The Shallow-to-Deep Transition in Convective Clouds During GOAmazon 2014/5

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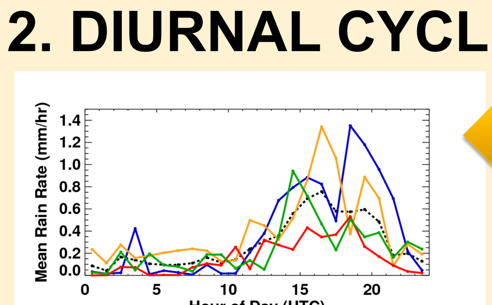
ABSTRACT

The lifecycle of convective clouds, particularly the transition from shallow to deep convection and the environmental controls of this transition, are poorly understood and not represented well in climate model simulations. Nearly two years of observations from the ARM Mobile Facility (AMF) taken during GOAmazon 2014/5 campaign (Martin et al. 2015) are analyzed in order to investigate the environmental conditions controlling the transition from shallow to deep convective clouds. The ARSCL value-added data product is used to qualitatively define two subsets of convective clouds: 1) Transition cases, where a period of shallow convective clouds is followed by a period of deep convective clouds and 2) Non-transition cases, where shallow convective clouds persist without any subsequent deeper development. For these two subsets, observations of the time varying thermodynamic properties of the atmosphere, including surface heat and radiative fluxes, and profiles of atmospheric state variables, are composited to define averaged properties for each transition state. Initial analysis indicates that the presence of a transition depends strongly on the pre-dawn mid-level humidity, convective inhibition, and surface temperature and humidity with little dependence on the convective available potential temperature and surface heat fluxes.

1. MOTIVATION

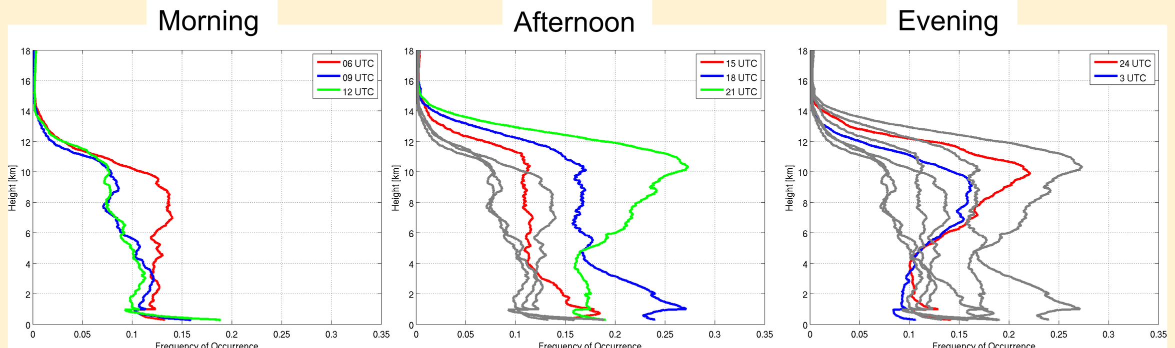
- Climate models do not get timing of rainfall peak over land correct (Dai et al. 1999; Yang and Slingo 2001)
- Lack of intermediate stage in convective growth, and associated effects, e.g. moistening of the free troposphere (Guichard et al. 2004)
- Similar to Zhang and Klein (2010) [Z&K], determine 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



Mean Rain Rate from disdrometer observations

Cloud Frequency of Occurrence from WACR-ARSCL



- Low cloud fractions throughout column.
- Little rainfall.

- Increased low clouds at 15-18 UTC.
- Upper level clouds (and rainfall) increase from 15-18-21UTC.
- Clouds throughout column.

