Improved WP-GITM Simulations of Natural Hazard-Induced Atmospheric Disturbances

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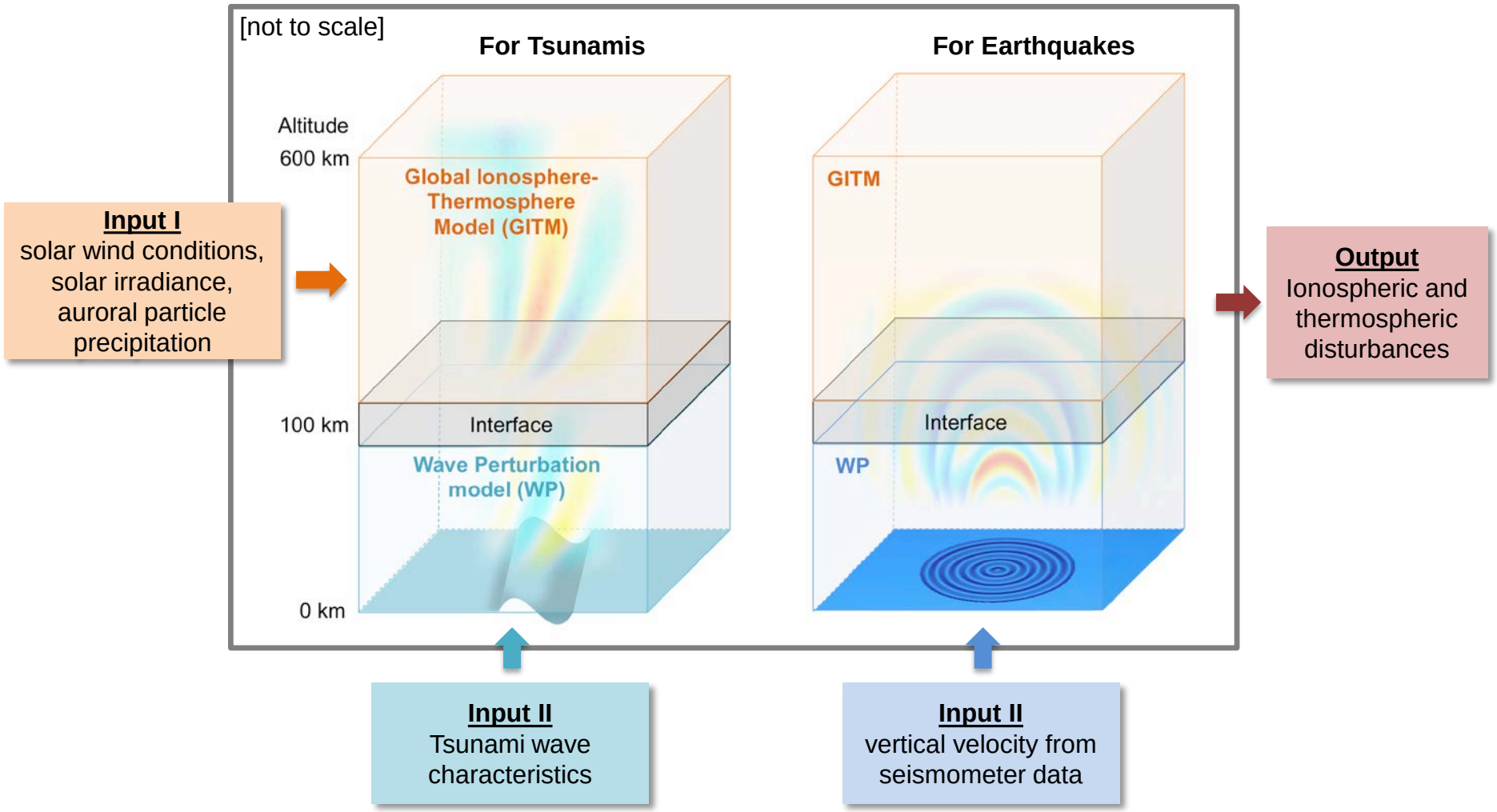
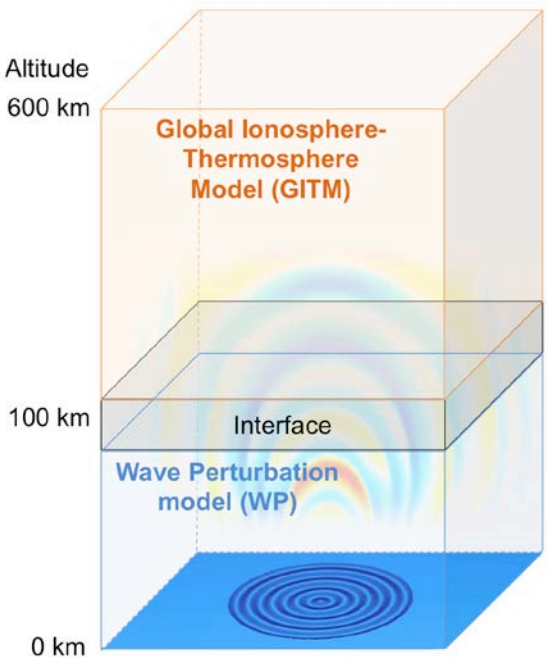
WP-GITM Overview



