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On the sensitivity of large scale sea ice models to snow thermal conductivity

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In both hemispheres, the sea ice snow cover is a key element in the local climate system and particularly in the processes driving the sea ice thickness evolution. Because of its high reflectance and thermal insulating properties, the snow pack inhibits or delays the sea ice summer surface melt. In winter however, snow acts as a blanket that curtails the heat loss from the sea ice to the atmosphere and therefore reduces the basal growth rate.

Among all snow thermo-physical properties, thermal conductivity is known to be one of the most important with regard to the sea-ice-related thermodynamical processes. For the purpose of large scale modelling, one issue is then to have the snow conductivity profile correctly represented while, for computational cost reasons, a comprehensive snow scheme can generally not be used in such models. While various density-depending paramterisations exist for snow heat conductivity, most of the large scale sea ice models use the typical constant value of 0.31 W m^{-1} K^{-1}, and a relatively simple single-layer snow representation.

In this study, the capabilities of the Louvain-la-Neuve Sea Ice Model (LIM, version 3) including a new snow multi-layer thermodynamic scheme are assessed through sensitivity experiments to snow heat conductivity parameterisations. Three main formulations are tested. Each one of the first two provides good results in the Arctic or the Southern Ocean, with respective mean errors with observations of 0.4 10^6 km^2 and 0.72 10^6 km^2 for sea ice extent and 0.64 m and 0.34 m for sea ice thickness, but not in both hemispheres simultaneously. Although resulting in larger errors, the third parameterisation gives a realistic sea ice state in both the Arctic and the Antarctic. Findings also show that the constant value commonly utilized for snow effective thermal conductivity leads to a significant overestimation of the sea ice thickness in a model using a multi-layer snow scheme, especially in the northern hemisphere. Interestingly, experiments using formulations giving low values for snow heat conductivity systematically outperforms the others in simulating the sea ice extent variability over the period of analysis. A common feature observed from these runs is that the oceanic heat flux plays a more important role in the evolution of the sea ice concentration's geographical distribution. Finally, the results highlight the importance of improving the representation of blowing snow effects on the model's snow depth distributions.

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