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Relation of variation of NmF2 and neutral temperature profile in Dynamo region around Large earthquake days - Case of Sechuan and Pingtung earthquakes

Y. Y. Sun[1], K. I. Oyama[2], J. Y. Liu[1] , and H. K. Jhuang[1],

[1.]Institute of Space Science, National Central University, No. 300, Jongda Road, Jhongli City, Taoyuan County 32001, Taiwan.
[2.]Plasma and Space Science Center, National Cheng Kung University, No.1, University Road, Tainan City 701, Taiwan.

Abstract
We analyze data to find the source of a seismo-electric field, which is considered changing the ionosphere around a large earthquake, by assuming that the neutral wind pattern, disturbed by some mechanism before the large earthquake, modifies the electric field in the dynamo region. The relationship between the electron density at the F2-peak NmF2 and the neutral wind height profile is studied for two large earthquakes (2008 M7.9 Sechaun, and 2006 M7.0 Pintung doublet). It is found that when the NmF2 shows a large deviation from the normal data, wavy structure which is usually superposed on the height profile of neutral temperature shows the shorter scale structure with smaller amplitudes in daytime. This tendency is found both for the two large earthquakes. This fact seems to support our idea. However to further correlate this wavy feature with the ionospheric electron density disturbances we need direct observations around dynamo region.

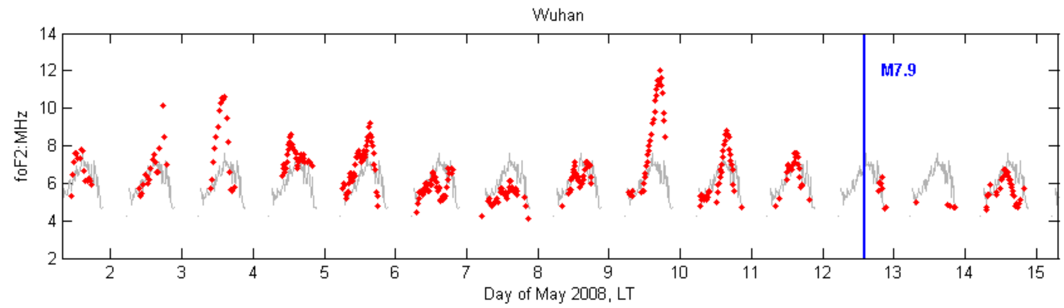
1.Introduction

Disturbance of the ionosphere which appears prior to large earthquake has been repeatedly reported. A number of the paper is drastically increasing and the quality of the paper is also improving. It is no doubt that large earthquake is modifying the ionosphere by some reason (Liu et al., 2008). It is noted that we do not know whether all large earthquakes disturb the ionosphere, because morphology of the ionosphere disturbance has not been established yet. Fig.1a shows large increase of NmF2 can be seen on the 9th of May (3 days before the 12 May 2008 M7.9 Sechuan earthquake). The similar small increase of the NmF2 is seen as well on the 3rd of May. After these two days, the NmF2 reduces gradually, and 3 days later, it becomes smaller than the normal values. The similar feature can be seen before the 26 December 2006 M7.0 Pintung doublet earthquake as shown in Fig.1b. Increase of the NmF2 occurred right before the earthquake. Another increase of the NmF2 can be seen on the December 23, and the increase gradually reduces. Including the Sehaun and Pintung earthquakes, most of the features which have been reported so far in relation to large earthquakes can be explained by assuming the existence of seismo-electric filed.

