

Correlation between the MJO and the ITCZ in the central to eastern Pacific

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1 Motivation

The Madden-Julian Oscillation (MJO) is known as a strong signal in tropical convection. Although the MJO convection is most pronounced in the Indian Ocean and western Pacific, its upper level signal can travel through the dateline and influence the eastern Pacific. Studies have shown that the MJO can modulate tropical storms in the eastern Pacific by changing the sea surface temperature or the low level zonal wind (e.g., Maloney and Hartmann 2001).

In our recent observational study of the Intertropical Convergence Zone (ITCZ) using spectral analysis (Magnusdottir and Wang 2007), we found significant power associated with the MJO in the wavenumber-frequency diagram (Figure 1). Therefore, we are interested in how the ITCZ and the MJO are related in the central to eastern Pacific.

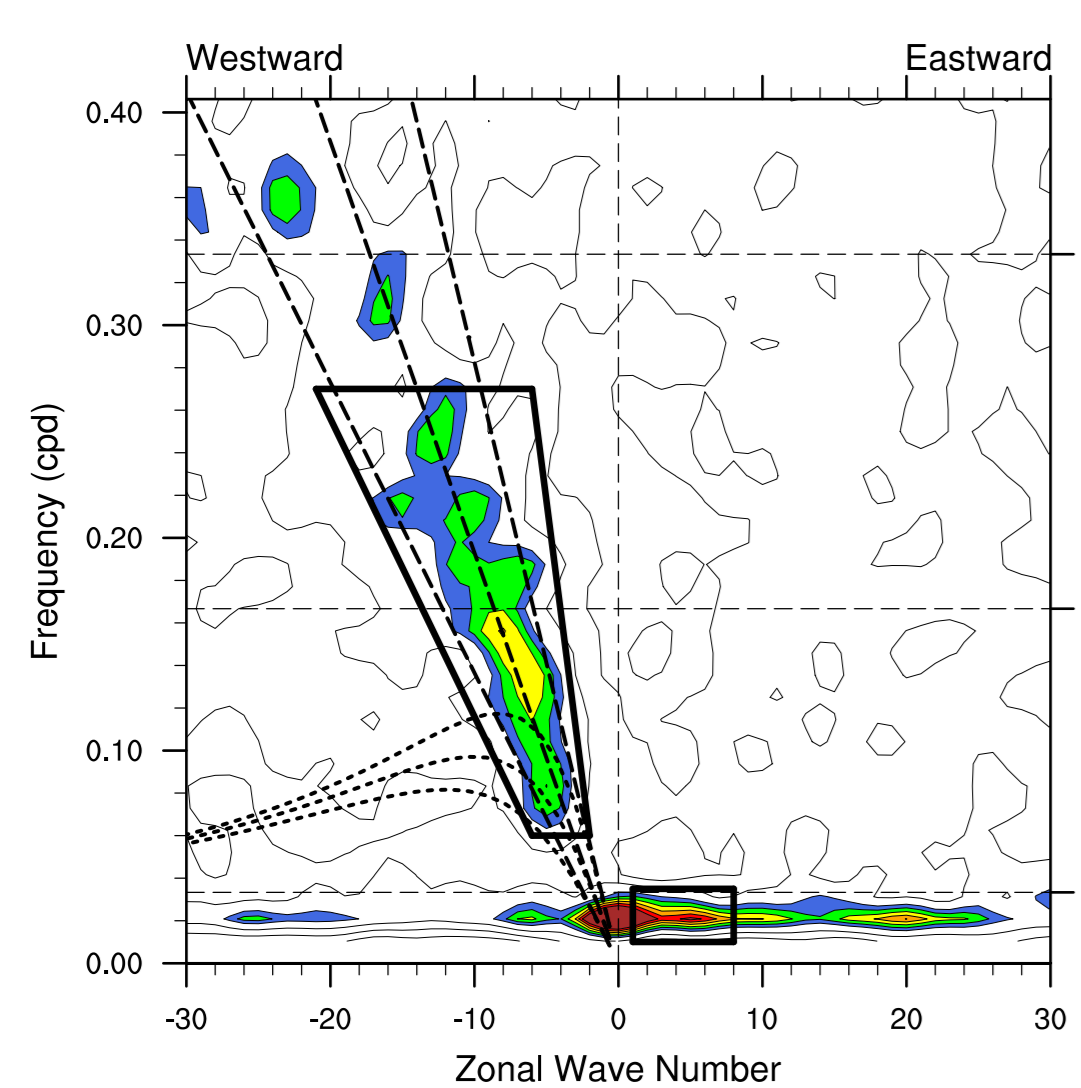


Figure 1: Power spectrum of 850 hPa relative vorticity in the eastern Pacific (5°N – 20°N , 180° – 80°W) using 23-year ERA40 reanalysis, May–Oct. Contour interval is 0.1. Shading starts at 1.1 where it is statistically significant at 95% confidence level. Boxes indicate the filters of the ITCZ and the MJO. Curved dashed lines are the Rossby wave dispersion lines for $n = 1$. Straight dashed lines are the corresponding long-wave approximation.

2 Data and Methodology

Daily averaged ERA-40 reanalysis data are used over 23 years, 1979–2001. We choose to use 850 hPa relative vorticity to represent tropical variability. Low-level relative vorticity represents synoptic-scale ITCZ and weak westward propagating disturbances (WPDs) the best (Wang and Magnusdottir 2006). Most previous studies of variability in the tropics have made use