13B.4 DIURNAL CYCLE OF CONVECTION IN THE EAST PACIFIC ITCZ DURING EPIC-2001

Dennis J. Boccippio*, Walter A. Petersen†, Robert Cifelli† and Steven A. Rutledge†
* NASA / MSFC, Marshall Space Flight Center, AL
† Colorado State University, Ft. Collins, CO

1. INTRODUCTION

Radar and radiosonde data at 10°N, 95°W are analyzed for three weeks (Sep 10-Oct 1, 2001) of the EPIC-2001 field campaign, along with remote lightning observations. Data from the *R/V Ronald H. Brown* C-band radar include 150-km full volume scans at 10 min updates (3043 scans), post-processed to yield 1-km and 6-km reflectivity CAPPIs, 15 and 30 dBZ echo top height, and Vertically Integrated Liquid (VIL). Radiosonde data include 4-hrly Vaisala soundings with GPS winds. Lightning data include climatological (1995-2001) Jul-Sep total lightning observations from the Optical Transient Detector (OTD) and Lightning Imaging Sensor (LIS) low-earth orbit (LEO) instruments, and Sep 2001 long-range ground strike data from the National Lightning Detection Network (NLDN).

A pronounced diurnal cycle of convection is observed, modulated by the passage of 3-5 day easterly waves (paper 13B.3). Convective intensity rises from sunset until local midnight, while total convective frequency-of-occurrence peaks just after dawn. Some evidence of bimodal peaks in convective intensity (near midnight, and in the morning) is found in echo height and lightning data. Conditional instability peaks prior to midnight, and appears driven by surface flux moistening of the boundary layer during the early nighttime hours.

2. QUALITATIVE OBSERVATIONS

The recurrent diurnal cycle of convection was apparent to radar scientists during the EPIC-2001 IOP even before statistical analysis of the radar data. On typical days (and most pronounced in ‘suppressed’ periods between easterly wave passage), few precipitating cells were present just after local dusk. After nightfall, cell frequency and depth increased, and by midnight, flashing cells were not uncommon. Visually observed nighttime flash rates from cell complexes were often ~4 fl/min, ‘healthy’ flash rates for tropical oceanic storms. Intracloud channels were unusually well-delineated visually, perhaps consistent with atypically low liquid water content oceanic cells. Convective cells clustered and aggregated through the early morning, pre-dawn hours, and large organized systems often persisted through morning hours. Decay during late morning and early afternoon was typical. Exceptions to these patterns included the actual easterly wave trough passages, although statistical examination suggests diurnal modulation continued during these events. Cells typically formed in-situ within the analysis domain, rather than advecting offshore from the Central American coast (several hundred km N/NE). Cell intensity, coherence, vertical development and observed lightning were on average greater than observed by the authors during the COARE IOP-3 at 155°E, 2°S.

• *Corresponding author address:* Dennis J. Boccippio, NASA/MSFC SD-60, Marshall Space Flight Center, AL 35812; email: Dennis.Boccippio@msfc.nasa.gov.

3. RADAR OBSERVATIONS

Figure 1 depicts the diurnal convective cycle, shown as a frequency distribution of observed 30 dBZ (top) and 15 dBZ (bottom) echo top height distributions. (Units in the left panels are km²/km/hr; i.e., mean area of occurrence of an echo top height “bin” at each local hour). The hourly means are overlay (solid line in left hand panels). For 30 dBZ echo top heights, there is no diurnal variation in the mean, although the frequency distribution evolves significantly. From 0000–0600 UTC (1800–2400 local), convective cells are comparatively infrequent, but the occurrence of the most intense cells grows significantly. From 0700–1800 UTC (0100–1200 local), cells in the “tail of the distribution” diminish, although domain total frequency of occurrence continues to rise. The pattern is similar,

