Rapid characterization of tsunami sources with GNSS-TEC ionospheric monitoring

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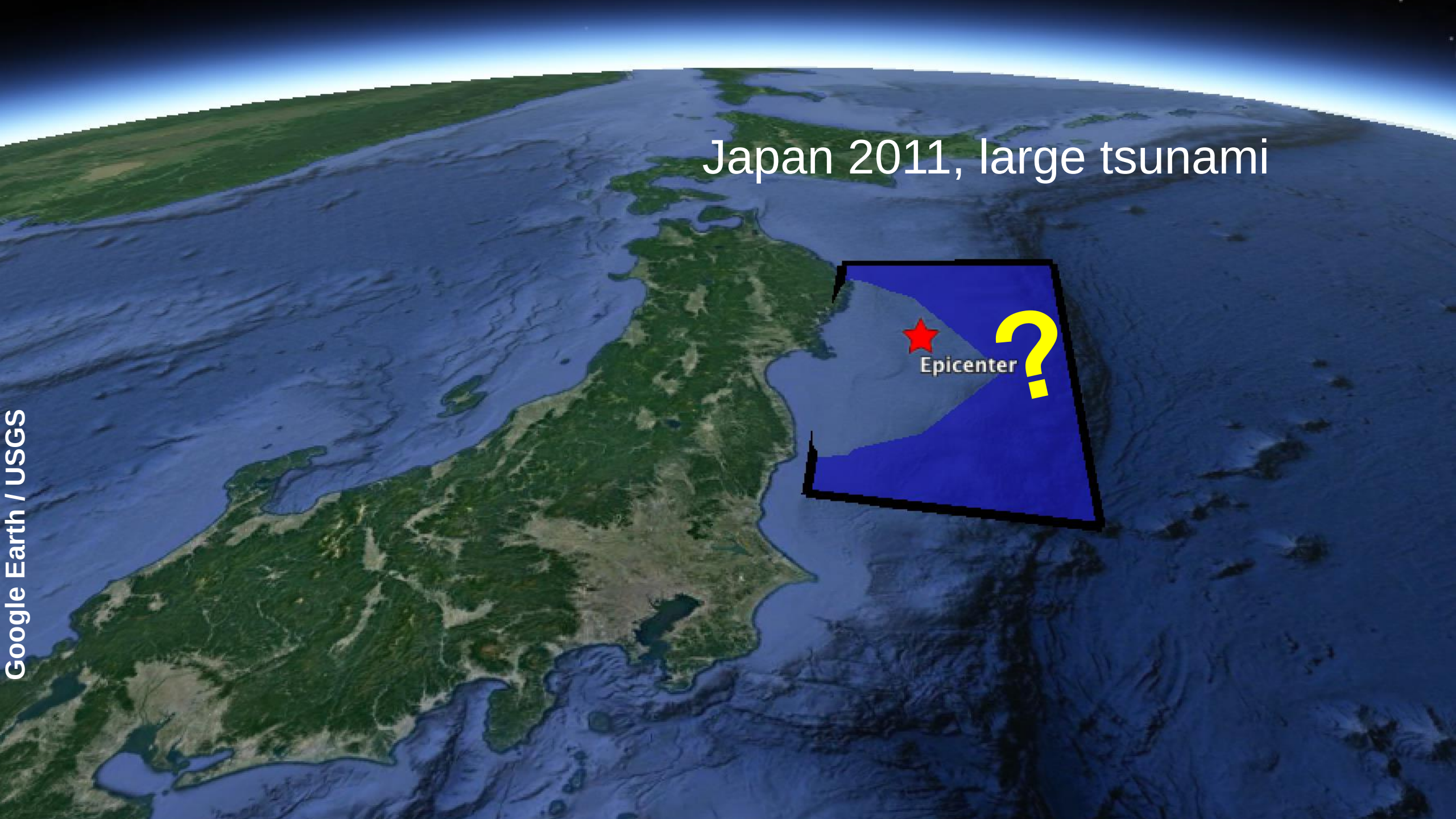
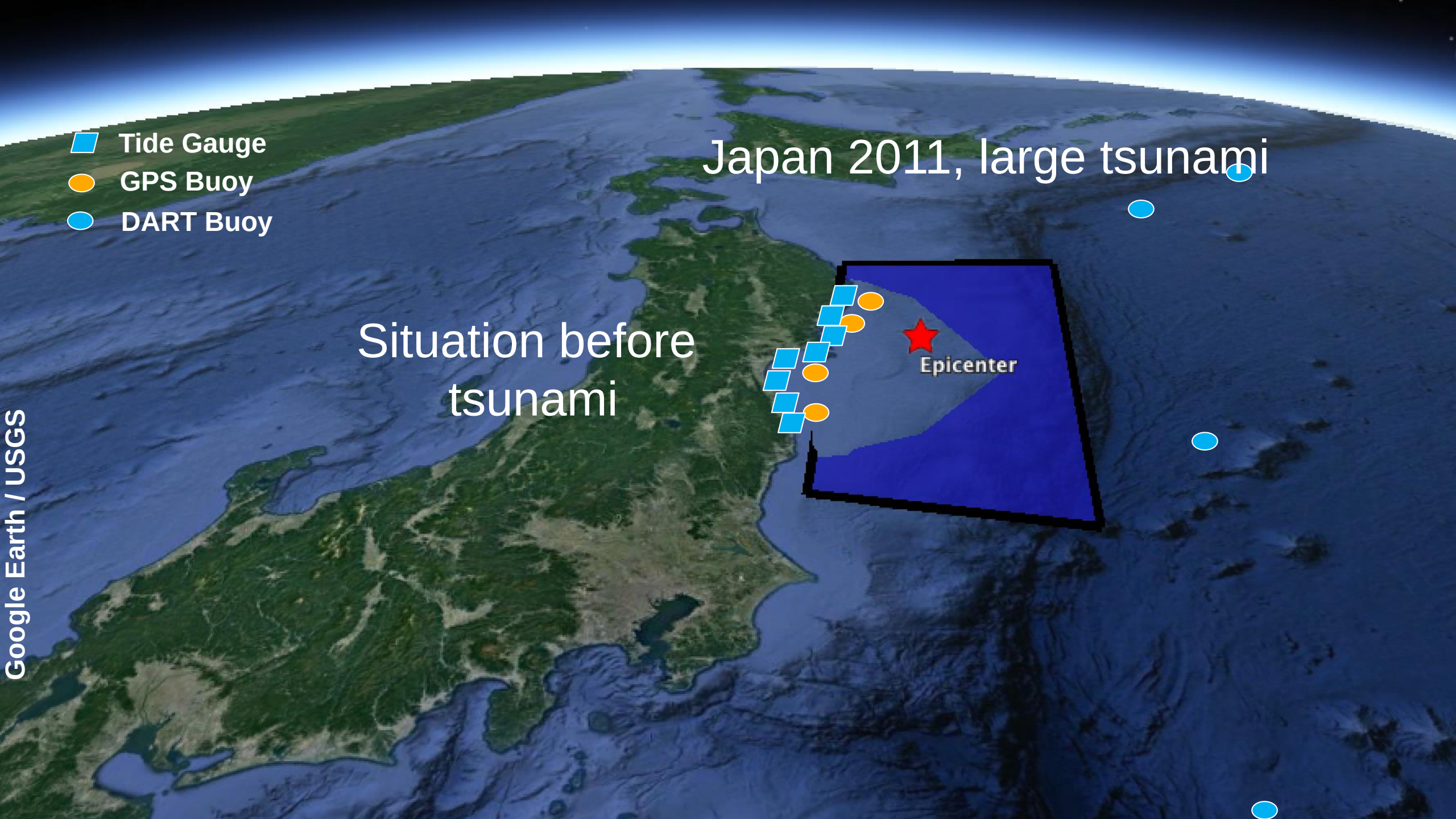

