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Variability of lightning activity over India on ENSO time scales

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Abstract

ENSO, the reliable indicator of inter-annual climate variation of the ocean-atmosphere system in the tropical Pacific region, can affect the overall lightning activity which is another atmospheric phenomenon. In the present study, the impact of the ENSO on the total lightning activity over India has been studied for the period 2004–2014. During the El-Nino period (July 2004–April 2005 and July 2009–April 2010), total number of lightning flashes increased by 10% and 18% respectively and during La-Nina period (July 2010–April 2011 and August 2011 to March 2012), the total number of lightning flashes decreased approximately by 19% and 28% respectively as compared to the mean of corresponding period (2004–14) of the Non-ENSO. Seasonal variation of flash density is also examined for the El-Nino and La-Nina period. The result shows that in the El-Nino period of the pre-monsoon and monsoon seasons, there is an increment in the flash density approximately by 48% and 9% respectively than the Non-ENSO and the spatial variation also having high flash density along the foot of Himalayas region. In the post-monsoon season, there is a marginal change in the flash density between El-Nino and the Non-ENSO. In the winter season, there is an increment in flash density in the El-Nino period approximately by 45% than the Non-ENSO. In the La-Nina period of the pre-monsoon and monsoon seasons, there is the decrement in the flash density approximately by the 44% and 24% respectively than the Non-ENSO. In the Post-monsoon season and winter season of La-Nina, the flash density is increased by about 24% and 33% over India. These findings can be applied to do proper planning of lightning induced hazard mitigation as lightning is of one of the major natural disasters of India.

Keywords: Lightning activity; ENSO impact; El-Nino impact; La-Nina impact; Flash density

1. Introduction

El-Nino–Southern Oscillation (ENSO) is an uneven variation in winds and sea surface temperatures (SSTs) over the tropical Eastern Pacific Ocean. The warm phase is referred as El-Nino and the cool phase as La-Nina. Southern Oscillation is the atmospheric factor associated with the sea temperature change. El-Nino is accompanied with high surface pressure, and La-Nina accompanied with low air surface pressure in the tropical western Pacific (Climate Prediction Center, 2009). ENSO is well-known as the reliable indicator of inter-annual climate variation of the ocean-atmosphere system in tropical Pacific region and the lightning activity can be affected by ENSO on global and regional scales (Yuan and Yuelun, 2014). The transportation of moisture, heat, and momentum during changes in the upwelling region of the Pacific Ocean influence Pacific trade winds, SSTs, the upper atmospheric circulation, the distribution of precipitation and convective activity on a global scale influences the frequency and intensity of tropical storms and deep convection (Williams, 1992). Accordingly, the lightning activity, related to the phase of convective cloud development (Williams et al., 1989; Cifeli et al., 2002; Ushio et al., 2001), cloud-top height (Price and Rind, 1992), updrafts intensity (Williams, 1992; Goodman et al., 1998), CAPE (convective available potential energy) (Williams, 1992;

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Williams and Renno, 1993; Zipser, 1994; Petersen et al., 1996), precipitation rate (Petersen and Rutledge, 1998) and surface air temperature (Williams, 1992; Williams et al., 1994; Price, 1993; Reeve and Toumi, 1999), is affected. The updraft intensity that transports supercooled ice crystals and vertical development of convection are positively correlated in mixed phase region. The vertical development is also related to the lightning activity (Rosenfeld, 1999). El-Nino normally continues between 9 and 12 months and under extreme El-Nino conditions, it can be dangerous to aquatic life (Ahrens, 2003).

The impact of ENSO on lightning activity has also been studied on a global and regional scale in various parts of the world. A change in the mean of land wet bulb temperature of the world by 1 K would change the lightning activity approximately by 40% (Reeve and Toumi, 1999). Goodman et al. (2000) concluded that an increase of 100–200% in lightning activity during the 1997–98 ENSO year. Hamid et al. (2001) stated a total increase of 57% in the number of lightning flashes over Indonesia during the warm (El-Nino) period of the 1997–98 ENSO. Kandalgaonkar et al. (2010) have stated that lightning activity in the El-Nino period of 2002 increased by 18% compared to the La-Nina period of 1998–2001 and the flash density during El-Nino period shows that the effect of El-Nino is more prominent over the land region over India. Warm (El-Nino) and cold(La-Nina) ENSO periods based on a threshold of +/− 0.5 °C for the Oceanic Nino Index (ONI) [3 months running mean of ERSST.v4 SST anomalies in the Nino 3.4 region (5°N–5°S, 120°–170° W)], The El-Nino (warm) period started from July 2004 and disappeared in April 2005. Again it is started in July 2009 and ended on April 2010. La-Nina (cold) events started in July 2010 and disappeared in April 2011 and started again in August 2011 and continued until March 2012 (Climate Prediction Center, 2015).

