Observations of traveling ionospheric disturbance triggered by earthquakes and tsunamis using GPS

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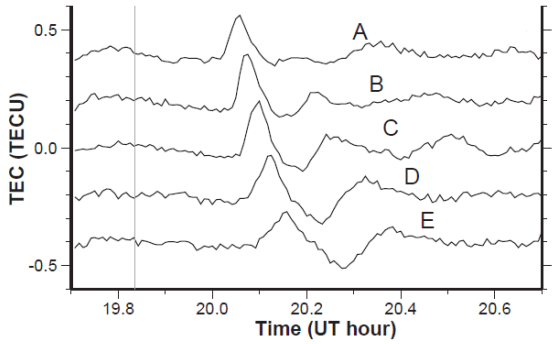
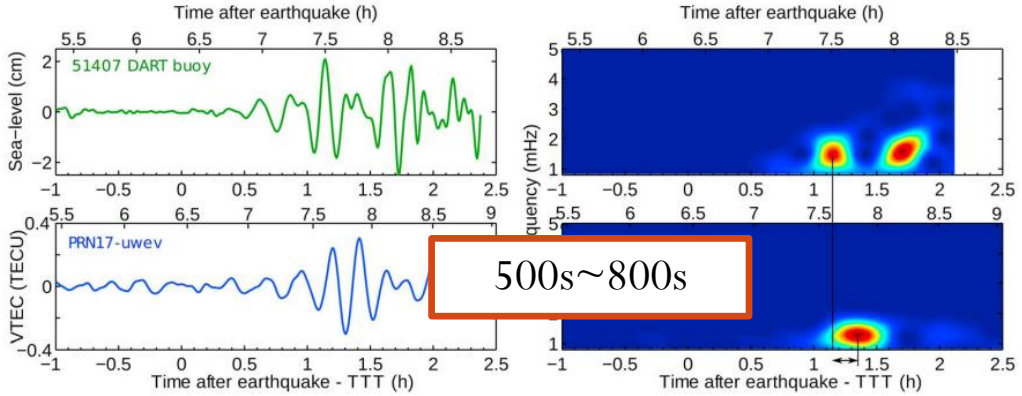
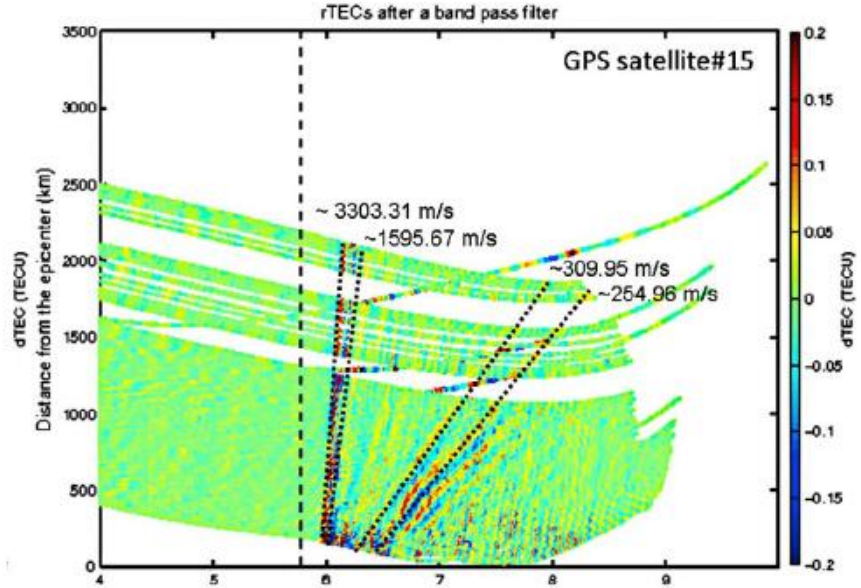
Introduction



[Heki & Ping, 2005]



[Rolland et al., 2011]



[Liu et al., 2011]

