Impact of ENSO on extreme temperatures in Vietnam

Duc Ngu Nguyen*

Centre for Hydro-Meteorological and Environmental Sciences and Technologies

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Abstract:

This paper presents the results of research on the effects of ENSO to extreme temperature in Vietnam [1] through the frequency deviation of the occurrence extreme temperatures during ENSO and non-ENSO seasons. The results demonstrate that in an El Niño winter, the frequency of absolute maximum temperature decreased over mountainous areas of the temperature in comparison to those under the influence of a non-ENSO winter. In summer, the effects of El Niño and La Nina generally led to a reduction in the frequency of maximum temperatures in comparison to the non-ENSO condition. For minimum temperatures, the effect of El Niño winter led to a decrease in the appearance of the temperatures, while the effect of La Nina led to an increase in the appearance of this characteristic. In contrast, the effects of El Niño and La Nina led to a reduction in the frequency of minimum temperatures during summer. Generally, in both El Niño and La Nina conditions, significant changes were observed in the distribution of frequency deviation with regard to both patterns and values of seasons, in which the South obviously exhibited more changes than the North.

Keywords: ***effects of ENSO, extremes temperature, winter.***

Classification number: ***6.2***

Introduction

Research on weather and climate extremes is of particular importance for both scientific and practical purposes. Most climate extremes occur under conditions of abnormal variability in terms of atmospheric circulation or solar radiation. In the context of global climate change, some of the weather and climate extreme events are likely to occur more frequently in the 21st century [2]. In fact, the variation in extreme weather and climate has been exhibited in many places; further, even the moderating climate of local climate conditions also causes to extreme changes [3]. The climate extreme has occurred increasingly more, especially the El Niño and La Nina (ENSO) phenomenon [4] that effects a change in the frequency distribution and intensity of climatic extremes that affect production, and more importantly, can cause severe natural disasters such as heat waves, cold weather, floods, prolonged droughts, unusually strong typhoons, among others.

This study investigates the distribution of extreme temperature in the seasons of El Niño (E), La Nina (L), and non-ENSO (N) during winter and summer across regions spread throughout the country. The impacts of ENSO on extreme temperatures in Vietnam have been assessed, an evaluation that facilitates the creation of forecasting and early warning methods that can contribute to the prevention and reduction of damage caused by natural disasters.

Data and methods

Data

To investigate the distribution of extreme temperature, we have utilized the average maximum and minimum temperature and monthly absolute maximum and minimum temperature data from 38 meteorological stations from the period 1961-2000 and ENSO data from the period 1951-2000.

Methods

The periods of ENSO (El Niño and

*Email: nguyenducngu@yahoo.com.

La Nina) that occurred during the period 1951-2010 are determined with red to the following regulations:

- El Niño (La Nina) forms a continuous period of no less than 6 months with a 5-month moving average of the monthly mean sea surface temperature anomalies in NINO.3 (5°N-5°S, 150°W-90°W) that is greater than or equal to 0.5°C (less than or equal to - 0.5°C) [3].

- Define months and seasons as (3 months) El Niño (E), La Nina (L), and non-ENSO (N):

From the El Niño and La Nina periods defined as above, the months E, L, and N are determined. To determine the ENSO seasons (El Niño and La Nina), each season is defined as constituting 3 months, wherein the spring stretches from March to May, summer from June to August, Autumn from September to November, and winter from December to February, while the average sea surface temperature anomaly (SSTA) in the NINO.3 area is in accordance to the following criteria:

SSTA ≥ 0.5°C El Niño (E)

- 0.5°C ≤ SSTA < 0.5°C neutral or non-ENSO (N)

SSTA < - 0.5°C La Nina (L)

Each season must comprise at least two consecutive months to satisfy one of the above provided criteria. In the case where there are no two consecutive months that fulfill the above criteria, the average SSTA of 3 months must meet that criterion. The frequency and frequency deviation of temperature extremes in ENSO (El Niño, La Nina), and non-ENSO seasons are calculated as follows:

- Calculates the 5th, 10th, 25th, 50th, 75th, 90th, 95th percentile of the extreme temperature in non-ENSO seasons).

