signal at different frequencies. The Fourier Transform is lossless and invertible, which means that the original signal can be perfectly reconstructed using inverse Fourier transform. The results showed that the values of AOD (Aerosol Optical Depth) varies yearly and seasonally. Different windows are used to compare the results and the best result is given by Kaiser Window. The results derived are highly dependent upon the quality and quantity of data. When the sampling is non consistent then the results derived are not accurate and hence they cannot be used for further work. The application of different windows reveals different results. In this study the Kaiser window gives the best results as it gives a sharp peak representing frequency and narrow side lobes. The power spectrum shows different cycles in the data. The half cycle is because we get a large value in July and December. The reason for these fluctuations cannot be stated on the basis of total AOD values. For this purpose there is a need to study the fine mode and coarse mode AOD so that the types of particles causing greater AOD value can be discerned. The results are in accordance with the previous studies showing the concentration of aerosols in each season, however consistent sampling and data over a longer range could reveal more precise results.

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Paolo Gamba, Andrea Marinoni

Italian activities within the USHIER project

The USHIER (Utilizing SAR and Hyperspectral Integrated data for Emergency Response in the Mediterranean) project has been funded by ASI in the framework of the Italy-Isarel joint research call.

USHIER aimed at developing a framework to exploit polarimetric SAR and hyperspectral data sets at different spatial resolutions in an emergency situation. Challenges are posed in combining information referring to completely different wavelengths and thus to different scattering phenomena. Far from being a disadvantage, this is considered as a way to collect a wider range of information and also to infer from one data set some clues to extract features in the second one. For instance, by a precise and semi-automatic spatial analysis using VHR SAR data from the COSMO/SkyMed constellation, maps of damages or areas under threat can be obtained in reduced time. Similarly, hyperspectral data analysis on the identified areas may be able to characterize materials on the ground and infer the focus of further analyses using SAR data during short-term passages of the COSMO/SkyMed constellation.

The idea of the project was to design a novel framework to exploit SAR and hyperspectral data and deal with emergency scenarios due to natural as well as man-made disasters and involving damages to infrastructures and subsequent pollution of water or land. The overall framework was designed by means of the integration of two major steps, feature extraction and feature fusion, at multiple spatial scales in an iterative way.

Results of this study were obtained at the technological level, by designing, implementing and evaluating novel algorithms to extract and fuse information that is relevant to natural and man-made disaster management in peaceful situations. More specifically, the project developed a framework to use COSMO/SkyMed, hyperspectral and VHR optical data for emergency situations involving cascade effects in the Mediterranean basin. Within this framework, techniques referring to the novel point highlighted in one of the previous sections will be developed. Data fusion algorithms to merge information extracted from a first assessment step and look for secondary effects due to air/water/land pollution were also considered.

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Federico Di Traglia¹, Teresa Nolesini¹, Lorenzo Solari¹, Andrea Ciampalini², William Frodella¹, Nicola Casagli¹

Catching geomorphological response in volcanic environments by means of advanced remote sensing techniques

With the aim of understanding the relationship between geomorphologic evolution and slope instability at Stromboli volcano (Italy), displacement data from X-band, space-borne, COSMO-SkyMed satellites (CSK-SAR) and a permanent-sited, Ground Based Interferometric Synthetic Aperture Radar (GBInSAR) device were analysed. To trace lithological and geomorphological changes in space and time, the evolution of reflectivity (amplitude) of CSK-SAR were also examined.

This study is focussed on Stromboli (Italy) volcano, optimal environmental setting and case history of volcano slope instability phenomena, since: i) it experienced moderate to major instability events, ii) its slopes are prone to mass-wasting phenomena, iii) it is affected by persistent volcanic activity that can significantly affect the stability of slopes, iv) landslides from its flanks could generate tsunamis that could affect areas inhabited, and iv) it is one of the best studied and, among all, monitored volcanoes on Earth, providing exceptional validation data and ground-truth constrains.

GBInSAR data were collected every 11 minutes in the period 1 January 2010 – 18 December 2014, whereas the CSK-SAR images were collected between 22 February 2010 and 18 December 2014. Multi-Temporal InSAR (MT-InSAR) algorithms were used for both CSK-SAR and GBInSAR datasets.

Backscattered intensity of each CSK-SAR image was transformed in amplitude image and then decibel scaled. To detect and interpret changes in land-cover in correspondence of the SdF slope, two steps were applied in the employed procedure: i) RGB colour composites, and rationing, ii) texture analysis, using the GLCM (Grey Level Co-occurrence Matrix) method.

The analysis of the entire dataset cover a period characterized by "normal" Strombolian activity, punctuated by episodes of "high-intensity activity", with the occurrence of overflows from the crater terrace toward the Sciara del Fuoco (SdF), and the 2014 flank eruption. This study highlights that during periods characterized by "normal" Strombolian activity, the production of materials ejected from the crater terrace to the SdF is generally low, and erosion is the prevailing process, mainly affecting the central portion of the SdF. GBInSAR apparatus allows for the identification of very low displacement rates (0.01–0.001 mm/h). After the emplacement of the 2014 lava field, high displacements in the area located between the central and the northern portions of the SdF were recorded. The lava accumulation on the SdF slope, has favoured the detection of slope instability due to the difference in the involved material (lava flows and breccia layers vs volcanoclastic loose deposits) below the newly emplaced lava.

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Maria Libera Battagliere, Maria Daraio, Maria Virelli, Fabrizio Lenti, Alessandro Coletta

COSMO-SkyMed space data supporting Disaster Risk Reduction

According to International Displacement Monitoring Centre (IDMC) natural disasters displaced around 24,2 million people across 118 countries and territories in 2016. This means an increase compared to previous years and more than three to one the number which fled conflict and violence. Over the past nine years, since 2008 a total of 227,6 million displacements, corresponding an average of 25.3 million displacements per year have been recorded. Generally, natural hazards such as earthquakes, floods, drought and cyclones cannot be prevented but the number of lives they take and the damage they cause can be greatly reduced thanks to preparation and protection measures. Improving Disaster Risk Reduction (DRR) saves lives and strengthens the resilience of communities enabling them to anticipate, absorb and bounce back from shocks. Today, improving the understanding of disaster risks is an important step forward and constitutes the key point on which to define emergency preparedness and planning measures. Therefore, DRR has assumed an important political role since International Organizations such as the United Nations Office Disaster Risk Reduction (UNISDR), the World Bank (WB) and the European Commission (EC) have focused their actions in this operational framework. Thanks to its features, COSMO-SkyMed mission operative since 2008 is playing a key role in emergency response activities, being a largely exploited SAR mission during disaster events for damage assessment and support to logistic. In this context, the system is also able to monitor efficiently the different phases of crisis: early warning, recovery operations and post-crisis, representing a more efficient approach for managing and limiting the effects of natural disasters.

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Lorenzo Arcidiaco, Lorenzo Bottai, Bernardo Gozzini, Massimo Perna

Coastline extraction from a stereoscopic model derived from UAV images

In photogrammetry, to allow the three-dimensional display of the photographed objects and the accurate measurement of the coordinates of the returned points, a procedure similar to the physiological mechanism of human vision is reproduced: The

Stereoscopic vision can be defined as the ability to perceive and evaluate the distance between objects observed with respect to the observer. In people, stereoscopic vision is innate and is due to the possibility of observing a scene from two different points of view (the two eyes).

Nowadays UAV platforms are an important source of data for inspection, surveillance, mapping and 3D modeling. New applications are being developed every day, as acquisition through UAVs represents a low-cost alternative to classic manned aerial photogrammetry. This document reports the development of a method of processing UAV images and a photogrammetric application aimed at the manual extraction of the coastline from a digital stereoscopic model derived from UAV images, acquired along the shoreline of Donoratico; Castagneto Carducci (LI) - Italy.

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Francesco Immordino, Elena Candigliota

Photointerpretation and Image Processing of multiscale and multispectral satellite data to the geoarcheological study in the Alba Fucens area (AQ)

In the last few years the processing of high and very high resolution images has entered strongly in the geoarcheological studies; through the direct and indirect interpretation of the earth's surface shapes and the chromatic tones, it is possible to extract from the multispectral satellite scenes morphostructural information (paleo-river beds, ancient anthropic features) and associate them with the environmental context. The NIR and MIR spectral bands allow the detection of gray shades not visible to the human eye, highlighting potential buried structures through anomalies in the distribution of moisture and/or soils vegetation.

In this study the photointerpretation tools and numerical processes of digital satellite images are described for the geoarcheological characterization of the Alba Fucens area (AQ) where there is an Roman Age archaeological site (303 BC) and located along the route of Via Tiburtina Valeria (near Lake Fucino, 1 km SO of today's Alba), destroyed by the earthquake of 346 AD and progressively abandoned. A multiscale and multispectral study was performed on Landsat 8 and GeoEye images that allowed the geo-morphological characters extraction of the study area and its geoarcheological reconstruction associated with the Roman site.

The remote sensing interpretation data is now a proven technology for the identification of buried or submerged archaeological sites, through the geomorphological analysis of the territory for the reconstruction of paleoenvironments in relation to ancient settlements, for the planning of geophysical prospecting for the identification of structures buried and hypogean cavities. The elements extracted from the multispectral images associated with the geological, hydrogeological and structural surveys are a valid support to the studies for the recovery, for the protection and conservation of archaeological sites.

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Luca Salvati

Integrating new applications from GMES-Copernicus Land for multi-scale monitoring of Green Infrastructure and Land Take

The present study identifies new applications from the initiative GMES-Copernicus-Land proposing new indicators of soil sealing as a contribution to the debate on land consumption and landscape fragmentation driven by urban growth in Europe. Indicators for permanent monitoring of land take were derived from land imperviousness maps provided by GMES-Copernicus enriched with digital information from Google Earth, digital planning tools (zoning) and ancillary layers organized in a Geographic Information System. Spatial statistics were used to identify and calculate the most relevant and reliable indicators of landscape transformation and soil sealing. A validation session was presented by applying the proposed approach to a relevant case study. Soil sealing and green infrastructure indicators proved to be effective tools when assessing land take in metropolitan regions.