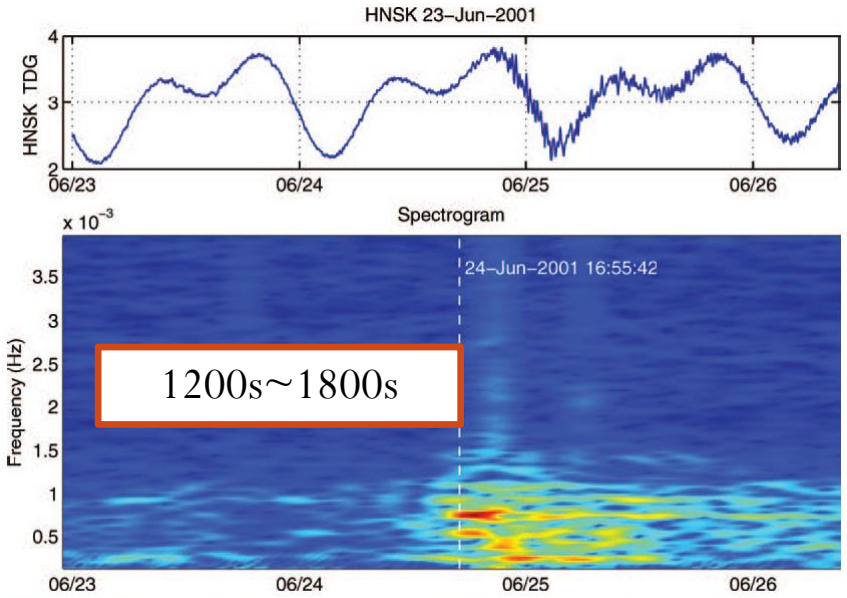
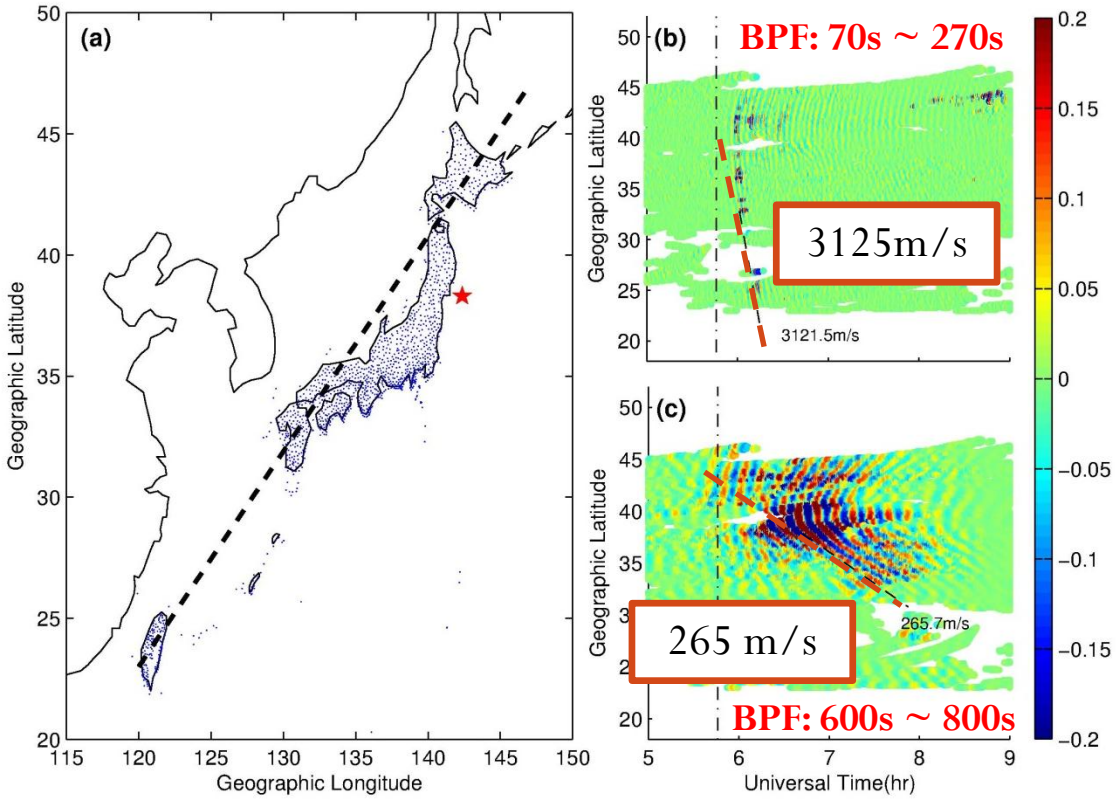


Figure 4. HNSK (Hanasaki, Hokkaido) Tide gauge time series and spectrogram. The tsunami clearly appears as short-period, small amplitudes fluctuations compared to the tidal signal. Two frequency peaks are observed, corresponding to 20 and 30 min of period.

