Effects of ENSO on cold - air activities and tropical cyclones in Vietnam

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Received 19 May 2017; accepted 6 June 2017

Abstract:

This paper presents a summary of the results of a study into the effects of ENSO (El Niño and La Niña) on the frequency of cold fronts and tropical cyclones affecting Vietnam. The results show that, during the ENSO periods, cold air activities affecting Vietnam were reduced. The ratio of total positive anomalies to negative anomalies of front frequency was 68% in the case of El Niño, and 60% in the case of La Niña. The frequency of tropical cyclones affecting Vietnam decreased by 28% in the case of El Niño, and increased to 38% in comparison with the multi-year average in the case of La Niña. During the El Niño period, hurricanes affecting Vietnam were often evenly distributed or concentrated in the first half of the typhoon season, but during the La Niña period, hurricanes were concentrated in the second half of the hurricane season.

Keywords: *cold air, effects of ENSO, tropical cyclones.*

Classification number: *6.2*

Introduction

ENSO - El Niño-Southern Oscillation - is an oceanic - atmospheric phenomenon that occurs in the Pacific Ocean, and brings on strong transformations in the weather and climate of many places around the world, and impacts economic and environmental activities [1]. Over the last half of a century (1951-2016), 20 warm ENSO (El Niño) - and 13 La Niña - related occurrences have been identified according to the Oceanic Niño Index - ONI) [2]. Many scientists have been researching this phenomenon, and many programs have been implemented, including surveys gathering empirical research about oceans and the atmosphere, especially the TOGA program (1985-1994) [3-5]. ENSO often causes severe fluctuations of weather in Vietnam, in which the activity of tropical cyclones and cold air is notable.

This paper studies the impact of ENSO on the intrusion of cold air and the effects of typhoons and tropical depressions on Vietnam.

Methodology and Data

Methodology

The main research method used in this study was a standard deviation analysis that contained the following statistical characteristics:

1) Mean: $\overline{X} = \frac{1}{n}\sum_{t=1}^{n} Xti$

2) Anomaly: $\Delta X = Xt - \overline{X}$

Where : $\Delta Xt > 0$, Positive anomaly

$\Delta Xt = 0$, Anomaly 0

$\Delta Xt < 0$, Negative anomaly

3) The method of determining the periods of warm ENSO phase (El Niño) and the periods of cold ENSO phase (La

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Niña): The study compared the correlation coefficient between the average annual sea surface temperature in NIÑO areas with the mean annual air temperature at 14 climate stations representing the climatic zones in Vietnam, in this study, one El Niño episode was defined as a continuous period of no less than six months with a five-month moving average of the standard deviation of monthly sea surface temperature average (SSTA) of NIÑO-3 (150°W-90°W, 5°N-5°S) greater than or equal to 0.5°C. A La Niña episode is a continuous period of no less than six months with a five-month moving average of SSTA in the NIÑO-3 area less than or equal to - 0.5°C.

Data

- Monthly average sea surface temperature data and anomaly in the NIÑO period of 1950-2000.

- Southern Oscillation Index (SOI) in the period of 1876-2001 [6].

- Data on climatic elements including sea level pressure at four stations in Hanoi, Da Nang, Vung Tau, and Con Dao; cold fronts and typhoons affected Vietnam during the periods of 1950-2000 [7-9].

Results and discussions

The El Niño and La Niña episodes during the period of 1956-2000

As was stated above, during 1956-2000, there was an occurrence of 12 El Niño episodes: 1957/1958, 63/64, 65/66, 68/70, 72/73, 76/78, 79, 82/83, 86/88, 91/92, 93, and 97/98, and eight La Niña episodes: 64/65, 67/68, 70/71, 73/74, 75/76, 84/85, 88/89, and 98/00. The 1997/1998 El Niño season had the highest SSTA value of 3.9°C, which occurred in December 1997 and was considered the strongest El Niño season out of the above mentioned El Niño episodes. The 1998/2000 La Niña had the largest negative SSTA value of -1.6°C, recorded in January 2000, which was considered the strongest La Niña occurrence in the above mentioned La Niña season [10]. These two ENSO batches are used in the case study.

The impact of ENSO on the operation of cold air in Vietnam

Fluctuations of atmospheric pressure:

Checking fluctuations of atmospheric pressure in Hanoi, Da Nang, Vung Tau, and Con Dao for the 1997/1998 El Niño and 1998/2000 La Niña showed that suitable for SOI, the strongest fluctuations, decrease in the north (Fig. 1 and 2). In the El. period of 97/98, the pressure anomaly of the stations was positive (as opposed to the SOI index) and increased according to El's development cycle. Until the peak stage and then gradually decrease in the period of recession El. During the 98/2000 La Niña, the pressure anomaly of the stations is positive and fluctuate in the La. Cycle, corresponding to the volatility of the SOI.

