Intra-Seasonal Variability of Cross Equatorial Flow, Mascarene High and Circumpolar Lows: Monsoon Season 2015

P. Chandrasekhara Rao, Vishal S. Thorat and Sonali A. Raval
India Meteorological Department
E-mail: pcsraoimd@gmail.com

ABSTRACT

Indian summer monsoon rainfall (ISMR) of the year 2015 has been deficient as emphasized by many seasonal forecasting communities. And, the prime reason for deficiency was the southern oscillations in the Pacific, where the eastern pacific is much warmer than the normal, leading to El-Nino phase. But there are other factors from the southern hemisphere contributed to the deficient rainfall over India. It was observed that the Mascerene High (MH), which acts as a prime engine that drives the whole circulation of the Indian summer monsoon, was very weak. The intensity and position of the MH decides the speed of the cross equatorial flow over Somalia region. Since cross equatorial flow (CEF) over Somalia region has good correlation with the ISMR, here weekly wind composites of Somalia region and the area weighted average rainfall of the Indian region for the monsoon 2015 were computed to investigate the Somali Jet Speeds with corresponding ISMR. Strong wind speed patterns are observed for the June and September whereas they were weak during August, July months. The CEF was related to MH, which is in turn regulated by the circumpolar lows (CPLs). Hence, the strength and locations of the CPLs have been studied to identify the corresponding temporal variations of the MH which in turn is manifested in the deficient sub periods during the current deficient monsoon. CPL has very good correlation with MH during the month of June, for which correlation coefficient is- 0.51 whereas correlation is almost negligible during Months of July and August, for which correlation coefficients are --0.04 and -0.1 respectively. And reverse correlation is observed for the month of September, it has correlation coefficient of 0.04 on the positive side.

Keywords: *Monsoon, Australian High, Mascarene High, Cross Equatorial Flow and Circumpolar Low.*

1. Introduction

The Indian summer monsoon has vigorous intra-seasonal oscillations in the form of ‘‘active’’ and weak (or ‘‘break’’) spells of monsoon rainfall within the summer monsoon season (Goswami 2000). These ‘‘active and break spells of the monsoon are associated with fluctuations of the tropical convergence zone (Sikka and Gadgil 1980). Southwest monsoon rainfall is to a large extent dependent on the strength of cross equatorial flow and also its meridional variation over the Indian region (Rao and Bhongale 2012). Correlation analysis (Feng 2004) reveals that interannual variability of MH is dominated by Antarctic Oscillations, and MH tends to be intensified with the development of the circumpolar lows, in high southern latitudes. Objective of the study is to justify the corresponding rainfall patterns with the intra-seasonal variation of the Somali jets, Mascarene high (MH) and circumpolar lows (CPL), rather than looking at the tropical convergence zone. Also, dependency of the MH on CPL is studied.

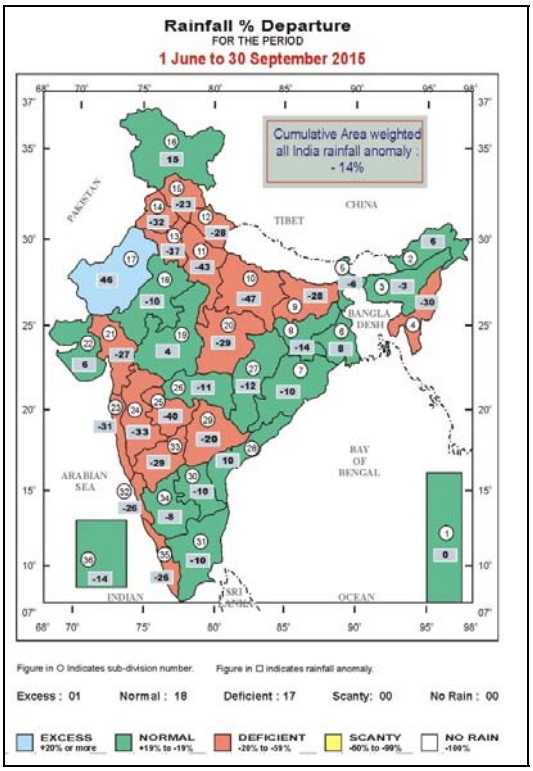

Figure 1: Rainfall Percentage Departure

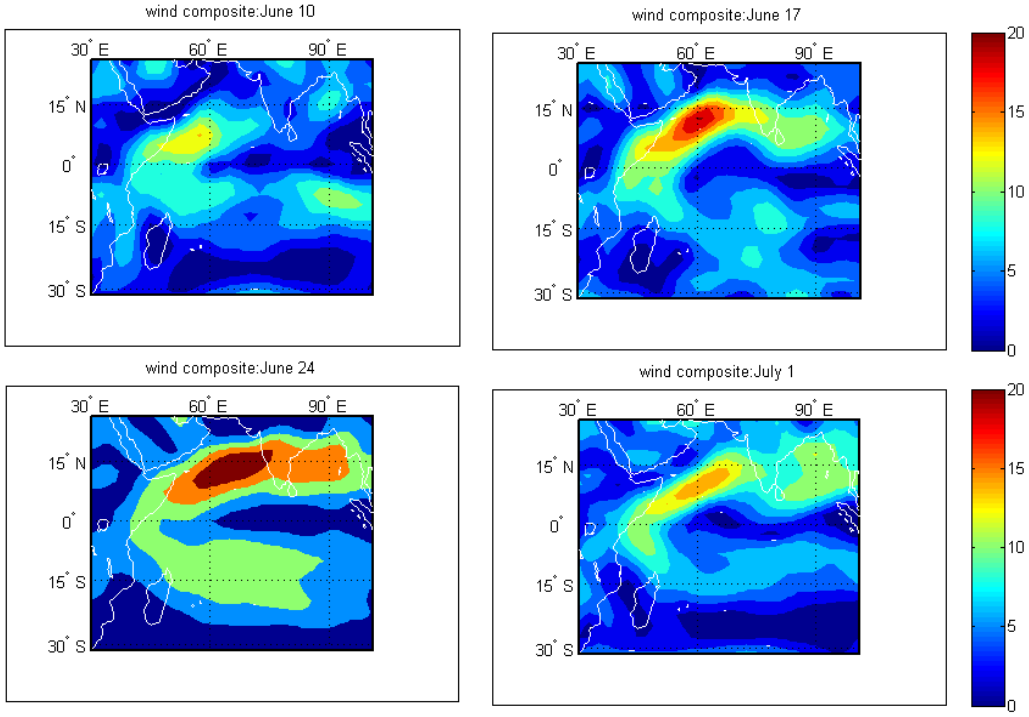

Figure 2(a): Intra-Seasonal Variability of Somali Jets (June-2015)

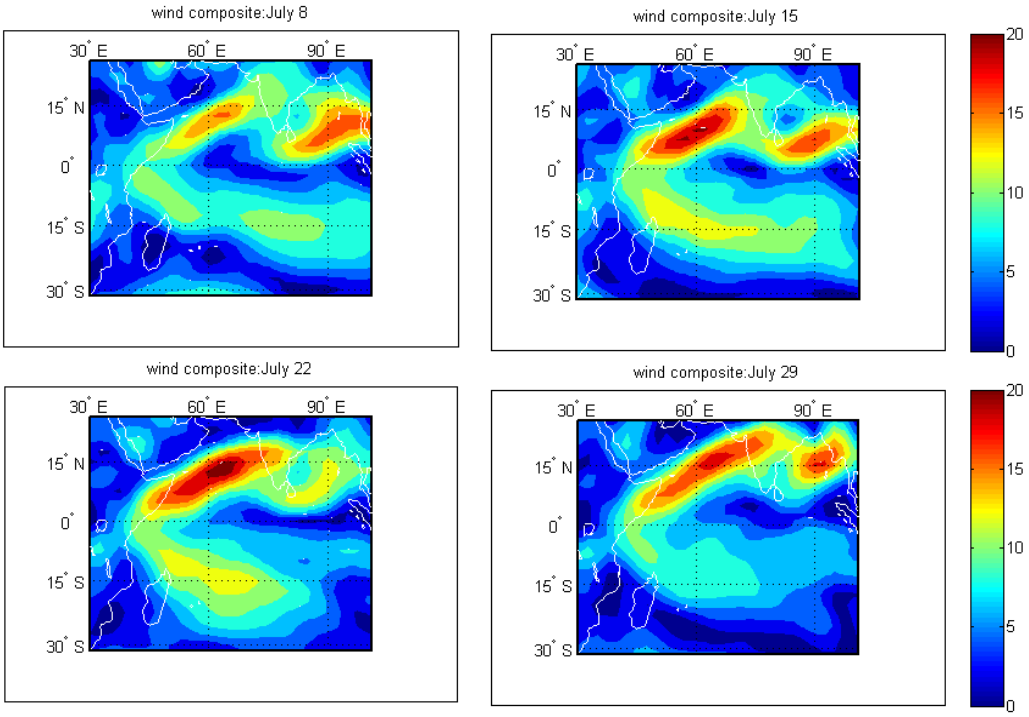

Figure 2(b): Intra-Seasonal Variability of Somali Jets (July-2015)

