Seismo-ionospheric GPS TEC anomalies before and after earthquakes中

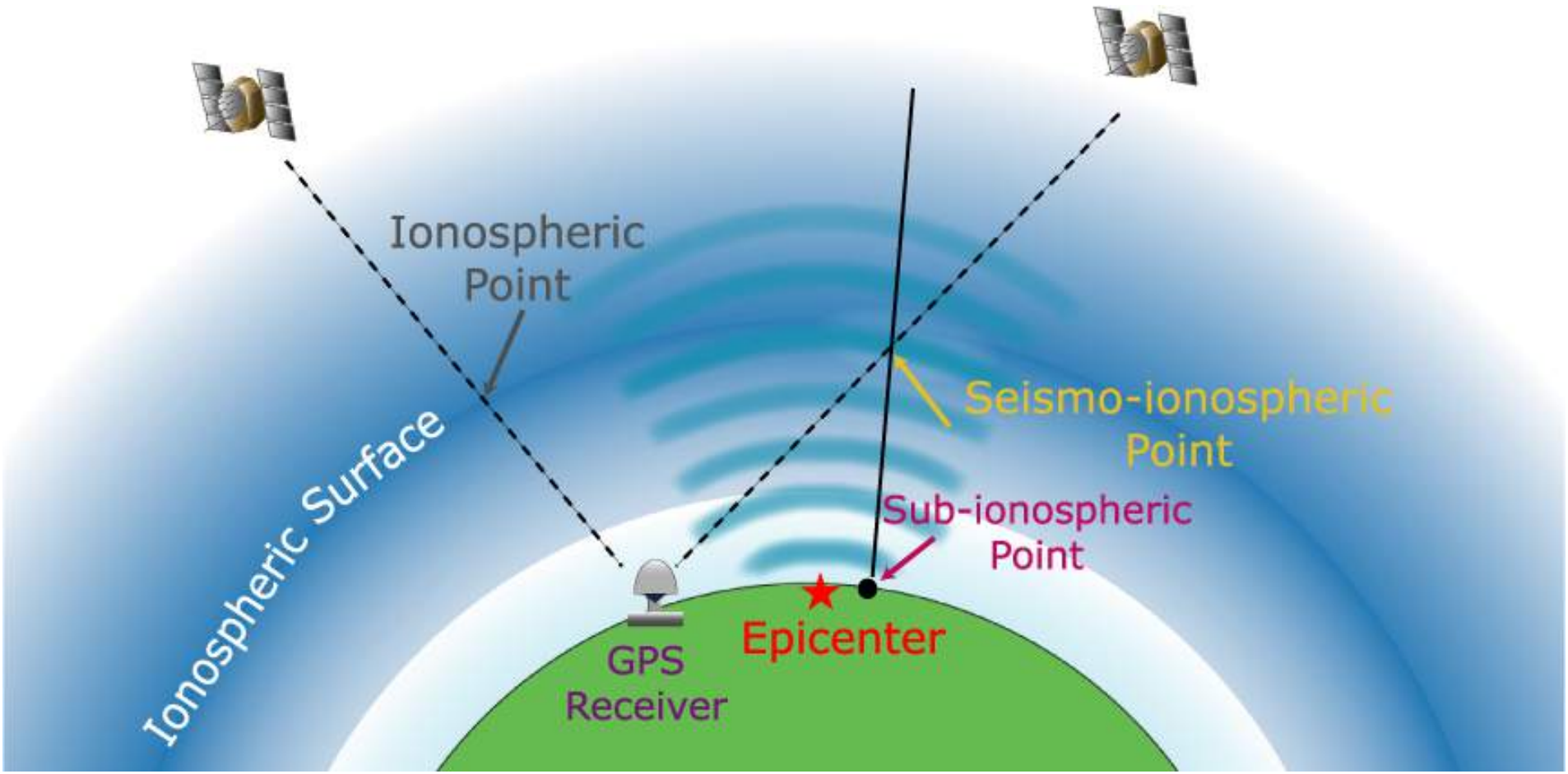
Tiger J. Y. Liu

jyliu@jupiter.ss.ncu.edu.tw 中
National Central University, Jhongli City, TAIWAN

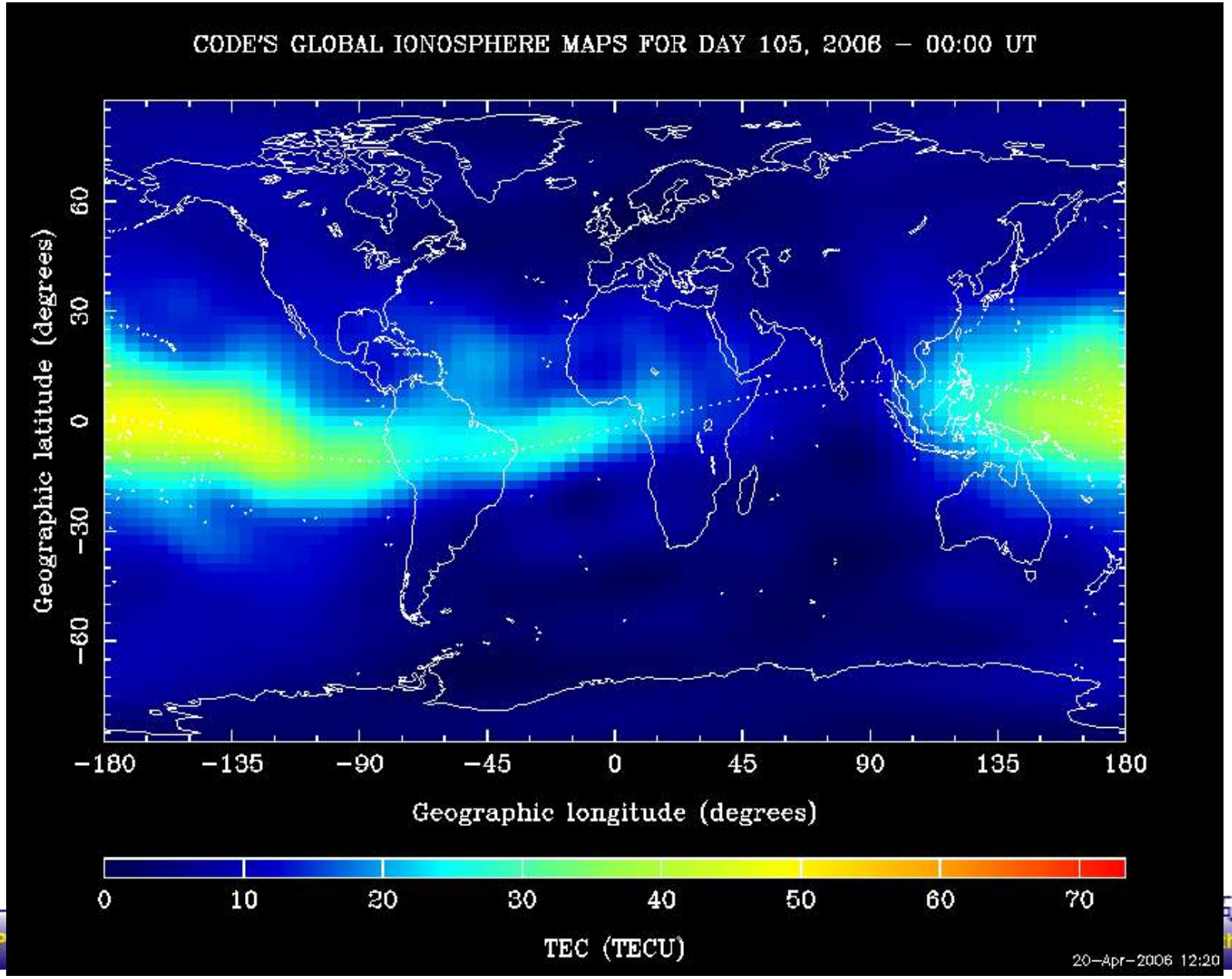
Content中

- Introduction
  - temporal Precursor
  - Spatial Precursor
- Haiti Earthquake
  - Observation
  - Simulation
- Seismo-Traveling Ionospheric Disturbance
- Conclusion中