[Artru et al., 2005]

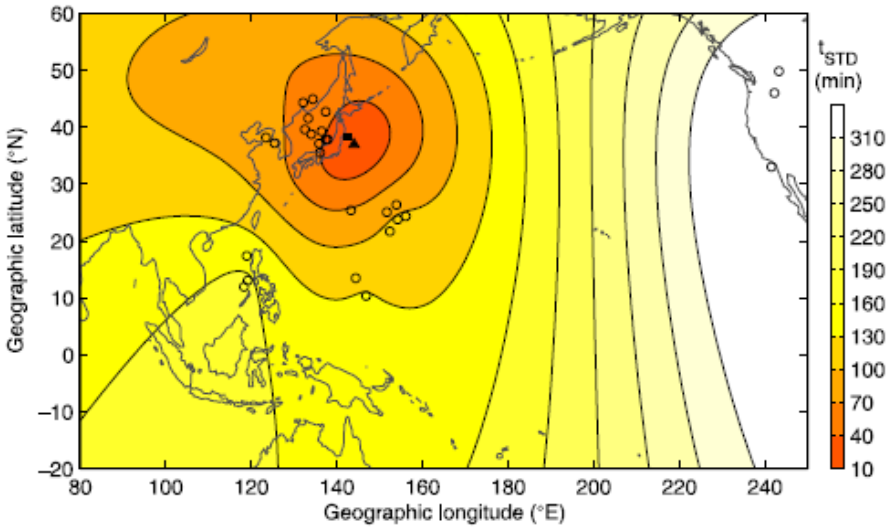
Introduction

- The Mw9.0 earthquake occurred at 05:46:23 UT on March 11, 2011 in Japan. The GPS-TEC data with different period of filter get different velocity.

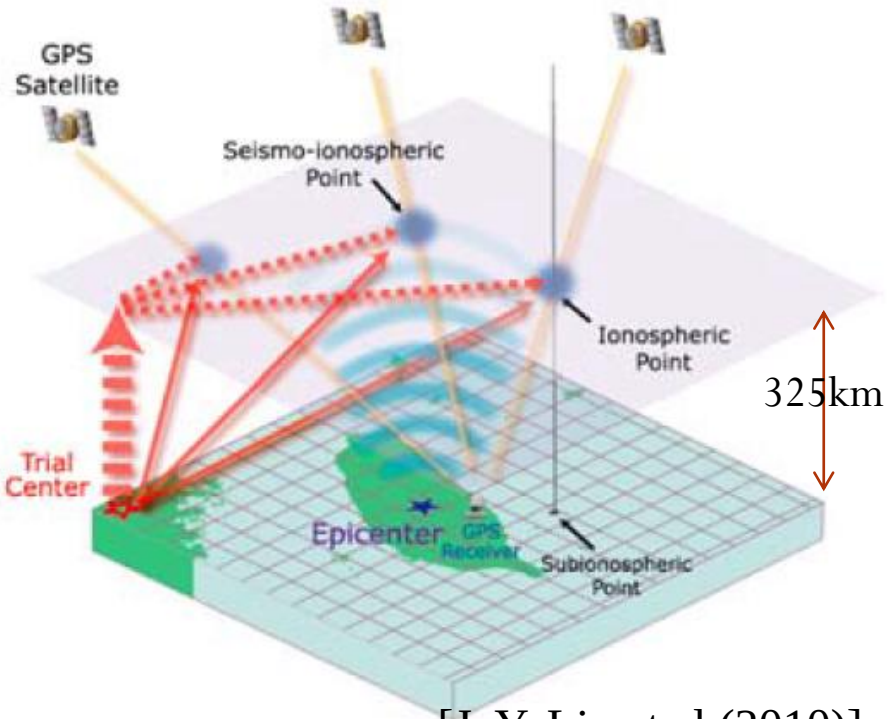


Method

- **Wavelet analysis**
- **Ray tracing**
  - $\Delta t_{i,j} = \Delta Z_{i,j}/V_Z + \Delta S_{i,j}/V_H$
  - $t_{Gi} = t_i - \Delta t_{i,j}$
  - $\sigma_j = [\sum (t_{Gi,j} - \mu_j)^2/N]^{1/2}$



