Geophysical Research Abstracts
Vol. 18, EGU2016-1004, 2016
EGU General Assembly 2016

Modelling MIZ dynamics in a global model

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Exposure of large, previously ice-covered areas of the Arctic Ocean to the wind and surface ocean waves results in the Arctic pack ice cover becoming more fragmented and mobile, with large regions of ice cover evolving into the Marginal Ice Zone (MIZ). The need for better climate predictions, along with growing economic activity in the Polar Oceans, necessitates climate and forecasting models that can simulate fragmented sea ice with a greater fidelity. Current models are not fully fit for the purpose, since they neither model surface ocean waves in the MIZ, nor account for the effect of floe fragmentation on drag, nor include sea ice rheology that represents both the now thinner pack ice and MIZ ice dynamics. All these processes affect the momentum transfer to the ocean. We present initial results from a global ocean model NEMO (Nucleus for European Modelling of the Ocean) coupled to the Los Alamos sea ice model CICE. The model setup implements a novel rheological formulation for sea ice dynamics, accounting for ice floe collisions, thus offering a seamless framework for pack ice and MIZ simulations. The effect of surface waves on ice motion is included through wave pressure and the turbulent kinetic energy of ice floes. In the multidecadal model integrations we examine MIZ and basin scale sea ice and oceanic responses to the changes in ice dynamics. We analyse model sensitivities and attribute them to key sea ice and ocean dynamical mechanisms. The results suggest that the effect of the new ice rheology is confined to the MIZ. However with the current increase in summer MIZ area, which is projected to continue and may become the dominant type of sea ice in the Arctic, we argue that the effects of the combined sea ice rheology will be noticeable in large areas of the Arctic Ocean, affecting sea ice and ocean. With this study we assert that to make more accurate sea ice predictions in the changing Arctic, models need to include MIZ dynamics and physics.