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Ionospheric precursors of M9.0 Tohoku earthquake on March 11, 2011

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ABSTRACT
An earthquake of magnitude M 9.0 hit the Japan on 11th March 2011. The earthquake triggered one of the deadliest tsunamis. We analyzed the temporal variation of ionospheric parameters ten days before and five days after the main shock. These parameters measured by the ground based Ionosonde characterize the state of ionosphere. We have used the data of Kokubunji Ionosonde station, which lies at a distance of 440 km from the epicenter of the earthquake. The data analysis revealed a sharp enhancement in the height parameters hmF2, h′F2 and h′F of F layer seven days prior to the main shock, while critical frequency of F2 layer foF2 showed a slight decrease. We also examined the variation of electron density (NmF2), Ionospheric Electron Content (IEC) and ionospheric slab thickness parameters and found that while slab thickness increased around the same time the values of NmF2 and IEC underwent a decrease. Since the ionosphere was raised to higher heights the density decreased correspondingly. We also performed the cross correlation analysis of the Kokubunji station with other stations of Japan. From this analysis we found that on 3rd March 2011 Kokubunji followed a negative correlation with other stations of Japan.

INTRODUCTION

Natural events like earthquakes, tsunamis and volcanic eruptions are inevitable and unpredictable. Therefore, it is one of the major challenges felt presently by the scientific community world over to find a reliable seismic precursor. The researchers have started efforts in this direction a couple of decades ago. In case of an earthquake rupture, certain precursory activity can be expected, if the observation is made in the near vicinity of causative rupture. These precursory activities may include radon and helium emanation, electromagnetic emissions, water level and temperature changes, ground uplift and tilt and changes in ionospheric parameters.

Global efforts to predict earthquakes were started about a century ago and peaked during 1970s. The first scientifically well documented earthquake prediction was made on the basis of temporal and spatial variation of ts/tp relation in Blue mountain Lake, New York on 3rd August 1973 (Aggarwal et al., 1975). Seismologists then successfully predicted the Heicheng China earthquake of 4th February 1975 (Cha Chi Yuan), which raised the hopes that it could be possible to make reliable earthquake forecasts. The seismologists have now narrowed down their studies from long term prediction to short term prediction.

Among the different precursory phenomena mentioned in the publications on earthquake prediction, the ionospheric ones are youngest. It has been now established that ionosphere is not only sensitive to solar influences, but it is also affected by lithospheric processes. The occurrences of some specific phenomena at different altitudes and in different layers of ionosphere are believed to be caused by lithospheric processes happening prior to a seismic event. The researchers are of the view that there is a perfect connection between lithosphere and ionosphere, which may be established either from ground or from space. Above the epicenter of future earthquake, macroscopic changes can appear in the ionospheric parameters at an altitude between 400 km to 1000 km. There are many evidences of seismic associated ionospheric disturbances (Hayakawa and Fujinawa, 1994; Parrot et al., 2006). The first publication concerning seismic associated ionospheric effects came just after Alaska Good Friday earthquake in 1964 (Davies and Baker, 1965; Moore, 1964). Since then a wide range of ionospheric-seismogenic phenomena have been acquired by in-situ satellite