STUDIES ON THE INFLUENCE OF TWO LARGE EARTHQUAKES (M > 6) UPON 9 kHz SFERICS RECORDED FROM KOLKATA

P. HAZRA[1], S. BARUI[2], S.S. DE[2], S. PAUL[2]

[1] Narula Institute of Technology, Agarpara, Kolkata 700 109, India
[2] Centre of Advanced Study in Radio Physics and Electronics, 1, Girish Vidyaratna Lane, University of Calcutta, Kolkata 700 009, India, E-mail: de_syam_sundar@yahoo.co.in
(Corresponding Author)

Received July 2, 2014

The outcome of the analyses of some significant observations in the records of VLF sferics over Kolkata (Lat. 22.56º N, Long. 88.5º E) at 9 kHz during the occurrences of two large earthquakes on July 07, 2013 will be presented here. Discrete spike-type signals are obtained as the precursors of two earthquakes with magnitude M > 6. The number of spikes and their intensities are found to vary irregularly and reached their maximum value on the day of occurrence. It then decreases gradually and finally ceased.

Key words: Earthquake, seismo-electromagnetism, ionospheric perturbation, precursory effects.

1. INTRODUCTION

Seismo-electromagnetic emissions are observed in ULF-ELF-VLF bands in the seismically active zones prior to the incidence of any large earthquake [1–3]. During any large earthquake, electromagnetic radiations, chemical and gaseous particle emanations would cause ionospheric effects that modulate the electric charge distribution. These incidents are taken as the signatures of lithosphere-atmosphere-ionosphere coupling influencing the conductivity, electron density fluctuations, changes in temperature and ionic composition of the lower atmosphere [4]. There is rapid enhancement in the occurrences of H_2, CO_2, CH_4 along with the increase of atmospheric radioactivity connected to the emissions of elements like radon, radium, uranium and their decay products [5, 6].

2. OBSERVATIONAL RESULTS

We detected the effects of the two large earthquakes upon 9 kHz sferics from several days prior to the day of occurrence which continued for some days during the post earthquake period.

Rom. Journ. Phys., Vol. 60, Nos. 7–8, P. 1218–1224, Bucharest, 2015

These earthquakes occurred on July 7, 2013 at New Ireland Region, Papua New Guinea (PNG): epicenter located at Lat. 3.9º S, Long. 153.9º E, magnitude M = 7.3 and the other one with Lat. 5.9º S, Long. 149.7º E, magnitude M = 6.8, respectively. The depth of the hypocenter of the first shock (occurred at 18:35:29 IST) is about 372 km and the second shock (occurred at 20:30:08 IST) is about 75 km. No aftershocks have been reported after these two initial shocks. The distance between epicenter of the first shock and Kolkata is nearly 7619 km whereas it is about 7321 km for the other shock. These are shown in Fig. 1.

Fig. 1 – The distance path of epicenters of two earthquakes occurred at New Ireland Region, Papua New Guinea (PNG) relative to Kolkata are shown by two curve lines. Seismically active zone is depicted by the red dashed rectangle.

The fractional change in the mean signal amplitude became higher in the night time than the day time. For higher reflection height, the VLF signals have lower attenuation. The reduction of signal strength is due to higher attenuation at the earth-ionosphere wave guide. The variations in signal amplitude due to solar-flares during the occurrence of lightning, electron density perturbation in the lower ionosphere can not affect the decrease in daily mean amplitude and these are neglected in comparison to earthquake associated effects. Storm effects on VLF propagation show some decrease of the VLF phase and amplitude at night time during the main phase of storm. The parameters, *e.g.*, surface temperature; radon emanation may influence the conductivity of the lower ionosphere leading to the modification of atmospheric electric field.

In the seismoactive region (red dashed rectangular area in Fig. 1) surrounding the place of occurrences of the two earthquakes at 515.7 km apart, because of lithosphere-ionosphere coupling and perturbation of temperature on the earth's surface, the atmospheric medium is further excited that move towards the ionosphere. By this, electromagnetic emissions from lithosphere propagate upwards modifying the ionosphere.

Various features are observed from the continuous records of VLF sferics at 9 kHz near Kolkata. Spiky variations at 9 kHz records are noticed during the occurrences of these two earthquakes on July 7, 2013 having magnitudes M = 7.3 and M = 6.8 with different depths of their hypocenter. Figure 2 shows the time series graph of sferics on April 01, 2013 at 9 kHz recorded at Kolkata in a normal day where no spiky variations are observed.

