

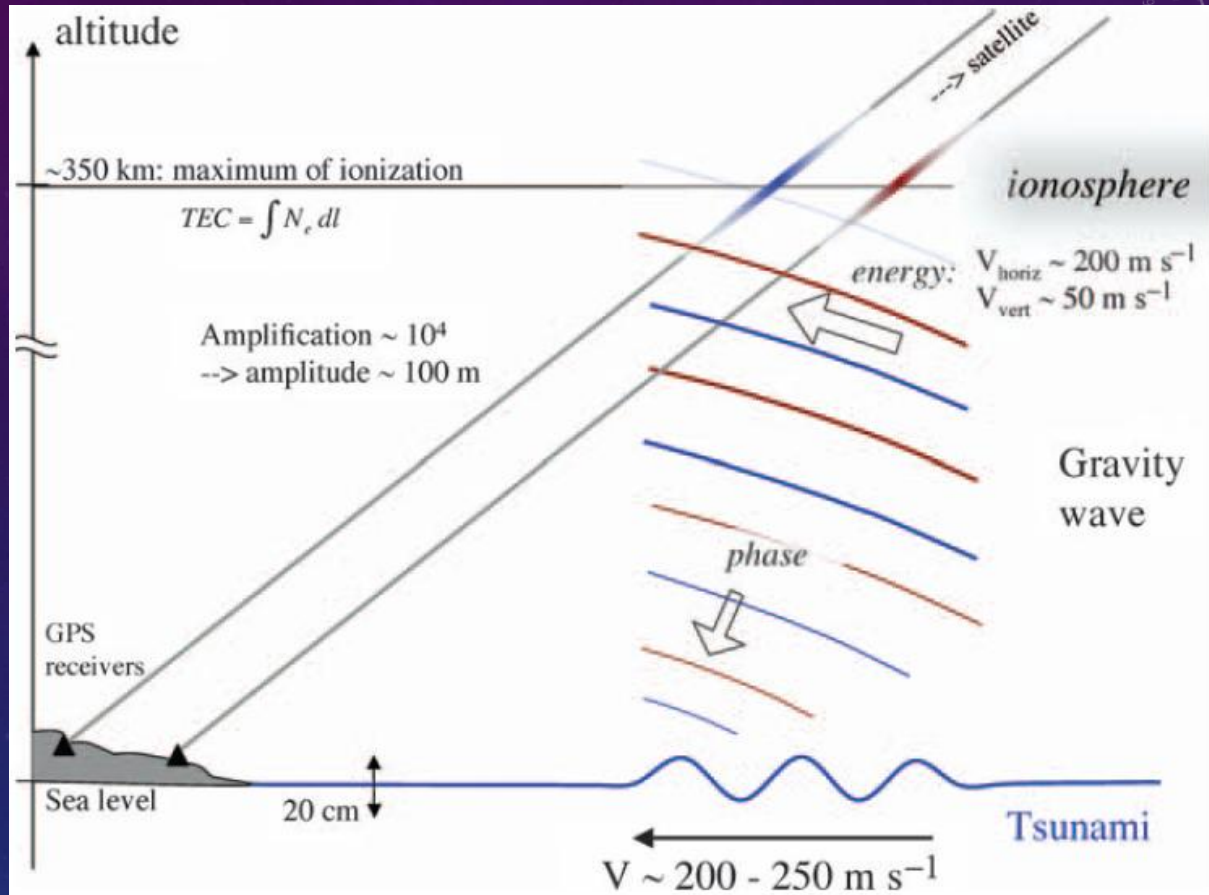


Traveling Ionospheric Disturbances Observed at Ground-Based GPS and HF Doppler Sounding Systems During the 2011 Tohoku Earthquake Tsunami

