Lifecycle of Tropical Convection and Anvil From Satellite and Radar Data and Regional Model Simulations

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Motivation

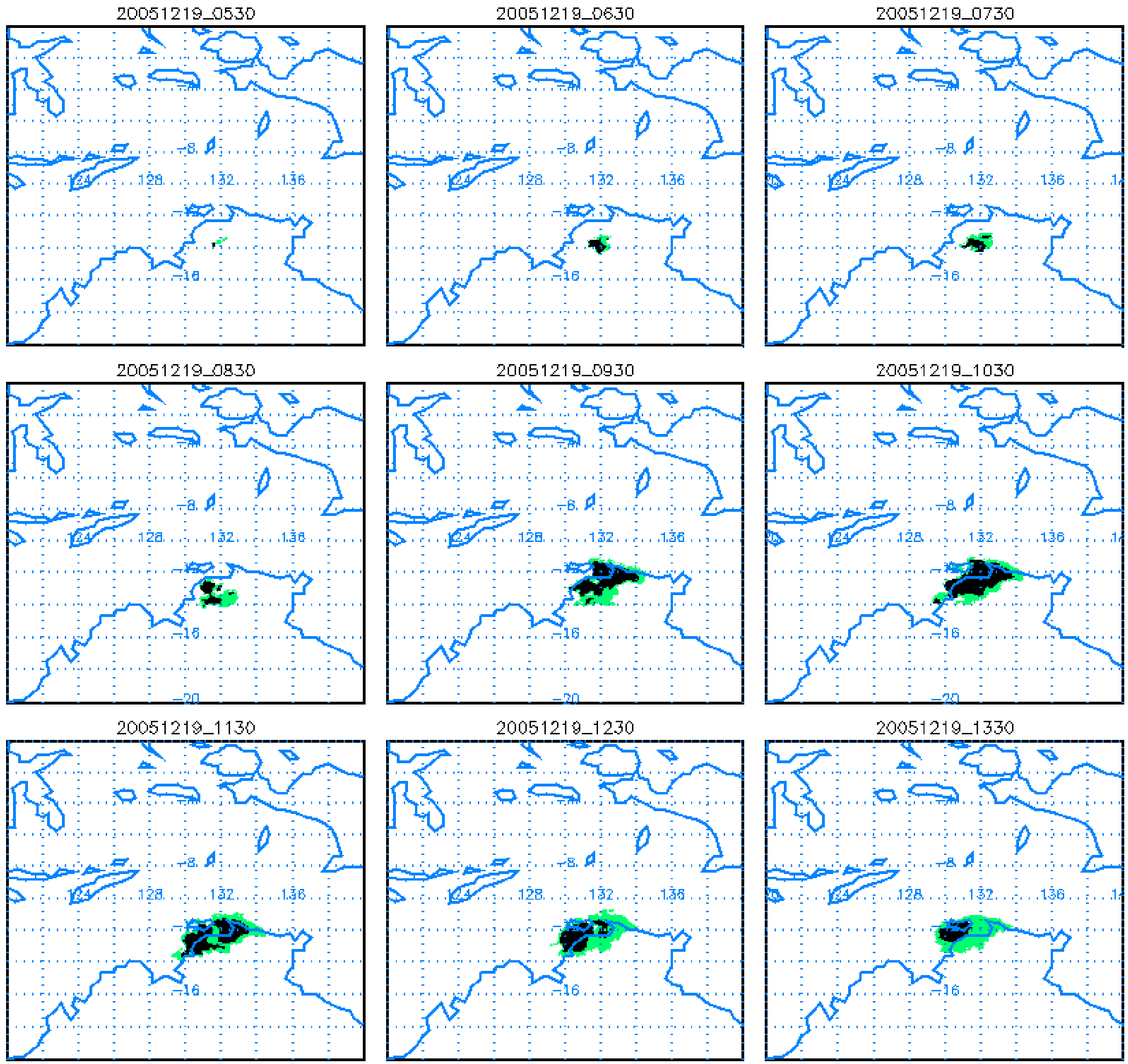
- Tropical convection is important to hydrological cycle & produces cirrus anvils which are important to radiative energy balance
- Large uncertainty in simulating deep convection and its associated anvil in current climate models
- ARM site at Darwin provides a comprehensive view of convection and anvil from precipitation radar, cloud radar and lidar, and satellite

Objectives

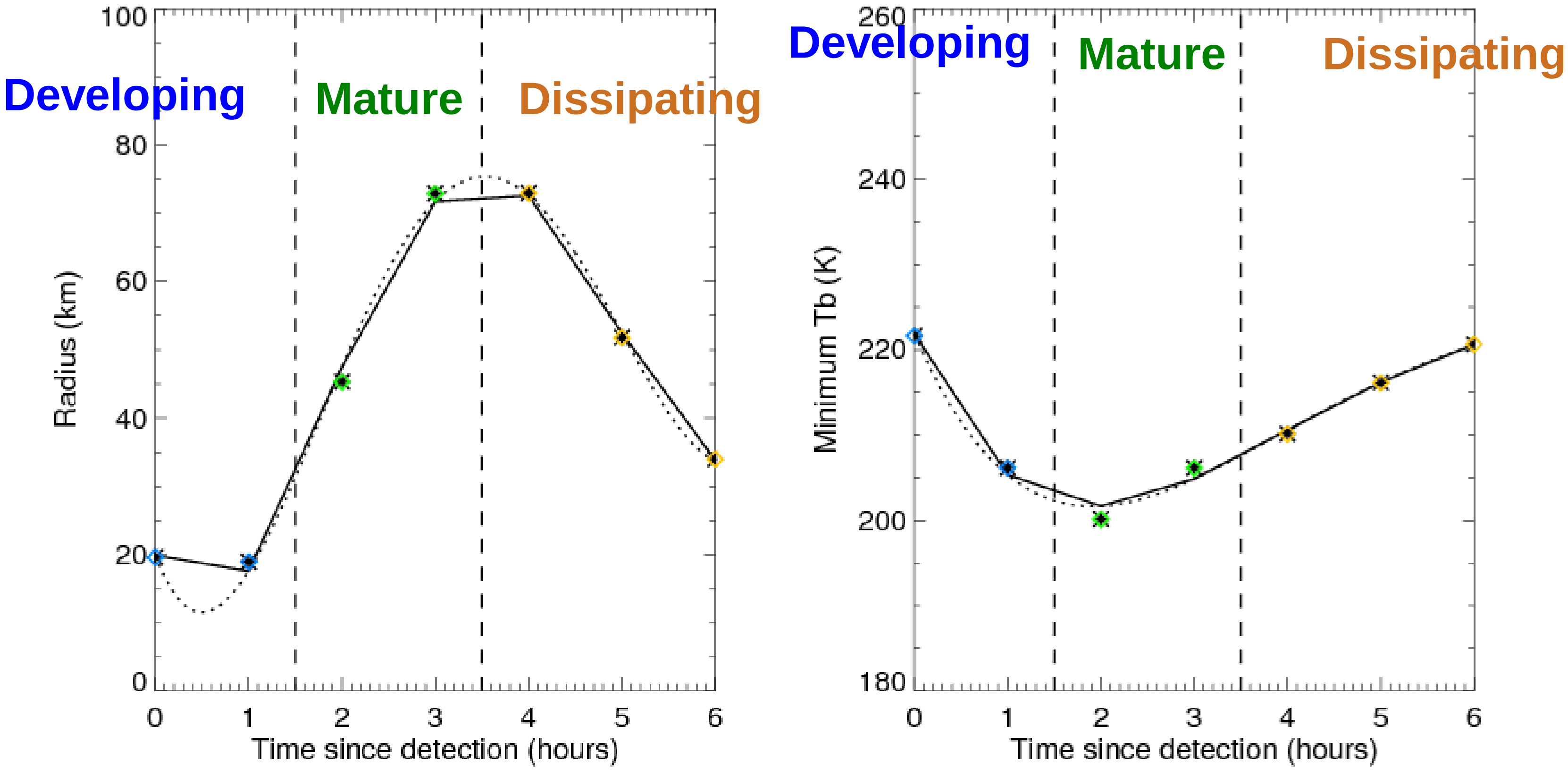
- Track life cycle of convective systems from satellite data.
- Link satellite obs to detailed vertical structure and microphysics from ARM data – create database of convective systems and associated anvil for analysis.
- Compare observations of convective systems to results from high-resolution, large-domain regional model simulations to evaluate model representation of convective systems.
- Eventually use observations and regional model simulations to guide parameterization development for climate models.

