5B.5 INFLUENCES OF DYNAMICS ON CONVECTION AT THE TROPICAL PACIFIC ARM SITES

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1. INTRODUCTION

Convection in the Tropical Western Pacific (TWP) and Maritime Continent (MC) regions plays an important role in driving global-scale atmospheric circulation. While the TWP is climatically important, global-scale models have a difficult time capturing the intricacies of convection in this region (Neale and Slingo, 2003). The Atmospheric Radiation Measurement (ARM) program has three sites in the tropical TWP region: Manus, Nauru, and Darwin (Mather et al., 1998). An examination of cloud frequency and radiation data from these sites reveals variability on a wide range of time scales. This paper will focus on variability associated with the annual solar cycle.

2. ANNUAL CYCLE IN THE TROPICAL PACIFIC

The annual cycle in the TWP/MC is dominated by the oscillation of the Asia and Australia monsoons. During the Northern Hemisphere (NH) summer, convection is most prevalent over Asia while in the NH winter, convection is shifted to northern Australia and the TWP/MC region. Study of Outgoing Longwave Radiation (OLR) data indicates that during the transition seasons, convection is most common over the large islands of the Maritime Continent. The influence of this cycle can be seen in the time series of downwelling solar radiation obtained at the Manus ARM site (Figure 1). These data have been low-pass filtered by applying a Gaussian-weighted mean. The half-width of the filter is 20 days thus much of the intraseasonal variability has been removed. An oscillation can be seen throughout this data with a period of approximately 90 – 180 days (spectral analysis shows a peak centered at 120 days. This signature is particularly clean in 1999 and 2001 when Manus experienced relatively little cloudiness during the autumn and spring (weak cloud radiative forcing) and a greater amount of cloudiness during the NH winter and summer.

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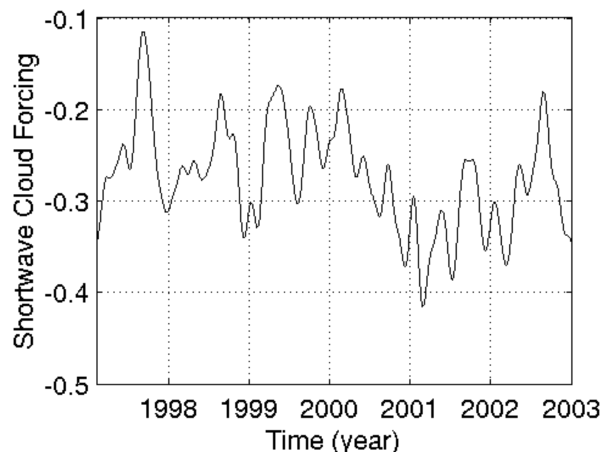

Figure 1. Cloud radiative forcing, CRF, at Manus. Where CRF is defined as (Fobs – Fclr)/Fclr. Fobs is the observed broadband shortwave flux at the surface and Fclr is the modeled clear sky flux.

3. IMPACT OF LARGE ISLANDS ON MANUS

Study of OLR over the tropics indicates that the equinoxes are periods when convection is concentrated spatially over the large islands of the Maritime Continent. Neither the Australia nor the India/Asia monsoon is active at this time but solar heating is very strong at the equator. In Figure 2, a time series of OLR over New Guinea indicates convection is prevalent from October - June but is relatively suppressed during NH summer. Plotted with the OLR data in Figure 2 is the frequency of high clouds (14-16 km) observed at the Manus ARM site. These data indicate that cirrus are a common occurrence throughout most of the period when convection over New Guinea is active.

The high frequency of cirrus clouds over Manus during periods when convection over Manus combined with the observation of concentrated convective activity over New Guinea suggests that many of the cirrus over Manus were formed by convection over the larger islands of Papua New Guinea. Upper level winds from radiosondes further point to New Britain, which lies approximately 300 km to the southeast, as the likely source of these clouds. Because cloud properties are likely to be different for maritime and island-based convection, it is important to understand the dynamical processes that govern the frequency with which each occurs.

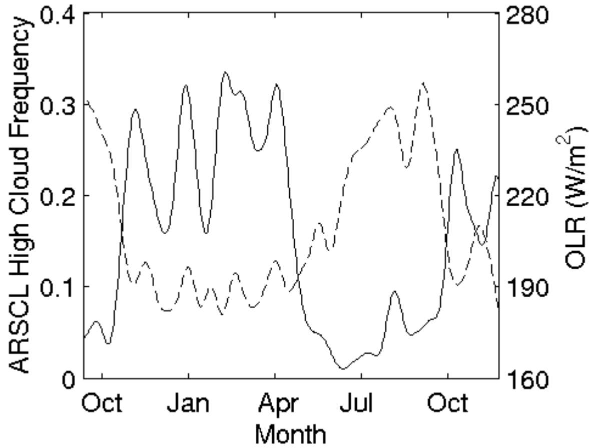

Figure 2. Cloud Frequencies between 14-16 km at Manus (solid line) and OLR (dashed line) over the island of New Guinea for Oct. 1999 – Nov. 2000. Cloud frequencies were obtained from ARM radar and lidar observations. OLR data were obtained from the NOAA Climate Diagnostics Center (www.cdc.noaa.gov).

4. SEASONAL FEATURES AT NAURU

Nauru lies 2000 km East of Manus in the central Pacific. This location was chosen because of its high sensitivity to the El Nino cycle. During the first two years of operation (1999-2000) convection in the central Pacific was largely suppressed. The time series of cloud radiative forcing in Figure 3 illustrates that despite the generally suppressed conditions, there was an annual cycle of convective activity at Nauru with the strongest forcing (most convection) occurring during NH summer. Precipitation also exhibits a maximum during the NH summer, the season in which convection in the Maritime Continent is least active. The coincidence of active convection over the Maritime Continent and suppressed conditions over Nauru during NH winter suggests that large scale divergence aloft, above the Maritime Continent drives subsidence over Nauru during that season.

Even in the absence of local convection at Nauru, thin cirrus frequently observed near the tropopause, particularly during the NH winter. These cirrus layers are likely generated by large scale dynamical lifting (Boehm and Verlinde, 2000; Comstock et al., 2002). Examination of NCEP reanalysis winds suggests that the source of this upper level moisture is the deep convection within the South Pacific Convergence Zone.

At both Manus and Nauru, the frequency of convection, the occurrence of clouds, and the impact of these clouds are being modulated by large scale processes. Understanding these processes is critical for interpreting observations of radiation and clouds at the ARM sites.

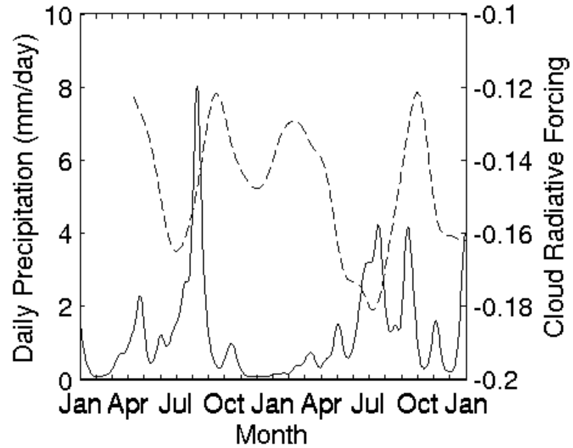

Figure 3. Daily averaged precipitation (solid line) and solar cloud radiative forcing (dashed line) over Nauru. Period is January 1999 – January 2001.

5. REFERENCES

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