Experimental analysis of seasonal processes in shallow landslide in a snowy region through downscaled and in situ observation

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CONTEXT AND OBJECTIVES

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CLIMATE CHANGE

- Strongest snow melting cycles
- Earlier seasonal snow melting
- Different soil moisture conditions

Slope instabilities (**shallow landslides**)

- Shallow portion of soil.
- Fast and difficult to forecast.
- Triggered by short and intense rainfalls or events of medium intensity but prolonged over time (snow melting).

Objective: Studies of variables affecting more the shallow landslide phenomena triggered by snow melting activity

13 CLIMATE ACTION

In-situ: statistical analysis performed on data acquired from Mascognaz weather-snowpack station

Laboratory: snow melt simulation on a small-scale soil slope

Result: Improve the assessment of precise shallow landslides triggering thresholds in mountain environment

Sharing is encouraged

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IN-SITU ANALYSIS

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Understand main snow **wet metamorphism** driving factors from a statistical point of view.

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Data gathering
(10 minutes time-interval acquisition)

<u>Weather station</u> for atmospheric condition records (temperature, pressure, radiation, rainfall, pressure, wind, relative humidity)
<u>Snowpack station</u> for detecting snow layer parameter (density, weight, depth)

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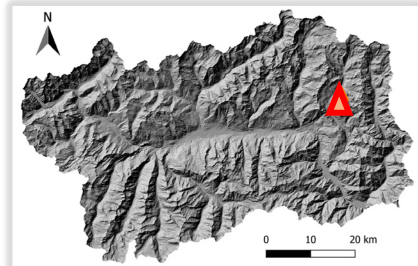
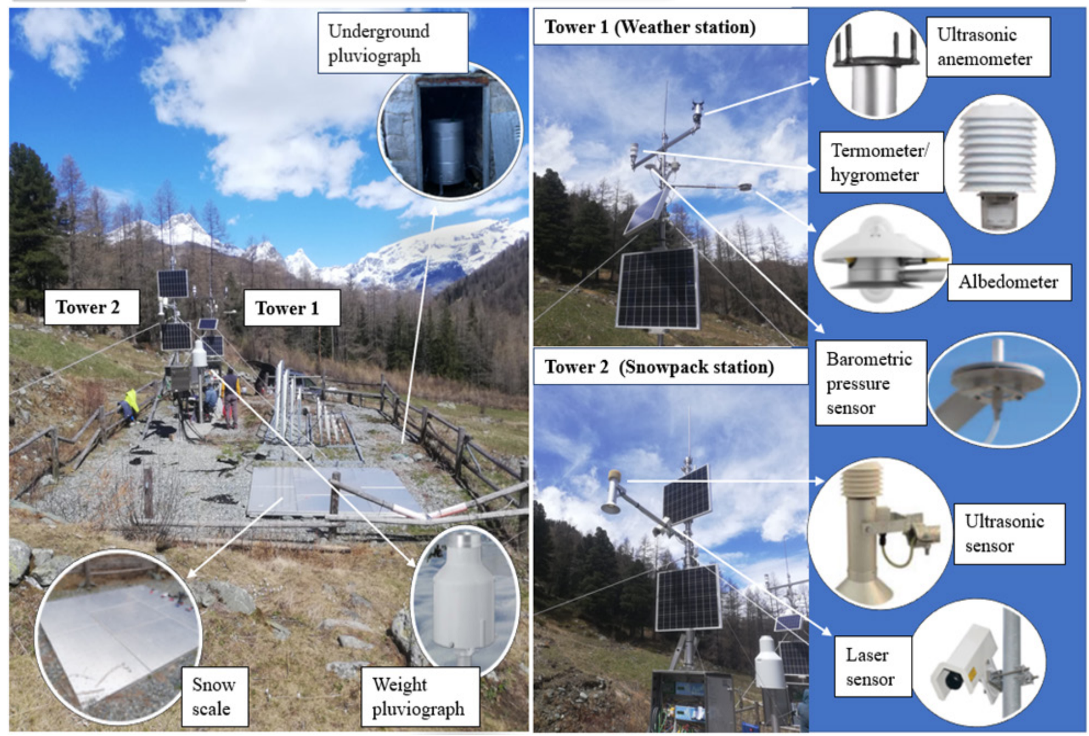
Analysis performed: MLS (Multiple Linear Regression) PCA (principal component analysis), Sobol indexes analysis

<u>Main variables influencing the melting process</u>: Temperature, Absorbed radiation, Snow density, Snow depth, Relative Humidity.



