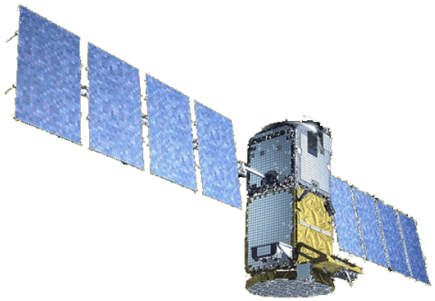
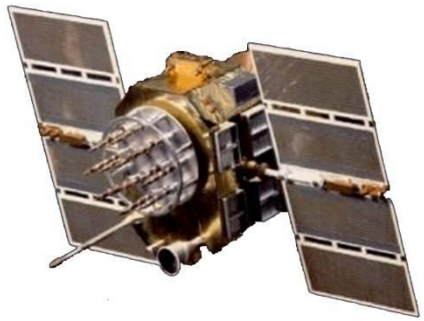
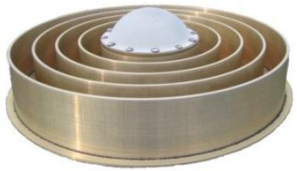




GNSS Real-Time activities at GFZ: Short overview

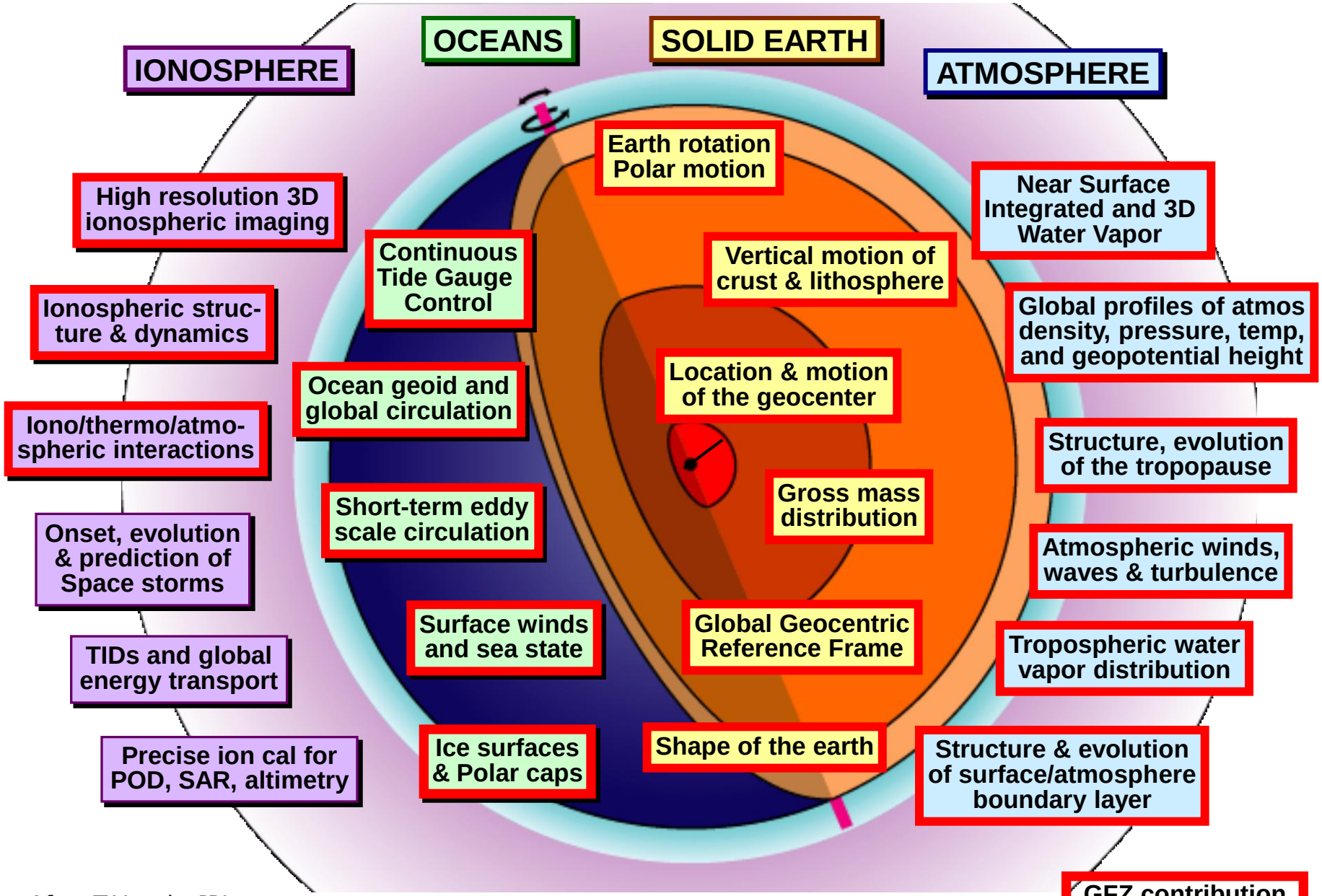
J. Wickert, M. Ge, C. Falck, G. Gendt,

X. Li, T. Nischan, M. Ramatschi, H. Schuh



Background:
GNSS as powerful tool for Earth Observation

Earth Observation with GNSS at GFZ



After T.Yunck, JPL

GNSS Observation Infrastructure

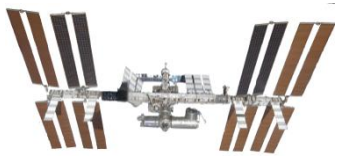
(Observation on different scales in space and time feasible)

GNSS Earth Observation is significantly changing:

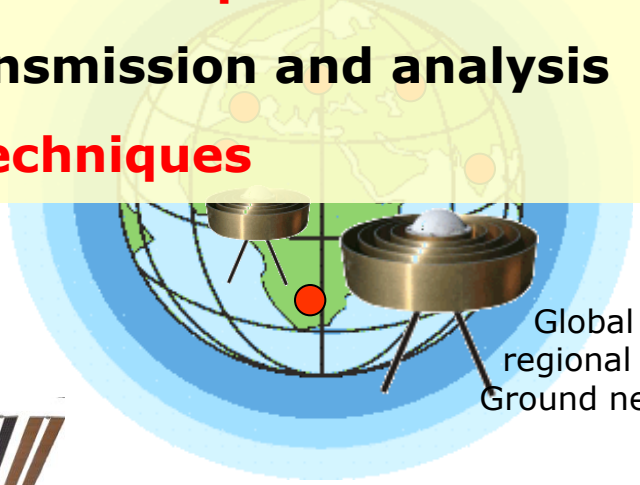
The major Challenges:

