

# EPOS-RT: Software for Real-time GNSS Data Processing

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## ➤ **G-SEIS Project**

**GPS-SurfacE Deformations WithIn Seconds**  
Landslide, Volcano, GPS Shield, ...

## ➤ **GITEWS Project**

**German-Indonesian Tsunami Early Warning System**

**GPS Shiled, GPS Buoy and Reflector**

## ➤ **Real-Time IGS(IGS-RTPP)**

**Real-time orbits and clock products**

# ***Special Consideration***

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- **Base of the future GFZ software**
- **Multi-technology**
  - **GNSS (GPS, GALILEO, GLONASS, COMPASS, ...)**
  - **SLR**
  - **VLBI**
- **Multi-Function**
  - **Real-time/Post-mission**
  - **Static/Kinematic/Dynamic**
  - **High spatial&time resolution**
  - **Integrated solution**
  - **.....**

- **New Concepts**
- **Software Structure**
  - **Architecture**
- **Software evaluation**
  - **Real-time PPP**
  - **Real-time network solution**
- **Investigation of IGS-RTTPP**
- **Conclusions**

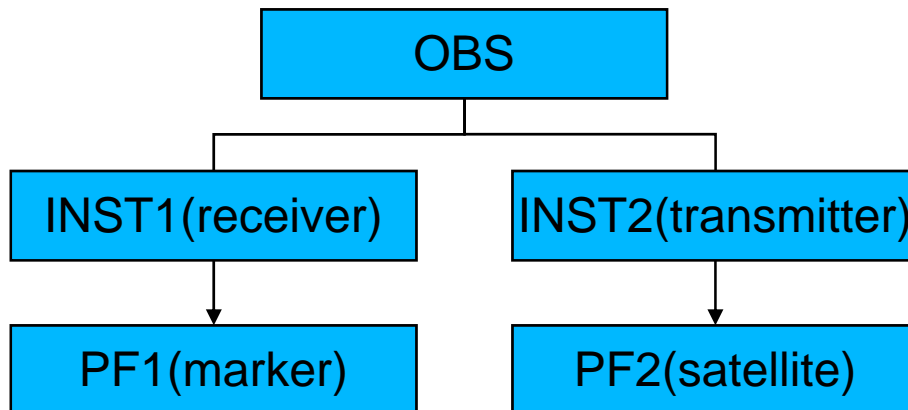
# New Concepts

- **The station-satellite-concept does not fit to the requirement.**

*Think about a LEO with GPS receiver, SLR reflector, KBR and even a GPS transmitter (Pseudo satellite). What is it, a station or a satellite?*

- **Platform(PF)/Instrument(INST)/observation(OBS)**

- **Parameters are defined within these elements**
- **Data and parameters for the modelling of an observation are available via pointer or simple index.**