Determine the extreme temperature values for the 95th, 90th, 5th, and 10th percentile utilized as the "threshold" values of the "warm" ("cold") events with the following rules: The "extreme" events occur when maximum/minimum temperature in the ENSO seasons are higher (lower) than the "threshold" values that correspond to the 90th, 95th (5th, 10th) percentile for the non-ENSO (normal) seasons.

- Calculate the frequency of occurrence of extreme temperatures in ENSO seasons, with the extreme temperature as higher (lower) than the "threshold" of extreme temperatures with percentiles 90th, 95th (5th, 10th) in non-ENSO seasons of the corresponding seasons.

- Calculate the frequency deviation (P_{anom}) of extreme temperatures in ENSO seasons that correspond to the percentiles 90th, 95th (5th, 10th) ("threshold") in non-ENSO seasons of the corresponding seasons through the application of by the formula given below [5]:

$$P_{anom} = 100\left(\frac{p}{100-m} - 1\right)$$

where:

p forms the frequency of extremes for ENSO seasons higher (lower) than the "threshold" values for the m percentile in the non-ENSO seasons (base seasons) of the corresponding seasons;

m represents the number of percentiles.

Thus, the frequency anomaly reflects the increase or decrease in the frequency of extremes during ENSO seasons in comparison to their occurrences during non-ENSO seasons for the corresponding seasons.

Results and discussions

For the above definition, the years and seasons of El Niño (N), La Nina (L), and non-ENSO (N) are presented in Table 1

Mean winter, summer of E, L, N seasons' extreme temperature distribution (spring and autumn cases are omitted)

Monthly average maximum temperature ($\overline{Tx}$):

- Winter:

In the North-West, the values of monthly $\overline{Tx}$ in E seasons were found to be higher in N and L seasons with 0.5-2°C. The difference between the highest value and the lowest value of the average monthly maximum temperature (Δx) in E and L seasons was determined to be nearly 8-10°C, values that are comparatively lesser than that in N seasons (about 12°C).

In the North-East, monthly $\overline{Tx}$ in E seasons was found to be greater than that in L seasons, but at the same level as that of N seasons. In contrast, the maximum value of monthly $\overline{Tx}$ in E seasons was found to be greater than L and N seasons of 2-3°C, while the minimum value for the monthly $\overline{Tx}$ in E seasons was determined as being greater than that in L seasons and less than that in N seasons of about 1-2°C. Δx in E seasons is 10-11°C higher than that in L seasons (9-10°C) and N seasons (7-9°C).

In North central and South central regions, monthly $\overline{Tx}$ in E seasons was found to be higher in N and L seasons, especially in the North central region (2-5°C) (in the South central, it was only 0.5-1°C). Δx in E seasons in the North central reached 9-10°C, while for N and L seasons it was only 7-8°C. In the South central region, the value of this

Table 1. ENSO (E, L) and non-ENSO (N) seasons in the period 1950-2000.

Spring (III-V)			Summer (VI-VIII)			Autumn (IX-XI)			Winter (XII-II)		
E	*L*	*N*	*E*	*L*	*N*	*E*	*L*	*N*	*E*	*L*	*N*
1953	1950	1951	1951	1954	1950	1951	1954	1950	51/52	49/50	50/51
1957	1954	1952	1953	1955	1952	1953	1955	1952	57/58	64/65	52/53
1958	1955	1956	1957	1964	1956	1957	1964	1956	63/64	67/68	53/54
1969	1964	1959	1963	1970	1958	1963	1967	1958	65/66	70/71	54/55
1972	1968	1960	1965	1971	1959	1965	1970	1959	68/69	73/74	55/56
1982	1971	1961	1969	1973	1960	1968	1971	1960	69/70	75/76	56/57
1983	1985	1962	1972	1975	1961	1969	1973	1961	72/73	84/85	58/59
1987	1988	1963	1976	1985	1962	1972	1975	1962	76/77	85/86	59/60
1991	1999	1965	1979	1988	1966	1976	1984	1966	79/80	88/89	60/61
1992		1966	1982	1999	1967	1979	1985	1974	82/83	98/99	61/62
1993		1967	1983		1968	1982	1988	1977	86/87	99/00	62/63
1997		1970	1987		1974	1986	1998	1978	87/88		66/67
1998		1973	1991		1977	1987	1999	1980	91/92		71/72
		1974	1993		1978	1991		1981	97/98		74/75
		1975	1997		1980	1997		1983			77/78
		1976			1981			1989			78/79
		1977			1984			1990			80/81
		1978			1986			1992			81/82
		1979			1989			1993			83/84
		1980			1990			1994			89/90
		1981			1992			1995			90/91
		1984			1994			1996			92/93
		1986			1995			2000			93/94
		1989			1996						94/95
		1990			1998						95/96
		1994			2000						96/97
		1995									00/01
		1996									
		2000									

E: El Niño, L: La Nina, N: non-ENSO.

characteristic was merely about 3-6°C.

