On The Sensitivity of the Diurnal Cycle in the Amazon to Convective Intensity

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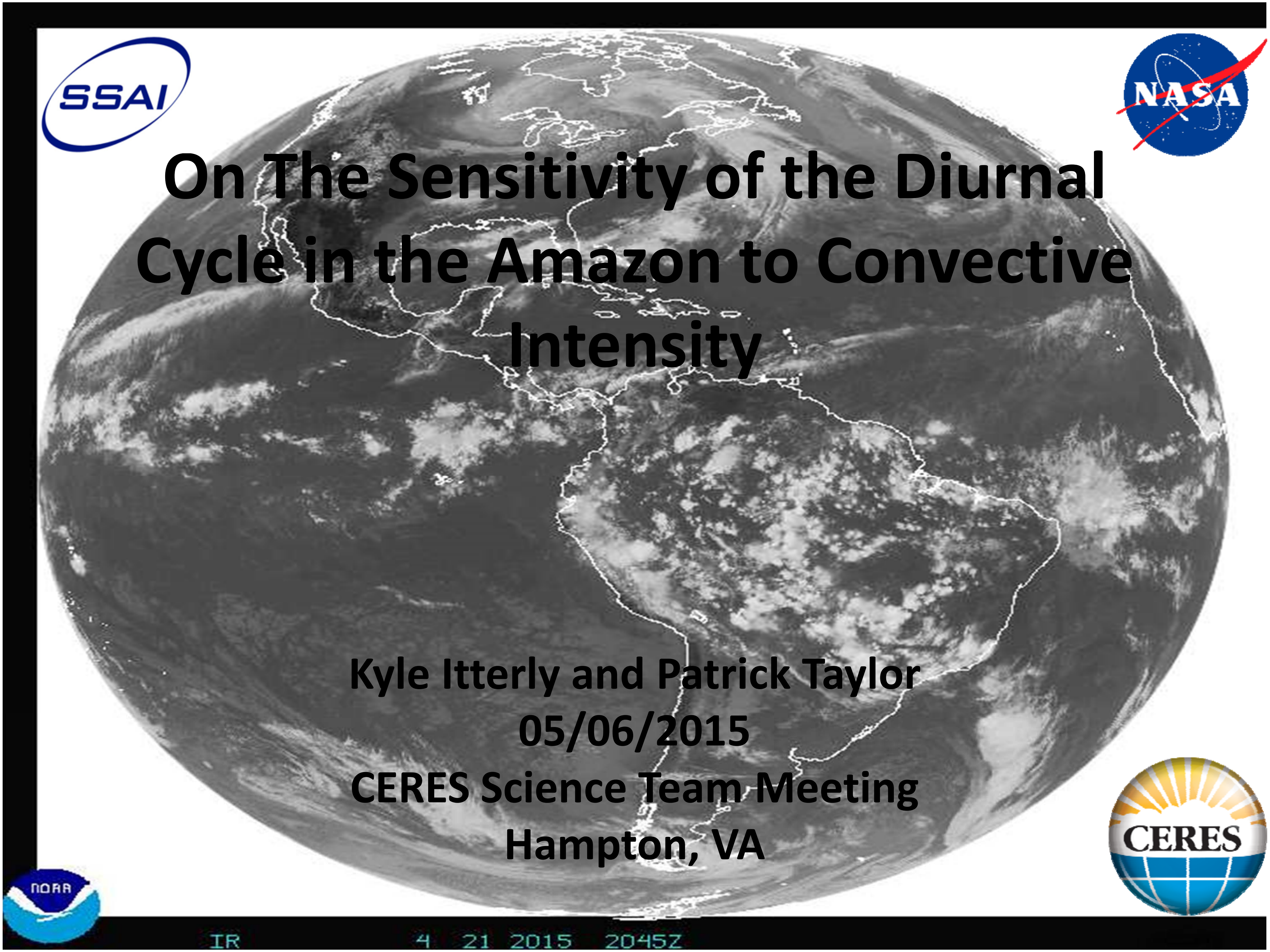
05/06/2015

CERES Science Team Meeting

Hampton, VA



Data/Methodology

- Collocate daily, 3-hourly **CERES SYN1DEG** and 3-hourly 0.25x0.25° **TRMM 3B42** observations with data from 5 **radiosonde** stations in the Amazon with valid data from 2002-2012.

- Apply compositing techniques to explore atmospheric physics for different convective regimes, seasons and stations.

- "brute force" the impact of the diurnal cycle on a daily level by relating diurnal cycle statistics to convective parameters.
  - **Diurnal statistics** include: phase, amplitude, duration of precip, onset time of precip, diurnal mean
  - **Convective Parameters** include: LCL, LFC, EL, CAPE, CIN, upper and lower tropospheric humidity (UTH and LTH), lower tropospheric stability (LTS), LTS equivalent, Buoyant Condensation Level Height, TDEF (potential temperature deficit for buoyancy), lower tropospheric lapse rate, maximum lower tropospheric wind speed and direction (low level jet), K-index, Cap Strength, and many others analyzed.

IGRA Radiosonde Data

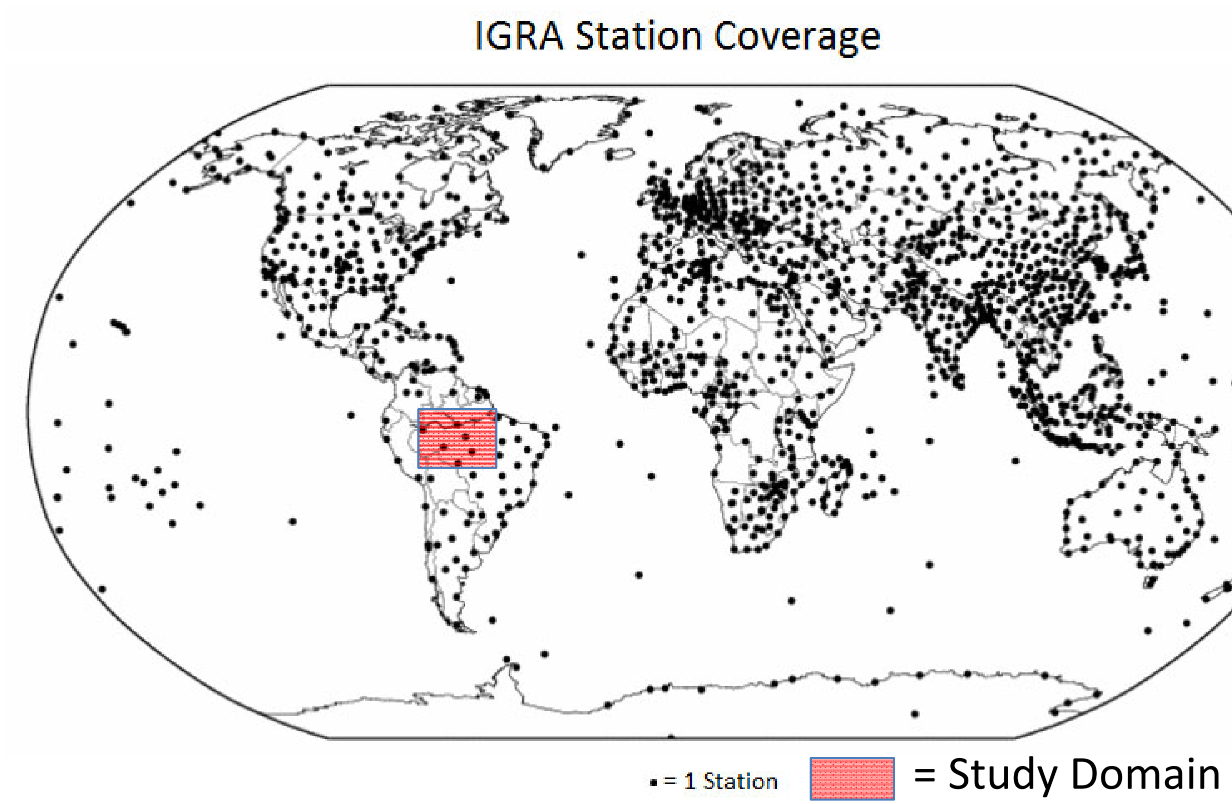
- http://www.ncdc.noaa.gov/data-access/weather-balloon/integrated-global-radiosonde-archive

Problem:

Only 5 valid RAOB stations in study domain with spotty temporal coverage.

Solution:

Use 12 years of daily data to lessen concerns of statistical significance.



Convective Intensity Classification

- **Average valid days of radiosonde data together into bins of convective intensity.**
- Also used **percentile** and standard deviation bins (for model evaluation, next)

Daily Minimum CERES OLR bins:

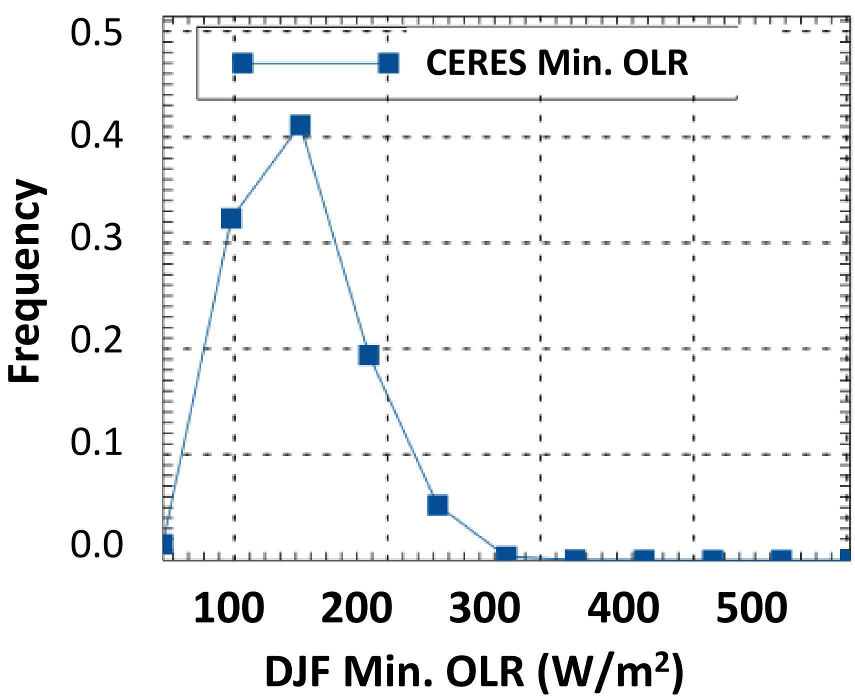
[*Very Conv., Mod. Conv., Low Conv., Neutral, Stable, All*]