Japan 2011, large tsunami
Epicenter
?
Google Earth / USGS


Tide Gauge
GPS Buoy
DART Buoy
Japan 2011, large tsunami
Situation before tsunami
Epicenter
Google Earth / USGS

Tide Gauge
GPS Buoy
DART Buoy

Japan 2011, large tsunami

Situation during tsunami

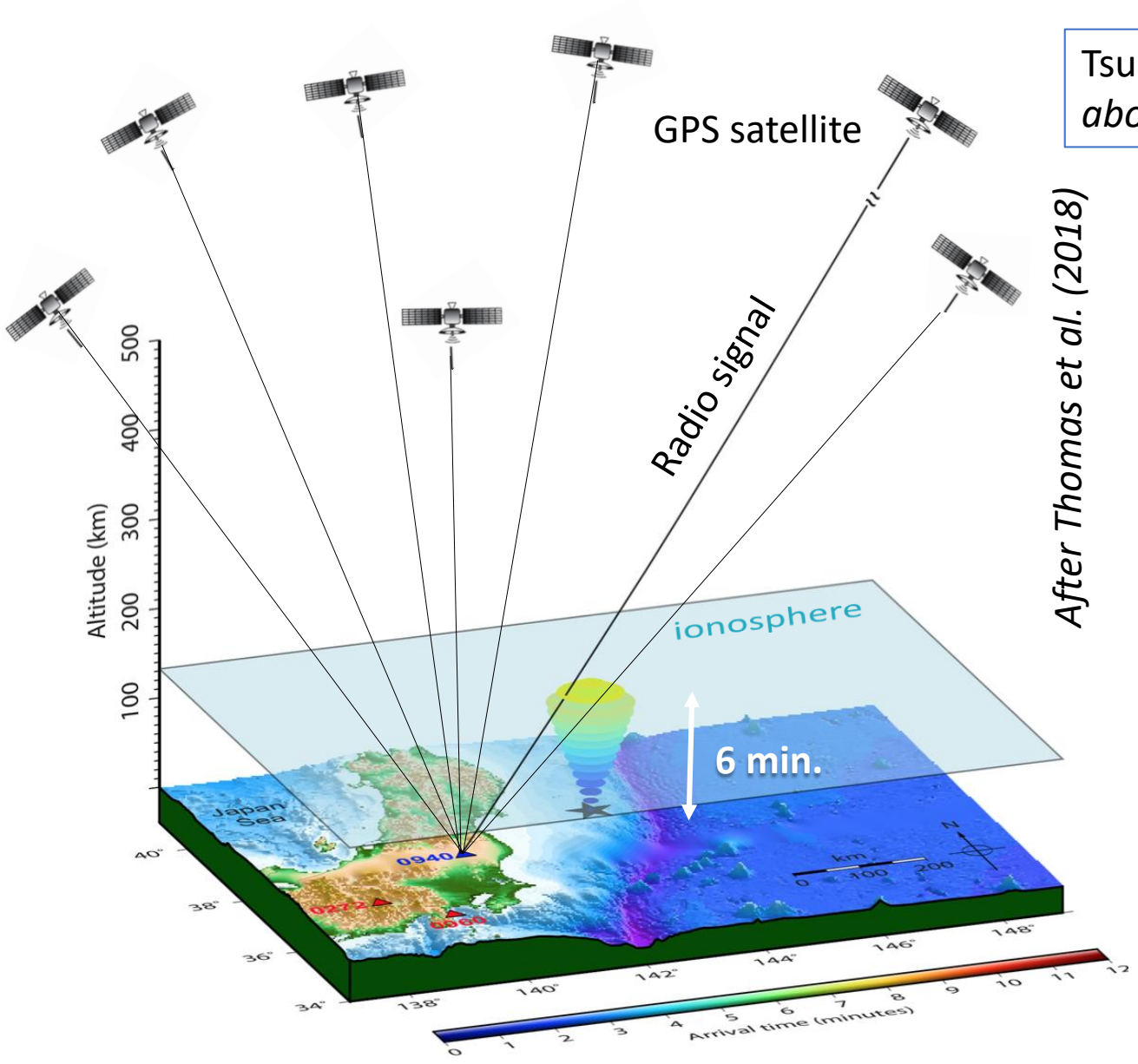
Delay : 1/2h (too late)

