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## **The use of remote sensing for landslide studies in Europe**

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The existing remote sensing techniques and their actual application in Europe for landslide detection, mapping and monitoring have been investigated. Data and information necessary to evaluate the subjects have been collected through a questionnaire, designed using a Google form, which was disseminated among end-users and researchers involved in landslide. In total, 49 answers were collected, coming from 17 European countries and from different kinds of institutions (universities, research institutes, public institutes and private companies). The spatial distribution of the answers is consistent with the distribution of landslides in Europe, the significance of landslides impact on society and the estimated landslide susceptibility in the various countries.

The outcomes showed that landslide detection and mapping is mainly performed with aerial photos, often associated with optical and radar imagery. Concerning landslide monitoring, satellite radars prevail over the other types of data followed by aerial photos and meteorological sensors. Since subsampling the answers according to the different typology of institutions it is not noticeable a clear gap between research institutes and end users, it is possible to infer that in landslide remote sensing the research is advancing at the same pace as its day-to-day application. Apart from optical and radar imagery, other techniques are less widespread and some of them are not so well established, notwithstanding their performances are increasing at a fast rate as scientific and technological improvements are accomplished. Remote sensing is mainly used for detection/mapping and monitoring of slides, flows and lateral spreads with a preferably large scale of analysis (1:5000 - 1:25000). All the compilers integrate remote sensing data with other thematic data, mainly geological maps, landslide inventory maps and DTMs and derived maps.

Concerning landslide monitoring, the results of the questionnaire stressed that the best results can be obtained combining remote sensing with ground based networks data and in field observations, as this can allow defining the deformation patterns of a landslide and its relationship with the triggering conditions .

According to the research and working experience of the compilers, remote sensing is generally considered to have a medium effectiveness/reliability for landslide studies. Moreover this depends also on how remote sensing is used: an increase in the number of used remote sensing data type (aerial photos, satellite optical, satellite radar etc.), corresponds to a growth of the degree of effectiveness/reliability.

In general the number of parameters detectable through remote sensing is linked to the number of techniques employed: an increase in the number of measured parameters is related to an increase in the number of the techniques used, both for monitoring and for detection/mapping. Many answers reported the possibility of detecting more than one parameters by only using radar technologies: this could be considered as an indicator of a better efficiency of radar with respect to optical techniques.

The results of the questionnaire thus contribute to draw a sketch of the use of remote sensing in current landslide studies and show that remote sensing can be considered a powerful and well established instrument for landslides mapping, monitoring and hazard analysis and highlight that a wide range of available techniques and source data can be approached depending on the size and velocity of the investigated phenomena