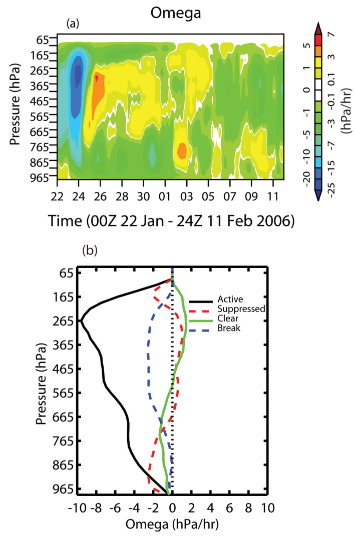
Large-Scale Structures and Diabatic Heating and Drying Profiles Revealed by TWP-ICE

Research Highlight

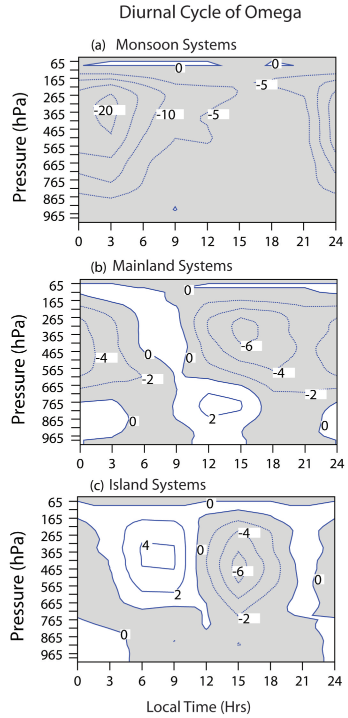
The large-scale dynamic and thermodynamic structures play an important role in destabilizing the tropical atmosphere, initiating and maintaining deep convection. On the other hand, latent heating released from tropical convective systems is a major energy source to the large-scale circulation. Documenting these structures of tropical convective cloud systems from observations is a key step to understand how cumulus convection interacts with its large-scale environment.

This study documents the characteristics of the large-scale structures and diabatic heating and drying profiles observed during the ARM Tropical Warm Pool-International Cloud Experiment (TWP-ICE), which was conducted in January-February 2006 in Darwin during the northern Australian monsoon season. The examined profiles exhibit significant variations between four distinct synoptic regimes which were observed during the experiment. The active monsoon period is characterized by strong upward motion and large advective cooling and moistening throughout the entire troposphere, while the suppressed and clear periods are dominated by moderate mid-level subsidence and significant low- to mid-level drying through horizontal advection. During the break period, upward motion and advective cooling and moistening are located primarily at mid-levels. Strong diabatic heating and drying are seen throughout the troposphere during the active monsoon period, while they are moderate and only occur above 700 hPa during the break period. The diabatic heating and drying tend to have their maxima at low-levels during the suppressed periods.

These structures also exhibit significant differences in their diurnal variations between different regimes. Convection during the monsoon period was weak during the day, increased rapidly in the evening, and reached its maximum intensity in the early morning hours. Convection over the mainland and Tiwi Islands regions during the break period was initiated primarily by the sea-breeze circulation and confined in the lower troposphere in the mid-morning and then quickly developed into deep convection and reached its maximum intensity in the afternoon. The monsoon systems featured upward motion throughout the day with the maximum ascending level in the upper troposphere at 0300 LST due to the nocturnal deep convection. In contrast, the mainland and island systems showed an afternoon maximum in vertical velocity in the mid- to upper-troposphere. At their initial system development stages (around 0900-1000 LST), the mainland and island systems developed in an environment with an ascending layer near the surface due to the sea breeze circulation and a subsidence layer above, especially for the island systems. The subsidence layer contributes to limiting the mainland and island convective systems to low-levels at their initial stages and to focusing convection along sea-breeze convergence lines later in the day.



Analyzed vertical velocity (omega): (a) Temporal evolution; (b) Averaged profiles for different periods. Significant variations between the four distinct synoptic regimes are shown in the vertical velocity profiles observed during TWP-ICE.



Diurnal cycle of vertical velocity (hPa/hr) for the monsoon systems observed during the active monsoon period and the mainland and island systems observed during the break period. In the figures, negative values are shaded.

Reference(s)

Xie S, T Hume, C Jakob, SA Klein, RB McCoy, and M Zhang. 2009. "Observed large-scale structures and diabatic heating and drying profiles during TWP-ICE." Journal of Climate, , . ACCEPTED.

Contributors

Shaocheng Xie, *Lawrence Livermore National Laboratory*

Working Group(s)

Cloud Modeling