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An anomaly on April 1, 2015 '*Kalbaishakhi*'as experienced over West Bengal: A Case Study

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ABSTRACT: *Lightning in the form of electromagnetic radiation is received in the VLF and LF bands from 10 kHz to 300 kHz over Kalyani (22.9750° N, 88.4344° E) and its characteristics is examined by simultaneous consideration of Doppler Radar and Satellite data on April 1, 2015 with a view to examine the spectral pattern as well as the anomaly noted over the area. The results have been interpreted by the existing knowledge of source activity.*

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I. INTRODUCTION

The third thundershower in West Bengal observed on April 1, 2015 with tall cumulonimbus clouds that had formed over south Bengal but stayed away from Kolkata. Due to non-supporting of the relevant meteorological parameters rain and squall are unlikely on this occasion as well with the low-pressure trough that triggered the cloud formation likely to dissipate. The low-pressure trough extended from Sikkim to Jharkhand on early hours of the day, sucking in moisture from the Bay of Bengal and causing clouds to form. "It was expected that the clouds would move towards Calcutta and reach the city by evening," pointed out from Alipore Meteorological Department but that never happened in practice. In general, thunderclouds develop over an area if the day's maximum temperature is high and there is moisture in the air. The maximum temperature on Wednesday was 34.4 degrees Celsius, a notch below normal for this time of the year. "The clouds did not reach the city. There was not enough moisture in the city air to cause rainfall," added the meteorological department. According to meteorological concept for thunderclouds to persist, there needs to be enough moisture in the air. Though the squall gave Calcutta a miss on this occasion, Nadia district in south Bengal only about 40 km away from Kolkata received rain and experienced storm in the evening hours. We in our observatory, situated in the Department of Physics of the main campus of Kalyani University (22.9750° N, 88.4344° E), were able to monitor and record by using our system the whole life cycle of the storm which we have reported in this communication.

II. CONDITIONS REQUIRED FOR FAVOURABLE CONVECTIVE ACTIVITY

The conditions needed for favourable convective activity are as follows:

i) Suitable synoptic conditions to cause low level convergence and high-level divergence which will act as a trigger and release the instability present in the air mass, daytime heating, orography etc.

ii) Suitable upper air flow which by advocating warm air in the lower troposphere and cold air in the upper troposphere can increase the instability.

iii) Conditional and convective instability in the atmosphere and adequate supply of moisture in the lower troposphere.

Each of these conditions is considered favourable for convective development though their relative importance and the role of each factor have not yet been well established. Formation of a thunderstorm is a rapid process whose three stages together, viz., the development, mature and dissipating stages happen within a short period of a few hours. Prior to this development, there is a highly noted gradual and continuous change in the atmospheric conditions. The general trough in a region becomes favourable for development of lows.

When the low-pressure system becomes strong, it leads to a well-marked inflow of moisture from the Bay into Gangetic West Bengal and adjoining areas.

III. EXPERIMENTAL SETUP

We have used Log-periodic Dipole Array (LPDA), Spectrum Analyzer and Digital Storage Oscilloscope (DSO) for capturing the radio signals originating from lightning discharges in the VLF and LF band. The photograph of the Log-periodic Dipole Array installed in the Department of physics and the receiving system recording the spectral pattern of the lightning in the frequency range 10 kHz to 300 kHz is shown in Figure 1.

