PRIDE Lab
Positioning Racers to Image & Decipher the Earth

CENTER NSS 武汉大学卫星导航定位技术研究中心 国家卫星定位系统工程技术研究中心

GSeisRT: GNSS point positioning engine for wide-area geohazard monitoring in real time

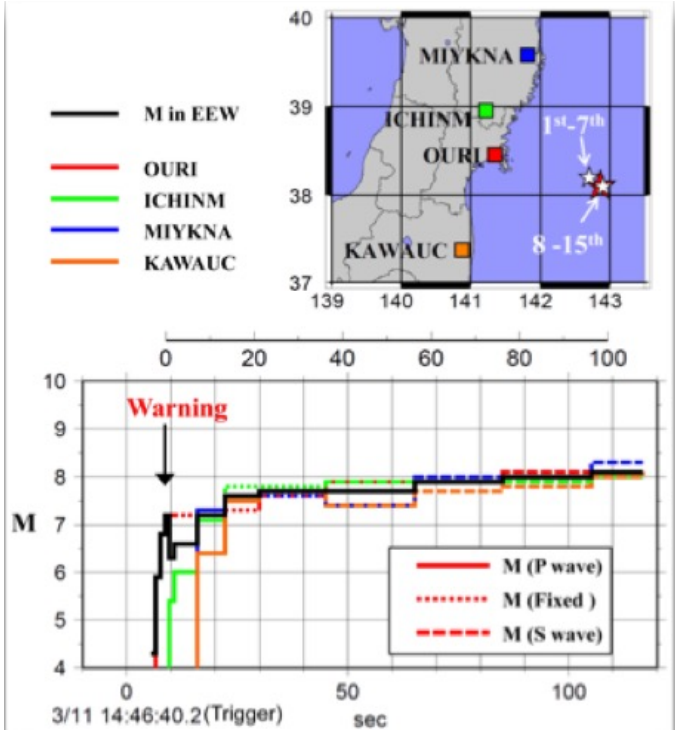
Jianghui GENG, Kunlun ZHANG, Jiang GUO

GNSS Research Center, Wuhan University, China

18 Oct 2023
Madrid, Spain

Rapid response to earthquakes/tsunamis

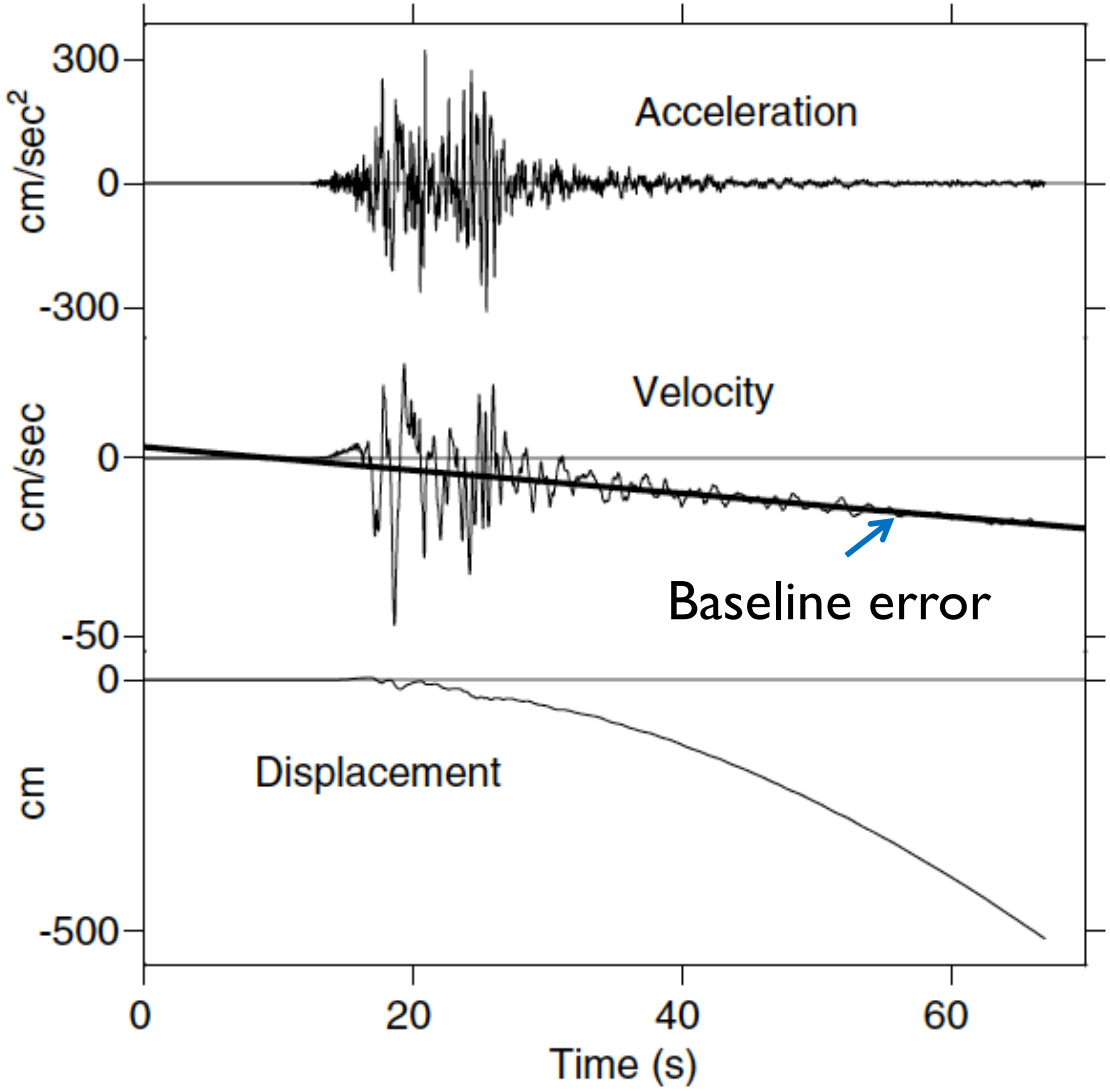
- Increasing resilience to earthquakes
  - Capture earthquake motions in real time
  - Rapid magnitude determination
  - Issue timely & accurate alerts
- However, lessons from 2011 M9.0 Tohoku-Oki earthquake/tsunami response
  - Seismic sensors to capture motions
  - M7.9 only until hours later
  - Underestimate evacuation regions
  - Tens of thousands of casualties



