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Research Paper

AN INVESTIGATION OF RAINFALL DEFICIENCY IN OCTOBER AND NOVEMBER IN THE CENTRAL VIETNAM DURING THE 1997 - 1998 EL NINO EVENT

Nguyen Van Thang[1], Vu Van Thang[1]

ARTICLE HISTORY

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ABSTRACT

In this article, the rainfall deficiency in October, November over the Central Vietnam during the 1997 - 1998 El Nino event are investigated based on large-scale moisture transport circulation, wind at 10m and 850hPa levels and sea-level pressure.The results show that there were 9 months in total of 12 months from May1997 to April1998 of this El Nino event observed the rainfall deficiency over some climatic regions of Viet Nam. In which, the most significant deficiency occurred in October, November 1997 in the Central Vietnam in a range of 100 - 150 mm, especially the deficiency reached up to 200 mm at some heavy rainfall centers such as Ky Anh, Hue, Tam Ky, Tra My, Ba To. This deficiency seems to be caused by a weakening of the North East monsoon circulation in comparison to the long-term mean, which leads to formation of an anomalous anticyclonic vortex over the East Sea. The appearance of anticyclonic vortex causes a decrease in moisture transport that suppling to rainfall in the Central Viet Nam. In addition, there is only a main source of moisture from East Sea that favors rainfall formation over Central Viet Nam is lower than climatology.

Keywords: *El Nino, Moisture transport, Rainfall deficit*

1. Introduction

For years, moisture transport on a global and regional scale has been studied in many regions of the world. The relationship between water vapor transport in the atmosphere and rainfall at the specific places, inparticularlythose affected by monsoons, is indicated by the researches (Vu Van Thang, 2016; Nguyen Van Thang, 2017; Liu 2003; Simonds, 1999; Xiaoxia, 2010; Zhou, 2005). The shortage of moisture leading to drought in some areas, especially in El Nino conditions have been studied by some authors (Vu Van Thang, 2014; Liu, 2004; Valsala, 2005; Vu Van Thang, 2016; Zhang, 2015).

Moisture transport is considered one of the elements of circulation because it is computed from humidity and wind. Therefore, moisture transport has an effect on not only rate but also rainfall distribution at any region. In El Nino condition, this effect become clearer. Due to effect of El Nino, drought could last on many regions of Viet Nam from 5 -7 months, especially in the Central and Central Highlands (Nguyen Trong Hieu, 2014). The reduction in rainfall by El Nino events in Viet Nam has been statistically analyzed and the physical mechanism causing that decrease is determined through characteristics ofatmospheric circulation and moisture transport (Nguyen Duc Ngu, 2017; Vu Van Thang, 2016;Nguyen Van Thang, 2017; Vu Van Thang, 2016). Nguyen Van Thang et

NGUYEN VAN THANG
nvthang.62@gmail.com
[1]Viet Nam Institute of Meteorology, Hydrology and Climate change

al.(2017)showed that the prominent features of atmospheric circulation related to the shortage of rain in Vietnam during El Nino 2014 - 2016 are decline of the Pacific Ocean high-pressure; the southeastward shift of the equatorial low pressure enhancing of air pressure on the Pacific Ocean Equator. According to Vu Van Thang et al.(2014), 2016 reasons of autumn rainfall reduction in Central Vietnam under El Nino condition are the weakening of North East monsoon circulation leading to formation of an anomalous anticyclonic vortex over East Sea which decreases moisture suppling to rainfall in Central Viet Nam. The shortage of rain in May El Nino in the Central Highlands is due to the weakening of the southwest monsoon circulation which reduces the moisture source from the Indian Ocean through the Bay of Bengal to provide rainfall in the area.

The goals of this paperareto indicate the role of circulation on autumn rain reduction in Vietnam during the 1997 - 1998 El Nino event.

2. Data and method

The total moisture transport vectors (Q, kgm 1s 1) of air column is computed based on (Nguyen Thi Hien Thuan, 2004; Sminov, 2000;Xiaoxia, 2010), using the following equations:

$$\vec{Q} = -\frac{1}{g}\int_{Ps}^{P0}(\vec{V}q)dp \qquad (1)$$

where g is the gravitational acceleration (ms^{-2}); V is wind vectors; q is specific humidity (gkg^{-1}); p_s and p_o are respectively the lower and upper atmospheric limits of the atmosphere column. The total moisture transport vector is caculated for East Asia region (10^0S - 50^0N, 60^0E - 160^0E), then it is averaged for October, November 1997.