of the outgoing longwave radiation (OLR) field. The OLR field has the largest signature for deep convection and is ideal for studying convectively coupled waves. However, we are looking for signatures of systems that may be less mature, or less vertically developed than convectively coupled waves.

We broadly follow the analysis method in Wheeler and Kiladis (1999), except we apply their technique to the dynamical field of 850 hPa relative vorticity. To further isolate the region of interest, we set the 850 hPa vorticity field to zero outside the region of interest (5°N to 20°N and 180° to 80°W) while linearly tapering the edges to zero.

3 Preliminary results

Figure 1 shows the power spectrum, divided by a background spectrum, of 850 hPa vorticity for May–Oct. 1979–2001 for the area 5°N – 20°N , 180°W – 80°W . The statistically significant part of the spectrum at less than monthly timescale is westward propagating and approximately aligns itself along the straight lines shown in dashed. This is the signal of the ITCZ and the associated WPDs. Another spectral peak is located at wavenumbers from 1 to 8 with timescale slower

than 30 days. This is the MJO signal.

Following Wheeler and Kiladis (1999), we apply wavenumber-frequency filtering by extracting certain features from the spectrum. First, the box filter was chosen to extract the ITCZ and the WPDs. The spatial distribution of the variance of the filtered vorticity, an example shown in Figure 2, can be used to determine the geographical region associated with the spectral peaks (Note that figure of the variance was obtained by using a global power spectrum). The area with the highest variance is an elongated zonal stretch in the eastern Pacific at approximately 10°N . This area clearly corresponds to the ITCZ and associated WPDs.

