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Impacts of ocean waves on Sea Ice and the Polar Oceans

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Sea ice retreat and opening of large, previously ice-covered areas of the Arctic Ocean, to the wind and ocean waves leads to the Arctic sea 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 and impacts on the ocean with a greater fidelity.

We examine effects of ocean surface waves on the polar sea ice and ocean using a sea ice-ocean general circulation global model NEMO (stands for Nucleus for European Modelling of the Ocean) coupled with the ocean wave model output from model of the European Centre for Medium-Range Weather Forecasts (ECMWF). In the model the wave-ice interactions include: ice fragmentation due to break–up by waves in the vicinity of the ice edge; wave attenuation due to multiple scattering and non-elastic losses in the ice, wave advection and evolution of ice fragmentation. We analyse the impact of the waves on sea ice and the upper ocean, focusing on MIZ, where the wave impacts are the most. A combined Collisional rheology, reflecting the granular behaviour of MIZ sea ice, and Elastic-Viscous-Plastic (EVP) rheology are seamlessly implemented in the model with the effect of surface waves on ice motion is included in the turbulent kinetic energy. We found that the new rheology combined with ice fragmentation make a substantial effect on sea ice and upper ocean dynamics in the Arctic and the Southern Oceans.

The study compares the model results with the observations, and highlights a need to farther theoretical understanding of sea ice fragmentation and summarise requirements for observational techniques. For this research we acknowledge the funding from the project ‘Ships and waves reaching Polar Regions (SWARP)’ supported by the European Union’s Seventh Framework Programme (FP7/2007-2013) under grant agreement No 607476 and from the Grant NE/R000654/1 ’Towards a Marginal Sea Ice Cover’ funded by the UK Natural Research Council (NERC). We also acknowledge funding from the NERC Programme “The North Atlantic Climate System Integrated Study (ACSIS)” NE/N018044/1.