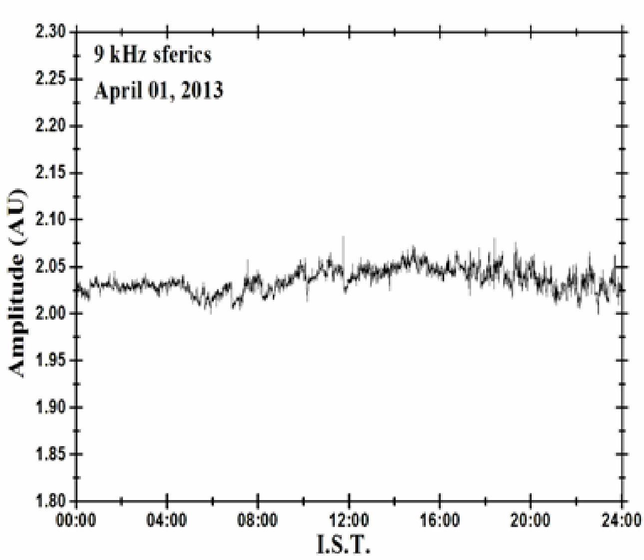
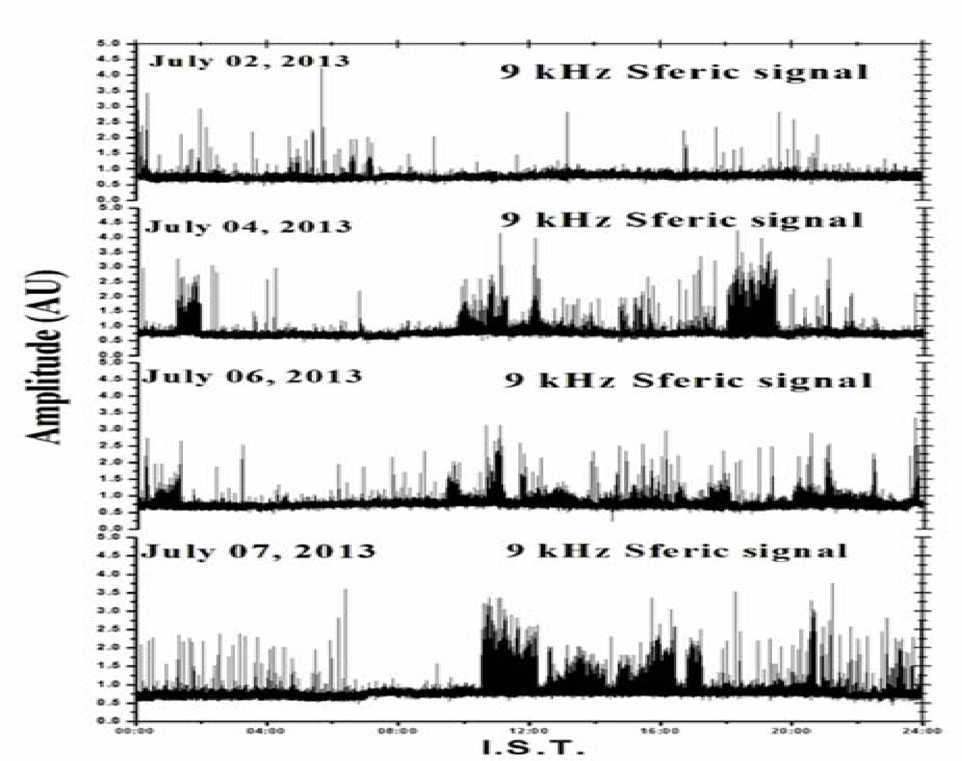


Fig. 2 – Normal day record of 9 kHz sferics signal observed near Kolkata of April 01, 2013, a meteorologically clear day.

The normal day means meteorologically and geophysically clear day and there is no occurrence of any earthquake having M > 5. The figure shows the diurnal variations with sunrise and sunset effects. The commencement time of spikes is several hours earlier than the commencement of the earthquakes or around the time of their occurrences. The number of spikes per hour, *i.e.*, the intensity of spikes varies from one earthquake to the other. The spiky variations for these two strong earthquakes have been considered for analyses during July 02 – 13, 2013.