Very costly $$$

- **Earthquake**
- **Volcano**
- **Landslide**

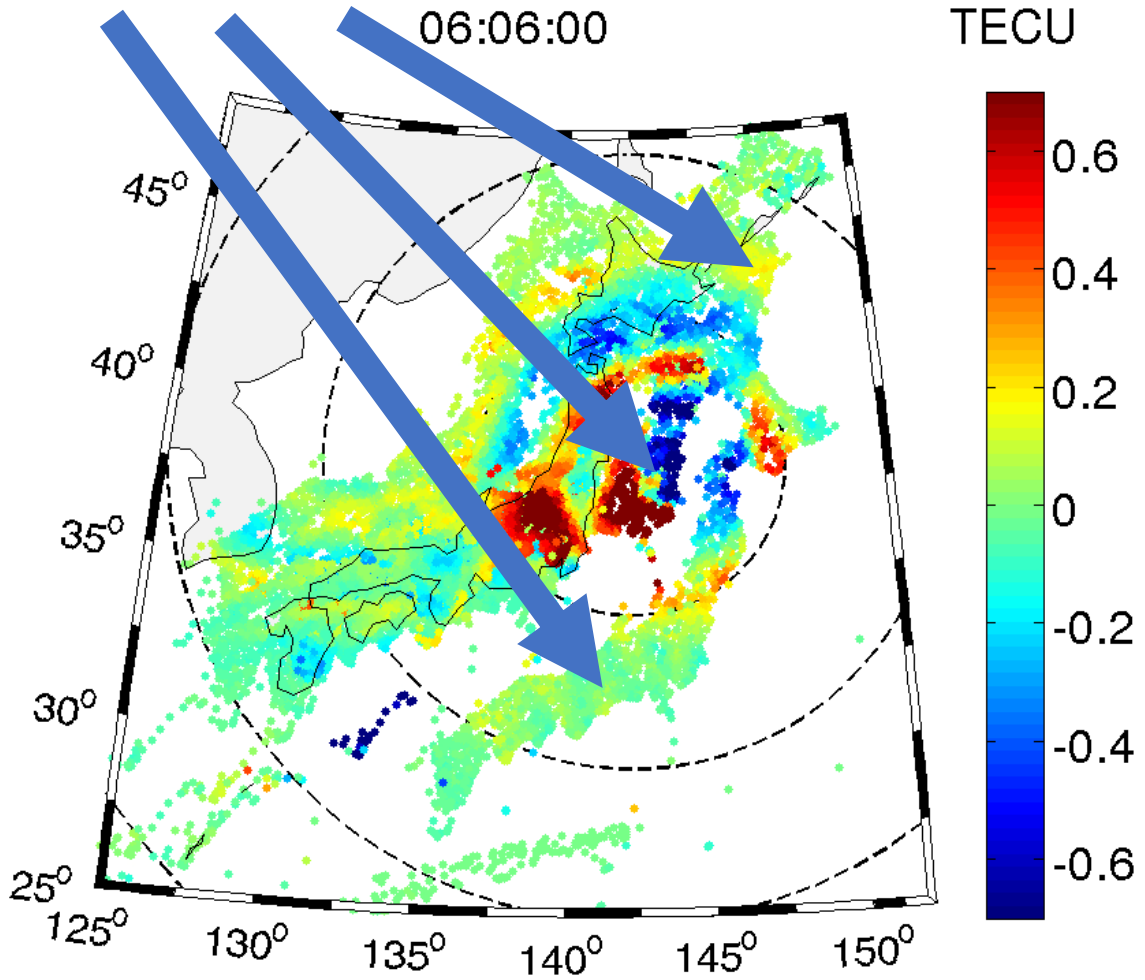
Google Earth / USGS

GNSS-TEC for Tsunami early warning



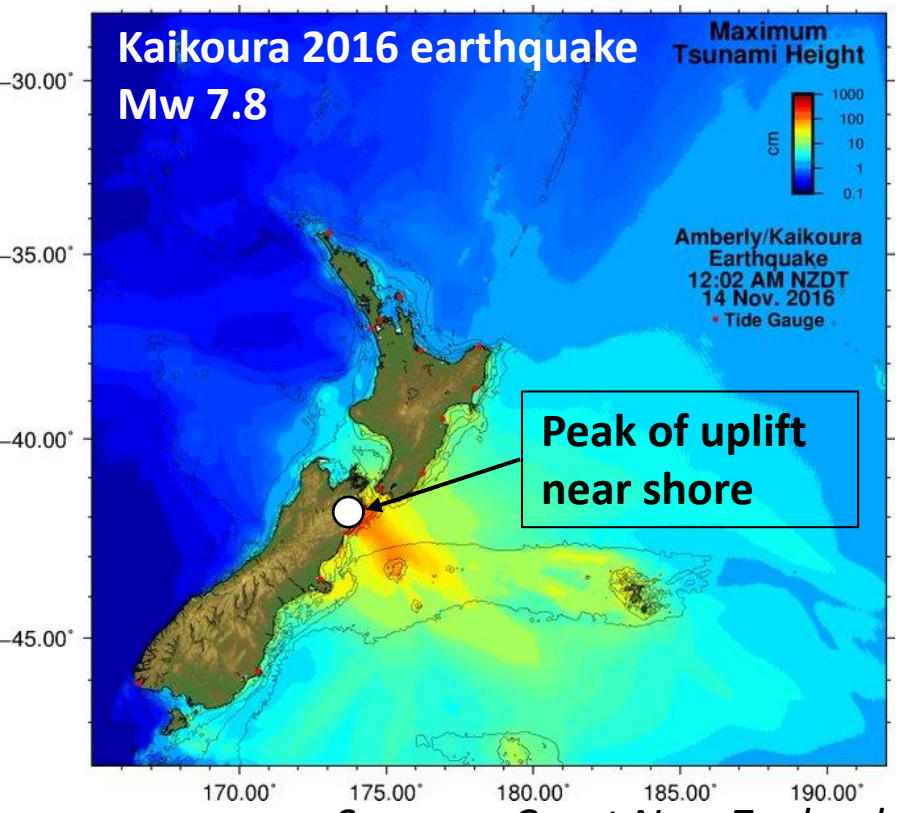
Tsunami sounding
above the ocean

After Thomas et al. (2018)



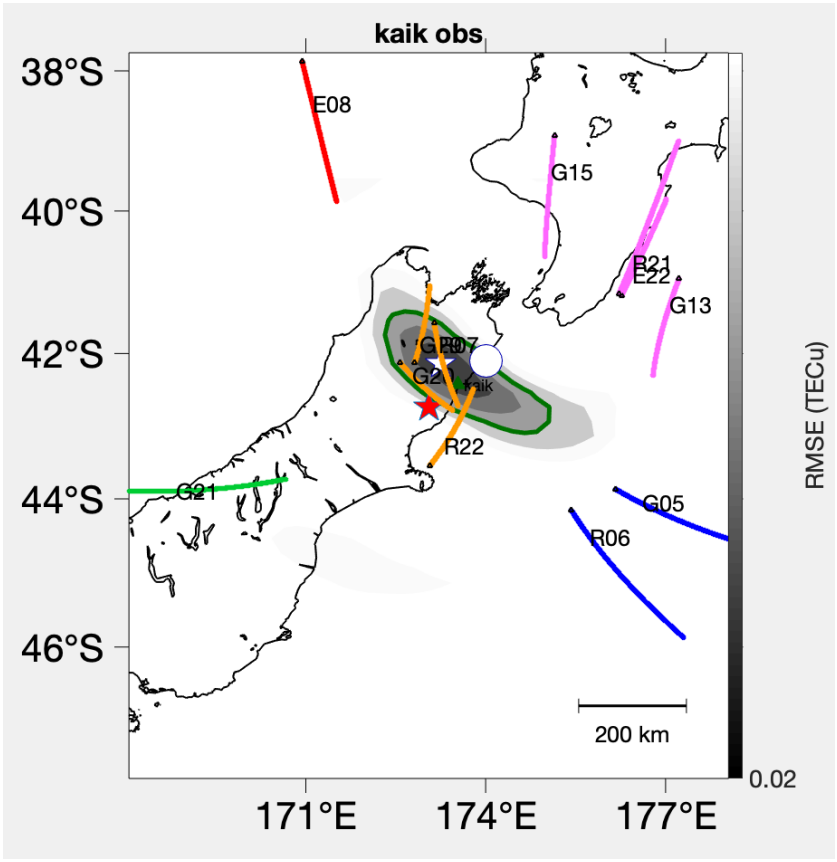
Rolland et al. (2011)

