Interannual Variability in Northwest Pacific Tropical Cyclone Genesis

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1. Introduction

Chan (1985), Dong (1988) and Lander (1994) have documented reduced numbers of tropical cyclones (TC) genesis west of 160E, but increased cyclogenesis events in a region east of 160E and south of 20N during El Niño events. These studies suggest that the opposite occurs during La Niño events. Lander (1994) further suggests that the TCs distribution and the preferred areas for genesis are governed primarily by the location and the behavior of the monsoon trough.

Many of previous studies hypothesized relationships between ENSO and TC activity but the overall large-scale climate background associated with interannual variability of TC genesis remains unclear. In this study, we investigate the relationship of genesis position of TC in the western North Pacific from the viewpoint of large-scale circulation without making a priori assumption of significant ENSO impact.

2. Data and methodology

The historical record of TC activity in the western North Pacific was obtained from the best track archives of the Joint Typhoon Warning Center (JTWC), Guam. The data from 1979 to 1999 are used in this study. In addition, the following data are used: the monthly reanalysis of the NCEP-NCAR for the period 1979-1999 (Kalnay et al. 1996), the monthly OLR obtained from the Climate Diagnostics Center (Liebmann and Smith 1996) and the reconstructed Reynolds sea surface temperature (SST) produced by the NCEP (Smith et al. 1996). ENSO is characterized by the Nino3.4 (5S-5N, 120W-170W) index obtained from NCEP Climate Prediction Center (CPC). In this study, we focus the analysis only on the July to October season, rather than the mean annual TC occurrences as done by several other studies.

3. Results

Figure 1, provides one way to characterize interannual variability. In most years the mean TC genesis positions tend to align along a northwest to southeast axis with respect to the 1979 to 1999 mean seasonal position. Two distinct TCs genesis groups can be defined by dividing the domain to quadrants with the seasonal mean genesis position as the origin (see Fig. 1). Group B is defined as the TCs falling in the upper left-hand quadrant and includes 1981, 1985, 1996, 1998 and 1999. Group D is defined as the TCs falling in the lower right hand quadrant, which includes 1987, and the relatively prolonged warm period years of 1991-1995 (Trenberth and Hoar 1996).

Figure 2 shows large differences of vertical wind shear anomalies structure in the western North Pacific between composites for group B and D. For group B (Fig. 2a), large vertical wind shear anomalies dominate the southern part of the western North Pacific, inhibiting TC genesis to the southeast of the 1979 to 1999 mean TC position. In contrast, the group D composite, Fig.

3b, shows a weak vertical wind shear anomaly to the southeast of the 1979 to 1999 mean TC position.

For group B TCs, the vertical wind shear anomaly pattern is associated with strong upper level westerly wind anomalies (not shown) and low-level easterly wind anomalies (Fig. 3a) which appear to be associated with tropical heating anomalies (Fig. 3a). Large east to west shifts in the equatorial Pacific convection patterns are suggested in the positive-negative anomaly "dipole" pattern in the OLR (Fig. 3a). The development of the anomalous anticyclone feature associated with the easterly wind anomaly in the 850-hPa wind field indicates the monsoon trough is weaker and retreats westward thus favoring the northwest quadrant for TC genesis as would be expected for a Group B composite. In contrast, the anomalous cyclone feature associated with low-level westerly wind anomaly can be seen in the group D composites, Fig. 3b, indicating an intensification and eastward extension of the monsoon trough. As a result, favorable conditions for TC genesis tend to shift southeast.

The composite of the July-October seasonal SST anomaly for years represented by groups B and D, Fig. 4a and Fig. 4b. The composite for the group B TCs features negative SST anomalies across the eastern tropical Pacific to central tropical Pacific Ocean (Fig. 4a) straddled by near zero or weak positive SST anomalies to the north and south. This pattern is reminiscent of composite La Niña conditions with the additional feature of relatively strong positive SST anomalies along the coast of East Asia down to South China Sea (Fig. 4a). The differences between SST anomalies for the group B TCs and group D TCs are large for the equatorial central Pacific but negligible for the East Asia coast. In contrast to the negative central equatorial SST anomalies for group B, the composites for group D show the large positive SST anomaly along the dateline, Fig. 4b. This pattern is reminiscent of El Niño composites but with the largest positive SST anomalies situated near the dateline and almost no anomaly in the Eastern Pacific. This SST anomalies pattern does not occur in the evolution of every El Niño suggesting that El Niño is not always a significant factor for TC genesis during the July-October season.

4. Discussion

The interannual modulation of the TC genesis regions, represented by groups B and D in this study may be related to the interannual variation of the equatorial central Pacific heating and its Rossby wave response (Gill 1980). This response may manifest itself as changes in the circulation features over the Philippine Sea as suggested in the composite wind fields, Figs. 4.

While large SST anomalies in the central equatorial Pacific appear to be a factor in TC genesis the analysis suggests that any relationship to ENSO and TC genesis is not simple. This is manifest most clearly by the observation that the TC genesis regions do not simply fall into categories based on El Niño/La Niña. The complicated nature of this role is likely associated with the differences in the timing and evolution of individual ENSOs with respect to the peak of the TC season e.g., the mature phase of ENSO tends to be in winter (Rasmusson and Carpenter 1982), but the typhoon season runs from July to October.

