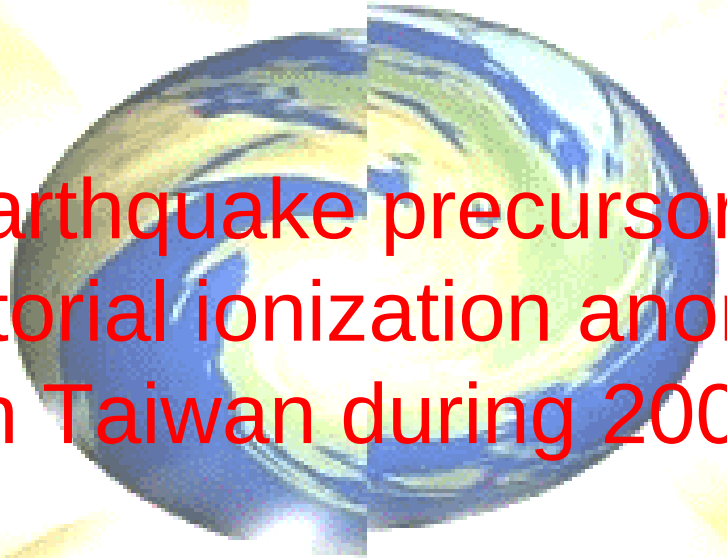
卓越計畫

iSTEP

integrated Search for Taiwan Precursor



Ionospheric earthquake precursors monitored by using equatorial ionization anomaly of GPS TEC in Taiwan during 2001-2007

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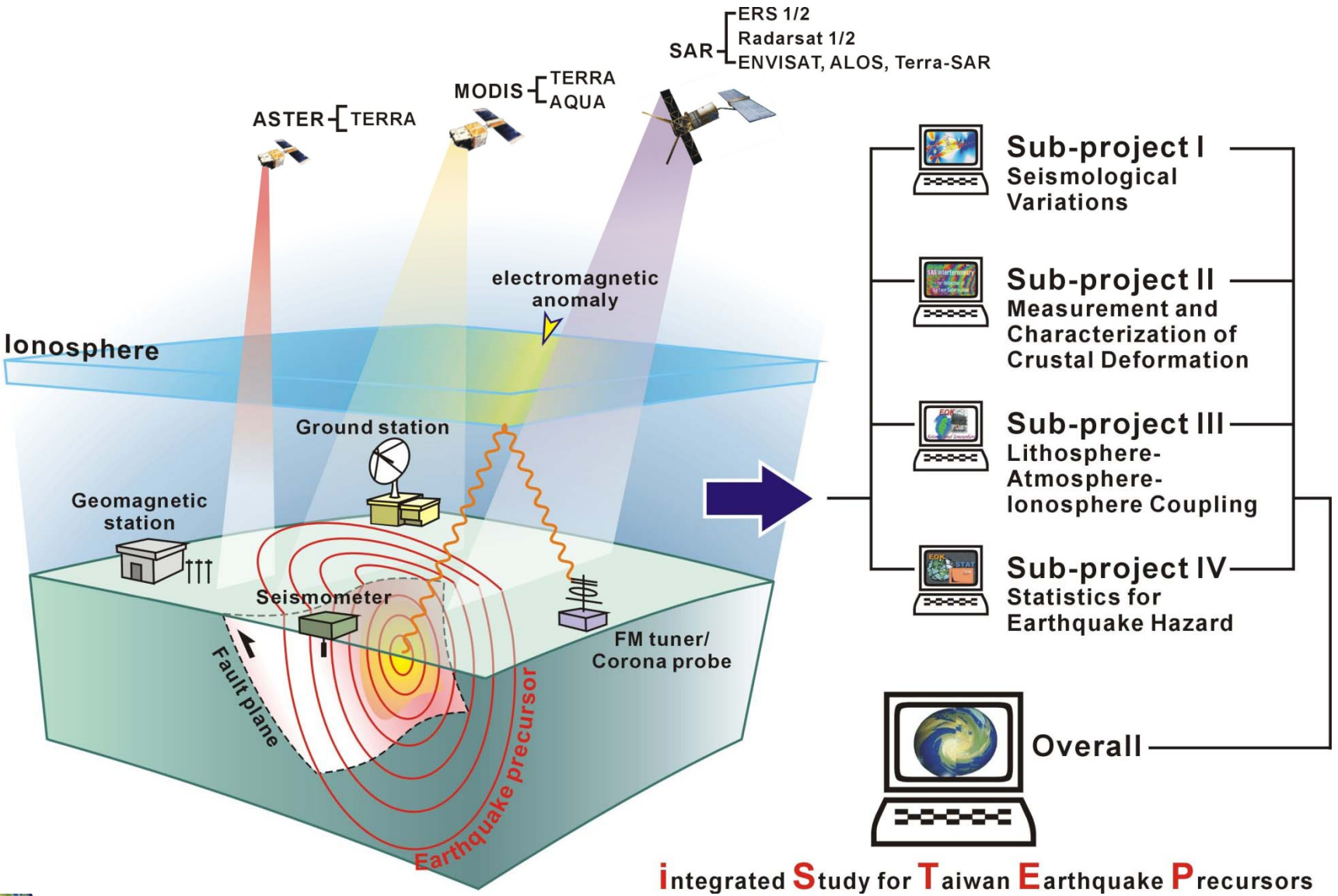
National Central University, TAIWAN

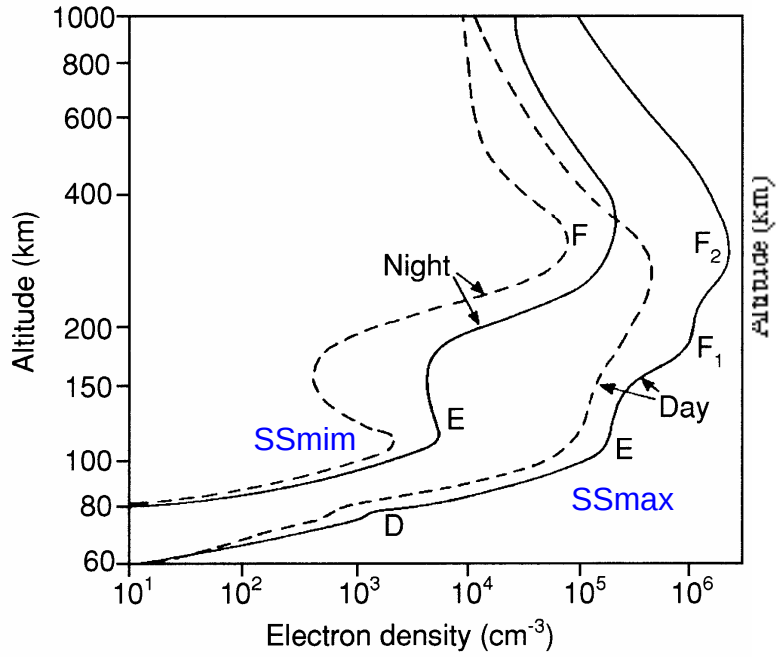
integrated Study for Taiwan Earthquake Precursors (*i*STEP-2)

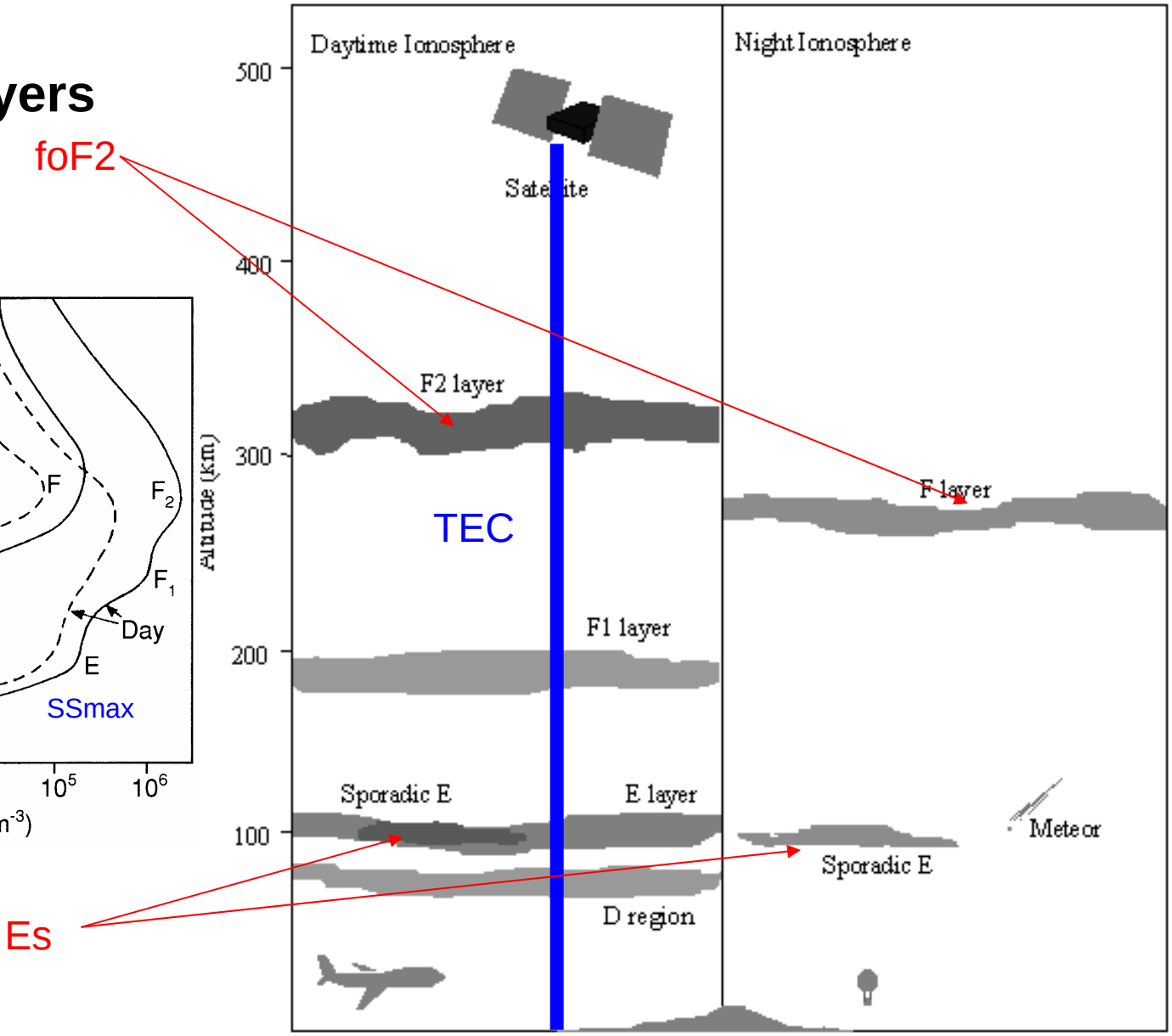


Content

- Introduction
  - Ionosphere
  - (1) GPS TEC
  - (2) Equatorial ionization anomaly, EIA
- Seismo-ionospheric EIA precursor
- Ionospheric electron temperature anomaly
- Conclusion

Ionospheric Layers





- The F_2 layer is much thicker near the equator than elsewhere.
- There are region of high electron concentration at geomagnetic latitudes of about ± 20°(dip) or ± 10°(geomagnetic latitude) during the early evening, which arise from fountain effect.