One single GNSS station can locate the tsunami initiation zone (origin of TEC perturbation)

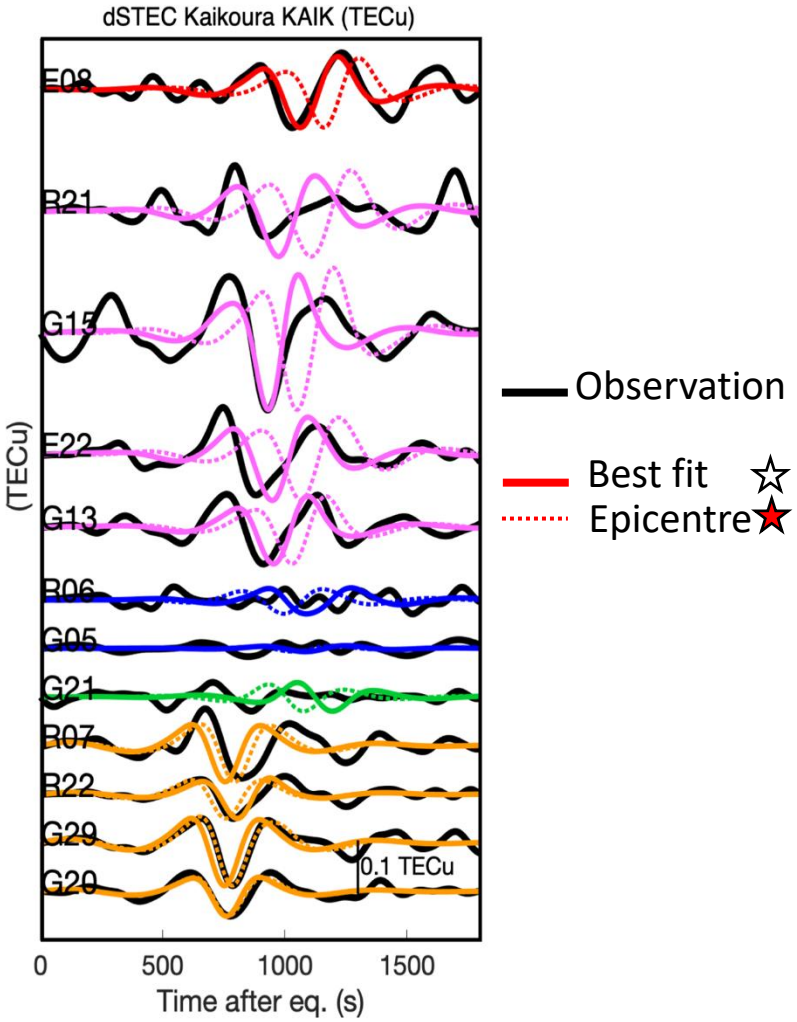


Source: eCoast New Zealand

7 meters tsunami run-up

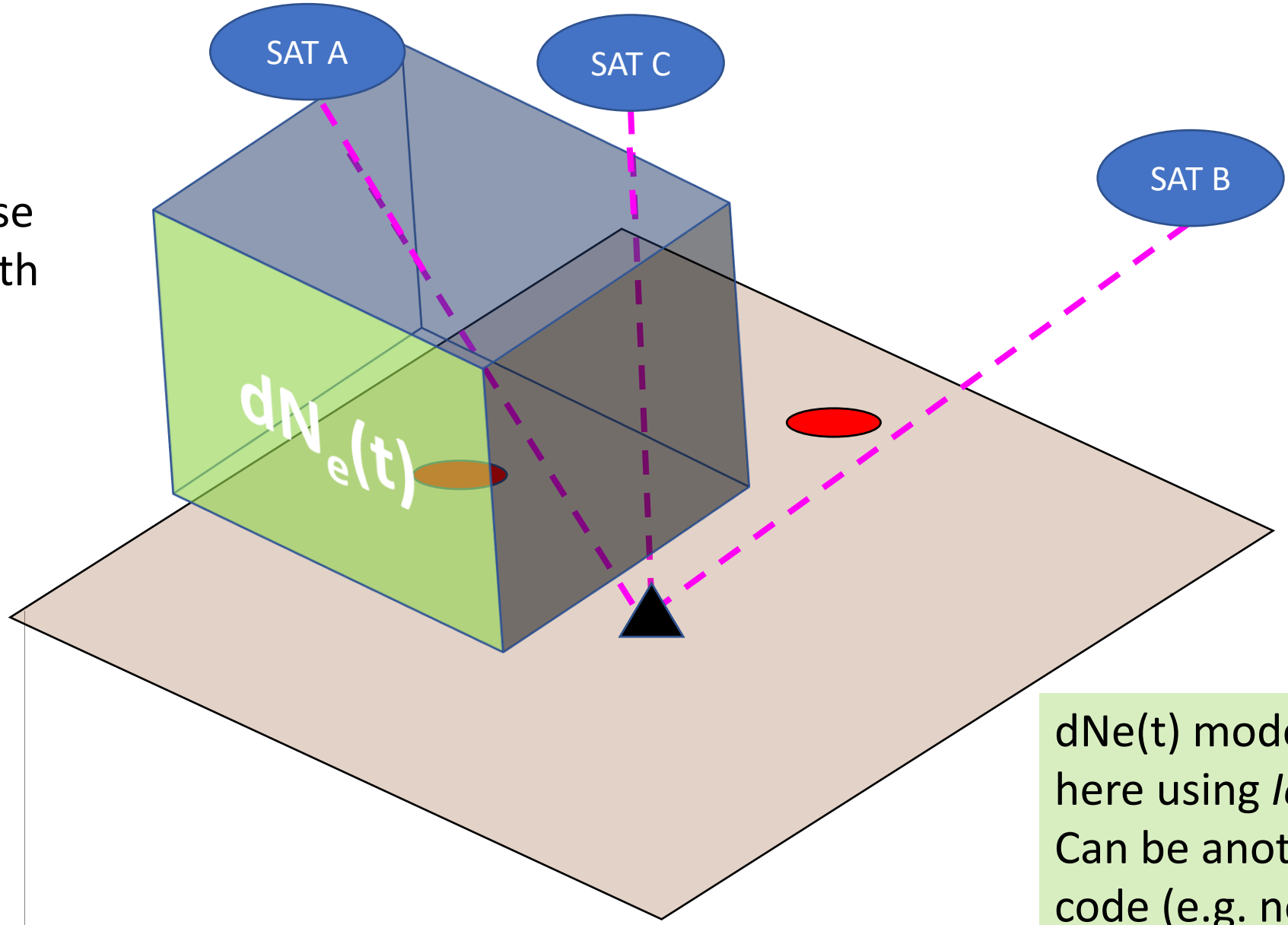


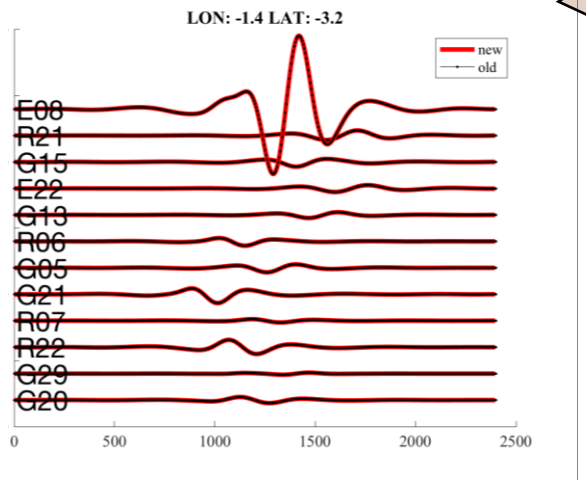
Zedek et al. (2021)