- **New satellite navigation systems**
- **Complex and new receiver platforms**
- **Real-Time data transmission and analysis**
- **New observation techniques**

Future Missones
(e.g. GRACE-C)



ISS



Global and
regional GNSS
Ground networks

Airships,
Aircrafts
(HALO)

Bouys, ships

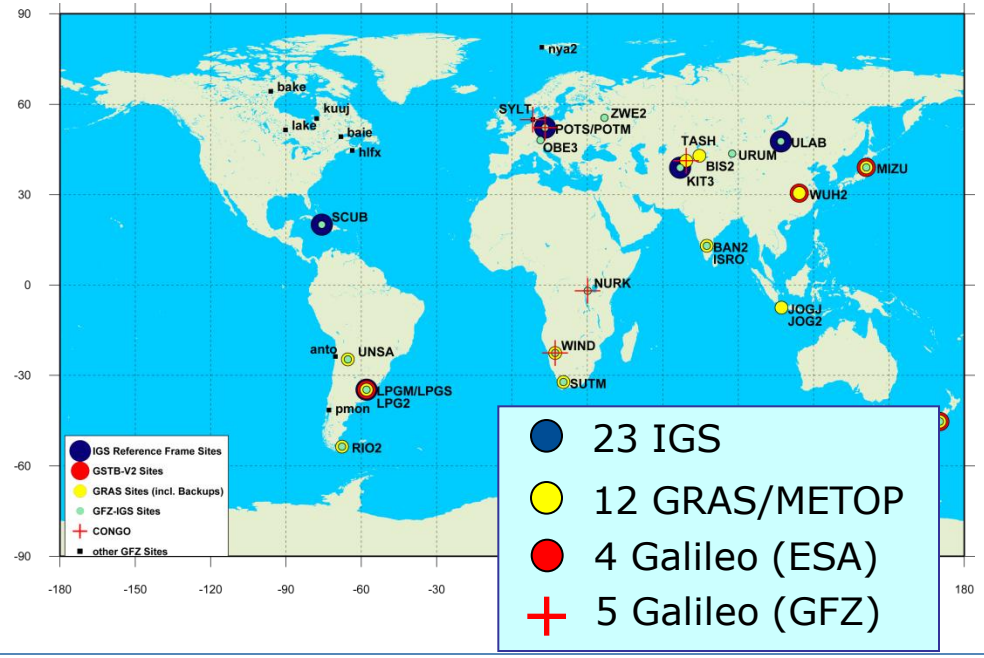
One Backbone: GFZ contribution to the IGS

Analysis Centres (Standard and Real-Time)

- Products: Reference frame GPS/GLONASS orbits and clocks, final, rapid, ultra-rapid, GPS reference for tide gauges; Real Time clocks

Contribution to the ground network

- Station hardware developments, Installation and Operation of ~40 global stations, 25 of them in real-time, provision of the entire IGS-RT data streams also via GFZ caster in parallel to BKG



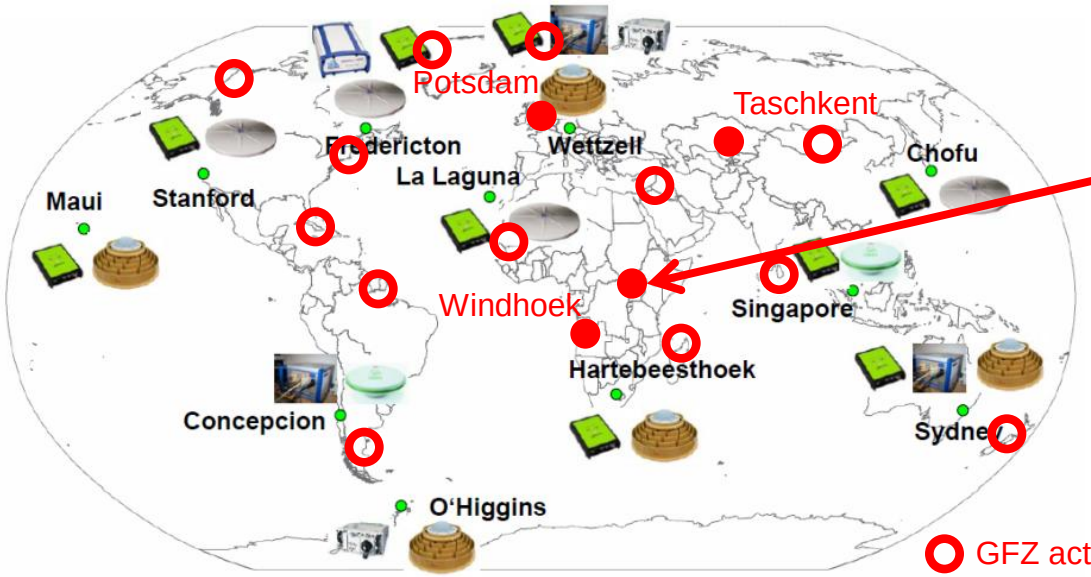
Real-Time:

Data"streaming" for 25 Stations already realised

In addition:

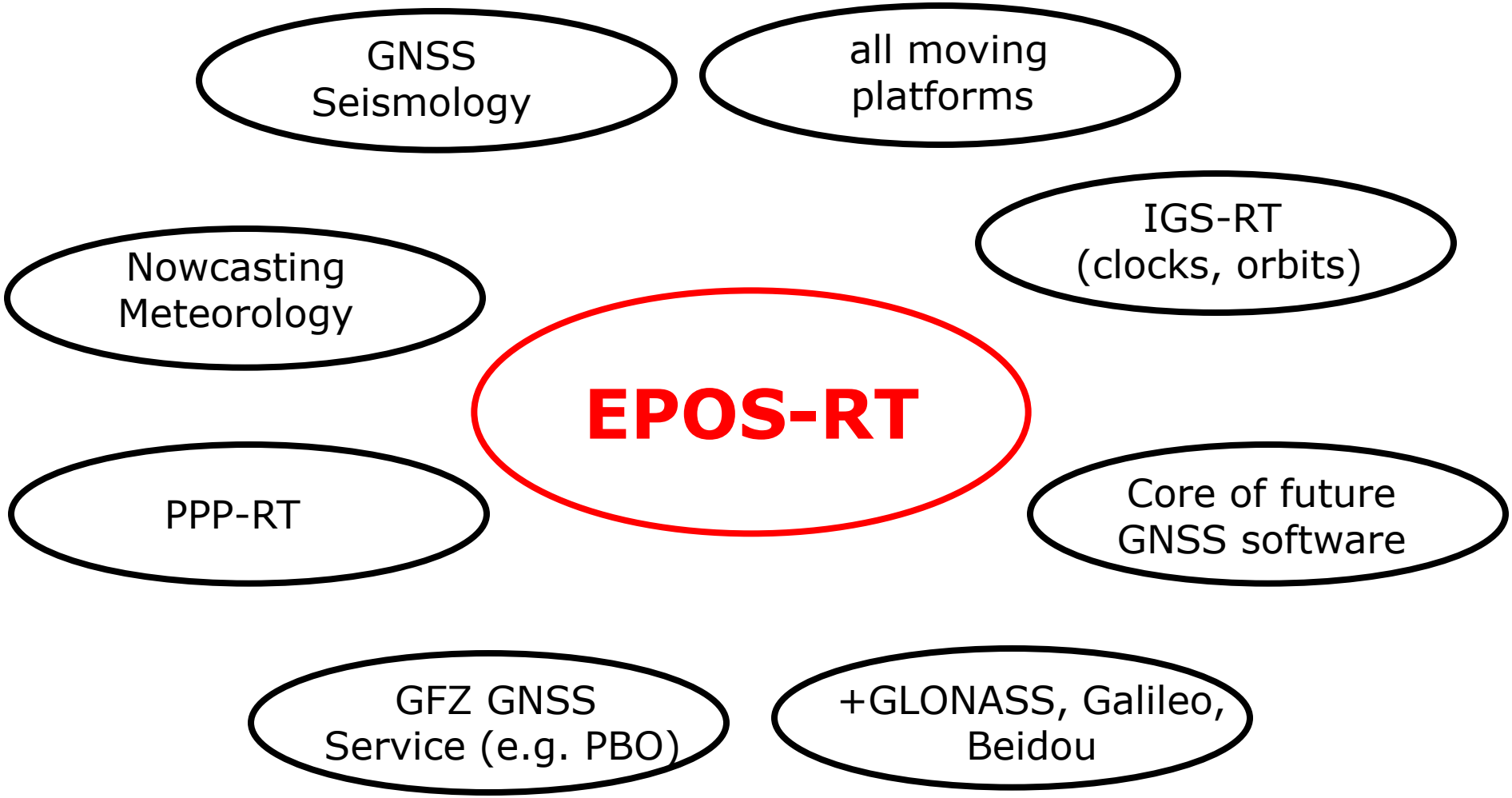
regional Campaigns for geodynamics world-wide + 9 at Germany

Galileo data in Real-Time



- Transformation of the global GPS network to Multi-GNSS with Galileo and Realtime data transfer in cooperation with BKG and DLR (CONGO)