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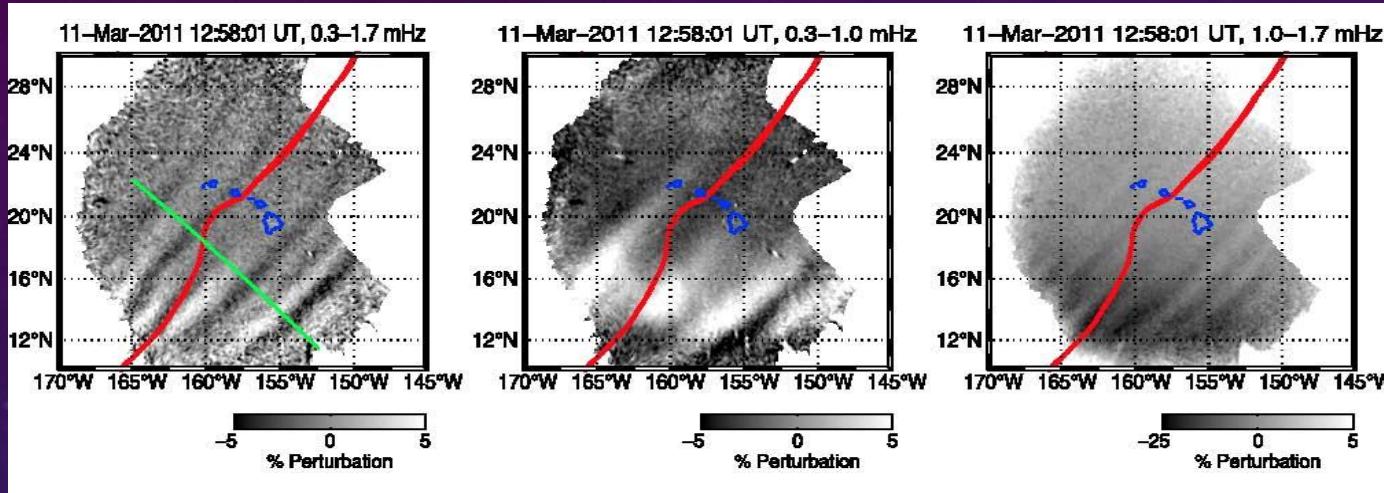
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Tsunami-Induced Ionosphere Disturbances

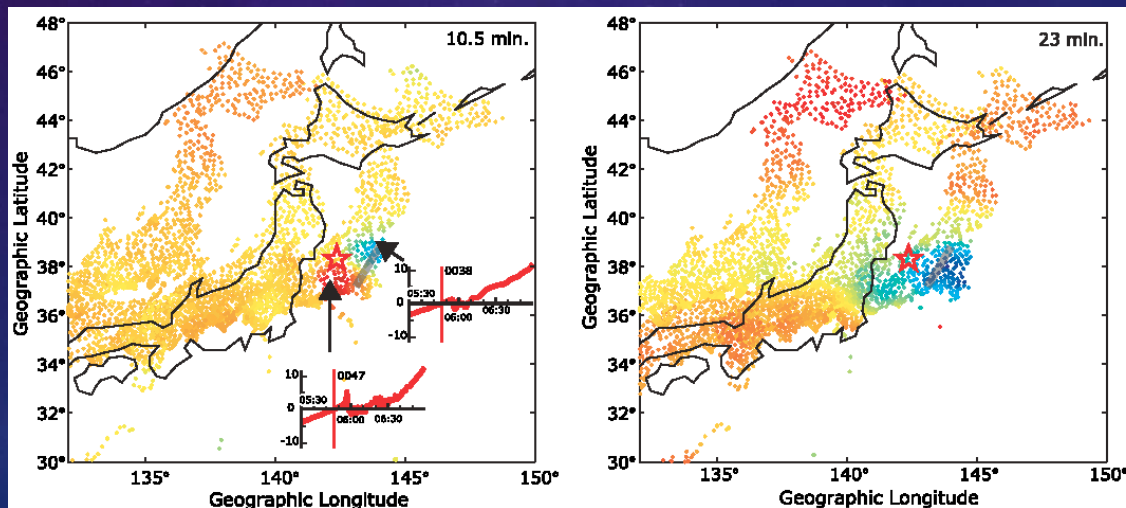


Artru et al. (Geophys. J. Int., 2005)

