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Thermal regime and potential bedrock weathering in alpine rockwalls of Austria: Results from eight years of monitoring (2006-2014)

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Bedrock temperature at sites with a minor winter snow cover gives a good indication for the effects of air temperature anomalies on ground thermal conditions as well as for the intensity of near-surface physical weathering in bedrock. In this study we present results from an ongoing bedrock temperature monitoring program initiated in 2006. Within the framework of this program nine surface boreholes in rockwalls with different slope orientations and two additional boreholes at flat bedrock sites were drilled between August and September 2006 and subsequently instrumented. The altogether eleven rock temperature sites (RTS) are located in the alpine periglacial zone of the Austrian Alps at latitude 46°55' to 47°22' and longitude 12°44' to 14°41'. All RTS have been installed in metamorphic rock (5 x mica schist; 6 x gneiss) at elevations between 1960 and 2725 m asl (mean 2491 m asl.). Three temperature sensors (PT1000) have been inserted at each borehole site at vertical depths of 3, 10 and 30-40 cm. At each RTS the three sensors are connected to a 3-channel miniature temperature datalogger (MTD) manufactured by GeoPrecision, Germany. Our analysis focussed on (a) the variation of mean and extreme daily temperatures at the rock surface and at depth, (b) the variation of the daily temperature range, (c) the number of freeze-thaw-cycles (FTC) and (d) effective freeze-thaw cycles for frost shattering (eFTC), (e) the duration and intensity of freeze-thaw-cycles (DI-FTC), (f) the number of hours and days within the so-called frost-cracking-window (FCW), and effects of (g) aspect and (h) snow cover on the thermal regimes in the bedrock. Results show for instance that the number of FTC and eFTC varied substantially during the observation period at all eleven RTS and at all sensor depths. However, this variation differs from site to site related to snow cover condition, elevation and aspect. For instance, at one lower-elevated (2255 m asl) north exposed RTS the number of FTC and eFTC was lowest during the hydrological year 06/07 (snow poor and warm winter) whereas highest in 11/12 (snow poor but rather cool winter). In contrast, results are completely different at two substantially higher-elevated but also north-exposed RTS (2639 and 2700 m asl) with highest FTC values in 06/07 and lowest in 11/12. Furthermore, at the two flat bedrock sites (at 2603 and 2650 m asl) the number of FTC and eFTC was highest in 06/07 related to the thin and short winter snow cover. The latter observation suggests that supposed warmer and snow-poor winters in the future will enhance diurnal freeze-thaw cycles and the intensity of near-surface physical weathering in the bedrock of the Austrian Alps. This seems to be feasible at least for elevations above c.2600 m asl.