

Possible Earthquake Effect on Electron Temperature in the Afternoon Overshoot at 600km

- Contribution of Space Plasma Chamber to the Accurate Measurement of Te -

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Abstract: We are studying the effect of the 3 big earthquakes on the ionosphere by using electron temperature (Te) and electron density (Ne) data which were obtained by HINOTORI satellite. The three big earthquakes occurred in November, 1981, and in January 1982 in Philippine. Te of the afternoon overshoots which appears around 15-17 local times in the low-mid latitude totally disappears or strongly depressed about 5 days prior to the earthquake. This is explained by the excess deposit of photoelectron energy caused by the enhanced Ne which occurs below 600km. The enhanced Ne is possibly generated by westward electric field associated with earthquake. This study is only possible by using contamination free instrument, such as a resonance rectification probe, which was invented and improved in Japan by using Space Plasma Chamber.

Introduction

HINOTORI was operational for 14 months with the circular orbit of 600km and inclination of 31 degrees since it was launched on 24 January 1981.

Two unique plasma instruments, resonance rectification probe (Oyama, 1981) and impedance probe were onboard. The former picks up the floating potential shifts which appear as the result of sinusoidal wave at the floating potential of current - voltage characteristic curves. The floating potential shifts are the function of electron temperature of ambient plasma. Impedance probe which was originally developed by Oya (1890) detects the upper hybrid resonance, from which plasma frequency is calculated. Both probes are not influenced its measurements by electrode contamination, which is the most serious problem associated with DC Langmuir probe. The probes are light weight, and compact and require small amount of sampling bit rates, especially the bit rate for the resonance rectification probe is far less than those required for DC Langmuir probe. Both these probes have been installed in many sounding rockets and scientific satellites in Japan and their performances are well established. Especially Resonance rectification probe has been flown in sounding rockets of many countries such as India, Brazil, Germany, Canada, USA, and in satellites of Brazil and Korea.

Studies of Te behaviors

To study the effect of the earthquake on the ionosphere, we need to take 3 stages. We first need to grab general features of Te/Ne such as on local time, season, solar flux, latitude and longitude (Su et al.1997, 1997, 1998) . We then tried to understand the various features in more detail, such as Te in the plasma bubble (Oyama et al.,1988), effect of the electric field on the morning

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overshoot in the equatorial region (Oyama et al.,1999), Te behavior of equatorial ionization anomaly (Oyama et al.,1999), annual behavior of Ne/Te (Su et al.,1999), effect of neutral wind upon Te/Ne (Watanabe and Oyama, 1996) regarding tilted magnetic meridian. After we understood features above, we have constructed Te/Ne model. The Te model was made by Marinov et al (2000), and Ne model was made independently by first Isoda and recently by Kakinami (2006). Model input parameters are local time, season, solar flux, latitude, longitude, and month. Te behavior during geomagnetic disturbance has been studied by applying models. We found that both Te/Ne models are quite reasonable. Especially Te model shows that 50 degrees K deviation at night has geophysical meaning (Oyama et al., 2005). Finally the third step is to find the effect of the earthquake on the ionosphere by using the models, that is, to try to find deviation of Te from the model value because Te is more sensitive than Ne variation. So far we have studied three earthquakes; those are: EQ1 which occurred on 22 November 1981 with magnitude of 6.6, depth of 37 km, and epicenter of 14.09E and 124.35 N, EQ2. which occurred on 11 January, 1982 with magnitude of 7.4, depth of 45 km, and epicenter of 13.75E and 124.36N, and EQ3 which occurred on 24 January, 1982 with magnitude of 6.6, depth of 37 km, and epicenter of 14.09 E, 124.35 N.

We found that Te in the afternoon overshoot reduces prior to and after earthquake. Fig 1 shows one example of the satellite orbit, which probably shows earthquake effect on 11 November, 1981. To reach this present conclusion, we have checked magnetic disturbance and solar radio flux, F10.7. We cannot find any reason to cause the reduction of Te except earthquake. The figure shows Te (model and observation) and the deviation from the model Te in the top two panels, Ne (model and observation) and the deviation from the model Ne in the third and fourth panels, longitude and geographic latitude in the 5th and 6th panels, and finally local time in the bottom panel.

Te follows the model quite well except near afternoon overshoot. The Te model (black dots) illustrates that Te shows two Te maxima; one in the early morning around 9 LT (morning overshoot) and the second in afternoon around 16 LT (afternoon overshoot). Whilst the observation (blue dots) keeps constant value at the point where model Te should elevate and it merges to the model later. Ne observed follows the model value or takes slightly higher values than the model. These features seem to start about 5 days prior to the earthquake and recovers after 5 days. Figure 2, summarizes the deviation of Te from the model for the earthquake EQ2 and EQ3. Deviation of Te from the model is plotted against 1-31 January (top panel), against longitude (middle panel), and against latitude (bottom panel).

The figures show the followings.

