DEBRIS-FLOW CALAMITIES: VALIDATION OF THE HAZARD MAPPING METHODOLOGY BASED ON THE TRENT2D MODEL, THROUGH A COMPARISON WITH A REAL CASE EVENT

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ABSTRACT

How reliable is a procedure of hazard mapping?

In this work we want to give a first answer to this important question by comparing the results of a back analysis of a real event with the ones obtained from a blind hazard mapping based on the model Trent2D [1] [5].

The studied event occurred in August 2010 in the village of Campolongo (Province of Trento, Italy) as a result of torrential rains. The back analysis has been carried out starting from the application of a rainfall-runoff model in order to obtain liquid discharge. Solid discharges have been estimated from the measured volume of deposits. With these boundary conditions, several numerical simulations have been performed and the optimal values of model parameters that minimize the difference between measured and computed deposits have been obtained.

Afterwards, the model has been used in a predictive mode and the hazard map for the area has been obtained. In this step we used a blind approach, in which the model parameters have been fixed a priori, according to an assumption of local equilibrium in the upstream section of the flow field, without considering any indication from the back analysis.

Comparison of the hazard mapping results with the event reconstruction shows that the real event is well included in the prediction of the hazard map. This gives a first concrete evaluation, on one side, of the robustness of the physical assumptions of the Trent2D model and, on the other, of the reliability level reached by the current hazard mapping approach.

EVENT DESCRIPTION

The catchment

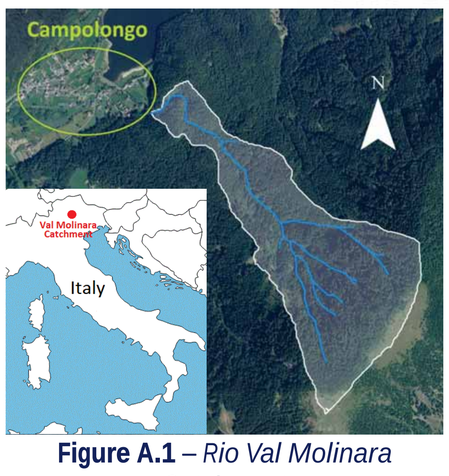


Figure A.1 – *Rio Val Molinara Catchment*

Catchment Properties	
Area	0.93 km^2
Stream length	2.6 km
Mean slope	35%
Min elevation	1029 m
Max elevation	1951 m

The town of Campolongo is located on the alluvial fan formed by the Rio Val Molinara. It was hit by a debris flow during the night of the 14th-15th August 2010 (*Figure A.1*).

The rainfall event

Rainfall characteristics	
Rainfall height	128.9 mm
Rainfall period	4h 45’
Return period of each cloudbrust of the whole event	≈ 100 years > 200 years

The triggering rainfall was characterized by two distinct cloudbursts.

NUMERICAL MODEL TRENT2D

The **Trent2D** mathematical model [1] [5] adopted in the study is based on a **two-phase** description of the debris flow, with **immediate adaptation** of the transport to the local flow conditions. It adopts a rheological closure valid in the grain-inertial regime.

The equations are solved on a structured Cartesian grid, using a **finite-volume method with Godunov-type fluxes.** These are evaluated using the LHLL Riemann solver with a MUSCL-Hancock approach to obtain second order accuracy in space and time.

EVENT RECONSTRUCTION

a) From rain-gauge data, the **discharge** at the catchment outlet was computed using a simple rainfall-runoff model (TOPMODEL [2]) (*Figure B.1*).

b) The **solid and total discharges** of the debris flow (*Figure B.2*) were estimated distributing the measured solid volume by mean of the volumetric method of Takahashi [6].

c) A **set of 27 simulations** was run, changing three characteristic model parameters and comparing predicted and real (obtained from surveys) deposition areas. Results corresponding to the optimal choice of parameters are shown in *Figure B.3.*

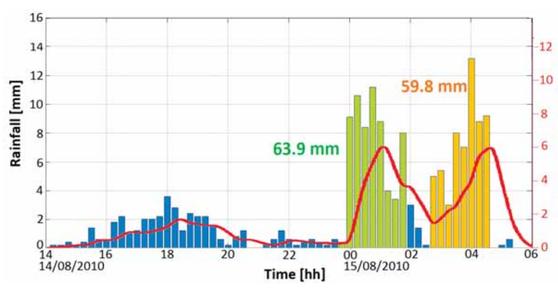


Figure B.1 – *Hydrograph measured for the event by Sant’Orsola rain gauge and liquid discharge reconstructed for the event in the Val Molinara catchment.*