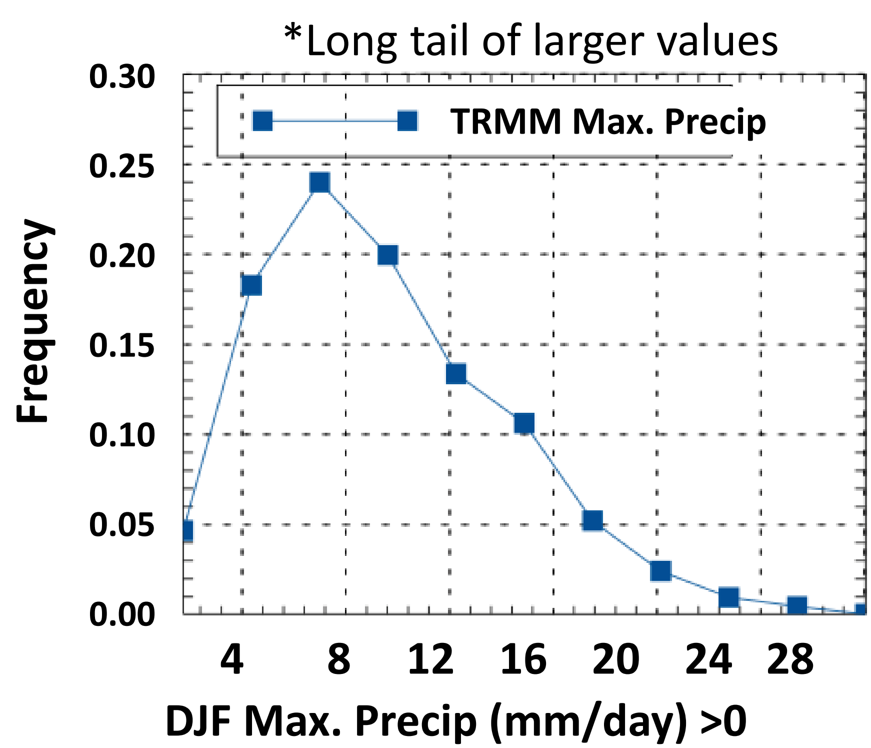
[<150, 150-175, 175-200, 200-225, >225, All] *Units: W/m²*

Daily Maximum TRMM Precipitation bins:

[*Very Conv., Mod. Conv., Low Conv., Neutral, Stable, All*]

[>50, 25-50, 10-25, 1-10, 0-1, All] *Units: mm/day*





Methodology

- Explore the sensitivity of the TOA flux/precipitation diurnal cycle to convective intensity in one of the most diurnally-forced convective regions in the world.
- Briefly discuss local topography, seasonality and specific features of convection in the Amazon.
- Correlate 3-hourly diurnal cycle statistics from TRMM/CERES with convective parameters at 12z and 00z.
  - 12z = preconvection, 00z = post convection
  - Future: Apply similar analysis to models to validate their physics, and to other regions with better radiosonde data.

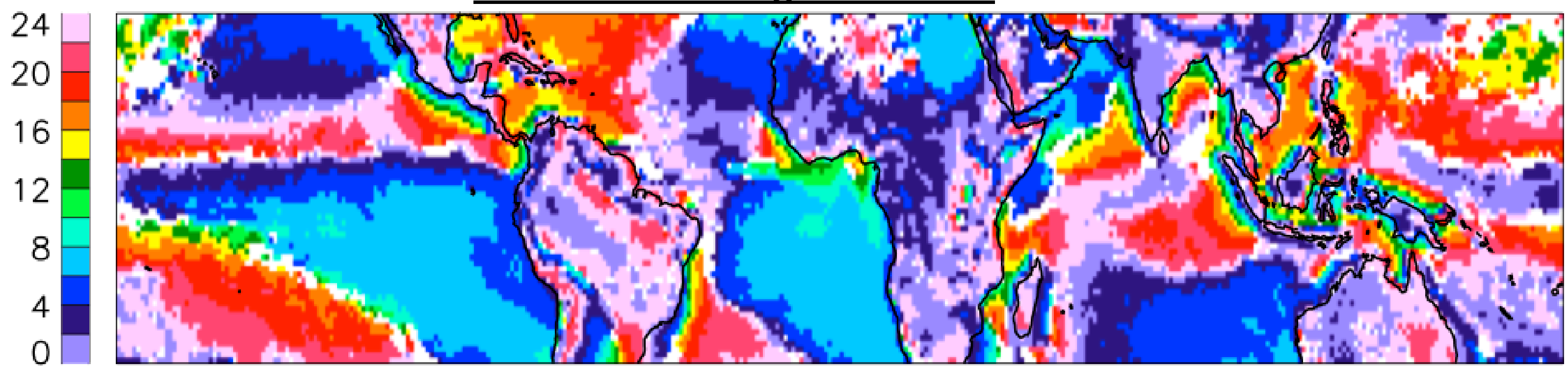
CERES 2002-2012 Diurnal Climatology

- LWCF Amp and Phase Calculated with Fourier harmonics

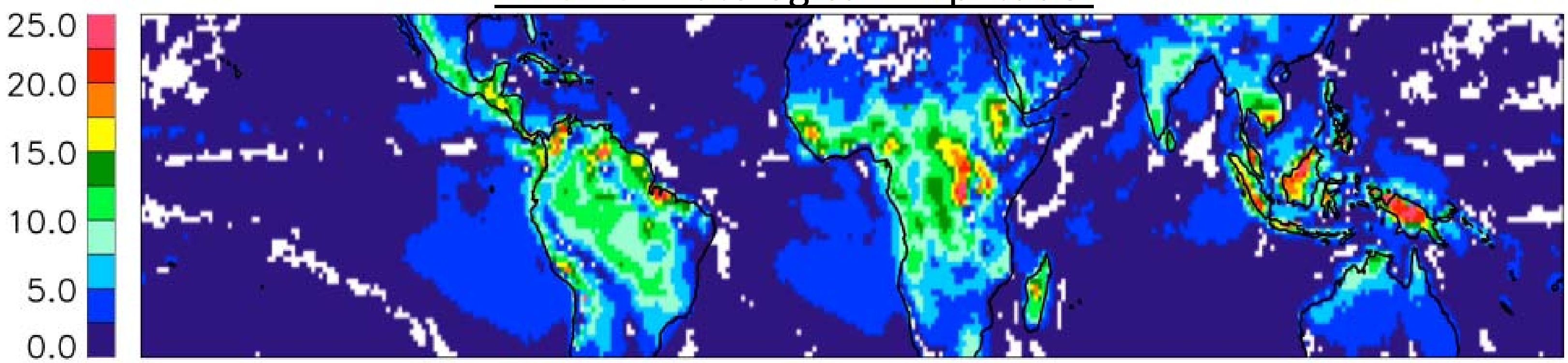
- Harmonic fit below 90% confidence (F-test) in white.

- SWCF DC impact uses albedo directional model to separate diurnal component of albedo (all-sky and clear-sky).

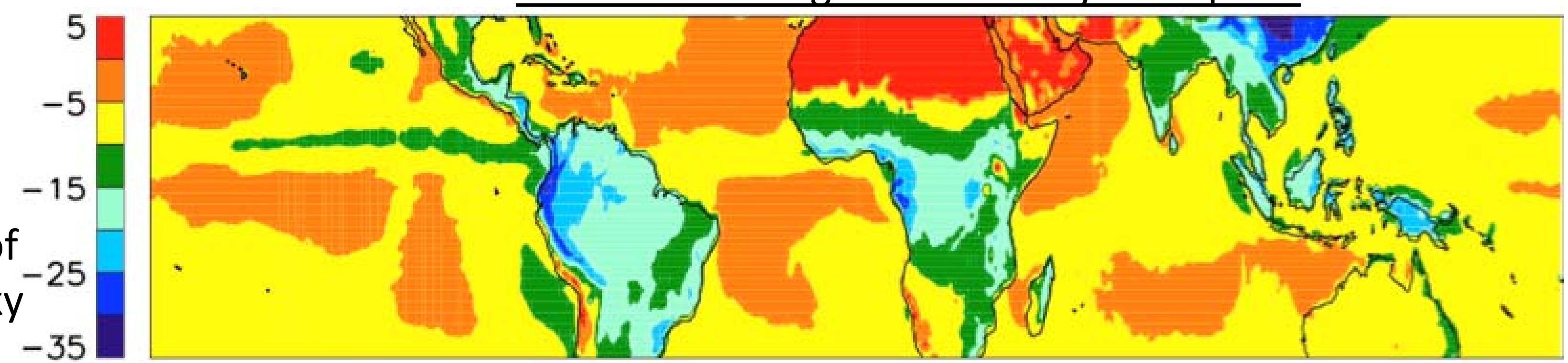
LWCF Climatological Phase:



LWCF Climatological Amplitude:



SWCF Climatological Diurnal Cycle Impact:

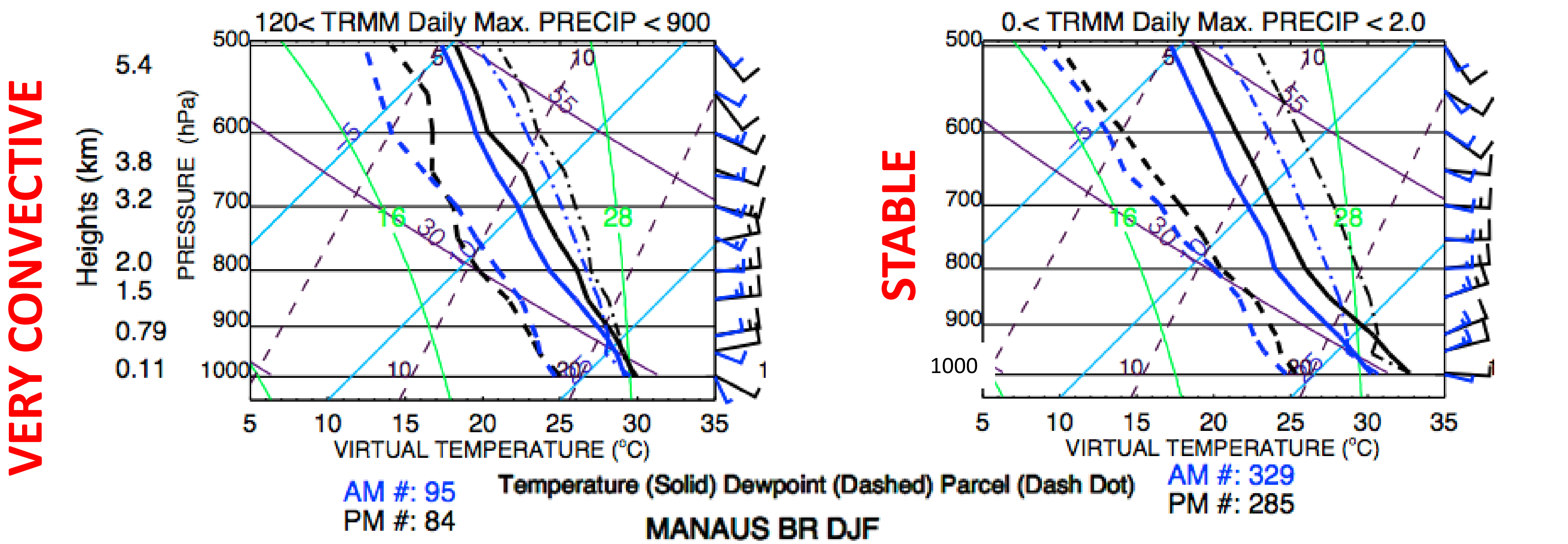


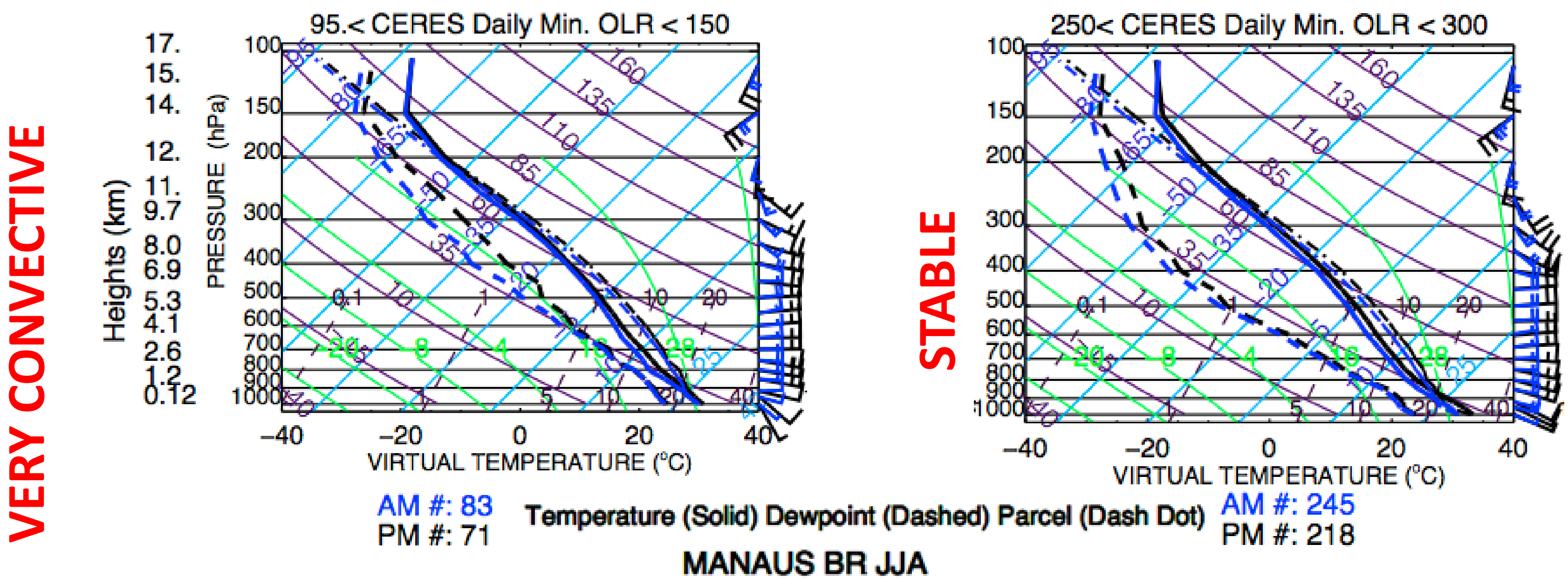
(largest climatological features only)

(Itterly and Taylor, 2014)

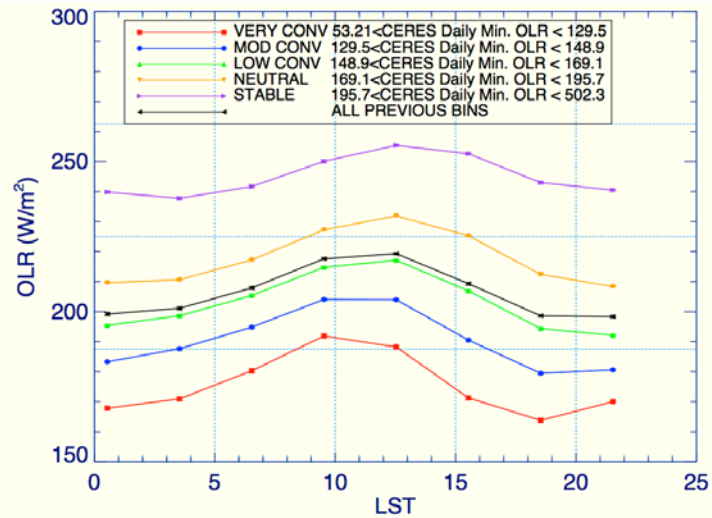
Taking a closer look…

Black(00Z) / Blue(12Z)



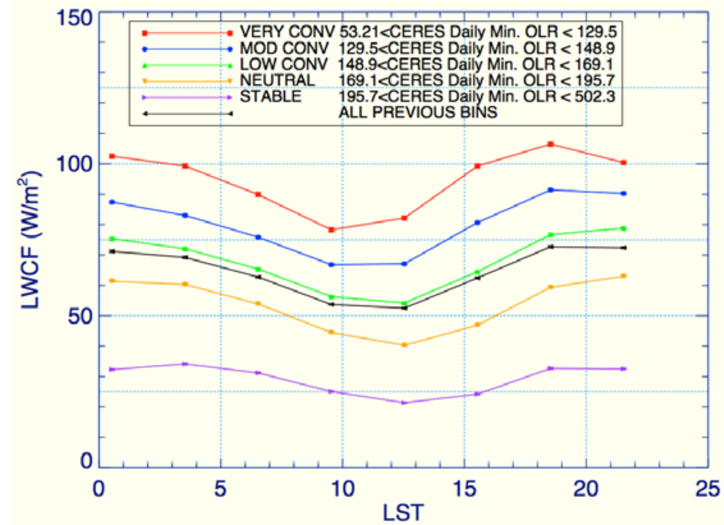


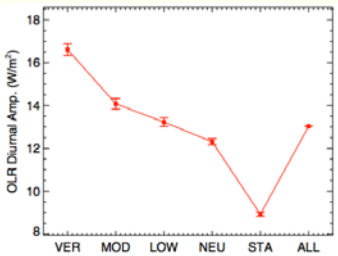
Diurnal Cycle Characteristics by Regime of Convective Intensity

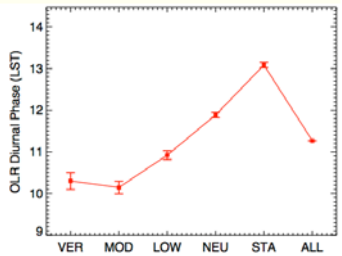


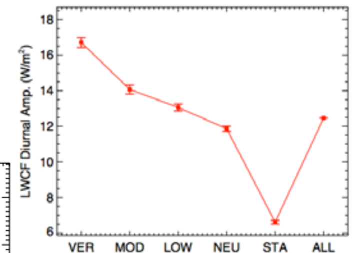
•OLR Phase ~3 hours earlier on convective days vs. stable days.