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Mirko Grotti¹, Francesco Chianucci², Nicola Puletti³, Valerio Quatrini⁴, Walter Mattioli⁵, Alessandra Gentile⁶, Michele Pisante⁷, Piermaria Corona⁵

A plot sampling strategy for estimating the area of olive tree crops and olive tree abundance in a Mediterranean environment

Olive tree (*Olea europaea* L.) is a long-living evergreen plant with relevant cultural, economic and landscape relevance. Accurate inventory and mapping of olive surface and olive abundance represents a central issue to support the olive production system. With reference to the cultivation, there is a high heterogeneity and complexity in the cultivation of olive trees. In addition, olive is cultivated in a wide variety of soils and can tolerate a broad range of physicochemical conditions. Such heterogeneity in production systems is reflected in the large variability in olive surfaces, which poses some challenge in accurately estimating the area of olive tree crops and olive tree abundance via traditional inventory approaches, as e.g., commonly adopted for national forest inventory. From a methodological point of view, the complexity and heterogeneity of olive tree crops can be comparable to the problem of accurately estimating tree outside forests (TOF) attributes. TOFs are defined as small groups of trees within rural and urbanized areas not classified as forests. Only relatively recently the importance of including TOF to integrate forest inventory estimates have been addressed by some studies. Similarly to traditional forest inventory, TOF inventory strategies are usually based on environmental sampling scheme such as plot sampling, and its integration with information derived from remotely sensed imagery. A successful plot sampling strategy (PLIS50) have been recently verified in TOF from Fattorini et al. (2016).

In this study we verified whether the plot sampling approach proposed for TOF is suitable for estimating the area of olive tree crops and olive tree abundance. For the purpose, the approach was tested in a case study where the census of the olive crop area, number of olive crops (polygons) was manually conducted from photo-interpretation of high resolution aerial orthoimagery, which were used as benchmark to test the effectiveness of the point sampling approach. The main results of this study is that the plot sampling method, formerly applied in TOF inventorying, can be applied for estimating olive tree attributes. In our case study we obtained accurate estimates of olive tree attributes, whose RSEs were always below 10%, with a limited sampling of about 6% of the studied population (olive grove polygons), with considerable reduction in cost and time efforts required compared with manual census from photointerpretation. Using robust statistical procedures among countries, should allow obtaining harmonized and comparable information, which can increase the knowledge of olive geographical distribution and structure at its relevant Mediterranean scale.

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Jean-Francois Mas

A comparison of methods for filling missing lines in RapidEyes images

Due to sensor or ground station malfunction and poor atmospheric conditions, missing information in optical remote sensing data is common and reduces the usage of such data. Over the past decades, a large number of algorithms have been created in order to reconstruct missing remotely sensed information. The objective of this study is to compare simple methods for filling missing data in a particular case usual in imagery such as RapidEyes or MODIS acqua: one band presents missing information but the other bands are complete.

The first method is based on spatial interpolation and takes advantage of the spatial autocorrelation observed in remote sensing images. For this, spatial convolution filters (3x3 and 5x5 windows) assign the mean values of neighbors to pixels with missing data. The other methods use redundant spectral information to reconstruct the missing data in a specific band. In the first one, an unsupervised classification of the missing lines strip and its surrounding is first performed using the complete bands. Then, the average value of the missing band is calculated for each cluster, and assigned to the missing data pixels taking into account the cluster the pixels belong to. The others methods based on the correlation between spectral bands are regression models which established a relationship between the values of the band affected by the missing lines and the complete bands using data from the adjacent area to the missing lines. Two regression models were fitted: a global model (one equation for the entire image) and geographically weighted regression (GWR) models. The premise of GWR is that the relationship between variables might vary spatially. Therefore, instead of assuming that one unique global model can describe this relationship for the entire study area, GWR uses a search window moving over space to fit many regression models giving most weight to closest observations. In both regression models, the equations were used to estimate pixel values of the missing lines. In order to assess the performance of the different methods, missing line strips of different sizes were simulated and reconstructed using the five methods. Visual effect of the images after the reconstruction was inspected and several indices were computed to compare the true values and the estimated values of the pixels from the missing area: Root mean square error (RMSE), correlation, maximum deviance and bias. In order to identify the causes related to the performance of each method, some characteristics of the missing lines, as correlation between spectral bands and spatial autocorrelation, were also calculated. All the processing was carried out using the R program (<https://www.r-project.org/>) and imagery provided by the Planet Education and Research Program (<https://www.planet.com>).

Results showed that the GWR model presents the lower RMSE because it was able to fit the relationship between the missing band and the complete bands locally. This is important in heterogeneous landscape with cuts across different types of land cover and therefore across objects with different spectral features. Moreover, this method do not present bias. Reconstructions based on spatial filtering were the most inaccurate except when the missing strip width was only one pixel. The performance of the methods depends on image characteristics such spatial correlation, spatial heterogeneity along the missing line and correlation between spectral bands. Therefore, computing indices to assess these characteristics can be helpful in order to choose the adequate method.

As concluding remarks, the reconstruction results and evaluation showed that GWR can be used to remove missing lines effectively and was able to keep most of the image information. However, this technique is computing time-expensive and some parameters as the optimum bandwidth of the search window should be determined. GWR was applied successfully to RapidEyes images of the surroundings of Belo Horizonte, Minas Gerais, Brazil which presented missing lines due the data loss during down-link.

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Mariano Bresciani¹, Claudia Giardino¹, Maria Antonietta Dessena², Paola Buscarinu², Loretta Cabras², Karin Schenk³, Thomas Heege³, Hendrik Bernet³, Giorgos Bazdanis⁴, Apostolos Tzimas⁵, Evangelos Romas⁵

Improved water quality products for freshwater reservoirs from Earth observation

This study presents a scientific study dealing with the use of remote sensing techniques for monitoring fresh water resources. The study has been developed within the framework of the SPACE-O (Space Assisted Water Quality Forecasting Platform for Optimized Decision Making in Water Supply Services) Project, on the Horizon2020 program. SPACE-O is catalyzing innovation with a service platform created to facilitate interoperability between the Earth Observation (EO) data, ecological and hydraulic models and Decision Support System (DSS) for an improved management of freshwater reservoirs for supplying drinking water. The activities based on EO data analysis are presented for the two artificial reservoirs: Mulargia (Sardinia-Italy) and Aposelemis (Creta-Greek).

The Mulargia reservoir serves as a drinking water source for the town of Cagliari (southern Sardinia) its hinterland plus about 20 villages, summing up to a population of 700.000 inhabitants. The total annual abstraction for drinking water purposes is estimated to 100 hm³. The Aposelemis reservoir serves as a drinking water source for the towns of Heraklion and Agios Nikolaos as well as local communities in the greater area summing up to a population of 300.000 inhabitants. The total annual abstraction for drinking water purposes is estimated to 17 hm³.

EO data gathered from Landsat-8 and Sentinel-2A & B are operationally used with the SPACE-O project to observe a set of key variables for water quality monitoring. The EO products, obtained with the physics-based image-processing-chain based Modular Inversion and Processing System (MIP), consist of time-series imagery of the water quality parameters, that for the purposes of the project are covering the four years of 2013-2017. The MIP architecture systematically handles the independent properties of sensor parameters and specific optical properties as well as the radiative transfer relationships. The processing includes the acquisition or harvesting of satellite data, radiometric calibration, spatial subsetting (clipping) of region of interest, land-water-cloud masking, adjacency correction, sunglint correction coupled atmospheric and water surface correction, including aerosol and in-water Inherent Optical Properties (IOPs) retrieval, retrieval of water constituent concentrations from IOP's and creation of quality indicators and quality control. In particular the following parameters are obtained: chlorophyll-a concentration, turbidity, Secchi disk depth. In addition other ecological and warning indexes are produced, such as the trophic status index, and the harmful algal bloom probability. Moreover, The Thermal Infra-Red Sensor (TIRS) on board of Landsat-8 data was used, in combination spectral information obtained from the optical sensor (namely, OLI), to map the lake surface temperature, the heat fluxes and the evaporation rate in the study areas. In particular, lake surface temperatures are retrieved from top-of-atmosphere brightness temperature in the TIRS band 10 (10.9 μm). Then, the surface energy budget is estimated according to the evaporative fraction method by combining the lake surface temperature to lake surface albedo (as estimated from OLI bands) and by considering air temperature, wind speed, and relative humidity data from the hydro-meteorological stations.

In order to be able to provide the managers of the dams a given uncertainty about the use of EO products, as a standard part of the processing, an accuracy or quality indicator is calculated for each retrieved parameter and for each detected water pixel. This measure comprises a comprehensive range of factors that can impact the derived product quality (e.g. the estimated sun glint probability; residuals of the measured and modelled sensor radiances and subsurface reflectances; pixels affected by cloud shadow). The quality information is part of each standard geodata delivery and is visualized by different maps from which the final product masks are obtained. Moreover, the comparison of EO products showed a good agreement vs. in situ data (turbidity $R^2 = 0.82$ and chl-a $R^2 = 0.72$), then the trends of the EO and in situ observations during the years show a common tendency.