Outline

- Model description
- Simulating earthquake-generated TEC perturbations for
  - 2011 Tohoku-Oki event
  - 2015 Illapel event
- Summary

WP-GITM for Earthquakes



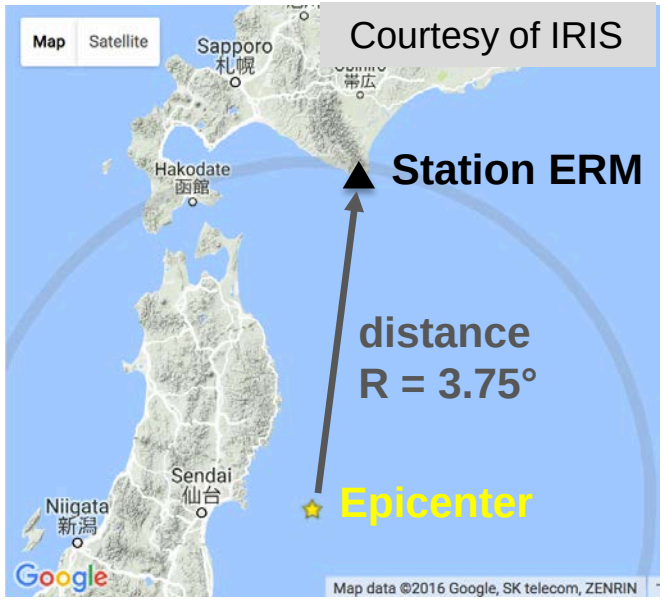
Major Assumptions

1. Epicenter as a point source of spherical waves in the neutral atmosphere
2. Seismic-atmosphere coupling via surface vertical velocity

Key Developments

1. Spherical acoustic-gravity waves from a point source
2. Source specification with seismometer data

2011 Tohoku Event: Source Specification

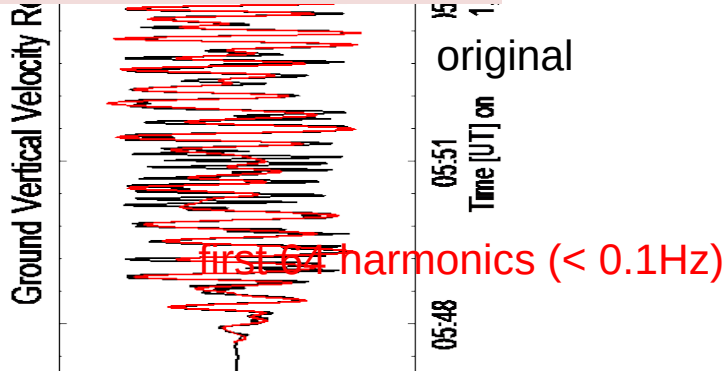


Seismic wave amplitudes decay due to geometrical spreading, intrinsic absorption, and scattering attenuation.

