Congresso biennale 2019
della Società Svizzera di Geomorfologia

The Cimaganda rockslide (2012): recent geomorphological evolution of the paleo-event

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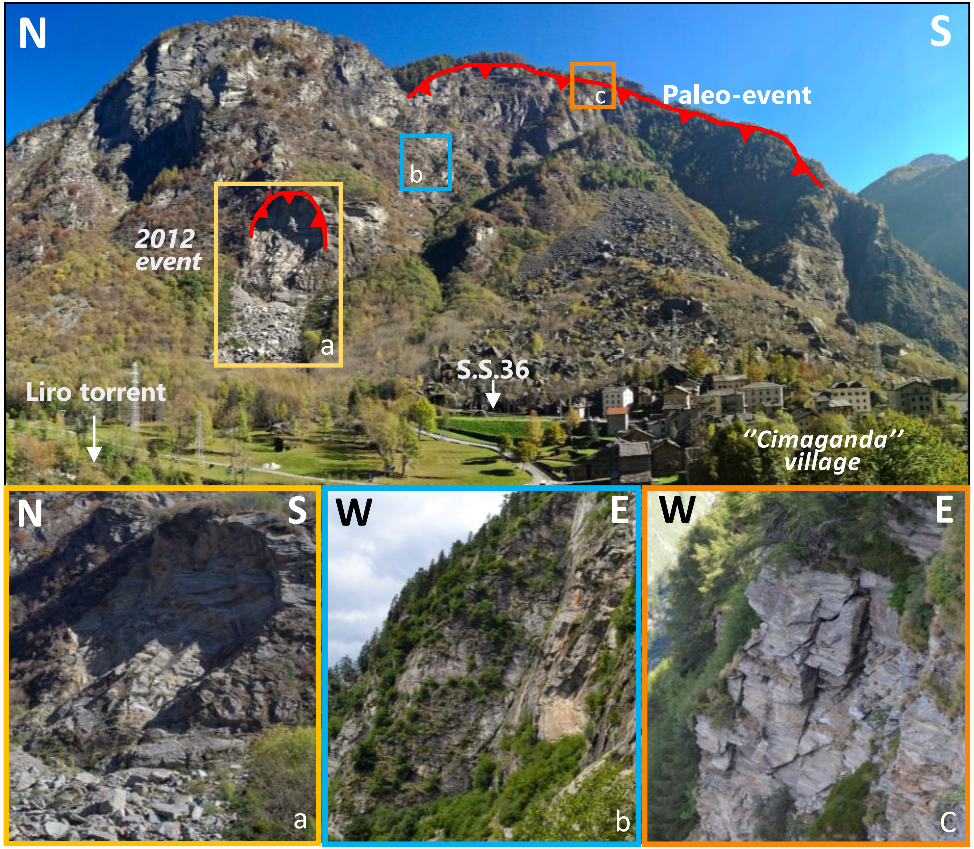


Cimaganda rockslide

PALEO-EVENT, *17th century (1698)*:

Rock volume involved: 7,5 Mm^3
Two or more steps (Mazzoccola D., 1996)

