2B.1 SHIP RADAR OBSERVATIONS OF A DEVELOPING TROPICAL STORM IN THE EAST PACIFIC

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1. INTRODUCTION

During the recently completed East Pacific Investigation of Climate Processes in the Coupled Ocean-Atmosphere System (EPIC) field program, the NOAA research vessel Ronald H. Brown (RHB) was deployed in the east Pacific Inter Tropical Convergence Zone (ITCZ) for approximately 3 weeks near 10º N, 95º W. One of the principal objectives of the EPIC-ITCZ program was to observe the modulation of convection by synoptic-scale easterly waves and the air-sea coupling process in this poorly sampled region of the east Pacific. In addition to the RHB, major observational platforms deployed during the EPIC-ITCZ field phase included the NSF research vessel New Horizon as well as the NOAA P-3 and NCAR C-130 aircraft. Data from the experiment will be used as validation to improve forecast models.

The RHB carried a variety of platforms to sample atmospheric and oceanic phenomena, including a scanning C-band Doppler radar, radiation flux instrumentation, air-sea flux system, Doppler lidar, 35 GHz cloud radar, UHF wind profiler, sea surface temperature (SST) sensors, as well as standard surface meteorological instrumentation and a suite of rain gauges. Herein, we focus on the analysis of C-band radar data that was collected on 10 September, 2001 as the ship passed through an easterly wave which later developed into tropical storm Ivo.

2. DATA AND METHODOLOGY

The RHB departed San Diego on September 5, 2001 en-route for approximately seven days to it's on-station position in the east Pacific ITCZ. On September 10th, the ship passed through the center of developing tropical storm Ivo (Fig. 1). The ship instrumentation sampled approximately 12 hours of convection associated with the tropical disturbance starting near 7 UTC. The C-band radar conducted an alternating series of low-level and full volume scans for rain mapping and to characterize three-dimensional structure of the convection. The full volume scans included a 21-tilt sequence up to 52° for single-Doppler kinematic retrievals (Matejka and Srivastava, 1991). In subsequent processing, the radar data were interpolated to a cartesian grid and partitioned into convective and stratiform components using a reflectivity-based texture algorithm similar to Rickenbach and Rutledge (1998).

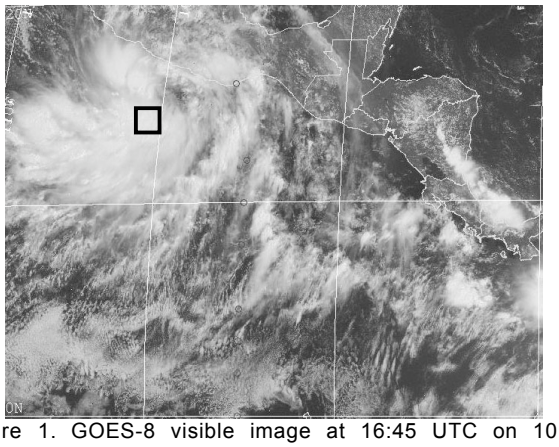

Figure 1. GOES-8 visible image at 16:45 UTC on 10 September 2001. The black rectangle indicates the approximate position of the R.V. Brown (13.5°N, 101°W).

3. RESULTS

During the 10 September event, the domain sampled by the radar (approximately 71,000 km^2) contained a significant number of echo features (Fig. 2). Specifically, the fraction of the domain containing radar echo above 10 dBZ reached 80% for over two hours and remained near 60% for a continuous seven hour period. Figure 2 also shows that the peak in relatively weak (stratiform) echo lagged the peak in intense (convective) echo by several hours.

The radar documented the change in precipitation vertical structure as the ship passed through regions of significant convection with echo tops approaching 14 km and 30 dBZ echo tops extending to near 9 km embedded in regions that were predominantly stratiform in nature. After about 17 UTC, the relative fraction of convective echo decreased (Fig. 3) as Ivo moved off the northwest and the ship passed through the outer reaches of the disturbance.