Figure 3 represents the time-series graphs of amplitude of 9 kHz signals at different dates before and after the day of occurrence of these earthquakes. It is seen that the commencement of spike events occurs some days prior to the strong earthquake and then decrease gradually. The variation in spike heights and the variation of total number of spikes per hour increase with the approach of the day of occurrence and reached their maximum values. The variations gradually reduce during the post earthquake period and finally ceased. In the time scale, the spikes occurred in the duration of the order of a few minutes. The experimental site is situated at a distance of 70 km from Kolkata, free from big and small industries, and dense locality. So, the occurrences of man-made and other industrial noises were absent. The power supply system for the receiver is thoroughly checked and no fault or any leakage was detected. So, the nature of the spikes does not depend on any of those causes. Also, the nature of the spikes and their characteristic separations are completely different from the local thunderstorm transient variations or from any other effects, *e.g.*, solar flare, meteor shower, geomagnetic storms [7].

The total number of spikes per hour as observed during the month of July, 2013 for 7 days are represented by bar diagram in Fig. 4. The amplitude is maximum for the earthquake with large M value. The bars with different heights indicate the precursory and post seismic effects. The diurnal pattern observed in Fig. 2 is absent in the records of the earthquake occurrence dates (Fig. 3).



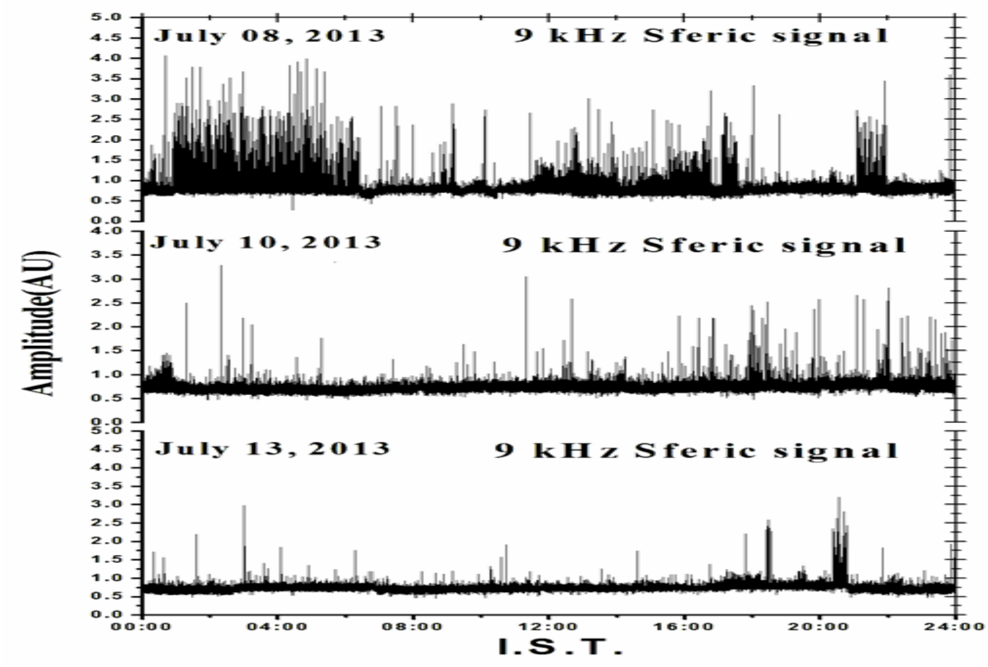


Fig. 3 – Diurnal variation of 9 kHz sferics signal observed near Kolkata.

3. CONCLUSIONS

Some characteristic features of two large earthquakes have been analyzed from the recorded data. Some of their aspects are shown in Fig. 3. The night time intensity and the number of occurrence of spikes are found to be much higher than the day time [8]. The signal is characterized by spiky variations commencing several hours prior to the occurrence of earthquakes. The nearer the epicenters from the receiver, the higher is the amplitudes of spikes. The amplitude of spikes is very much dependent on the magnitude of the earthquake.