2012 EVENT:

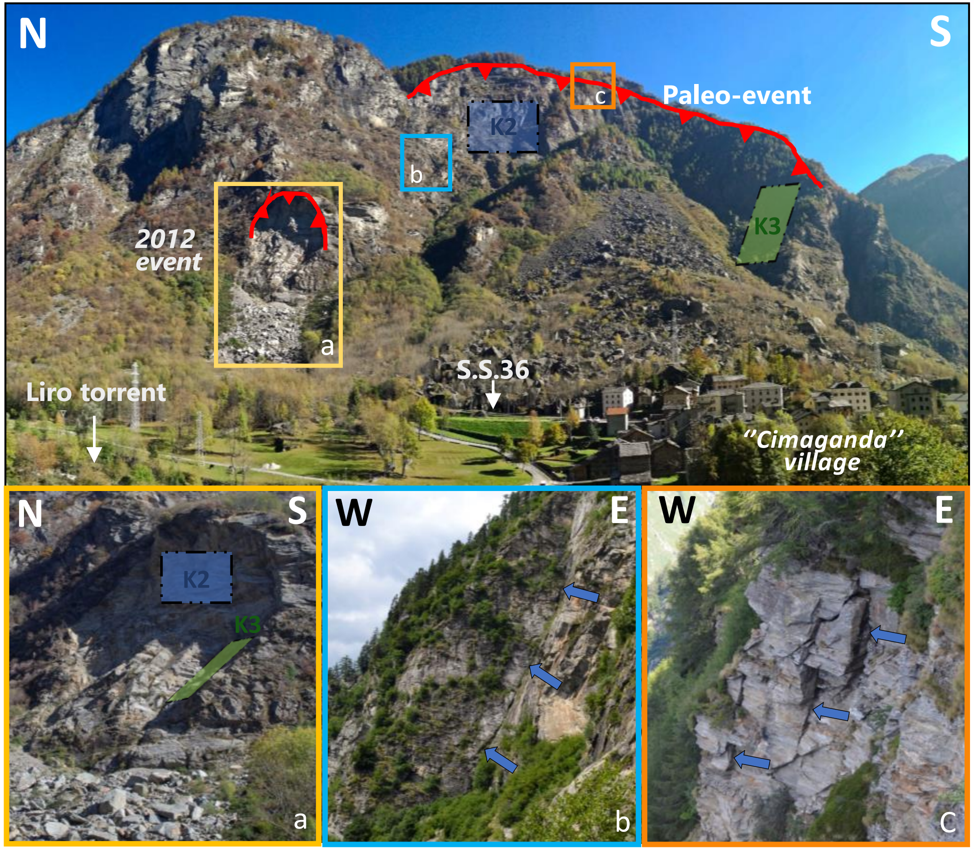
Rock volume involved: 20.000 m^3
Triggering factor: 267 mm of rain in 4 days (return time: 50 yr)

PREDISPONENT ELEMENTS TO ROCK FALLS AND INSTABILITY EVENTS ALONG THE SLOPE:

- Discontinuity sets features:
  - K2 Vertical tensile fractures // axial Valley (N-S)
  - K3 Shear planes (NE-SW diping to NW)
- Steep slopes with vertical cliffs

TARGET:

GEOMECHANICAL CHARACTERISATION → **CONCEPTUAL MODEL** → **BACK ANALYSIS 2012 EVENT** / **BACK ANALYSIS PALEO-EVENT** / **FUTURE EVOLUTIONS**



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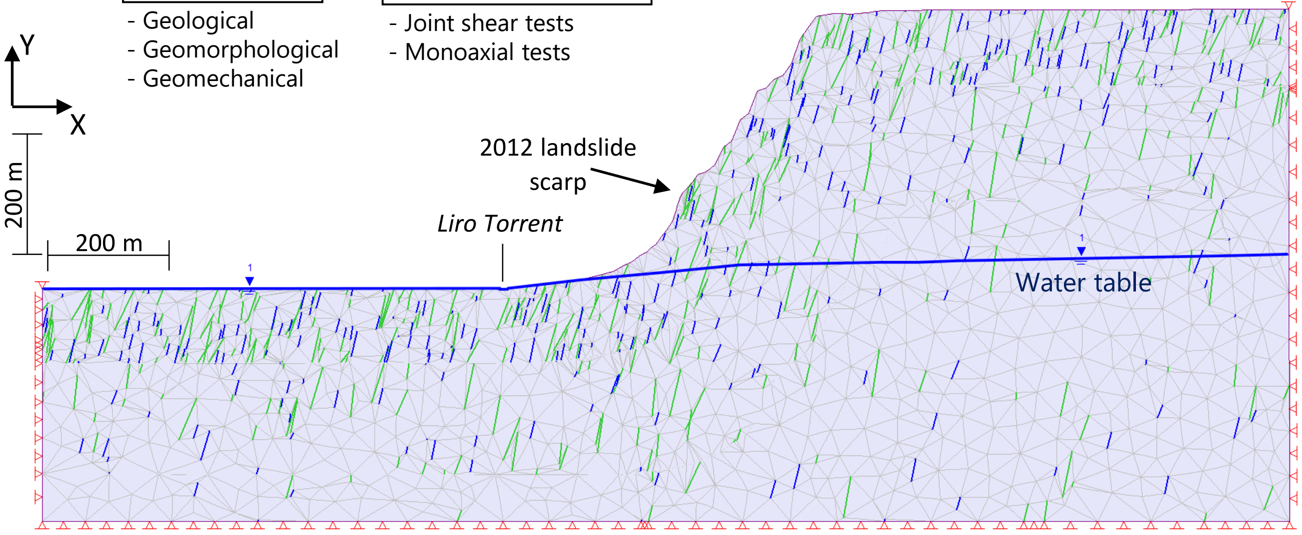
FIELD SURVEYS + **LABORATORY TESTS** → # Numerical model