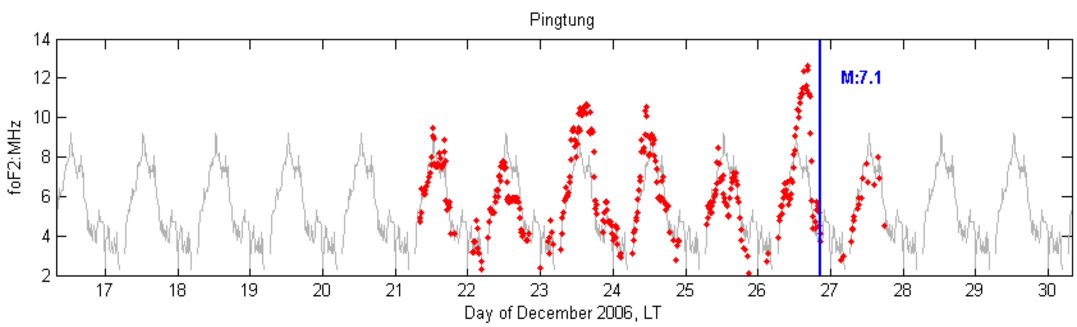
Some change of the ionosphere at magnetic conjugate point is found for some earthquake, which imply the effect of electric field (Ruzhin et al., 1998). Provided that the electric field is working, next question is “Where and how the electric field is generated?”. One of plausible mechanisms is the internal gravity wave. The internal gravity wave is generated on the ground before the earthquake by some mechanism, and it propagates up to about 100km, and then change the wind pattern (Klimenko, 2010). Once wind pattern changes at this Dynamo region, the electric filed is modified and propagated to the higher ionosphere along magnetic field line.

In order to find the evidence the suggested mechanism which we, we study the neutral temperature profile obtained by SABAR, and TIDI instrument on board TIMED (Thermosphere-Mesosphere

Electrodynamics) satellite for the two large Earthquakes and available for the existing ionospheric data. Figure 2 shows show that locations of the Pintung Earthquake (2006/12/26, latitude 21.89 degrees Longitude 120.56 degrees, and, M7.0, Depth 41 km), and the Sechaun Earthquake (2009/05/12, latitude; 31.1 degrees, Longitude 103.3 degrees, M7.9, Depth 18 km).



(a)



(b)

Fig.1 The FoF2 around Sechuan (a) and Pintung Earthquake (b). The black curves are 15-day and 7-day moving average for the Sechaun and the Pintung earthquakes, respectively.

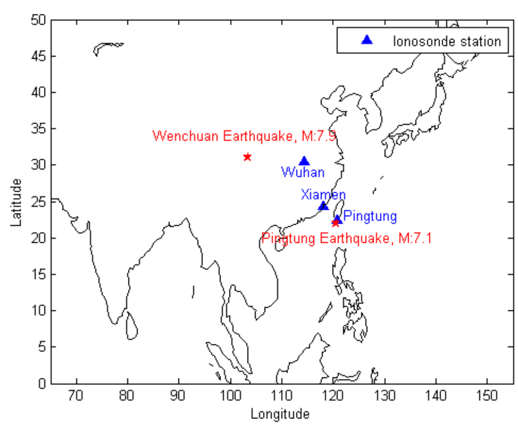


Fig.2 Location of two earthquakes which we studied(red stars).
Three blue triangles indicate the location of ionosondes

2. Data analysis

We first study the magnitude of the temperature, and however no clear difference from other normal period is found before the earthquake. Then we examine the irregular structure of height profile of the neutral temperature ,Tn. Generally, the Tn profile at around 100km shows a wavy structure modified by internal gravity waves. We find that when the NmF2 reveals a large deviation from its normal value, the neutral temperature profile does not show wavy structure, which usually appears. Instead the deviation from the average, the neutral temperature depicts small scale fluctuations. These small scale fluctuations seem to be a part of destroyed wave, having the vertical wave length of 20-30 km.

2.1 Local time and annual variation

Figure 2 shows one of the examples of neutral temperature profiles from 20 km to 140 km around the Wenchuan Area. As shown in Fig.2, the height profile of neutral temperature in the height range of 70-130 km shows irregular structure. The irregular structure is mainly from internal gravity waves. The neutral temperature changes against local time LT, solar activity, longitude, and latitude. Figure 3a shows local time variations of the neutral temperature at two height range of 15-20km and 115-120 km accumulated during 2002-2009. Between 10:00-14:00LT, the data are not available. Figure 3b shows annual variations of the two height regions for 2002-2009. We find that the variation of temperature at two height region is too large to detect the change of neutral temperature associated with large earthquakes. Then we focus on the small change of daily temperature from the averaged height profile value as shown in Fig.4. Again, we find the difficulty to identify the feature possibly associated with large earthquake.

