IONOSPHERIC PERTURBATIONS OVER DELHI CAUSED BY THE DECEMBER 26, 2004 SUMATRA EARTHQUAKE

(1)H.N. Dutta, (2)R.S. Dabas, (3)Rupesh M. Das, (4)Bhupender Singh

(1)Radio and Atmospheric Sciences Division, National Physical Laboratory, New Delhi-110 012, INDIA
hndutta@mail.nplindia.ernet.in

(2) "As (1) above, but Email": rsdabas@nplindia.ernet.in

(3) "As (1) above, but Emil": rupesh@nplindia.ernet.in

(4) "As (1) above, but Email": s_bhepender@nplindia.ernet.in

ABSTRACT

The death and destruction caused by the Sumatra earthquake on December 26, 2004 has once again jolted the seismologists to find a reliable precursor of an impending major earthquake. The F-region ionosphere or ionospheric parameters offer the precursory signatures of at least major earthquake to be picked up for forecasting an impending earthquake. To study the ionospheric perturbations caused by the earthquake, digital ionosonde data collected at every 15 minutes of interval at the National Physical Laboratory, New Delhi(28.6N; 77.2E) has been analyzed. Results indicate severe perturbations in foF2 and hmF several hours before the Sumatra deadly earthquake.

INTRODUCTION

On 26 December 2004, a magnitude 9.0 earthquake off the coast of Sumatra triggered a series of tsunami waves that devastated coastal areas of the Indian Ocean, killing more than 300,000 people [1]. This was the fourth largest earthquake in the world since 1900 and is the largest since the 1964 Prince William Sound, Alaska earthquake. The earthquake-triggered tsunami caused more casualties than any other in recorded history and was recorded nearly worldwide on tide gauges in the Indian, Pacific and Atlantic Oceans. Subsidence and landslides were observed in Sumatra. A mud volcano near Baratang, Andaman Islands became active on December 28 and gas emissions were reported in Arakan, Myanmar. Prior to this devastation by tsunami, India witnessed mass death and destruction by the Bhuj earthquake on January 26, 2001[1]. In this short period of ~4 years, the Indian society has experienced losses to such an extent that the Government and the people are seriously looking at the seismologists to find a reliable precursor for at least major earthquakes.

Scientifically, efforts are being made to look for several types of precursory signatures of major earthquakes-one of the most complex natural systems [2-7]. Disturbances in the ionospheric plasma are considered to be one of the indicators for observing precursory signals originating due to earthquakes [8-10]. To fulfill this objective, continuously monitoring of the ionospheric parameters using closely spaced digital ionosonde/GPS receivers or satellite-based systems are required [11-13]. Also, in the case of F-region, perturbations are normally caused by the sudden changes in the solar geophysical conditions such as solar flare, magnetic disturbances etc.[14-15]. However, in rare cases, when the normal disturbing processes are calm, there may be a powerful event on the earth, which may cause measurable signatures at these ionospheric heights. Incidentally, the Sumatra earthquake falls in this category, as no solar geophysical disturbances were present during December 21-29, 2004.

IONOSPHERIC DATA

To study the ionospheric perturbations caused by the Sumatra earthquake, digital ionosonde (IPS-71) data collected at every 15 minutes of interval at the National Physical Laboratory, New Delhi (28.6N; 77.2E) has been analyzed along with a number of ground based atmospheric observations along the Indian east coast. The digital ionosonde installed at Delhi shall form part of an ionospheric network planned to be installed in India by the year 2006.

RESULTS

The Sumatra earthquake struck at 06:28:53 AM (Indian Standard Time) along the west coast of Sumatra (3.30N 95.96E) on December 26, 2004 at 07:58:53 AM local time at the epicenter. Fig.1 presents percentage deviation of observed foF2 values (foF2 Δ% = foF2 observed value– median value/median value x 100) during December 24-29, 2004. This shows that on December 25, 2004, there was a large enhancement around 2100 hrs.(IST) for a duration of ~2 hours, which subsided next day in the morning at about 0600 hrs. It is important to note that normally, the foF2 values must fall after sunset and in the absence of any normal geophysical phenomena, 30% enhancement in foF2 should be a cause of scientific quest to look for possible ground based sources, which may be responsible to cause such changes at the ionospheric levels.

On December 26, presence of several oscillations with periods varying between 2 to 4 hours can be seen. Also, it shows that foF2 values remained above the median values for most of the time, while on December 27; the values remained mostly below the median. There was a buildup of foF2 again on December 28, which also had oscillatory nature of period about 4 hours. It is important to note that there were several aftershocks in this region.

