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The 1513 Monte Crenone rock avalanche Numerical model and geomorphological analysis

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1. Introduction & Objectives

The 30th September 1513 Monte Crenone rock avalanche (MCRA) was the first direct documented catastrophic event in the Swiss history. The huge mount of debris deposited just up of the village of Biasca, created a natural dam that led at the formation of a temporary lake named Lago di Malvaglia (~130 million cubic meter of water). The 20th May 1515 the huge mass of water broke the dam and destroyed the territory towards the Riviera Valley and Magadino Plain, going down in history as the well known "Buzza di Biasca". With this study, we use historical, morphological and geotechnical evidences to recostruct volume and kinematics of the Monte Crenone rock avalanche.

2. Materials & Methods

The volume of the MCRA has been derived by:
- *in situ* investigations (Fig. 1);
- 2D photo-interpretation using SWISSIMAGE orthophotos and swissALTI3D hillshade, ©swisstopo (Fig. 2a);
- drilling data from the geotechnical studies carried out for the Chiasso - San Gottardo highway works (Fig. 2b);

All the previous data were used to validate a run out model reproducing the kinematics of this rock avalanche (Fig. 3). We applied the Ramms Debris Flow model, employed by the WSL Istitute for Snow and Avalanche Research SLF and based on the Voellmy metod (1955).