Introduction



Global Ionospheric Map中

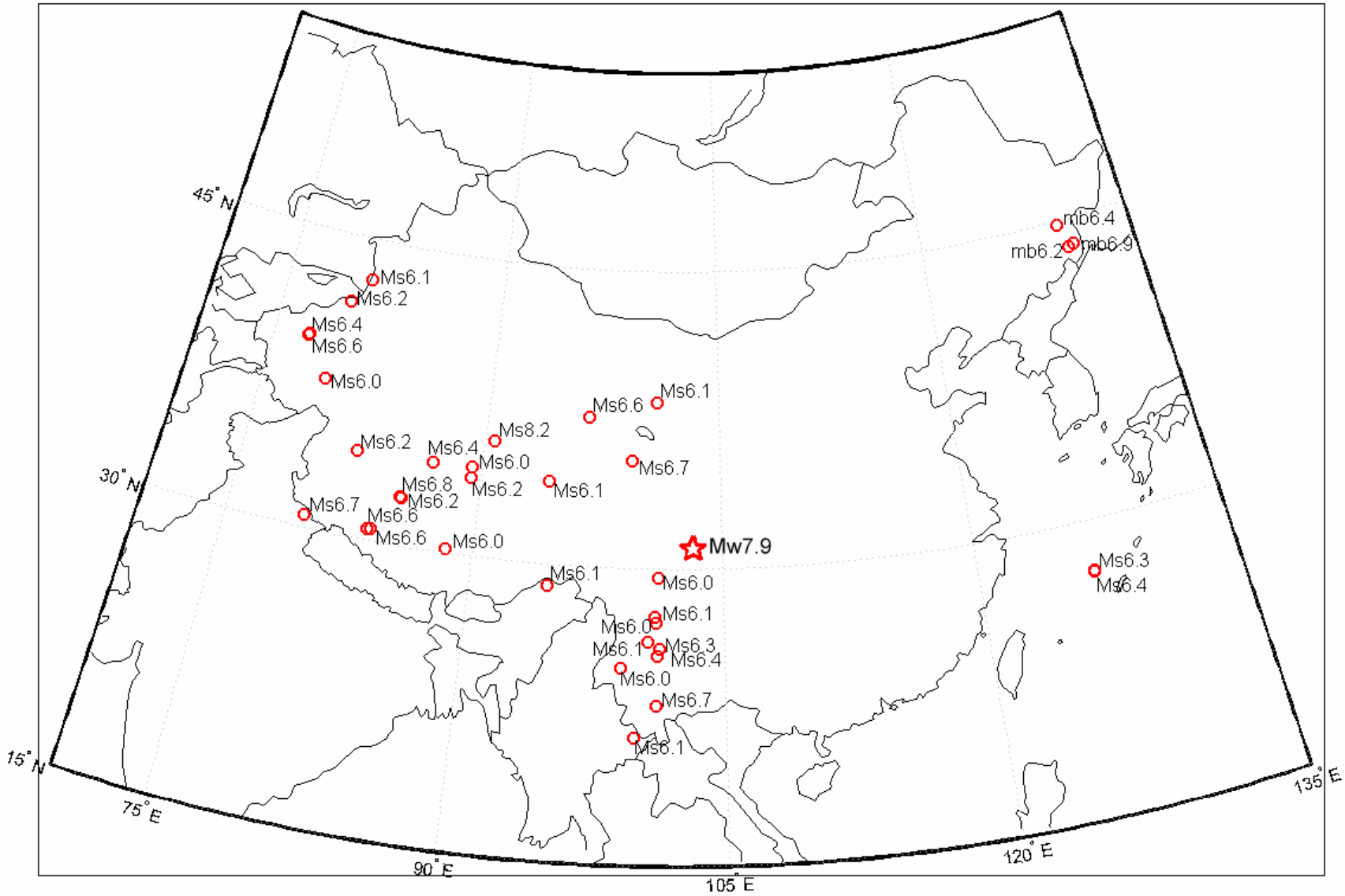


Temporal Precursor

1998/05/01~2008/05/12　36 M≧6.0 earthquakes in China

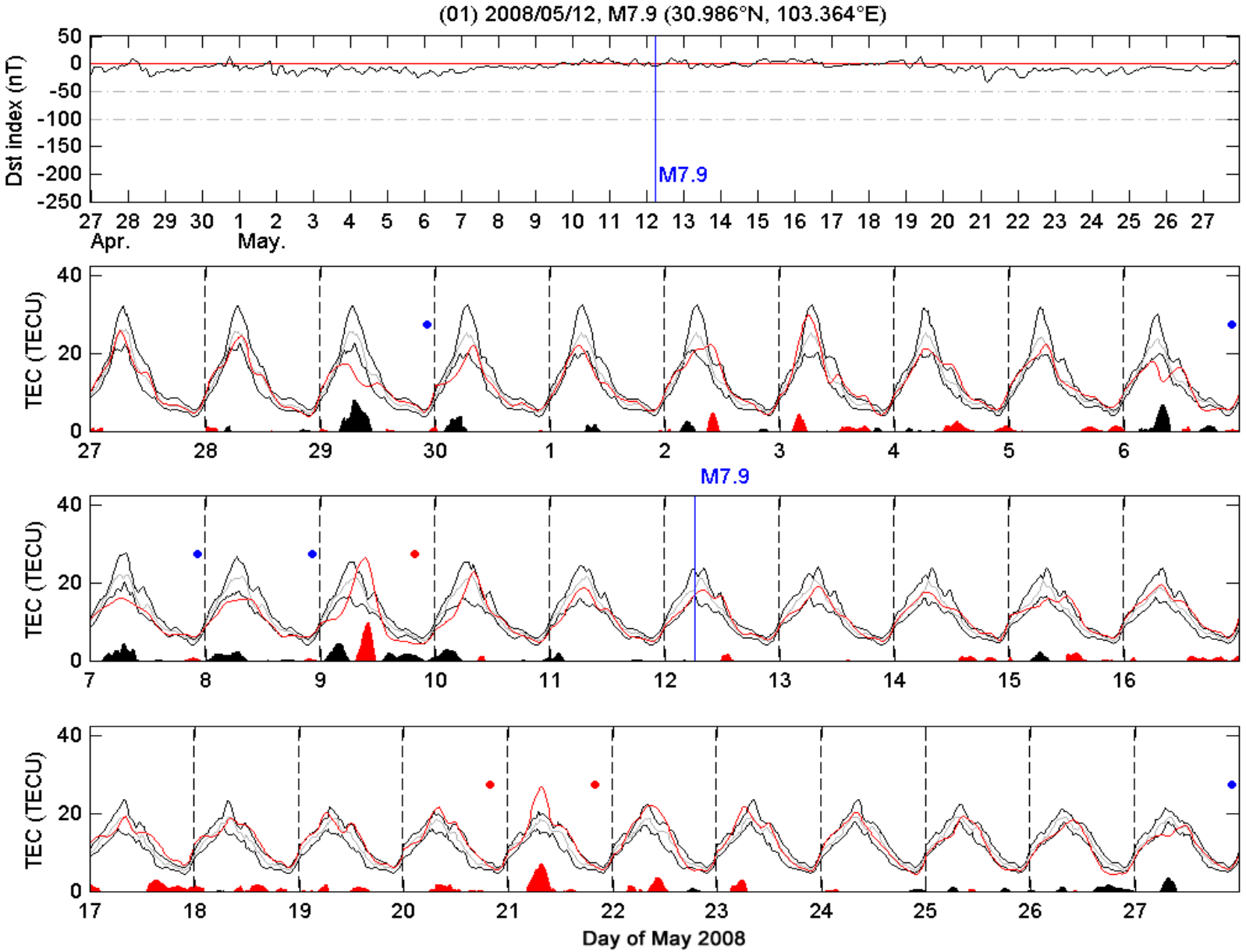
2008/5/12 M7.9 Wenchuan Earthquake

Locations of the 35M≥6.0 earthquakes together with Wenchuan earthquake occurred in China during May 1, 1998-May 12, 2008.

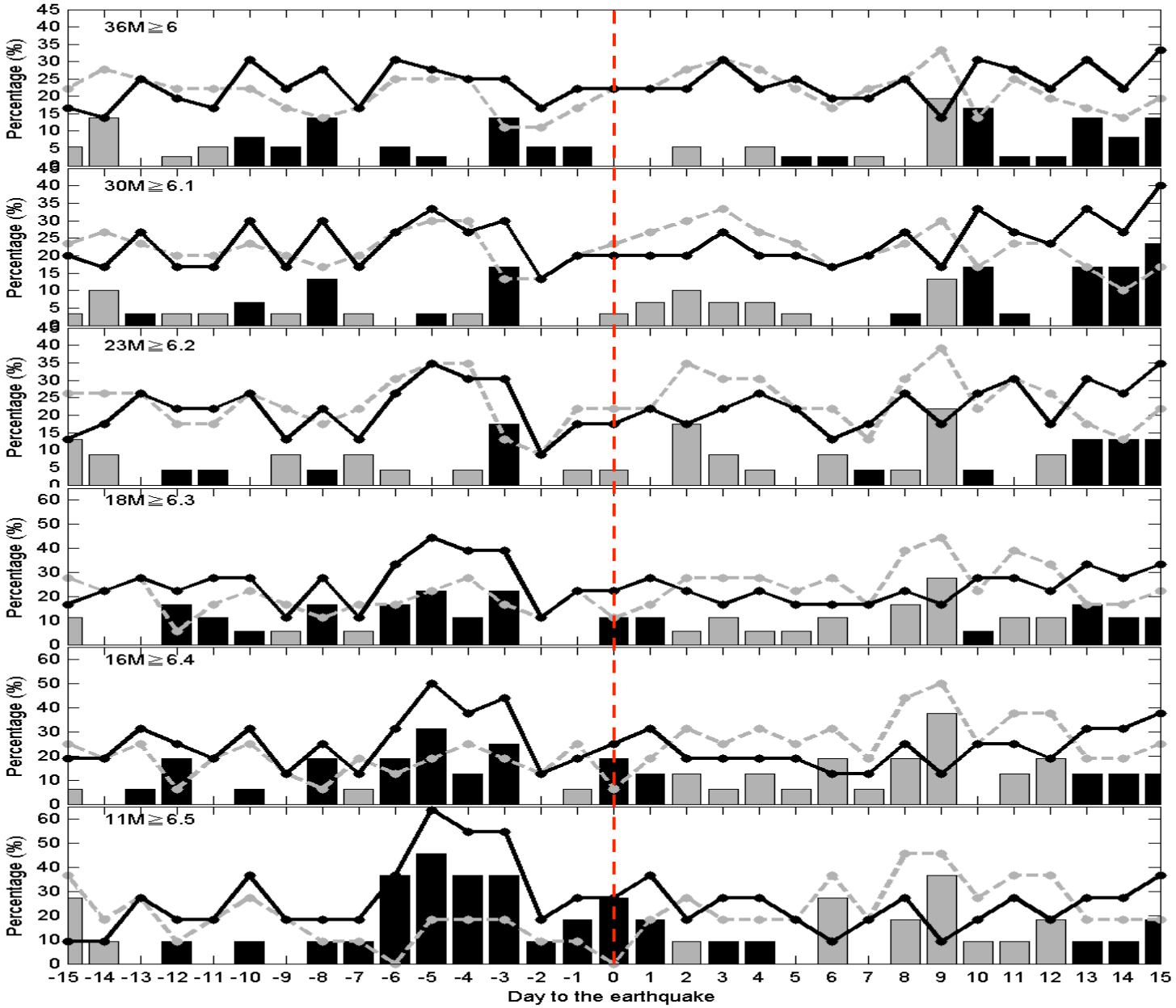


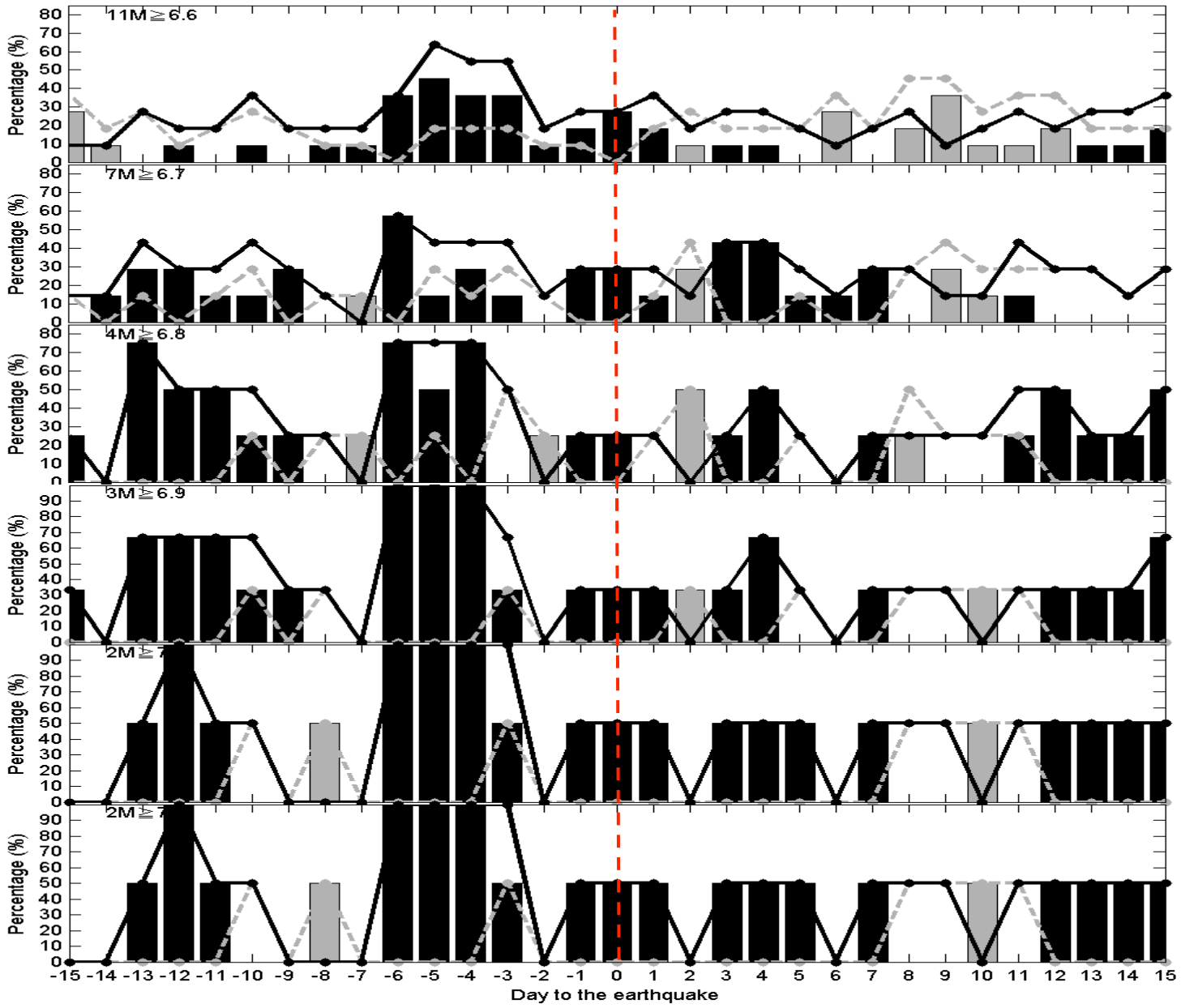
Liu et al. (JGR 2009)

A time series of GPS TEC right above the epicenter of the M7.9 Wenchuan earthquake on May 15, 2008.