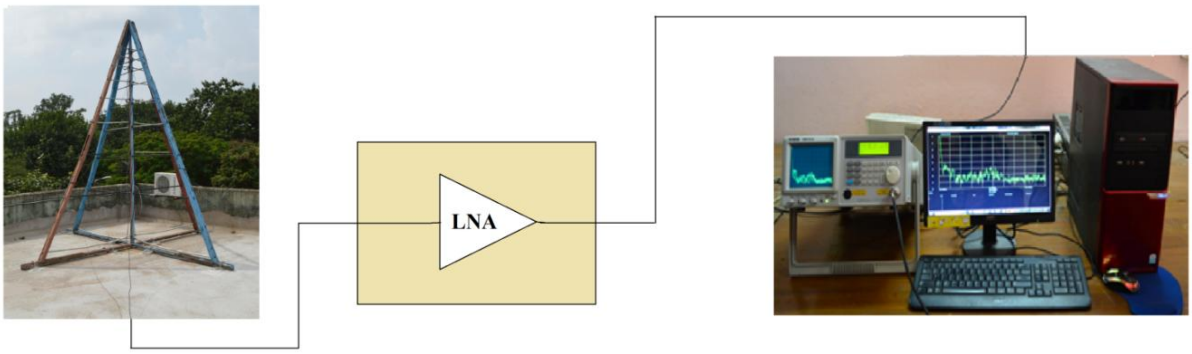


Figure 1. The photograph showing the LPDA and the receiving system connected through LNA

The wind-proof time-shared LPDA constructed at Kalyani (22.98°N, 88.46°E) for the purpose of capturing radio signals emitted during disturbed condition of the atmosphere producing electromagnetic signals and thereby to investigate its plasma behavior under such situation. In fact, the log-periodic antenna built is to prevent from possible damages owing to high-speed air movements even during the days of '*Kalbaishakhi'*.

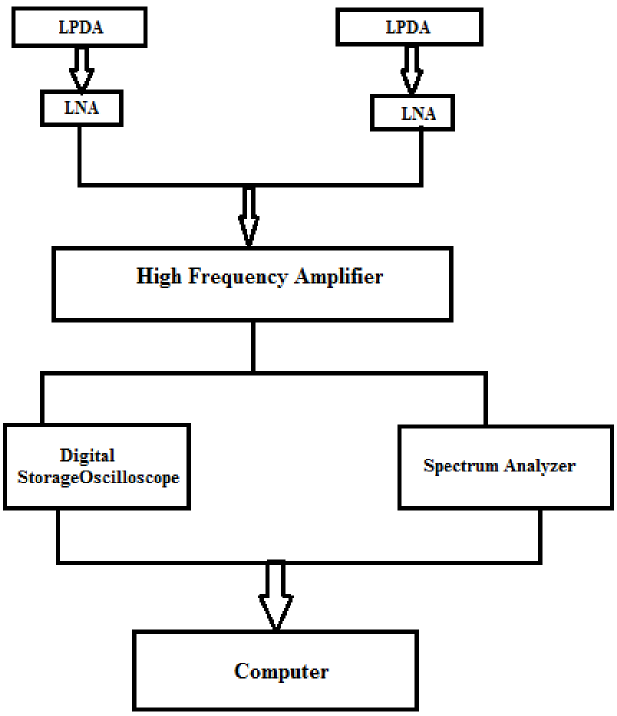


Figure 2. Arrangement of the receiving system

We used Digital Storage Oscilloscope (DSO) of GDS-1000 series as well as the spectrum analyzer for recording purposes. Use of two low noise amplifiers (LNA) reduces the local noise significantly. Two low noise amplifiers are used to amplify the received signal. The received signal through the amplifier is fed to connect to the master computer. The whole arrangement of the receiving system is shown in Figure 2.

IV. 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 enabled for managing huge quantity of data on continuous basis for a large number of odd sensors including DWR. The radar sends out electromagnetic waves that strike moisture particles and create a digital image. Figure 3 shows four DWR pictures of April 1, 2015, marked as (a), (b), (c) and (d), before the onset of local pre monsoon thunderstorm when the cloud was in the developing stage of formation. The pictures illustrate the distribution of cloud when the activity appears as a stable shape locally. DWR images reveal significant formation of clouds distributed over the Kalyani sky as well. These signatures provide a lot of insight into physical and dynamical processes involved in the pre monsoon thundercloud activity.

