6D.5

ATMOSPHERIC WATER VAPOR AND TROPICAL CYCLONE INTENSITY CHANGES

Derek Ortt* and Shuyi S. Chen
RSMAS, University of Miami, Miami, FL

1. INTRODUCTION

For years, it has been accepted that the atmospheric moisture has played a role in the intensity changes of a tropical cyclone (TC). However, there has been little quantification as to what constitutes a dry or a moist environment, making it difficult to determine how much the moisture affects a tropical cyclone's intensity change. One composite that is available consists of a low-resolution, gridded SSM/I dataset (Pennington, 2003), and indicates than atmosphere averages roughly 55 mm of precipitable water from the center out to 300 km However, it may not hold true for different intensities. In addition, there is little understanding as to how the vertical distribution of water vapor affects tropical cyclone intensity.

2. METHODOLOGY

To determine what constitutes a moist or dry environment and how this relates to TC intensity change, the set of TC's that were of tropical storm intensity or greater are being analyzed by using satellite SSM/I data with a ¼ degree spatial resolution for systems since 1987. The total integrated water vapor (precipitable water) data was analyzed. Data south of 35N to the equator was used. Atlantic TC's were classified into three categories: category 3 and higher, category 1 and 2, and tropical storms (all categories based upon the Saffir-Simpson Scale). The storms were the subdivided based upon whether they intensified (as determined by a 6 mb pressure fall over a 12-hour period; 3 mb for tropical storms), remained at constant intensity, or weakened (as determined by a 6 mb pressure rise over a 12-hour period). Each TC was divided into seven sections: the center and successive 50 km concentric radii. The mean of each area was taken. These means were averaged to determine the composite mean. All storms were then compared against the composite mean.

To determine the vertical distribution of water vapor, we use GPS dropsonde data from the NOAA G-IV aircraft. The vertical water vapor profiles are compared to the 1958 Jordan Sounding to determine what consists of a dry environment. The dropsondes are grouped according to the storm-relative motion quadrants, providing information as to the water vapor distribution in the different quadrants.

3. RESULTS

At the time of this writing, all major hurricanes (there were 162 SSM/I passes) from 1987 to the present have been analyzed. We find that the mean moisture content for a major hurricane is significantly higher in the core than indicated in Pennington's composite. In addition, the findings suggest that the amount of moisture does affect a storm's intensity change.

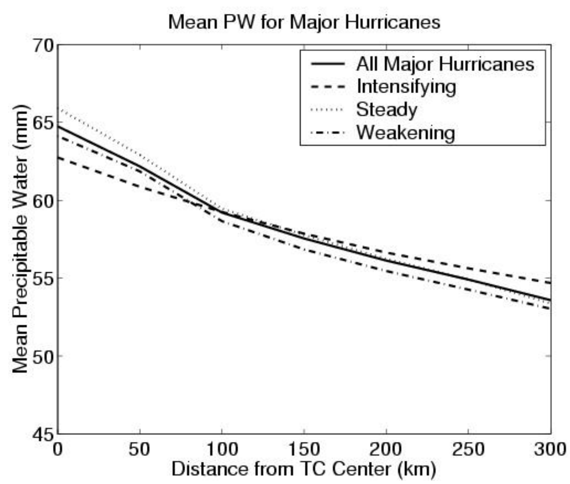

Figure 1: Radial mean precipitable water distribution for all major hurricanes (solid line), intensifying (dashed), steady (dotted), weakening (dashed-dot).

Storms that intensify have more environmental moisture on average than do weakening systems, as indicated in Figure 1. However, there is variability from storm to storm. Major hurricanes have weakened despite having greater than average environmental moisture. In addition, major hurricanes seem to be more affected by the environmental moisture than by the amount of moisture in the inner-core. Our study shows no correlation between the amount of moisture in the core and the intensity changes (Fig 2). The correlation increases with moisture at increasing radii (See Fig 3).

