Environmental Conditions Controlling the Shallow-to-Deep Transition in Convective Clouds During GOAmazon 2014/5

Michael P. Jensen¹, Scott E. Giangrande², Cari Gostic³,⁴, Virendra Ghate⁵, David Mechem⁵, Tami Toto⁵

¹Brookhaven National Laboratory  ²DOE Science Undergraduate Laboratory Internship  ³Cornell University  ⁴Argonne National Laboratory  ⁵University of Kansas

Corresponding author: Mike Jensen, mjensen@bnl.gov, (631) 344-7021

1. MOTIVATION

- Climate models do not get timing of rainfall peak over land correct (Dai et al. 1999; Yang and Slingo 2001)
- Lack of intermediate stage in convective growth, and associated effects, e.g. moistening of the free troposphere (Guichard et al. 2004)
- Similar to Zhang and Klein (2010) [Z&K], determine atmospheric conditions that favor different convective regimes (i.e. those that transition to deep vs. those that don’t)

2. DIURNAL CYCLE – CLOUDS and PRECIP

- Increased low clouds at 15-18 UTC.
- Upper-level clouds (and rainfall) increase from 15-18-21UTC.
- Clouds throughout column.
- Much less low clouds at 24-3 UTC.
- Still prevalent upper-level clouds, but decreasing.
- Little precipitation.

3. TRANSITION VS. NON-TRANSITION CLASSIFICATION

How? - Visual inspection of WACR time-height cross sections

Transition cases (Z&K - late afternoon deep convection):
- Shallow clouds < 5 km thick transition to deep clouds > 8 km thick with cloud bases in the BL (lowest 1-2 km)
- No cloud > 8 km thick occur after 3 UTC and prior to the transition
- Transition occurs before sunset

Non-transition cases (Z&K - fair-weather shallow cumulus):
- Low clouds < 5 km in thickness with some clouds > 2 km thickness
- Clouds persist between sunrise and sunset
- No clouds > 5 km thickness occur within observation area
- Non-transition cases verified using satellite observations

4. COMPOSITED CLOUD OCCURRENCE

Question? How do environmental factors differ between these two classes?

5. COMPOSITE DIURNAL CYCLE – SURFACE FLUXES (Transition / No Transition)

- Differing regimes impact surface fluxes.
- SH/LH fluxes are in phase with downwelling shortwave fluxes.
- Transition days have smaller SW, SH and LH fluxes at the surface.
- Differences due to cloud forcing and low-level humidity

6. COMPOSITE DIURNAL CYCLE – SURFACE METEOROLOGY

- Pre-sunrise T. & nearly identical for two regimes (“No-transition” slightly moister, higher LCL).
- “No-transition” surface warmer and drier during day (consistent with response to increased SW flux).

7. DIURNAL COMPOSITES – PWV and LWP

- LWP confirms regime classifications.
- Larger pre-sunrise LWP in “transition” cases.
- Significantly more column moisture over entire day for transition cases.

8. SAM RESULTS 6 JUNE 2014

- ‘Best estimate’ transition is too shallow compared to observations.
- ‘Best estimate’ initial state
- Removing freezing level stable layer permits growth to deeper convection.
- Both simulations produce observed mid-level cloud signal.
- Next steps include examining the evolution of the moisture profile.

9. CONCLUSIONS

- Diurnal cycle similar to that observed in OK, i.e., afternoon precipitation and deep convection.
- Transitions to deep clouds occur on days with pre-sunrise cloudiness and larger mid-level humidity.
- This is consistent to what was observed in OK.

10. FUTURE WORK

- Additional variables (e.g. PBL height, wind shear).
- Variability of large-scale forcing.
- Influence of sea and river breeze forcing.
- Additional LES/CRM model simulations.

REFERENCES


