Observations of the 1997-1998 Warm El Niño-Southern Oscillation Event at the Manus Island ARM Site

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Introduction

The 1997-1998 warm El Niño-Southern Oscillation (ENSO) event is one of the strongest on record. Several signatures of the atmospheric manifestation of ENSO have been observed at the Manus Island Atmospheric Radiation Measurement (ARM) site (2.060°S, 147.425°E). These signatures have been observed in several data streams including the solar radiation, water vapor column and rainfall measurements. Under normal conditions, the east-west circulation over the tropical Pacific, called the Walker Circulation, is characterized by convective ascent over the Tropical Western Pacific (TWP), eastward motion aloft, descent over the cold waters of the eastern equatorial Pacific and surface easterlies. During warm-ENSO conditions, a collapse of the Walker Circulation is observed such that the ascending branch moves to the east over the central Pacific, and descending motions are observed over the TWP. In extreme conditions, a reversal of the Walker Circulation is observed. The result of this change is that during warm-ENSO conditions we observe a suppression of convective activity over the TWP and, therefore, less clouds and rainfall, which result in drought conditions over this region. Figure 1 illustrates this cycle showing outgoing longwave radiation (OLR) that may be viewed as a surrogate for convective activity. During warm-ENSO events (1986-1987, 1991-1992, 1997-1998), there is a movement to the east of the most convective region, while during cold-ENSO years (1988-1989, 1995-1996), the region of high OLR extends much farther west than normal. In order to see how this cycle manifests itself at the Manus ARM TWP site, 1997 observations were compared with longer-term averages of OLR (24 years) and rainfall (15 years). This warm-ENSO year clearly shows higher (lower) values of OLR (rainfall) beginning in August and extending at least through the end of the year.

It has been suggested that warm ENSO events occur following an anomalous westerly wind in the equatorial Pacific, coined a "westerly wind burst." These winds are suggested to be responsible for generating an eastward-propagating equatorially trapped Kelvin wave in the ocean (Harrison and Schopf 1984). Figures 2a and 2b show the

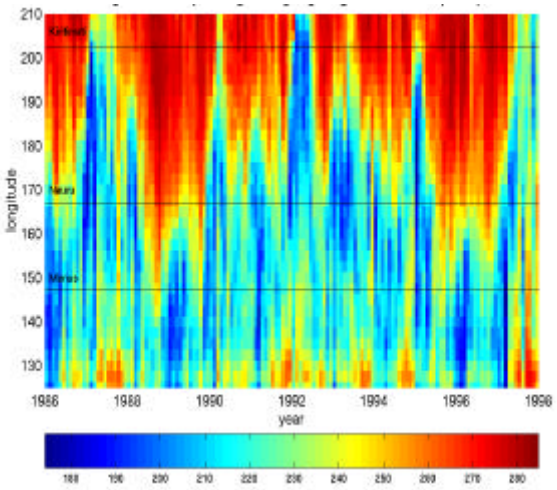

Figure 1. Monthly average OLR averages over ±5° latitude as a function of time and longitude from the National Oceanic and Atmospheric Administration (NOAA) polar-orbiting satellite advanced very high resolution radiometer (AVHRR) measurements. High values of OLR correspond to suppressed convective activity. The locations of Manus and the future ARM TWP sites are indicated by horizontal lines. (For a color version of this figure, please see *http://www.arm.gov/docs/documents/technical/conf_9803/jensen-98.pdf*.)

smoothed daily averages of the surface wind measurements on Manus for 1997 to 1998. During March 1997, for a period of approximately 3 weeks, a northwesterly burst of wind preceded the occurrence of sea-surface temperature anomalies off the coast of South America. This is consistent with the analysis of Nitta (1989).

Signatures of decreased convection over the TWP have been observed by several instruments in the TWP-Atmospheric Radiation and Cloud Station (ARCS). These signatures have been found in measurements of downwelling radiation, water vapor column and rainfall. Figures 2c through 2f summarize these measurements. In the 3-month period between August and October, there is a relatively higher direct and total solar flux along with a prolonged period of