In the Central highlands and the South, the difference between the monthly $\overline{Tx}$ in the E, L, and N seasons were not significant, although it can be seen that the $\overline{Tx}$ in E seasons was slightly higher than in the others (not more than 1°C). The values of Δx also fluctuated between 2 and 5°C.

- Summer:

In general, the difference in the monthly $\overline{Tx}$ for the E, L, and N seasons in all of the aforementioned areas was significantly smaller than that observed in winter. In the case of E seasons, the monthly $\overline{Tx}$'s maximum and minimum values were found to be generally higher than those for L and N seasons by about 0.5-1°C. The value of Δx fluctuated along the range 3-5°C, except in the Central highlands where it varied in the range 5-8°C.

Monthly average minimum temperature ($\overline{Tm}$):

- Winter:

In the North-West, the $\overline{Tm}$ in the E seasons was found to be higher than that for the L and N seasons that ranged around 1°C. However, the maximum and minimum values of the $\overline{Tm}$ were dissimilar between Lai Chau (in the north) and Son La (in the south). In Lai Chau, the maximum values of $\overline{Tm}$ in E seasons were higher than that for the N and L seasons that had a value of about 1°C. In contrast, in Son La, the maximum value of $\overline{Tm}$ in N seasons was greater than that observed in E and L seasons, which were around 1°C. For the minimum value of $\overline{Tm}$, the temperature value for the L seasons was smaller than that for E and N seasons that had values around 2°C. The difference between the maximum value and the minimum value of $\overline{Tm}$ (Δm) for E and N seasons was found to be less by about 5-8°C in comparison to L seasons (6-9°C).

In the Northeast, the $\overline{Tm}$ in E seasons was higher in N and L seasons by about 0.5-1°C. The maximum value of $\overline{Tm}$ was at the same level with a difference of 1.5-2°C. Particularly for the minimum value, a difference was observed for the northern mountains, where in the N seasons the values were lower than those for the N and L seasons by about 1-2°C; while in the Northern delta, the values in the L seasons were lower than those for N and E seasons by about 0.5-1.5°C. The (Δm) values in E and L seasons were in a range of 7-8°C, while the ones in N seasons were in the range 6-9°C.

In the North central, $\overline{Tm}$ in E and N seasons was higher than the one in L seasons of around 0.5°C; while in the South central region, the $\overline{Tm}$ in E and L seasons was slightly higher than that observed during the N seasons. The peak of $\overline{Tm}$ in E seasons and in the North central was higher than the one noted in the L seasons and the N seasons of 0.5-1°C. Further, in the South central region, the values in the L seasons were found to be greater than the ones observed in E seasons and similar in the N seasons. The minimum values of $\overline{Tm}$ in N seasons of the North and the South center were slightly lower than the ones observed for E and L seasons. The Δm for all three seasons of E, L, N in the North central region was higher than the one sobered in the South central coast, in a range of 5-10°C for E and N seasons and 3-7°C for L seasons. In the South central region, the values were in a range of 3-4°C.

In the Central highlands, the $\overline{Tm}$ and its maximum and minimum values for the N seasons were lower than the ones in the E and L seasons of 0.5-1°C. The Δm in E and N seasons were around 3-7°C, whereas the one in L seasons was only 2-6°C.

In the South, the $\overline{Tm}$ and its maximum and minimum values in the N seasons were lower than the values in the E and L seasons, although they were only less than 0.5°C. The Δm values were also small, comprising only 2-4°C.