- Geological
- Geomorphological
- Geomechanical

- Joint shear tests
- Monoaxial tests



Numerical code: Finite element (RS2, Rocscience)

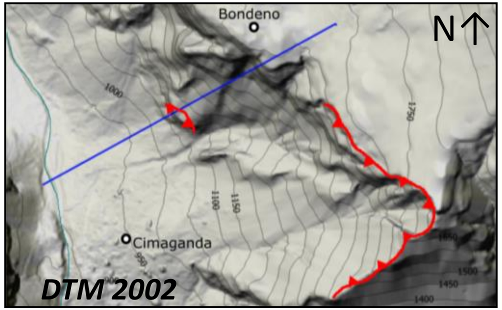
Morphology:
DTM 2002 Regione Lombardia (20x20)

Material properties:
HB parameters, E_0 as function of depth;
Anisotropy behaviour.

Joint network:
Fracture intensity as function of depth;
MC /equivalent MC parameters

Boundary conditions:
Auto restrain surface (pins)

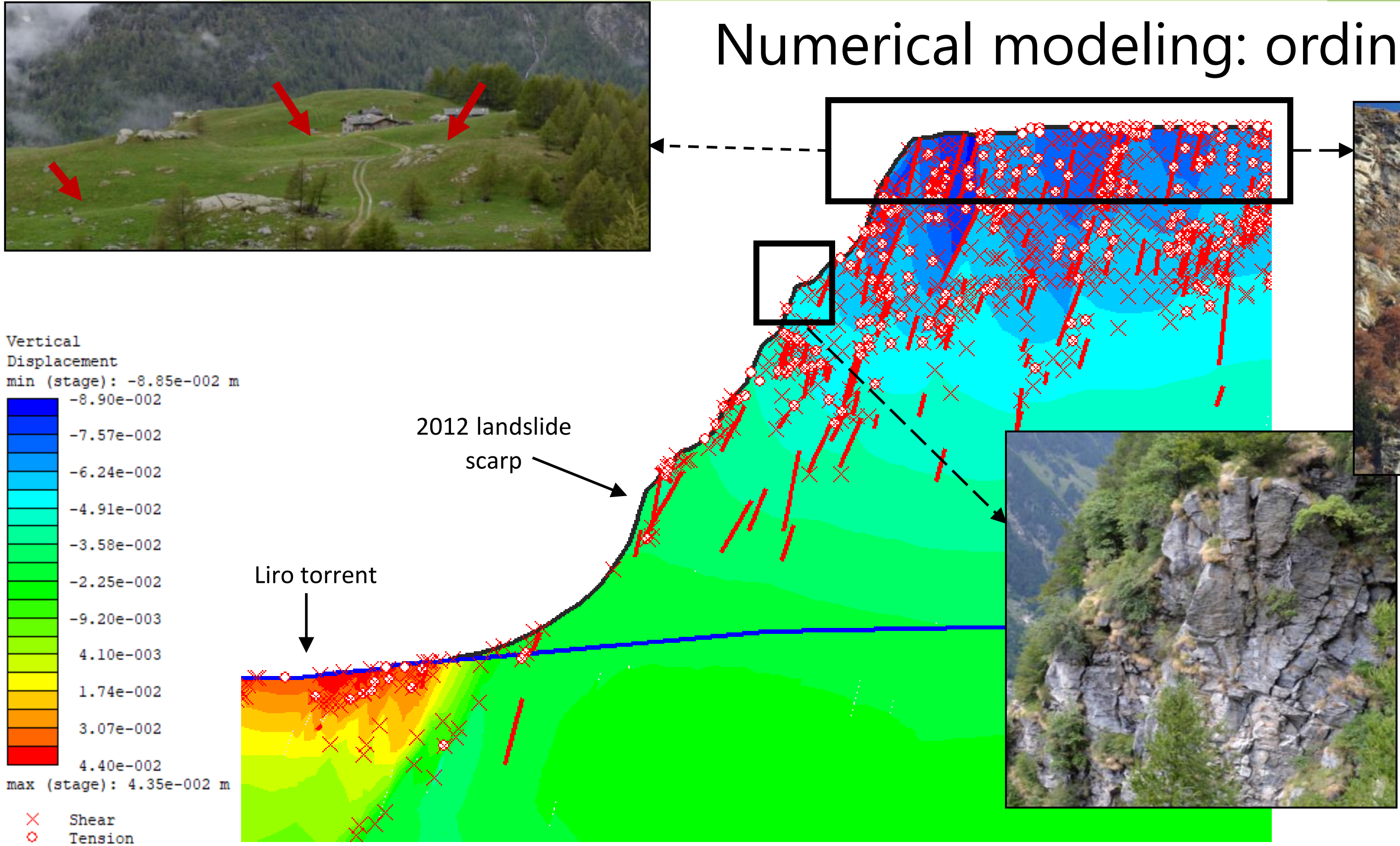
Mesh:
Uniform 6 noded triangles

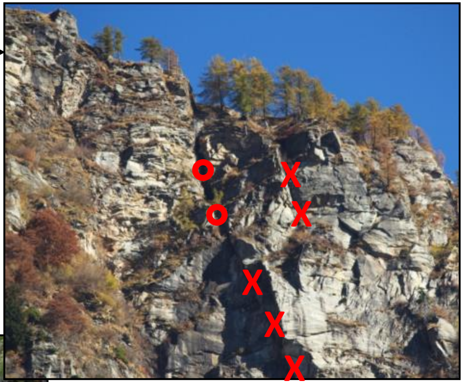


Joint network: ''Beacher" model

SET	TIPO	Imm. [°]	dip [°]	Mean length [m]	Intensity of fracturing	
K1	Shistosity	34	27	/	/	→ IMPLICIT
K2	Joint	287	78	58.2	0.00013	EXPLICIT
K3	Joint	222	79	34.3	0.00013	

