Monitoring current impacts of climate change on slope stability in the Ormonts valley, western Switzerland

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I. Introduction

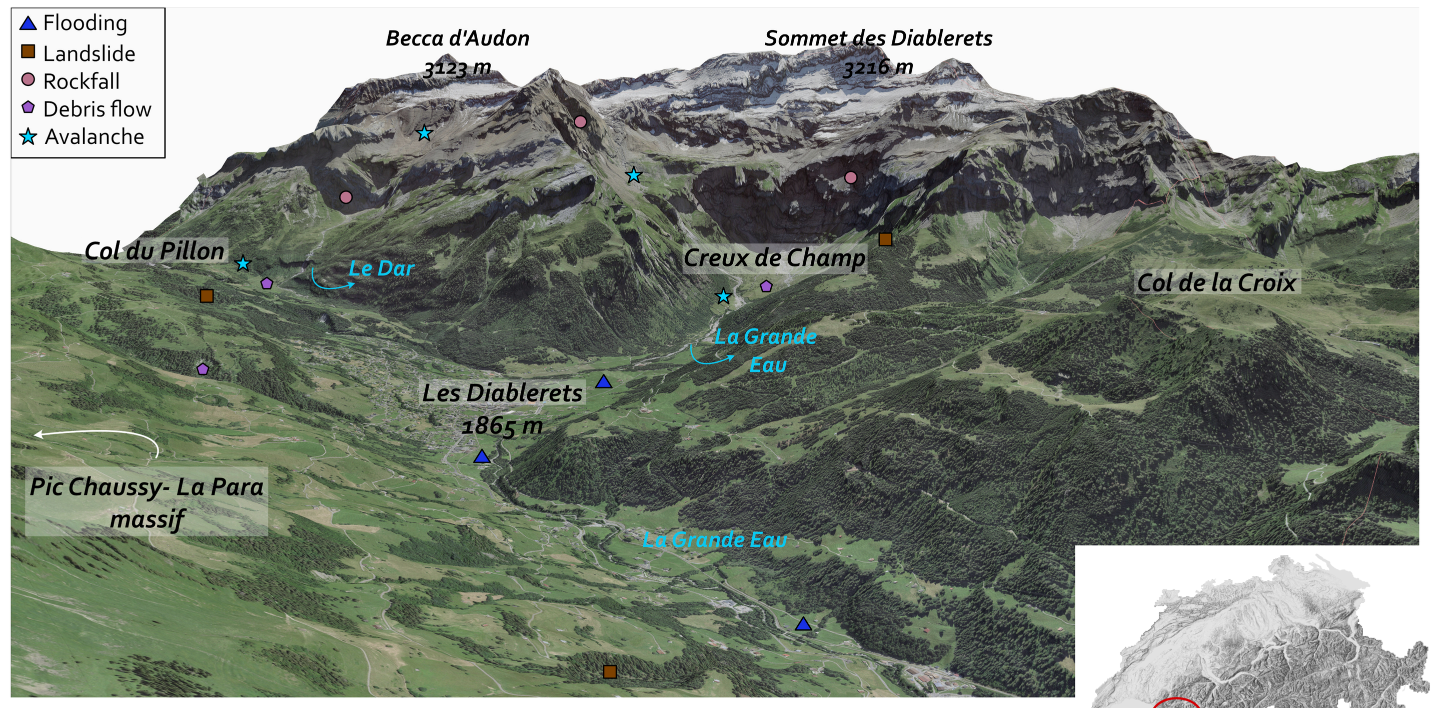


Figure 1: 3D View of the Upper Ormonts valley with the Diablerets massif in the back. Symbols indicate some well-kown locations of the natural hazards present. Inset: location of the valley in Switzerland (red circle).

The Upper Ormonts Valley, located in western Switzerland, has a general east-west orientation, represents the transition from the Pre-Alps to the Alps and is exposed to many natural hazards including avalanches, floods, landslides, rockfalls and debris flows.

