12A.5 CAN DETAILED SATELLITE ANALYSIS DISTINGUISH BETWEEN DEVELOPING AND NON-DEVELOPING DISTURBANCES?

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1. INTRODUCTION

The large-scale environment conditions favorable for genesis are well known (Gray 1968, McBride and Zehr 1981). They include SST greater than 26.5^{0}C, elevated low-level cyclonic vorticity, low shear, and enhanced mid-level moisture content. Genesis does not occur in the absence of a large-scale disturbance with favorable large-scale environment conditions. What is less understood is the role of convection for the spin-up of the storm-scale vortex.

There are two main competing hypotheses. In the top-down hypothesis a vortex first appears at mid-levels, intensifies, and builds down to the surface (Ritchie and Holland 1997). Because mid-level mesoscale convective vortices (MCVs) are associated with stratiform rain, stronger mid-level vortices would be expected in a disturbance with more widespread stratiform rain. In this case, the most important vorticity generation occurs on the mesoscale. In contrast, the bottom-up hypothesis (Hendricks et. al. 2004) claims that the vorticity generation important for genesis occurs at the convective scale in association with intense convective cores (i.e. vortical hot towers).

This paper uses the Tropical Rainfall Measurement Mission (TRMM) precipitation radar (PR) to search for clues as to which hypothesis is most supported.

2. DATA AND METHODS

The basic approach is to look for differences in precipitation feature (PF) properties between developing and strong non-developing disturbances. If developing PFs are larger and rainier than non-developing Pfs, it lends credibility to the top-down hypothesis. On the other hand, if developing PFs are intense but not non-developing PFs, it supports the bottom-up mechanism.

2.1. DISTURBANCE TRACKING

Disturbances are tracked as vorticity maxima (VM) in the ERA-40 Reanalysis. Time filtering and spatial smoothing is done before tracking to isolate the 2.5-10 day timescale and ~600 km length scale. Developing VM are associated with best track storms. For this study, the period from 24 hours pre-genesis to 24-hours after genesis is considered.

Non-developing CONV VM did not track to any storm in the best track and had greater than 10% coverage of cloud tops below 270 K within a 7-degree radius. The cloud top temperatures from ISCCP DX are used. The convection must track coherently along with the VM. The relatively warm temperature threshold is used to include convective minima with little deep convection but a large area of leftover warmer clouds. Often deep convection re-develops in these disturbances.

The tracking method and resulting climatology are presented by Kerns et al. (2007, accepted to *Mon. Wea. Rev.*).

2.2. MAIN MCS AND PF SELECTION

PFs are defined as contiguous areas of TRMM PR near surface radar reflectivity above 20 dBZ. Only PFs within 7 degrees of the VM centers are considered. Main MCSs with TRMM overpasses were searched for among the non-developing VM that have favorable environment conditions, as determined by an objective discriminant analysis method similar to that of Hennon

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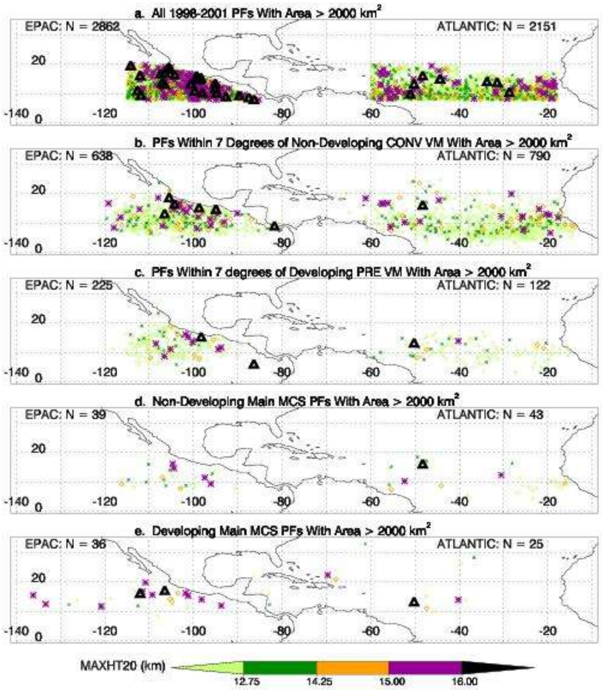