**No difference to handle data from different systems and different techniques**

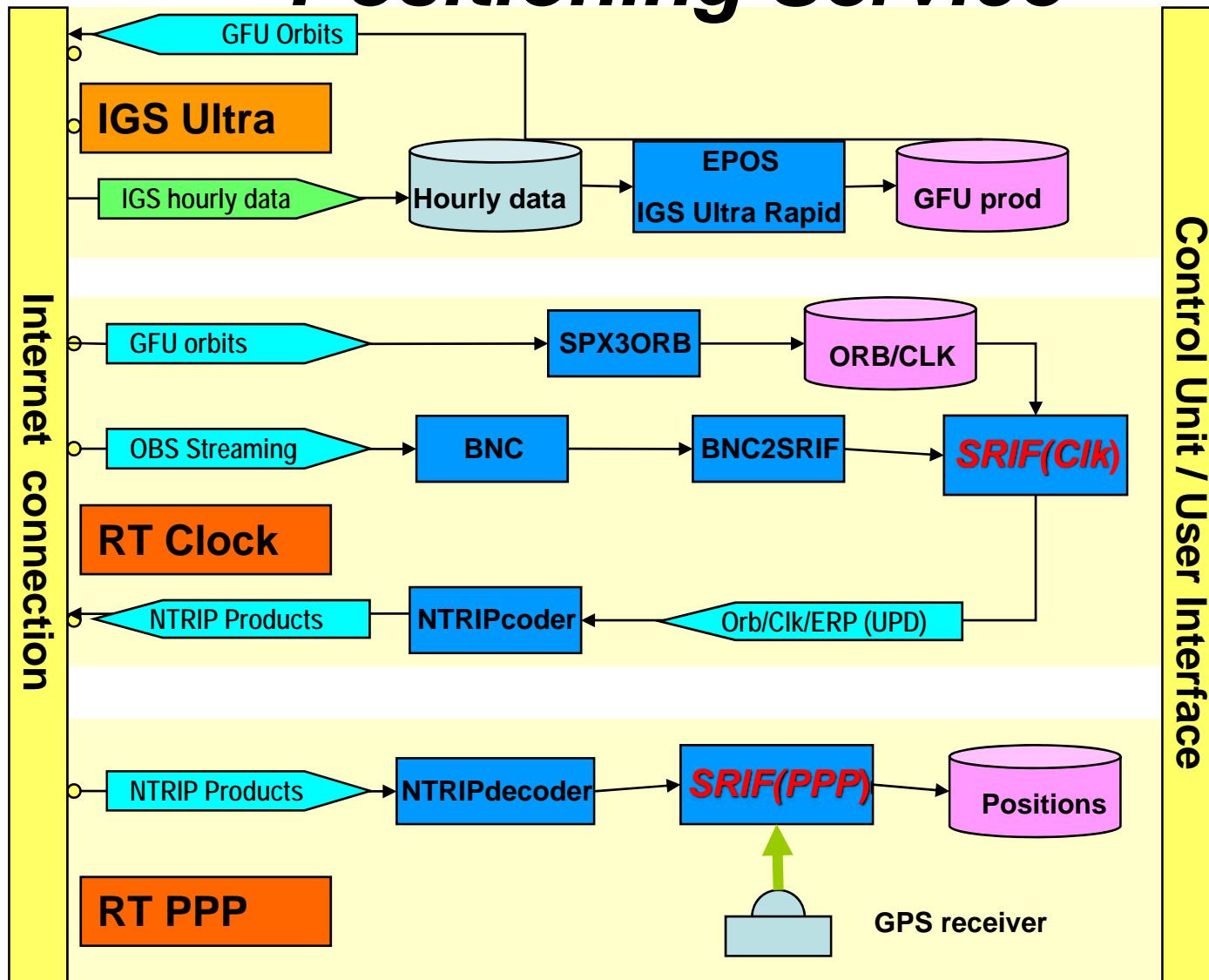
**EPOS-RT(SRIF) is developed based on these new concepts**

