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Sentinel-1 data promote a more effective and affordable use of multi-temporal interferometry in slope instability detection and landslide monitoring

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Landslides and potentially unstable slopes are present in almost every country of the globe. Moreover, the population growth, with increasing impact of humans on the environment and the urbanization of areas susceptible to slope failures implies that landslide hazard mitigation only via traditional engineering stabilization works and in situ monitoring is no longer considered economically feasible. Given the global dimension of the problem of slope instability, a sustainable way towards landslide hazard reduction seems to be via increased exploitation of affordable remote-sensing systems, with focus on early detection, long-term monitoring, and possibly early warning. In particular, satellite-based remote sensing, and especially the synthetic aperture radar (SAR), multi-temporal interferometry (MTI), has great potential thanks to the wide-area coverage of space-borne sensors, day/night image acquisitions and the capability to provide high precision (mm-cm), spatially dense (from hundreds to thousands points per km2) measurements of slow displacements of the ground surface. In this context, Sentinel-1 A/B (S-1) twin satellites of the European Space Agency (ESA), launched in 2014 and 2016, are now providing truly global capacity for innovative, research-oriented and practical MTI applications, such as mapping, characterizing and monitoring of landslides. The regularity of S-1 acquisitions, timeliness of data delivery, increased revisit frequency (days) and the resulting high coherence, as well as the availability of free imagery, facilitate a more effective and innovative use of MTI.
The main aim of this work is to compare and assess the potential of MTI based on S-1 data in slope instability investigations with respect to MTI relying on the earlier C-band sensors (ERS and ENVISAT), as well as the high resolution X-band sensors (COSMO-SkyMed, TerraSAR-X). This is done by considering different areas characterized by a wide range of geomorphic, climatic, and vegetation conditions, with case study examples of local to regional scale MTI applications comprising hill slopes in the Apennine Mts. (Italy) and in the European Alps, and unstable slopes in two large open-cast mines of Central Europe. The results show that, by using S-1 data, MTI can now be more effective and affordable in long-term slope/landslide monitoring, early detection of slope instability hazard, and (in some cases) in slope failure early warning.

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