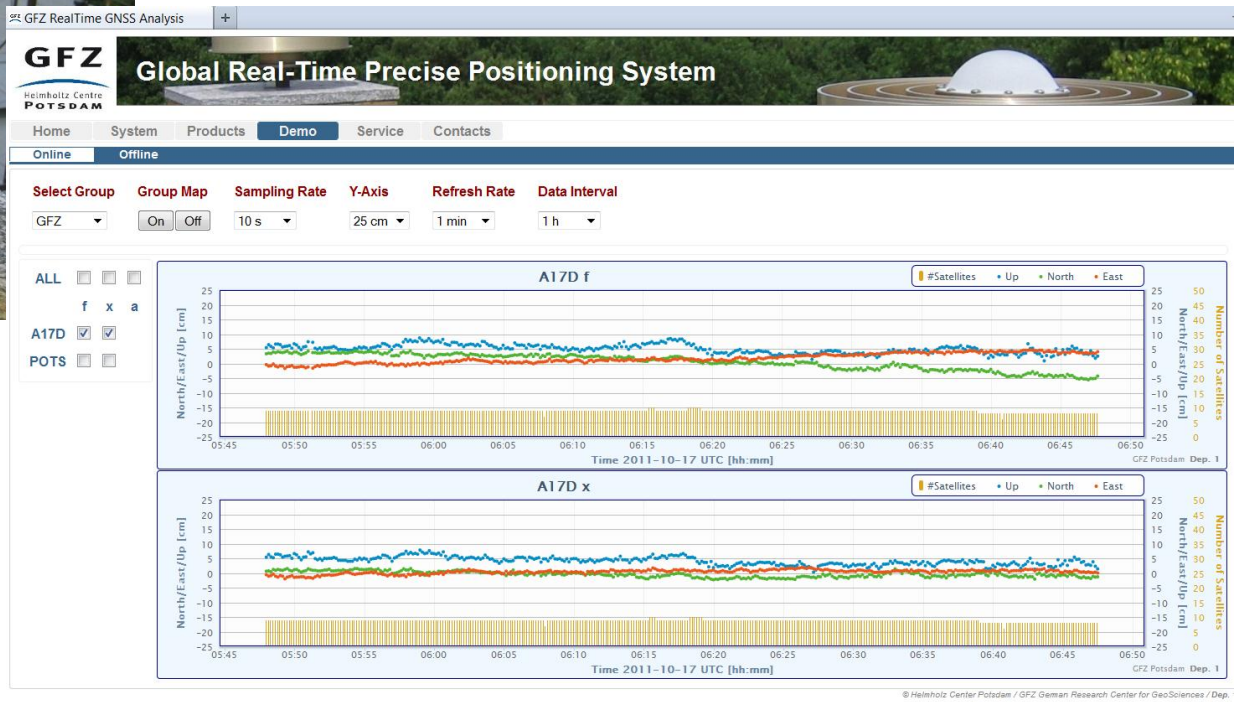
GNSS Real-Time software



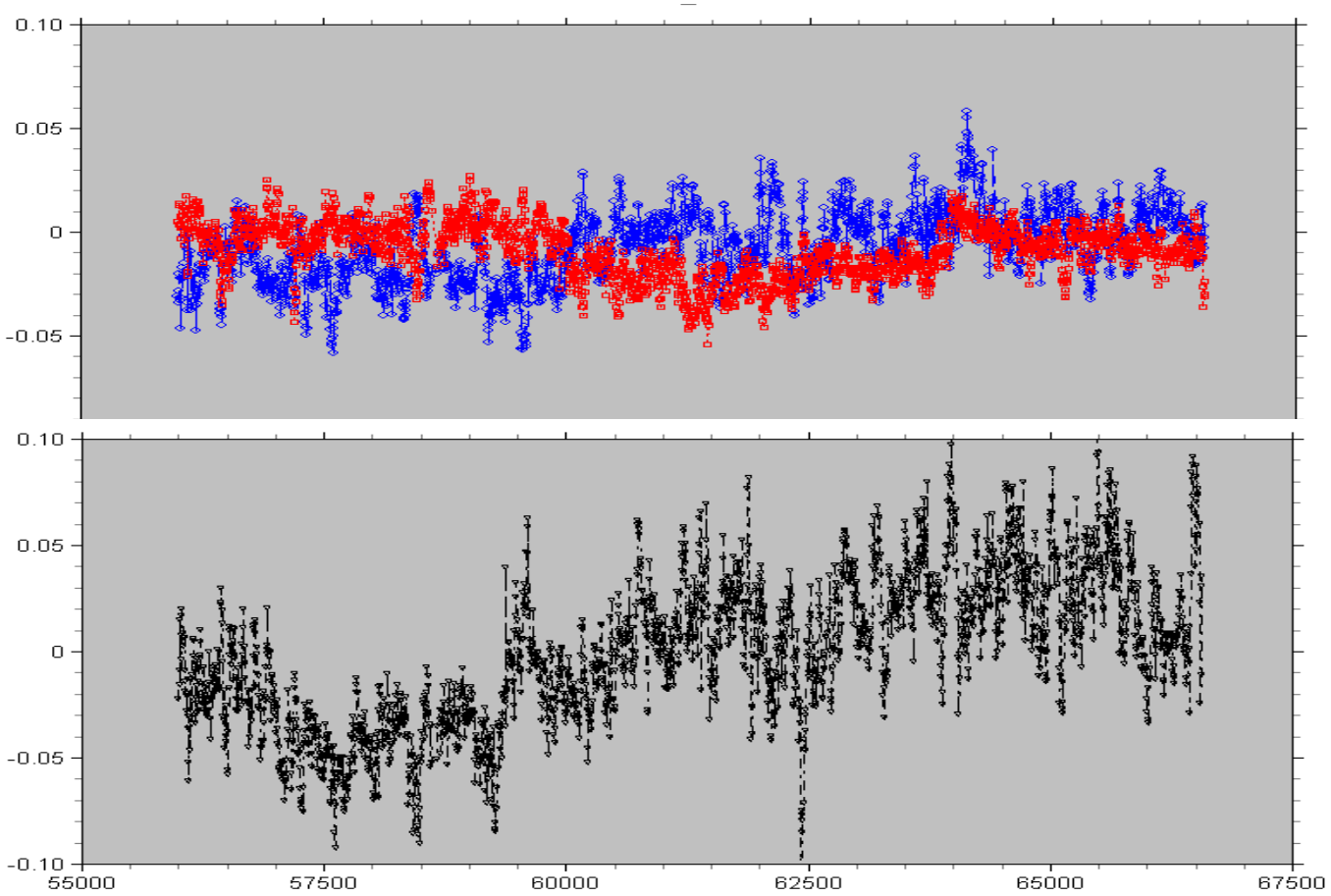
Real-Time Application: PPP for early warning systems

PPP in Real-Time at GFZ

Webinterface for analysis results (100+ stations)



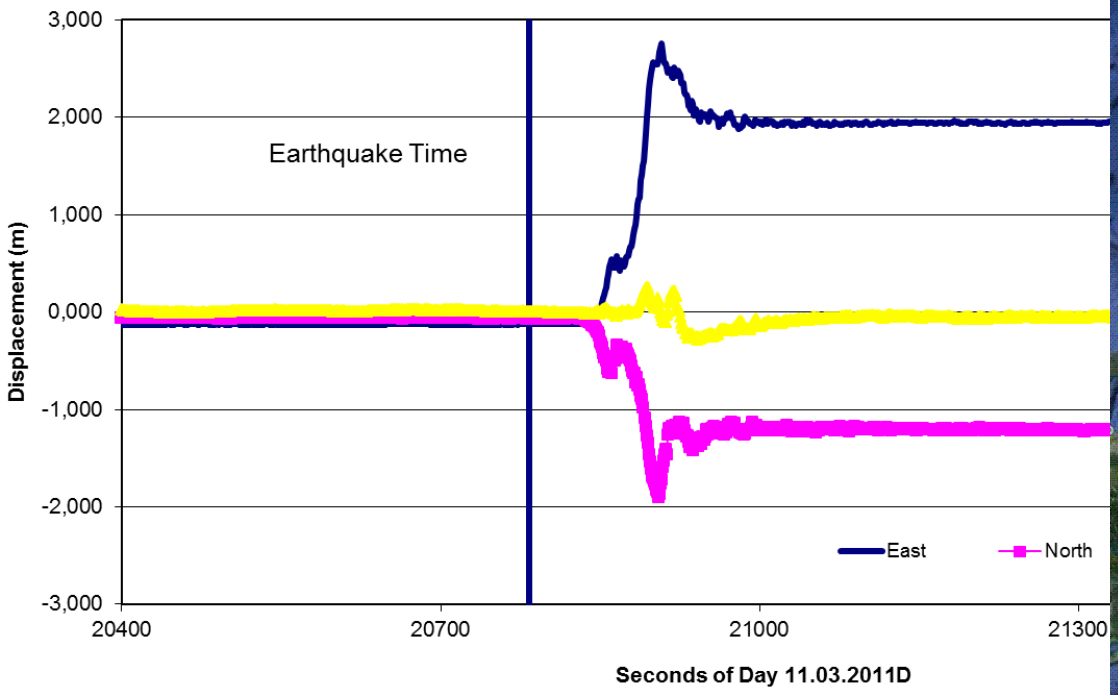
Accuracies of Real-Time Fixed Solution: Example

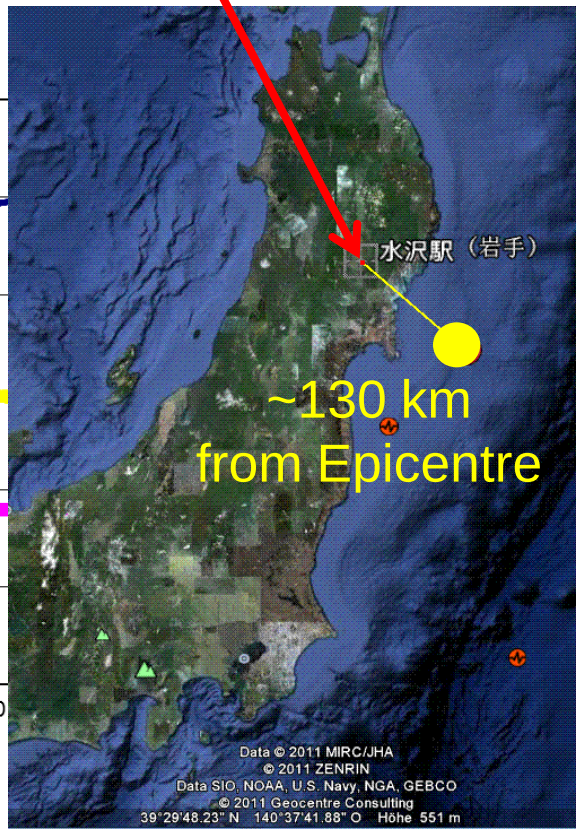


PPP+AMBFIX:
1-2 cm in Horizontal, 3-4 cm in Vertical.
Initialization Time 15-20 Min.

