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North-East monsoon rainfall extremes over the southern peninsular India and their association with El Niño

Prem Singh, C. Gnanaseelan*, J.S. Chowdary

Indian Institute of Tropical Meteorology, Pune 411008, India

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ABSTRACT

The present study investigates the relationship between extreme north-east (NE) monsoon rainfall (NEMR) over the Indian peninsula region and El Niño forcing. This turns out to be a critical science issue especially after the 2015 Chennai flood. The puzzle being while most El Niños favour good NE monsoon, some don't. In fact some El Niño years witnessed deficit NE monsoon. Therefore two different cases (or classes) of El Niños are considered for analysis based on standardized NEMR index and Niño 3.4 index with case-1 being both Niño-3.4 and NEMR indices greater than +1 and case-2 being Niño-3.4 index greater than +1 and NEMR index less than −1. Composite analysis suggests that SST anomalies in the central and eastern Pacific are strong in both cases but large differences are noted in the spatial distribution of SST over the Indo-western Pacific region. This questions our understanding of NEMR as mirror image of El Niño conditions in the Pacific. It is noted that the favourable excess NEMR in case-1 is due to anomalous moisture transport from Bay of Bengal and equatorial Indian Ocean to southern peninsular India. Strong SST gradient between warm western Indian Ocean (and Bay of Bengal) and cool western Pacific induced strong easterly wind anomalies during NE monsoon season favour moisture transport towards the core NE monsoon region. Further anomalous moisture convergence and convection over the core NE monsoon region supported positive rainfall anomalies in case-1. While in case-2, weak SST gradients over the Indo-western Pacific and absence of local low level convergence over NE monsoon region are mainly responsible for deficit rainfall. The ocean dynamics in the Indian Ocean displayed large differences during case-1 and case-2, suggesting the key role of Rossby wave dynamics in the Indian Ocean on NE monsoon extremes. Apart from the large scale circulation differences the number of cyclonic systems land fall for case-1 and case-2 have also contributed for variations in NE monsoon rainfall extremes during El Niño years. This study indicates that despite having strong warming in the central and eastern Pacific, NE monsoon rainfall variations over the southern peninsular India is mostly determined by SST gradient over the Indo-western Pacific region and number of systems formation in the Bay of Bengal and their land fall. The paper concludes that though the favourable large scale circulation induced by Pacific is important in modulating the NE monsoon rainfall the local air sea interaction plays a key role in modulating or driving rainfall extremes associated with El Niño.

* Corresponding author.
E-mail address: seelan@tropmet.res.in (C. Gnanaseelan).

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1. Introduction

While, most parts of India receives the major share of the annual rainfall during southwest monsoon (during June to September), the southeast peninsular India falls under the rain-shadow region during this season. However during October to December (OND), rainfall is mostly concentrated over south-eastern peninsular India and is called as Northeast (NE) monsoon (e.g., Ramaswamy, 1972; Dhar and Rakhecha, 1983; Singh and Sontakke, 1999; Balachandran et al., 2006; Rajeevan et al., 2012). NE monsoon is associated with northeast trades and has less vertical extent compared to southwest monsoon (e.g., Dhar and Rakkecha 1983; Sridharan and Muthuswamy 1990; Singh and Sontakke 1999). During this season depressions and cyclonic storms occasionally form over the south Bay of Bengal (BoB) with modulation during El Niño years (e.g. Sreenivas et al., 2012) and provide widespread rainfall over southern India. NE monsoon rainfall (NEMR) has important implications on agricultural production over southern peninsular India.

The NEMR displays strong interannual variability (28%), which is more than twice the variability of southwest monsoon rainfall (11%) (e.g., Nageswara Rao 1999; Sreekala et al., 2012). This indicates the higher probability of witnessing extreme deficit/excess monsoon rainfall years during NE monsoon season. Previous (e.g., Bhanu kumar et al., 2004; Kripalani and Kumar, 2004b; Zubain and Pepelewski 2006) studies have also pointed out the relationship between NE monsoon and Indian Ocean Dipole (IOD; Saji et al., 1999). Kripalani and Kumar (2004) suggested the possibility of positive IOD events enhancing the NEMR. Some recent studies have shown that the inter-annual variability of the NEMR is significantly influenced by ENSO (Zubair and Ropelewski 2006) with strengthening relationship during the recent years. Kumar et al. (2007) have shown that this strengthening in the relationship between ENSO and the NEMR over south Asia is due to anomalous low-

