

ON THE TROPICAL CYCLONE ACTIVITY IN THE NORTHWEST PACIFIC
BASIN AND BIEN DONG SEA IN RELATIONSHIP WITH ENSO

Phan Van Tan

University of Sciences, Hanoi

Abstract

Based on data sets of tropical cyclone tracks in the period of 1945-2000 of Hurricane Data Archives from <http://www.unisys.com>, the activity of tropical cyclones (TCs) in the Northwest Pacific basin and Bien Dong sea is investigated with respect to the ENSO phases and intensity of TCs. The intensity of tropical cyclones is divided into two classes: TCs that reach the intensity of tropical depression and tropical storm (weak TCs), and TCs that reach the intensity of typhoon (intense TCs). The results showed that, ENSO events influence frequency of occurrence and the genesis location of TCs. In general, the TCs occurred and generated in Bien Dong sea are increased during the La Nina years and decreased during the El Nino years, in number. During the El Nino (La Nina) phases, the genesis locations of tropical cyclones displace toward to the East (West). Further more, the genesis locations of tropical cyclones in the Bien Dong sea tend to the North, while in Northwest Pacific basin tend to the South, during the El Nino phases.

1. Introduction

Tropical cyclones (TCs) are the costliest and deadliest natural disasters around the world, as the approximate 300000 death toll in the infamous Bangladesh Cyclone of 1970 [5] and the thousands of fishermen and fishing boats are destroyed in the South of Vietnam by the Linda typhoon in 1997. Typhoon property losses exceeds that due to earthquakes by a factor of four. Understanding and being able to predict how both tropical cyclone frequencies and intensities vary from year to year is obviously a topic of great interest to meteorologists, public and private decision-makers and the general public alike.

“Tropical cyclone” is the generic term for a non-frontal synoptic scale low-pressure system that develops over tropical or sub-tropical oceans with organized convection and a well-defined cyclonic surface wind circulation. Its energy source is primarily derived from evaporation and sensible heat flux from the sea in the presence of high winds and lowered surface pressure. These energy sources are tapped through condensation and fusion in convective clouds concentrated near the cyclone's "warm-core" center [3]. Tropical cyclones with maximum sustained surface winds of less than 18 m/s are called "tropical depressions" (TD). Once the tropical cyclone reaches winds of at least 18 m/s they are typically called a "tropical storm" (TS) and assigned a name. If winds reach 33 m/s, they are then called a "typhoon" (TY).

Landsea C. W. [5] showed that the necessary (but not sufficient) environmental conditions before tropical cyclogenesis and development can occur are: 1) Warm ocean waters (of at least 26.5 °C) throughout a sufficient depth (unknown how deep, but at least on the order of 50 m); 2) An atmosphere which cools fast enough with height such that it is potentially unstable to moist convection; 3) Relatively moist layers near the mid-troposphere; 4) A minimum distance of around 500 km from the equator so that the Coriolis force to provide for near gradient wind balance to occur; 5) A pre-existing near-surface disturbance with sufficient vorticity and convergence; and 6) Low values (less than about 10 m/s) of vertical wind shear between the 850 and 200 mb levels.

Seasonal variations of tropical cyclone activity depend upon changes in one or more of the above parameters. Globally, tropical cyclones are affected dramatically by the El Nino - Southern Oscillation (ENSO). ENSO is a fluctuation on the scale of a few years in the ocean-atmospheric system involving large changes in the Walker and Hadley Cells throughout the tropical Pacific Ocean region [9]. The state of ENSO can be characterized by the sea surface temperature (SST) anomalies in the eastern and central equatorial Pacific: warmings in this region are referred to as El Nino events and coolings are La Nina events. The Southern Oscillation Index (SOI), the standardized difference in sea level pressure between Tahiti and Darwin, Australia, also describes the state of ENSO with high (low) pressures at Darwin and low (high) pressure at Tahiti corresponding to El Nino (La Nina) events.