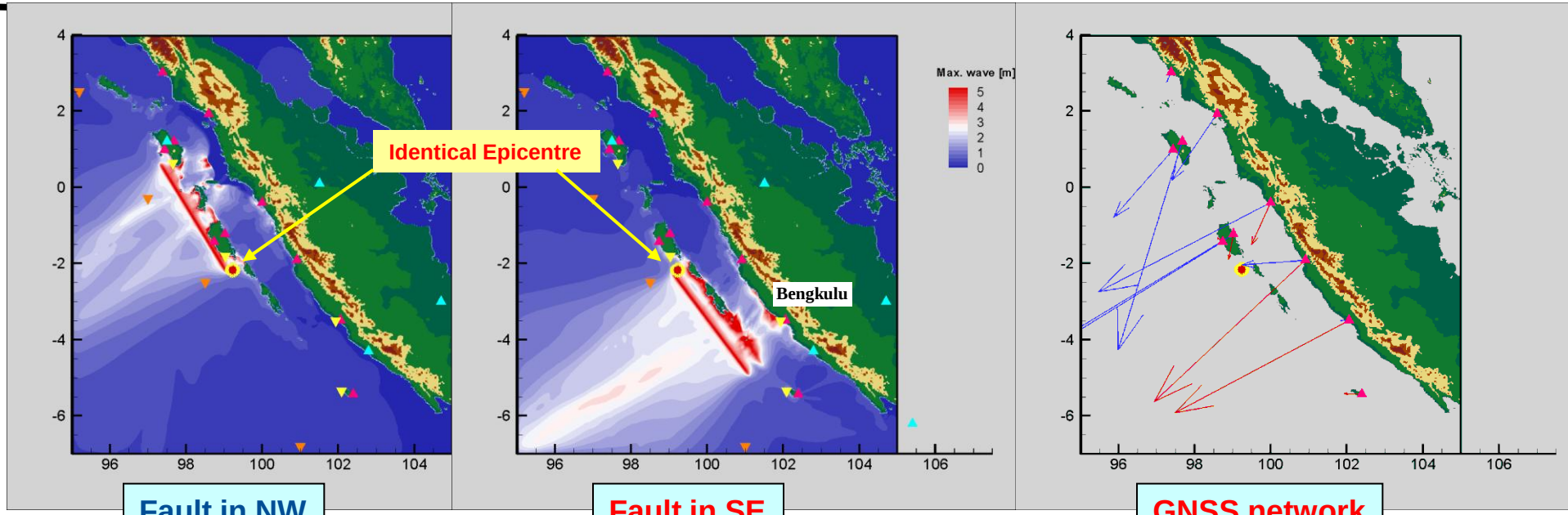
Co-Seismic deformation monitoring: Japan Quake

- **Software: EPOS-RT, GFZ station MIZUSAWA**
- Kinematic coordinates (One set each second) with
  GFZ-real-time-GPS-orbits and –clocks in RT-mode
- Comparison with coordinates from day before





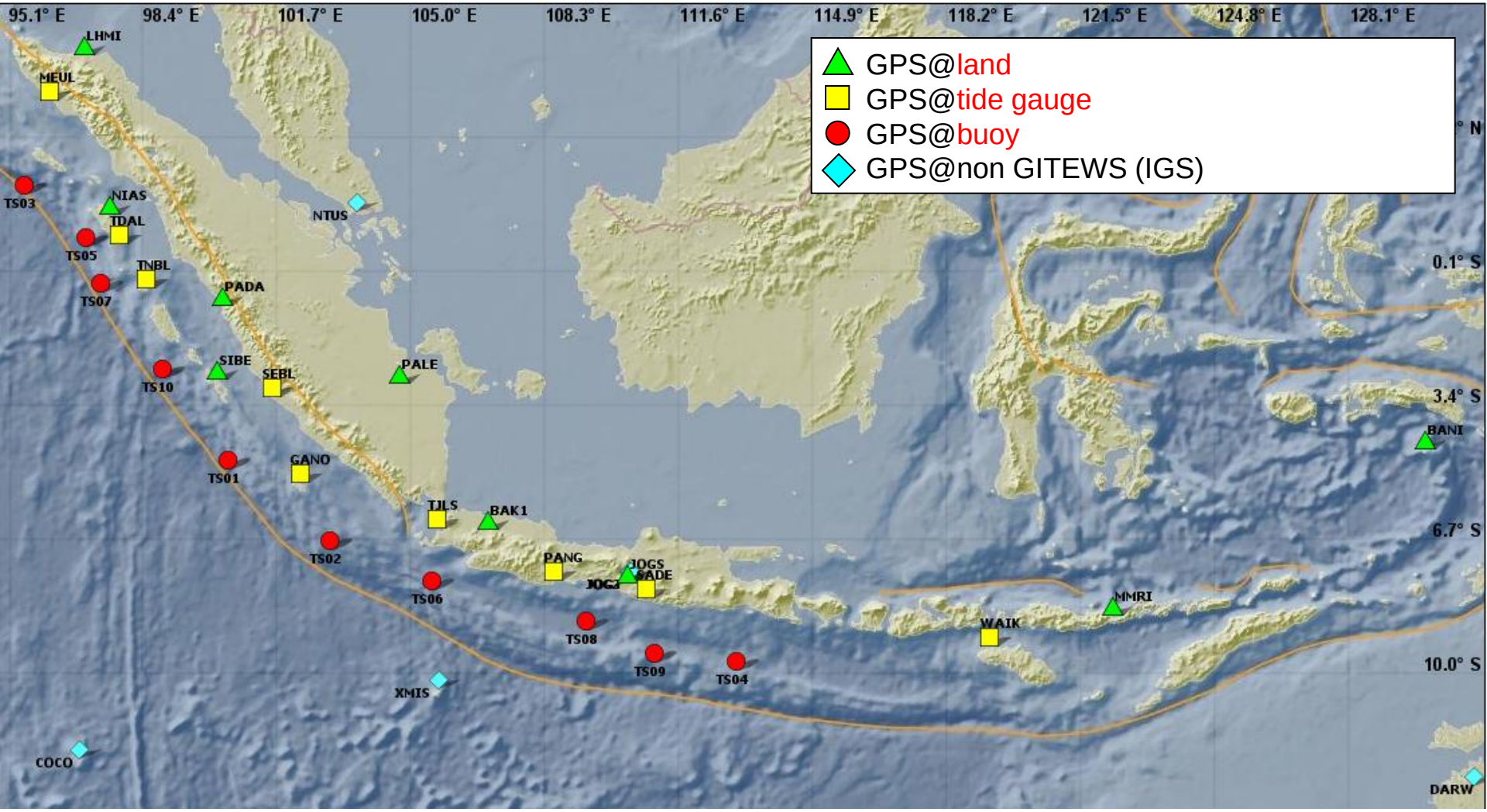
Why is GNSS important for Early Warning? Deformation fields