Tracking Convective Systems

- Methodology from Williams & Houze (1987); Futyan & Del Genio, (2007)
- Hourly MTSat 10.8 um Tb at 5 km resolution
- Identify convective cores and cold anvil as contiguous regions with Tb < 215K & Tb < 235K, respectively
- Track systems in successive images by requiring 50% overlap of core or cold anvil

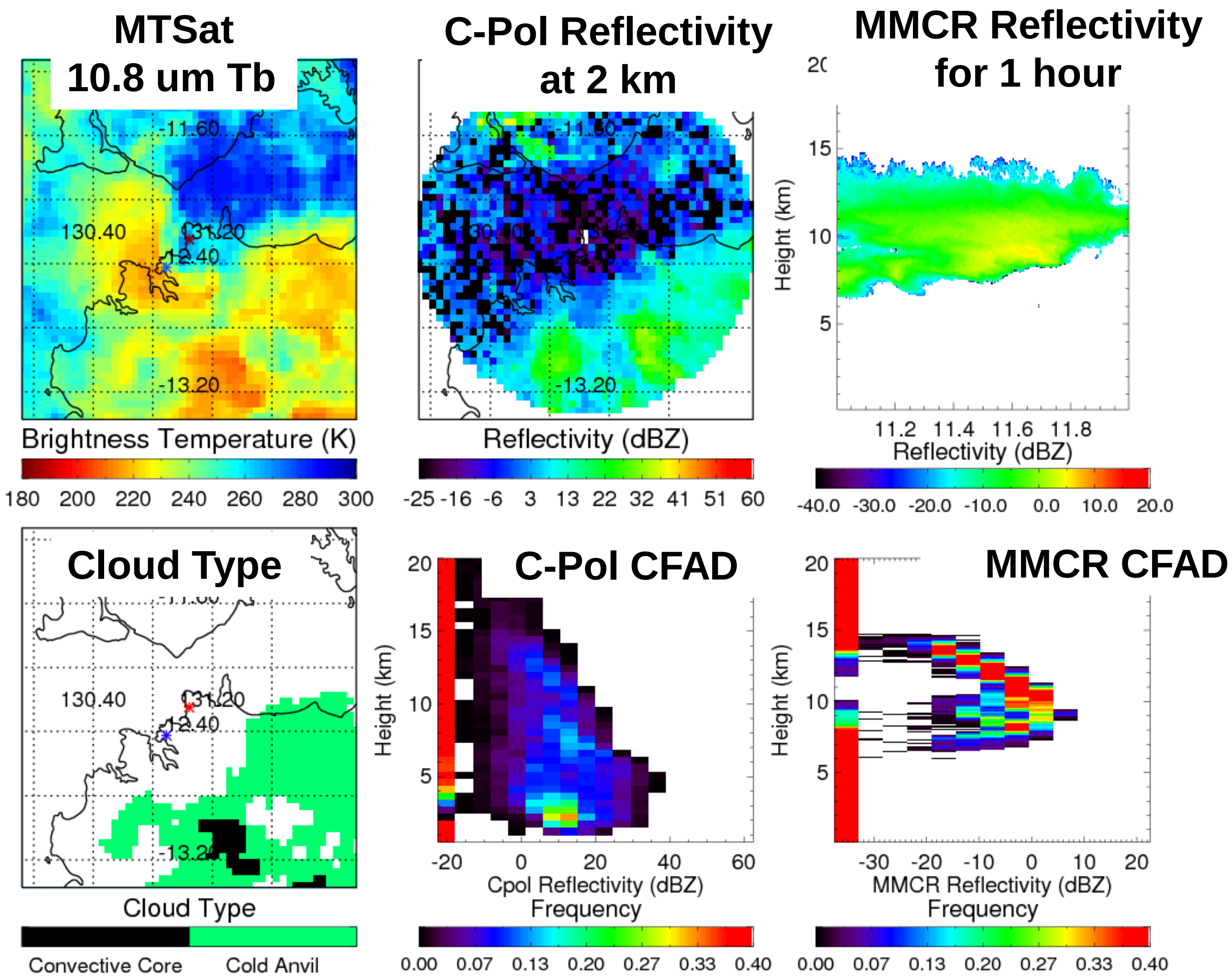


Defining Lifecycle Stage

