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Lagrangian Diagnostics of Tropical Cirrus

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Motivation

We are studying the life cycle of tropical cirrus clouds and their effects on upper tropospheric humidity while creating a Lagrangian data base of convective systems.

1. Lagrangian Tracking

We are obtaining trajectories of tropical convective systems by following water vapor spatial patterns in hourly geostationary satellite imagery. Specifically, we track potential targets of 200 km x 200 km, forward and backward in time, for 24 hours using cross-correlations (Fig. 1).

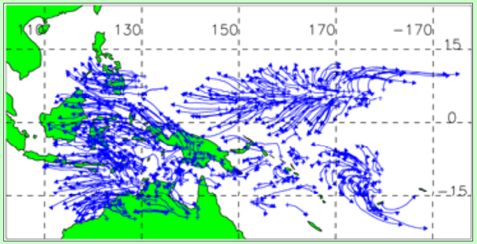

Fig. 1. Forward trajectories on 6 January, 2006.

2. Segmentation - Synchronization

Based on brightness temperatures, we next subdivide each cloud system into deep convection (DC) and cirrus anvil. Finally, we select individual DC events with a max deep convective cloud cover (DCC) of at least 10% and synchronize them to the time of max DCC (Fig. 2). For 1-8 January, 2006, this has yielded 6509 DC events in 3230 trajectories.

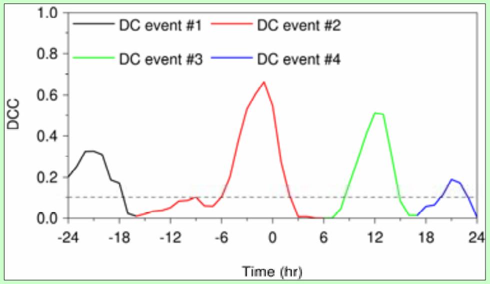

Fig. 2. Segmentation of a trajectory to DC events.

Summary

Preliminary results indicate that evaporation of detrained ice does *not* play a significant role in regulating the vapor budget of the upper troposphere.

3. Trajectory Composites

The Lagrangian evolution of DCC, cirrus anvil cloud cover (CAC), and upper tropospheric humidity (UTH) averaged from all synchronized trajectories is shown in Fig. 3. The corresponding ice water path (IWP) values for the DC and Ci components are shown in Fig. 4.

Note that CAC peaks ~3-4 hours after DCC, characterizing the anvil spreading time-scale for tropical convection, while UTH lags behind CAC by ~1-2 hours. The evolution of the mean DC and Ci IWP closely follows that of DCC and CAC.

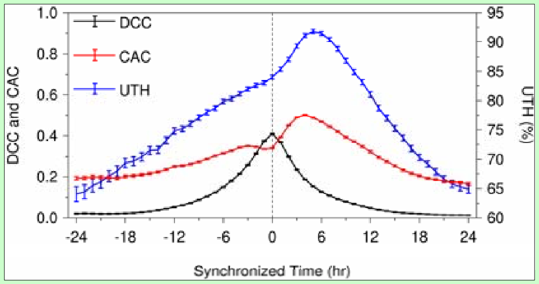

Fig. 3. Evolution of DCC, CAC, and UTH.

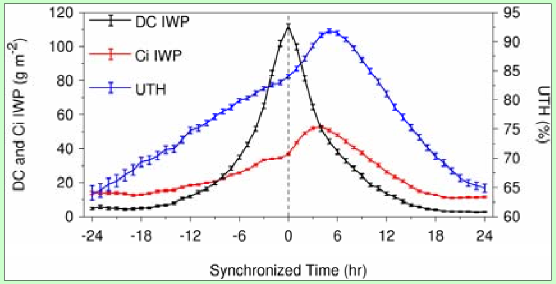

Fig. 4. Same as Fig. 3 but for DC IWP and Ci IWP.

Acknowledgements

MTSAT (Multi-functional Transport Satellite) imagery was obtained from the ARM External Data Center, while cloud property products were provided by Dr. Patrick Minnis of the NASA Langley Cloud and Radiation Research Group.

4. Humidity Tendencies

We have also been investigating the relationship between UTH and anvil cirrus by comparing the UTH tendency as a function of CAC and IWP tendencies (Figs. 5a and 5b, respectively). Results indicate that shrinking cirrus anvils are associated with enhanced drying of the upper troposphere, while cirrus anvil growth entails enhanced moistening. Furthermore, the amount of evaporated or condensed cirrus ice water appears to have no correlation with UTH. This suggests that upper tropospheric moisture is primarily influenced by the same vertical transport processes responsible for cirrus formation and dissipation, *not* by the evaporation of detrained ice.

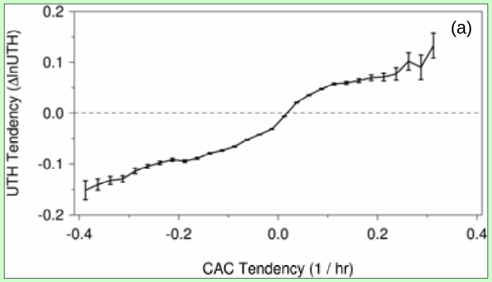

Fig. 5a. UTH tendency vs. CAC tendency.

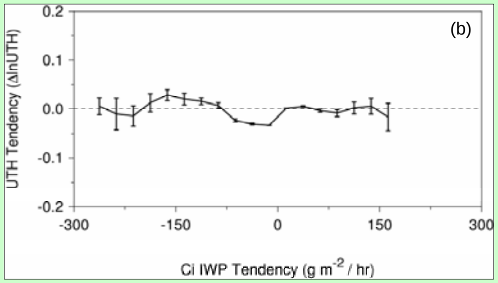

Fig. 5b. UTH tendency vs. Ci IWP tendency.