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Research On How Severe Cyclonic Storm AMPHAN-2020 Affects VLF Sferics

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Abstract

The recorded on VLF sferics above Kolkata (latitude: 22.56° N, longitude: 88.5° E) at 3 kHz and 9 kHz VLF sferics was significantly impacted on May 20, 2020, by the extremely powerful cyclonic storm AMPHAN, which was accompanied by intense thundershowers and lighting. The results and analysis of this recorded data, along with a few other distinctive characteristics, will be presented in this study.

Keywords: Atmospheric depression; violent cyclonic storm; Thunderstorm and lightning; VLF sferics.

1. INTRODUCTION

Lightning discharges have been documented in the vicinity of equatorial zones on the continents. Lightning electrical discharges produce E.M. signals known as sferics. The Lithosphere ionosphere waveguide is used to scatter lightning electrical signals. Global statistics on lightning discharges are used to study weather forecasts, storms, cyclones, tsunamis, and other unusual weather events (1-6).

We are collecting continuous recordings of 3 kHz and 9 kHz VLF sferics from Kolkata (latitude: 22.56° N, longitude: 88.5° E) in order to recognize and comprehend unique meteorological and solar phenomena in the field of atmospheric electricity. Solar radiation, global thunderstorm activity, and the concentration and presence of aerosol composition in the lower atmosphere are all associated with variations in air ambient temperature, electrical potential, air-earth current, and conductivity over the Earth's surface at tropical (25°) and temperate (60°) latitudes during normal weather conditions as well as during disturbed ones (7–12).

Thermodynamic models can be used to estimate a tropical cyclone's maximum possible field intensity (13–15). These studies have looked into the ocean's role in creating an environment that is favorable for cyclone formation and then supplying the extra energy needed for the development of powerful cyclones. There is discussion of tropical cyclones' impact on the atmosphere and role in climatic processes. At Kamchatka, VLF receiver devices that capture E.M. radiation from thunderstorm discharges are being used to determine the features of cyclones and the dispersion of cyclone epicenters (16–20).

A severe thunderstorm front passed through the Bay of Bengal during May 16–21, 2020. Strong thunderbolt discharges were observed in Kolkata (6). Significant impacts on the sferics were caused by the extremely severe cyclonic storm AMPHAN on May 20, 2020, which was followed by lightning and thunderstorms. An area of low pressure formed over the southern Bay of Bengal and the southern Andaman Sea on May 1. Before fading on the sixth day, it hovered above the region for the following five days. INSAT imagery showed the emergence of a depression over the Bay of Bengal at 05:30 IST on May 16, 2020.

The depression strengthened into a super cyclonic storm and was centered at lat: 16.0° N, long: 86.8° E at 08:30 IST on May 19, 2020. At 11:30 hours IST on May 19, 2020, it morphed into an exceptionally strong cyclonic storm, AMPHAN, which was centered nearly in the same spot. AMPHAN, a very severe cyclonic storm, crossed the West Bengal – Bangladesh coasts during 15:30-17:30 IST, near lat: 21.65°N, long: 88.3°E, with maximum sustained wind speeds of 157.42 km/h^{-1} gusting to 185.2 km/h^{-1}, near

lat: 21.65°N, long: 88.3°E, near lat: 21.65°N, long: 88.3°E It passed through Kolkata as AMPHAN between 19:30 and 20:30 IST, with wind speeds of 140 to 150 km/h^{-1} and accompanied with severe lightning.
It continued with a strong and stimulating explanation. This talk will analyze the effects on VLF sferics that were detected at frequencies of 3 kHz and 9 kHz that were recorded from Kolkata during this AMPHAN. Special studies about advances in very high signal amplitude will be presented.

2. EXPERIMENTAL ARRANGEMENTS

A straight horizontal copper wire of 8 SWG with a length of 120 m is employed in the shape of an inverted L shape antenna to observe the power spectrum of VLF sferics at 3 kHz and 9 kHz. The antenna, which is 30 meters above ground, can receive vertically polarized atmospherics in the ELFVLF ranges from both near and far lightning discharge sources. The schematic diagram of the experimental arrangement is shown in Figure 1.