FIGURE 1

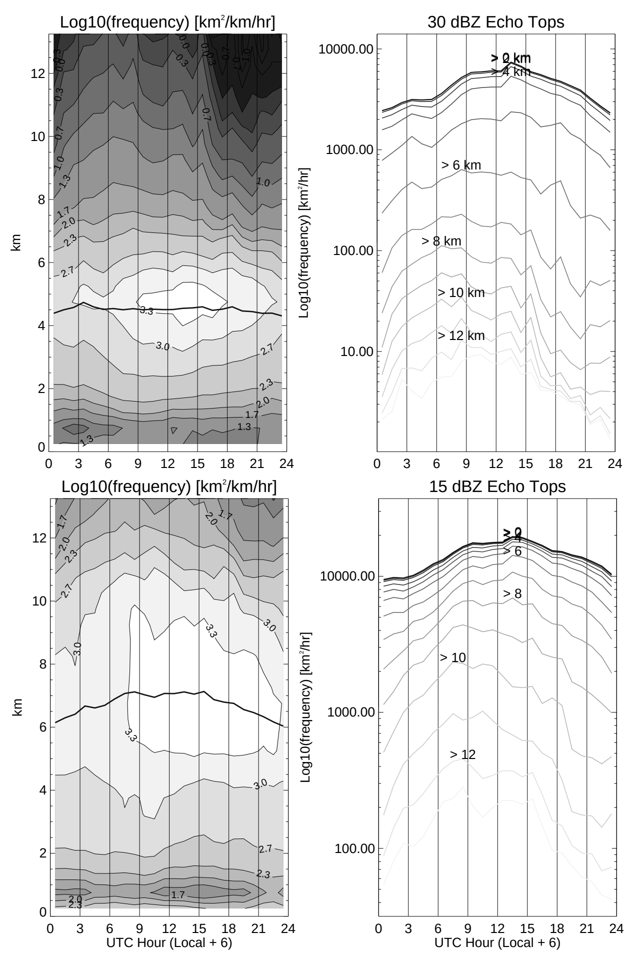


FIGURE 2

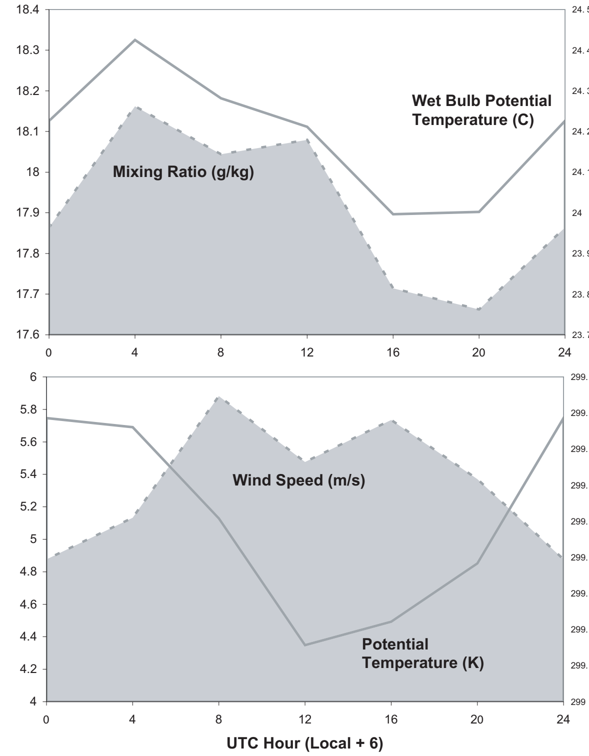
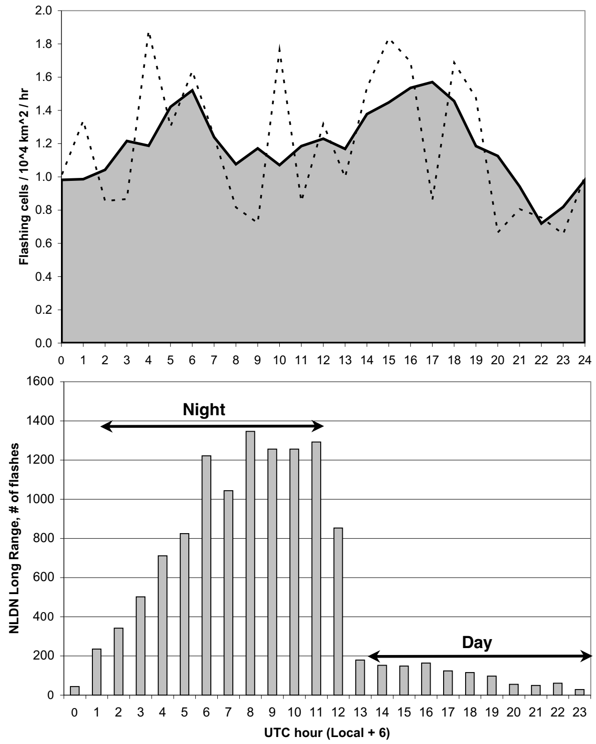


