

Sereno A. Barr-Kumarakulasinghe¹Marine Sciences Research Center, State University of New York
Stony Brook, NY 11794-5000

1. Introduction

Small scale deep convective clouds are a mechanism for transport of boundary layer moisture to the mid and upper troposphere (Barr-Kumarakulasinghe, 1996). In addition Mapes (1993) demonstrates through gravity wave dynamics that a mesoscale convective system can create favorable conditions for additional convection resulting in gregarious convective clusters. Though the present study is more concerned with substantially smaller deep convective systems it is reasonable to expect similar induction of conditions favorable to convection by smaller convective systems as well. Hence, it is clear that understanding the trigger mechanisms for formation of small scale deep clouds will provide insights into conditions associated with transport of boundary layer moisture into the upper troposphere. In addition it will provide guidelines for considering the appropriateness of parameterizing small scale deep convection with respect to large scale circulation features.

This study examines the conditions associated with small scale deep convection in the Tropical Western Pacific (TWP) during otherwise quiescent time periods in order to find the trigger mechanisms initiating deep convection. A quiescent time period was chosen to ensure absence of large scale convection and hence enable examination of small scale deep convection. Though the initial focus is on convection over islands it is expected the results will also hold over open ocean with appropriate scaling.

2. Data & Methods

Geostationary Meteorological Satellite (GMS-4) 10 km gridded infrared (IR) brightness temperature values were used as a proxy for identifying deep convection (MRI, 1993). The sounding data created by the Integrated Sounding System were obtained from the public domain and were available in 6 hourly intervals (Parsons et al., 1994; Miller & Riddle, 1994).

Sounding data were used to calculate Lifting Condensation Level (LCL), Level of Free Convection (LFC), Convective Available Potential

were calculated using Bolton (1980) for 5mb parcels in the lowest 50mb and averaged. In addition the rate of change of CAPE was also calculated.

The study period is from January 10th-20th 1993 and within the TOGA-COARE experiment. This study is an examination of localized convection over Manus (147.0E, 2.1S) an island in the warm pool region of the Tropical Western Pacific. The island has dimensions of 40 km x 10 km and a mountain with an elevation of 690 m.

The study period occurred during an extended El-Nino event and the study area was within an area of positive low level divergence ($0.0-0.5 \times 10^{-6} s^{-1}$) as calculated using ECMWF analysis (Hennon & Vincent, 1996). Immediately prior to this study period intense westerly wind bursts and associated storms had swept through the region during Dec. 18 1992 -Jan. 2nd 1993. Average surface zonal winds were $0-2 \text{ ms}^{-1}$ (eastward) and average surface meridional winds were -2 ms^{-1} (southward) (Hennon & Vincent, 1996). The average humidity at the 850 mb level was 75% (Hennon & Vincent, 1996). The surface temperature and virtual temperature of the lowest 50mb were $300.6 \text{ K} \pm 0.8 \text{ K}$ and $303.7 \pm 0.8 \text{ K}$ respectively. The average LCL was $907 \text{ mb} \pm 11 \text{ mb}$ and LFC $812 \pm 64 \text{ mb}$ level. CAPE average for the study time period was $573 \pm 313 \text{ J kg}^{-1}$.

3. Results & Discussion

Isolated occurrences of convection occurred over the island on January 11th 1993 at -07 GMT (18 LST), January 14th 1993 at -03 GMT (14 LST) (see Figure 1 for example of development). On January 17th 1993 at -03 GMT (14 LST) and January 18th 1993 at -04 GMT (15 LST) the convection initially started over the island and then spread over to the Bismarck Sea to become a synoptic scale disturbance and is seen in the Hovmuller diagrams as well (Figure 2). Solid horizontal lines across the right panel denote occasions convection was initiated over the island. There were other occasions of cold high clouds traversing the island and are seen in

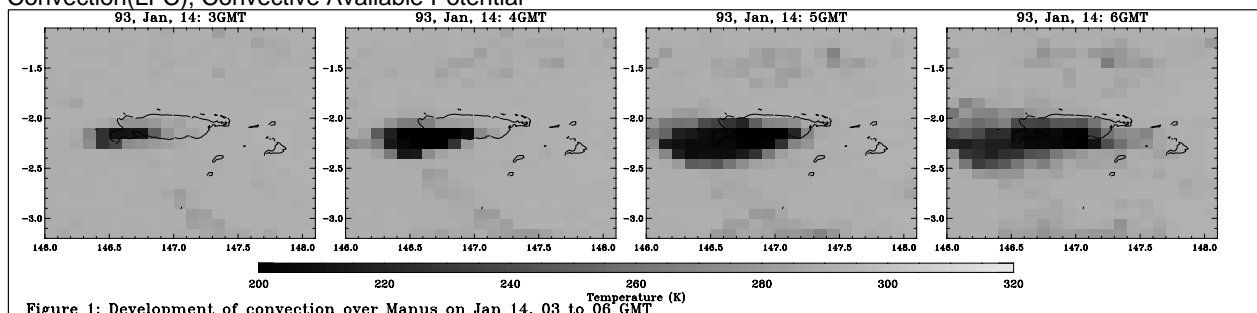


Figure 1: Development of convection over Manus on Jan 14, 03 to 06 GMT
Energy (CAPE) for a pseudoadiabatic process and Equivalent Potential Temperatures (EPT). LCL and EPT

