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Antarctic Cloud Property Retrievals from Infrared Radiances

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Clouds exert a strong radiative impact on the surface and have complicated effects that are still not well understood, particularly in the Antarctic. The amount of supercooled liquid water in Antarctic clouds, for example, is still poorly constrained, due to the low number of observations on the continent. It is also not clear how the radiative properties of supercooled liquid in those clouds should be represented in climate models. In particular, the complex refractive index (CRI) of liquid water is known to depend on temperature, but this dependence is typically ignored in climate models.

Here, we present cloud properties retrieved from Antarctic downwelling infrared radiance measurements made by an Atmospheric Emitted Radiance Interferometer (AERI) and by the Polar AERI (PAERI), using the CLoud and Atmospheric Radiation Retrieval Algorithm (CLARRA). Preliminary retrievals were made of cloud height, optical depth, thermodynamic phase, and effective radius for field experiments at Amundsen-Scott South Pole Station (2001) and at McMurdo Station (2016).

At South Pole, we find that clouds are typically thin and near the surface, in keeping with prior work. For thin clouds, the mode of the effective radii of liquid droplets (~4 μm) and ice particles (~15 μm in summer, ~12 μm in winter) at South Pole are found to be smaller than typical Arctic values (~9 μm for liquid and 17 to 25 μm for ice). Although ice cloud was found to dominate year-round at South Pole, significant supercooled liquid water was present in the summer. Cloud properties retrieved at South Pole will be compared to retrievals from McMurdo.

We further find that ignoring the temperature dependence of the CRI of supercooled liquid cloud leads to negative biases in part of the atmospheric window region (700 – 1000 cm^{-1}), indicating underestimation of the greenhouse effect. These biases are expected to be partially offset by positive biases below 600 cm^{-1}. Based on these considerations, we recommend using temperature-dependent CRI for infrared radiance simulations of supercooled liquid water cloud.