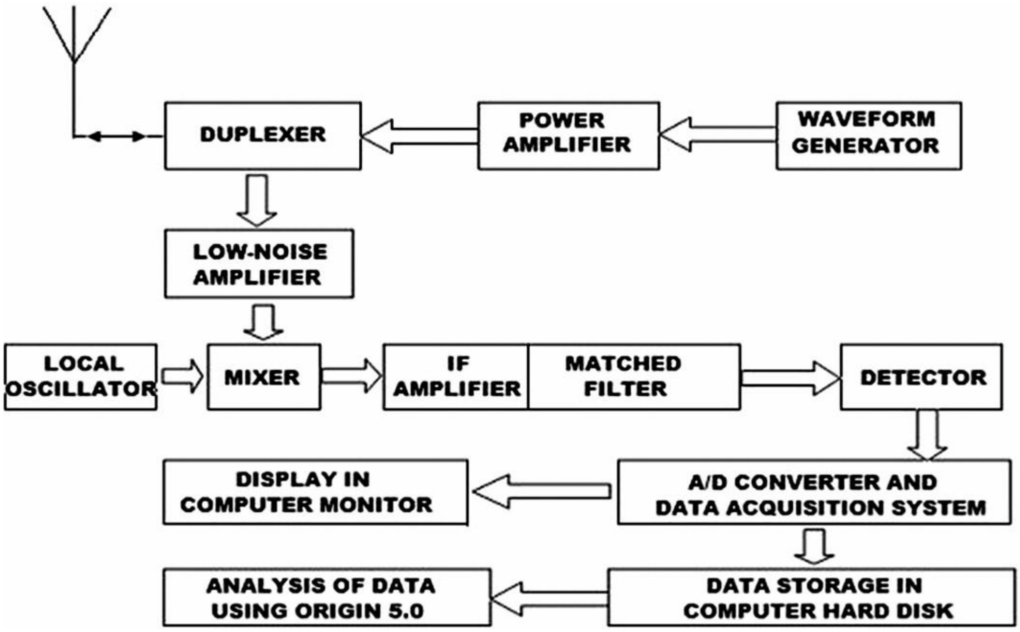

Figure 1: Schematic diagram of ELF-VLF receiver

The antenna is sandwiched between two buildings' roof tops. The effective height is expected to be lowered by 20% due to the wall effect. The high antenna height results in a significant induced emf in the antenna. Even with a considerable height, the long horizontal length results in a large antenna capacitance. The VLF sferics are recorded using a PCI 1050 16 channel 12 bit DAS card and an automated data gathering system. These two frequencies were used to adjust the VLF receivers. The amplifiers' overall gain is roughly 40 dB. The signals' rms value is stored in a computer. Origin 5.0 software was used to examine the captured data.

3. ANALYSES

During the AMPHAN occurrence period in Kolkata, the VLF spectral properties of the sferics at 3 kHz and 9 kHz were investigated. Figures 1 and 2 illustrate the levels of sferics at 3 kHz and 9 kHz during AMPHAN. The levels are significantly higher than the ambient levels that existed for the previous 15 days. The findings were in agreement with satellite and RADAR readings.
Figure 2 shows the temporal fluctuation of the sferics at 3 kHz on May 20, 2020 (red colored neat line), as well as its normal trend calculated from an average of 15 days before to the day of
AMPHAN occurrence (black colored neat line). Standard deviations are represented by error bars. The strength of 3 kHz sferics (in arbitrary unit) begins to rise around 10:00 hrs IST, remains relatively constant until 12:00 hrs IST, and then rises dramatically to a higher value at 13:10 hrs IST during AMPHAN's landfall near Sundarbans. During the time that AMPHAN passed through Kolkata, it maintained greater value to some extent. Then, until local midnight, the level drops slightly, albeit the amount remains much greater than the norm. The observed increase above the standard deviation implies the presence of extremely violent cyclonic storms, according to
AMPHAN.