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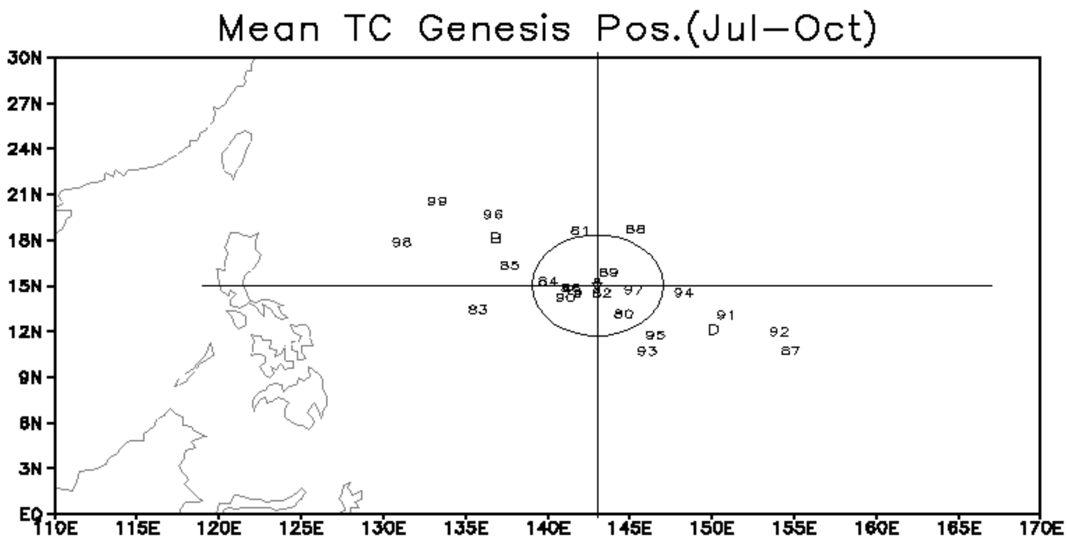


Figure1. The seasonal mean (July-October) TC genesis position from 1979 to 1999. (E.g., "87" is the seasonal mean genesis position for 1987 etc, the triangle shows the long-term (1979-1999) seasonal mean genesis position as the center of circle. The radius is the standard deviation of the seasonal TC genesis position. Letters "B" and "D" indicate the mean TC genesis positions for each of these quadrants.

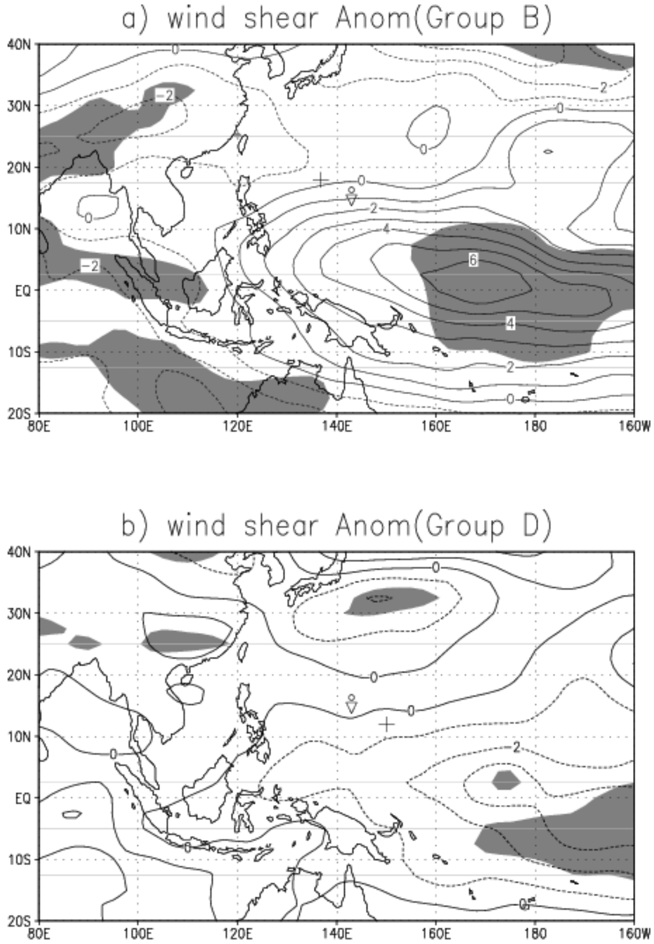


Figure 2. Composite seasonal vertical wind shear anomaly based on NCEP/NCAR Reanalysis, Kalnay et al (1996) for (a) Group B (1981, 1985, 1996, 1998 and 1999) and (b) Group D (1987,1991-1995), respectively. Areas where a t test indicates significant differences from the mean shear at the 95% level or above are shaded. The 1979 to 1999 mean TC genesis region is indicated by the triangle-dot (shower) symbol on each panel. The “+” sign indicates the composite mean TC genesis position for each group.

