Using Reanalysis SST Data for Establishing Extreme Drought and Rainfall Predicting Schemes in the Southern Central Vietnam

Dr. Nguyen Duc Hau[1], Dr. Nguyen Thi Minh Phuong[2]
National Center For Hydrometeorological Forecast, Viet Nam
[1]tshau04@yahoo.com, [2] ntmphuong@yahoo.com.au

!. INTRODUCTION

The Southern Central Vietnam is located in Bien Dong Sea coastal region. Every year it is seriously affected by droughts, floods and inundation, causing heavy socio-economical damages. Therefore, droughts-floods and inundation forecasting is of great importance in Seasonal Forecasting in Vietnam. These disastrous weather phenomena are correlated with the South East Asian monsoon variability. In its turn the South East Asian monsoon variability is correlated closely with atmospheric-ocean coupling in Western North Pacific equatorial tropics and ENSO activity. Based on these correlations the authors established drought and heavy rainfall predicting schemes for the Southern Central Vietnam.

Before 1999 due to the lack of data this study faced numerous difficulties. Since 2000 thank to reanalysis SST data supplied by JMA and IRI, so the correlation between SSTA (SST anomaly) and thermo-humidity balance in drought years and rainy years had studied successfully. Therefore, the 1960-1999 reanalysis SSTA data were used to establish seasonal drought and heavy rainfall predicting schemes in the Southern Central Vietnam.

2. SOME SOUTHERN CENTRAL VIETNAM'S GEOGRAPHICAL AND CLIMATOLOGICAL CHARACTERISTICS

The Southern Central Vietnam region includes provinces located along coastal line (Fig.1). To the North there is Truong Son ranges oriented NW-SE that prevented the NE monsoon invasion, to the West there is highland area, to the East and South there is Bien Dong Sea. The climate regime of this region varies very complicatedly under influence of topographical and monsoon activities, the the heat-humidity regime is depend on the activities of oceanic air masses. The varibility of above mentioned air masses leads to significant varibility in weather regime : droughts, heavy rains and inundations occur cyclicly and frequently.

Figgure 1. Map of the Southern Central Vietnam region

3. DROUGHT AND HEAVY RAINFALL DEFINING INDEX

In this paper the author uses the heat-humid index Sa.I (the Sazonov Index) for evaluating and predicting drought and heavy rainfall in the Southern Central Vietnam. The result shows that the monsoon variability leads to the large variability in the Sa.I in this area: it ranges from serious drought to serious inundation. The Sa.I is defined by the following formula:

$$Sa.I = \frac{\Delta T}{\sigma T} - \frac{\Delta R}{\sigma R} \qquad (1)$$

where ΔT: Anomaly of monthly mean temperature;
σT: Monthly mean temperature's standard deviation
ΔR: Anomaly of monthly rainfall;
σR: Monthly rainfall 's standard deviation.
According (1), the drought – inundation status is defined as followings:
Sa.I > 1 : drought ; Sa.I < -1 : lots of rains;
Sa.I > 2 : severe drought; Sa.I < -2: inundation.

Consequently, the large positive Sa.I values indicate the severe drought and in reverse, the small negative Sa.I values indicate the serious inundation.

The Sa.I showed appropriate results in evaluating the drought-inundation status because it includes the temperature factor: rainfall deficiency plus high temperature leads to severe drought.

4. PROBABILITY OF DROUGHT - INUNDATION DEFINED BY THE SA.I FOR THE SOUTHERN CENTRAL VIET NAM

The rainfall and temperature data series between 1960-2000 of Meteorological stations characterized for the Southern Central Vietnam region are used in this research.

Evaluating the probability of drought - inundation by the Sa.I values are shown in table 1.

