6A.5 EXTRA-TROPICAL DRY AIR INTRUSIONS IN THE WEST AFRICAN MOONSON REGION

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1. INTRODUCTION

In the Tropics, deep convection and water vapor interact in a two-way process. First, convection transports moisture in the upper troposphere where the water vapor radiative effects are substantial. Second, the distribution of humidity in the immediate environment of convection regulates the convective activity. The presence of dry air can inhibit the moist convection initiation but can also favor the squall line development for convection yet triggered. In both cases the water vapor, long understood as a passive scalar plays an active role in interacting with the dynamical forcing that transports it. The presence of dry air within the active convective region and their interactions have been investigated over the Warm Pool region (e.g., Parsons et al., 2000), but the existence of such dry air intrusions is less known over the West African Monson region. We present here observational evidence for such phenomenon. First the humidity variability in the subtropical northern band is investigated during the 1992 wet season. Then, the extra-tropical origin of these dry regions is assessed. Finally, a discussion of the potential interaction with convection is offered.

2. HUMIDITY INTRASEASONAL VARIABILITY

The moisture content of the free troposphere is analyzed thanks to the Upper Tropospheric Humidity (UTH) parameter. It is derived from the METEOSAT-4 "water vapor" channel radiances measurements according to Schmetz et al., (1995). The UTH corresponds to the mean relative humidity of a broad layer of the troposphere, covering roughly 600-200hPa. The resolution of the UTH imagery is 0.625x0.625 degrees every 3 hours. The figure 1 shows the hovmuller diagram of the UTH during the 1992 monsoon season over the northern Tropics. First, very dry conditions are encountered over the Sahara (25N) with UTH often below 15%. Second, these dry air regions southwards extension, as depicted by the 15% iso-line, can reach down to the convective region centered around 12.5N. In order to quantify the intra seasonal variability of UTH, a spectral Hayashi-like method has been used. The analysis highlights the major modes of variability in the northern subtropical band around 25°N with maximum energy in the 6-12 days band. Westward propagating modes are dominant in this band with typical speed and wave lengths of about 9 m/s and 3000 km respectively. To the north, around 30°N, eastward propagating modes dominate with faster speed and shorter wave lengths. Such variability is consistent with intra seasonal rainfall variability over the region.

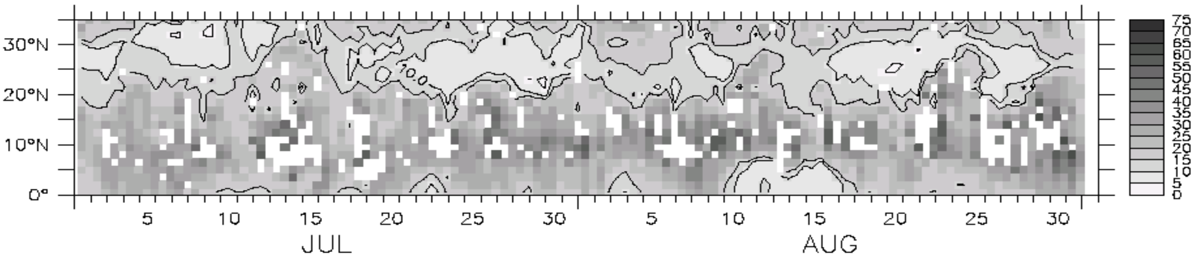

Figure 1 : Hovmuller diagram of Upper Tropospheric relative Humidity over the 5W:5E region. Two UTH images per day are used. The 5,10 and 15% isolines have been overlaid. The white areas correspond to overcast situtation where no UTH retrieval is available.

3. ORIGIN OF AIR MASS

The origin of air mass is investigated using back trajectories. The model used is described in Pierrehumbert and Roca, (1998). The NCEP analyses wind fields are used to compute the trajectories. From an initial position, the trajectory is computed up to 12.5 days backwards in time, interpolating the 3D wind fields with a resolution of 0.5x0.5 degrees and 6 minutes. A rapid check did not reveal any marked differences between the analyzed vertical velocity and the one derived from the continuity equation. So the former is used in the present study. Of major interest during the 1992 season, is the very dry event (below 5%) occurring around the 20-21st of August (Figure 1). Indeed, on the 21st around 1000LT, convection starts to develop over the Air mountains (2.5E, 12.5N) and turns into a strongly organized squall line (Diongue et al., 2002). This convective event is the strongest of the 1992 season (Redelsperger et al., 2001). The figure 2 shows an example of back trajectories for the 21st August at 00LST at 500hPa. The 500hPa level is chosen as a surrogate for mid-tropospheric conditions and as a replacement of UTH which is a highly integrated indicator of moisture in the troposphere .

