The Role of Intraseasonal Variability in Supporting the Shallow-to-Deep Transition in the Amazon

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Abstract

The suite of observations from GOAmazon and CHUVA offers a unique opportunity to examine land-based convective processes in the tropics, including the poorly represented shallow-to-deep transition. Several studies have begun to address this issue by distinguishing days when shallow clouds transition to deep convection from those that do not. This study builds on that framework by investigating how the shallow-to-deep transition of convection differs by season and through large-scale and local circulations. In this initial stage of the analysis, we highlight the diurnal cycle in key variables and discuss how they differ between the wet and dry season and in the presence of intraseasonal Kelvin wave activity. Future work will further explore conditions affecting the transition to deep convection as well as how well they are represented in both global and regional model simulations of differing resolution and convective parameterizations.

Research Questions:

1) How does the diurnal cycle in convection vary with season in the Central Amazon?

2) What was the Kelvin wave activity over the Central Amazon in 2014 and 2015?

3) Did this activity favor particular convective classes / organization?

Seasonal Analysis:

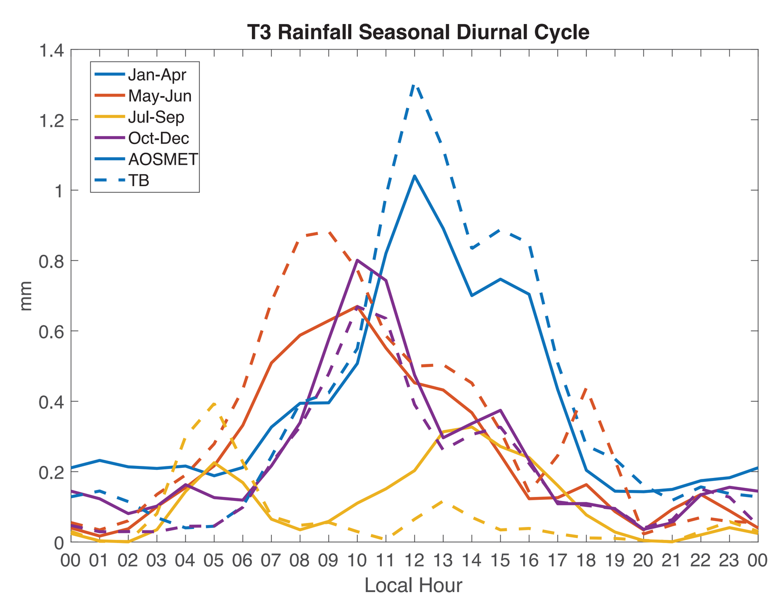

Figure 3. The modulation of the diurnal cycle in rainfall by season at the GOAmazon site for 2014-15.

