Characteristic of Integrated Field Intensity of Atmospherics during Monsoon of West Bengal

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Abstract: **Low Frequency (LF) radio telescope has been utilized to investigate the onset and stable conditions of Indian monsoon. Round-the-clock observations of atmospherics have been taken at 40 kHz over Kalyani (22.98°N, 88.46°E), West Bengal for six consecutive years 2011 to 2016. The average noise level of atmospherics taken round-the-clock at 40 kHz for 15 days before the onset as well as for the same period from the onset date of the monsoon have considered for all the individual years. We have also considered temperature, dew point, wind speed, humidity, sea level pressure and visibility for the same period of 15 days before and after the monsoon onset. Under the stable condition of the monsoon a characteristic variation has been noted in the atmospherics record. This paper reports a comparative study of precursory phenomenon in the atmospherics record during the onset of Southwest monsoon. Some related meteorological parameters besides Doppler Weather Radar information at such time have been taken into consideration at length. The recorded precursory phenomena have been examined and their probable explanation is given in terms of electrical discharges at such times.**

Index Trems- **Atmospherics; Tropical Monsoon; Thunderclouds; Electrical discharges**

I. INTRODUCTION

A study of the influence of the monsoon on the atmospherics level has been a subject of great interest for the last few decades [1-5] and many scattered reports have been published in the literature from time to time [6-8]. However, the transitional days from pre- monsoon to arrival of monsoon have not yet been examined at length in the tropics. In this paper we report a precursory effect as recorded at 40 kHz atmospherics in Kalyani (22.98°N, 88.46°E), West Bengal for the successive three years from 2011 to 2013. The recorded precursory phenomena have been examined and their probable explanations are given in terms of electrical discharges originating in accompanying thunderclouds. Our observational site at Kalyani lies in Southern part of West Bengal and its distance is about 150 km away from the Bay of Bengal. The map shown in Figure 1 indicates the location of the Bay of Bengal where SW monsoon originates as well as the location of the observing station Kalyani situated at about 150 km away from the Bay of Bengal.

The South West (SW) monsoon normally arrives at South Bengal, that includes Kalyani and Kolkata, by June 7 but the dates are usually changed from year to year. Table 1 shows the onset of monsoon for the six years under consideration.

TABLE 1
Onset of SW monsoon during 2011 to 2016
(Data Source: IMD)

Year	Date of onset of monsoon in Kalyani, West Bengal
2011	13th June
2012	17th June
2013	9th June
2014	18th June
2015	20th June
2016	17th June

It appears that most of the years, a delayed monsoon is observed by around a week due to lack of low pressure formations in the vicinity.

II. EQUIPMENTS

The receiver employed for the observations at 40 kHz is designed in such a manner so that it can successfully handle variation of field intensities due to atmospherics originating due to meteorological disturbances. The receiving system was constructed by Radio Astronomical Supplies (RAS), USA with audio monitoring facility. The unit has tuned RF stages followed by a detector and DC amplifier which in turn feed the recorder where a master computer is used for recording the atmospherics data in digital form.

