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Airborne and ground based measurements in McMurdo Sound, Antarctica, for the validation of satellite derived ice thickness

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Melting and freezing processes in the ice shelf cavities of the Ross and McMurdo Ice Shelves significantly influence the sea ice formation in McMurdo Sound. Between 2009 and 2013 we used a helicopter-borne laser and electromagnetic induction sounder (EM bird) to measure thickness and freeboard profiles across the ice shelf and the landfast sea ice, which was accompanied by extensive field validation, and coordinated with satellite altimeter overpasses. Using freeboard and thickness, the bulk density of all ice types was calculated assuming hydrostatic equilibrium.

Significant density steps were detected between first-year and multi-year sea ice, with higher values for the younger sea ice. Values are overestimated in areas with abundance of sub-ice platelets because of overestimation in both ice thickness and freeboard. On the ice shelf, bulk ice densities were sometimes higher than that of pure ice, which can be explained by both the accretion of marine ice and glacial sediments. For thin ice, the freeboard to thickness conversion critically depends on the knowledge of snow properties. Our measurements allow tuning and validation of snow cover simulations using the Weather Research Forecasting (WRF) model. The simulated snowcover is used to calculate ice thickness from satellite derived freeboard.

The results of our measurements, which are supported by the New Zealand Antarctic programme, draw a picture of how oceanographic processes influence the ice shelf morphology and sea ice formation in McMurdo Sound, and how satellite derived freeboard of ICESat and CryoSat together with information on snow cover can potentially capture the signature of these processes.