P2.31 KINEMATIC CHARACTERISTICS OF RICO UPDRAFTS: COMPARISONS WITH OTHER TROPICAL REGIONS

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1. INTRODUCTION

A description of the structure and dynamics of updrafts is essential to our understanding of clouds such as those in RICO. Cloud features such as the cloud lifetimes, the times available for growth of precipitation, the cloud entrainment, etc., are all related to updraft structures and their dynamic evolution. When compared to Midlatitude continental clouds, tropical oceanic clouds exhibit similar cloud base heights and lapse rates, so we might anticipate their updrafts to have some similar characteristics. Recently, Anderson et al., (2005) compared the kinematics of strong updrafts from precipitating cumuli in the Central Tropical Pacific Ocean (near Kwajalein, Marshall Islands) and a region in the Amazon during the clean (non-burning) season. These were studied as part of the NASA Tropical Rainfall Measuring Mission (TRMM) field campaigns KWAJEX and TRMM-LBA, respectively. Information on the microphysical structure of the updrafts in these two studies is given in Stith et al. (2004). Anderson et al. utilized the techniques of LeMone and Zipser (1980), which had been used in previous tropical updraft studies to analyze airborne in situ measurements of updraft strength. This also allowed comparisons with previous studies of tropical oceanic updrafts. They found that the average speed, the maximum speed, the width, and the mass flux of updraft cores from Kwajalein and the Amazon (580 updrafts) were generally similar to each other and also to results from previous studies of tropical oceanic updrafts.

In this study I examine the properties of the updrafts in the RICO clouds, using this technique. Since the microphysical structure of cumuli (e.g. drop size distributions) is closely related to their updrafts, if RICO updrafts follow a similar pattern as other tropical regions, their microphysical structures are likely to be similar, at least for tropical regions with similar CCN concentrations, as might be expected over many remote regions of the tropical oceans. However, most RICO clouds were smaller than the deeper tropical convection studied in Anderson et al. and references therein, so we might also expect significant differences to occur.

2. METHODS AND DATA SOURCES

1 Hz average vertical wind data from the NCAR/NSF 130 gust probe were used for this study, which includes a five-hole radome flow angle gust probe and an inertial navigation system, which is similar to that used by Anderson et al., who utilized data from the University of North Dakota Citation gust probe system. Using the LeMone and Zipser criteria, an updraft core is required to have a vertical velocity of 1 m s^{-1} for a length of at least 0.5 km in cloud. As in Anderson et al., cloud data from Particle Measuring Systems (PMS) instruments were used to identify cloudy regions: An FSSP concentration of at least 10 cm^{-3} or a 2DC concentration greater than 0.5 L^{-1} was used to identify cloud boundaries (our study used 2DC concentration, while Anderson et al., used 2DC shadow-or concentration; this is not expected to affect the results significantly). The average updraft speed is the mean of the vertical wind over the width of the updraft core. The maximum updraft speed is the maximum 1 Hz value during the width of the updraft core. The width is defined to be the mean flight speed (in km s^{-1}) times the number of seconds the aircraft was in the updraft core. The mass flux per unit horizontal distance across the aircraft track is defined as the product of the air density, updraft core width, and the mean updraft core speed (LeMone and Zipser 1980). This is referred to as mass flux in this paper.

3. RESULTS

3.1 Comparison of RICO updrafts with those from Kwajalein and the Amazon.

Figure 1 adds the RICO updraft results to those for Kwajalein and the Amazon from the