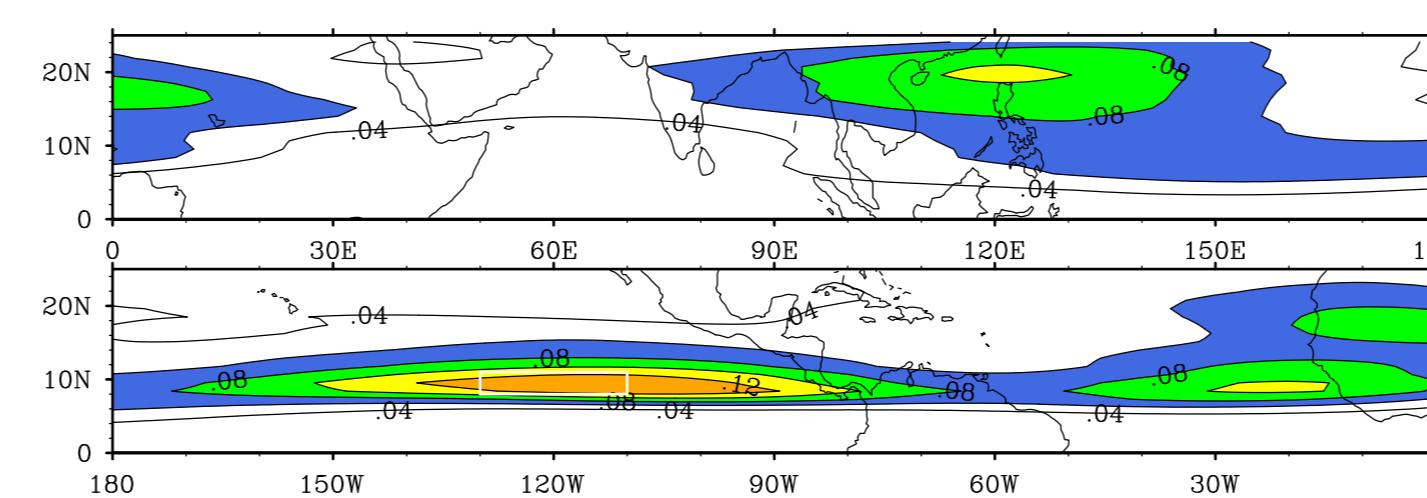


Figure 2: The Latitude, longitude (eastern hemisphere on top, western hemisphere on bottom) plot of the variance of filtered 850 hPa vorticity for 0 – 25°N , May–Oct., 1979–2001. Contour interval is $0.02 \times 10^{-10} \text{ s}^{-2}$. White box indicates the area used for producing the ITCZ index.

In the tropical east Pacific north of the equator, we are particularly interested in establishing a composite of ITCZ behavior. This is the region where we found active ITCZ evolution and breakdown on synoptic time scale for the summer half years of 1999–2003 (Wang and Magnusdottir 2006). The composite of the ITCZ cycle (Figure 3) is done by projecting the raw vorticity field onto the ITCZ index (see Magnusdottir and Wang 2007 for details). The lead/lag regression gives us the time evolution of the ITCZ cycle. Some may argue that the ITCZ is a string of tropical convection on the synoptic timescale. We want to emphasize that the ITCZ on synoptic timescale is behaving more like a wave packet which follows the long wave approximation.