The various basins do not respond identically to ENSO. Some show changes in frequency of cyclogenesis, while others show shifts in the genesis locations. Recent works showed that the tropical cyclones in the vicinity of Australia are reduced in number during the El Nino years and this reduction is compensated by an increase in the South Pacific east of 165°E, because of a shift in the center of action in tropical cyclone genesis. The opposite is observed in La Nina events. Likewise, the Northwest Pacific basin experiences a similar change in the location of tropical cyclone genesis without a total change in frequency. But the western portion of the Northeast Pacific basin has been suggested to experience more tropical cyclone genesis during an El Nino year and more tropical cyclones tracking into the sub-region in the year following an El Nino.

Beside the ENSO, there are some other global factors that appear to force change in tropical cyclone activity, such as the stratospheric Quasi-Biennial Oscillation (QBO), variations of local sea level pressures, SSTs and tradewind and monsoon circulations (called local effects),...

Understanding tropical cyclone variability on interannual to interdecadal timescales is very important not only for scientists but also for decisionmakers. As mentioned above, many studies have focused upon the variations in the number of tropical cyclones. While the bulk of these studies has been centered upon the Atlantic basin, the Bien Dong sea and coastal zone

of Vietnam have been analyzed to some degree. So, this paper will firstly explore the role that the ENSO have upon tropical cyclones around the Bien Dong sea and Northwest Pacific basin.

2. Data and methodology

In order to investigate the role of ENSO in an activity of tropical cyclones around the Bien Dong sea and Northwest Pacific basin, we use the best-track data sets of tropical cyclones from <http://www.unisys.com> of the years from 1945 to 2000. The intensities of TCs are classified based on category of Saffir-Simpson scale:

Type	Category	Pressure (mb)	Winds (knots)
Depression	TD	-----	< 34
Tropical Storm	TS	-----	34-63
Typhoon-1	TY-1	> 980	64-82
Typhoon-2	TY-2	965-980	83-95
Typhoon-3	TY-3	945-965	96-112
Typhoon-4	TY-4	920-945	113-134
Typhoon-5	TY-5	< 920	>134

It is convenient to represent we make some conventions as the following:

- Due to the time series of data sets are limited, it is reasonable to partition the intensities of TCs into two classes: 1) Tropical cyclones that reach intensities of TD and TS (hereafter referred to Case-1) and 2) Tropical cyclones that reach intensities of typhoon TY-1, TY-2, TY-3, TY-4 and TY-5 (hereafter referred to Case-2).

- Northwest Pacific basin is the part of Pacific ocean between 100^oE and 180^oE of the North hemisphere. BienDong sea is the part of Northwest Pacific basin, separated by meridian of 120^oE towards the West (Fig. 1).

- Generating position of tropical cyclone is defined as the first detected coordinate of its center.

- Tropical cyclones which have centers occur in the Bien Dong sea are treated as the Bien Dong sea TCs, despite of their genesis positions.

- The activity of TCs is considered in relationship with ENSO phases. The sample size for examining Northwest Pacific TCs with respect to ENSO is small, with 12 El Nino years, 12 La Nina years, and 32 neutral (Non-ENSO) years. From these data sets, the number and frequencies of genesis positions of TCs in the Northwest Pacific basin and Bien Dong sea during the ENSO phase are calculated.

3. Results and discursions

Table 1 lists the number of TCs that occurred and generated in the Northwest Pacific basin and Bien Dong sea in the ENSO events corresponding to the TCs intensities. It shows that there are 1532 TCs in the data series. Among them, 915 TCs reach the intensities of TY, occupying 59.7%. The mean annual number of TCs generated in the Northwest Pacific basin is 27.2, during the El Niño years and La Niña years these values are 25.9 and 26.5, respectively. Thus, there are no remarkable differences in the number of TCs in the Northwest Pacific basin between El Niño and La Niña years. However, during the El Niño years, TCs that reach the intensities of TY (case-2) tend to increase and those that reach the intensities of TD and TS (case-1) tend to decrease in number in comparison with during the La Niña years.