Numerical modeling: ordinary conditions

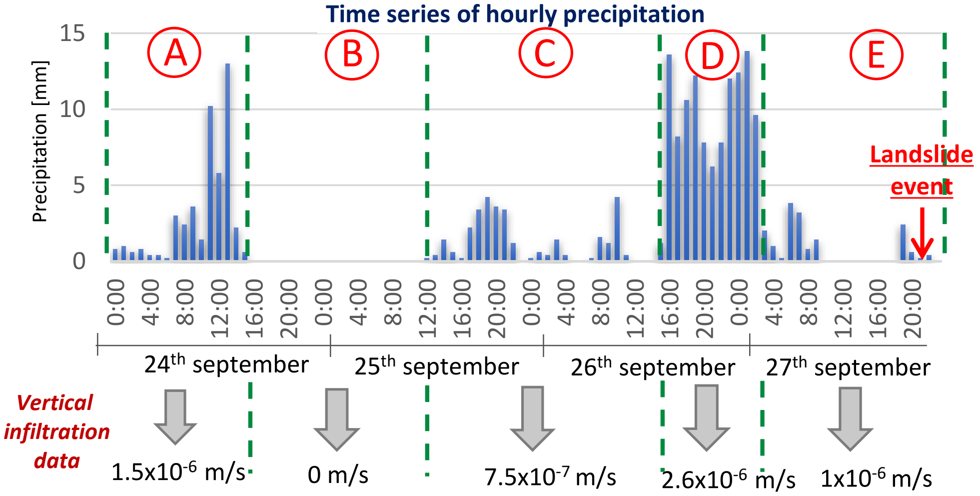


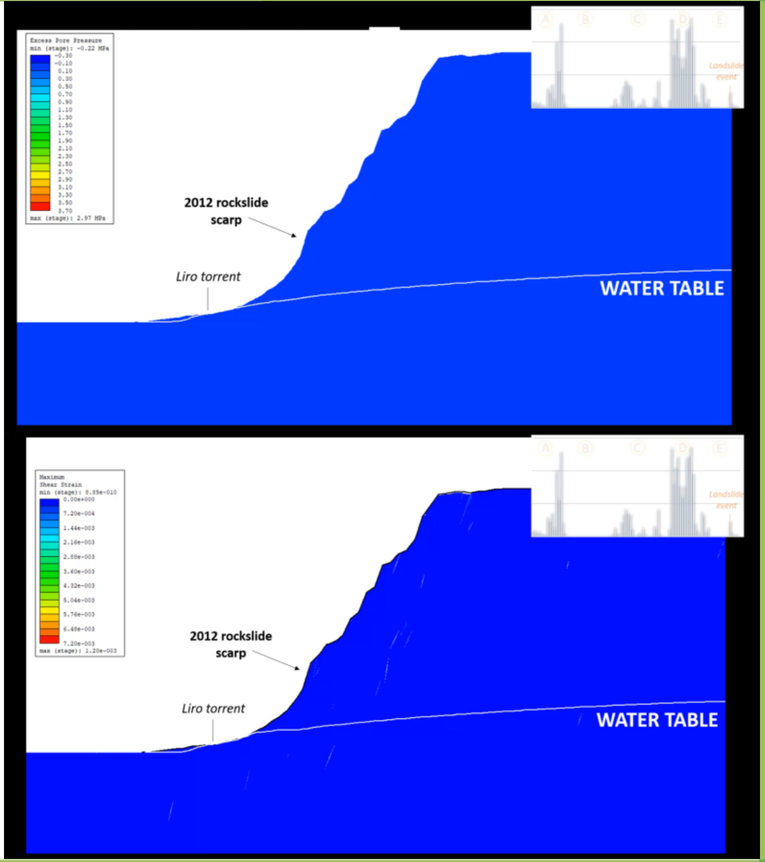


The distribution and entity of simulated displacements are suitable with the direct measurements and observations carried out during geological surveys

Transient finite element analysis

Vertical infiltration: imput data





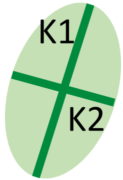
Hydraulic parameters

Rock masses principal hydraulic conductivities were calculated considering