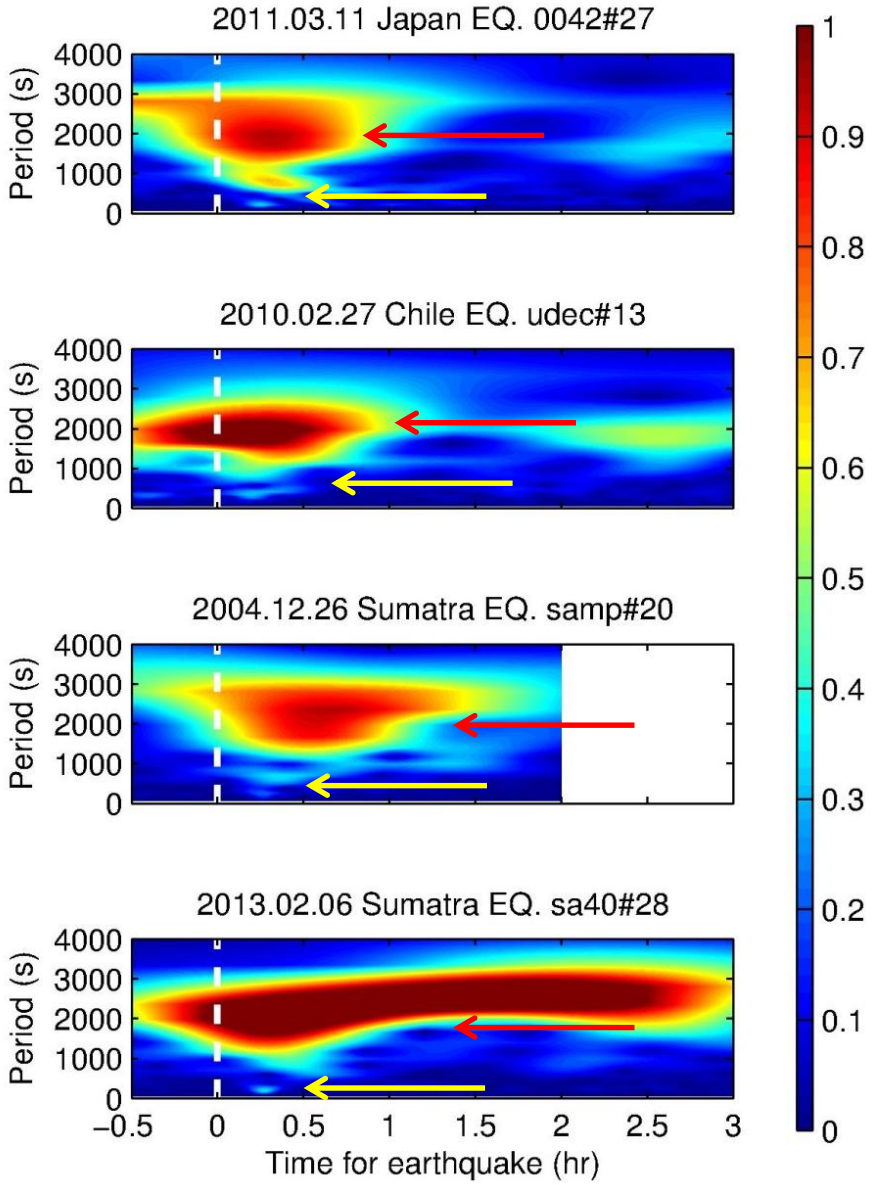
[Tsai et al., 2011]



[J. Y. Liu et al.(2010)]

Result

- The characteristic periods of response spectra for four earthquake events shows two characteristic periods:
  - 150s~240s (yellow arrow)
  - 1200s~2000s (red arrow)

