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Wave-generated aerosols over the Southern Ocean

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Interactions between aerosols and clouds constitute the single largest uncertainty in radiative forcing. Since the first assessment report from the Intergovernmental Panel on Climate Change in 1996, there has not been any substantial improvement in atmospheric model capabilities to predict cloud albedo at high latitudes, especially over the Southern Ocean where biases are as large as 30 Wm^{-2}. The Southern Ocean is the birthplace of the fiercest waves on the planet, which regulate the exchange of heat, momentum and mass fluxes between the ocean and the atmosphere. The strong winds trigger highly nonlinear physics which induce a rapid wave growth and energetic wave breaking. Through these processes, sea spray aerosols (SSA) are produced and injected into the atmosphere. These SSA become an important source of cloud condensation nuclei (CCN) that influence cloud albedo. At present, nonetheless, the role played by wave-generated aerosols on cloud properties is poorly quantified. In current models, SSA generation is primarily accounted for as a function of wind speed, while specific wave characteristics are largely overlooked.

Here we present the first data set from the Southern Ocean of collocated in-situ aerosol observations and radar-based wave measurements. Highly time-resolved data were acquired during the Antarctic Circumnavigation Expedition between 20 December 2016 and 19 March 2017. The itinerary covered the Indian, Pacific and Atlantic Oceans between Cape Town, Hobart, Punta Arenas and Cape Town. Sea spray aerosols were measured behind a standard Global Atmosphere Watch aerosol inlet with an Aerodynamic Particle Sizer (0.7 – 19 μm) and a Wide-band Integrated Bioaerosol Spectrometer (0.5 – 15 μm). Wave parameters were recorded with the WaMoS II radar system installed on the research ship Akademik Tryoshnikov.

First results show a clear dependence of SSA number concentrations on basic variables over a large value range of wind speed (0 – 25 ms^{-1}), wave height (2 – 13 m) and wave speed (5 – 25 ms^{-1}). Using a novel approach through combining wave and meteorological parameters, we show that SSA number concentrations are a function of wave age and wave height. This new perspective of describing SSA number concentrations can lead to improvements in modelling CCN and cloud albedo over the Southern Ocean.