The detailed results of EO products generation are the following: for Mulargia, 138 clouds free images produce many information about the water quality, the average chl-a was 10.8 mg/m³ (Min 0.8 and Max 77.2), and average turbidity was 5.9 ETU (Min 0.9 and Max 44). The results show that in spring and autumn period the quality of the water is lower, in particular in the period when decreasing the level of the water and when the precipitation was copious and determine a high run-off of particulate matter from the basin. Inorganic component of suspended matter was predominant in spring, while its organic fraction was more dominant in autumn. For Aposelemis, 129 clouds free images show that the average chl-a was 16 mg/m³ (Min 1.7 and Max 45.2) with reduced spatial variability within the lake, the turbidity values show a greater inhomogeneity's with south zone of reservoir have the higher value

(average 6.8 ETU; standard deviation 4.3) respect to the northern part near to the dam (average 5.2 ETU; standard deviation 3.5). The highest values were recorded in the period January-March 2015 and 2017. Inorganic component of suspended matter was predominant in winter, while its organic fraction was more dominant in summer. For both freshwater reservoirs, the trophic state judgments obtained with EO data was mesotrophic.

In order to overcome temporal gaps, calculation of statistical means from EO data was applied, this includes monthly and seasonal means and the minimum, maximum, quantiles (0.25,0.75), standard deviation, range and count of all images which have been taken into account for a certain pixel are extracted.

Within SPACE-O, additional satellite data at very high spatial resolution were gathered thanks to the Copernicus data-warehouse. Rapid-Eye images of 2015 were used to investigate the presence of localized cyanobacteria surface blooms, by applying band ratio approaches of red and near-infrared red bands, in Mulargia Dam. The results show a presence of a patchy distribution of red cyanobacteria on 8 April and on 23 October, with a coverage of 2.6 and 1.4 Ha respectively. Normalized difference aquatic vegetation indexes applied to Rapid-Eye acquired on 22 August 2014, also revealed the presence of floating vegetation in Aposelemis and with a coverage of 2.4 Ha of floating vegetation.

The results presented in this study are then used in the SPACE-O to support the implementation of the Mulargia and Aposelemis monitoring as well as to perform a water quality forecasting.

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Francesca Chiocchini, Marco Ciolfi, Maurizio Sarti, Marco Lauteri, Marcello Cherubini, Luca Leonardi, Pierluigi Paris

Remote sensing and GIS methods to detect tree hedgerows in agroforestry landscapes

Agroforestry denotes land use systems in which trees grow in combination with agricultural crops and/or livestock. The woody component usually consists of scattered or linear trees (planted or naturally growing), that can be located either inside the field or along the field boundaries, as tree hedgerows. This land use approach is aimed at the optimization of both ecological interactions and economical revenue. Agroforestry is increasingly perceived as providing ecosystem services, environmental benefits, and economic commodities as part of a multifunctional working landscape. These services and benefits occur over a range of spatial and temporal scales: from the farm/local scale, through the landscape/regional scale up to the global scale. The use of Remote Sensing and GIS spatial analysis is of the utmost importance for detecting landscape patterns, understanding the interactions between biological and physical components, and for assessing, mapping and quantifying the socio-economic values of the agroforestry systems services.

Agroforestry systems have traditionally been used in different places of Europe employing several types of practices at different levels of intensity. However, a decline of this land use system occurred all through the 20th century due to agricultural intensification and mechanization. To slow down the decrease of these good practices, the European Common Agricultural Policy is currently supporting establishment and preservation of agroforestry systems, because of their higher ecological and socio-economic value. Most of the Italian territory is naturally suited for agroforestry systems due to its environmental setting, geomorphological and climatic conditions, as well as for the historical and cultural land management practices. Although that, few information is available concerning the current extent of agroforestry systems because tree detection in large agricultural areas is time consuming. Additionally, the magnitude of ecosystems services of agroforestry systems strongly depends on tree number and dimension. Thus, detecting these tree parameters by remote sensing is of dramatic importance. This study is focused on an agroforestry landscape located in the Umbria region (central Italy), where we investigated a farm managing over 600 ha of arable land and woods. The main land uses include herbaceous crops, tree hedgerows, shelterbelts and forest belts. In these systems, trees grow only at the edges of fields, within hedgerows, or on scarps and drainage ditches between fields; the trees provide established positive effects on soil erosion, wind shielding and ecological enrichment as well as an aesthetic enhancement of the landscape.

We combined different methodologies comprising Remote Sensing, photo interpretation, GIS analysis and field survey to detect the spatial distribution of the land cover/use of the study area and to reveal the spatial interactions between the crop and tree components of the system. In particular, we used the hemispherical canopy ground photography technique to assess the shading effect of trees on crops. The aims of this study were: i) to map and estimate the extant of Tree Hedge Rows (THR) in the study area; ii) to quantify the influence of THRs on the yield of crops at the plot scale.

Basing on the land use classification, performed by photo interpretation (Data source: AGEA 2011), we identified two experimental sites (ES) to study the continuous and discontinuous THRs along the margins of the cultivated fields. Each site contains a plot of annual crops and THRs along at least one of the borders consisting of oaks, mainly *Quercus pubescens* and *Quercus cerris*. Through the aerial photos (2011) and Google Earth images (2017), we identified two test areas (TA) of 100 ha (1km x 1km squares) each one containing one of the two ES. We tested a procedure for the GIS inventory of THR over the two TAs, consisting in: 1) survey of THRs with GPS device in the ES, for the proper georeferencing and actual measurement of the tree linear systems, measurement of height (H), diameter at breast height (DBH) for each tree of the THRs and of the distance between adjacent individuals; 2) recognition of THRs by photo interpretation of aerial and satellite images; 3) comparison of field measurements against estimates by photo interpretation for the error evaluation; 4) estimation of the incidence of THRs per hectare of cultivated area over the two TAs and over the whole farmland.

The recognition of THRs was based on photo interpretation of high-resolution multispectral Sentinel2 (HRS2) images. In particular, evaluating the NDVI (Normalized Difference Vegetation Index, $NDVI = (NIR - VIS) / (NIR + VIS)$), we could easily discriminate between areas with dense vegetation coverage ($0.6 < NDVI < 0.9$, tree covered) and areas with low/zero vegetation cover (cultivated areas or bare soil areas). Starting from the HRS2 images and using the raster algebra of the SNAP (Sentinel Application Platform), the NDVI was derived and the corresponding raster file was generated for the TAs. The vectorization of the raster file generated a vector file of polygonal elements

that were classified according to the NDVI. The 10m spatial resolution of HRS2 scenes allowed the identification of long and narrow polygons corresponding to the crowns of trees. The THRs in the two TAs were identified and confirmed by the photo interpretation, subsequently the THRs have been validated by comparison with the field GPS surveys. This procedure was applied throughout the study area to estimate the incidence of THRs per hectare. We also collected samples for yield estimations of crops adjacent to THR, along four transects (25m long) for each ES, two of which being under the influence of tree crowns, at increasing distances from the tree rows. During the summer 2017, we collected five wheat samples from each transect, amounting to a total of 20 plots per site (each one measuring 1 m²). 24 hemispherical photos were also taken along the four transects of each ES. Using these photos, we estimated the light transmission during the growing season in relation to the canopy structure of the tree rows, indirectly calculating the effect of the trees' shade on crops. We used the Gap Light Analyzer software to analyze the digital hemispherical canopy photos.

Our results show that, in the study area, the 14% of the total fields' perimeter is covered by THRs dominated by oaks, consisting mostly of adult trees with a high aesthetic added value. The linear density of THRs is variable, amounting to an average value of 67 m / ha. The existing THRs along the field boundaries also play an essential ecological function, connecting the otherwise fragmented forest patches. The effects of the trees on the yield of wheat as an adjacent crop were inconclusive, but they indicate that these effects were at least not entirely negative. To assess the conceivable effects of the THRs on crops in greater detail, further studies with an increased number of transects should be performed.

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Sofiane Tahraoui, Mounira Ouarzeddine

Surface Moisture content Retrieval over Vegetated lands

Water content data of the land next to plants is quite important in the follow-up process of the phenological cycle. The basic idea in this study, is to employ a decomposition-based Volume/surface discrimination approach which is aimed at quantifying the moisture content in classified pixel as bare soil neighboring vegetation.

As the scattering of electromagnetic wave from surface is well document to be affected by the dielectric constant which in turn is linked to the moisture content of the target per unit volume.

This property is efficiently used to perform the retrieval of water content from using only the surface scattering component, once the volume scattering contribution is removed.

The outputs are 2D maps showing the spatial (and temporal) variation of the moisture. The algorithm was tested for different window sizes to investigate the effect on the classifier performance.

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Imane Serbouti, Mohammed Raji, Hakdaoui Mustapha

Contribution of spatial multi-sensor imagery to the cartography of structural lineaments: case study of the Paleozoic massif of Rehamna, Morocco

Lineaments constitute an interesting approach in the geological mapping and the exploration of resources such as minerals, energy, groundwater, etc.

The remote sensing technology occupies an important place in the detection of structural lineaments, due to strong advances in using data and methods that enable us to exceed the usual classical procedures and achieving more precise results.

The aim of this work is combining and comparing the different techniques of the automatic extraction of lineaments in the Paleozoic massif of Rehamna located in the western Moroccan Meseta.

In the first step, four derived images were generated from frequential directional filters in all possible directions (NS, NE-SW, EW, and NW-SE), of the colored composite and the principal component analysis (PCA) of Landsat 8 OLI. These filters increase the contrast in the image and allowed mapping a large number of lineaments.

In the second step, the lineaments were extracted automatically by using level 1 GRD (Ground Range Distance) of Sentinel 1, according to IW mode with the polarizations (VH) and (VV).

The third step consists in using 8 azimuth angles (45° - 90° - 135° - 180° - 225° - 270° - 315° - 360°) of the shaded relief images that were generated from the DEM of radar interferometry with the resolution of 13m, made by two Single Look Complex (SLC) of sentinel 1 images, and the DEM SRTM with a resolution of 30m.

The final map of automatic extraction of lineaments is compared with pre-existing geological data and Google Earth images to validate the methods used.

