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Complex data management for landslide monitoring in emergency conditions

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Urbanization, especially in mountain areas, can be considered a major cause for high landslide risk because of the increased exposure of elements at risk. Among the elements at risk, important communication routes such as highways, can be classified as critical infrastructures, since their rupture can cause deaths and chain effects with catastrophic damages on society. The resiliency policy involves prevention activities but also, and more importantly, those activities needed to maintain functionality after disruption and promptly alert incoming catastrophes.

To tackle these issues, early warning systems are increasingly employed. However, a gap exists between the ever more technologically advanced instruments and the actual capability of exploiting their full potential. This is due to several factors such as the limited internet connectivity with respect to big data transfers, or the impossibility for operators to check a continuous flow of real time information.

A ground-based interferometric synthetic aperture radar was installed along the A16 highway (Campania Region, Southern Italy) to monitor an unstable slope threatening this infrastructure.

The installation was in an area where the only internet connection available was 3G, with a limit of 2 gigabyte data transfer per month. On the other hand interferometric data are complex numbers organized in a matrix where each pixel contains both phase and amplitude information of the backscattered signal. The radar employed produced a 1001x1001 complex matrix (corresponding to ~7 megabytes) every 5 minutes. Therefore there was the need to reduce the massive data flow produced by the radar.

For this reason data were locally and automatically elaborated in order to produce, from a complex matrix, a simple ASCII grid containing only the pixel by pixel displacement value, which is derived from the phase information. Then, since interferometry only measures the displacement component projected along the radar line of sight, data needed to be re-projected. This was performed by dividing the ASCII grid by a correction matrix, where every element of the matrix was the percentage of the actual displacement that was measurable by the radar; such percentage can be obtained with trigonometrical arguments knowing the position of the radar and the direction of movement of the landslides (which, in our case, corresponded with the slope direction) thus enabling the calculation of the radar line of sight.

To further reduce the size of the grids, they where cropped in order to contain only those pixel where relevant information could be extracted.

The ASCII grids where also averaged to reduce noise, so 8-hours and 24-hours averaged grids were obtained. According to the early warning procedures that were defined, during periods characterized by low or null slope movement, only 8-hours and 24-hours data where transferred, together with the last displacement measurement of a reduced number of control points.

The transfer was performed after transforming the grids into strings and by sending them through a middleware to the Data Acquisition and Elaboration Centre, where control points displacement values where compared with warning thresholds and the grids where projected on a GIS environment as 2D displacement maps.