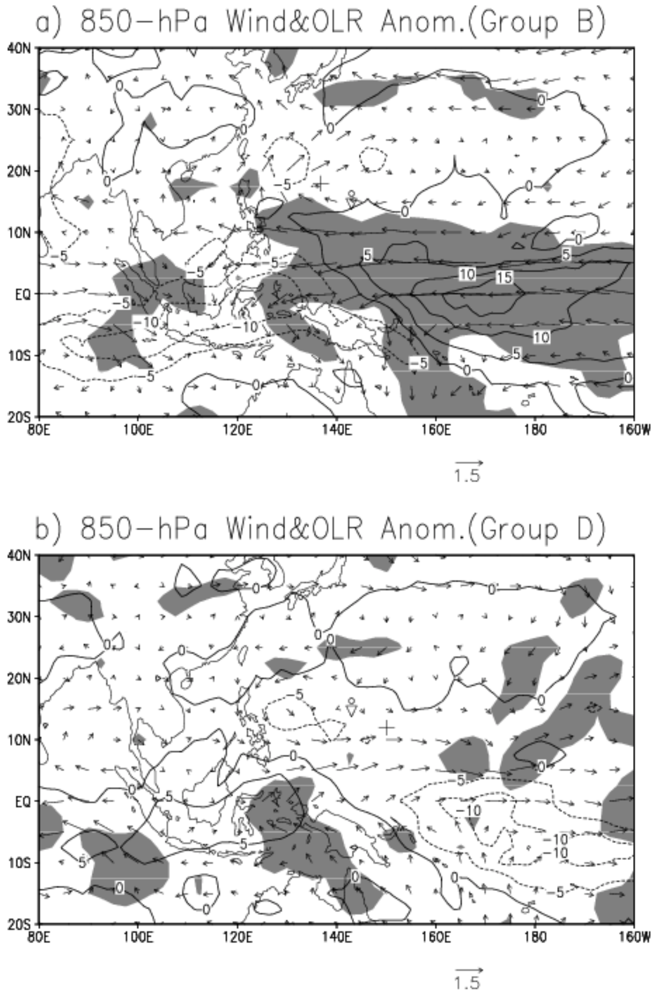
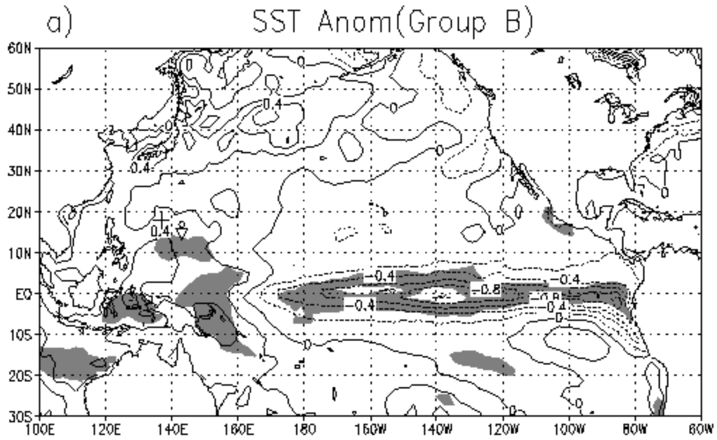


Figure 3. Composite of the seasonal 850-hPa wind vector anomaly (m/s) and OLR anomaly for a) Group B and b) for Group D. Solid contours indicate reduced convection regions and dashed contours indicate enhanced convection regions. The contour interval of OLR anomaly is 5 W/m^2. Areas where a t test indicates significant differences from the mean winds at the 95% level or above are shaded. The 1979 to 1999 mean TC genesis region is indicated by the triangle-dot (shower) symbol. The “+” sign indicates the composite mean TC position in each group.



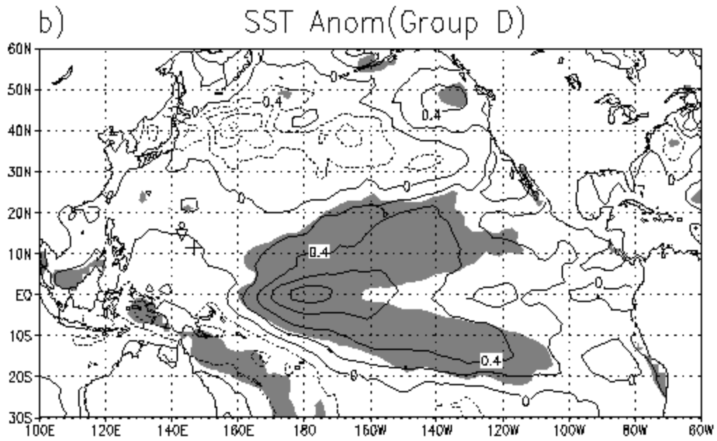


Figure 4. Composite of the seasonal sea surface temperature (SST) anomaly based on SST from Smith et al., 1996, a) Group B and b) Group D. The contour interval is 0.2C. Areas where a t test indicates significant differences from the mean winds at the 95% level or above are shaded.