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Nicola Puletti¹, Mirko Grotti¹, Roberto Scotti²

Assessing accurate stem taper functions for poplar plantations

The value of wood and of different timber assortments can vary by a factor of ten thus, optimization of stems assortment is a key element in the wood products supply chain, particularly in plantations. 'Taper function' are commonly used in other countries to tackle this issue. In Italy this approach has not yet entered operational use. The functions are developed based on measures of stem diameters taken at different distances from the base. Such measurements are commonly taken felling the tree and using a tape meter and the tree caliper, clearly assuming some approximations. This research assesses the advantages, in terms of assortments evaluation, that can be obtained if the diameters at different heights are extracted adequately processing Terrestrial Laser Scanning (TLS) output. TLS data have been collected, in a poplar plantation, on 36 trees distributed on three stands with different plantation densities. Sensitivity of the models to stem eccentricity and plantation density will be tested, providing tools that will hopefully favour the diffusion of taper functions in operational environments.

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Sofia Hakdaoui

Multisource approach for monitoring spatial position and moisture/dryness surface information of water cavities of Imlily Sebkhats in southwestern Morocco

Sebkhats zones represent a wet depressions in desert environments, they are generally considered as floodable wetlands of great environmental interest strongly linked to numerous environmental issues such as climate change, water quality, wildlife habitat and the biodiversity. The studies carried out recently by our team in the Sebkhats of Imlily in the south of Morocco, have shown that these geomorphological structures often contain the marks of the last climatic variations in the Sahara. The Sebkhats of Imlily represents a zone of intrigue to scientists, for cause more than 160 permanent water cavities, 0.4 and 4.6 m deep and the water has a salinity between 24 and 350g /liter, however it hosts life, many animals and fishes had been reported during a scientific field trip in January 2009. For this study, optical and radar images are used to contribute to understand the functioning of the Sebkhats through the discovery of underground hydrological networks. These data had contributed to the updating of the recent geological map made in 2012, by the Moroccan geological service. The main objective is to investigate and evaluate capability of the complementarity of sentinel 2 data and SAR radar in this particular desert environment. Results have revealed that radar images are not only well suited to the study of desert areas, but also allow better monitoring of spatial position of water cavities in these flood zones. Their sensitivity to variations in slope of the topographic surface improves the geological and geomorphological analysis of these deserts zones.

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Reviewing ecological requirements for the main forest tree species in Italy

The future dynamics of forest species and ecosystems are dependent on climate change impacts and are related to forest management strategies. The main expected effects of climate change are a possible shift on average climatic values as well as variation in frequency, intensity, duration and timing of extreme events. The main aim of this work is to determine and describe the climatic requirements of forest tree species in Italy. While spatial tree-level data were retrieved from the National forest inventory, ecological drivers were extracted from the most recent maps of climatic variables available at national level. Data were analysed to describe the geographic distribution of the main nineteen tree species on the basis of current climate conditions. Finally, a novel dataset with new ecological ranges of the analysed species was proposed. Results were compared to existing literature to assess possible discrepancies and to allow a further review of national forest management policies.

Results highlighted that while the range proposed in literature turned out to be fairly adequate to describe the average requirements of the tree species, in particular extreme values (maximum and minimum) were available but poorly supported by empirical evidences. Indeed, this represents a critical issue for forest managers, being the margins of a distribution the key "zones" where climate change effects are expected stronger and unpredictable. Indeed, Italy is known to be located at the margins of a Pan-European framework. Therefore, the proposed new ranges might be an important starting point to spatialization of forest variables. In fact, in combination to biomass stock and ancillary information this information can be used to identify optimum ecological zones to deal with local or national needs and so to realized map of forest at high level of resolution. Finally, timber production and biodiversity hotspots are further examples of potential services delivered by forests and probably threatened by climate change effects.

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Aafaf El Jazouli, Ahmed Barakat, Rida Khellouk

Soil degradation mapping using GIS, Remote sensing and Laboratory analysis in the Oum Er Rbia high basin, Middle Atlas, Morocco

Soil degradation mapping is based on field observations, laboratory measurements and remote sensing data, integrated with quantitative methods to map the spatial characteristics of soil properties at different spatial and temporal scales to provide up-to-date information on the grounds. Since soil salinity, texture and organic matter play an important and vital role in the assessment of topsoil characteristics and soil quality, remote sensing can be considered an effective method for studying these properties. Therefore, it would be advantageous to be able to map the properties of the soil from one or more sets of satellite imagery data. The main purpose of this research is to assess soil degradation combining remote sensing data and laboratory analysis. To achieve this aim the study required soil samples which were collected at 50 locations in the Oum Er Rbia high basin in the Middle Atlas of Morocco. These samples were dried, sieved at 2 mm and analyzed in laboratory. Landsat 8 OLI images have been analyzed using physically-based or empirical methods to derive soil properties. Moreover, remote sensing can be used as a data source supporting. The potential deterministic (Spline and Inverse Distance Weighted) and probabilistic (Ordinary Kriging and Universal Kriging) interpolation methods were used to produce maps of each textural classes and soil properties using a GIS software. As results a correlation has been found between soil texture and soil organic matter content. This approach developed in the current research will enhance the perspectives of using remotely sensed data for soil degradation mapping in arid and semi-arid environments.

Team of Geosciences and Environment, Sultan Moulay Slimane University, Faculty of Sciences and Techniques, Morocco

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Chiara Giuliani¹, Matteo Piccinno¹, Adrienn Veisz¹, Fabio Recanatesi²

Estimating vulnerability of Bracciano Lake using remote sensing data

The Italian Ministry of the Environment and Protection of Land and Sea with the Water Framework Directive (WFD) 2000/60/CE aims to achieve ambitious goals: avoiding deterioration of freshwater quality and quantity, improving water quality and promoting sustainable water use based on a long-term protection of available water resources. Caused of the concomitance of several factors related to progressive climate changes and increased in water subtraction of anthropogenic nature, drastic fall in level of Bracciano Lake was reported in the summer of 2017, when the water decreased 0,181 meters below the hydrometric zero established at 163.04 meters s.l.m. reaching greater criticality in November 2017 with a decrease of 0.198 meters s.l.m. Such alarming rate has not been seen in the last seventeen years.

The consistent change in the level of the water body causes modifications in its environment on the edge of the coasts and specifically, the decreased water level brings about an increase in the level of eutrophication, a process that mainly affects closed-basin lakes characterized by long time water exchange.

The determination of the volume of water contained in the water body was estimated with the GIS tools modeling the bathymetry of the Bracciano Lake and the application of the supervised classification using multispectral Sentinel-2 images, which allowed us to identify the reservoir and consequently to reconstruct the course of the coastline. Once defined the reduction of the water body for the observed period the Vollenweider model was used to quantify nutrients concentration and relative increase of eutrophication status as a consequence of the anthropic activities practiced in the belonging basin. Inizio modulo

The quantification of the change in the water volume of Bracciano Lake, before and after the water crisis that occurred in 2017, related to the estimate of the level of eutrophication, allows to define the degree of vulnerability of the lake ecosystem.

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Najam ul Hassan Syed^{1,2}, Mohd Nadzri Md. Rebaa¹, Dostdar Hussain³, Aftab Ahmed³

Spectral quality assessment of Landsat 8 and Sentinel 2 bands for glacier identification in Upper Indus Basin

Hindu Kush Karakoram Himalaya (HKKH) has 60,000 km² glacier that is responsible to world climate. Glacier studies in this region are hindered by inadequate knowledge due to inconsistent statistics and anomalies that vary with altitude. The stability of glaciers in the Upper Indus Basin (UIB) of HKKH is the major highlight and known for anomaly study. Despite of synoptic measuring schema offered by satellite sensors the quality of glacier anomaly estimate is always on debate and understudied. The advancement of optical space-based sensors onboard the Landsat-8 and Sentinel named Operational Land Imager (OLI) and Multi Spectral Instrument (MSI) respectively offers the potential future of glacier measurement in UIB. Therefore, this study envisages to assess the quality of OLI and MSI images in mapping the glacier anomaly by taking glaciers of Hunzza sub basin in UIB as target feature. The proposed methodology is based on acquisition of Landsat Enhanced Thematic Mapper Plus (ETM+) Level 1C and OLI Level 2 science data from the Earth Observation and Science (EROS) while for Sentinel MSI Level 2A data was derived using Level 1C through Sen2Core processor. Both OLI and MSI product were initially calibrated with lower production uncertainty of 3% than 5% of the raw ETM+. Glacier outlines were digitally delineated based on the Randolph Glacier Inventory (RGI 6.0) and the snow line altitude (SLA) was demarcated through contour of Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM) to differentiate between permanent snow and clear ice in the overall glacier polygon. Later the reflectance of each band was derived and thus the Normalized Snow Differential Index (NDSI) was computed through Sentinel Application Platform (SNAP). Complete statistics were applied in spectral quality assessment for each glacier parameter. Overall glacier surface exhibited range of reflectance about 0.08 to 0.12, 0.07 to 0.11 and 0.06 to 0.09 at blue, green and red band of OLI that was differed about 20%, 22% and 25% than that of MSI bands respectively derived from the maximum pixel frequency distribution of 200 to 800. This was no a case in infrared band in which both sensors agreed by the mean reflectance of 0.10. Reflectance correlation between both sensors derived a result of 0.7 to 0.9 at visible band and 0.5 to 0.6 at infrared one. This study suggested that the reflectance correlation of 0.43 to 0.47 allows clear discrimination between the clear ice and snow at 60% reflectance difference in single glacier by using OLI. Though there was an overlap of reflectance within 0.2 to 0.5 and 0.35 and 1.0 in MSI bands that has led to erroneous identification between clear ice and snow. To complement the results, NDSI of OLI indicated that combination with NIR and SWIR with 0 to 0.25 and 0.75 to 1.0 respectively become good indicator to distinguish different glacier features. Unlike OLI, NDSI of MSI was consistent in NIR and SWIR combinations with intensity of 0 to 0.1. Based on these results, it is clearly shown that OLI and MSI have promising capability to map glacier anomaly and both variants can be synergised for better interpretation in climacterically intrinsic high-altitude zone of UIB. Synergic operation provides great potential to reduce radiometric uncertainty, increase temporal revisit time and

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Jean-Francois Mas

Monitoring the growth dynamics of water hyacinth (*Eichhornia crassipes*)

The water hyacinth (*Eichhornia crassipes*) is a highly invasive aquatic plant native of South America. Its ability for growth and propagation causes huge conservation problems in many regions of the world. In Mexico, it is estimated that *E. crassipes* covers 40,000 ha of lakes, dams and canals. Some of the impacts of the water hyacinth in bodies of water are declines in pH, temperature, oxygen, nutrient levels and water flow and an increase of water loss by evapotranspiration.