Coseismic dTEC reconstruction method: first trial source

dTEC unit function **:**
synthetic TEC response to one trial source with unit amplitude measured at the satellite-receiver pair

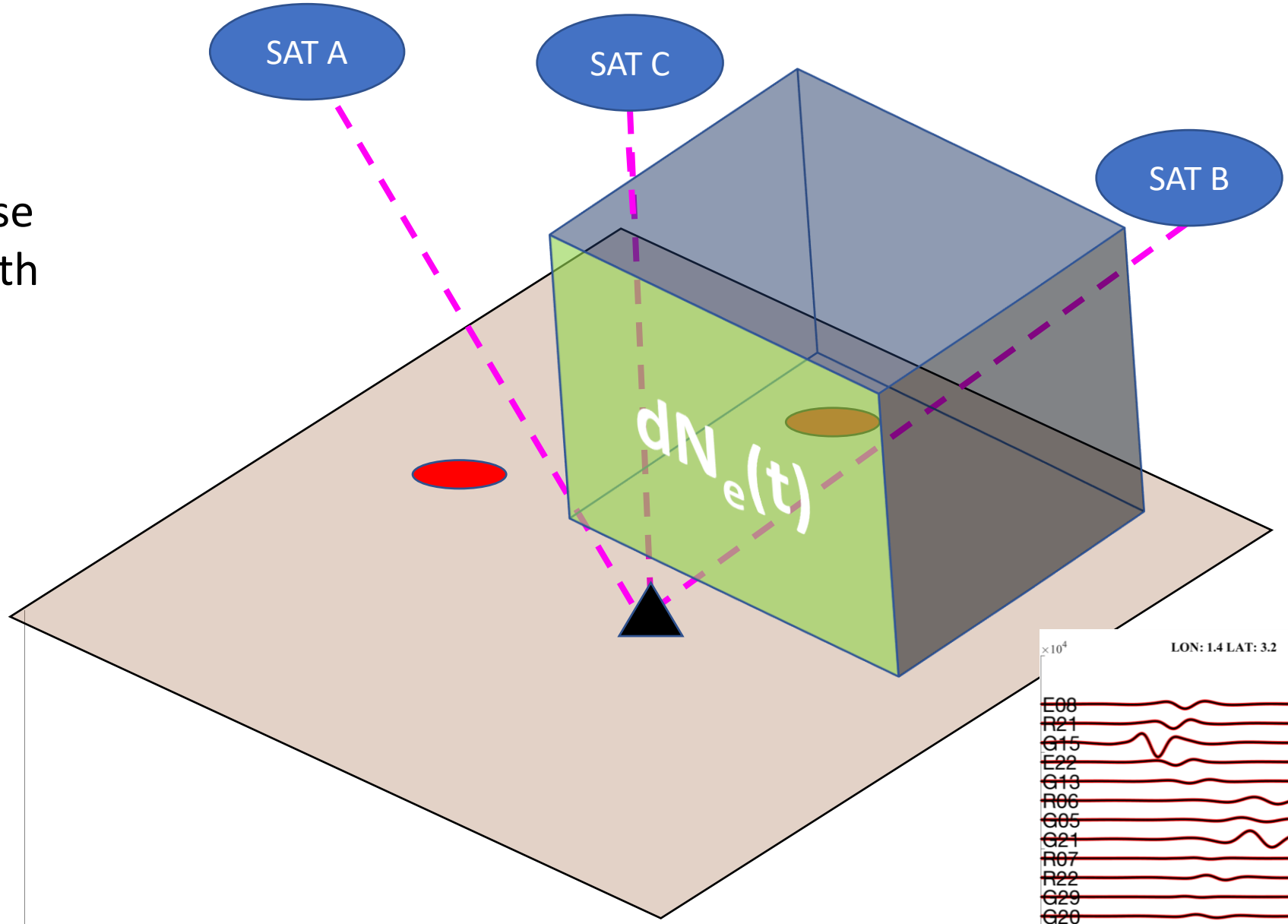


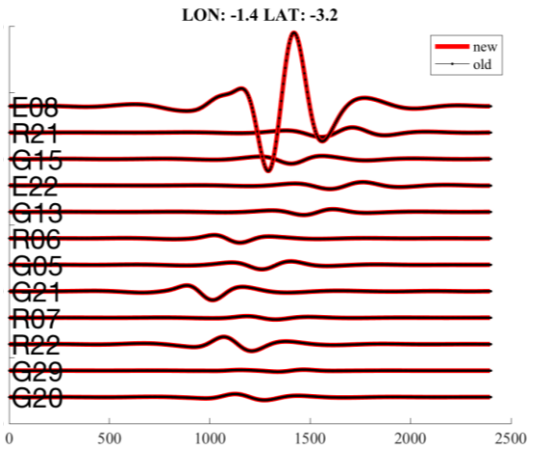


dNe(t) modelled here using *IonoSeis* Can be another code (e.g. normal modes)

