Date of Submission	30/03/2019

IPL Project (IPL - 198) Annual Report Form 2018

1 January 2018 to 31 December 2018

1. **Project Number and title**

   IPL-198 (2015) Multi-scale rainfall triggering models for Early Warning of Landslides (MUSE)

2. **Main Project Fields**

   (1) Technology Development

   A. Monitoring and Early Warning, B. Prediction of triggering in real-time

   (3) Capacity Building

   A. Setting up of Operational Early Warning Systems

3. **Name of Project leader**

Filippo Catani
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Core members of the Project:
Nicola Casagli, Professor, DST-UNIFI
Veronica Tofani, Assistant Professor, DST-UNIFI
Samuele Segoni, Researcher, DST-UNIFI
Elena Benedetta Masi, PhD Student, DST-UNIFI

4. **Objectives: (5 lines maximum)**

   The main objective of this IPL project is the enhancement of knowledge and methodologies related to the integration of landslide prediction models at different scales to build an effective operational multi-scale system for real-time early warning of rainfall triggered mass movements.

5. **Study Area: (2 lines maximum)**

   Northern Tuscany (Italy) for the analysis of soil parameters and Eastern Valle d'Aosta (Italy), for regional scale landslide forecasting using the HIRESS physically based model.

6. Project Duration (1 line maximum)

4 years

7. Report

1) Progress in the project: (30 lines maximum)

WP1: Soil properties variability study

In perspective of EWS applications over very large areas in Italy, a statistical study was performed to identify the main lithological units and the main land cover classes most frequently associated to shallow landslides and debris flows in Italy. Focusing on just 6 lithologies or 5 land cover classes, it is possible to account for almost 80% of the shallow landslides occurred in Italy. This result is important to optimize and prioritize the efforts in collecting soil properties and to obtain reliable reference values to be applied in the largest possible set of case studies with little amount of new calibration measures. A geodatabase was built to collect, homogenize and organize relevant information on soil properties coming from different sources. The objective is to allow the expansion of the dataset with the results of new and old tests, using a standard that allows an effective use in HIRESSS with reduced pre-processing efforts.

WP2. Analysis and integration of rainfall data and rainfall forecasts

During this year, a methodology was defined that will result in a new algorithm for the extraction of soil moisture from Sentinel SAR data in near real time. The methodology consists in collecting a high number of ground control measures of soil moisture (on average, a measure a week for a whole year in a set of control points). Then, the measurements will be used as ground truth in an artificial neural network (ANN) and will be correlated with reflectivity data of the satellite, to infer spatially distributed near-real time data on soil saturation. A series of 10 control points scattered around Florence (Tuscany) was defined after several surveys and analysis on the quality and coherence of the satellite signal. TDR instruments were calibrated with field measures and laboratory tests. To allow future applications of multi-scale models in the province of Florence, a geodatabase containing all the landslide occurrences from 2010 to 2017 was built.

WP3. Wrap-up into integrated multi-scale models

HIRESSS code was modified to speed up calculations (thus increasing the lead time of forecasts). Failure probability maps are now produced at hourly time steps and at daily aggregations and it is possible to use a raster of bare rock areas as an additional input layer, to filter-off from the calculations the area where soil is absent and shallow landslides cannot occur. Moreover, the effect of root reinforcement in the modelling was improved by considering the 4th level of classification of the Corine Land Cover map. All these new features were tested in the Valle d'Aosta case study, obtaining satisfactory results, since a reduction of false alarms with

respect to previous tests was observed.

2) Planned future activities or Statement of completion of the Project (15 lines maximum)

WP1 – Expansion of the geodatabase with new measures and inclusion of past tests contained in the archives of the Earth Science Department of the University of Florence.

WP2 – Fieldwork and calibration of ANN to infer spatially distributed near-real time data on soil saturation from satellite data.

WP3- Applications to existing and new test sites; tests on different approaches to spatially aggregate the probabilistic results for early warning and for model validation.

3) Beneficiaries of Project for Science, Education and/or Society (15 lines maximum)

Many beneficiaries could directly take advantage of the project outcomes. Among these: Civil Protection offices and agencies, research institutes, Universities, public administrations, international organizations. In particular, since we have worked for the selected test cases in close cooperation with the public administrations in charge of risk management, we expect that the governmental administrations will use the project outcomes to design, implement, and validate regional landslide early warning systems.

4) Results: (15 line maximum, e.g. publications)

Tofani V., Bicocchi G., Rossi G., Segoni S., D'Ambrosio M., Catani F., Casagli N. (2017). Soil characterization for shallow landslides modeling: a case study in the Northern Apennines (Central Italy). Landslides, 7, Vol. 14, pp 1-16 – DOI: 10.1007/s10346-017-0809-8

Tofani V., Bicocchi G., Rossi G., D'Ambrosio M., Catani F., Casagli N. (2017). Soil characterization for landslide forecasting models: a case study in the Northern Apennines (Central Italy). In book: Advancing Culture of Living with Landslides, June 2017, pp.381-388 - DOI: 10.1007/978-3-319-53498-5_44

Salvatici T., Tofani V., Rossi G., D'Ambrosio M., Tacconi Stefanelli C., Masi E.B., Rosi A., Pazzi V., Vannoci P., Petrolo M., Catani F., Ratto S., Stevenin H., and Casagli N. (2018) Application of a physically based model to forecast shallow landslides at a regional scale. Nat. Hazards Earth Syst. Sci., 18, 1919-1935, https://doi.org/10.5194/nhess-18-1919-2018

Bicocchi G., D'Ambrosio M., Tacconi-Stefanelli C., Tofani V., Vannocci P., Casagli N., Lavorini G., Trevisani M., Catani F. (2019) Geotechnical and hydrological characterization of hillslope deposits for regional landslide prediction modeling. Bull. Eng. Geol. Environ. https://doi.org/10.1007/s10064-018-01449-z