Ionospheric Response to the Pacific Tsunami

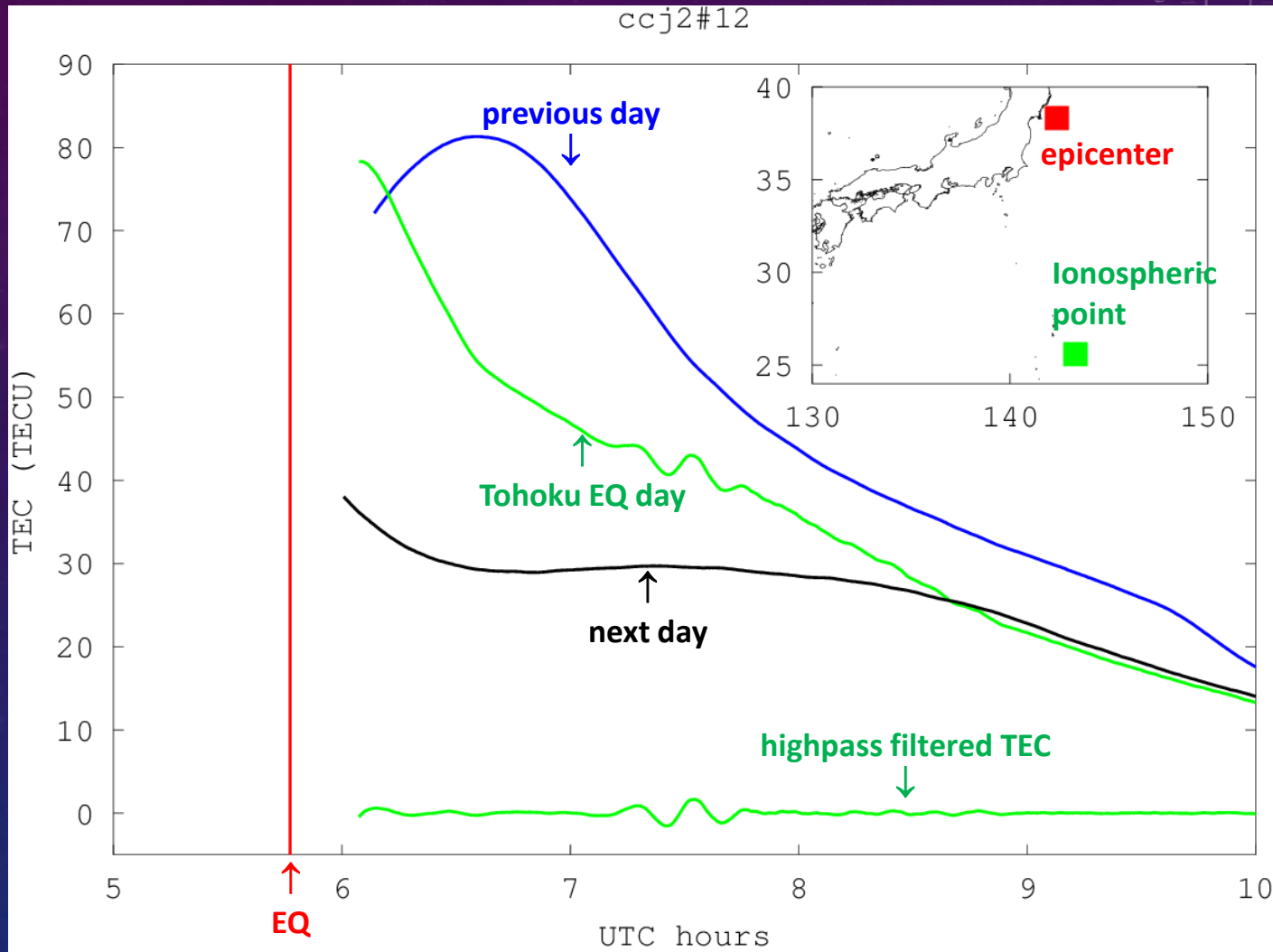


Ionospheric airglow response to the tsunami after the Tohoku earthquake in 2011 (Makela et al., GRL, 2011)



