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Development of a Snow Water Equivalent (SWE) Algorithm over First-Year Sea Ice using In-Situ Passive Microwave Radiometry

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The Arctic is thought to be an area where we can expect to see the first and strongest signs of global scale climate variability and change. We have already begun to see a reduction in: i) the aerial extent of sea ice at about 3 percent per decade and ii) ice thickness at about 40 percent. At the current rate of reduction we can expect a seasonally ice-free Arctic by midway through this century given the current changes in thermodynamic processes controlling sea ice freeze-up and decay. Many of the factors governing the thermodynamic processes of sea ice are strongly tied to the presence and geophysical state of snow, yet snow on sea ice remains poorly studied.

In this work, we present results from a snow water equivalent algorithm development study over first-year sea ice from the Canadian Arctic Shelf Exchange Study (CASES) overwintering mission in 2003-2004. The analysis provides the current state of knowledge pertaining to the geophysical, thermodynamic, and dielectric properties of snow on sea ice. A detailed analysis is first provided on snow thermophysical properties and the existing linkages with passive microwave scattering and emission mechanisms in a temporal evolution pattern. Results show that winter snow thickness has a significant impact on thermophysical properties as well as the seasonal surface energy balance. Winter thermodynamic processes such as desalination and snow metamorphism are more important than previously expected and their control on brightness temperatures through the dielectric properties can be significant. The known/found linkages between snow thermophysical properties and passive microwaves are employed to retrieve snow water equivalent (SWE). Predictions are significant throughout the season over evolving snow thickness with a R2 of 0.95 with in-situ measured data. The developed algorithm is applied to satellite remote sensing and predicted SWE values statistically agree with in-situ validation measurements for two AMSR-E pixels located in the Franklin Bay region.

Keywords: Climate Change, Arctic, Snow, Sea Ice, Geophysical Properties, Surface Energy Balance, Seasonal Evolution, Passive Microwave, Remote sensing.