Plasma fountain

Equatorial ionization anomaly

EIA

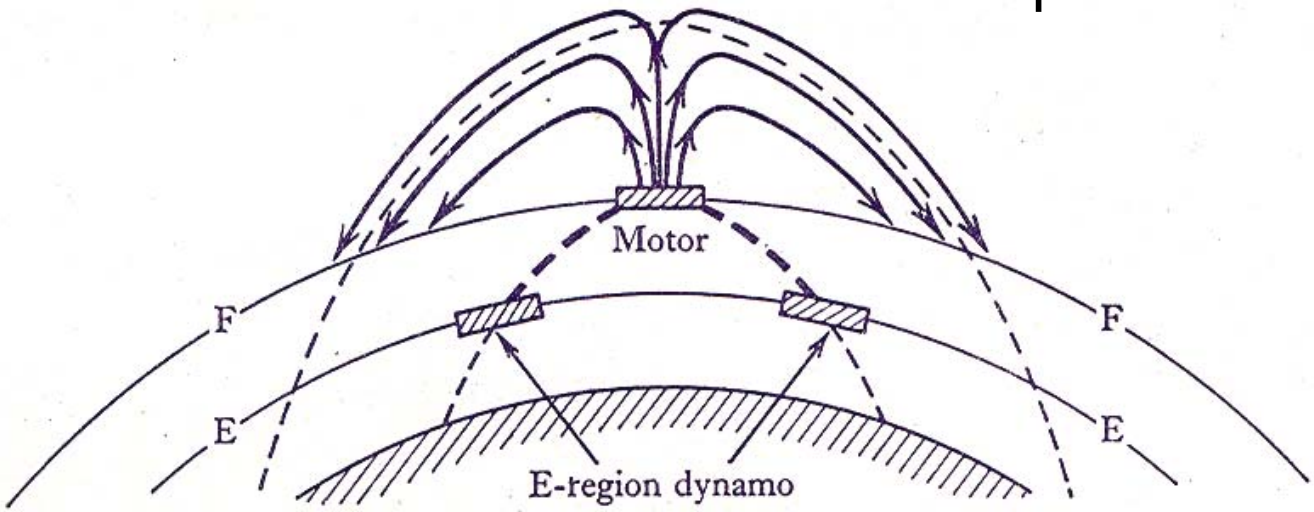


Fig. 3.1. The F region geomagnetic anomaly. Near the equator the electric fields of the atmospheric dynamo in the E layer are conveyed upwards along geomagnetic lines of force to the 'motor' in the F layer where they produce an upwards movement of the plasma during the day. The raised plasma then diffuses down lines of force to produce enhanced concentration at places on each side of the equator, and decreased concentration at the equator itself.

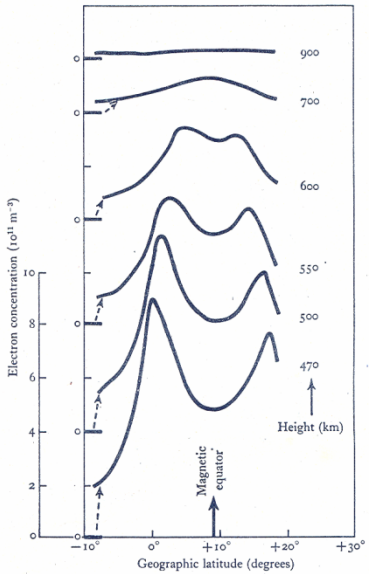
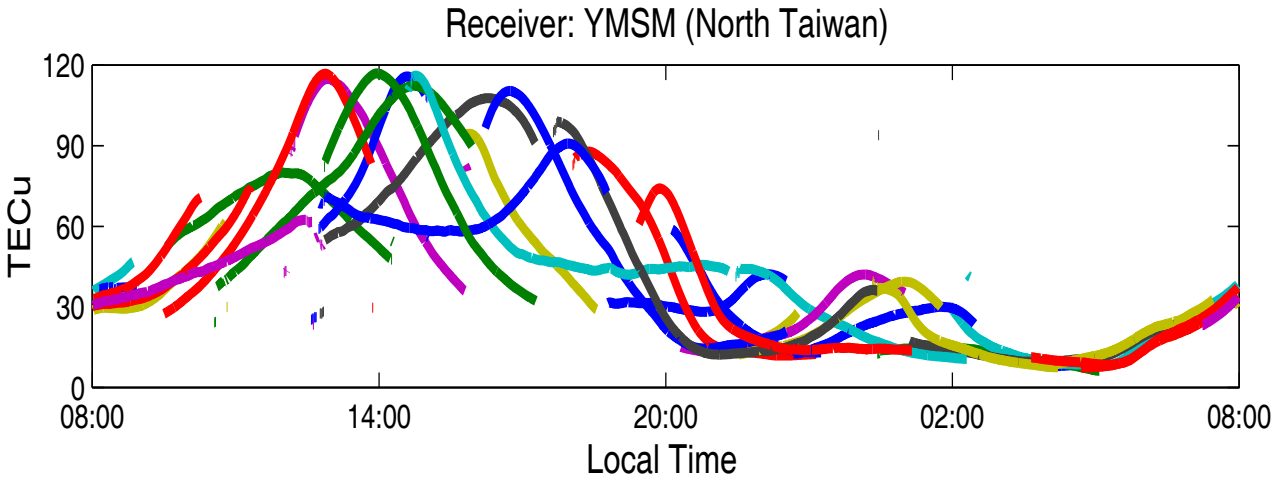
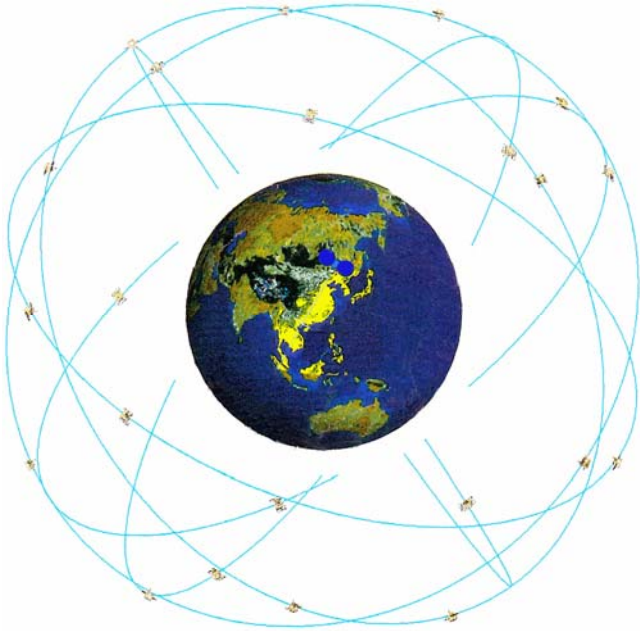


Fig. 3.2. In the daytime topside ionosphere the electron concentration is increased along a geomagnetic line of force that reaches up to a height of about 700 km. When the concentration is plotted, at lower heights, against latitude there is thus a minimum on the magnetic equator and maximum on each side. The maxima are closer together at the greater heights.

Ionospheric total electron content (TEC) derived from GPS





TEC (total electron content)
unit: TECu (10^{16} ele/m^2)

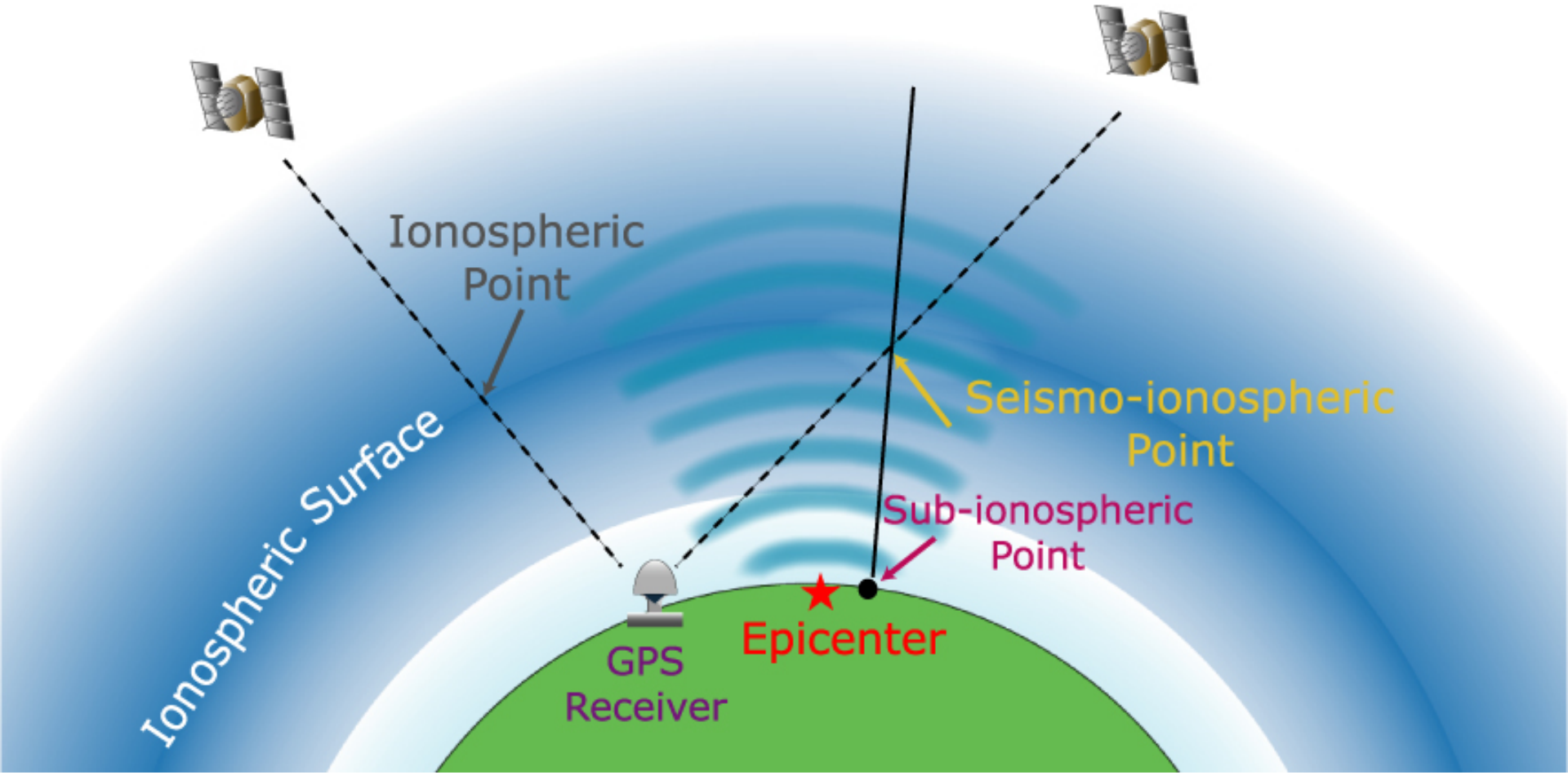
ionosphere

Line-of-sight

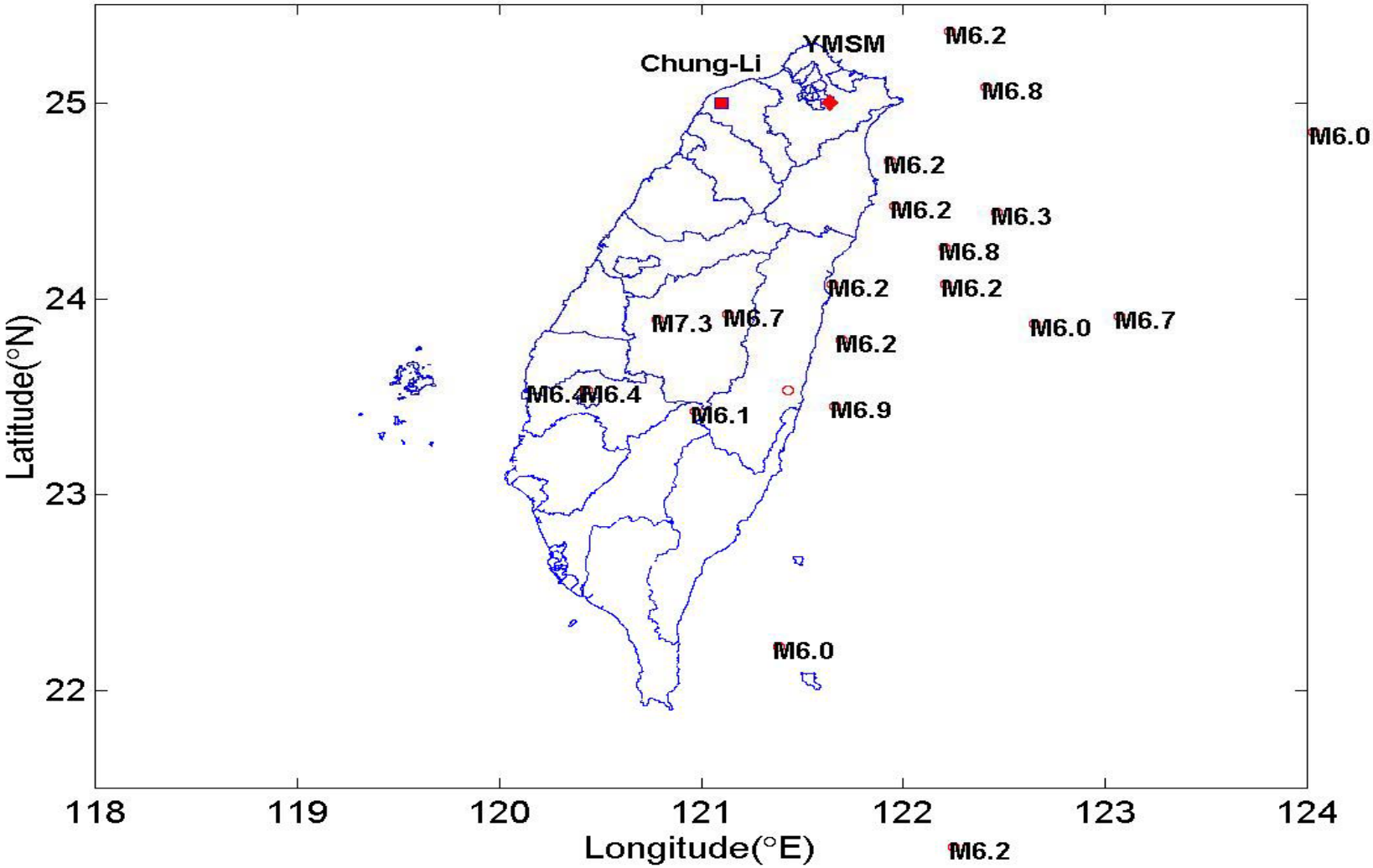
$S_o=[(x^i-x_j)^2+(y^i-y_j)^2+(z^i-z_j)^2]^{1/2}$