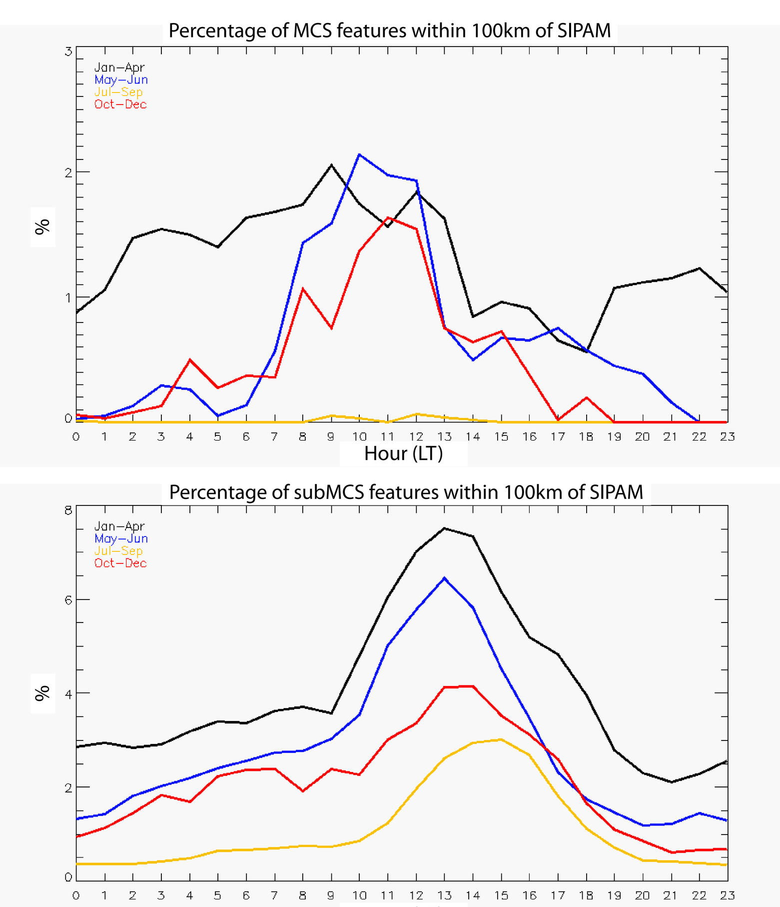

Figure 4. The percent of rainy features (>20dBZ) within 100 km of SIPAM (includes T3) classified as (top) MCS and (bottom) sub-MCS.

The Diurnal Cycle (Figs. 3&4)

- The diurnal cycle in rainfall at T3 suggests a midday peak is common in both the wet (Jan-Apr) and dry (Jul-Sep) seasons. The dry season also has an early morning peak comparable in magnitude to the wet season nighttime to early morning rainfall.
- The wet season peak rainfall is earlier than that for the dry season by about 1 hour (12 LT vs. 13 LT, respectively).
- The transition seasons (May-Jun, Oct-Dec) both have peak rainfall between 09-10 LT, suggesting something other than locally forced convection driven by surface heating dominates the diurnal cycle in rainfall during these seasons.
- The SIPAM radar suggests MCSs dominate the wet season rainfall throughout the night and into the early afternoon. These systems contribute to the earlier peak in rainfall during the wet season seen at T3.
- Sub-MCS scale convection dominates the midday rainy features in the SIPAM during all seasons, consistent with locally forced convection driven by surface heating.
- The SIPAM radar suggests the transition seasons are dominated by mid-morning MCSs. Future work will investigate the timing and origin of these MCSs over the region.

These results highlight how different convective classes (MCS vs non-MCS) vary by season. They also illustrate how the diurnal cycle in rainfall is modified by the level of convective organization.

Atmospheric Moisture (Figs 5&6)

- The GPS PWV at GOAM (approximately 1 km south of T3) compares well with the MWR PWV in terms of the observed variance and seasonal cycle over the GOAmazon period.
- The GPS has consistently lower values of PWV than those obtained from the MWR. PWV from the T3 radiosonde as well as other GPS sites will be examined to understand this discrepency.
- The higher PWV during the wet season is seen to be the result of both higher boundary layer moisture, as well as mid-tropospheric moisture, with a very dry mid-troposphere seen midday for the dry season.

Combining the vertical information from the MWRP with the all-weather capabilities of the GPS and its spatially distributed sites, we aim to better understand the role of water vapor in the transition to deep convection and its sources.

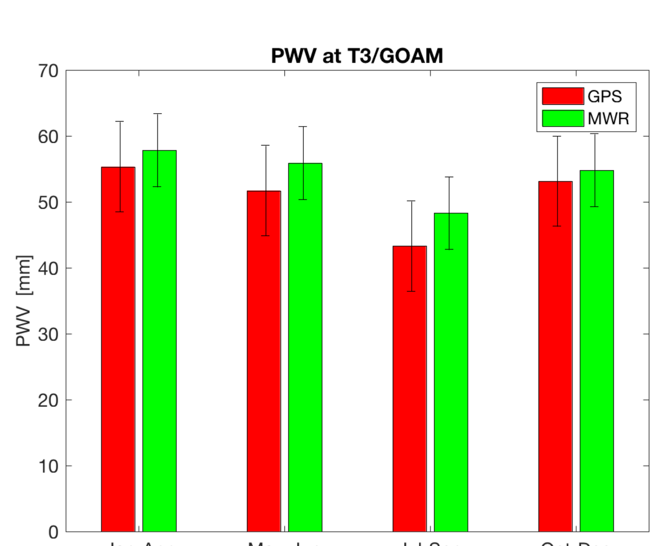

Figure 5. The seasonal cycle in PWV at GOAM/T3 sites.

