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Mapping wave heights in sea ice with Sentinel 1

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Sea ice plays an important role in the Earth system by regulating air-sea fluxes. These fluxes can be enhanced by the breaking of ice into floes which critically depends on wave heights propagating across the ice. Remote sensing with SAR provides a unique coverage of the polar regions but so far the measurement of wave heights has been performed routinely only for open water. The presence of ice completely changes the mechanisms by which waves make patterns in radar images. Namely, in the open ocean, the constructed images appear blurred due to the fact that the high frequency waves are unresolved by the sensor. Instead, in ice-covered seas, high frequency waves have been dissipated or scattered away, and only the low-frequency swell components are observed. Two new algorithms have been proposed by Ardhuin et al. (2015).
Refining these algorithms, we analyze the intricate wave patterns captured over sea ice by Sentinel 1-A, and measure both the wave heights and directional spreading of the wave spectrum.

The procedure is a two-step process which uses an estimation of the orbital vertical velocities that produce the observed image intensity. The first step is implemented when wiggly lines are present. Wiggly lines are created by the presence of two swell systems and are removed by estimating the wave orbital velocity that causes the amplitude in the wiggly line. The second step uses Fourier analysis to invert the straightened image into a velocity field. As a result we obtain a full non-linear inversion the mapping from the velocity field to the SAR intensity image. The inverted velocities can be used to obtain the wavenumber-direction spectrum. Our algorithm is applied to S1A images from the Arctic and Antarctic and discussions follow in terms of wave-ice interaction.

These data will be validated using in situ measurements from the ONR Sea State DRI (Beaufort sea, 2016), and combined with numerical modeling using the WAVEWATCH III model to adjust parameterization of dissipation and scattering effects.