For our study it has three main zones of interest, due the interactions of hazards: (a) the Pic Chaussy – La Para massif, and the Diablerets massif with its two main catchments (b) the Dar catchement including the upper Dar glacial circus, and (c) the Grande-Eau catchment including the Creux-du Champ circus.

II. Collected data (2023-2025)

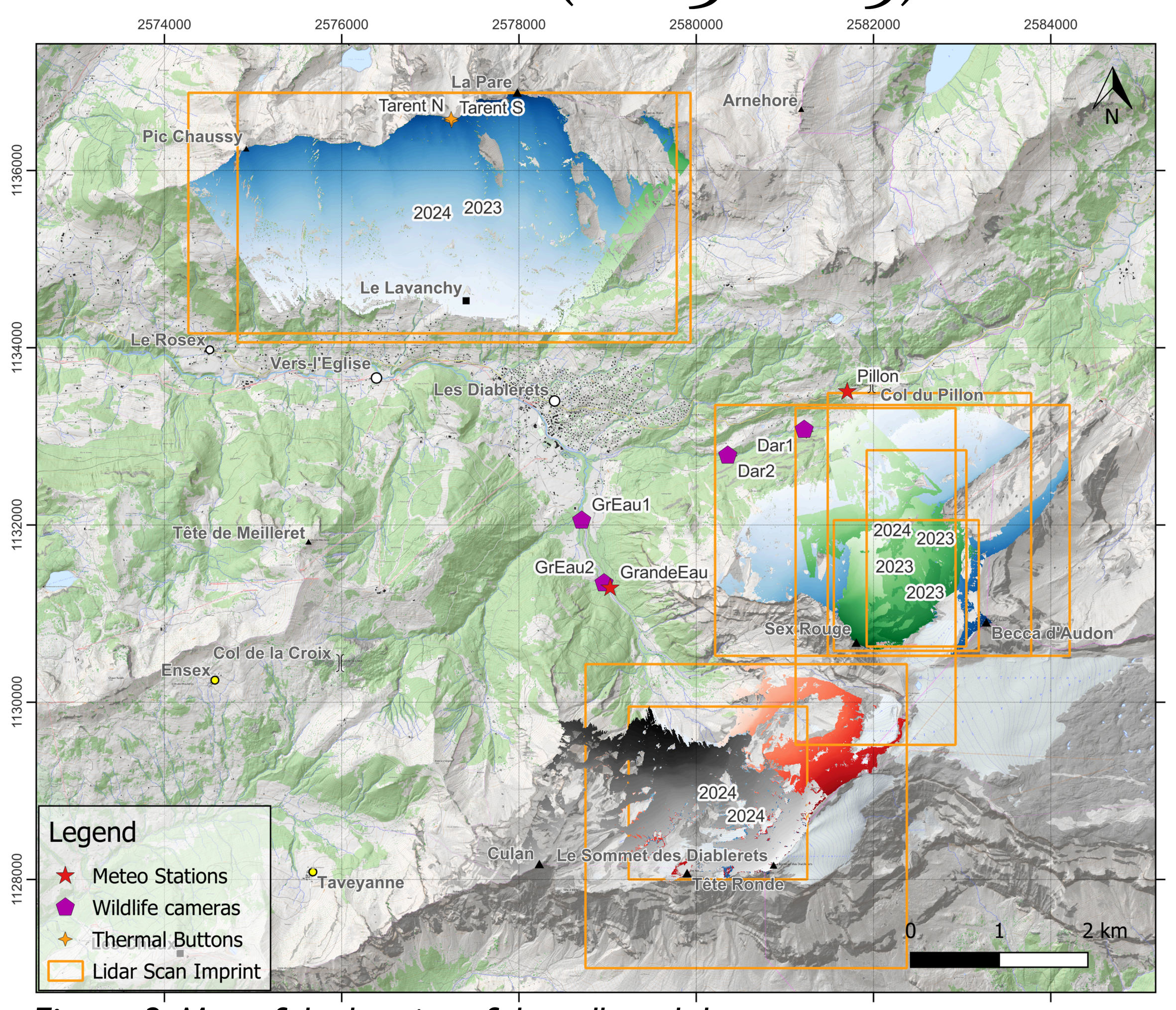


Figure 2: Map of the location of the collected datasets

Data collected from our study area include: summer and winter* lidar scans, temperature data from thermal buttons and meteorological stations, precititation data from a manual station (MétéoSuisse) and wildlife camera pictures every 15 minutes of the Dar and Grande Eau riverbed (summer 2023 and 2024).

III. Sediment migration and associated hazards (Dar & Grande Eau basins)

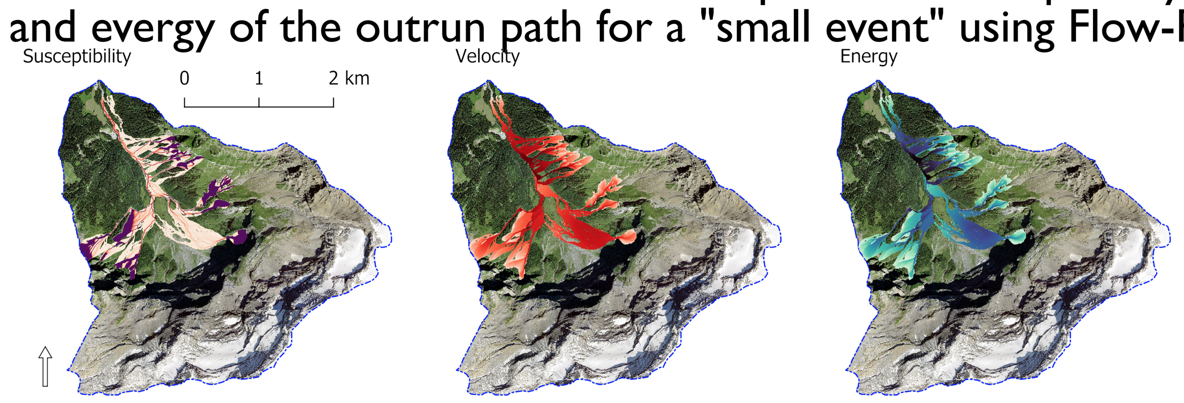
Deglaciation of the Diablerets massif and potential permafrost degradation are large sources of sediment in the Dar and Grande Eau basins, which could lead to an event similar to the 2005 debris flow/ flood which was initiated in the Dar Glacial circus and reached the Diablerets village downstream. In the Creux du Champ circus, steep walls and a number of growing instabilities are also an important source of sediments wich could potentially impact the village.

***Tables 1 and 2** : erosion and accumulation from DoD's for the lower Dar (left) and available sediment estimation from SLBL upper Dar (right)*

Lower Dar		
Measure	**2005-2016**	**2016-2020**
Erosion (m^3)	-11 890.35	-8 716.04
Accum. (m^3)	24 793.24	16 964.67
total moved	36 683.59	25 680.71

Upper Dar		
Value	**Slbl vol (m^3)**	**est. Vol (m^3)**
Inverse SLBL	234 767.68	-
Poly 3 Small	-59 422.40	385 551.57
Poly 4 Big	-590 358.75	2 354 437.18

Estimation of available sediment volumes for the Dar catchment (using DoD's and SLBL) and identification of the source areas in both catchements allowed us to model the potential susceptibility, velocity and evergy of the outrun path for a "small event" using Flow-R.



