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OBSERVATIONS DURING EPIC2001 – DIURNAL CYCLE IN THE EAST PACIFIC

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1. INTRODUCTION

The diurnal cycle in the east Pacific seems to have a considerable impact during the initiation stage of tropical storms Raymond et al. (1997). For studies of tropical cyclogenesis, it is therefore important to understand the origin and variability of this cycle. As part of this effort, in this work, we offer documentation of this oscillation as observed during the field campaign EPIC2001 (East Pacific Investigation of Climate 2001).

EPIC was a field campaign designed to improve our understanding of the physical processes governing deep convection in the east Pacific warm pool (Raymond et al. 2003). It took place from September 1 to October 14, 2001. During this period the warm pool was investigated using a variety of platforms and instrumentation. Here, we use the observations taken over a $4° \times 4°$ box centered at (95°W, 10°N). This box is called the ITCZ (Intertropical Convergence Zone) box.

Although many variables were measured, we present results based on several derived fields that seem to capture the sequence of events in relation to the convection over the ITCZ box. We use the properties of the moist entropy and mass fluxes to determine the peak in convective activity, which occurs around 10 UTC. This peak appears to be coincident with a maximum in mid-level moisture, but preceded by the minimum in convective inhibition by about 4 hours. Satellite infrared temperature, which is commonly used as a surrogate for convection, has its minimum about two hours later than the maximum in convective activity.

2. DATA SOURCES

Infrared cloud top temperatures are frequently used as a surrogate for convection. We use the images taken by the GOES satellite at one hour intervals to get an idea of the diurnal cycle of convection as observed by the satellite.

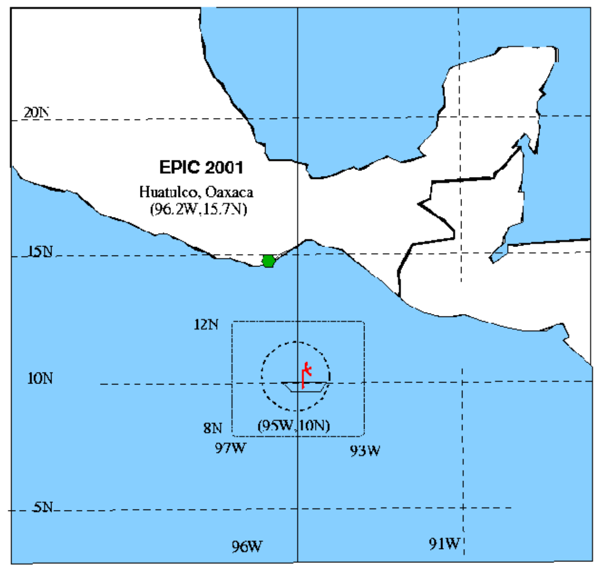

Figure 1: NOAA vessel Ron H. Brown station over the east Pacific during EPIC2001.

The rest of the data used in this study were obtained on-board the NOAA vessel *Ron H. Brown*, which was stationed at the center of the ITCZ box from September 10 to October 1. Insitu observations of the environment are obtained from soundings, launched every four hours, and surface observations, reported at a 5-minute resolution. Furthermore, the *Ron H. Brown*operated a C-band Doppler radar almost continuously in the ITCZ box. We have used the volume scans performed at the 0,3,6,9,12,15,18, and 21 UTC. These scans contain reflectivity and Doppler velocity information. The Nyquist velocity of the radar is 12.2 $\mathrm{m\,s^{-1}}$; the beam width is 1.0 degree; the maximum range is 150 km with gate spacing of 250 m. The azimuthal rotation rate of the radar was 18 degrees per second and the elevation angles range from 0.8 to 53.4 degrees.

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3. DATA ANALYSIS & RESULTS

In order to visualize the diurnal oscillation of a given field, a function of time for this field is constructed as follows: all data of the given field collected during the project at the same nominal time are averaged and the result is assigned to that time:

$$F_d(t) = \frac{1}{n}\sum_{i=1}^{n} F_i(t) \tag{1}$$

This function represents the averaged diurnal cycle for the project.