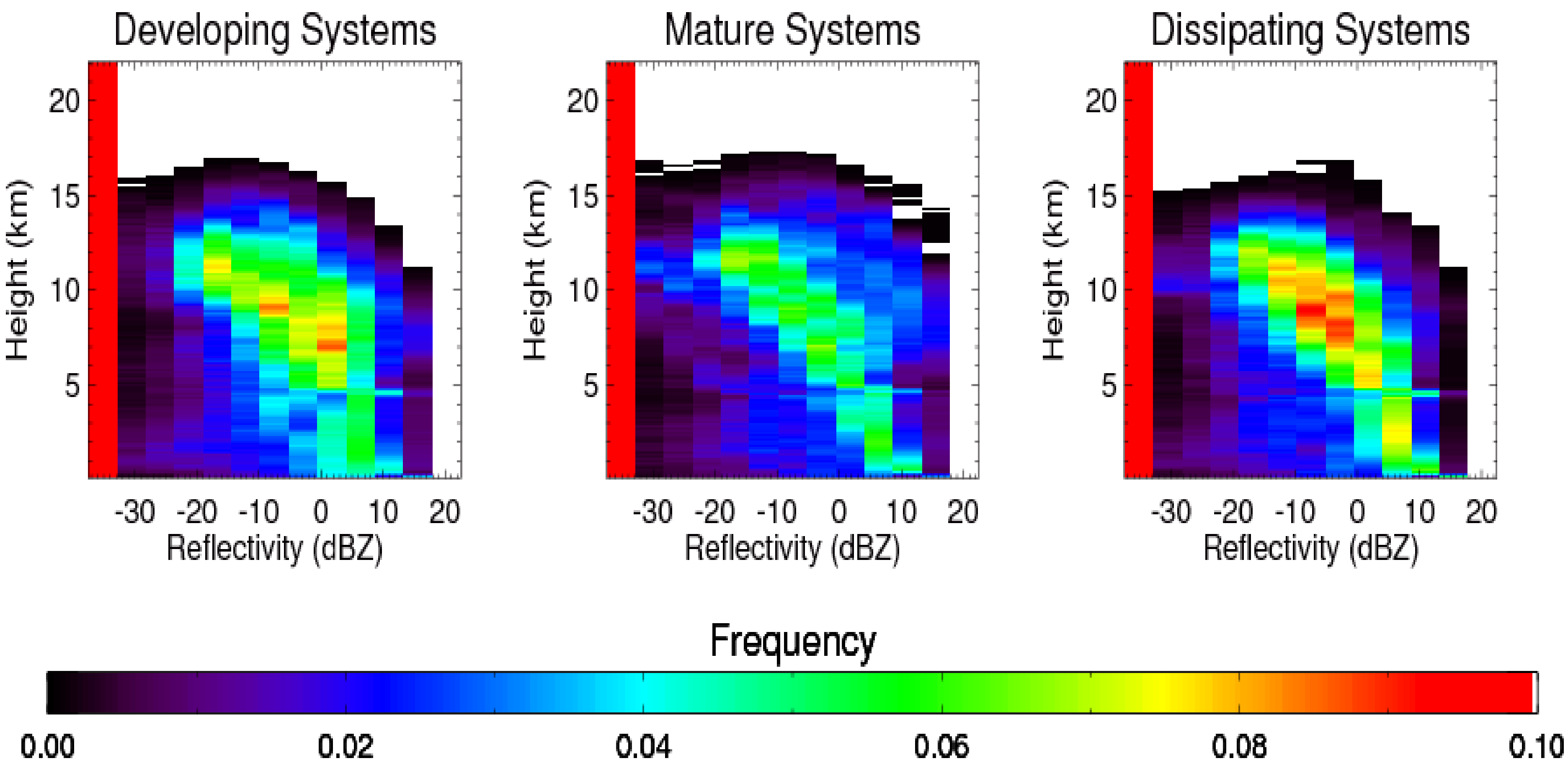


• Define life cycle stage based on maximum radius and minimum brightness temperature following Futyan & Del Genio (2007)

Linking Satellite and Radar Data



MMCR Reflectivity by Life Cycle Stage



- 3 months of data (wet season 2005-2006) ; 74 cloud systems that passed over Darwin

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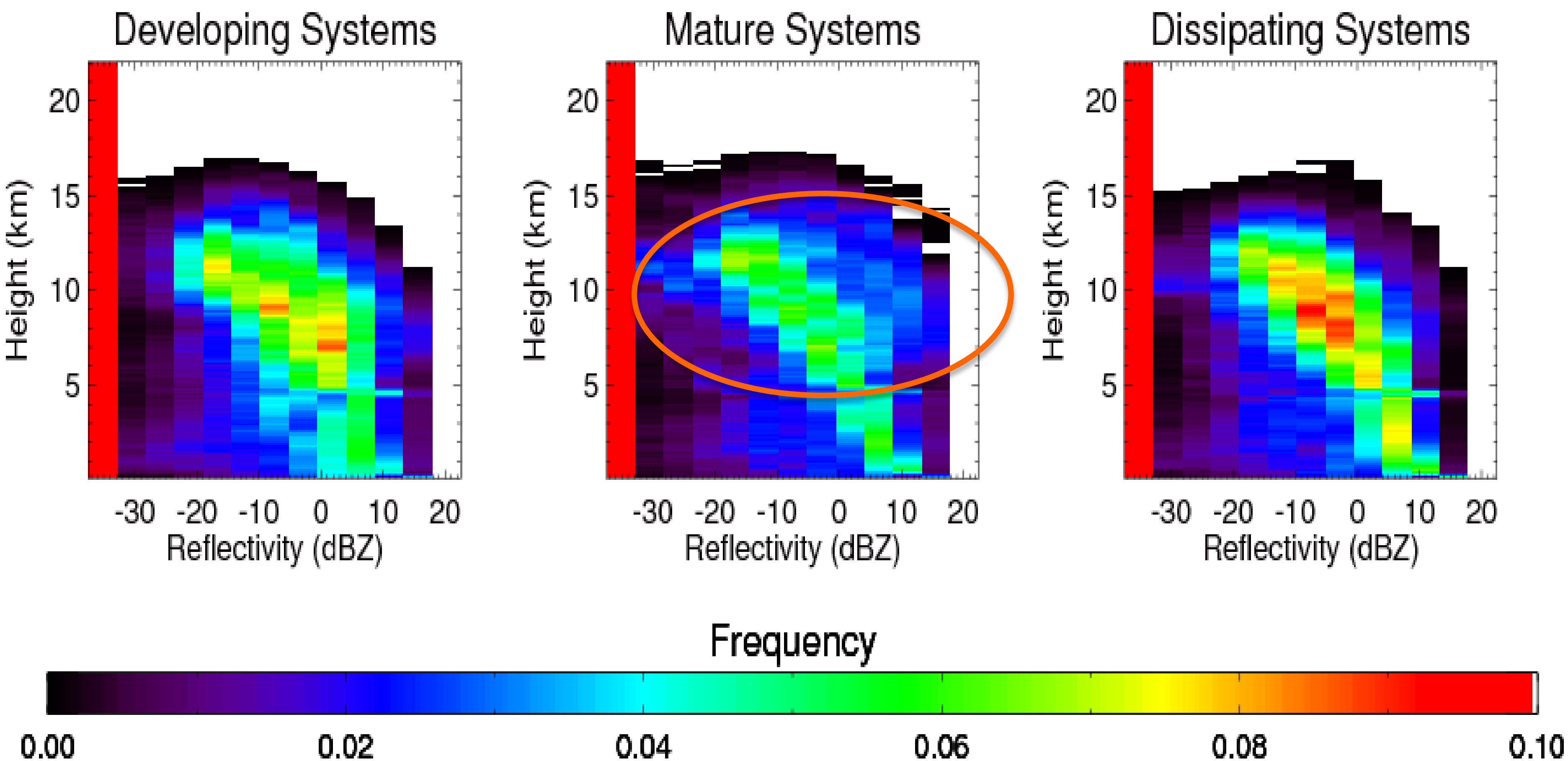

