

# The Trend of Numbers of Tropical Cyclone Moves toward Thailand under Climate Change

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**Abstract** – In the past, there would be annual averaged 3-4 tropical cyclones moving toward Thailand. Most of the rainfall from these tropical cyclones have been collected in many big and small reservoirs, and used to support mainly in agricultural activities and daily life consumption. Besides, the number and intensity of the tropical cyclones in each year might cause of flood and drought.

There are studies of climate change in Thailand that show an increasing trend of temperature. Therefore, it is necessary to study on trend of tropical cyclones moves into Thailand from the past to present under climate change. This study used data from various sources namely; the annual numbers of tropical cyclone in Thailand, the annual sea surface temperature (SST) over the tropical ocean and the oceanic Nino index data.

Using the simplified statistical analysis namely; averaging and linear correlation for all concerned data, it was found that the trend of the decadal numbers of tropical cyclone moves through Thailand was the significant linear trend decreasing until 1-2 tropical cyclones during 2011-2014. The SST in some regions of the South China Sea was increasing from 27.7 to 28.2°C and the Western North Pacific Ocean was increasing from 28.2 to 28.9°C. Additionally for El Nino year, the numbers of tropical cyclone was less than La Nina and normal year.

Lastly, all these results will be used for public and private sectors to take into account in short, medium and long-term water management planning to reduce risk of flooded, drought events shortly.

**Keywords** – Tropical cyclone, Climate change, Sea surface temperature, El Nino, La Nina

## 1. INTRODUCTION

The most general definition of climate change is a change in the statistical properties of the climate system when considered over long periods of time, regardless of cause [1]. From IPCC reporting in 2007 [2], the warming of the climate system is evident from observations of increasing in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level. Changes in climate are not only effect

average temperatures but also extreme temperatures, increasing the likelihood of weather-related natural disasters [3]. For Thailand, the Climatology Center of Thai Meteorological Department [4] has analyzed the long term changes of annual temperature and rainfall during 1951-2008 and found that there were the increasing in both average maximum and minimum temperatures, but the long term trend of rainfall was still uncertainty in meaning that some years were decreasing and other were increasing. In addition, the number and intensity of tropical cyclones that affects or moves toward Thailand in each year might cause of flood and drought, including the water management problems as well.

Thailand is an agricultural country which the whole total area is approximately 514,000 square kilometers in which indeed 41 percent of the area is used for agricultural purposes [5]. Subsequently, the amount of rainfall stored from a tropical cyclone which originated in the Western North Pacific Ocean or the South China Sea is a major factor to supply water for the abundance of agricultural products in every year.

In the record of 30 years ago, there would be averaged at least 3-4 tropical cyclones moved toward through Thailand [6] with mostly tracking through upper regions of the country into the northeastern part and moved westward into the northern part with finally to Myanmar respectively. As aforementioned, most of the rainfall would have been collected in many big and small reservoirs along tracked moving in these parts such as Ubonorat Dam, Lam Poa Dam, Sirikit Dam and Bhumipol Dam, etc. All water will be stored and used to support mainly in agricultural activities, ecosystem preservation, sea water intrusion and daily life consumption respectively as well.

Additionally, for changing of SST in the global warming environment, Webster et al. [7] have indicated that tropical ocean SST was increased by approximately 0.5°C between 1970 and 2004. Also, most studies suggested that SST is closely related to tropical cyclone activity [8, 9, 10]. Therefore, the study on the trend of numbers of the tropical cyclone which moves through Thailand and the relation to SST is important manipulation with resulting of water management planning and reduces the risk of flooded, drought events in every year.

Therefore, the objective of this study will be as the following;

1. To study the trend and variation of decadal numbers of tropical cyclone moves toward Thailand during 1951-2014
2. To find out the relationship between the numbers of tropical cyclone moves toward Thailand and SST from the tropical oceans
3. To compare the decadal numbers of tropical cyclone moves toward Thailand with the SST from the South China Sea and the Western North Pacific Ocean
4. To study the numbers of tropical cyclone during El Nino, La Nina and normal events

## 2. DATA & MATERIAL

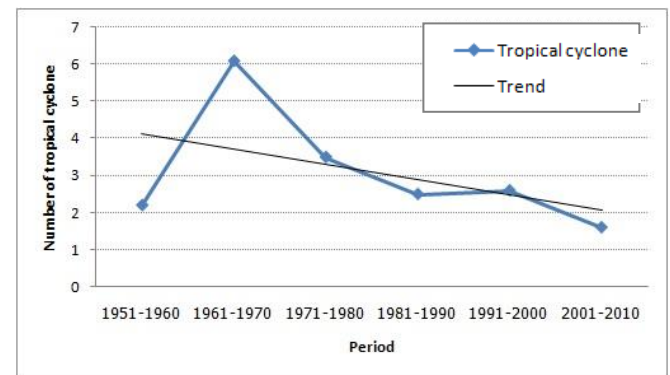
The set of climatic data of Thailand, SST over the tropical oceans and the oceanic Nino index (ONI) were used as follow;

