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## From Sentinel-1 data processing to field survey: an operating workflow for the continuous monitoring of the Earth surface deformations

**Davide Festa**, Pierluigi Confuorto, Matteo Del Soldato, Silvia Bianchini, and Nicola Casagli  
University of Firenze, Department of Earth Sciences, Via La Pira 4, Firenze, Italy (davide.festa@unifi.it)

The launch of the Sentinel-1 constellation by the European Copernicus Program, primarily devoted to scientific community research, has allowed acquiring huge volumes of radar images with worldwide coverage and a short temporal sampling (12 days reduced to 6 days thanks to their position at 180° in the same orbit). The systematic collection of imagery and the repeated processing of each new pair of images acquired opened the unprecedented possibility of conducting a continuous monitoring of Earth surface deformations, such as subsidence and slope instabilities over different geomorphological settings. At present, Tuscany, Veneto and Valle d'Aosta regions (Italy) are benefiting from systematic Sentinel-1-based monitoring of geological and geomorphological hazards. The promising outcomes so far obtained constitute a decisive step towards near-real-time monitoring and therefore a valid support for geohazard risk management activities. Retracing the pattern set by the encouraging results from the three Italian Regions, an operating workflow chain is proposed in the framework of an operational monitoring service, from the collection of satellite images to the possibility of conducting field surveys. The procedure is based on 4 different steps: i) continuous collection of Sentinel-1 images, constant data processing through an MT-InSAR (Multi-Temporal Interferometric Synthetic Aperture Radar) technique and exploitation of a data-mining algorithm able to retain only meaningful Measurement Points (MP) in terms of abrupt change of displacement rate; ii) radar-interpretation of the filtered MP for the detection of the possible causes of the anomalies through the use of ancillary informative layers or pre-existing databases; iii) dissemination of the relevant radar-interpreted information to hydrological risk managing actors by a direct alert or periodic bulletins; iv) field investigation, preliminary risk assessment and possible remedial works design. The procedure was successfully applied gathering evidence of its usefulness in practical terms. The cases of the Bosmatto landslide (Valle d'Aosta Region) and the case of the Zeri Landslide (Tuscany Region) which belong to two alpine and apennine environments, respectively, are reported. In the first example, in response to a relevant acceleration interpreted from the MP available on the area of interest, an alert was sent to the regional officers who increased their awareness related to the risk posed by the Bosmatto Landslide. In the second example, a monitoring bulletin which is periodically delivered for the Tuscany Region pointed out the meaningfulness and persistency of anomalies identified in the Zeri municipality. This led the regional authorities to conduct a site investigation oriented to the assessment of preliminary risks. The presented results highlight the effective

benefits-cost ratio, the high precision and the short amount of time required to complete the procedure representing a best practice for the early detection of ground deformation events.