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An Evaluation of the WRF Simulations of the Clouds over the Southern Ocean with A-Train Observations

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The radiative budget over the Southern Ocean (SO) strongly depends upon the thermodynamic phase of the ubiquitous low-altitude clouds observed over the region (Mace et al. 2010). This budget has been found to be poorly represented in both state-of-the-art reanalysis and coupled global climate models (Trenberth and Fasullo, 2010). Recently, the study by Bodas-Salcedo et al. (2012) using the UK Met Office United Model highlights that the largest bias of the surface downwelling shortwave radiation over the SO is due to the underprediction of the low- and mid-top postfrontal clouds typically associated with supercooled liquid water (SLW).

The A-Train satellite constellation has been used to evaluate the Weather Research and Forecasting (WRFV3.3.1) NWP Model in simulating the postfrontal clouds over Tasmania and the SO to directly address the findings by Bodas-Salcedo et al. (2012). Common cloud regimes associated with two frontal passages over this region are studied. The simulated cloud structure, radar reflectivities, cloud thermodynamic phase and cloud-top and column integrated properties are compared against the along-track A-Train observations. The statistics of cloud-top phase composition and the potential impact on the radiative transmission are explored in comparison with the observed climatology constructed with MODIS and the A-Train merged product DARDAR-MASK. Experiments have also been undertaken to test the sensitivity of the simulated cloud properties to model resolution, microphysics (MP) scheme, planetary boundary layer (PBL) scheme and cloud condensation nuclei (CCN) concentration.

Results of the study show that the simulation is capable of capturing the macrostructure and thermodynamic phase composition of the frontal convective clouds and the postfrontal stratocumuli. The mid-top stratiform SLW clouds within the postfrontal air mass can be reproduced but are sensitive to MP scheme. The simulated cloud-top phase population depends strongly upon both the MP scheme and vertical resolution. The vertical resolution and CCN concentration have a large impact on the simulated liquid water path, particularly for marine boundary layer (MBL) clouds. The simulation is only found to be marginally sensitive to the PBL scheme. The simulation, however, has great difficulties capturing the widespread MBL clouds that are not immediately associated with the fronts, even at high resolution.