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A Study on the Cloud Thermodynamic Phase over the Southern Ocean with A-Train Observations and In-situ Measurements

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Trenberth and Fasullo (2010) found that “disproportionately large biases exist in both the reanalysis and global coupled models” over the Southern Ocean (SO) which are “directly linked to the simulation of clouds in this region.” Moreover, they find a “remarkably strong relationship between the projected changes in clouds/climate and the simulated current-day cloud error.”

A 4-yr climatology of the cloud thermodynamic phase is constructed with the A-Train merged product DARDAR-MASK over the SO (40-65S, 100-160E) during Austral winter (Jun-Aug) and summer (Dec-Feb) 2006-2009. Low-altitude clouds (cloud-tops below 1km) with very little seasonal cycle dominate this climatology. Such clouds are challenging for the DARDAR-MASK due to its dependence on the Cloud Profiling Radar (CPR) on CloudSat being unable to distinguish returns from the lowest kilometer due to the ocean surface. It is further limited for these clouds as they predominantly reside in the temperature range from freezing to -20C, where the CPR cannot directly assess the cloud thermodynamic phase.

A comparison of the cloud-top phase climatology over the SO is made between CALIPSO, MODIS ONLY and the DARDAR-MASK. All products highlight the prevalence of supercooled liquid water (SLW) between 0 and -20C, particularly during summer. However, MODIS detected substantially more warm cloud-tops, whereas the DARDAR-MASK recorded more glaciated cloud-tops below -50C. Ice and mixed phase are also frequently recorded by the merged product in the mid-level cloud-tops. Moving beyond the cloud-top, the DARDAR-MASK finds ice to be dominant at heights greater than 1km. Below this height, the uncertain class is dominant as there is no CPR signal and the lidar signal is commonly attenuated.

Limited secondary in-situ data from the recent global transects performed in the HIAPER Pole-to-Pole Observation (HIPPO) missions shows evidence supporting the climatologies inferred from the satellites. High quantities of SLW were observed in clouds colder than -10C during different seasons, and observations of supercooled drizzle drops suggest that warm rain process may be important even in these cold clouds.

Given the limited in-situ observations and the ambiguity remaining in spaceborne sensed cloud properties, dedicated field campaigns with in-situ cloud microphysical measurements and ground based observations are required to better understand the SO clouds and define the energy and water budget.