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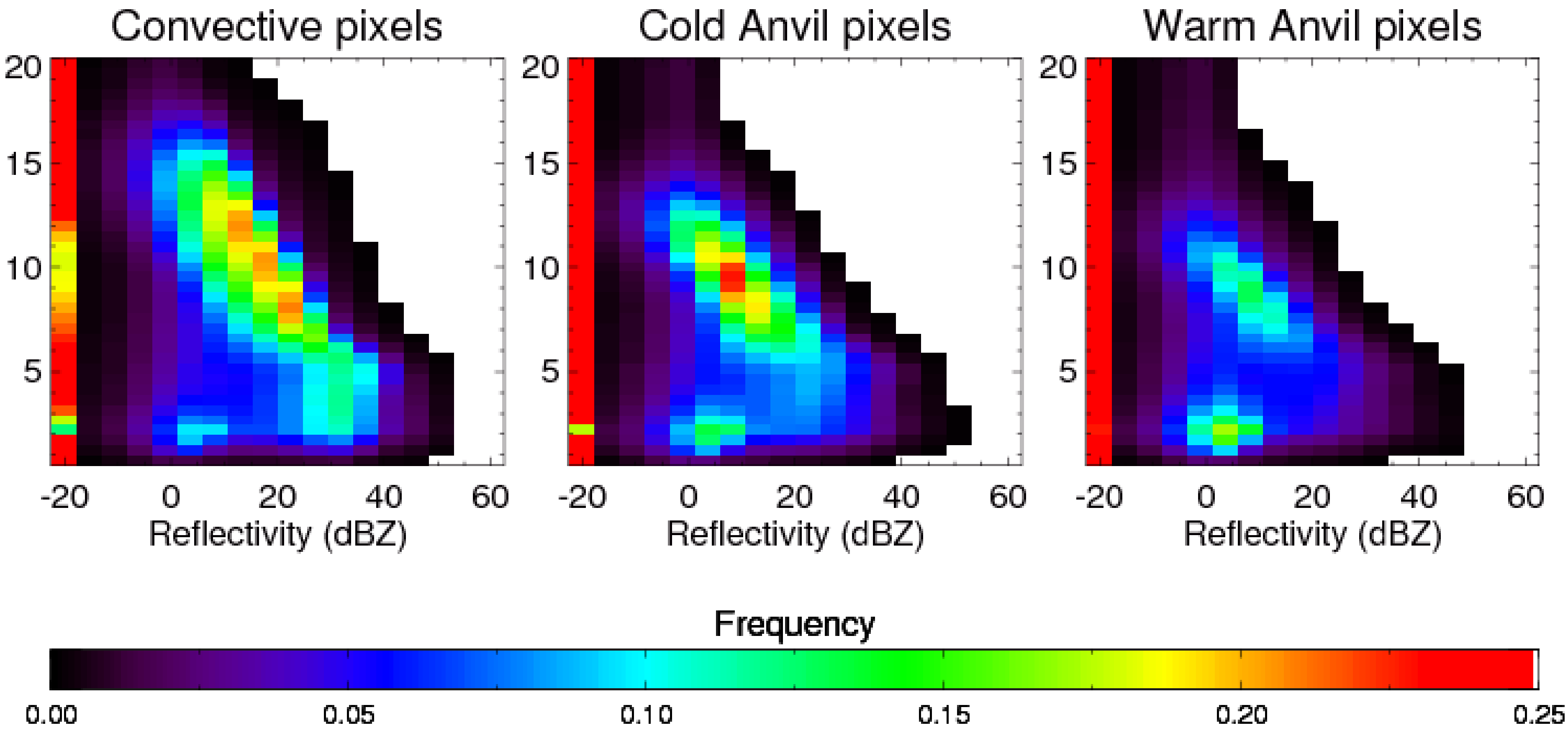
C-Pol Reflectivity Distributions by Cloud Type



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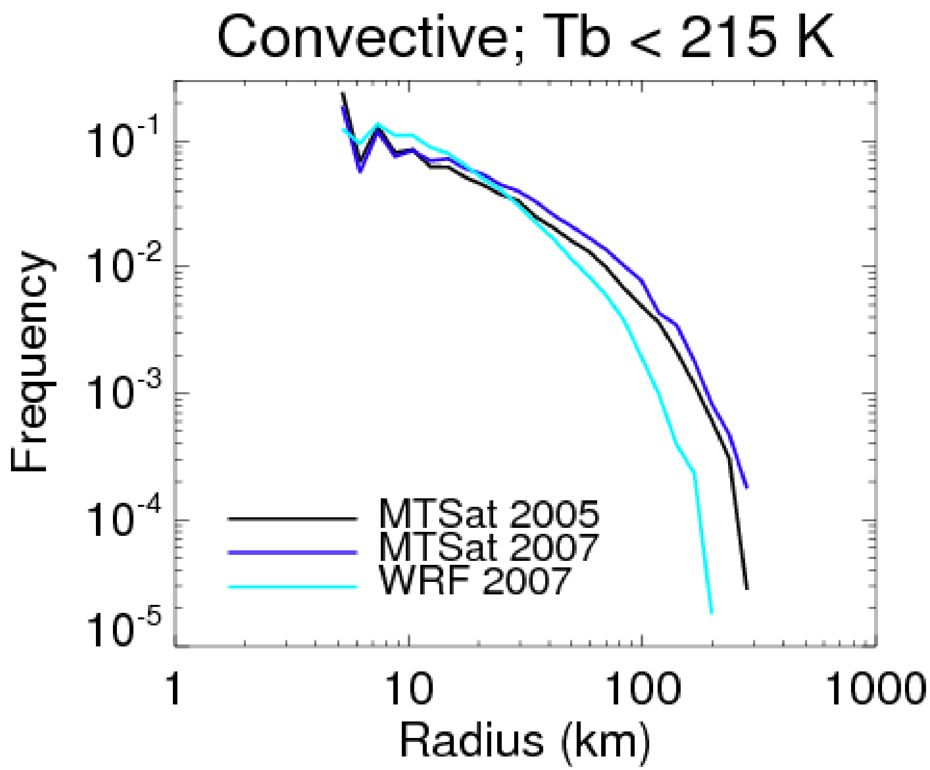
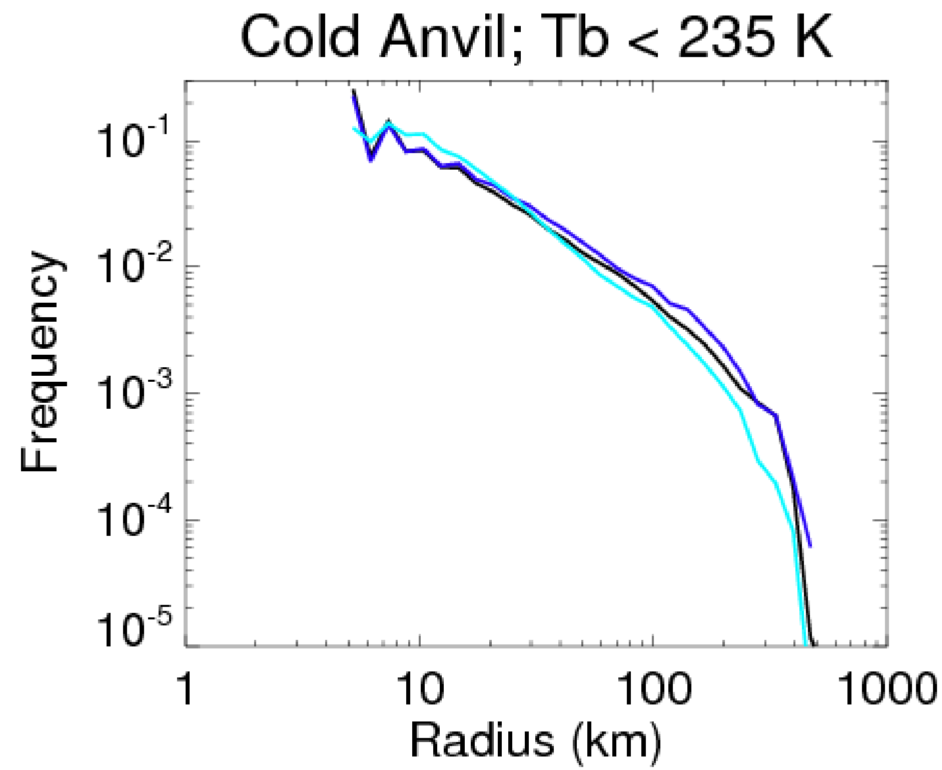
Preliminary Observation/Model Comparisons