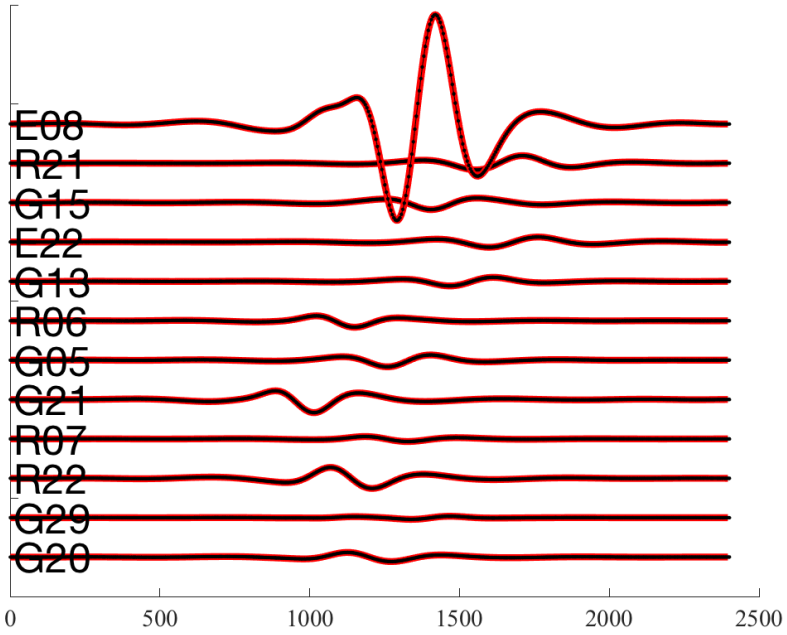
Coseismic dTEC reconstruction method: a 3D view – second trial source

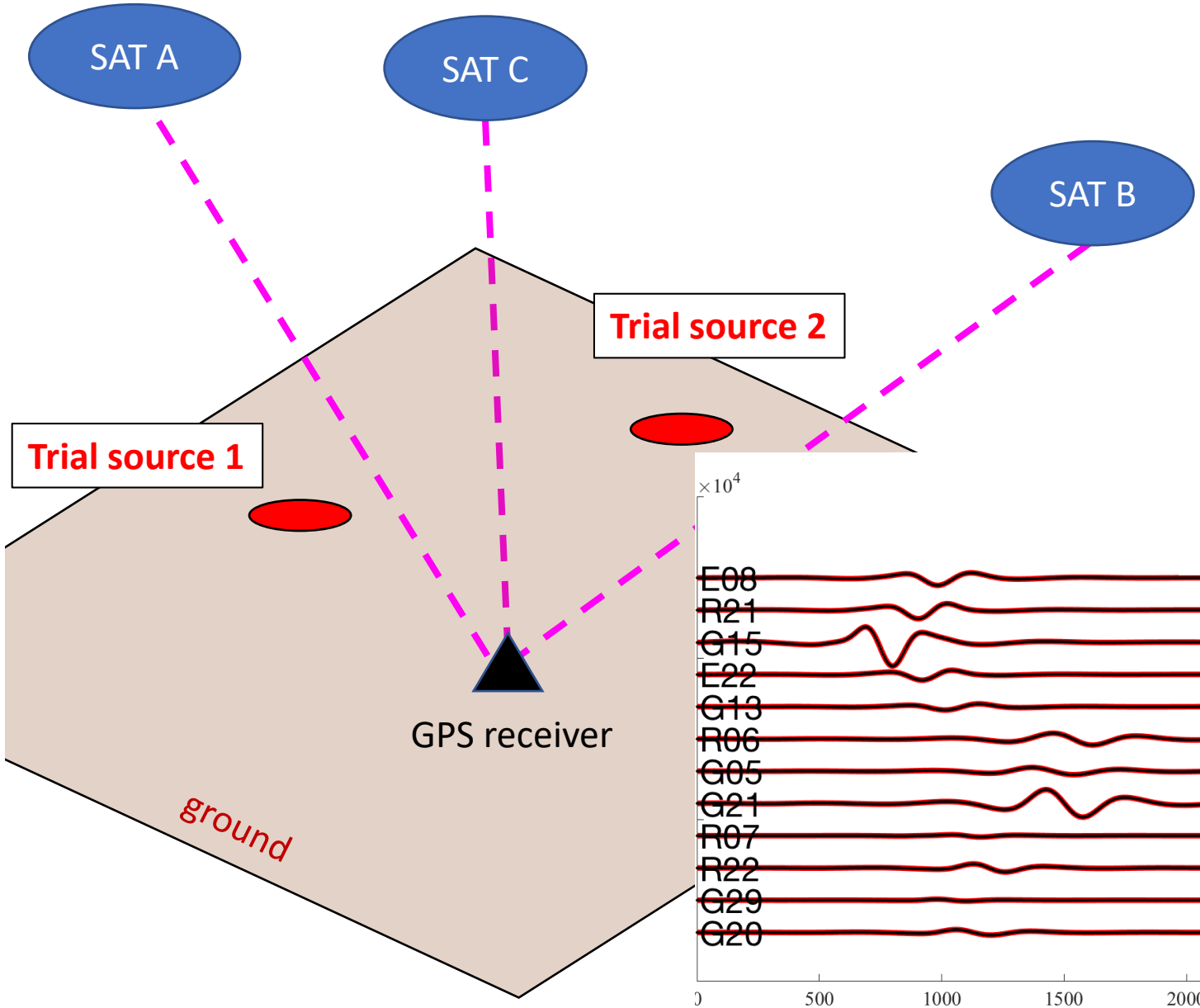
dTEC unit function **:**
synthetic TEC response to one trial source with unit amplitude measured at the satellite-receiver pair