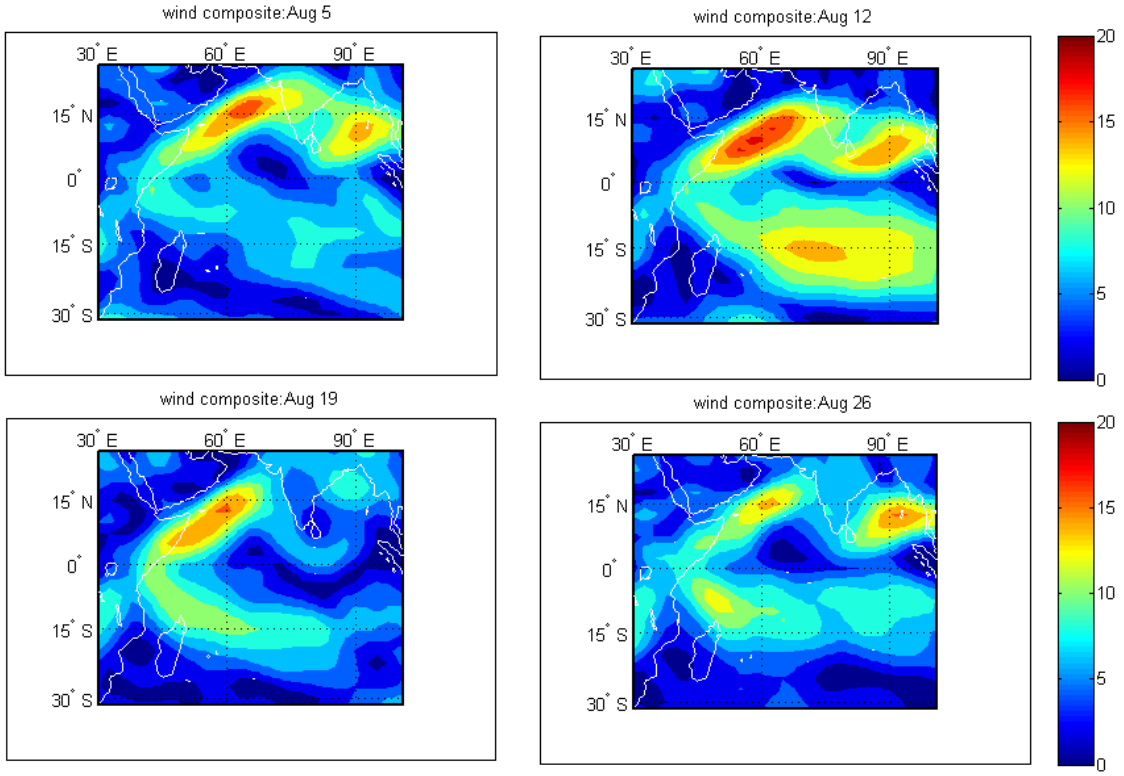

Figure 2(c): Intra-Seasonal Variability of Somali Jet (August-2015)

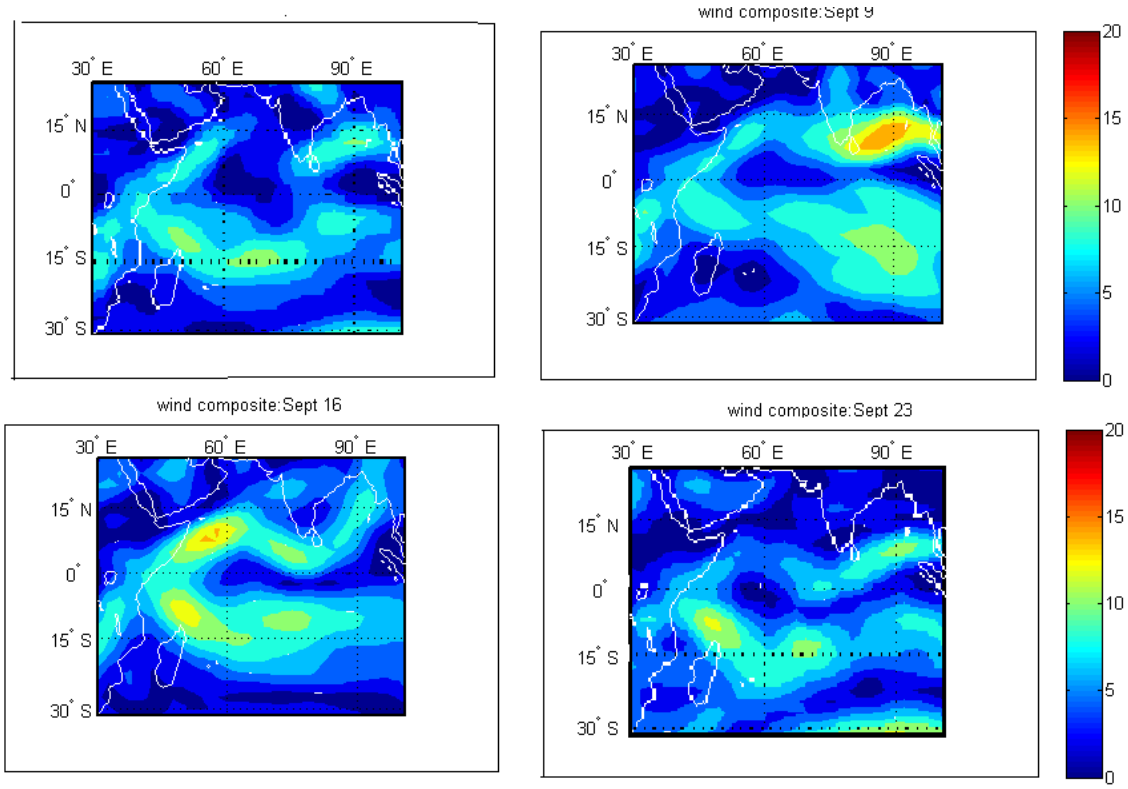

Figure 2(d): Intra-Seasonal Variability of Somali Jet (September-2015)

