VERTICAL DISTRIBUTION OF WATER VAPOR IN A TROPICAL DEEP CONVECTIVE REGIME

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OVERVIEW

In equatorial regions, deep convective clouds control the spatial and temporal distribution of water vapor and, thus, should play a critical role in determining the water vapor-cloud feedback in earth's climate system. The details of how convection actually redistributes water vapor into the free troposphere, particularly in the vertical, and what this implies for the atmospheric energy balance has remained a challenging question in tropical meteorology and climate studies (Gray et al., 1975; Betts 1990; Soden e Fu 1995; Sherwood 1999, Soden 2000, Horvath e Soden 2008).

A strong role for free-tropospheric relative humidity in controlling tropical deep convection (i.e., "thermodynamic control") has been suggested by Raymond (2000). Precipitation rates in the tropics were argued to be most strongly related to the mean saturation deficit present in the atmosphere (Raymond 2000). If deep convection is shown to be highly modulated by the vertical distribution of humidity, then this also has important implications for climate modeling. Most convective parameterizations are essentially insensitive (other than virtual temperature effects) to the vertical distribution of humidity (Derbyshire et al., 2004; Grabowski e Moncrieff 2004). Hence, it is very necessary to understand the humidity-convection relationship.

PURPOSE OF STUDY

Examine vertical structure of water vapor in Amazon
Develop preliminary "climatology" of seasonal variation and within season convective activity/supression. This will shed light on the question, Is total pwv dominant in determining convective activity or is it in fact how water vapor is distributed in the troposphere?
This study represents a "first look" at a tropical continental deep convective regime.

Data and Study Region

Water Vapor Data

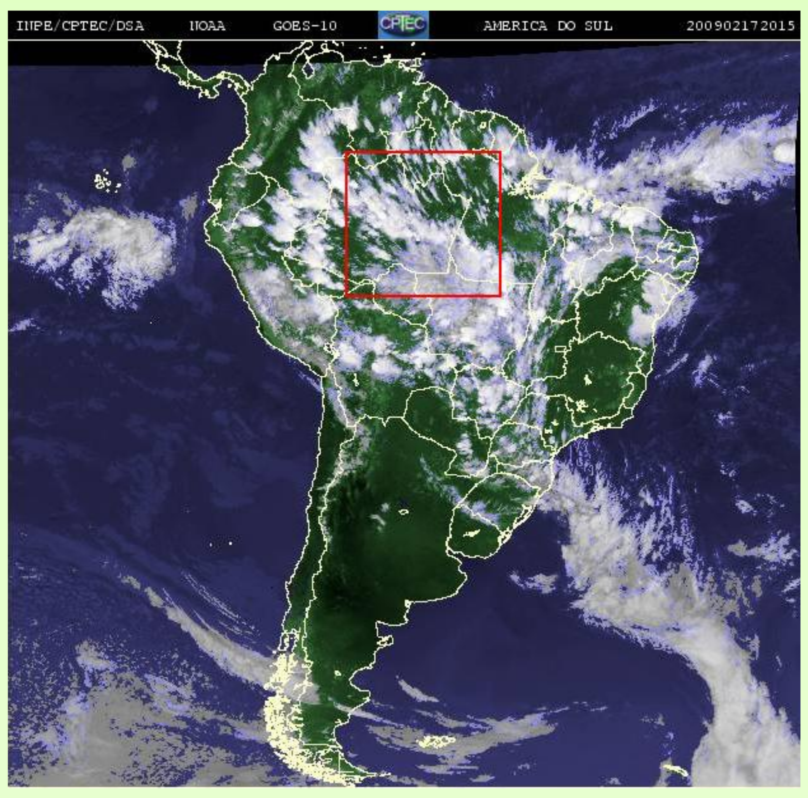
10 years of sounding data from Manaus.
3 years COSMIC water vapor retrievals (radio-occultation).
3 years water vapor retrievals (AIRS)

Convective Activity Data

AIRS Cloud Top Temperature Retrieval (Aqua Satellite)

