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World Centre of Excellence (WCoE-2017-2020)
Progress Report Form 2017

29 May 2017 to 31 December 2017

1. **Short Title of WCoE**: Advanced Technologies for LandSlides (ATLaS)

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4. **Progress report of activities up to 31 December 2017 (up to 30 lines)**

The research activities, in the framework of the proposed WPs, are described below:

WP1: *Ground-based SAR interferometry for landslide monitoring and development of reliable procedures and technologies for early warning*.

The DST-UNIFI continue its monitoring activities of unstable slopes in order to estimate their spatial and temporal evolution and to implement increasingly effective early warning systems (EWS) according to variable critical situations. Through the application of the most up-to-date GB-InSAR technology (latest generation system with "on-fly" acquisition methods), a systematic plain of activities was developed on the slopes of Stromboli volcano with the intention of contributing to the growth of knowledge and methods useful for assessing dangerous scenarios associated with gravitational slope phenomena typical of this geological

environment. The activity focused on the acquisition and analysis of data of the NE of "Sciara del Fuoco" slope and of the NE sector of the crater area using two independent GB-InSAR devices: one installed at an altitude of 400 m asl and another one positioned at an altitude of 190 m asl. The fields of view of the two GB-InSAR systems are partially overlapped, ensuring data redundancy in the most critical area. In this framework, we analyzed the extrapolated information both individually and in a coupled way before the integration with other external data. For example, by comparing the results of the stability analysis both in static and dynamic conditions with all the areas monitored by the GB-InSAR systems it was possible to define the criticality levels along the subaerial flank of Sciara del fuoco, in order to define the tsunamigenic potential (and therefore the volumes) of those portions characterized by anomalous speed. Furthermore, a specific tool was developed that allows calculating areas and volumes involved in the material acceleration. After the identification of an area with anomalous deformations, the software establishes its extension in pixels (by manually drawing it on the interferogram), the maximum length, the width and the corresponding area in square meters. Through an empirical relationship that approximates the estimated depth of the landslide to 10% of the maximum width of the area, it is possible to obtain the volume involved in the gravitational process.

WP2: *EO (Earth Observation) data and technology to detect, map, monitor and forecast ground deformations.*

Research activities within WP2 were dedicated to increase the exploitation of satellite remote sensing data for the identification (detection and mapping), analysis and monitoring of landslides in order to define proper risk scenarios and to support the management of their evolutionary phases. Activities were performed at different scales of investigation (from local to regional) and at different geological contexts using advanced processing techniques and interpretation of data derived from satellite images acquired by old and new systems. In order to optimize this satellite surveillance procedure during forecast, emergency and post-emergency cycles, the performed activities were concentrated on:

- Exploitation of phase (through multi-temporal interferometry) and amplitude information (through speckle tracking techniques) of the TerraSAR-X SAR (Synthetic Aperture Radar) images to detect and map the area affected by the complex landslide of Ponzano in Abruzzo Region, Italy collapsed on 12 February 2017. The results of the analysis allowed to *i*) detect and record precursory movements (in the order of 50 mm/yr) in and around the village of Ponzano, through the use of multi-temporal InSAR techniques and to *ii*) detect and measure the displacement field produced by the landslide failure on February 2017 (with several meter of displacement for large sectors of the landslide), using amplitude-based method;
- Exploitation of the potential of the new generation ESA (European Space Agency) Sentinel-1 constellation of satellites for the monitoring and kinematic characteristics of the Maoxian landslide occurred on 24 June 2017 in the Sichuan Province (China). The landslide, classified as a rock avalanche, buried 62 houses of the Xinmo village and claimed more than 100 people. Multi-interferometric results highlight the presence of active movements in the source area of the landslide above the Xinmo village. Analysis of displacement time series confirmed that the measured deformation rates are consistent with

the occurrence of precursory movements over a large sector of the slope affected by the 24 June 2017 landslide. A progressive acceleration starting in April 2017 is clearly visible in time series of deformation, leading to the failure of the landslide of 24 June 2017.

WP3: *Coupling of short-term weather forecasting with geotechnical modeling for shallow landslide prediction*.

The activity has focused on application of a physically based model, namely the HIRESSS (High REsolution Stability Simulator) model, to forecast the occurrence of shallow landslides at regional scale. The final aim is the set-up of an early warning system at regional scale for shallow landslides. HIRESSS is a physically based distributed slope stability simulator for analysing shallow landslide triggering conditions in real time and in large areas using parallel computational techniques. The software can run in real-time by assimilating weather data and uses Monte Carlo simulation techniques to manage the geotechnical and hydrological input parameters. The model has been applied in Valle d'Aosta region, located in North-West Alpine mountain chain. In order to apply the model and to increase its reliability, an in-depth study of the geotechnical and hydrological properties of hillslopes controlling shallow landslides formation was conducted. The data collected contributes to generate input map of parameters for HIRESSS model. In order to take into account the effect of vegetation on slope stability, the contribution of the root cohesion has been also taken into account based on the vegetation map and literature values. The model was applied in back analysis on two past events that have affected Valle d'Aosta region between 2008 and 2009, triggering several fast shallow landslides. The validation of the results, carried out using a database of past landslides, has provided good results and a good prediction accuracy of the HIRESSS model both from temporal and spatial point of view.

5. Plan of future activities (up to 30 lines)

In the framework of **WP1**, the planned activities for the next year are aimed at developing automatic methods for identifying scenarios at greater danger associated with the beginning of gravitational slope phenomena. Stromboli will be a stable laboratory from which to transfer from time to time the most up to date acquired knowledge to the management of the different landslides emergencies in which the use GB-InSAR device and related ground-based instruments, installed as a sensor network, is possible. Furthermore, in continuity with previous activities, we will continue to increase our knowledge on rapid methods for defining reference scenarios (in deferred and real time) useful for planning and identifying the best emergency operational response.

The proposed activity in the framework of **WP2** for the next year will rely on the further used of Sentinel-1 constellation. In particular, the short revisiting time, the regional-scale mapping capability, the regularity of acquisitions, the free data access, as well as the availability of new InSAR algorithms capable of maximizing the spatial density of measurement points will be exploited for continuous monitoring of ground deformation at regional scale.

The activity of the **WP3** in the next year will focus on the further development and refinement of the physically-based HIRESSS model in terms of preparation of input data and analysis and validation of the

results. A special attention will be devoted to evaluation of the contribution of vegetation, in terms of root reinforcement, to the stability of slopes at regional scale. Furthermore, the activity will focus on the development of a methodology to couple rainfall thresholds and susceptibility maps for dynamic landslide hazard assessment at regional scale. Both inputs will be combined in a purposely-built hazard matrix to get a spatially and temporally variable definition of landslide hazard: while statistical rainfall thresholds are used to accomplish a temporal forecasting with very coarse spatial resolution, landslide susceptibility maps can provide static spatial information about the probability of landslide occurrence at fine spatial resolution.

6. Publication (in Landslides, proceedings, meeting reports, or WEB)

Scientific articles

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