14D.6 DIURNAL VARIATION OF PRECIPITATION OBSERVED OVER PALAU IN THE WESTERN PACIFIC

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1. INTRODUCTION

An enormous number of convections produce much rainfall over the tropical western Pacific region of the warm water pool. Convections have multiscale variability over the tropical region and variable temporal and spatial scales structures over the equatorial region. One of the most prominent variability is diurnal variation. Recent studies of using satellite data provided us a widespread averaged view of diurnal variation of convection over an open ocean with nocturnal maximum (Hendon and Woodberry 1993; Nitta and Sekine 1994). Intensive observation of TOGA COARE demonstrated that diurnal variation of precipitation had different characteristics depending on the existence of large-scale disturbances (Chen and Houze 1997; Kubota and Nitta 2001). In case of heavy rainfall, diurnal variation was apparent during nighttime, however light rain represented afternoon maximum (Sui et al. 1997). Large-scale disturbances were associated with the passage of intraseasonal oscillation over equatorial tropical region. While over the off-equatorial region, seasonal variation exists. In addition to intraseasonal oscillation, seasonal march influences the characteristics of diurnal variation of precipitation.

The IORGC conducted an observational project over Peleliu Island (7.05 N, 134.27 E) and the Aimeliik State of Babeldaob Island (7.45 N, 134.47 E) in the Republic of Palau (Kubota et al. 2005) (Fig. 1). The seasonal variability of diurnal variation of precipitation over off-equatorial region of western Pacific is investigated in this study. A small island, Peleliu Island was chosen for studying oceanic feature. To extract the oceanic diurnal variation features, island effect is discussed by comparing the other islands observations.

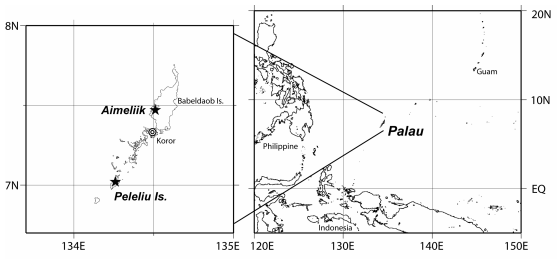

Figure 1. Maps of the western Pacific region. (left) Enlarged map of the Palau region.

2. DATA

Automatic weather station (AWS) and Ceilometer were installed in Peleliu Island station on June 2001. Precipitation was accumulated to hourly data. Equivalent cloud amount was calculated using the frequency of the cloud base measurement of Ceilometer in each hour. Koror National Weather Service (NWS) launched upper-air sounding twice a day at 0000 and 1200 UTC (local time was 9 hours ahead of UTC) (Fig. 1). X-band Doppler radar was installed in Aimeliik site on December 2004. Intensive observation of Doppler radar was performed every 7.5 minutes from 15 December 2004 to 15 January 2005 and from 24 May to 15 July 2005. Surface rainfall data was estimated by 1.5 km height radar reflectivity.

3. RESULTS

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3.1 Seasonal variability

Seasonal variability of zonal wind observed at 850 hPa in Koror is plotted in Fig. 2. Westerly wind was prevailed from July to November 2001. And wind direction was shifted to easterly after December 2001 until middle of May 2002. Seasons can be divided westerly wind regime from easterly wind regime in Palau. A threshold of 5 m/s was used for the definition. Using this threshold, westerly wind regime was continued until 25 November 2001. Next westerly wind regime was started from 18 May 2002. Equivalent cloud amount is also plotted in Fig. 2. The correlation coefficient between zonal wind and equivalent cloud amount reached 0.71 during the westerly wind regime. When westerly wind was intensified, the equivalent cloud amount increased, indicating that convective activity was intensified. On the contrary, during the easterly wind regime, this relation is not clear.