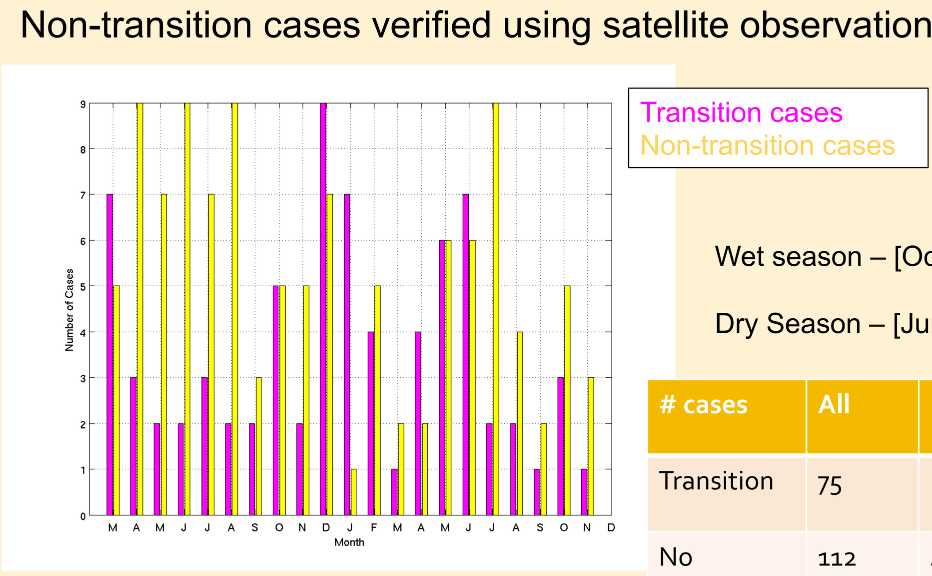
- Much less low clouds at 24,3 UTC.
- Still significant upper level clouds, but decreasing.
- Little precipitation.

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

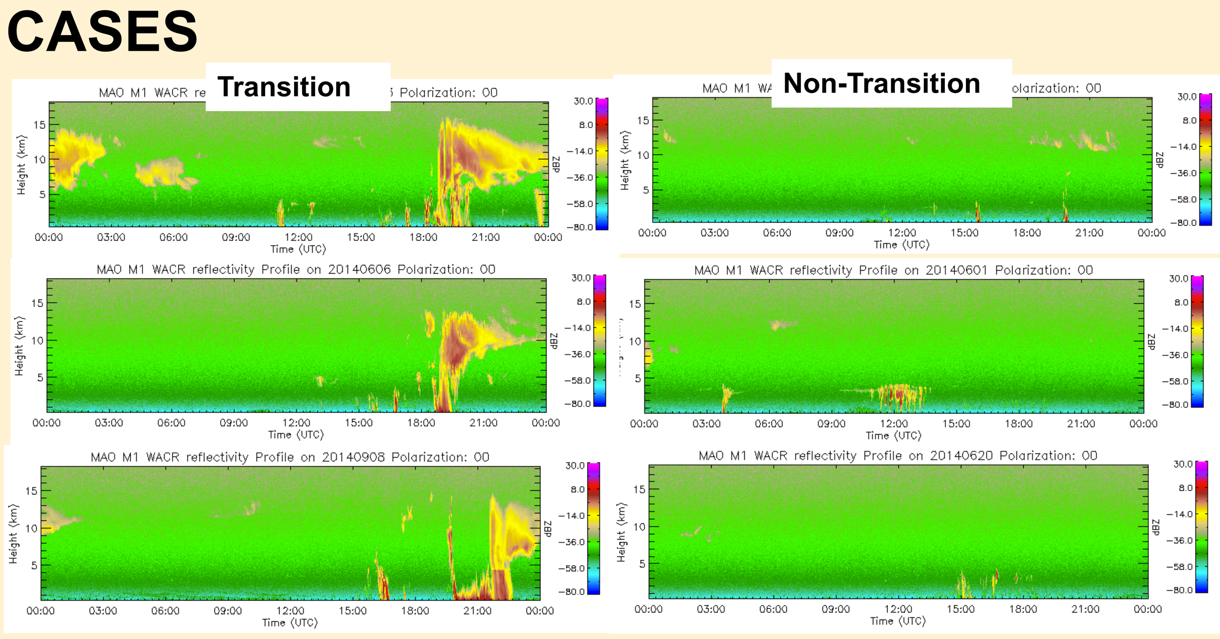


Wet season – [October – May]