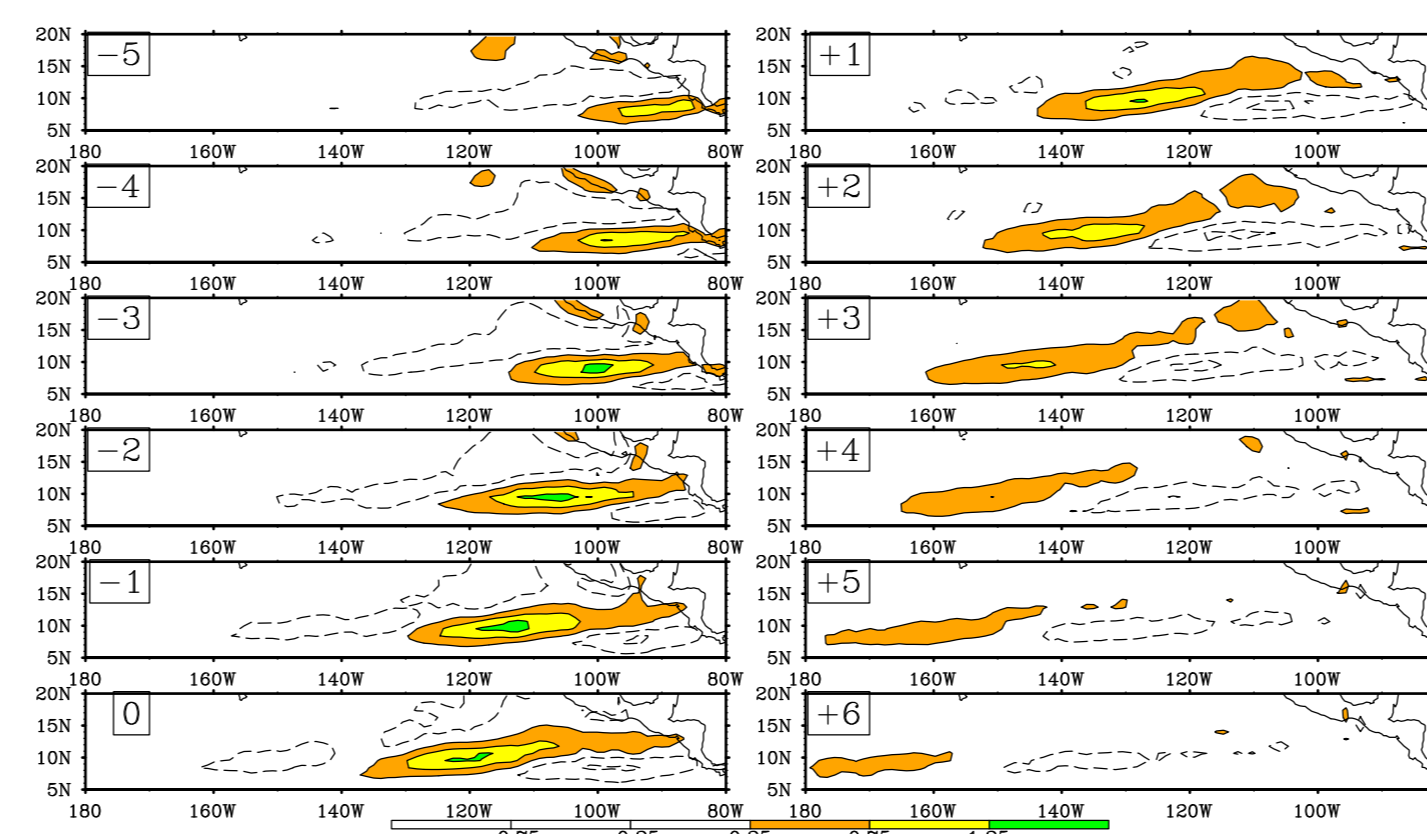


Figure 3: Composite of the ITCZ filtered vorticity anomaly at 850 hPa in the east Pacific in May–Oct., 1979–2001. The lag/lead is indicated in each frame, from -5 days to +6 days. Contour interval is $0.5 \times 10^{-5} \text{ s}^{-1}$.

The running variance of the filter band can be used to see how active this particular band is during a period of time. The results of the ITCZ band and the MJO band are shown in Figure 4(a) and (b). The length of the running window is chosen by the slowest frequency of the filtering for each band. Only summer months are considered. For the ITCZ band, the variance is averaged over the index box (white box in Figure 2). The time series of the running variance of these two bands have the correlation of 0.36 which is statistically significant considering the amount of data points (more than 4000 points for 23 years).

The correlation of each individual year shows large inter-annual variability,

ranging from -0.5 to 0.8. Figure 5 is the histogram of the correlations, showing more than half of the years have correlation higher than 0.5. This suggests that the ITCZ variability is highly correlated with the MJO variability in some years. From the time series of the running-variance, we speculate that the ENSO may play a big role since the intensity of the variance is low in the ENSO years (i.e., 1982–1983, 1987–1988, and 1997–1998) for both.