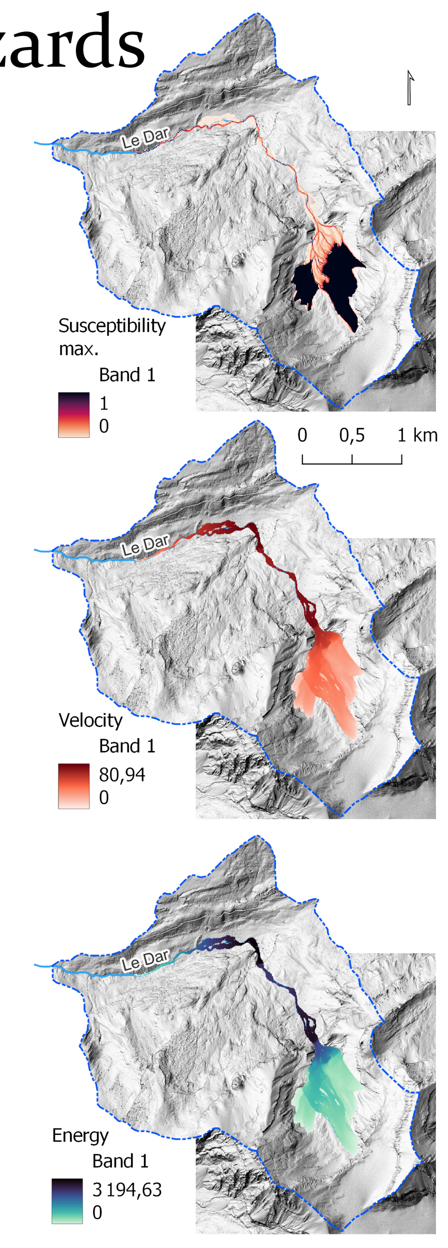


Figure 3: Maps of the debris-flow event Flow-R modelling outputs for the upper Dar basin (top) and for the Creux de Champ (Grande Eau basin) (left)