<u>Uncertainty in Q^{-1}</u>: For S-waves between 0.01Hz and 0.1Hz, Q^{-1} = 0.05 ~ 0.0005; For S-waves < 0.01Hz, unknown. [Sato et al., 2012]

We set fQ^{-1} = 0.005

Vertical velocity data at ERM



Main shock

Amplitude multiplied by

$$e^{-\pi R f Q^{-1}/v} / R$$

[Sato et al., 2012]

Vertical velocity at Epicenter

Tohoku Event Simulation

Simulated local region:
31°N – 47°N, 135°E – 151°E

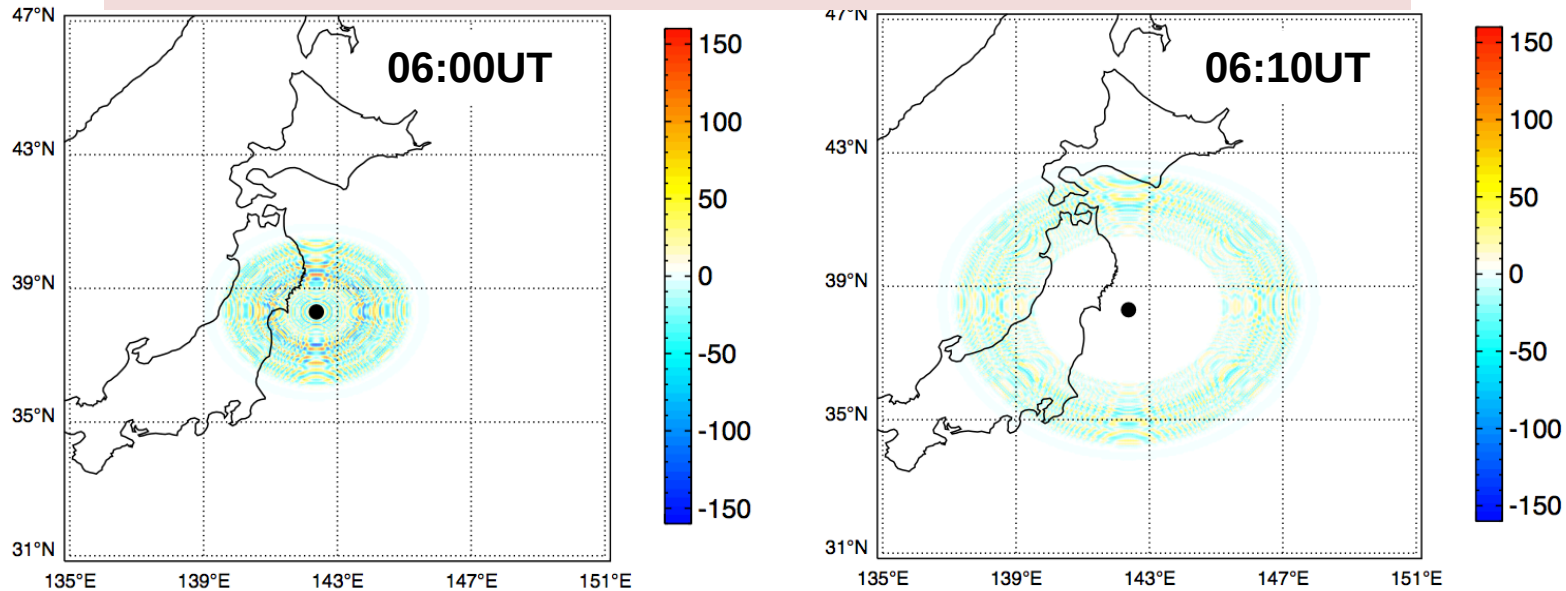
Simulated time interval:
05:40 UT – 07:00 UT
11 March 2011