Table 1. Probability (%) of the Sa.I values in the months

Stations	Sa.I	Months											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Da Nang	≥ 2	5.3	10.5	10.8	5.4	8.1	7.9	7.9	10.5	10.5	10.5	0	5.3
	≥ 1	23.7	26.3	24.3	24.3	32.4	28.9	26.3	26.3	34.2	21.1	15.8	23.7
	≤ -1	21.1	23.7	21.6	16.2	27.0	23.7	18.4	31.6	28.9	23.7	13.2	18.4
	≤ -2	7.9	5.3	8.1	8.1	8.1	7.9	7.9	7.9	7.9	7.9	10.5	7.9
Quang Ngai	≥ 2	5.4	5.4	2.7	10.8	10.8	16.2	5.3	15.8	7.9	15.8	5.2	5.2
	≥ 1	27.0	32.4	27.0	29.7	24.3	27.0	26.3	31.6	28.9	28.9	23.7	23.7
	≤ -1	21.6	21.6	21.6	32.4	21.6	24.3	23.7	34.2	34.2	26.3	21.1	13.2
	≤ -2	8.1	5.4	10.8	8.1	16.2	10.8	10.8	15.8	10.8	7.9	5.3	5.3
Tuy Hoa	≥ 2	0	5.6	5.6	11.1	16.7	13.9	5.4	8.1	16.2	5.6	2.7	8.1
	≥ 1	19.4	22.2	27.8	27.8	25.0	33.3	32.4	24.3	21.6	19.4	29.7	18.9
	≤ -1	25.0	25.0	22.2	19.4	25.0	33.3	27.0	16.2	18.9	11.1	21.6	24.3
	≤ -2	8.3	5.6	8.3	13.9	16.7	13.9	13.9	8.1	5.4	5.6	10.8	10.8
Phan Thiet	≥ 2	5.6	2.8	2.8	2.8	5.4	10.8	8.1	5.4	10.8	10.8	5.4	2.8
	≥ 1	19.4	19.4	22.2	41.7	27.0	27.0	18.9	16.2	24.3	27.0	27.0	16.7
	≤ -1	22.2	8.3	19.4	25.0	27.0	29.7	16.2	18.9	27.0	18.9	21.6	13.9
	≤ -2	5.6	0	5.6	22.2	13.5	8.1	8.1	8.1	10.8	10.8	10.8	8.3

Probability of the Sa.I values in table 1 are shown:

- In considered region the drought and inudation could occur in any month during the year, however they concentrate in Spring-Summer and Summer-Autumn periods
- Probability of drought and inundation in different locations is significant and approximately equivalent to each other. Therefore, the drought and inundation forecast is of equal importance.
- Probability of drought (Sa.I > 1) is greater than that of inundation (Sa.I < -1). However, the probability of severe events of heavy rainfall (Sa.I < -2) is greater than that of severe droughts (Sa.I > 2).

5. THE CORRELATION BETWEEN THE SSTA IN 4 PACIFIC EQUATORIAL – TROPICAL AREAS AND THE SA.I IN THE CHARACTERISTIC LOCATIONS OF SOUTHERN CENTRAL VIETNAM

According to the above mentioned geographical and climatologically characteristics in Southern Central Viet Nam region, the weather there is regulated by the oceanic-atmospheric coupling processes. Based on this the correlation between the SSTA in 4 characterized ENSO regions of Pacific tropical equatorial area (A(4^0S-4^0N; 160^0E-150^0W), B(4^0S-4^0N; 150^0W-90^0W), C(10^0S- 0^0; 90^0W-80^0W), D(0^0-14^0N; 130^0E-150^0E)) and the Sa.I variation in monthly and seasonal periods (3 months) in characterized locations for this region is investigated. The results will be used in building the drought- inundation forecasting schemes for this region.

5.1. The correlation between the SSTA in 4 characterized ENSO regions of Pacific tropical equatorial area and the Sa.I variation

The correlation matrix between the monthly and seasonal Sa.I values and the monthly and seasonal SSTA in above mentioned places was established. Analyzing data in table 2 showed that:

- The correlation between Sa,I and SSTA in area D (negative correlation) is not as high as that in areas A, B, C (positive correlation).
- The monthly anomaly correlation: in some places $\gamma > 0.5$, for example, Quang Ngai: 0.57 (area B), Tuy Hoa:

0.62 (area B), Phan Thiet: 0.65 (area A)

- The Seasonal anomaly correlation: in most areas has $\gamma > 0.5$, in some places $\gamma > 0.70$, for example, Quang Ngai: 0.73 (area B), Tuy Hoa: 0.73 (area B), Phan Thiet: 0.77 (area A)
- The correlation coefficient has increasing trend from the North (Hue) to the South (PhanThiet) of this region. This trend indicates that ENSO affects the weather in provinces in the South greater.

