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Changes in the internal structure of polythermal glaciers over the last decade: the case study of Fridtjofbreen and Erdmanbreen from 2010 to 2021, Svalbard

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Glaciers on Svalbard have been shrinking in recent decades in response to current climate change. Most of them have decreased in size, area and surface elevation with stable negative or even accelerated changes in mass balance. Many of them are of the polythermal type, and as they shrink, their thermal regime might also change significantly depending on climate and local parameters, such as distribution of ice facies, firn thickness, and other factors affecting hydrology and glacier movement. In this study, we used data from repeated GPR surveys in 2010/12 and 2020/21 to identify likely changes in the thermal regime of the two polythermal glaciers Fridtjovbreen and Erdmanbreen in the western part of the Nordenskiöldland. These changes we have identified by comparison of changes in the depth of the internal reflection horizon (IRH) which corresponds to the cold-temperate transition surface (CTS) in polythermal glaciers.

Comparison of radio-echo sounding (RES) data obtained along the same transverse and longitudinal transects shows that in the last decade the most prominent CTS changes have occurred in the upper western basin of the Fridtjovbreen, where the mean total ice thickness decreased with rate −0.76 m a^{-1} (from 151 to 144 m in 9 years), meanwhile the thickness of the temperate ice core decreased with rate −2.52 m a^{-1} (from 115 to 92 m). As a result, with a general reduction in the thickness of the glacier, its upper cold layer increased from 36 to 52 m. These changes we attribute to the reduction of the firn area in this basin, which resulted in less thermal insulation and water retention and internal refreezing, and, therefore, in the fast cold front penetration into the glacier body with rates more than 3 times higher than the glacier thinning.