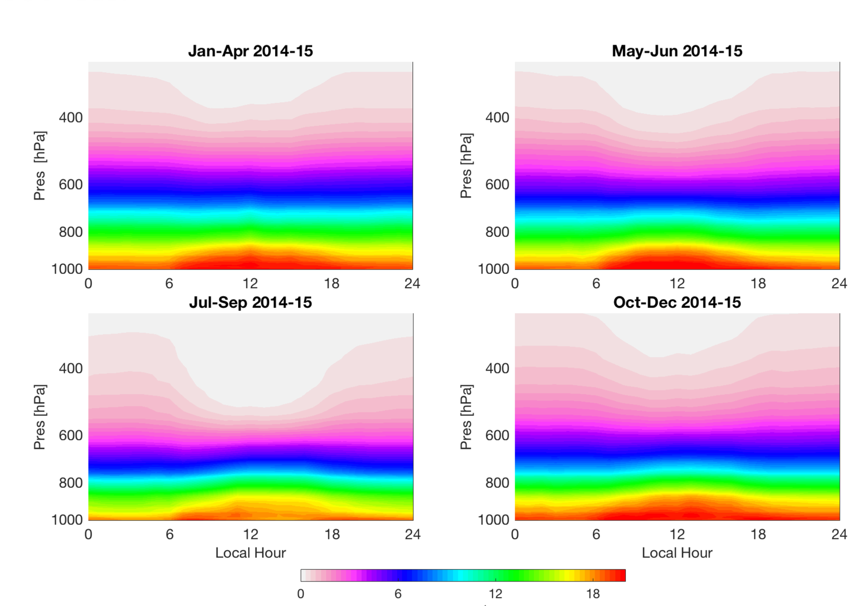

Figure 6. The seasonal cycle in q as a function of height at T3 from the MWRP.

Acknowledgements:

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Data and Methods:

This study uses observations from the DOE AMF site (T3), as well as PWV (total column precipitable water vapor) and surface meteorology from a dense GNSS network within 50 km of Manacapuru (Figure 1, Table 1). A feature-based identification algorithm with a 20 dBZ threshold was applied to SIPAM to determine subMCS and MCS using a 100-km major axis threshold.

We also make use of 2xdaily NOAA OLR at 2.5° resolution provided by NOAA/PSD from 1980-2015. Kelvin wave activity is isolated using a space-time filter following the methods of Wheeler and Kiladis (1999). In situ data are then composited by periods of suppressed (*olra* ≥ +1.5σ), active (*olra* ≤ -1.5σ) and neutral (-1.5σ < *olra* < +1.5σ) wave actvity, where *olra* are the filtered OLR anomalies.

Table 1. A list of data from the DOE ARM mobile facility (AMF) and CHUVA and GNSS sites used for this study. The DOE AMF facility was deployed from 15 January 2014 - 31 December 2015.

Sites	Instruments	Measurement
DOE AMF / CHUVA-T3	Surface Meteorological Station (AOSMET)	Surface precipitation (AOS)
	Profiling Microwave Radiometer (MWRP)	Vertical profiles of humidity
	Microwave Radiometer (MWR)	Column integrated water vapor
	Rain gauge (tipping bucket)	Surface precipitation (TB)
	W-Band Radar (WACR)	Cloud fraction value added product which also relies on the MPL and ceilometer at T3.
GNSS – GOAM	GPS-MET	Column precipitable water
Manaus	S-band Doppler Radar (SIPAM)	Rain area and MCS identification

Figure 1. Map of study region and GNSS network (red), CHUVA Project sites (cyan) and INPE Embrapa site (blue). DOE AMF site is CHUVA-T3.