Table 2. Maximal correlation coefficients (γ) between SSTA - Sa.I (1960-2000)

Area	Periods	Hue	Da Nang	Quang Ngai	Tuy Hoa	Phan Thiet
A	Monthly	0.49	-0.43	0.49	0.59	0.65
	Seasonal	0.57	0.45	0.66	0.66	0.77
B	Monthly	0.46	0.47	0.57	0.62	0.59
	Seasonal	0.51	0.54	0.73	0.73	0.64
C	Monthly	0.42	0.41	0.55	0.59	0.58
	Seasonal	0.45	0.45	0.68	0.70	0.60
D	Monthly	-0.51	-0.46	-0.41	-0.51	0.45
	Seasonal	-0.55	-0.46	-0.51	-0.52	-0.36

5.2. The correlation between ENSO and the Sa.I variation

Study on the Sa.I variation and the ENSO activity shows that between them there is significant correlation as following:

- In most of El Nino years Sa.I in observed points is positive that means droughts. During years of intensive El Nino activity, the value of Sa.I is large, for example, 1997-1998 ($Sa.I_{Max} = 4.65$) (table 3). In contrast, during years of La Nina activity Sa.I value is negative (table 4) that pointed out the heavy rainfall and inundation, for example, in intensive La Nina years Sa.I reached $Sa.I_{min} = -4.47$ (1974-1975) and $Sa.I_{min} = -6.29$ (1988-1989)
- In El Nino years positive Sa.I can last 4 to 13 months, so very serious water insufficiency and drought could occur
- In La Nina years althought lasts only 1 - 3 months, but negative Sa.I has large absolute value that shows the significant probability of flash floods and floods in this region

Table 3. Maximal Sa.I in El Nino years

El Nino years	Hue	Quang Ngai	Tuy Hoa	Phan Thiet
1963	2.22	1.37	2.70	1.13
1965/1966	2.16	2.35	2.20	1.65
1969/1970	2.40	2.49	2.28	3.18
1972/1973	3.08	3.68	2.83	3.31
1976/1977	1.53	2.10	0.76	1.53
1982/1983	2.99	3.52	2.64	2.94
1986/1987	3.63	2.69	2.31	4.05
1991/1992	1.53	1.58	2.09	1.95
1993	1.67	3.07	1.70	1.70
1997/1998	2.03	3.50	3.48	4.65

Table 4. Minimal Sa.I in La nina years

La nina years	Hue	Quang Ngai	Tuy Hoa	Phan Thiet
1964	-3.00	-4.22	-2.37	-3.50
1967/1968	-1.94	-1.85	-3.18	-1.78
1970/1971	-5.42	-3.80	-3.19	-2.26
1973/1974	-2.75	-4.05	-2.41	-2.30
1974/1975	-3.05	-4.47	-2.09	-3.01
1984/1985	-3.21	-1.57	-2.75	-2.35
1988/1989	-3.84	-4.06	-6.29	-3.86
1996/1997	-2.76	-2.80	-2.40	-3.99
1998/1999	-2.56	-1.27	-2.48	-3.50

6. SEASONAL AND MONTHLY DROUGHT AND FLOOD FORECASTING MODEL

The research results showed very significant correlation. The result shows: the maximal correlation coefficient γ between SSTA in 4 characterized ENSO regions and Sa.I. Therefore, the 1960-2000 reanalysis SSTA data were used to establish seasonal drought and heavy rainfall predicting schemes in the Southern Central Vietnam. The SSTA in 4 regions are used as factors for filtered regression and discrimination equations for the seasonal and monthly drought forecasting models.

The 2001-2005 reanalysis SSTA data were used to verify these schemes. The 2006-2007 experimental forecast results were encouraging.

7. THE EXTREME DROUGHT-HEAVY RAINFALL WARNING SCHEMES

7.1. The extreme drought warning scheme

The extreme values Sa.I >+2 are used to predict the extreme drought events. The extreme drought event could happen when the Sa.I values reach the maximum for season (3 months) when comparing with the data set in large area.

According to this criterion the extreme drought events often are observed in this area during Aprel-May-June to August-September-October with Sa.I to > +4.

The SSTA field in the Pacific tropical equatorial area in the extreme drought years is used to creating the forecasting model (figure 2 and figure 3).