Spatial resolution:
0.02° horizontally
0.2 local scale height vertically (1 km – 10 km)

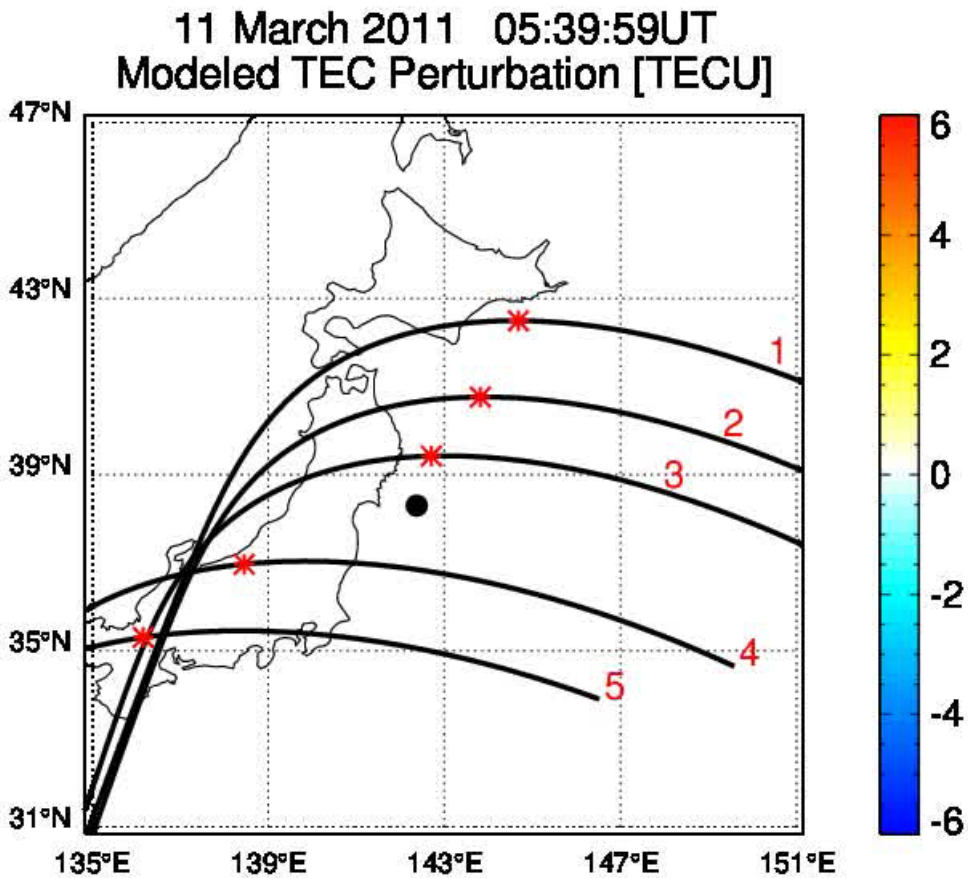
Temporal resolution: ~ 1 second

Input: vertical velocity at epicenter

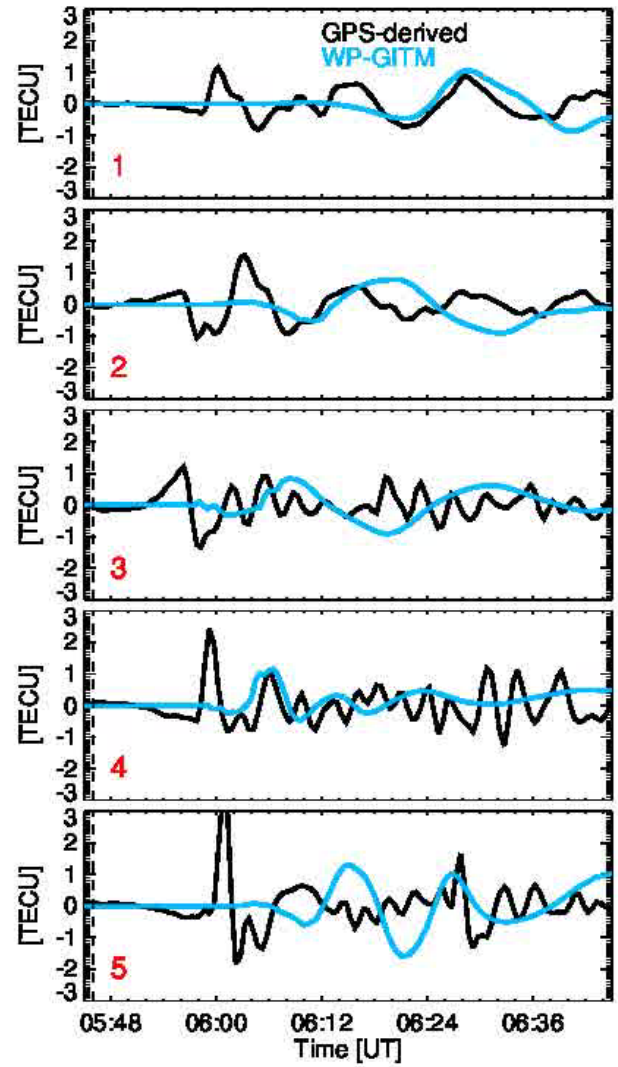
Vertical neutral velocity perturbation [m/s] at 100km altitude



