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16B.2 VERTICAL PROFILES OF TROPICAL CONVECTION AS OBSERVED BY THE TRMM SATELLITE

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1. INTRODUCTION

We have utilized Tropical Rainfall Measuring Mission (TRMM) Precipitation Radar (PR; 2A-25 algorithm) and Lightning Imaging Sensor (LIS) data to conduct statistical studies of the vertical structure of convection and precipitation processes over a wide variety of rainfall regimes in the global topics (boxes of 5-10° on a side over seasonal time-scales). By combining analyses of TRMM LIS and PR reflectivity statistics over these rainfall regimes, inferences can be made regarding the microphysical and kinematic structures of the convective ensembles observed. The objective of this research is to relate variability in the mean vertical structure of tropical precipitation to associated latent heating characteristics.

2. DISTRIBUTIONS OF REFLECTIVITY AS COMPARED TO ICE WATER CONTENT AND LIGHTNING FLASH DENSITY

Relative frequency distributions as a function of height for TRMM-PR reflectivities observed in tropical oceanic and continental rainfall regimes are indicated in Figs. 1a-d. The relative ordering of Figs. 1a-d is intended to distinguish both the transition from, and stark contrast between, oceanic and continental cloud ensembles. These differences are similarly manifested in plots of LIS Lightning Flash Density (LFD) and Ice Water Content (IWC) as diagnosed from TRMM-PR reflectivity values (Fig. 2).

Figure 1a is representative of a heavy rainfall regime encountered over the tropical oceans, in this case the western Pacific warm-pool. These regimes are characterized by heavy convective rainfall but relatively weak vertical development. This is reflected in Fig. 1a by a marked increase in the frequency of reflectivities ≥ (≤) 30 dBZ at levels below (above) the freezing level (~5 km). The predominance of warm-rain processes over the tropical ocean is suggested by this reflectivity distribution and is further supported by the relatively low LFD’s and IWC’s shown for oceanic regimes in Fig. 2 (cf., Zipser, 1994; Petersen et al., 1996).

As the rainfall regimes become more continental in nature (Figs. 1b-d) the reflectivity structure aloft suggests an ever increasing role for ice processes in the production of precipitation. However, it is clear that the relative contribution of ice processes cannot be clearly assessed utilizing only a simple partitioning scheme such as the “continental” or “oceanic” nature of a region. For example, the Amazon (AMZ) region studied here can certainly be considered “interior” to a tropical continent. However, the characteristics of the reflectivity distribution (Fig. 1b) during the *wet-season* (Dec. – Feb.) exhibit characteristics similar to those observed over the tropical ocean (Fig. 1a, 2; cf. Mohr et al., 1999) with only a hint of the “continentality” characteristic of the N. Australia and Congo distributions (Figs. 1c and 1d respectively).

Indeed, both the AMZ and Congo regions are at approximately the same latitude, covered by dense tropical rain-forest, and bordered on one side by mountains and on the other by ocean (distant). However, by contrasting the AMZ and Congo region *wet-season* reflectivity distributions it is clear that both convective intensity and precipitation ice-processes are more enhanced in the convective clouds observed over the Congo. This is consistent with a marked increase in both IWC and LFD in the Congo relative to the Amazon (Fig. 2). The differences between these reflectivity distributions, IWC’s and LFD’s suggest that the shape of the latent heating profiles over the AMZ and Congo are likely to be different.

The IWC’s and LFD’s shown in Fig. 2 further elucidate regional/regime specific variations in precipitation microphysics and convective intensity. Not unexpectedly, oceanic regions (e.g., Fig. 1a) exhibit consistently low IWC’s (computed in the mixed phase region -12°C to -30°C) and LFD’s, while the reverse is generally true of continental regimes. The interior of the AMZ during its wet-season seems to best fit with oceanic or pronounced “monsoon” wet-season regimes such as that of India. Interestingly, oceanic regions affected by nearby land masses (e.g., Gulf of Mexico, Gulf Stream, E. Pacific ITCZ near 10°S and 95°W; “ocean/coast” in Fig. 2) exhibit a broad range of characteristic IWC’s and related lightning flash densities that are also reflected in their respective reflectivity distributions (not shown).

3. CONCLUSIONS

TRMM-PR and LIS observations suggest that a wide, but identifiable variety of convective rainfall regimes exist in the tropics. Further categorization of these rainfall regimes utilizing vertical structure information from the TRMM-PR combined with ancillary information provided by instruments such as the LIS, will enable relative differences in the diabatic heating profiles of each regime to be identified.