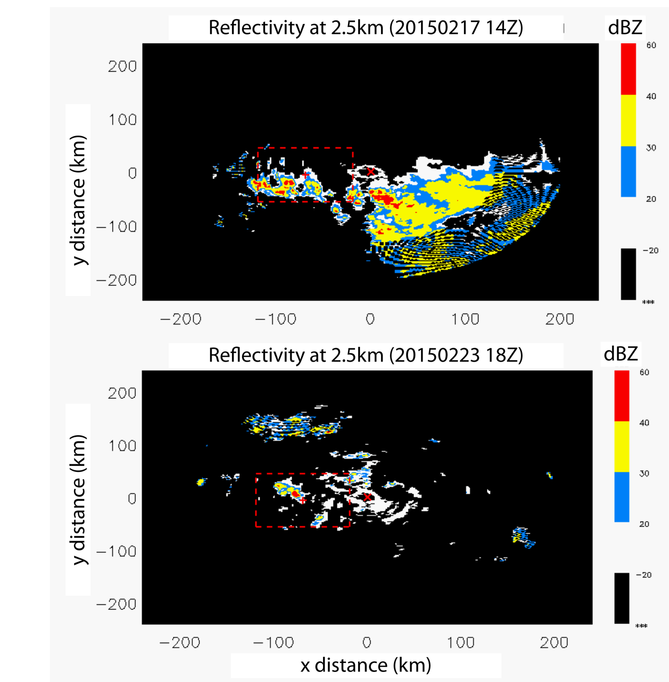

Figure 2. Examples of the 20 dBZ threshold applied to the SIPAM CAPPI at 2.5 km. Also shown is a 50 km box around T3 used for more focused comparisons with the in situ data at this site.

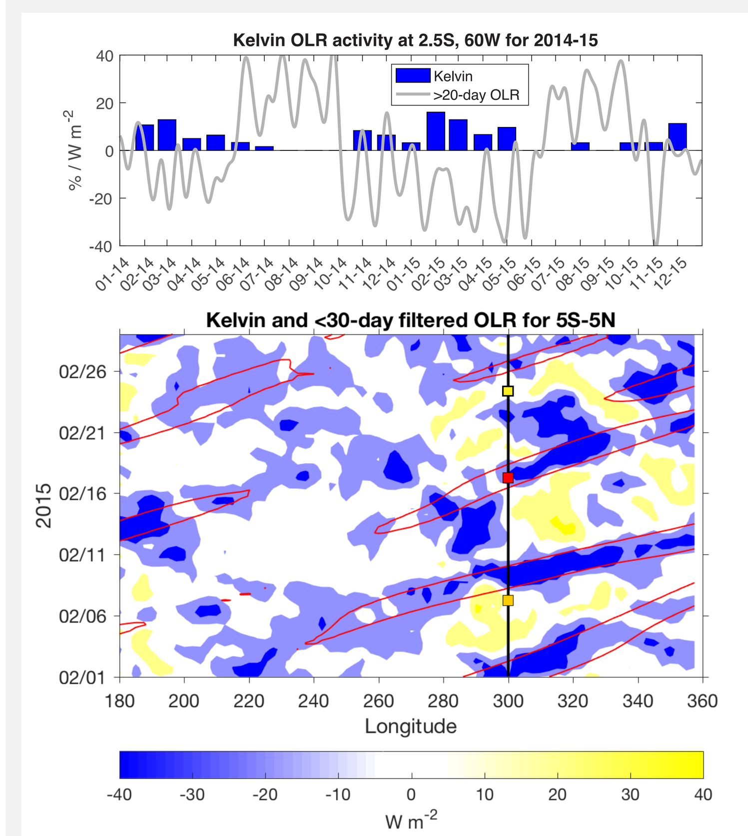

Figure 7. (Top) The >20-day OLR anomalies at 2.5°S, 60°W along with the percent of time within the month Kelvin OLR anomalies are below -1.5σ for the wave filtered OLR. (Bottom) Time-longitude plot of <30-day OLR anomalies and wave filtered OLR averaged from 5°S to 5°N for February 2015.