Liu et al. (JGR 2009)中

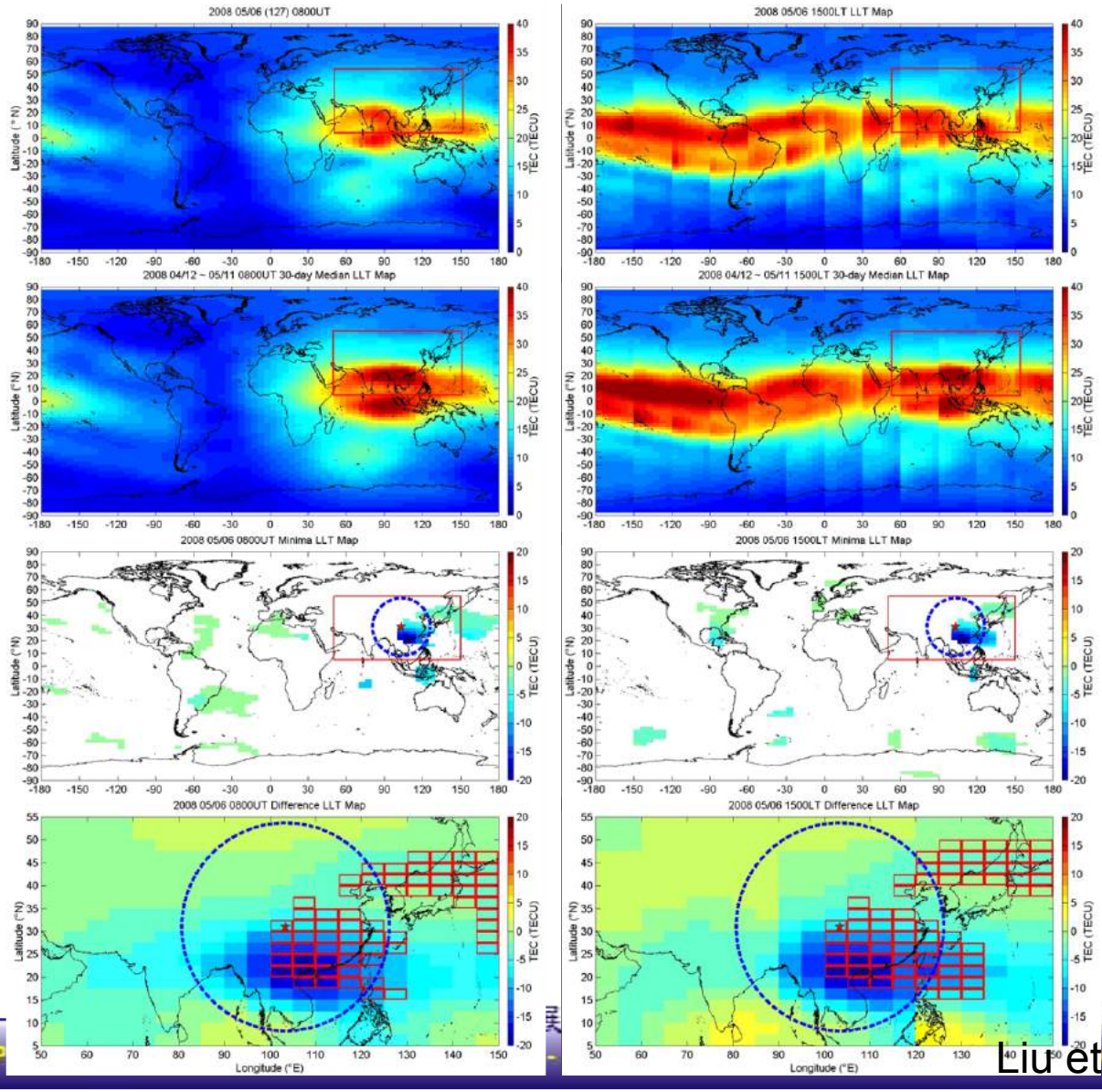

36M≧6
30M≧6.1
23M≧6.2
18M≧6.3
16M≧6.4
11M≧6.5
Percentage (%)
Day to the earthquake


11M≧6.6
7M≧6.7
4M≧6.8
3M≧6.9
2M≧7
2M≧7
Percentage (%)
Day to the earthquake

Spatial Precursor教

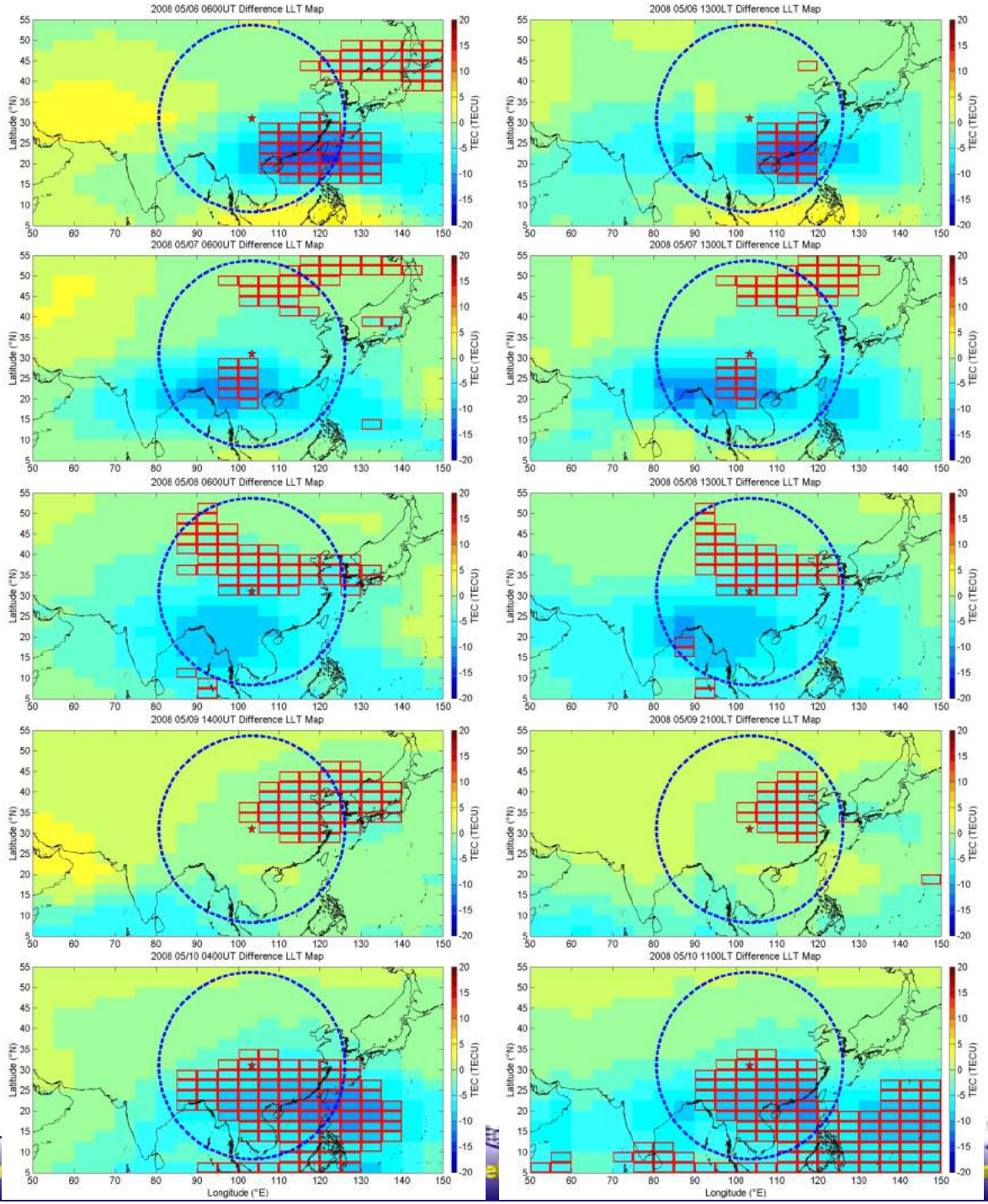
The GIMs observed at 08:00UT and global fixed 15:00 LT on day 6 before the 2008 Mw7.9 Sichuan Earthquake.

0800UT 1500LT



$R = 10^{0.43M}$

Liu et al. (JGR 2009)



D-6, 5/6 2008
0600UT, 1300LT中

D-5, 5/7 2008
0600UT, 1300LT中

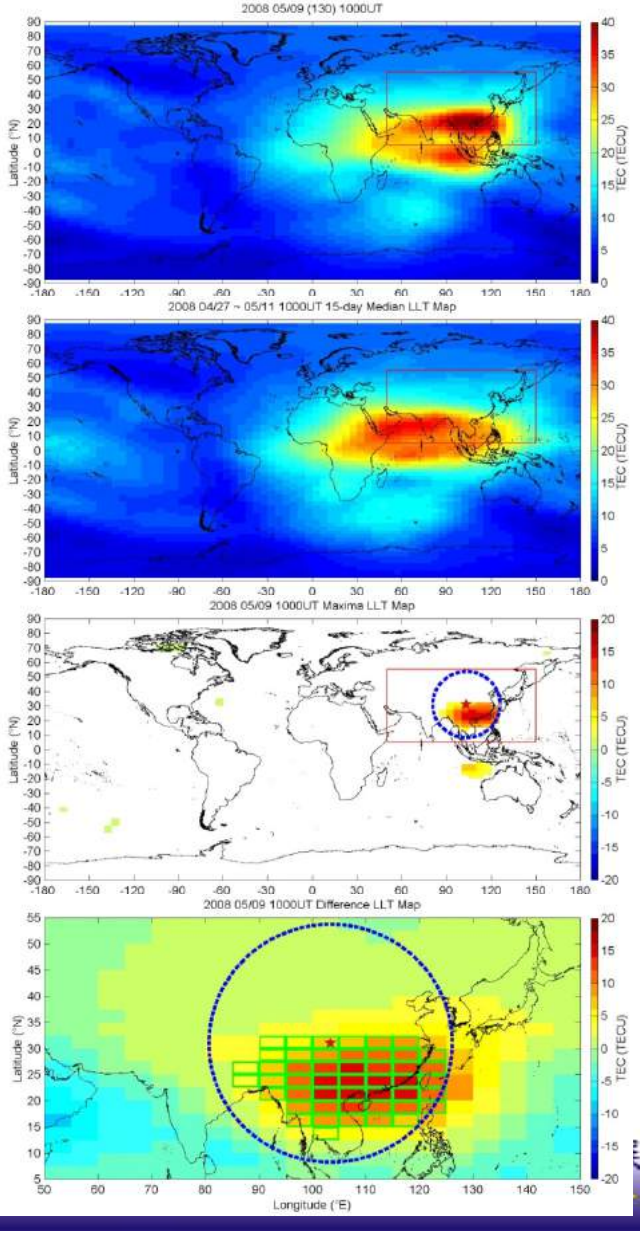
D-4, 5/8 2008
0600UT, 1300LT中

D-3, 5/9 2008
1400UT, 2100LT中

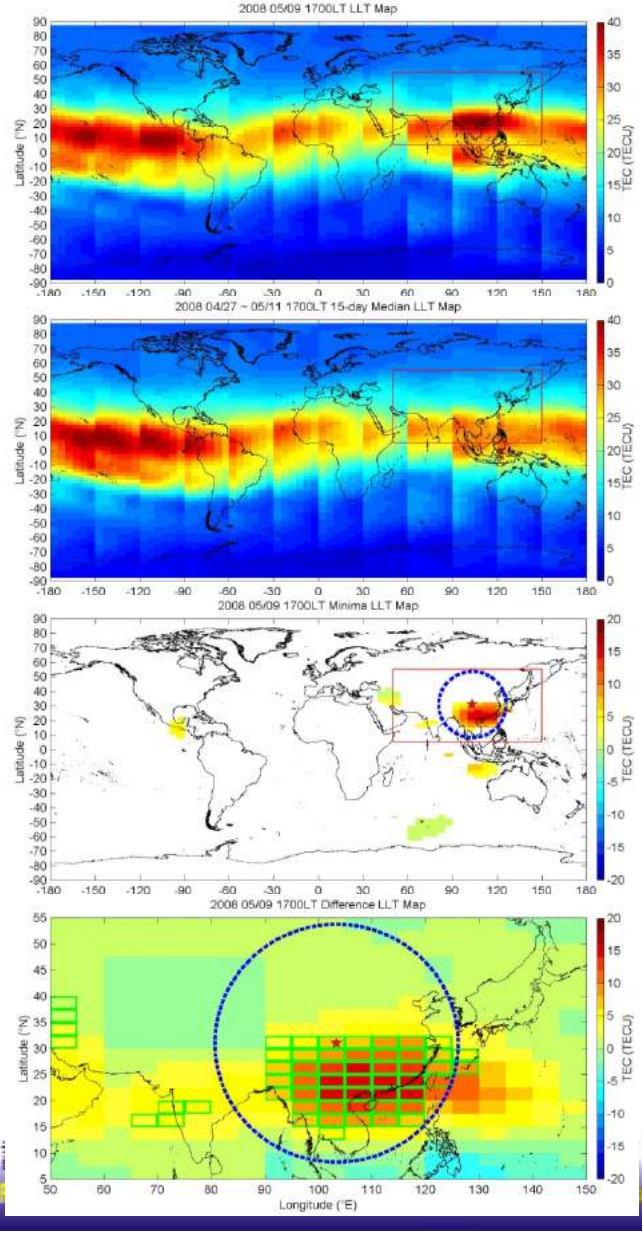
D-2, 5/10 2008
0400UT, 1100LT中

The GIMs observed at 08:00UT and global fixed 15:00 LT on day 3 before the 2008 Mw7.9 Sichuan Earthquake.