# ***Main Features of EPOS-RT(SRIF)***

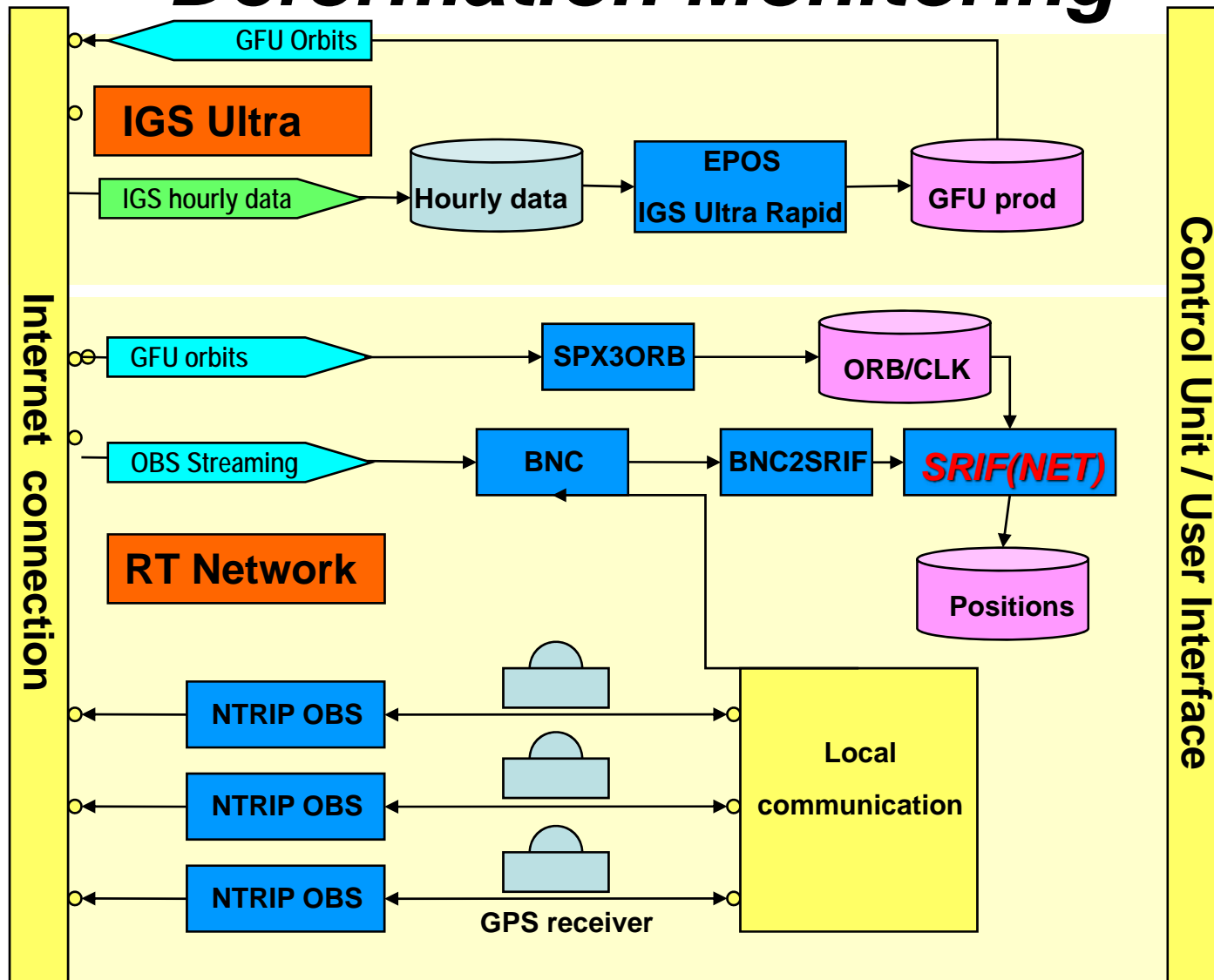
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- **Blackbox design**
  - For users, only one ctrl file is needed
  
- **Multi-GNSS processing**
  - GPS, GLONASS, GALILEO...
  
- **Real-time and Post-processing supported**
  - Epoch-wise processing
  
- **Network solution and PPP supported**
  - Un-difference modeling
  
- **Same software(SRIF) for orbit determination/clock estimation/PPP/Network solution**

## Positioning Service



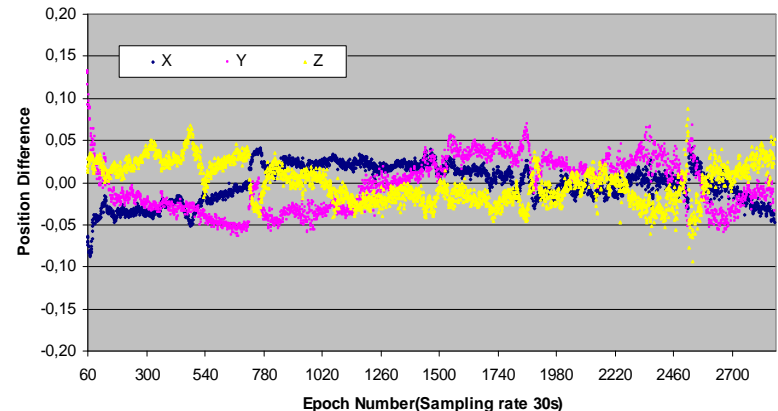
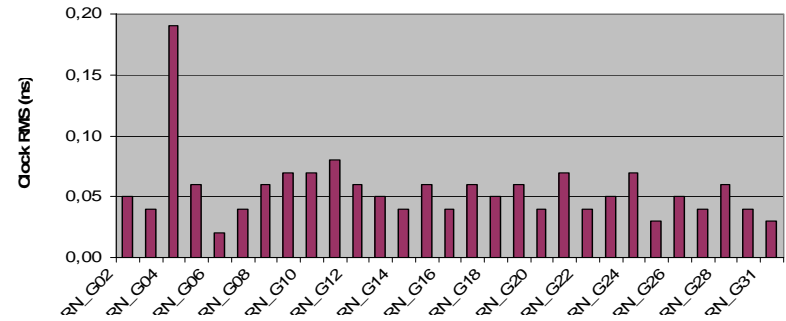
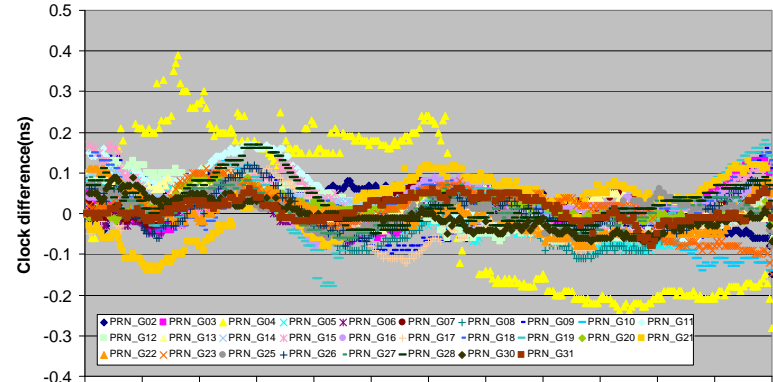
## Deformation Monitoring