1. Deviation of Te starts about 5 days prior to the earthquake and recovers to the original value after about 5 days. Deviation of Te seems to start earlier and recovery is slower as the magnitude of the earthquake increases.
2. The deviation ranges from 40 degrees to the west and 40 degrees to the east.
3. In latitude wise the range of deviation extends from north to south with steep reduction in high latitude.

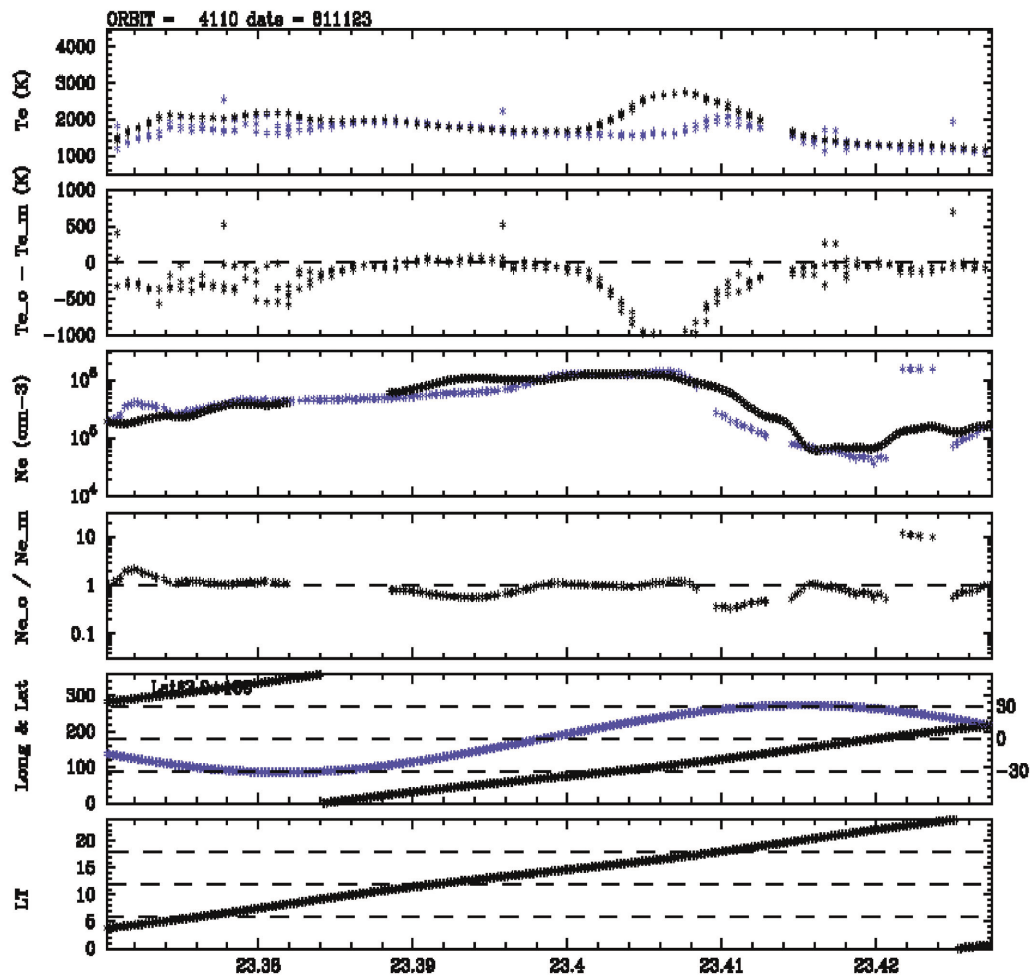


Fig.1. One example of Te reduction in the afternoon overshoot on the 23rd Nov.1981.

Upper panel; black and blue dots show model value and observation

Second panel; deviation of Te observed during one satellite orbit from model values. Note that the deviation of the Te at around 23.406 UT shows the maximum.

Third panels; Ne observed during one satellite orbit. Black dots shows model value, blues dots show Ne observation.

Fourth panel ; deviation of Ne observed from model values.

Fifth panel; Longitude(black) and latitude(blue) of the satellite

Bottom panel; Local time

The numbers at the bottom indicate UT. For example 23.4 means that 23 Hours 24 minutes in UT.