Dry Season – [June – September]

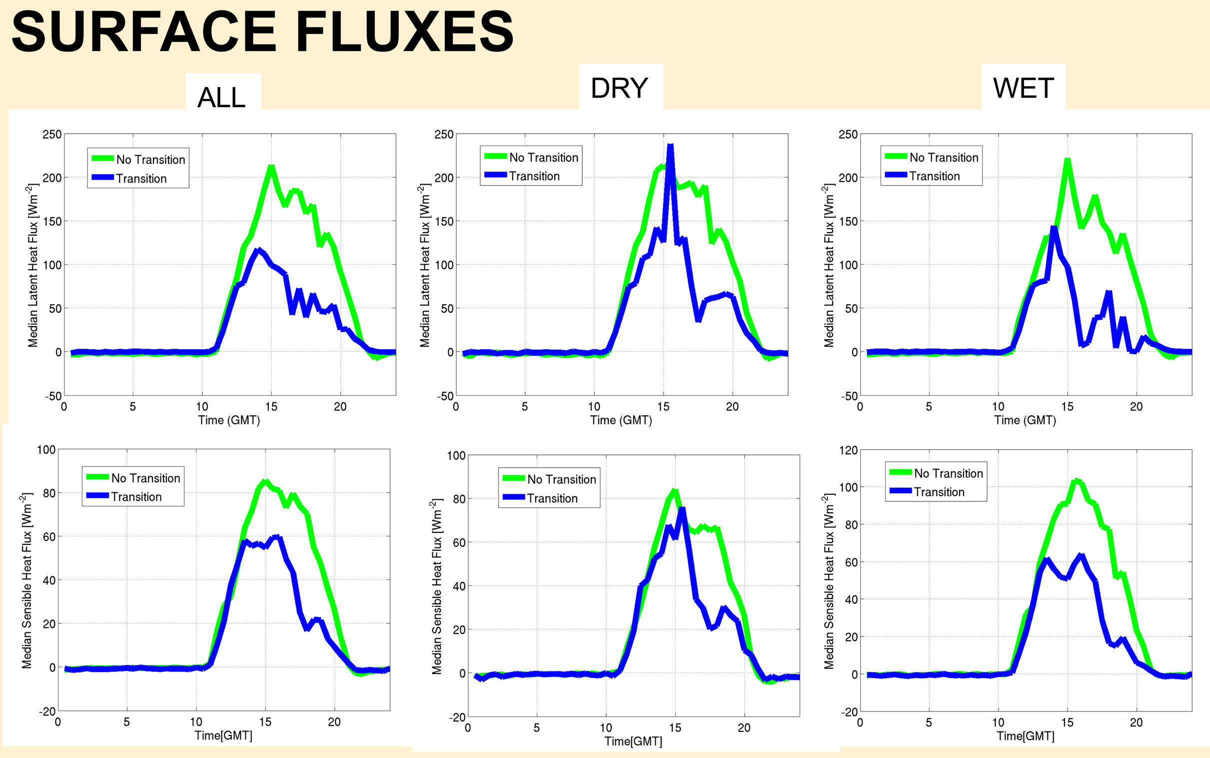
# cases	All	Dry	Wet
Transition	75	21	54
No Transition	112	49	63

