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Statistical significant changes in ground thermal conditions of alpine Austria during the last decade

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Longer data series (e.g. >10 a) of ground temperatures in alpine regions are helpful to improve the understanding regarding the effects of present climate change on distribution and thermal characteristics of seasonal frost- and permafrost-affected areas. Beginning in 2004 – and more intensively since 2006 – a permafrost and seasonal frost monitoring network was established in Central and Eastern Austria by the University of Graz. This network consists of c.60 ground temperature (surface and near-surface) monitoring sites which are located at 1922-3002 m a.s.l., at latitude 46°55'-47°22'N and at longitude 12°44'-14°41'E. These data allow conclusions about general ground thermal conditions, potential permafrost occurrence, trend during the observation period, and regional pattern of changes. Calculations and analyses of several different temperature-related parameters were accomplished. At an annual scale a region-wide statistical significant warming during the observation period was revealed by e.g. an increase in mean annual temperature values (mean, maximum) or the significant lowering of the surface frost number (F+). At a seasonal scale no significant trend of any temperature-related parameter was in most cases revealed for spring (MAM) and autumn (SON). Winter (DJF) shows only a weak warming. In contrast, the summer (JJA) season reveals in general a significant warming as confirmed by several different temperature-related parameters such as e.g. mean seasonal temperature, number of thawing degree days, number of freezing degree days, or days without night frost. On a monthly basis August shows the statistically most robust and strongest warming of all months, although regional differences occur. Despite the fact that the general ground temperature warming during the last decade is confirmed by the field data in the study region, complications in trend analyses arise by temperature anomalies (e.g. warm winter 2006/07) or substantial variations in the winter snow cover at a given site (onset, duration, thickness, melt-out data). The results presented here highlight the importance of long-term as well as regional-wide ground temperature monitoring in alpine terrain, often a difficult task commonly related to personal and funding restrictions.