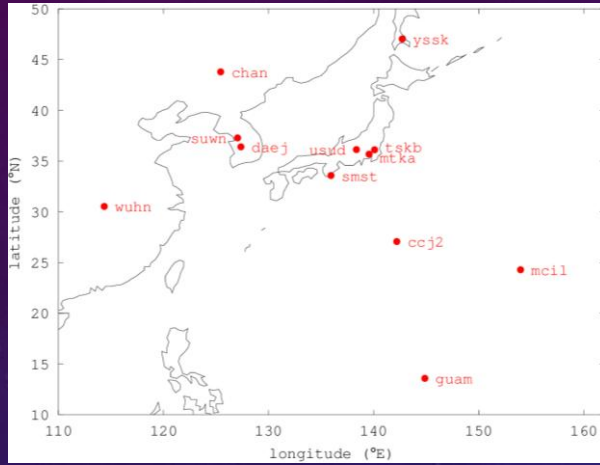
GPS-TEC differences generated by the tsunami (Kakinami et al., GRL, 2012)

GPS TEC after Tohoku EQ

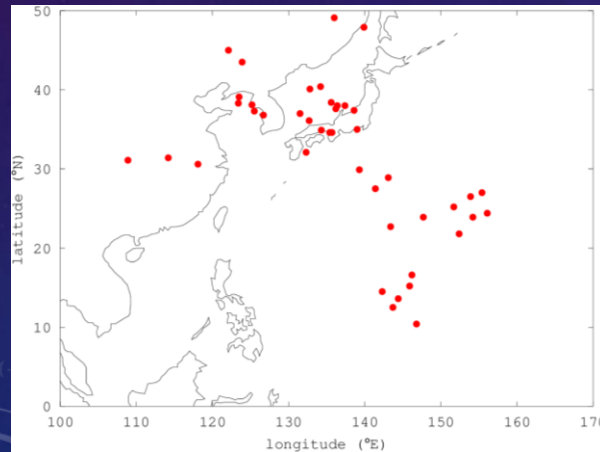


Highpass Filtered TEC Variations