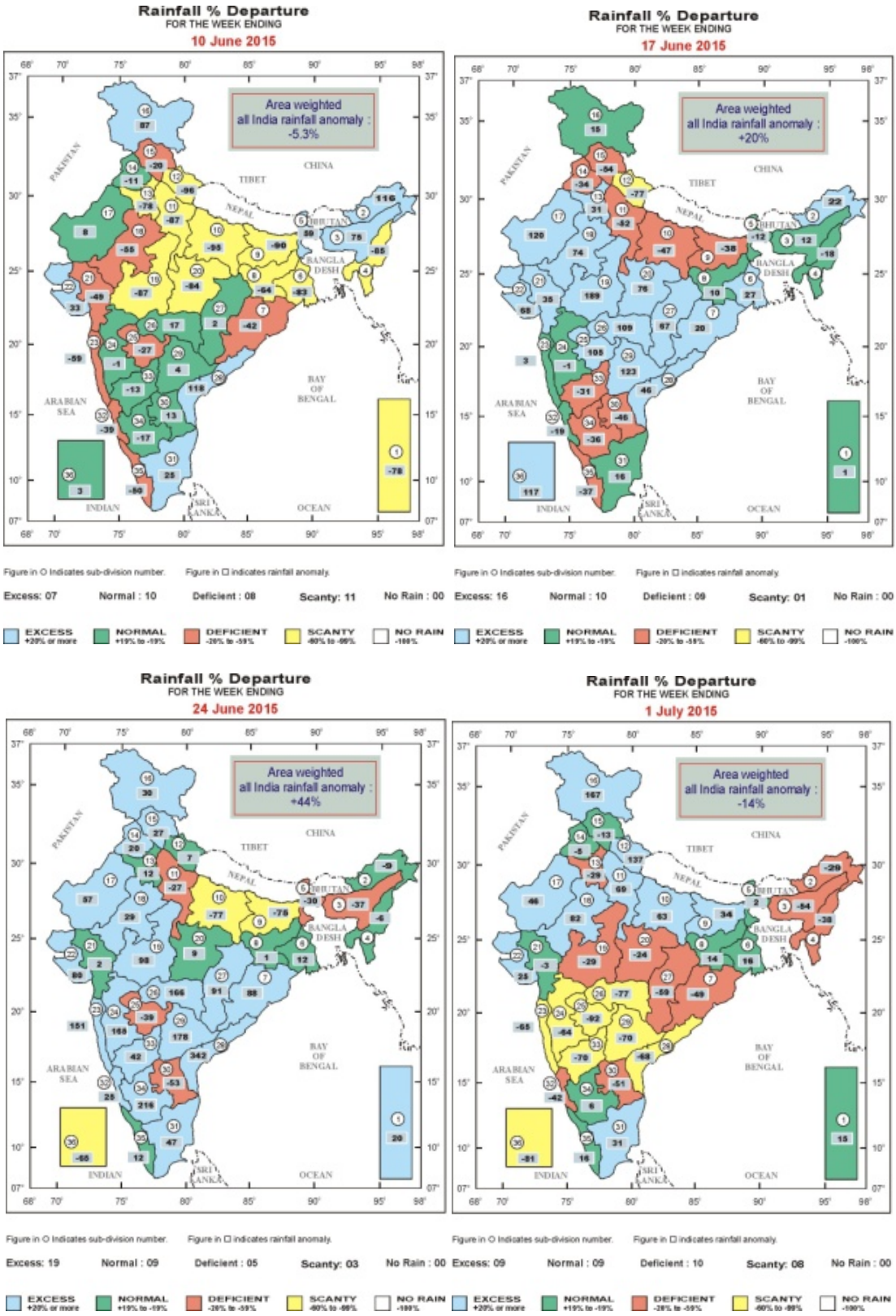

Figure 3 (a): Weekly Rainfall Patterns of June 2015

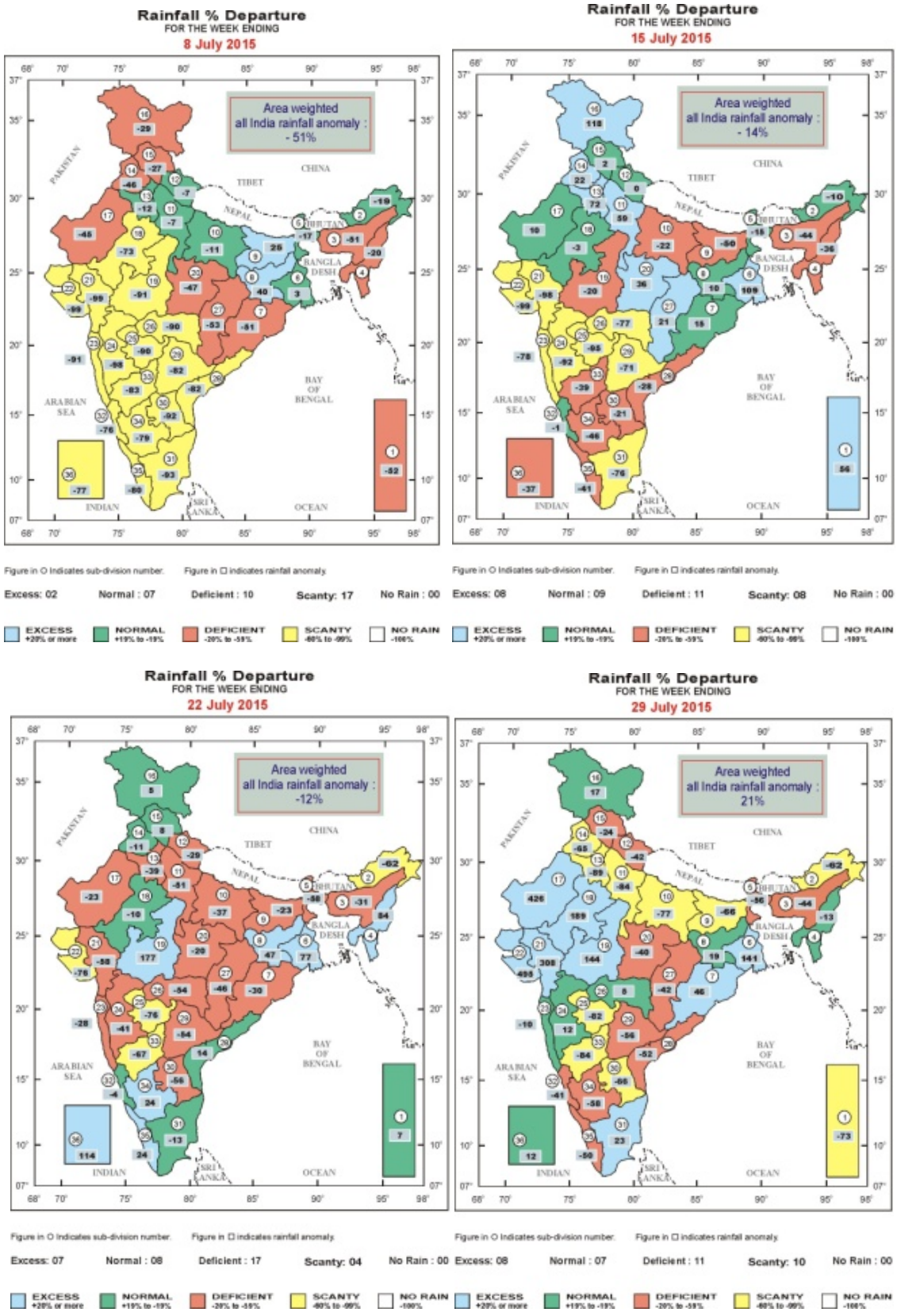

Figure 3(b): Weekly Rainfall Patterns of July 2015

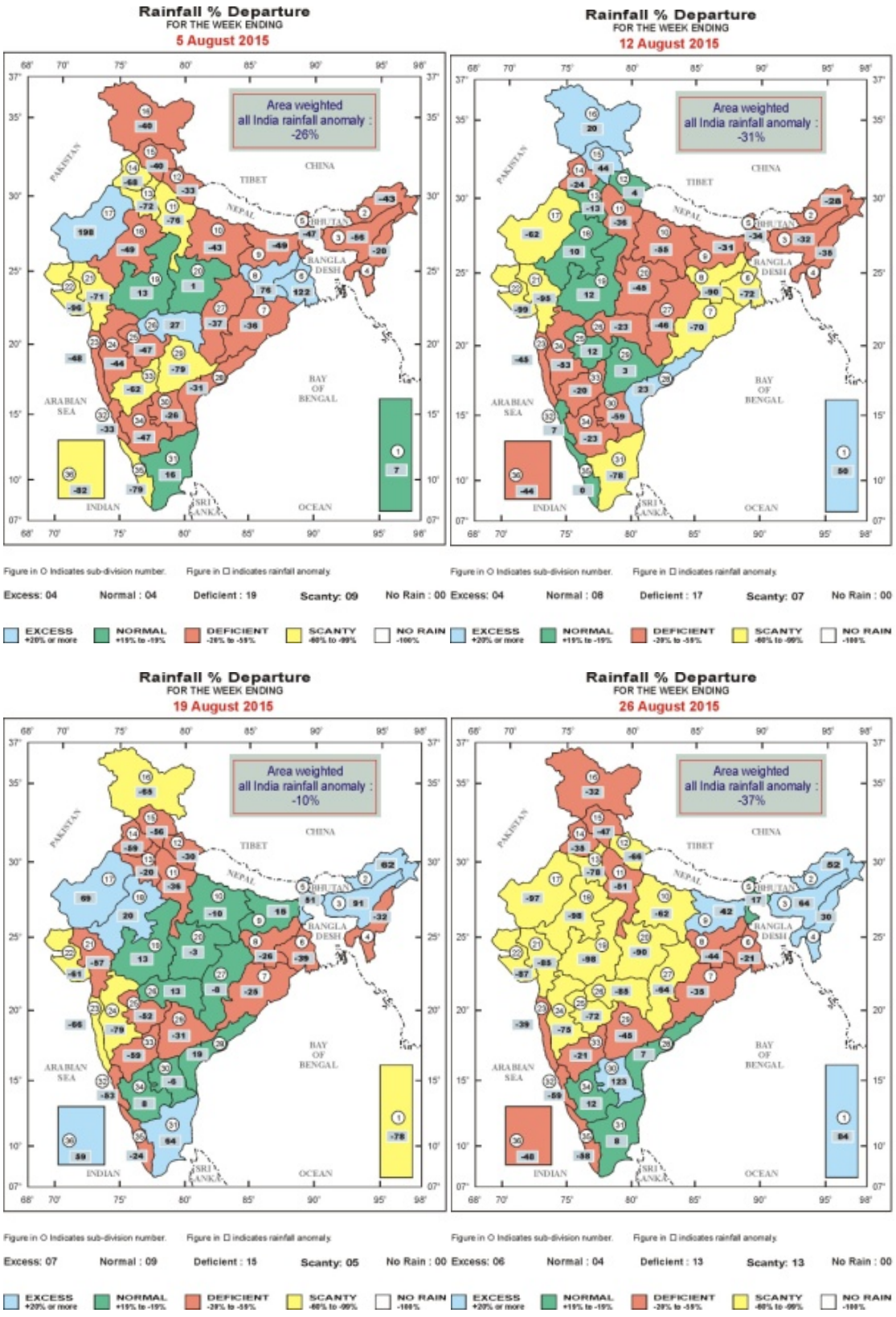

Figure 3(c): Weekly Rainfall Patterns of August 2015

It can be seen from Figure 1 that observed rainfall of the monsoon season 2015 was below normal. Out of 36 subdivisions 17 were deficient and rest were normal but mostly on the negative side of the range. Hence in this paper, Indian summer monsoon season 2015 is studied in connection with the southern hemispherical features such as Mascerene high