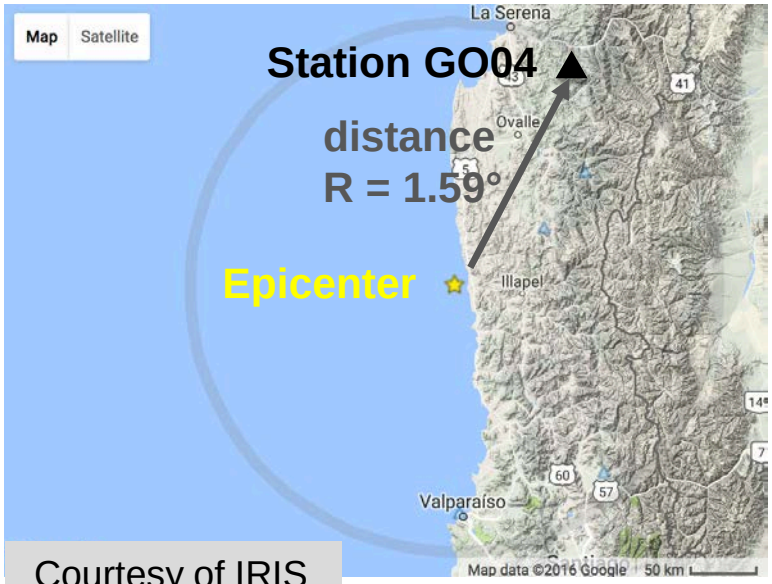
Tohoku Event: TEC Perturbations



Comparison with GPS TEC data



2015 Illapel Event



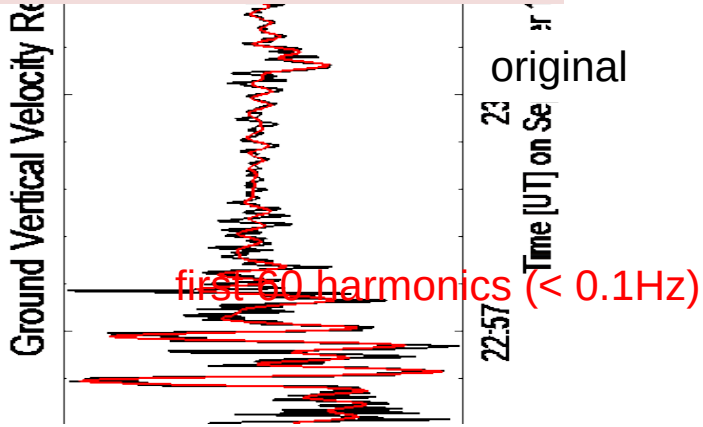
Courtesy of IRIS

Simulated local region:
22°S – 34°S, 78°W – 66°W

Simulated time interval:
22:50 UT – 23:45 UT on 16 September 2015

Spatial resolution:
0.02° horizontally
0.2 local scale height vertically

Vertical velocity data at GO04

