# Convective Signals from the ARM Surface Observations at Manus

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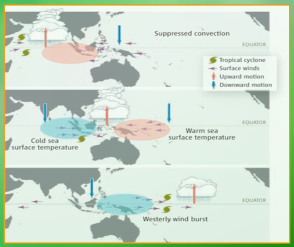
## Abstract

The Madden-Julian Oscillation (MJO) signal has been detected using surface observations from the Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) Climate Research Facility (ACRF) Tropical Western Pacific (TWP) Manus (1996-2006). We also analyze in a similar manner the satellite-retrieved values of precipitation from the Global Precipitation Climatology Project (GPCP), and interpolated outgoing longwave radiation (OLR) from NOAA for the same location. Our results indicate that the major convective signal is associated with the MJO. This MJO convective signal has a strong seasonal to interannual evolution that may be correlated with the interannual variability of ENSO (El Niño Southern Oscillation). On the other hand, the first version of the nested regional climate model (NRCM, developed at NCAR) has produced a 5-year tropical channel simulation from 1996 to 2000. Compared to our observational study, this simulation shows some skills to capture the tropical deep convection and MJO signals.

## Introduction

The MJO is one of the major convective activities in tropical regions (Madden and Julian, 1994) and results in many important atmospheric and oceanic variability at intraseasonal timescales (30-80 day periods). The current climate models have shown a wide range of skills in simulating the observed MJO and tropical intraseasonal oscillation signals.

(**Hartmann and Hendon, Science, 318, 1731**).



## MJO signals from Manus CRF and FSC

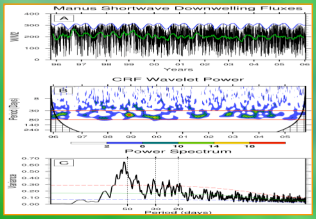


Figure 1

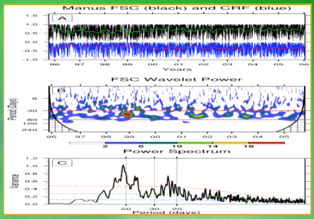


Figure 2

Strong MJO signals at a 50-day periodicity is evident (Figs. 1C and 2C). The consistency of Figs. 1 and 2 indicates that the signal in the FSC comes mainly from the CRF that is caused by the tropical deep convective cloud formation.

## MJO signals from NOAA OLR and GPCP Precipitation

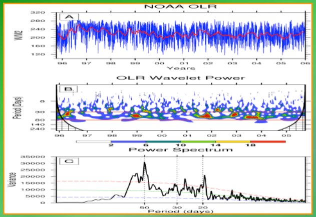


Figure 3

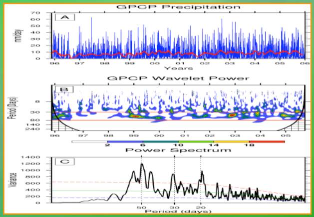


Figure 4

Strong MJO signals at a 50-day periodicity in NOAA OLR and GPCP precipitation is also evident (Figs. 3C and 4C). The consistency of Figs. 1,2,3, and 4 gives confidences in detected MJO signals over Manus. The wavelet powers are normalized with the corresponding variances.

## Observations, Data and Methodology

The Manus broadband shortwave downwelling fluxes (SWDN) are processed to produce continuous clear sky downwelling flux (CSWDN), cloud radiative forcing (CRF), and fractional sky cover (FSC) (Long and Ackerman, 2000; Long et al., 2006). The combination of CRF and FSC analyses reveals the signal of convective cloud formation surrounding Manus.

CRF = (SWDN-CSWDN)/CSWDN

The NOAA OLR (4-grid average, 500x500 km, http://www.cdc.noaa.gov).

The GPCP precipitation (9-grid average, 300x300 km, http://precip.gsfc.nasa.gov).

To isolate the MJO mode, the long-term climatology and the first three harmonics of the annual cycle are removed. To further filter out the low-frequency signal (i.e., ENSO), we apply an 89-point Lanczos "high-pass" filter with a cut-off periodicity of 240 days.

We then calculate the Morelet wavelet power spectra and the corresponding 95% confidence (Torrence and Compo, 1998). Fourier power spectrum analysis with a 95% confidence envelope over the best-fit red noise is also applied.

## MJO signals from Nested Regional Climate Model

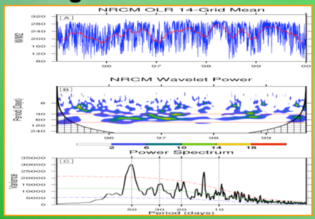


Figure 5

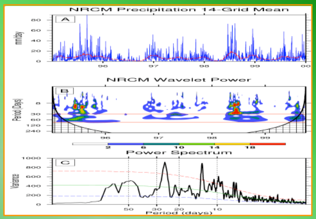
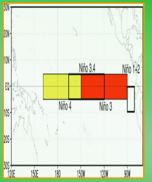


Figure 6

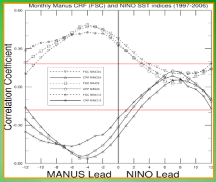
The NRCM tropical channel simulation has a 36-km horizontal resolution and covers from 30°S to 45°N. The OLR and rainfall data are extracted over Manus (about 500x500 km average). The NRCM's OLR field shows some of the MJO signal (Fig. 5C). However, the precipitation is not well simulated so that higher-frequency signals (Kelvin-wave related) are dominated (Fig. 6C).

## MJO and ENSO

Significant lead of the MJO signals at Manus of 9-10 months indicates a future possibility of ENSO prediction. During the strong El Niño year of 1997-98, the MJO is suppressed, while in the strong La Niña year of 1999-2000, the MJO is activated (Figs. 1,2,3 and 4).



**NIÑO SST indices**



## Summary and References

The long-term highly sampled observations at DOE ACRF TWP Manus provide a unique view of the MJO evolution from the surface. With the combination of the CRF and FSC data, we report the dominated MJO signal. Our convective signals agree well with the NOAA OLR and GPCP rainfall retrievement. On the other hand, a high-resolution climate model simulation shows some of the MJO signal in the OLR at the same location. For other variables (e.g., CRF, rainfall), the MJO signals are not well simulated.

R. Madden and P. Julian, Mon. Wea. Rev. 122, 814 (1994); C.N. Long and T.P. Ackerman, J. Geophys. Res. 105, 15609 (2000)

C.N. Long, T. P. Ackerman, K.L. Gaustad, J.N.S. Cole, J. Geophys. Res. 111, D11204 (2006); C. Torrence, G. P. Compo, Bull. Amer. Met. Soc. 79, 61 (1998)

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