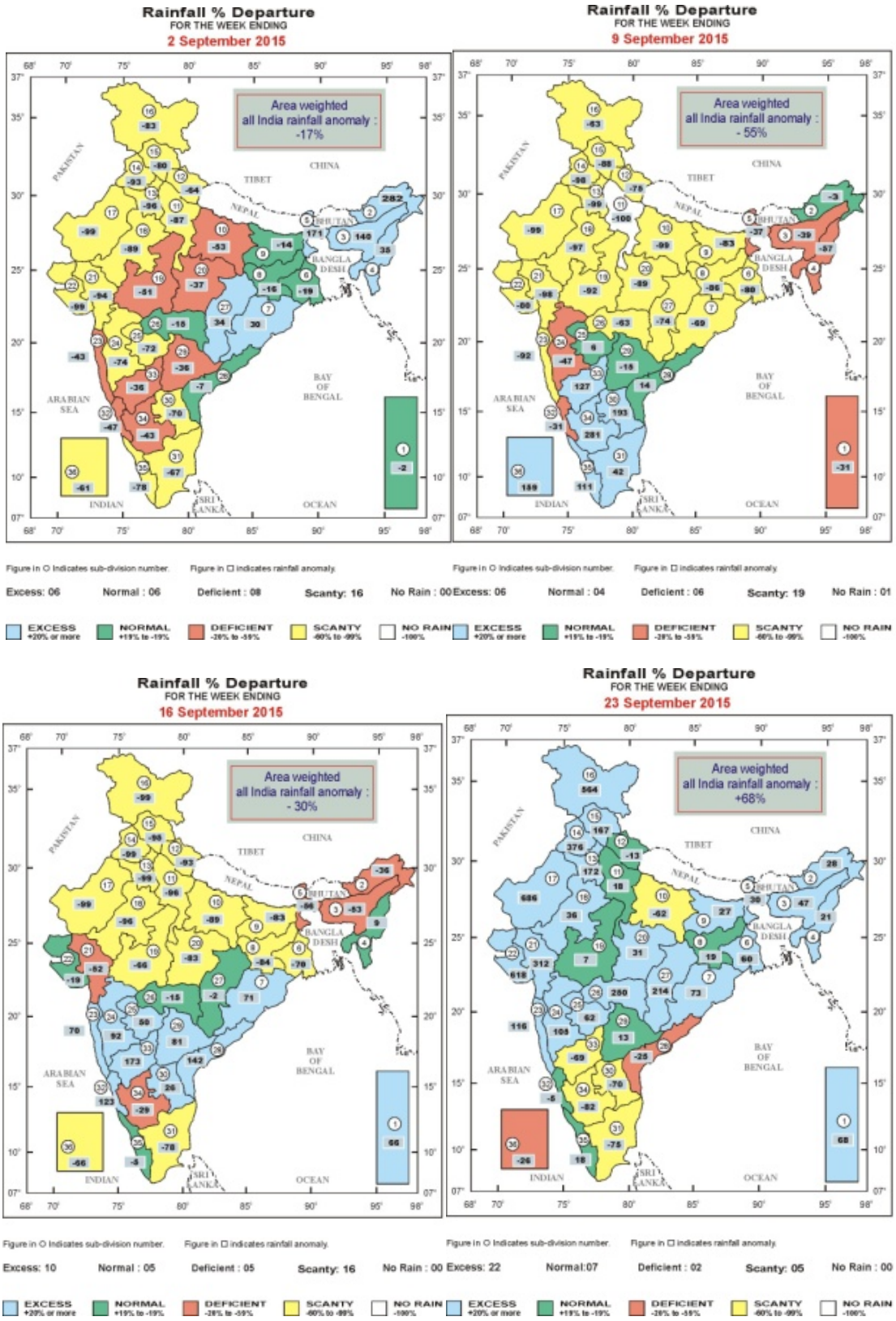

Figure 3(d): Weekly Rainfall Patterns of September 2015

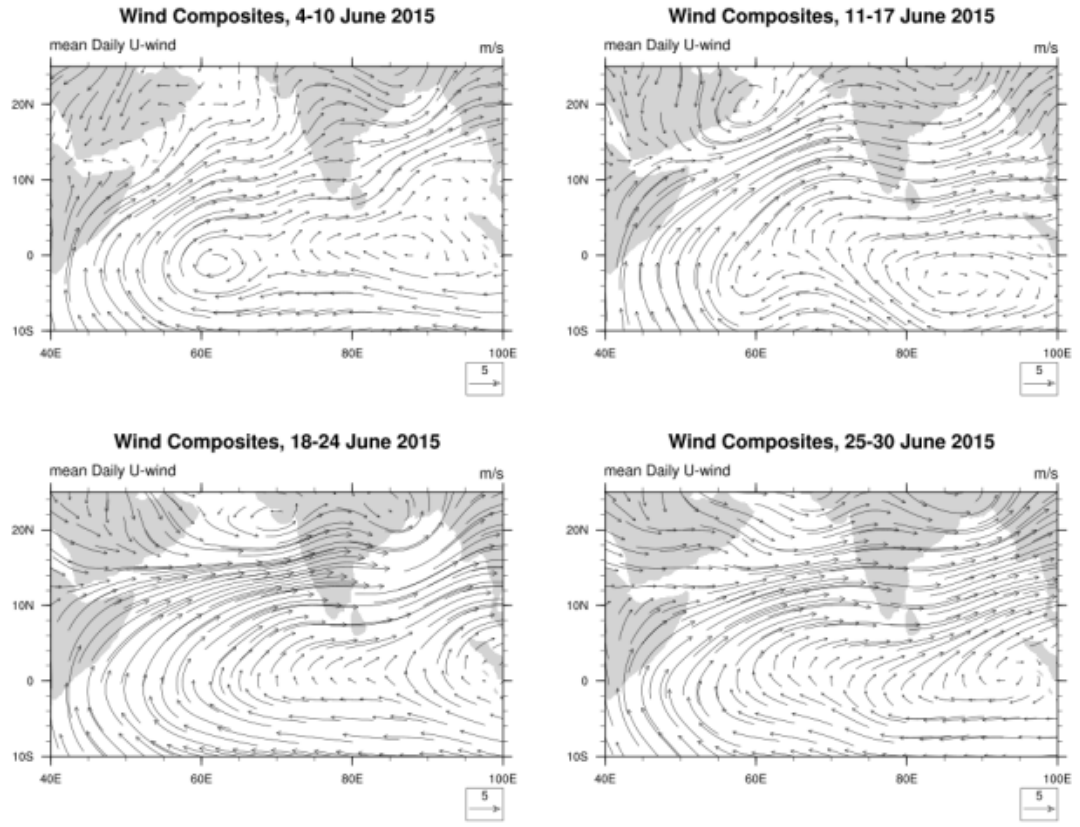

Figure 4 (a): Intra-Seasonal Wind Vectors (June-2015)

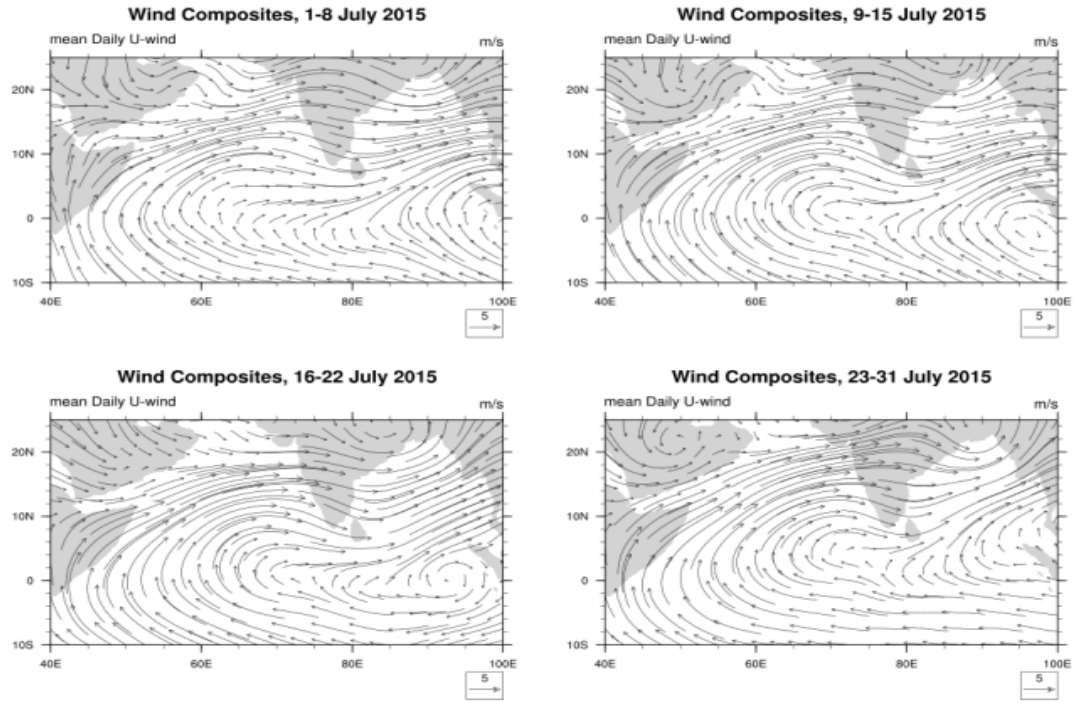

Figure 4 (b): Intra-Seasonal Wind Vectors (July-2015)

