TOA Radiation Budget of Convective Core/Stratiform Rain/ Anvil Clouds from Deep Convection

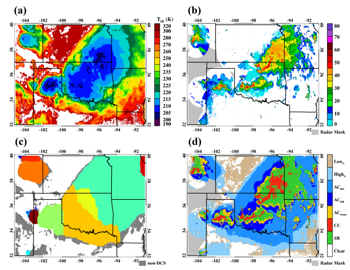
ARM CLIMATE RESEARCH FACILITY

Research Highlight

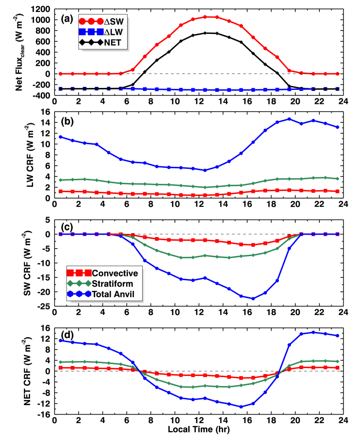
Deep Convective Systems (DCSs) have traditionally been divided into the deep convective precipitating portion and the non-precipitating anvil canopy. The former is important to the atmospheric hydrologic cycle because of the heavy precipitation in the convective cores (CC) and widespread precipitation in the stratiform rain (SR) regions, and the latter are dominant in the atmospheric radiation budget due to their extensive spatial coverage. Satellite observations have been widely used to examine the radiative impact of DCSs. Debates on whether tropical DCS have positive or negative radiative feedback further highlight their importance to the Earth's climate system.

In this study, we have developed a new hybrid classification method to objectively identify DCSs and subsequently classify their convective cores (CC), stratiform rain (SR) area, and non-precipitating anvil cloud (AC) through an integrative analysis of collocated ground-based scanning radar and geostationary satellite data over the SGP region. In developing the algorithm, AC is delineated into transitional, thick, and thin components. While there are distinct physical/dynamical differences among these subcategories, their top-of-atmosphere (TOA) radiative fluxes are not significantly different. Therefore, these anvil subcategories are grouped as total anvil, and the radiative impact of each DCS component on the TOA radiation budget is quantitatively estimated.

We found that more DCSs occurred during late afternoon, producing peak AC fraction right after sunset. AC covers three times the area of SR and is almost an order of magnitude larger than CC. The average outgoing longwave (LW) irradiances are almost identical for CC and SR, while they are slightly higher for AC. Compared to the clear-sky average, the reflected shortwave (SW) fluxes for the three DCS components are greater by a factor of 2–3 and create a strong cooling effect at TOA. The calculated SW and LW cloud radiative forcing (CRF) of AC contribute up to 31% of total NET CRF, while CC and SR contribute only 4 and 11%, respectively. The hybrid classification further lays the groundwork for studying the life cycle of DCS and improvements in geostationary satellite IR-based precipitation retrievals.



An example of the hybrid classification process. (a) GOES IR temperature, (b) NEXRAD radar reflectivity at 2.5 km MSL, (c) cloud patch segmentation from GOES IR temperature (the color patches are identified as deep convective systems [DCSs] and the gray patches are other high clouds; both GOES IR temperature and NEXRAD indicated precipitation features are used to identify DCSs), (d) the final hybrid classification output.



The hourly mean values of (a) clear-sky fluxes, (b) longwave (LW), (c) shortwave (SW), and (d) NET cloud radiative forcings (CRFs) at TOA over the study domain. The LW, SW, and NET CRFs for three DCS components are weighted by their corresponding cloud fractions.

Reference(s)

Feng Z, XQ Dong, BK Xi, C Schumacher, P Minnis, and M Khaiyer. 2011. "Top-of-atmosphere radiation budget of convective core/stratiform rain and anvil clouds from deep convective systems." Journal of Geophysical Research – Atmospheres, 116, D23202, doi:10.1029/2011JD016451.

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Cloud Life Cycle