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Thermal profile of ice/snow covers on three north faces of the Mont Blanc massif (European Alps, France)

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Ice/snow covers (ISCs) are among the most unknown elements of the cryosphere despite some qualitative descriptions from the 1960s. Located on steep rock faces, they are important elements of the high mountain landscape and an ascent context for mountaineers. While thermal state of adjacent steep rock walls is studied since the 2000s in order to prevent risks related to permafrost warming, the thermal state of the ISCs is largely unknown. To help fill the gap in knowledge of the ISCs thermal conditions, three ISCs of different thickness have been drilled down to the bedrock using a steam-operated ice drill in the north faces of Tour Ronde (3792 m a.s.l.), Mont Blanc du Tacul (4248 m a.s.l.) and Aiguille du Midi (3842 m a.s.l.) in the framework of the ANR VIP Mont Blanc project. Located between 3500 and 3650 m a.s.l., the boreholes are 1.0, 8.8 and 15.9 m deep, respectively. Each borehole has been equipped with temperature sensor chains (Geoprecision Dallas DS18S20, accuracy: $\pm$ 0.25°C, resolution: 0.065°C). Temperature is recorded (logger Dallas M-Log5W) every 4 hours since December 2016 at the Tour Ronde (9 sensors), March 2017 at the Mont Blanc du Tacul (4 sensors), and October 2017 at the Aiguille du Midi (7 sensors). Geoprecision PT1000 sensors (with an M-Log5W logger) were also installed at 10 cm depth in the rock walls close to the boreholes.
Data allow a preliminary characterization of the ISCs thermal fields. At the Tacul, because of the thin cover thinness, daily ISC temperature is fully dependent on air temperature. At the Tour Ronde and Aiguille du Midi, ISC daily temperature is extremely constrained by the air temperature in the shallowest meters, whereas only seasonal air temperature signal affects ice temperature at and below 5 m depths which record the lowest temperature during the early summer. At ice-rock interface, temperature ranges from -4.2 to -6.0°C at the Tour Ronde (8.8 m depth, from Dec. 2016 to Oct. 2017), and is around -0.5°C at the Aiguille du Midi (15.9 m depth, from Oct. 2017 to Feb. 2018). In this latter case, ice seems quasi-isothermal from c. 7.5 m depth. These strong temperature differences at depth, despite similar aspect and elevation, may result from different glaciological contexts. The Tour Ronde is a rocky and sharp permafrost-affected nunatak; the opposite slope to the Aiguille du Midi ISC is covered by the thick, likely temperate Géant glacier, suggesting a weak thermal gradient in the bedrock − a setting that could favor the current existence of quasi-temperate ISCs.