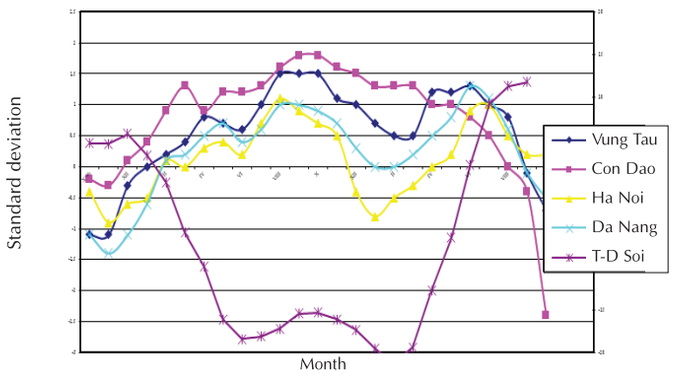

Fig. 1. Variation of the standard deviation of sea level pressure of moving average of five months in El Niño.

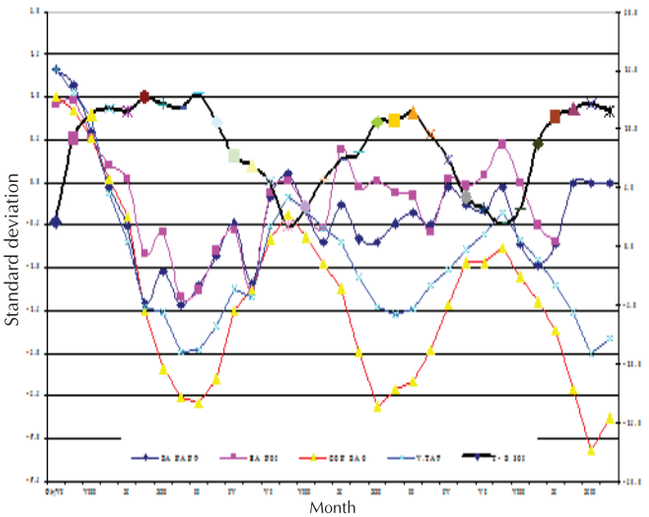

Fig. 2. Variation of the standard deviation of sea level pressure of moving average of five months in La Niña 1998/2000.

Fluctuations of cold fronts affect Vietnam:

Cold front activity affecting Vietnam is reflected through the frequency of cold fronts and the cold front seasons in Hanoi. The impact of ENSO including the El Niño and La Niña's influences were analyzed on a basis of the data on the anomaly of cold front frequency and unusual behavior of cold seasons.

1) Standard of frequency and standard of cold fronts season

The period of 1956-2000 had 1.303 cold fronts, which averages at 29.1 phase for a year, and 2.42 cold fronts per month (Table 1). That is a typical value for the frequency of cold fronts in a month, assuming the number of fronts distributed throughout the year for 12 months. So the cold season in

Vietnam can be considered to be from October to May the next year. June and September are considered as transition months, and July and August are the interruptions of cold fronts.

Table 1. Frequency of cold front over Hanoi from 1956 to 2000.

Months	1	2	3	4	5	6	7	8	9	10	11	12	Year
Total	181	144	148	120	121	68	6	7	61	131	160	156	1303
Average	4.0	3.2	3.3	2.7	2.7	1.5	0.13	0.16	1.4	2.9	3.6	3.5	29.1

2) The effect of El Niño on the frequency of cold fronts

In the 150 months of El Niño, during the period of 1956-2000, there were 356 cold fronts throughout Hanoi. On average, each month there had 2.37 cold fronts, less than the average monthly amount. Although the number of El Niño occurrences had fewer cold fronts, at approximately equal to the number of El Niño cold fronts, the number of El Niño months was negative anomalies than that number of El Niño months that had positive anomalies. The negative anomaly occurs much in the last months of the cold season (II, III, IV, V) and two months of cold interruption (VII, VIII). On the contrary, the positive anomaly is greater than the negative anomaly in the first few months of winter and winter. This leads to the conclusion that, under El Niño conditions, the cold front season has a higher frequency in the first half of winter and is more likely to end sooner than normal (Table 2).

Table 2. Anomaly of cold front frequency in El Niño months.

Sign of anomaly	1	2	3	4	5	6	7	8	9	10	11	12	Total
Positive	7	4	1	2	5	7	2	1	7	9	9	6	60
Negative	4	7	7	10	8	6	11	12	8	4	4	7	88
No Anomaly	2	0	0	0	0	0	0	0	0	0	0	0	2
Total	13	11	8	12	13	13	13	13	14	13	13	13	150

3) La Niña's influence on cold fronts

In the 107 months of La Niña, during the period of 1956 to 2000, there were 243 cold fronts in Hanoi. On average, La Niña had 2.27 cold front phases, less than the normal average during those months (Table 3). As in the El Niño months, the number of La Niña months had a negative effect on cold fronts, more than the positive anomaly. Almost all months that had negative anomalies are superior, especially during the half months after winter. Only in May, October, and December, opposite situation was observed, in which the positive anomalies were greater than the negative anomalies. In addition, the La Niña season of 1998-2000, which lasted for only four months (in 18 months of existence), was the period of interruption and transition of the cold front season but still very little cold front.