Mascognaz Weather-Snowpack Station (1950 m a.s.l.)



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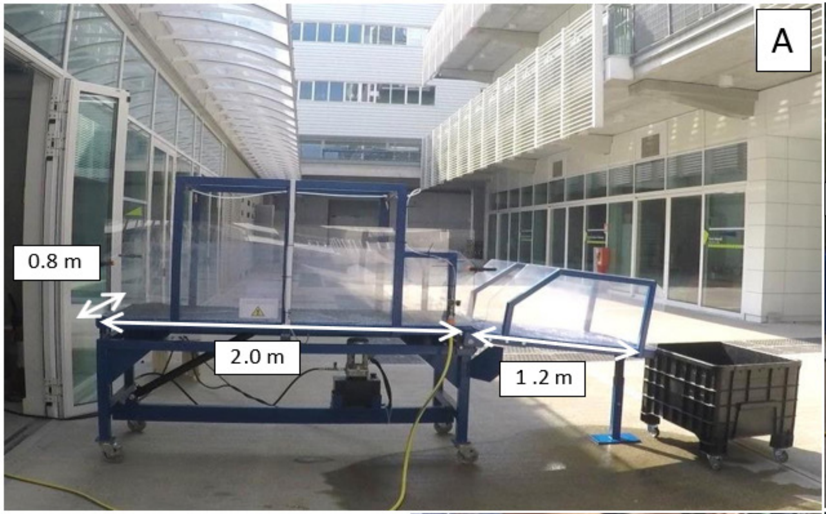
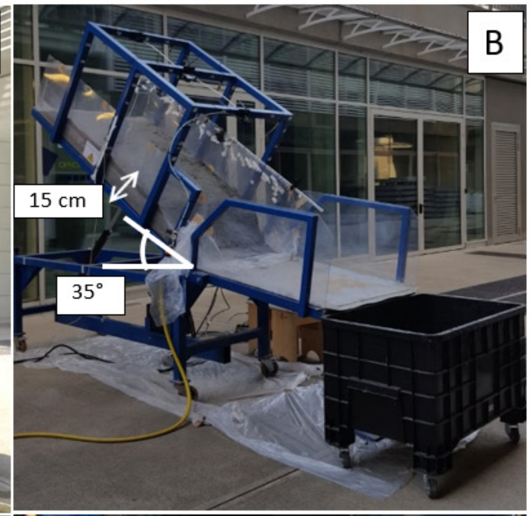
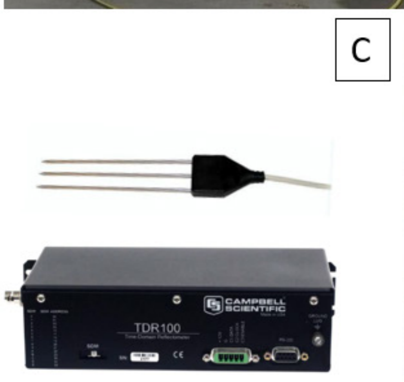
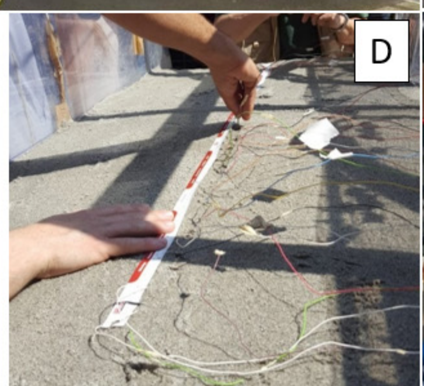
EXPERIMENTAL SET UP

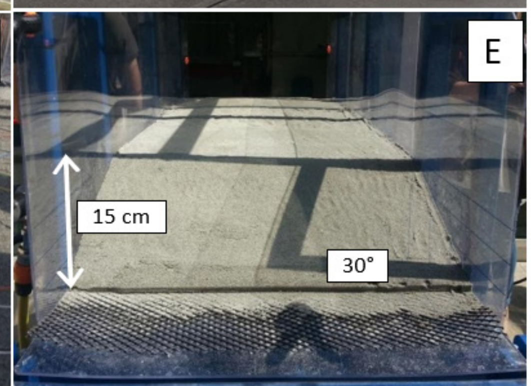
Applied Geology department of Lecco campus (Politecnico di Milano)