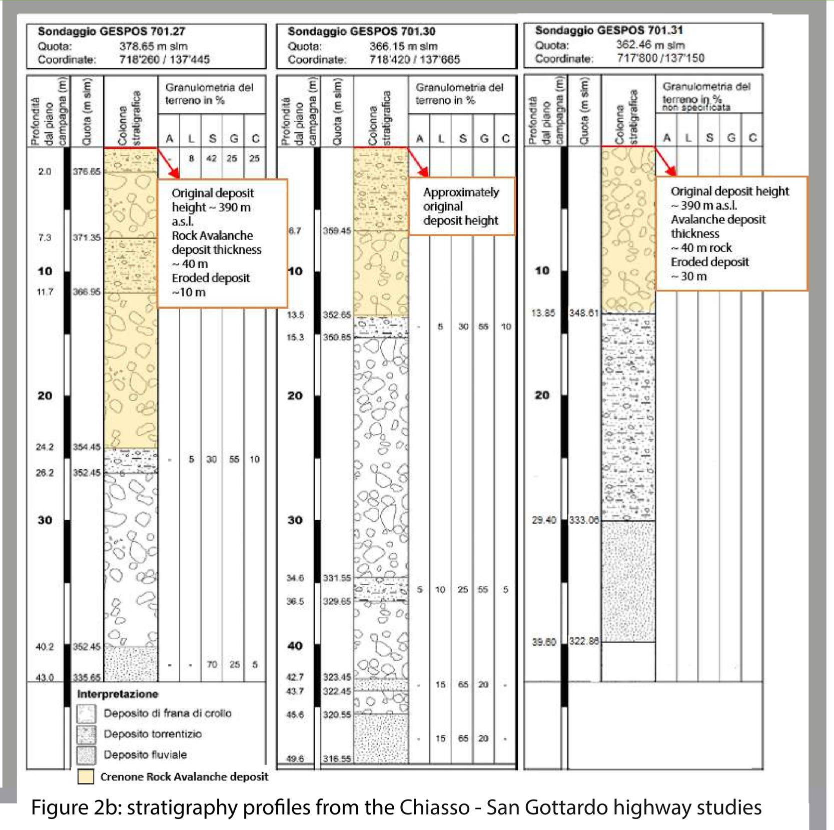

Figure 2b: stratigraphy profiles from the Chiasso - San Gottardo highway studies

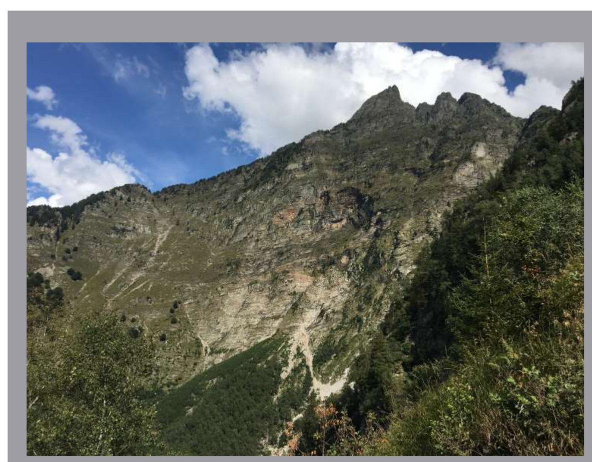

Figure 1a: view of the Mount Crenone west side

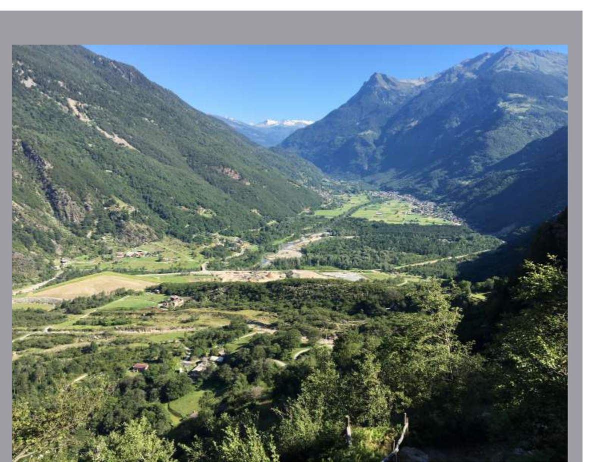

Figure 1b: view northwards, rock avalanche debris cone

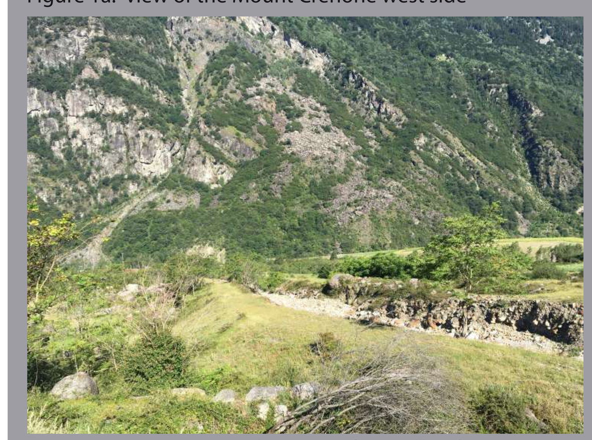

Figure 1c: view westwards, accumulation detail

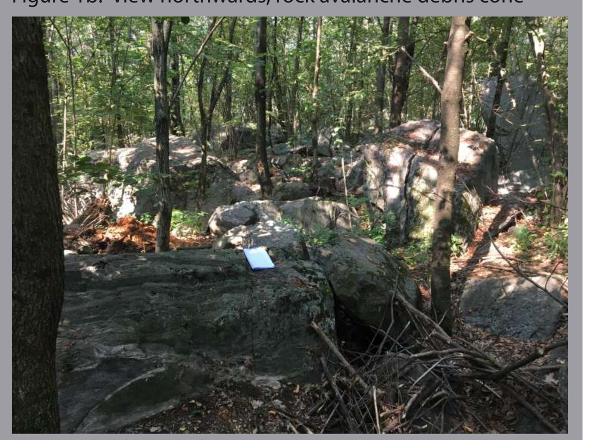

Figure 1d: blocks belonging at the rock avalanche deposit

Figure 1e: recent landslide downstream the Canvasgia

Figure 1f: detailed view of the fig. 1e

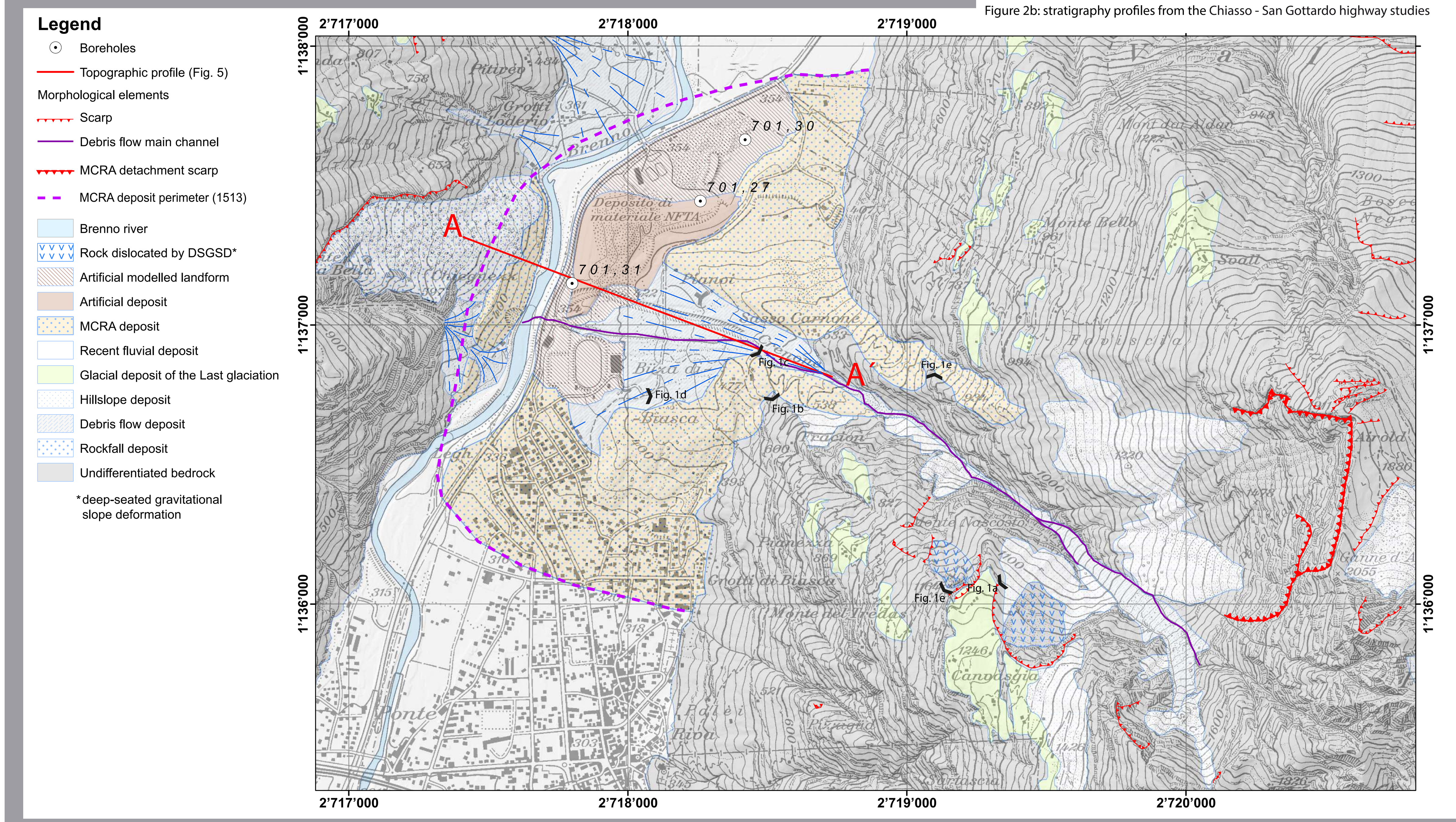

Figure 2a: geomorphological detailed map

Ramms software model - principles of operation