Ozaki 2011

Challenges to seismic sensors

- Drifting displacements of meter level recovered from accelerograph



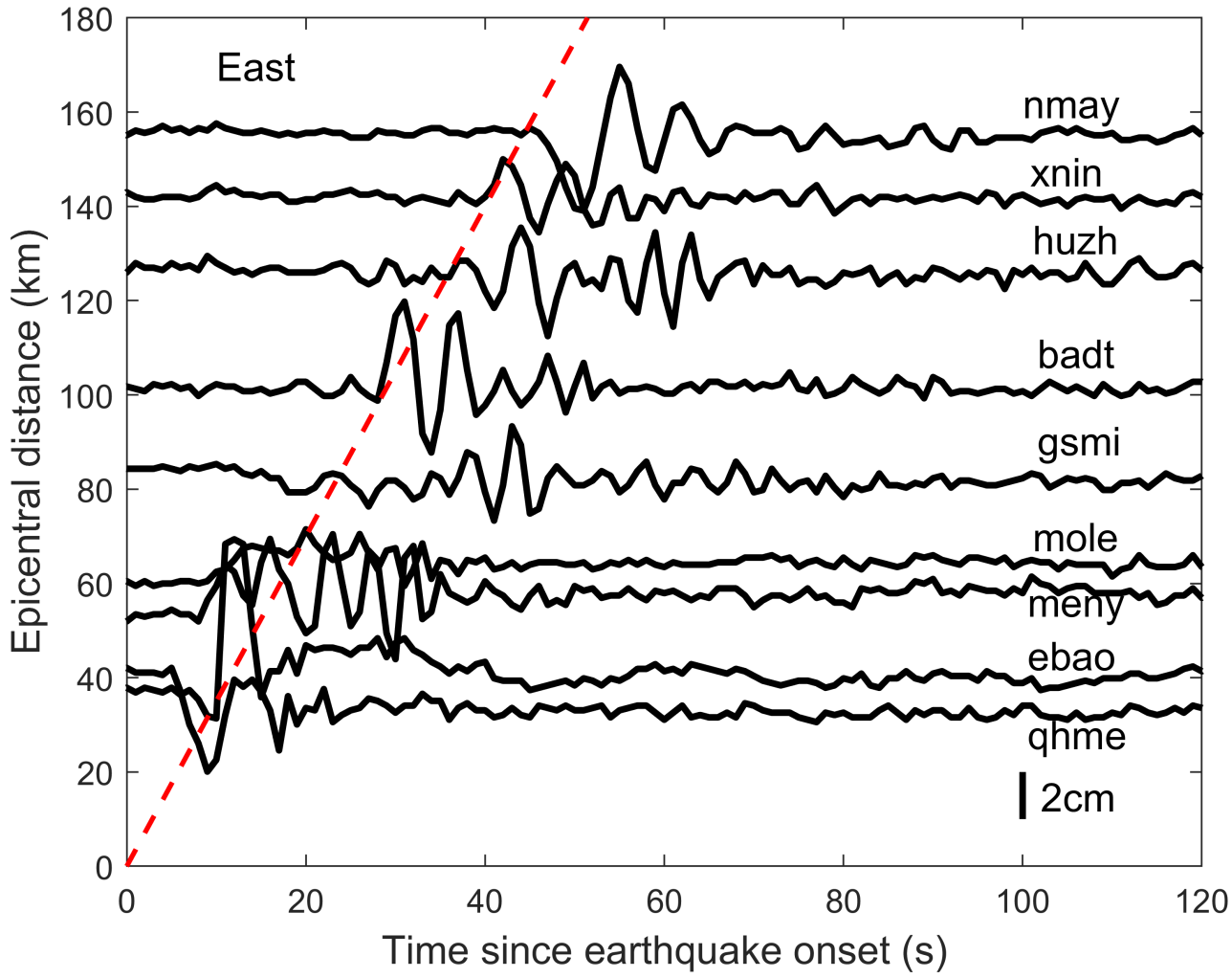
Raw accelerograph

Baseline corrections can hardly be done in real time

1.0 mm/s2 baseline error results in 1.8 m displacement drift