and circumpolar lows, rather than looking at the remote climatic conditions. Also, intra-seasonal variability of the Somali jet, Mascerene high and the circumpolar lows is

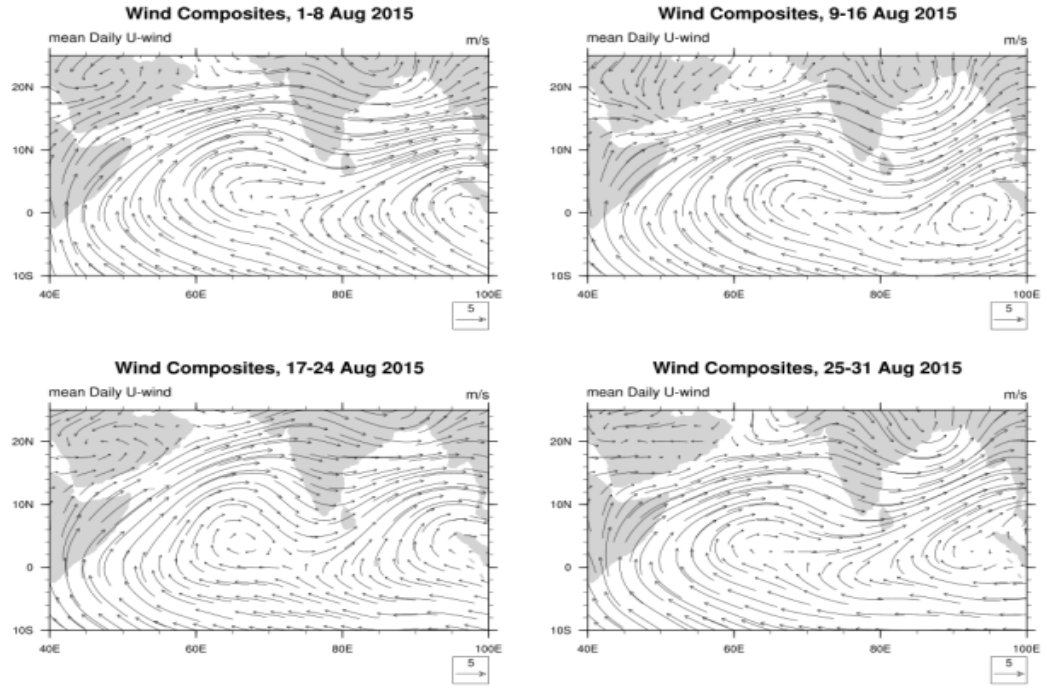

Figure 4 (c): Intra-Seasonal Wind Vectors (August-2015)