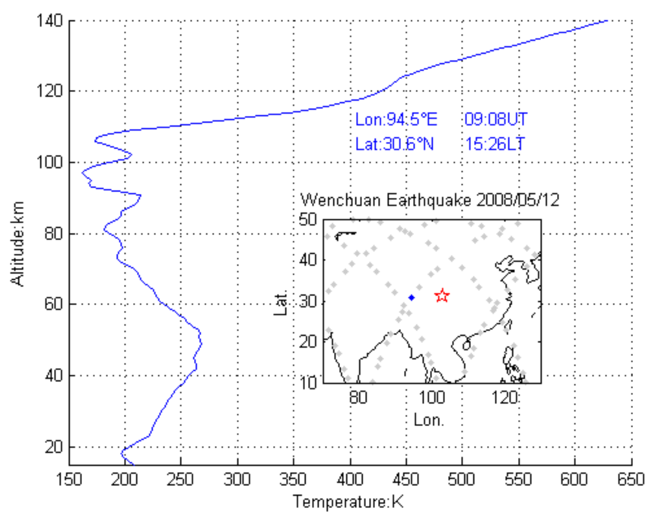
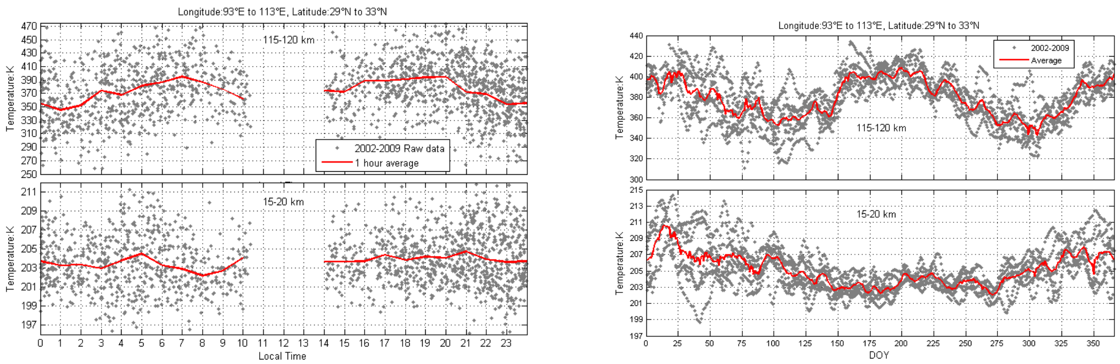


Fig.3 Example of height profile of neutral temperature near Sechuan. A red star in a square zone of longitude-latitude coordinates indicates an epicenter .



(a) (b)

Fig.4

(a) Accumulation of local time variation of neutral temperature at two height regions(115-120 km Upper panel, 15-20 km lower panel during 2002-2009) . (b) The annual variation of neutral temperature at two height regions(5 day-nights time value averaged) .

The differences of the neutral temperature from the averaged values are shown in Figure 4. It is difficult to identify the change of neutral temperature from these data. For the Pintung earthquake, the same data processing has been conducted, as Figure 5, showing no clear feature.

