Lifecycle View of Tropical Deep Convection & Cirrus Clouds

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Investigation of Tropical Cirrus, Their Variability, Evolution, and Relation to the Upper Tropospheric Water Vapor

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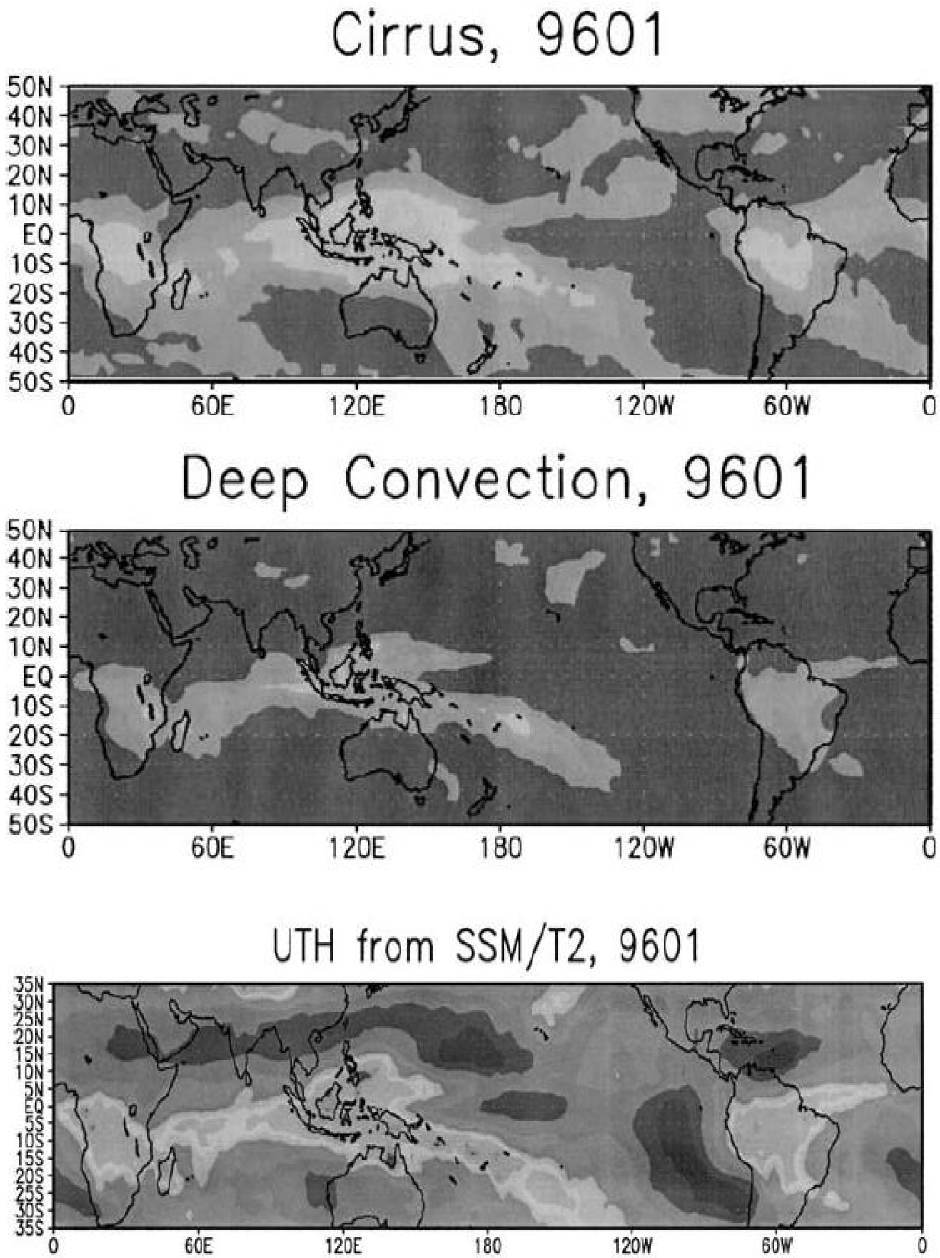
1977

A few considerations:

- Where does tropical cirrus come from?
- What fraction of the tropical cirrus clouds is directly produced by deep convection outflow (detrainment)?
- What's the best strategy for observing cloud lifecycle with satellite measurements?