- Summer:

Similar to the $\overline{Tx}$, the difference in $\overline{Tm}$ in the summer seasons for E, L, and N seasons in all regions was lesser than the one observed in winter, and in general, did not exceed 0.5°C. In all areas, the maximum values of $\overline{Tm}$ in E and N seasons were greater than the values for L seasons of 0.5-1.5°C, for which, the difference in the North-West was the greatest (1-1.5°C), and the difference in the Central highlands was the lowest (0.5°C). The minimum values of $\overline{Tm}$ did not exhibit significant difference. The Δm for summer values was also smaller in comparison to the ones recorded for winter and showed fluctuation ranging between 1-4°C, where Δm for N seasons was usually greater in comparison to that for E and L seasons.

In conclusion, the influence of ENSO on the monthly average maximum temperature ($\overline{Tx}$) and monthly average minimum temperature ($\overline{Tm}$) in Vietnam exhibited the following central characteristics:

1) The segregation of $\overline{Tx}$ and $\overline{Tm}$ in winter for E, L seasons and N seasons was found to be greater than the segregation in summer.

2) In most cases and across most areas, $\overline{Tx}$ and $\overline{Tm}$ in the E seasons were higher than those in the L and N seasons.

3) The difference between the

maximum and minimum value of $\overline{Tx}$ (Δx), as well as the difference between the maximum and minimum value of $\overline{Tm}$ (Δm) in E seasons was higher than that observed in L and N seasons.

4) In addition to the three general characteristics mentioned above, there were some inconsistencies in some places, for certain E, L and N seasons.

Distribution of extreme temperature characteristics corresponding to the 90th and 10th percentile (25th, 50th, and 75th percentile cases are omitted)

Monthly average maximum temperature ($\overline{Tx}$):

- Winter:

For the 90th percentile, in most stations, $\overline{Tx}$ reached the maximum value in E seasons, while the minimum value was attained in the L seasons. However, the minimum values of $\overline{Tx}$ also occurred in about one quarter of the stations in the N seasons, mainly in the northern mountainous areas, the Central coast, and the Central highlands.

For the 10th percentile, almost half of the stations recorded maximum values of $\overline{Tx}$ in the N seasons, mainly in the North and the Central coast. The other stations observed the maximum value of $\overline{Tx}$ in the E seasons, while the minimum value of $\overline{Tx}$ was noted in most stations in the L seasons.

- Summer:

For the 90th percentile, nearly half of the stations exhibit the maximum values in the E seasons and in N seasons.

In the L seasons, the minimum values were observed across most stations of the country. For the 10th percentile, the maximum and minimum values of E, L, and N at stations were relatively uniform (about one third of each).

Monthly average minimum temperature ($\overline{Tm}$):

- Winter:

For the 90th percentile, in most stations, the minimum $\overline{Tm}$ was observed in E seasons, while about half the stations recorded the minimum values of $\overline{Tm}$ in L seasons and nearly half of the stations observed the minimum values in N seasons, mainly in the North East, South central, and Central highlands.

For the 10th percentile, there were about half of stations, mainly in the northern mountainous region, that had a maximum value of $\overline{Tm}$ in the E seasons and N seasons. In the Northern delta and North central coast, about two-thirds of the stations reported the minimum values of $\overline{Tm}$ in the L seasons.

- Summer:

For the 90th percentile, most (about 70%) of the stations noted the maximum values of $\overline{Tm}$ in the N seasons and the minimum values of $\overline{Tm}$ in the L seasons.

For the 10th percentile, about half of the stations reported the maximum values of $\overline{Tm}$ in the N seasons and about half of the stations observed the minimum values of $\overline{Tm}$ in the E seasons. In the L seasons, about one-third of the stations recorded the minimum value of $\overline{Tm}$ and one-third of the stations observed the maximum value of $\overline{Tm}$.

Thus, it can be seen that for the 90th percentile, the effect of ENSO on the distribution of the maximum and minimum values of $\overline{Tm}$ was rather prominent in winter and relatively consistent as well: the maximum values of $\overline{Tx}$ and $\overline{Tm}$ were observed in the E seasons. These findings are consistent with the distribution of $\overline{Tx}$ and $\overline{Tm}$ provided in section 3. For the 10th percentile, the effect of ENSO on the maximum values of $\overline{Tx}$ and $\overline{Tm}$ was inconsistent, especially in summer.