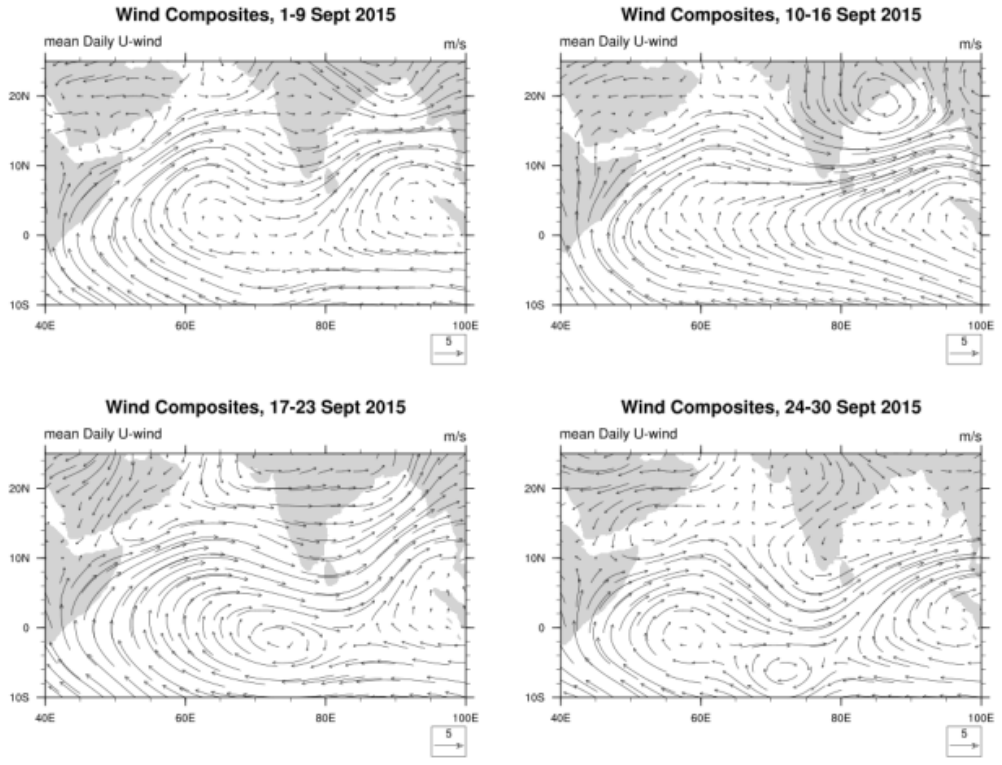

Figure 4 (d): Intra-Seasonal Wind Vectors (Sept-2015)

studied. It was observed that during the month of June and second half of September had a good rainfall, whereas the months of July and August had very less amount of rainfall. In the following sections, we have attempted to justify the corresponding rainfall patterns with the intra-seasonal variation of the Somali jets, Mascarene high (MH) and circumpolar lows (CPL). Next section explains about the data and methodology used in this study. After that

analysis results are discussed and finally concluding remarks are given.

2. Data and Methodology

The daily reanalysis datasets used in this study are from the National Center for Atmospheric Research (NCEP/NCAR) global atmospheric reanalysis data of the year 2015. The variables include sea level pressure (SLP) and horizontal winds at various pressure levels. Daily mean SLP data is used to analyze MH and CPL,

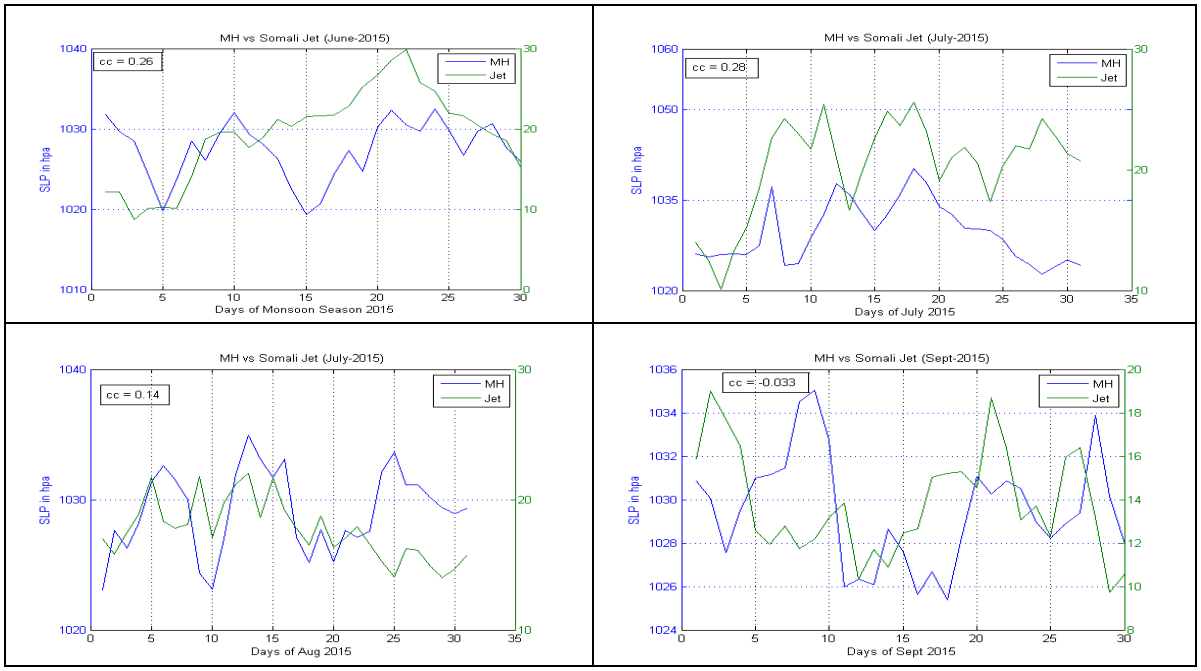

Figure 5: Intra-Seasonal Correlation of the MH and Somali Jets (Monsoon-2015)

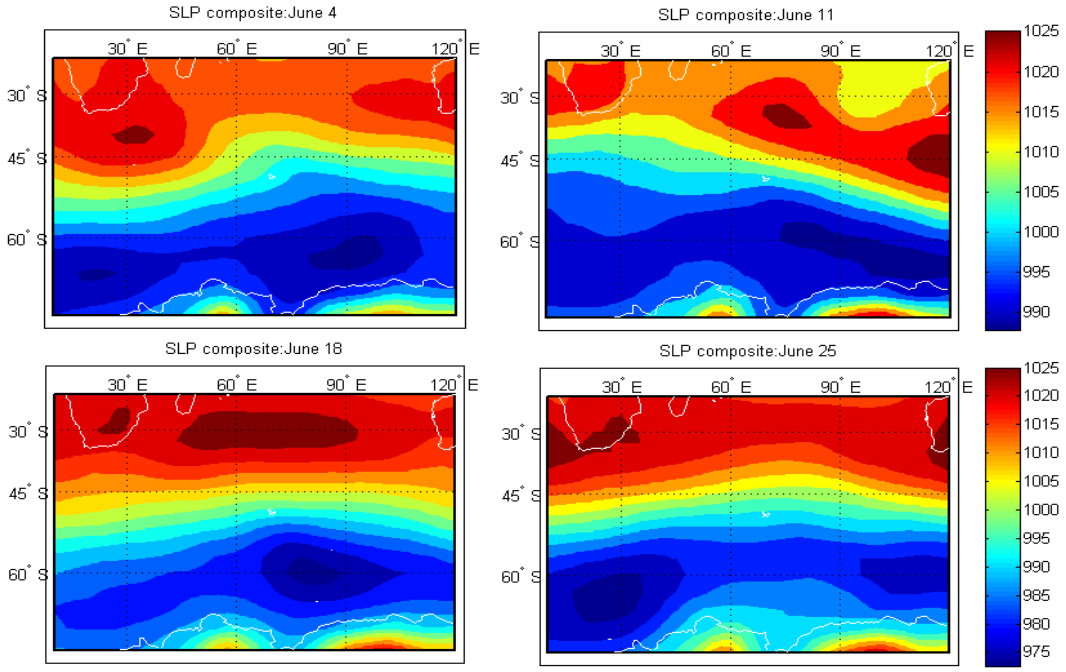

Figure 6(a): Oscillations of the Low and High Pressure Belts (June-2015)