(x_j, y_j, z_j)

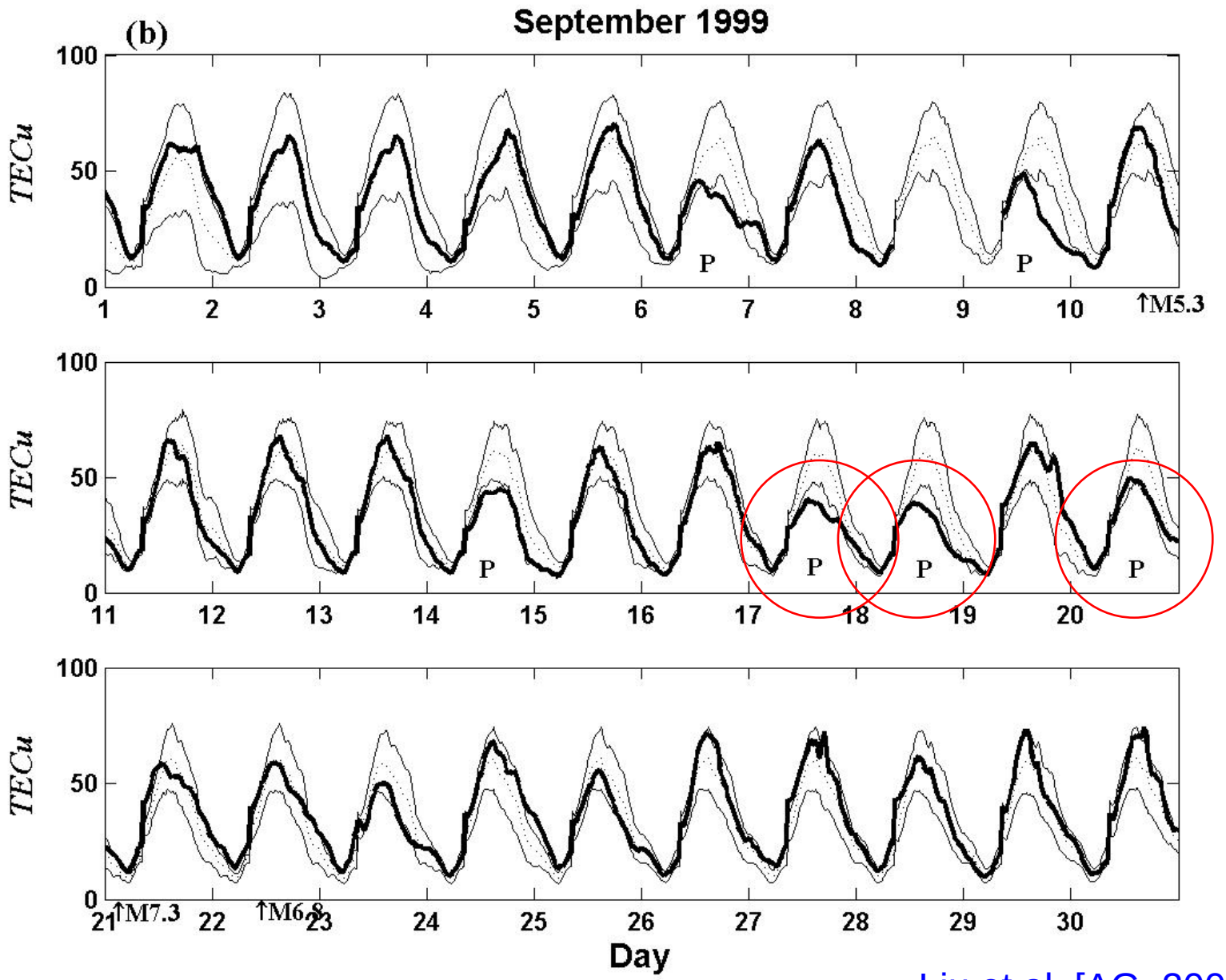
SIP observed by GPS TEC



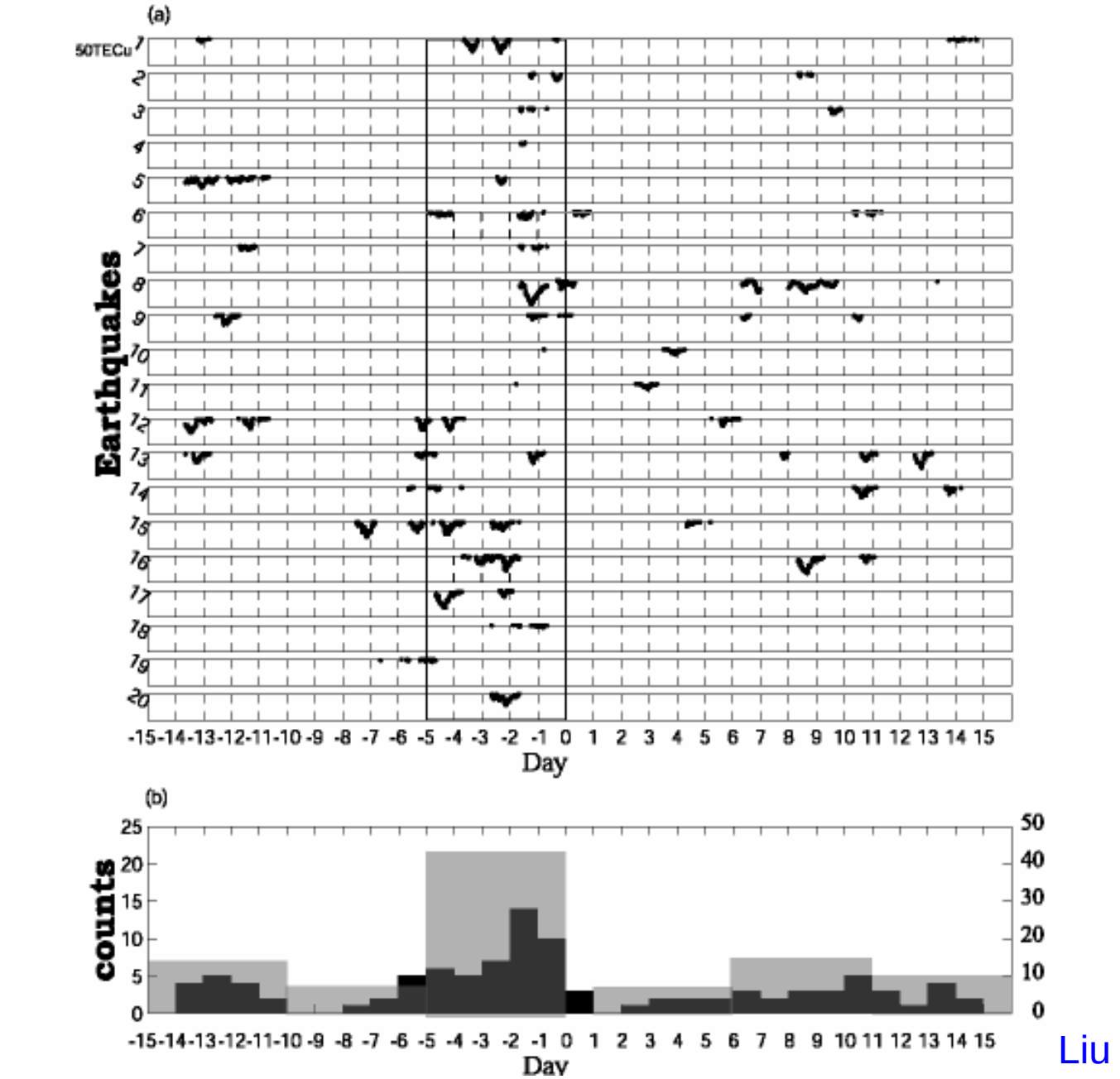
20 M≥6.0 Earthquakes, 9/21 1999-12/31 2002



Liu et al. [AG, 2004]

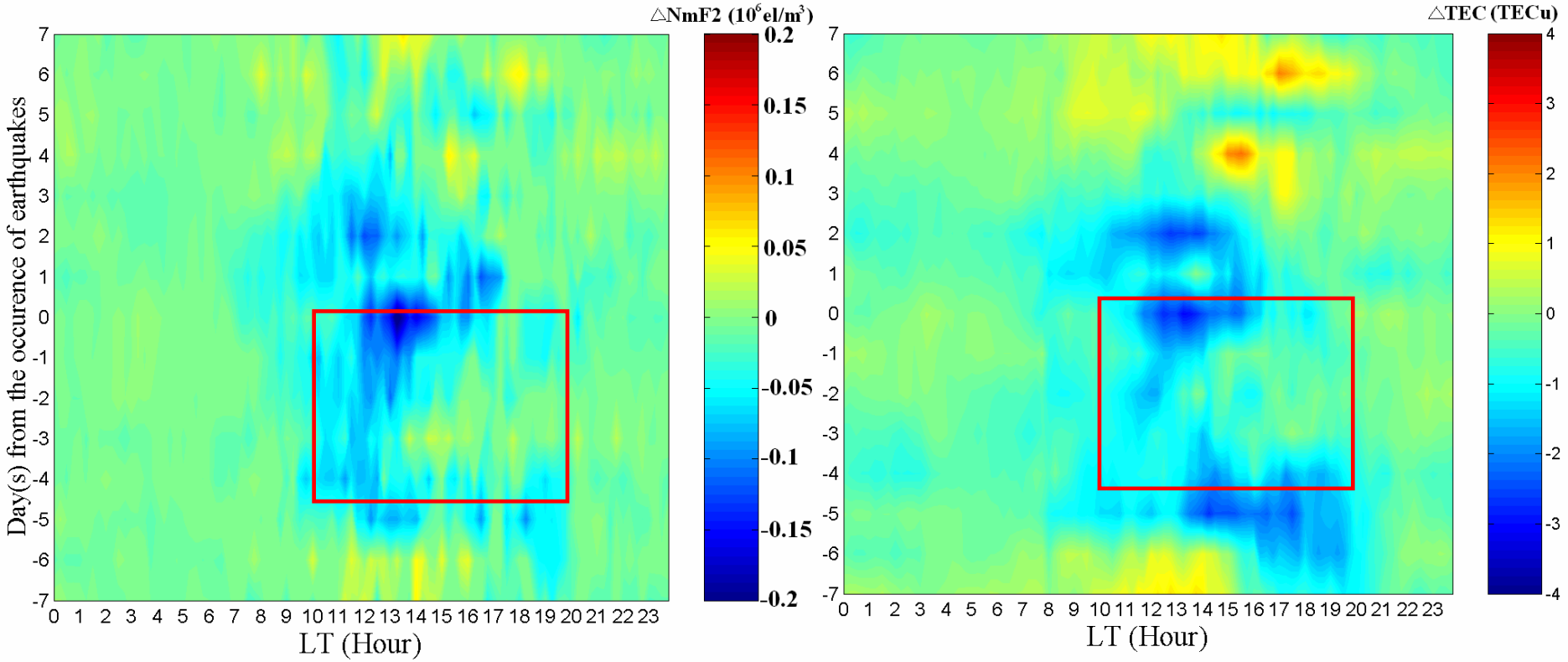


Liu et al. [AG, 2004]

