7A.4 COMPARISON OF ECHO CHARACTERISTICS OBSERVED DURING CAMEX4 AND CRYSTAL-FACE

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1. INTRODUCTION

The Keys Area Microphysical Project (KAMP), which was a component of the 4th Convective and Moisture Experiment (CAMEX4), and the Cirrus Regional Study of Tropical Anvils and Cirrus Layers - Florida Area Cirrus Experiment (CRYSTAL-FACE) field campaigns provided a unique opportunity to study the precipitation characteristics in the Florida Keys and in South Florida, respectively. The new NASA polarimetric (NPOL) 10 cm radar was deployed in both campaigns. During KAMP, NPOL was located near Key West. For CRYSTAL FACE, NPOL was deployed on the southwest side of the Florida peninsula south of Naples.

KAMP was conducted from mid-August to the end of September in 2001. CRYSTAL FACE took place during July 2002. Both experiments provided the opportunity to collect high resolution ground based measurements of convection. These data provide another database for ground validation of the Tropical Rainfall Measuring Mission (TRMM) satellite observations. It has been discussed that Key West could be used as an ocean validation site for TRMM. The main motivation of this study is to determine if Key West is a representative ocean site. For this study, statistical properties of echoes observed near Key West are compared to echoes observed over the Florida Peninsula.

NPOL radar data were used from both experiments. Data collected in Key West during KAMP were considered the "ocean" dataset. Whereas, echoes observed over the Florida Peninsula during CRYSTAL FACE were considered representative of "land" convection. Fractional echo area, echo top heights, and area averaged rainfall were used as the statistical measures. We are currently comparing the vertical structure of precipitation observed by the ground based radars to TRMM Precipitation Radar (PR) retrievals. These results will be discussed during the presentation.

2. DATA

NPOL radar is a 10 cm wavelength (3 GHz) dual-polarized Doppler radar that transmits and receives in the horizontally and vertical planes. It has a 3 dB beamwidth of 1.4° and transmits at a peak power of about 850 KW (425 KW/channel). NPOL records a variety of observables including: reflectivity, mean Doppler velocity, spectrum width, differential reflectivity, differential phase, linear depolarization ratio, and the correlation coefficient between the horizontal and vertical channels. We focus on the reflectivity in this study. Other variables will be compared in future studies.

For both campaigns, data were collected nominally at a temporal resolution of 10 min and spatial resolution of 1° (azimuth) x 250 m (range). Approximately 3000 volume scans were evaluated in this study. We quality controlled the data by hand to ensure artifacts such as incomplete scans, wet antenna, and side lobes were excluded in the analysis.

The TRMM satellite passed over NPOL many times during both campaigns. Because of the stability of the TRMM precipitation radar (PR) calibration (Kozu et al. 2001), we used the TRMM PR as a standard to compare the relative calibrations on NPOL for the two projects. NPOL and PR data were compared using a technique similar to Anagnostou et al. (2001). For both experiments, NPOL reflectivity measurements were adjusted to the PR in order to minimize biases in the results.

3. METHODOLOGY

Results for this study were generated using the original polar coordinate data to ensure the highest resolution possible. The analysis was limited to a maximum range of 100 km to minimize range dependence effects in the vertical structure profiles and rainfall estimates. To study "ocean" and "land" precipitation, data were examined only over water and land, respectively. The sector west of Key West (azimuths of 180°-360°) was used for the ocean analysis. The sector east of NPOL during CRYSTAL-FACE (azimuths of 0°-180°) was used to study convection over the Florida Peninsula. We make the assumption that the precipitation observed in these sectors originated in the same environment (i.e. over water or land). This assumption breaks down if large-scale systems such as tropical storms or frontal boundaries pass through the regions. For both datasets, there were no large-scale features observed.

Three main statistics were examined in this study. The first statistic was the fractional area above various reflectivity thresholds. Two thresholds were used: 10 and 40 dBZ. The 10 dBZ threshold was used to determine the overall extent of echo and at the same time, reduce the amount of noise included in the analysis. The 40 dBZ threshold was used as an index to measure the amount of convective precipitation.

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Because of the limitations of the extended abstract, only the 10 dBZ threshold results will be shown.

To measure the vertical extent of the radar echoes, a 30 dBZ echo top threshold was used. The threshold was based on the study by DeMott and Rutledge (1998). They indicate that the height of the 30 dBZ threshold has been linked to the microphysical properties and lightning activity. Also, a higher threshold reduces the probability of echo at a smaller threshold falling below the minimum detectable signal of the radar at distant ranges.

