A 'subsurface weather station' to measure boulder-mantle heat fluxes on Murtèl rock glacier

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The debris cover of rock glaciers partially decouples the underlying ice-rich permafrost from the atmosphere, retarding permafrost degradation and making rock glaciers locally important water storages in future deglacierized arid mountain ranges. Heat exchange between atmosphere and permafrost table mainly governs seasonal active layer thawing and long-term permafrost ice melt. However, in the open-framework boulder mantle, heat exchange processes are complex. Numerical modelling and laboratory experiments showed that long-wave radiation between boulders (Lebeau & Konrad, 2016) and convection by air circulation (Wicky & Hauck, 2020) are not negligible with respect to simple conduction.

We attempt to quantify the relative importance of the different energy fluxes by measuring heat-flux components in the boulder mantle of the rock glacier Murtèl (Upper Engadine). This intensively studied rock glacier is an ideal test site because the internal stratigraphy (active-layer thickness, ice content) is known from boreholes and the surface meteorological conditions are continuosly measured (Fig. 1, boreholes and meteo station).

We augment the decade-long (surface) meteorological time series and borehole temperature data of the Murtèl rock glacier with a three-part array of sensors: First, we place microclimate sensors in a natural cavity within the open-framework boulder mantle (Fig. 1, boulder-mantle sensors). They capture conduction in boulders, radiation, and air and moisture flow in the active layer. The upper boundary condition (BC) is resolved by additional sensors for eddy-correlation based turbulent heat flux calculations and sensors for snow-cover characterization (Fig. 1, atmospheric and snow sensors). Ground heat flux from the underlying rock-glacier core (lower BC) is calculated via existing borehole temperature data. Second, this point measurement is complemented with temperature and wind-speed loggers distributed over the rock glacier to capture large-scale air circulation patterns. Time-lapse images in the visible light and thermal infrared ranges monitor seasonal snow-cover and surface temperature evolution (Fig. 1, cameras). Third, hydrological measurements in the rock-glacier forefield consisting of electrical conductivity, water temperature and water column height serve to track water provenance and to estimate discharge (Fig. 1, hydrological sensors).

The project focuses on understanding the temporal evolution of water resources in periglacial catchments and more reliable ice-rich permafrost runoff forecasts. This process understanding will also improve predictions on downwasting rates of debris-covered glaciers.

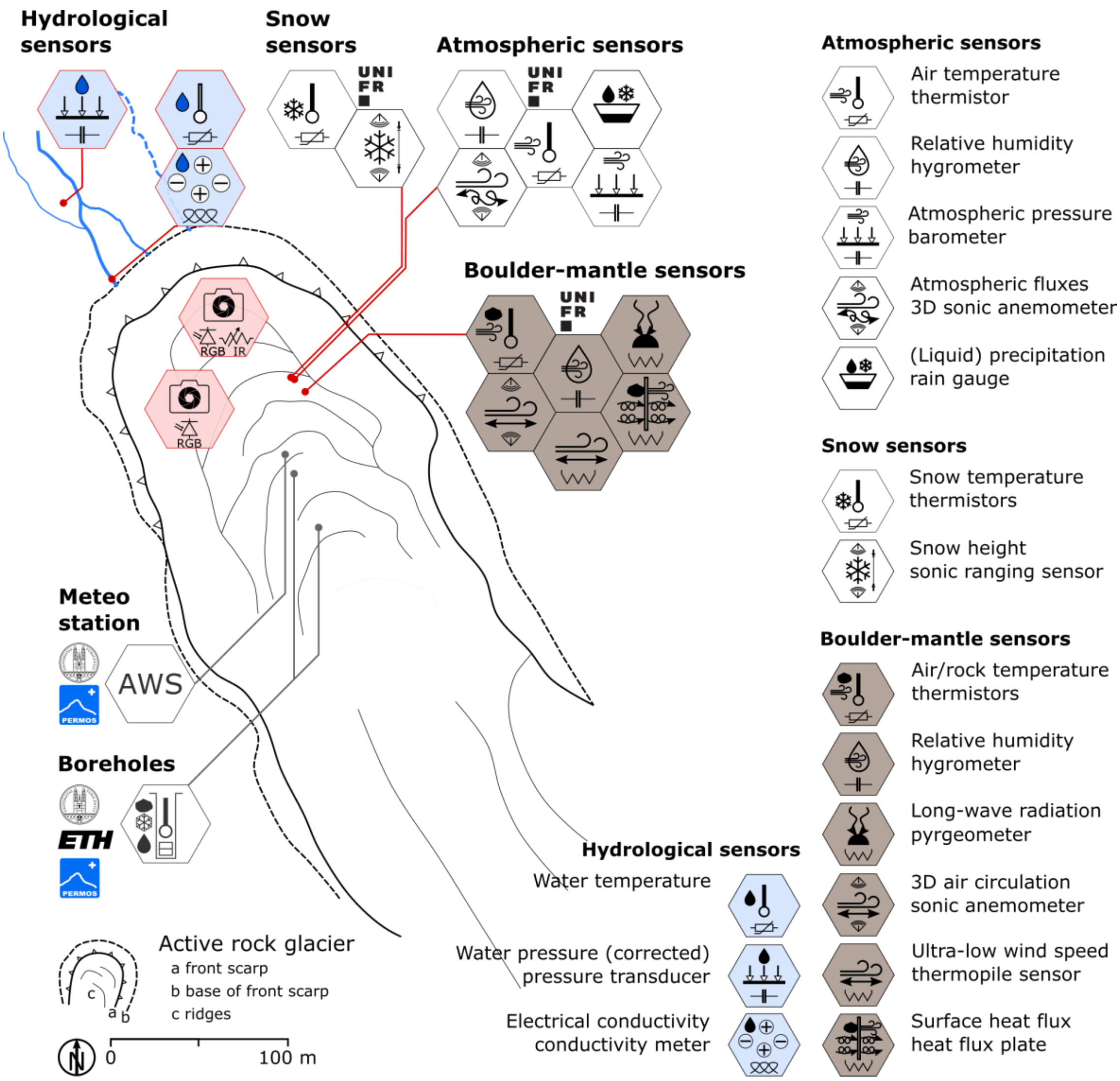

Figure 1. Sketch map of the Murtèl rock glacier with existing sensors (meteo station and boreholes) and newly deployed sensors (cameras, hydrological, snow, atmospheric and boulder-mantle sensors).

REFERENCES

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