4. TRANSITION VS. NON-TRANSITION CASES



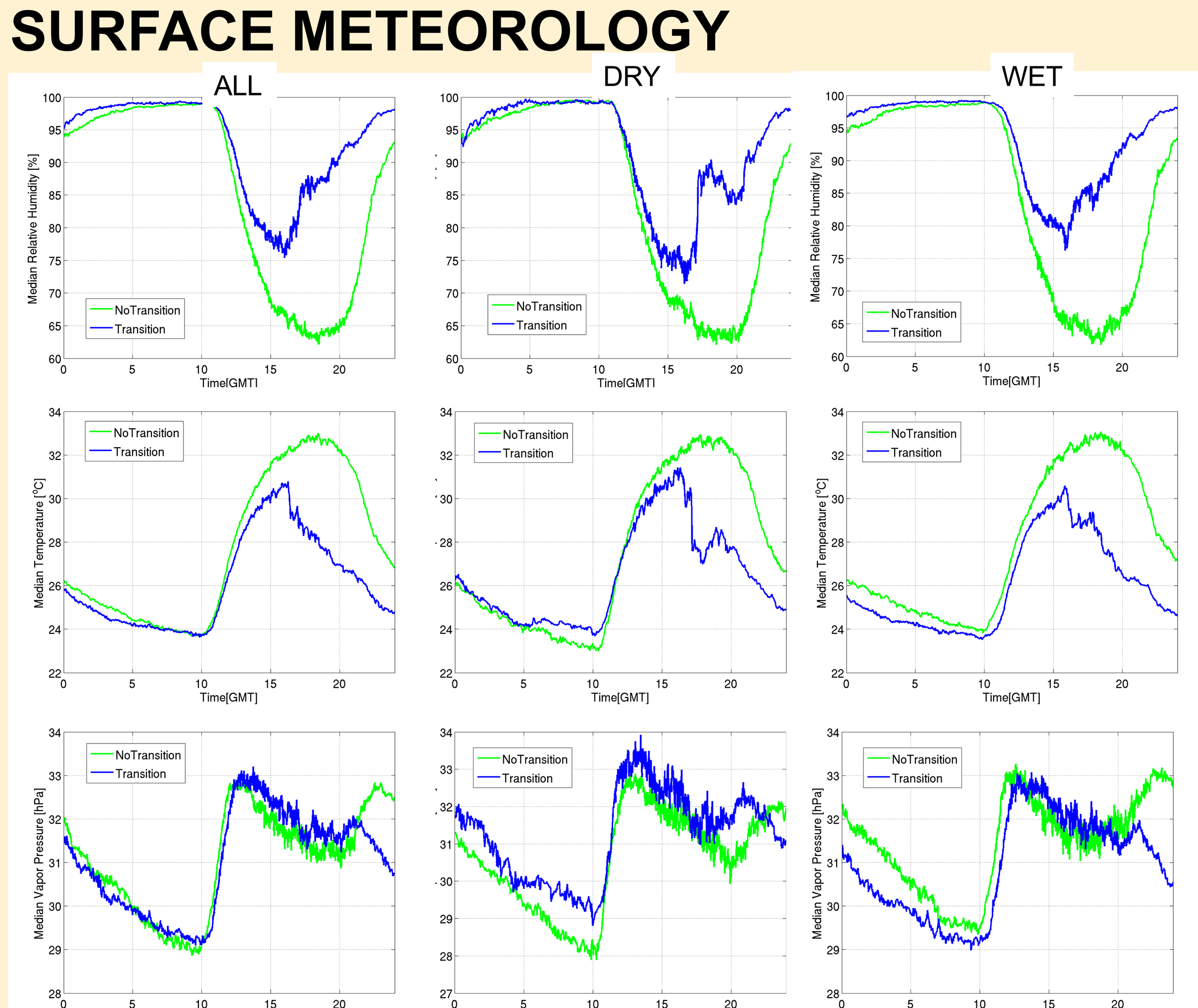
Question? How do environmental factors differ between these two classes?

