Seismo-electric ULF/ELF anomaly observed before 5.9 magnitude Arunachal Pradesh earthquake in India by data analysis from DEMETER satellite

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Abstract

The investigation of seismo-electromagnetic phenomena has drawn considerable attention of the scientific community in the past few decades. In this paper, the authors present a case study where seismo-electric ULF/ELF anomaly is observed a few days before an earthquake in Arunachal Pradesh, India that occurred on 01.06.2005 (28.87ºN, 94.60ºE, 20:06:42 hrs UT, Depth = 37 km) of magnitude 5.9. The study has been carried out by data analysis from DEMETER satellite which is a low earth orbiting satellite, primarily aimed at detection of ionospheric perturbations linked with seismic activities.

1. Introduction

In the past few decades, the subjective investigation of seismo-electromagnetic phenomena has acclaimed specific attention in the scientific community. On a broader note, the seismo-electromagnetic effects involve magnetic field changes, variation in telluric current, ionospheric perturbations and nightglow observations [1-4]. The generation of seismo-electric anomalies [5-7] is another interesting aspect constituting to the seismo-electromagnetic phenomena that may be observed effectively as perturbations in the ionosphere, varying from a few days to a few hours before the seismic shock [8]. In this paper, the authors present a case study where seismo-electric perturbations have been observed in the ULF/ELF (Ultra Low Frequency/Extremely Low Frequency) range a few days before a seismic event in the state of Arunachal Pradesh in India that occurred on 01.06.2005 (28.87ºN, 94.60ºE, 20:06:42 hrs UT, M = 5.9, Depth = 37 km) with the help of data analysis from DEMETER (Detection of Electromagnetic Emissions Transmitted from Earthquake Regions) satellite.

2. Data Investigation by DEMETER Satellite

The launch of DEMETER micro-satellite on 29.06.2004 has been a major advancement in the field of seismo-electromagnetic studies. It is a polar circular satellite (altitude = 710 km) and weighs around 130 kg. DEMETER is a space mission primarily dedicated to study the ionospheric perturbations linked to geophysical hazards such as earthquakes and volcanic eruptions. The scientific payload comprises of various complex on-board instruments necessary for detection of various important ionospheric parameters (viz electric and magnetic field, electron and ion densities, electron temperature etc.) which have been found to vary significantly with the occurrence of moderate and strong seismic events. The description of the various experiment on-board DEMETER have been mentioned in works through various significant publications [9,10] Here the authors are primarily concerned with the measurements pertaining to electric field data that is recorded by the on-board Instrument Champ Electrique (ICE) sensors in the ULF/ELF range.

3. Results

The state of Arunachal Pradesh located in the Eastern part of India experienced a major seismic activity on 01.06.2005 measuring a magnitude of 5.9 on Richter scale (28.87ºN, 94.60ºE, 20:06:42 hrs UT, Depth = 37 km), for which results detected and analysed through DEMETER satellite data are presented and discussed.