GNSS displacements

- Ground displacements directed measured using real-time GNSS



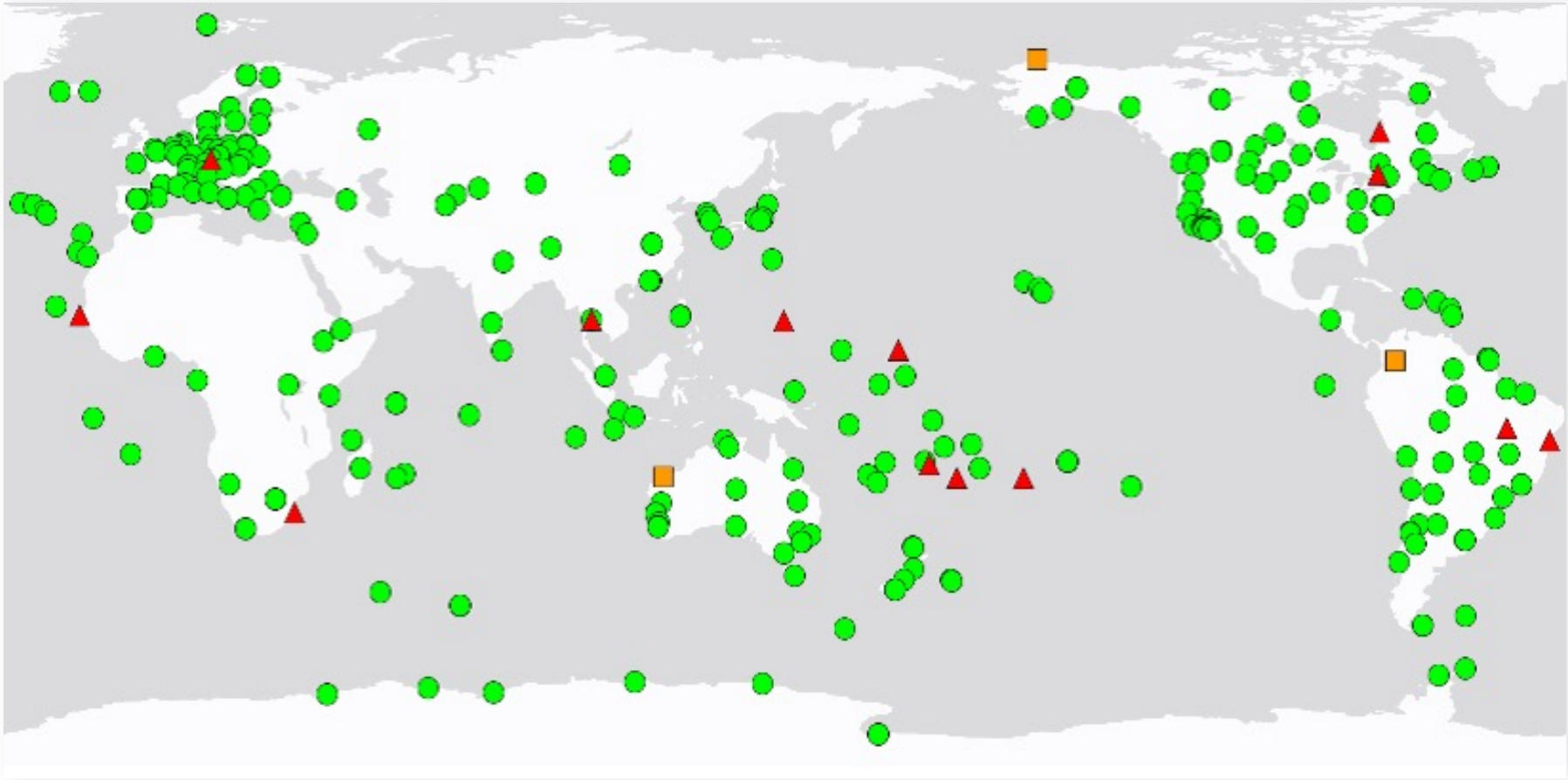
Broadband frequency

mm-cm level precision

Permanent displacements

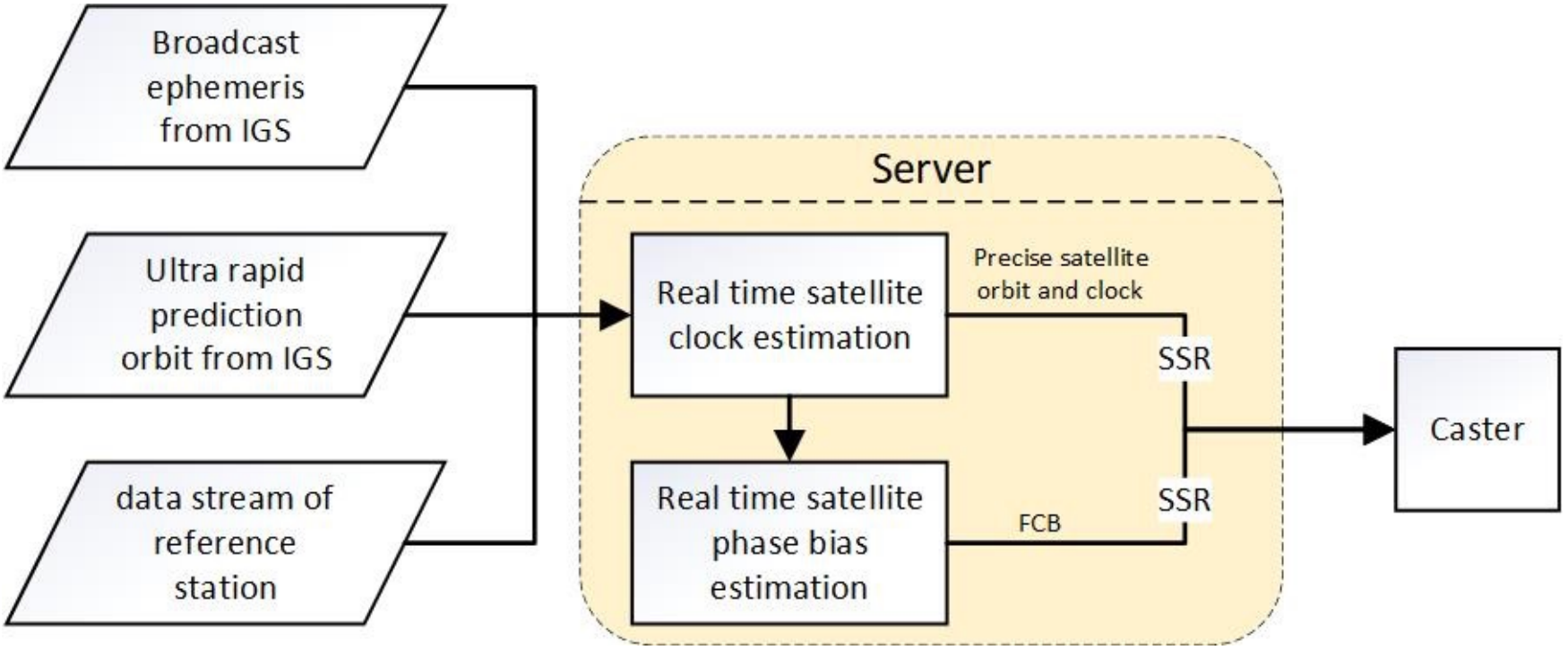
IGS-RT to provide globally applicable products

