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Investigation of ice with geophysical measurements during the transit of cryobots

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Several icy moons of our Solar System like Jupiter's moon Europa have a global ocean of liquid water below their icy crust. These ocean worlds are possible targets for space missions that aim to assess their potential for habitability or even to search for life. Cryobots (or ice melting probes) are suitable tools to reach the subglacial oceans for in-situ investigations. The necessary ice shell transit provides an excellent opportunity to investigate structure and composition of the ice itself by means of geophysical and other in-situ measurements. This will allow us to better understand the evolution of icy moons and their role in our solar system.

We present current ideas as well as first results from terrestrial analogue studies. Acoustic data obtained during a field test on Langenferner Glacier, Italy was used to conduct a travel time tomography, which yields insight into heterogeneities in the local acoustic wave propagation speed through the ice. The acoustic sensor set-up was originally designed for localization of the melting probe rather than an investigation of the ice structure. However, we can still show that such opportunity data can be used to obtain a wave velocity distribution which can be further interpreted with respect to ice properties like porosity.

While we already investigated the acoustic data, we evaluate the potential of other measurements. For example, Radar measurements in combination with the acoustics can be used to identify the ice-water boundary and, in addition, cracks and inclusions in the ice. Conductivity measurements provide information on the salinity. At ice-water interface regions, the salinity is in thermochemical equilibrium with the temperature and porosity of the ice. We present our concept for on-board electrical conductivity measurements and analyze its potential, for example, to constrain ice properties and to predict ice-water interfaces based on existing terrestrial field data and process models. Furthermore, some of the cryobot's housekeeping data might be of interest for investigating the ambiance, too. For example, the temperature and the density of the ice affect the melting velocity of the cryobot, which constitutes an inverse problem to get further information on the ice.