Luo and Rossow (2004)

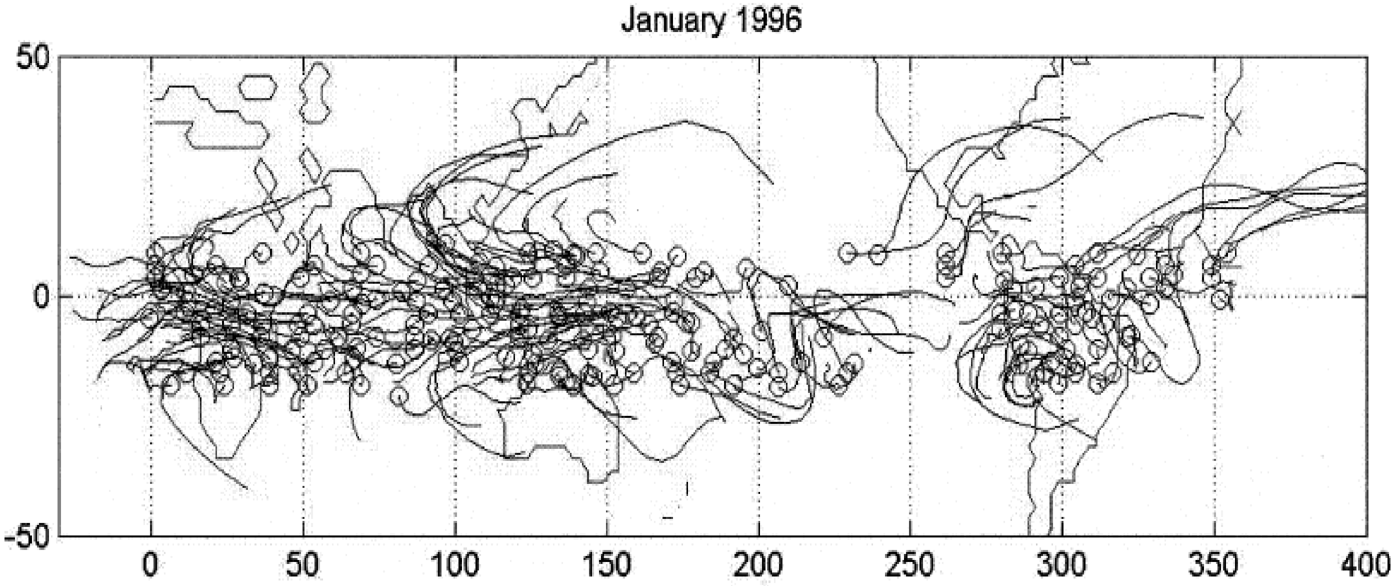
Climatology of tropical deep convection, cirrus and UTWV shows high correlation spatially.

Does this suggest any causal relationship among them?

We need to go deeper than just starring at these climatology maps to understand the underlying processes

Eulerian → Lagrangian

Lagrangian Trajectories



Starting from where convection dies out, follow the large-scale UT air trajectory (as determined from NCEP/NCAR analysis) for 5 days.

The idea is to *sample the transition from deep convection to cirrus anvil to thin cirrus*.

Luo and Rossow (2004)

Characterizing Tropical Cirrus Life Cycle, Evolution, and Interaction with Upper-Tropospheric Water Vapor Using Lagrangian Trajectory Analysis of Satellite Observations

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of cirrus. Cirrus properties continuously evolve along the trajectories as they gradually thin out and move to the lower levels. Typical tropical cirrus systems last for 19–30 ± 16 h. This is much longer than cirrus particle lifetimes, suggesting that other processes (e.g., large-scale lifting) replenish the particles to maintain tropical cirrus. Consequently, tropical cirrus can advect over large distances, about 600–1000 km, during their lifetimes. For almost all current GCMs, this distance spans more than one grid box, requiring that the water vapor and cloud water budgets include an advection term. Based on their relationship to convective systems, detrainment cirrus are distinguished from in situ cirrus. It is found that more than half of the tropical cirrus are formed in situ well away from convection. The interaction between cirrus and UTWV is explored by comparing the evolution of the UTWV along composite clear trajectories and trajectories with cirrus. Cirrus are found to be associated