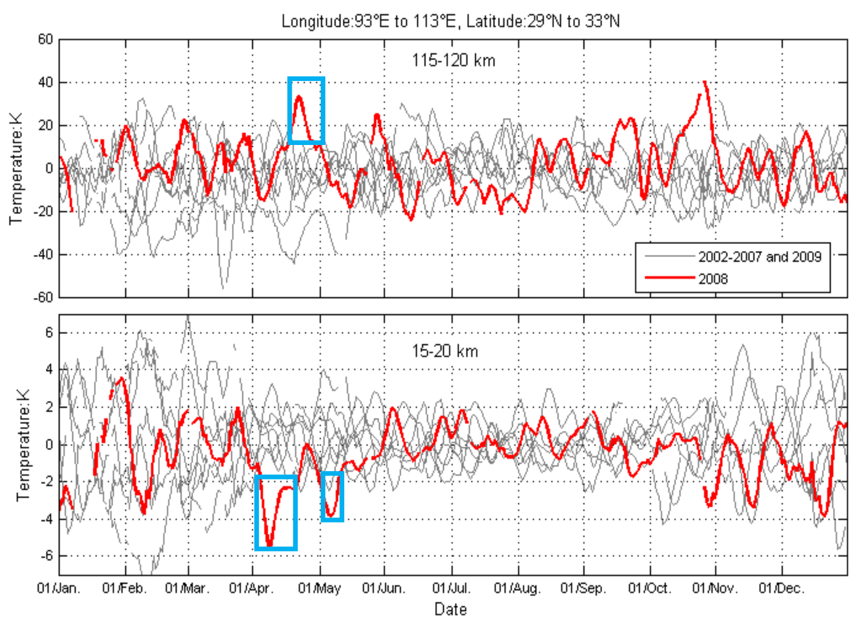


Fig.5 Deviation of neutral temperature from averaged neutral temperature for Sechuan Earthquake. Blue colored square indicate the values which seems to give larger deviation. However the deviation is not clear enough for us to attribute this deviation as earthquake effect.

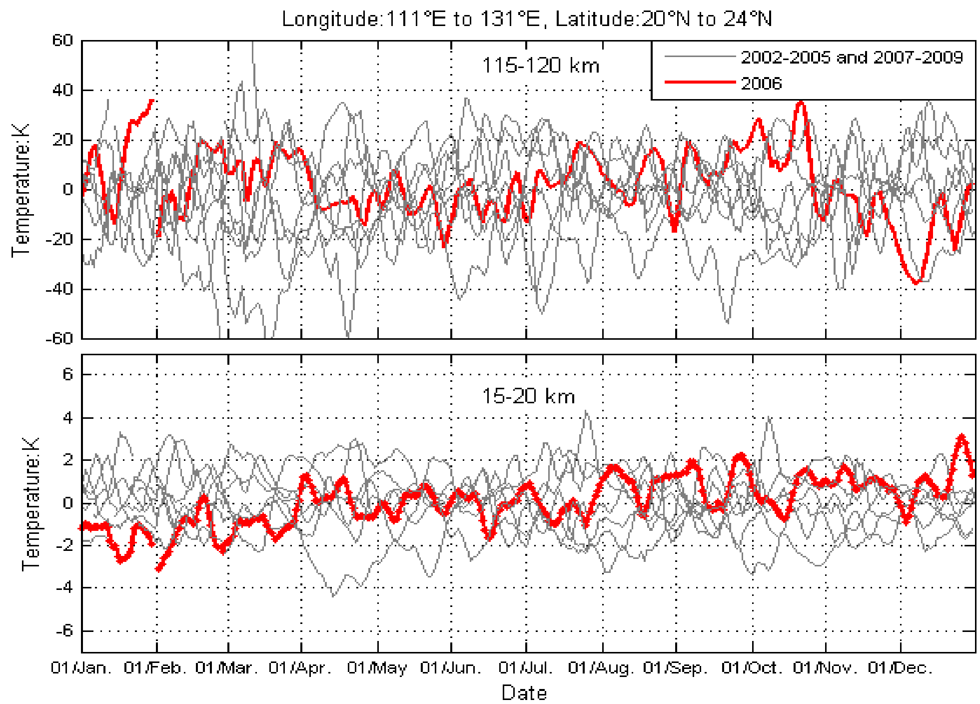


Fig.6 Deviation of neutral temperature for Pintung earthquake at two height regions. Thin black lines show the annual variation of individual years from 2002-2009. Ed thick line shows the average of whole years.

2.1 Small scale variation of neutral temperature profile.

2.1.1 Sechuan Earthquake

Upper panel of Fig. 5 shows the NmF2 observed by ionosondes at Wuhan (114.4 E,30.5 N) and Xiamen(118 E,24.4 N). The NmF2 shows about 2 times increase from normal days on 124 and 130 total days. The change is considered to be assoicated with the Wenchaun earthquake (Liu et al., 2009 and Zhao et al., 2008). In the lower panel differences from the averaged neutral temperature profile are shown. For these two days, we find that the devioation form the averaged neutral temperature is smaller and at the same time when the wavelength is shorter.

