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A model for waves-in-ice and sea ice dynamics in the marginal ice zone

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Ocean swell generated in the open ocean can propagate remarkable distances into ice-covered seas and breakup large ice sheets in many smaller floes a few hundreds kilometers from the ice edge in a relatively short time. The conjunction of waves and sea ice can constitute a severe threat for personnel working on sea-ice and make offshore operations challenging (for example during platform evacuation). By altering the size and shape of individual floes, waves can significantly change the dynamical and thermo-dynamical responses of sea ice at scales managed by numerical models. For example, it may increase lateral melting, decrease ice compactness, reduce ice resistance to deformation, and modify drag coefficients, potentially exerting control on ice edge location and ice motion in the marginal ice zone (MIZ). However, waves-in-ice and floe size information are absent from today's state-of-the-art models. In this paper, we present the first realistic implementation of a 3D coupled sea ice-ocean numerical model that includes a novel MIZ rheology, a waves-in-ice propagation and attenuation module, and a floe breaking parameterization working together to simulate MIZ dynamics. It provides the waves-in-ice spectrum, the floe size distribution, and a flag identifying the MIZ as prognostic outputs. The MIZ model is applied in high-resolution nested Hybrid Coordinate Ocean Model (HYCOM) configurations of Fram Strait and the Barents Sea. Boundary conditions are provided by the TOPAZ system covering the North Atlantic and Arctic Oceans. Simulation and validation results will be presented for both regions.

The validated MIZ model will eventually run in an operational forecasting mode in the course of the Waves-in-Ice Forecasting for Arctic Operators (WIFAR, 2010-2013) project. It will provide predictions of the new state variables (floe size and waves-in-ice spectrum) and thus crucial information for risk assessment and safety of offshore operations in or near the marginal ice zone. Model developments will be integrated in the data assimilative TOPAZ system (http://topaz.nersc.no), which assimilates various satellite and in-situ observations of the ocean and sea ice using the Ensemble Kalman Filter. This MIZ project is financially supported by Total E&P, and the WIFAR project is co-funded by Total (20%) and the Research Council of Norway through the PETROMAKS programme (80%).