The gridded data include the zonal wind (u, m s^{-1}), the meridional wind(v,m s^{-1}) at 10m and 850 hPa level with a resolution of 0.5x0.5 (reanalysis data CFSR), wind u, v and specific humidity (q, kg kg^{-1}) at 1000, 925, 850, 700, 600, 500, 400 và 300hPa levels at a resolution off 2.5 x 2.5. The Asian Precipitation Highly Resolved Observational Data Integration Towards Evaluation (APHRODITE) rainfall data with resolution of 0.25x0.25 obtained from:

www.chikyu.ac.jp.

3. Results

The strong El Niño event of 1997-1998 lasted about 12 months from May1997 to April1998. During that time, about 9 months occurred the decrease in rainfall over some Viet Nam's climatic regions by this El Nino; the most serious lack of rainfall took place in October and November 1997 over the Central, especially the coastal zone (Vu Van Thang, 2016).

The rainfall anomaly distribution maps in October and November 1997 (Fig.1) show that in October1997 (Fig.1a), the El Nino caused reduction in rainfall over the Central with a range of 100-150mm; the largest decrease (about 200mm) occurred at the heavy rainfall centers including Ky Anh, Hue, Tam Ky, Tra My and Ba To. In contrast, effects of this El Niño linked to rainfallincrease from 20 - 40 mm over the North and the South, especially an increase of more than 60 mm at Bac Quang station. In November 1997 (Fig.1b), reduction in rainfall occurred over almost Viet Nam regions except the South. In the North decreased from 30 - 60 mm, the coastal region of Ha Tinh - Da Nang had faster decline in a range of 100 - 150 mm, some places decreased greater than 150mm such as Ky Anh, Hue. In the South, rainfall increased from 40 - 60 mm.

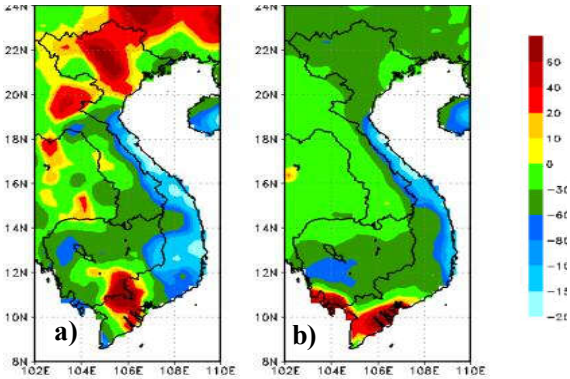

Fig. 1. Rainfall anomaly(mm) over Viet Nam: a) October, b) November 1997

The shortage of rainfall in Central Viet Nam in October/1997 by El Nino is explained based on circulation elements such as wind vector, sea level pressure and total moisture transport vector. Wind vector anomalies at 10m (Fig.2a) and 850hPa (Fig. 2a) levels in October1997 show that there is an anticyclonic circulation in the middle East Sea. The anticyclonic wind circulation in Fig.2 linked to an anomalous of high sea level pressure anomaly (Fig.4a). It is quite same as in November (Fig.3), however the anticyclonic circulation moves to the southern East Sea and extends to the west of Philippine. The anticyclonic wind circulation in Fig.3 is consistent with an anomalous of high sea level pressure anomaly in Fig.4b. The presence of the anticyclones in the end of autumn is resulted from the weakening of the North East monsoon at 10m and 850 hPa levels. Besides, the reduction of major moisture source over East Sea that supplying moist for rainfall in Vietnam leads to the weakening of the low-level wind circulation that carries moist air from the offshore Pacific Ocean to the East Sea and Central Viet Nam.

