Thunderstorm Days and Lightning Activity in Association with El Nino

M.K. Kulkarni, J.V. Revadekar, Hamza Verikoden and Swati Athale
Indian Institute of Tropical Meteorology, Pune
Email: mkk@tropmet.res.in

ABSTRACT

El Niño and La Niña events are well known to be associated with significant monthly/seasonal climate anomalies at many places around the globe. The teleconnections of the Indian monsoon with El Niño/ Southern Oscillation is widely known, which form the basis for seasonal prediction of the monsoon. However, not much is known about its influence on thunderstorm days and lightning activity. In view of this, a study is attempted on the analysis of association between El Nino and thunderstorm activity in terms of thunderstorm days and lightning flashes. Present study is based on the data on lightning flashes from Lightning Imaging Sensor (LIS), which is a space borne optical sensor on the Tropical Rainfall Measuring Mission (TRMM) to detect tropical lightning. The data on lightning flashes from LIS are available from 1998 onwards. Therefore, the analysis is done for all the El Niño episodes which cover the years 1998-2013. The thunderstorm day data are collected from India Meteorological Department for the same period. The study reveals that during El Nino events, the number of thunderstorm days decreases and on the other hand there is an increase in lightning flashes, flash rates and flash density. During El Nino events, Southeast Asia gets warmer and drier which may result in the fewer thunderstorms. The fewer thunderstorms that occurred during El Niño episodes are much more intense, convectively more active and therefore produce more lightning.

Keywords: *Lightning, Thunderstorm, El Nino, ENSO, LIS.*

Introduction

One of the dramatic manifestations of the interaction between the oceans and the atmosphere and its effects on both climate and weather is the Southern Oscillation, one of the consequences of which is El Niño. On global scale, sea surface temperatures have an important role to play in affecting the weather changes. This is most prominently evident with variations in different weather patterns during El Nino or La Nina conditions. These conditions can lead to extreme weather events. The El Nino Southern Oscillation (ENSO) is a climate anomaly which is responsible for weather impacts throughout the globe. This weather impacts can be either droughts or floods. Sea surface temperatures are the signatures of extreme weather conditions like either El Nino or La Nina (Goodman et al., 2000). El Nino episodes occur near equatorial pacific and in the central and eastern Pacific Ocean due to sea surface temperatures warmer than normal and La Nina conditions occur in the central and eastern Pacific Ocean near equatorial Pacific Ocean due to cooler sea surface temperature. During El Nino events, the trade winds over the equator off the east coast of South Africa are weaker than the normal winds. Influence of El Nino on lightning activity has been addressed by Shinji et al, 2011, and revealed the contrast of the convective activities between El Nino and La Nina periods over the East Asia during the strong episode of El Nino (1997-98). They found that, during El Nino period/La Nina period the numbers of lightning flashes increase/decrease. Ramesh Kumar and Kamra (2012) have assessed the variability of lightning activity in South/South East Asia during strong El Nino year 1997-98 and 2002-2003. Their study revealed that during El Nino episodes total lightning flashes and flash rates increased and decreased during La Nina episodes as compared to corresponding normal years. Hamid et al (2001) have explored the impact of El Nino (1997-98) on lightning over Indonesia. They found increasing lightning flashes over Indonesia during El Nino period with respect to normal period. Manohar et al., (1999) have used thunderstorm days and found decreasing thunderstorm days during El Nino episodes. Kandalgaonkar et al (2010) have compared the lightning activity for El Nino year (2002) and La Nina year (1998 – 2001) and explored the increasing lightning activity (18%) over the land region. Satori et al., (2009), have addressed the variability of global lightning on the Enso time scale and observed more lightning in the tropical – extra tropical land regions during warm El Nino episodes, especially in South East Asia. On Enso time scale global lightning was addressed by Chronis et al., (2008) and revealed over the western maritime continents where typical drought conditions during a warm ENSO phase are related to enhanced lightning activity. From ENSO perspective, convective activity in Southeast Asia and over Western Pacific was explored by Yoshida et al., (2007). Association of El Nino with thunderstorm days over the Indian land region was explored by Kulkarni et al., (2013). They have studied the effect of El Nino on thunderstorm days and found that the numbers of thunderstorm days are decreasing during El Nino episodes. Their results were in contrast with the earlier studies by Ramesh Kumar and Kamra (2012) and Kandalgaonkar et al (2010) but in agreement with Manohar et al., (1999). These studies by Ramesh Kumar and Kamra (2012) and Kandalgaonkar et al (2010) are dealt with lightning flash rates/flash densities etc. Therefore, in the present study an attempt has been made to compare the effect of El Nino both on lightning activity as well as on thunderstorm days.