- Test of methodology using existing large-domain, high resolution WRF simulation (Hagos et al. 2011) :
  - WRF v3.1 at 4 km resolution
  - Original domain: Indian Ocean to Manus to study MJO
  - Subset domain: 10S to 10N; 123 E to 153 E
  - Currently one month of simulation (Oct 2007)
  - GFS forecast data for lateral, initial, and surface boundary conditions
  - RRTM, YSU, and WSM-6 schemes for radiation, boundary layer, microphysics; No cumulus parameterization
- Convert OLR to 10.8 um brightness temperature (Yang and Slingo 2011)
- Apply same cloud identification and tracking methodology to model and observations

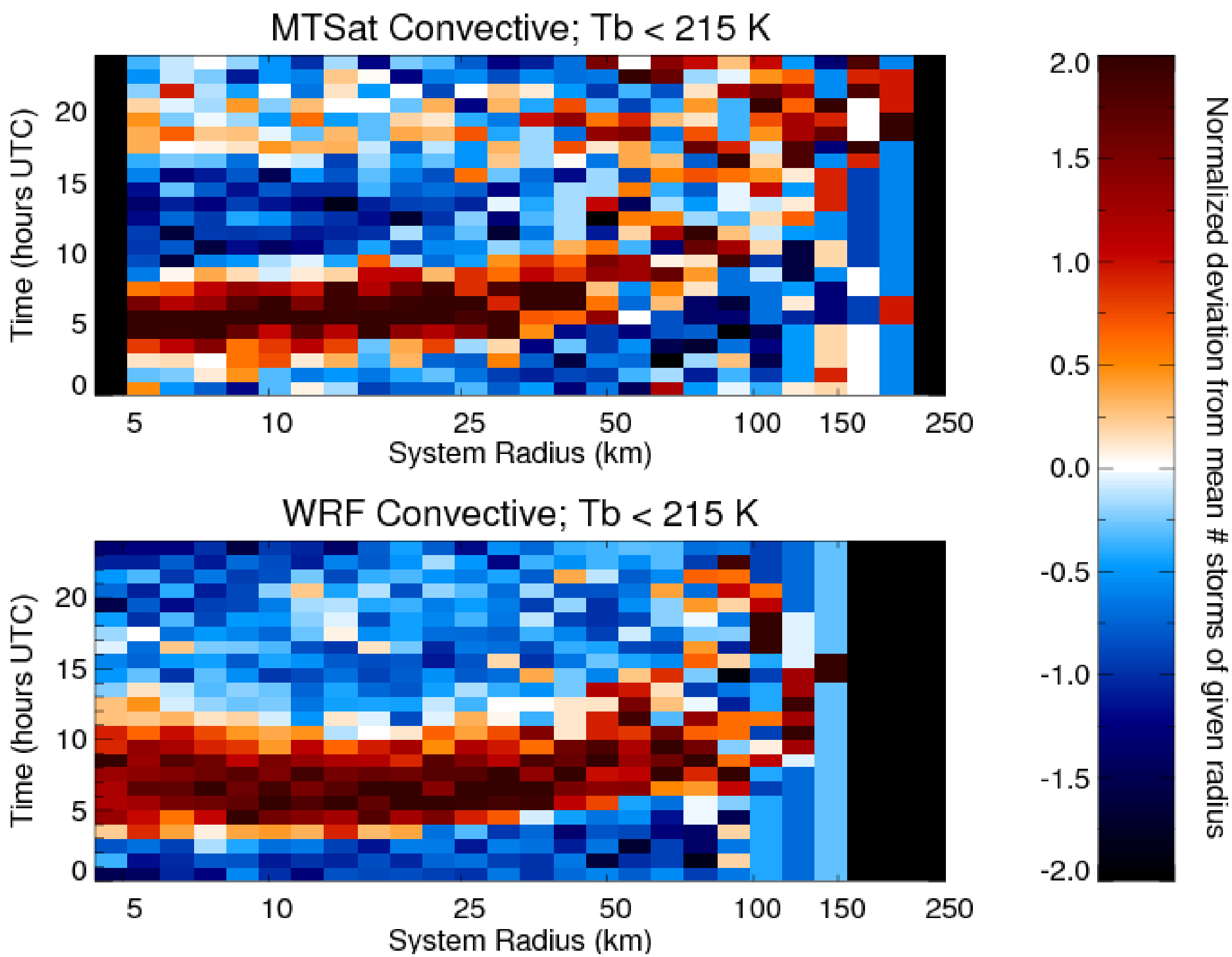
Comparison of cloud system sizes





- WRF somewhat overestimates number of small convective systems but shape of distribution is reasonable