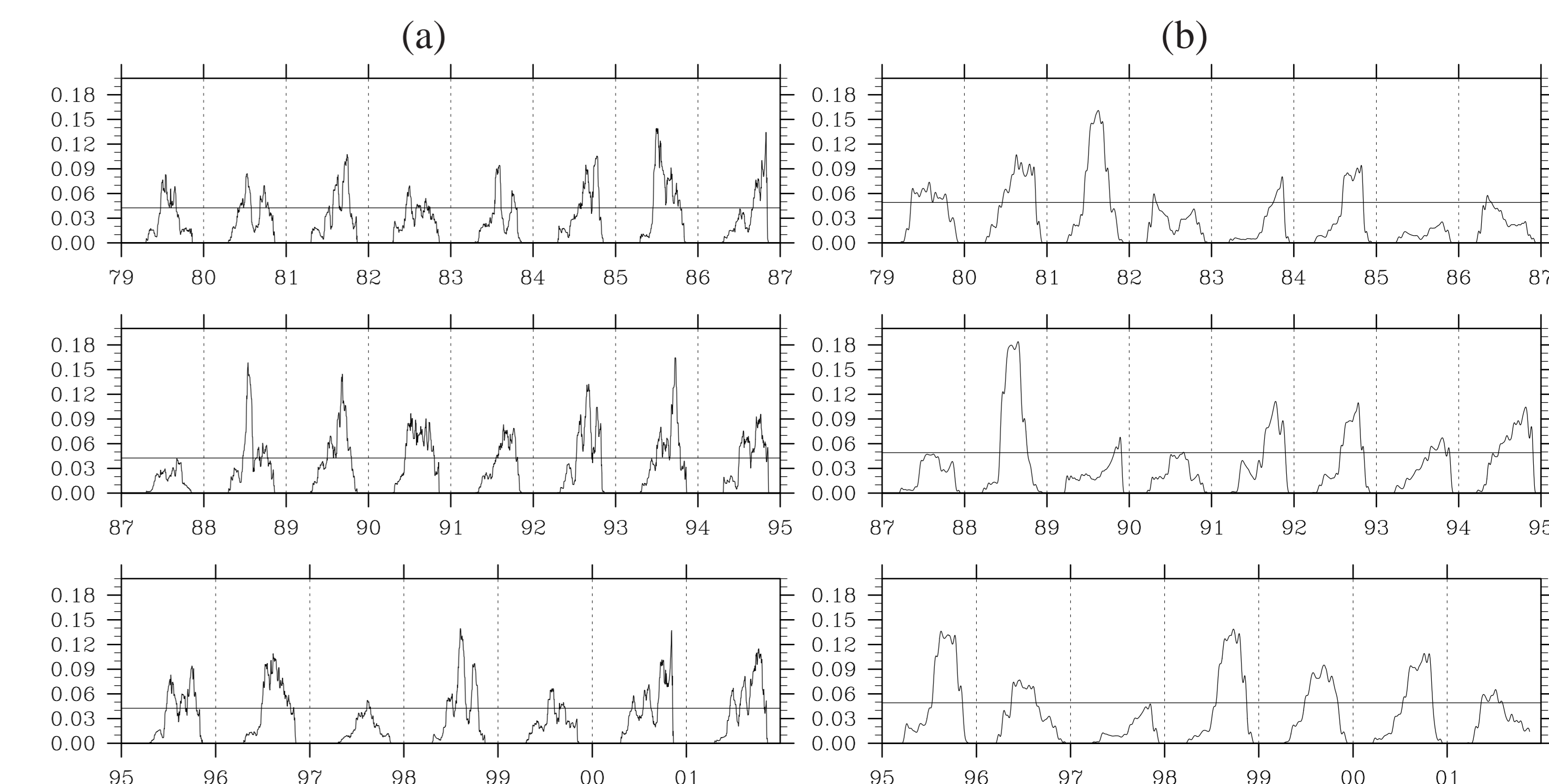


Figure 4: (a) Running-variance of the ITCZ band. The running window is 25 days. The horizontal line is the reference line which is the long-term variance. (b) For the MJO band. The running window is 90 days.