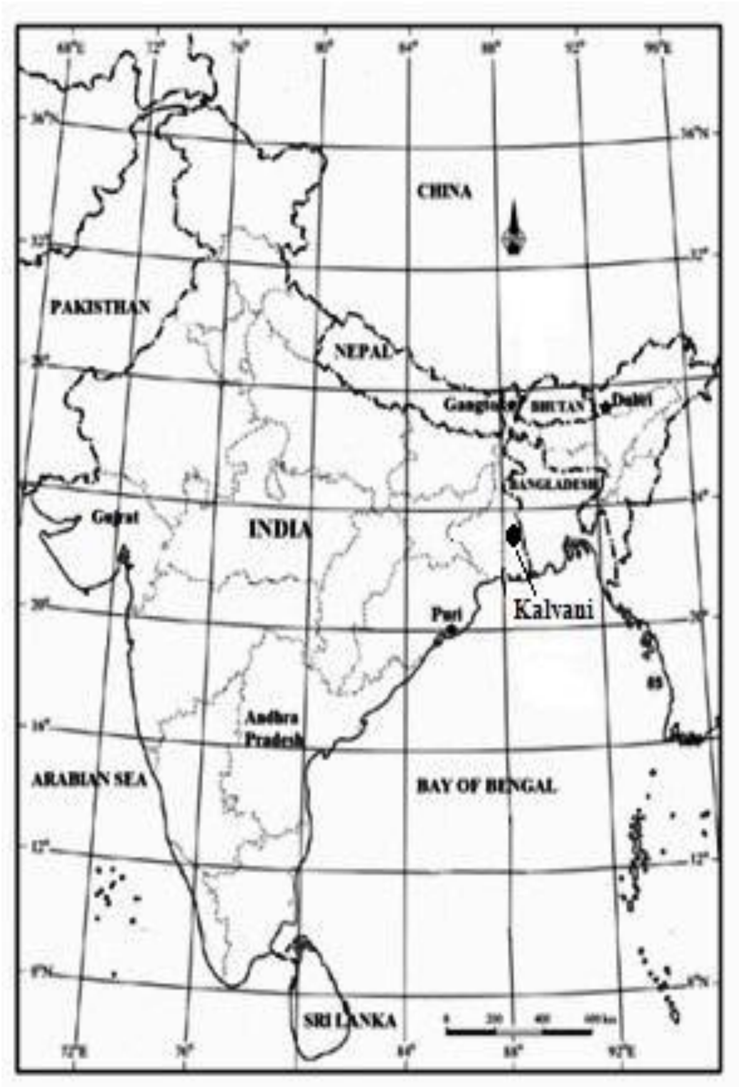


Fig.1. Map of India showing North and South Bengal including the locations of the Bay of Bengal and the location of Kalyani where atmospherics data were recorded

The type of antenna used with the receiver is governed by the nature of polarization of the signal to be received and also occasionally by the direction of arrival of the wave while the dimension of the antenna with horizontal part 30 ft and vertical part 10 ft largely depends on the wavelengths, the ratio of the signal picked up by the antenna to the inherent receiver noise. The polarization of the atmospherics field is mainly vertical in the designated frequency range. In our observation we used an inverted-L antenna whose vertical part would receive this field with an omni directional azimuthal pattern while the function of the horizontal part is simply to add to the top capacitance of the antenna causing an increase of current to the vertical part. In order to further mention the technical part of the instrument it may be pointed out that the receiver is composed of a very sharp double tuned filter and three stages of amplification in cascade. The gain of the cascade stages is set by a single potentiometer. The output of the amplifiers is fed to a diode detector and then to a 10 second integrator.

III. ATMOSPHERICS RECORD

Figure 2 shows the characteristic variations of atmospherics at 40 kHz recorded for the consecutive six years when the Southwest monsoon advances in the Bay of Bengal but before arrival at Kalyani. After a distinct and a very short period fall of the intensity level it reveals an enhancement followed by a clear pause time and subsequently a sudden fall of atmospherics (SFA) is observed which finally regains the normal level soon.