In this paper, we have studied the monthly variations of the total number of flashes, as well as seasonal flash density variation during the ENSO of the El-Nino period 2004–05 & 2009–10 and the La-Nina period 2010–11 & 2011–12 in the region of India as shown in Fig. 1 to understand the

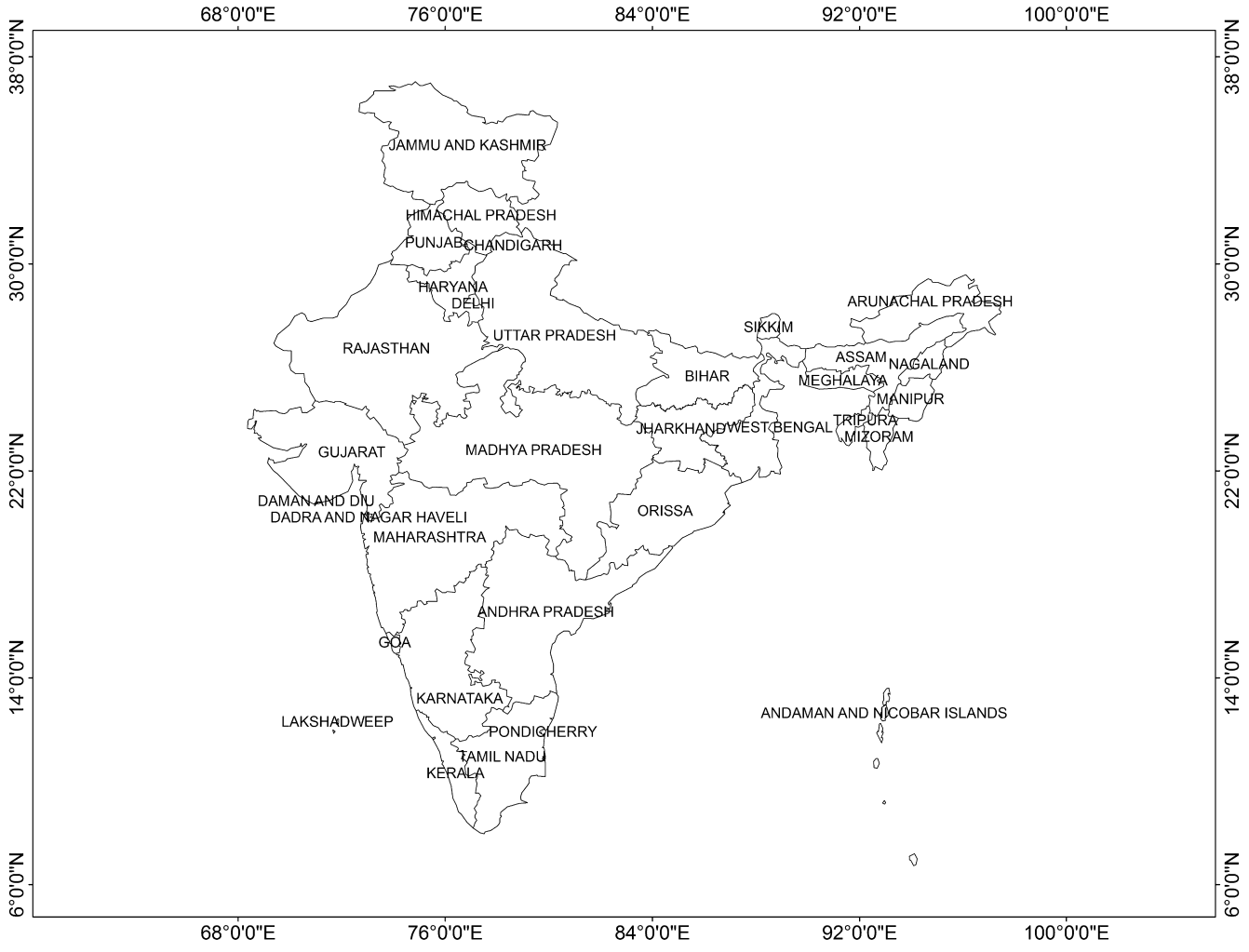

Fig. 1. Map of the study region INDIA (8°4′ to 37°6′ North latitude and 68°7′ to 97°25′ East longitude).