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Implementation of a Combined Elastic-Viscous-Plastic and Collisional Sea Ice Rheology

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The Marginal Ice Zone (MIZ) is a transitional area between the open ocean and pack ice. The MIZ is present in the Arctic and Southern Ocean and measures up to several hundred kilometers across. It is characterized by high surface ocean waves and consists of severely fragmented sea ice with ice floes less than 100m in diameter. With declining summer Arctic sea ice cover and increased wave heights in the Arctic Ocean, in the Arctic the MIZ widened by about 40 percent during the last three decades. The changes in sea ice and growing economic activity in the Polar Oceans necessitate new climate and forecasting models that can simulate the MIZ. Current models are not fit for the purpose since they do not model the surface ocean waves, which determine the MIZ width, or the sea ice rheology that represents MIZ ice dynamics. This study presents an implementation of collisional ice rheology that takes into account jostling of ice floes and also includes the effects of the ice floe distribution on internal ice stresses. The collisional contribution is derived from the magnitude of velocity fluctuations of ice floes. These are calculated from a kinetic energy evolution equation for the ice floes. Properties taken from a coupled wave-in-ice module determine the maximum floe size. This information is taken form a coupled wave-in-ice module. The rheology is derived in the framework of the Elastic-Viscous-Plastic rheology. This allows combination with the Elastic-Viscous-Plastic rheology and thus formulation of a unified sea ice rheology suitable for both the central pack ice and MIZ. The combined ice rheology is implemented in the Los Alamos CICE model and tested in the 2-degree resolution global NEMO Ocean General Circulation model. The 10-year run is forced by CORE2 climatological forcing. Prelimary results show that in the Arctic the new rheology decreases ice thicknesses near the coasts where ice is stationary. Overall, the change in the basin-scale Arctic ice thickness is small. Most of the ice thickness changes in the Central Arctic can be explained by the changes in the ice dynamics, except for the Beaufort Gyre where the oceanic influences through the Ekman convergence may play a role. In the Southern Ocean the impact of the new rheology is small due to ice thickness being unrealistically low in the simulations. The model results in the area are inconclusive. In conclusion, the simulations with the Combined rheology demonstrated a moderate affect on the ice distribution, which we expect to be larger in the higher resolution simulations, which would resolve the MIZ better, and in the coupled atmosphere-sea ice-ocean climate models in which the atmosphere-sea ice-ocean feedbacks, absent in the forced simulations, will be present.