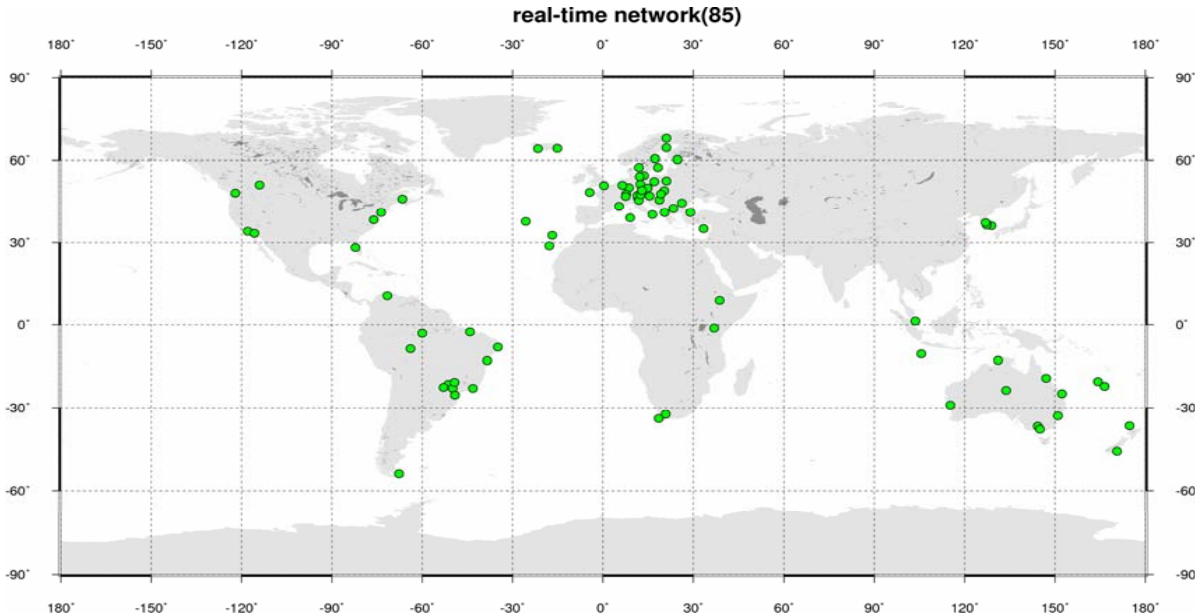


# Clock Estimation & PPP with IGS final orbits

- GFZ IGR Network
- Orbits & ERP fixed to IGS final products
- Station coordinates fixed to IGS combined solution
- Estimated satellite & receiver clocks and ZTD at each station
- Compared to IGS final clocks, **STD=0.04ns (12mm)**
- **PPP:** Kinematic position DUBR, 2 cm each component

