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Non-opaque and Opaque Ice Cloud Properties from Infrared Radiances at 3.7, 6.7, 11.0 and 12.0 μm

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Retrieval of ice cloud properties using IR measurements has a distinct advantage over the visible and near-IR techniques by providing consistent data regardless of solar illumination, which is particularly important for diurnal variations of ice cloud properties and their radiative effects. The IR bands at 3.7, 6.7, 11.0, and 12.0 μm have been used to infer ice cloud parameters by various methods, but the reliable retrieval of cloud optical thickness (COT) is limited to non-opaque ice cloud with a visible COT < 8. The present study is to develop retrieval algorithms for ice clouds covering both non-opaque ice clouds (COT < 8) and opaque ice clouds (COT > 8). Combining a developed IR fast radiative transfer model, a physical retrieval algorithm is developed on the basis of an old technique for estimating cloud temperature (CTT) for non-opaque ice clouds using 6.7 and 11.0 μm. Non-opaque ice cloud COT is then estimated on the basis of 11-μm brightness temperatures or/and the brightness temperature difference (BTD) between 6.7 and 11.0 μm. Finally non-opaque ice cloud particle size (De) is retrieved by BTD among 3.7, 6.7, 11.0, and 12.0 μm. For opaque ice clouds, an artificial neural network (ANN) approach is developed to train radiances from the MODIS 3.7, 6.7,11.0, and 12.0-μm channels against CloudSat estimated COT during the nighttime for 2007 globally. The developed ANN approach is applied to the MODIS IR measurements for 2008 globally region and then compared to CloudSat measurements. The correlations between the ANN-estimated COT and those from CloudSat measurements are above 0.7 for opaque ice clouds.