We try to confrim this feature with the Wenchaun earthquake first. For each heigh profile of the neutral temperature, we conduct a frequnecy spectrum analysis. First, the area is limited to 25-35 degrees in latitude, 93-113 in longitude. The second area is 20-40 degrees in latitude, and 83-123 degrees in longitude. The third area is 15-45 degrees in latitude, and 73-133 degrees in longitude.
First square area is limited to 73-133 in Longitude,and 15-45 in latitude.

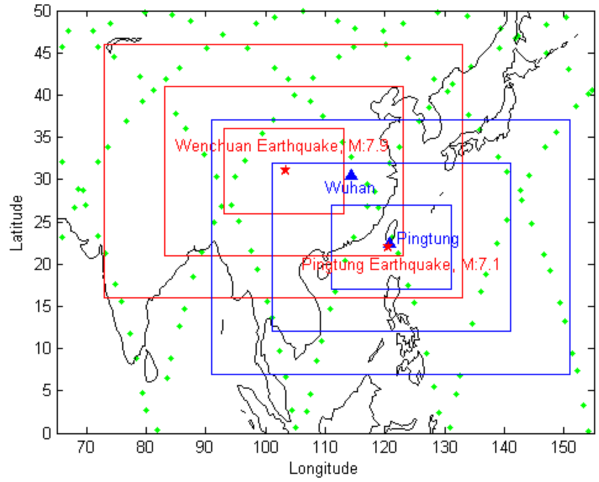


Fig.7 Area where spectrum analysis is conducted. Wave length analysis in these tree regions for two large earthquake are plotted in Figs.8 and 9.