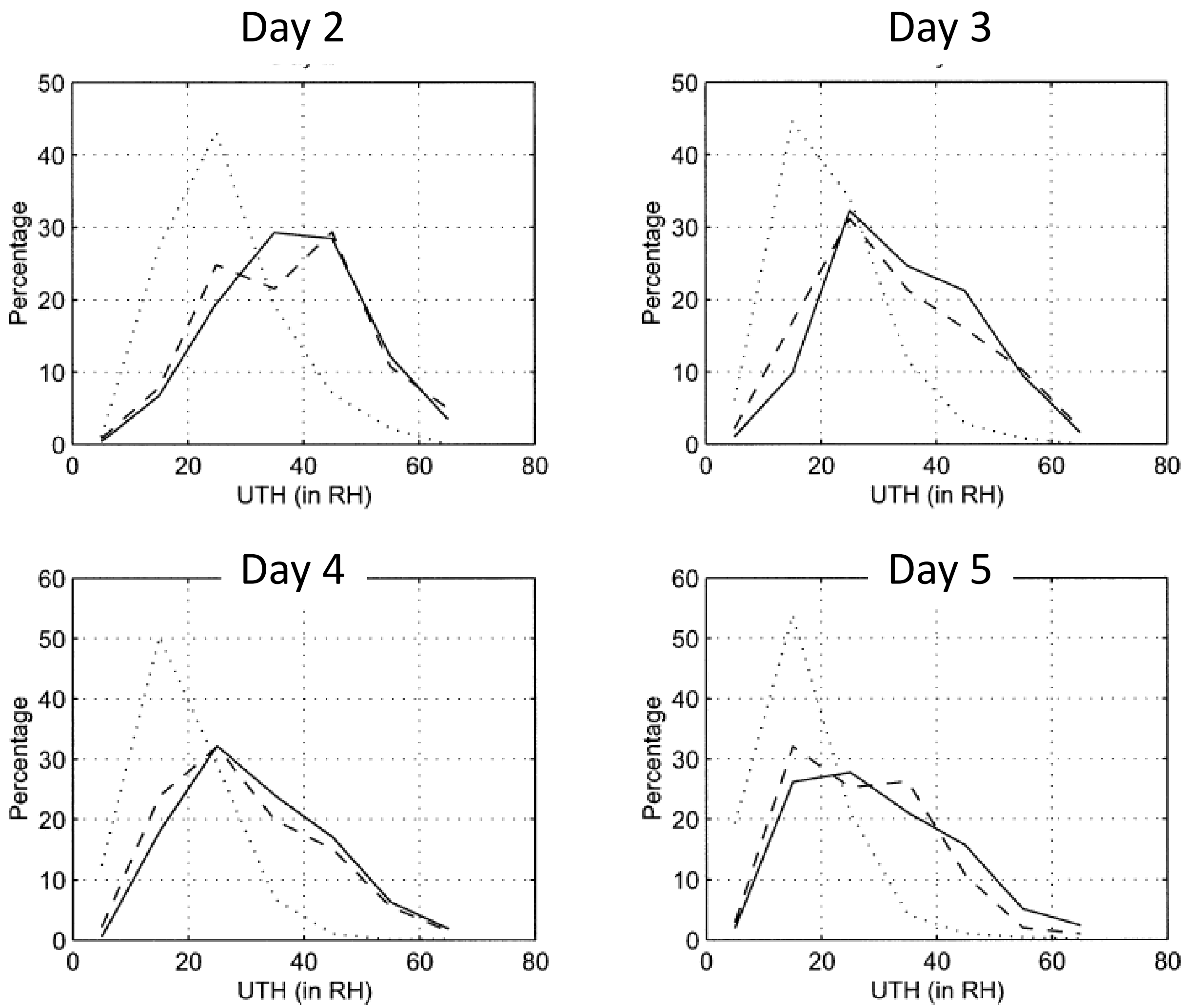

FIG. 13. Histograms of UTH for days 2, 3, 4, and 5 for three categories of clear cases: one that has upstream cirrus history in the past 12 h (solid), one that has cirrus downstream in the next 12 h (dashed), and another that has been clear for the past or future 12 h (dotted).

All histograms are for *clear-scene* UTH, but 3 types of *clear scene*:

1) one that has upstream (in time) cirrus (solid),

2) one that has downstream cirrus (dashed)

3) one that stays clear for the past and future (dotted).

<u>Interpretation</u>: it's dynamics that moistens the upper troposphere and, at the same time, make cirrus.

What do we observe cloud lifecycle with LEO measurements?