4. REFERENCES

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5. ACKNOWLEDGMENTS

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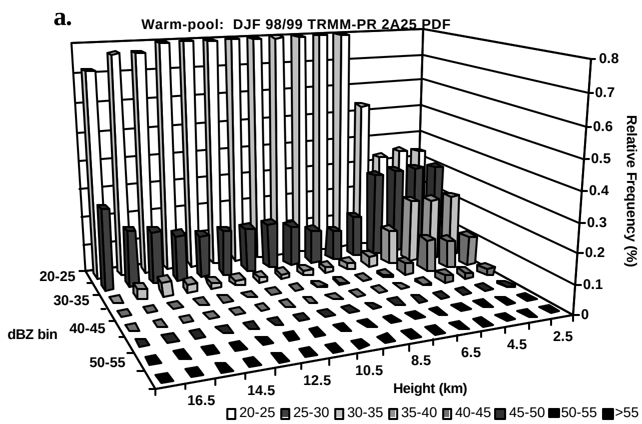

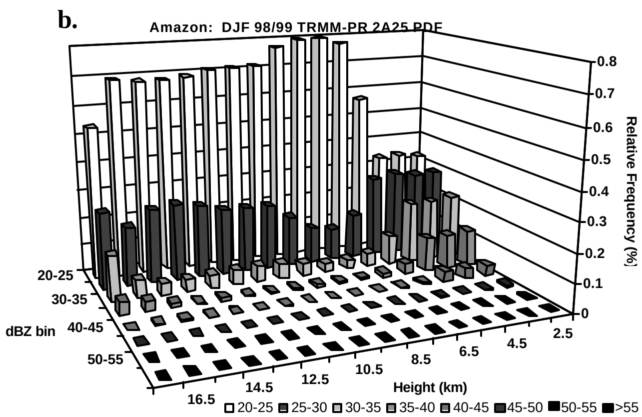

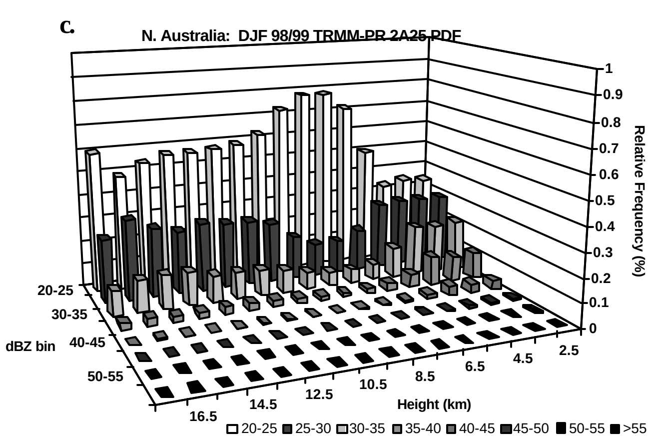

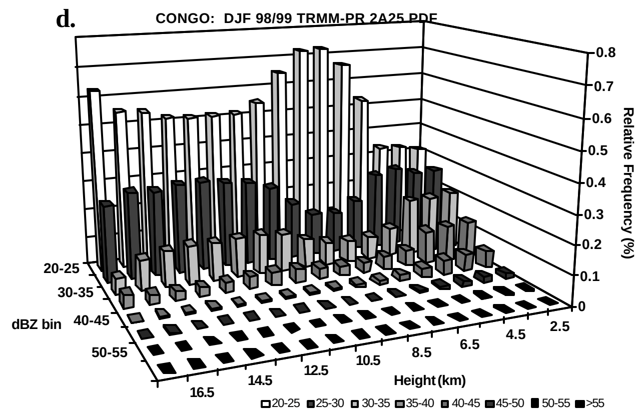

Figure 1. 3-D *layer-relative* frequency histograms of TRMM-PR reflectivity for the **a)** western Pacific warm-pool (5-15°S, 170-180°E); **b)** Amazon (0-10°S, 60-70°W); **c)** N. Australia (11-21°S, 130-135°E); and **d)** the southern Congo basin (0-10°S, 17-27°E). Reflectivities are binned every 5 dB starting at 20 dBZ for height bins of 1 km, starting at 2 km. The relative frequency of a given reflectivity bin is indicated for each height layer on the vertical axis.

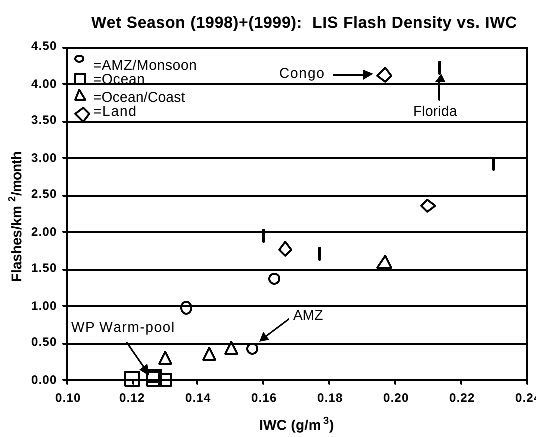

Figure 2. 1998/99 TRMM-LIS flash density vs. TRMM-PR-diagnosed Ice Water Content (IWC) for four tropical *wet/warm season regimes* (cf. figure legend). IWC's were computed for two seasons and then averaged for each location (several locations identified for reference) in the altitude range of 7 to 10 km (~-12° C to -30°C).