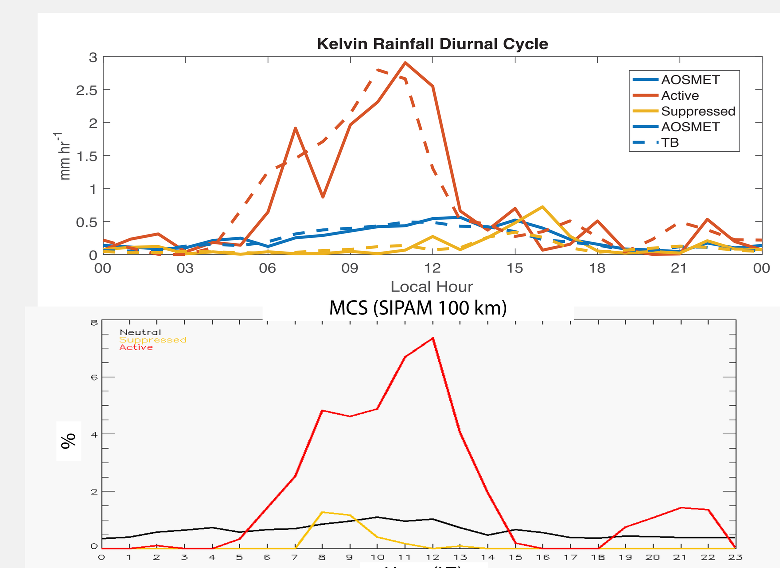

Figure 8. The modulation of the diurnal cycle in (top) rainfall and (bottom) MCS coverage by Kelvin waves.

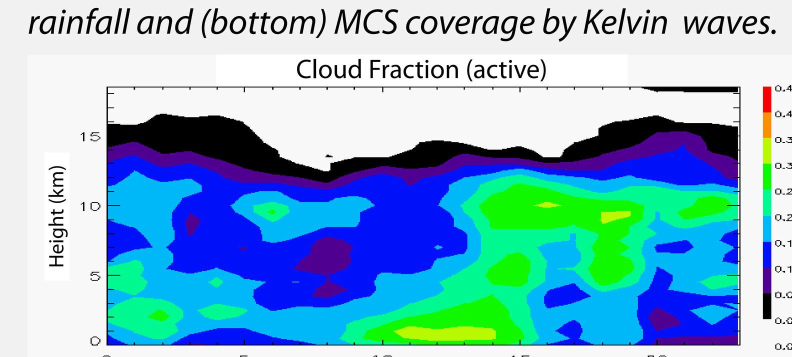

Figure 9. The diurnal cycle in cloud fraction for the active phase of the Kelvin wave.

