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Coupling of the multi-category sea ice model LIM3 with the atmospheric model IPSL-CM5

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The first generation of sea ice models, including LIM2 (Louvain-la-Neuve Sea-Ice Model), represented sea ice in a grid cell with a single thickness and area (mono-category). More recent models, including LIM3, represent sea ice in each grid cell as made of several categories. Each category is characterized by a specific thickness and area. This multi-category approach raises technical issues for the sea ice[U+F02D]atmosphere coupling in climate models. The mass balance of sea ice is largely driven by the energy budget at the ice-ocean interface. Both radiative and turbulent atmospheric heat fluxes to the sea ice are intrinsically coupled to the sea ice surface temperature (SIST): any change in heat flux affects the SIST, which itself determines the magnitude of the atmospheric heat fluxes.

Ideally, an atmospheric model should enable to compute an energetic balance for each thickness category. However, the atmospheric component of the French AOGCM IPSL-CM5 (Atmosphere-Ocean General Circulation Models) do not provide this possibility and the way the atmosphere[U+F02D]sea ice heat flux is redistributed among the ice categories may strongly affect the sea ice mass balance. Therefore, we developed a flux distributor to best redistribute the atmosphere[U+F02D]sea ice heat flux among the ice categories.
The simplest distributor is to prescribe the same atmospheric heat flux to each ice category. However, this approach leads to potential problems, as the surface flux depends non-linearly on the ice thickness and the surface state. Thus, we propose a more complex approach, based on the linearization of the non-solar heat flux based on the difference of the category value of SIST with the category-weighted mean SIST.

In this study, we tested the flux distributor in forced mode with NEMO-LIM3 (Nucleus for European Modelling of the Ocean) using a pseudo-coupler, and then in the framework of a coupled climate model IPSL-CM5/NEMO-LIM3. Analysis reveals that the flux distributor allows capturing the intensified winter heat loss over thin ice, which promotes more intense and more realistic ice growth, and prevents spurious loss of ice in summer. With only one flux, the ice growth rate in the thinnest ice category is too mild, the ice is resultingly too thin and retreats too far polewards in summer. This gives reasonable confidence in the ability of the flux distributor to approximate the distribution of the non-solar heat fluxes over the different ice categories.