Over Indian land mass, the annual variation of thunderstorm and lightning activity follow a biannual pattern. That means thunderstorm activity and lightning activity attain a peak in the pre monsoon season and second peak at the withdrawal of summer monsoon season/onset phase of post monsoon season. The peak during pre monsoon is higher in magnitude than the peak in post monsoon. The electrical activity is vigorous during pre monsoon season than in the post monsoon season. The development of deep isolated convective thunderstorm is the characteristic feature of the tropical land mass in the pre monsoon season due to local thermals and hence isolated convective systems (Manohar and Kesarkar, 2005). In case of post monsoon season thunderstorms, these are caused by the weaker convection leading to moderate to minimum growth of cloud resulting in weaker electrification

2. Data and Methodology

Monthly mean number of thunderstorm days are obtained from Indian Daily Weather Reports of India Meteorological Department, for whole Indian land region, from 1998-2013. The lightning flash data are collected from Lightning Imaging Sensor (LIS) on the Tropical Rainfall Measuring Mission satellite. Since LIS is launched in 1997, the data utilized in the present study are from 1998-2013. Details of Lightning Imaging Senor can be seen elsewhere (Christian, H. J. 1999a, Bond et al., 2002, Williams, et al., 2000) All India average values of thunderstorm days and lightning flashes are computed as arithmetic averages of the monthly mean and yearly mean numbers of thunderstorm days and lightning flashes. Lightning flashes along each latitudinal belt has been collected. Average and percentage of lightning flashes along each latitude has been computed.

3. Results and Discussion

Fig 1 shows yearly variations of thunder-storm day's and lightning flashes. Among the data utilized

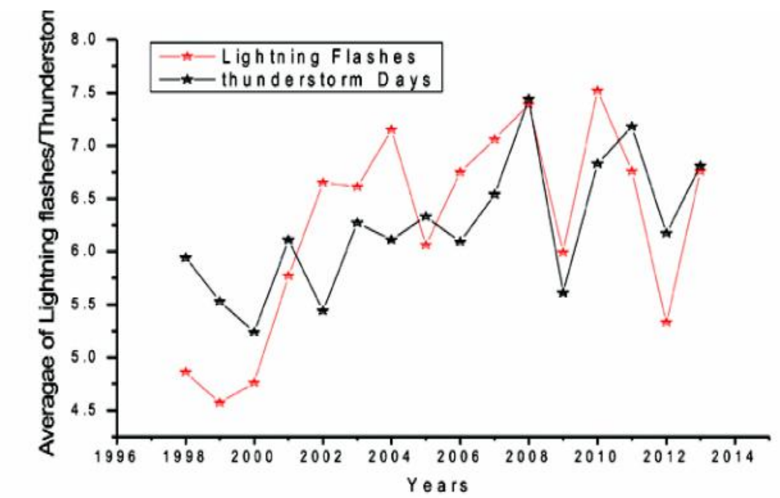

Fig 1. Yearly variations of thunderstorm day and Lightning Activity.

in the study (1998-2013), four episodes of El Nino have occurred i.e. 2002, 2004, 2006, and 2009. It can be clearly seen that during all these four years of El Nino episodes, the thunderstorm days are reduced but average lightning flashes are increased. This indicates that though thunderstorm days are decreasing the intensity and number of lightning flashes is increasing. This supports earlier studies by Manohar et al, (1999) Kulkarni, et al., (2013). Manohar, et al., (1999) used thunderstorm day's data for a period of 10 years and found that thunderstorm days decrease during El Nino episodes. Present observations are in agreement with the research carried out by Prof. Colin Price and his group at Tel Aviv. Researchers at Tel Aviv are working to identify the impacts of changing climate on specific weather elements such as clouds, lightning and rainfall. They say that the increasing temperature of earth can lead to a significant increase in the violence of thunderstorms. They assess the increasing violence in the thunderstorms to the impact of raising global temperature. The El Niño occurs in the Pacific Ocean due to which Southeast Asia gets warmer and drier and produces fewer thunderstorms, but 50% more lightning activity is observed. Drier conditions are expected to produce lesser thunderstorms. The fewer thunderstorms that occurred during El Niño episodes are more intense, convectively more active and therefore produce more lightning.

The annual variation of lightning flash distribution, on an average, during study period of 1998-2013, is shown in Fig.2. The lightning activity picks up from the month of January and reaches the peak in the month of April (25.9). From April onwards it starts decreasing through May to August and again increases in September. After September, the lightning activity starts decreasing through October to December. This is the characteristic feature of thunderstorms and lightning activity over the Indian land region. The numbers besides the stars indicate the number of events lightning occurred.