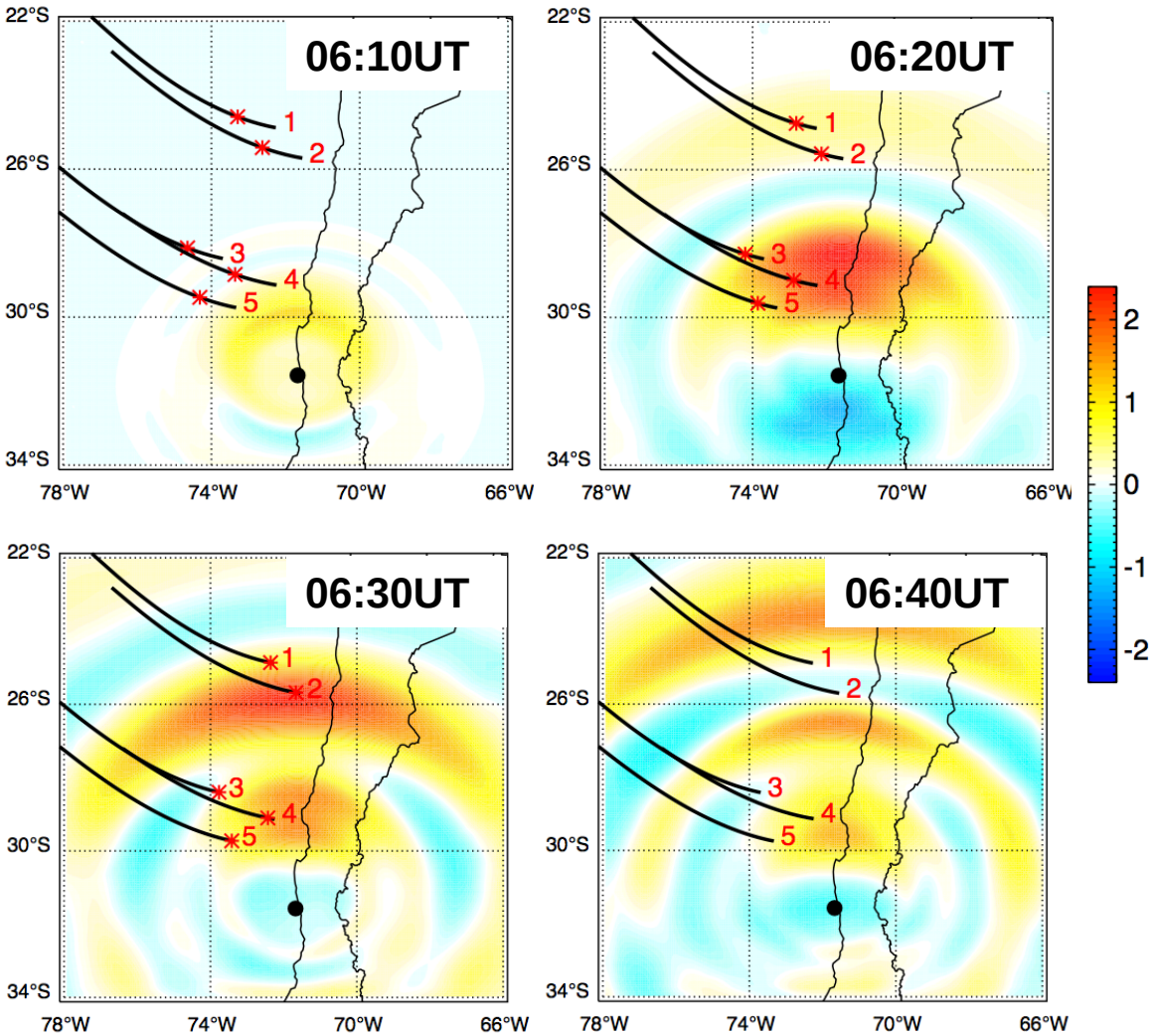


amplification factor

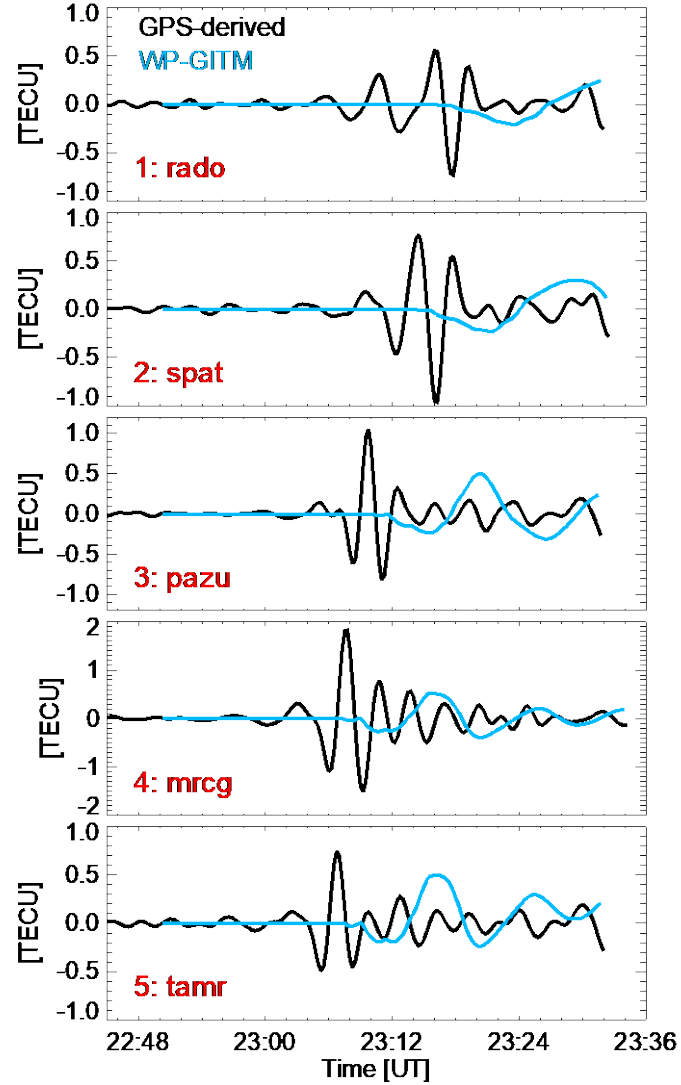
Input:
vertical velocity at epicenter

Illapel Event: TEC Perturbations

Simulated TEC perturbations [TECU]



Comparison with GPS TEC data



Summary

- We have extended WP-GITM capabilities to model earthquake-induced traveling ionospheric perturbations. WP-GITM simulations can now be driven by seismic measurements.

- Modeling of the two large earthquake events show promising results: TEC perturbation magnitudes are found to be in agreement with GPS-derived TEC observations.

- Timing and phase of simulated TEC perturbations require further research.

- Future work:
  - Improve vertical velocity representation at epicenter
  - Extend modeling approach from the point source to an area source

Acknowledgement

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