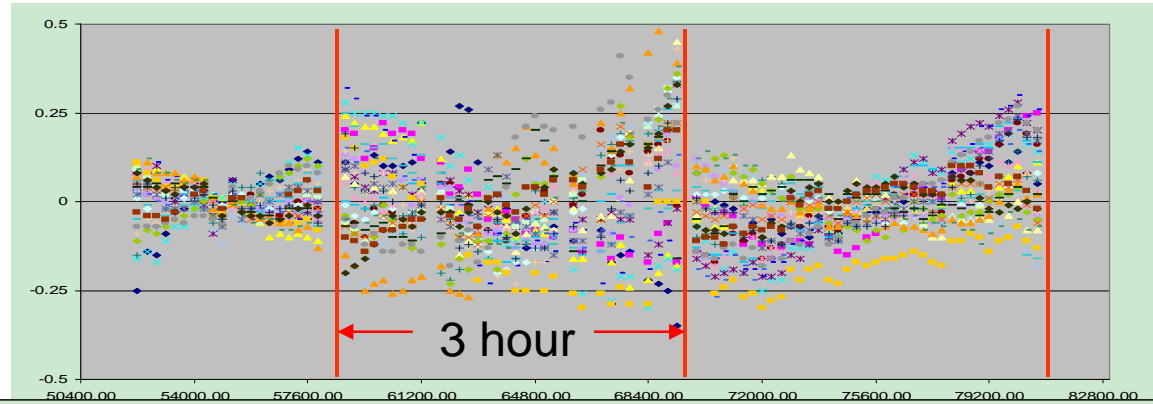


# Real-Time Clock Estimation & PPP

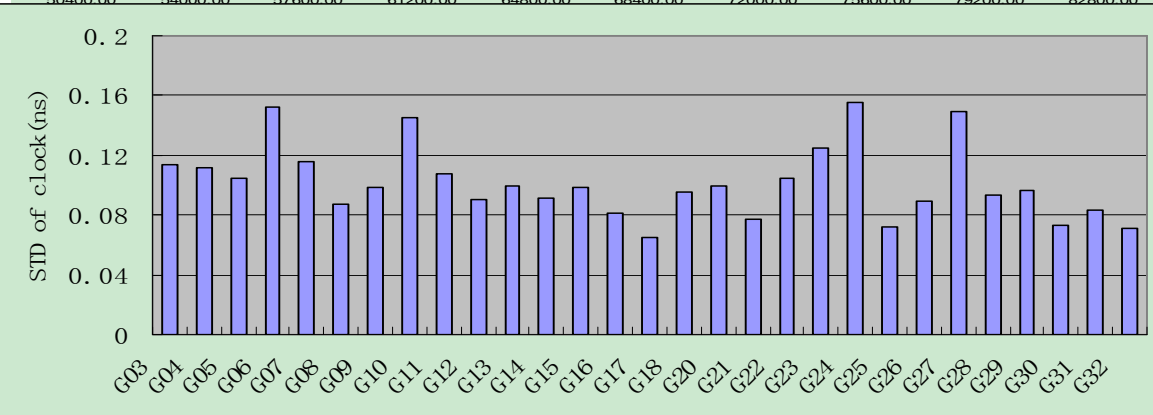


- IGS real-time network from BKG NTRIP, about 85 stations, 13. February 2009
- **Orbits&ERP fixed to GFZ ultral-rapid products (3h update)**
- Station coordinates fixed to our PPP results
- Differenced Observations between epoch
- Estimated satellite&receiver clocks and ZTD

