General Macrophysical and Microphysical Properties of Deep Convective Clouds as Observed by MODIS

Research Highlight

Deep convective clouds (DCCs) are characterized by high vertical reach and relatively small areal coverage. They play an important role in the climate system. In climate modeling studies, several parameterizations have been proposed. Ice crystal effective radius (CER) is assumed to be determined by cloud temperature and/or ice water content or by in-cloud depth from the cloud top. Most of these parameterizations are based on measurements of thin cirrus clouds.

With the global coverage of remote sensing data, it is possible to identify the spatiotemporal variations of ice properties and the relationship between CER and temperature. Using the MODIS cloud products, we investigated DCCs with a cloud-top brightness temperature less than 243 K and cloud optical depth larger than 40.

The general properties are studied over the East Asian monsoon region, the Indian monsoon region, North America, South America, and Africa, during boreal summer. The frequency of DCC occurrence (FDO) is strongly influenced by large-scale circulation patterns, except for highland areas, where solar heating of the landmass in the summer generates enough energy to form frequent DCCs. The distribution of the FDO for an ensemble of DCCs is found to be rather stable, with little change from year to year, but varying from location to location, especially in different latitude zones. Cloud-top pressure shows a latitudinal dependence, decreasing toward lower latitudes. The detraining height determined by analyzing the distributions of brightness temperature (BT) is found to have a preferential level.

Our analysis on general cloud properties illustrates that seasonally and spatially averaged COD distributions for mature clouds have signature shapes for individual DCC active regions. The distributions of model-generated cloud

optical properties may be compared with our observation results. This serves as a reality check for these model parameterizations and could potentially help point to

directions for future parameterization efforts. The stable statistics for specific regions suggests that organization of cloud ensembles of specific regions may be governed by certain kind of inherent ‘‘statistical mechanics of clouds.’’ Ensemble simulations by cloud-resolving models with representative large-scale forcings for a region can generate ensemble distributions of cloud properties. These simulated ensemble distributions can be analyzed to evaluate a cloud-resolving model's ability to capture the statistics of cloud organization.

Reference(s)

Contributors

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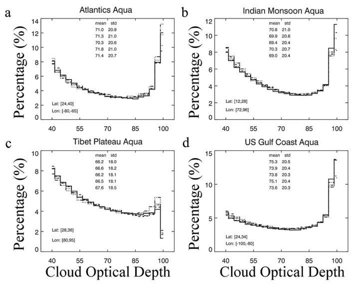
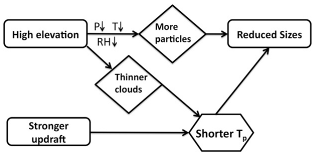
Working Group(s)

Cloud Life Cycle



Distributions of cloud optical depth from Aqua in four regions. The mean and standard deviation of the distributions are given for each region indicated by latitude and longitude range in each panel. The means and standard deviations are for the years 2003–2006 and 2002, from top to bottom, in each figure's legend.



The schematic diagram of factors and processes favorable for generating small cloud droplets over highland areas and small ice particles.