Fig. 1. Maps of the locations of the TRMM PFs considered in this study, coded by MAXHT20. a.) All PFs during June-October 1998-2001; b.) PFs within 7 degrees of non-developing CONV VM; c.) PFs within 7 degrees of developing VM 6-48 hours prior to genesis (developing PRE); d.) Non-developing main MCS PFs, and e.) Developing main MCS PFs. Only PFs with size at least 2000 km^2 are included.

and Hobgood (2003) and reported in Kerns and Zipser (2008, submitted to *Mon. Wea. Rev.*). Two subsets are considered: one with all PFs within 7 degrees of the VM center and another with only main MCSs. For developing cases, the main MCSs are defined as follows:

1.) For as long as the tropical depression MCS can be backtracked, it is considered to be the main MCS.
2.) If convection is rotating around a common center, the MCS nearest the center is selected.
3.) Otherwise, the largest MCS is selected.

For non-developing MCSs:

1.) If convection is rotating around a common center, the MCS nearest the center is selected.
2.) Otherwise, the largest MCS is selected.

3. RESULTS

3.1. MOST INTENSE AND LARGEST PFS

Plate 1 shows the PFs and main MCS PFs selected, coded by PF maximum height of 20 dBZ echo. Maximum height of 20 dBZ > ~15 km is a proxy for intense convection (Zipser et al. 2007). The PFs are ranked by class as follows:

Class 1: bottom 50%
Class 2: next 40%
Class 3: next 5%
Class 4: next 4%
Class 5: top 1%

The ranking is based on all PR observed PFs for June-October 1998-2001. The cutoffs for each class are given by the colorbar. The top two classes correspond roughly with intense convection. The map is designed to emphasize the top two classes of PFs.

Clearly the EPAC PFs are overall stronger than the Atlantic PFs. However, there is no large difference between the developing and non-developing PFs in the occurrence of top PF classes. *The majority of intense PFs are associated neither with developing VM nor with non-developing CONV VM, as defined in this study*. Thus, based on 4-years of TRMM data for the Atlantic and EPAC it does not seem likely that pre-genesis convection is predominantly intense convection.

Similar to PF maximum height of 20 dBZ, the EPAC has many more top 5% area PFs than the Atlantic, and there is little difference in top 5% PF occurrence between developing and non-developing CONV PFs (not shown). Like the most intense PFs, most of the very largest PFs do not occur during the genesis period, or even in association with ERA-40 VM.

3.2 DISTRIBUTION OF PF INTENSITY AND AREA

Cumulative distribution function (CDF) plots can be used to look at the entire distribution of PFs rather than just the most exceptional. There are differences of ~1-2 km in the median MAXHT20 (Fig. 2). However, these differences are not as great as the factor of two difference in median PF area (Fig. 3). The distributions of PF ice scattering area and volumetric rainfall are essentially identical to those of size but with different units (not shown). Especially in the Atlantic, the greatest differences in the distributions are at the lowest quartile. There are many more small PFs associated with the non-developing CONV VM than with developing VM.

The large difference in distribution of PF area is interpreted as an inability of convection to organize into large contiguous raining areas in non-developing cases. This is probably due to environment conditions that are unfavorable for the creation of extensive stratiform rain areas, such as the presence of dry air at mid-levels.

4. DISCUSSION

Based on 4 years of TRMM PR observations in Atlantic and EPAC developing and non-developing disturbances, the greatest differences between developing and non-developing disturbances are in terms of PF raining area, ice scattering area, and volumetric rain. The larger PF area in developing PFs suggests larger diabatic heating and vorticity generation on the storm scale. There are also statistically significant differences in the maximum height of 20 dBZ (and other intensity proxies), and this does probably contribute some to the diabatic heating in developing storms. Nevertheless, it does not appear that intense convection (top 5%) is favored in developing disturbances. Therefore, based on the limited dataset used for this study, it appears that the top-down hypothesis is more plausible than the bottom-up hypothesis.

