Tracking Earthquakes in 4D: The 2011 Tohoku-oki Event, Japan

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Special thanks to: Team ARIA (JPL/Caltech), and L.Meng, JP Ampuero (Caltech)

–Real-time GPS for Seismology and other Applications–
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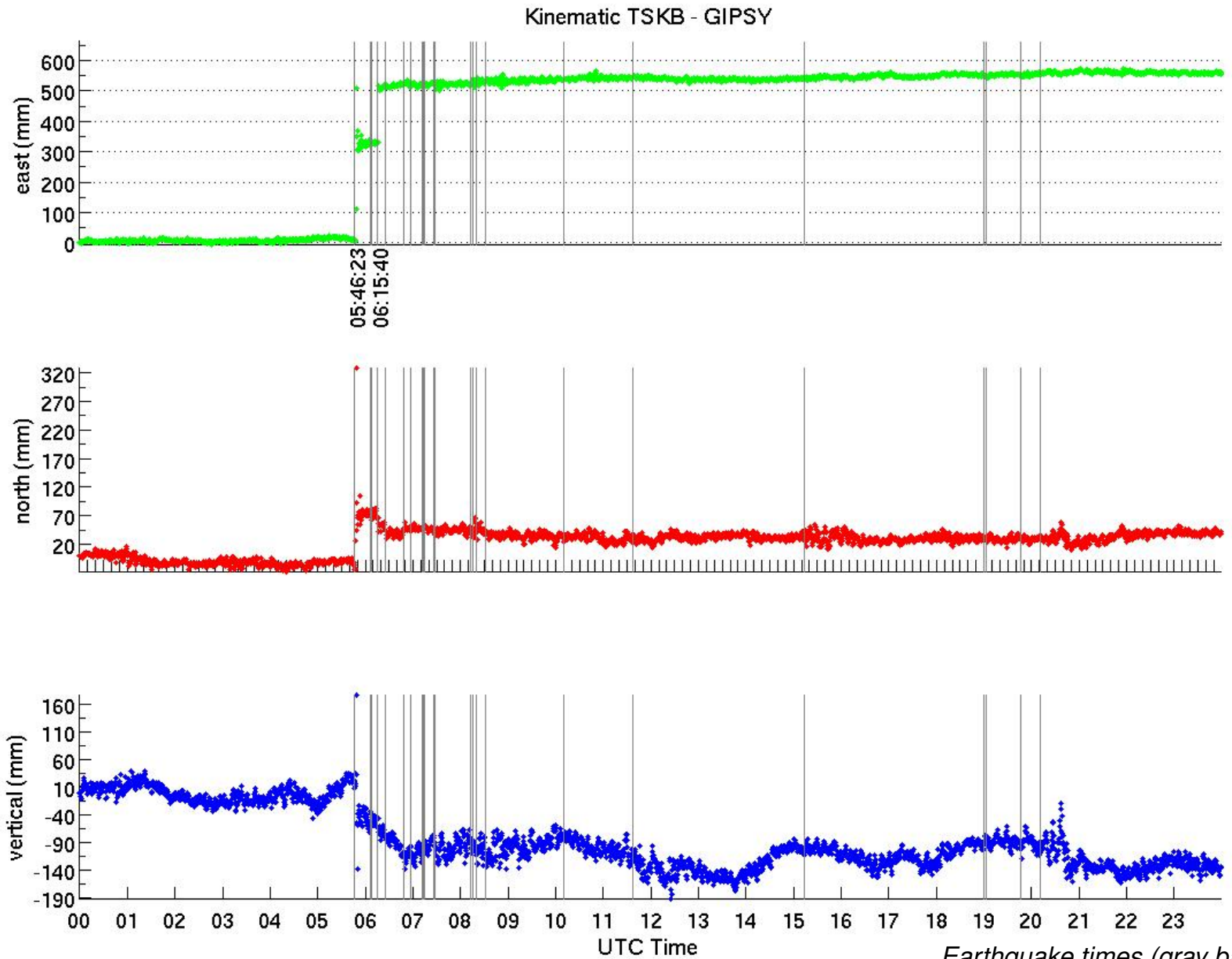
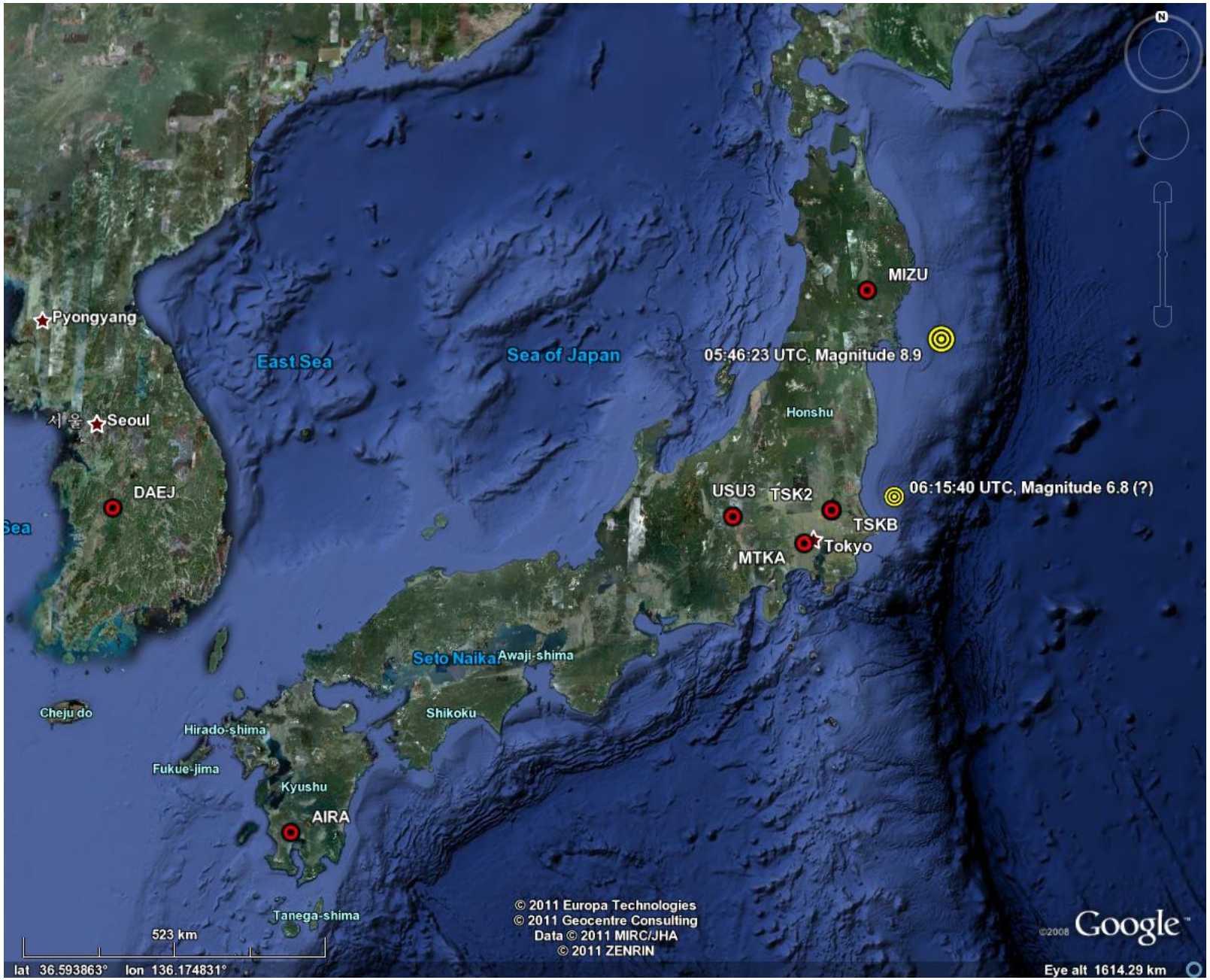
IGS station TSKB/2: 30 s solutions

