IDENTIFICATION OF THE DEBRIS FLOW TRIGGERING AREAS TO ASSESS LAND SUSCEPTIBILITY AND HAZARD AREAS

R. Pastorello, T. Michelini, V. D'Agostino

Department of Land, Environment, Agriculture and Forestry (TeSAF), University of Padua

Reference to: roberta.pastorello@studenti.unipd.it

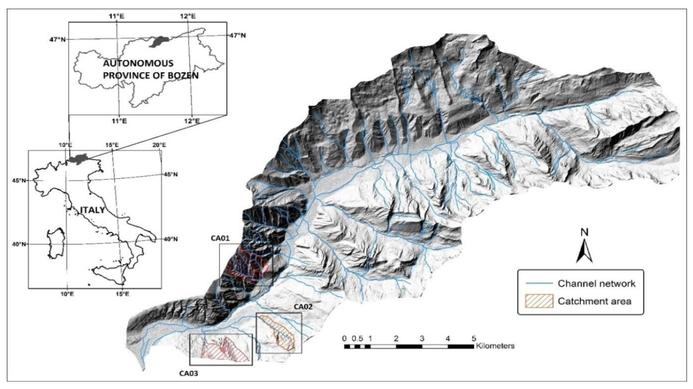
ABSTRACT

Studies of susceptibility to debris flows at a large scale (100-1000 km^2) are becoming more important every year because they help to identify the most susceptible areas of entire valleys. To do such studies, the topographical models are needed because they can predict susceptible areas with low data requirement. In this work, a new methodology to predict the susceptible areas to debris flows is proposed. The Flow-R model (Horton et al., 2013), developed at the University of Lausanne (Switzerland), has been used for the simulations. The methodology has been tested in the Vizze Valley (North-Eastern Italy), as the Province of Bolzano collected the extent of the triggering and deposition areas after the 4 August 2012 debris flow events in different catchments . The best predicting parameters to use for the regional scale simulation have been identified at a local scale in three catchments. For the identification of the triggering areas at the regional scale, a threshold for the upslope contributing area coupled with a threshold for the terrain slope gradient have been proposed. The results show that this methodology gives a good overview of the most susceptible areas. All the fans stroke by past debris flows have been identified as susceptible areas. The susceptibility map obtained from this study can be a useful instrument for further studies of hazard and risk.

OBJECTIVES

- Identification of the debris flow simulation parameters to use in Flow-R, most suitable for the study area
- Identification of the triggering areas at the regional scale
- Creation of a susceptibility map to debris flow of the Vizze Valley

STUDY AREA



	CA01	CA02	CA03
Area (km^2)	1.40	0.98	1.06
Min elevation (m)	1330	1257	1060
Mean elevation (m)	1949	1815	1540
Max elevation (m)	2563	2323	1950
Mean slope (°)	44.56	35.19	34.32
Max slope (°)	82.79	79.48	75.93

The Vizze valley (Pfitschertal) is an Alpine valley located in the northern part of Alto Adige-Südtirol (Italy), near Austria boundary. It is a secondary valley of the Isarco valley (Eisacktal) that begins from Passo di Vizze (Pfitscherjoch) (2248 m a.s.l.) and ends near Vipiteno (Sterzing) (948 m a.s.l.), so it has a NE-SW orientation. The higher peak of the area is Gran Pilastro (Hochfeiler) (3510 m a.s.l.), located at the eastern limit of the valley.

METHODOLOGY

1° STEP: Simulation at the local scale in three catchments to find the best simulation parameters to be used at the regional scale:

- Use of the real source areas
- Assessment of the simulations accuracy comparing the results with the real deposition areas

2° STEP: Identification of the source areas at the regional scale using two methodologies

METHOD 1

AUTOMATIC IDENTIFICATION THROUGH FLOW-R USING 3 INPUT MAPS:

- Plan curvature -2/100 m^{-1}
- Terrain slope >15°
- Flow accumulation $\begin{cases} tan\beta_{thres} = 0.32 S_{uca}^{-0.2} & if\ S_{uca} < 2.5\ km^2 \\ tan\beta_{thres} = 0.26 & if\ S_{uca} \geq 2.5 km^2 \end{cases}$

METHOD 2

DEFINITION OF TWO TRIGGERING THRESHOLDS WITH A GIS ANALYSIS:

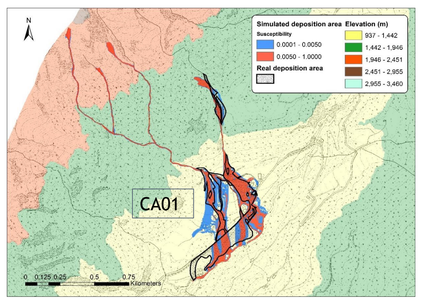
- Terrain slope >15°
- Flow accumulation >1ha

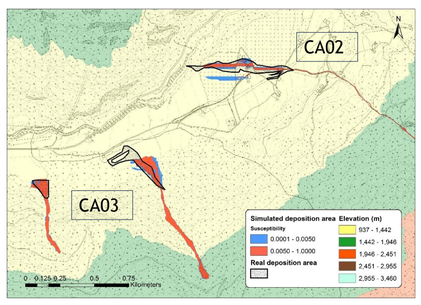
3° STEP: Regional scale simulation and evaluation of the accuracy comparing the result with past debris flow events.