- Identical Epicentres/Magnitudes, but different faults result in different Tsunami-scenarios (here – for City Bengkulu, Indonesia)
- Only GNSS data provide deformation vectors

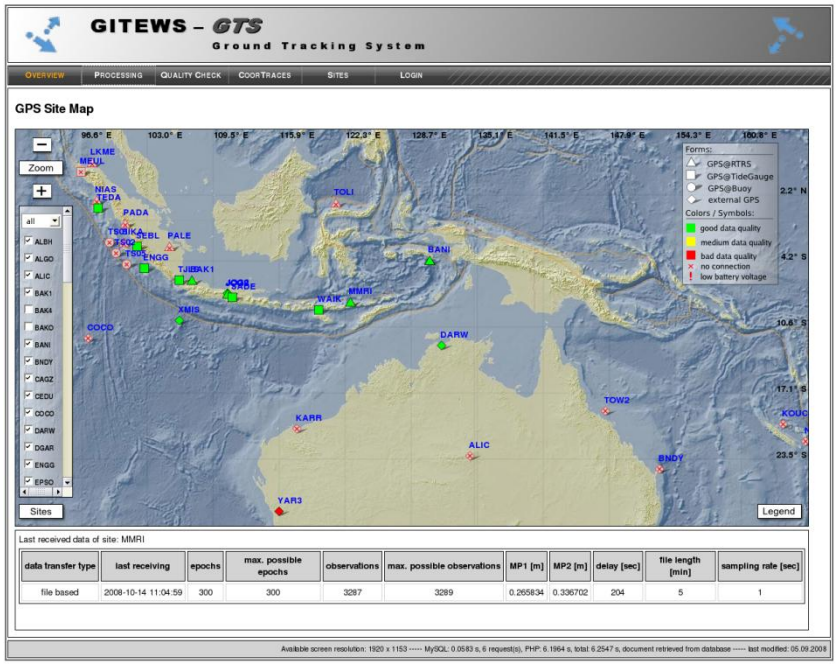
Thanks: A. Babeyko (GFZ)

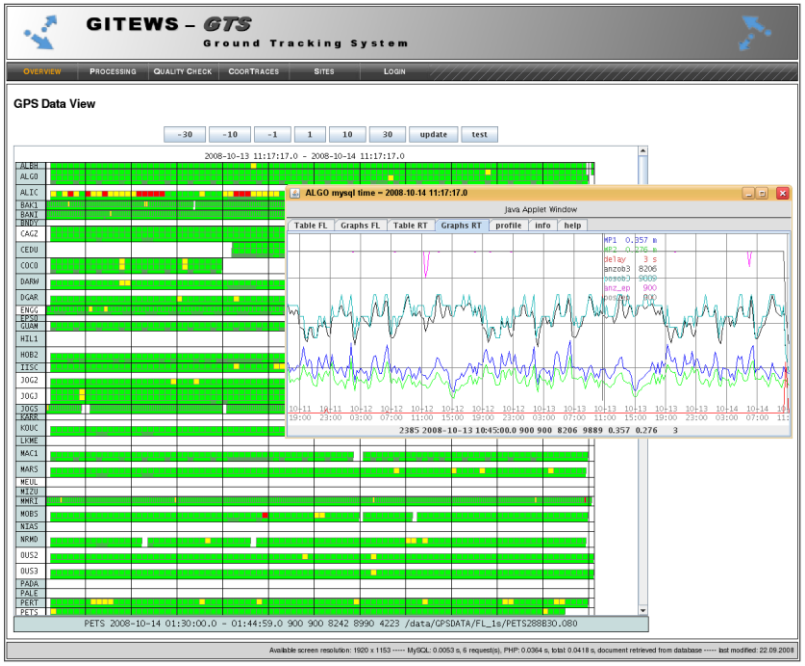
Part of Tsunami Warning: GPS shield



Falck et al., GFZ

Graphical User Interface for GNSS Real-Time system as part of GITEWS





Know how for GNSS operation centers

GITEWS GPS operator at Indonesian tsunami early warning center

Recent GFZ publication: Tsunami and GNSS-RT

Nat. Hazards Earth Syst. Sci., 13, 1285–1292, 2013
www.nat-hazards-earth-syst-sci.net/13/1285/2013/
doi:10.5194/nhess-13-1285-2013

Natural Hazards and Earth System Sciences
Open Access

Instant tsunami early warning based on real-time GPS – Tohoku 2011 case study

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GFZ German Research Centre for Geosciences, Potsdam, Germany

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Received: 20 November 2012 – Published in Nat. Hazards Earth Syst. Sci. Discuss.: –
Revised: 29 March 2013 – Accepted: 18 April 2013 – Published: 17 May 2013