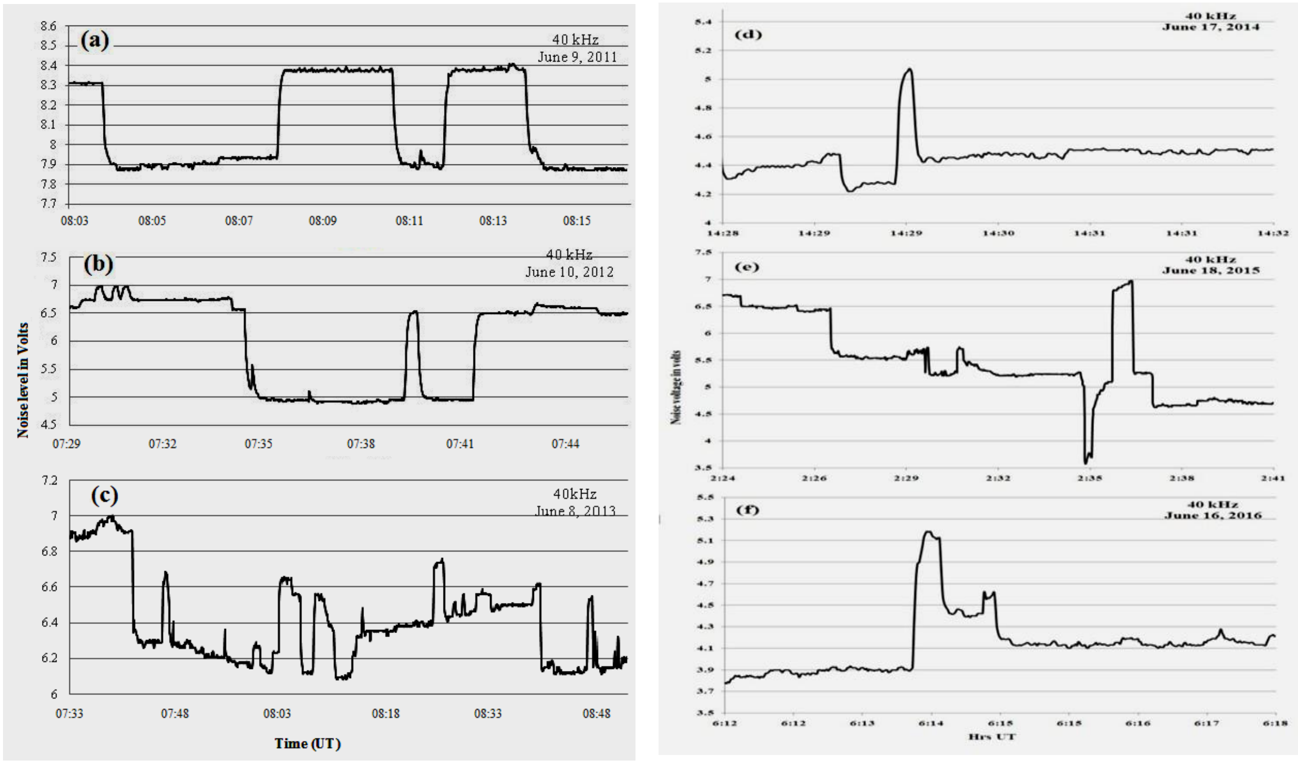


Fig. 2.Precursory effects in the atmospherics level before the arrival of SW monsoon at Kalyani, West Bengal