IV. Current impacts of changes in temperature

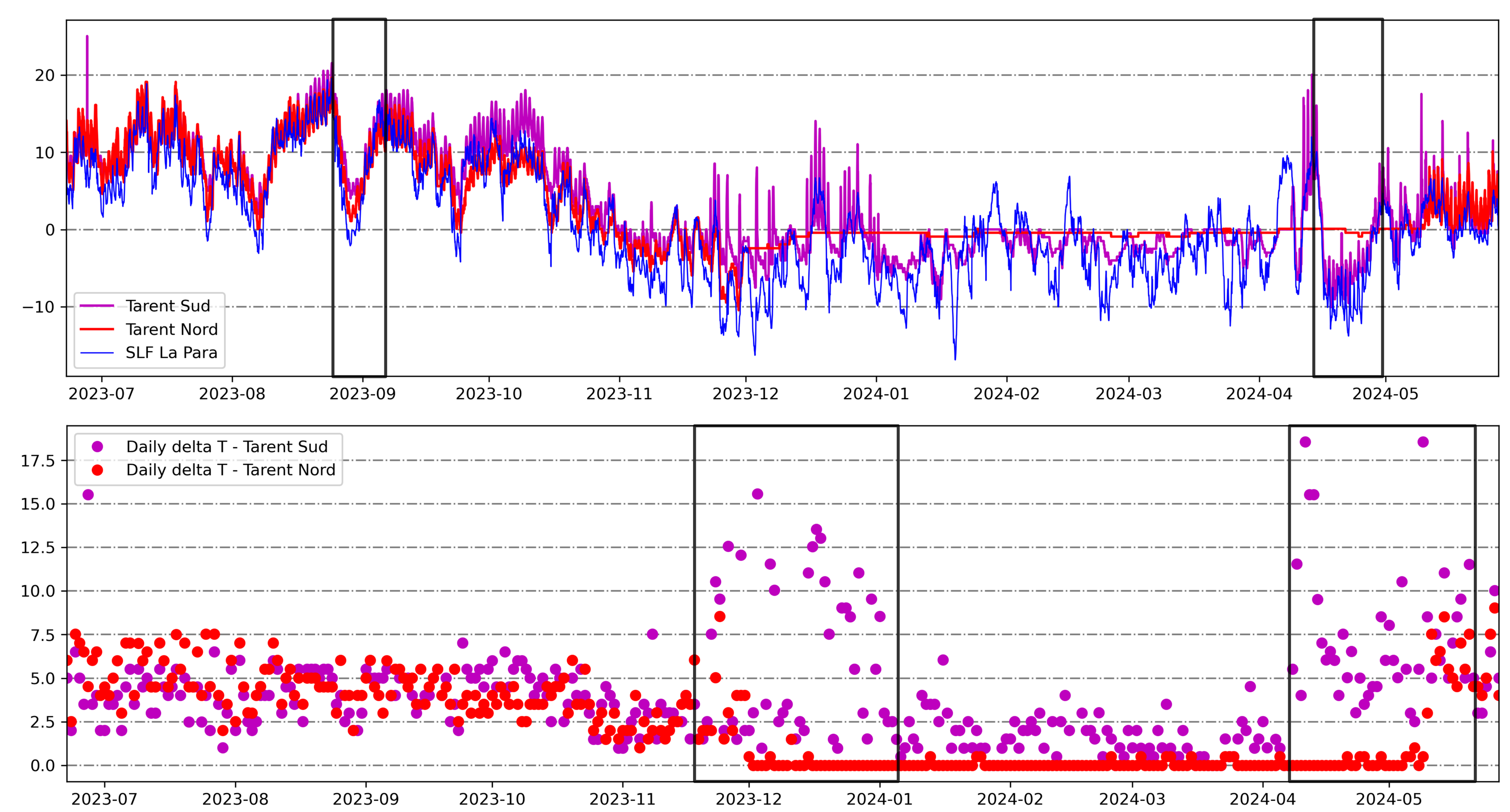
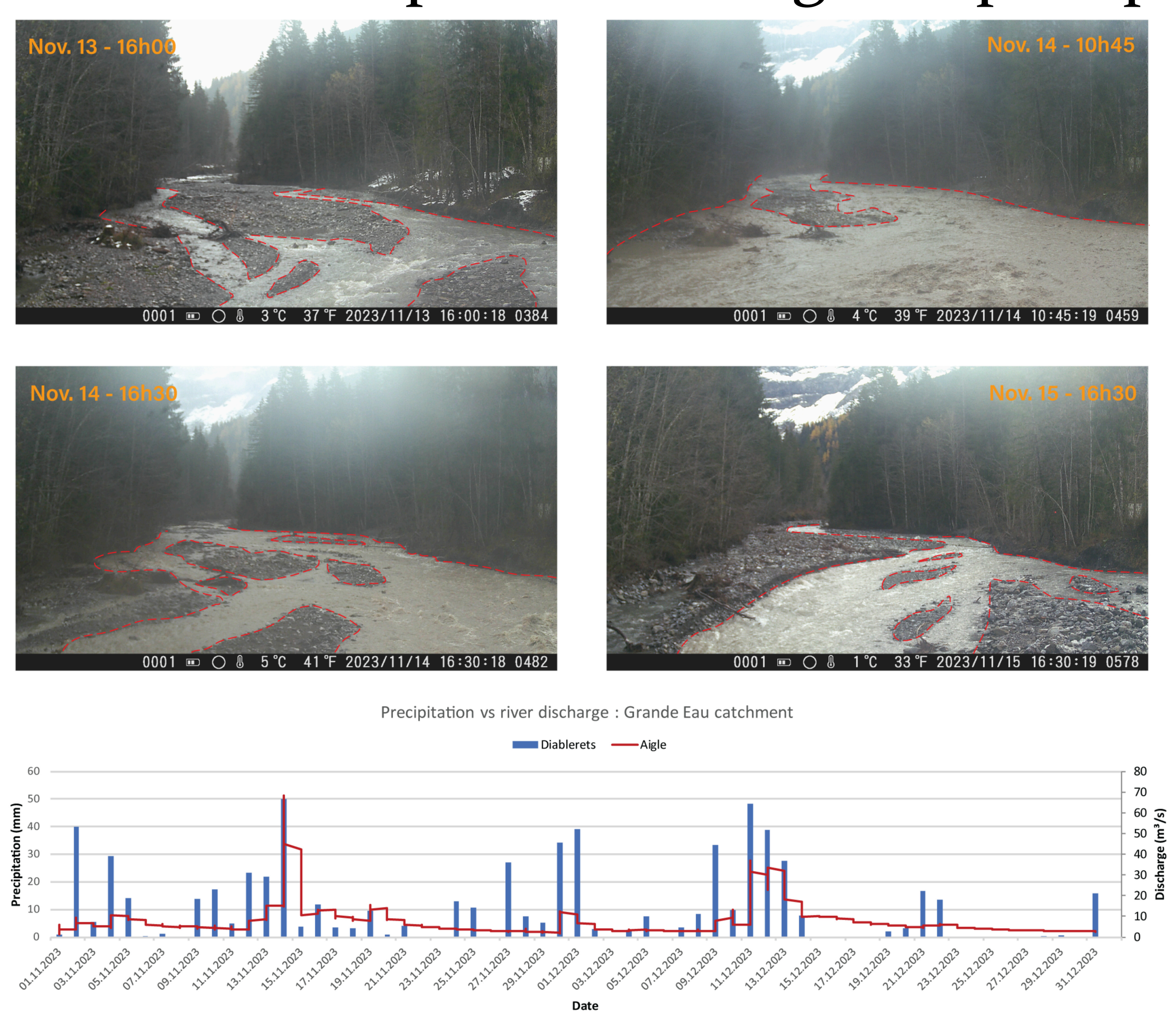