FIGURE 3



although shifted slightly later, for 15 dBZ echo tops, although these show a diurnal cycle in their mean. Similar, although less pronounced, distributions are found in analyses of 1 and 6 km CAPPI and VIL products.

4. THERMODYNAMIC OBSERVATIONS

Figure 2 shows 3-wk composites of the mean thermodynamic properties of the lowest 400m (typical mixed layer depth) of the 4-hrly Vaisala soundings. BL potential temperature shows an expected warming from 1200–2400 UTC (0600–1800 local), and cooling from 0400–1200 UTC (2000–0600 local). In contrast, the BL dries from 1200–2000 UTC (0600–1400 local), moistens in the late afternoon, and remains moist through the night. The diurnal variation of water vapor mixing ratio dominates the diurnal cycle of wet bulb potential temperature, which peaks at 0400 UTC (2000 local). Full-sounding analyses of thermal buoyancy indicate that instability is very closely coupled to BL θ_w, whose diurnal cycle closely resembles the diurnal deep convective cycle shown in section 3.

The diurnal cycle of θ_w, closely coupled to mixing ratio, may be consistent with an explanation in which communication of moisture from the BL to the lower troposphere by thermals or nonprecipitating cumulus is curtailed during early nighttime, while surface moisture fluxes continue.

5. LIGHTNING OBSERVATIONS

LEO satellite and ground network lightning observations are shown in Figure 3. At top, the diurnal cycle of flashing cell (>1 fl/min, the LIS/OTD threshold) frequency of occurrence is shown (1-hr means, dashed; 6-hr running means, solid/filled; satellite data for Jul–Sep 1995–2001, 8°N–12°N, 97°W-93°W). The 2100–2300 UTC minimum and 0400–0600 UTC maximum are consistent with the radar deep convective and soundng BL thermodynamic signals. The 1500–1700 UTC maximum, if real (the LEO sampling of such a small domain is poor), reflects a secondary intensification in the morning hours which may have a weak counterpart in the echo top distributions. Secondary signals are not seen in CAPPIs or VIL.

At bottom, long range cloud-to-ground (CG) network data for Sep 15–30, 2001 are shown. At long ranges, due to variations in ionospheric height, day and night network data are not intercomparable (the day/night detection efficiency [DE] differs by about a factor of 10). At night, steadily increasing CG production occurs from 0000–0600 UTC, and remains roughly constant frm midnight to dawn. During the day, flash production drops from approximately 1600–2400 UTC (mid-morning til dusk). While day/night DE differences complicate interpretation, there is little evidence of the bimodal peak shown in flashing cell frequency of occurrence, suggesting that diurnal evolution of per-cell flash rate may be occurring as well.

6. CONCLUSIONS

A pronounced diurnal cycle of BL moist enthalpy, deep convection and lightning is found in the East Pacific ITCZ. The cycle appears locally driven (cells do not advect offshore from Central America). Inconclusive evidence exists for a secondary convective peak in the early morning hours, not directly coupled to BL moist enthalpy.

Acknowledgements: Partial support for this research is provided by NSF Grant #ATM-0002256. We are grateful to the crew of the *R/V Ronald H. Brown* for their professional support and dedication during this research.