Coseismic dTEC is highly sensitive to the location of its origin/source

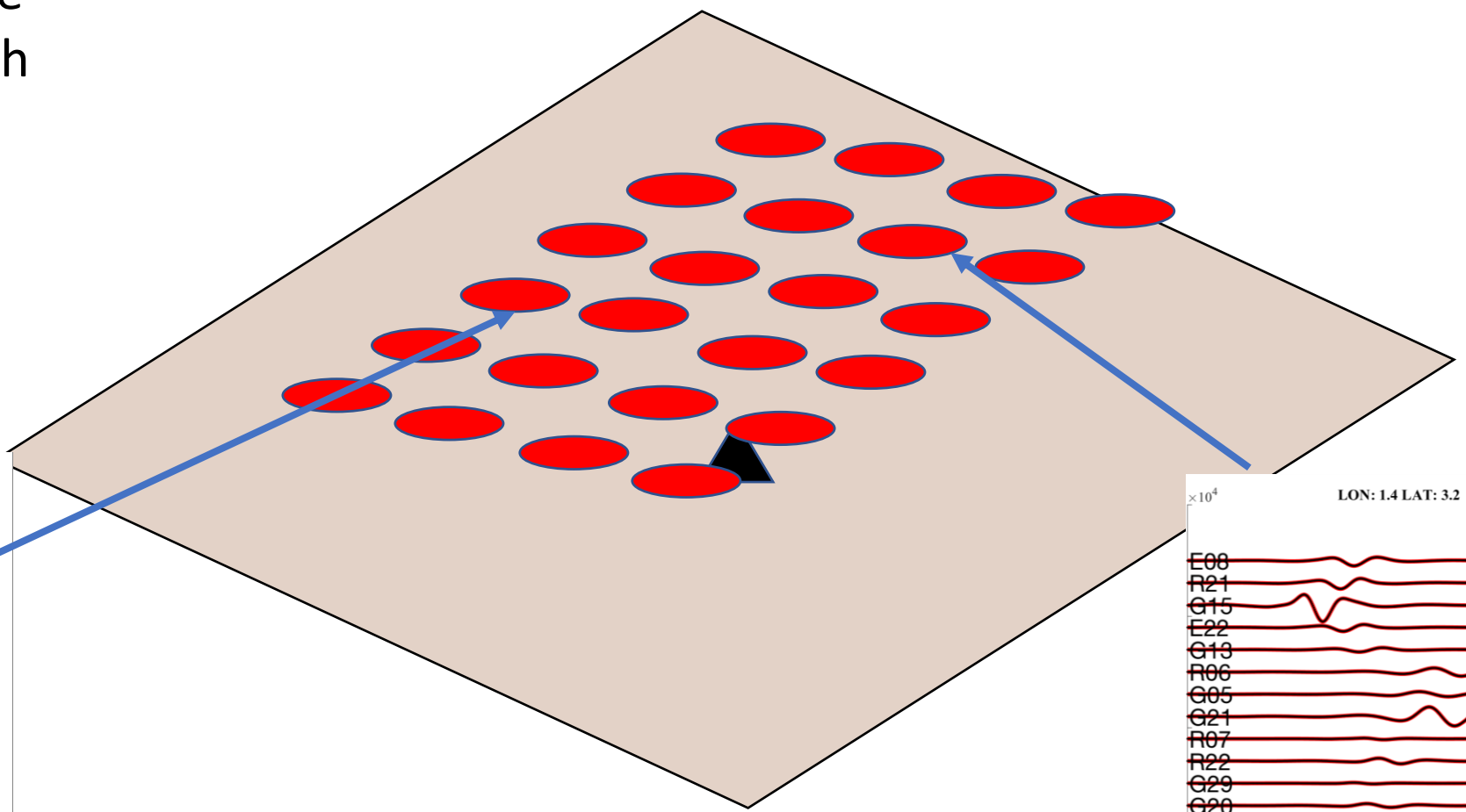


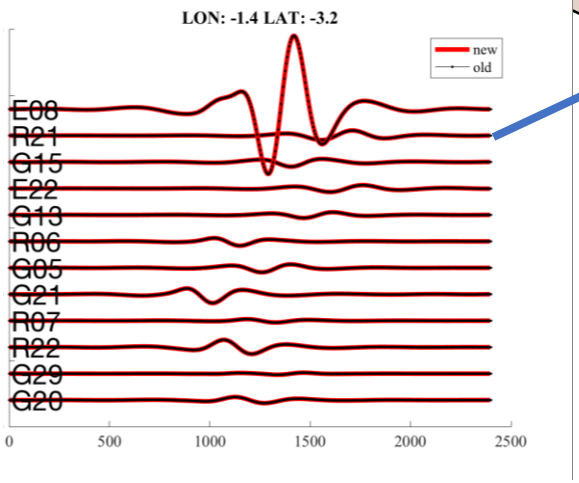


Coseismic dTEC reconstruction method : a 3D view – grid of trial sources

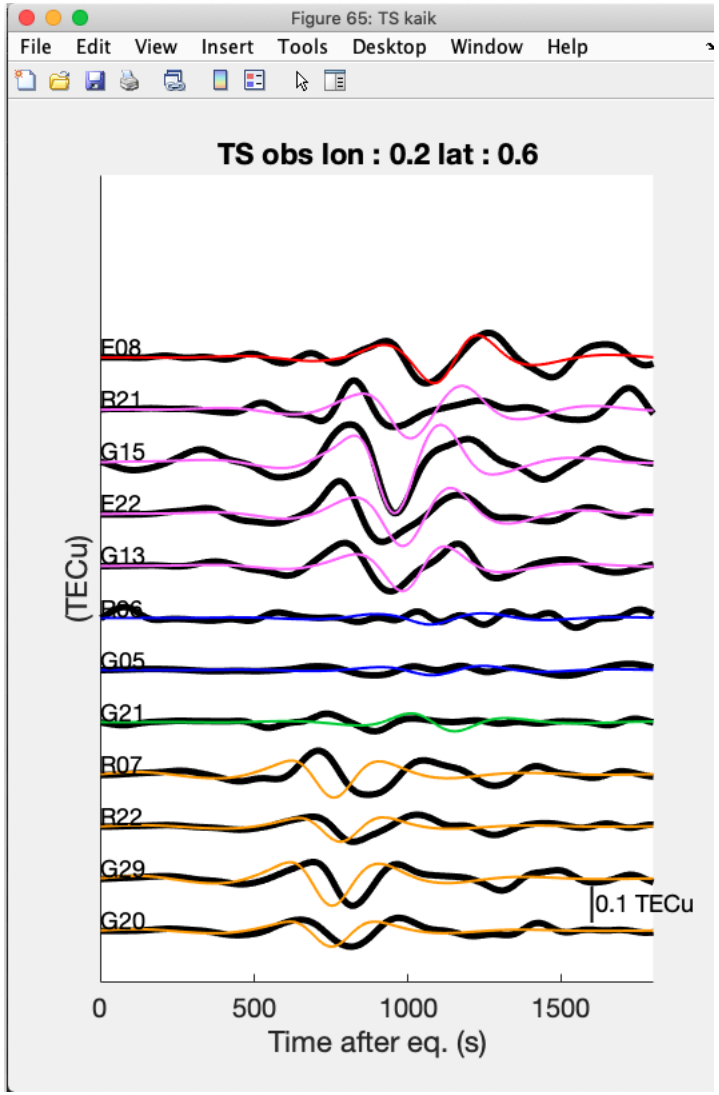
dTEC unit function **:**
synthetic TEC response to one trial source with unit amplitude measured at the satellite-receiver pair