3.2 Diurnal variation of precipitation

Previous studies demonstrated that diurnal variation of precipitation was apparent with nocturnal maximum when convection was active over equatorial western Pacific. Equivalent cloud amount of 5-day running mean was used for the definition of active phase of convection and inactive phase. Threshold of greater than 4 is active phase and less than 3 is inactive phase (see Fig. 2). Additionally diurnal variation was investigated at both regimes. Figure 3 shows diurnal variation of precipitation observed at Peleliu Island of active and inactive phases during the westerly wind regime. Precipitation increased in the nighttime and decreased during the afternoon in the active phase. In the inactive phase, diurnal variation was weak and had a lesser afternoon maximum. The behavior of diurnal variation of precipitation during the westerly wind regime was consistent with previous work over the equatorial western Pacific. Figure 4 indicates diurnal variation of

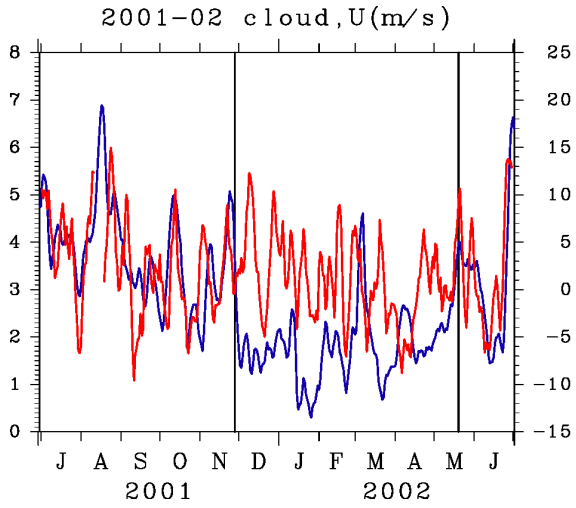

Figure 2. Times series of 5-day running mean zonal wind at 850 hPa (blue line) and equivalent cloud amount (red line) from 28 June 2001 to 30 June 2002.Withdrawal and onset date is indicated by vertical solid lines.

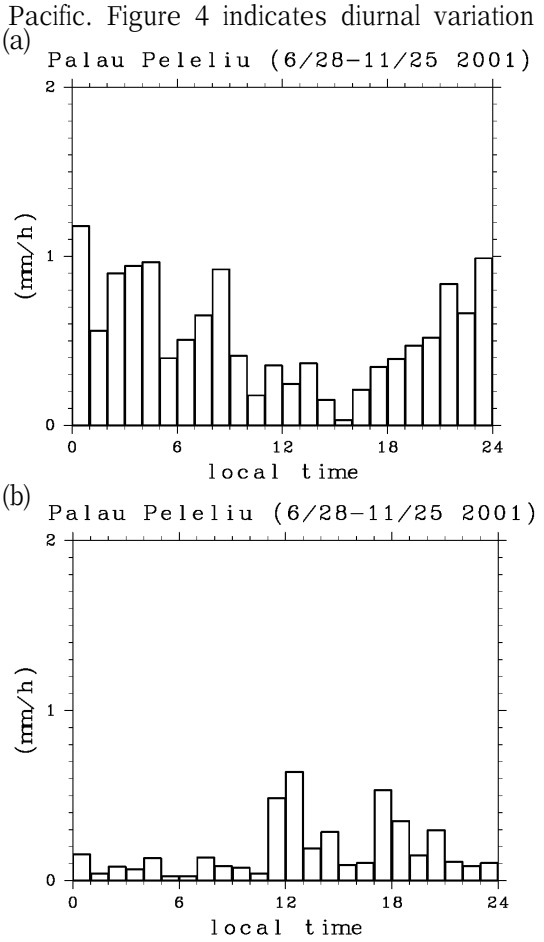

Figure 3. Diurnal variation of precipitation averaged in the (a) active phase and (b) inactive phase during the westerly wind regime.