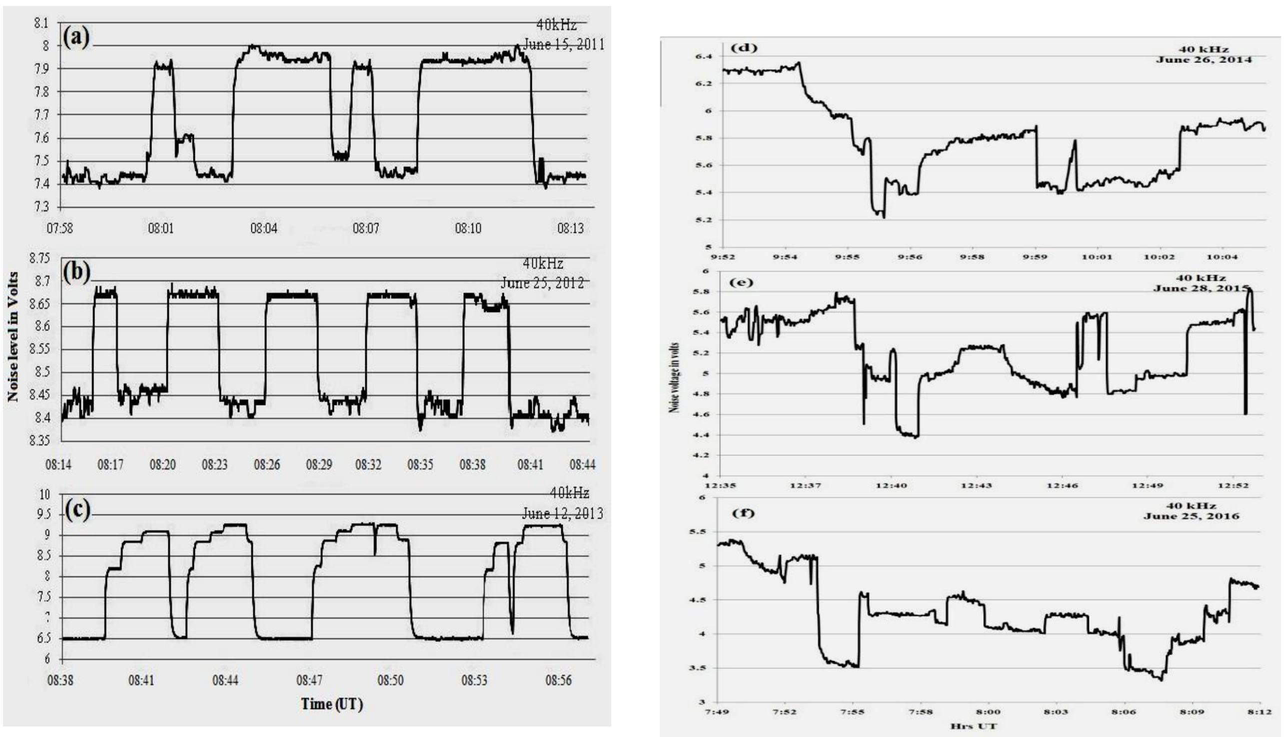


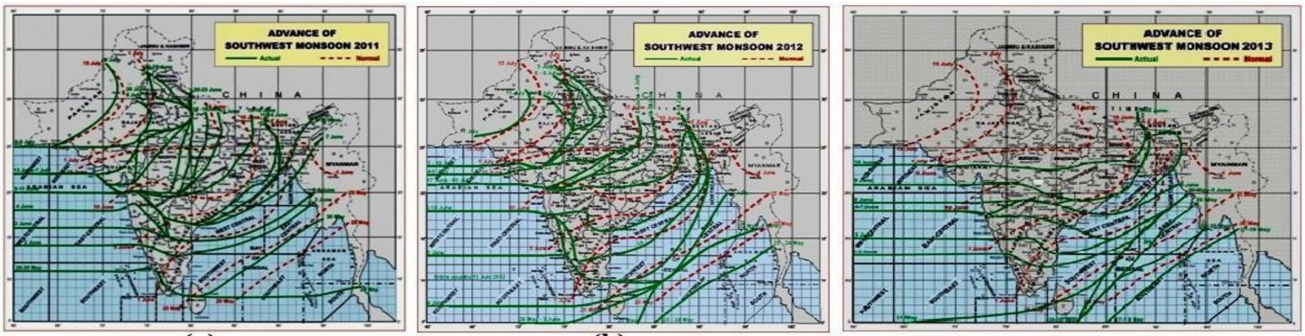
Fig. 3. Some typical patterns of atmospherics, when the monsoon gets a very stable shape. The data were recorded on (a) June 15, 2011, (b) June 25, 2012, (c) June 12, 2013, (a) June 26, 2014, (b) June 28, 2015 and (c) June 25, 2016

Figure 3, on the other hand, reveals some typical patterns of atmospherics when the monsoon gets a very stable shape. The data samples shown in the figure were recorded on (a) June 15, 2011, (b) June 25, 2012, (c) June 12, 2013, (d) June 26, 2014, (e) June 28, 2015 and (f) June 25, 2016. A close scrutiny of the records reveals some interesting features. From the consideration of the magnitude of variation we find that the sudden fall of atmospherics (SFA) is comparable to that obtained during the sudden enhancement atmospherics (SEA). From a careful visual observation it has been noted that there has been a finite time delay by a few seconds between the SFA and the associated raining when the sky was covered with overcast cloud and torrential rainfall with repeated lightning discharges caused by surrounding monsoon thunderclouds.

IV. ASSOCIATED METEOROLOGICAL PARAMETERS

If we consider the first three years 2011 to 2013, as a close look, we find that the northern limit of the monsoon was visible on June 13 for both the years 2011 and 2012.

In the year 2013, monsoon was reached after a slight late according to the onset date of the monsoon calendar. The northern limit of the monsoon was visible on June 9 for the year 2013. Figure 4 (a), (b), and (c) represents the advance of SW monsoon for the three successive years.



(a) (b) (c)

Fig. 4. Advance of SW monsoon for the years (a) 2011 (b) 2012 and (c) 2013 [*www.imd.gov.in*]

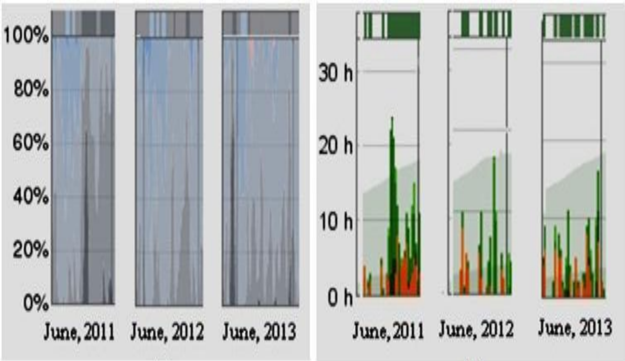
TABLE 2
Dates of advance of southwest Monsoon for the years of 2011, 2012 and 2013