Analysis of Diurnal Cycle of Convection



- Each column is normalized
- Colors represent deviation from mean # of storms of given radius
- Red = more storms of given size than average at given time
- Blue = fewer storms than average at given time

(Methodology from Pearson et al., JGR, 2010)

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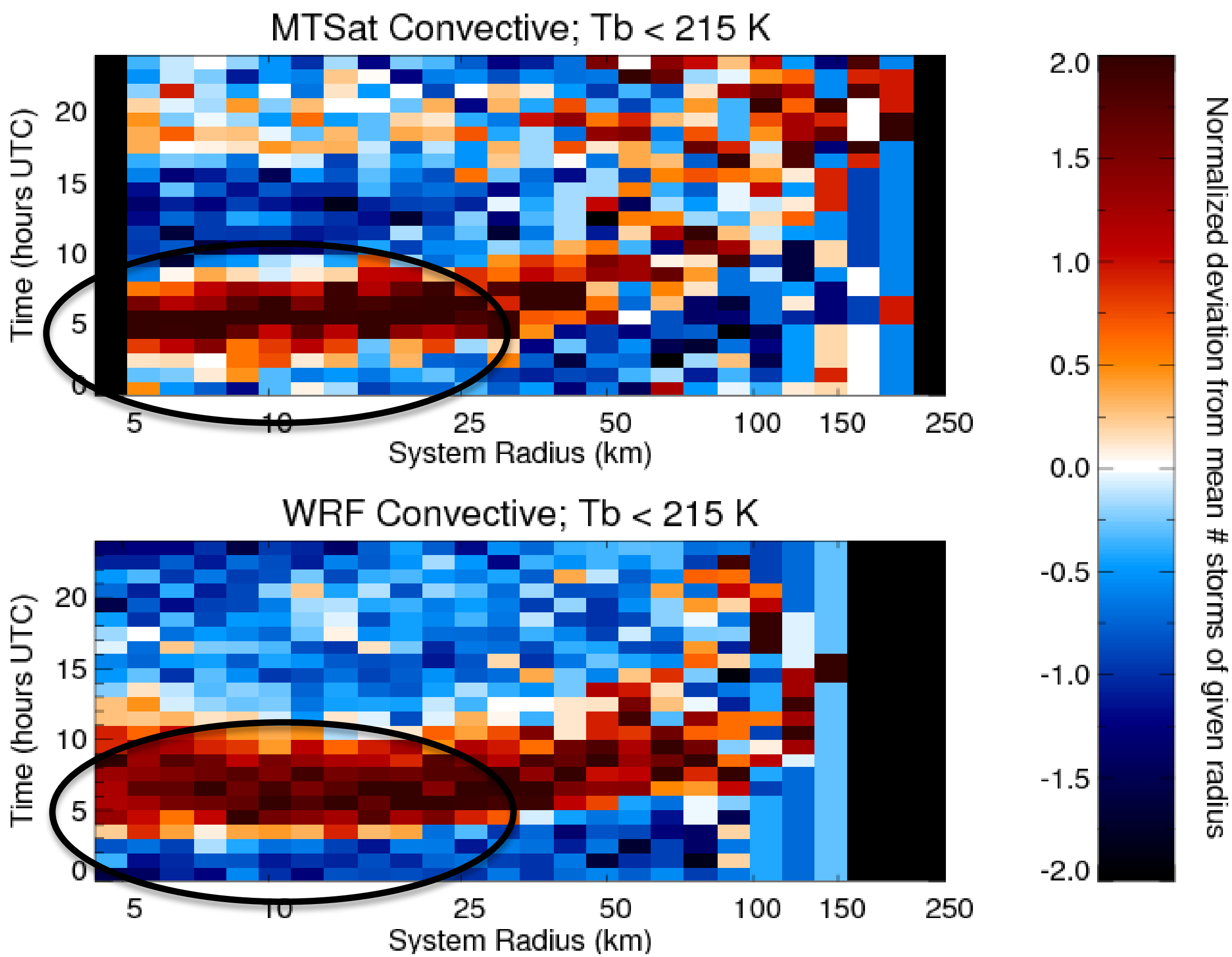

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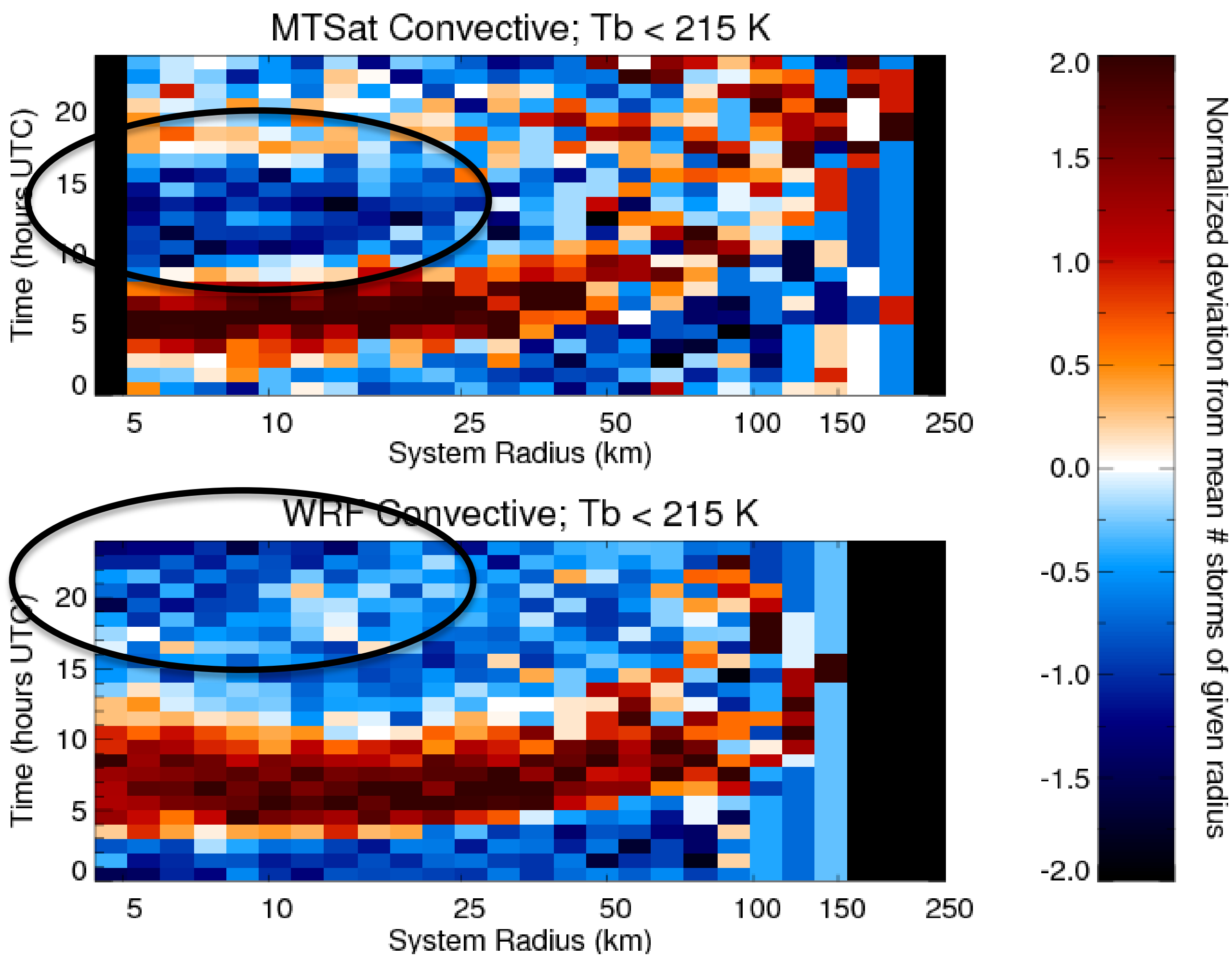