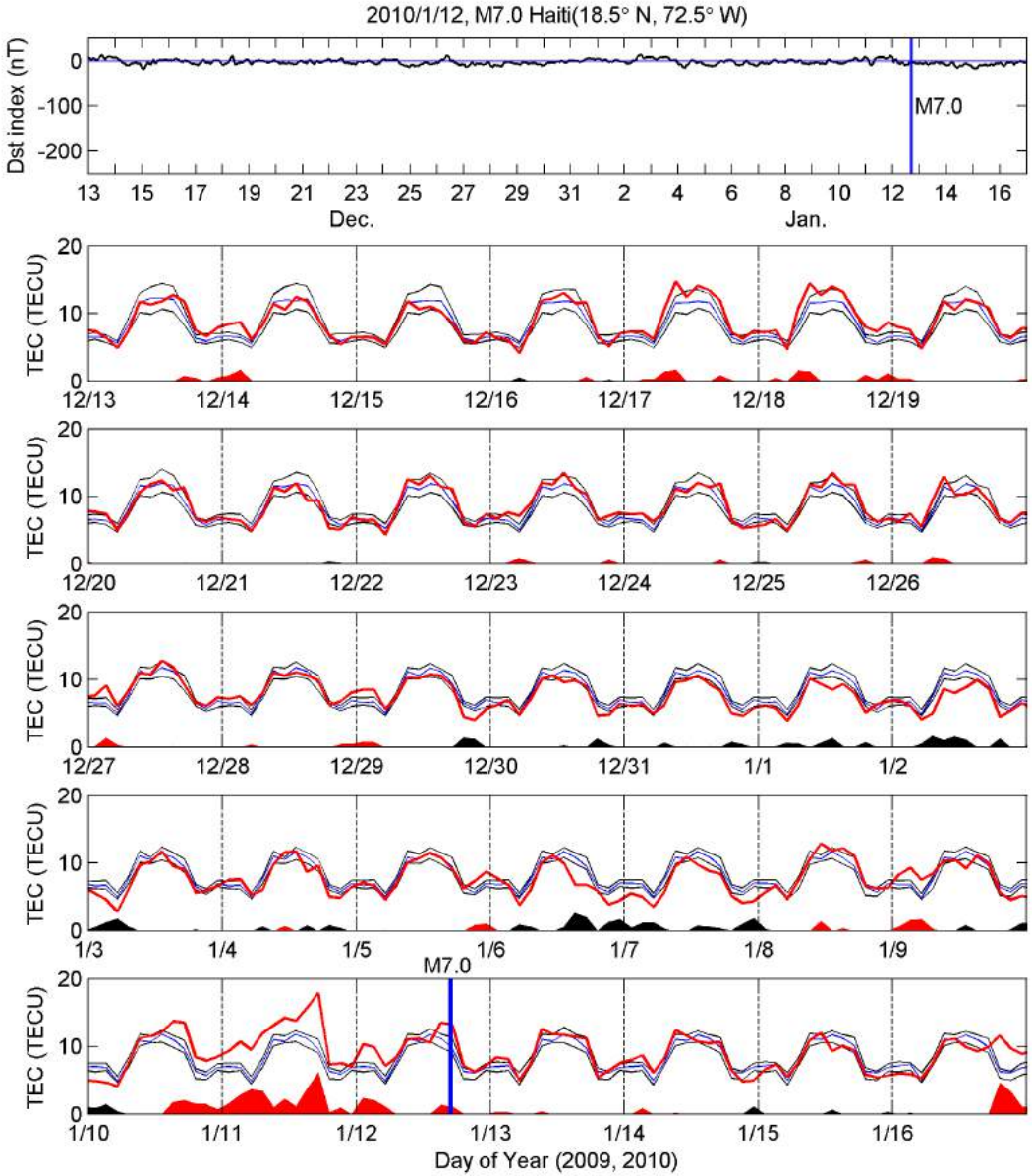
1000UT



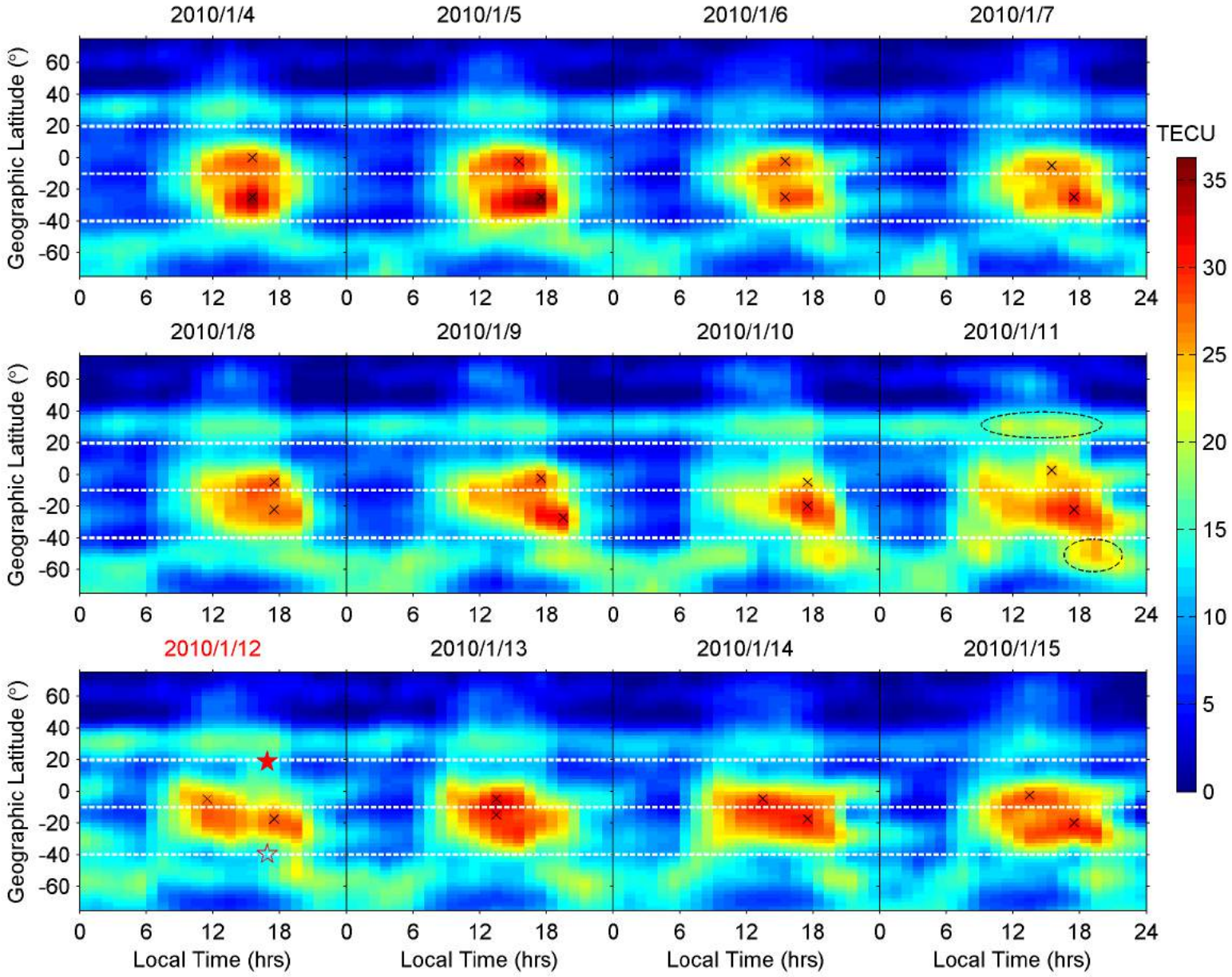
1700LT



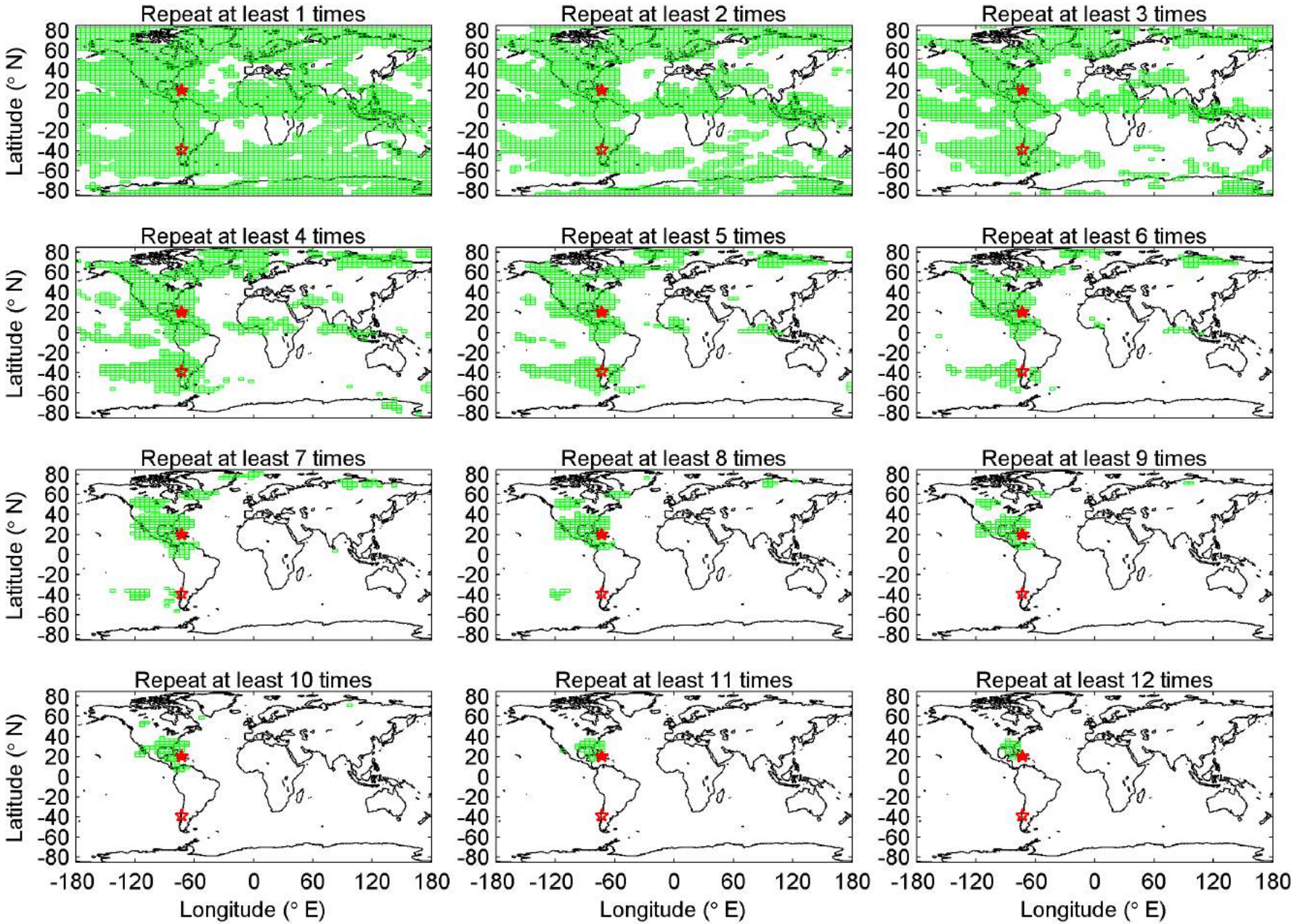
Observations and Simulations of seismo-ionospheric GPS TEC anomalies before the 12 January 2010 M7.0 Haiti Earthquake教



A time series of the Dst index and the GPS TEC right above the Haiti epicenter extracted from the GIM during 12/13/2009-1/16/2010. The M7.0 Haiti earthquake occurred at 16:53 LT on 12 January 2010.