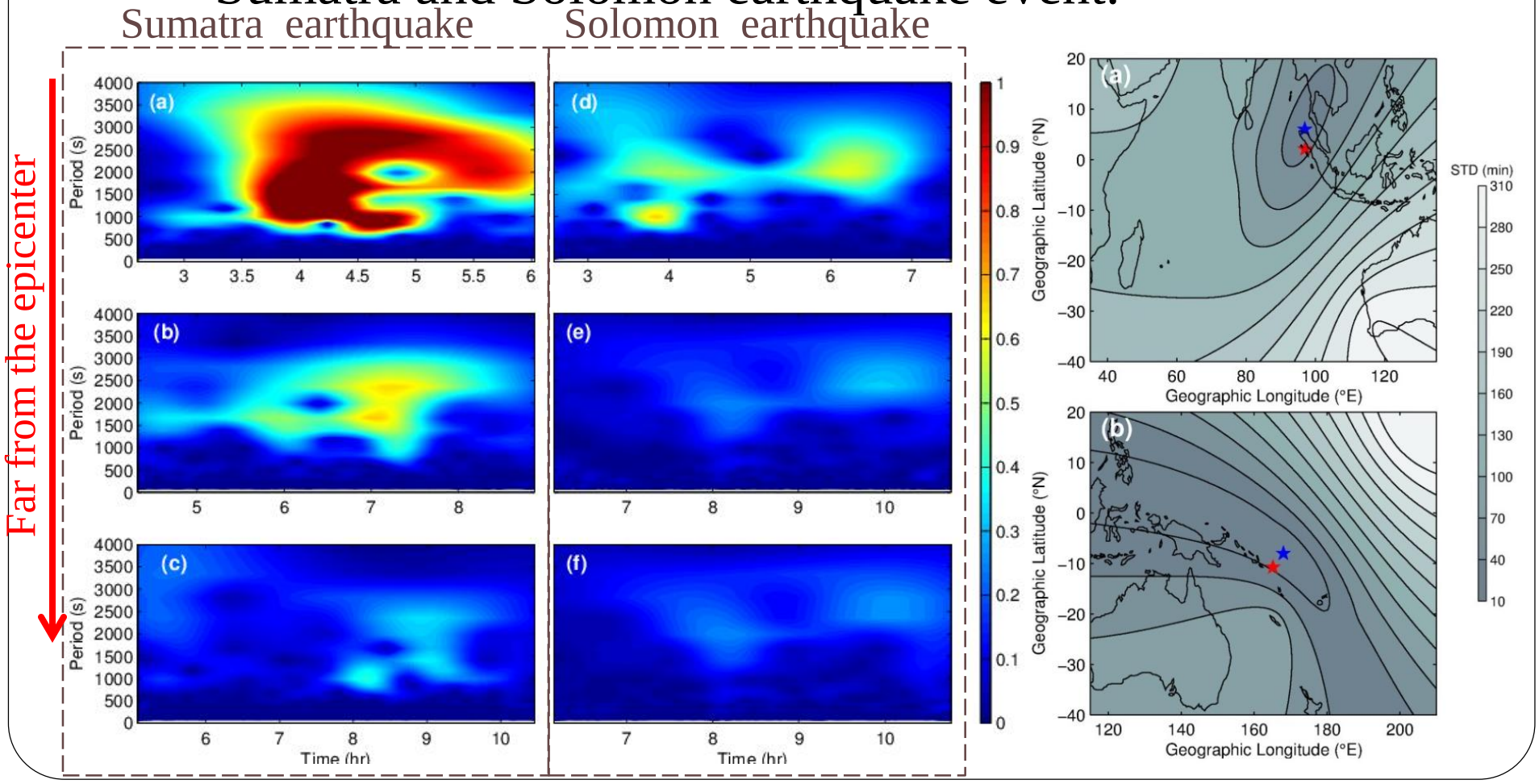


Date	Time	Location	Magnitude
2013.02.06 (037)	UT 01:12	Solomon	Mw 8.0
2011.03.11 (070)	UT 05:46	Japan	Mw 9.0
2010.02.27 (058)	UT 06:34	Chile	Mw 8.8
2004.12.26 (361)	UT 00:58	Sumatra	Mw 9.1