Fig 3 shows the distribution of the lightning activity along the Indian latitudes. The percentage of lightning flashes along the Indian latitude fallows a unimodal variation. Warm and humid, sun heated tropical land surface favors the development of thunderstorms because heating is strong close to the tropics than at higher latitudes. During the period of 1998-2013, lightning activity is not much prominent upto 14°N. The activity picks up from 15°N and is highest at 26°N and thereafter the lightning activity starts decreasing. The northeast part of Indian subcontinent at 26°N is the seat of severe thunderstorm activity. (Krishna Rao, 1961, Rao and Raman, 1961, Subramanian and Seghal, 1967, Rao,et al.,1978). During pre-monsoon season quite a big number of thunderstorms and intense lightning are registered in this area (Sen and Basu, 1961, Chaudhari, 1961, Mukherjee et al., 1964). The highest percentage of lightning flash (11.2) is at the northeast region at latitude of 26°N. Similar studies of latitudinal variation of lightning activity on seasonal scale by Ranalkar and

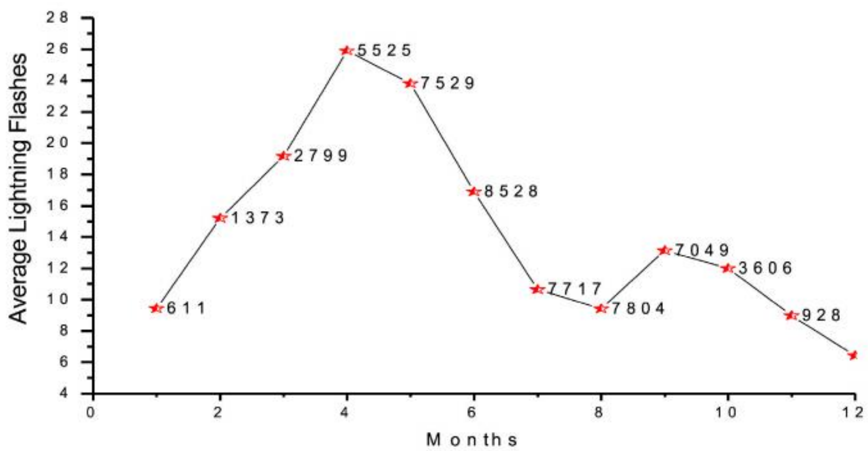

Fig. 2: Annual variation of Lightning Activity over Indian land mass.

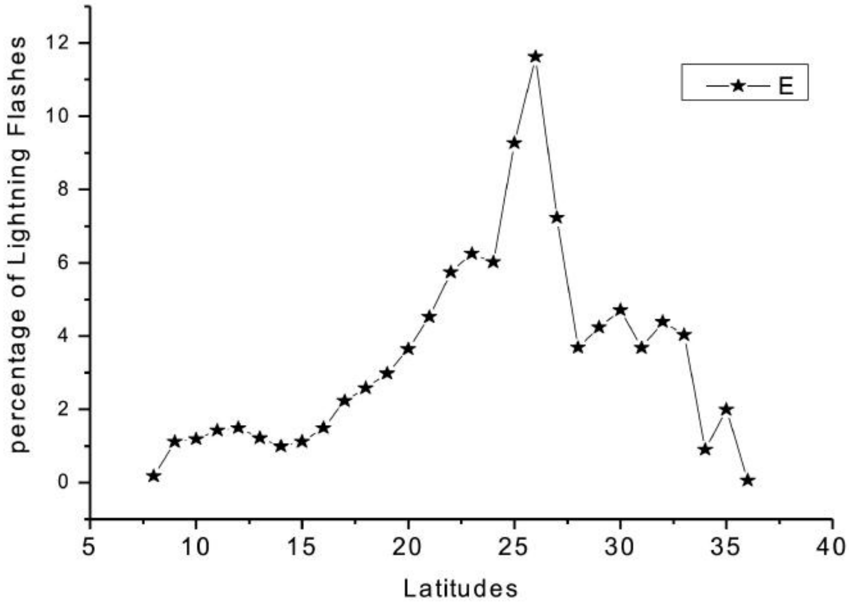

Fig.3: Latitudinal variation of Lightning Activity over the Indian land mass.

Chaudhari(2009) have got peak of lightning flash at 33°N. Chaudhari and Banarjee (1983) have studied hailstorms over Northeast part of India and observed maximum number of hailstorms occurring in 24°N - 26°N latitudinal belt.

4. Conclusion

The above study suggest that during El Nino episodes the thunderstorm activity is reduced whereas lightning flashes and flash rates are increased over the Indian land region. During El Niño years, Southeast Asia gets warmer and drier and produces fewer thunderstorms, but more lightning activity is observed. Drier conditions are expected to produce lesser thunderstorms. The fewer thunderstorms that occurred during El Niño episodes are more intense, convectively more active and therefore produce more lightning. Annual variation of lightning activity showed semiannual variation. Latitudinal variation of lightning flashes show a prominent peak at the northeast part of India at latitude of 26°N which is the most proned area of lightning activity.

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