The latitude-time-TEC plots extracted from the GIM during 4-15 January 2010.中

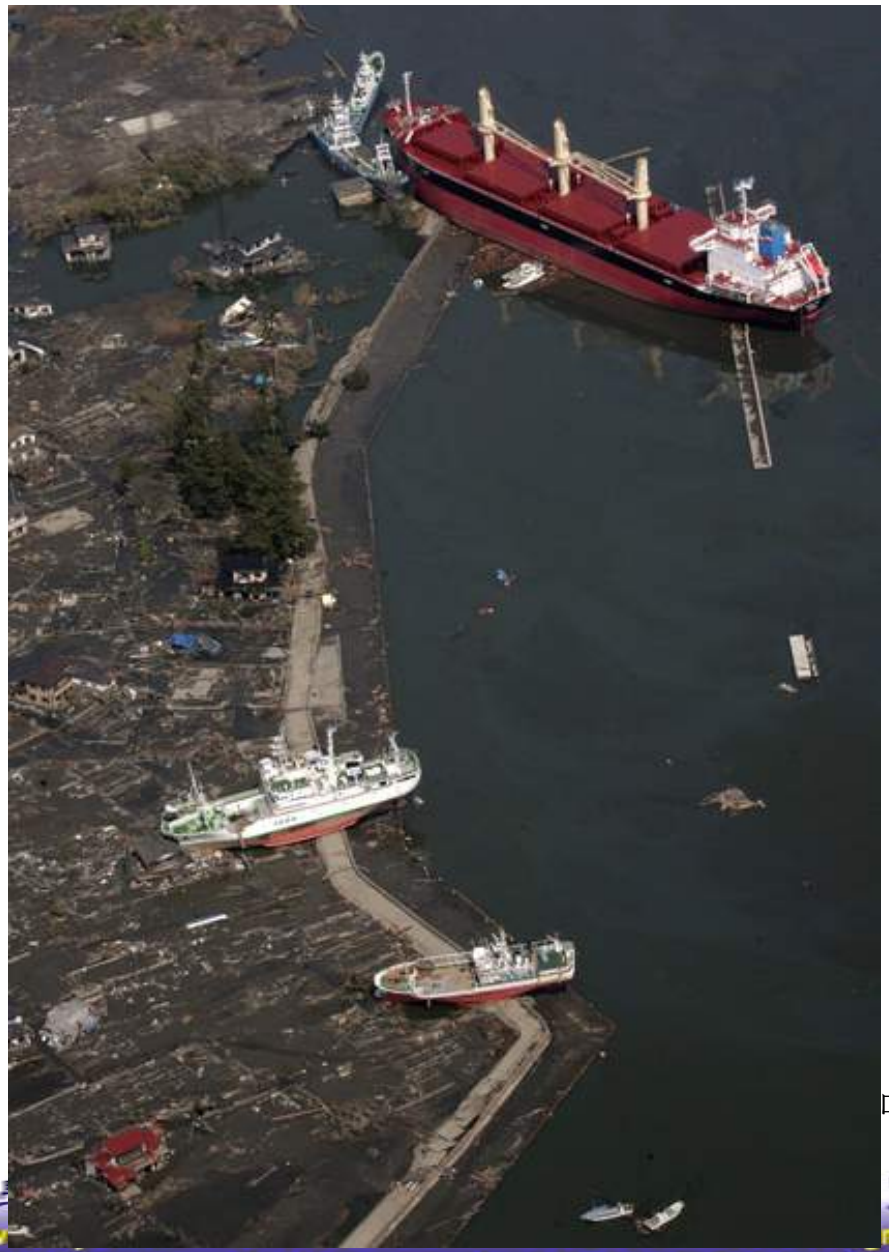


Locations of the 30-day extreme enhancement (maximum) repeatedly appear at various time points on the local day of 11 January 2010 in Haiti.

Conclusion中

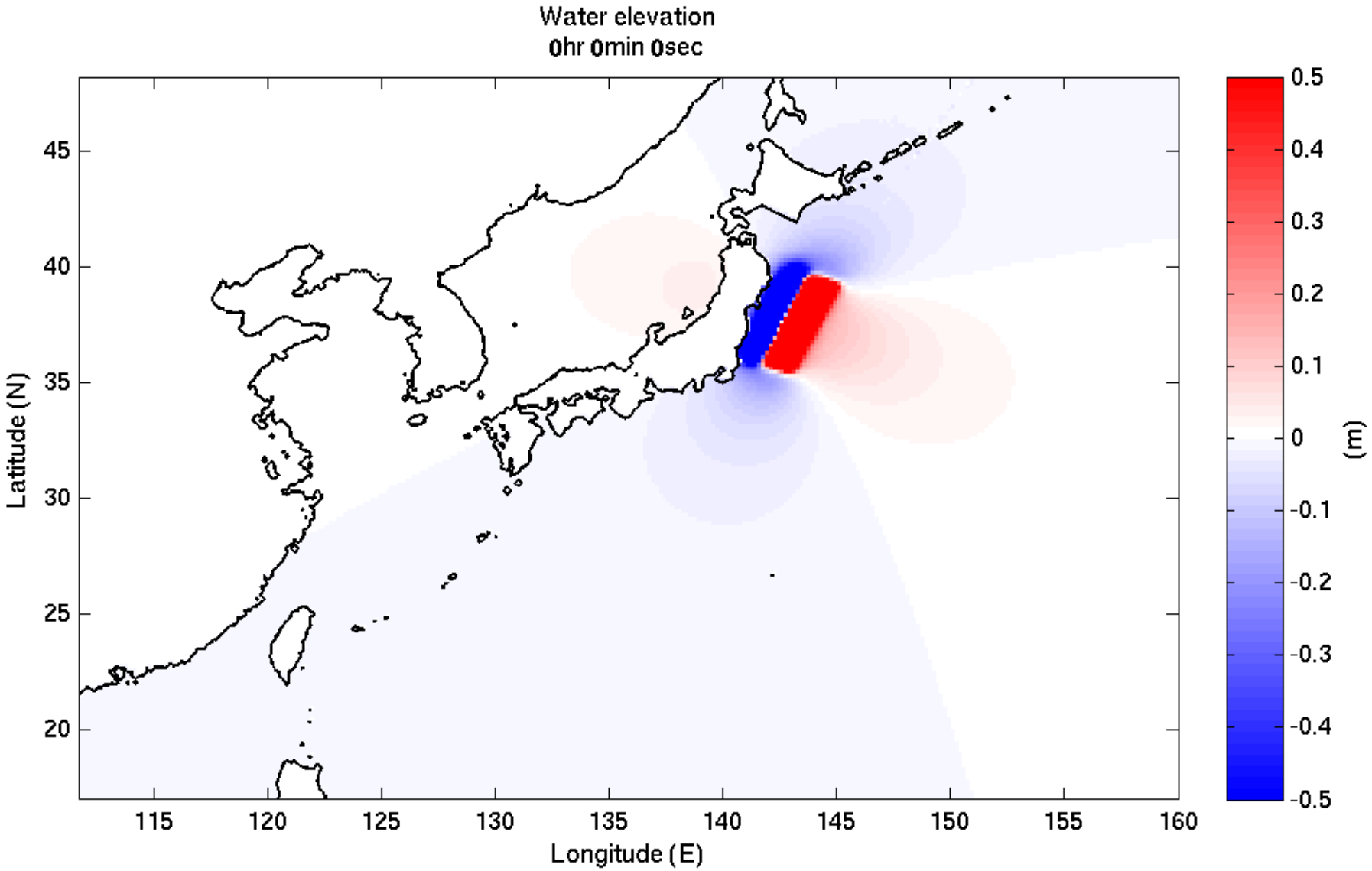
- The observation shows that the TEC over the epicenter significantly enhances on 11 January 2010, 1 day before the Haiti earthquake.
- The spatial analysis further demonstrates that the enhancement anomaly specifically and persistently appears for the entire day in a small region in the northern epicenter area.

