Variations of Cloud and Radiative Properties of Boundary-layer and Deep Convective Systems with Sea Surface Temperature Anomalies

Kuan-Man Xu
NASA Langley Research Center
Hampton, VA 23693
Email: Kuan-Man.Xu@nasa.gov

Gridded monthly-mean satellite data contain compositing information from different cloud system types and clear-sky environments. To isolate the variations of cloud physical properties of an individual cloud system type with its environment, orbital data are needed. In this study, we will analyze the variations of cloud and radiative properties of boundary-layer clouds and deep convective cloud systems with sea surface temperature (SST) anomalies. We use Terra-CERES (Clouds and the Earth's Radiant Energy System) Level 2 data to classify distinct "cloud objects" defined by cloud-system types (deep convection, boundary-layer cumulus, stratocumulus and overcast clouds), sizes, geographic locations, and matched large-scale environments. This analysis method identifies a cloud object as a contiguous region of the Earth with a single dominant cloud-system type. It determines the shape and size of the cloud object from the satellite data and the cloud-system selection criteria. The statistical properties of the identified cloud objects are analyzed in terms of probability density functions (PDFs) of a single property or joint PDFs between two properties.

The SST anomalies are defined as the differences from five-year annual-cycle means. Individual cloud objects are sorted into one of five equal size subsets, with the matched SST anomalies ranging from the most negative to the most positive values, for a given size category of deep convective cloud objects, boundary-layer cumulus, stratocumulus and overcast cloud objects. The PDFs of cloud and radiative properties for deep convective cloud objects (between 30 S and 30 N) are found to largely similar among the five SST anomaly subsets except for the lowest SST anomaly subset. The different characteristics from this SST anomaly subset may be related to some cloud objects resulting from equatorward movement of extratropical cloud systems. This result holds true for all three different size categories (measured by equivalent diameters of 100-150, 150-300 and > 300 km). The PDFs of cloud and radiative properties for boundary-layer cloud types are more variable for macrohysical properties than for microphysical properties, due probably to different large-scale environments where these cloud objects are formed. Implications of these results for the cloud feedback will also be discussed.