The diurnal cycle for the satellite infrared temperature is obtained by applying (1) to the the spatial averages of this field over ITCZ box. The result is shown in panel D of figure 2.

We have chosen to characterize the environment using moist entropy. This variable is calculated from temperature, pressure, and relative humidity via the entropy definition given in Lopez Carrillo and Raymond (2005). The diurnal cycle of the vertical profile of moist entropy is shown in figure 3. Because moist entropy is approximately conserved during convection, one expects contour lines in this figure to bend upward during convection. Such deformation is a good indicator of convection taking place. Environmental moisture can be visualized by plotting the difference between the saturated and unsaturated moist entropy. We call this difference the saturation deficit. The diurnal cycle of the saturation deficit profile is shown in figure 4. For comparison, figure 5 shows the diurnal oscillation of the relative humidity profile. It can be seen that moisture changes in the lower troposphere display better when the moist entropy is used. A measure of the saturation fraction of the whole column is obtained by taking the ratio of the vertical integrals of the difference between moist entropy and dry entropy, and the difference between saturated and dry entropy. The result is plotted in panel A of figure 2.

We have also constructed the diurnal cycle for two indices of deep tropical convection in east Pacific: DCIN(deep convective inhibition), and DCINLOW (low DCIN values from the tail of their distribution) (Raymond et al., 2003). The results are shown in panel C of figure 2.

Since the reflectivity measured by the C-band Doppler radar is basically due to the presence of precipitation-sized particles, the reflectivity can be used to estimate the fractional area cover by precipitation. The resulting diurnal cycle is shown in figure 6. Radial velocities observed by the Doppler radar can be used to estimate mass fluxes associated with precipitating systems, which are helpful identifying signatures of convective activity. An estimate of the divergent mass flux is shown in figure 7.

Since moist entropy is approximately conserved in moist processes, the gross moist stability of the column can be estimated by determining the net flux of moist entropy passing through the column. We have combined the radar divergence and moist entropy profiles to estimate the flux of entropy. The result is shown is the panel B of figure 2.

4. CONCLUSIONS

In order to characterize the diurnal cycle of convective activity, we have constructed the average diurnal cycle of several indicators of convection. By examining the evolution of the moist entropy and radar-derived divergence profiles (figures 3 and 7), we conclude that the maximum in convective activity occurs around 10 UTC. This conclusion is reinforced by the results obtained for the convective inhibition and infrared brightness temperature, figure 2 panel C and D respectively. These figures show the peak in convective activity preceded by the minimum in convective inhibition and followed by the minimum in infrared brightness temperature. The evolution of the environmental moisture shows a steady increase before and sharp decline after the convective peak.

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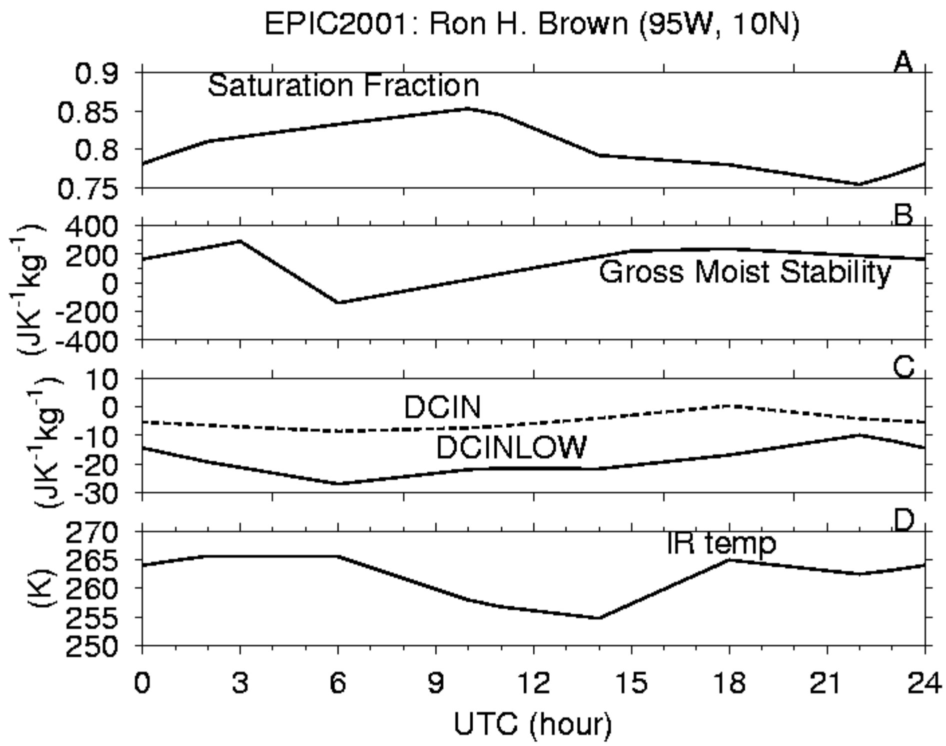