The final statistic examined in this study was unconditional area averaged rainfall rate. Reflectivity data were transformed in polar coordinates and then averaged using the Marshall-Palmer Z-R relationship ($Z = 200\ R^{1.6}$). The reason for using a simple Z-R relationship was because we are looking at relative contributions of rainfall and not focusing on absolute quantities. Future work will include rainfall estimation using polarimetric techniques (i.e. Bringi and Chandraseker (2002)). In the next section, we present the results of this analysis.

4. RESULTS AND DISCUSSION

Figure 1 shows distributions of fractional area, 30 dBZ echo top height, and area averaged rainfall. For all the plots, the “ocean” observations are indicated by a solid line and land observations are indicated by a dashed line. The fractional area results (Fig. 1a) for both the land and ocean have similar lognormal distributions. However, the results show that there is a larger frequency of smaller echoes over the ocean then land. The mode occurs around a fractional area of 2-4% for both but the peak for land is about a factor of 2 lower (15% in comparison to 34%). The plot also shows that the echoes observed over land are larger in comparison with the tail decreasing at a slower rate. The mean (median) is 13% (9%) for land and 8% (4%) for the ocean. This would indicate that the systems over land have a population of larger, more organized systems than observed over Key West.

The 30 dBZ echo top height distributions are significantly different between the ocean and land echoes. However, the range of variation of echo top heights is consistent with DeMott and Rutledge (1998) for convection observed over the Tropical Western Pacific Ocean. Both distributions range from about a minimum of 2 km to a maximum of 11 km in height. The frequency of occurrence increases to a maximum of 20% at an echo top height of 6 km before decreasing to zero at a height of 11 km for the ocean echoes. On the other hand, echo top height observations remain relatively uniform over land. There is slight maximum at a height of 10 km. The mean 30 dBZ echo top height over the ocean was 6.0 km and 6.6 km over the land. The deeper convection over land corresponds to the strong daytime heating over South Florida.

Figure 1c shows the distribution of area averaged rainfall rate. The plot indicates that precipitation observed over land has a larger variability the ocean precipitation. For both distributions, the modesoccur at rainfall rate of 0.075 mm/h. However, ocean rainfall estimates range from 0.05 mm/hr to 0.15 mm/h. Whereas, land rainfall estimates have a maximum of about 0.3 mm/h. The mean rainfall rate for the ocean distribution is 0.096 mm/h and 0.123 mm/h over the land, which indicates there was more intense convection observed over the land. All three statistics show that precipitation observed near Key West differs from precipitation observed over the Florida Peninsula, which is indicative of more ocean type characteristics.

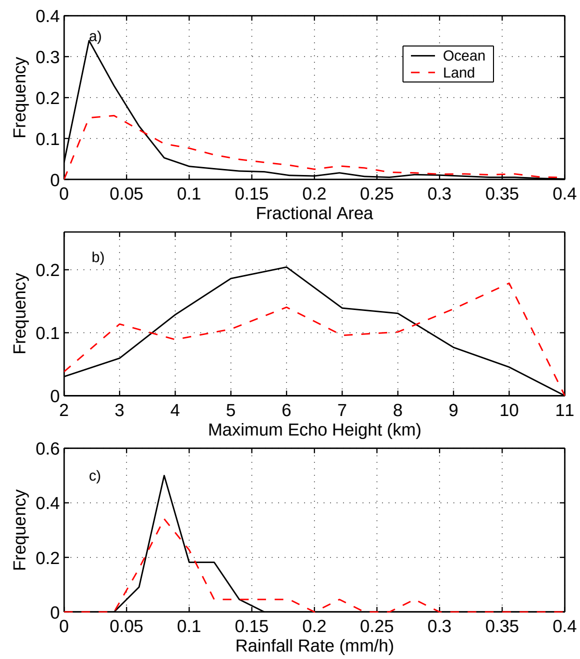

Figure 1: Frequency distributions of a) fractional echo area, b) 30 dBZ echo top heights, and c) area averaged rainfall rate. Ocean observations are displayed as solid lines whereas land observations are shown as dashed lines.