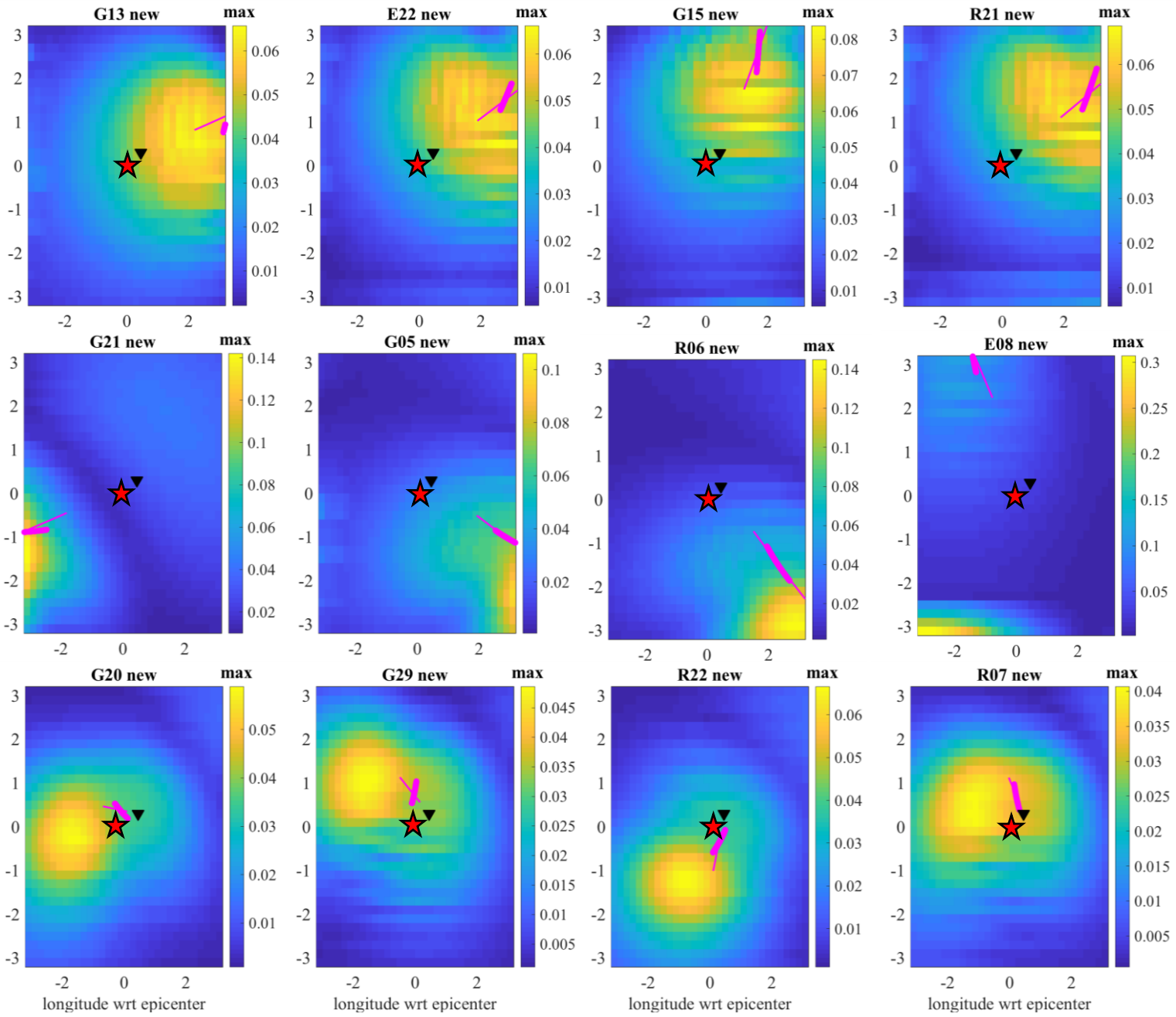
33x33 grid
-3.2 to 3.2 wrt epicenter 0.2° step



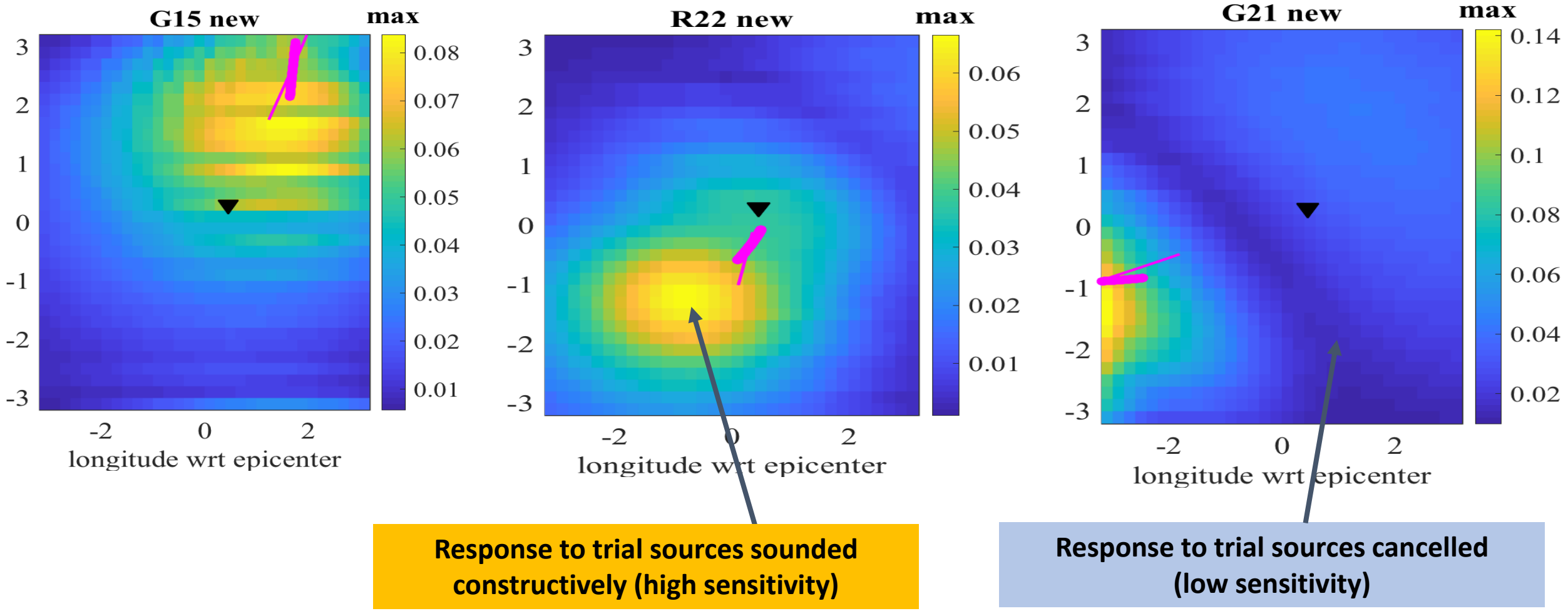


The amplitude of the perturbation for a given satellite-receiver pair informs on the source location





Seismic sources are better sensed by ionospheric receivers moving close



Response to trial sources sounded constructively (high sensitivity)

Response to trial sources cancelled (low sensitivity)

Satellites are more sensitive to sources located close to IPPs (NE, SW and far SW for G15, R22, G21, respectively) but not just below them

Conclusions

Development of a method that rapidly informs on where the tsunami initiates

- **more GNSS satellites** allow to better characterize the tsunami initiation zone
- depends on the presence of GNSS receivers within 300km distance. **Sparse** GNSS networks with **multi-constellation** capability are useful.
- **quality** of the GNSS measurements is critical (minimize cycle slips) and **low elevation** tracking is appreciated.

Now: tackle the challenge of **assessing the tsunami height** using the absolute amplitude.