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New snow thermodynamics for the Louvain-la-Neuve Sea Ice Model (LIM)

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The **L**ouvain-la-Neuve sea **I**ce **M**odel (LIM) is a three-dimensional global model for sea ice dynamics and thermodynamics that has been specifically designed for climate studies and that is fully coupled with the oceanic general circulation model OPA on the modelling platform NEMO. This study presents and assesses the skills of a new one-dimensional snow model developed for the thermodynamic component of LIM, by comparison with the former model thermodynamics and observations.

Snow is a key element in sea ice physics and in the interactions between sea ice and atmosphere. Owing to its low thermal conductivity and hight albedo, the snow cover is a very efficient insulator and it contributes directly and indirectly to the sea ice mass balance. Given the high variability and heterogeneity of the snow cover above sea ice, it is necessary to represent different types of snow, depending on their characteristics. A multilayer approach has been chosen for the model, with time varying temperature, density and thermal conductivity for each layer. Vertical heat diffusion, surface and internal melt, precipitations, snow ice formation and a parameterisation for melt pond albedo are included in the model.

The model has been validated at Ice Station POLarstern (ISPOL) in the western Weddell Sea during summer and at Point Barrow (Alaska) during winter. The new model simulates better temperature profiles, with an amount of good correlations between modelled and observed profiles increasing from 12% to 42% for the 2-layer and 6-layer configurations, respectively. Conductive fluxes and temperatures are highly sensitive to albedo and ocean heat flux during summer, and to the thermal conductivity parameterisation during winter. Ice ablation rate is quite insensitive to snow thermal conductivity in summer because almost all the variability at the surface is absorbed by snow, making the temperature gradient in the ice relatively small and steady. Nevertheless, during winter, when the air temperature falls far below the freezing point, thermal conductivity plays a larger role as temperature gradients steepen and drive the amount of "cold" transmitted to the ice. Overall, accretion rates and ice maximum thicknesses are in better agreement with observations. Further tests must be undertaken to assess the model skills under coupled conditions and determine the minimum number of layers to keep for global-scale simulation purposes.