EGU21-3274, updated on 23 Oct 2021
https://doi.org/10.5194/egusphere-egu21-3274
EGU General Assembly 2021

Firn changes at Colle Gnifetti revealed with a high-resolution process-based physical model approach

Enrico Mattea[1], Horst Machguth[1], Marlene Kronenberg[1], Ward van Pelt[2], Manuela Bassi[3], and Martin Hoelzle[1]

[1]Department of Geosciences, University of Fribourg, Fribourg, Switzerland
[2]Department of Earth Sciences, Uppsala University, Uppsala, Sweden
[3]Department of Forecasting Systems, Regional Agency for Environmental Protection of Piedmont, Turin, Italy

Cold firn is progressively transitioning to a temperate state under a changing climate. This process is expected to affect ice core records and the mass balance of cold and polythermal glaciers. Thus there is a need to gain better understanding of this transition and develop quantitative, physical models, to predict cold firn evolution under a range of climate scenarios.

Here we present the application of a distributed, fully coupled energy balance and sub-surface model, to simulate high-alpine cold firn at Colle Gnifetti over the period 2003–2018. For the first time, we force such a model with high-resolution, long-term, quality-checked meteorological data measured in closest vicinity of the firn site, at the highest weather station in Europe (Capanna Margherita, 4560 m a.s.l.). The model includes the spatial variability of snow accumulation rates, and is calibrated using several, partly unpublished high-altitude measurements from the Monte Rosa area.

Overall, the simulated firn temperature profiles reach a very good agreement in comparison with a large archive of borehole measurements. Our results show a 20 m-depth firn warming rate of 0.44 °C per decade. Moreover, we find that surface melt over the glaciated saddle is increasing by 3–4 mm w.e. yr^{-2} (+29–36 % in 16 years) depending on the location, although with a large inter-annual variability. The simulation also indicates that atmospheric humidity is a prominent control over melt occurrence, with considerable amounts of sublimation taking place in dry conditions. Hourly-resolution analysis of the melt dynamics reveals a marked tendency towards frequent, small melt events (< 4 mm w.e.): these collectively represent a significant fraction of the total amounts.