Result

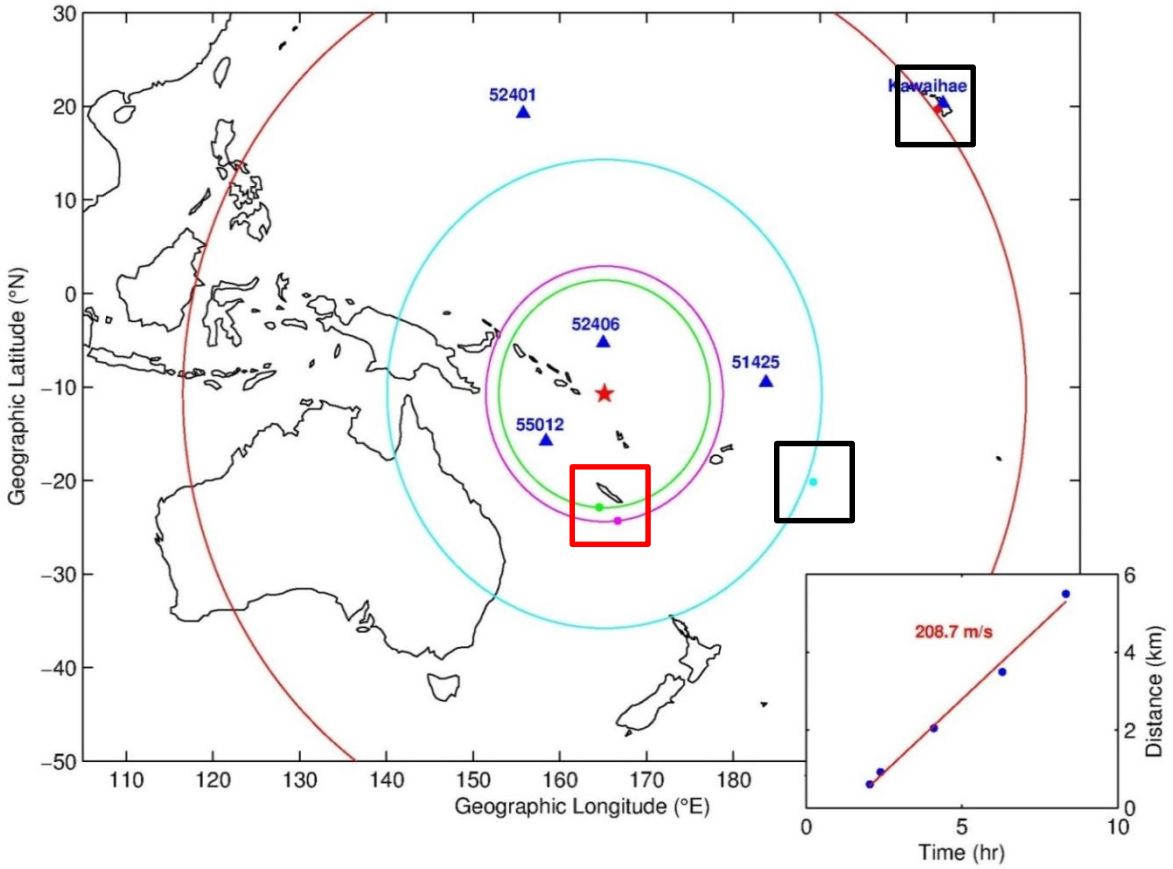
Date	Time	Location	Magnitude
2013.02.06 (037)	UT 01:12	Solomon	Mw 8.0
2004.12.26 (361)	UT 00:58	Sumatra	Mw 9.1

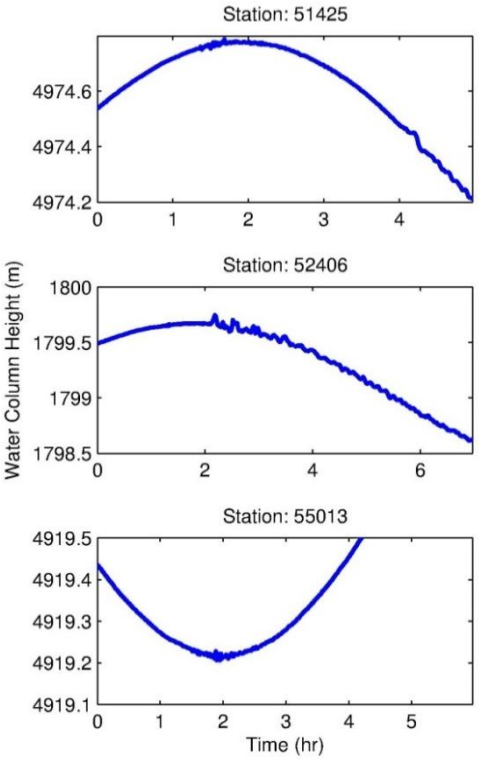
- the spectra results of three GPS stations for the Sumatra and Solomon earthquake event.