The second statistical analysis examined the diurnal variability of echoes observed over the ocean and land. Figure 2 displays the diurnal variability of the three statistics discussed previously. Figure 2a shows that the fractional area for both the land and ocean echoes vary on a daily timescale. The amount of echo observed over the ocean has a minimum around 0800 local time (LT) and a maximum 12 hours later at 2000 LT. In contrast, the maximum echo coverage over land peaks around local midnight and is at a minimum around 1100 LT. This result is somewhat surprising as it would be expected that the maximum would occur in late afternoon/evening after the maximum daytime heating (similar to the ocean curve). Upon further investigation of the observations, it was discovered that peak at midnight LT was due to strong AP that occurred over land at night, but was not seen over the ocean. If the AP was removed, it is likely that the diurnal distribution of echo area will look similar to the ocean observations.

It is interesting to note that the amount of echo over land is almost a factor two more than the ocean for many of the hours. This would indicate that more organized, large-scale precipitation was observed over land. We believe it is a combination of more organized convection and non-meteorological effects such as AP.

The diurnal distributions of the 30 dBZ echo top height are shown in Figure 2b. The variability observed over land is typical with the most intense convection occurring during the peak daytime heating. Echo top heights over land range from a minimum of about 5.3 km at 0700 LT to a maximum near 8 km at 1600 LT. Over the ocean, echo top heights are relatively uniform throughout the day with a small maximum of 6.5 km occurring around 1500 LT and a minimum of 5.5 km being observed around local midnight.

The final plot shows the diurnal variability of area averaged rainfall rate. Both the ocean and land observations have peak in the late afternoon (~1800 LT) and minimum occurring around 0600 LT. The peak lags the peak in echo top height by several hours which is reasonable being the storms will have reached largest extent and maximum intensity around this time of day. The minimum corresponds to the period of most stable conditions just before sunrise. The rainfall variability over land is almost a factor of two greater over land than the ocean. Both distributions have a minimum around 0.07 mm/h, but the rainfall rate over land peaks around 0.17 mm/h whereas the rainfall rate over the ocean reaches maximum of only 0.12 mm/h. The diurnal analysis would indicate that echoes observed near Key West have some characteristics that would typically observed over land.

5. CONCLUSIONS

This study utilizes a relatively large radar database to determine if Key West could be considered an ocean validation site for TRMM. We compared NPOL radar data collected during August-September 2001 near Key West to NPOL radar data collected during July 2002 over the Florida Peninsula.

Distributions and diurnal cycles of echo area, echo top height, and area averaged rainfall rates indicate that convection observed near Key West has different characteristics than convection observed over the Florida Peninsula. However, the analysis shows that the echoes observed over the "ocean" near Key West have some similar features to echoes observed over land. For example, echo area, echo top height and area averaged rainfall rate statistics show an afternoon peak, which is typical of strong daytime heating observed over land. Previous studies indicate the maximum in these statistics generally occur during the early morning hours over the ocean (Kucera 2002; Short et al. 1997). The smaller variability observed in the echo statistics over the ocean would indicate that the precipitation is strongly influenced by the ocean environment.

Our preliminary analysis indicates that Key West has characteristics of a coastal site and would not be suitable as an ocean site. However, Key West would be useful for TRMM validation studies to evaluate the performance of the TRMM satellite rainfall algorithms near coastal regions.

6. ACKNOWLEDGEMENTS

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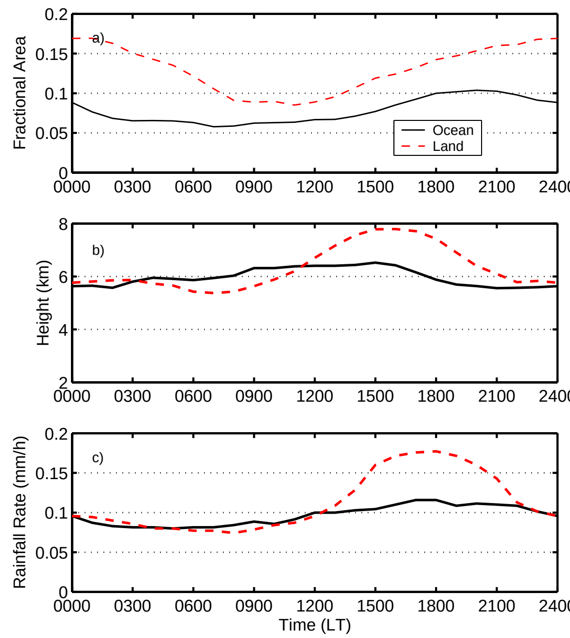

Figure 2: Diurnal cycle of a) fractional echo area, b) 30 dBZ echo top heights, and c) area averaged rainfall rate. Ocean observations are displayed as solid lines whereas land observations are shown as dashed lines.

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