In addition to radar data, we have shown below the satellite pictures taken by using KALPANA-I Satellite during the late noon hours of the day with a view to illustrate the cloud activity well before the formation of the pre monsoon thunderstorm on Apriil1, 2015. KALPANA 1 (formerly METSAT 1) is an Indian (ISRO) meteorological, geostationary satellite which was launched by an upgraded, four-stage PSLV-C4 rocket. The satellite carries a Very High-Resolution Radiometer (VHRR) for three-band images: one in the visible, the second in the thermal infrared and the third in the water vapor infrared bands, each at a spatial resolution of 2-km x 2-km resolution, to obtain atmospheric cloud cover, water vapor and temperature. The METSAT is the first in the series of exclusive meteorological satellites built by ISRO.

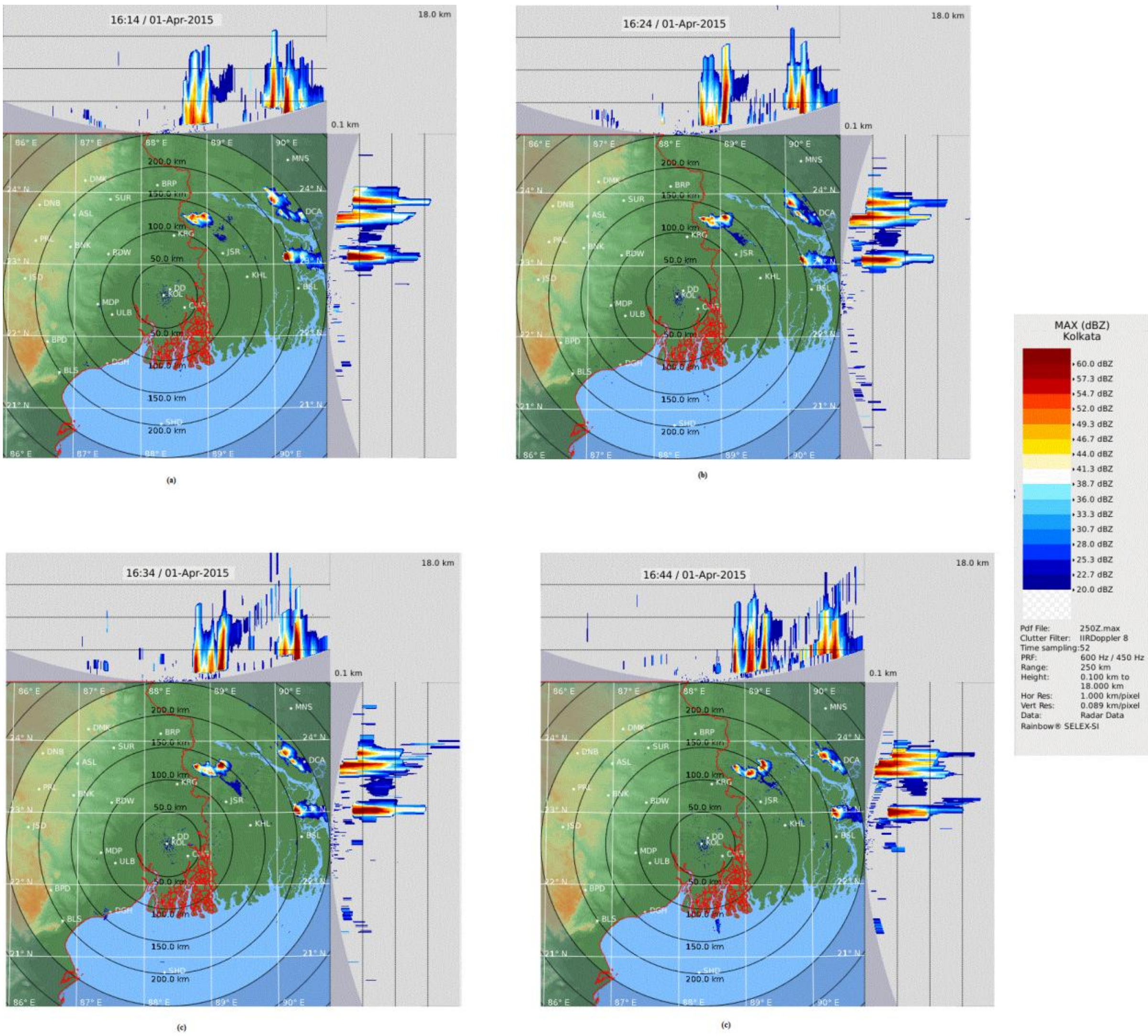
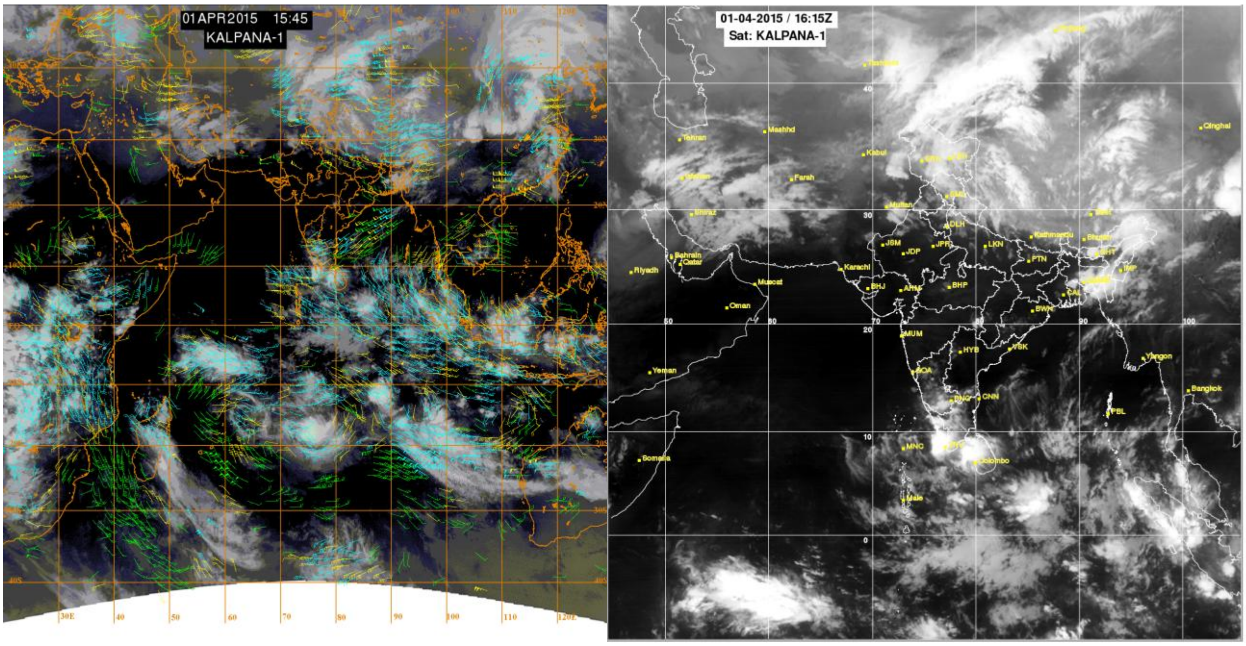