joint orientation, JRC, aperture and fracture frequency of each discontinuity set

$$K_1 = 1.26\text{x}10^{-5}\ \text{m/s}$$
$$K_2 = 2.21\text{x}10^{-9}\ \text{m/s}$$

K1 ϑ angle of 80°

ANISOTROPY



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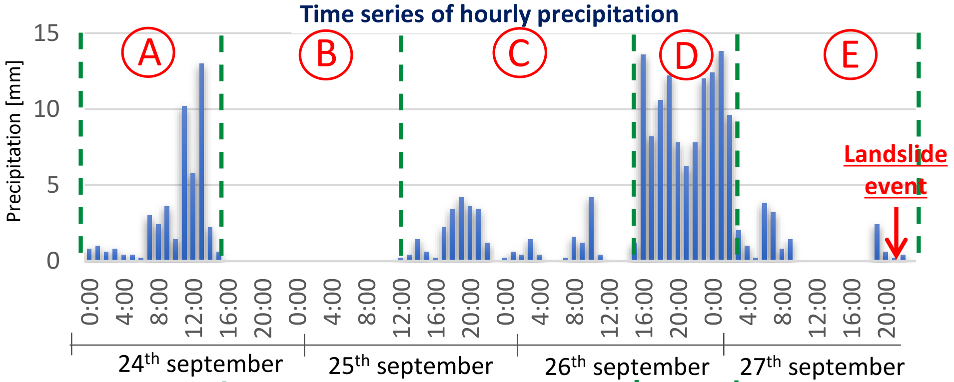

Vertical infiltration data

A	B	C	D	E
1.5×10^{-6} m/s	0 m/s	7.5×10^{-7} m/s	2.6×10^{-6} m/s	1×10^{-6} m/s

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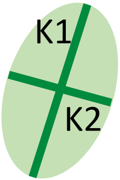