In this study, PlanetScope remotely sensed images, provided by the Planet Education and Research Program, were used to assess the growth of the water hyacinth in the dam of Cointzio, near the city of Morelia, in central Mexico. The PlanetScope constellation is composed by more than 120 micro-satellites which image the entire surface of the Earth with both high spatial (3 m) and temporal resolution (<https://www.planet.com>). The analysis showed that between June 2017, after the mechanical removal of the weeds, re-invasion began to emerge in September. In April 2018, 200 ha (45% of the dam superficie) was covered by water hyacinth. Based on field measurement, density of 200 tons per hectare was found. These water hyacinth infestations are related with pollution from agricultural runoff and rural and urban drainage. However, water hyacinth can be used for the removal of pollutants.

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Saiful Azim

Assessing the opportunity to geo-reference UAV Ortho-mosaics through open source software to improve the spatial accuracy for it's use to Precision Agriculture Research

The use of unmanned aerial vehicle (UAV) in precision agricultural research is relatively widespread. The UAV platforms proves a high flexibility of use, optimized operational costs and high spatial resolution down to less than a centimeter. The higher the spatial resolution, the better details can be distinguished in images but higher spatial accuracy also matters to utilize the higher spatial resolution properly and this higher spatial accuracy mostly depends upon the image processing techniques. In this process, the spatial accuracy depends on internal and external orientations of the camera. Current photogrammetry software makes it possible to produce ortho-mosaics with high spatial resolution under the conditions that input images are supplied with accurate geo-information or ground control points are used. But Geo-tagged UAV images and GCPs with high spatial accuracy are both associated with extra costs for users of low-cost consumer UAVs. In an attempt to reduce costs needed for RTK-GPS measurements, ortho-mosaics produced on the basis of UAV images with low accuracy GPS information can be corrected afterwards by manually geo-referencing the ortho-mosaics using ground features from reference maps. This geo-referencing can be done by Geographic Information System (GIS) and Remote Sensing (RS) software as processing tools, and satellite images with visible ground features can be used as references. Commercial GIS software, however, are also costly, which may just cast-off the financial benefit of using cheaper UAV. Therefore, it is relevant to do the geo-referencing using Free and Open Source Software (FOSS) GIS and RS software such as QGIS. This study wanted to assess this and want to understand that whether georeferencing with QGIS using satellite images and A-B lines can improve the spatial accuracy of high resolution UAV ortho-mosaics to make it useful for precision agricultural research without spending a much on high quality UAV or ground truth instruments. It considered other methods such as drones with RTK GPS (eBee RTK) and ground based RTK GPS measurement to improve spatial accuracy. Results from this study successfully identified geo-referencing with QGIS as a good method to improve spatial accuracy ranges between 87% to 93% and recommends it as a choice to the users who wants to use cheaper drones in precison agriculture reasearch to minimize cost.

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Maliheh Arekhi

Introducing a reliable method for the correction of the misregistered remotely sensed images

Spatially-referenced satellite images provide an extraordinary opportunity for long-term sub-pixel exploring earth's surface especially for Landsat 8 OLI (Operational Land Imager) and Sentinel 2 MSI (Multi-Spectral Instrument) images. In recent years, the images misregistration and offset between Landsat 8 OLI and Sentinel 2 MSI has been reported which is needed to be matched up geospatial images and also omitted especially in sub-pixel investigations such as time series monitoring studies and subpixel based investigations. In the present research "geoshift" function which is available in the "Landsat" package is introduced as a reliable and fast approach which match images effectively with just moving and changing images pixels vertically or horizontally in the X and Y axis without performing and wrapping images. Finally, users can reduce and omit the images misalignment by conducting "geoshift" function on images. Using this function will be a great revolution and assist to all satellite images users to perform sub-pixel images without doing image to image georeferencing which resample the pixel values and it can be used instead of image to image georeferencing method.

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UAV Digital photogrammetric analysis for soil erosion evaluation in the Rivo catchment

Introduction

Soil erosion is one of the major concerns of cultivated land. Its field measurement by means of fixed instruments such as equipped parcels is not easy to obtain due to elevated costs and the technical personal to be involved in a continuous and lasting way.

The recent development of photogrammetric UAV technologies is offering new opportunities for field survey and monitoring. This technology allows obtaining in a short time accurate and effective Digital Elevation Models (DEMs) with relatively simplicity. Moreover, the small dimensions and weights of UAVs make them easy to be transported also in rural areas where is possible to do frequent flights just after significant land cover changes and/or rainfall events. In general, fixed wing drones are particularly effective for remote topographic analyses of wide areas, but due to their elevated flight height are less suitable to obtain high-accuracy DEMs. Multirotor drones, instead, can operate very close to the ground surface maintaining a fixed position, therefore, are extremely suitable for producing high resolution DEMs and micro-morphological surface analyses.

Here we present the development of a simple, sensitive and inexpensive field method for the quantification of soil loss based on the use of a DJI Phantom 3 drone system. The goal is to produce high precision digital elevation models (DEMs) of the soil surface that is investigated monthly and after significant rainfall events. The volumetric quantification of soil erosion is evaluated by overlapping the high precision DEMs produced over time.

Study area

The study area is located in the southern Apennines, in the hilly, Adriatic sector of Molise region. Precisely, it falls in the headwater portion of the Rivo Stream basin, a small (80 km²) 6th order sub-catchment of the Trigno River, one of the three major rivers of this Region.

Prevailing clayey, marly and arenaceous rocks underlie the Rivo basin. Particularly, the arenaceous-pelitic successions of the Tufillo Unit and S. Bartolomeo Flysch, along with the clayey-marly terrains of the varicolored scaly clays referring to the Sannio Unit are dominating. Regarding the soil cover, Inceptisols are prevailing (63%), followed by Vertisols, Entisols and Mollisols. The Rivo basin is under the influence of a warm temperate, mediterranean climate with annual precipitations of 650 to 800 mm, and monthly temperatures ranging between 5 and 30°.

In the study area, crop cultivation is prevailing and typically represented by cereals and fodder that well reflect the traditional agriculture of the Molise region and, in general, of the Central-Southern hilly Apennines.

To apply the developed method, two parcels (test areas) have been taken into consideration, characterized by a surface area of approximately two hectares and average slope gradients of 40 to 50%. To monitor the precipitations, the study area has been equipped with a rain gauge station and data logger.

Materials and Methods

According to the developed methodological procedure, high-resolution aerial images have been acquired by a drone system (DJI Phantom 3) flying at low altitudes (10-20 meters) on test areas up to 2 hectares in size in order to assure a very high image resolution. For each test area, at least seven, homogeneously distributed GCPs (Ground Control Points) have been acquired by using a DGPS Trimble device.

The DJI Phantom 3 is equipped with a 3-axis stabilized camera that compensates for involuntary movements due to wind and system vibration, and a GPS module that records the position during photo shooting. The camera has a resolution of 12Mpx (4000x3000px) and a shutter speed between 8 and 1/8000 s. The Field of view angle is 94° (35mm equivalent) with an aperture of f/2.8. The range of ISO is 100 to 1600, but the ISO value was set to 100 in order to limit the noise in the photographs.

High definition 3D models (obtained from overlapping multi-photos) are generated by an algorithm called Structure from Motion (SfM). In this study, we used Agisoft Photoscan professional commercial software that implements the SfM algorithm. The SfM process follows a workflow:

- 1) Image matching: the images are aligned, and common points (tie points) are matched (in this way, also a rebuild of the camera orientation is obtained);
- 2) Construction of a dense point cloud from the orientation of the images and homologous points;

3) Building of the model by the triangulation of a dense point cloud and exportation as DEM.

For the assessment of model accuracy, ground targets with a size of 20x20 cm were used. Each target is composed of four 10x10 cm squares, each 10x10 cm square is composed of four 5x5 cm squares, etc., up to the smallest square size of 1.25x1.25 cm. Targets are black and white, and are easily recognizable in photos.

Results and conclusion

At the moment, three DEMs of the same area have been realized. In particular, the first two DEMs, were acquired just after few days characterized by absence of rainfall events. Comparing these two DEMs has been possible to better define the degree of accuracy of the method. The product of this procedure are DEMs with a spatial average resolution of 1.5 cm, and horizontal and vertical errors of about 3 and 4 cm, respectively. This resolution allows to easily investigate the development of rills and erosion forms at a smaller scale such as those related to sheet wash and raindrops impacts.

The developed method, based on the use of low-cost commercial drones, is suitable for the measurement of soil erosion, however requires extremely long time for data processing, therefore is time-consuming. In fact, in order to obtain good results with the SfM technique the forward overlap and side lap of photos have to reach at least 70-75% and 50-.60%, respectively, therefore a high number of photos has to be processed.