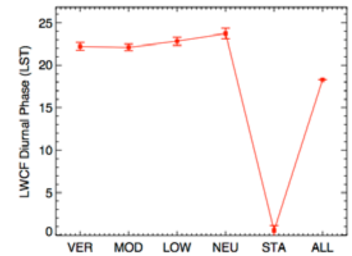
•LWCF Phase lags precip, ~3 hours later on stable days

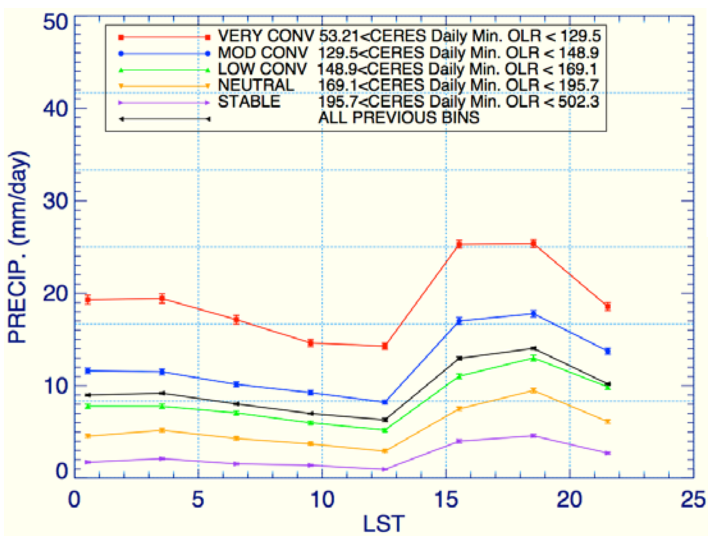


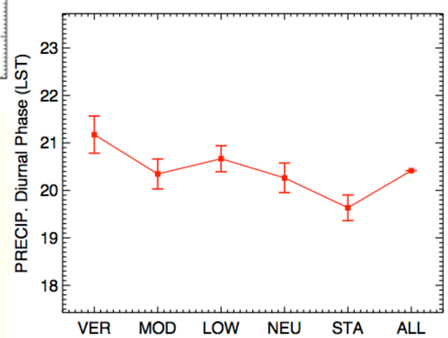


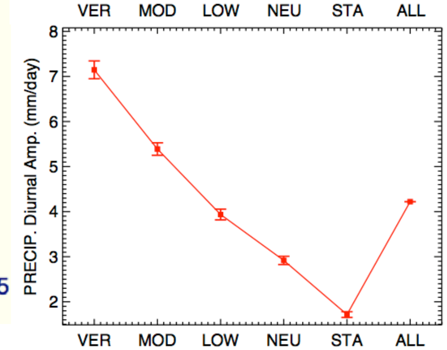












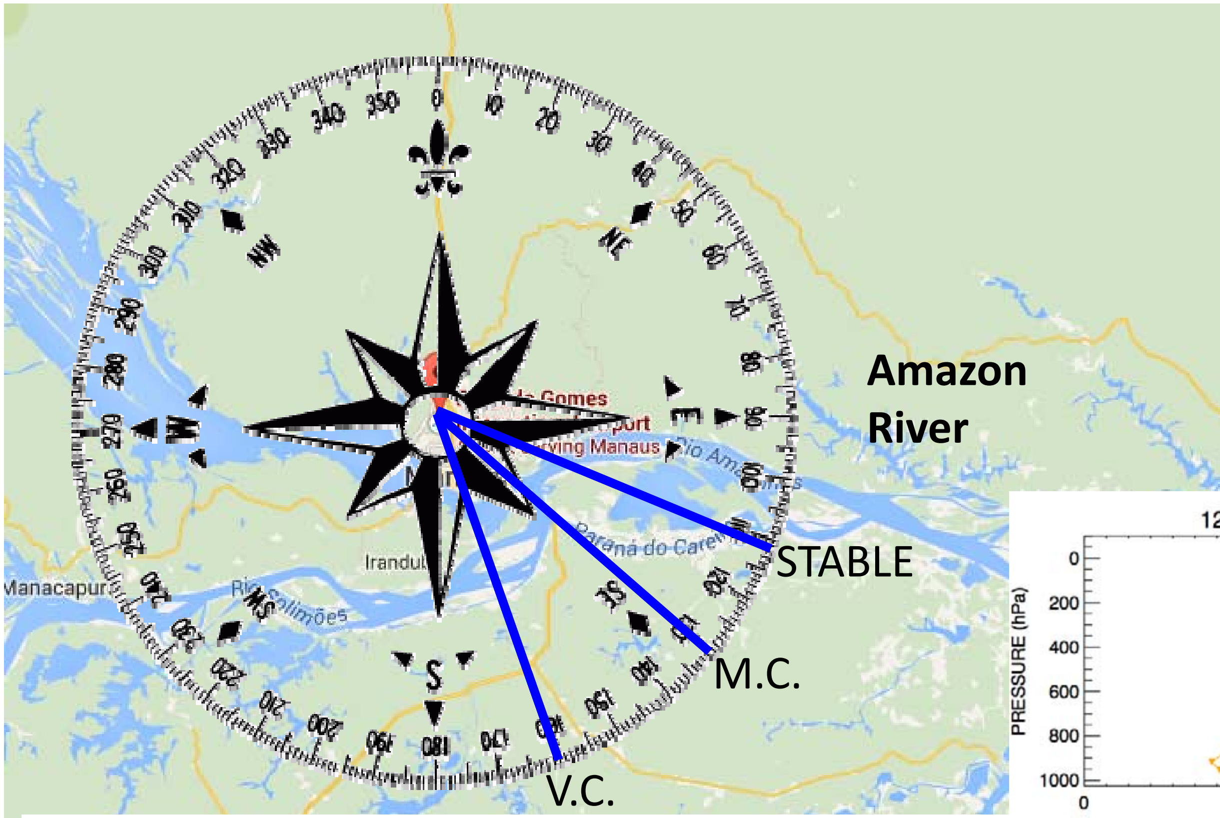
•Precip. Phase not very sensitive to convective intensity.

•Duration, amplitude and onset time are however.

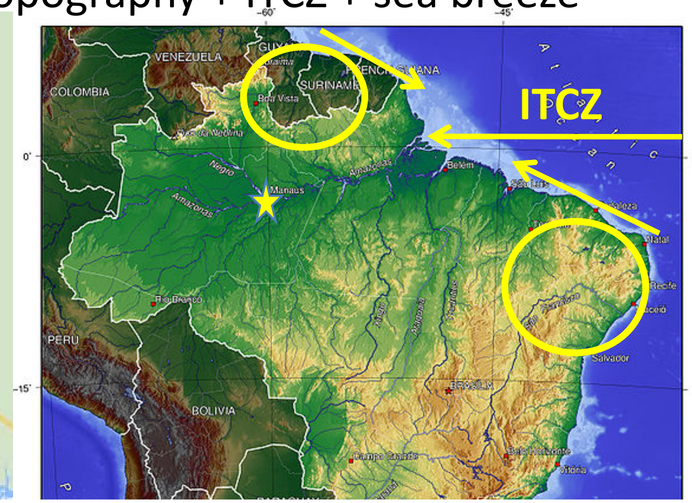
•Slightly later phase on convective days (propagation)

