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Fast-moving landslides mapping contribution using Sentinel-2

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According to the World Atlas of Natural Hazards (McGuire, 2004), landslides are the most frequent and widespread natural hazard on Earth. They can occur on any terrain, particularly hilly and mountainous areas and mostly given the suitable conditions of soil or bedrock, groundwater, and the angle of slope (Varnes, 1978). Landslides can be characterized by low probability of evolution into a catastrophic event but can have very large direct and indirect impacts on man-made structures (Klose et al., 2014). Mapping of existing landslides in areas of known slope instability produces maps that can potentially deliver knowledge for landslide risk management strategies. Landslide activity maps represent a shortcut in the assessment of the hazard related to slope movements (Parise and Wasowski 1999), and show the areal extent of slope subject to failure, probable maximum extent of ground movement and highlight areas where more detailed studies should be conducted.

“Traditional” ground motion monitoring methods are based on field surveys. These methods include mainly geodetic/levelling measurements and Global Positioning System (GPS) networks, extensometers etc. However these methods of ground deformation monitoring except that provide information only about a few points present furthermore many disadvantages, such as high costs, time consuming and most of the monitoring systems require installation by experts of special equipment which in many cases is impossible nor are they able to produce knowledge of the past (retrospective products).

Earth Observation (EO) satellites, a non-invasive source of knowledge, host a diverse range of sensor types that utilize different parts of the electromagnetic spectrum (optical and radar sensors), a very rich archive of scenes and different techniques to provide a range of measurements from space offers several opportunities to map and monitor natural and human-induced Earth hazards from space (Cigna, 2018). Specifically, for landslides the ability to quantify them from space using repeat imagery depends, in principle, on the precision of the method used, the total displacement between two data acquisitions, the rate of displacement, and the existence of corresponding features in phase data (for radar) or amplitude data (for radar and optical sensors) that can be tracked over time (Delacourt et al., 2007, Kääb and Leprince 2014). Since 90’s differential repeat-pass interferometry radar (DInSAR) based on SAR images processing has proven an interesting tool for the measurement and observation of ground deformation (Massonnet and Rabaute., 1993). The basic idea of the method is the analysis of the phase of the reflected wave radar from two or more images which cover the same region to observe ground displacement.

In recent years using large stacks of SAR images acquired over the same area, long deformation time series can be analysed using multitemporal differential SAR interferometry techniques which overcomes several limitations of repeat-pass interferometry. These coherent methods exploit either permanently coherent Persistent Scatterers (PSs) or temporally coherent Distributed Scatterers (DSs) known by names Persistent or Permanent Scatterer Interferometry (Ferretti et al., 2001, Werner et al., 2003) and Small Baseline Subset (Berardino et al., 2002) Both techniques have been widely applied for monitoring of slope instability with millimetric precision (Raucoules et al., 2013, Casagli et al., 2017). The most important advantage of the method is the ability to construct maps of yearly rates of ground displacement or the change to the rates. Nevertheless, significant difficulties are found when using this technique. These difficulties are related to the large variability of slope (steep and rough topography typical of landslide-prone areas) instabilities in terms of mechanisms of movement, failure geometries, size of unstable areas and deformation rates causing phase ambiguity problems and signal decorrelation. Additionally, in regions with strong topographic relief presented local atmospheric variations can in many cases lead to strong atmospheric phase artifacts; all these parameters , often obstract the interferometric pre-processing, making it difficult to estimate surface displacements (Hanssen 2001, Delacourt et al., 2003, Strozzi et al. 2005).

Monitoring and measurement of landslide activity using optical satellite sensors is also an efficient method which has been used since the end of 70’s (Sauchyn and Trench 1978) mainly based on visual interpretation.The increasing of Very High Resolution (VHR) optical sensors, since beginning of 2000, led to the increase of new methods to monitoring land motion including landslides although that optical images are strongly dependent on atmospheric conditions. The methods can be split into two categories, pixel-based and object-based, both containing techniques applicable to single and multi-temporal images and frequently making use of additional data. In recent years and from the beginning of the anvailability of high resolution optical data different methods with processing differentiation and in order to improve the accuracy of the measurements under different conditions have been developed.

The current research work aims to examine further contribution of medium resolution of free optical satellite images and specifically Sentinel 2 in the mapping of landslide of moderate and/or rapid velocity of travel regardless of the cause induced them in three different area specifically in USA (Yakima County, WA), Italy (Ponzano, Central Italy) and Greece (Amyntaio, Northern Greece). Also validate the results based on knowledge derived from other sources of knowledge. For the purpose of this study the normalized cross-correlation (NCC) method of image matching was used (Debella-Gilo and Kääb 2010, Heid and Kääb, 2012).