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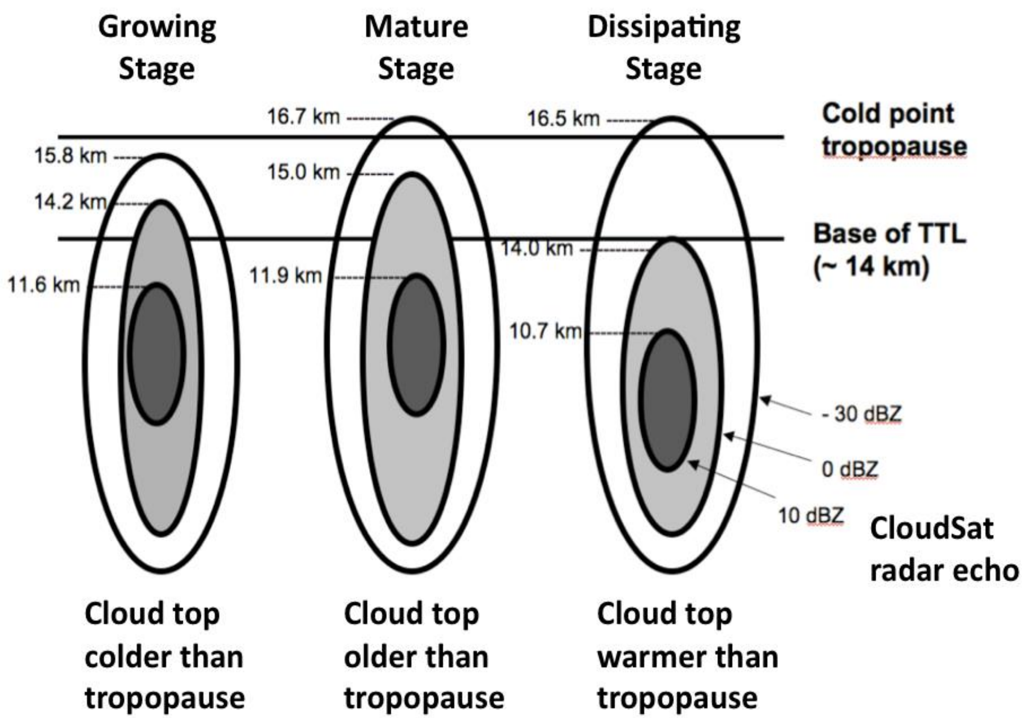
Approach 1: Sort the LEO snapshots in lifecycle views



Luo et al. (2008)