Absolute maximum temperature (Tx):

- Winter:

Nearly two-thirds of the stations recorded the highest value of Tx that occurred in E seasons with the 90th percentile, while only about one-third of such stations with the 95th percentile. Meanwhile, for the 90th and 95th percentiles, the lowest values of Tx in two-thirds of the stations occurred in the L seasons. Particularly in the North-West, the highest value of Tx corresponds to 90th and 95th percentiles that occurred in the L seasons. The lowest values occurred in the N seasons.

- Summer:

For the 90th and 95th percentiles, nearly two-thirds of the stations reported the highest values of Tx in the E seasons, mostly in the Red river delta, South central coast, Central highlands, and South-West. About one-third of the stations recorded the highest values of Tx that occurred in N seasons, mainly in North East and North central. The lowest value of Tx was observed in most stations in the L seasons, mostly in the North, Central highlands, and South-West.

The highest values of the Tx in the summer season that correspond to 90th and 95th percentiles fall in the range 37-39^{o}C in Lai Chau, 35-36^{o}C in Son La, 37-39^{o}C in the Northern mountainous region, and 38-40^{o}C in the North delta, 39-41^{o}C in the North central, 38-40^{o}C in the South central, 32-36^{o}C in the Central highlands (27-30^{o}C in Da Lat), and 35-37^{o}C in the South.

Absolute minimum temperature (Tm):

- Winter:

In most stations, for the 10th and 5th percentiles, the highest values of Tm were observed in the E seasons; the lowest values were found in L seasons. Further, nearly one-third of the stations observed the highest values of Tm in the N seasons, mainly in the Red river delta and Northern highlands. Therefore, the highest value of Tm was rarely observed the in L seasons. The lowest values of Tm in this season that corresponded to the 5th and 10th percentiles were 3-4°C in Lai Chau, -0.1 to 0.4°C in Son La, -1 to 4°C in the Northern mountains, 0-6°C in the North delta, 5-10°C in the North central, 10-15°C in the South central coast, 6-12°C in the Central highlands (4-5°C in Da Lat) and 15-18°C in the South.

- Summer:

About half of the stations observed the highest values of Tm for the 10th and 5th percentiles that occurred in the E seasons, and for about one-third of the stations, it occurred in N seasons, mostly in North and North central regions. In contrast, for most of the stations, the lowest Tm occurred in the L seasons.

The lowest values of Tm in summer that correspond to the 10th and 5th percentiles were 18-19°C in Lai Chau, 15-17°C in Son La, 15-20°C in the Northern mountains, 18-20°C in the North and North central coast, 20-22°C in South central coast, 16-18°C in Central highlands (only 10-11°C in Da Lat), and 18-22°C in the South (Table 2).

Thus, in terms of the highest and lowest values of Tx and Tm both in winter and summer, the effect of El

Table 2. Absolute maximum temperature in summer and absolute minimum temperature in winter corresponding with percentages at some stations in ENSO (E, L) and non-ENSO (N) seasons.

Percentiles (%)	Tx (Summer)						Tm (Winter)					
	90			*95*			*10*			*5*		
Station	***N***	***E***	***L***	***N***	***E***	***L***	***N***	***E***	***L***	***N***	***E***	***L***
Lai Chau	37.78	37.48	38.16	38.47	38.26	38.20	6.33	6.76	3.66	5.22	6.13	3.41
Son La	34.77	34.86	34.94	34.90	35.28	35.00	2.20	3.70	0.41	–0.10	2.25	– 0.17
Lang Son	36.77	37.08	36.39	36.99	37.58	36.97	0.13	1.10	– 1.60	– 1.49	– 1.00	– 1.70
Bai Chay	36.00	35.89	35.39	37.84	36.19	35.40	5.21	6.32	6.26	1.87	5.92	5.54
Ha Noi	38.68	39.26	38.61	39.58	39.97	38.70	6.31	6.10	5.15	6.20	5.43	5.01
Thanh Hoa	39.35	39.59	38.75	39.69	40.27	39.47	6.71	7.52	5.94	6.32	6.65	5.62
Vinh	39.98	39.34	40.19	40.88	39.69	40.30	7.73	8.41	5.45	7.03	7.25	5.21
Da Nang	39.79	39.37	38.89	40.20	39.50	38.90	11.91	13.21	10.49	10.36	11.20	9.25
Nha Trang	37.18	37.43	37.75	37.80	37.88	37.80	16.06	16.91	15.44	15.80	16.62	15.12
Plei Ku	31.75	31.79	31.33	31.90	33.04	31.40	7.61	7.61	6.15	7.31	6.46	6.01
B.M.Thuot	33.60	34.29	32.29	35.04	34.40	32.30	11.81	11.62	10.02	11.32	11.32	9.15
Da Lat	26.68	26.68	26.29	29.46	27.18	26.30	5.63	5.11	5.36	4.53	5.01	4.92
Can Tho	34.98	36.13	35.22	35.67	37.25	35.30	17.35	16.83	16.10	16.07	16.51	14.86
Ca Mau	35.26	34.88	34.17	35.88	35.00	34.20	16.33	18.42	17.15	15.34	18.02	16.82