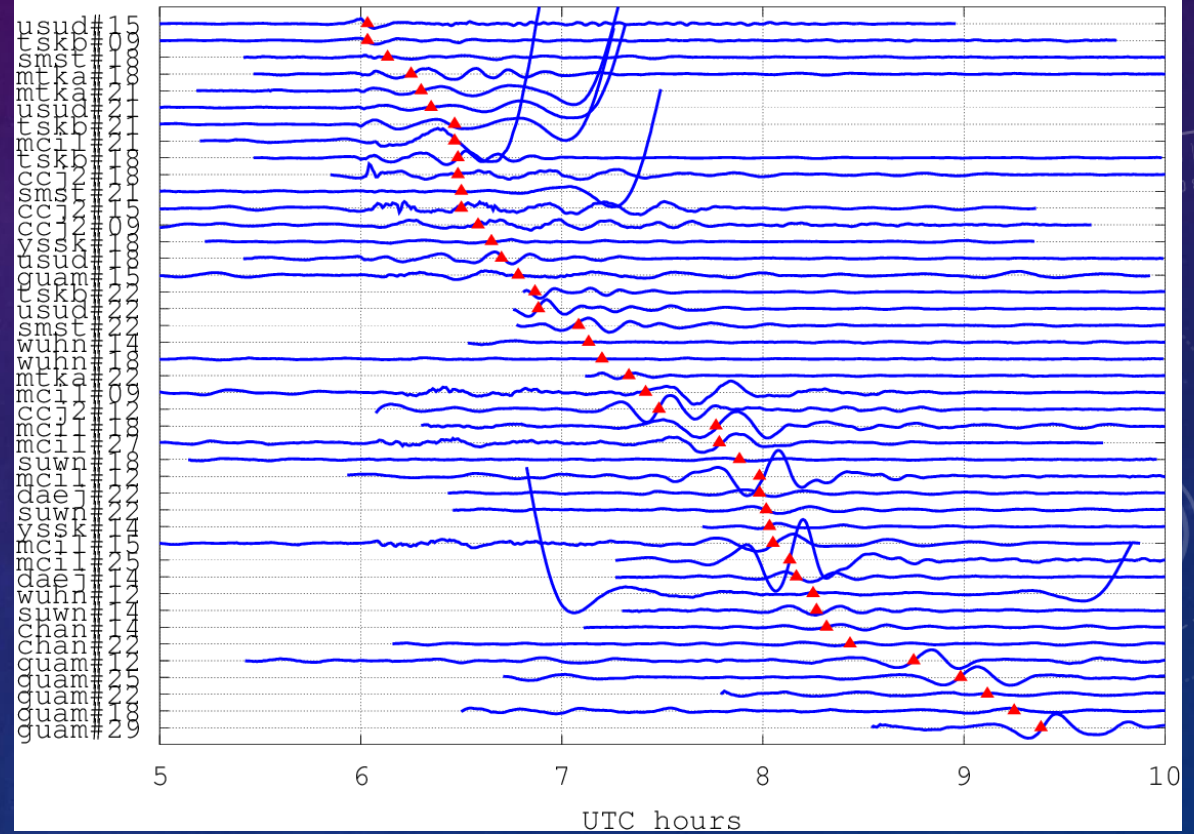
GB GPS receivers used



Detected ionospheric points

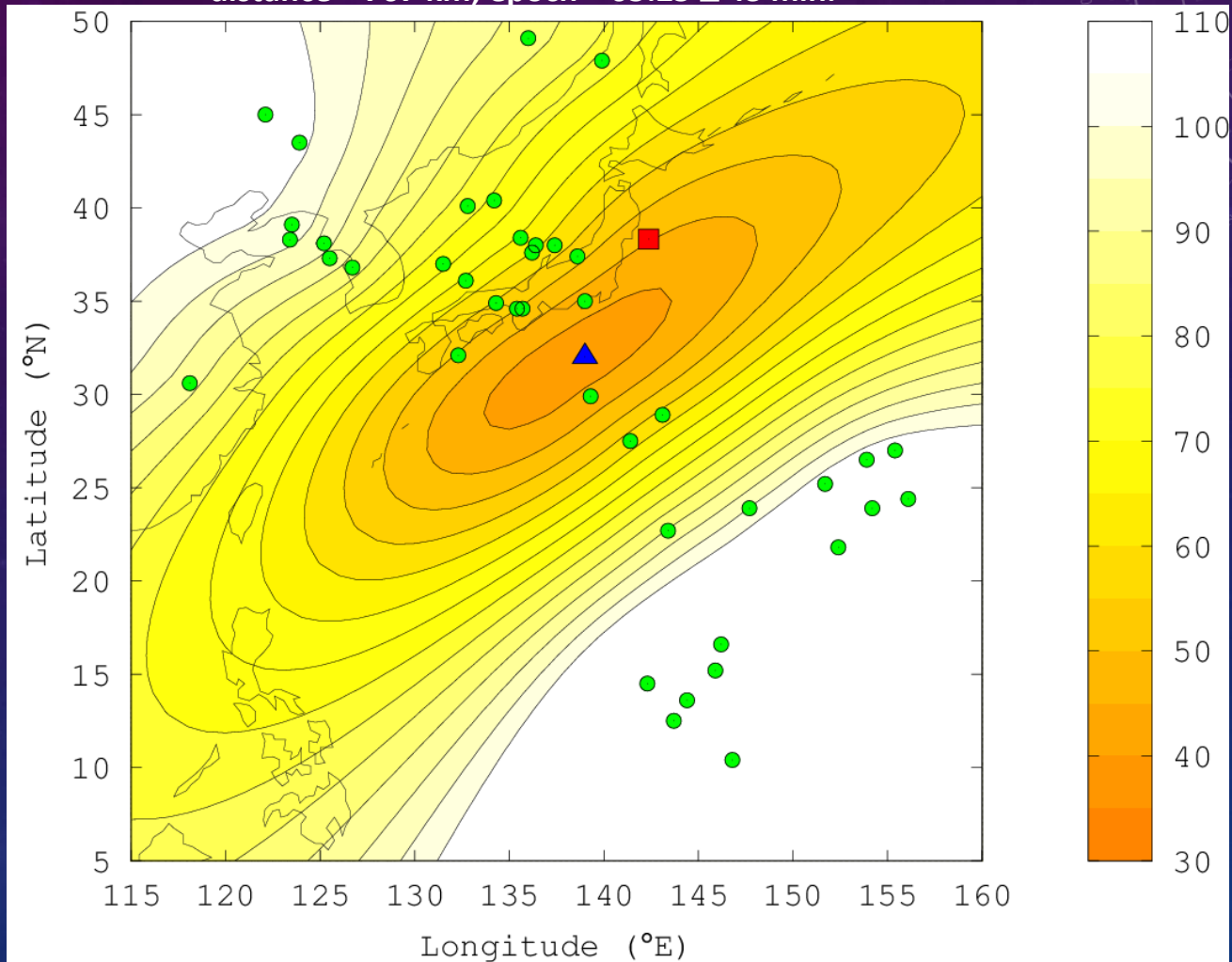


Filtered TEC (2 TECU for each Y-grid; tsunami day)