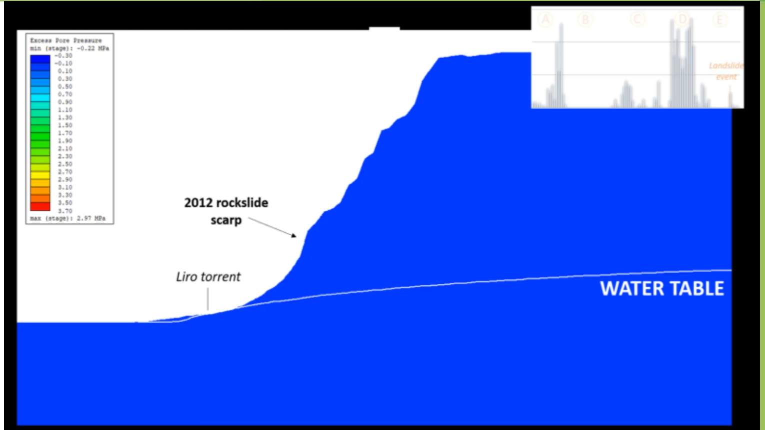

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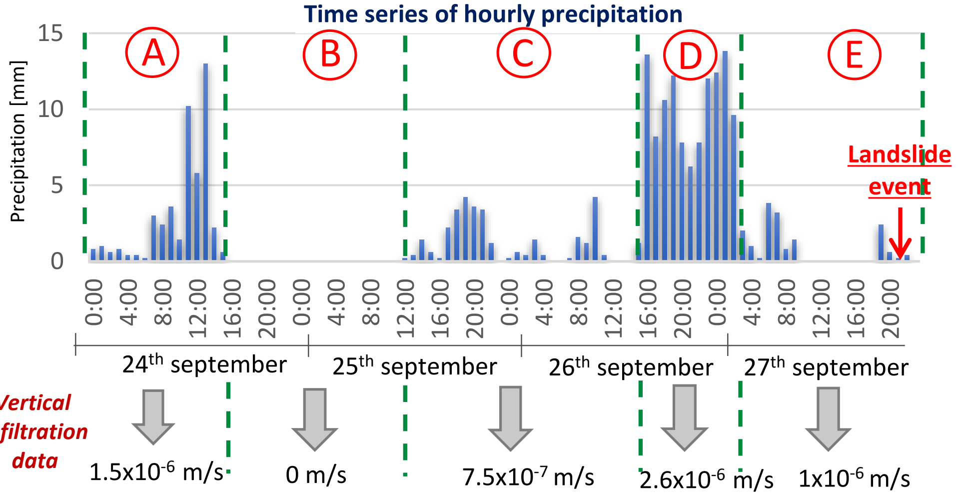

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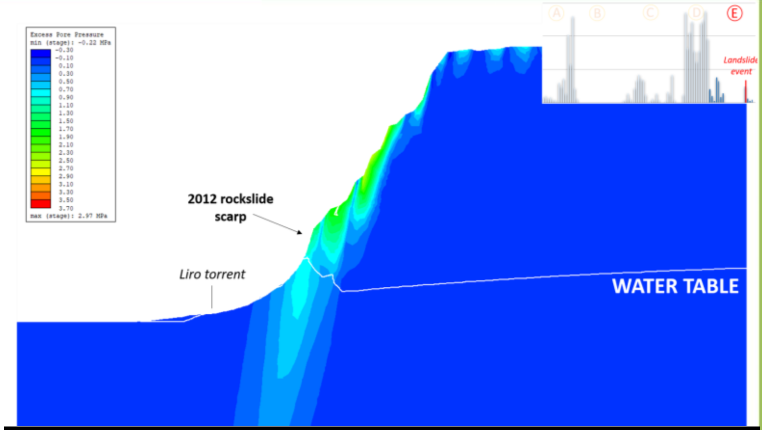

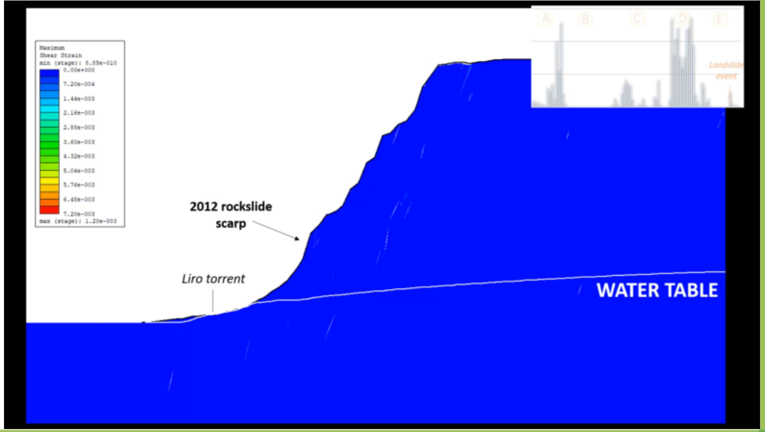

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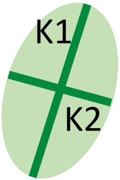