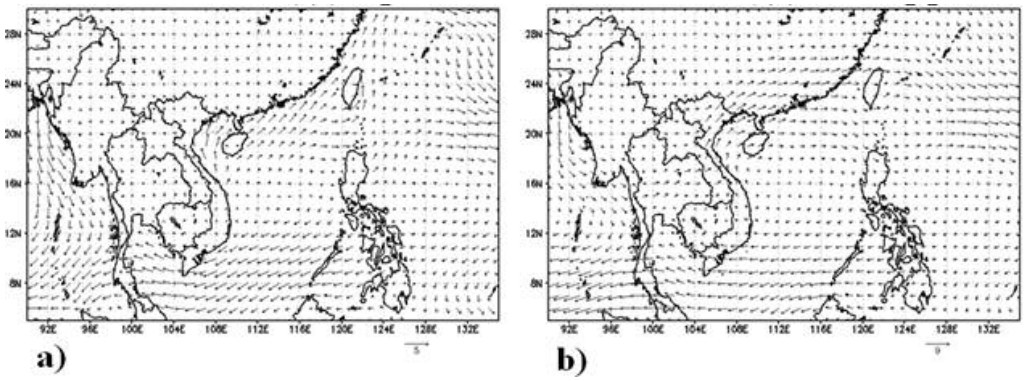

Fig. 2. Anomaly of sea level pressure(m s^{-1}) October/1997: a)- 10m; b)-850hPa.

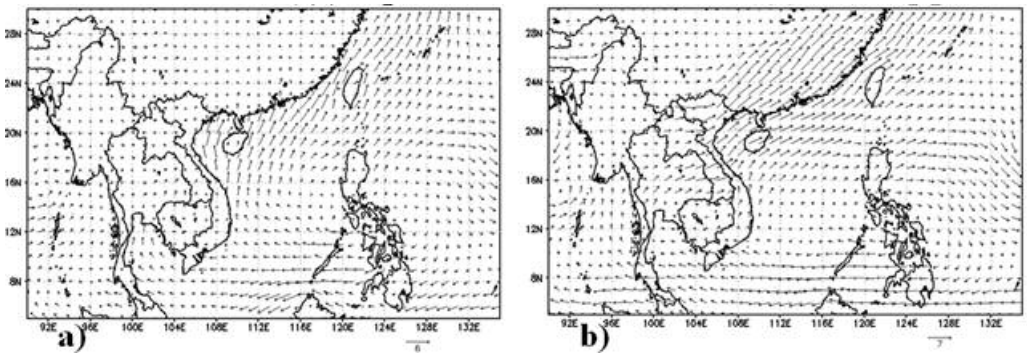

Fig. 3. Wind vector anomaly (m.s^{-1}) November1997: a) 10m; b)850hPa.

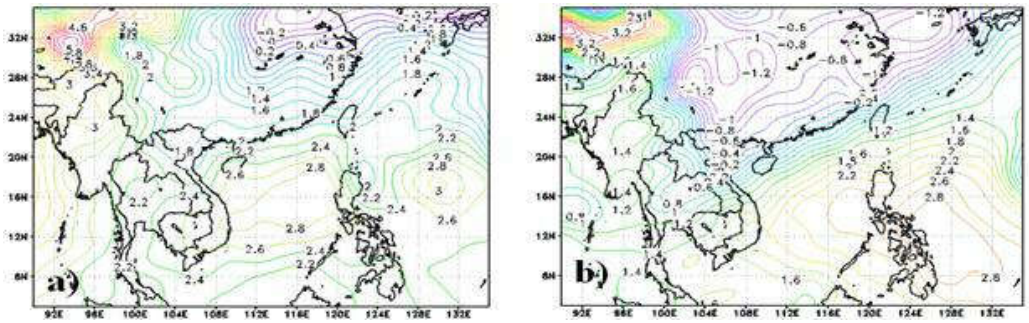

Fig. 4. Sea level pressure anomaly (hPa): a) October/1997, b) November/1997

The distribution of total moisture transport vector in October and November 1997 (Fig. 5a, Fig. 6a) shows that only one main source of moisture that supplying for rainfall over the research region in these 2 months which is from East Sea. However, there is a reduction of 10-20 kg m-1s-1 in content of this moisture sourc compared to the long-term mean. The reason is due to exitence of an anomalous anticyclonic vortex over the East Sea which is indicated in Figs. 2-4. The anomalous moisture transport in October1997 (Fig. 5b) show that the easterly and north-easterly moisture transport vectors to the Central is weaker than the normal. In addition, moisture transport from the Southern Hemisphere could not reach the Central. The total moisture transport vector in November 1997 (Fig.6a) shows range of large moisture source over the East Sea is narrower and its location moves to south of the East Sea much more than that in October 1997. The moisture in the offshore Pacific Ocean is lower in comparison to the long-term mean. The anomaly of moisture transport vector in November 1997 (Fig.6b) shows a reduction in easterly and north-easterly moisture transport vector.