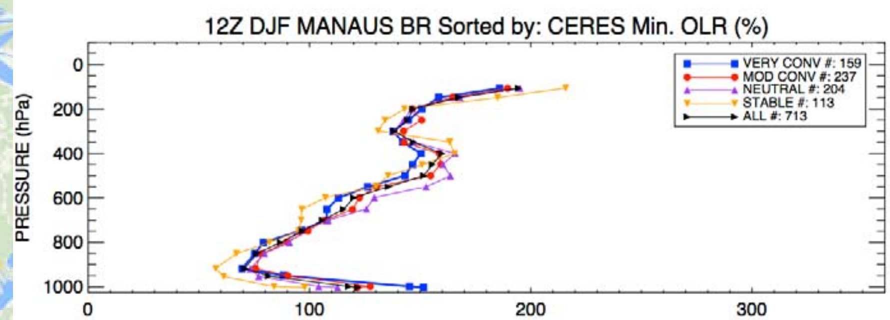
Local Effects: Manaus, BR

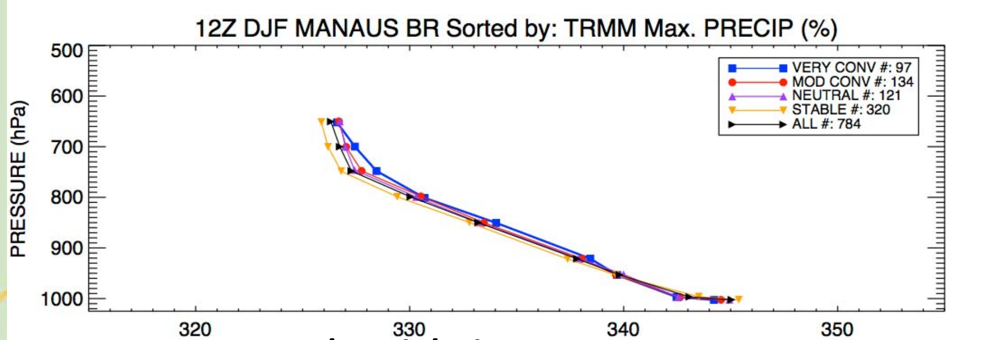
Surface 8AM Wind Direction by Regime



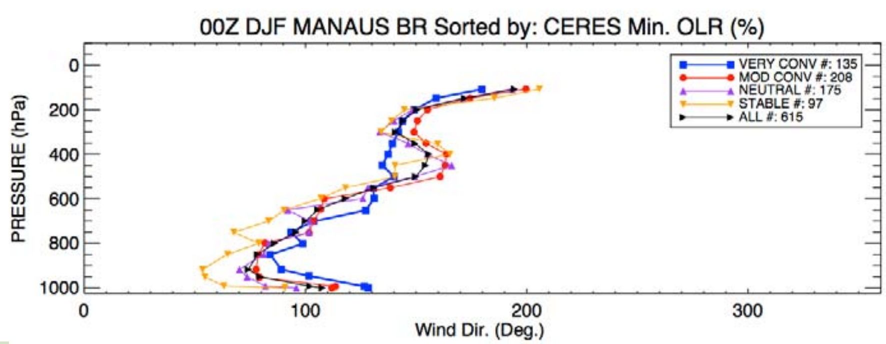
Topography + ITCZ + sea breeze



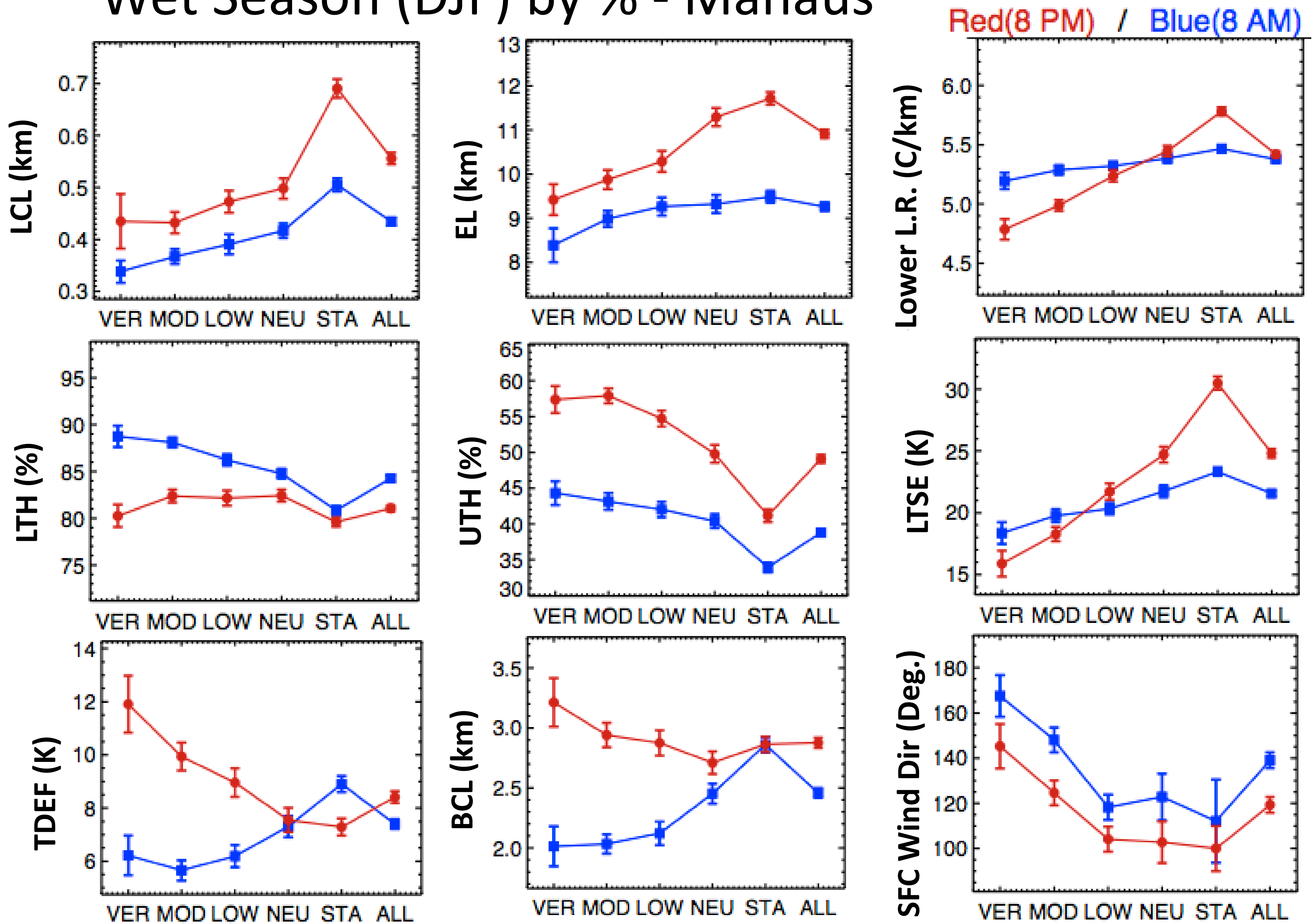




MSE/cpd (J/kg)



Wet Season (DJF) by % - Manaus



MANAUS BR DJF Sorted by: (%) TRMM Max. Precip.

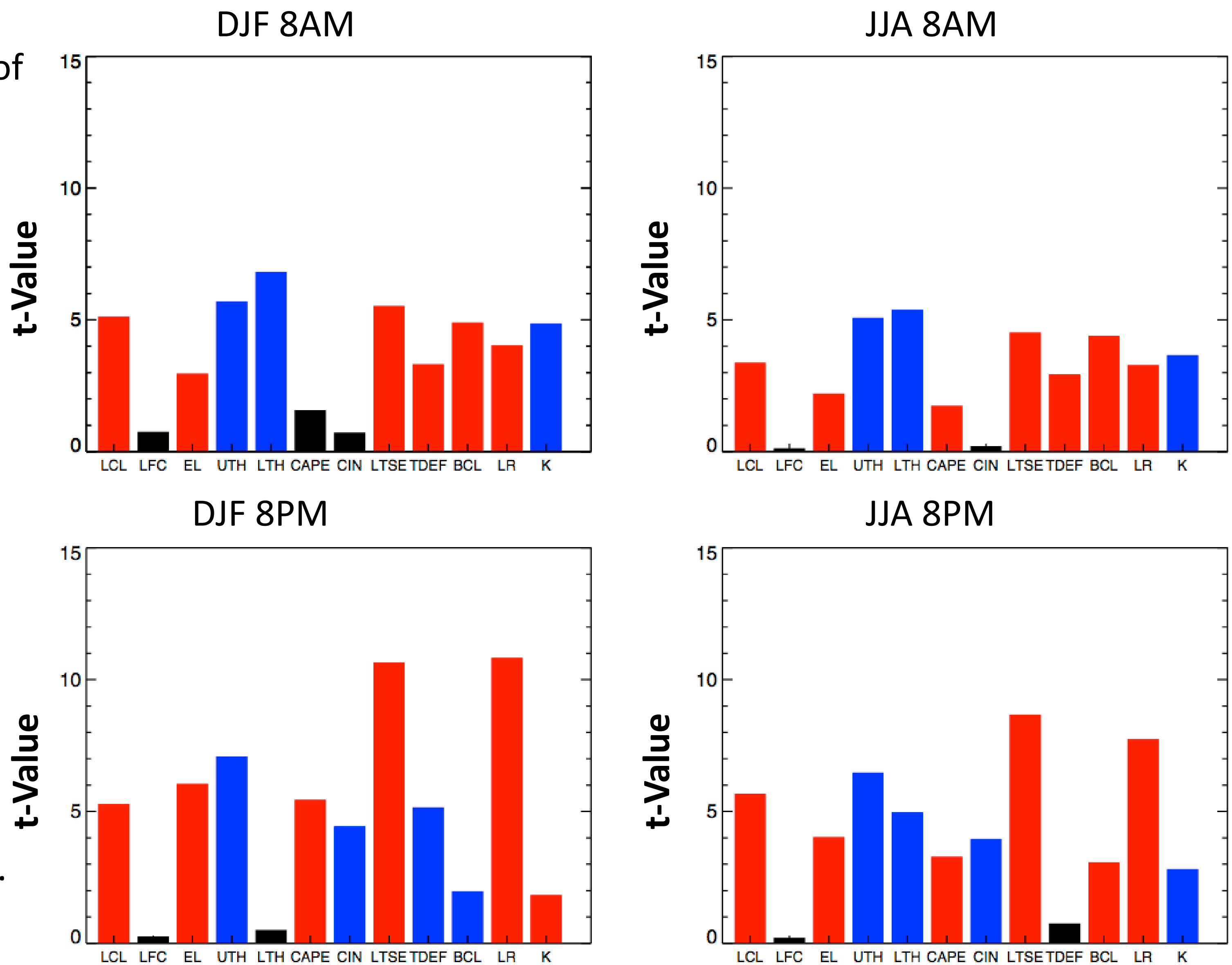
X axis: "LCL LFC EL UTH LTH CAPE CIN LTS TDEF BCL LR K"

- **T-test** to compare mean of very convective days with the mean of stable days.

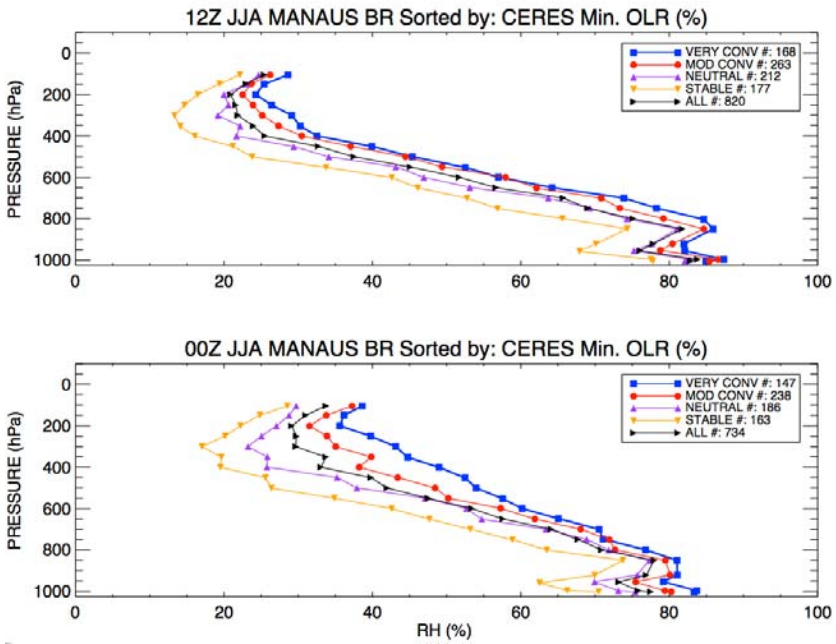
Blue = Higher values on very convective days

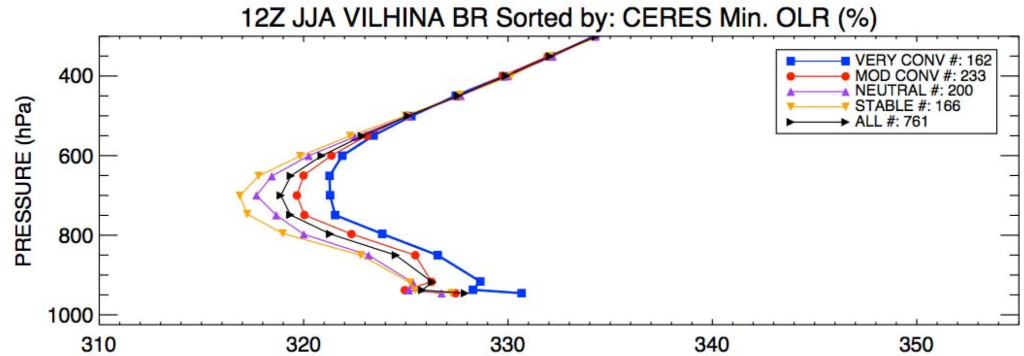
Red = Higher values on stable days.