Figure 4: (a) Hourly temperature readings for the Col du Tarent (2357 m a.s.l.) on the North and South face, as well as readings from the SLF automatic station (La para, 2540 m) and (b) the calculated daily thermal gradient (Tmax - Tmin) for the North and South faces of Col du Tarent

Temperature anomalies as well as days with high thermal gradients, for example those recorded at the col du Tarent, can be directly linked to rockfall activity during winter* (freeze and thaw cycles) and rockfalls and landslides during spring and summer.

V. Current impacts of changes in precipitation



High precipitation events, such as the one of Nov. 14th 2024 (50 mm in 24h) show not only rapid changes in the riverbed of the Grande Eau river, but also overflow in some points, bank erosion and even a small debris flow event in a tributary downstream. These events will become more frequent, especially in winter.

Figure 5: Riverbed changes during Nov 14th event.: before (top left), during (top right and middle left) and after (middle right). Precipitation measured near the camera site and the discharge 15 km downstream (bottom)

VI. Discussion and preliminary conclusions

In spite of the short observation period (2023-2025), current effects of climate change are already visible in the Ormonts region. Although links to gravitational mass movements (rockfall, landslides and debris flows) are harder to establish unequivocally, the collected data allows us to prove the effects of abrupt changes on slope stability. Mild winters and wet springs such as that of 2023/2024 resulted in exceptional precipitations at mid-elevations, causing a number of shallow landslides in the Pic Chaussy - La Para south slope. While large daily temperature variations at high elevations due to warming periods, as in winter 2024/2025, triggered both a large block detachment and a 10'000 m³ rockfall in the Creux de Champ region (see figure 6). Wet conditions in winter (in particular rain over snow) favored shallow landslides, strong riverbank erosion and a few high discharge events in the Grande Eau River. While in summer, localized storm cells causing extreme precipitation events, pose a significant threat, whose precise impacts on slope stability remain to be proved.

Figure 6: Image of the February 14th 2025 rockfall at Creux du Champ.