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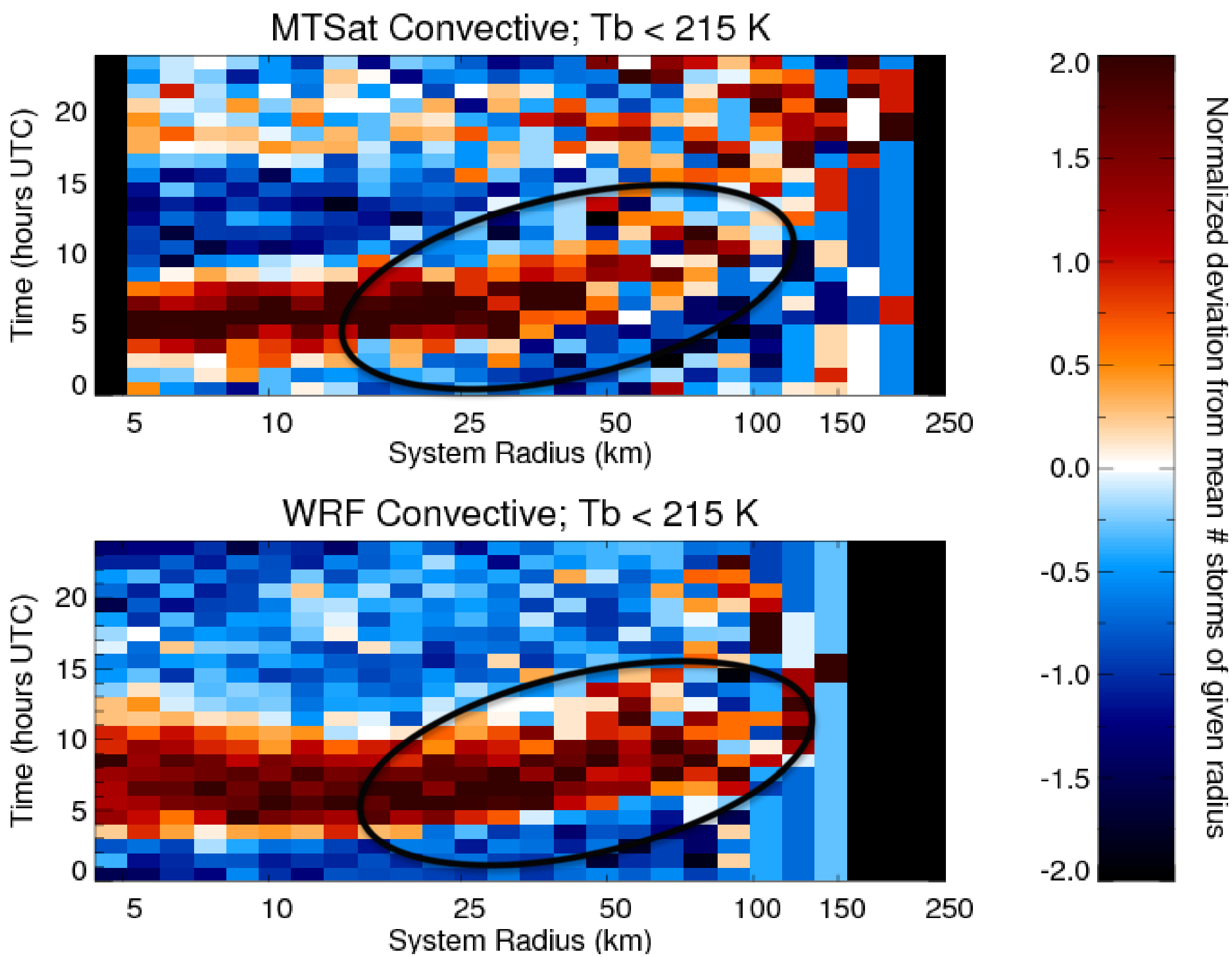