The figure indicates that the dry air region seen in the Figure 1 in the subtropical band is originating from the northern hemisphere jet stream around 48N and 200-300hPa over the North Atlantic Ocean. The time to subside down to 500hPa (6days) is in agreement with typical subsiding velocity of around 50 hPa/day.

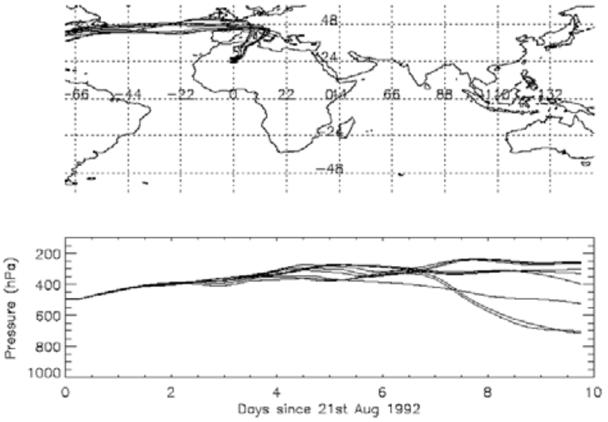

Figure 2: *Back trajectories example for the 21st August 1992. air mass position (top) and pressure along the trajectory (bottom). An ensemble of 9 trajectories centered at OE±0.5,25N±0.5 and 500hPa is shown.*

The air reaching the subtropics has hence been processed trough the cold extra-tropical jet stream environment. From the North Atlantic to the Sahara, the air parcels do not experience any phase change (no condensation occurs) and hence keep the specific humidity encountered in the jet. The thermal conditions being warmer at 500 hPa over the subtropics, yields to the observed extremely low relative humidity. The vertical structure (not shown) of the 21st August dry intrusions event reveals strong mixing of extra tropical air together with the deep convective upper level outflow in agreement with Pierrehumbert and Roca (1998) results. The case study indicates that the dry UTH spots are associated with extra-tropical dry air advection at 500hPa, suggesting that the variability of UTH highlighted above could be associated to dry air intrusions. This is further confirmed over the season in Figure 3.

The latitude of origin is considered as the latitude of the air parcels 5 days ago expressed in terms of anomaly with respect to the reference position (here 22.5N). On the top of the 21st August event, one can notice 2 other strong northerly outflow events. These 3 events are followed within the 5 days by an anomalously dry upper troposphere confirming the link between dry UTH spots and extra-tropical origins. While this is indicating of a dry intrusion similar to observed in the warm pool, the connection with the convective activity is not yet achieved. Indeed, to operate as a controlling and/or modulating factor of convection, the dry air intrusions has to further reach the active region in the lower levels (600-700hPa).

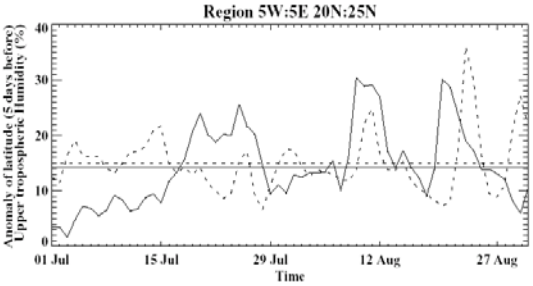

Figure 3: *Time series of the anomaly latitude of origin (plain line) at 500 hPa and of UTH (dotted) line for the region 5W:5E,20N:25N during the 1992 season. The respective mean of each parameters is overlaid.*

4.CONCLUSION

The present study highlights the existence of dry air intrusion from the extra-tropics into the African monsoon region. The signature of these intrusions on the mid-tropospheric water vapor distribution of the subtropical band is associated with a period of 6-12 days, consistent with the intra seasonal variability of rainfall in West Africa and appears as a robust feature of the whole July-August season. Currently only part of the dry intrusion dynamics is documented. On going analysis reveals extra-tropical dry intrusions penetrating down to the convective regions and will be presented at the conference. These features could explain part of the observed intra-seasonal rainfall variability.

5.ACKNOWLEDEGMENTS

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6.REFERENCES

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