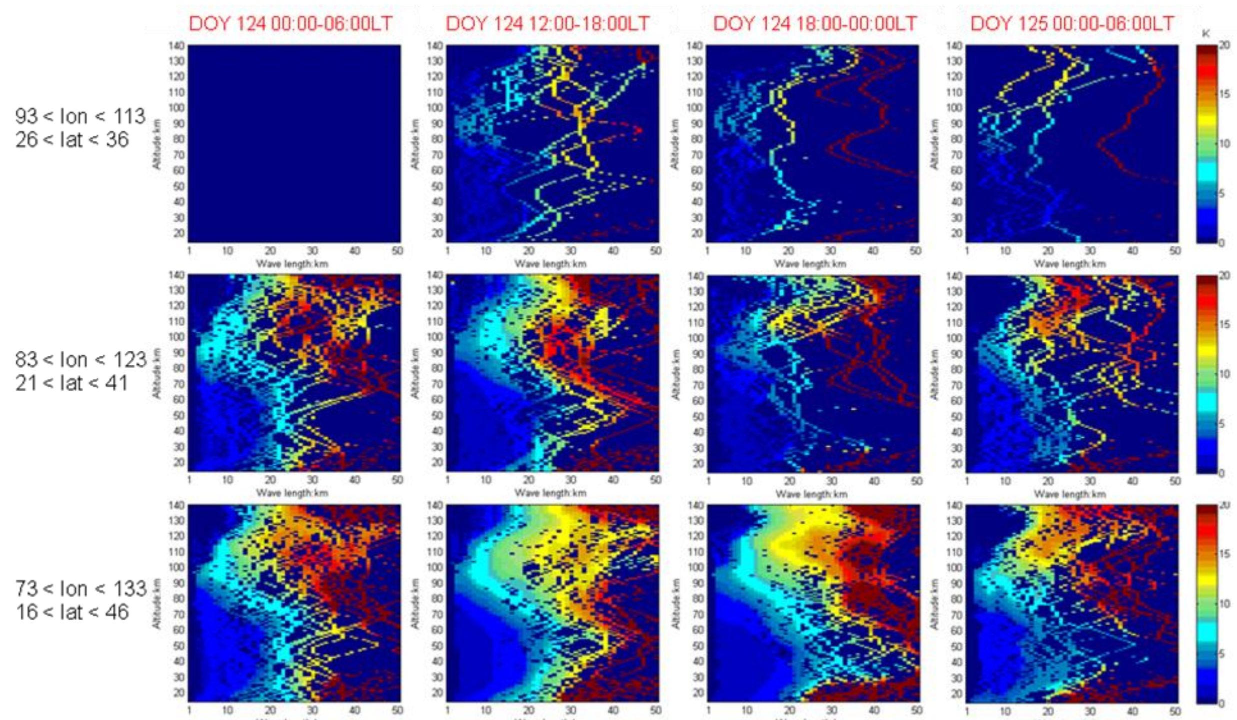


Fig.8 Result of frequency spectrum analysis, for the day of 124 for Wencual earthquake. Local time regions are 12:00-18:00.and 18:00-00 for three areas. Feature which should be noted in DOY (day of year) 124 12:00-18:00 is that in the local time range of 12:00-18:00, in the area of 93-113 in Longitude,and 26-36 in latitude, waves of vertical wave length of 20-30 km is dominant, and as the area is expanded, waves of the longer wave length start to prevail.

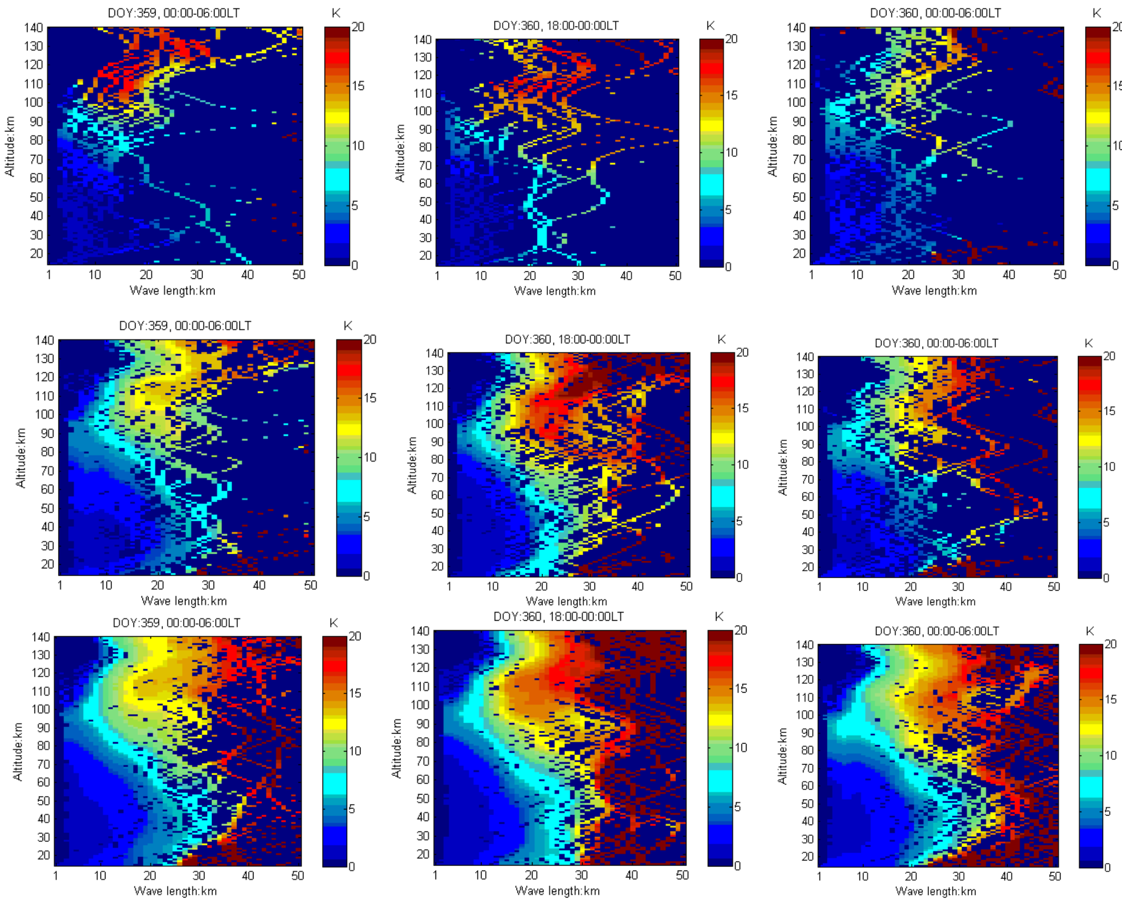


Fig.9 Frequency analysis for each height profile from the Pintung earthquake. Left (DOY359.00:00-06:00). Middle (DOY 360 18:00-000:00LT),Right (DOY 361 00:00-06:00). From the top to the bottom, the area is expanded.

