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How Extreme Can Southern Ocean Waves Be?

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Waves in the Southern Ocean are the largest in the planet. In the Southern Hemisphere, the absence of large landmasses at high latitudes allows the wind to feed energy into the ocean over a virtually unlimited fetch. The enormous amount air-sea momentum exchanged over the Southern Ocean plays a substantial role on the global climate. However, large biases affect the estimation of wave regime around the Antarctic continent making climate prediction susceptible to uncertainty. Two main factors hinder reliable prediction of wave conditions in the Southern Ocean: (i) the scarcity of wave observation needed to calibrate wave models and (ii) the inability of the latters to reliably predict the formation of extreme wave events. To improve the understanding of the physical processes in the Southern Ocean, the Antarctic Circumnavigation Expedition (ACE, December 2016-March 2017) sailed these waters. For the entire duration of the cruise, wave data were acquired with a WAMOS radar providing a unique insight on the wave climate in the Southern Ocean. Here, measured wave spectra are used as input condition for Monte Carlo simulations of the sea surface using the Higher Order Spectral Method (HOSM). The HOSM is a phase-resolved method capable to accurately reproduce statistical properties of nonlinear waves. Starting from realistic spectra measured during the ACE cruise, the goal is to reconstruct the height distribution of waves in the Southern Ocean. In a number of storms, waves resulted to be highly nonlinear and numerical simulations indicate that extreme waves larger than twice the significant wave height exceed standard predictions based on the Rayleigh distribution.