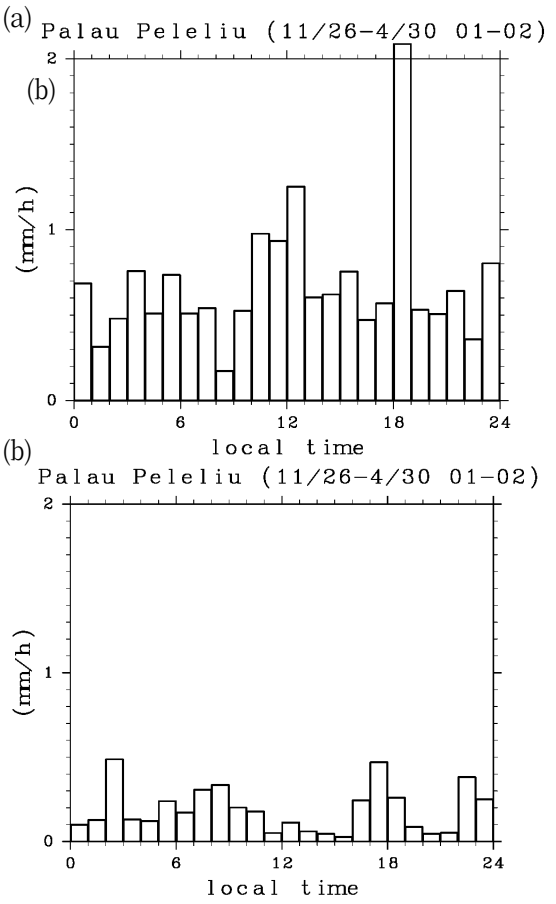

Figure 4. Same as in Fig. 3, except indicating the easterly wind regime.

precipitation during the easterly wind regime. Diurnal variation was not apparent in either the active phase or the inactive phase.

3.3 Precipitation properties and the environment

Rain event was defined by using hourly precipitation in Peleliu Island to identify the duration and intensity of rainfall. Continuous rain is defined as a rain event, and a rain event was divided into another event, if the rain intermittence was 3 hours or more. Figure 5 depicts the frequencies and intensities of rain events during westerly and easterly wind regimes. The maximum frequency of a rain event appeared at 1 hour duration and decreased as duration increased. The frequency of longest duration exceeding 13 hours during the easterly wind regime has twice that of westerlies. The intensity of rain increased as

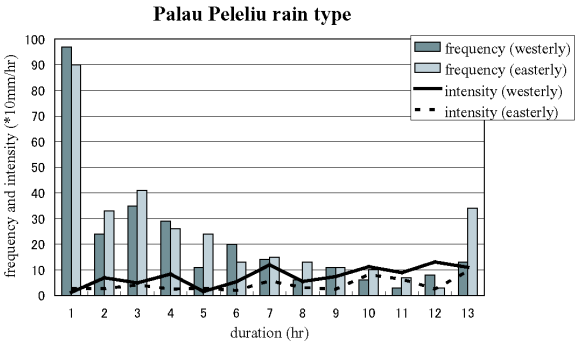

Figure 5. Frequencies (boxes) and intensities (lines) of a rain event distributed for the length of the duration of the rain event. The unit of frequency is numbers, and the intensity is 10xmm/h. The abscissa is duration (h), and 13 represents more than 13 h.

duration of rain event became longer. Almost all durations represents that rain events were more intense during the westerly wind regime.

However, the difference in precipitation at Peleliu Island between westerly wind regime and easterly was small. Averaged precipitation is 8.8 mm/day during the westerly and 8.2 mm/day during the easterly.

The composite of relative humidity profile during active phase is shown in Figure 6 to represent the seasonal variability of the environment. Even at the active phase, middle layers around 250 to 700 hPa were dryer during the easterly wind regime.

4. DISCUSSIONS

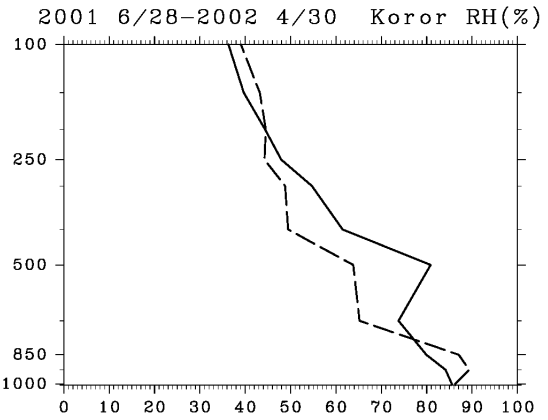

Figure 6. The composite of relative humidity profile at Koror during the active phase of the westerly wind regime (solid line) and easterly wind regime (dashed line).