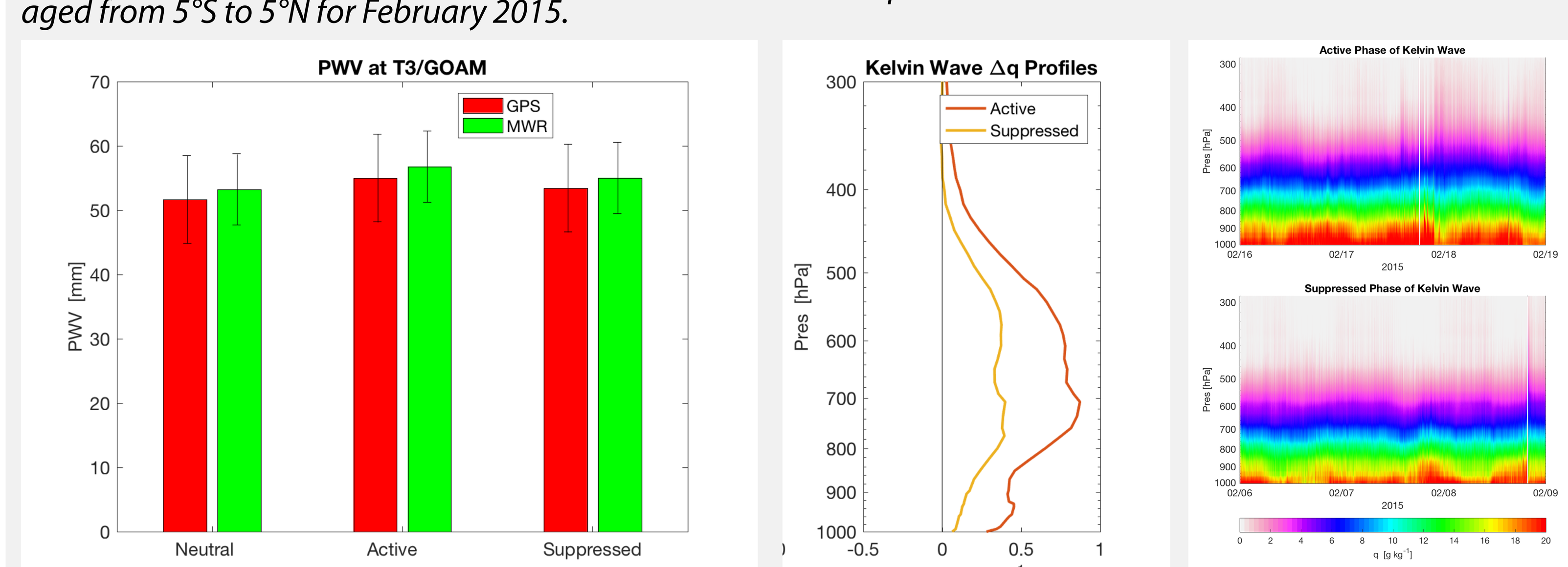

Figure 10. (left) PWV at T3/GOAM for the different phases of the Kelvin wave. (middle) Difference in q profiles for Active - Neutral and Suppressed - Neutral from MWRP. (right) Case study of q profiles for active and suppressed.

Kelvin Wave Activity:

Seasonality (Fig. 7)

- The >20-day OLR anomalies highlight the wet (Jan-Apr) and dry (Jul-Sep) seasons over the Central Amazon, however intraseasonal variability is observed throughout the year over the GOAmazon region.
- Kelvin waves are most active during the wet season, with little to no activity during the dry season.
- Kelvin waves generally originate over the central or eastern equatorial Pacific, however a few waves originate over South America.

The Diurnal Cycle (Figs. 8&9)

- The diurnal cycle in rainfall for the active phase of the Kelvin wave is similar to that of the transition season, with a peak in late morning to midday (09-12 LT).
- The diurnal peak in T3 rainfall is aligned well with the peak in MCS activity seen over the region as a whole during the active phase.
- The WACR cloud fraction suggests cloud top heights rise following the peak in rainfall and MCS activity, indicating spreading cirrus from this activity. Early morning low level clouds are also seen prior to the onset of heavy rain.

Atmospheric Moisture (Fig. 10)

- The active Kelvin wave period does not show significant differences in PWV in the GPS or MWR, however the q profiles for the active phase suggest a moister troposphere at all levels compared to the suppressed phase.
- Both the active and suppressed phases are moister than the neutral phase, which tends to occur during the dry season (Fig. 7).

Kelvin waves are an example of large-scale forcing over the Central Amazon that impact the occurence of organized deep convection through their impact on the environment. Here we have shown their impact on the vertical distribution of moisture. Future work will investigate other factors that might contribute to the observed increase in MCSs over the region during the active phase of the wave.

We anticipate that the degree of large-scale forcing will also play a role in how well models capture the transition to deep convection and thus this work will better inform our model evaluation studies.