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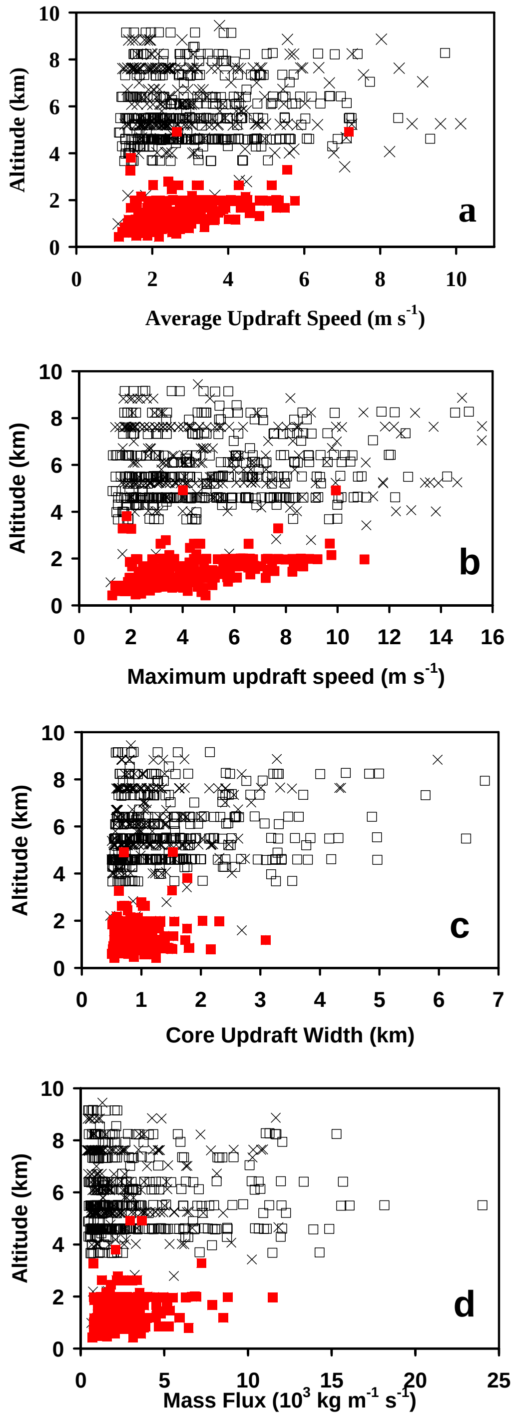

Figure 1. (a) Average core updraft speed, (b) maximum 1 Hz updraft speed within the core, (c) updraft core width, and (d) Mass Flux, for each of the updraft cores in RICO (red squares) and the KWAXEX (X) and TRMM-LBA (outlined squares). Adapted from Fig. 1 in Anderson et al. (2005).

Anderson et al. studies. These results illustrate how the RICO updraft kinematics compare with those in KWAJEX and TRMM-LBA. However, the RICO clouds were smaller and only occasionally sampled near their top and only a few vertical wind measurements were available in the lower regions of the clouds in KWAXEX or TRMM-LBA, so there are inadequate data to provide comparisons at similar altitudes. For that we turn to other studies of tropical updrafts, below.

3.2 Comparisons of RICO updrafts with other tropical clouds

Anderson et al. averaged their updraft core results over altitude bins and compared them with previous studies of tropical oceanic cumulus updrafts. These studies included the GARP Atlantic Tropical Experiment (GATE), the Taiwan Area Mesoscale Experiment (TAMEX), and the Equatorial Experiment (EMEX).

In RICO, because of the small size of the clouds, only a rather limited altitude range is available. The data from RICO were divided into two categories, data above 1 km altitude and below 1 km altitude. The mean altitudes of each category were computed to be 0.69 and 1.6 km, respectively. Figure 2 presents median values of the parameters in Fig.1, which were computed for each category and added to the summary provided in Anderson et al.

These results suggest that, in terms of updraft speed (average or maximum), at similar altitudes, RICO updrafts are similar to those from other tropical oceanic regions, which include deeper tropical clouds. In terms of updraft size (or mass flux), however the RICO updrafts are smaller, as might be expected.

4. IMPLICATIONS FOR CLOUD MICROPHYSICS.

Given similar conditions of pressure, temperature and humidity the concentration of cloud droplets near cloud base in cloudy updrafts is a function of the updraft speed and the activity of Cloud Condensation Nuclei, provided the amount of precipitation scavenging is low. Since both RICO and KWAJEX are relatively remote oceanic locations, they might be expected to be the most similar in terms of background CCN. If, the hypothesis of similar updraft speeds is true, then we should expect similar droplet concentrations to be present in the two cases.