1. The recorded data of annual numbers of tropical cyclone moved into Thailand in 64 years during 1951-2014 obtained from Thai Meteorological Department were used to find out the trend and variation of tropical cyclone.
2. The annual SST data over the tropical oceans during 1951-2014 from NCEP/NCAR reanalysis were used to provide the correlation between SST and the annual numbers of tropical cyclone in Thailand (Source: <http://www.esrl.noaa.gov/psd/data/correlation>)
3. The COBE2 annual SST data in South China Sea located between Latitude 5-20°N and Longitude 105-120° E and in the Western North Pacific Ocean located between Latitude 5-20°N and Longitude 125-145°E during 1951-2010 from NOAA/ESRL/PSD were used to find out the exact numbers of SST in these areas. (Source: <http://www.esrl.noaa.gov/psd/data/gridded/data.cobe2.html>)
4. The ONI data which indicated the El Nino, La Nina and normal events during 1951-2014 from Climate Prediction Center were used to find out the numbers of the tropical cyclone in each event of Thailand. (Source: [http://www.cpc.ncep.noaa.gov/products/analysis\\_monitoring/ensostuff/ensoyears.shtml](http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml))

## 3. METHODOLOGY

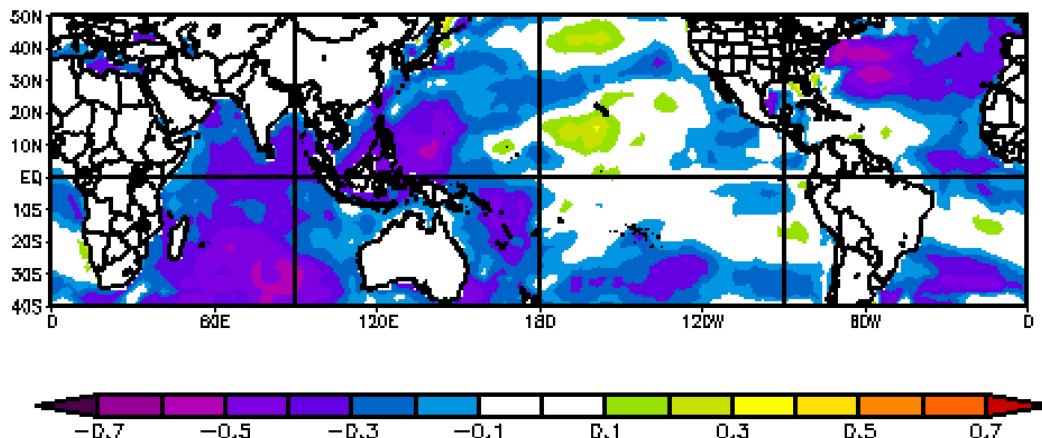
As aforementioned, the climate change in Thailand had been studied on analysis the long term change of meteorological parameter such as temperature and rainfall. Therefore, this study will be focusing on the investigating of the numbers of tropical cyclone moves toward Thailand using the simplified statistical analysis namely; averaging and linear correlation to compute and find out appropriate required values as follow;

Step1. The data of annual numbers of tropical cyclone moved into Thailand in 60 years during 1951-2010 were averaged to decadal data as 1951-1960, 1961-1970, 1971-1980, 1981-1990, 1991-2000 and 2001-2010. The result was shown on Figure 1.



**Figure 1** The variation and trend of tropical cyclone moved into Thailand every ten years during 1951-2010

Step2. The linear correlation technique was used to provide the relationship between the annual SST data over the tropical oceans and the data of annual numbers of tropical cyclone moved into Thailand during 1951-2014. The result was shown on Figure 2. The color scale represents values of correlation coefficient (R).



**Figure 2** The correlation between the annual numbers of tropical cyclone and SST (Image provided by the NOAA/ESRL PSD, Boulder Colorado from the Web site at <http://www.esrl.noaa.gov/psd/>)

Step3. To verify the result of Figure 2 and find out the exact SST values in higher correlation coefficients areas (purple area). Therefore, the comparison between the decadal data of numbers of tropical cyclone moved into Thailand during 1951-1960, 1961-1970, 1971-1980, 1981-1990, 1991-2000 and 2001-2010 with the COBE2 decadal SST data in South China Sea located between Latitude 5-20°N and Longitude 105-120°E and in the Western North Pacific Ocean located between Latitude 5-20°N and Longitude 125-145°E were shown in Table 1.