Volume of deposits

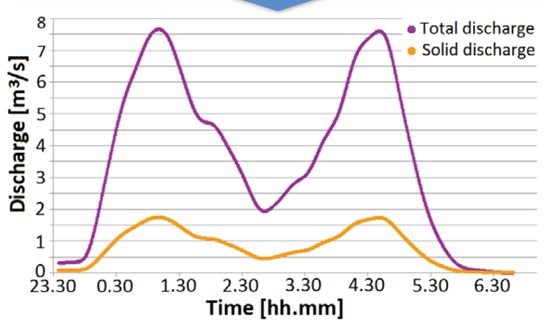
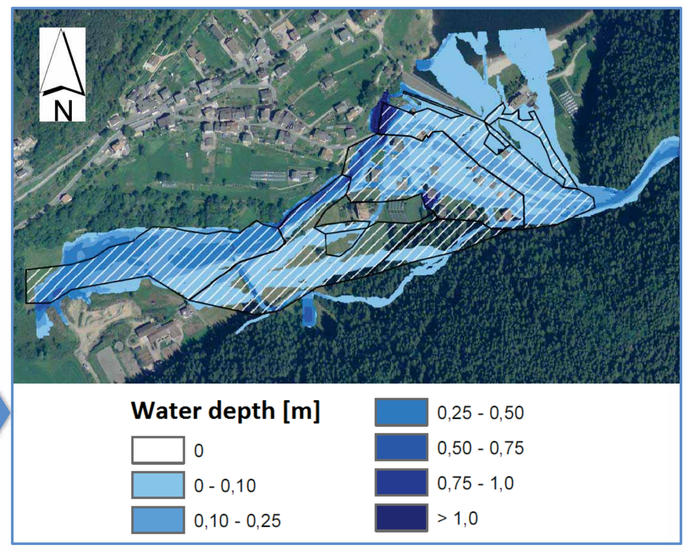


Figure B.2 – *Debris flow and solid discharge of the event in the Val Molinara catchment, reconstructed using field information by mean of the volumetric method.*

Trent2D^{DF}

Figure B.3 – *Maps of reconstructed flooded area and real flooded area (from surveys).*



HAZARD MAPPING METHODOLOGY

Data collection + preliminary analysis → Hydrological and geological analysis → Boundary conditions and parameters → Simulations for three return periods → Intensity maps → Hazard maps [4]

H = H(i,f)

H = Hazard, **i** = Intensity, **f** = Frequency

Intensity **i** and frequency **f** are classified according to local regulations criteria [3].

VALIDATION OF HAZARD MAPPING

Using the model in **predictive mode** within the hazard mapping methodology described in the left box, in general there is no data to be used for model calibration. Therefore, simulations must be run using **standard reference values** (based on physical properties of the soil) **of parameters** and considering equilibrium conditions at boundaries.

The extension of the mapped area obtained with equilibrium parameters was compared with the extent of the real deposition area (*Figure C.1*), with an **overall very good match**.

These results show the capability of the model to provide **reliable results** even in absence of a specific calibration. In this case, standard parameters turned out to be only slightly different from optimal ones. Results may be less accurate when flow conditions are far from equilibrium.

The main discrepancy is highlighted in *Figure C.1.* The model cannot still predict the occurrence those local processes due to pavements behaving like fixed bed and this may affect the final results.

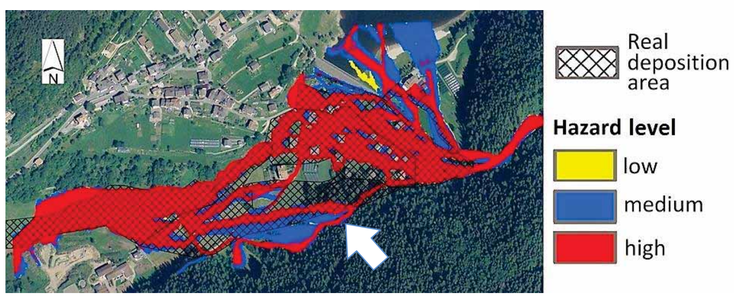


Figure C.1 – *Comparison between the extent of the global hazard map and the extension of the real deposition area of the 2010 event.*

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[2] Beven and Kirkby (1979), “A physically based variable contributing area model of catchment hydrology”, *Hydrol. Sci. Bull.*, *24*, 43-69

[3] D. G. P. 2759/2006, in the field “Disposizioni tecniche e organizzative per la redazione e l’aggiornamento delle carte delle pericolosità”

[4] Heinimann, Hollenstein, Kienholz, Krummenacher and Mani (1998), “Methoden zur Analyse und Bewertung von Naturgefahren”, *Umwelt-Materialien*, *85*

[5] Rosatti and Begnudelli (2013), “Two-dimensional simulation of debris flows over mobile bed: Enhancing the TRENT2D model by using a well-balanced Generalized Roe-type solver”, *Comput. Fluids*, *71*, 179-195

[6] Takahashi (1991), *Debris flow*, Rotterdam, Balkema

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