Date	Southwest monsoon advanced over	Northern Limit of Monsoon Passed through
June 13 to June 15, 2011	Madhya Maharashtra, Marathwada, Vidarbha, Chattisgarh, Jharkhand and Bihar, Telangana and Orissa, Karnataka, Sub-Himalayan West Bengal & Sikkim, coastal Andhra Pradesh and Bay of Bengal and entire Gangetic West Bengal including Kalyani.	Lat. 22°–27°N and Long. 60°–87° E
June 17, 2012	Konkan, Karnataka, Andhra Pradesh, Bay of Bengal, South Gujarat, Madhya Maharashtra, Vidarbha, Marathwada, Chattisgarh, Orissa and Gangetic West Bengal including Kalyani, Sikkim, Jharkhand, Bihar and Madhyapradesh	Lat. 21°–27°N and Long. 60°–88°E
June 6 to June 15, 2013	West Rajasthan to north Bay of Bengal, Gangetic West Bengal including Kalyani	Latitudes 12–28°N and Longitudes 70–95°E

Table 2 represents dates of advance of southwest Monsoon for the years of 2011, 2012 and 2013. The latitude and longitude ranges through which the northern limit of monsoon passed through have shown in the table also.

We have compared the cloud coverage and precipitation for the month of June for the first three years (Fig. 5). In case of cloud coverage most gray indicates that the sky was largely cloudy or overcast. In case of precipitation orange indicates thunderstorms, dark to light green represent heavy, moderate, and light rain and lightest green indicating drizzle.

Fig. 5. (a) Cloud cover and (b) Precipitation for the month of June for three consecutive years



(a) (b)

We have also compared cloud coverage and precipitation with occurrence of thunderstorm for the month of June for the three years as shown in Figure 6(a) and Figure 6(b) respectively. In case of cloud coverage most gray indicates that the sky was mostly cloudy or overcast. In Figure 6(b) black line indicates precipitation for the month of June of 2011, 2012 and 2013 and red star indicates occurrence of thunderstorms during the month of June for the respective years

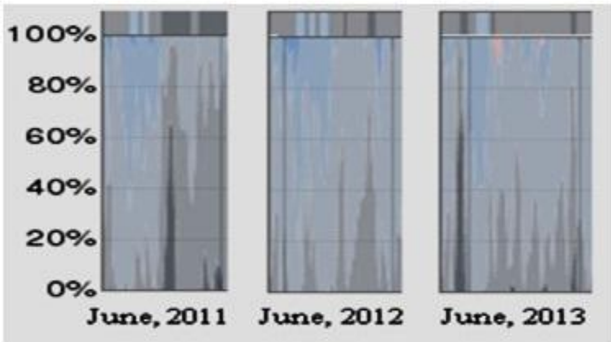


Fig. 6. (a) Cloud cover for the month of June for three consecutive years

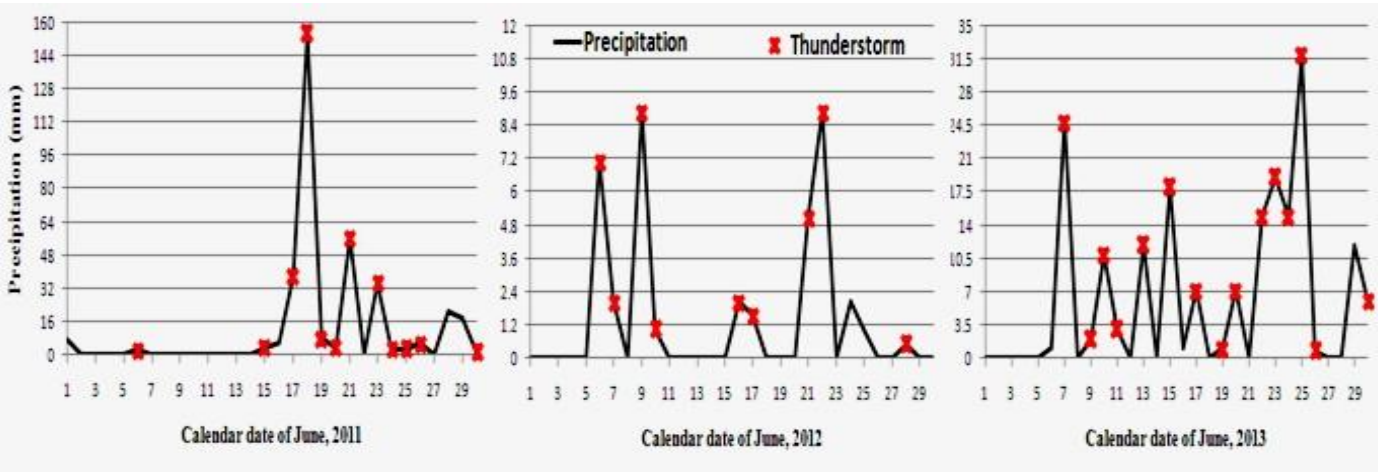


Fig. 6. (b) Precipitation with occurrence of thunderstorm for the month of June for three consecutive years

Again, we are comparing number of rainy days, average maximum temperature, average minimum temperature and cumulative rainfall for the first 19 days of monsoon for the three consecutive years (Fig. 7).

