Observationally Constraining a Snow-on-Sea-Ice Model to Estimate Arctic Snow and Sea Ice Thickness with Associated Uncertainties

ALEX CABAJ[1], PAUL KUSHNER[1], AND ALEK PETTY[2]

ABSTRACT

Snow on Arctic sea ice plays many, sometimes contrasting roles in Arctic climate feedbacks. Snow depth is also a key input for sea ice thickness derived from ice altimetry measurements, such as satellite lidar observations from ICESat-2. Making direct snow measurements is logistically challenging in the Arctic due to the remoteness of the region, so basin-wide snow depth on sea ice is difficult to observationally constrain. Likewise, uncertainties in snow-on-sea-ice and in derived sea ice thickness are challenging to quantify.

Snow-on-sea-ice models, such as the NASA Eulerian Snow-On-Sea-Ice Model (NESOSIM), can provide basin-wide snow depth and density estimates over Arctic sea ice. NESOSIM includes free parameters which dictate the strength of snow densification and loss processes, but these parameters are not directly observationally well-constrained. We present a calibration of NESOSIM to snow depth and density observations using a Metropolis Markov Chain Monte Carlo method. This method provides estimates of the model free parameters and their uncertainty distributions. We propagate the parameter uncertainty estimates through NESOSIM to produce uncertainty estimates for model-output snow depth and density. Finally, we estimate the resulting sea ice thickness using NESOSIM snow output and ICESat-2 altimetry measurements, and quantify the contribution of snow uncertainty to uncertainty in sea ice thickness.

---

[1] Department of Physics, University of Toronto, ON, Canada
[2] NASA Goddard Space Flight Center, Greenbelt, MD, USA