Black = Not significantly different at 98%.



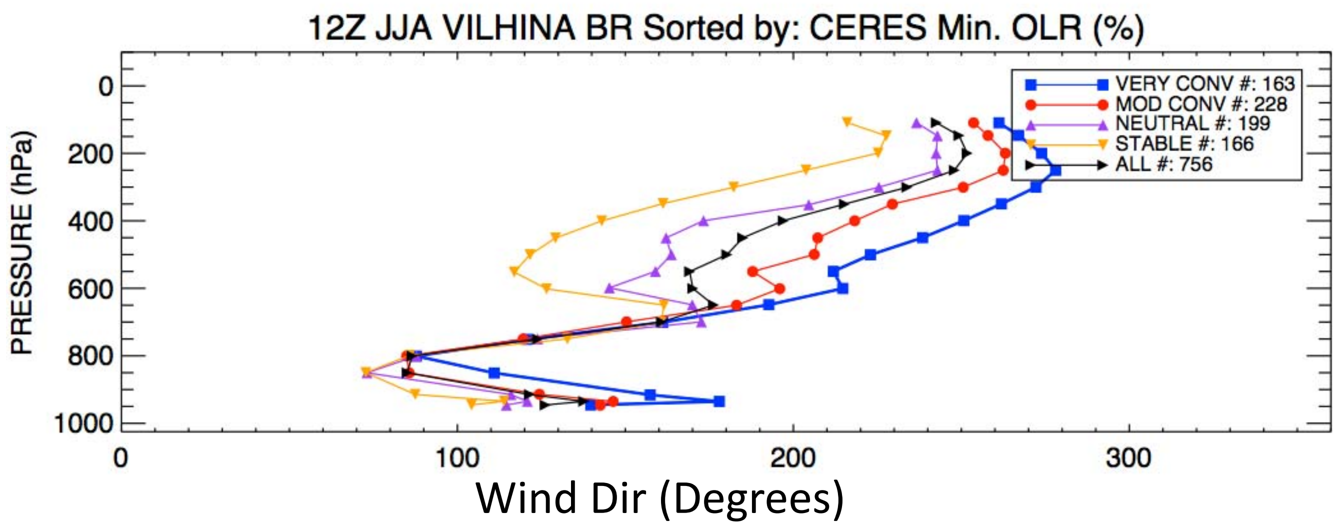
Dry Season Convection: Easy





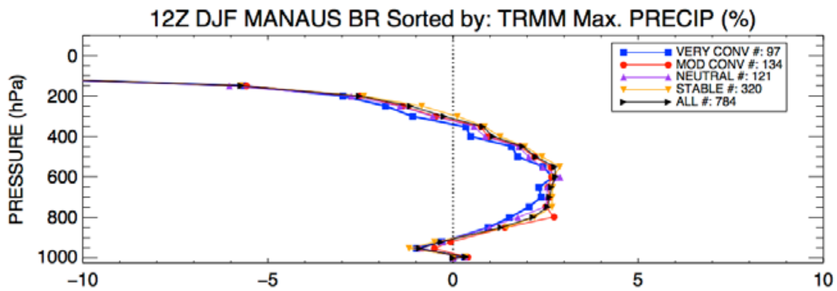
Moist static energy = sensible heat + geopotential + latent heat (J/kg)

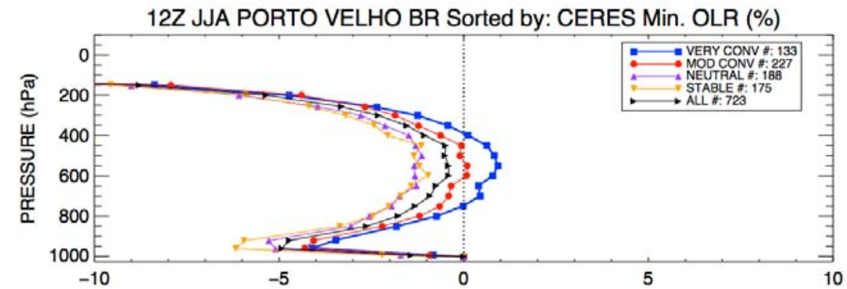
- **Southerly wind component** in JJA for this station associated with more humidity than easterly.
- Mesoscale/synoptic forcing

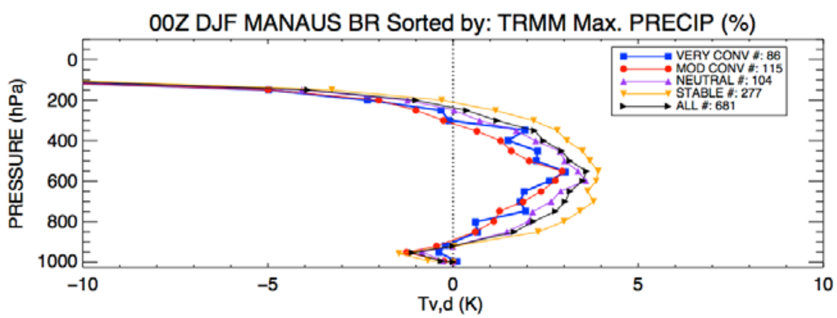


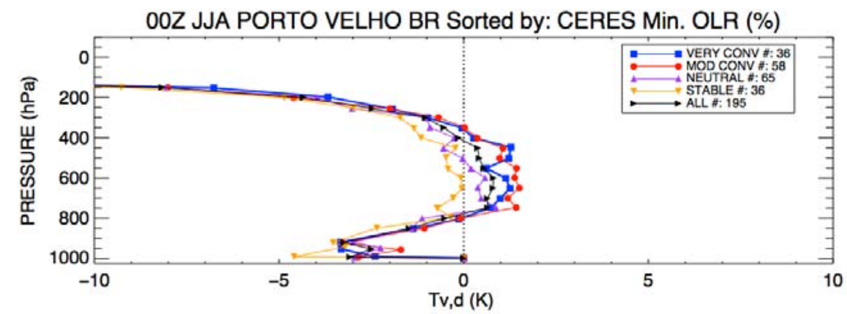
Buoyancy Plots

•A visual measure for CAPE and CIN (~positive and negative areas)
After Zhang et al, 2010









•8AM CAPE/CIN are not significant drivers of convection for Manaus in DJF.

•Notice the **stabilizing effects of convection**, buoyancy decrease between 8AM and 8PM in Very Conv and Mod Conv bins.

•Lower EL before/after convection.

•8AM CAPE/CIN ARE significant drivers of convection for some of the drier stations and seasons.

•Neutral and Stable bins:

- •Zero 8AM CAPE
- •Much higher 8PM LFC

Correlation Analysis

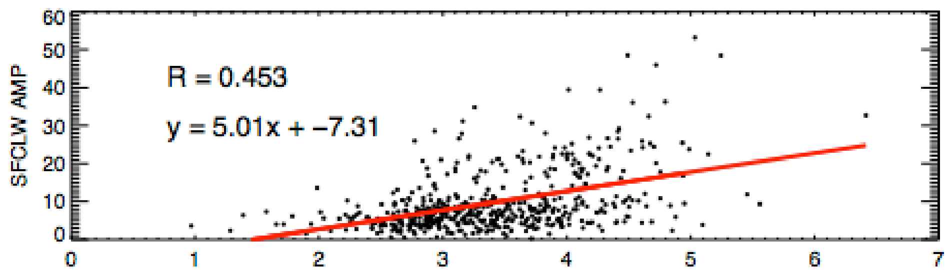
- Correlation between atmospheric state from IGRA (at 8AM) and CERES/TRMM diurnal Amp, Phase, Time of Onset, Duration
- Covariance.
  -Between state variables
  -Between mean state and amplitude

DJF 8AM Best R-Values on Very Convective Days Only

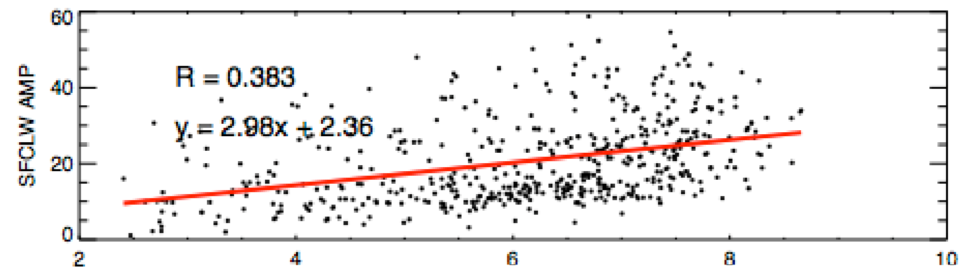
8AM IGRA Variable	TRMM Onset	TRMM Phase	TRMM Amp.	TRMM Duration	OLR Phase
UTH	0.60	0.43	0.25	0.58	0.45
LTH	0.43	-0.5	0.27	0.27	
LTSeq	0.48	0.59	-0.23	-0.46	-0.42
BCL		0.52			
TDEF	0.52				0.30
CAPE		-0.52		-0.36	
EL				-0.40	-0.46