Figure 3. Four DWR pictures of April1, 2015

Satellite picture as recorded on April1, 2015 related to the third thunderstorm of the year over West Bengal is shown in Figure 4. The information gathered at two successive observations are evident from Figure 4(a) and 4(b).



(a) **(b)**

Figure 4. Satellite pictures as recorded by KALPANA-I before the onset of pre monsoon thunderstorm ('*Kalbaishakhi*') in West Bengal

V. SPECTRAL PATTERN

Characteristic average power spectra corresponding to different frequency intervals in the VKLF and LF bands from 10 kHz to 300 kHz are considered for electromagnetic radiation fields originating from some specific lightning events related to preliminary breakdown processes, downward stepped- and dart- leaders and return strokes. The spectra are obtained by a spectrum analyzer used for recoding the output of the receiving system connected to the antenna through Low Noise Amplifier. The spectral patterns when analyzed reveal very interesting results. A close similarity in the spectral patterns has been observed in the two frequency bands chosen for recording the data. Some typical records have shown in Figure 5 to justify the similarity in our records. In course of our observations, we started for recording the data from 10 kHz and continued at all the harmonically related frequencies up to 300 kHz. The mean spectral patterns for all those frequencies are then taken into analysis by plotting the noise level corresponding to different frequencies. This is presented in Figure 6, showing a clear fall of the levels as frequency increases, which strongly supports the existing knowledge of electromagnetic signal propagation during lightning.