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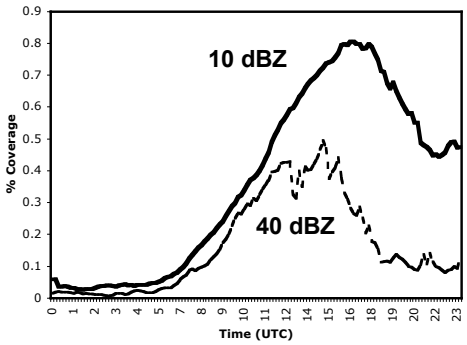

Figure 2. Time series of fractional area echo coverage on 10 September 2001 using 10 dBZ (solid) and 40 dBZ (dashed) reflectivity thresholds.

Animation of radar images showed distinct rotation in echo features associated with the passage of the disturbance (not shown). Despite an approximate 4º C drop in surface air temperature and sustained winds approaching 20 m s^{-1}, the SST remained nearly constant throughout the observation period (~29.5º C – not shown). Peak values of latent and sensible heat flux exceeded 400 and 100 W m^{-2}, respectively.

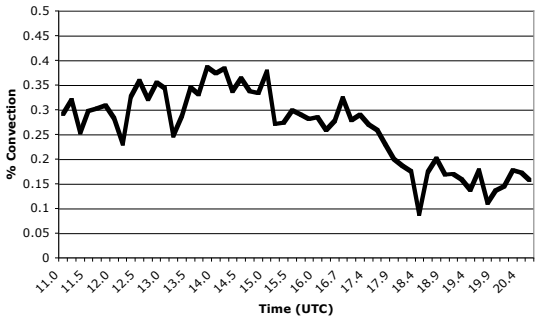

Figure 3. Time series of the relative fraction of convective echo sampled by the C-band radar on 10 September.

EVAD (Extended Velocity Azimuth Display) single-Doppler retrievals were conducted continuously at 10-minute resolution for approximately 4 hours in the latter part of the observation period (Fig. 4). The EVAD retrievals documented the transition from convection (low-level convergence, upper level divergence) to stratiform (mid-level convergence sandwiched between upper and lower level divergence) kinematic structure between about 18:00-19:30 UTC. Note that the kinematic field in Fig. 4 shows a convective signature prior to 18 UTC despite the fact that the partitioning algorithm indicates that the region was dominated by stratiform echo at this time (Fig. 3). The results illustrate the potential shortcomings of reflectivity-based texture algorithms in non-squall line type environments where the transition from convective to stratiform echo is not always well defined.

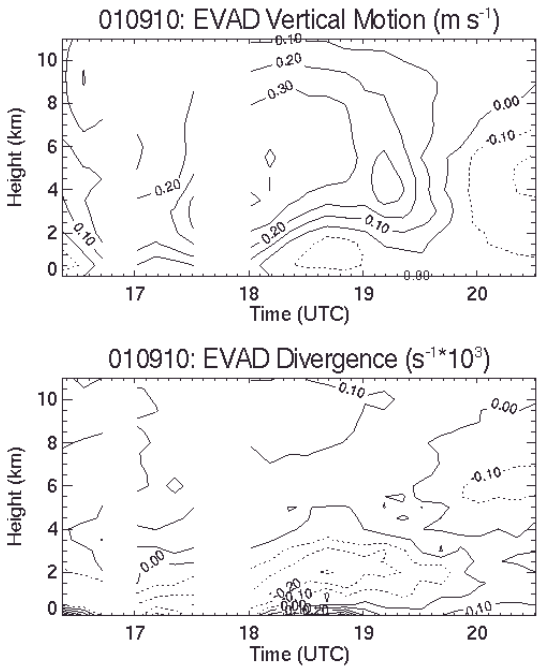

Figure 4. Time-height cross section of vertical air motion (top) and divergence (bottom) for 10 September 2001 using the EVAD retrieval technique. Positive (negative) values are solid (dashed).

4. SUMMARY

The passage of the RHB through Ivo provided a unique opportunity to study the kinematic and microphysical characteristics of a tropical storm for an extended time period. Future work will focus on combining the radar results with the RHB surface meteorological and flux data in order to ascertain the effects of the disturbance on air sea coupling processes.

5. REFERENCES

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