Towards a fully physical representation of snow on Arctic sea ice using a 3D snow-atmosphere modelsnow-atmosphere model

David Nicholas Wagner[1], David Clemens-Sewall[2], Markus Michael Frey[3], Océane Hames[1], Mahdi Jafari[1], Amy R Macfarlane[1], Adrien Michel[4], Martin Schneebeli[1], Matthew D. Shupe[5], Nander Wever[5], and Michael Lehning[6]

[1]WSL Institute for Snow and Avalanche Research SLF
[2]Thayer School of Engineering, Dartmouth College, Hanover, NH, USA
[3]British Antarctic Survey
[4]EPFL
[5]University of Colorado Boulder
[6]EPFL and SLF Davos

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Abstract

Snow plays a crucial role in the heat transfer between the ocean and atmosphere in sea ice due to its insulating properties. However, wind-induced transport causes the snow distribution to be inhomogeneous, as snow forms dunes and accumulates mostly around pressure ridges and, leading to a heterogeneous underlying ice growth and melt. While models can help to understand the complex interactions of snow and sea ice, there is currently no 3D snow cover model for sea ice that considers detailed snow cover properties. This study presents the first application of the 3D-snow cover-atmosphere model ALPINE3D with the drifting snow module to Arctic sea ice. The model was calibrated and validated with measurements from the MOSAiC expedition. Wind fields used by the snow drift routine were generated with OpenFOAM which was forced by observations. A sensitivity analysis showed the impact of an increased fluid threshold on snow redistribution. The model performed well in simulating snow transport and mass fluxes, but underestimated erosion and poorly reproduced dune formation due to the missing dynamic mesh. The density was partially reproduced very well by the model, but uncertainties still exist in some cases. Comparing the surface snow density results with 1-D SNOWPACK simulations, ALPINE3D produced smaller differences but larger temporal variation in between setups. The study also investigated details of deposition and erosion using cross sections, showing good agreements of snow height differences between model and observations and revealing spatially high-resolution parameters such as age of deposited snow, density, and thermal conductivity.