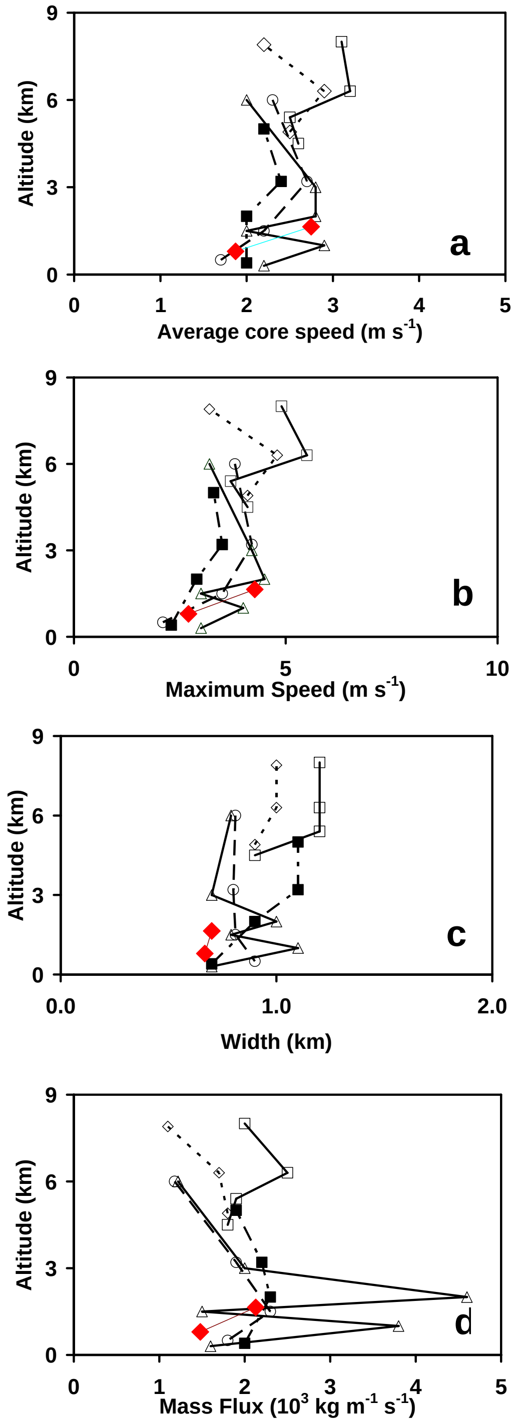

Figure 2. Median values of the parameters in Fig. 1, for TRMM-LBA (open diamonds), KWAJEX (outlined squares), GATE (outlined circles), TAMEX (outlined triangles), EMEX (black squares), and RICO (red diamonds). See text for more explanation. Adapted from Fig. 3 of Anderson et al. (2005).

Although updraft data in the lowest regions of KWAJEX clouds are not available, data were available below 4 km on 9 September 1999. Since the results in Fig. 2 suggest that the changes in updraft speed with altitude are rather gradual, especially above about 2 km, we compare these data with data from a RICO case that had a significant number of updrafts above 1.5 km in altitude. The RICO updrafts and FSSP concentrations above 1.5 km are compared with similar data below 4 km from KWAJEX in Fig. 3.

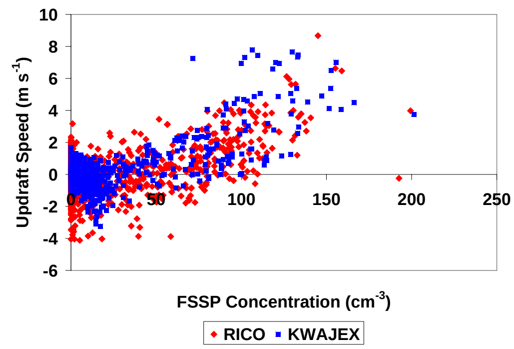

Figure 3. Comparisons of updraft strength versus FSSP drop concentration for 9 September, 1999 in KWAJEX (Blue squares), with similar data from 1 December 2004 in RICO clouds (red diamonds). See text for more explanation of the regions selected for study.

Given the likely differences in the data set (different sized clouds, different instruments and aircraft, different locations, etc.), the results are surprisingly similar.

5. SUMMARY

The similarities in updraft speed between RICO and the other tropical regions are encouraging, because it suggests that tropical cumuli of various sizes exhibit similar updraft speeds at similar altitudes. This suggests that the microphysical results from RICO are likely to be applicable to a wide range of tropical convection, at least for regions with similar aerosol. However, most of the airborne studies do not include the strongest storms (for safety reasons), so these results are somewhat biased towards smaller convective systems.

Further studies will examine airborne data from other regions and a wider set of cloud properties to better understand and document the similarities among tropical clouds from various regions.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

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