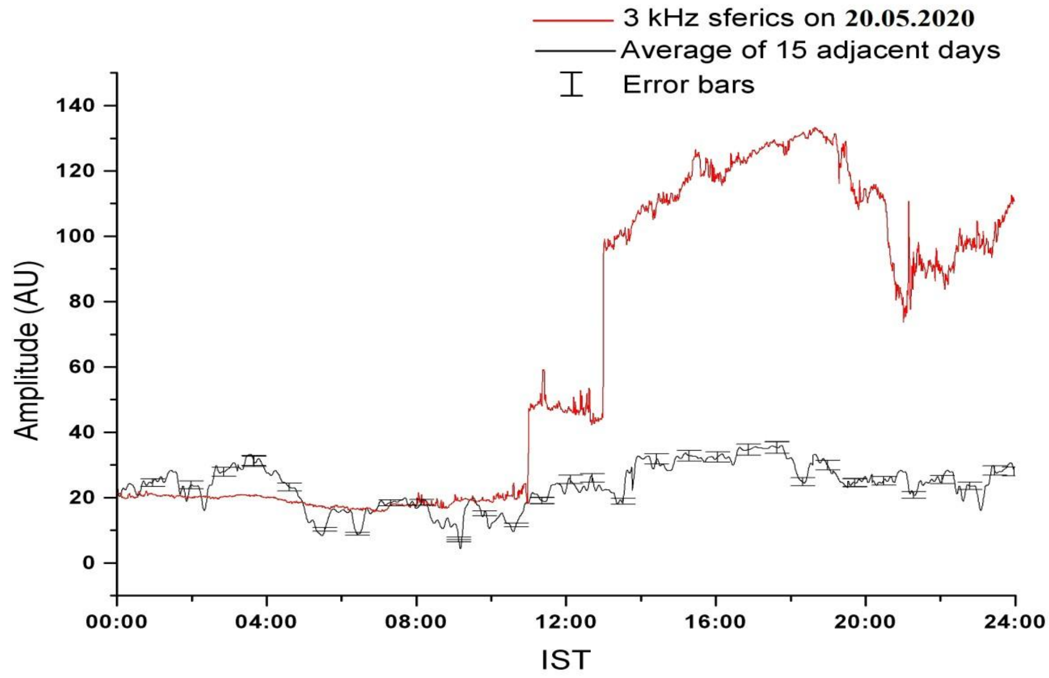

Figure 2: The red coloured unbroken line curves show the temporal fluctuation of 3 kHz sferics on May 20, 2020. The black coloured unbroken line curve depicts the average of nearby 15 days of AMPHAN incidence. Error bars represent standard deviations.

Figure 3 depicts similar charts for sferics at 9 kHz. Variation is basically identical to 3 kHz sferics in terms of nature. During the peak times of occurrences over Kolkata, the strength of sferics reaches a high value (140 AU), which begins to rise around 10:00 IST. The fact that the strength at 9 kHz is higher than at 3 kHz suggests that the 9 kHz sferics is more responsive to thunderstorms and lightning than other frequencies. When AMPHAN began to lessen its indignation and was turned to a tropical cyclone around 20:10 hours IST, the value began to decline.