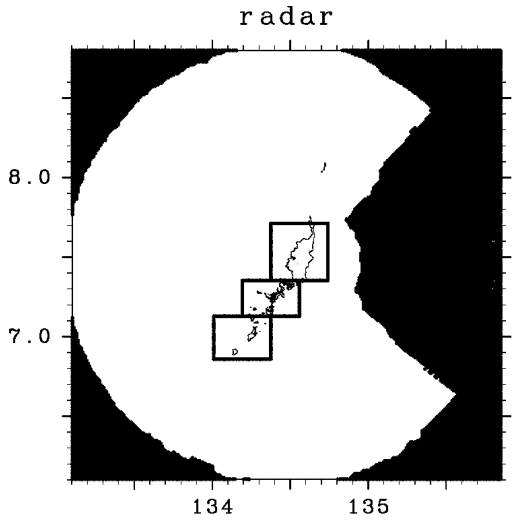

Figure 7. Observational coverage of Doppler radar. Selected area are represented by boxes. From the north, Babeldaob island area, Koror Island area, and Peleliu Island area.

Over Palau region, season can be divided into westerly wind regime and easterly wind regime. In spite of averaged rainfall was similar, precipitation properties and the environment had differences between the regimes. During the westerly wind regime, the atmosphere is wet and rain events had features of strong intensity with short duration. The environment is presumably affected by the equatorial region. The behavior of diurnal variation of precipitation was similar to the equatorial region. However, during the easterly wind regime, the ITCZ shifted south of Palau and subtropical dry air propagated around Palau latitude (not shown). The different environment may diminish the diurnal cycle of precipitation during the easterly wind regime.

Doppler radar observation was performed over Palau region (Fig. 7). To identify the island effect, three areas were selected. From the north, the largest island Babeldaob area, Koror and Rock Islands area, and Peleliu and Angaur Island area were chosen. During the intensive observation period in northern hemisphere summer, diurnal variation of estimated precipitation in active and inactive phase is plotted in Figure 8. Daytime maximum was prevailed during the inactive phase over

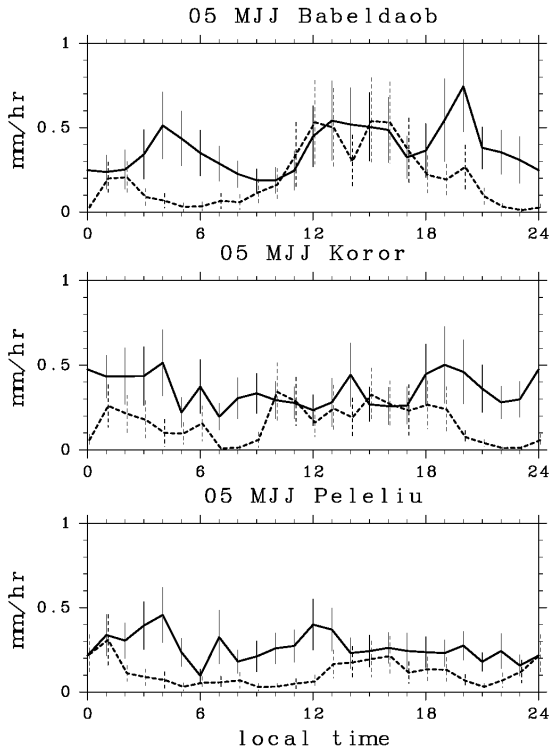

Figure 8. Diurnal variation of estimated precipitation over (a) Babeldaob Island area, (b) Koror Island area, and (c) Peleliu Island area during the active phase (solid lines) and inactive phase (dotted lines). Error bars are plotted in each hour.

Babeldaob and Koror area. Insolation of solar radiation heated the land and convection was promoted over the island during daytime. During the afternoon the difference of precipitation between active and inactive phase is small over Babeldaob and Koror area. Diurnal variation became weak during the active phase. However, over Peleliu area, afternoon maximum was weak during the inactive phase and early morning maximum was appeared during the active phase. These results support that island effect is small in Peleliu Island area and which has an oceanic feature.

5. SUMMARY

Diurnal variation of precipitation was investigated over Palau in the tropical western Pacific. Compared to other larger islands, heating effect of the island is assumed to be small in Peleliu Island. Peleliu Island was chosen for the representative of oceanic feature.

Over Palau region, the season can be divided into westerly and easterly wind regime. Furthermore, active and inactive phase of convection were defined by equivalent cloud amount data. Diurnal variation of precipitation was apparent during the westerly wind regime with nocturnal maximum in active phase and weak afternoon peak in inactive phase. In contrast, diurnal variation was vague during the easterly wind regime. Precipitation properties and the environment had a difference between westerly and easterly wind regime. These differences may influence of the seasonal variability of diurnal variation in Palau.

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