The 11 March 2011 M9.0 Tohoku earthquake



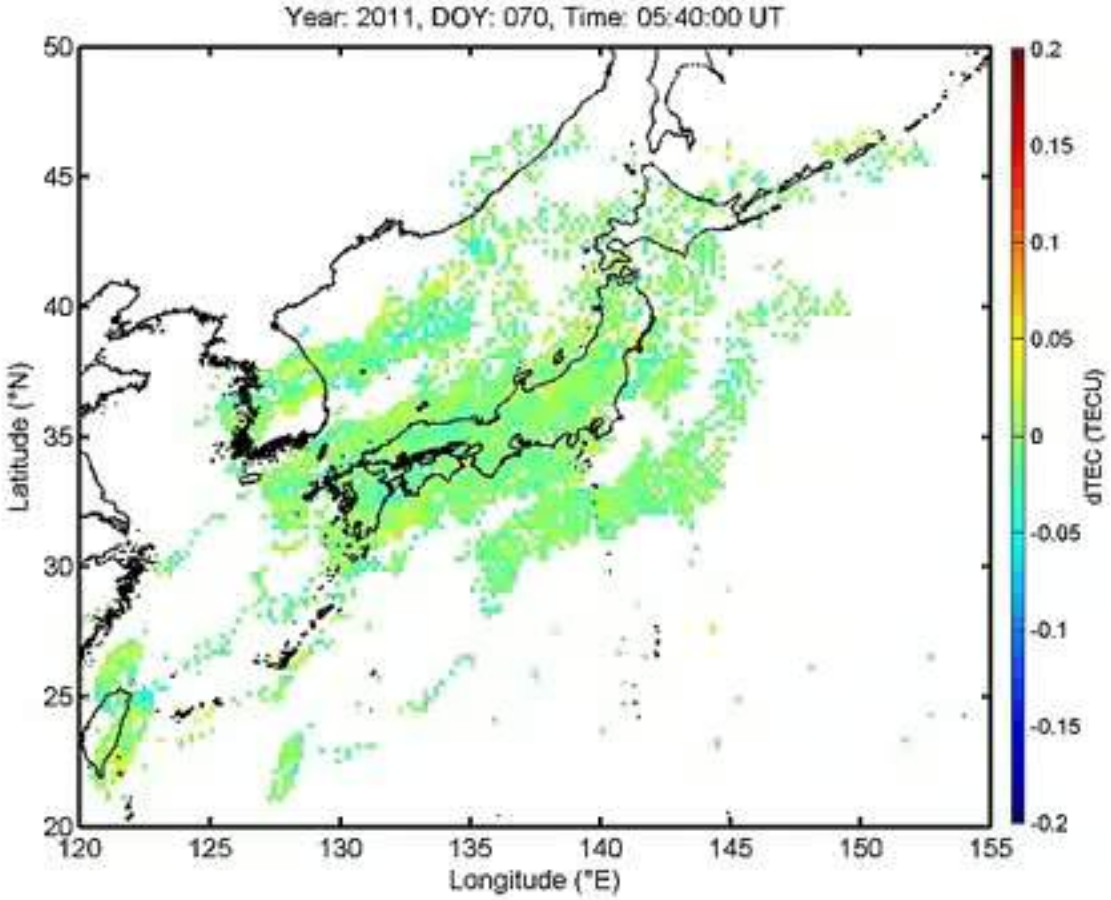
中大水海所吳祚任

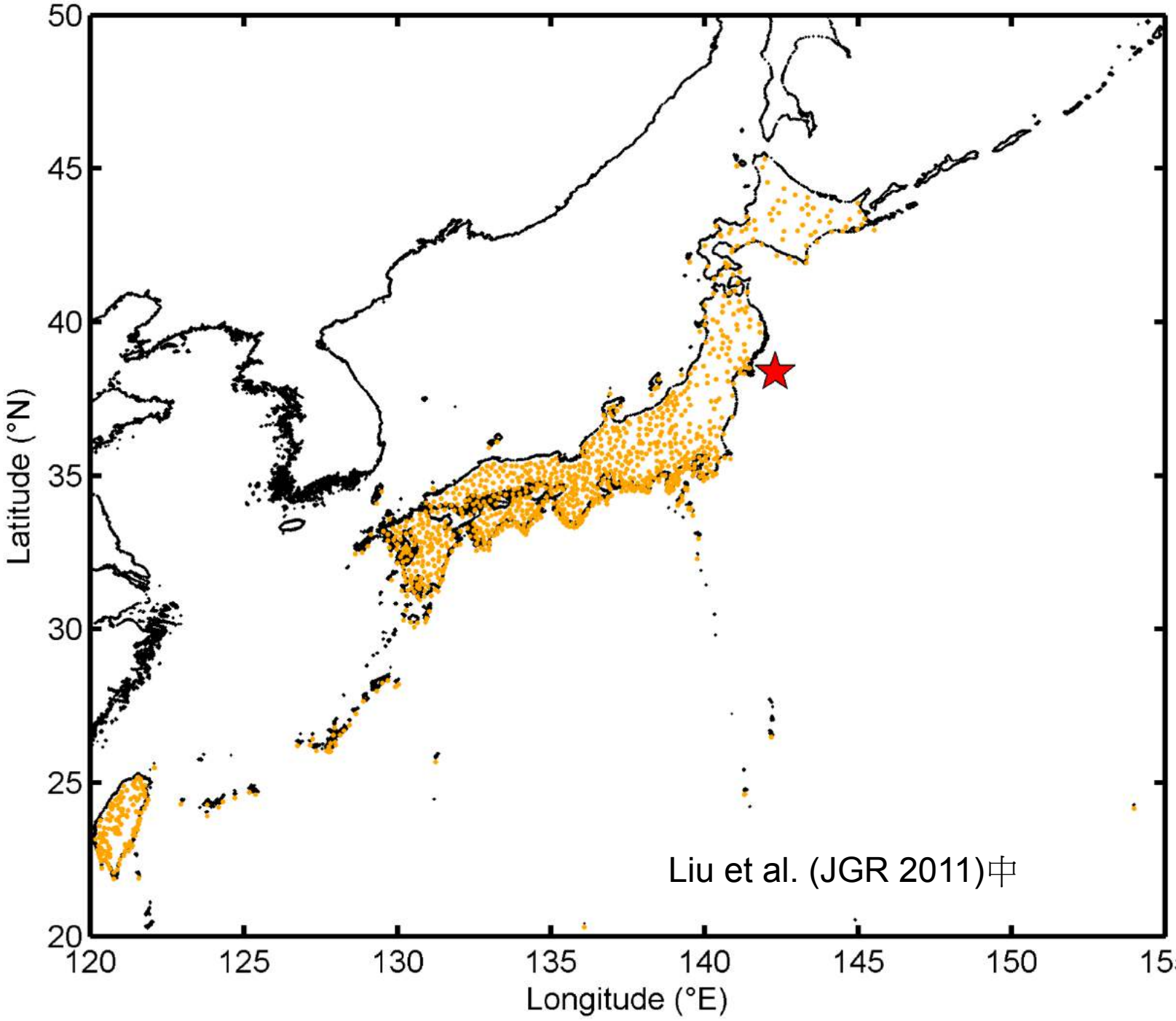
陸上
東北
城・名取市
1日
自衛隊撮影
名取市沿岸部

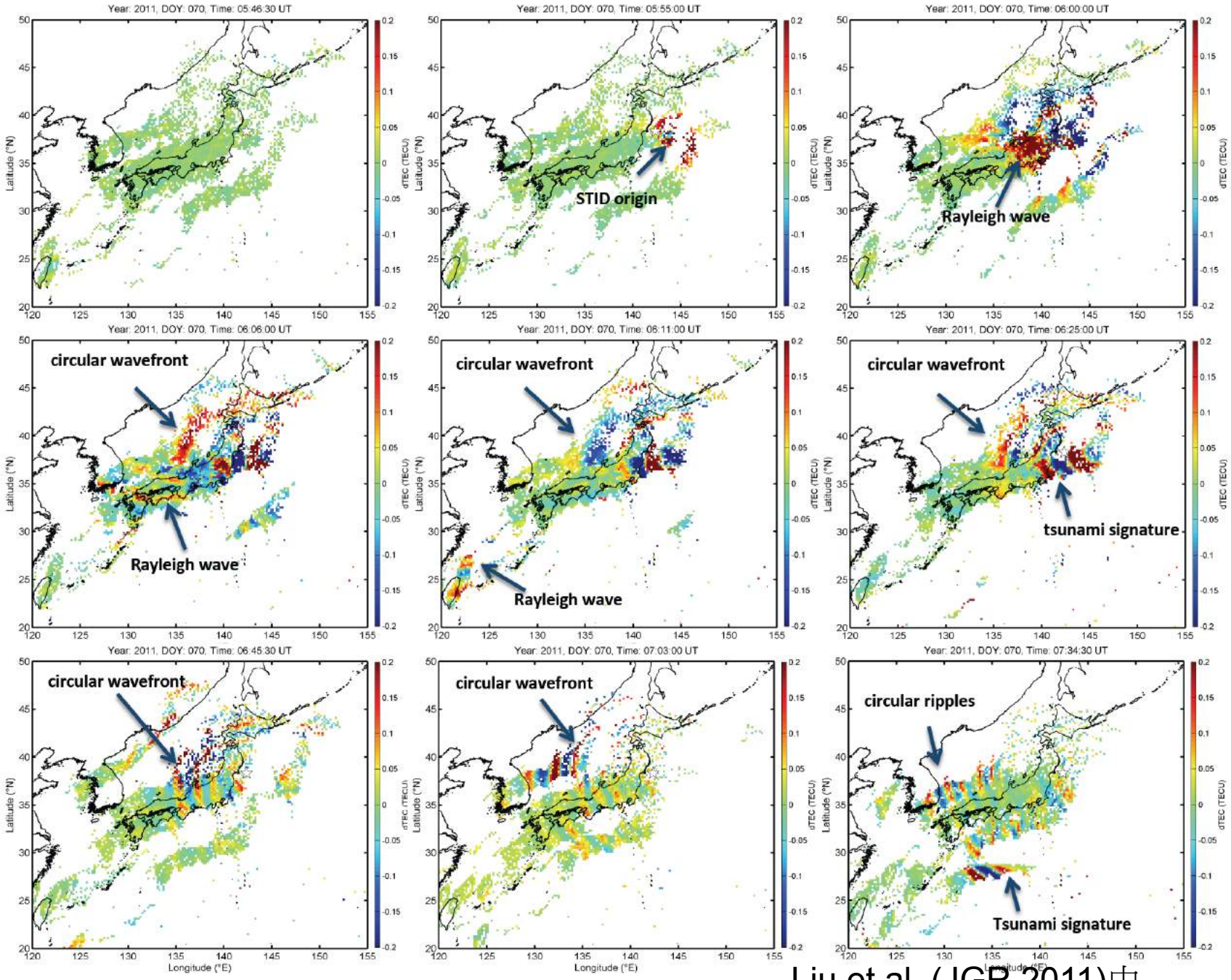


中大水海所吳祚任

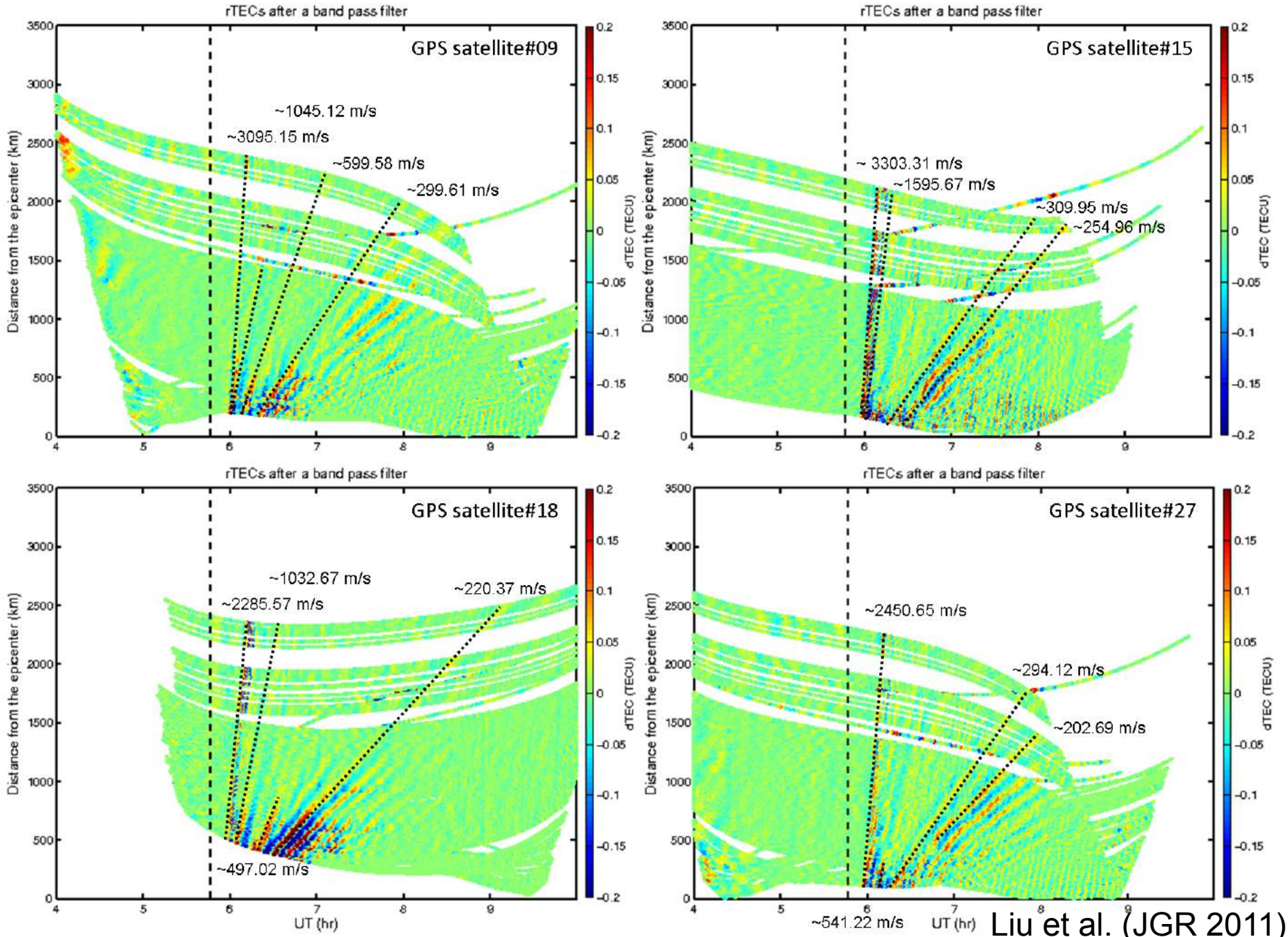
模擬結果可知海嘯到時與浪高中


Year: 2011, DOY: 070, Time: 05:40:00 UT
Latitude (°N)
Longitude (°E)
dTEC (TECU)
50
45
40
35
30
25
20
120
125
130
135
140
145
150
155
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2

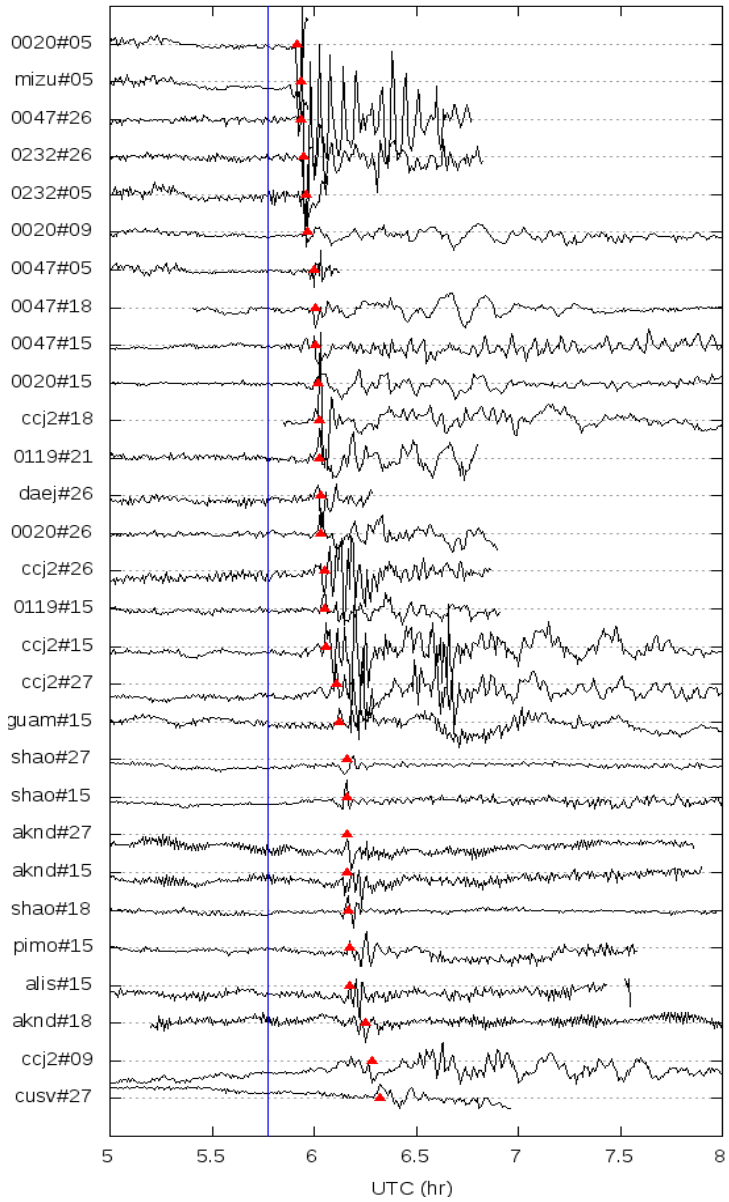

50
45
40
35
30
25
20
Latitude (°N)
120
125
130
135
140
145
150
155
Longitude (°E)
Liu et al. (JGR 2011)中