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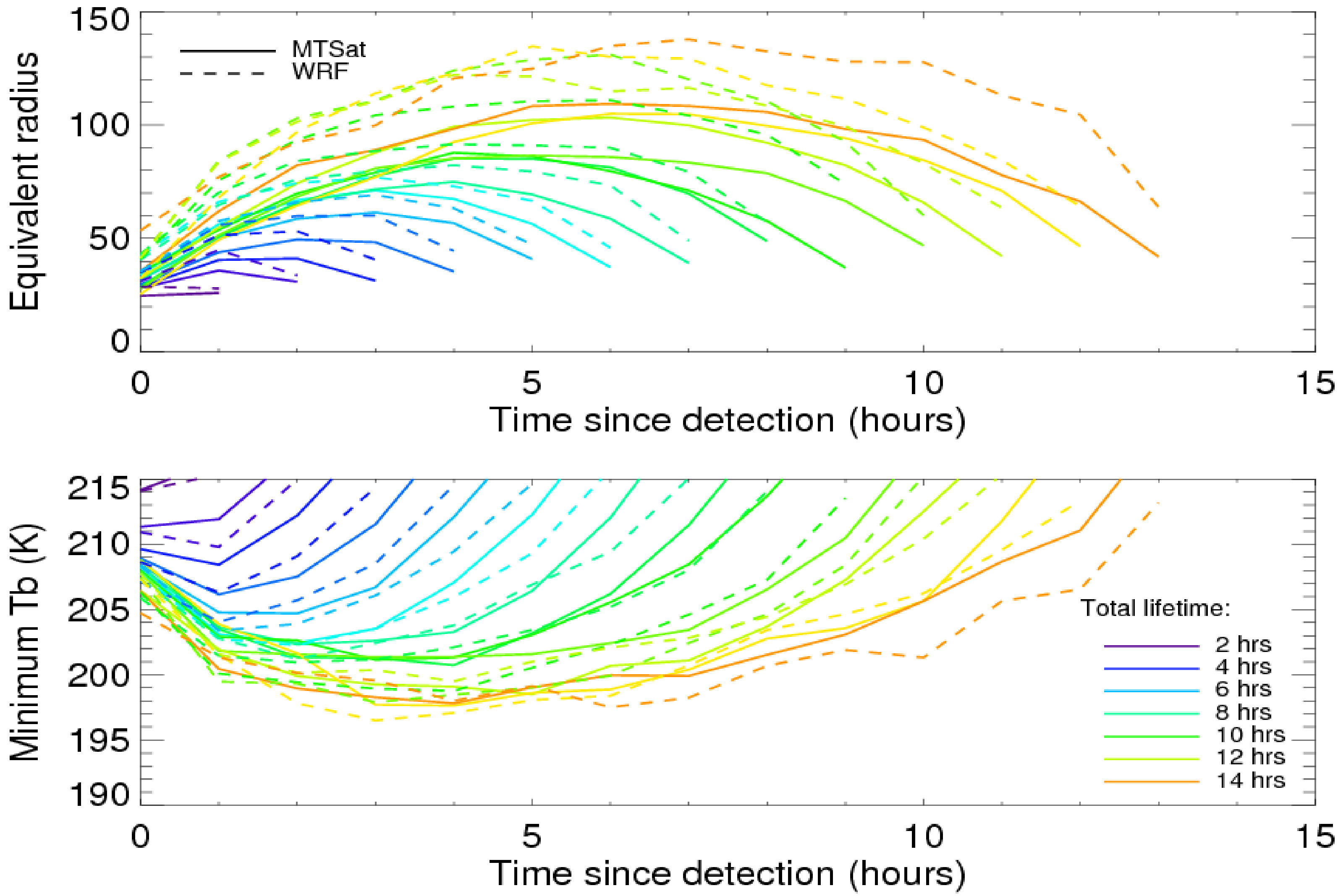
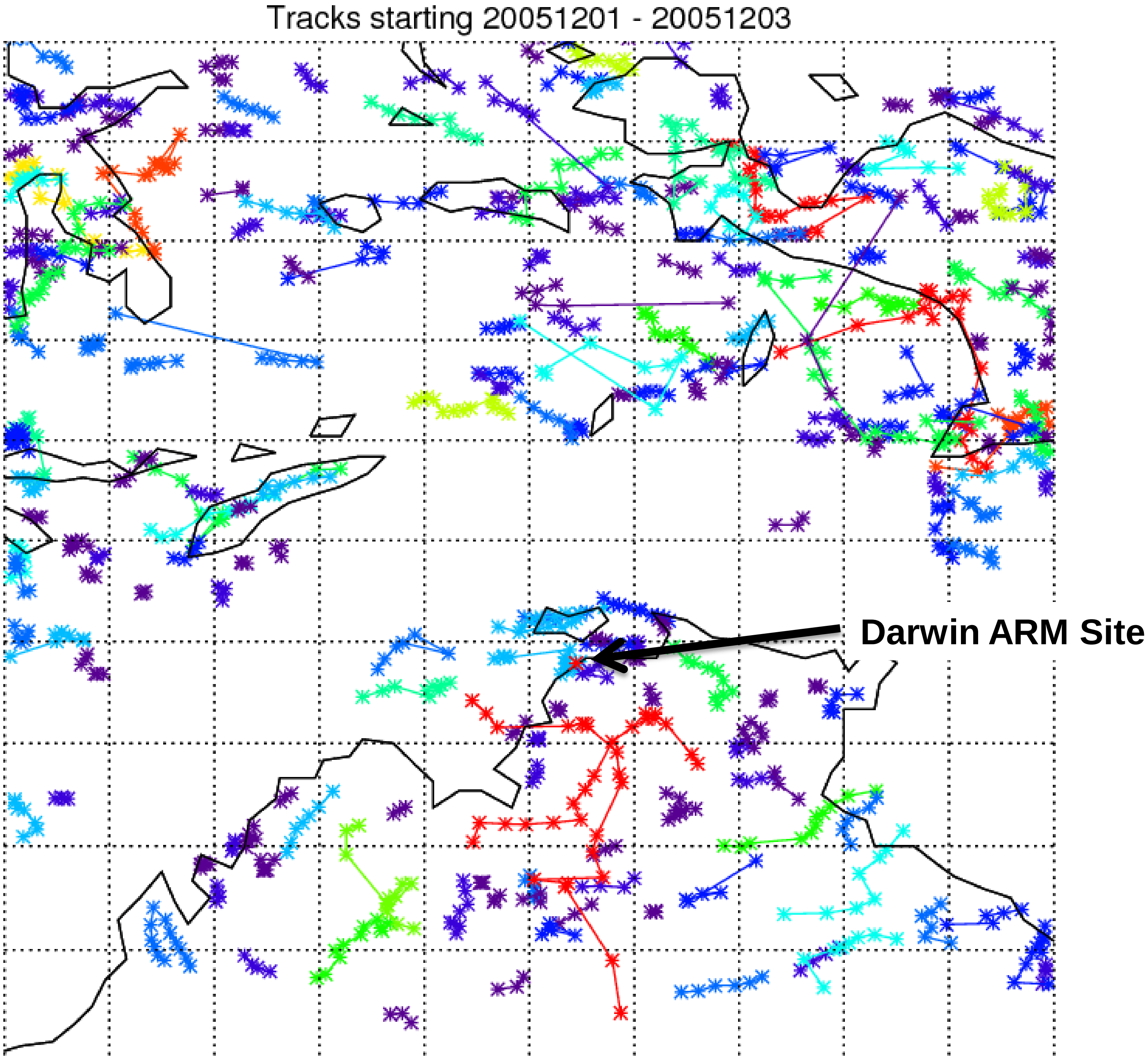
Life Cycle Comparison



(Following Pope et al., JClim, 2008)

Summary and Future Work

- Implemented methodology to develop database of convective systems over TWP from satellite data and link to ground-based radar data
- Initial comparison of WRF and satellite data shows WRF high-resolution simulation does reasonable job on # of systems and diurnal cycle
- Future work:
  - Process multiple years of data and assess tracking methodology
  - Further analysis of anvil and convective properties as function of storm size, intensity, lifecycle stage
  - More detailed analysis of WRF convection lifecycle; sensitivity tests to resolution, microphysics, convective parameterizations


Tracks starting 20051201 - 20051203
Darwin ARM Site