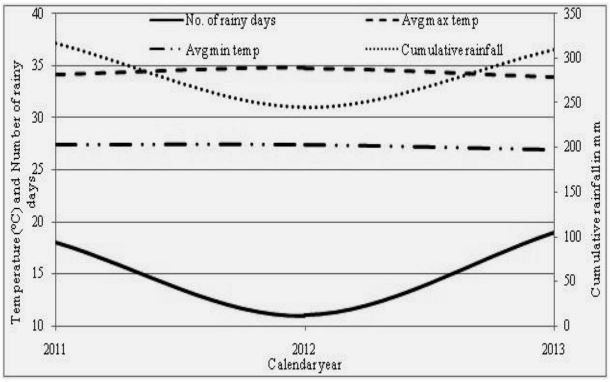


Fig. 7. Comparison of number of rainy days, average maximum temperature, average minimum temperature and cumulative rainfall for the first 19 days of monsoon for the three consecutive years

We have again compared number of rainy days, average maximum temperature, average minimum temperature and cumulative rainfall for the first 19 days of monsoon for the three consecutive years and presented in Table 3.

It appears from the figure that the nature of the graphs involving different meteorological parameters exhibit almost similar variation. However, in the year 2012, number of rainy days as well as cumulative rainfall is lowest. We have further calculated the average noise level of atmospherics taken round-the-clock at 40 kHz for 15 days before the onset of the monsoon at all the individual years. In a similar way, the average noise level for the same frequency has also been calculated for a period of 15 days starting from the onset date of the monsoon. The results are presented in Table 3, showing that the noise level of atmospherics after the onset of monsoon becomes higher than 10 dB for all the years, varying from 12 dB to 18 dB during the years 2011 to 2013.

TABLE 3

Average noise level of atmospherics at 40 kHz

Date of onset of monsoon	Average noise level before the onset (in dB)	Average noise level after the onset (in dB)	Difference of noise level (in dB)
June 13, 2011	46	59	13
June 17, 2012	44	62	18
June 9, 2013	48	60	12

We have plotted temperature, dew point, wind speed, humidity, sea level pressure and visibility for 15 days before the onset of monsoon and also for 15 days from the date of monsoon onset in Figure 8. The X-axis represents the calendar dates of the individual year 2011, 2012 and 2013 separately while the Y-axis represents the six atmospheric parameters. The thin solid line indicates the date of onset of monsoon that differs a little from one year to another. This thin solid line thus separates the atmospheric changes before and after the onset of monsoon. The characteristic variations of the parameters are evident from the figure.

V. DOPPLER WEATHER RADAR RECORD

The S-band (10 cm) imported Doppler Weather radar has been installed by Indian Meteorological Department at Kolkata. The data management software is enabling for managing huge quantity (25 Terabytes) of data on continuous basis for 20,000 odd sensors including DWR. The software allows to access relevant data from the data respiratory. The Doppler radar locates precipitation and identifies its type like rain or hail. It is capable of detecting the minute motion of raindrops too. The radar sends out electromagnetic waves that strike moisture particles and create a digital image. In Table 4 we have presented the DWR particulars used for the present study.

