Comparison of Freeboard Retrieval and Ice Thickness Calculation From ALS, ASIRAS, and CryoSat-2 in the Norwegian Arctic to Field Measurements Made During the N-ICE2015 Expedition

We present freeboard measurements from airborne laser scanner (ALS), the Airborne Synthetic Aperture and Interferometric Radar Altimeter System (ASIRAS), and CryoSat-2 SIRAL radar altimeter; ice thickness measurements from both helicopter-borne and ground-based electromagnetic-sounding; and point measurements of ice properties. This case study was carried out in April 2015 during the N-ICE2015 expedition in the area of the Arctic Ocean north of Svalbard. The region is represented by deep snow up to 1.12 m and a widespread presence of negative freeboards. The main scattering surfaces from both CryoSat-2 and ASIRAS are shown to be closer to the snow freeboard obtained by ALS than to the ice freeboard measured in situ. This case study documents the complexity of freeboard retrievals from radar altimetry. We show that even under cold (below −15°C) conditions the radar freeboard can be close to the snow freeboard on a regional scale of tens of kilometers. We derived a modal sea-ice thickness for the study region from CryoSat-2 of 3.9 m compared to measured total thickness 1.7 m, resulting in an overestimation of sea-ice thickness on the order of a factor 2. Our results also highlight the importance of year-to-year regional scale information about the depth and density of the snowpack, as this influences the sea-ice freeboard, the radar penetration, and is a key component of the hydrostatic balance equations used to convert radar freeboard to sea-ice thickness.