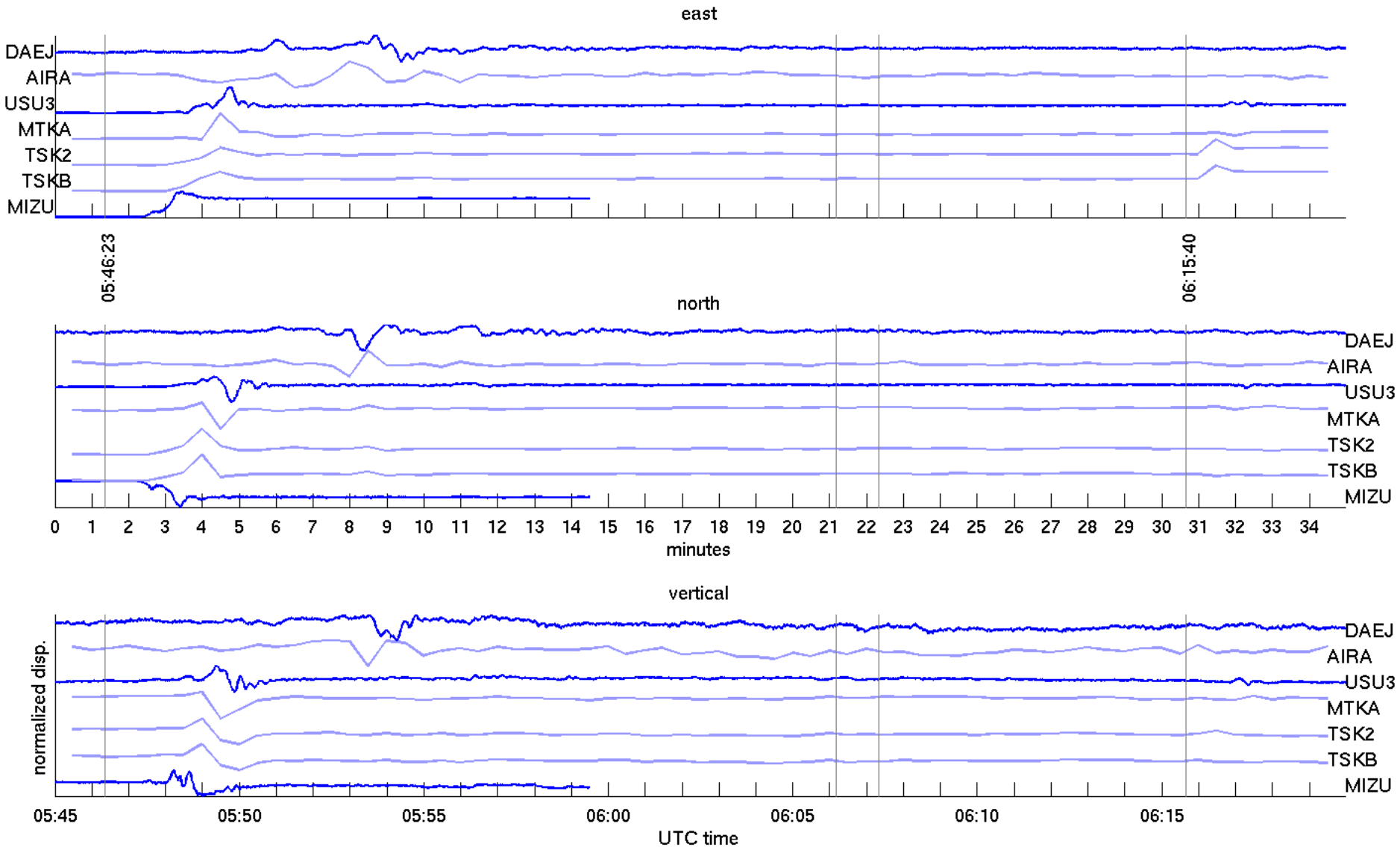


Earthquake times (gray bars): USGS