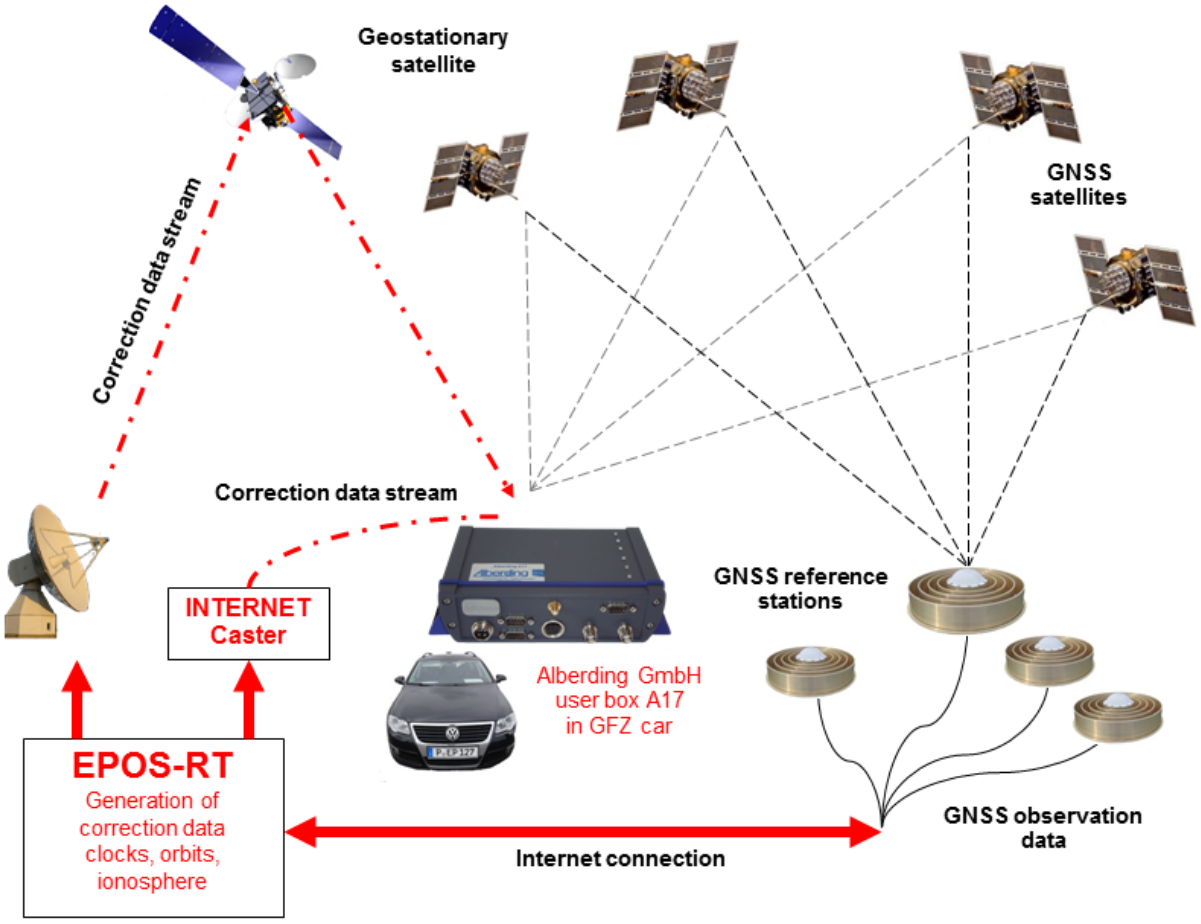
Abstract. Taking the 2011 Tohoku earthquake as an example, we demonstrate the ability of real-time GPS to provide qualified tsunami early warning within minutes. While in earlier studies we demonstrated the power of the so-called GPS shield concept based on synthetic data, we here present a complete processing chain starting from actual GPS raw data and fully simulate the situation as it would be in a warning center. The procedure includes processing of GPS observations with predicted high precision orbits, inversion for slip and computation of the tsunami propagation and coastal warning levels. We show that in case of the Tohoku earthquake, it would be feasible to provide accurate tsunami warning as soon as 3 min after the beginning of the earthquake.

an hour, demonstrated run-ups exceeding 40 m (Mori et al., 2012) and locally inundated up to 5 km inland (Fujii et al., 2011). It caused more than 15 000 fatalities and massive devastation, including damage of the Fukushima nuclear power plant.

Due to numerous and various sensor networks deployed in Japan and in the Pacific, this event is now the most extensively recorded megathrust event ever. Coseismic deformation was recorded by the GEONET GPS array (GSI, 2011) and deduced by sea floor geodesy (Sato et al., 2011). Source parameters were the scope of many investigations including inversion of ocean data, seismic waveforms, as well as joint inversions (Romano et al., 2012; Yokota et al., 2011). Most studies reveal a compact slip distribution (Pollitz et al.,

PPP for commercial positioning solutions

RealTime Positioning: Interface to commercial Applications: Project with BMWi and Fa. Alberding



Wickert, Alberding, Ge 2011

PPP-Project: Possible application fields

- Precision navigation of moving objects (Cars, Airplanes, railway, Ships, Container) to cm-level (e.g., Farming)
- Traffic management (Spurhaltung, Kollisionsvermeidung)
- Logistics of traffic and goods streams
- Precise measurements (Building constructions, planning, land register)
- Early warning systems, Earth observation
- Meteorology, Space weather
- Oceanography, Geophysics
- Tourism, Spare time, (Integration with mobile phones)

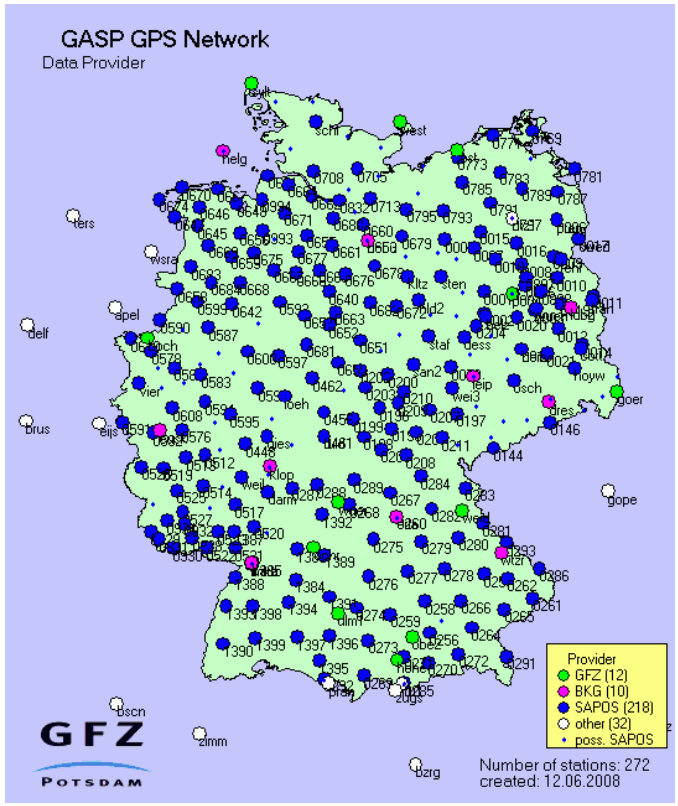
REalTime-Infrastructurmonitoring (Bridges)