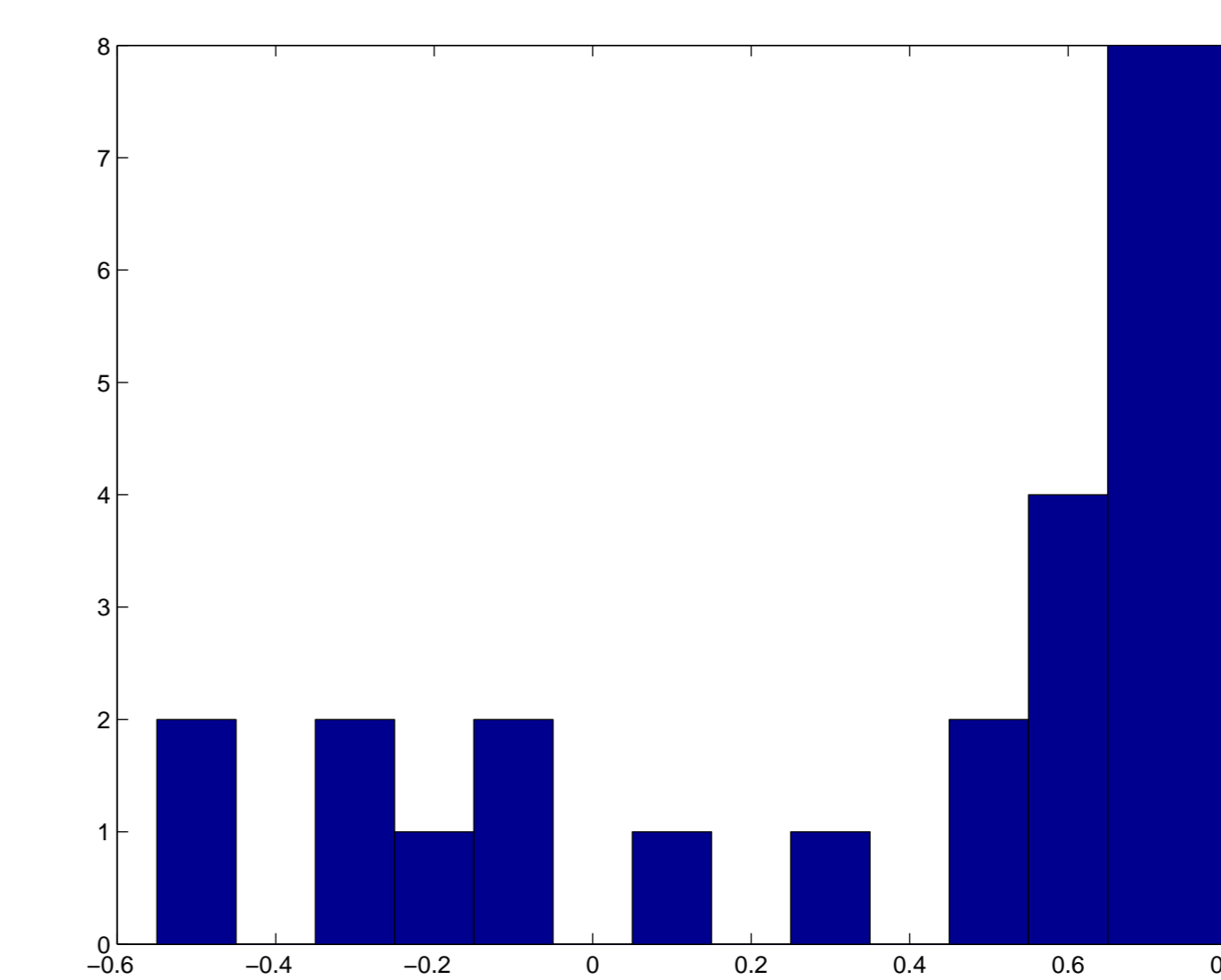


Figure 5: Histogram of the correlation between the ITCZ and the MJO variance. X-axis is the correlation from -0.6 to 0.8 and Y-axis is the number of years.

Some interesting questions to be answered are:

- (1) How is the ITCZ related to the MJO?
- (2) Why is there large inter-annual variability in their correlation?
- (3) What is the role of ENSO in this interaction?

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