Niño was usually observed in the case of maximum values, while the effect of La Nina was usually observed for minimum values (corresponding to the 90th and 95th for Tx and 10th and 5th percentiles for Tm).

Frequency deviation of absolute maximum temperature during ENSO (E, L) seasons exceeded the threshold values for different percentile in non-ENSO (N) seasons

Monthly absolute maximum temperature (Tx):

- Winter:

El Niño: The monthly absolute maximum temperature (Tx) in the El Niño winter months exceeded the monthly Tx that corresponds to the 90th percentile in the winter months of non-ENSO that constituted the frequency deviations of - 45 to - 100% in the North-West and Northern mountains, and - 20 to - 100% in Central coast and Central highlands. This implies that in the El Niño winters, P_{anom} of Tx that corresponds to the 90th percentile in the non-ENSO decreased by 20-100%. In contrast, the frequency deviations were positive (10-40% in the North-East and the Red river delta, 40-100% in the South). This indicates that during the winter months of El Niño, the frequency of occurrence of monthly Tx exceeded the Tx of the month that corresponds to the 90th percentile in the winter months of non-ENSO in these areas increased in comparison to the winter months of non-ENSO.

For the 95th percentile, in most regions, the frequency deviation was less than 0 (- 45 to 100%), especially in the South, with a positive frequency deviation.

La Nina: The monthly absolute maximum temperature during the winter months of La Nina exceeds the monthly Tx that corresponds to the 90th and 95th percentile of the non-ENSO winter seasons in most areas (except the North-West) had a frequency deviation less than 0, with values of - 70 to - 100% and - 30 to -100%, respectively. In the North-West, there were positive deviations of 0-30%. Thus, the influence of La Nina in winter mainly led to a reduction in the probability of occurrence of the maximum values of Tx in comparison to the winter months of non-ENSO.

- Summer:

El Niño: The frequency deviation of monthly Tx in El Niño summer months exceeds the monthly Tx that corresponds to the 90th percentile of the summer months of non-ENSO that was less than 0 in most stations. Out of these, P_{anom} were - 20 to - 70% in the Northwest and the Northern mountains, - 40 to - 100% in the Central region, and + 10 to - 70% in the Central highlands. In contrast, in the Northern and Southern delta regions, mainly, the frequency deviation was positive (+ 10 to + 40%). Thus, for the 90th percentile, the influence of El Niño in summer mainly led to a reduction in the probability of occurrence of the maximum values of Tx per month in most regions (except for the North and the South) in comparison to the normal summer months. Similarly, for the 95th percentile, the frequency deviation in most stations ranged from - 45 to - 100%.

La Nina: At most stations, the frequency deviations of Tx per month in La Nina summer seasons exceeds the Tx value that correspond to the 90th percentile of the non ENSO summer months, which was lesser than zero. Out of these, P_{anom} was - 20 to -50% in the North-West and Northern mountains and the South central coast, - 100% in the Red river delta and the Central highlands, and - 50 to 100% in the South. Similarly, for the 95th percentile, the frequency deviation was - 100% in all regions. It can be observed that the influence of La Nina during the summer months also reduced the probability of occurrence of the maximum values of monthly Tx in comparison to the normal summer months.