**Table 1** The ten years average numbers of the tropical cyclone moving through Thailand with SST in the South China Sea and the Western North Pacific Ocean

Year	Numbers of tropical cyclone	SST in the South China Sea (°C)	SST in the Western North Pacific (°C)
1951-1960	2.2	27.7	28.3
1961-1970	6.1	27.7	28.2
1971-1980	3.5	27.7	28.3
1981-1990	2.5	27.9	28.5
1991-2000	2.6	28.1	28.6
2001-2010	1.6	28.2	28.9

Step4. The ONI data which indicated the ENSO events (El Nino, La Nina and normal) were used in this study with the following definition;

1. The occurrence of warm SST (El Nino) or cold SST (La Nina) events would be considered on  $\pm 0.5^{\circ}\text{C}$  of ONI (3 months running mean of SST anomalies in the Nino 3.4 region) values.

2. The values of  $\pm 0.5^{\circ}\text{C}$  must occur at least five months continuously.

3. In this study, how to define whether was El Nino, La Nina or normal year we would consider only in occurrence time during June-December (7 months) because this time was the most frequencies of the tropical cyclone moving into Thailand. Therefore if the occurrence time of each event were equal or more than five months, then it would be defined to be the year of that event, and if it were less than five months then we would abandon it and label to other. Subsequently, the data of annual numbers of tropical cyclone moved into Thailand during 1951-2014 would be revealed and compared for each of El Nino, La Nina and normal years along ONI values. The result was shown in Table 2.

#### 4. RESULTS & DISCUSSION

From Figure 1 it was found that the decadal variations and trend of the numbers of the tropical cyclone moving through Thailand was the significant linear trend decreasing, from 3-4 tropical cyclones in 1951-1980 to 2 tropical cyclones in 2001-2010. In addition, the average numbers of tropical cyclone was equal one during 2011-2014.

**Table 2** Total numbers of the tropical cyclone moving through Thailand for each of El Nino, La Nina and normal years

Event	Year	Numbers of tropical cyclone	Percent
El Nino	16	45	23.8
La Nina	19	60	31.75
Normal	17	60	31.75
Other	12	24	12.7
Total	64	189	100

From Figure 2 it was found that the areas with higher correlation coefficients (purple area) were in the South China Sea, between Latitude 5-20°N and Longitude 105-120°E and in the Western North Pacific Ocean, between Latitude 5-20°N and Longitude 125-145°E with R values was between -0.3 to -0.7. It concluded that both of data set had a significant statistical relationship in opposite direction with meaning that whenever the SST was increasing then the numbers of the tropical cyclone would be decreasing.

From Table 1 it was found that numbers of the tropical cyclone were decreasing from 6.1 to 1.6 during 1961-2010 whereas SST in the South China Sea was increasing from 27.7 to 28.2°C and SST in the Western North Pacific Ocean also increasing from 28.2 to 28.9°C. It was corresponding to the reason that has been above mentioned.

Table 2 shows that during the 64 years period of time, the El Nino, La Nina and normal years were 16, 19 and 17 years respectively. For the El Nino year, there were 45 tropical cyclones moving through Thailand were like 23.8 %. Whereas La Nina and normal years, there were 60 tropical cyclones moving through Thailand were of 31.75%. For other years, there were 24 tropical cyclones were like 12.7%. Therefore, it was concluded that for El Nino year, the number of tropical cyclones was less than La Nina and normal year.

#### 5. CONCLUSIONS & RECOMMENDATIONS

From the decadal average numbers of the tropical cyclone moving through Thailand during 1951-2010, it concluded that the trend of numbers of tropical cyclone was clearly decreasing up to present particularly during 2011-2014 with an average of one tropical cyclone only.

From the results of the relationship between the annual SST (over the South China Sea and the Western North Pacific Ocean) and the annual numbers of tropical cyclone moved into Thailand, these were corresponding to the study of Leung and Leung [9] from Hong Kong Meteorological Offices which was concluded that the annual numbers of tropical cyclone affecting Hong Kong were correlated to SST anomalies as well, even though the correlation area would be in the equatorial Central and Eastern Pacific. Additionally, there are same results that

for El Nino year, the annual numbers of the tropical cyclone affecting the country was less than whenever comparing with the La Nina year.

For the further research, it was recommended that the study of intensities of the tropical cyclone moving toward Thailand needed to be done for the present situation to reduce and alleviate the damage from the impact of climate change in the future.

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