Figure 2: Panels: (A) saturation fraction, (B) gross moist stability, (C) convective inhibition and convective inhibition at the tail of the distribution, (D) average of the infrared satellite temperature.

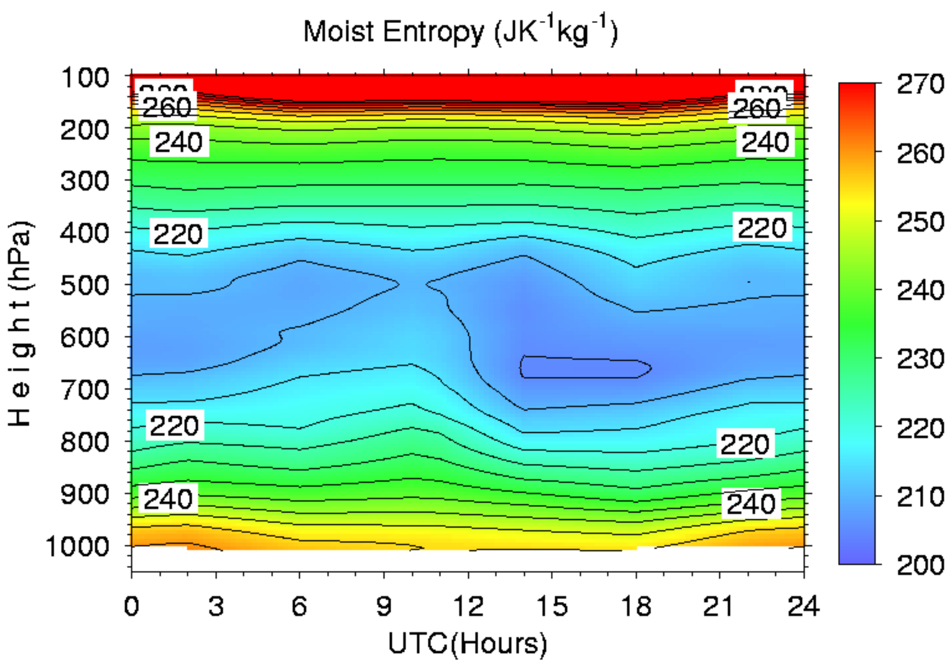

Figure 3: Diurnal cycle of moist entropy.