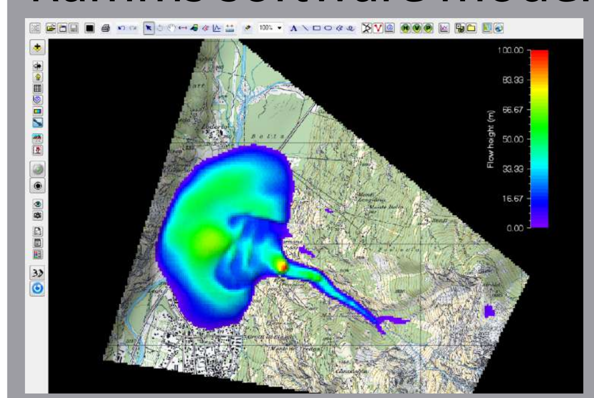

Figure 3a: Numeric model set using V 60.000.000 mc
p **10%** ξ 600 μ 0.35

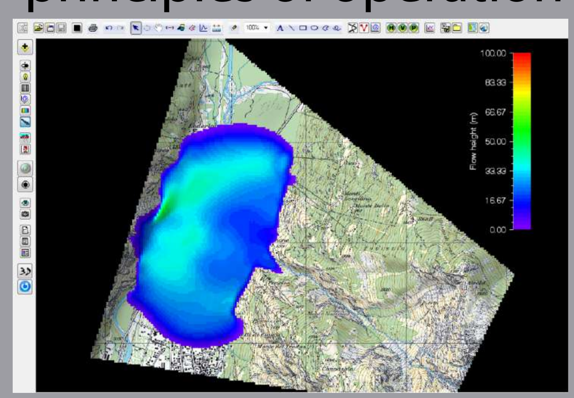

Figure 3b: Numeric model set using V 60.000.000 mc
p **1%** ξ 600 μ 0.35

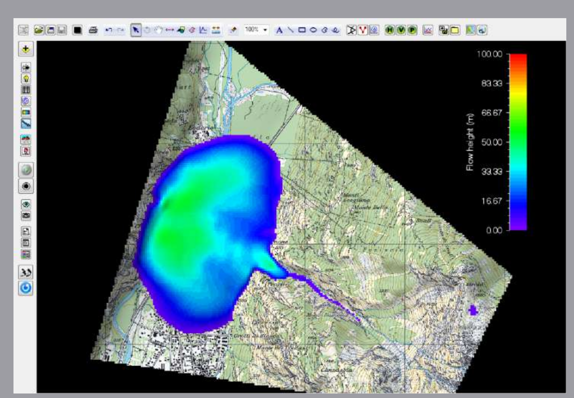

Figure 3c: Numeric model set using V 60.000.000 mc
p 2% ξ **1000** μ 0.35

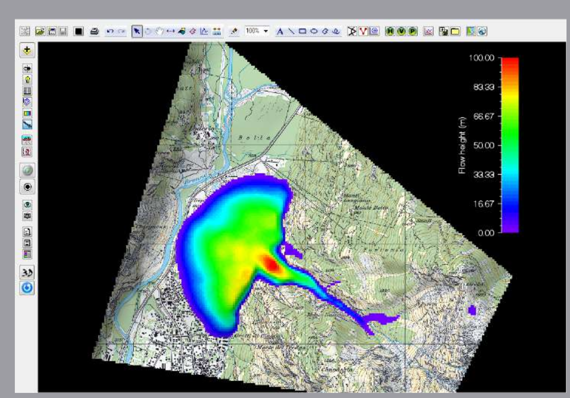

Figure 3d: Numeric model set using V 60.000.000 mc
p 2% ξ **100** μ 0.35

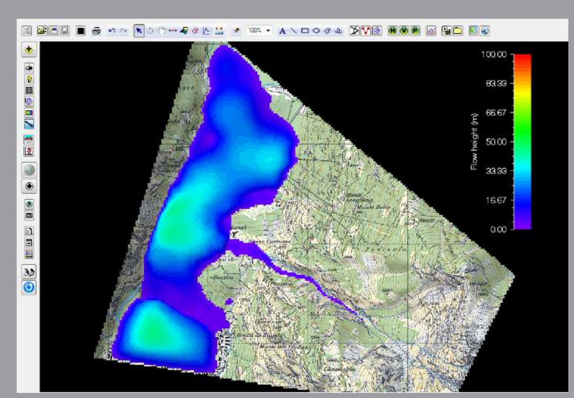

Figure 3e: Numeric model set using V 60.000.000 mc
p 2% ξ 600 μ **0.10**

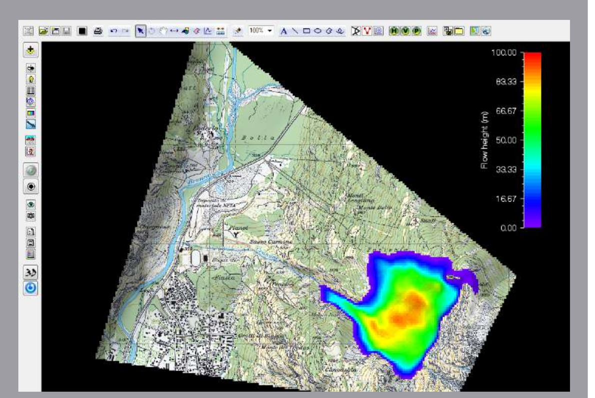

Figure 3f: Numeric model set using V 60.000.000 mc
p 2% ξ 600 μ **1**

The stopping criteria *p* is based on the momentum (kg*m/s). Tipically, this parameter range between 1-10% .
Changing the stopping criteria it is possible to change the development and the model advancement.

The viscous-turbolent friction parameter ξ (m/s^2) describes the turbolent behavior of the flow.

	Granular flow (solid dominated)	Mud flow (fluid-like)
Viscous-turbolent friction, ξ m/s^2	100-200*	200-1000*

* These vales are only suggestions not fixed definitions
- data from RAMMS:DEBRISFLOW User Manual

The dry-Coulomb Friction μ is sometimes expressed as the tangent of the internal share angle.
Normally range between 0,05 and 0,4 - Ramms user manual.

	stopping criteria parameter	ξ m/s^2	parameter μ
Final numeric model parameters	2%	600	0,35