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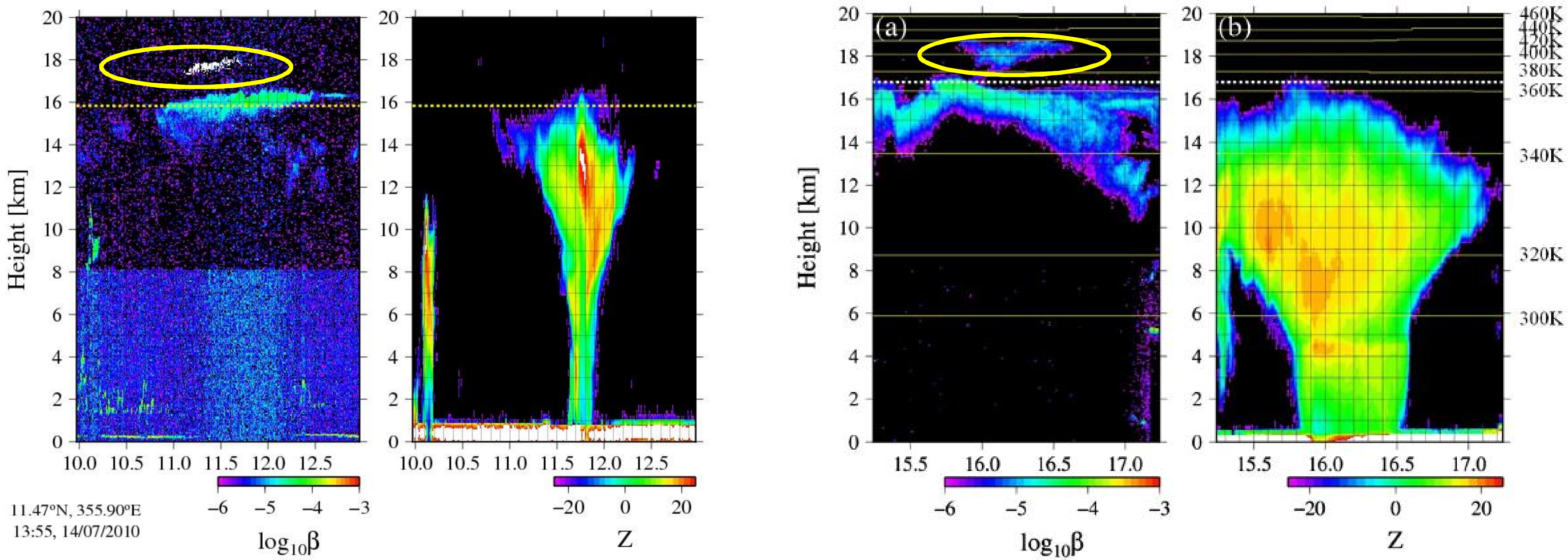
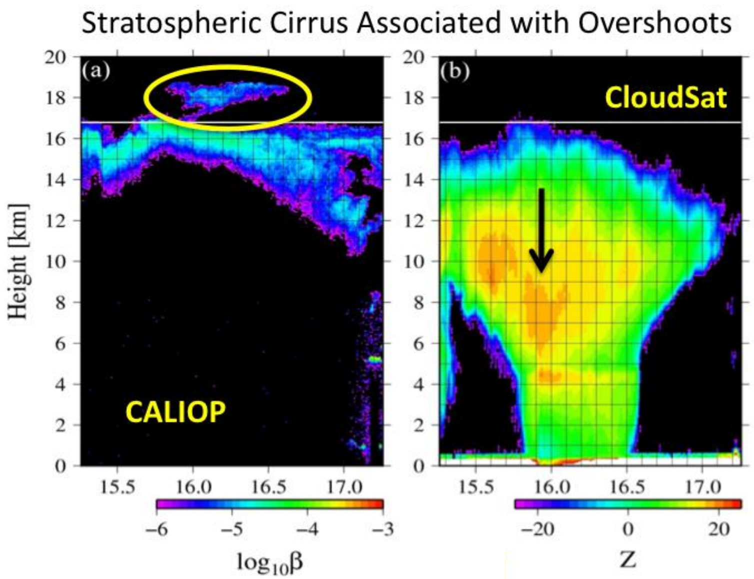


Iwasaki, Luo et al. (2015)

What do we observe cloud lifecycle with LEO measurements?

Approach 2: Place the LEO msmts in the context of GEO observations



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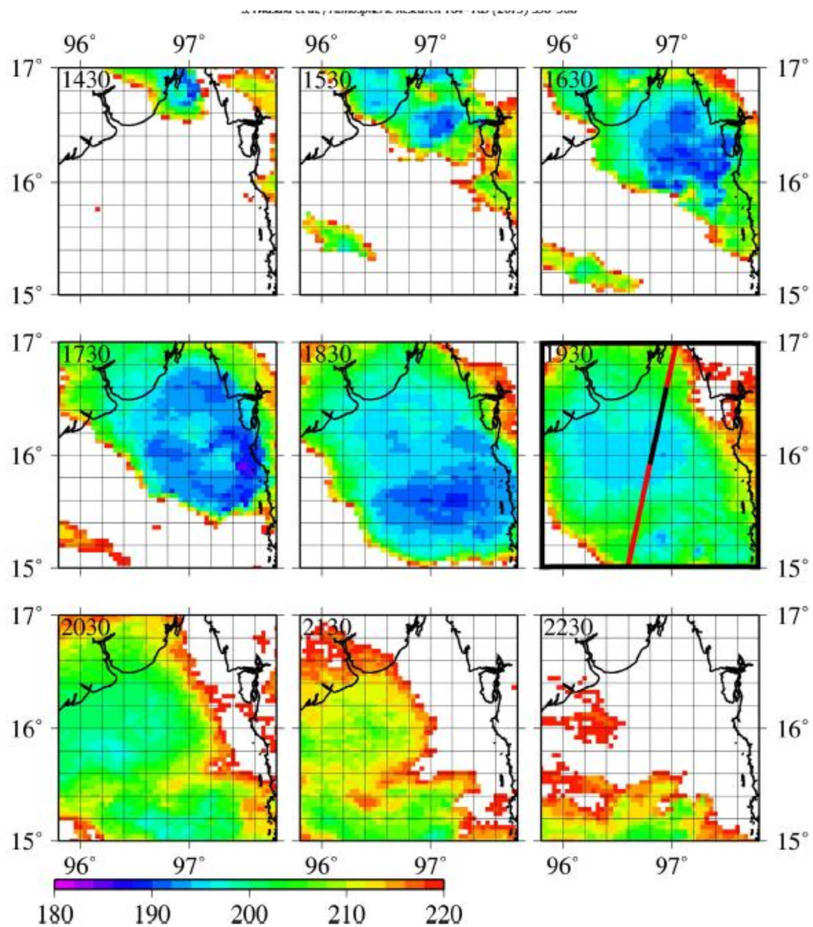