¹ Corresponding Author address: Sereno A. Barr-Kumarakulasinghe,
MSRC, SUNY, Stony Brook, NY 11794-5000
e-mail: sbarrkum@kafula.msrc.sunysb.edu

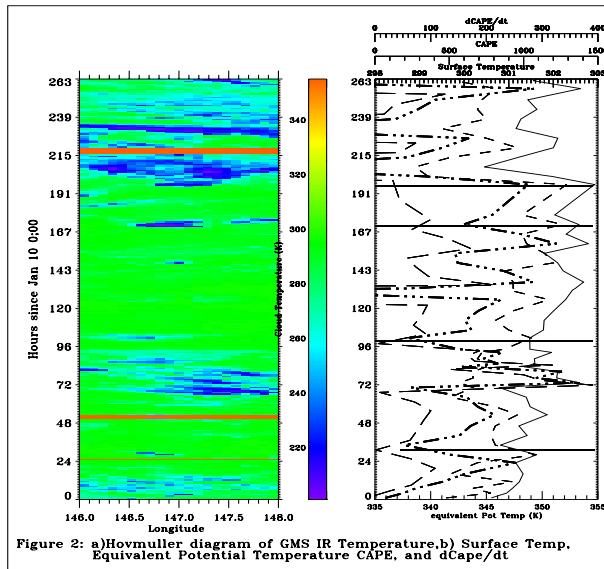


Figure 2: a) Hovmuller diagram of GMS IR Temperature. b) Surface Temp, Equivalent Potential Temperature CAPE, and $d\text{Cape}/dt$

the left panel of Figure 2. However, these cold clouds were not initiated over the island and hence not within the focus of this study

All incidences of local convection occurred when there was an inflection in the velocity profile below the LFC (Figure 3a). These velocity profiles satisfy the Rayleigh-Fjortoft condition necessary for instability in inviscid parallel flows (Kundu, 1990 for details). Also associated with convective episodes were elevated surface temperatures above 301 K due to surface heating at midday. In contrast midday soundings during clear conditions did not have an inflection point in the wind speed profiles. When the convection was localized over the island CAPE was minimum as was the rate of change of CAPE. During the two occasions (167 and 191 hours) the disturbance grew to synoptic scale proportions, CAPE values were near average and above average respectively (Figure 2). Equivalent potential temperature showed no discernible pattern with convection.

Conclusion

Conditions necessary for initiation of local small scale deep convection is controlled by the dynamics of the boundary layer in conjunction with surface temperature elevation. Gravity flows initiated by a nearby convective episode could have created the dynamics associated with the convective episodes and this is not inconsistent with Mapes (1993) gregarious convection hypothesis. Further examples of local small scale deep convection should be examined before concluding that the Rayleigh-Fjortoft condition in association with surface temperature elevation are necessary and sufficient conditions initiation of local deep convective episodes. For these four episodes of convective activity CAPE and rate of change of CAPE do not appear to be good predictors of convection.

This study indicates boundary layer instability as trigger mechanisms for localized deep convection in the TWP. Hence further examination of the processes initiating local deep convection is warranted.

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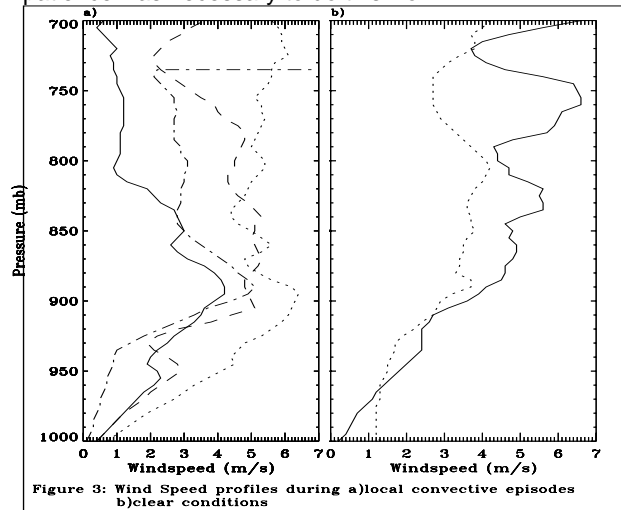


Figure 3: Wind Speed profiles during a) local convective episodes b) clear conditions

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