1. Introduction

The NOAA Research Vessel Ronald H. Brown (RHB) was located at approximately 10 N and 95 W from September 10-31, 2001, focusing on studies of deep convection in the eastern Pacific (EPZ). A vertically pointing cloud radar (Ka-band, 6.66 mm wavelength) was present. Although cloud radars are not normally applied within heavily-raining regions, they are useful for elucidating the cloudiness vertical structure. Uncertainty in the echo values from attenuation by rain is mitigated by the large (80%) percentage of data from EPZ not affected by precipitation below the melting level, and by a high radar sensitivity (-40 dBZ at 10 km, or -34 dBZ at 15 km, without attenuation) that preserves the data’s utility for all but the most strongly precipitating of conditions.

Coincident precipitation radar data evaluates the vertical structure of the precipitation and can provide statistics for a larger spatial area than is sampled by the cloud radar.

This poster presents the cloud and precipitation vertical structure observed during EPZ as a function of time of day, easterly wave phase, and “disturbed” versus “undisturbed” periods. An unusual observation is a cloudiness and precipitation peak at 8 km. A peak at this altitude has not been previously documented, and it is not evident within precipitation radar data from the TEPPS experiment that occurred at approximately 125 W and 6-8N. A hypothesis for the existence of the peak is presented, but further work is required to fully understand the presented observations.

2. Experiment-mean Statistics

As shown in Fig. 1, a maximum in cloud radar echo frequencies occurs between 1-2 km, 5-6 km, 8 km, and approximately 11-12 km. These peaks coincide with maxima within a frequency distribution of stable layers from all of the EPZ soundings (Fig. 2).

The 1-2 km peak can be explained as boundary-layer cloudiness and rain. The 11-12 km peak coincides with the level of maximum wind divergence, shown in Fig. 3a from precipitation radar data, and with the mean sounding lapse rate minimum (not shown). The 5-6 km peak occurs slightly above the melting/freezing level and is discussed by Johnson et al. (1999) and others. The 8 km peak is not previously documented, coincides with the level of maximum vertical velocity, as denoted by the regression of the divergence upon the precipitation given within Fig. 3b.

4. "no-rain" versus "heavy rain"

Cloud radar from vertical scans containing no precipitation below 4.5 km is examined to remove concerns about attenuation. The dilational pattern is similar to that shown in Fig. 4, but no longer shows an 8 km peak in the afternoon.

The precipitation radar data is composited into “disturbed” and “undisturbed” times, based on the rainfall rate, and diurnal cycles constructed. The 8 km relative maxima for the “undisturbed” times occur about 3 hours after the relative maxima for the “disturbed” times.

5. Easterly Wave Composite

Both the precipitation and cloud radar data are composited according to the phase of three easterly waves that swept through the experiment site, using the criteria outlined in Peterson et al., (2002). Within the cloud radar data, a slight preference of the 8 km peak is seen for the trough and southerly phases. This is less obvious within the precipitation radar data.

5.6 Easterly Wave Composite

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6. Hypothesis (and Future Work)

The existence of an 8 km peak is puzzling. At 8 km the mean temperature is -18 C and the atmosphere is still buoyant for surface parcels. Within previous modeling work (Zuidema, 1998), however, the level is a preferred detrainment level for surface parcels experiencing only liquid water condensation and no ice deposition (figure below). Although it is generally more realistic to include ice deposition above the freezing level, conditions during EPZ may have been favorable for lifting liquid to high altitudes. Such an explanation would help explain why a peak at 8 km was observed during EPZ, but not during other tropical ocean field experiments. In the words of one well-seasoned participant, EPZ was “the rainiest field experiment I have ever been on!”. (C. Fanall, pers. comm.), suggesting the unique conditions of the experiment. As documented by Peterson et al., 8 km is also an altitude of strong wind shear. The strong wind shear may contribute to mid-level outflow that is then perceived as a high cloud fraction at that altitude. Further work is required to solidly this hypothesis.

References