Fig.9 shows the frequency spectrum for the Pingtung Earthquake. On day of year DOY 360 (December 26, 2006), in the local time period of 18:00-00:00LT (middle three panels), as the area is expanded, the waves whose wave amplitude is larger and shifts to the longer wave length. These features are also found for the Wenchuan earthquake.

3. Wind system around dynamo region

Recently Raznoi et al., reported the evidence of internal garvity waves which is psssibly generate prior to the large earthquake(2007). Here we search the evidence of wave associated with lartge earthquake. Wind obtained from TIDI instrument on board TIMED are plotted for 90-100km. For the Wenchaun earthquake, the wind was plotted from DOY 123-132. Figure 10 shows the typical wind pattern on DOY 129 to 131, and duirng the period NmF2 of ionograms show the increase as we mentioned before. The neutral temperature was measutred during 12:00-15:00LT. One clear feature is that the wind velocity aroundequatorial region becomes storng and it is well oriented twoward east. In mid latitudes in China continet, the northward wind component is strong. Comparing with DOY 129 and 130 data, it is found that DOY 130 data has more northward component in the China region. This means that due to the enhancement of the northward west component, dynamo effect is enhanced, and as a result wind over equator is also enhanced. These two effects enhance the eastward electric field. According to the enhanced eastward electric filed, ionopshere is lifted, and as a result, NmF2 being increased. Unfortunetely for the Pintung earthquake, no data was available.