5. COMPOSITE DIURNAL CYCLE – SURFACE FLUXES



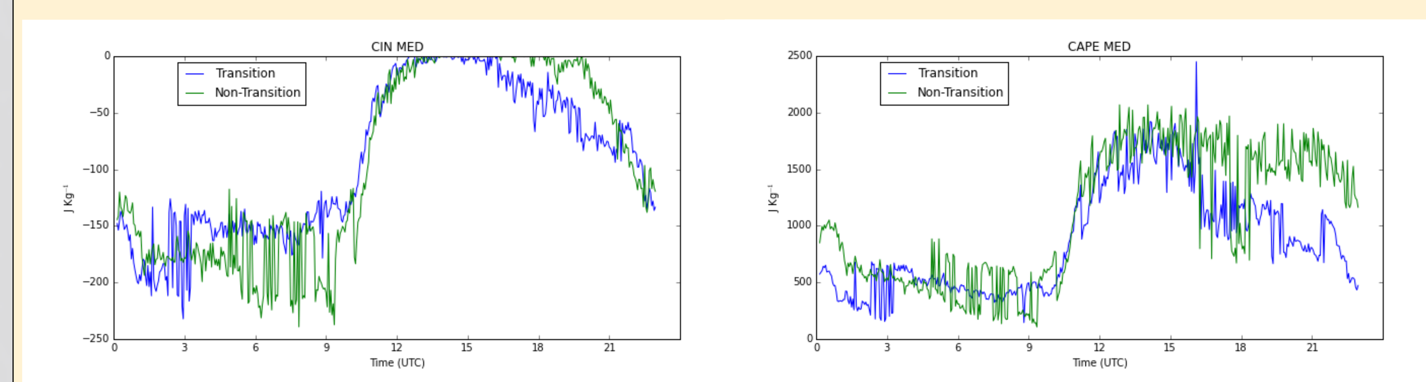
- Differing regimes impact surface fluxes.
- SH/LH fluxes are in phase with the downwelling shortwave fluxes.
- Transition days have smaller SW, SH and LH fluxes at the surface.
- Differences due to cloud forcing and low-level humidity

