ARCTIC 2022 – IMPLEMENTED PROJECTS

Arctic and Antarctic Sea Ice – Thickness variability and change, ice loads, and navigability

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ABSTRACT

The thickness of sea ice is one of its most important properties affecting the energy and freshwater balance, ecosystem functions, and navigability of ice-covered waters. Sea ice thickness is also an important climate indicator revealing the state of the ice at a given time. Therefore we have observed ice thickness in the high Arctic Ocean and near the North Pole for over 30 years, beginning with the first Polarstern voyage to the North Pole in 1991 (e.g. Haas, 2004; Haas et al., 2008; Haas et al., 2017; Belter et al., 2021). These data provide impressive evidence of the more than 50% thinning of Arctic sea ice in the last 30 years, from more than 2.5 m thick in 1991 to only about 1 m thick since 2007. Here **we propose to carry out ship-based ice thickness observations during all upcoming North Pole voyages of Le Commandant Charcot (LCC) using it's on-board Sea Ice Monitoring System (SIMS)**. In addition, we propose to carry out as many in-situ ice thickness measurements with **sledge-mounted EM systems towed on the ice** while LCC is stationary with in the ice, and, if possible, to use the on-board helicopter to carry out **airborne ice thickness surveys with our EM Bird** (Haas et al., 2009).

The seasonal ice thinning during summer and changes of melt pond coverage and depth provide important insights into the surface energy budget of melting ice and related feedback processes (e.g. von Albedyll et al., 2021). The repeat North Pole cruises of LCC in a given summer provide unique opportunies to **study the melt of nearly the same ice during several months in summer**. We plan to observe this with the SIMS during all cruises as proposed above, and will in addition **observe melt pond coverage, floe size, and other surface properties visually/photographically** from the bridge as well as by as many **drone flights** as possible. **Melt pond depths** will be measured in-situ while walking over the ice during the EM surveys mentioned above, or photogrammetrically with the drone. We propose to **deploy GPS-equipped sea ice drifting buoys** with some ice and under water measuring capabilities (e.g. with ice mass balance and CTD sensors) near the North Pole which can be used to track and revisit the same ice during one summer.

Ice thickness, together with ice concentration and ice pressure, is also the dominant environmental parameter governing **navigability of sea ice regimes**. **Efficient and safe ice breaking** requires knowledge of ice conditions, **ship-ice interactions**, and **icebreaking performance** under various scenarios. In order to better understand

navigability, ice loads, and ship-performance, we propose to carry out **various measurements** which are routinely used by the Hamburg University of Technology (TUHH):

- **Ice load and strain measurements** on the ship's hull, using existing instrumentation or installing our own.
- **Ship motion observations** based on accellerometers or inertial motion units (IMUs) and other ship data (COG etc.).
- Estimate **ice resistance** based on ice thickness data combined with engine data and ship particulars.
- Perform detailed temperature measurements and installation of gauges for **structural thermal shrinking and expansion.**
- **Ship vibration measurements** at dedicated locations for later analysis on their correlation with propeller rpms, ice thickness and ship speed.

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