Liu et al. (JGR 2011)中

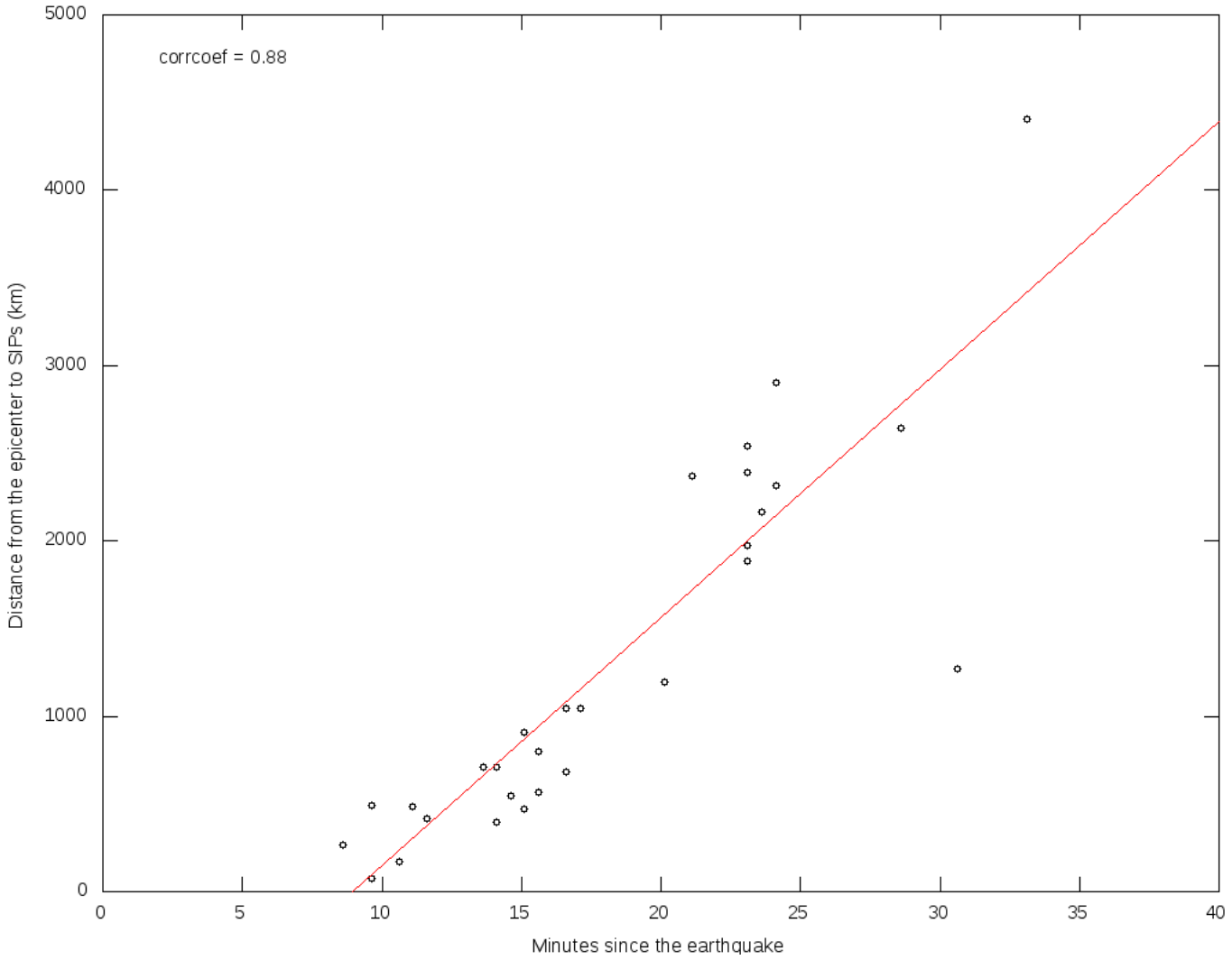


Liu et al. (JGR 2011)中



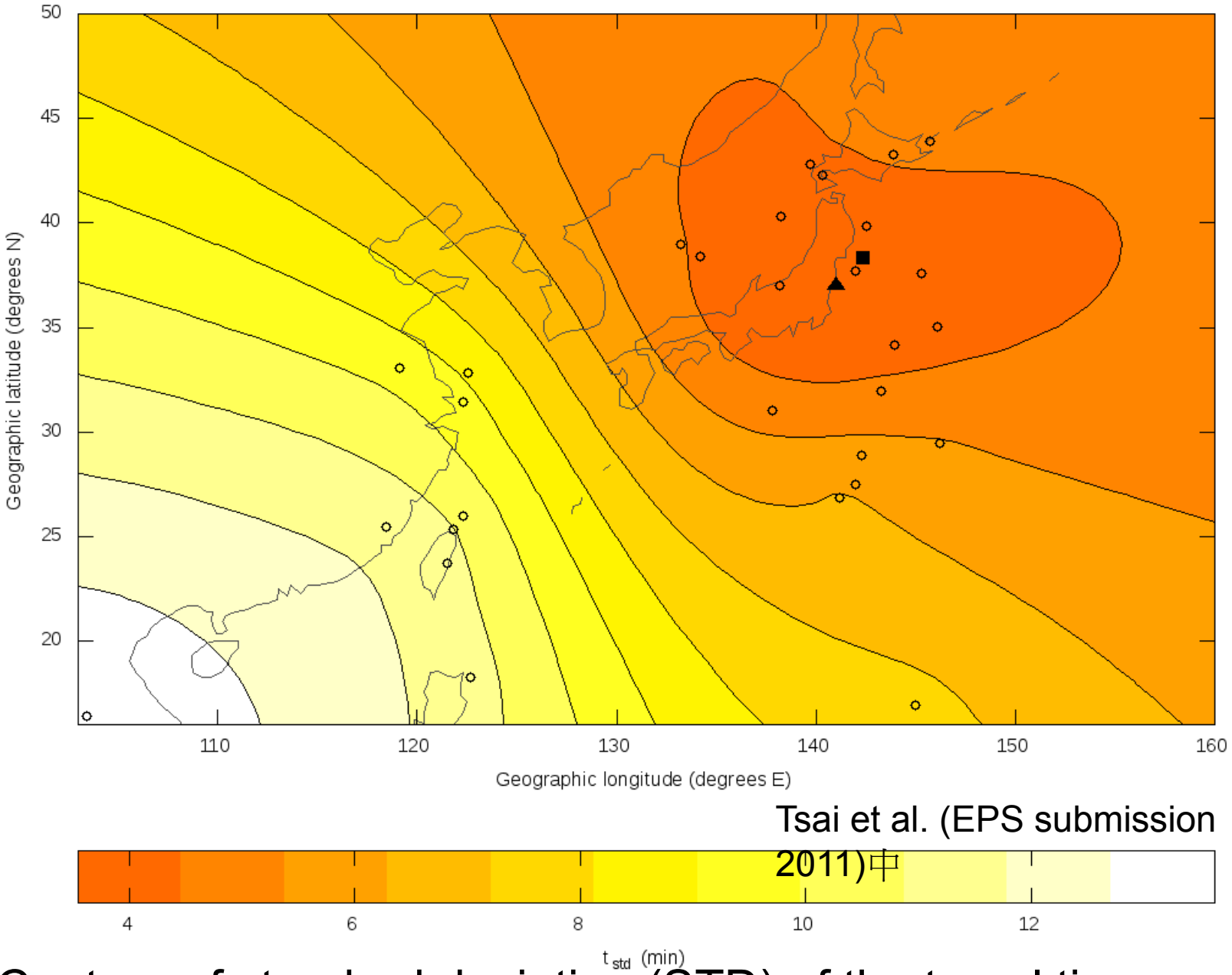
Tsai et al. (EPS 2011)中

Time-differencing TEC (dTEC) for 29 GPS receiver-satellite pairs.中



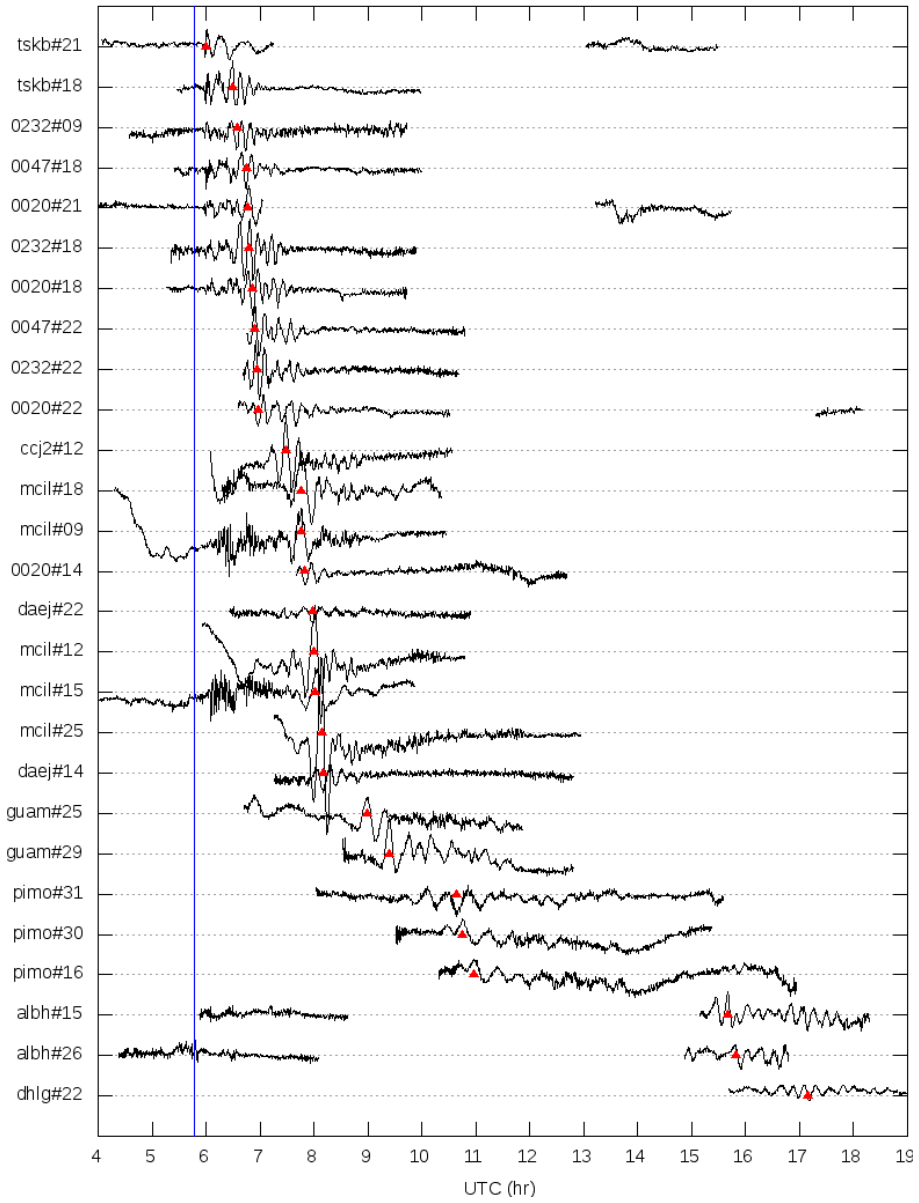
The correlation between the 29 epochs of the maximum dTEC and the corresponding distances from the epicenter reported by USGS to the sub-ionospheric points (SIPs), denoted by circles.中