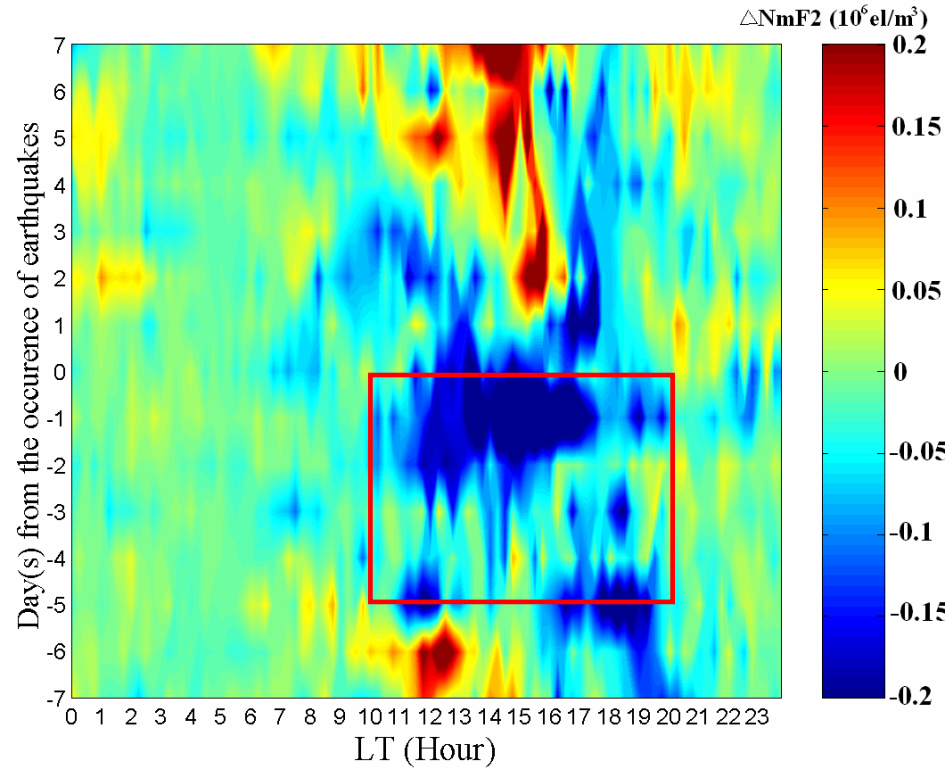


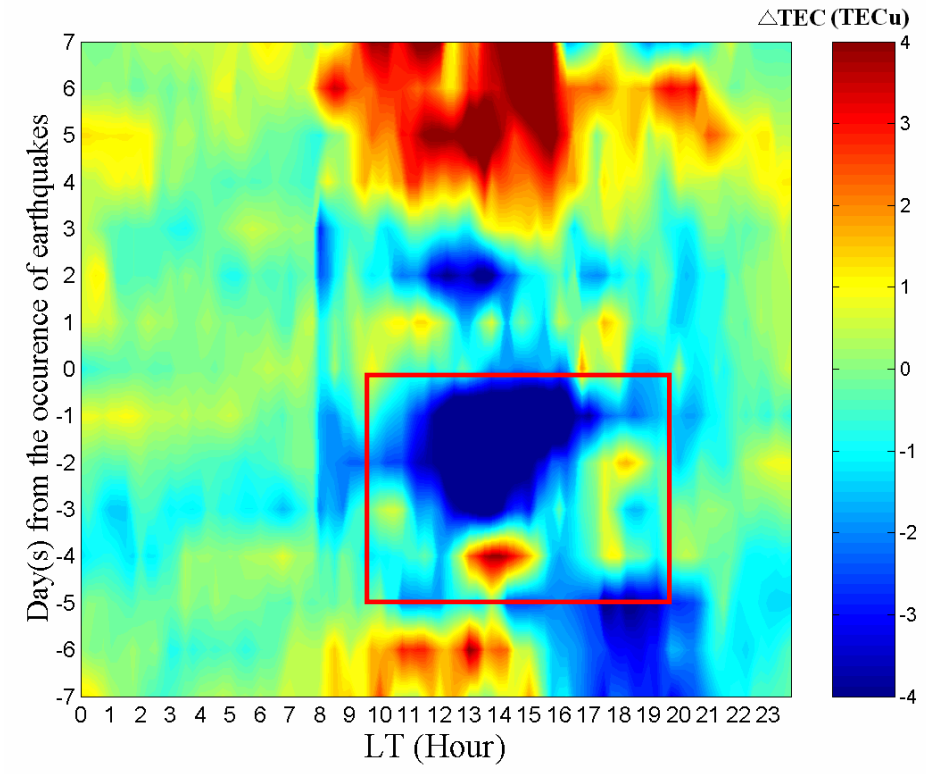
Liu et al. [AG, 2004]

Difference between Observations and the Median of NmF2 and GPSTEC for $M_L \geqq 5.0$ Earthquakes

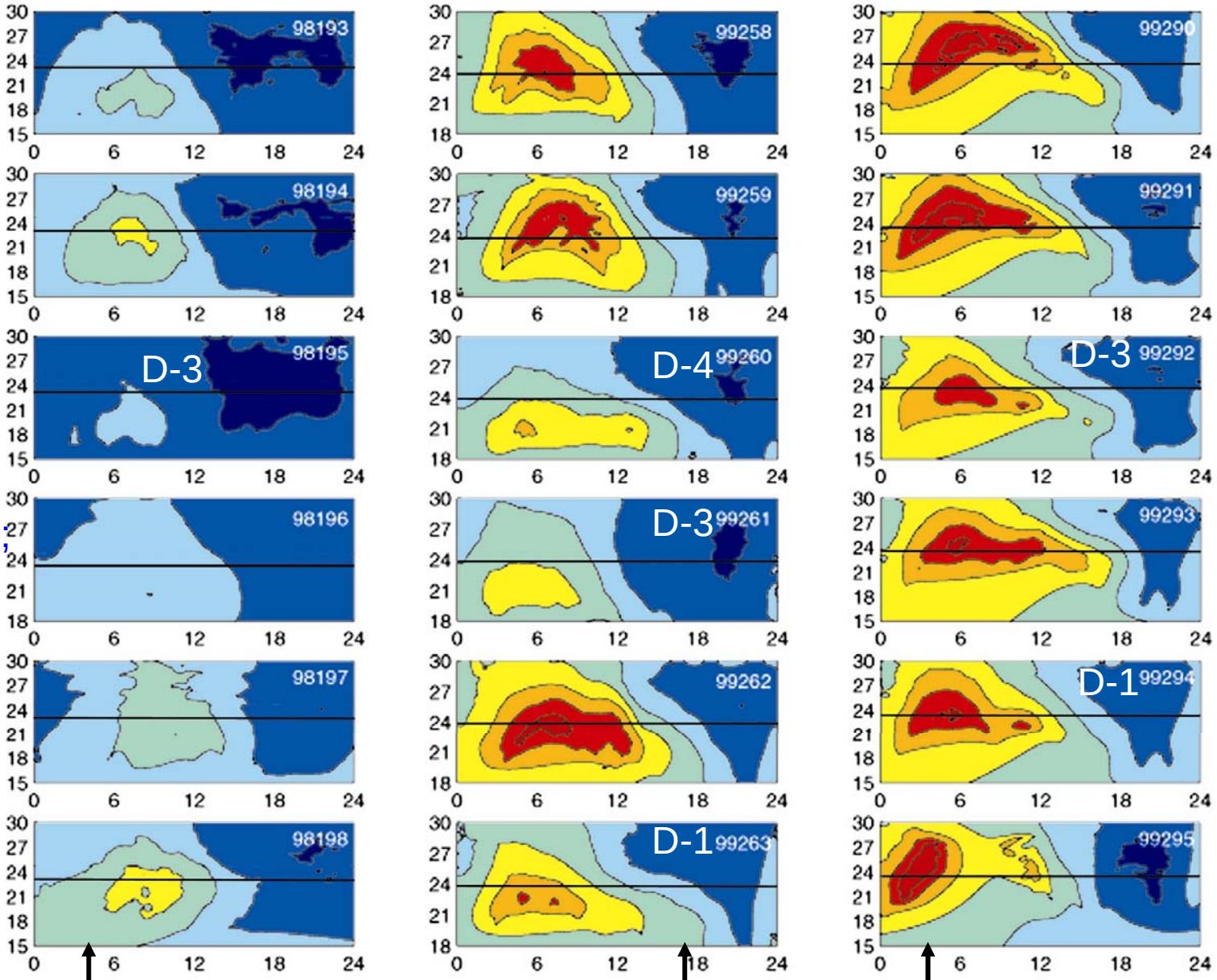


Difference between Observations and the Median of NmF2 and GPSTEC for $M_L \geqq 6.0$ Earthquakes