A) Landslide simulator geometry
B) Adjustable slab inclination
C) TDR sensor to records water content
D) Electrodes array to derive resistivity tomography
E) Slope soil layer geometry
F) Pressure-Temperature transmitters

DOWN SCALE SNOW MELTING EXPERIMENT: SOIL- SNOW DIRECT INTERACTION

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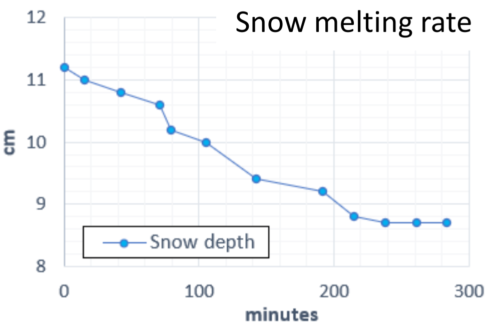
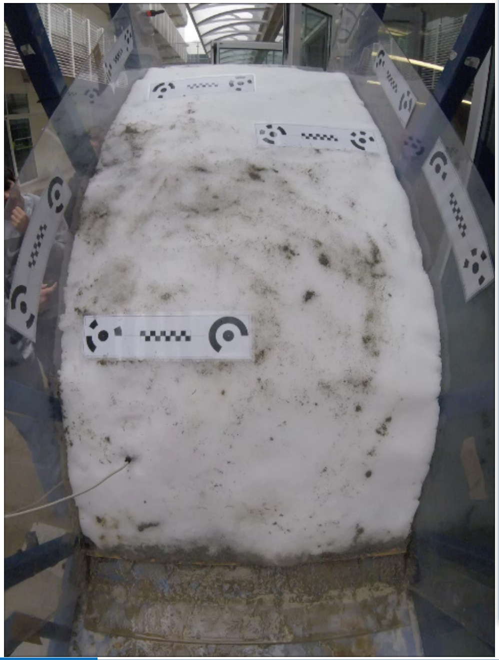
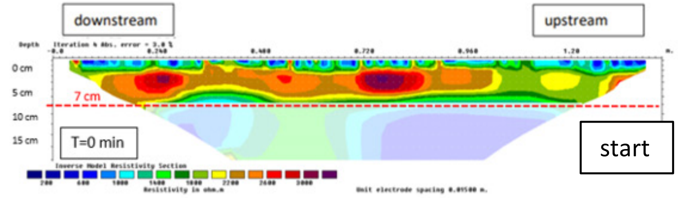
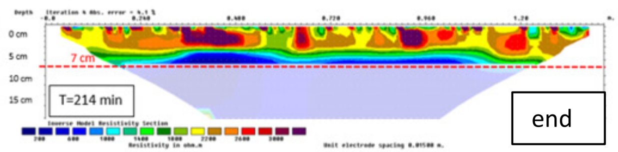
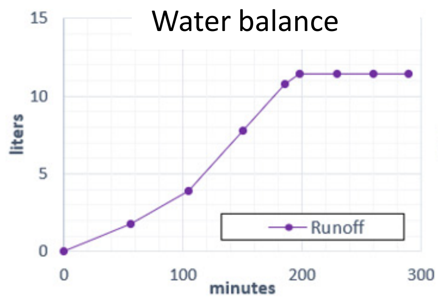
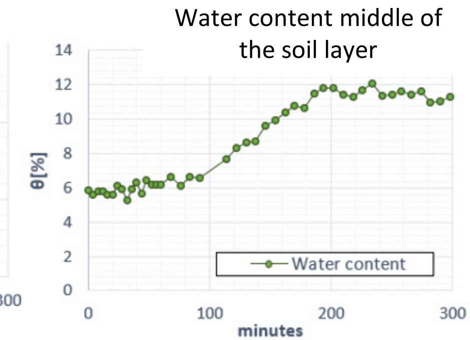