Because intense convection and vortical hot towers are likely to be short-lived, it is pre-mature to conclude that they do not occur in the pre-genesis environment. It is possible that there were simply not enough intense convection hits in the limited database to affect the statistics. A follow-up study using 10 years of TRMM PR data globally is currently underway. Another possible way to extend this study is to incorporate passive microwave data from the TRMM microwave imager (TMI), SSM/I, and AMSR-E on AQUA.

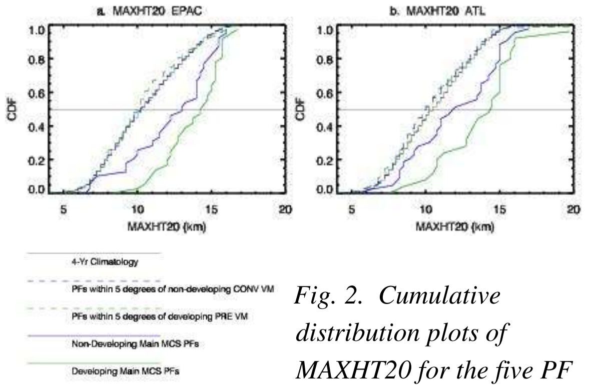

Fig. 2. Cumulative distribution plots of MAXHT20 for the five PF subsets of Fig. 1.

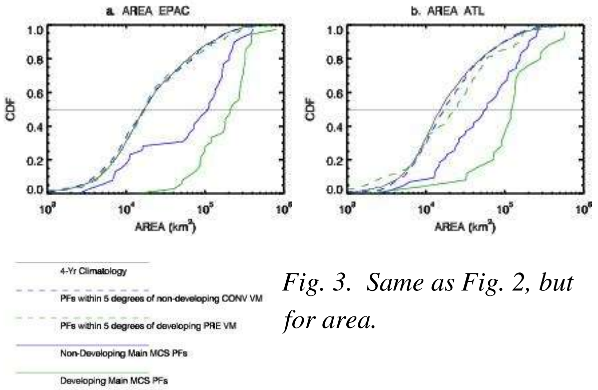

Fig. 3. Same as Fig. 2, but for area.

However, some clarification is needed as to whether the passive microwave data are more sensitive to *intense* convection with updrafts on the order of 10 m s^{-1} or ordinary deep convection with large mass and heat flux, large diabatic heating, and heavy rainfall.

Acknowledgments. This study is part of the first author's doctoral dissertation at the University of Utah, supported by the NASA Earth and Space Science Fellowship under Training Grant #NNX06AF94H. The support of Dr. Ramesh Kakar and the NASA TRMM office is much appreciated as well as the support of the first author's faculty advisor Prof. Edward J. Zipser.

REFERENCES

Hendricks, E. A., M. T. Montgomery, and C. A. Davis, 2004: The role of "vortical" hot towers in the formation of tropical cyclone Diana (1984). *J. Atmos. Sci.,* **61,** 1209-1232.

Hennon, C. C. and J. S. Hobgood, 2003: Forecasting tropical cyclone genesis over the Atlantic basin using large-scale data. *Mon. Wea. Rev.,* **131,** 2927-2940.

Gray, W. M., 1968: Global view of the origin of tropical disturbances and storms. *Mon. Wea. Rev.,* **96,** 669-700.

McBride, J. L. and Zehr, R., 1981: Observational analysis of tropical cyclone formation. Part II: Comparison of non-developing versus developing systems. *J. Atmos. Sci.,* **38,** 1132-1151.

Zipser, E. J., D. J. Cecil, C. Liu, S. W. Nesbitt, and D. P. Yorty, 2006: Where are the most intense thunderstorms on earth? *Bull. Amer. Meteor. Soc.,* **87,** 1057-1071.