In fig. 2 and fig. 3 it can be seen that SSTA field is positive in the whole equatorial area of Eastern Pacific Ocean and Bien Dong Sea and maximum value is observed in C area.

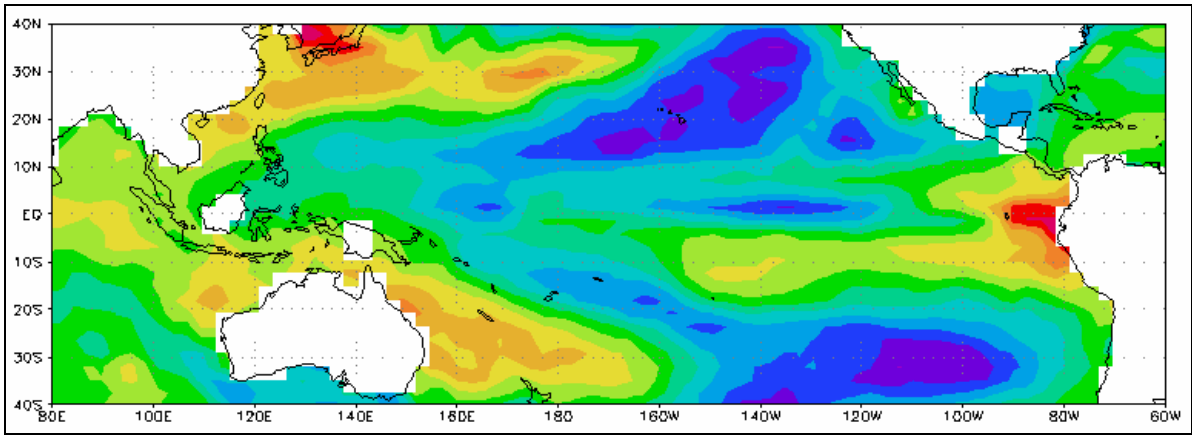

Figure 2. SSTA pattern for predicting anomalous drought in the Southern Central Vietnam, in Season April- May - June

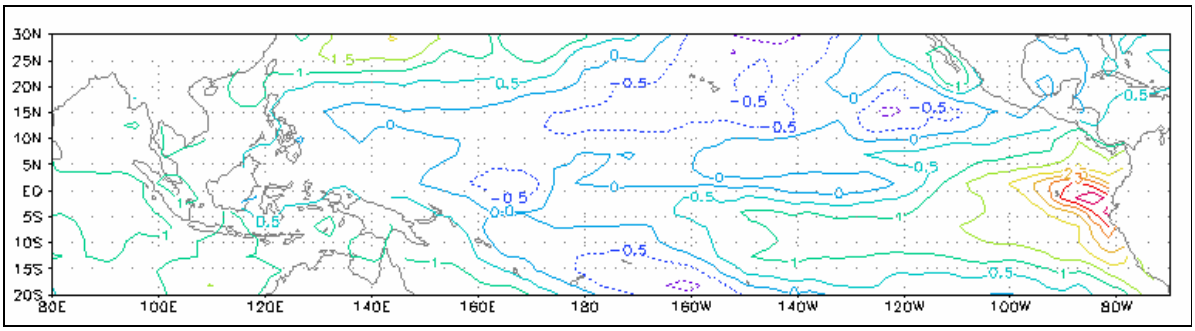

Figure 3. SSTA pattern for predicting anomalous drought in the Southern Central Vietnam, in Season July - August – September.

7.2. The extreme heavy rainfall forecasting scheme

Sa.I <-2 shows that extreme heavy rainfall could be happen during April-June and July-September (maximum value Sa.I could be less than -4)

Due to the complication of topographical condition the heavy rainfall distribution is not equal in large scale: it concentrates locally in some locations

Fig.4 shows the forecasting patterns for predicting anomalous heavy rainfall in the Southern Central Vietnam during April-June and fig.5 shows the forecasting patterns for predicting anomalous heavy rainfall during July-September. It can be seen in fig.4 and fig.5 SSTA field in A, B and C regions is negative and the minimum value is observed in C region.

