

## SnowMicroPen (SMP) Estimates of Snow Density on Sea Ice for Altimetry Applications

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### ABSTRACT

Observations of Arctic sea ice thickness are critical for evaluating the biological and climatological response to a warming climate. Basin scale observations of sea ice thickness have been routinely made with radar and laser satellite altimeters by estimating freeboard height and assuming a hydrostatic equilibrium. Using this approach, errors in snow load strongly influence freeboard height, ultimately impacting accuracy of the estimated ice thickness. In the in case of radar, spatiotemporal variations in the snow density influence velocity of the propagating wave, introducing further uncertainty in the freeboard estimates. Given the limited availability of *in situ* measurements, snow depth and density on sea ice are often assumed from climatology (i.e. Warren *et al.*, 1999) across large spatial and temporal domains. Here, we introduce an extensive suite of *in situ* snow property measurements on first and multiyear sea ice to establish a reference dataset and quantify potential errors in altimetry-based retrievals. Measurements of the SnowMicroPen (SMP), a high-resolution penetrometer, are used to retrieve high vertical resolution (5 mm) snow density profiles following the empirical model of Proksch *et al.*, (2015). Calibrated against a distributed set of snow pit measurements, the SMP profiles are used to describe spatial variability at horizontal scales of up to 100 m. Probability density functions generated from the SMP analysis allow development of radar and lidar altimeter error budgets. The results of this study will improve treatment of snow volume in current CryoSat-2 based-estimates of sea ice thickness as well as future altimetry missions such as IceSat-2.

### REFERENCES

- Proksch M, Löwe H, Schneebeli M. 2015. Density, specific surface area, and correlation length of snow measured by high-resolution penetrometry. *Journal of Geophysical Research: Earth Surface*, **120**(2): 346-362.
- Warren SG, Rigor IG, Untersteiner N, Radionov VF, Bryazgin NN, Aleksandrov YI, Colony R. 1999. Snow depth on Arctic sea ice. *Journal of Climate*, **12**(6): 1814-1829.

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