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Progress on wave-ice interactions: satellite observations and model parameterizations

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In the open ocean, numerical wave models have their largest errors near sea ice, and, until recently, virtually no wave data was available in the sea ice to. Further, wave-ice interaction processes may play an important role in the Earth system. In particular, waves may break up an ice layer into floes, with significant impact on air-sea fluxes. With thinner Arctic ice, this process may contribute to the growing similarity between Arctic and Antarctic sea ice. In return, the ice has a strong damping impact on the waves that is highly variable and not understood. Here we report progress on parameterizations of waves interacting with a single ice layer, as implemented in the WAVEWATCH III model (WW3 Development Group, 2016), and based on few in situ observations, but extensive data derived from Synthetic Aperture Radars (SARs).

Our parameterizations combine three processes. First a parameterization for the energy-conserving scattering of waves by ice floes (assuming isotropic back-scatter), which has very little effect on dominant waves of periods larger than 7 s, consistent with the observed narrow directional spectra and short travel times. Second, we implemented a basal friction below the ice layer (Stopa et al. The Cryosphere, 2016). Third, we use a secondary creep associated with ice flexure (Cole et al. 1998) adapted to random waves. These three processes (scattering, friction and creep) are strongly dependent on the maximum floe size. We have thus included an estimation of the potential floe size based on an ice flexure failure estimation adapted from Williams et al. (2013).

This combination of dissipation and scattering is tested against measured patterns of wave height and directional spreading, and evidence of ice break-up, all obtained from SAR imagery (Ardhuin et al. 2017), and some in situ data (Collins et al. 2015). The combination of creep and friction is required to reproduce a strong reduction in wave attenuation in broken ice as observed by Collins et al. (2015). Ongoing developments include the coupling of WAVEWATCH III to the NEMO-LIM3 and NEMO-CICE models using the OASIS3-MCT communicator. This coupled system will provide a meaningful memory of the ice floe sizes, as the ice is advected. It will also make possible the investigation of feedback processes on the ice.