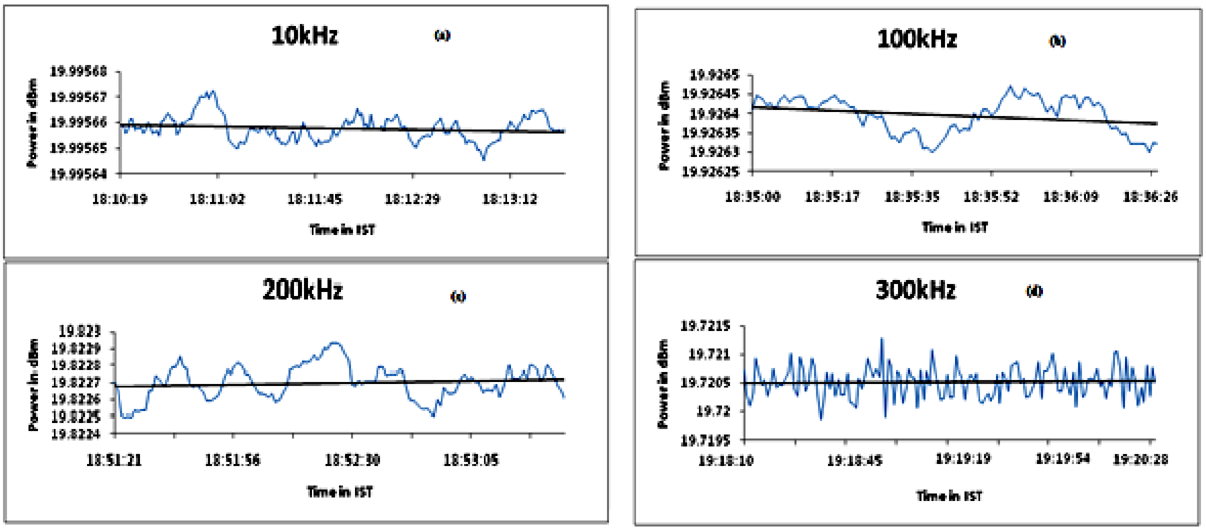


Figure 5. Some typical records of the spectral pattern at 10 kHz, 100 kHz, 200 kHz and 300 kHz

