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Snow on permafrost: the effect of spatial snow variability on soil temperature in Trail Valley Creek, NWT, Canada

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Snow is a potent insulator, influencing the temperature of the active layer and the permafrost in the Arctic region. However, our understanding of spatial patterns of snow properties and their interplay with vegetation remains limited due to scarcity of local and regional snow data. Furthermore, the duration, depth, and physical properties of the Arctic snow cover are changing with rising air temperature and new precipitation patterns. We study the spatial snow distribution and its drivers and consequences around the Trail Valley Creek research catchment in the Northwest Territories, Canada. Our dataset includes a 143 km² snow depth raster captured on April 2, 2023, at a 1-meter spatial resolution, as well as data from 13 spatially distributed loggers measuring air/snow temperature, soil surface temperature, and soil temperature at 8 cm depth from August 27, 2022, to August 9, 2023. Detailed information on vegetation types, structure, and soil properties at all locations is included. Our analysis covers the timing of soil freeze and thaw, snow and soil temperatures, and their correlation with vegetation characteristics, particularly focusing on April snow depth. Our findings underscore the pivotal role of snow in regulating soil temperature, making it a key driver for permafrost protection or thaw. The results reveal significant variability in April snow depth across the 13 study locations, ranging from no snow to 1.7 meters, resulting in winter minimum soil temperatures between -31°C and -4°C. The study confirms that thicker snow cover contributes to warmer soil temperatures. While the soil at 8 cm freezes uniformly in mid-October across all sites, snow patterns lead to high variability in soil thawing dates, which span one month between May 10 and June 08, 2023. Understanding the spatial patterns of snow depth, thermal properties, and timing is crucial for assessing the snow effect on soil temperature. The large range of winter soil temperatures, which we observed, may lead to differences in thaw depth development in the following summer and potentially to talik formation affecting permafrost stability.