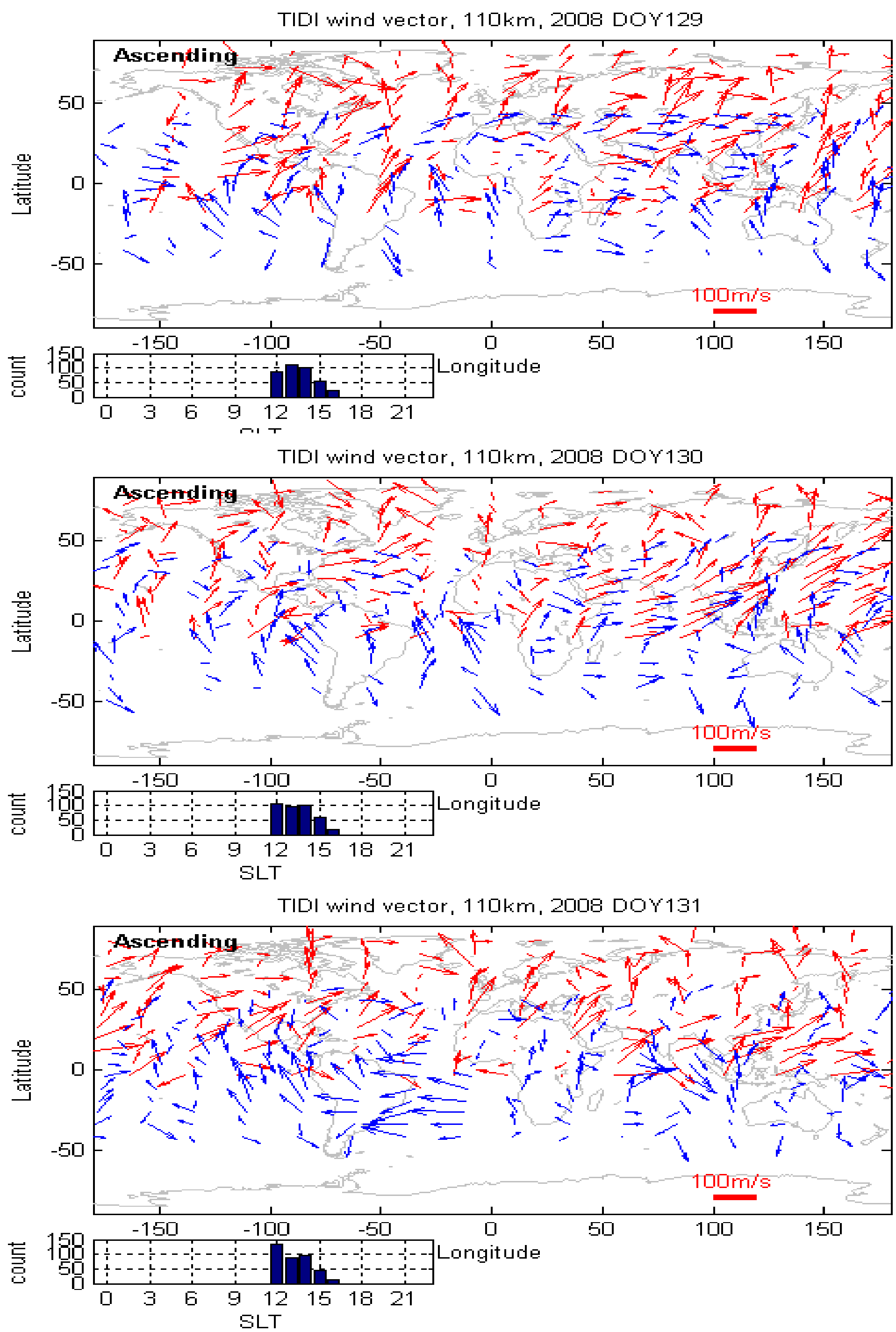


Fig .10 Wind pattern from 129-131 total day. On 131 Total days, NmF2 shows large increase. Red and blue vectors show the observation obtaned when the sensor see the dayside and night side. Bar graph at the left bottom hsows the number of the3 dta and local time when the data are obtained.

Conclusion

We have reported here our test study to show that the dynamo filed is modified by the wind which is modulated by the wind below prior to the large earthquakes. We have both temperature and wind pappern data for the Wenchauhn earthquake. For the Pintung earthquake only temperature data is obtained. Both earthquakes show similar feature of neutral temperature height profile. That is, the neutral temperature profile shows smal irregularities. As for the Pintun case, the wind pattern is not available, we cannot reach conclusinon whether similar wind pattern is identified. To further support the eveidnece on the change of wind pattern, we need observations of another large earthquakes. As we cannot discuss the detail of our study in the limitetd pages of this symposium, more detailed results will be published somewhere in the near future.

Reference

England, S.L., S.Maus, T.J.Immel, and S.B.Mende (2006), Longitudinal variation of the E-region electric fields caused by atmospheric tides, *Geophys.Res.Lett., 33*, L22205, 1-5.

Klimenko, M., V.Klimenko, I.Kaprov, I.Zakharenkova (2009), Generation of zonal electric fields in the Earth's ionosphere by internal gravity wave prior to strong middle-latitude earthquakes, International Journal of Remote sensing, in press.

Liu, J.Y., Y.I.Chen, C.H.Chen, C.Y.Liu, C.Y.Chen, M.Nishihashi, J.Z.Liu, Y.Q.Xia, K. -. I. Oyama, and K.Hattori, and C.H.Lin (2008), Seismo-ionospheric GPS TEC anomalies observed before the 12 May 2008 Mw7.9 Wenchuan Earthquake, J.Geophys.Res., doi: 10.1029/2008JA013698.

Ruzhin, Yu.Ya.,V.A.Larkina, and A.Kh Depueva (1998), Earthquake precursors in magnetically conjugated ionosphere regions, *Adv.Space Res., 21,525*-528.

Rozhnoi, A., M.Solovieva, O.Molchanov, P. -F.Biagi, and M.Hayakawa (2007), Observation evidences of atmospheric gravity waves induces by seismic activity from analysis of subionospheric LF signal spectra, Nat. Hazards Earth Syst., Sci., 7, 625-628.