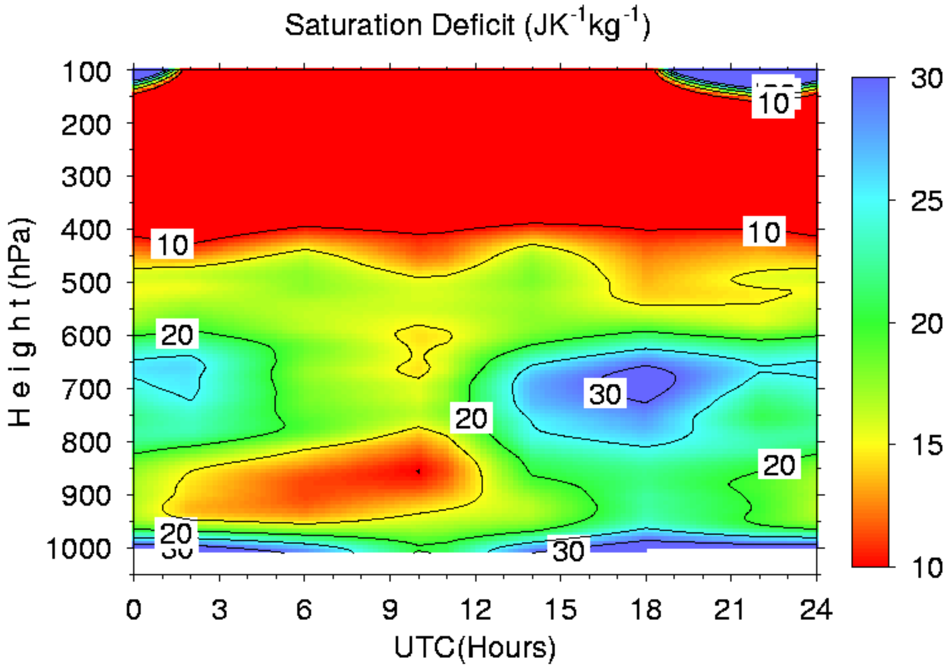

Figure 4: Diurnal cycle of the saturation deficit(difference between saturated and unsaturated moist entropy).

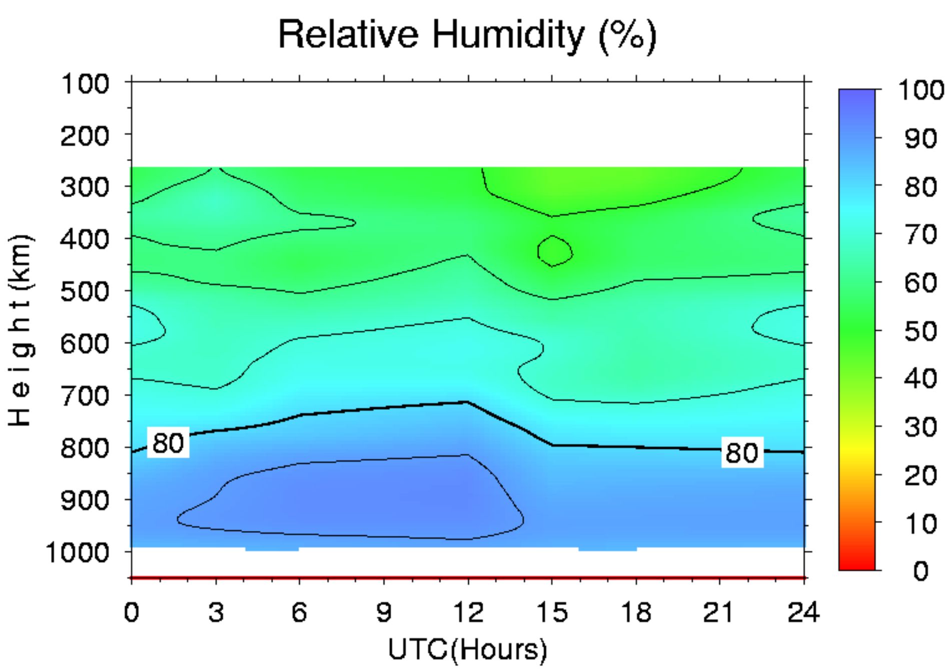

Figure 5: Diurnal cycle of the relative humidity.