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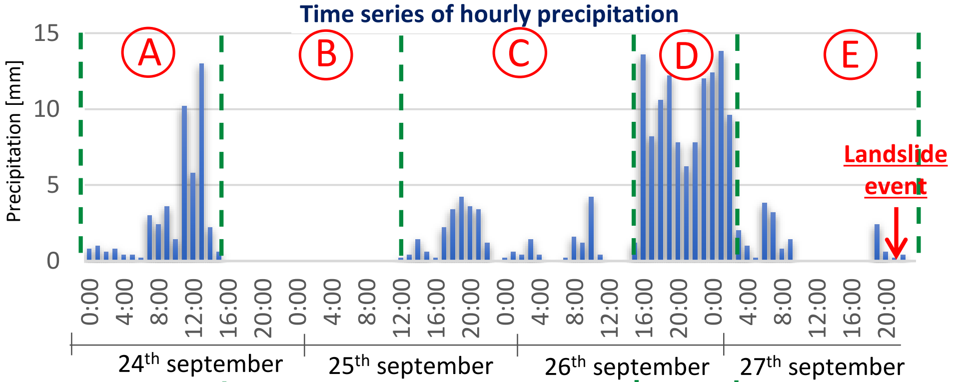

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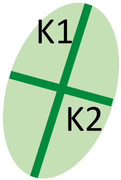
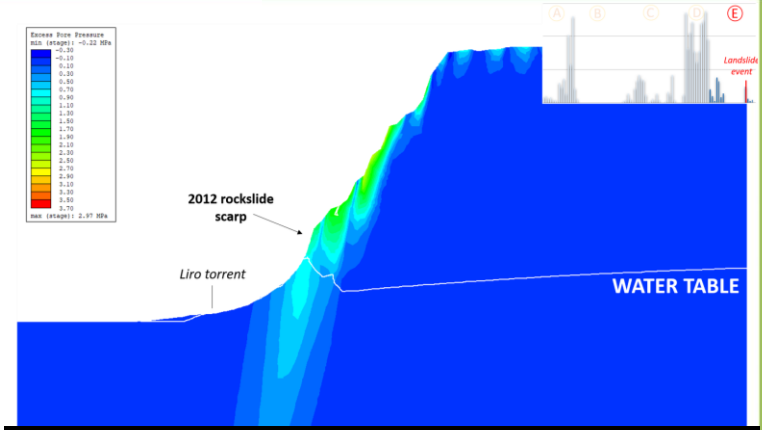
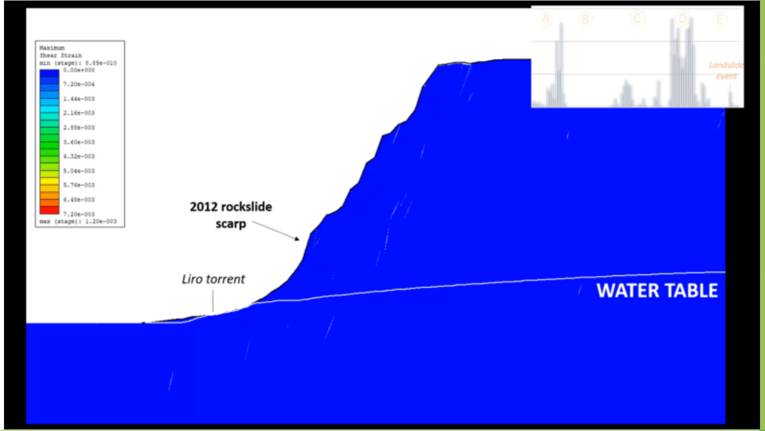