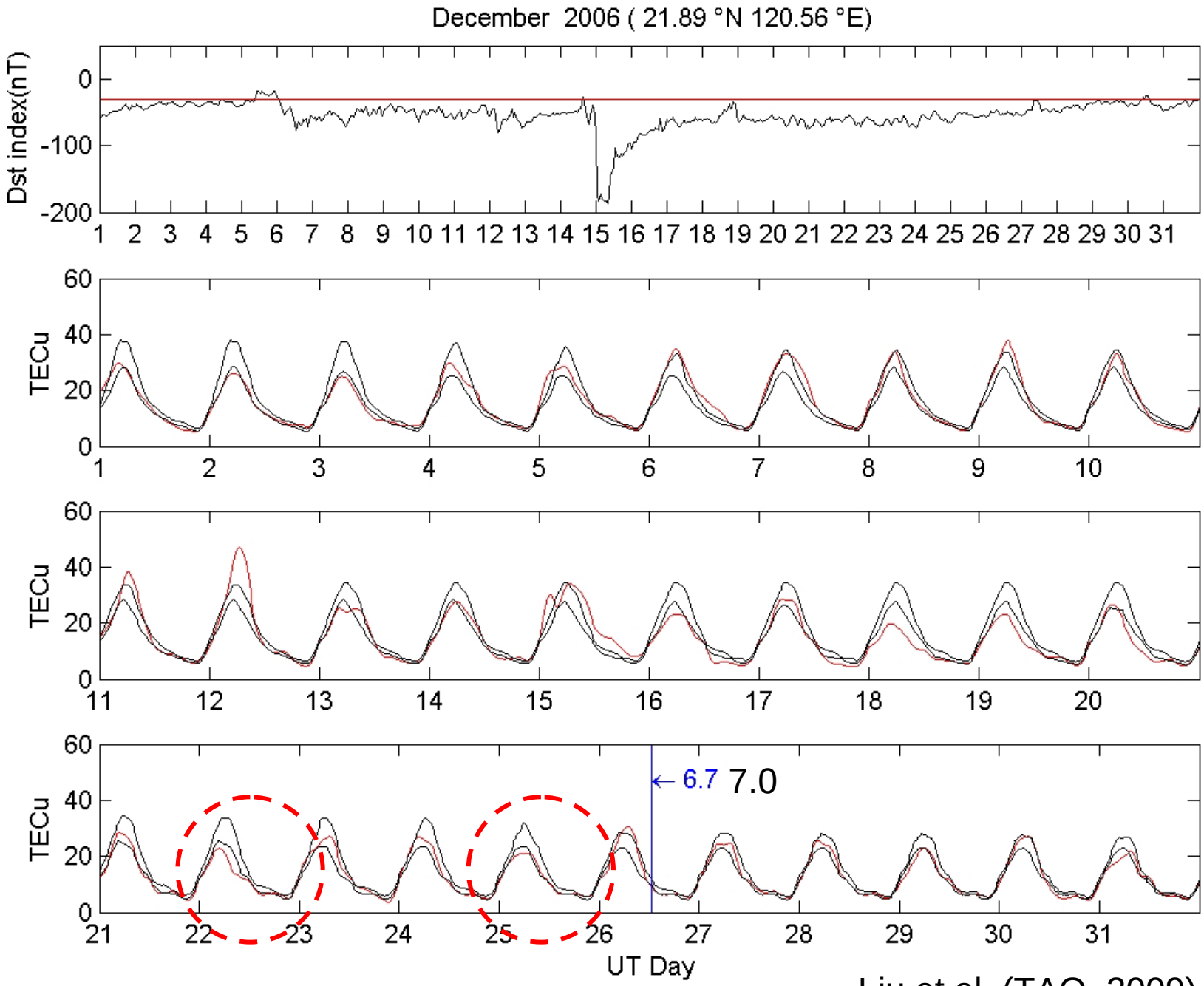




LTT plot

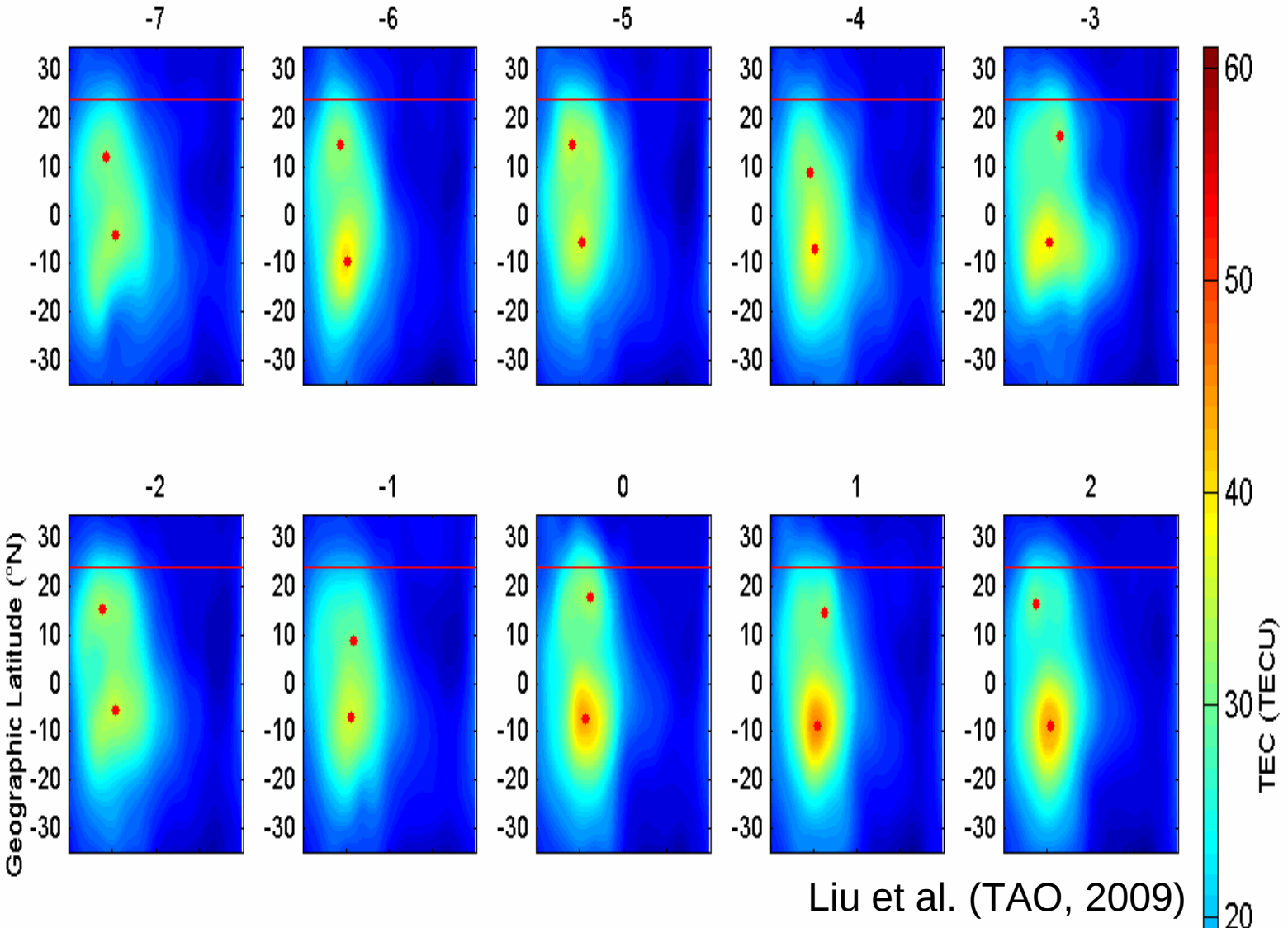


Liu et al. [IWSE,2000; SEM, 2002]



Liu et al. (TAO, 2009)

Seismo-ionospheric precursors of the 26th December 2006 M7.0 Ping-Tung earthquake double



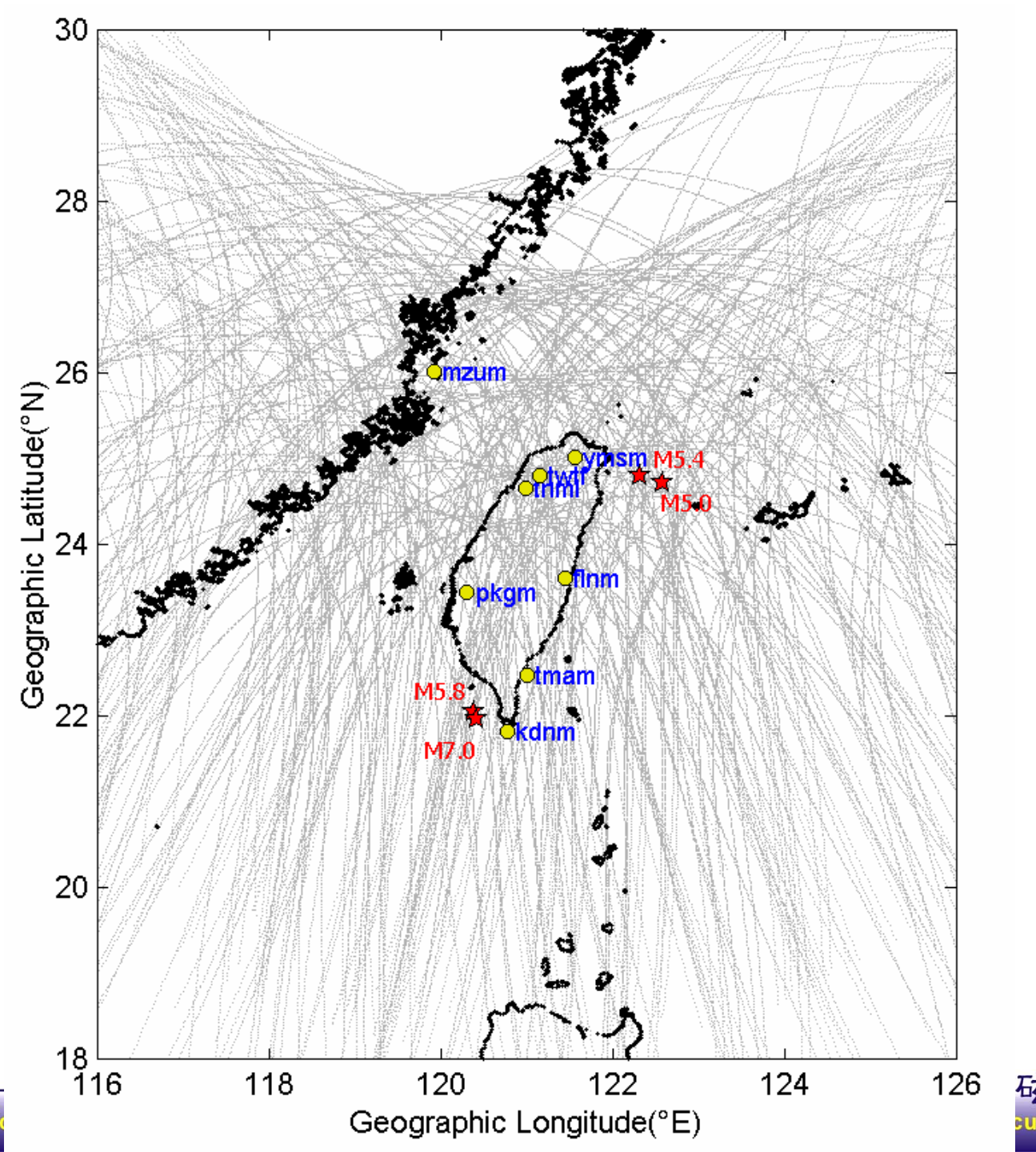
Liu et al. (TAO, 2009)

Summary

- Results demonstrate that GPSTEC significantly decreases in the afternoon to evening period of day1-5 before M≥6.0 earthquakes in Taiwan.
- The crest of equatorial ionization anomaly (EIA) reduces and/or moves equatorward during the SIP appearance.

Observation and Analysis

- 150 M≧5.0 earthquakes in the Taiwan area during 2001-2007.
- A 15-day running median of the three parameters and the associated upper and lower quartiles are utilized as the references for identifying abnormal signals.
- A z-test confirmation.


30
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120
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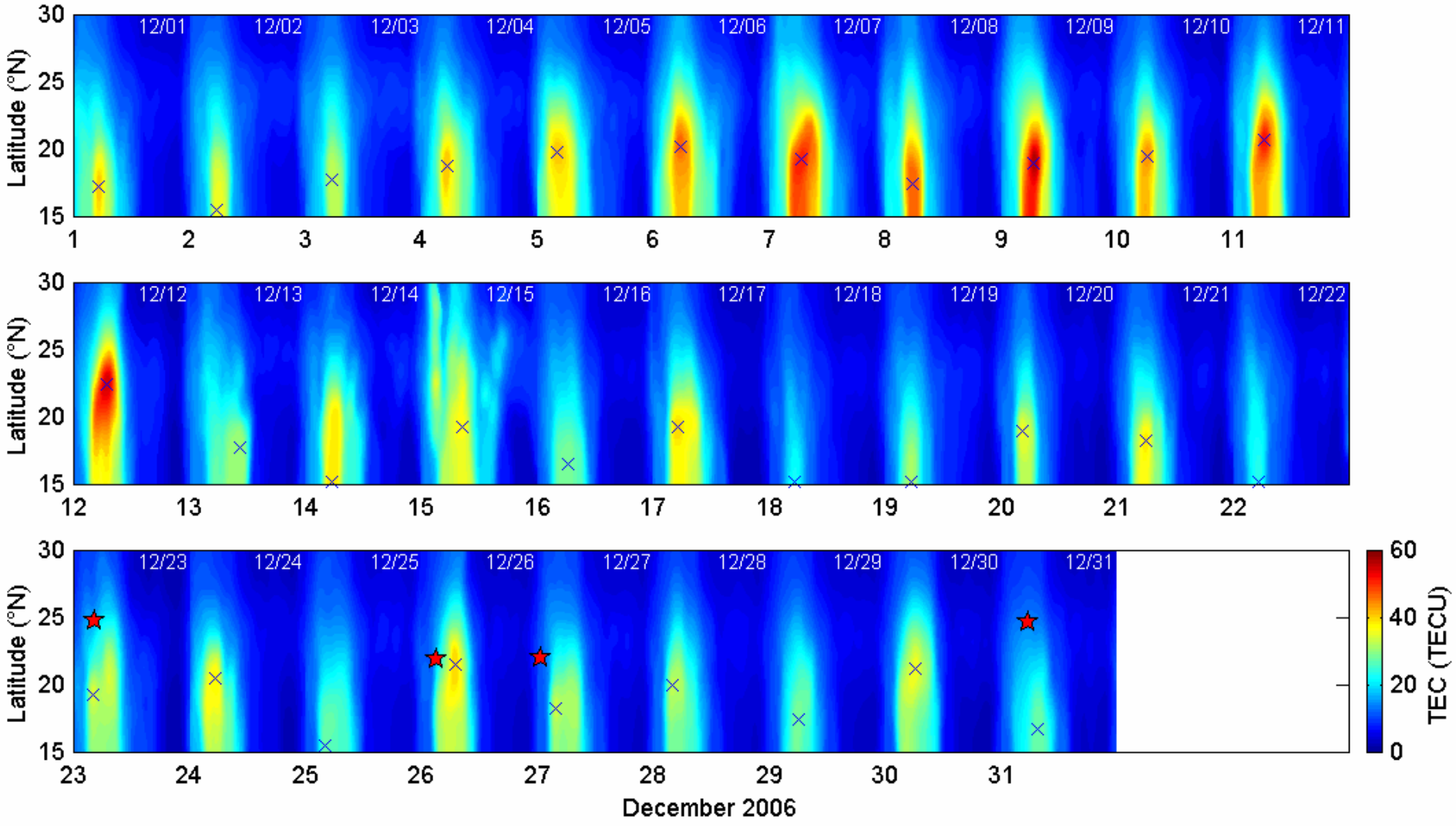
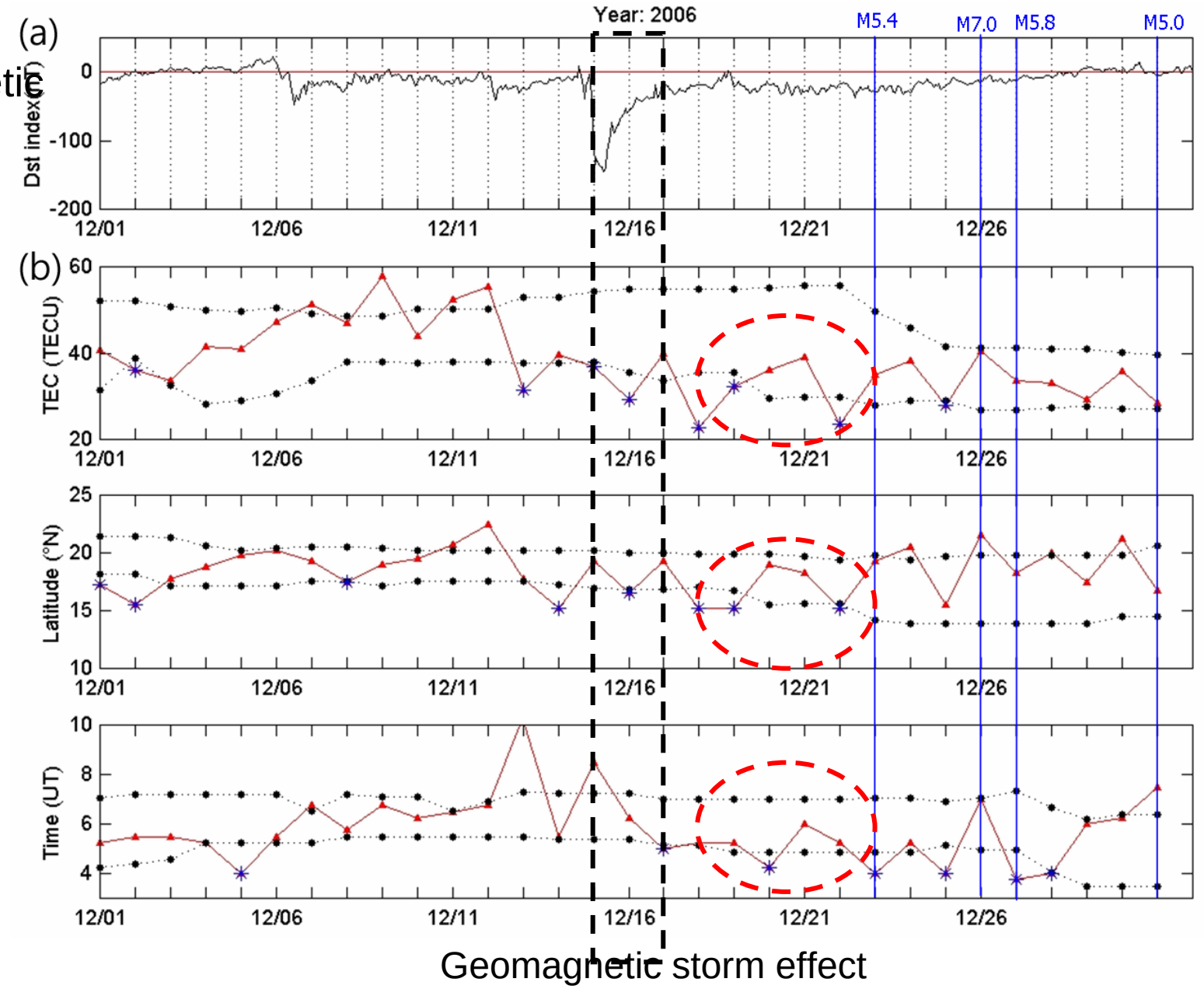
124
126
Geographic Latitude(°N)
Geographic Longitude(°E)
mzum
ynsm
M5.4
fwtf
tnml
M5.0
flnm
pkgm
tmam
M5.8
kdnm
M7.0



