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An integrated model for prediction of shallow landslides at regional scale with the integration of satellite hydrological data

Massimiliano Bordoni[1], Valerio Vivaldi[1], Luca Brocca[2], Luca Ciabatta[2], and Claudia Meisina[1]
[1]University of Pavia, Department of Earth and Environmental Sciences, Pavia, Italy
(massimiliano.bordoni01@universitadipavia.it)
[2]National Research Council, Research Institute for Geo-Hydrological Protection, Perugia, Italy

Rainfall-induced shallow landslides are dangerous natural hazards, mainly due to their high temporal frequency, which causes fatalities and high economic damage worldwide. Early Warning Systems (EWS), generally based on definition of rainfall thresholds needed for landslides triggering, are useful tools for risks mitigation. Thresholds generally do not take into account soil hydrological conditions, which play an important role both in landslide triggering. Rainfall measures are also uncertain due to the limited spatial representativeness of ground sensors and the low density of currently available measuring networks. Moreover, in the last years, soil moisture data have become available over large areas (basin and regional scales), thanks to their measurement through satellite sensors.

The aim of this research is to develop a new integrated model to predict shallow landslides, based on a multidisciplinary approach involving physical models, data-driven methods and the implementation of satellite soil moisture and rainfall. The model is developing in Oltrepò Pavese (Northern Italy, Southern Lombardy), affected during the last 11 years by numerous events triggered by intense and frequent rainfalls, causing human fatalities, damaging/blocking roads and bridges, destructing cultivations (mainly vineyards).

To define satellite soil moisture (and rainfall) products, different remote sensing platform are investigating. A very new soil moisture product provided by Sentinel-1 images by ESA (European Space Agency) allows a fine spatial resolution (1 km) and a revisit time of ~7 days. Coarse resolution soil moisture products (~20 km) characterized by a daily temporal resolution and higher accuracy (e.g., SMAP–Soil Moisture Active and Passive, SMOS–Soil Moisture Ocean Salinity, ASCAT–Advanced SCATterometer) is used. These are validated through two hydrological monitoring stations already installed in two representative basins.

The prediction of shallow landslides are carried on by means of a model able to integrate spatial probability of occurrence and temporal occurrence, considering also satellite soil moisture and rainfall products. Empirical and physically-based thresholds considering different initial soil hydrological conditions on soil moisture, which seem the best indicators for shallow landslide triggering, are developing.

Predicition model is tested and validated with real cases, assessing its reliability, to build a prototypal Early Warning System for shallow landslide prediction, that will constitute a valuable tool for Civil Protection in attempt to mitigate the risk in the Oltrepò Pavese area. This work was made in the frame of the project ANDROMEDA, funded by Fondazione Cariplo.