Table 3. The anomaly of cold front frequency in La Niña months.

Sign of anomaly	1	2	3	4	5	6	7	8	9	10	11	12	Total
Positive	0	2	2	3	5	3	0	4	4	7	4	8	42
Negative	4	6	6	5	2	6	8	4	5	4	7	3	60
None	5	0	0	0	0	0	0	0	0	0	0	0	5
Total	9	8	8	8	7	9	8	8	9	11	11	11	107

An overview of the ENSO cold-front relationship:

- In the El Niño and La Niña periods, the frequency of cold fronts usually decreased, especially in the last months (for El Niño) and the second half of the seasons (for La Niña).

- During the El Niño and La Niña periods, the cold front seasons usually began no sooner or later than usual, but sometimes ended sooner than usual.

- In the El Niño and La Niña periods, cold front interruptions were usually longer than in normal years. During the El Niño years, the number of colder waves deepened further south during the La Niña years. In the years of El Niño and La Niña, the number of cold fronts affecting our country is less than normal. The ratio of total the positive and negative anomaly of the front frequency in Hanoi for the months of the year was only 68% in the case of El Niño and 60% in the case of La Niña. The time interruption of a front is longer, especially in the last months of the cold front season and therefore, the cold front season ended earlier than normal.

The impact of ENSO on the occurrences of tropical cyclones in Vietnam

The standard number of storms and storm seasons in Vietnam:

During the period of 1956-2000, there were 311 storms and tropical depressions (here-in-after referred to as "storms"), and their impact on Vietnam averaged 6.9 attacks per year and 0.58 each month (Table 4). In this study, the mean values of monthly and yearly storms during the 1956-2000 monitoring period were considered to be monthly and yearly storms. If the hurricane season is a period of months with an average of 0.33 times/month or more (at least an average of 3 years with 1 storm), the storm season in Vietnam is from June to December.

Table 4. The average of number storm for per month and year.

Months	1	2	3	4	5	6	7	8	9	10	11	12	Year
Number of storm	0.0	0.02	0.07	0.07	0.11	0.67	0.73	1.16	1.42	1.33	1.00	0.33	6.91

Impact of ENSO on the occurrences of storms:

- Hurricanes affect Vietnam under El Niño conditions

During the period of 1956-2000, there were 12 El Niño periods with a total of 150 El Niño months and 63 storms. On average, there were 0.42 typhoons in Vietnam for each El Niño month, less than the average number of 0.16 attacks (about 28%). Most of the storms affecting Vietnam during the El Niño months of the hurricane season are less than the monthly standard (negative anomaly). Hence, the negative anomaly of the year is also significantly greater than the positive anomaly (Table 5). Thus, the number of hurricanes affecting Vietnam under El Niño conditions is less than normal.

Table 5. Sign of anomaly storm in El Niño months of the hurricane season.

Month	6	7	8	9	10	11	12	Year
Positive anomaly	3	7	4	5	1	2	3	25
Negative anomaly	9	5	8	9	12	11	10	64
Total	12	12	12	14	13	13	13	89

- Hurricanes affect Vietnam under La Niña conditions

During the period of 1956-2000, there were nine occurrences during the La Niña phase with a total of 107 La Niña occurrences and 86 storms. On average, each La Niña month during this period had 0.8 storms affecting Vietnam, more than the standard average of 38% and twice the number of storms affecting Vietnam under El Niño conditions. The difference between the positive anomaly and the negative anomaly is not much but the absolute value of the positive anomaly is significantly greater than the absolute value of the negative anomaly, so the number of storms in the months and in both The hurricane season under La Niña condition is still higher than the average (Table 6).

Table 6. Sign of storm anomaly in La Niña month of the hurricane season.

Month	6	7	8	9	10	11	12	Year
Positive anomaly	4	3	3	4	8	6	3	31
Negative anomaly	3	5	5	5	3	5	8	34
Total	7	8	8	9	11	11	11	65

Conclusions

1. The phenomenon of ENSO clearly affects the distribution of pressure in Vietnam. During the El Niño cycles, the sea surface pressure at Vietnam stations had increased. The sea level pressure anomaly is positive, increasing according to the El Niño development cycles, as opposed to negative values and the process of the SOI. In the La Niña cycles, the situation is reversed; the monthly pressure anomalies are negative, as opposed to the positive and the SOI. As far south, these effects are clearer.

2. The frequency of cold fronts that affects Vietnam in periods of warm ENSO and cold ENSO are less trivial. The frequency of cold fronts decreased much in the last months of the season in the case of El Niño and the second half of the cold season in the case of La Niña. The cold front season ends earlier than usual.

3. The frequency of storms affecting Vietnam in El Niño was 28% less than usual, while in La Niña, the frequency of storms affected Vietnam more than usual by about 38% and nearly twice the frequency of storms affected during the El Niño waves. During the El Niño periods, typhoons affecting Vietnam are often evenly distributed or concentrated in the first half of the typhoon season, while during the La Niña periods, typhoons are concentrated in the second half of the hurricane season.

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