Geophysical Research Abstracts
Vol. 20, EGU2018-2627, 2018
EGU General Assembly 2018

Using soil moisture instead of antecedent rainfall to improve the performances of a regional scale landslide warning system

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Regional scale landslide warning systems (RSLWS) are usually based on empirical rainfall thresholds, which in turn are based on rainfall parameters easy to measure and monitor by means of rain gauges.
However, soil moisture conditions before the triggering rainfall event can play a crucial role in the initiation of landslides, especially for deep-seated landslides and for terrains with complex hydrological settings. Therefore, in RLWS antecedent rainfall is often used as a proxy for soil moisture conditions.
In this work we explore the possibility to improve an existing RSLWS by using averaged soil moisture values instead of antecedent rainfall, finding a more robust correlation with landslide triggering over wide areas (thousands of squared kilometers).
We test this hypothesis in the Emilia Romagna region (Italy), where a RSLWS is based on the combination of short term rainfall measures and long term antecedent rainfall. We developed two alternate version of the RSLWS, substituting long term antecedent rainfall with soil moisture estimates obtained by a state-of-the-art physically based model.
The first tested approach is the simplest: it is based on a soil moisture threshold value under which rainfall thresholds are not used because landslides are expected to never occur. When tested with a back analysis, this approach reduced consistently false alarms, but produced an additional missed alarm. This approach is very simple and can be easily replicated elsewhere after a simple calibration against the local soil moisture and landslide datasets.
The second approach is more complex: it is based on the idea that rainfall thresholds based on antecedent rainfall accumulated over very long periods can be substituted by soil moisture thresholds. A back-analysis demonstrated that a new version of the model based on soil moisture and short term rainfall is by large more effective than the original version based on short term rainfall measures and long term antecedent rainfall, as both false alarms and missed alarms were consistently reduced (-48% and -22%, respectively).