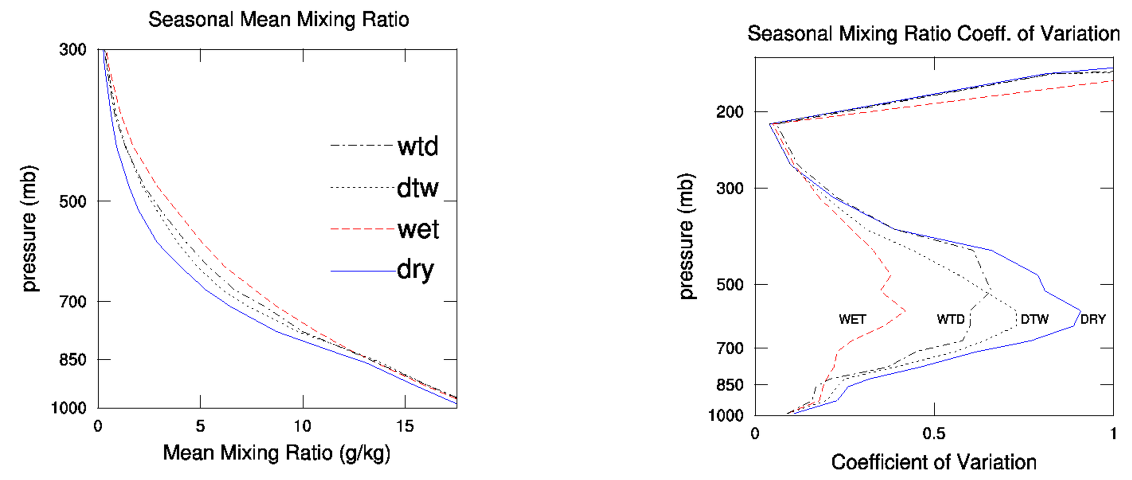
Study Region 10x10 degrees lat/lon box centered on Manaus, AM

2 AIRS Soundings per day over region and typically 2 COSMIC radio-occultations per day over the region.



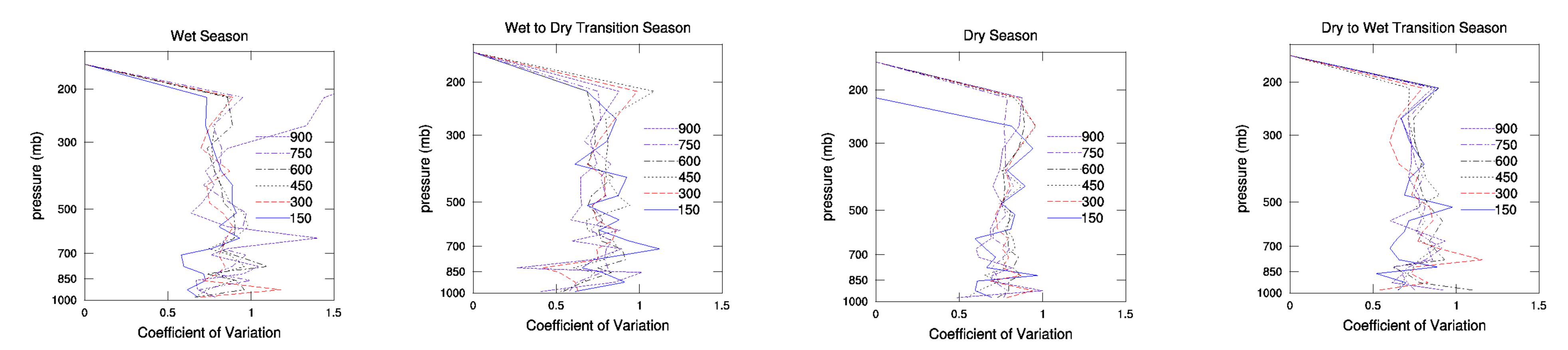
Water Vapor Climatology

Seasonal Mean Vertical Distribution of Mixing Ratio and Coefficient of Variation (Based on 10 years of Soundings Seasonal Distribution: wet (Jan. to April), wtd (May to June), dry (July to Sept.), dtw (Oct. to Dec.)