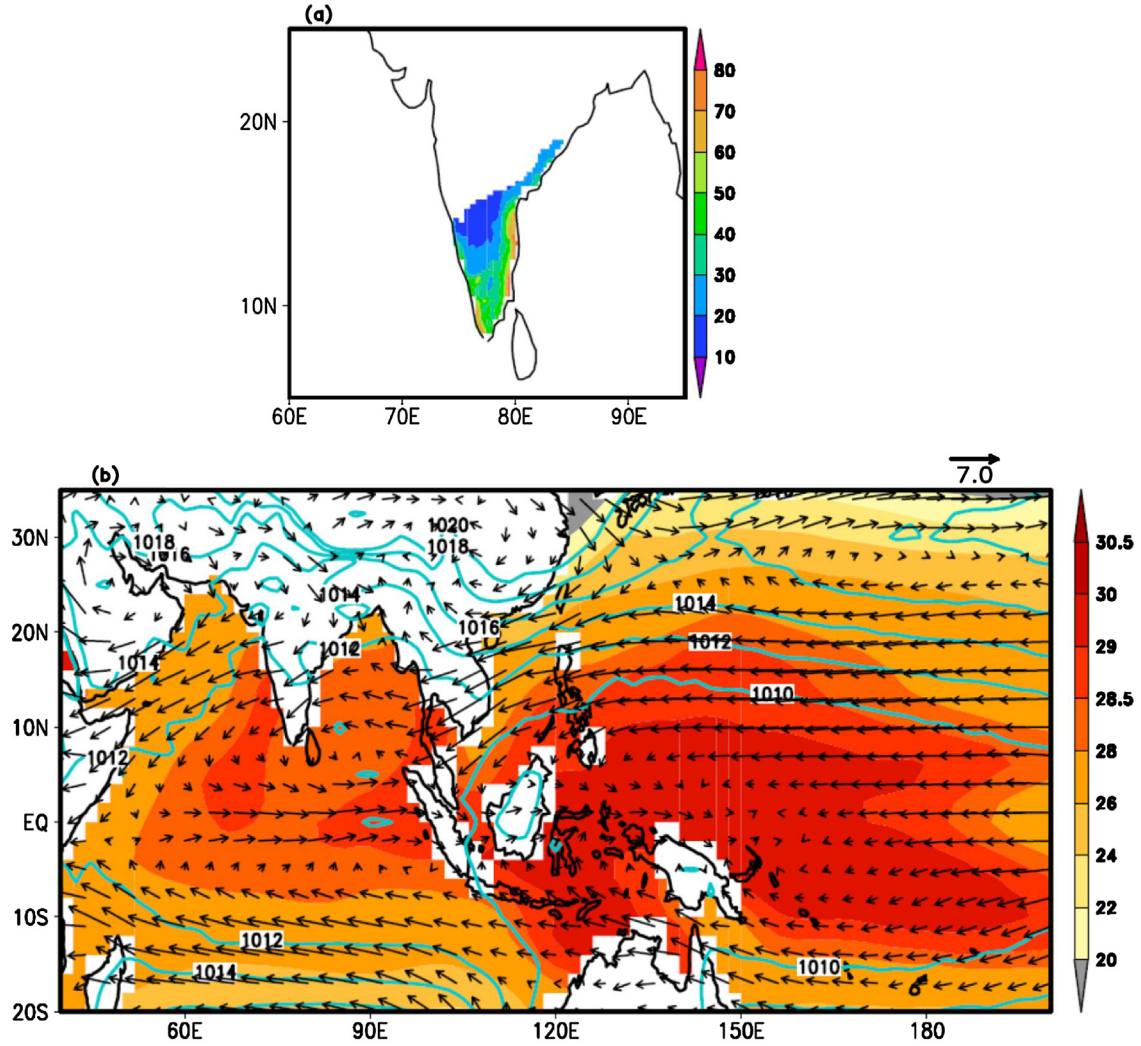

Fig 1. October to December (OND, 1958–2015) climatological (a) precipitation (mm/day) for North East monsoon region, (b) SST (shaded, °C), SLP (contours, hPa) and 850 hPa winds (vectors, m/s).