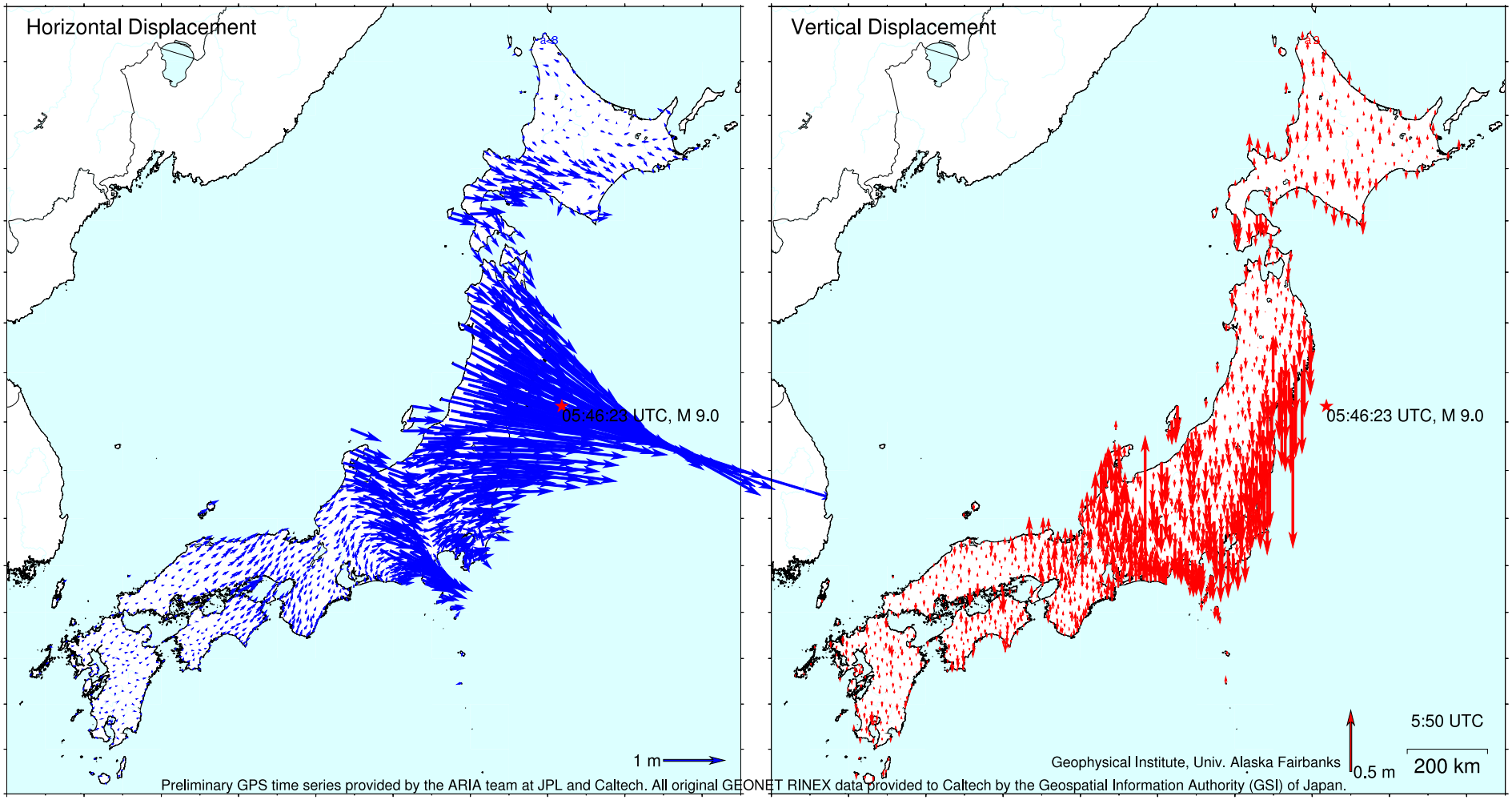
Setting the stage: Japan



