A 3-D modeling study to explore aerosol formation processes in the summertime Southern Ocean during the Antarctic Circumnavigation Expedition

*Sakiko Ishino[1,2], Julia Schmale[2], Hélène Angot[2,3], Betty Croft[4], Jeffrey Pierce[5], William Porter[6], Linia Tashmim[6]

1. Institute of Nature and Environmental Technology, Kanazawa University, Japan, 2. Extreme Environments Research Laboratory, École Polytechnique Fédérale de Lausanne, Switzerland, 3. Institut des Géosciences de l'Environnement, Université Grenoble Alpes/CNRS, France, 4. Department of Physics and Atmospheric Science, Dalhousie University, Canada, 5. Department of Atmospheric Science, Colorado State University, CO, USA, 6. Department of Environmental Sciences, University of California, Riverside, CA, USA

Summertime Southern Ocean aerosols are dominantly formed from natural sources and still exhibit preindustrial-like aerosol properties (Hamilton et al., 2014). Understanding of aerosol formation processes across the Southern Ocean is therefore of particular importance as an analogue of preindustrial conditions of aerosol properties which introduces a large uncertainty in estimates of anthropogenic radiative forcing caused by aerosol-cloud interaction (Carslaw et al., 2013). With this context, we used GEOS-Chem-TOMAS, a global chemical transport model coupled with size-resolved aerosol microphysics, to compare with a shipborne observation of aerosol microphysical and chemical properties across the Southern Ocean during the Antarctic Circumnavigation Expedition (ACE project, December 2016 to March 2017; Schmale et al., 2019) to explore the characteristics of aerosol formation processes during the project. We evaluate the modeled number concentrations of particles with different diameter ranges of > 7 nm, > 80 nm, and > 700 nm (N_7, N_{80}, and N_{700}) along with the ship track, all of which underestimate the observations by 40 to 90%. We also find that the aerosol hygroscopicity parameter κ at 0.2% supersaturation is significantly higher in the model (median: 0.69, IQR: 0.64–0.77) compared to the observation (median: 0.36, IQR: 0.29–0.45), indicating the insufficient contribution of secondary organic aerosols (SOA) in the model. We discuss the possible impact of marine SOA on particle number concentrations and size distributions over the Southern Ocean, based on our sensitivity studies incorporating flux of precursor organic vapors from ocean surface.

Keywords: Southern Ocean, Aerosol-cloud interaction, Secondary organic aerosol