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Characterizing tropical overshooting deep convection from joint analysis of CloudSat and geostationary satellite observations

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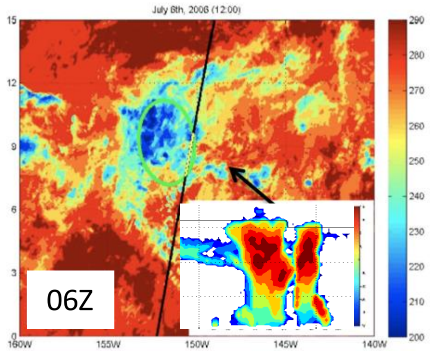

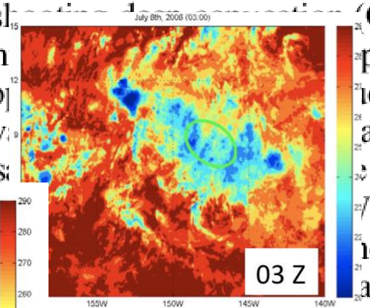

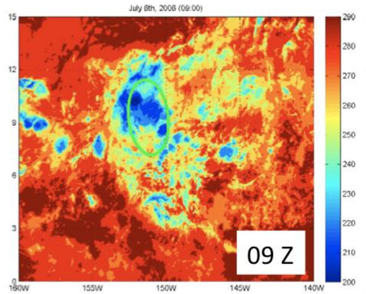

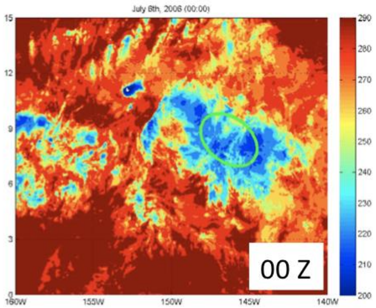

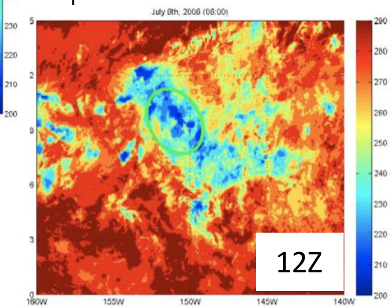

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... cycle view of tropical ODC. Climatology of tropical ODC based on
... presented and compared with previous works. Various parameters from
... pertaining to cloud vertical extent, convective intensity, and
... nt are analyzed. Although results broadly agree with previous studies, we show that CloudSat CPR is capable of capturing both small cloud particles and large precipitation size particles, thus presenting a more complete depiction of the internal vertical structure of tropical ODC. Geostationary satellite observations are analyzed in conjunction with CloudSat data to identify the life stage of the convective systems (CSs) in which ODC is embedded. ODC associated with the growing, mature, and dissipating stages of the CSs represents, respectively, 66.2%, 33.4%, and 0.4% of the total population. Convective intensity of the ODC is found to be stronger during the growing stage than the mature stage.

Citation: Takahashi, H., and Z. J. Luo (2013), Characterizing tropical overshooting deep convection from joint analysis of CloudSat and geostationary satellite observations, *J. Geophys. Res. Atmos.*, *118*, doi:10.1002/2013JD020972.

Summary

- Much of the tropical cirrus (slightly more than 50%) are not produced by direct detrainment of deep convection.

- Most of the advanced cloud observations are on board LEO satellites, which miss the time dimension.

- Two approaches are suggested to place the LEO observations in the context of cloud lifecycle