During any large earthquake, there will be coupling between lithosphere–atmosphere and ionosphere through some probable channels, *e.g.*, chemical channel, acoustic channel and electromagnetic (EM) channel. From chemical channel, there will be water elevation, gas emanation/radon emanation, changes in geophysical parameters which introduce chemical/conductivity changes in air resulting in a modification of the atmospheric electric field perturbing the plasma density in the ionosphere. Acoustic channel introduces excitation of atmospheric oscillations that propagate up to the ionosphere thereby modifying the ionospheric density. EM channel is supposed to introduce VLF emission, ionizations, electric charge redistribution above the surface of the earth by which anomalous electric field would be generated producing large-scale irregularities. Anomalous field propagates into the inner magnetosphere and interacts with energetic particles. These particles precipitate into the lower ionosphere initiating direct heating, liberation of exo-electrons, and/or ionization of the ionosphere by seismo-ELF-VLF waves. These are detected as precursors of any large earthquake of large M-value.

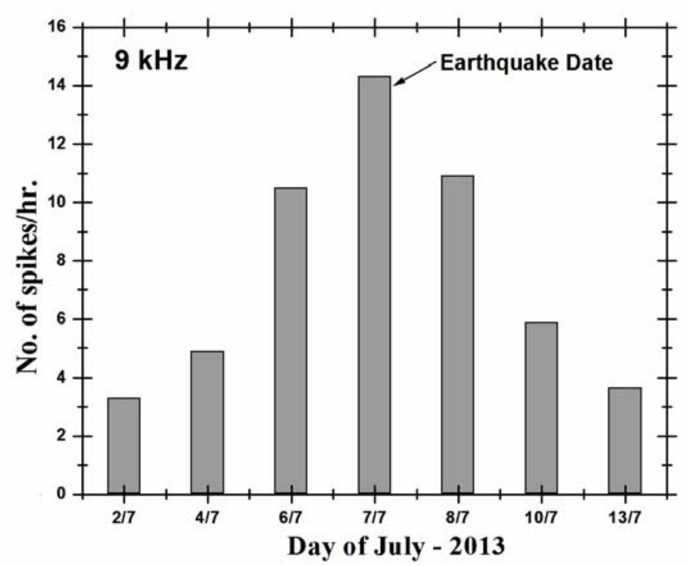


Fig. 4 – Variation of number of spike per hour on 9 kHz due to two strong earthquakes.

Although any quantitative relation between the observed signals and the earthquake source parameters are lacking [9], the claim of background noise also fails to comply with the time-series records of any observed signals during the occurrence of large earthquake.

Acknowledgments. The data regarding the location and magnitudes of the earthquakes which have been dealt in the present paper are collected from the following website: http://www.imd.gov.in/section/seismo/dynamic. Distance between two points is calculated using the website: http://www.movable-type.co.uk/scripts/latlong.html. These are duly acknowledged with thanks and gratitude.

REFERENCES

1. Y. Fujinawa, K. Takahashi, IUGG Meeting Boulder, Colorado, 2–4 July 1995 (1995).
2. M. Hayakawa, Y. Kasahara, T. Nakamura, F. Muto, T. Horie, S. Maekawa, Y. Hobara, A.A. Rozhnoi, M. Solivieva, and O.A. Molchanov, J. Geophys. Res. **115**, A09305, doi.: 10.1029/2009JA015143 (2010).

3. V.M. Sorokin, A.K. Yaschenko, and M. Hayakawa, Nat. Hazards Earth Syst. Sci. **7**, 155–163 (2007).
4. J. Boskova, I. Smilauer, P. Triska, and K. Kudela, Studia Geophysica et Geodaetica **38**, 213–220 (1994).
5. P.F. Biagi, L. Castellana, T. Maggipinto, D. Loiacono, L. Schiavulli, T. Ligonzo, M. Fiore, E. Suciu, and A. Ermini, Nat. Hazards Earth Syst. Sci. **9**, 1551–1556 (2009).
6. Y. Yasuok, T. Isikaw, H. Nagahama, Y. Kawada, Y. Omori, S. Tokonami, and M. Shinogi, *Radon anomalies prior to earthquakes,* M. Hayakawa (Ed.), *The Frontier of Earthquake Prediction Studies,* Nihon-senmontosho-Shuppan, Tokyo, Japan, 410–427 (2012).
7. S.S. De, B.K. De, B. Bandyopadhyay, S. Paul, D.K. Haldar, A. Bhowmick, S. Barui, and R. Ali, Nat. Hazards Earth Syst. Sci. **10**, 843–855 (2010).
8. A. Kumar, S. Kumar, M. Hayakawa and F. Menk, J. Atmos. Sol.-Terr. Phys. **102**, 71–80 (2013).
9. V.N. Pham, R.J. Geller, Geophys. Res. Lett. **29**, doi.:10.1029/2002GL015328 (2002).