Latitude, Time, and TEC plots along 120°E longitude sector in December 2006.



Geomagnetic index

Strength

Latitude

Time

Daily EIA crest strength, latitude, and time in December 2006.

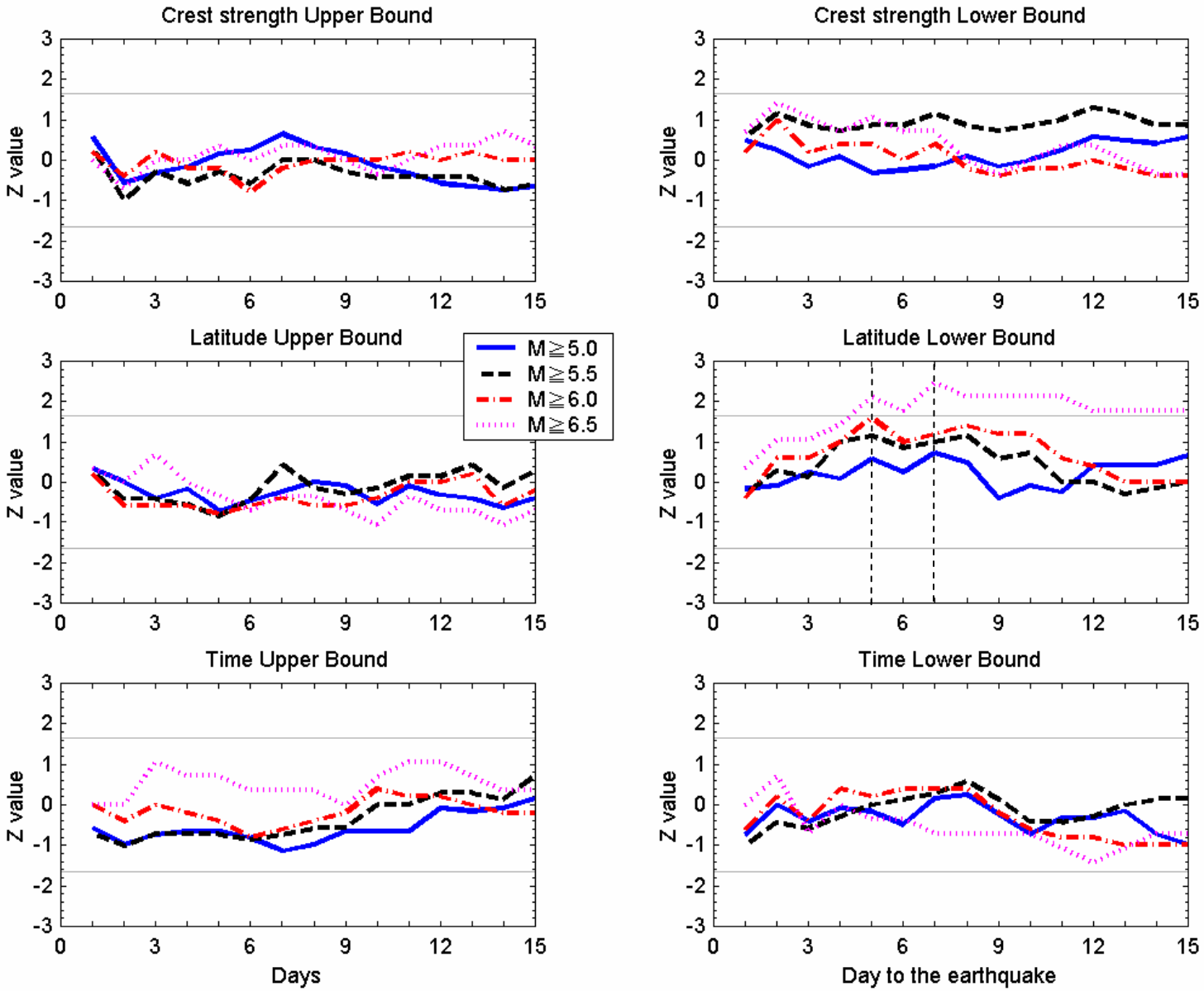
z-test

- The test concerning the proportion is based on the standardized test statistic (Neter et al., 1988),

$$z = \frac{p - 0.5}{\sqrt{\frac{0.5(1-0.5)}{n}}}$$

- where *n* is a sample size. Under the 5% level of significance of the test, if $z \geqq 1.645$, *p* is then considered to be very different from the normal level 0.5, which means that appearances of the anomaly before and after the earthquakes are significantly different, and in turn, suggests existence of the earthquake anomaly.

Z test of the strength, location and time of the GPSTEC crest

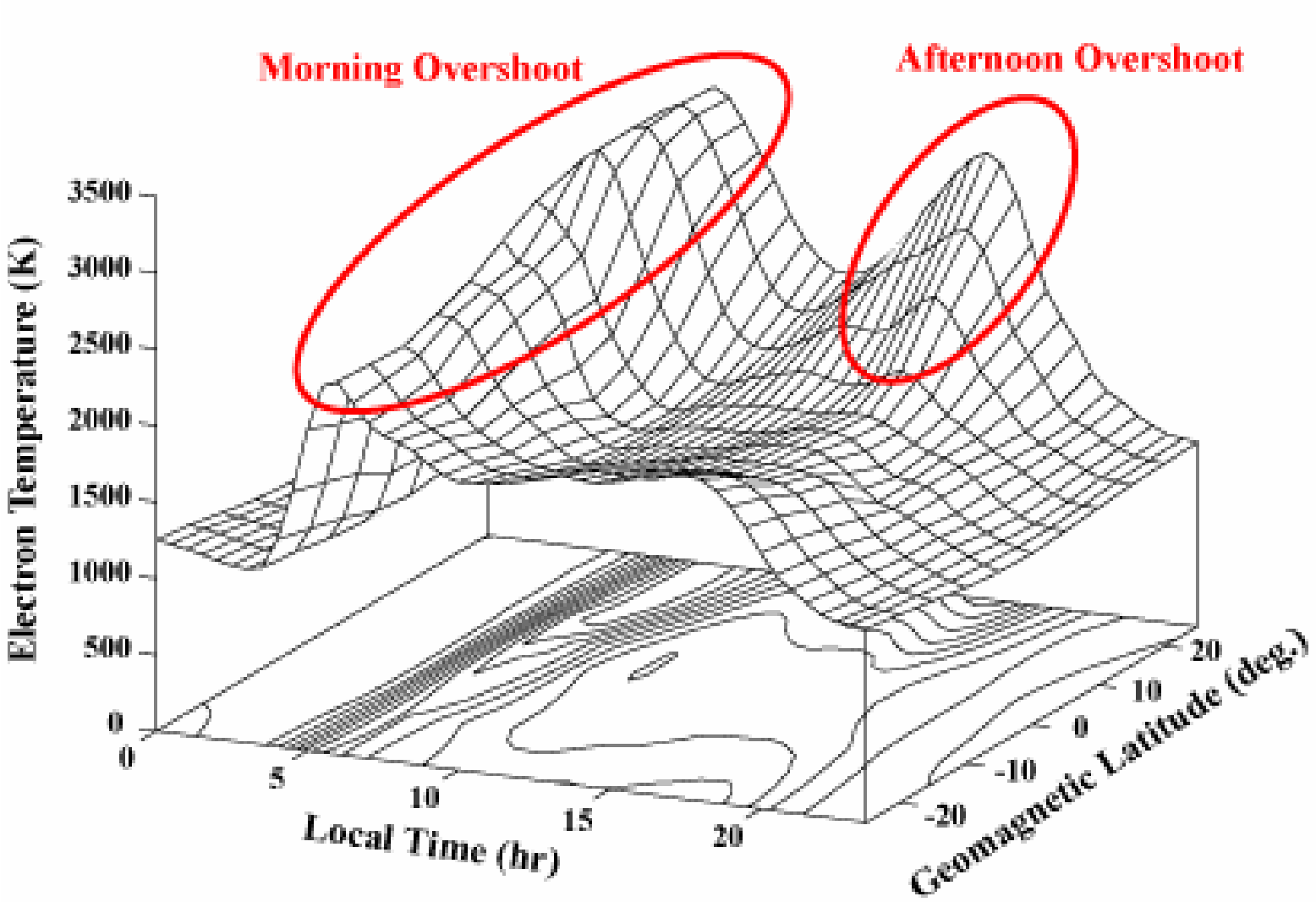


Reduction of electron temperature in low latitude ionosphere at 600km before and after large earthquakes