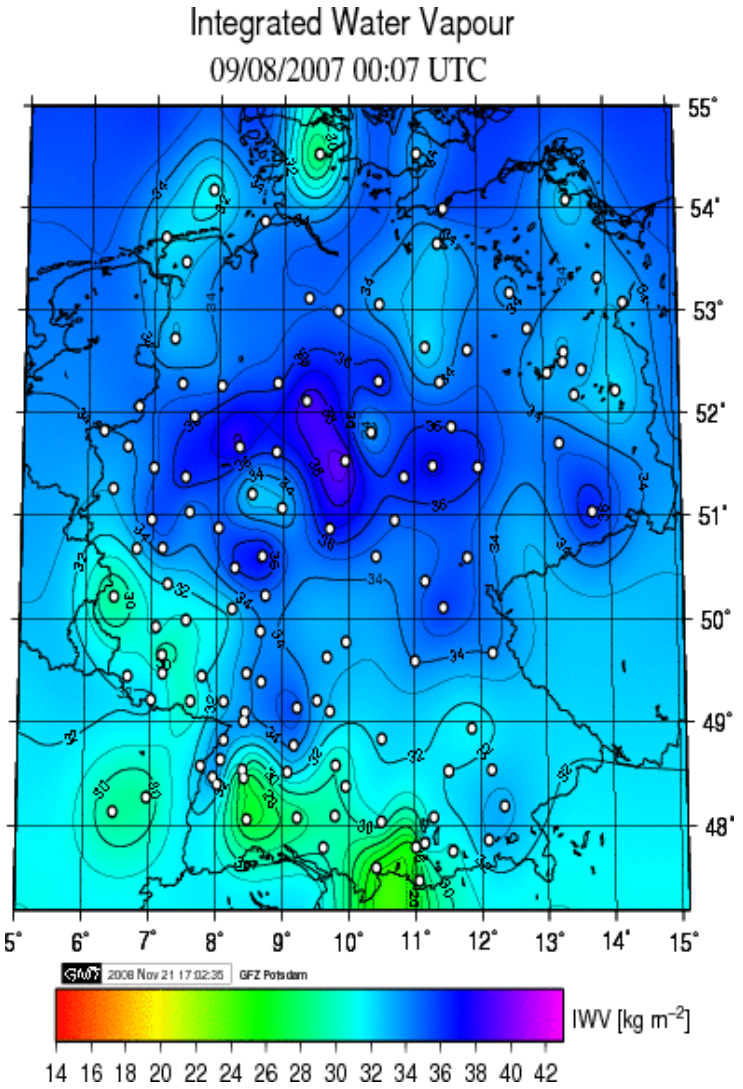
Precise Farming with Fa. Alberding

Demonstration project at new Berlin Airport BER

Weather forecast, Nowcasting

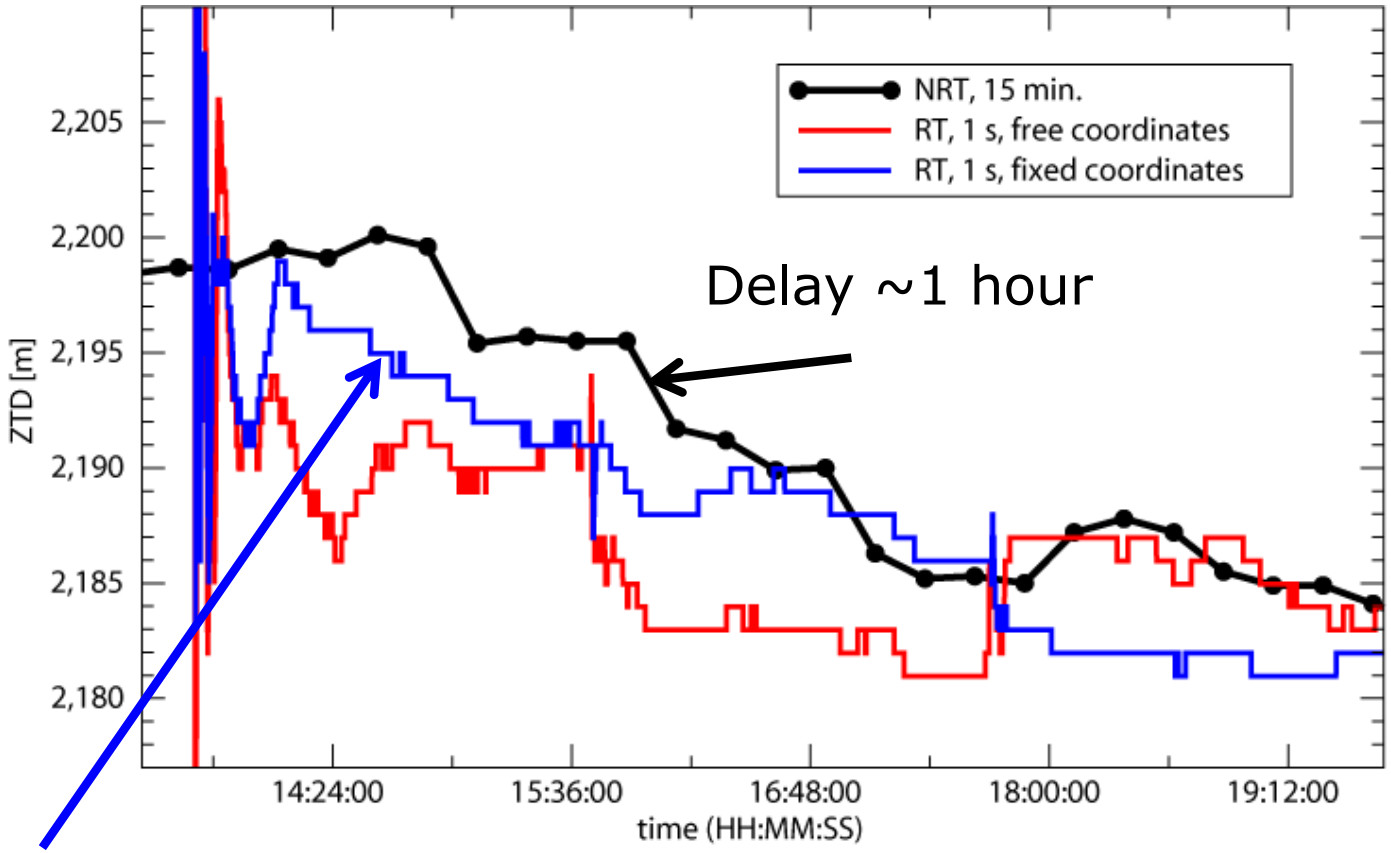
German network (~300 stations)





Water vapor monitoring
in Near-Real-Time

Outlook: Meteorological parameters in Real-time



Delay ~20 milliseconds

Station Wettzell, March 30, 2011

More extended investigations within new COST action, results will be presented at IAG 2013

? Real-Time products from IERS

Use of ERP in Real-Time data analysis (M. Ge; G. Gendt)

- ERP predicitions are provided already in Bulletin A in a long-term
- Accuracy should be sufficient for current PPP in cm-level (rough estimates based on the current Bulletin A acuracies for ERP) but no specific and more extended investigations performed
- ERP parameters in RT are potentially interesting in the initial 24 hours of prediction period, could be significant in future PPP (if mm accuracy reached) but need more investigation