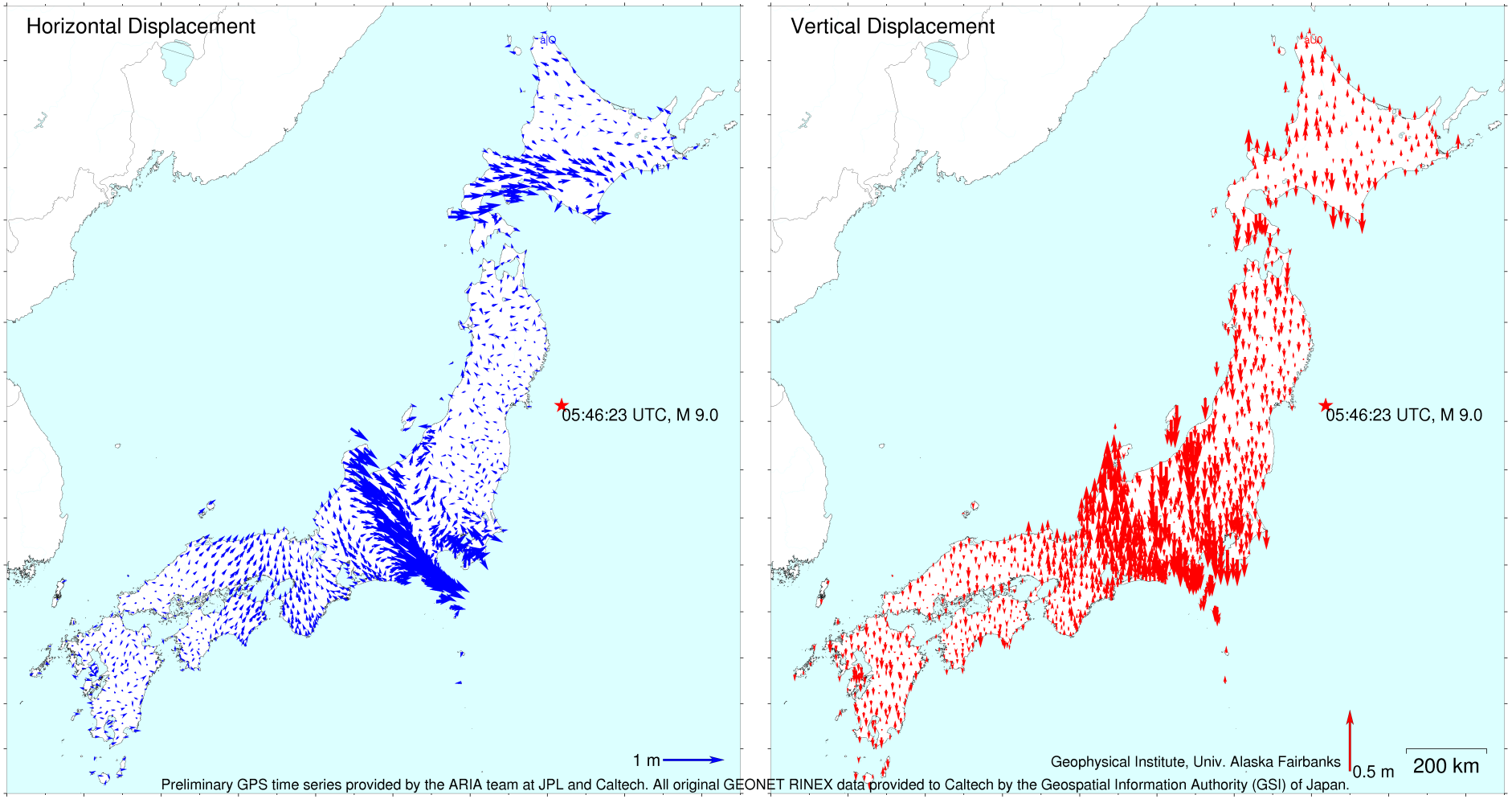
IGS station waveforms, sorted by distance from epicenter