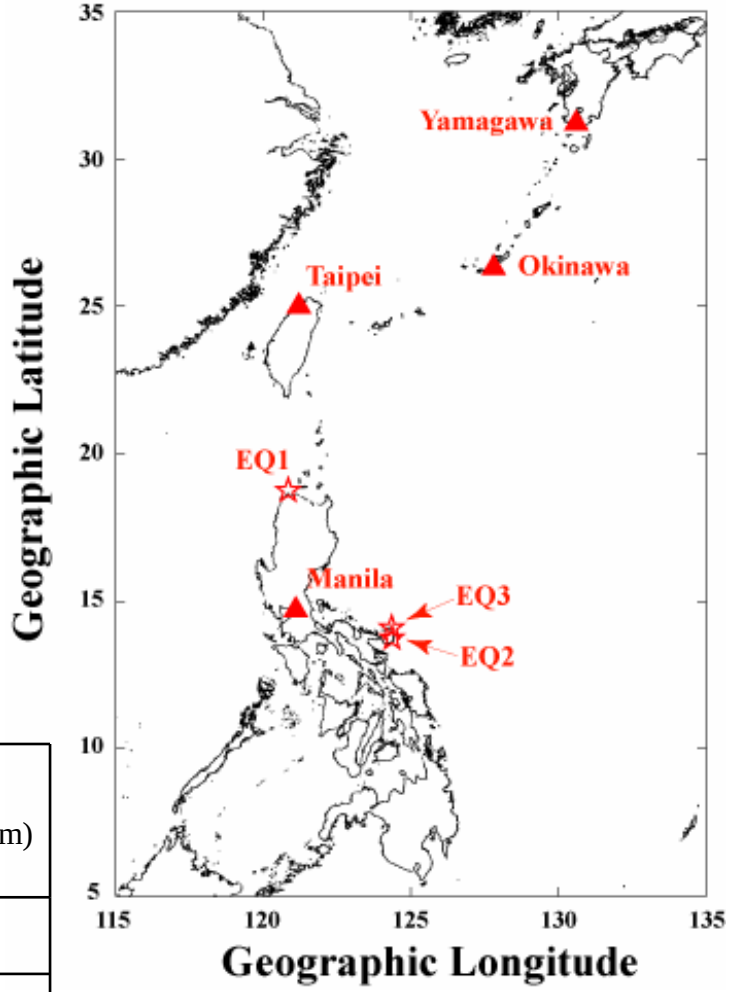
Japanese Sun Observation satellite HINOTORI

An equatorial orbit at the height of 600 km

February 1981



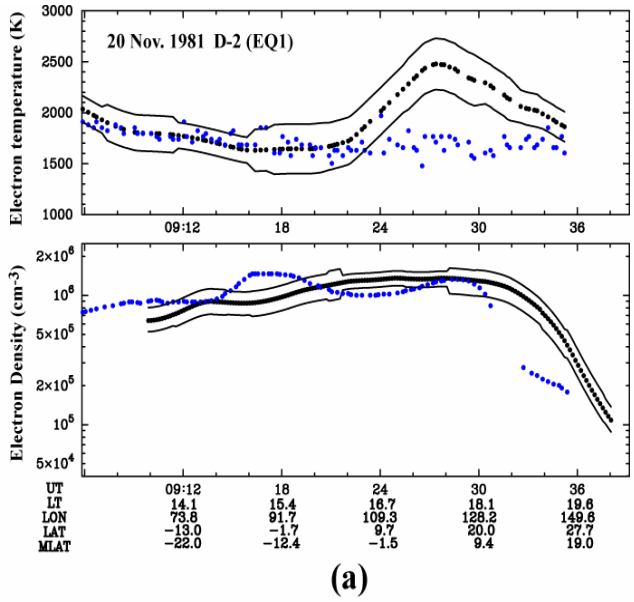
Oyama et al. (JGR, 2008)

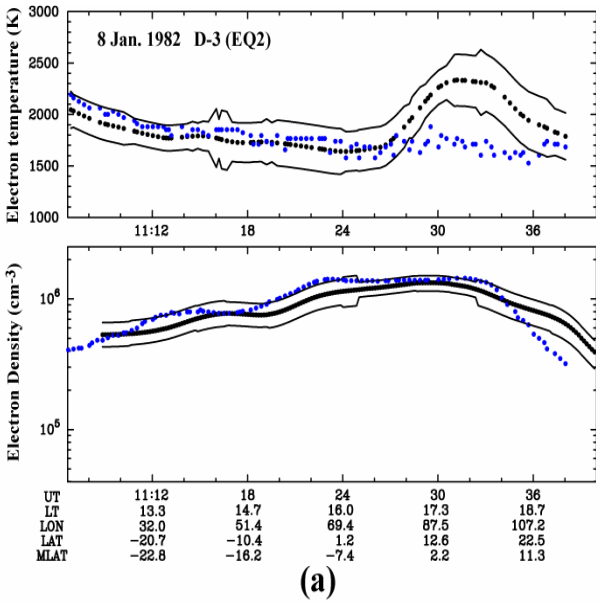


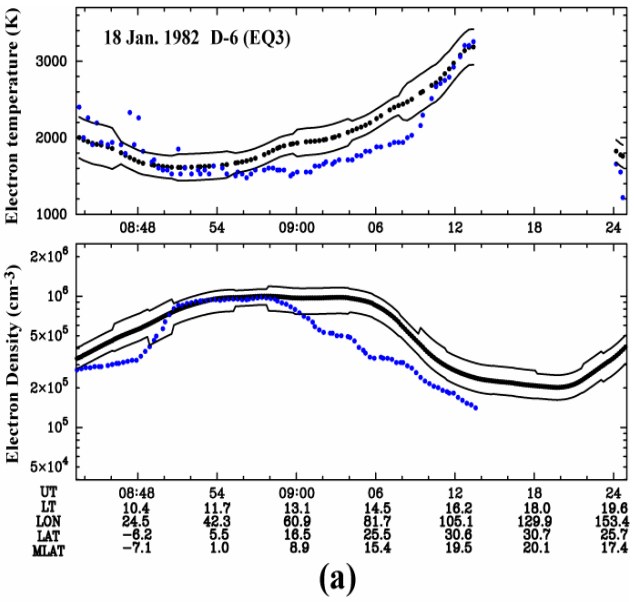
	Date	Longitude	Latitude	Magnitude	Depth (km)
EQ1	22 Nov. 1981 15:05	120.8 E	18.8 N	6.7	24
EQ2	11 Jan. 1982 6:10	124.4 E	13.8 N	7.4	45
EQ3	24 Jan. 1981 6:08	124.3 E	14.1 N	6.6	37

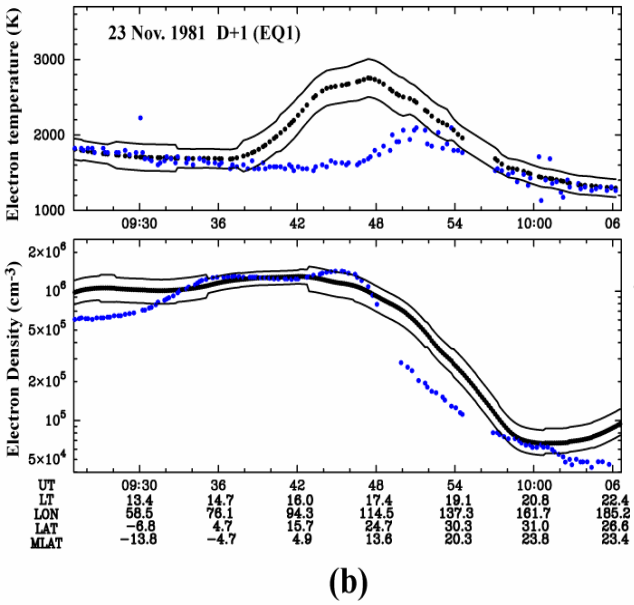
Oyama et al. (JGR, 2008)

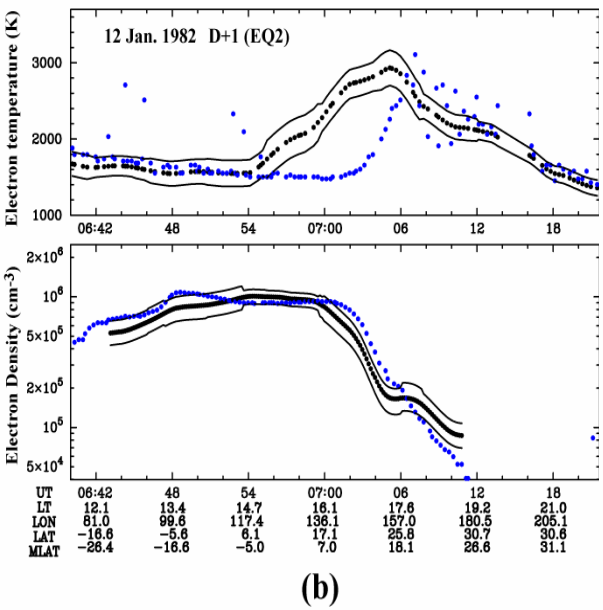
Oyama et al. (JGR, 2008)