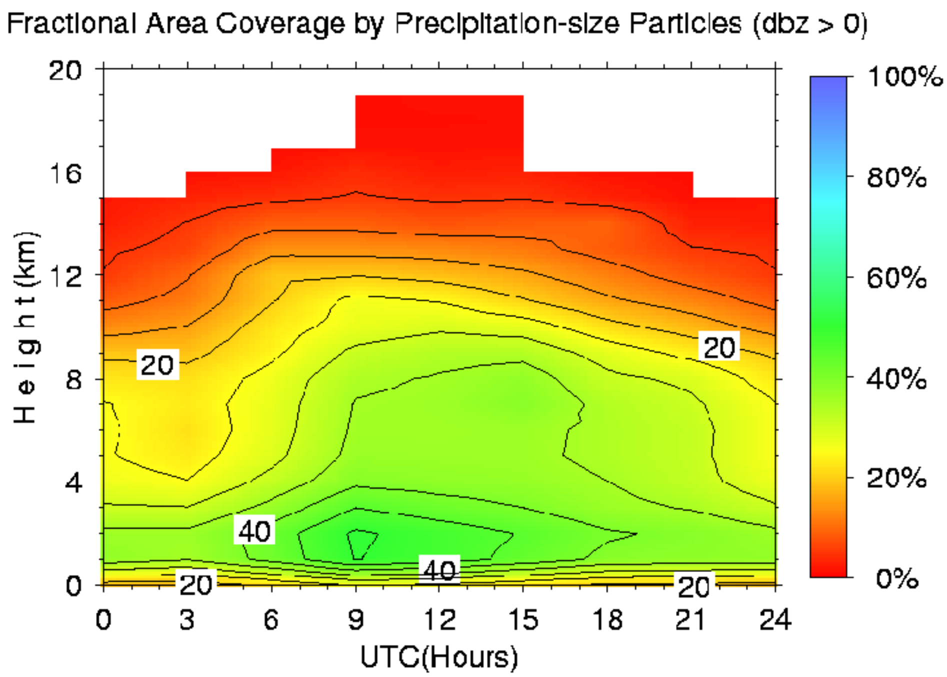

Figure 6: Diurnal cycle of fractional area cover by precipitation.

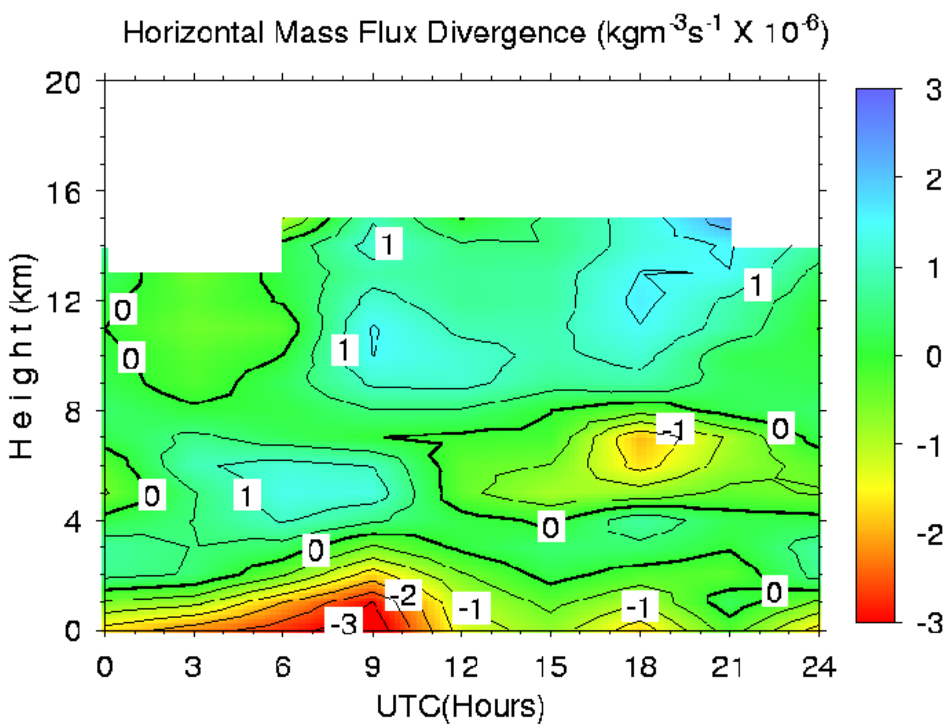

Figure 7: Diurnal cycle of divergent mass flux profiles.