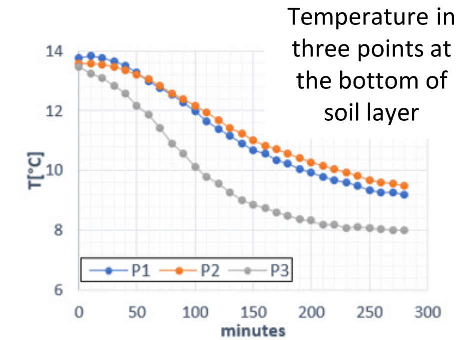




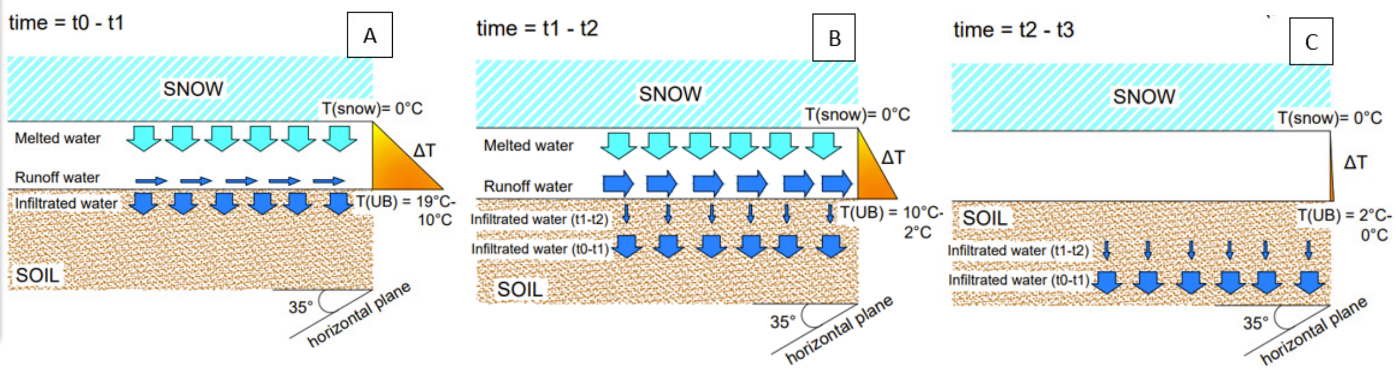








Process reconstruction:



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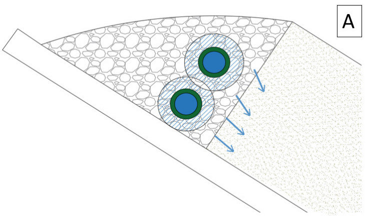
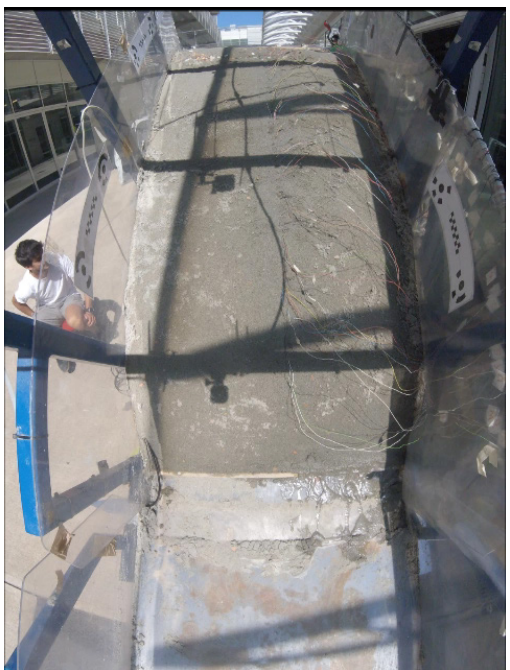
DOWN SCALE SNOW MELTING EXPERIMENT: SOIL- SNOW INDIRECT INTERACTION

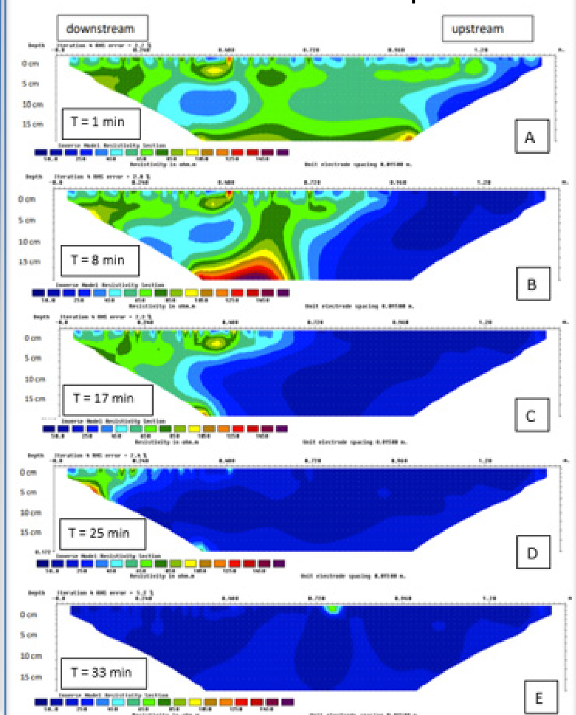
Artificial drain releasing water positioned above the soil layer





Simulation of uncovered soil that receive water from upstream snow melting water activity. Temperature of soil assumed to be in equilibrium to the air temperature (20°C).