Result

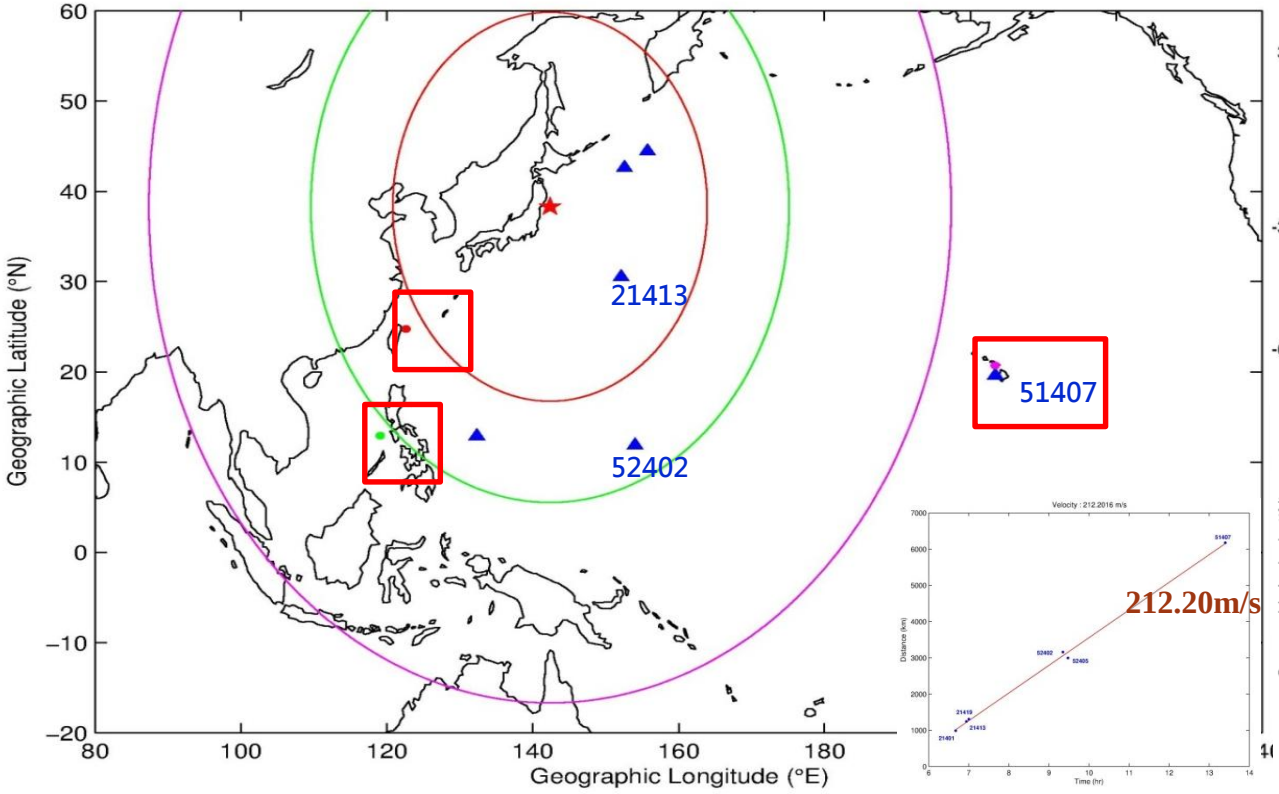
- Compare with tsunami and disturbance signal for Solomon earthquake event.