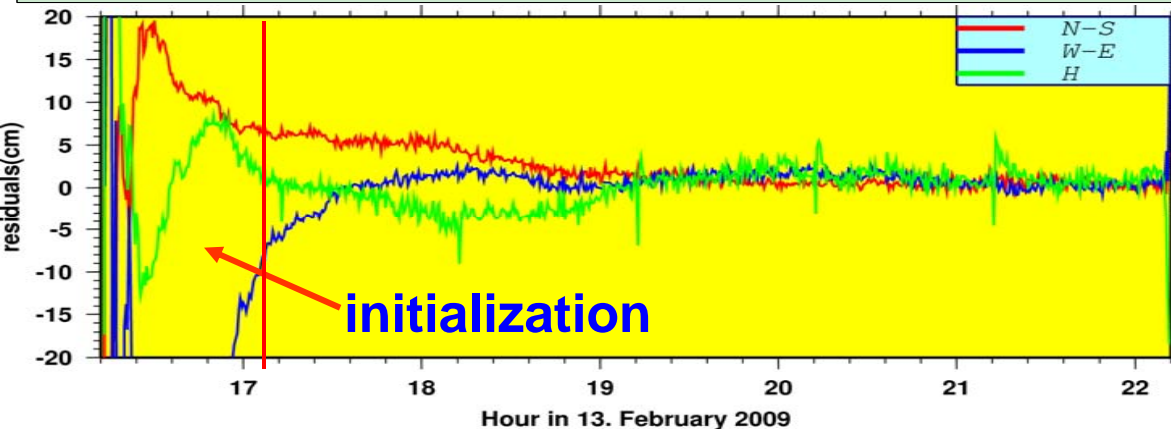
# Real-Time Clock Estimation & PPP



- Comparison with GFZ Rapid Clock, session by session
- Few short gaps

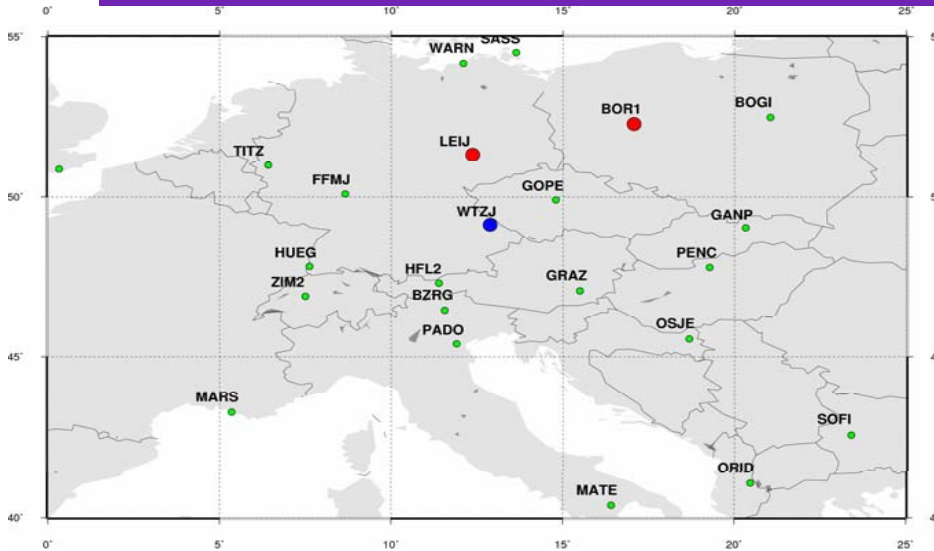


- Average STD = 0.1ns



- PPP precision after convergency(BOR1): (2.0,1.3,2.2) cm

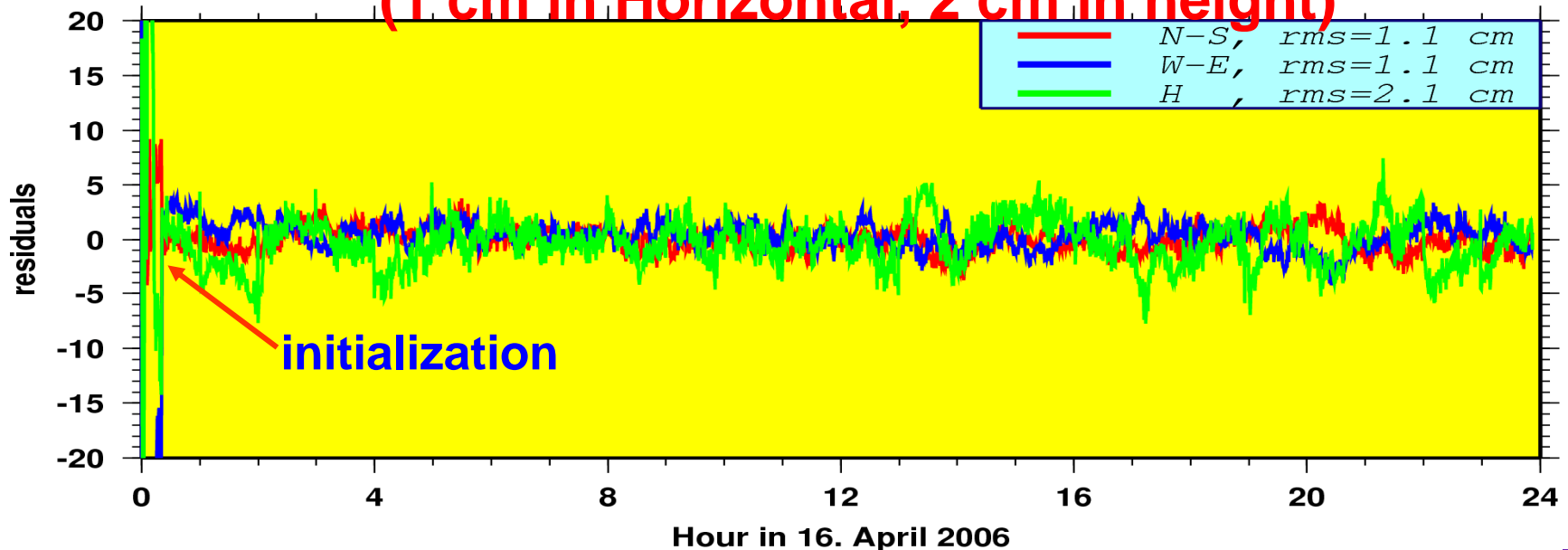
# GFZ *Network solution in Post-processing*