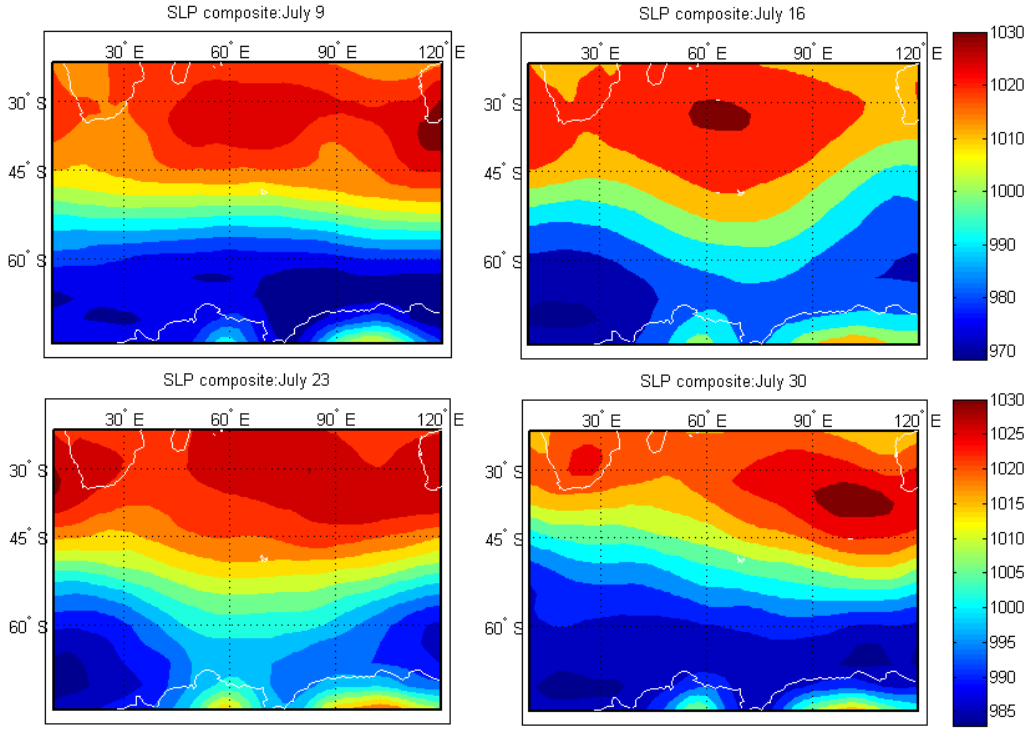

Figure 6(b): Oscillations of the Low and High Pressure Belts (July-2015)

whereas daily mean horizontal wind data at the 850 hpa pressure level is used to analyze the Somali jets speeds. Rainfall data is acquired from the India Meteorological Department (IMD) Dataset.

Data from IMD is the week ending rainfall of the monsoon season 2015. It has helped to find the corresponding rainfall patterns with respect to the Somali jet speeds (CEF). Later, this CEF was analyzed together with the MH to estimate the correlation coefficient among them. Finally, MH is studied with the CPL by defining square grid boxes for both the

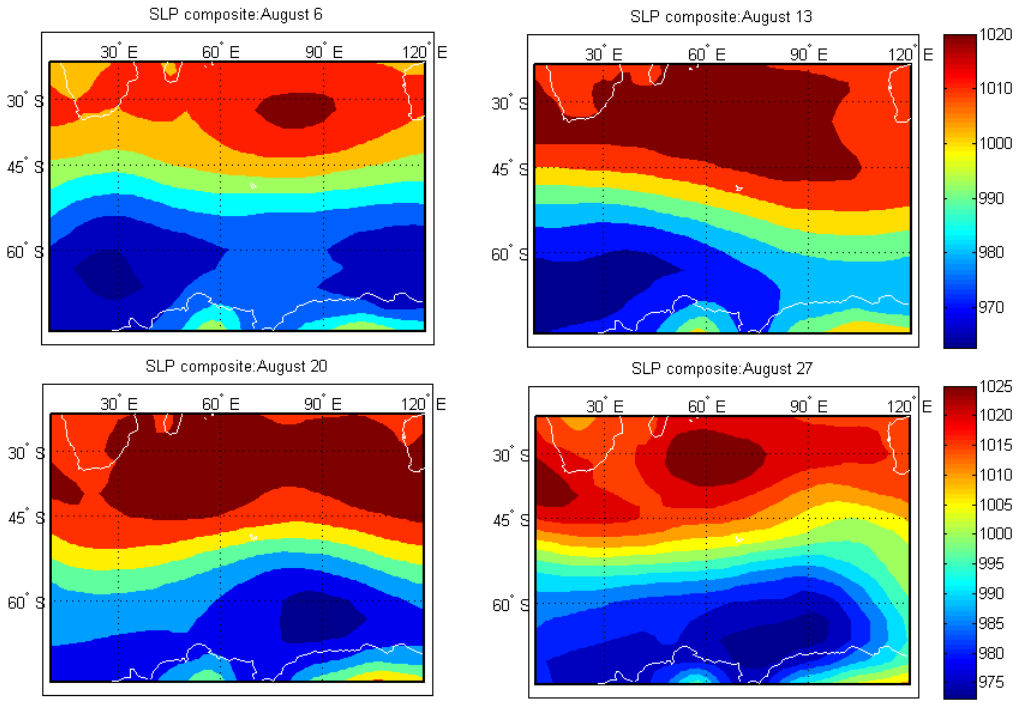

Figure 6(c): Oscillations of the Low and High Pressure Belts (August 2015)

phenomenon. Grid box was defined at 25o S to 45o S Lat and 40o E to 65o E Lon for the MH, whereas 45o S to 75o S Lat and 20o E to 50o E Lon for the CPL. By purpose the CPL pocket was defined at the left of the MH pocket, so that CPL formation would affect the MH intensity.

During the monsoon season 2015, except the month of June, very little rainfall occurred over the Indian region. Most likely the rainfall that have occurred is due to the low pressure systems.

Along with the low speeds of the Somali jets, anti-cyclonic flow at the south-west of Indian

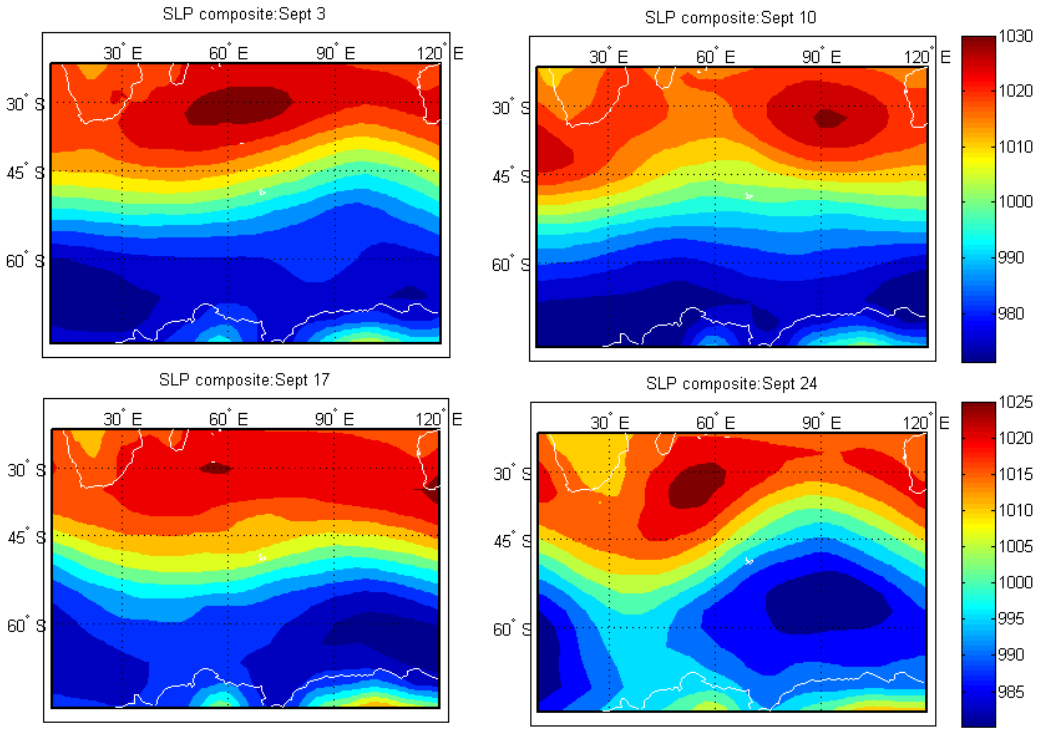

Figure 6(d): Oscillations of the Low and High Pressure Belts (Sept 2015)

3. Results and Discussion

Good amount of rainfall occurred (Fig 3) in the mid of June over India, it can be seen from fig 2 that wind speeds are quite pronounced in the corresponding period. In the month of July, good wind speeds were observed but very little rainfall occurred due to the anti-cyclonic flow at the south west of Indian region. During the months of August very weak winds in September were observed near the Somalia coast and corresponding deficient rainfall patterns over the Indian region. The rainfall that occurred during the August and September months was due to the low pressure systems that have formed near the head Bay of Bengal and the Arabian Sea.

region (Fig 4) is the main cause of deficient or scanty rainfall patterns during the months of August and September (Fig 3). Anti-cyclonic flow has prevented the winds that carried moisture to blow over the Indian region. Also, month of July had little bit of anti-cyclonic type of wind flow patterns at the south west of the Indian region (Fig 4).