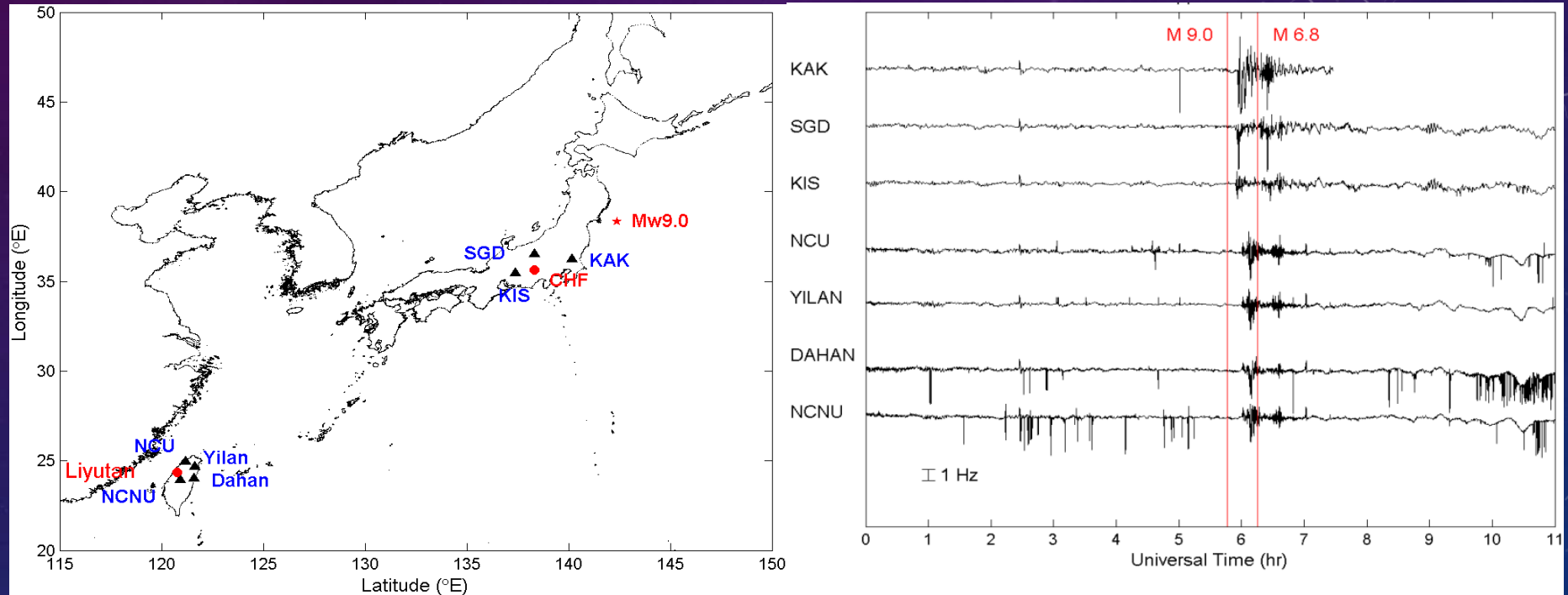


Ray-Tracing Results