*All values significant at 95%

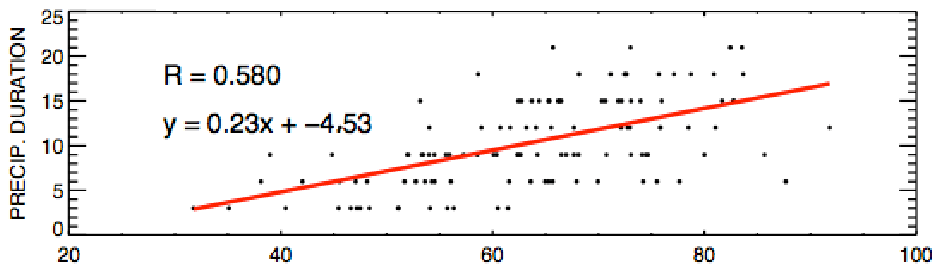
Correlation Analysis



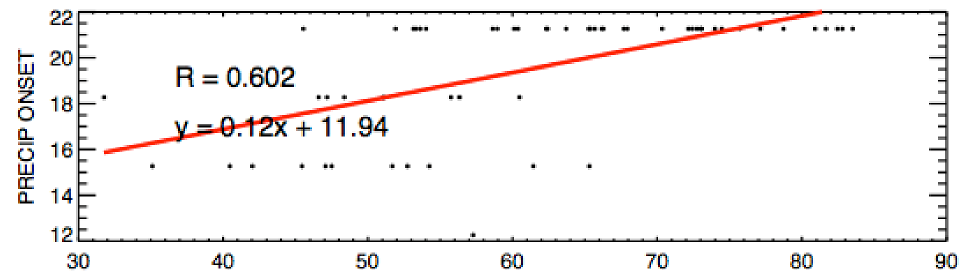
8 AM DJF ALTA FLORESTA BR BCL



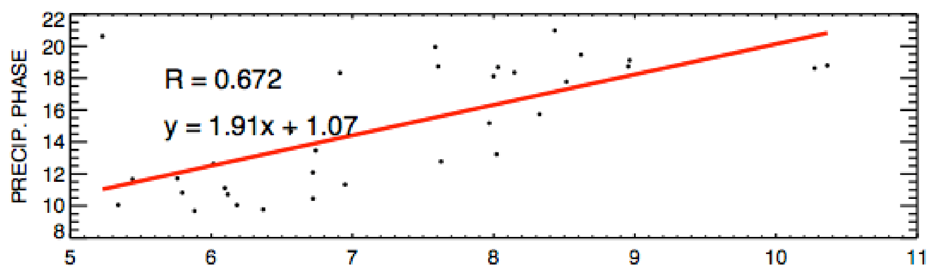
8 AM JJA ALTA FLORESTA BR BCL



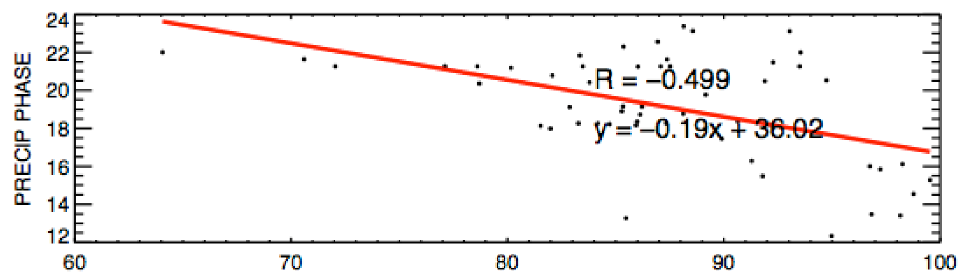
8 AM DJF PORTO VELHO BR UTH



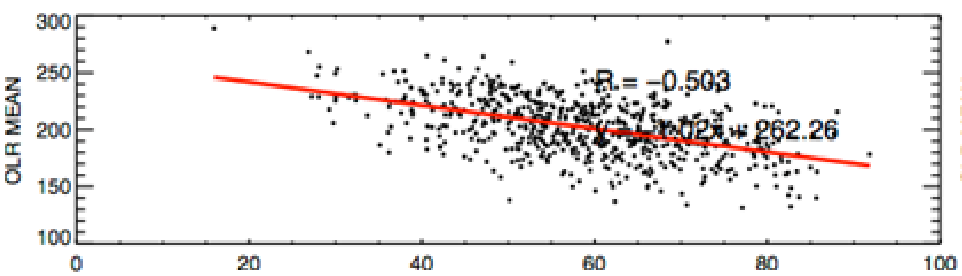
8 AM DJF Porto Velho UTH



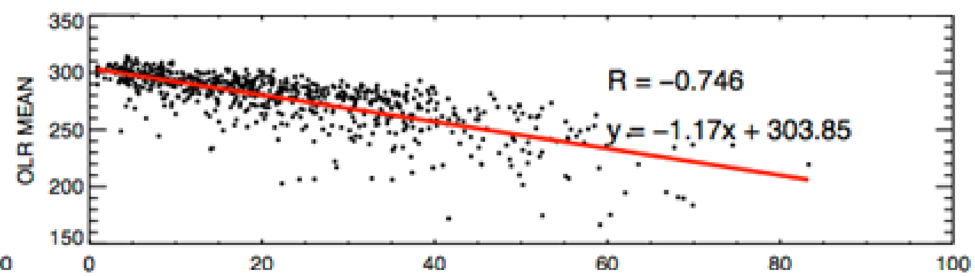
8 AM ALTA FLORESTA BR EL



8 AM DJF MANAUS BR LTH



8 AM DJF PORTO VELHO BR UTH



8 AM DJF PORTO VELHO BR UTH

Conclusions

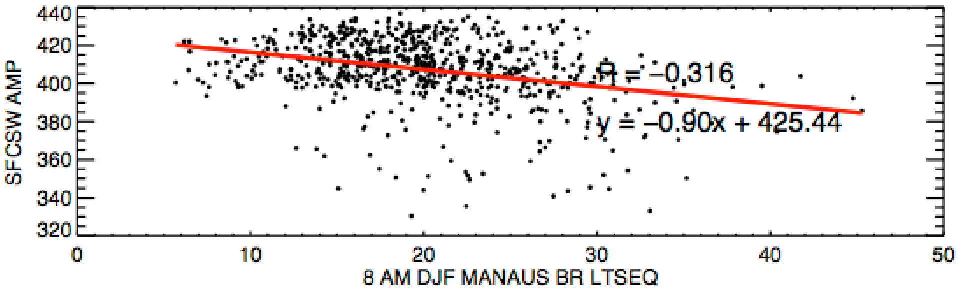
- Averaging surface observations into regimes of convective intensity defined by satellite shows great promise for physical understanding of convection.
- Convective processes in the Amazon are highly variable seasonally and locally.
- Buoyancy/CIN more important JJA
  - Mesoscale/synoptic features easier to separate
  - Length/depth of buoyancy layer very important in DJF (EL).
- Moisture more important DJF, esp. UTH
  - Humidity of lower atmosphere significantly impacts LTS, LCL and ability for parcels to reach LFC.
- Lower level jet strength/direction important
- Convective initiation correlated with LTS, LR, LTH, EL
- Duration/Phase better correlated with humidity variables
- Surface Flux amplitude well correlated with convection.

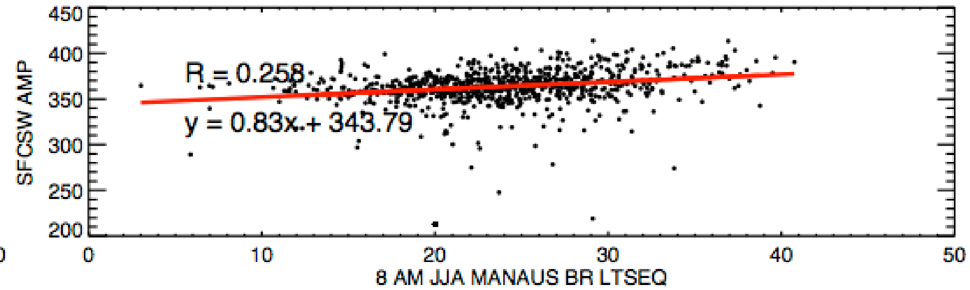
Questions/Comments?

Correlation Analysis

REMOVE SLIDE BUT LOOK AT THESE AGAIN QUICKLY!!!!!!!!

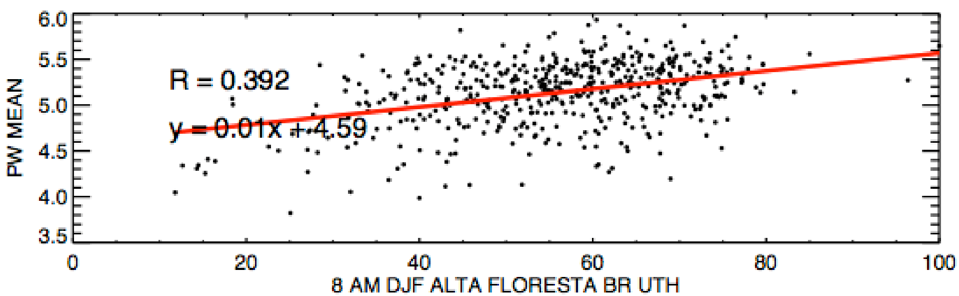
- SFC**SW** Net Amplitude well correlated with LTS/LTSEQ for Manaus