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David Moravec, Jan Kropáček

Total lake water storage on the Tibetan plateau from thermal satellite data

Tibetan Plateau, the largest high elevation plateau of the world is since recently in the focus of attention due to its marked influence on both regional and global climate. Various symptoms of climate change such as glacier down wasting and permafrost degradation have been pointed out in recent studies. Plateau is often referred to as 'The water tower of Asia' because it is the source of major Asian rivers such as Indus, Brahmaputra/Tsangpo, Salween, Mekong, Yangtze and Yellow River. A large part of the runoff generated by precipitation, snow and glacier meltwater terminate in endorheic (close basin) lake systems. The lake system of the Tibetan Plateau is the largest high elevation lake systems in the world. It contains hundreds of lakes, with 65 lakes having the area > 100 km². The information on the total volume of the lakes is not available. Bathymetric measurements were published only for several large lakes so far. In our approach, we aim at an estimation of lake volume based on the thermal behavior of lakes measured by satellite sensors with a coarse resolution such as Sentinel-3. In theory, the larger lakes warm up and cool down slower than the smaller ones due to the thermal inertia. The surface temperature should, therefore, reflect the lake volume. The known volume of several lakes should help to develop a functional relation that would allow the volume estimation of lakes.

Methods

We used Sentinel-3 thermal data to create a time series of surface temperature for 59 lakes in central Tibet for the season 2017-2018. Sentinel-3 is a constellation of four satellites operated in the frames of Copernicus program of the EU, the first Sentinel-3 satellite being launched in 2016. The data product SLSTR Level-2 LST with spatial resolution 1 km provides land surface temperature (LST) in Kelvins also for lake surfaces.

To define the lake extents we used The Global Lakes and Wetlands Database Level 1 (GLWD-1). This database encompasses shorelines of lakes with the area larger than 50 km². The inner buffer of 1 km from the shoreline has been excluded from the analysis to account for disturbing effects of the shore and for possible mismatches between the used datasets. We focused on an area in central Tibet covered by one Sentinel-3 scene. The area contains 59 lakes with size ranging from 51 km² to 1641 km². A time series was assembled from data of nine satellite overpasses on the descending orbit in the period from 30 July 2017 to 30 March 2018. The data from the descending orbit are acquired in the morning hours (descending node 10:00) and they are thus less affected by diurnal surface temperature oscillations. Mean temperature and standard deviations of the surface temperature were extracted for each lake from the SLSTR datasets and correlated with lake area which we use as a proxy of the volume in this stage.

Preliminary results

Due to a number of disturbing effects the correlation of LST with lake area is in general low. The highest correlation was found for the data taken on 15 November 2017. For this date, the temperature of studied lakes reached 0.51 °C with the standard deviation of 3.06 °C. The correlation $r = 0.27$ between lake area and the temperature is significant (with p -value = 0.041). Obviously, some smaller lakes were already frozen.

Discussion

Our results indicate a significant correlation between lake size and temperature just before lake freezing. In this period the lake tends to lose stable summer stratification of different temperature water levels. The cooled surface water started to be denser, sinks and mix all the lake's water during the process called autumn overturn. The LST starts thus to reflect the lake size.

Outlook

The key issue seems to be to find the right moment for the measurements when mixing of lakes is maximal. A finer temporal resolution would be of help in this respect.

Alternatively, passive microwave approach could be used for the measurement of LST. It could result in a better correlation with lake area this measurement corresponds to the temperature in deeper water layer and is thus less affected by diurnal temperature oscillation.

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Filiz Bektas Balcik, Baturalp Arisoy

Monitoring Spatio-Temporal Changes of Brightness Temperature in Istanbul

Dense construction zones, industrial centers, high-rise buildings, anthropogenic activities, asphalt and concrete surfaces have been associated with Urban Heat Island phenomena. This phenomenon is related with air quality, heat stress, environmental problems, heat related mortality and morbidity.

Thermal Infrared (TIR) remote sensing techniques have been widely used in urban climate studies. Brightness temperature calculated from radiance, is a key parameter and used to determine land cover and land use properties and urban heat island. The aim of this study is to determine the spatial and temporal differences of brightness temperature profiles of Istanbul using freely available 2009 dated Landsat 5 TM and 2017 dated Landsat 8 OLI & TIRs data. Selected study area, Istanbul is huge metropolitan city where the population increases rapidly every year. In consequence of this increase, land cover and land use is changing constantly. One of the biggest changing is about mass urbanization. Brightness temperatures were acquired using thermal bands of the images that detect and record the emitted energy from earth surface at 10.40-12.50 wavelengths. Band 6 used for Landsat 5 TM images and Band 10 used for Landsat 8 OLI&TIRs with 30 m resampled spatial resolution. Radiometric and geometric correction were applied to images. Calibrations were applied based on USGS website. Digital numbers were converted radiance values and then radiance values were transformed to satellite brightness temperature values using Top of Atmosphere spectral radiance, band specific thermal conversion constants from metadata. In the second step, Normalized Difference Vegetation Index and Index Based Built-up Index were calculated to determine especially green areas and artificial surfaces of city. After brightness temperature and remote sensing indices images were produced, regression analysis was done between BT&NDVI and BT&IBI and finally BT change detection was analyzed between the years of 2009 and 2017.

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Annamaria Nassisi¹, Clelia Iacomino²

Earth Observation Market Dynamic Changing and New Actors

The Earth Observation (EO) Market growth is driven by fast-developing and emerging governmental programs as well as the new small constellations. The emergence of these "low-cost" constellations has the potential to disrupt the market by opening up new services areas and application that requires high revisits and by offering data and solution at a lower price. New markets have been opened up by technological advances in small satellites beyond their traditional role of technology demonstration applications. Small satellites have given birth to a fresh set of new businesses, some of which have generated particular murmur in the venture capital community. Due to relatively low capital requirements, small-satellite efforts are also tapping into types of financing that have historically not been available to the space sector. Over the past few years, a large number of start-ups have entered in the space community; their activities are based on the use of relatively inexpensive small satellites, which enable these companies to provide today services almost equivalent to gigantic and heavy satellites launched by national space organizations. This kind of market presents some key characteristics of a potentially disruptive innovation: they are much simpler, cheaper and non-competitive in the traditional space market parameters. Disruptive technologies together with the new business model represents a new challenge for the industry, they can be envisaged as a part of a new trend which underpins global economic cycles, leading a prospect of growth potential in the long term. Small satellites show another way of thinking about doing space and a new approach in manufacture, operations, financing and risk management. Commercial data supply expected to go through a significant expansion, together with lighter of commercial resolution control, improving spectral and temporal resolution, the adoption of cloud/"big data" solutions that facilitate the utility of EO data to end-users, increased availability of venture capital funding and increased popularity of small satellites.

What will be the main market implications? Are we ready to reach this goal? The market dynamic changing and new actors are opening the gates for innovation and applications using satellite imagery driven by numerous other applications to support wider economic development, such as in infrastructure, engineering and natural-resources monitoring. North America remains by far the largest consumer of commercial EO data followed by Europe but other regions, such as Asia, are displaying a much stronger growth profile.

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Jan Kropacek, Tomas Kloucek

Rapid river aggradation in Ethiopia analyzed by a combination of historical aerial photographs and satellite images

Ethiopian Highlands is an area of rough relief formed by a deep incision of rivers in the uplifted plateau. A pronounced precipitation seasonality, thick mantle of weathered volcanic material and active tectonics are the major factors in the sediment transport processes in the area. Soil erosion especially gullying and mass wasting are the main sources of the transported material. We utilize historical aerial photographs and recent satellite images to analyze fluvial deposition processes in the Ethiopian Highlands.

We used the recently discovered archives of stereoscopic black and white aerial photographs of Ethiopia acquired during the Italian invasion and occupation of the country in the 1930's. The photographs were acquired from a low flying Caproni aircraft by Santoni system consisting of four cameras, one for nadir, two for low oblique and one for high oblique views. At each camera station, one image quadruplet with only tiny overlaps was taken. The stereoscopic overlap was achieved in the along-track direction. The photographs represent a unique testimony of Ethiopian landscape almost one century ago. We orthorectified blocks of up to about 40 image quadruplets using structure from motion (SfM) photogrammetry approach. The comparison of the historical aerial photographs with recent satellite images in Google Earth revealed a marked aggradation of a number of rivers draining the central part of the Ethiopian Highlands. Tributaries of the Blue Nile and rivers draining the rift escarpment via marginal grabens towards the rift valley feature the strongest aggradation intensities. This indicates highly active transport processes in the recent decades.

The evolution of the river beds since the 1980's was further investigated using a time series of Landsat images. The changes in the river bed width were highlighted by a numerical division of vegetation indices calculated from data for two dates. In an attempt to relate the aggradation pattern with landslide occurrence in the upstream areas we mapped the recent landslides in the area. Our observations suggest that in the study area the mass movements result in mobilization of the major part of material deposited in the downstream parts of the river beds. The marked river aggradation can be thus used as an indicator of the recent landsliding activity in the upstream part of the particular drainage basins.