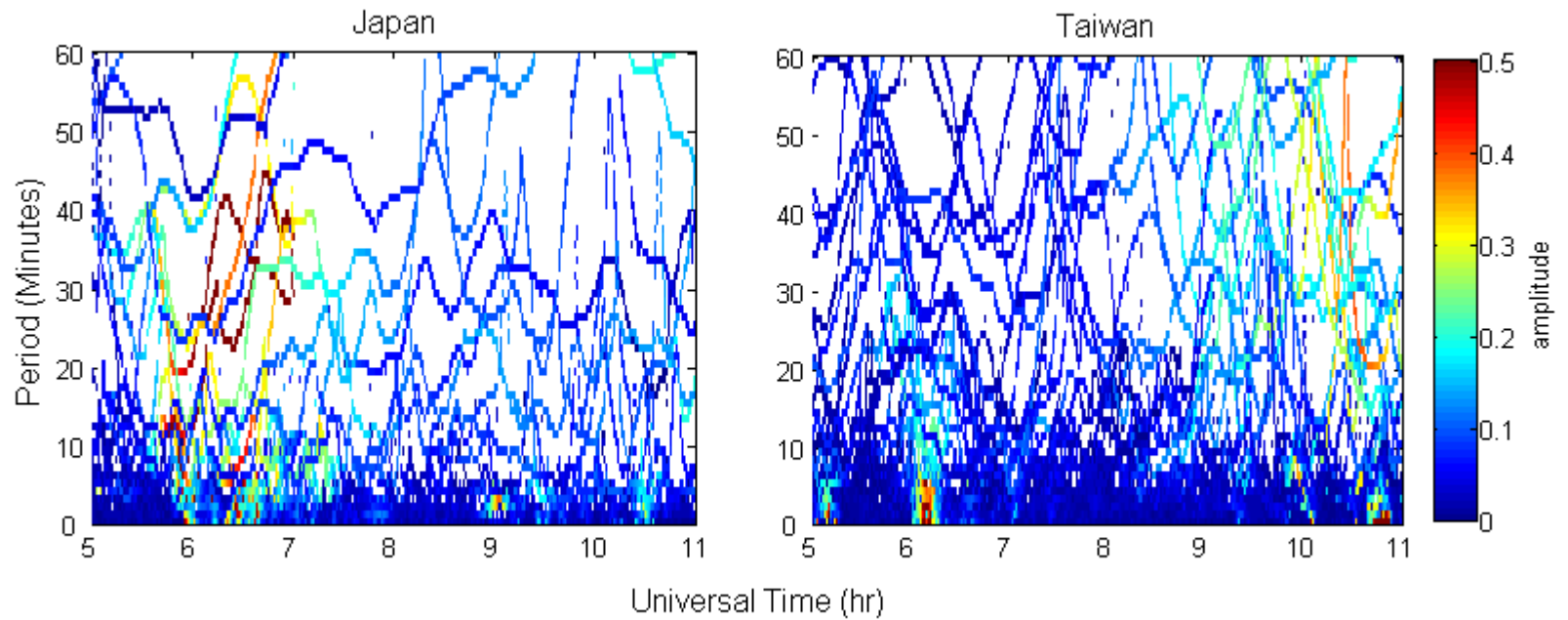
distance = 767 km; epoch = 05:25 ± 43 min.