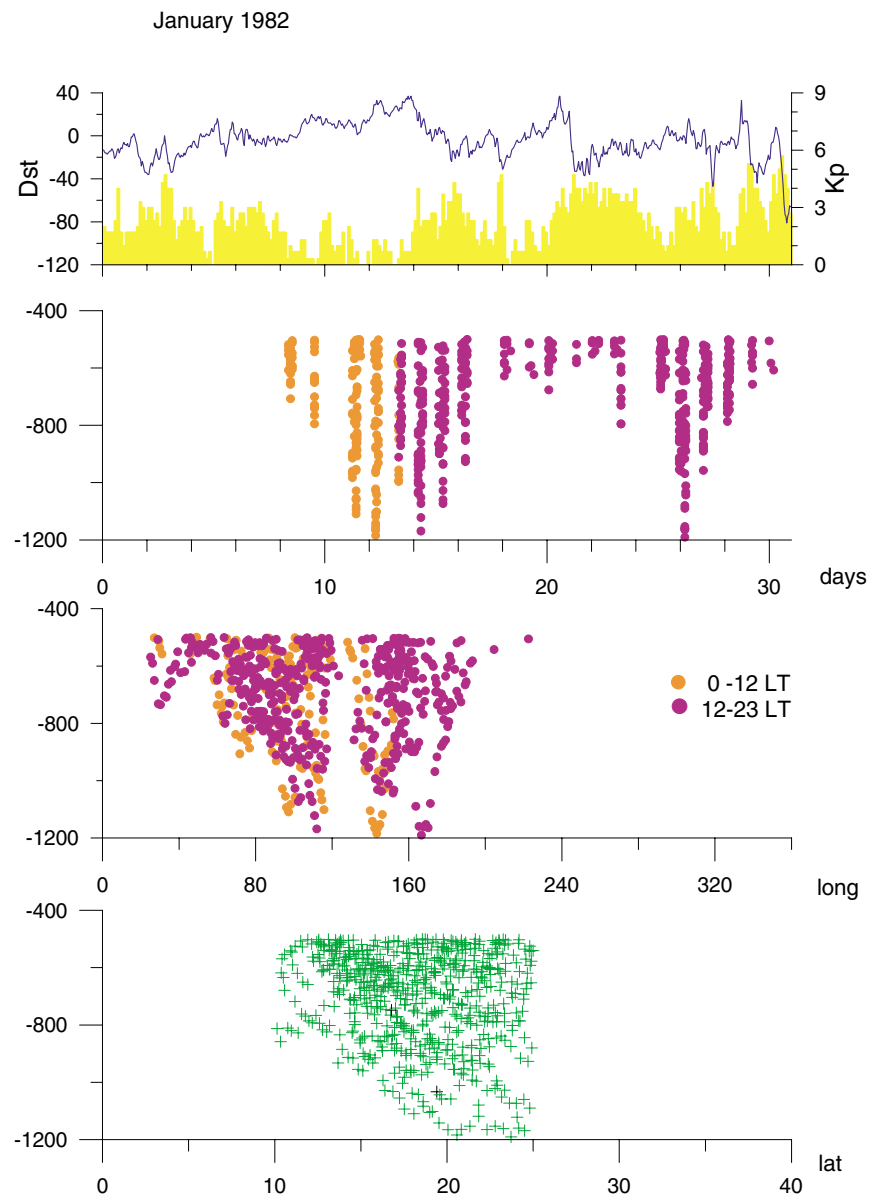


Fig.2. Reduction of T_e during January, 1982.

Top panel; Kp index and Dst value.

Middle; deviation of T_e from model value versus date. Two arrows show the dates with maximum negative deviation of T_e from model value. Red and purple points are taken from morning overshoot which is located at 0-12 LT and from afternoon overshoot located at 12-23 LT.

Bottom panel; deviation of T_e from T_e model versus longitude.

Bottom; deviation of T_e from the model versus latitude.

Manila ionosonde data, and DE-2 data

Ionograms at Manila show that prior and after earthquake NmF2 does not show any remarkable change or shows small increase in the afternoon and reduction in the evening. When ionograms at Taipei show very slight reduction of NmF2 in the afternoon, Manila data shows the increase. Virtual height, h'F at Manila shows about 100km reduction, while no clear change of h'F in Taipei is found. This height variation is a common feature of EQ1, EQ2, and EQ3. Preliminary analysis of DE 2 data which were obtained on these periods seems to show the reduction of Te.

Concluding remarks:

Electron temperature probe which has been developed by using Space Plasma Chamber for pure science might be used for application. We believe that only our electron temperature which is not influenced by electrode contamination can be used to detect small deviation of Te. Based on our firm confidence above, we have studied three EQ events study. Both 3 events show common features. Reduction of Te in the afternoon overshoot appears to show earthquake effect and the way of reduction of Te seems to be different from that of other ionospheric disturbance such as magnetic storm. The mechanism of Te reduction which we have in mind is as followings. There is a region where Ne is enhanced between h'F height and 600km height, which causes photoelectron escaping from ionosphere. The photoelectrons lose their energies in the Ne enhanced region. This region might be able to be produced by electric field. If we try to explain the reduction of h'F observed at Manila ionosonde station, the electric field should be comparable to /or slightly less than dynamo electric field, which is usually of the magnitude of 1mV/m. Hinotori Te suggests that the electric field which disturbs the ionosphere should be more than 5 days continuation prior to and after the occurrence of earthquake. Further the data suggests that electric field should be westward. Although we still have no clear explanation on the generation of electric field, several possibilities can be speculated. For example, internal gravity wave modifies the cloud condition, which might increase the thunderstorm activities, and finally electric field is produced. If the result which we found is attributed to the electric field which might be generated under the ground in association with earthquake, the ground based observation should be paid attention to very small long time variations of magnetic/or horizontal electric field.

On the contrary to the above statements which, we believe currently, is associated with earthquake, we have still possibility that these are only coincidence. We are now studying other cases which are similar to these three cases.

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