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The impact of the implementation of new physical processes in the sea ice component of CNRM-CM5 ESM

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Gelato5 is a multi-category and multi-layer sea-ice model coupled with NEMO1° ocean model and ARPEGE-Climat atmospheric model, forming CNRM-CM5, one of the CMIP5 global coupled climate models. In comparison with CNRM-CM3, which produced climate simulations in the framework of CMIP3, the sea ice model contains new features. Sea ice salinity is now interactive, and the ice specific heat, enthalpy and vertical heat diffusion coefficient are functions of ice temperature and salinity.

A 10-member set of 1850-2012 coupled simulations including this new sea ice model was carried out with CNRM-CM5. A comparison of modeled sea ice in Arctic with observations and thickness products such as PIOMAS reveals that the sea ice simulated by CNRM-CM5 in the Arctic is too thin by about 0.50 m in winter and nearly 1 m in summer during the 1990-2009 period. In order to try and understand this bias, the ocean-sea ice component of CNRM-CM5 (NEMO-Gelato) was forced with an ERA-Interim-based forcing data set during 1990-2009. In this forced experiment, ice thickness biases are small, and the ice edge is very well simulated. A comparison of the detailed sea ice energy balance in the coupled and forced experiments shows that the coupled model simulates more summer melting due to short wave radiation and more short wave energy is absorbed by leads than the forced model. This is compensated for by the enhanced release of heat from leads in early fall in the coupled model. A more direct analysis confirms that the surface solar short wave input in the coupled experiment is overestimated by ARPEGE-Climat, the atmospheric component of CNRM-CM5.

Sensitivity experiments were conducted by changing some elements of the physics of sea ice in coupled mode and in the ocean-sea ice forced model. The design of these sensitivity experiment is to remove just one new feature of Gelato, the rest being unchanged. As expected, the impact of these model changes is more obvious in coupled mode due to various feedbacks. Our conclusion is that the interactive salinity tends to reduce the simulated sea ice thickness in the Arctic. By contrast, the non-constant specific heat formulation clearly increases sea ice thickness.