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Marya Cristina Rabelo Lanza, Maria Cleofe Valverde Brambila

Effects of drought on family farm production in the State of Ceara, Brazil

The Ceara State is located in the Brazilian semi-arid and presents a climatic inconsistency, with the lack of regularity of rains, elevated temperatures. Thus, affecting the planning of the production of family farming. The study used data from IBGE and FUNCEME. The rice, maize and bean crops were chosen because they presented themselves with greater demands in the activity of family farming in Ceará. The municipalities with the highest family farming practice were identified through a previous analysis carried out by the author, based on data from the Agricultural Census (IBGE), such as the total area of agriculture, area of agricultural and non-agricultural families, and number of establishments family and non-family. We calculated variables such as: total family agriculture area (%) and number of family establishments per municipality (%) and from these, two municipalities were selected for the analysis of each type of crop. Subsequently, the connection of the quantitative data and the spatial basis, the spatial and temporal mapping of the amount of rice, beans and maize produced from 1990 to 2014 was elaborated. For the punctual analysis of the municipalities studied, daily rainfall was extracted from the website of the Cearense Foundation of Meteorology (FUNCEME). The determination of the years with occurrence of drought was calculated by a drought index called Standard Precipitation Index - SPI, that later the analysis made it possible to understand if a decrease in the quantity produced of a crop was related to the occurrence of the drought. The results pointed out the areas of greatest concentration of family establishments in the state of Ceará, and it was identified that municipalities with 90% to 100% of family establishments, mainly in the Sertão Cearense area, obtain 40% to 60% of total agricultural area per municipality. In the analysis of the data of the Drought Index (SPI), we highlight the years of strong El Niño 1990-1993 and 1997-1998 that caused severe droughts, and directly influenced the decrease of the quantity of rice (Aurora), beans (Alto do Santo and Canindé) and maize (Tauá). Also in almost all the municipalities studied it was evident the decrease of the rains from the year 2012 until 2014, as indicated by the SPI index with indicative of moderate to extreme drought, especially in the municipalities of Aurora, Tauá and Canindé, with the consequent fall in production of rice, maize and beans. Thus, with these calculations, it was possible to perform the exploratory analysis through graphs, which facilitated the perception of the development of the rainfall regime in the region, thus showing the months with higher and lower rainfall indexes. Thus, this information is expected to contribute to the adaptation strategies of rural farmers to variations in the level of precipitation, since severe droughts result in a reduction in agricultural production, influencing the urban and rural development of semi-arid municipalities.

Para a análise pontual dos municípios estudados foi extraída a chuva diária do site da Fundação Cearense de Meteorologia (FUNCEME).

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 Wednesday, 4 July - Friday, 6 July
 Poster Area - Chairman: Gherardo Chirici

Maria Teresa Melis¹, Francesco Dessì¹, Paolo Loddo², Claudio La Mantia², Stefania Da Pelo¹, Anna Maria Deflorio², Giorgio Ghiglieri¹, Binyam Tesfaye Hailu³, Khamisi Kalegele⁴, Benjamin Mwasi⁵

A new mobile application to expand land cover classification based on SENTINEL-2 imagery

This study is part of the EU H2020 research Project FLOWERED (de-Fluoridation technologies for improving quality of WatEr and agRo-animal products along the East African Rift Valley in the context of aDaptation to climate change). FLOWERED project aims to develop technologies and methodologies to manage the risks associated with high Fluoride water supply.

FLOWERED Project has developed an application for mobile officially called FLOWERED GeoDBApp. The app is devoted to the ground geodata collecting about land cover, land and water use, in order to finalize information derived from satellite imagery.

A land cover map originated from ESA Sentinel-2 data classification is available through the map frame with real-time navigation offered by GPS integrated device.

The study area covers three test sites located in Ethiopia, Kenya and Tanzania.

Regarding the Land Cover map, Sentinel-2 data has been processed as follows:

- I. Data selection: a multitemporal dataset has been selected in order to create composite images with the purpose to avoid any cloud lack.
- II. Data pre-processing: image normalization and cloud masking.
- III. Intermediate products: NDVI and SAVI time series were calculated.
- IV. Open Street Map data integration
- V. First Land Cover map derived from supervised and unsupervised pixel-based classification algorithms.
- VI. Land Cover map finalization with post-classification activities to address specific issues.

At the moment, Tanzania and Kenya localities have already been the target of specific field activity in order to perform following activities:

- FLOWERED GeoDBApp general testing, also with local network and carriers
- Land cover map check and validation
- Collection of observations about water use and fluoride presence

For both study areas, a total amount of 540 location points has been acquired.

Furthermore, data collection has been finalized with a large number of georeferenced and oriented pictures, 322 for Tanzania and 578 for Kenya respectively.

Field surveys have geared across all the study area in order to acquire the biggest variety of land cover classes.

During the survey, the team established contact with local people and authorities in order to introduce the FLOWERED project and in order to acquire some information especially regarding the water use and the fluoride presence.

Land cover map derived from Sentinel-2 image classification has attended field activities in two ways:

- Digital format version, inside the FLOWERED GeoDBApp, with the possibility of real-time navigation provided by the GPS device, integrated into mobile devices
- Hardcopy printed version, with the possibility of better, understand the large context and surrounding landscape and environment.

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Session General Poster Session
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Sergey Golovachev, Mstislav Dubrov, Vladimir Smirnov, Victor Volkov

The earthquake triggering of level up to a catastrophic one as the result of the powerful hurricane system specific motions over the active tectonic zone

Interrelation of tropical cyclogenesis in the Ocean-Atmosphere-Land System and seismic activity of the Solid Earth is disputed during decade.

The possible correlation of typhoons in the Pacific Ocean and dynamics of seismic activity has been analyzed, the typhoon and earthquake spatial and temporal connection was attempted to be ascertained and substantiated.

The report will include the analysis of statistical, spatial-temporal information of physical interrelation of indicated processes being among the most powerful and destructive geophysical phenomena.

We present the results of statistical analysis of ten-years 1997- 2007 series of the major earthquakes $M=8-9$, occurred in different regions of the Earth, and the most powerful tropical cyclones of 1-5 Category SSHWS, which happened in all basins of World Ocean this period.

The recurring regularity of occurring time of cyclones and sequential earthquakes has been found from the obtained data analysis.

It was observed the spatial-temporal cyclones chain looks as W-E or N-S swings over Pacific, Indo-Australian, North-American and other tectonic plates.

The daily dissipation energy of the most powerful tropical cyclone (hurricane, typhoon) is estimated to be the order of an energy of strongest earthquakes.

The analysis has shown that strong cyclones may induce the crust deformations of tidal strain values 10^{-8} at seismogenic depth, which are comparable with time dependent tectonic deformations, and are significant enough for a possible triggering earthquake mechanism be started up.

The analysis has shown that strong cyclones may induce the crust deformations of tidal strain values 10^{-8} at seismogenic depth, which are comparable with time dependent tectonic deformations, and are significant enough for a possible triggering earthquake mechanism be started up.

Because of rapid intensification process of tropical cyclogenesis in the Ocean-Atmosphere-Land System a wide range of earthquake precursory phenomena is being recognized in influencing geospheres (lithosphere, hydrosphere, ionosphere) and is available to be measured, registered at far distances up to 10^3-10^4 km.

These precursors of earthquakes (observed with the optimized combining of the precise ground-based instruments and satellite measuring technics) need to be actively investigated and applied.

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Elisa Rosciano, Ettore Lopinto, Luigi Dini, Laura Candela

The Italian ASI Sentinel Collaborative Ground Segment

The Sentinel Collaborative Ground Segment (GS) is the set of facilities that, at a national level, complements the Copernicus Core Ground Segment to support the national use (both institutional, private and commercial) of Sentinel data. The ESA provides the Collaborative Ground Segment of each State with the availability of data (on the basis of requirements and prior to the formalization of an agreement) through a dedicated and properly sized interface with the Core Ground Segment. The Italian Collaborative GS will have its own data acquisition systems in the near future (both sent directly from Sentinel satellites and relaunched by geostationary satellites through the system called EDRS) and thus the generation and distribution of data in (almost) real time will become possible. ASI, as National Point of Contact, performs the interface tasks between ESA and national users, coordinating the demand for data at the national level and ensuring distribution to the various institutional and commercial users. The final result of the project aims to have a system that initially includes the dissemination capacity of the Sentinel constellation products formed by satellites 1A/B, 2A/B and 3 but, once completed, that also allows reception, demodulation and processing of the products (both in terms of direct visibility of the satellites by the Matera station and by relay based on EDRS) in Near Real Time (NRT) mode and includes a processing-on-demand system that allows the testing and development of new applications and services. This system will provide computing capacity programmable by the user via the Web and adjacent to the product archive, in order to eliminate the latency of transfer, a key factor especially for test applications based on the Big Data paradigm. The end user of the system is therefore constituted by the Italian community of Sentinel users 1, 2, 3 interested in experimenting and implementing services and applications based on the availability in NRT conditions of a large volume of such data, disseminated through specialized interfaces and adapted to the needs of each of the expected user classes and including the ability to communicate directly between computers (M2M interfaces). The system is in an advanced stage of implementation and will be made available to users within the first half of 2018.

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Aikaterini Karagianni

Detection of water bodies using open access satellite data: The case study of Kastoria Lake in north-western Greece

Water bodies play an important role in the environment as a part of the hydrological cycle. Particularly inland lakes, enclosed water bodies surrounded by land with no direct access to the sea, are complex systems presenting an interaction of various processes (hydrological, geological, physical, chemical and biological). Their study requires the involvement of various scientific principles offering multiple information and could contribute to environmental and development issues. Among the scientific disciplines that are involved in the study of lakes and their surroundings, satellite data and remote sensing techniques could provide valuable information regarding detection and monitoring of water bodies. This paper concerns the wide area of Kastoria Lake (Lake Orestiada) in north-western Greece, an area of particular interest as the lake is included in the Natura 2000 network and is surrounded by diverse landcovers (built up areas and agricultural land). Optical, open access satellite data derived from Sentinel-2 are being used and digital image processing techniques are applied in order to detect the water surface. The products are resampled to an identical resolution and a water index is calculated in order to delineate open water features and enhance their presence in the optical imagery. Further digital processing concerns the creation of a water mask to extract the water information. Visual interpretation of the area using various band combinations and applying enhancement techniques is also being done, contributing to the detection study. Due to the spatial resolution of Sentinel-2 data, the water surfaces are discernible and the coastal areas around the water body are well delineated. Water index eliminates the presence of soil and vegetation features, highlighting the water surfaces (even those of smaller size) despite the build-up noise which can affect the index causing some misclassifications in areas with ratio similar to water bodies'. In general, the results are satisfactory at this stage and can be used for further monitoring of the lake with possible extensions to a wider region. The ability to detect and map water surfaces effectively, which is offered from open access satellite data, may be essential to a variety of scientific and civil applications.