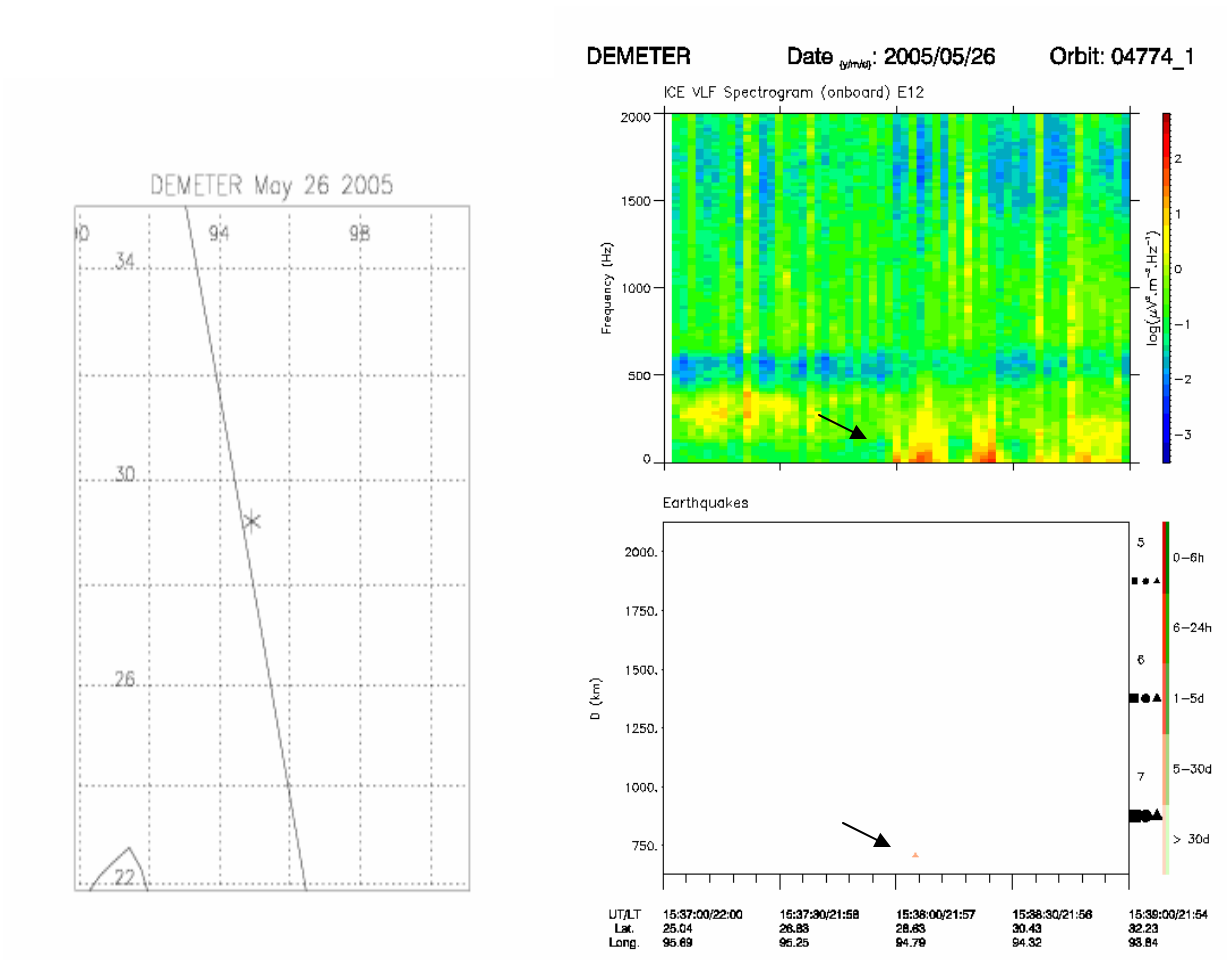
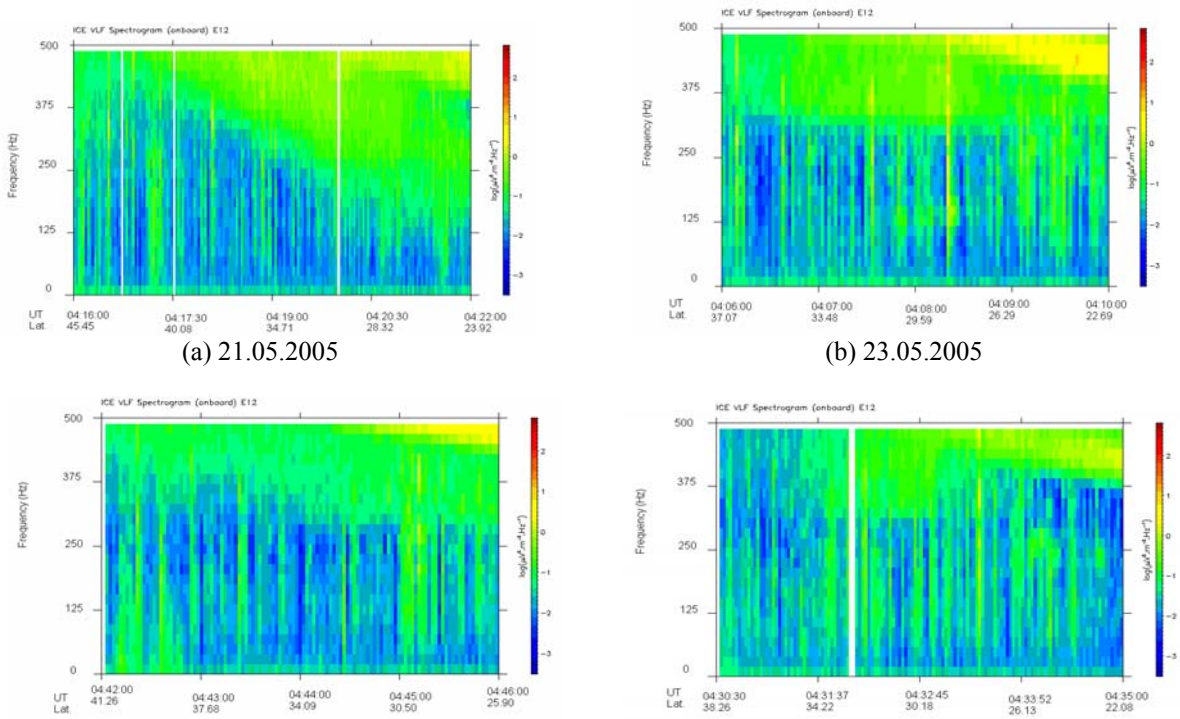


Figure1(a).Ground track of DEMETER on 26.05.2005. Figure1(b).Electric field spectrogram results on 26.05.2005.