- IGS: International GNSS Service
  - 300+ stations for real-time (RT) satellite orbit/clock/bias determination

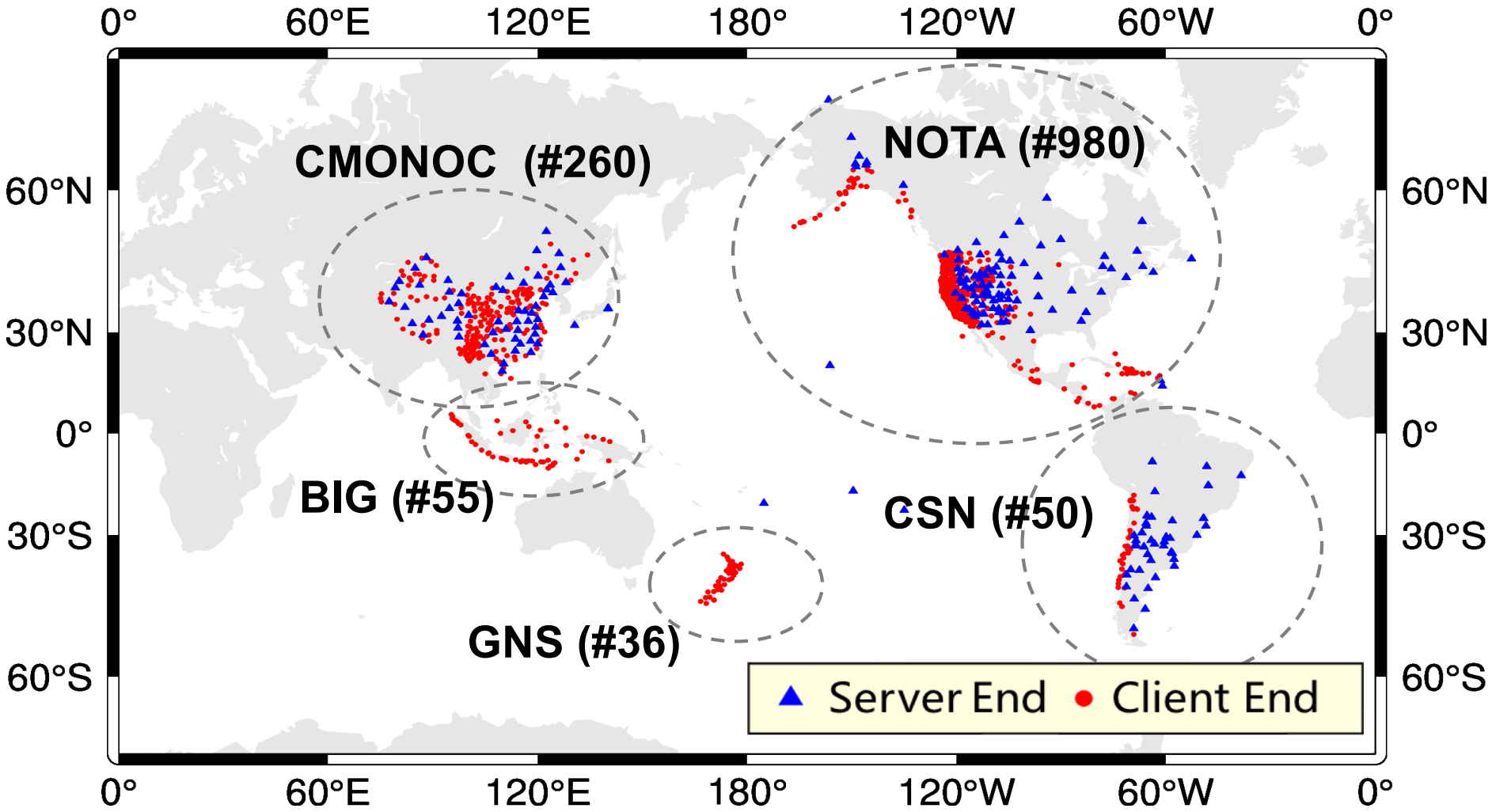


GSeisRT software

- Self-contained open-source point positioning engine
  - Undifferenced ambiguity resolution
  - Highest and steadiest positioning precision