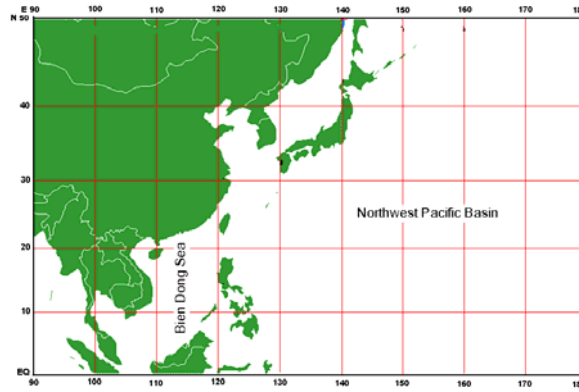


Fig. 1 Northwest Pacific basin and Bien Dong Sea

Table 1. Activity of TCs in the Northwest Pacific basin and Bien Dong sea

	El Niño		La Niña		Non-ENSO		Total	
	Num.	Aver.	Num.	Aver.	Num.	Aver.	Num.	Aver.
Number of TCs in the NW Pacific								
Case-1	101	8.4	122	10.2	394	12.3	617	11.0
Case-2	210	17.5	196	16.3	509	15.9	915	16.3
Total	311	25.9	318	26.5	903	28.2	1532	27.3
Number of TCs occurred in the Bien Dong sea								
Case-1	35	<u>2.9</u>	56	<u>4.7</u>	173	<u>5.4</u>	264	<u>4.7</u>
Case-2	73	<u>6.1</u>	90	<u>7.5</u>	204	<u>6.4</u>	367	<u>6.6</u>
Total	108	<u>9.0</u>	146	<u>12.2</u>	377	<u>11.8</u>	631	<u>11.3</u>
Number of TCs generated in the Bien Dong sea								
Case-1	19	1.6	30	2.5	82	2.6	131	2.3
Case-2	10	0.8	11	0.9	32	1.0	53	0.9
Total	29	2.4	41	3.4	114	3.6	184	3.3

Note: Num. = Number of TCs in whole period,
Aver. = Annual Average of number of TCs.

In contrast, from the table 1, we can also see that, the number of TCs occurred in the Bien Dong sea is decreased considerably during the El Nino phases in comparison with during the La Nina phases. The mean annual number of TCs during the El Nino and La Nina in both cases 1 and 2 are 9.0 and 12.2, respectively. Thus, while the TCs occurred in Northwest Pacific basin have no changed so much between warm phases and cold phases, the TCs occurred in Bien Dong sea are increased during the La Nina years and decreased during the El Nino years in number. The similar situations are showed in number of TCs generated in Bien Dong sea. Issue here, is whether shift of the genesis locations of TCs between warm phases and cold phases?

Fig. 2 presents frequencies of the genesis positions of TCs that occurred in Northwest Pacific basin with respect to longitude and latitude. It is obvious that, during the El Nino phases the genesis locations of TCs tend to displace toward to the East and to the South. In contrast, during the La Nina phases the genesis locations of TCs tend to displace toward to the West and to the North. For more detail, the mean co-ordinates of the genesis positions of TCs during the ENSO phases with respect to the intensities and the geographical regions are calculated and presented in the table 2. To do this, the Northwest Pacific basin is divided into two regions: Bien Dong sea region and its complementary part (referred as NW Pacific (1)). Again we can see that, in comparison with the Non ENSO phase, there is the noticeable shift of the genesis locations of TCs during the warm phases and cold phases. In the case of whole Northwest Pacific basin, the differences of the genesis positions during the El Nino and La Nina years corresponding to the intensities of TD and TS (case-1), TY (case-2) and TD, TS and TY (case-1 and case 2) are 8.0, 6.6 and 7.5 degrees in East-West direction, and are 2.9, 2.6 and 2.9 degrees in North-South direction, respectively.

