Presence-only approach to assess landslide triggering-thickness susceptibility. A test for the Mili catchment (North-Eastern Sicily, Italy)

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As the authors believed that the peculiar geomorphometry of this narrow and steep catchment played a fundamental role in generating two distinct patterns of landslide thicknesses during the initiation This study aims at comparing the performances of a presence only approach, namely Maximum Entropy, in assessing landslide triggering-thickness susceptibility within the Mili catchment, located in the north-eastern Sicily, Italy. This catchment has been recently exposed to three main meteorological extreme events, resulting in the activation of multiple fast landslides, which occurred on the 1st phase, a HRDEM was used to extract topographic attributes to express near-triggering geomorphological conditions. On the other hand, medium resolution vegetation indexes derived from ASTER scenes were used as explanatory variables pertaining to a wider spatial neighborhood, whilst a revised geological map, the land use from CORINE and a tectonic map were used to convey an even wider area October 2009, 10th March 2010 and 1st March 2011. Differently from the 2009 event, which only marginally hit the catchment, the 2010 and 2011 storms fully involved the area of the Mili catchment Detailed field data was collected to associate the thickness of mobilised materials at the triggering zone to each mass movement within the catchment. This information has been used to model the connected to the slope instability. The choice of a presence-only approach allowed to effectively discriminate between the two types of landslide thicknesses at the triggering zone, producing outstanding prediction skills associated with relatively low variances across a set of 50 randomly generated replicates. Thus, classified susceptibility maps can be used in master plans to better manage the associated risk. landslide susceptibility for two classes of processes clustered into shallow failures for maximum depths of 0.5m and deep ones in case of values equal or greater than 0.5m.

1- SETTING AND SURVEY



This methodology was applied to the piedmont of the Peloritani Mts., a 15 km² wide area, located in the north-eastern side of the Sicily Region (Southern Italy) at an altitude ranging between the sea level and 700 m a.s.l. Reference system for maps: Projected Coordinate System: UTM Zone 33 - Map Datum: WGS 1984

Geological setting

The study area is located on the eastern portion of the Peloritani Thrust Belt, that consists of seven Alpine units in a stack, whose geometrical order from the bottom to the top can be followed on the field from south to north. One of these units, namely the Mela Unit, outcrops in the sector where the study catchment is located and encompass medium to high metamorphic rocks: paragneiss, micaschists and amphibolites.

The area has undergone several tectonic phases dating from the Hercynian age up to the most recent Quaternary uplift.





4 - MODELLING - PREDICTOR ROLES

fall debris flow



Response Curves

-These curves show the relationship between each predictor domain and the final probability obtained across each of the fifty replicates.

-In red the values for "Thick" landslide activation type are shown whilst the in blue the "Thin" ones are plotted. Colored dashed lines show the dispersion boundary included between plus and minus 1 Standard Deviation. Grey dashed lines highlight the threshold at 0.5π between stable and unstable conditions.

-The prediction is initially tested using only one variable at a time across the fifty replicates. This procedure allows to establish the best contributors among the whole set of covariates. - In a second phase the models are built using all the covariates except one, one replicate at a time. This procedure allows to recognise the strongest contributors where the AUC drops significantly with



Jackknife tests

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In order to zoning landslide susceptibility at catchment scale, a methodology is expounded based on qualitative and quantitative analysis, following steps 1 to 6.

$$2 - DA$$

Landslides

In the catchment, 153 mass movements have been recognized (more than a hundred debris flow). Higher density of landslides (picture in step 1) occurs along the eastern coastal part where sandy, clay lithologies outcrops (MSS, PCT). These phenomena was triggered by extreme climatic events. The 10th of March 2010 or 1st March 2011 rainstorms overloaded the slopes whose soils had already been saturated by about two hundreds mm of rain in the 7 previous days.

Materials

The basic materials required to carry out the landslide susceptibility assessment procedure are:

- a detailed inventory of landslides;
- a geological map;
- a high resolution DEM;
- a landuse map;

Past landslides, classified by typology, were surveyed filling an original form to collect data about geolithological conditions, strata attitude, surface deposits, relief characteristics, landslide dimensions, and landuse.

respect to the average prediction skill.

5 - SUSCEPTIBILITY MUUDEL









Maps

-On the left: MIN, AVERAGE, MAX probabilities as well as the ST.DEV through the fifty models for both the categories. -Above: AVERAGE probabilities binarised into stable and unstable conditions adopting a 0.5π threshold. The result has been further combined to isolate unic conditions per each pixel of the catchment.





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6 - MODEL ERROR

Robustness through replicates

-As shown in the fifth step (Susceptibility Model) each pixel partitioning the catchment has been assigned with a probability value per each replicate. Average and standard deviation of the 50 susceptibility maps have been computed allowing not only to construct the corresponding maps but to plot the model error as well.

- The model error relates the average probability to its standard deviation as shown on the left side for the 'Thick' (top) and 'Thin' (bottom) landslide activation types.

- It is clear that both classes have been modelled producing high stability throughout the replicates in the left tail of the plot where densities reach the maximum of 1000 pixels per each of the synthetic 0.005 side mesh squared cells.

-Few values have been assigned with probability values close to 1 and the highest instability have been obtained at the threshold between stable and unstable conditions (at 0.5π).