GSeisRT has been applied to five areas

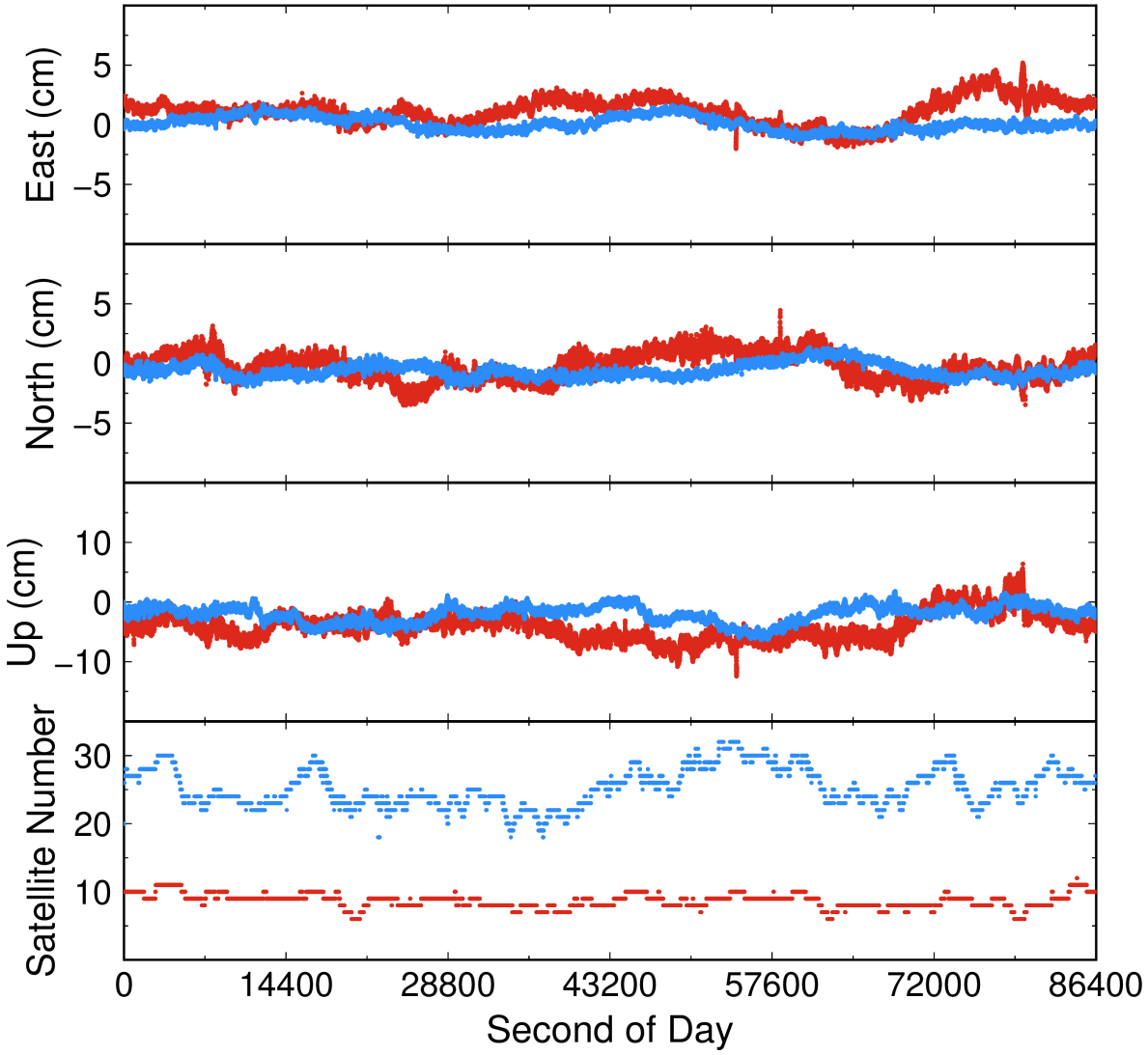


BIG: Badan Informasi Geospasial
CSN: National Seismological Center of Chile

CMONOC: Crustal Movement Observation Network of China
NOTA: Network of the Americas
GNS: Institute of Geological and Nuclear Sciences Limited