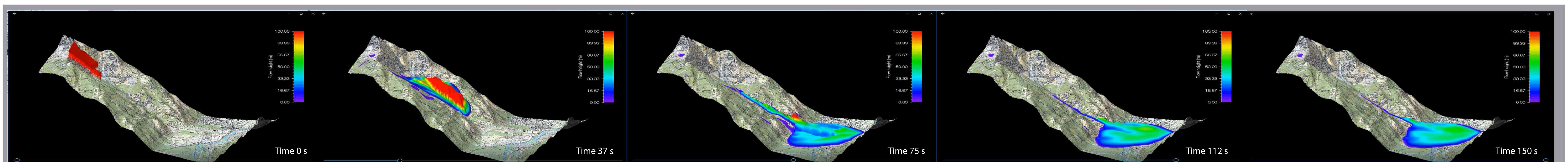

Figure 4: final sequence of the numerical simulation performed by Ramms Debris Flow. Parameters used: Xi 600 Mu 0.35

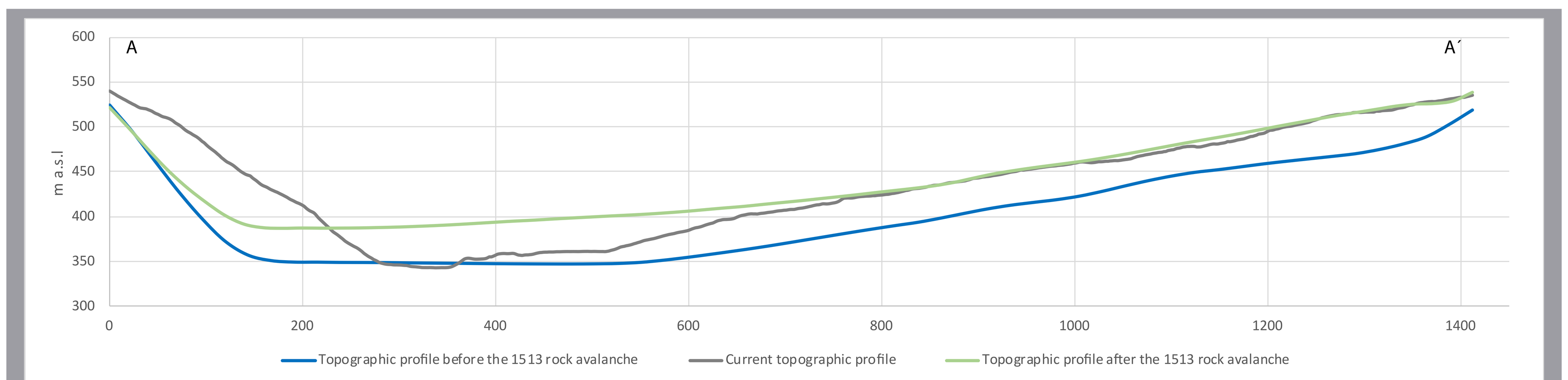

Figure 5: topographic profile across the Monte Crenone rock avalanche deposit dominating Biasca (CH). Profile direction W-E

The results of the numerical model (Fig. 4) shows a good fit with the current topography. Indeed, for the east side of the section the reproduced rock avalanche debris profile follows the current profile. In the central part instead, it is markedly visible the volume exported by the "Buzza di Biasca" of the 1515 and the following erosive Brenno river action. In this area, the height of the deposit reached 390 m a.s.l, corresponds at the highest point of the Malvaglia lake at the time of the overflowing (20th May 1515).
In the westernmost area, the gap between the 1513 profile and the current profile is explained by a later rockfall above the remains of the rock avalanche deposit.

3. Results

The new investigation of the historical Monte Crenone rock avalanche allowed to obtain the following data:
- identify a landslide debris volume of about 60 million cubic meters;
- the DEM pre-rock avalanche allows to get a satisfactory deposition morphology;
- the adopted parameters (ξ 600 μ 0.35) are within the range of values that usually simulate the majority of rock avalanches (Fig. 4);
- the deposit reached the maximal thickness of about 40 m in the area interested by the most intensive fluvial erosion (Fig. 5);
- the timing of the model (150 seconds) is reasonable.

4. Conclusions

The Ramms model, allowed us to recreate an exhaustive historical recostruction of the Monte Crenone rock avalanche occurred the 30th September 1513. The parametrization and validation of the Monte Crenone rock avalanche run out model will allow to study other potential rock avalanche affecting the right flank of the Blenio valley.

References

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Scapozza C., Tognacca C., Ambrosi C. & Seno S. 2015. 20 maggio 1515: la "Buzza" che impressionò l'Europa. Bollettino della Società ticinese di scienze naturali 103: 79–88.
WSL Istitute for Snow and Avalanche Research SLF - RAMMS::DEBRISFLOW User Manual v1.7.0