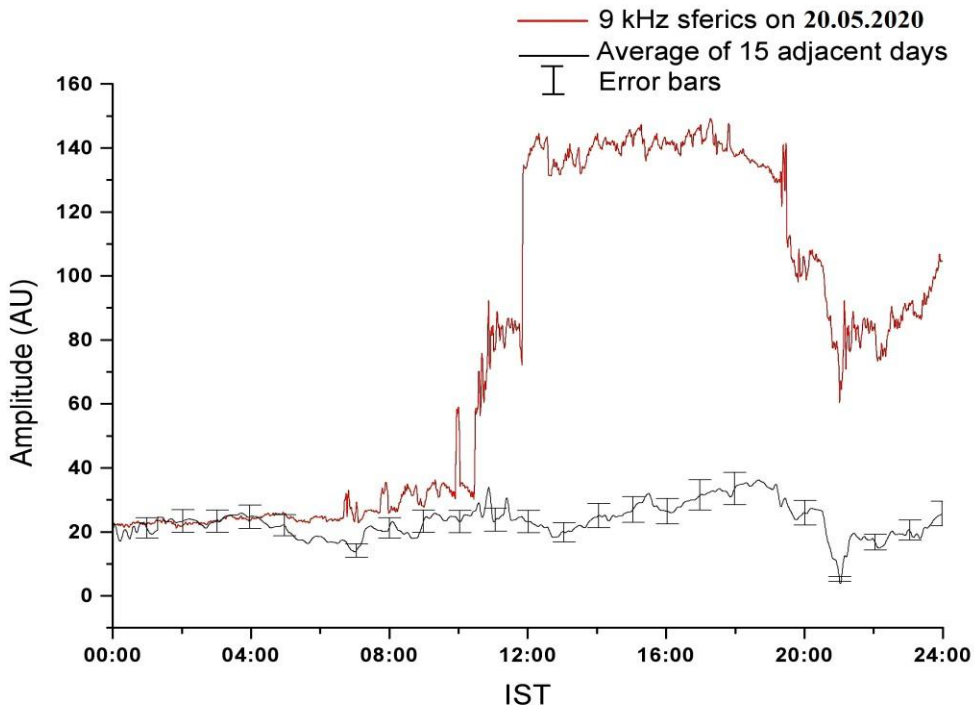

Figure 3: The red coloured unbroken line curves show the temporal fluctuation of 9 kHz sferics on May 20, 2020. The black coloured unbroken line curve depicts the average of nearby 15 days of AMPHAN incidence. Error bars represent standard deviations.

4. DISCUSSION

On May 20, 2020, at around 19:30 IST, AMPHAN, an extremely powerful cyclonic storm, passed through Kolkata. It's the first time a cyclone has struck in the month of May in decades. The horizontally pressure gradient, North-South wind gradient, and relative vorticity were all increased due to the South-West monsoon over the Bay of Bengal. It formed upper air cyclonic rotation that reached to the mid-troposphere and was linked to a convective cloud cluster. Due to the impact of cyclonic circulation, a low-pressure area emerged over the said location. It morphed into a depression that worsened into a deeper one. As the system proceeded northward, it transformed into a cyclonic storm. This signature was expanded to include the letters AMPHAN. AMPHAN was spotted and tracked by Traditional Cyclone Detection Radar (CDR) at Paradip and Doppler Weather Radar (DWR) at Kolkata. Satellites such as INSAT, METEOSAT, and WINDSAT kept an eye on the AMPHAN phenomena. On May 16, 2020, at 05:30 IST, a cyclonic low-level circulation formed. The area remained under low pressure the next morning. The system began to move northward, became stronger, and eventually produced a depression on May 17, 2020 at 05:30 IST in latitude 11.4° N, longitude 86.0° E, and progressively intensified during its propagation. On May 19, 2020 at 11:30 hrs IST, it changed to a deep depression and then to an extremely severe cyclonic at latitude: 16.5° N, longitude: 86.9° E, accompanied by severe thunderstorms, lightning, wind shear, turbulence, rainfall, and other meteorological outcomes at latitude: 16.5° N, longitude: 86.9° E. This very strong cyclonic storm (AMPHAN), which occurred in Sundarbans (latitude: 21.65° N, longitude: 88.3° E) on May 20, 2009 at 15:30 IST, passed through the Sundarbans region on May 20, 2020 between 15:30 and 17:30 IST. It passed through Kolkata as AMPHAN between 19:30 and 20:30 IST, with wind speeds of 140 to 150 km/h-1 and severe lightning. Deep depression began on May 21, 2009 at 11:30 hrs IST across Sub-Himalayan West Bengal, followed by depression around 17:30 hrs IST near Bangladesh, and low pressure developed on May 21, 2020 at roughly 23:30 hrs IST over North Bangladesh and neighboring regions. The monsoon current's strong southerly surge made the wind speed in the South-East sector substantially greater. METEOSAT estimated the sea surface temperature (SST) at around 30° C, which was roughly 1.0 to 2.0° C above normal.

5. CONCLUSION

Starting from the Bay of Bengal (latitude: 16° N, longitude: 86.8° E) on May 19, 2020 at 08:30 hrs IST, it crossed over Kolkata (latitude: 22.56° N, longitude: 88.5° E) on May 20, 2020, at around 19:30 hrs IST, and ended in the Sub-Himalayan northern Bangladesh and surrounding regions on May 21, 2020 at around 19:30 hrs IST.

Scientific research on the cause and effects have been conducted in significant numbers, yet the causes for such a paradigm shift and devastation are unknown to us. Only mankind can be notified long in advance of its appearance by high-powered radar systems, allowing them to take adequate precautions for protection and survival.

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