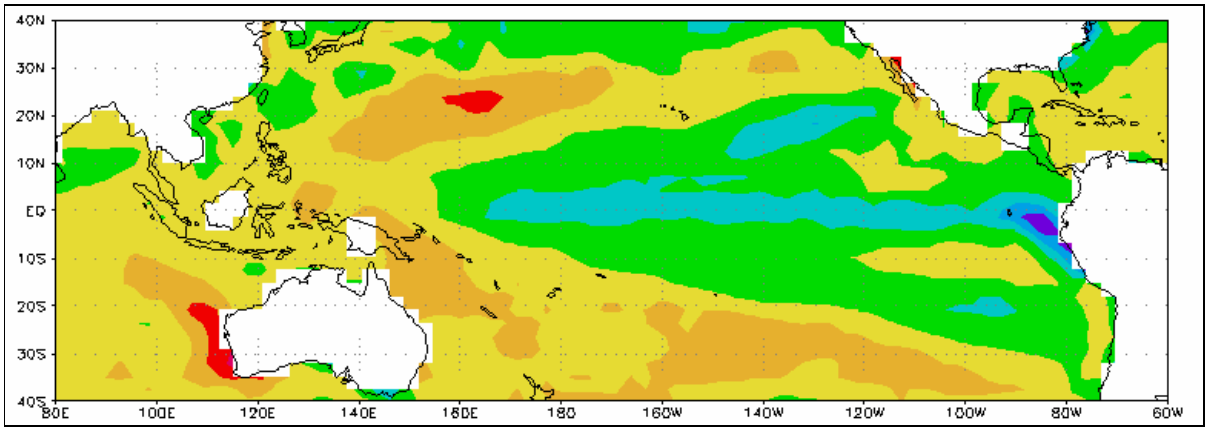

Figure 4. SSTA pattern for predicting heavy rainfall in the Southern Central Vietnam, in Season April - May - June

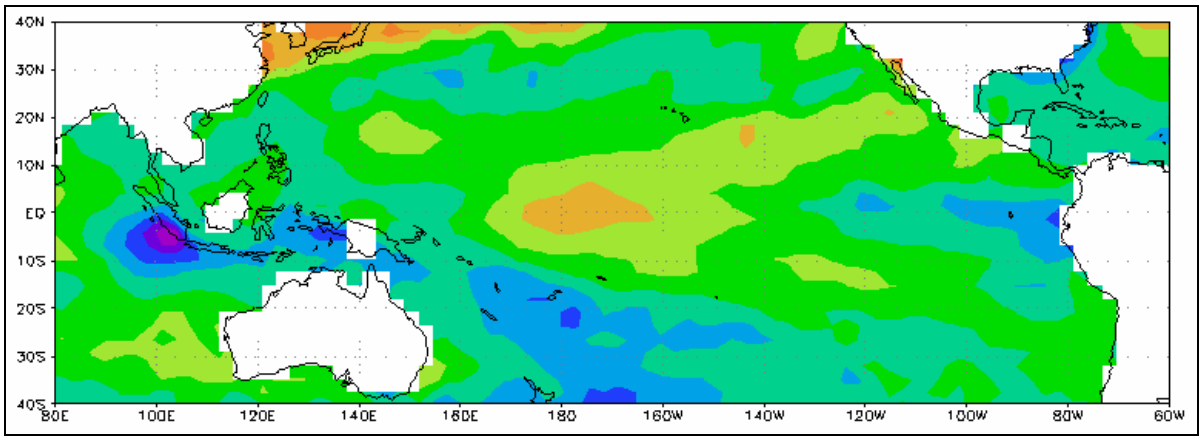

Figure 5. SSTA pattern for predicting heavy rainfall in the Southern Central Vietnam, in Season July - August – September.

CONCLUSION

- The ENSO activity significantly affects the heat – humidity regime in the Southern Central Vietnam. The Sa.I variation can reflect this correlation. Based on this correlation forecasters could predict probability of drought and heavy rainfall in this region.
- The correlation between Sa.I and SSTA in 4 characteristic ENSO is significant. Consequently, the SSTA can be used as predictors in seasonal forecasting equations for drought and inundation.

The research result shows that these schemes can be effective tools for seasonal drought and heavy rainfall prediction in the Southern Central Vietnam. So far the reanalysis data are very useful source for the author's research. The author's wishes to be supplied regularly by these data.

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