GPS-only vs. Multi-GNSS

- More satellites mean lower noise and smaller biases



GPS-only

E/N/U: 1.6/1.2/4.7 cm

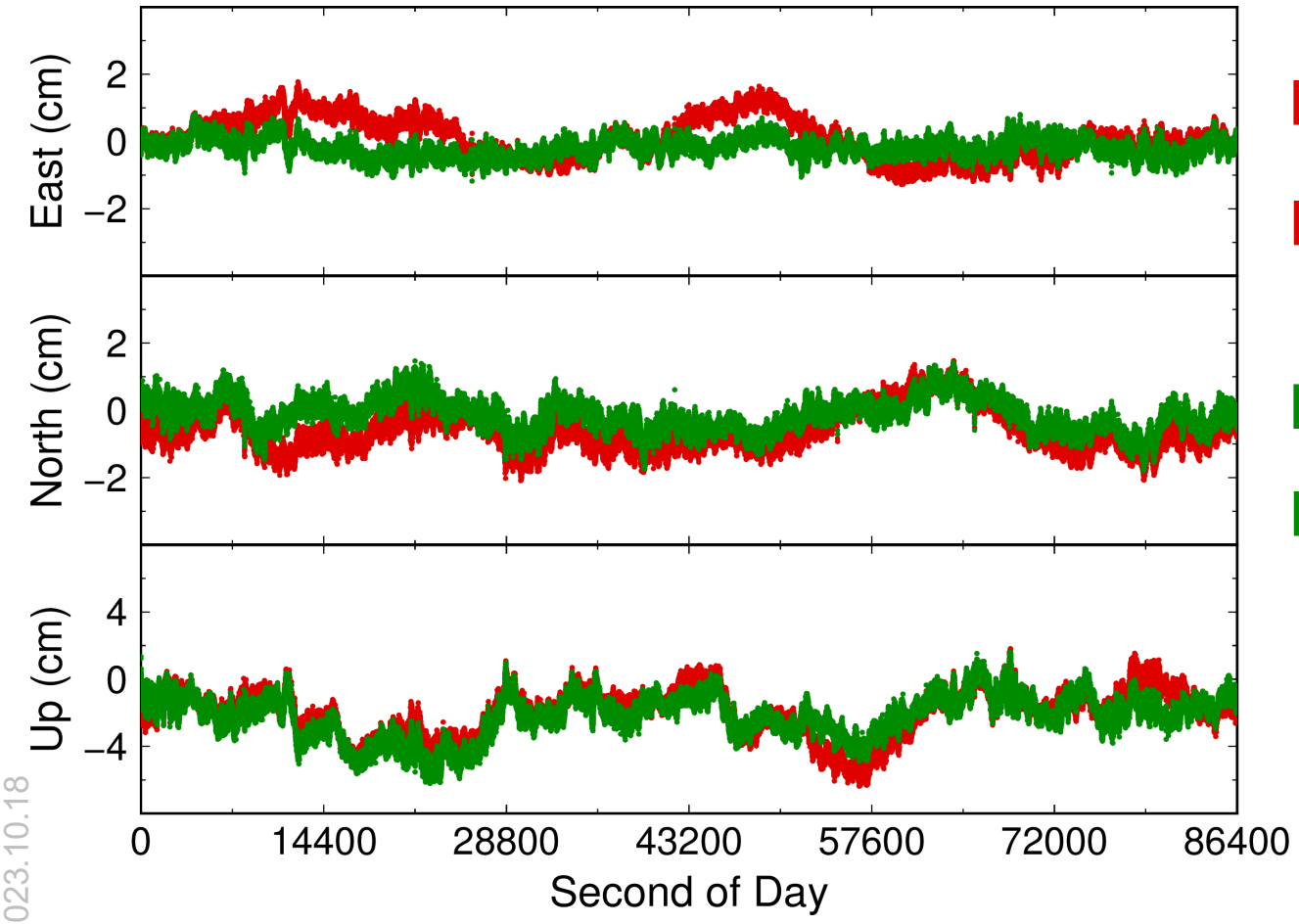
Multi-GNSS

E/N/U: 0.6/0.8/2.6 cm

No. of Satellites

PPP vs. PPP-AR

- Ambiguity fixing at a single station suppresses long-term variations