Tsai et al. (EPS submission 2011)中



Tsai et al. (EPS submission 2011)中

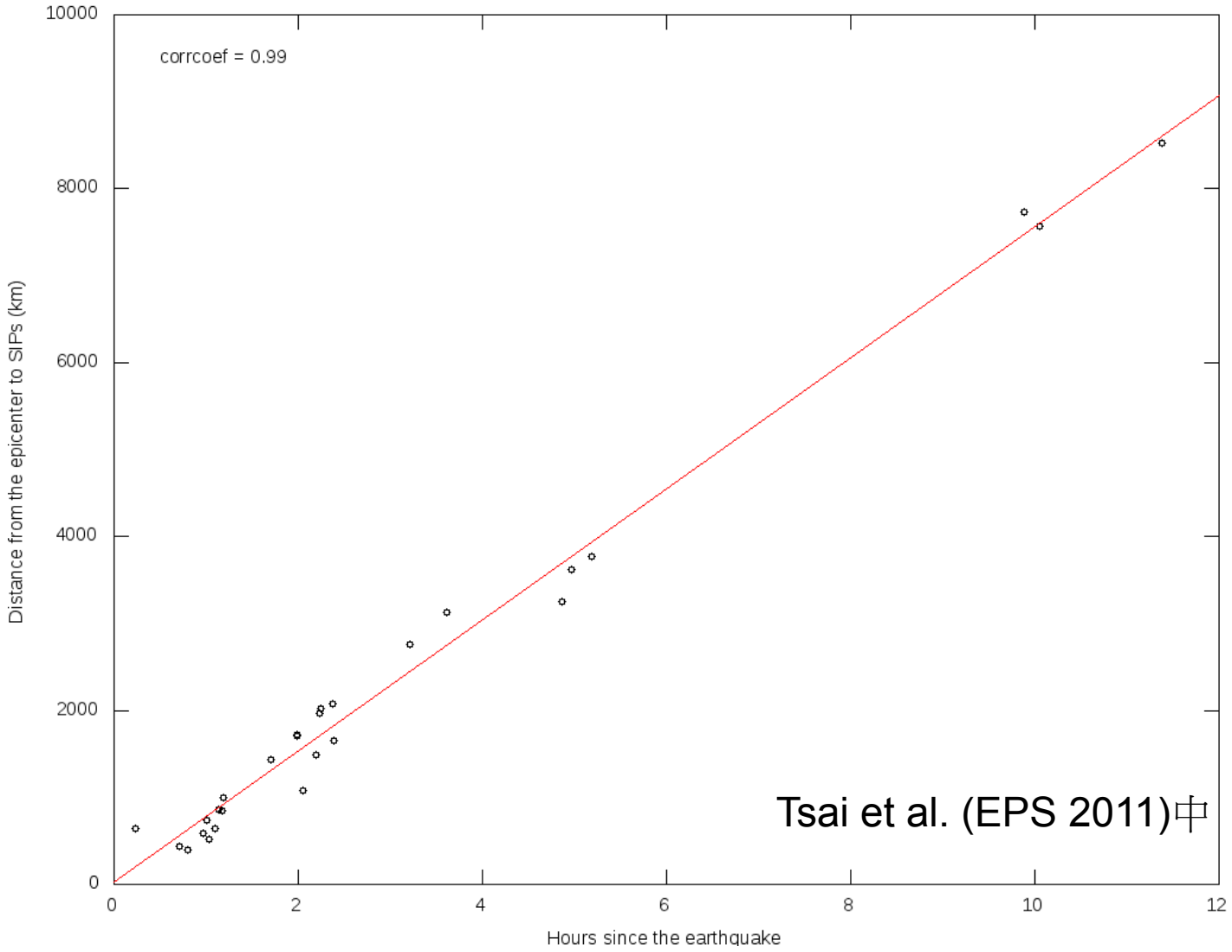
Contour of standard deviation (STD) of the travel times estimated by the 3-dimensional spherical simulation model.中



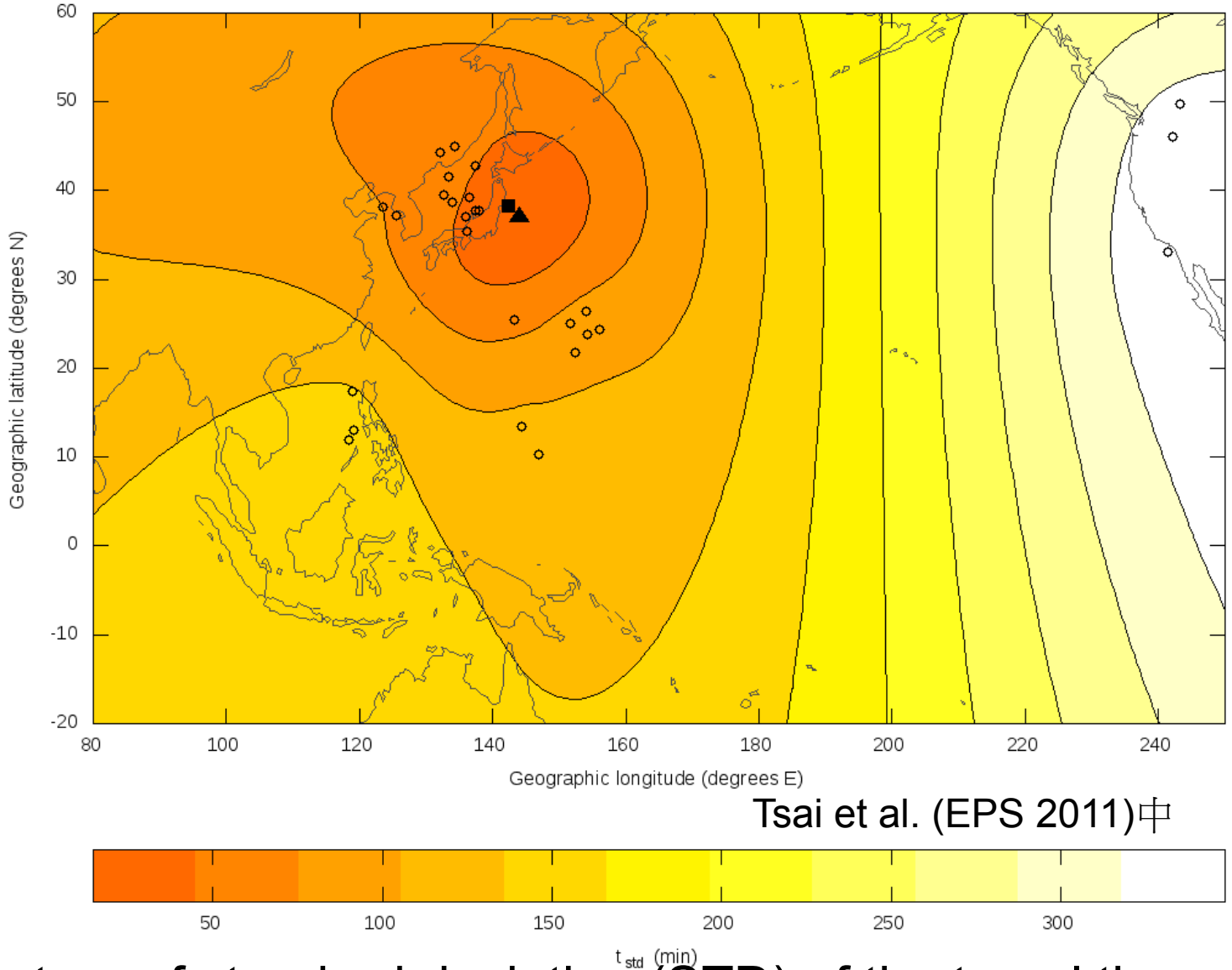
Time-differencing TEC (dTEC) for 29 GPS receiver-satellite pairs for tsunami.中

Tsai et al. (EPS submission 2011)中

大學學術追求卓越發展計畫 地震電磁前兆研究
Promoting University Academic Excellence - Research of Seismo-Electromagnetic Precursors of Earthquake

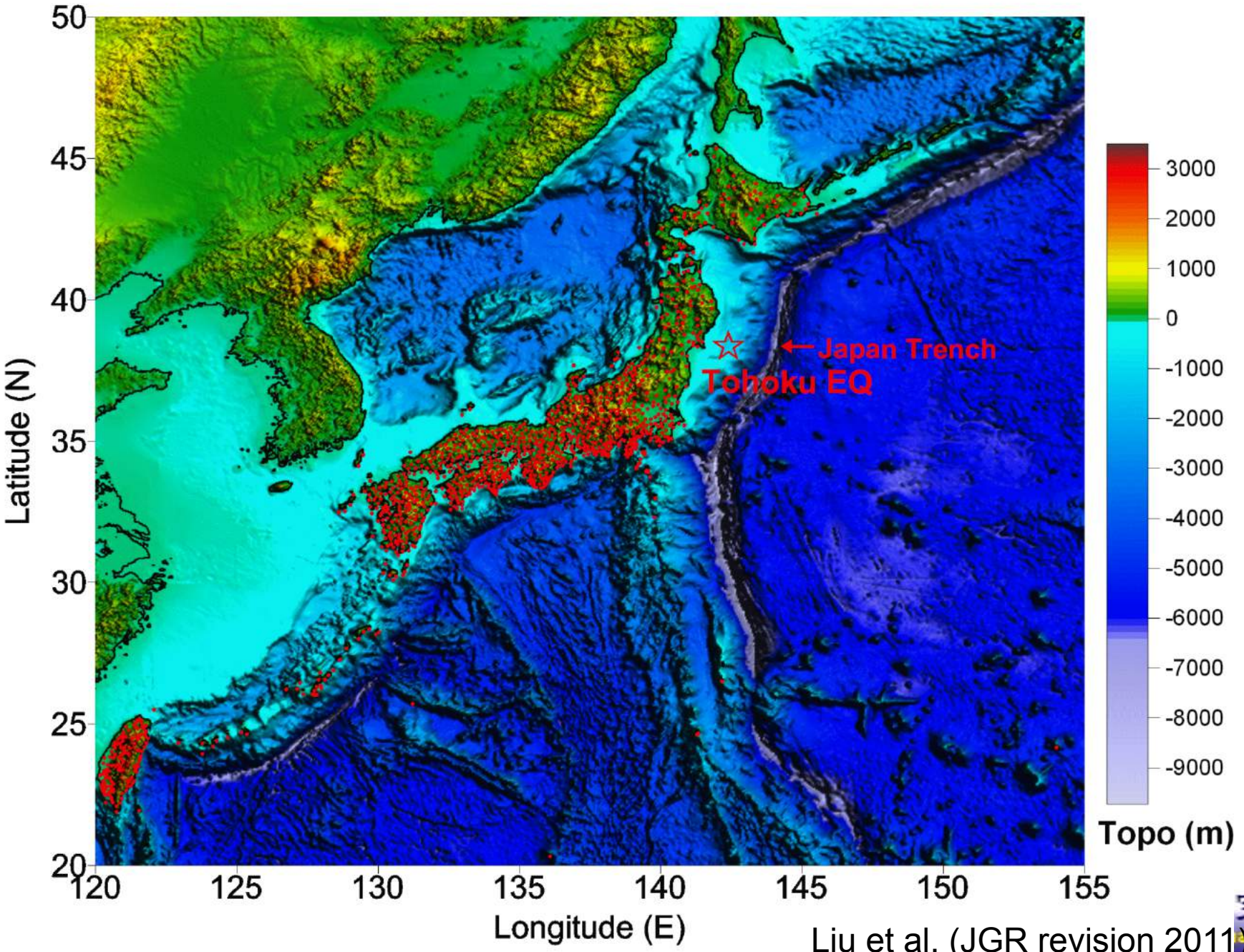


The correlation between the 29 epochs of the maximum dTEC and the corresponding distances from the epicenter reported by USGS to the sub-ionospheric points (SIPs), denoted by circles for tsunami.中



Tsai et al. (EPS 2011)中

Contour of standard deviation (STD) of the travel times estimated by the 3-dimensional spherical simulation model for tsunami.中



Liu et al. (JGR revision 2011)

Conclusion教

- The GPS TEC variations of the pre-earthquake anomalies and the co-seismic ionosphere disturbances are about 1 and 10 TEC units (1 TECu=10^{16} el/m^2), respectively.
- The pre-earthquake anomalies are possibly induced by seismo generated electromagnetic signals (EM process), while the co-seismic ionosphere disturbances could be triggered by vertical surface motions of seismic and tsunami waves (mechanical process).教

敬請批評指教 Thank you!!!