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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 the snow thermo-physical properties, snow thermal conductivity is known to be one of the most important with regard to the sea-ice-related thermodynamical processes. In the literature, both model and observational studies parameterize the snow thermal conductivity as a function of density and several different relationships are used. For the purpose of large scale modelling, one issue is then to have the snow density correctly represented while, for computational cost reasons, a comprehensive snow scheme can generally not be used in such models. Since it is known by observationalists that one of the key atmospheric parameters that affect snow thermal conductivity and density is the wind speed, one way to get around the problem is to try to have a realistic representation of the snow density profiles on the sea-ice directly using observations or simple wind speed depending parameterizations.

In this study, we analyze the importance of the snow density profile and thermal conductivity in the thermodynamic-dynamic **L**ouvain-la-Neuve Sea-**I**ce **M**odel (LIM3), which is part of the ocean modelling platform NEMO (Nucleus for European Modelling of the Ocean, IPSL, Paris). In order to do this, a new snow thermodynamic scheme was developed and implemented into LIM3. This scheme is multilayer with varying snow thermo-physical properties. For memory and computational cost reasons, it includes only 3 layers but the vertical grid is refined in thermodynamic routines. Although snow density is time- and space-dependent in the model, it is not a prognostic variable. The shape of the density profile is either prescribed as a function of snow and ice thicknesses and based on snow pit observations, or parameterized as a function of seasonally averaged wind speeds. LIM3 exhibits a large sensitivity to the different tested formulations in both the Arctic, due to considerable changes in the sea-ice bottom growth and melting rates and therefore significant total sea-ice volume changes between the various runs ; and the Antarctic, because of strong ice-ocean feedbacks impacting on the sea-ice volume and extent of the whole Southern Ocean.