In the similar way, deviation of hmF has been plotted in Fig.2. It shows the hmF started moving up-and-down from December 25 evening and continued up to the next morning. On December 26, hmF remained above the median values for most of the time, but it does show up and down movements. To study the periodicities hidden in the hmF data, using the

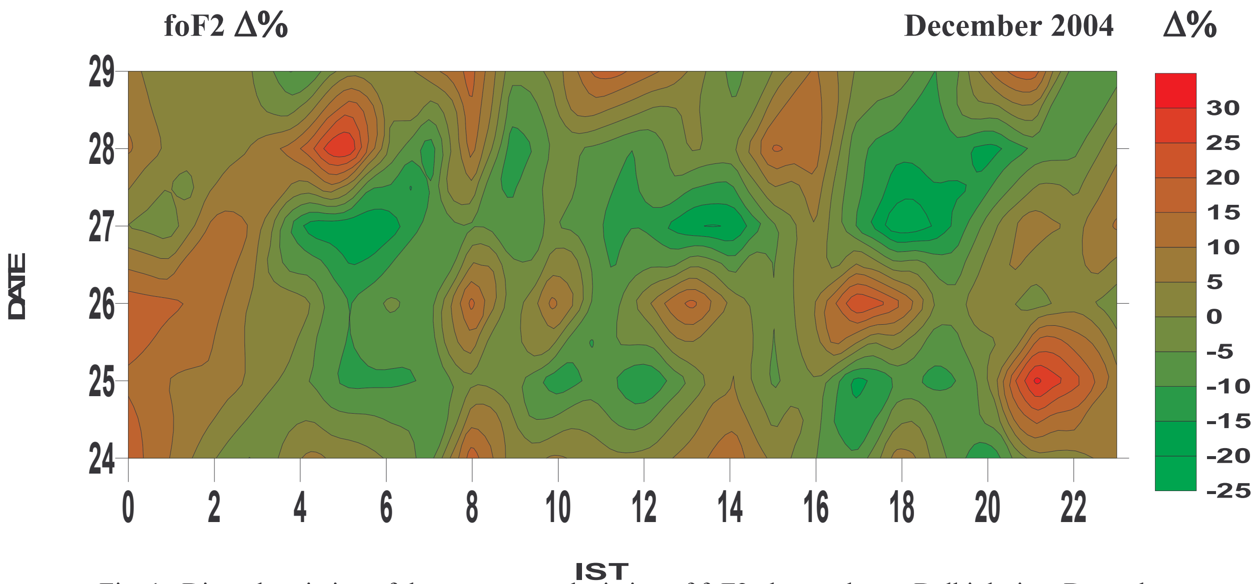

Fig. 1. Diurnal variation of the percentage deviation of foF2 observed over Delhi during December 24-29, 2004.

interactive wavelet software program [16], wavelet analysis has been plotted in Fig. 3. This shows that powerful oscillation with periods of 3-5 hours and 8-12 hours started about 6 hours and 30 minutes before the actual earthquake event was observed at Sumatra. Prominent oscillations of about 4-8 hours are seen on the subsequent days.

To support these earthquake induced ionospheric changes, the ionosonde data pertaining to February 24, 2003 earthquake in China has been examined. In this case, geophysical conditions were also calm and results again show similar ionospheric perturbations i.e. enhancement in Delhi foF2 values at 1700 LT on the earthquake day with overall depletion on the next