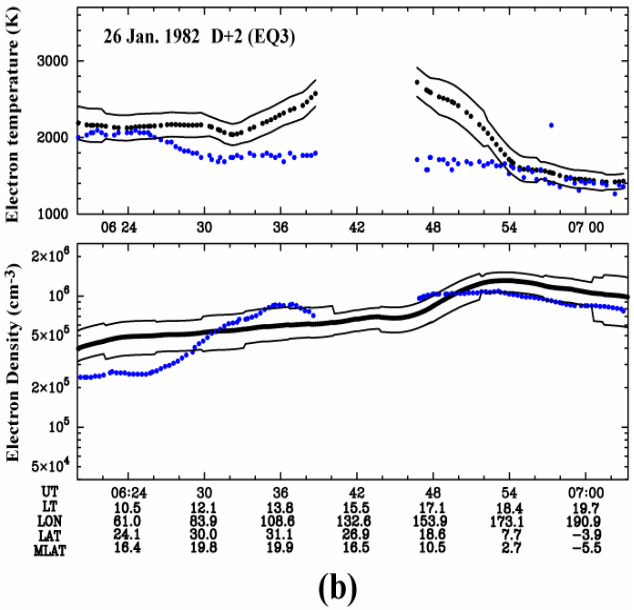


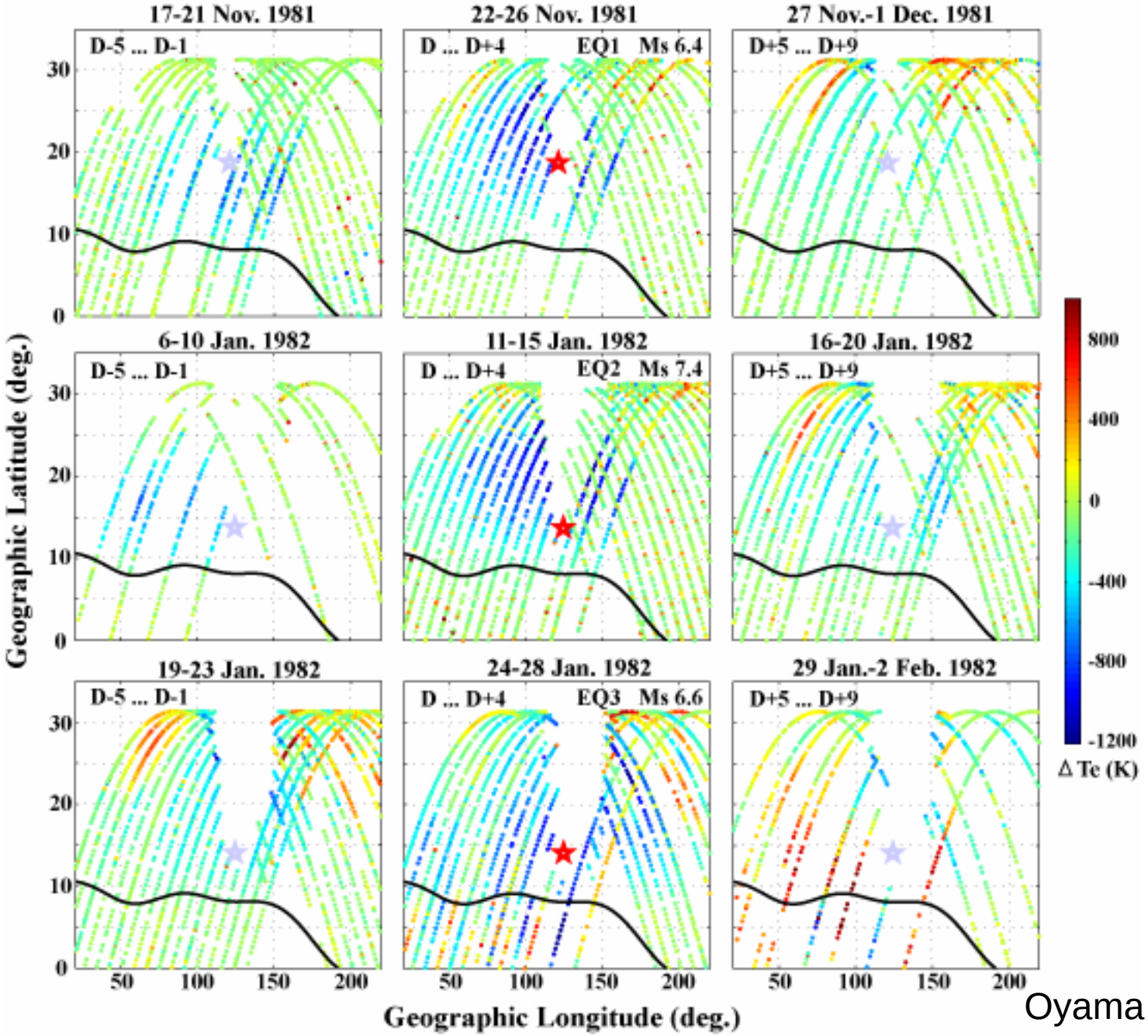




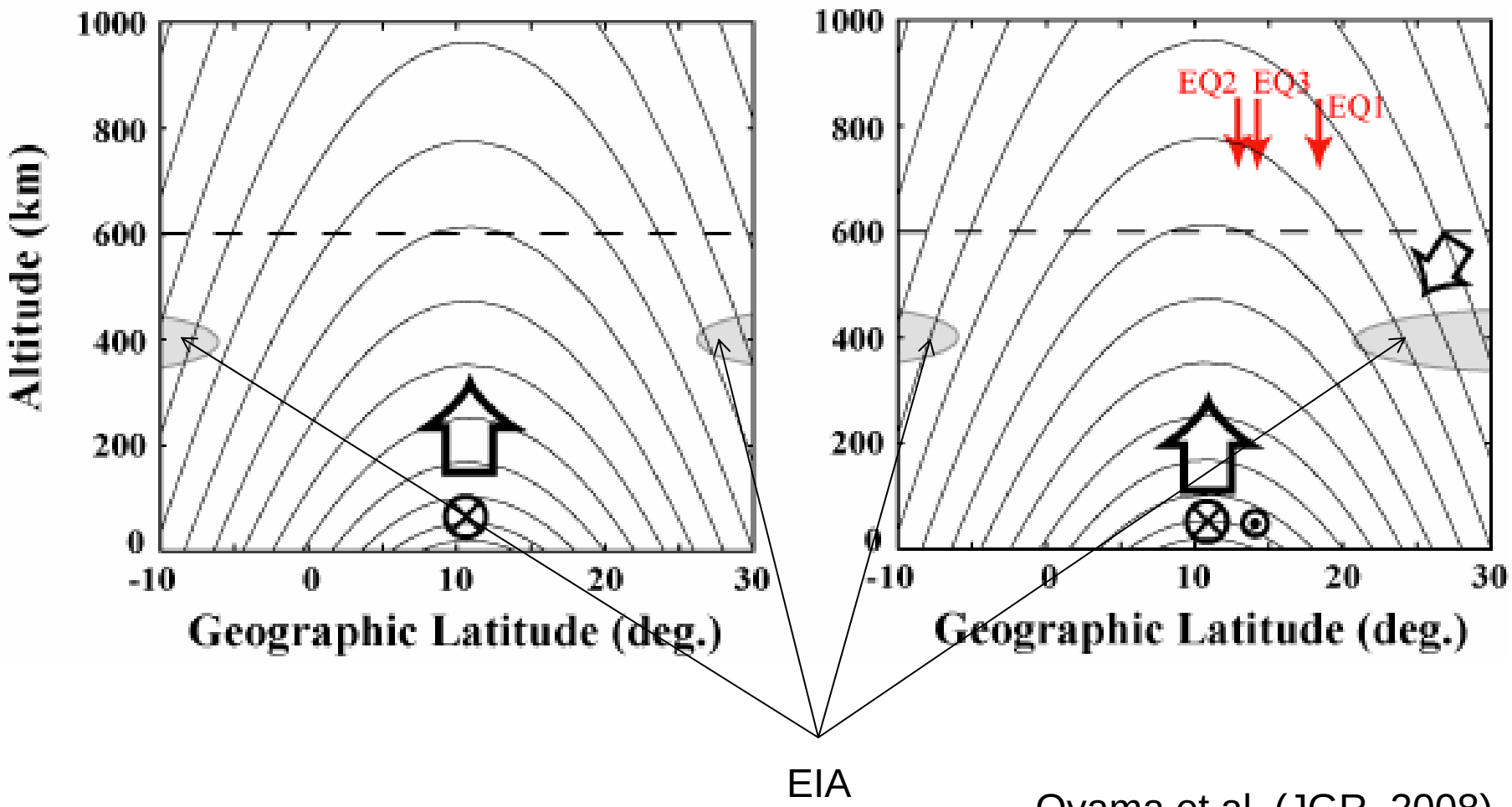








Oyama et al. (JGR, 2008)



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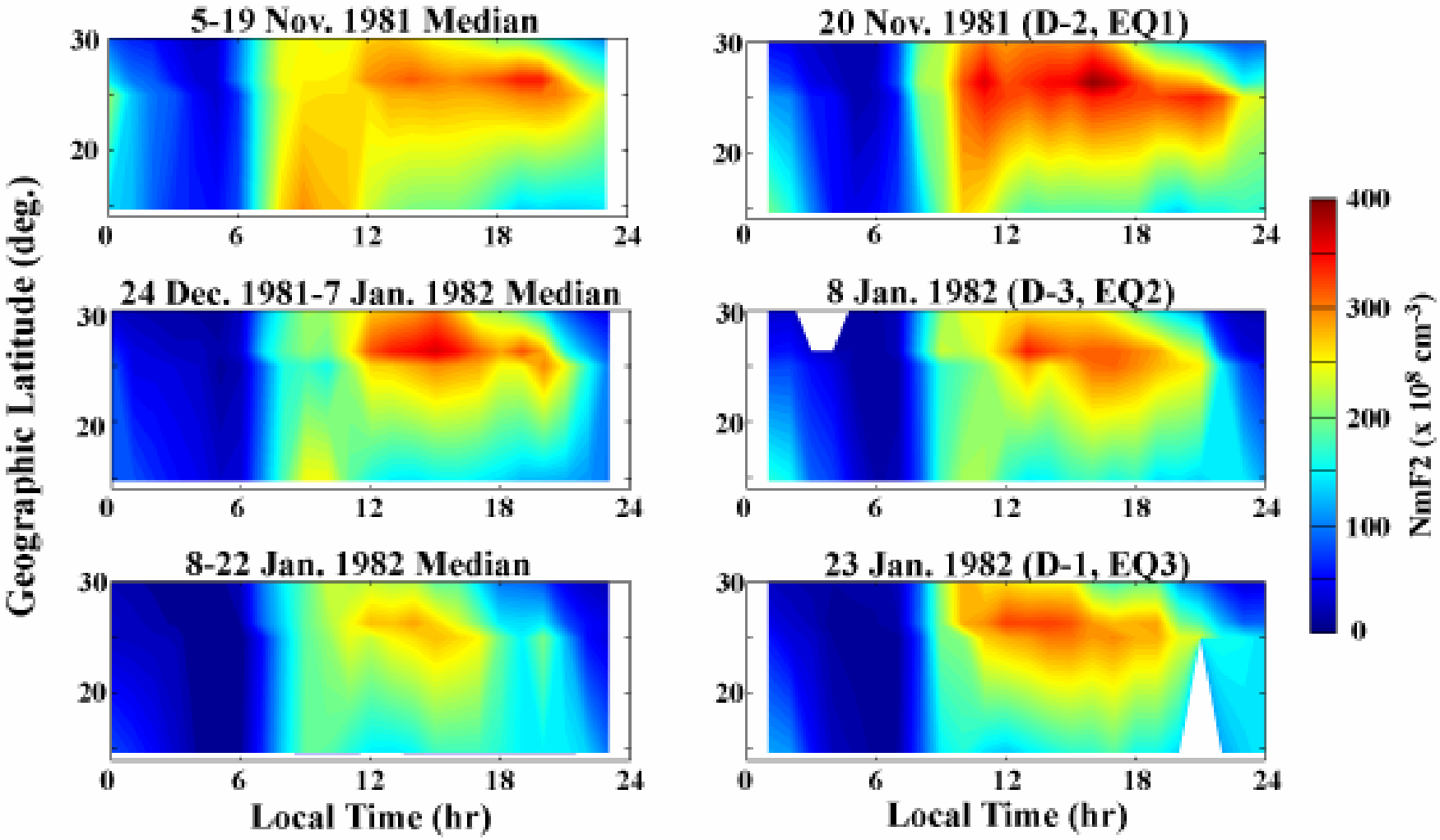
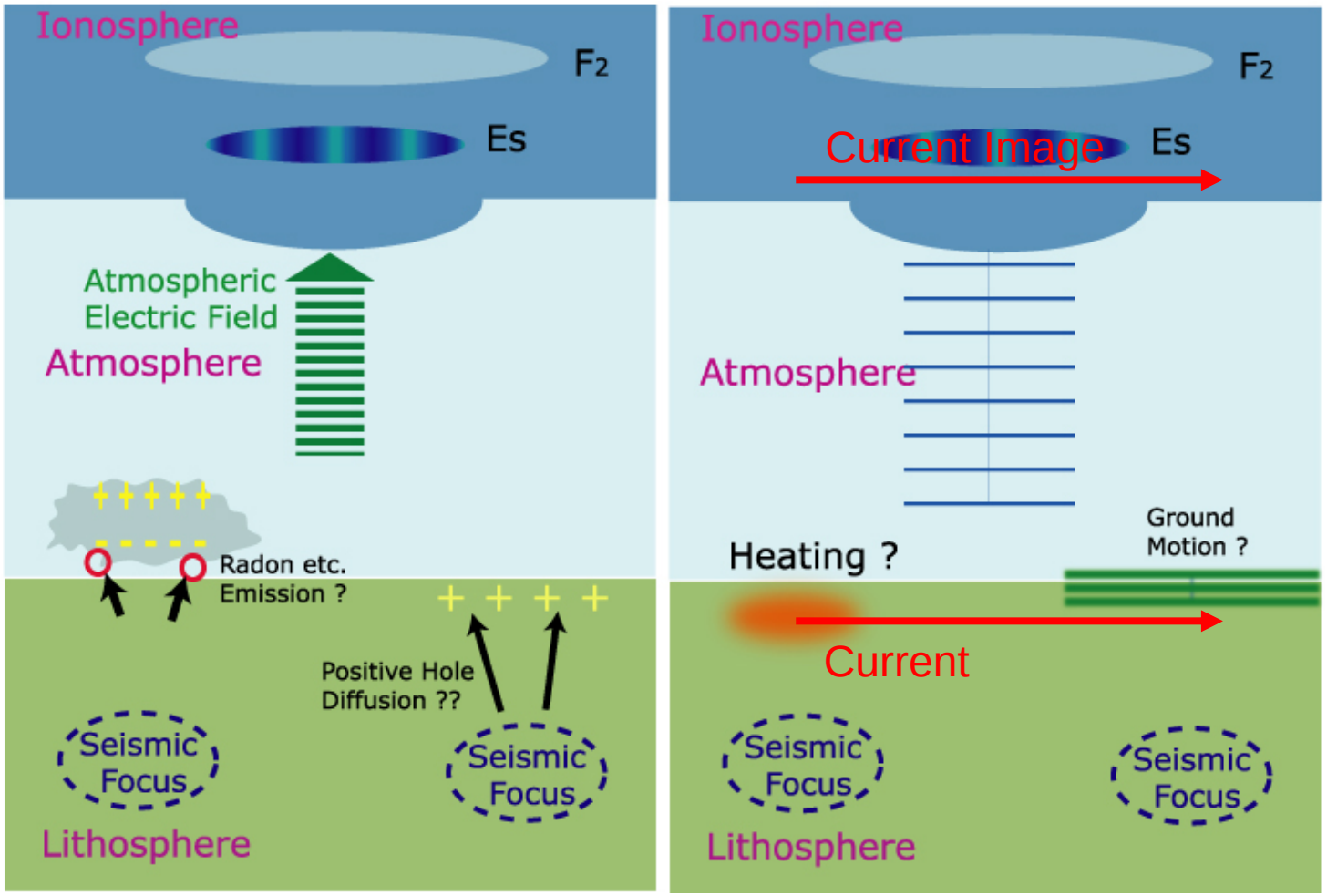


Oyama et al. (JGR, 2008)

Mechanisms of Seismo-Ionospheric Precursors



Conclusion

- The EIA crest strength tends to but not significantly decrease before the earthquakes.
- There is no significant change in the appearance time of the EIA during the earthquakes.
- The EIA crest significantly moves equatorward 4-7 days before the earthquakes.
- It is found that T_e around the epicenters significantly decreases in the afternoon periods within 5 days before and after the three earthquakes.
- The equatorward EIA crest might block the photo electrons generated at the lower ionosphere which results in the decreased T_e observed during the earthquakes.

敬請批評指教 Thank you!!!