An A-Train Convective Object Database for Studying Atmospheric Convective Processes

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Introduction

- Atmospheric deep convection contributes to the Earth’s climate through precipitation and cloud properties
  1. Latent heat is released when convective systems precipitate to form an approximate balance with radiative cooling on a global scale
  2. Convective clouds have competing SW and LW radiative effects, and whether they warm or cool the Earth constitutes the sign of the high cloud feedback (Stephens, 2005)
- Models contain large uncertainties in high cloud feedbacks due to the challenge of acquiring global-scale observations that capture convective behavior at fine spatial and temporal scales
- The A-Train, despite only twice-daily sampling, is able to capture cloud properties, precipitation, and radiative effects of convection on a nearly global scale

Guiding Questions

- How representative is A-Train-observed convection compared to previous spaceborne radar-based analyses (Zipser et al., 2006)?
- What added insight on convection can the A-Train provide?

Methods for Characterizing Convective Systems

A “cloud object” approach is used to identify all convective systems between August 2006 – December 2010 in the following manner:

- Convective cores are identified based on the height of the attenuating reflectivity (Z) profile from CloudSat’s 94 GHz CPR
- Contiguous “cloudy” pixels with Z < 1.5 km surrounding the cores are stored as “convective objects” (COs)
- Variables defining vertical intensity, horizontal extent, convective core properties, precipitation, and radiative response are calculated over the CO
- Relative Center of Gravity (CoG) defines the vertical intensity and is the height at which the mean Z-weighted mass of the core is located subtracted by the height of the freezing level

Where and when does convection occur most frequently?

- 95,620 COs are observed
- COs are most prevalent in the tropics over the Amazon, Congo Basin, Maritime Continent, and along the ITCZ
- Early afternoon convection is more prevalent over land in the tropics, while early morning convection is more common over tropical ocean
- The A-Train observes that convection peaks in the early afternoon east of the Rocky Mountains and over the Tibetan Plateau, as shown in previous studies (Xu & Zipser, 2011)

What is the global variability in cloud features and precipitation?

1. Mean distribution of COs
2. 5% most extreme COs by season

- Vertical intensity, horizontal extent, convective core properties, precipitation, and radiative response are calculated over the CO
- Spatial Extent
- Temporal Extent

How do clouds and radiation correspond to core prevalence?

- COs have a cooling impact with single-core systems having the largest cooling impact. Cooling does not significantly weaken as the number of embedded cores increase suggesting that processes beyond internal convective dynamics influence anvil radiative effects.

Future Work

- Do the differences in anvil thickness help explain the large spread in CRE?
- How do the links between convective characteristics, precipitation, and radiative effects vary as a function of the environment?
- How do the energetics of convection differ at the varying life-cycle stages?

References


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Image Ref: COs have a cooling impact with single-core systems having the largest cooling impact. Cooling does not significantly weaken as the number of embedded cores increase suggesting that processes beyond internal convective dynamics influence anvil radiative effects. COs with the longest extent: Reflectivity profiles of single core (top) and multi-core (bottom) COs with colored markers indicating deep convection region, non-raining and raining anvil regions, and rain too high. Right: MODIS-converted reflectances of each event with CloudSat flyover overlaid in pink.