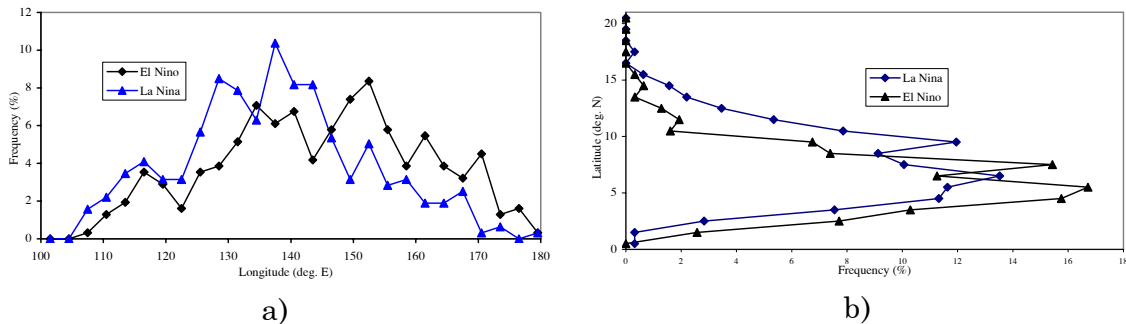


Fig. 2 Distribution of the TCs genesis position respect to a) longitude and b) latitude

It is worth attention here is that, unlike the cases of NW Pacific (1) and whole Northwest Pacific basin, the genesis locations of TCs in the Bien Dong sea tend to the North (but not to the South) during the El Nino phases. The differences of mean positions corresponding to the intensities of case-1, case-2 and both are 0.8, 2.0 and 1.2 degrees, respectively. This might be an important feature of activity of TCs in the Bien Dong sea.

Table 2. The mean genesis positions of TCs in the NW Pacific basin during the ENSO phases

	Longitude			Latitude		
	El Nino	La Nina	Non ENSO	El Nino	La Nina	Non ENSO
TD and TS						
Bien Dong Sea	115.5	113.8	114.5	15.0	14.3	15.2
NW Pacific (1)	147.2	139.5	142.1	13.1	17.1	15.2
TY						
Bien Dong Sea	116.3	114.5	116.5	16.5	14.5	16.2
NW Pacific (1)	148.3	141.6	145.6	11.6	14.5	13.3
TD, TS and TY						
Bien Dong Sea	115.7	114.0	115.0	15.5	14.3	15.5
NW Pacific (1)	147.9	140.9	144.2	12.0	15.4	14.0
Whole NW pacific basin						
TD and TS	141.2	133.2	136.3	13.5	16.4	15.2
TY	146.7	140.1	143.7	11.8	14.5	13.4
TD, TS and TY	144.9	137.4	140.5	12.4	15.2	14.2

Note: NW Pacific (1) is part of Northwest Pacific basin from 120°E to the East.

4. Conclusions

Understanding tropical cyclone activity depend mainly on the length of data time series and accurate records. Base on an available data sets from <http://www.unisys.com> we have made some examinations on the tropical cyclone activity in the Northwest Pacific basin, including Bien Dong sea. Analyses the results showed that:

1) During the El Nino events, tropical cyclones that reach the intensities of typhoon (case-2) tend to increase and tropical cyclones that reach the intensities of tropical depressions and tropical storm (case-1) tend to decrease in number in comparison with during the La Nina events.

2) The tropical cyclones occurred and generated in Bien Dong sea are increased during the La Nina years and decreased during the El Nino years, in number.

3) During the El Nino phases, the genesis locations of tropical cyclones in Northwest Pacific basin and Bien Dong sea tend to displace toward to the East. In contrast, during the La Nina phases, the genesis locations of tropical cyclones tend to displace toward to the West.

4) There are differences in the North – South shift direction of tropical cyclone genesis locations between Bien Dong sea and Northwest pacific basin during the El Nino and La Nina phases. The genesis locations of tropical cyclones in the Bien Dong sea tend to the North, while in Northwest Pacific basin tend to the South, during the El Nino phases.