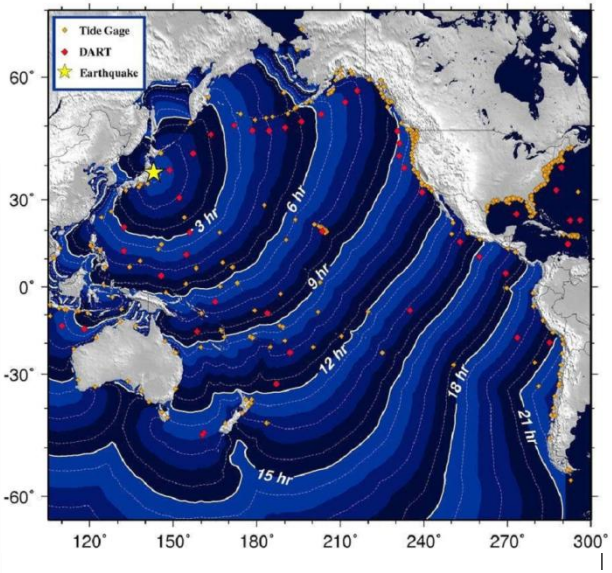


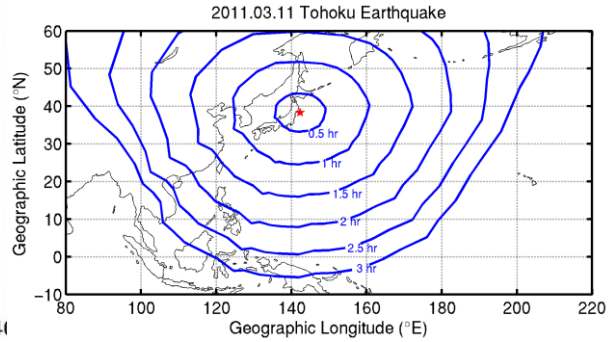


Result

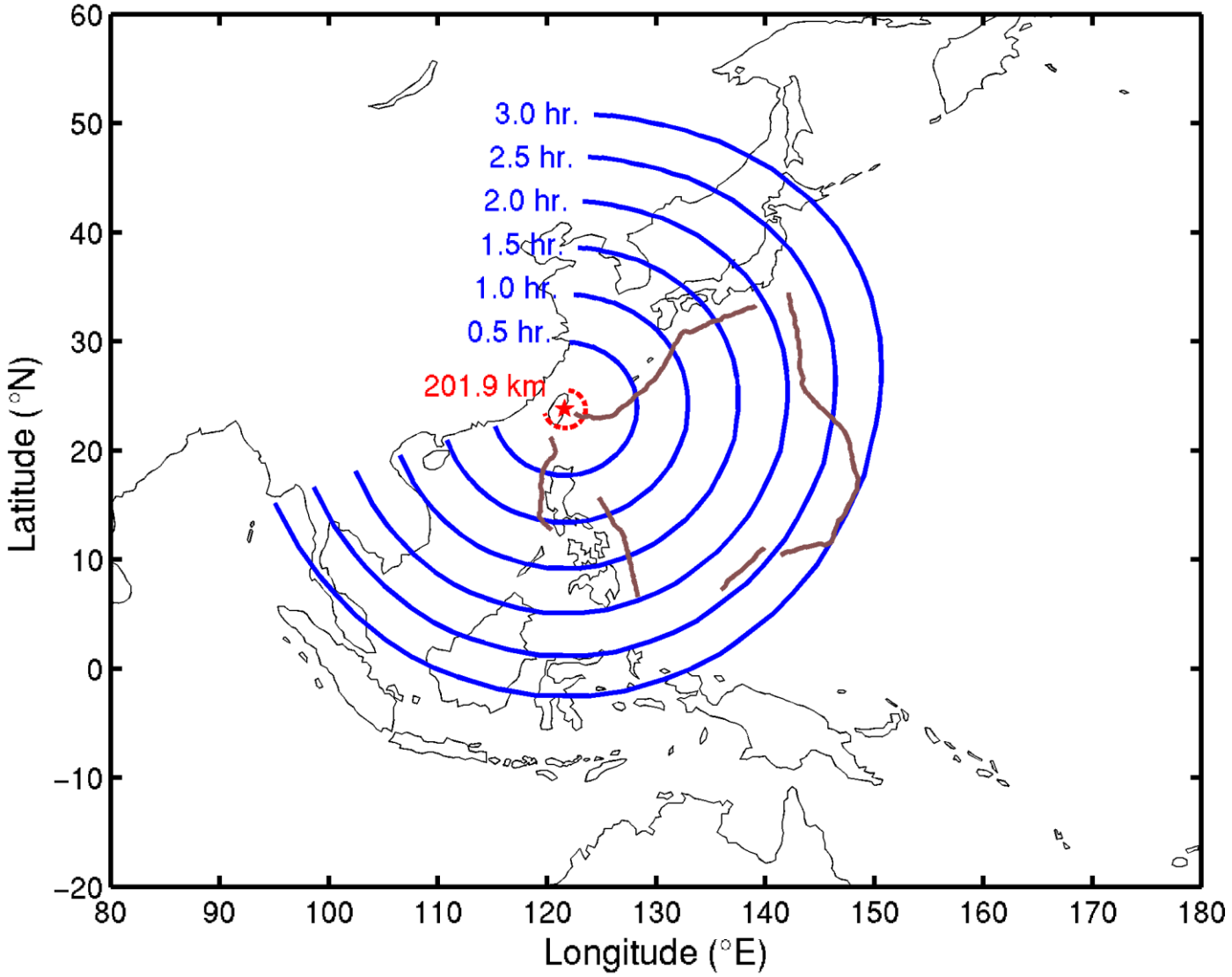
- Compare with tsunami and disturbance signal for Tohoku Japan earthquake event.







Result


3.0 hr.
2.5 hr.
2.0 hr.
1.5 hr.
1.0 hr.
0.5 hr.
201.9 km
Latitude (°N)
Longitude (°E)
60
50
40
30
20
10
0
−10
−20
80
90
100
110
120
130
140
150
160
170
180

Conclusion

- The characteristic periods of response spectra for earthquake events shown short and long period signal.
- The range of short period signal is during about 150s ~ 240s. It is only observed near the epicenter and weaker than long period signal.
- The range of long period signal is during 500s ~ 900s and over 1000s , it can be observed far from epicenter.
- The method for finding the source of perturbation shows the good result. That means the source of the signal on spectra come from the epicenter.
- Compare with TEC data and deep ocean duoy data shown the occurred time of disturbances is earlier than tsunami at far GPS station from the epicenter.
- The tsunami warning map around Taiwan shows that there have the leading time for warning for tsunamis occur 201.9 km away.

Thank you for your attention