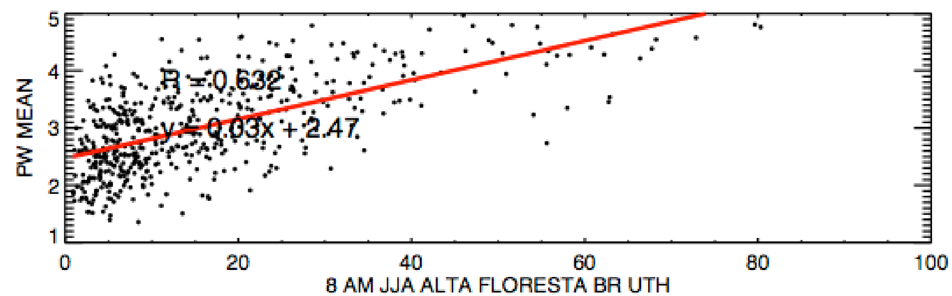




- SFC**LW** Net Amplitude well correlated with TDEF/BCLH for all

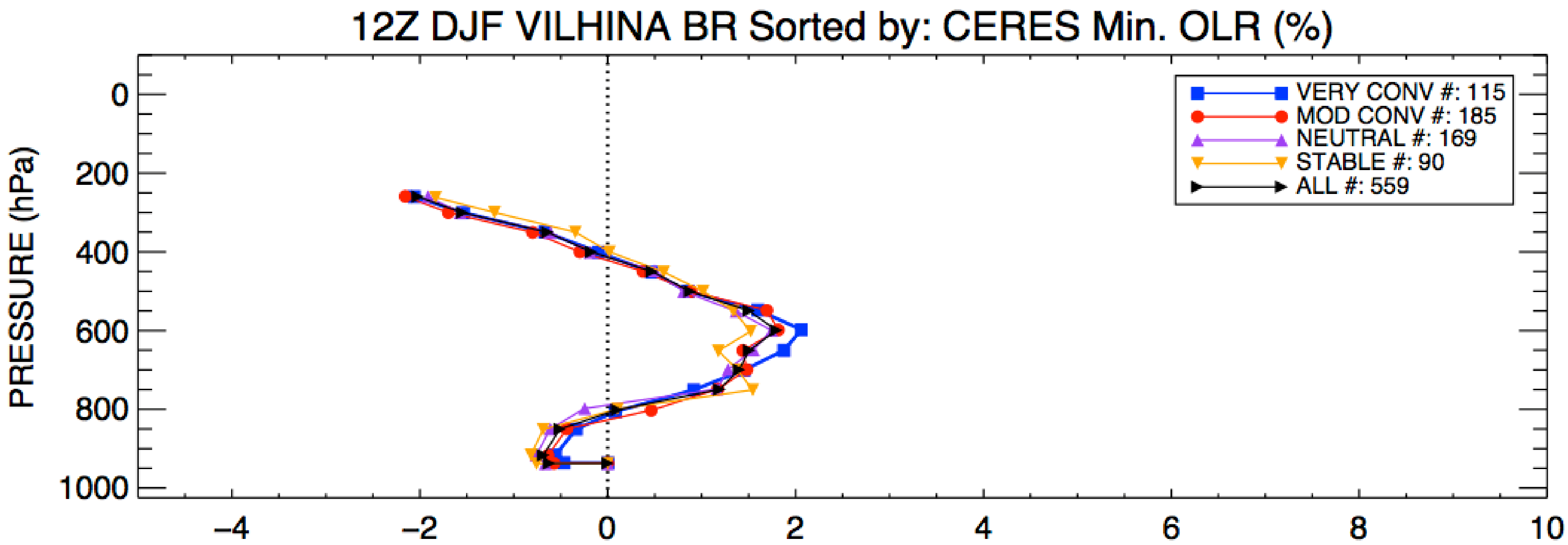
- Mean PW well correlated with humidity sensitive variables.





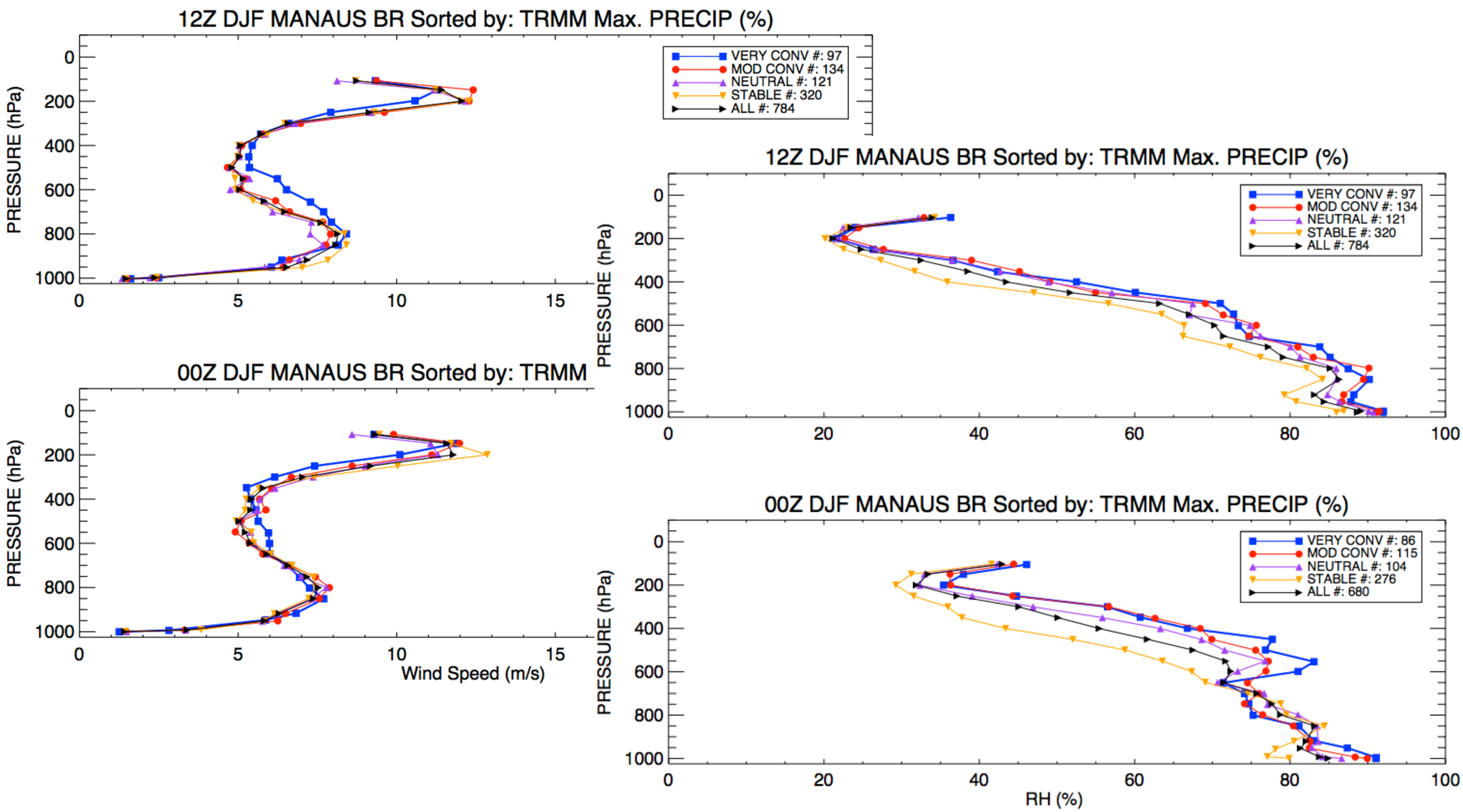
Buoyancy Plots

A visual measure for CAPE and CIN (positive and negative areas)
(Zhang et al, 2010)

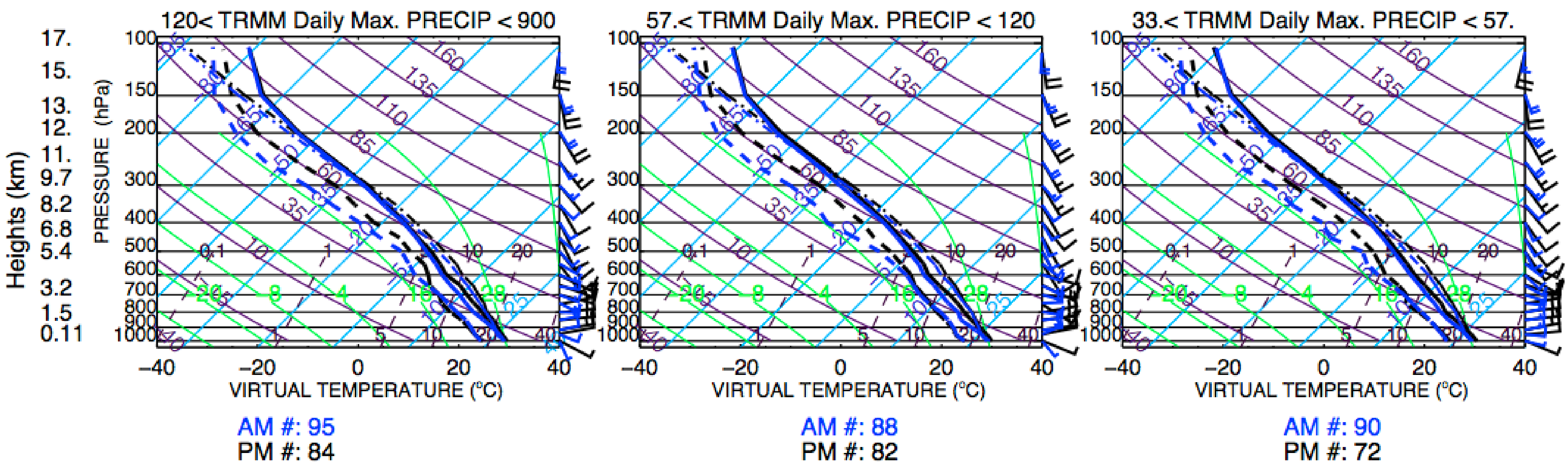


•8AM CAPE/CIN ARE significant drivers of convection for some stations in the wet season.
•Depth of buoyancy layer, short fat CAPE vs. longer skinny CAPE
•Lower LFC, lower EL on Very Conv

•Humidity differences largest above the boundary layer, not as large between 800-600hPa then much larger higher.
•Low level jet starts slightly lower on stable days, then wind speed decreases more rapidly to 500hPa.
•Stronger maximum winds at upper levels on stable days.



Black(00Z) / Blue(12Z)



Temperature (Solid) Dewpoint (Dashed) Parcel (Dash Dot)

MANAUS BR DJF