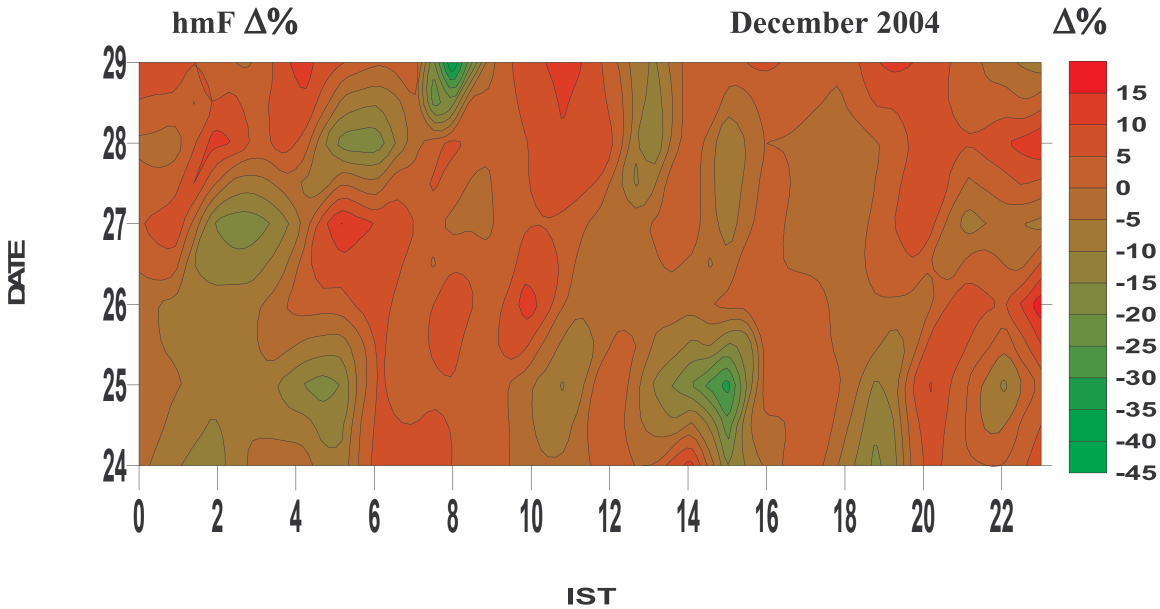

Fig.2. Diurnal variation of the percentage deviation of hmF observed over Delhi during December 24-29, 2004.

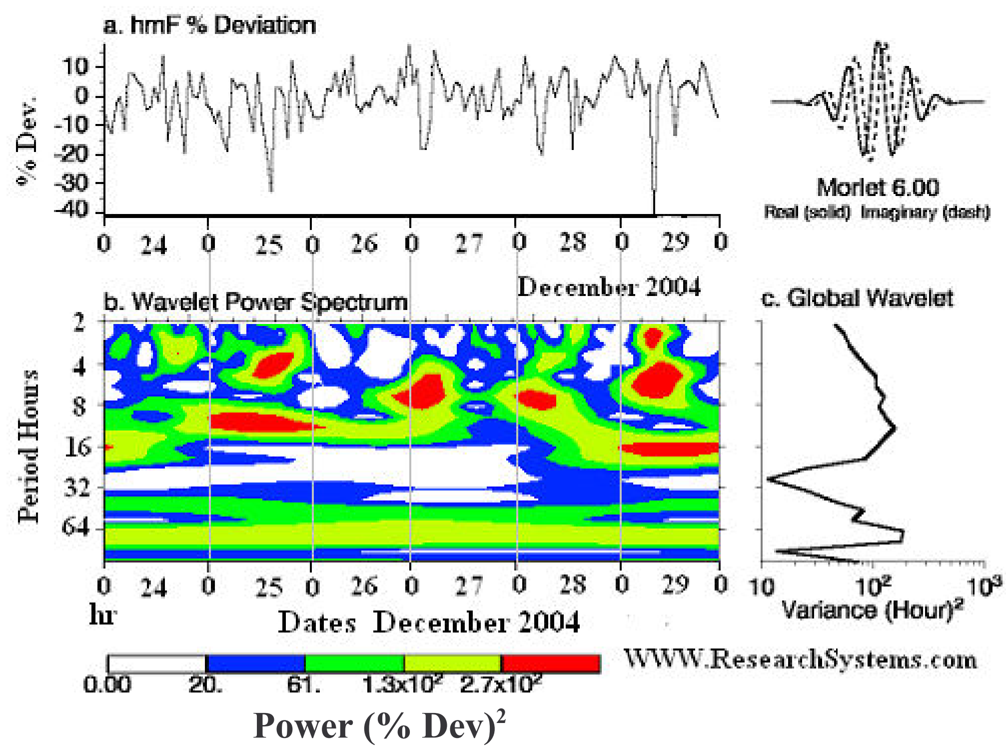

Fig. 3. Wavelet analysis of the hmF Δ% data shows prominent oscillations at ionospheric levels

day, and again at 1700 LT enhancement on the third day. The above results indicate a coupling between lithosphere-atmosphere-ionosphere, emphasizing the need for continuous monitoring of ionospheric parameters and speedy installation of the ionospheric monitoring network in India and over the neighboring countries.

CONCLUSION:

The Sumatra earthquake on December 26, 2004 provides examination of ionosphere under quite solar geophysical conditions and the results indicate seismo-ionospheric coupling far-off from its epicenter. This coupling may be explained on the basis of seismogenic electric field generation before strong earthquakes [17-18]. It also calls for coordinated effort to examine all the ionospheric data sets available over the Indian subcontinent to map the vast geographical area, which might have been effected before this 4th largest earthquake of the century.

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