Development of a dataset to explore properties of tropical convection and anvil cirrus

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Introduction

Tropical convective clouds are important elements of the hydrological cycle and produce extensive cirrus anvils which strongly affect the tropical radiative energy balance. In most climate models, the optical properties of anvil clouds are only weakly linked to the properties of the convective clouds that generate them. To improve simulations of the global water and energy cycles, and accurately predict cloud radiative feedbacks, models need more realistic links between the relationships between the properties of convective clouds and the anvil clouds they generate.

The Darwin ARM site provides a comprehensive view of convection and anvil cloud from a combination of C-Pol precipitation radar, cloud radar and lidar, and satellite datasets. We are developing a dataset which tracks the life cycle of convective systems from satellite data; and links properties of convection from C-Pol and satellite data with anvil properties from cloud radar and lidar.

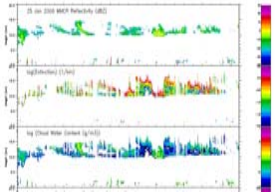
Future Work

- Extend satellite database to multiple years; examine convection and anvil characteristics as function of convective lifecycle and monsoon phase
- Develop anvil cloud property database from MMCR/MPL and associate with satellite convective systems; look for relationships between anvil properties and convective characteristics in C-Pol and satellite data
- Coarsen resolution of MTSat data to ~36 km and compare ability to track convection with full resolution data; apply tracking methodology to WRF mesoscale tropical runs at 36 km resolution
- Examine life cycle of convection in WRF simulations and relationships between convection and anvil properties in observations and WRF simulations

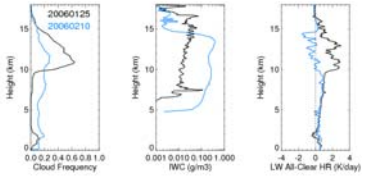
Tracking Convection to Build Database of Convective Life Cycle

- Convective systems identified and tracked in MTSat imagery using detect and spread approach (Boer & Ramanathan, 1997); classify convective core, cold anvil, warm anvil with Tb thresholds
- Convective systems classified based on minimum Tb, maximum size, and system lifetime (Futyan & DelGenio, 2007)
- Anvil that passes over the ARM Darwin site linked to appropriate convective system; calculate average anvil properties, distance from convective core, stage of convective life cycle

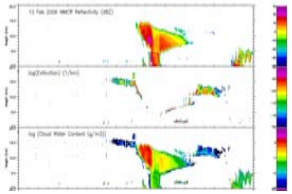
TWP-ICE Case Studies: 20060125 and 20060210



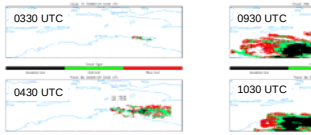
Radar reflectivity, lidar extinction, retrieved ice water content for 20060125 case.

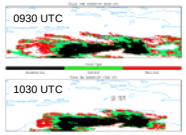


Cloud frequency, retrieved IWC profile (from Comstock et al 2010), and calculated LW cloud effect on radiative heating for the two cases.

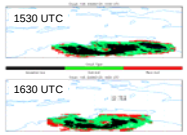


Radar reflectivity, lidar extinction, retrieved ice water content for 20060210 anvil.



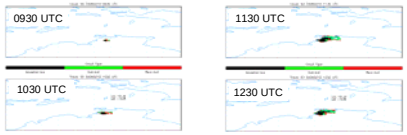


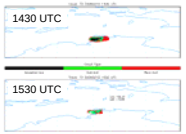
MTSat brightness temperature images showing 20060125 large-scale convective system with multiple convective cores.



20060125 – mesoscale convective system; lifetime > 20 hours, max number of pixels = 61298; min Tb = 188.15

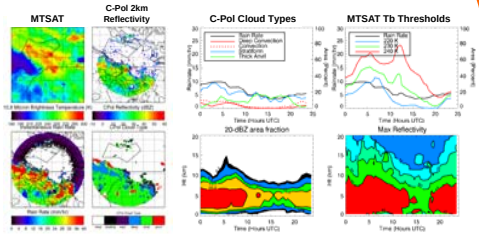
20060210 – local, smaller-scale convection: lifetime 7 hours; max number of pixels = 3515; min Tb = 188.65





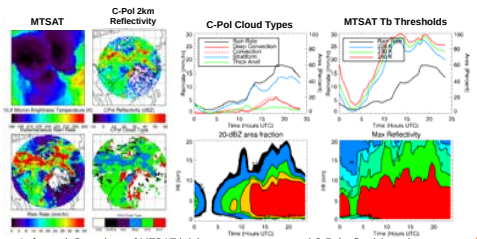
MTSat brightness temperature images showing 20060210 isolated convection over ARM site.

Linking C-Pol and Satellite Data



Left panel: Snapshots of MTSAT brightness temperature and C-Pol reflectivity, rain rate, and cloud type at 00:00 UTC on 20060120. Right panel: Time series of MTSAT and C-Pol statistics for 20060120.

- Geostationary satellites give little information on convective systems other than min Tb, size, and lifetime; while C-band radar has information on rain rate and convective intensity
- Combine C-Pol and MTSat data to study relationships between convective intensity factors and brightness temperature thresholds, area coverage, and time lags between convection and anvil properties (Rickenbach et al. 2008)



Left panel: Snapshots of MTSAT brightness temperature and C-Pol reflectivity, rain rate, and cloud type at 15:30 UTC on 20060123. Right panel: Time series of MTSAT and C-Pol statistics for 20060123.

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