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On the influence of model physics on simulations of Arctic and Antarctic sea ice

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Two hindcast (1983-2007) simulations are performed with the global, ocean-sea ice models NEMO-LIM2 and NEMO-LIM3 driven by atmospheric reanalyses and climatologies. The two simulations differ only in their sea ice component, while all other elements of experimental design (resolution, initial conditions, atmospheric forcing) are kept identical. The main differences in the sea ice models lie in the formulation of the subgrid-scale ice thickness distribution, of the thermodynamic processes, of the sea ice salinity and of the sea ice rheology. To assess the differences in model skill over the period of investigation, we develop a set of metrics for both hemispheres, comparing the main sea ice variables (concentration, thickness and drift) to available observations and focusing on both mean state and seasonal-to-interannual variability. Based upon these metrics, we discuss the physical processes potentially responsible for the differences in model skill. In particular, we suggest that (i) a detailed representation of the ice thickness distribution increases the seasonal-to-interannual variability of ice extent, with spectacular improvement for the simulation of the recent observed summer Arctic sea ice retreat, (ii) the elastic-viscous-plastic rheology enhances the response of ice to wind stress, compared to the classical viscous-plastic approach, (iii) the grid formulation and the air-sea ice drag coefficient affect the simulated ice export through Fram Strait and the ice accumulation along the Canadian Archipelago, and (iv) both models show less skill in the Southern Ocean, probably due to the low quality of the atmospheric reanalyses in this region and to the absence of important small-scale oceanic processes at the models' resolution (~ 1∞).