Figure 1(a) shows the ground track of DEMETER with the asterisk depicting the epicentre. In Figure 1(b), the top panel represents the electric field spectrogram data constituting to the ground track pass of DEMETER (Orbit no. 4774 upward). The lowermost panel in the same figure indicates the satellite's closest approach to the past and future earthquake epicentres that are within a feasible distance from the DEMETER's orbit (≤1200 km). The pre-seismic events are depicted by the red and orange filled triangles referring to the scale on right whereas the post-seismic events (if present) would be shown by the green squares. The orange triangle as shown by the arrow in this case indicates the closest approach of the satellite to the epicentre of an earthquake that will occur after a few days. It is clearly observed that perturbations are prominent in ULF/ELF range (around 10 Hz and extending to 350-400 Hz) just when DEMETER makes a pass over the epicentral region around 15:38:00 hrs UT. The perturbations are observed in the form of intensification (referring to the scale on right) and clearly they fade out as the satellite moves away from the epicentre. In order to confirm the anomalous ULF/ELF observations, the authors have checked the data for pass of DEMETER over the same epicentral regions for other days. A period of ±10 days was selected and the orbits for which the satellite was at distance ≤ 1200 km have been considered as evidences for such studies in the past suggest that short term anomalies are observable a few days to a few hours before such activities [11-13]. Figure 2(a) and 2(b) shows the electric field spectrogram (with pre-selected longitudinal range) results for two close orbital passes before the earthquake while Figure 2(c) and 2(d) shows the electric field spectrogram results for two closest passes of DEMETER after the earthquake. In both the cases, no such perturbations are observable on these days as well as on other days for such close pass of DEMETER (other days data not shown due to space constraints) which enhances the possibility of the perturbation on 26.05.2005, being associated with the seismic activity of Arunachal Pradesh on 01.06.2005.



(a) 21.05.2005 (b) 23.05.2005

(a) 02.06.2005 (b) 04.06.2005

Figure2 Electric field spectrogram results for other days for closest pass of DEMETER over the epicentral region before the seismic event [Figure 2(a) and 2(b)] and after the seismic event [Figure 2(c) and 2(d)].

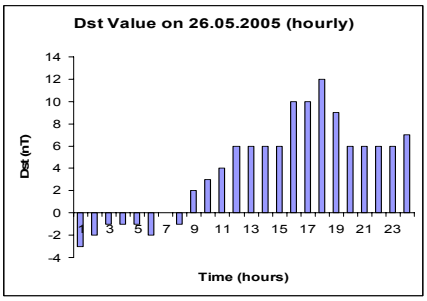


Figure3 Dst values on 26.05.2005.

Furthermore, to re-confirm that the observed phenomena is associated with the corresponding earthquake in Arunachal Pradesh, India, and not with geomagnetic events, the authors have depicted in Figure3, the Dst values (hourly) on 26.05.2005. Additionally it is also notable that the corresponding 3 hourly Kp value (12:00:00-15:00:00 hrs UT) was 0+ and the ∑Kp was 2o only which clearly indicates a geomagnetically quiet period.

4. Discussion and Conclusion

This paper presents a good example of seismo-electric perturbations observed by DEMETER satellite, prior to earthquake measuring 5.9 in the Arunachal Pradesh state of India. The phenomena was observed as anomaly in ULF/ELF range 5-6 days before the seismic activity. Finally, the results in this paper seem to be well complemented by the facts that:

1. The perturbations are observed right above the epicenter during the passage of DEMETER satellite and the pass of DEMETER on 26.05.2005 is just above the epicenter.
2. No such anomaly is observed on other days before or after the event has occurred in the same region.
3. The day (26.05.2005) is a geomagnetically quiet day constituting to the low Dst and Kp values.

Moreover, in order to study the stochastic nature of seismo-electromagnetic phenomena a greater degree of attention is required towards promoting space as well as ground based experimentations techniques involving magnetometers and electric field sensors networks. Comprehensive investigation in the near future, may prove to be extremely useful as they may assist to a great extent, in establishing the seismo-electromagnetic phenomena as one of the prominent precursors to earthquakes, not only benefiting the scientific community but the motivating the global community as well to overcome the challenges posed by earthquakes through early warning alarms.

5. Acknowledgements

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6. References

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