Monthly absolute minimum temperature (Tm):

- Winter:

El Niño: Frequency deviation of monthly Tm in El Niño winter was equal to or less than the monthly Tm that corresponds to the 5th percentile in non-ENSO winter months. For most stations, the P_{anom} of Tm was lesser than 0 (- 100%), especially in the Mid-Central coast, North-West highlands with the values of - 40 to - 100%. Similarly, for the 10th percentile, the P_{anom} was - 20 to - 70% in the North-West and Northern mountains, - 40 to - 70% in the Northern delta and North central coast, - 70 to - 100% in South central coast, - 20 to - 40% in the Central highlands and - 30 to - 40% in the South.

La Nina: In contrast to the El Niño winter, in the La Nina winter months, the frequency deviation of monthly Tm was equal to or less than the monthly Tm that corresponds to the 5th and 10th percentile of the non-ENSO winter months. In most stations, the P_{anom} of Tm was positive and ranged from - 30 to 200%, with the largest values observed in the North-West and North-West highlands, the smallest in the North, the South central coast and South, in which, 100-130% of the largest value were determined in the Northern mountain, while the smallest was observed in the North central coast. Particularly in the South-West highlands, the frequency deviation is negative, from - 20 to 100%. The result reveals that the influence of La Nina during winter months led to an increase in the probability of occurrence of the lowest values of the minimum temperature in most parts of Vietnam in comparison to normal winters.

- Summer:

El Niño: Frequency deviation of monthly Tm values in the El Niño summer months was equal to or less than the monthly Tm that corresponds to the 5th and 10th percentile of the non-ENSO summer months. The Panom in most stations was less than 0 and showed fluctuation in the range of - 40 to - 100% for the 5th percentile and - 40 to - 70% (except in the Central highlands with - 100%) for the 10th percentile.

La Nina: Frequency deviation of monthly Tm values in La Nina was equal to or less than the monthly Tm that corresponds to the 5th percentile of non-ENSO summer months. Panom of monthly Tm in most stations was less than 0 and fluctuated between - 20 and - 100% (except Southern central highlands with 90-120%). Similarly, for the 10th percentile, most stations showed negative frequency deviations (about - 60%, except - 100% in North central highlands). In the North-West and Northern mountains, the P_{anom} was from - 60% to + 25%. It can be observed that the influence of La Nina in summer mainly led to a reduction the probability of occurrence of the minimum Tm compared to the normal summer months.

The statistical prominence of the ENSO signals provided above was assessed through the conduction of tests at two tails with a prominent level of 0.05.

The results reveal that the above conditions are acceptable; this indicates that the ENSO signal (frequency deviation) is prominent.

Conclusions

1) Monthly maximum temperature ($\overline{Tx}$) and monthly minimum temperature ($\overline{Tm}$) during El Niño in both winter and summer were higher than the ones observed in La Nina and non-ENSO conditions. The changes that took place in winter were greater than the changes that occurred in summer.

2) With regard to the 90th percentile, the impact of El Niño on $\overline{Tx}$ and $\overline{Tm}$ was considerably prominent and consistent: both $\overline{Tx}$ and $\overline{Tm}$ attained the highest values.

In response to the 10th percentile, the impact of ENSO on $\overline{Tx}$ and $\overline{Tm}$ was inconsistent across regions and no significance, especially in the summer, was observed.

3) For the absolute maximum temperature (Tx) and absolute minimum temperature (Tm), El Niño generally displayed the highest values, both in winter and summer, while La Nina generally exhibited the lowest values corresponding to the 90th and 95th percentile (for Tx) and 10th and 5th percentile (for Tm).

- The effect of El Niño on the absolute maximum temperature led to an increase in the probability of occurrence of extremes values that exceed the value of the 90th percentile in non-ENSO conditions in the Red river delta and the South in winter and summer, and led to a reduction in the possibility of occurrence in mountainous areas. The influence of La Nina caused a reduction in the extreme values that were recorded across all regions, both in winter and summer.

- For absolute minimum temperature, the effect of El Niño led to a decrease in the extreme values for the 10th and 5th percentile, both in winter and summer, while the effect of La Nina led to an increase in the probability of common occurrence in all regions of the country compared to non-ENSO regions.

4) The ENSO information (obtained through the characteristics of frequency deviation of extreme events that occurr in seasons under ENSO conditions in comparison to non-ENSO conditions) is prominent. The results demonstrate that the effect of ENSO on temperature and extreme precipitation is evident that indicates the existence of the possibility of prediction of the occurrence of extreme temperatures based on ENSO information.

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