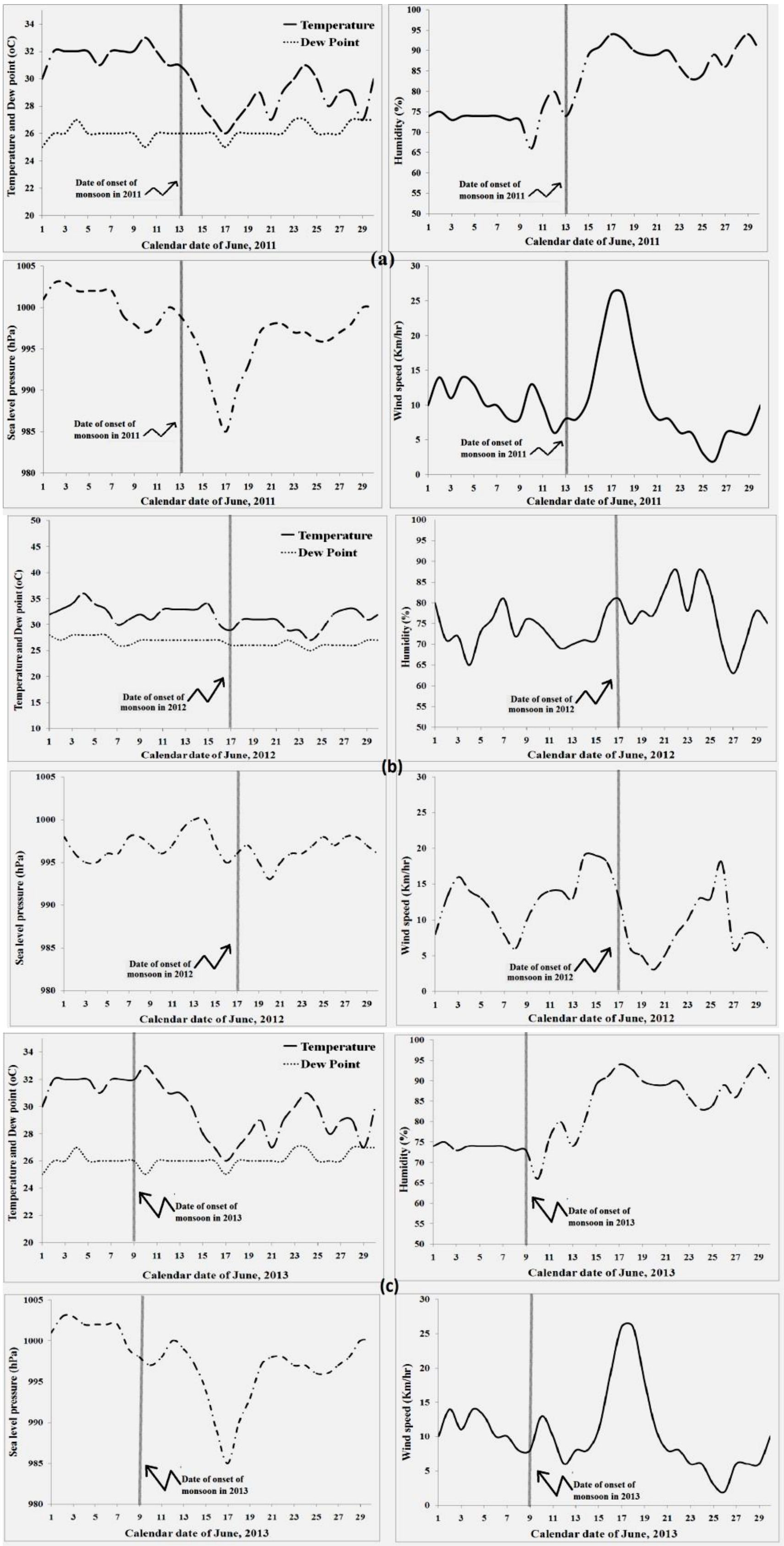
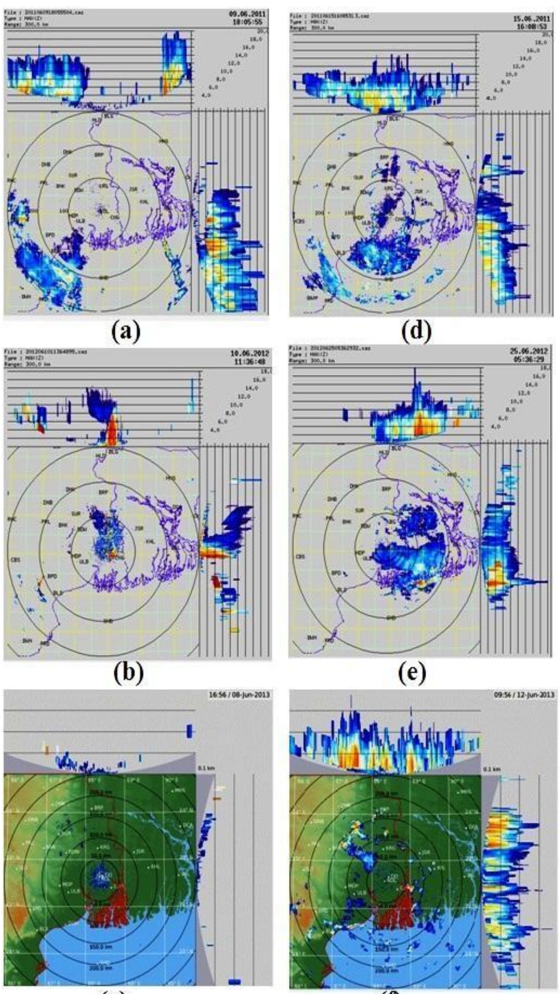