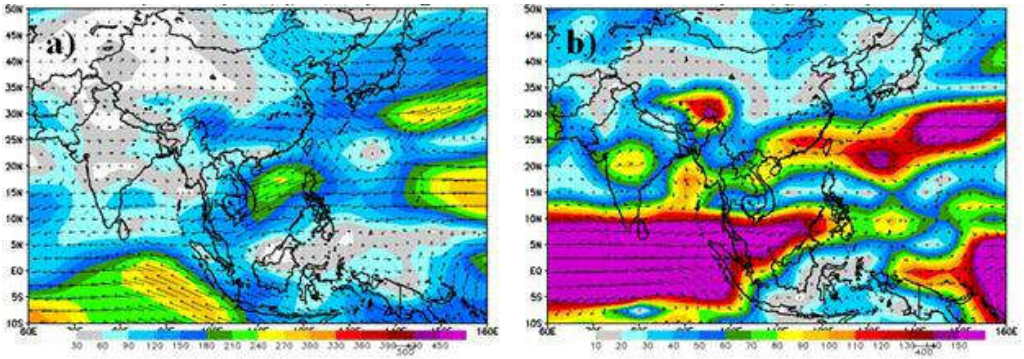

Fig. 5. Total moisture transport (kg m^{-1} s^{-1}) October/1997: a) Vectors, b) Anomaly

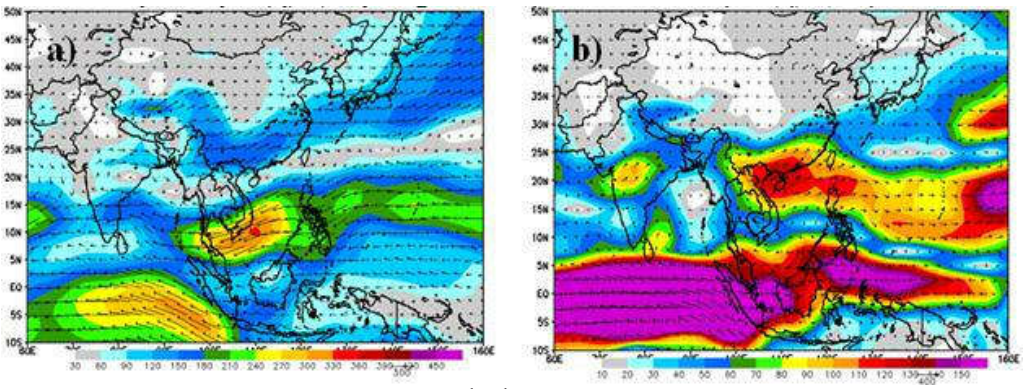

Fig. 6. Total moisture transport (kg m^{-1} s^{-1}) November 1997: a) Vectors, b) Anomaly

In summary, the deficit of rainfall over the Central Viet Nam in this El Nino event in October and November1997, especially at heavy rainfall centers relates to: (1) a weakening of the North East monsoon over the East Sea in comparison to the long-term mean; (2) The presence of anomalous anticyclone in the middle East Sea leading to the reduction of moisture source to the Central Viet Nam; (3) Existing only one source of moisture that supplying for rainfall in the research region; (4) Moisture content in the East Sea is lower than the long -term mean. It can be seen that the reasons leading the deficit of rainfall in this event is suitable to general mechanise. It can be seen that the reasons for the lack of rainfall in this event over the Central are similar tothe general mechanism indicated in the research of Vu Van Thang (2016).

4. Conclusion

During the 1997-1998 El Niño event from May1997 to April1998, there are 9 months in total of 12 months that occurring the rainfall deficiency over some Viet Nam's climatic regions. In which, the most serious deficiency took place in October and November 1997 over the Central, especially the coastal zone. The average of rainfall deficiency is in a range of 100 -150 mm; In particular, the deficiency reached up to 200 mm at some heavy rainfall centers such as Ky Anh, Hue, Tra My, Tam Ky and Ba To.

The shortage of rainfall in the Central Viet Nam in the last months of autumn (October and November 1997) under El Nino condition are related to the weaker North East monsoon circulation over the East Sea compared to the long-term mean that favors to form an an anomalous anticyclonic vortex over the East Sea that causing the reduction in moisture transport to the Central Viet Nam; the moisture transport in north and northeast direction is lower than the long-term mean. In addition, there is only a main source of moisture from East Sea that favors especially rainfall formation over Central Vietnam is lower than the climatology.

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