3.1 Correlation of Mascarene High with the Somali Jets

Mascerene high (MH) is the main engine that drives the meridional monsoon circulation. It has direct impact on the cross equatorial flow at the Somalia region. The position and intensity of the MH determines the speed of the Somali jets. Deflection of the MH to the south of 30^{o} S weakens the cross equatorial

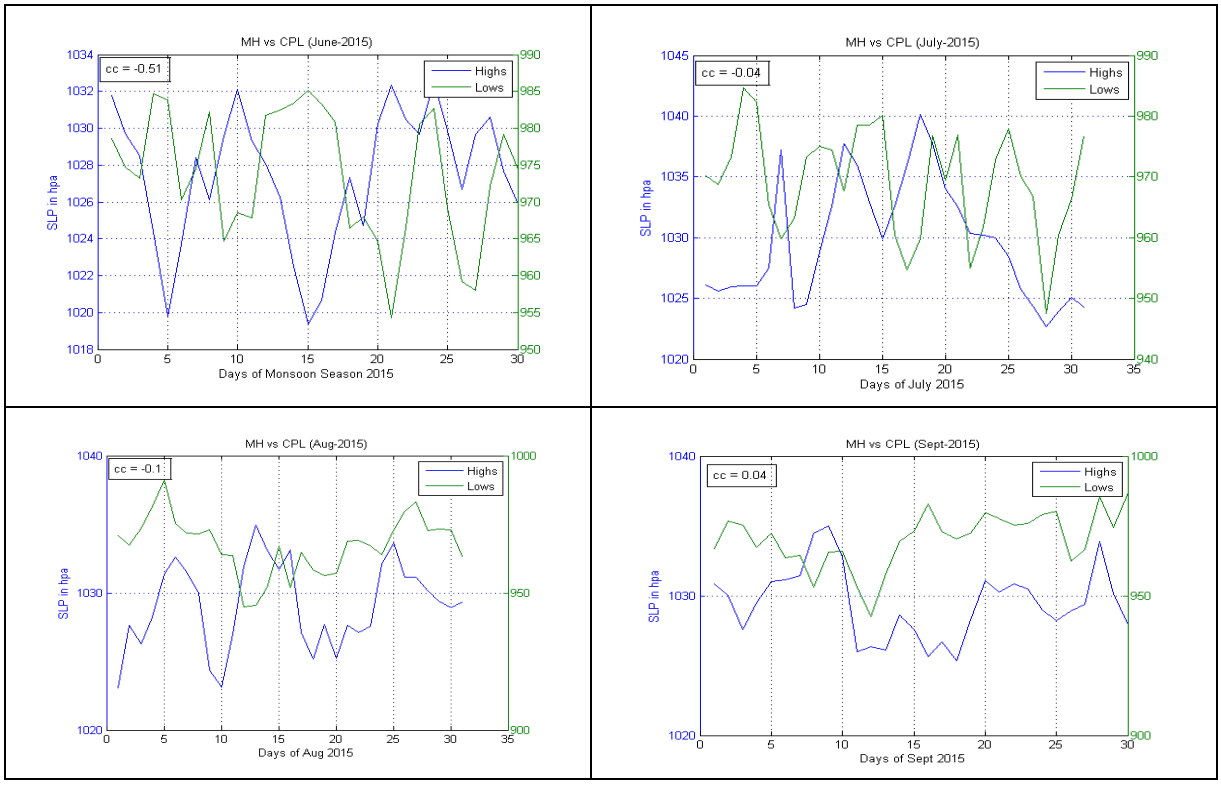

Figure 7: Intra-Seasonal Correlation of the MH and CPL (Monsoon-2015)

flow (CEF) and vice versa. In the Figure 5, monthly plots of the MH with CEF are shown. There are better correlation coefficients of 0.26 and 0.28 for the months of June and July respectively. A little less correlation coefficient of 0.14 obtained for the month of August, whereas correlation coefficient for the month of September is negligible. Significance level of the correlation coefficients for the months of June and July is 90%.

3.2 Correlation of Mascarene High with Circumpolar Low

The main focus of the study is to identify the relation of MH with that of the CPL. The chain of lows that is passing at southern higher latitudes has meridional oscillations (Fig 6). These oscillations of the low pressure belt cause the sub-tropical high pressure belt of MH to oscillate north-south as well. Also, the intensity of the low that has formed in the low pressure belt has impact on the intensity of the MH. It has found that, well marked low with more closed isobars around it has helped the intensity of the MH to increase. It can be seen from the monthly plots of the correlation between the MH and CPL (fig 7). If the correlation coefficient is negative, then it shows that low has very less pressure value and the MH has high pressure value. There is a very good correlation coefficient of -0. 51 found for the month of June, it is greater than 99% significant. Rest of the months of the season doesn't show significant correlation coefficients.

3.3 Correlation of Circumpolar Low with Cross Equatorial Flow

It has found that circumpolar low farther in the south does have an effect on the cross equatorial flow that considered here just north of the equator near Somalia coast. For the months of June and July have correlation coefficients of -0.33 and -0.45, which are 90% and 99% significant respectively (fig 7). Months of August and September have insignificant correlation coefficients.

4. Summary

Following are the salient results of this study:

- MH has direct impact on the cross equatorial flow at the Somalia region. The position and intensity of the MH determines the speed of the Somali jets. Any deviation of the MH to the south of 30o S and east of 50o E weakens the cross equatorial flow (CEF).
- In June, MH is in place and hence good CEF observed near the Somalia region. From the mid July, increase in anticyclonic vorticity over south Arabian sea resulted in reduced zonal flow inland.
- In August, MH was merged with the AH, hence weaker CEF observed in the Somalia region. Most of the CEF was in Bay of Bengal, east of 80 0 E. Rainfall occurred mostly due to the land depressions and cyclonic storm 'Kommen' that formed in the Bay of Bengal.
- The correlation coefficient of MH with CEF are found to be significant at 90% level for the months of June and July. They are not significant for August and September.
- The correlation coefficient of MH with CPL are found to be significant at 99% level for the month of June. They are not significant for July, August and September.
- The correlation coefficient of CEF with CPL are found to be significant at 90% and 99% level for the month of June and July respectively. They are not significant for August and September.
- Meridional oscillations of the CPL pressure belt bring about changes in the sub-tropical high pressure belt that determines the locus and intensity of the MH. The intensification of the low pressures that became marked in the belt impacts the intensity (positive) of MH.

References

Feng X., Wang H., 2004, Interannual Variability of Mascarene High and Australian High and Their Influences on East Asian Summer Monsoon, Jr. of the Met. Society of Japan, Vol. 82, 1173-1186.

Goswami B. N., Mohan R. S., 2000. Intra-seasonal oscillations and inter-annual variability of the Indian summer monsoon, Jr. of Climate, 14, 1180-1198.

Rao P. C. S., Bhongale M. M., 2012. Movement of low pressure systems over eastern Antarctic region and their influence on the rainfall over India during southwest monsoon, Vayumandal, 121-129.

Sikka D. R., and Gadgil S., 1980. On the maximum cloud zone and the ITCZ over Indian longitudes during the southwest monsoon. Mon. Wea. Rev., 108, 1840-1853