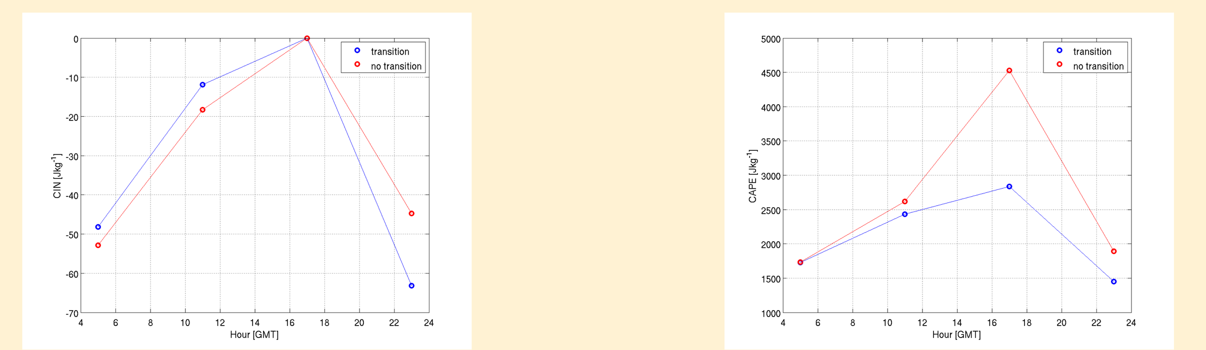
6. COMPOSITE DIURNAL CYCLE – SURFACE METEOROLOGY



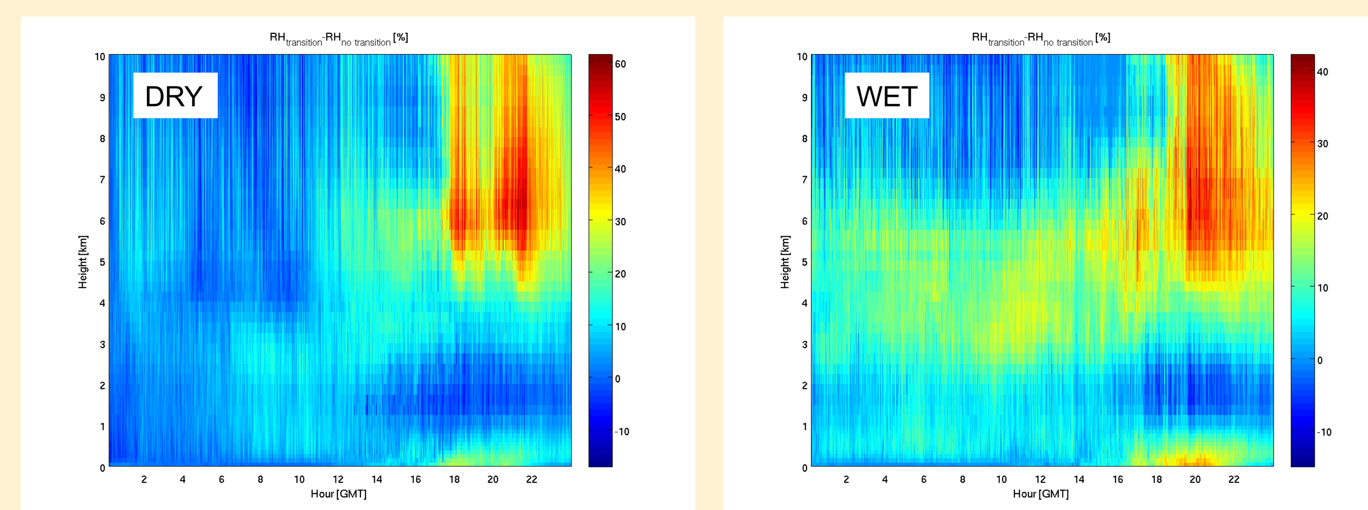
- Pre-sunrise – Non-transition cooler and drier during the dry season, warmer and moister during the wet season.
- After 12 UTC more surface warming and drying during non-transition compared to transition.

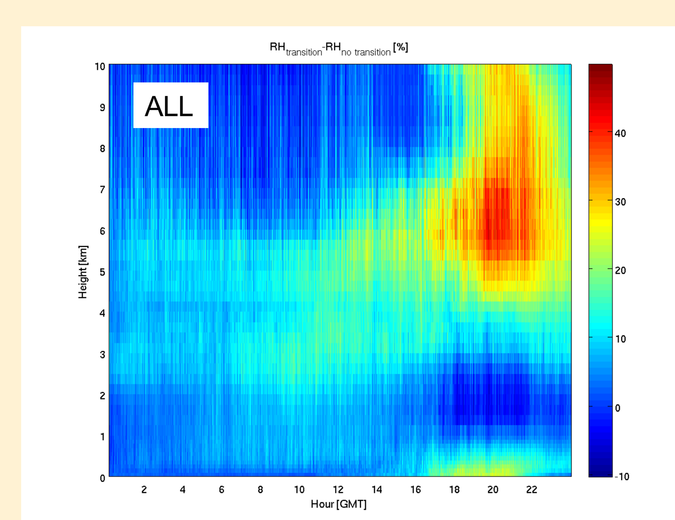
7. DIURNAL CYCLE – THERMODYNAMICS





- Pre-sunrise – Larger (more negative) CIN for non-transition case, similar CAPE. [Higher LFC for non-transition]
- Smaller (less negative), similar CIN and larger similar CAPE after sunrise.
- Transition cases "use" CAPE





* Difference in composite diurnal cycle of the relative humidity profile (as retrieved from the profiling microwave radiometer) between cases with a deep-to-shallow transition and those with no transition.

- Pre-sunrise – Higher RH above boundary layer for transition cases, especially in wet season.
- Surface humidity greater for transitioning cases also (consistent with surface meteorology measurements).

7. CONCLUSIONS

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

8. FUTURE WORK

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

9. REFERENCES

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