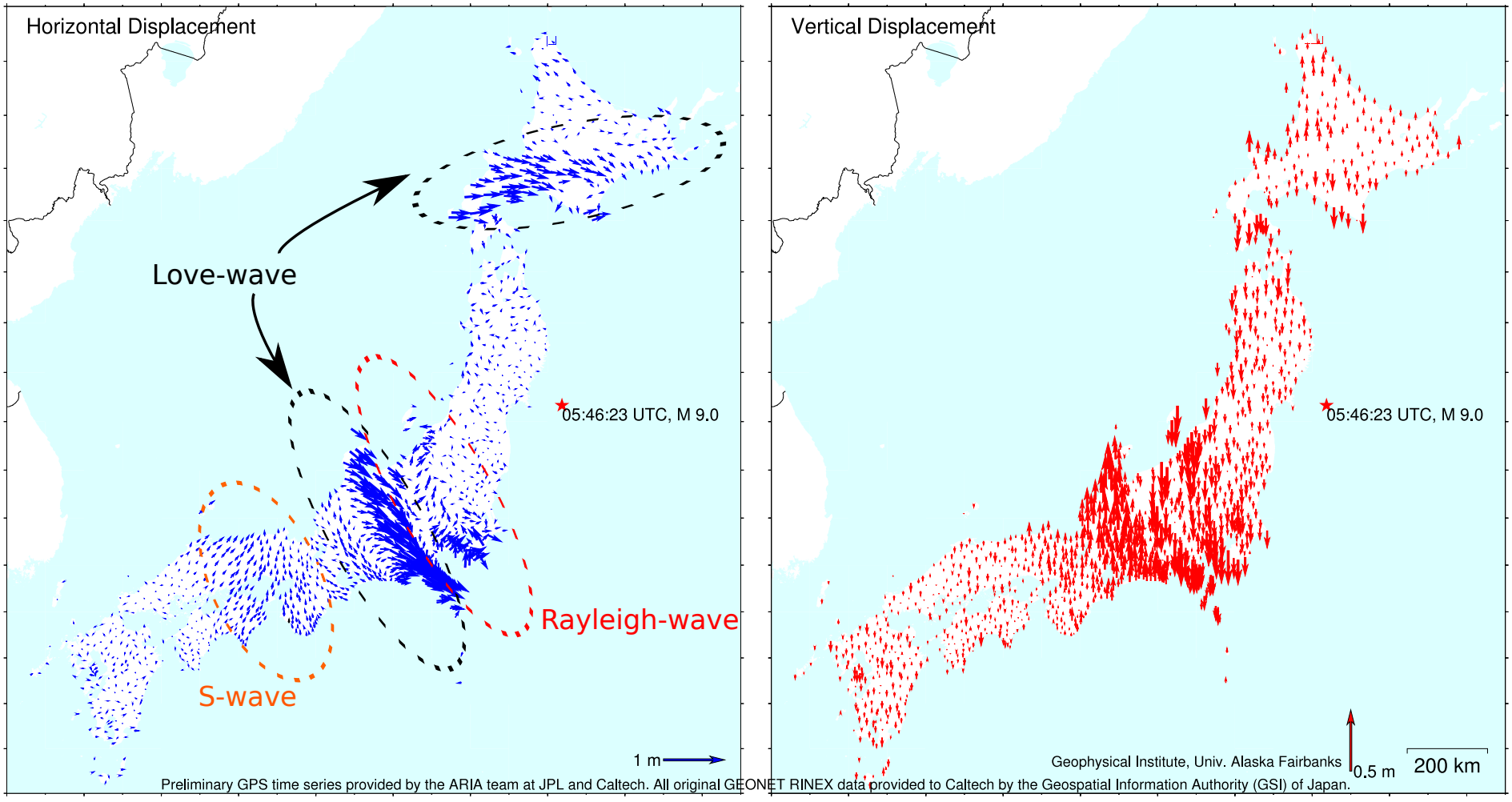
05:50 UTC (5 min solutions, ARIA)



05:50-05:55 UTC: dynamic feature



05:50-05:55 UTC: dynamic feature edited



30 s solutions (ARIA)

Movie of 30 s solutions

`http://gps.alaska.edu/ronni/sendai2011.html`

Acknowledgements: Preliminary GPS time series provided by the ARIA team at JPL and Caltech. All original GEONET RINEX data provided to Caltech by the Geospatial Information Authority (GSI) of Japan.

1 s solutions (GPS Solutions)

Movie 1 s solution

`http://gps.alaska.edu/ronni/sendai2011.html`

Acknowledgements:

- Geospatial Information Authority, Japan: operate GEONET
- NGDS (Nippon GPS Data Service, Japan): provide Real-time 1Hz data
- Hitz (Hitachi Zosen Co., Japan), GPSS (GPS Solutions, Boulder, CO, USA): RTNet software
- VERIPOS: Provide GPS satellite clock/orbit based on global network with real-time

1 s solutions (GPS Solutions) + back-projection

Movie 1 s solution

not yet published

Acknowledgements: Seismic back-projection: Lingsen Meng and Jean-Paul Ampuero, Caltech.

Major observations

- permanent displacements (arrive with s-waves/surface waves):
  - narrow band of subsidence suggests large tsunami
  - horizontal points to source region
  - maximum at about 157 s after rupture initiation
  - final permanent field at about 217 s

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  - final permanent field at about 217 s
- tracking of S-waves:
  - radiate outwards at *apparent* velocity of 6-8 km/s
  - swath about 160 km wide
  - takes about 20-27 s to pass
  - 4:30-5:00 min to traverse Japan (surface waves took about 8:30-9:00 min)

Conclusions/Suggestions

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- real time maps for rapid damage assessment (emergency response):
  - co-seismic displacements give a good first order estimate of maximum damage
  - track S-wave magnitudes and scale with factors such as soil composition, building code, etc.

Conclusions/Suggestions 2/2

- tool in early warning:
  - warn places before S-wave arrives ([virtual] self organizing network [*Fleming et al., Seis. Res. Lett., 2009*]); predict time, duration of shaking
  - near real time visualization of GPS displacements would provide an immediate visual and quantitative indication of earthquake size
  - coorperate with seismologists to integrate real-time 3D displacements in determination of locations, damage control.
  - displacements input to tsunami forecast models / tsunami warning