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Ground Penetrating Radar and dielectric property measurements of artificial sea ice

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Ground Penetrating Radar (GPR) has become an indispensable instrument for high-resolution studies of the shallow subsurface. The non-destructive nature of GPR combined with its excellent depth penetration and rapid deployment over large areas (thereby avoiding time-consuming drilling) has resulted in the extensive and routine application of this technology to fresh water ices. The use of GPR to study sea-ice is, however, much less common, despite its potential to provide valuable information related to, for example, regional effects of global warming. This is because GPR signal propagation in ices with high brine contents is characterized by a lossy behaviour which reduces radar signal penetration. To better understand and quantify this effect we conducted a series of GPR and Vector Network Analyzer (VNA) measurements during freezing at the Sea-ice Environmental Research Facility (SERF), University of Manitoba, Canada. The VNA measurements were performed by using a horizontal, multi-level probe immersed in the water before freezing, which allowed the retrieval of the dielectric properties of sea ice as a function of frequency and depth. The GPR data were collected along multiple transects and grids at different locations in the pool, including in the vicinity of the multi-level probe as well as across targets (steel bars) suspended at different depths below the surface. GPR and VNA data were used to monitor sea ice growth, thus allowing an estimate of the temporal evolution of the ice thickness. Furthermore, the daily measurements of electrical conductivity, extracted from the VNA data, highlighted the relationships between temperature and the evolution of the brine volume-fraction. Our results show that a well calibrated GPR can be employed to monitor the evolution of young sea ice also in critical thermal conditions close to the melting point.