PPP

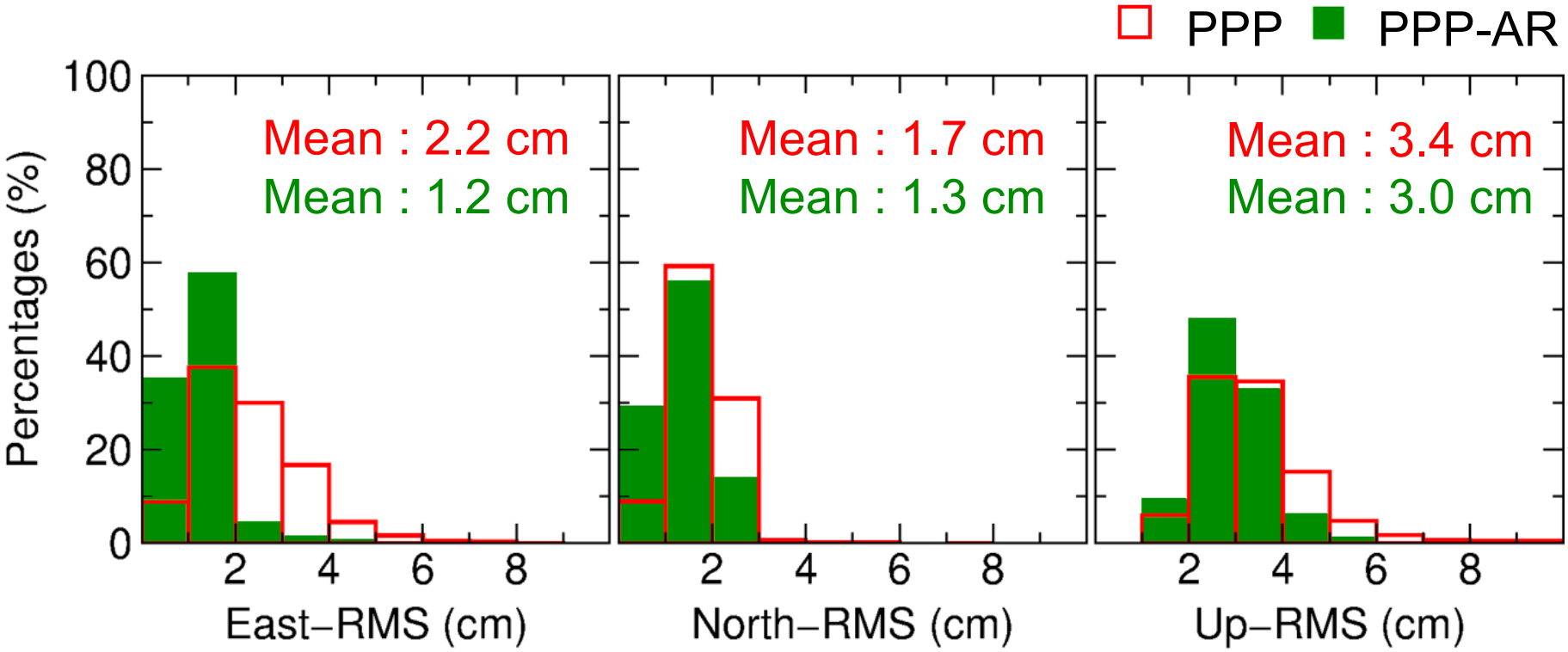
E/N/U: 0.6/0.8/2.6 cm

PPP-AR

E/N/U: 0.3/0.5/2.5 cm

PPP vs. PPP-AR

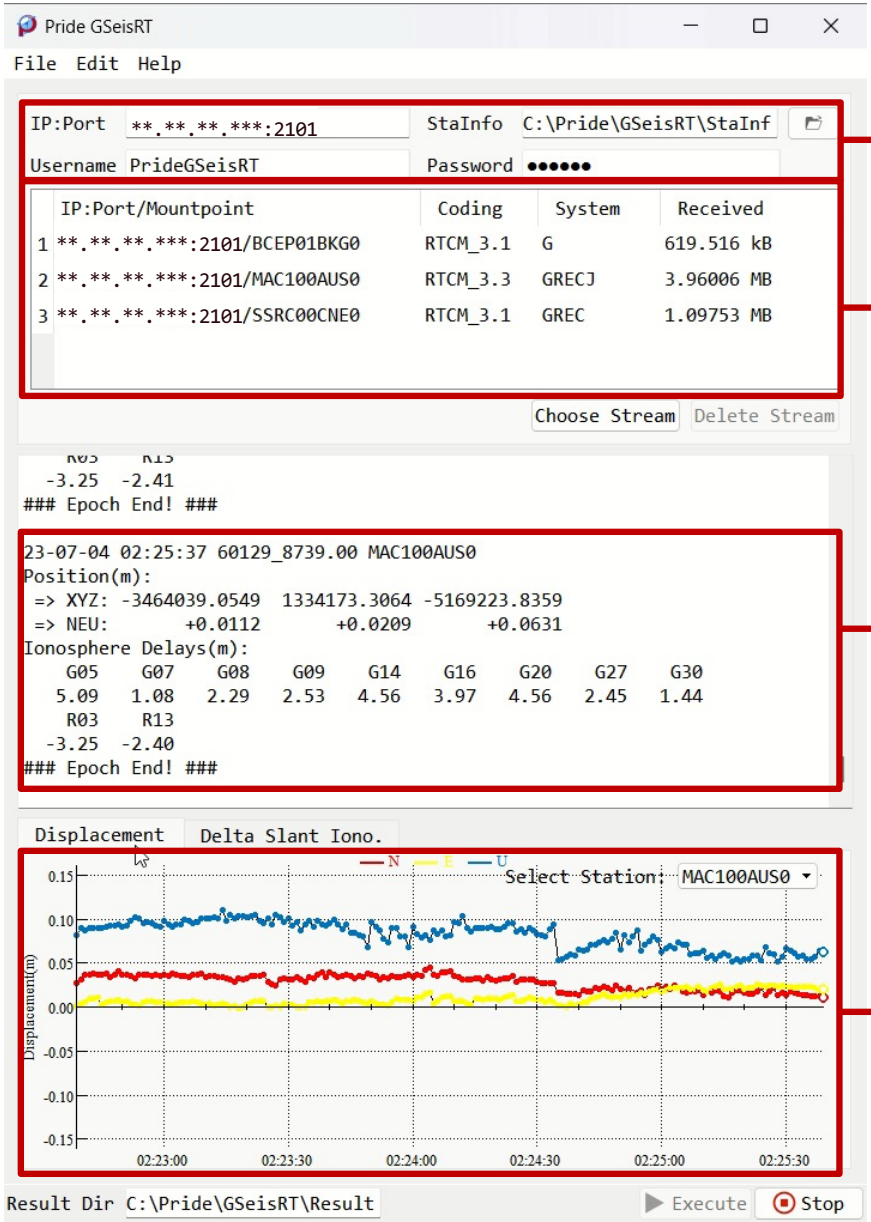
- 980 NOTA stations within 10 days
- RMS against IGS weekly solutions



