EMS Annual Meeting Abstracts
Vol. 16, EMS2019-224-1, 2019

Shallow convection and precipitation over the Southern Ocean: A case study during the CAPRICORN field campaign

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Persistent biases in the energy budget over the Southern Ocean (SO) within climate simulations and reanalysis products have been linked to the poor representation of clouds over the region, particularly in regions of shallow, post-frontal convection. Satellite observations suggest that cloud microphysics and boundary layer characteristics in this region is fundamentally different than over comparable oceans in the Northern Hemisphere.

In response to these challenges, the CAPRICORN (Clouds, Aerosols, Precipitation, Radiation, and atmospherIc Composition Over the southeRn oceaN) field campaign was carried out under the broad banner of SOCRATES to characterize the cloud, aerosol, precipitation and boundary layer properties over the SO. The Australian R/V Investigator undertook a 35-day cruise from March to April in 2016 making observations from Hobart (∼43°S) to the polar front (∼53°S). The ship was instrumented with a cloud radar, a lidar, a micro rain radar, a 2-channel microwave radiometer and a disdrometer. Regular radiosondes were also launched throughout the campaign.

One case is examined in this study with a focus on shallow convective clouds that were commonly observed during the cruise. Shipborne measurements, Himawari-8 products, and high-resolution simulations with a convection-permitting configuration of the Weather Research and Forecasting (WRF) model are integrated to investigate the dynamical and microphysical characteristics of the targeted marine boundary layer cloud fields. This case (26–28 March) focusses on a sustained period of open mesoscale cellular convection in a post-frontal environment. The observed cloud field resided primarily below 2.5 km and in the sub-freezing temperature range (0 to -8°C), where mixed-phase cloud tops were suggested by both the shipborne and Himawari-8 observations. Relatively heavy precipitation was observed to be generated from these clouds. Despite the relatively good representation of some surface meteorology, WRF simulation has difficulties in producing both the low-level cloud field, mixed-phase cloud tops, boundary-layer decoupling and surface precipitation.

Sensitivity experiments with different physical parameterisation schemes and modified microphysical parameters are performed to investigate the impact of boundary layer and microphysical processes on the simulations of the shallow convective clouds. Possible causes of the model deficiencies and possible pathways for model improvements will be discussed.