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Convective air venting from deep fractures and the temperature field of an alpine rock slope (Randa, VS)

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Thermal conditions in near-surface bedrock have gained a prominent role in alpine geosystems research. This is most evidenced in studies of mountain permafrost, where changes in the ground temperature distribution are increasingly implicated as a cause of anomalous slope failure in high alpine areas. In this study, we analyze a unique set of temperature measurements from an alpine rock slope at ∼2400 m a.s.l. in southern Switzerland. The monitored slope lies above the village of Randa in the Matter valley, and contains roughly 5 million m3 of unstable crystalline rock. The area is traversed by a network of tension cracks with varying widths and depths, some which have been traced 80+ m with geophysical imaging to where they cross a borehole. We first aim to describe the conductive temperature field based on distributed surface measurements and borehole profiles, highlighting deep steady temperatures and different transient effects. In a second step, we analyze the impact of air circulation in deep fractures on the predicted temperature field. On multiple visits to the study site in winter 2008-09 and 2009-10, we consistently noted the presence of warm air vents in the snow pack, lying directly over deep tension cracks. The observed vents followed the trace of certain steeply-dipping cracks, and many remained in the same location from year to year. To investigate the thermal conditions of these air vents, three thermistor dataloggers were suspended in a representative crack. Observations show that venting air in the winter changed temperature gradually between December and May from 3 to 2 °C, which is similar to the temperature at around 50 m depth. Comparison with air temperature data suggests favorable conditions for buoyancy-driven convective air flow, which acts to cool the deeper subsurface while warming the upper meters above the normal winter temperature. This process may have a significant effect on the subsurface temperature field, as suggested by an apparently disturbed temperature profile in one borehole.