GSeisRT GUI

Functions

- Real-time positioning
- Ionospheric monitoring
- Teaching Demo
- …



User Input

Data Streams

Log Results

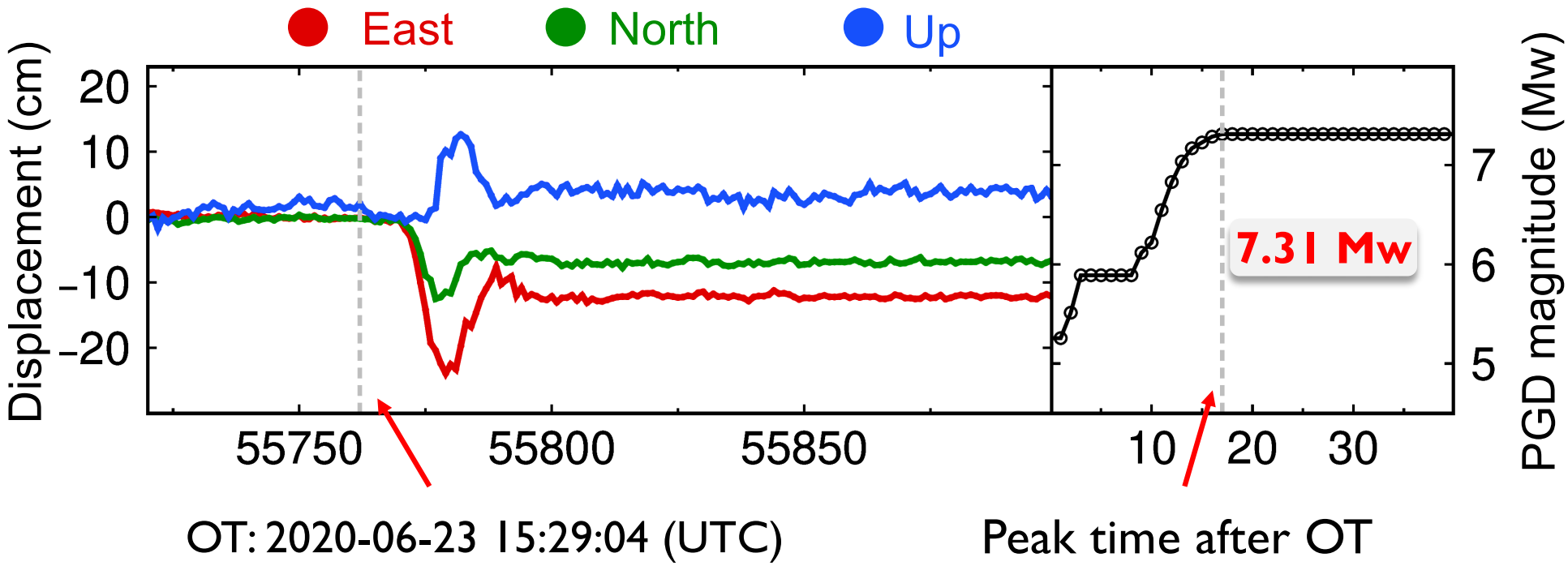
Dynamic Graph

Earthquakes captured by GSeisRT in real time

- 2020-06-23 M7.4 Oaxaca, Mexico

  Station : OXUM (58 km from the epicenter)

- Real-time magnitude is M7.3 from PGD scaling

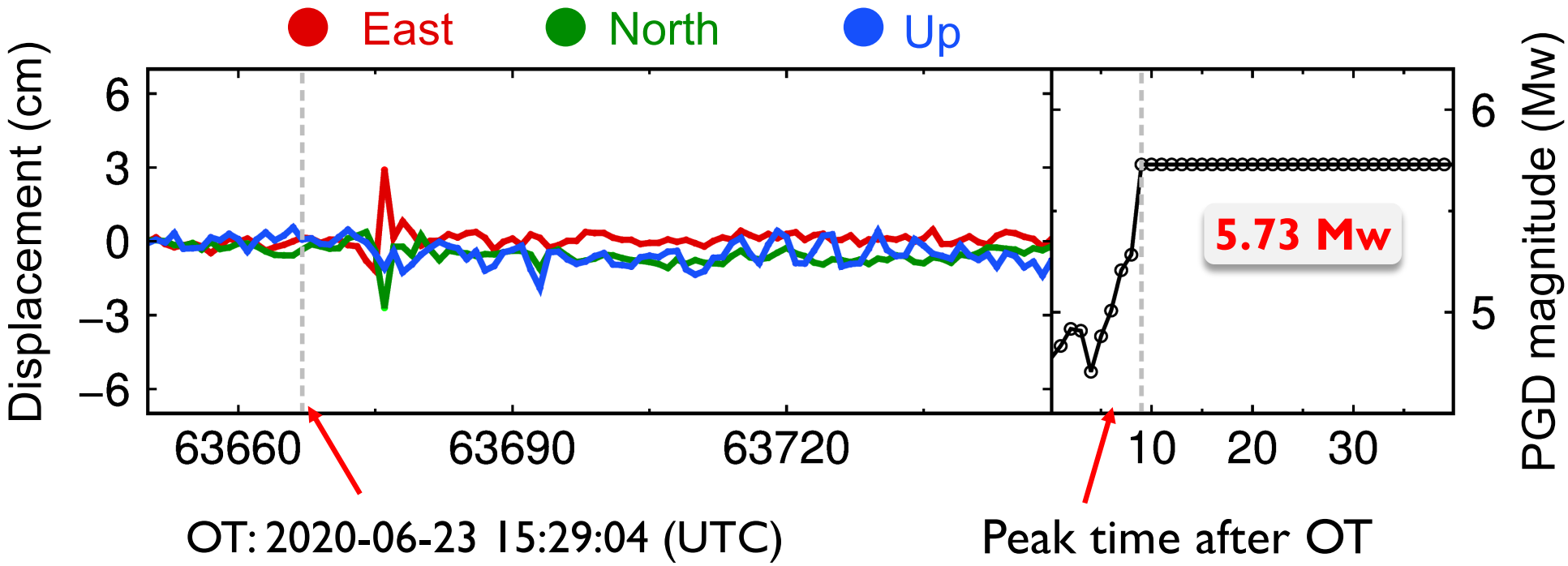


Earthquakes captured by GSeisRT in real time

- 2020-06-24 M5.8 California, USA

  Station : P466 (17 km from the epicenter)

- Real-time magnitude is M5.7 from PGD scaling



Summary

- GSeisRT can realize multi-GNSS PPP, ambiguity resolution and achieve cm to sub-cm precision in real time
  - The more satellites, the better positioning precision and robustness
  - Ambiguity resolution lead to higher accuracy and steady time series
- GSeisRT is open and free to the science community for joint geophysical research efforts

Thank you very much!

Jianghui GENG
jgeng@whu.edu.cn
pride.whu.edu.cn