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Thermo-Mechanical Modeling of a Glacier-Permafrost System in Spitsbergen, Implications for Subglacial Hydrology

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To study the hydro-glaciological response of glaciers impacted by recent climate change, the Austre Lovenbreen polar glacierized watershed (10 km2 located in West Spitsbergen, 79°N) was monitored. Field surveys show winter water discharges causing large icings. A 2D modeling approach along the main axis of the system is developed to study the thermal evolution of the glacier-bed system. Two codes are chained (cf. Pimentel et al. (2010) for the Thermo-Mechanical evolution of the glacier and Cast3M for the Thermal evolution of the substrate - www-cast3m.cea.fr). Transient reconstructions confirm radar study conclusions showing that the glacier is polythermal with a cold based terminus. Moreover, its rapid retreat (ca. 18 m.a-1) should lead to a cold glacier within decades to a century. Simulations further show that permafrost development in the substrate precedes glacier retreat (thin glacier tongue with -5°C MAAT at Ny Alesund) while in the mountainous part, a somewhat stable glacier position allowed permafrost to develop deeper over longer times. Prospective simulations of permafrost development show that the unfrozen soil extension below the glacier will progressively reduce probably causing the disappearance or a strong reduction of winter discharges within the next century. Further experimental and modeling studies are contemplated to understand the major processes controlling subglacial permafrost development, winter flows as well as their future evolution.