Fig. 8. Plots showing the variation of different atmospheric parameters before and after the monsoon onset for the years of (a) 2011, (b) 2012 and (c) 2013

TABLE 4

Some Features of Doppler Weather Radar

Features	Configuration
Scan Radius	375 km
Scan Resolution	0.50 km
Disp Radius	300 km
Disp Resolution	1.20 km
Frequency	3 GHz
PW	Short
PRF	800/0



(a) (d) (b) (e) (c) (f)

Fig. 9. Doppler Weather Radar pictures of some selected dates of interest as recorded at Kolkata observatory

Figure 9 shows six DWR pictures of Kolkata including our observing station Kalyani whose aerial distance is only about 45 km. In Figure 9 (a) to 9 (c) we have presented DWR pictures of June 9, 2011, June 10, 2012 and June 8, 2013 before the onset of local monsoon activity but when the cloud was in the developing stage of formation in the Bay of Bengal. Figure 9(d) to 9(f) are other selected DWR pictures corresponding to June 15, 2011, June 25, 2012 and June 12, 2013 that illustrate the distribution of cloud and associated rainfall when the monsoon appears as a stable shape locally and when torrential rainfall was experienced over a wide area for a long duration due to active monsoon clouds.

VI. DISCUSSION

During the localized cloud activity the intensity level in atmospherics records attains a higher value while with the disappearances of clouds the level comes down to its earlier scale. The characteristic development of the pattern [9] may be assumed to originate from the local active cloud sources causing short period rainfall purely from the local cloud developed and the lightning discharges owing to accompanied thunderclouds. The comparison of precursory effects of atmospherics reported in this paper might be largely dependent on height and density of monsoon clouds, nature of the pressure distribution and wind circulation associated with the phases of contrasting cloud distribution conditions. The interruption in the noise level is assumed to be characterized by a remarkable change in the lower tropospheric circulation over the monsoon zone that exhibits the area of monsoon climate [10, 12]. The occurrence of heat trough type circulation over the monsoon zone may contribute significantly in any major transition in the signal level [13-15]. In the paper we have documented some waveforms at low frequency that are representative of the transition to monsoon showing the precursory effects of atmospherics for the six consecutive years in the Bay of Bengal of eastern India. The results obtained here indicate that the discharges associated with the fall or enhancement of atmospherics is well governed by a tropical discharge pattern [16, 17]. If the observations are supplemented at other locations following similar study it may highlight further information regarding the monsoon onset. In reality, our investigation of the monsoon in India, may be extended at other locations (e.g. northern Australia), for achieving further supports.

VII. CONCLUSIONS

India has a long coast line. The waters of Bay of Bengal, Arabian Sea and Indian Ocean continuously touch its shores. This warm water develops considerable cloud clusters forming bands similar to squall lines. The variation of the intensity level in the records reported in this paper might be largely dependent on height and density of monsoon clouds, nature of the pressure distribution and wind circulation associated with the phases of contrasting cloud distribution conditions. The interruption in the noise level is assumed to be characterized by a remarkable change in the lower tropospheric circulation over the monsoon zone. The occurrence of heat trough type circulation over the monsoon zone may contribute significantly in any major transition in the signal level. In the paper the waveforms shown at LF are representative of the transition to monsoon in the Bay of Bengal. Emphasizing various meteorological parameters related to onset and break monsoon in association with LF data, the observed precursory effect with simultaneous radar diagnostics may be considered as a very valuable input for further study of monsoon in India.

VIII. ACKNOWLEDGEMENT

We are thankful to the Director, Regional Meteorological Center and to the Director, Doppler Weather Radar Centre, Kolkata for providing the relevant meteorological data. In our analysis we have used the “ROAB” data for considering some meteorological parameters partly before and after the onset of monsoon in addition to other available data from the website of http://www.wunderground.com.

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