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The influence of sub-seasonal to seasonal atmospheric temperature variability on alpine permafrost

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Alpine permafrost thawing due to climate warming has been rapidly intensifying in the past decades. Since permafrost stabilizes the rock, its thawing has and will become a growing risk for mountainous countries like Switzerland, with potential implications for rockfall magnitude and frequency, mountain infrastructure, mountain ecosystems, and tourism. The long-term trend in the thickening of the active layer and thus the subsidence of the permafrost table in the Swiss Alps due to climate warming is well observed and documented. However, less is known about how sub-seasonal to seasonal variability of atmospheric temperature, in particular individual multi-weekly heatwaves in summer, influence below-ground temperature from year to year. In this interdisciplinary study, we thus explore how atmospheric temperature variability on timescales of days to seasons affects the variability of below-ground temperature and the depth of the permafrost table, measured at various rock borehole stations of the Swiss Permafrost Monitoring Network PERMOS. In addition, we evaluate how well the snowpack and ground surface model SNOWPACK is able to reproduce this relationship. The insights from this analysis will pave the way to couple the SNOWPACK model to sub-seasonal to seasonal weather prediction models, which are increasingly being used to predict the probability of heatwave occurrence several weeks ahead. Such a coupling could allow for a prediction of the evolution of below-ground temperature and of significant permafrost anomalies on an operational basis, and thereby support early warning systems for alpine hazards.