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Waves in the Southern Ocean as observed by Sentinel1 synthetic aperture radars

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Sea ice plays an important role in the Earth system by regulating air-sea fluxes and moderating the global temperatures. These fluxes can be enhanced by the presence of waves, especially through the breaking of ice into floes which depends on the waves propagating across the ice. The paucity of adequate in-situ wave observations in ice covered seas limits our ability to understand wave-ice interactions. Synthetic Aperture Radar (SAR) imagery over sea ice appears consistent with a dominant modulation of the radar backscatter by velocity bunching (Ardhuin et al. GRL 2015). Because the presence of sea ice generally removes the blurring effects of short wave components, the SAR transformation is more simple than in the open ocean. This property makes it possible to retrieve phase-resolved maps of wave orbital velocities and wave spectra (Ardhuin et al., 2017 RSE). We can thus now use SAR imagery for scientific applications to wave-ice interactions.

With the all-weather capabilities and extensive space-time coverage, the Sentinel1 constellation composed of two satellites (S1A & S1B) both equipped with SARs provides the opportunity to extract valuable wave observations in polar regions. Through the high resolution acquisition modes of S1A and S1B which cover the Southern Ocean in 20x20 km images with 4 m spatial resolution we are able to extract an large sample of wave observations. We analyzed more than 35,000 images in the Southern Ocean. Nearly 28% of the images contain wave features and 6% of the images contain well-imaged single wave systems (>2000 wave spectra), with a narrow directional distribution. This dataset of more than 2000 wave spectra is unique in the fact we cover the entire Southern Ocean sea ice with an unprecedented amount of observations. These observations support the idea that the attenuation of waves with periods longer than 10 s is dominated by dissipation processes with a limited effect of scattering. Dissipation rates are estimated from pairs of wave measurements in the ice and/or comparison of open ocean swell heights with heights in the ice. These dissipation rates are compared with results of previous field experiences which were mostly conducted in the Arctic Ocean. Finally these data can be utilized to improve and adjust the parameterization of dissipation and scattering effects recently incorporated in the WAVEWATCH III model.