CREATION OF THE SUSCEPTIBILITY MAP

RESULTS

- Simulation parameters at the local scale:





Evaluation of accuracy: $\delta = 100 \times \frac{\alpha}{\beta+\gamma}$

α = POSITIVE ACCURACY -> correct predicted area

β = NEGATIVE ACCURACY -> wrong predicted area not affected by the real debris flow

γ = MISSING ACCURACY -> not predicted area affected by the real debris flow

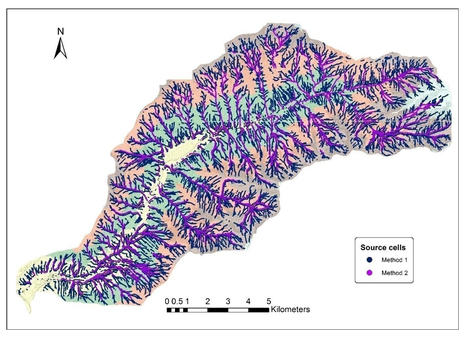
Analysed catchment	Set of parameters		
	CA01	CA02	CA03
CA01	74%	43%	70%
CA02	49%	63%	28%
CA03	53%	18%	69%

The parameters that gave the best accuracy rate (CA01) are the following: modified version of the Holmgren algorithm with x=07 and dh=1 m, for the assessment of the spreading width. SFLM method using a travel angle of 11° and a velocity limit of 20 m/s, for the assessment of the runout.

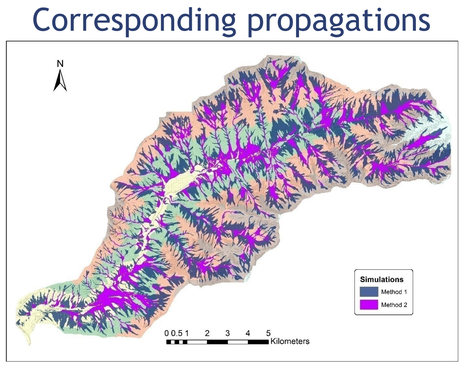
- Identification of the source areas at the regional scale:

Method 1 is represented with blue, Method 2 with violet

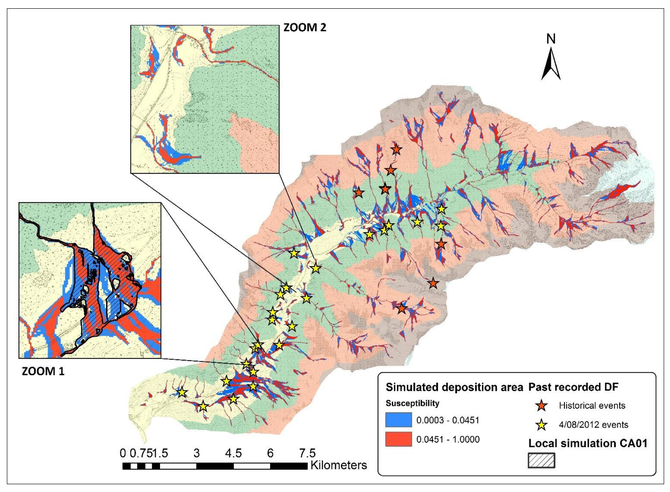
Identified source areas



Corresponding propagations



- Susceptibility map of the Vizze Valley:



The model identified 84 susceptible channels along the valley. Among these, 39 are not included in the digitalized channel network of the Autonomous Province of Bolzano. In total, the areas identified as susceptible to debris flow have an extension of almost 15 km^2, and cover the 11% of the valley.

CONCLUSIONS

- A topography-based model like Flow-R generally overestimates the susceptibility areas, and this is an advantage in a susceptibility study because it allows to be precautionary;
- The back analysis, using data from real events, allows to set the best simulation parameters adapted to the specific area of analysis;
- Identifying the source areas with Method 2 is a good alternative to the 'classic' source identification of Flow-R (Method 1). The threshold of upslope contributing area set up with a GIS analysis seems a stronger discriminating factor than the Upslope Contributing Area/Slope relationship, in the case of alpine valleys characterized by an overall high slope gradient.
- All the streams interested by a past debris flow event have been recognized as susceptible areas and several streams not included in the digitalized channel network have been highlighted as susceptible areas;
- The use of different triggering areas strongly affects the resulting propagation map. For this reason future studies will have to focus on the identification of the triggering areas.

REFERENCES

Horton, P., Jaboyedoff, M., Rudaz, B., Zimmermann, M., 2013. Flow-R, a model for susceptibility mapping of debris flows and other gravitational hazards at a regional scale. Nat. Hazards Earth Syst. Sci. 13, 869–885. doi:10.5194/nhess-13-869-2013