*Corresponding Author Address: 4600 Rickenbacker Causeway, Miami, FL 33149. E-mail: dortt@rsmas.miami.edu

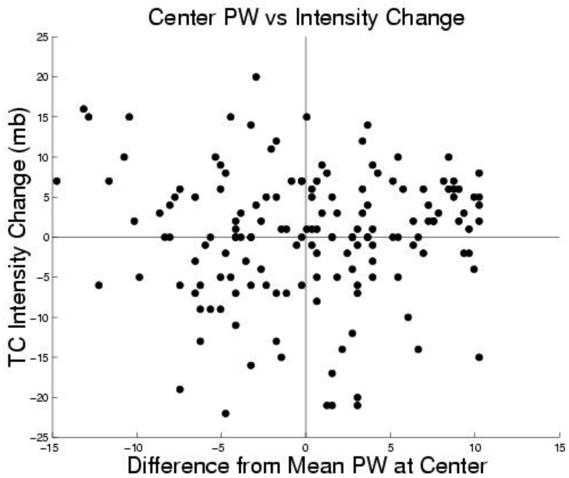

Figure 2. Scatter plot of difference from Mean PW at the center of major hurricanes vs intensity change.

PW in the inner-core is mostly related to deep convection. The convection is active and abundant in major hurricanes; thus, it is not sensitive to relatively small intensity changes while remaining in the major hurricane category.

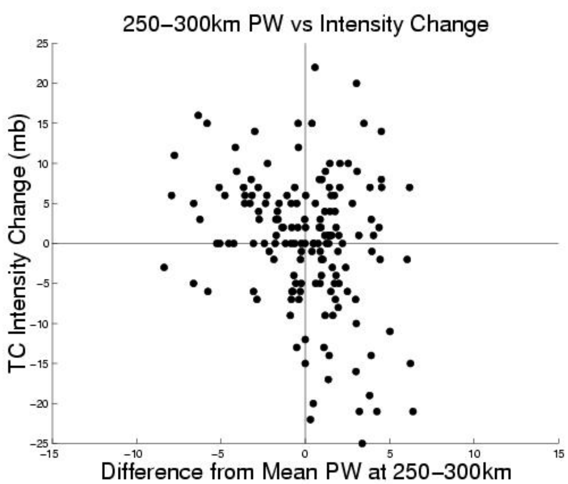

Figure3. Same as Fig 2, except at the 250-300km radius.

Preliminary analysis of the tropical storms suggests that the relationship between the amount of moisture and intensity changes are similar to major hurricanes. However, the total amount of moisture that is available for a tropical storm is generally less than a major hurricane and is much closer to the Pennington composite mean. As is the case with major hurricanes, systems that intensify have higher moisture content than those than remain steady or weaken. This is demonstrated in Figure 4. There is no inner-core in many tropical storms; therefore, the correlation is greater closer to the center than it is for major hurricanes.

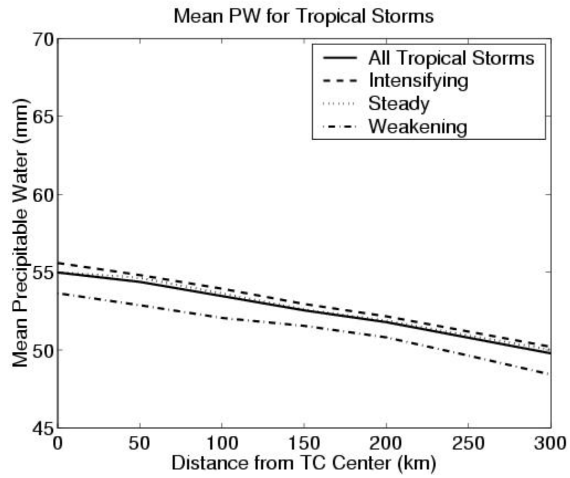

Figure 4. Same as Fig 1, except for tropical storms.

Preliminary results from the dropsonde data indicate that the dry air is located in the mid-levels of the atmosphere, between 2 and 5 km.

4. CONCLUSION

The preliminary results indicate that atmospheric water vapor is a significant contributor in TC intensity change. However, due to the fact that many systems weakened while having a greater than average amount of water vapor, it can also be concluded that atmospheric water vapor is not the only cause of weakening of a major hurricane. There are other causes, such as a storm moving over cool SST or into regions of high vertical wind shear. Future research will look into these causes and eliminate them from the sample set, in order to better determine which systems were in fact weakened by the dry air itself and if there are other factors causing the moist systems to weaken as well.

Further analysis of tropical storms and category 1 and 2 hurricanes will be conducted in order to make better comparisons between the differences in the moisture contents of these TC's and major hurricanes.

Acknowledgements: We would like to thank John Cangialosi and Manuel Lonfat for providing some assistance with the data analysis. In addition, we would like to thank Remote Sensing Systems (REMSS) for making the data available. This work was funded by a research grant from the office of Naval Research under the number N00014-01-1-0156.

References are available upon request