Resistivity tomography at different time-steps



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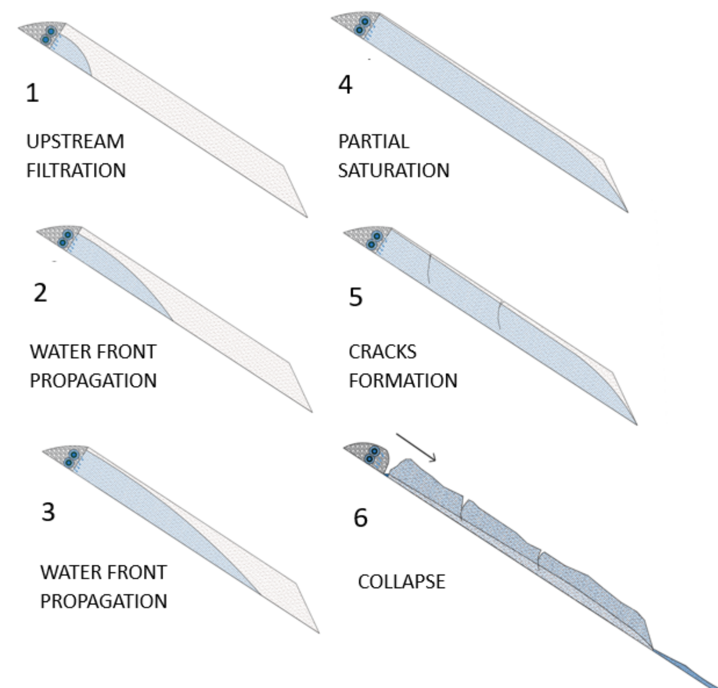

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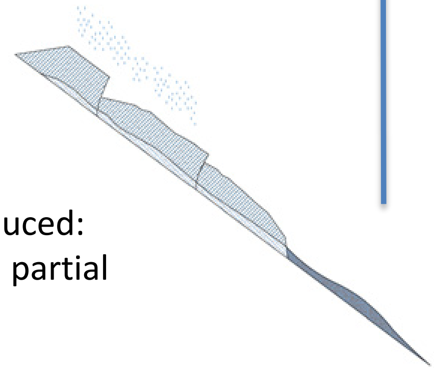
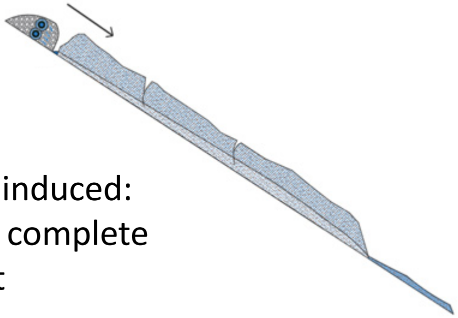
DIFFERENCE IN COLLAPSE MECHANISM

It has been noticed the difference between the **collapse mechanism** induced by rainfall and the one induced by uphill filtration process (snowmelt). The two simulation has been provided with the same rate of water, of course the quality of water input was different.

The collapse occurred after the **same time** of the simulation beginning for both the experiments: 35 min



Rainfall induced: Slower and partial movement



Snowmelt induced: Faster and complete movement

CONCLUSION

- Statistical elaboration of in-situ acquired data have shown that 2 hours averaged **temperature** values are correlated to the loss of water from snowpack in the same interval with 77% precision.
- **Soil temperature** is the other most important parameter affecting the infiltration process. Initially snow wets the upper portion of soil due to a thermal unbalance, afterwards, the energy balance is fulfilled and no more infiltration occurs.
- **Van Genuchten Mualem equations (HYDRUS)** are a very good mathematical approximation of what has been observed in experimental analysis when we deal with two phases porous media, water circulation and temperature variation.
- More prone to collapse are those soil areas **downstream** snowpack coverage. Here filtration-infiltration processes are occurring <u>without the thermal barrier protection.</u> In this case ground concave morphologies can be water accumulation zones, therefore, being more prone to saturation.

THANKS FOR YOUR ATTENTION

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