Wetting and Warming of the Active Layer caused by Changing Climate Conditions, Svalbard

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The active layer situated between the permafrost and the ground surface has changed greatly over the last decades at a site in Ny-Ålesund, Svalbard. While permafrost is defined as soil which has been below a temperature of 0°C for at least two consecutive years, the active layer is thawing every summer and refreezing in autumn. Svalbard has the warmest permafrost compared to other sites at the same latitude. At the top of the permafrost, soil warming is reduced as energy is used for thawing the ground. This process usually increases the volumetric water content.

In this study, we analysed climate data from 1998-2018 as well as soil temperature and volumetric water content data from the active layer. The air temperature in Ny-Ålesund has increased over the past 20 years by about 1.46°C (+/- 0.05°C) per decade. While the annual precipitation increased moderately, summer precipitation increased by a factor of two and autumn precipitation even by a factor of three as compared to the average of 1912-1993. Furthermore we observed earlier dates of snow melt. The active layer has doubled in thickness from 0.9m in 1998 to more than 1.5m in 2018. The freezing period starts later now compared to 20 years ago, leading to a shortening of the period where the soil is frozen (< -1°C) of 31 days (+/- 17 days) per decade. During the 20 years of observation, the active layer always completely refroze in winter, but the volumetric water content remained partly above 10%.

Our analysis of the active layer temperature and the volumetric water content revealed a general warming and wetting trend within the 20 years of observation. The main factors for the enhanced wetting of the soil in all seasons were approached with a correlation matrix. The volumetric water content in the active layer at 0.1-0.94m depth has increased between 0.6% and 3.2% per decade. The main influencing factors seem to be the air temperature, the shortening of the period where the soil is frozen in winter and the earlier snow melt in recent years. However, most of these parameters are in turn influenced by air temperature and precipitation changes. Surface volumetric water content declined slightly about 1.7% per decade, probably due to stronger evaporation. If the trend of the past 20 years continues, permafrost degradation on Svalbard will be massive over the next years causing landscape changes, landslides and stronger erosion and probably posing a risk to infrastructure.