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Combined measurement of snow depth and sea ice thickness by helicopter EM bird in McMurdo Sound, Antarctica

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Snow on sea ice is a controlling factor for ocean-atmosphere heat flux and thus ice thickness growth, and surface albedo. Active and passive microwave remote sensing is the most promising way to estimate snow depths over large sea ice areas although improved validation is understood as a missing information to support further progress. However, severe limitations in the representative measurement of snow depth over sea ice persist, which exacerbates sea ice mass balance assessments as well as the indirect estimation of consolidated ice thickness from remotely sensed freeboard.

We have designed and flown a snow radar in combination with an electromagnetic induction device for sea ice thickness. The goal was the simultaneous measurement of both the consolidated sea ice thickness and the snow depth on top as a tool to derive snow and ice statistics for satellite validation. The snow radar was integrated into an EM-bird and flown about 15 m above the surface by suspending the instrument from a helicopter. The combination of the applied technologies hasn't been deployed in this configuration before. The helicopter flight speed was around 70 knots, resulting in a snow measurement about every four meters. The EM instrument can detect ice thickness at 0.1m accuracy, whereas the snow radar is designed to measure snow depth at 0.05m accuracy.

Our field area was the land-fast sea ice and adjacent ice shelf in McMurdo Sound (Antarctica) in November 2021. During this time we found a relatively shallow but variable snow cover (up to about 0.3m) above sea ice of about 2m thickness. Deeper snow was only measured at the transition from the sea ice to the ice shelf, and on the ice shelf itself, where the maximum radar penetration in snow in ideal conditions is estimated to be around 2-3 meters.

We present first results of snow cover statistics in comparison to ground validation and observed snow characteristics, and we compare these results to airphotos and optical satellite imagery. We show that the measurement set-up meets the requirements for level ice and rough fast ice with patchy but dry snow cover. The system still needs to be tested over pack ice with potentially more complex snow morphology.

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