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Giandomenico Foti, Pierfabrizio Puntorieri, Caterina Canale

River anthropization: case studies in Reggio Calabria (Italy)

The considerable anthropic pressure that has affected most of Italian territory in the last 60 years has altered natural conditions of coasts and river, thus increasing exposure to environmental risks. In fact, the increase in soil waterproofing caused a reduction in hydrological losses with a rise in flood flows (with the same rainfall conditions), especially in urban areas. Furthermore, buildings of hydraulic works in river basins caused a reduction in sediment transport to the coasts, with consequent generation or increase of erosive processes.

From this point of view, recent advances in remote sensing and geographical information system (GIS) techniques allow us to analyze morphological changes occurred in river and in urban centers, in order to evaluate the possible increases in environmental risks related to the anthropization process.

This paper describes the effects of anthropization process on some rivers in the southern area of the Reggio Calabria city (the Sant'Agata, Armo and Valanidi rivers). This is an heavily anthropized area due to the presence of the airport, highway and houses.

The analysis was carried out through the comparison of cartography data of the last 60 years, which consists of aerophotogrammetry (provided by IGM), orthophotos taken from the Open Data section of the National Geoportal and satellite imagery provided by Google Earth Pro.

From the analysis of cartographic data it is possible to observe that Sant'Agata River has been restricted and the airport runway has been extended passing above the river. Instead, Armo River was diverted due to the extension of the airport runway. Furthermore, over the years, the type of crossing of Valanidi River has changed since in the '50s it was crossed directly into the watercourse, while in the '80s a highway was built that crossed the river through bridges. Finally, currently the highway has been lowered in altitude and passes below the river itself.

The methodology described above is of interest in the fields of geohazard assessment and urban planning.

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Enzo Pranzini, Lorenzo Rossi, Irene Mammì

A comparison of UAV and high resolution satellite images for multispectral bathymetry estimation

Shallow water bathymetric surveys are widely used in studies supporting ICZM and Maritime Spatial Planning, such as coastal erosion monitoring, management and Oil&Gas projects.

Remote sensing derived bathymetric mapping using high-resolution multispectral satellite imagery, such as Quick Bird, IKONOS and Worldview 2 and 3 are increasingly used, and the various remote sensing techniques are here discussed, tested and implemented.

The present study shows the results of a comparison between high resolution satellite and Unmanned Aerial Vehicle-(UAV) derived bathymetry. The UAV was equipped with a new multispectral camera (MAIA), acquiring in the same spectral bands of the WorldView-3 sensor.

The study area is about 0.5 km² and located in south of Tuscany Region (Italy).

Worldview-3 multispectral images were processed to retrieve bathymetric data with Stumpf algorithm that uses a ratio of reflectance to retrieve depths from imagery even in deep water (> 25 m). Further, different algorithms were used in order to obtain a better accuracy. Several AUV derived bathymetric maps were produced to investigate also how sea bottom truth points density influences the map accuracy.

A hydrographic survey was performed with a Multibeam echosounder (MBES) and a Side Scan Sonar echo sounders in order to better highlight the seabed morphology. A very high resolution 3D model were processed at the selected site in order to calibrate both satellite and UAV images and verify the accuracy.

Because of the high percentage of water present in the UAV images, a correct computing of bundle adjustment was impossible by the software in order to produce a georeferenced mosaic orthophoto.

A new method was here experimented using some buoys as GCPs and recording their position with onboard GPS at the time of the UAV overpass.

The aim of this study was to obtain a bathymetric map with lower operating costs and easy processing data and to investigate the possibilities to develop a monitoring system for the shallow water based on UAV survey.

The advantages of the UAV derived bathymetry compared to the high resolution satellite images are the lower cost, the possibility to acquire the images at the desired date, a variable flight altitude and spatial resolution and the unnecessary of performing any atmospheric corrections.

The end product is an automated bathymetric mapping method capable of a 0.5 m² spatial resolution and a vertical accuracy decreasing with the depth, errors in depth measurements are quantified.

The proposed methodology can become a useful cost-effective tool also for supporting coastal management and for regular monitoring programs of sensitive coastal areas. Another important advantage is the capability of filling the gaps for a 100% bathymetry coverage in very shallow water areas, under the 3 m depth, where MBES are usually unable to work properly.

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Meriam Mohajane¹, Ali Essahlaoui², Fatiha Oudija¹, Mohammed El Hafyani², Abdellah El Hmaidi², Giovanni Randazzo³, Ana C. Teodoro⁴

Vegetation change analysis using Landsat data in Azrou forest, the Central Middle Atlas of Morocco

The vegetation indices estimated through remotely-sensed images are important to change detection in forest ecosystems. Normalized Vegetation Difference Index (NDVI) is the most popular index in forest classification and land cover/land use (LCLU) change studies. The goal of this study was to use NDVI to describe the vegetation change of Azrou Forest in the Middle Atlas, Morocco. To achieve this, a set of Landsat images including: one Multispectral Scanner (MSS) scene from 1987; one Enhanced Thematic Mapper Plus (ETM+) scene from 2000; one Thematic Mapper (TM) scene from 2011 and one Landsat 8 Operational Land Imager (OLI) scene from 2015) were acquired and processed. After NDVI was computed and classified in order to produce land cover maps for each year. Three classes were considered by the classification of NDVI value, which were: bare soil (NDVI<0.2); bare soil and vegetation (0.2<NDVI<0.5) and vegetation only (NDVI>0.5). The results from the Landsat-based images analysis show that the area of bare soil was decreased from 18.6 to 0.34 percent over the past 30 year. While, in 2015, the class of vegetation only was increased to 73.03 of the total area of study area. The results of this study show that the total forest cover remained stable. The present study highlights the importance of NDVI index for better understanding the changes that have occurred in this forest ecosystem.

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Francesca Giannetti, Sofia Martini, Sabrina Raddi, Alberto Maltoni, Andrea Tani, Gherardo Chirici,
 Davide Travaglini, Barbara Mariotti

Is it possible monitoring plant physiological condition with a Near Infrared Consumer digital camera in forest nursery stock?

Monitoring plant physiological status is a fundamental tool to understand the relationships among environmental conditions and vegetation productivity and health, especially in Mediterranean areas where the intensity of dry periods is increasing. Therefore, the development of new methods to monitor plant physiology is a key point to strengthen new strategies for forest restoration projects in a context of climate change.

The recent availability of Near Infrared (NIR) Consumer Digital cameras has opened the possibility to improve in a cost-efficient manner the development of new methods to assess plant physiology without sophisticated instruments such as spectrometer and fluorimeter. NIR cameras are recognized by remote sensing communities as a cost-effective method to monitor vegetation health over large area. Several authors have demonstrated that these cameras provide highly detailed data of single plant in forest monitoring conditions thanks to the times series acquisitions. Therefore, what happen if the NIR Cameras are used to assess the physiological condition of forest seedlings in nursery and in the planting season?

The present study aims to test the possibility of monitoring physiology of seedlings by NIR camera images (i.e. CANOM S110 NIR) comparing the results with the ones obtained by spectrometer and fluorimeter (i.e. USB-2000 Ocean Optics and PAM-2000 Walz). The final objective is to evaluate if in future NIR camera can be a reliable tool to assess seedling physiological status both in nursery and after planting.

We carried out two experiments, in greenhouse and in field, on seedlings coming from the same nursery stock grown in 2017. We present the preliminary results of the "speed water-stress test" under controlled greenhouse conditions by exposing *Quercus* seedlings (*Q. ilex*, *Q. pubescens*, and *Q. robur*) grown in two substrates (peat and coconut fiber) with three fertilizations (nursery standard; phosphorous-enriched; and potassium-enriched) to three water stress levels: control (field-capacity irrigation), medium (50% of control irrigation) and strong (water-suspension).

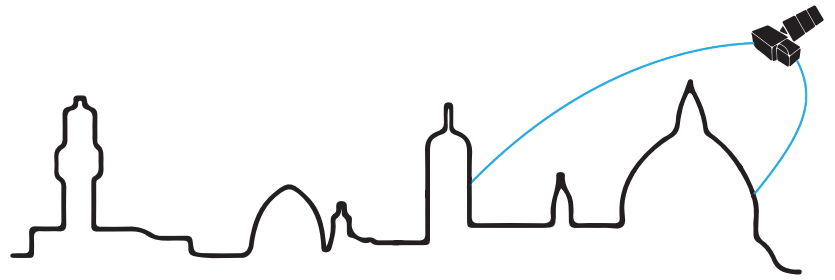
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Ziwu Pan

Research on hyper-spectral identification of altered minerals in Yemaquan West Gold Area, Xinjiang

Because of hydrothermal ore-forming Solution, most of endogenetic deposit has pyrite mineralization, sericitization, carbonizations etc alteration phenomena. Most of altered rocks have major $\text{Fe}^{3+}\text{OH}\text{CO}_3^{2-}$, these ions have unique diagnostic features spectrum belt in the electromagnetic spectrum. Based on Hyper-spectral resolution, Combined with the distribution of the study area of wall rock alteration and mineral white mica, respectively sericite, chlorite, epidote, kaolinite, hornblende, montmorillonite, limonite, hematite that eight kinds of typical mineral analysis. Remote sensing prospecting prediction was developed based on the hyperspectral alteration mineral mapping and remote sensing anomaly sieving, combined with Geological characteristics and abnormal mineral field verification. Established on the high spectrum prospecting model of research area, preferable ore-finding areas have been delineated, it pointed out the direction and destination for geology and mineral resources survey.

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