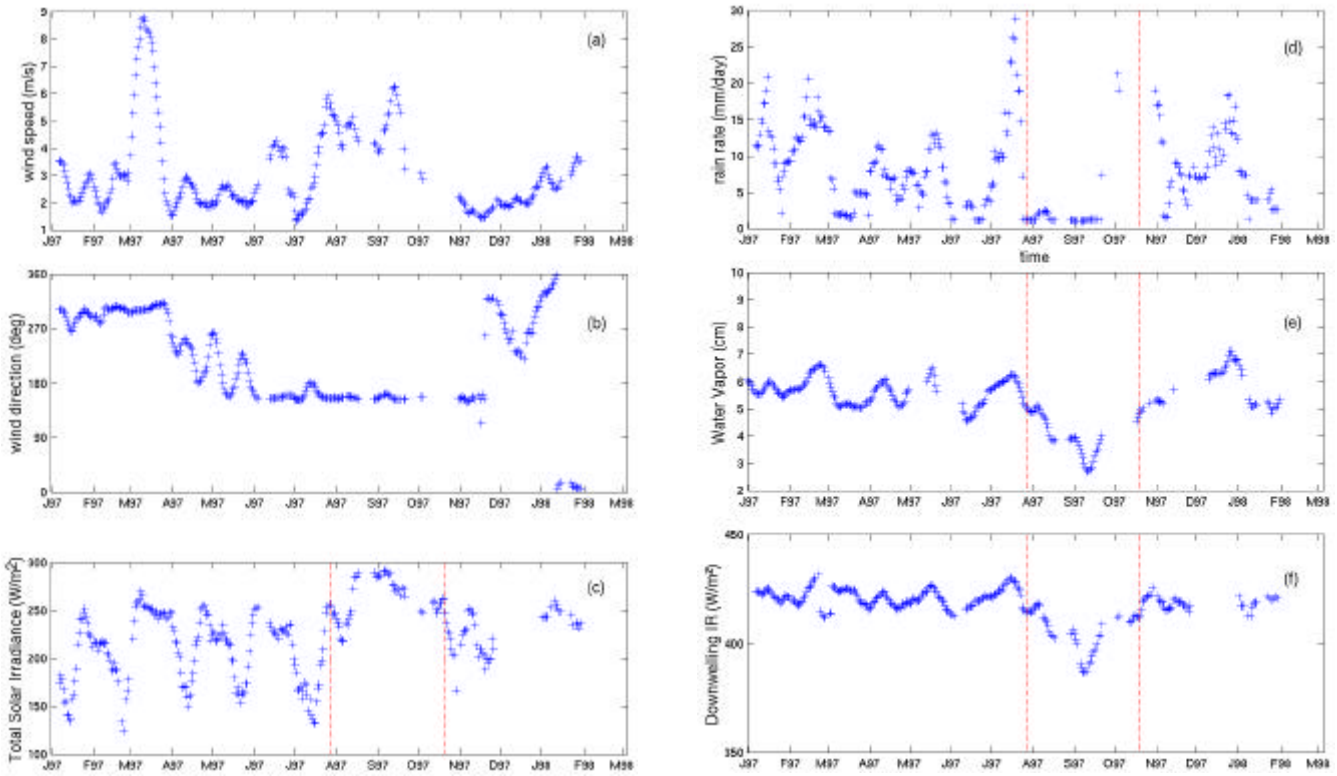

Figure 2. Ten-day running means of the daily average (a) surface wind components, (b) surface wind direction, (c) total downwelling solar flux, (d) rainfall, (e) column water vapor content, and (f) total downwelling infrared flux measured by the TWP-ARCS. (For a color version of this figure, please see *http://www.arm.gov/docs/documents/technical/conf_9803/jensen-98.pdf.*)

low rainfall amounts. These observations are all consistent with decreased cloudiness during this period. During the same time period, there is a relatively lower column water vapor content measured by the microwave radiometer along with a lower surface relative humidity. The radiation measurements show a decrease in the downwelling infrared and a lower daily minimum infrared thermometer temperature over this 3-month period further supporting the lower water vapor content.

In order to sample the variability of climatic parameters across the tropical Pacific, the ARM plan calls for the deployment of several more ARCS in this region (Mather et al. 1998). Figure 1 shows the location of two of these sites on a time-longitude cross section. The second site to be implemented in the TWP region will be on the southwest end of Nauru Island (0.53°S, 166.92°E) and is scheduled for installation in summer 1998. During La Niña conditions, the eastern edge of the oceanic warm pool reaches as far east as Nauru. A possible location for the third site is Kiritimati Island (1.87°N, 157.33°W), which is well out of the warm pool during La Niña conditions. Both Nauru and Kiritimati appear to show a great deal more variability in OLR during the time period plotted compared to Manus. During the warm ENSO events of 1986 to 1987 and 1991 to 1992, the region of low OLR extends as far east as Kiritimati and significantly contrasts the values seen there only a few months earlier. A similar pattern is observed at Nauru, but perhaps more significant is the change in OLR during the cold ENSO events of 1988 to 1989 and 1995 to 1996 where the region of high OLR extends west as far as Nauru.

The measurements taken by the TWP-ARCS at Manus Island have clearly exhibited the local influences of the 1997 to 1998 warm ENSO event and have shown consistency of time scales and observations with comparisons to satellite measurements. The future deployment of ARCS at Nauru and Kiritimati represent an oppurtunity to further characterize the climatic impact of the ENSO cycle in the tropical Pacific.

References

Harrison, D. E., and P. S. Schopf, 1984: Kelvin-wave-induced anomalous advection and the onset of surface warming in El Nino events. *Mon. Wea. Rev*., **112**, 923-933.

Mather, J. H., T. P. Ackerman, W. E. Clements, F. J. Barnes, M. D. Ivey, L. D. Hatfield, and R. M. Reynolds, 1998: An atmospheric radiation and cloud station in the Tropical Western Pacific. *Bull. Amer. Met. So*c., accepted for publication.

Nitta, T., 1989: Development of a twin cyclone and westerly bursts during the initial phase of the 1986-1987 El Nino. *J. Met. Soc. Jap*., **67**, 677-681.