On the tropical cyclone activity in the Northwest Pacific basin and Bien Dong sea in relationship with ENSO

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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 frequence of occurrence and the genesis location of TCs. In general, the TCs occured 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 fishermans 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 $^{\circ}$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 refered to Case-1) and 2) Tropical cyclones that reach intensities of typhoon TY-1, TY-2, TY-3, TY-4 and TY-5 (hereafter refered to Case-2).

- Northwest Pacific basin is the part of Pacific ocean between 100^0E and 180^0E of the North hemisphere. BienDong sea is the part of Northwest Pacific basin, separated by meridian of 120^0E towards the West (Fig. 1).

- Generating position of tropical cyclone is defined as the first detected co-ordinate 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 considerated 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 frequences 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 occured and generated in the Northwest Pacific basin and Bien Dong sea in the ENSO events corresponding to the TCs intensities. It show that, there are 1532 TCs in the data series. Among them, 915 TCs reach the intensities of TY, occupy 59.7%. The mean annual number of TCs generated in the Northwest Pacific basin is 27.2, during the El Nino years and La Nina years these values are 25.9 and 26.5, respectively. Thus, there are no remarkable difference in the number of TCs in Northwest Pacific basin between El Nino and La Nina years. However, during the El Nino years, TCs that reach the intensities of TY (case-2) tend to increase and that reach the intensities of TD and TS (case-1) tend to decrease in number in comparison with during the La Nina years.

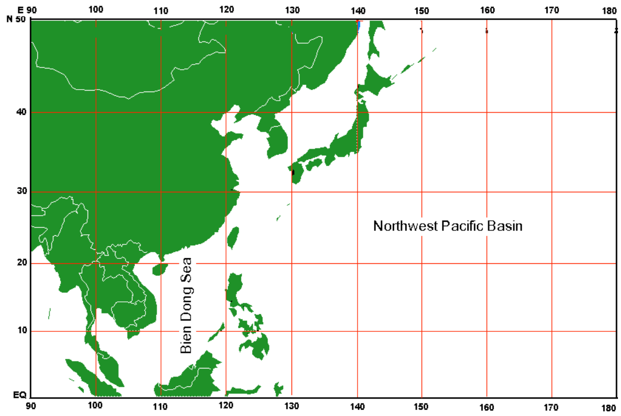


Fig. 1 Northwest Pacific basin and Bien Dong Sea

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

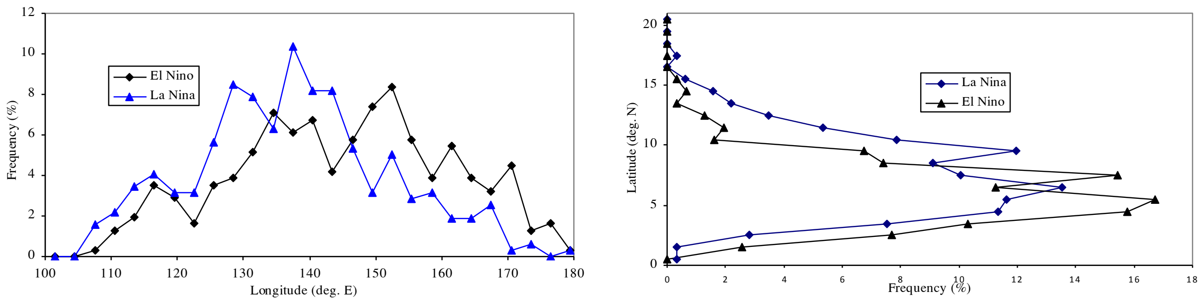
	El Nino		La Nina		Non-ENSO		Total	
	Num.	Aver.	Num.	Aver.	Num.	Aver.	Num.	Aver.
	Number of TCs in the NW Pacific							
Case-1	101	8.4	122	10.2	394	12.3	617	11.0
Case-2	210	17.5	196	16.3	509	15.9	915	16.3
Total	311	25.9	318	26.5	903	28.2	1532	27.3
	Number of TCs occured in the Bien Dong sea							
Case-1	35	2.9	56	4.7	173	5.4	264	4.7
Case-2	73	6.1	90	7.5	204	6.4	367	6.6
Total	108	9.0	146	12.2	377	11.8	631	11.3
	Nunber 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 occured 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 occured in Northwest Pacific basin have no changed so much between warm phases and cold phases, the TCs occured 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 frequences of the genesis positions of TCs that occured 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 (refered 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.



a) b)

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 120^0E 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 occured 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.

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Tãm t¾t

VÒ sù ho¹t ®éng cña xo¸y thuËn nhiÖt ®íi trªn khu vùc T©y b¾c Th¸i b×nh d¬ng vµ biÓn §«ng trong mèi quan hÖ víi ENSO

Trªn c¬ së tËp sè liÖu quÜ ®¹o xo¸y thuËn nhiÖt ®íi thêi kú 1945-2000 nhËn ®îc tõ kho lu tr÷ sè liÖu b·o qua ®Þa chØ Internet http://www.unisys.com, ®· kh¶o s¸t sù ho¹t ®éng cña xo¸y thuËn nhiÖt ®íi (XTN§) cã cêng ®é kh¸c nhau trªn khu vùc T©y b¾c Th¸i b×nh d¬ng vµ biÓn §«ng theo c¸c pha ENSO. Cêng ®é XTN§ ®îc chia lµm hai lo¹i: Lo¹i ®¹t cêng ®é ¸p thÊp nhiÖt ®íi (TD) vµ b·o nhiÖt ®íi (TS) vµ lo¹i ®¹t cêng ®é b·o m¹nh (TY). KÕt qu¶ cho thÊy hiÖn tîng ENSO cã ¶nh hëng ®Õn tÇn suÊt xuÊt hiÖn vµ vÞ trÝ h×nh thµnh cña XTN§. Nãi chung, sè lîng XTN§ xuÊt hiÖn vµ h×nh thµnh trªn biÓn §«ng cã xu híng t¨ng lªn trong nh÷ng n¨m La Nina vµ gi¶m ®i vµo nh÷ng n¨m El Nino. Trong c¸c thêi kú El Nino (La Nina) vÞ trÝ h×nh thµnh cña XTN§ dÞch chuyÓn vÒ phÝa §«ng (T©y). H¬n n÷a, vÞ trÝ h×nh thµnh cña XTN§ trªn khu vùc biÓn §«ng trong nh÷ng n¨m El Nino cã xu híng dÞch chuyÓn vÒ phÝa B¾c, trong khi ®ã ë khu vùc T©y b¾c Th¸i b×nh d¬ng l¹i cã xu híng dÞch chuyÓn vÒ phÝa Nam.