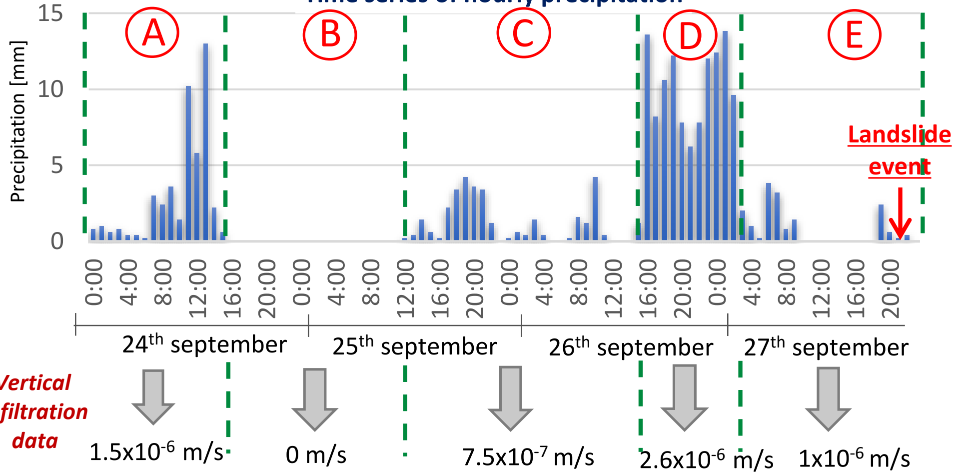




Transient finite element analysis

Vertical infiltration: imput data

Time series of hourly precipitation



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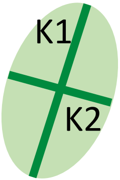
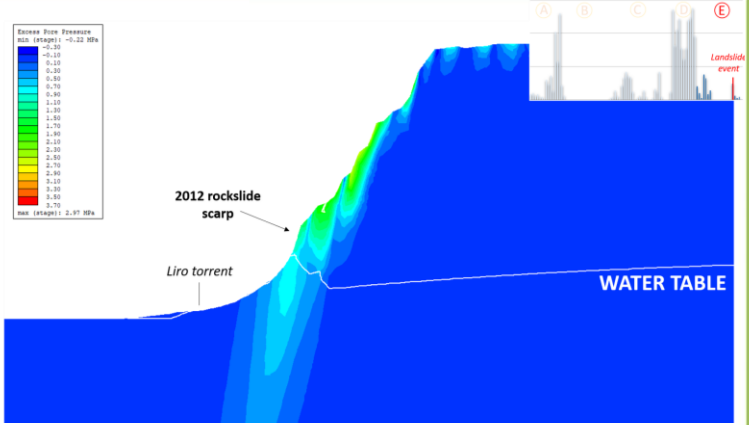




Final remarks and future plans

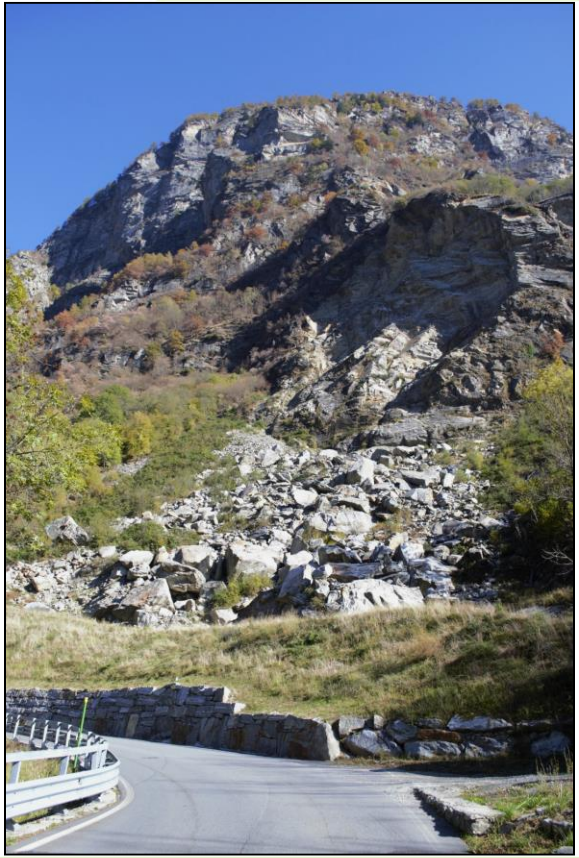
- An accurate geomechanical characterization of the "Cimaganda" rockslide slope was carried out. This led to implement a numerical model through which it was possible to simulate the general evolution of the slope;

- The simulation of the 2012 event was possible by applying the worst mechanical detected properties and considering the hydrogeological conditions with a return period of 50 years as triggering factor.

- After the 2012 rockslide, new events on right flank of the Cimaganda slope could develop only as a consequence of progressive hydro-mechanical degradation or very intense rainfalls. However this does not exclude single rock mass falls, which are favored by the orientation, persistency and aperture of discontinuity sets.

FUTURE PLANS

- This work represents a solid base to improve the analysis of the Cimaganda paleo-event and explore instability-forecasting scenarios in order to enhance rockslide risk management.



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Thanks for your attention!!

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