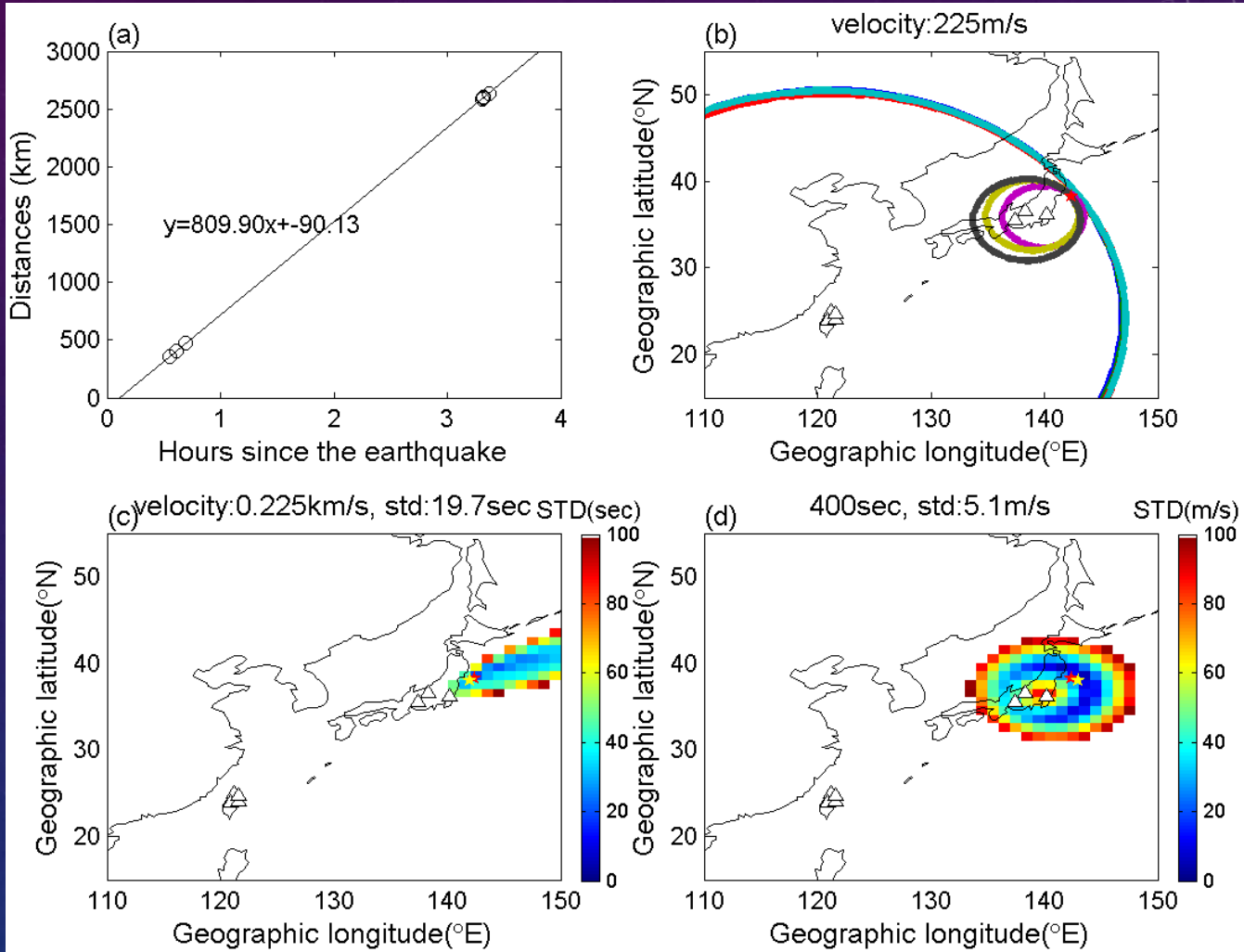


HF Doppler Sounding



Hilbert Spectra





Circle Method

Ray-Tracing

Beam-Forming



Summary

- Ionospheric disturbances triggered by the tsunami after the Tohoku earthquake in 2011 have been detected in TEC variations by means of GPS observation.
- 3D spherical ray-tracing method can be used to relocate the tsunami origin with lower cost than buoys.
- Analysis result shows clear tsunami-induced Doppler shifts in ionosphere with horizontal speed of 225 m/s.
- Hilbert spectra shows the instantaneous periods of the maximum STID waves are around 20-60 minutes for the tsunami.