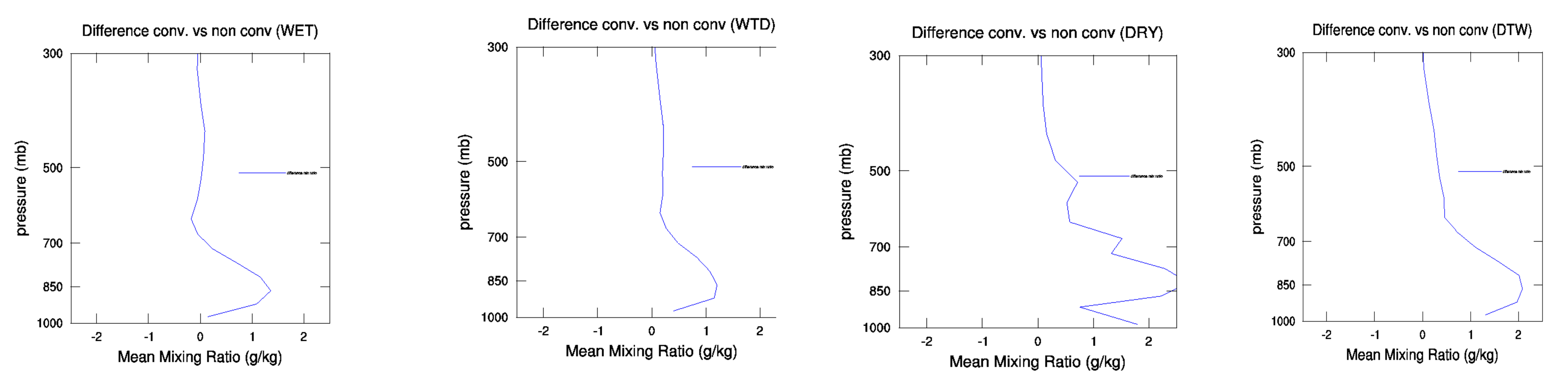
The dominant mode of variability is clearly found above the boundary layer regardless of season, concentrated betwee 800 and 400mb and peaking near 600mb. Is this mode dominant in modulating within season convective activity?

Regional Homogeneity in the Distribution of Water Vapor



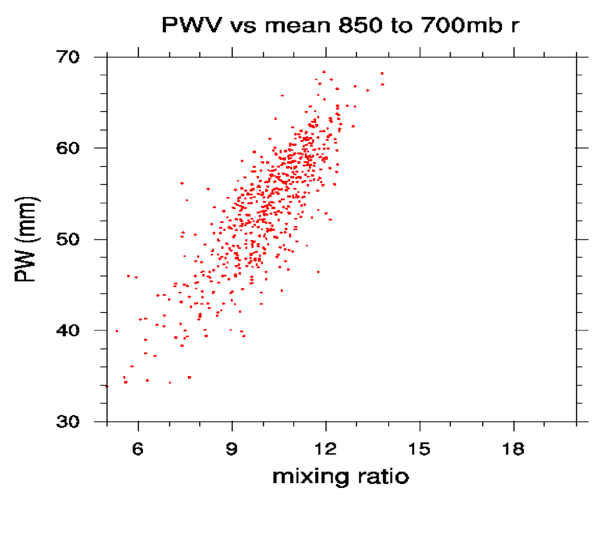
Variation in the difference between "simultaneous" occultation and radiosonde wv profiles as a function of radial distance (in km) from Manaus. Results indicate that strong gradients in wv are not characteristic of the region, regardless of season.

WV Distribution and Deep Convective Activity and Suppression



Mean difference in mixing ratio within-season convective days and non-convective days. The mean difference (conv – non conv), generally small, indicates that the water vapor from 850 to 700mb is important in determining convective activity. Convective and non convective wv profiles were calculated using all wv sources for a given day meeting cloud-top temperature criterion; T < 220, a convective day, T>260, a non convective day.

Precipitable Water Vapor vs. Mean 850 to 700mb Mixing Ratio



In the Amazon Basin, total column water vapor correlates most strongly with water vapor contained in the 850 to 700mb level. Changes in near surface mixing ratio are small even from season to season and water vapor above 500mb contributes very little to total column water vapor; hence the largest correlation with the 850-700mb level.

Summary of Results

This study, while admittedly simple, indicates that free tropospheric humidity plays a critical role in modulating convection (both seasonally and from day-to-day). The seasonal "suppression" of deep precipitating convection is strongly associated with a maximum in variability broadly centered around 600mb. Day-to-day convective activity appear to depend more heavily on moisture just above the boundary layer (around 850mb). Total column water vapor correlates most strongly with average mixing ratio between 850 and 700mb. This leads one to speculate that what "controls" convection is more so the total PWV than the vertical distribution of water vapor. A more detailed and precise study using 15 minutes Meteosat data to better determine convective vs. non-convective events is presently taking place.

Acknowledgments: Akos Horvath, Max Planck ; Alcielio Amorin and Patricia Sánchez Lizardi (U.E.A.)