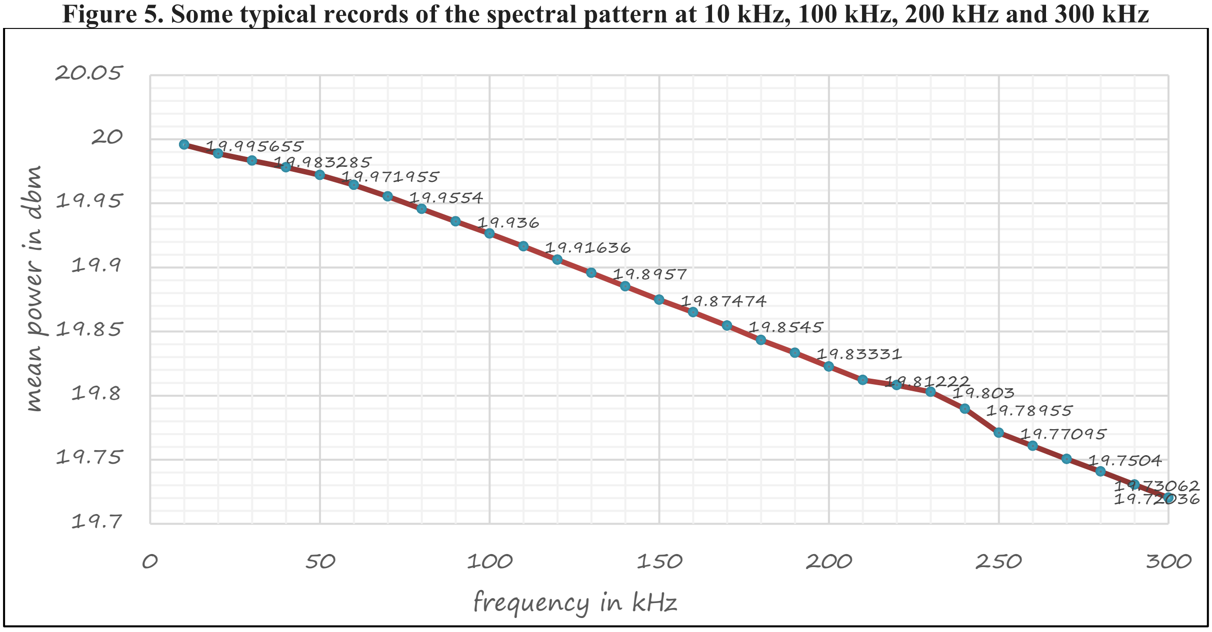


Figure 6. Frequency vs. mean power of the noise level

VI. DISCUSSION

According to the India Meteorological Departmental classification of the year into seasons, the three months March, April and May of the year have taken to constitute the 'Hot Weather Period' and is called as the 'Pre-Monsoon Season [1]. The hot weather period is familiar for its intense convective activity over land areas. Thunderstorm as a whole is a very vast subject and a significant amount of work has been done in this field during the past few decades [2, 3]. The various aspects of the subject include the physics of the thunderstorms, its structure, synoptic and climatologically aspects, radar and satellite studies etc. Thunderstorm is a natural phenomenon and has socio-economic impact. In the pre monsoon period (Mar-May) thunderstorm is of great concern in the Gangatic plains of South Bengal. It is the source of water in the region but has adverse effects on the inhabitants whenever it becomes severe. During the pre-monsoon months, the Eastern and North Eastern parts of India that include Gangatic West Bengal, Assam, Orissa are affected by high frequency of severe thunderstorms. The state West Bengal is subdivided into two major zones, viz. the North Bengal and the South Bengal. Thunderstorm is classified generally as a 'mesoscale' phenomenon with its space scale between a few hundred kilometres and its timescale from a few minutes to a few hours. Though thunderstorms are considered as one or two orders of magnitude less than the synoptic disturbances, the development of thunderstorms is largely governed by the overall synoptic scale disturbances. This synoptic scale disturbances create the conditions favourable for the out-break of thunderstorms.

Some of the known common features about the Kalbaishakhi in Gangetic West Bengal are as follows:

i) The frequency of Kalbaishakhi in Gangetic West Bengal increases from March onwards to May. April and May account for most of the thunderstorms. Bihar Plains have much less activity in comparison to other meteorological stations in this group;

ii) Majority of these Kalbaishakhi are associated with squalls which are mostly from a northwesterly direction. The highest speeds attained in these squalls are in the order of 140-150 km/h;

iii) There is a particular time sequence for the thunderstorms. In Indian scenario, they generally develop over Bihar Plateau, Southeast Madhya Pradesh or West Orissa and travel towards Gangetic West Bengal or head Bay of Bengal. They do not advance more than 130-160 km.

In an early study of thunder squalls at Kolkata, it was found that majority of the Kalbaishakhi was originated from Hazaribagh and Asansol area [4] and their speed of travel was roughly about 50 to 60 km/h. The most striking anomaly recorded in the present observation is that though the aerial distance of Kolkata is not too far from Kalyani, yet Kolkata was sunny and apparently clear while the vigorous charge activity followed by torrential and incessant rainfall that was experienced at Kalyani appearing something puzzling, uncommon and crazy in behaviour.

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