References

1. Bove M. C., O'Brien J. J., Elsner J. B., Landsea C. W., Xufeng Niu, 1998: Effect of El Nino on U.S. Landfalling Hurricanes, Revisited. *Bulletin of the American Meteorological Society*, **Vol.79, No.11**.
2. Gray W. M., Landsea C. W., Mielke P. W. Jr., Berry K. J., 1994: Predicting Atlantic basin seasonal tropical cyclone activity by 1 June. *Weather and Forecasting*, **Vol. 9, 103-115**.
3. Holland, G. J., 1993: Ready Reckoner - Chapter 9: Global Guide to Tropical Cyclone Forecasting. *WMO/TC-No. 560, Report No. TCP-31, World Meteorological Organization, Geneva*
4. Landsea C. W., 1993: A climatology of intense (or major) Atlantic hurricane. *Monthly Weather Review*, **Vol.121, pg. 1703-1713**.
5. Landsea C. W.: Climate Variability of Tropical Cyclones: Past, Present and Future. *Climate variability of tropical cyclones: Past, Present and Future. Storms, 2000 edited by R. A. Pielke, Sr. and R. A Pielke, Jr, Routledge, New York, 220-241*.
6. Landsea C. W., Gray W. M., 1992: The strong association between Western Sahel monsoon rainfall and intense Atlantic hurricanes. *Journal Of Climate*, **Vol. 5, No. 5**.
7. Landsea C. W., Gray W. M., Mielke P. W., Berry K. J., 1992: Long-Term Variations of Western Sahelian Monsoon Rainfall and Intense U.S. Landfalling Hurricanes. *Journal of Climate* **Vol. 5,1528-1534**.
8. Landsea C. W., Gray W. M., Mielke P. W., Jr., Berry K. J., 1994: Seasonal forecasting of Atlantic hurricane activity. *Weather* **49, 273-284**.
9. Landsea C. W., Pielke Jr., R. A., Mestas-Nunez A. M., Knaff J. A., 1999: Atlantic basin hurricanes: Indices of climatic changes. *Climatic Change*, **42, 89-129**.
10. Nicholls N., Landsea C. W., Gill J., 1998: Recent trends in Australian region tropical cyclone activity. *Meteorol. Atmos. Phys.* **65, 197-205**.
11. Pielke Jr., R. A., Landsea C. W.: La Nina, El Nino, and Atlantic Hurricane Damages in the United States. *Bull. Amer. Meteor. Soc.*, **80, 2027-2033**

TÓM TẮT

VỀ SỰ HOẠT ĐỘNG CỦA XOÁY THUẬN NHIỆT ĐỐI TRÊN KHU VỰC TÂY BẮC THÁI BÌNH DƯƠNG VÀ BIỂN ĐÔNG TRONG MỐI QUAN HỆ VỚI ENSO

Trên cơ sở tập số liệu quỹ đạo xoáy thuận nhiệt đới thời kỳ 1945-2000 nhận được từ kho lưu trữ số liệu bão qua địa chỉ Internet <http://www.unisys.com>, đã khảo sát sự hoạt động của xoáy thuận nhiệt đới (XTNĐ) có cường độ khác nhau trên khu vực Tây bắc Thái bình dương và biển Đông theo các pha ENSO. Cường độ XTNĐ được chia làm hai loại: Loại đạt cường độ áp thấp nhiệt đới (TD) và bão nhiệt đới (TS) và loại đạt cường độ bão mạnh (TY). Kết quả cho thấy hiện tượng ENSO có ảnh hưởng đến tần suất xuất hiện và vị trí hình thành của XTNĐ. Nói chung, số lượng XTNĐ xuất hiện và hình thành trên biển Đông có xu hướng tăng lên trong những năm La Nina và giảm đi vào những năm El Nino. Trong các thời kỳ El Nino (La Nina) vị trí hình thành của XTNĐ dịch chuyển về phía Đông (Tây). Hơn nữa, vị trí hình thành của XTNĐ trên khu vực biển Đông trong những năm El Nino có xu hướng dịch chuyển về phía Bắc, trong khi đó ở khu vực Tây bắc Thái bình dương lại có xu hướng dịch chuyển về phía Nam.