- 16.04.2006, sampling 30sec
- GFZ ultra-rapid orbits
- LEIJ & BOR1 fixed, LEIJ–WTZJ 248km
- Ambiguity fixing with Lambda method (Teunissen et al, 1995)

Kinematic coordinates compared to IGS weekly solution (WTZJ)

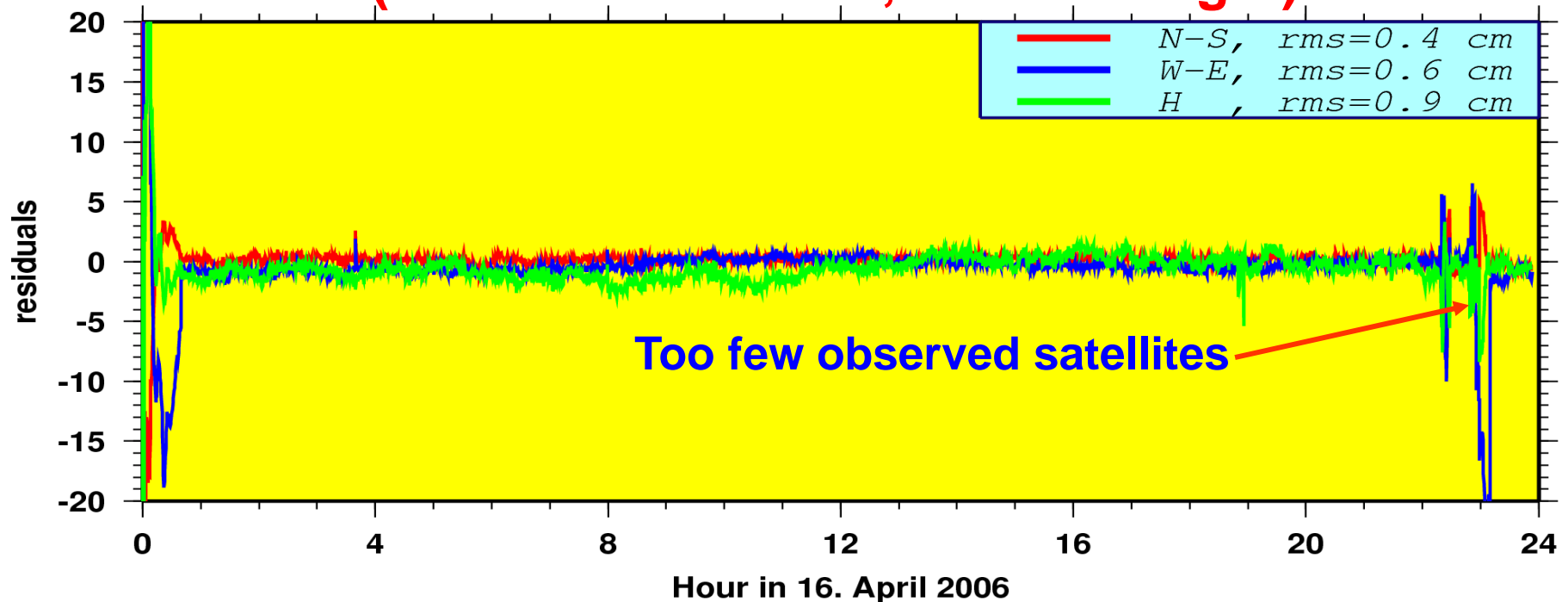
**(1 cm in Horizontal, 2 cm in height)**



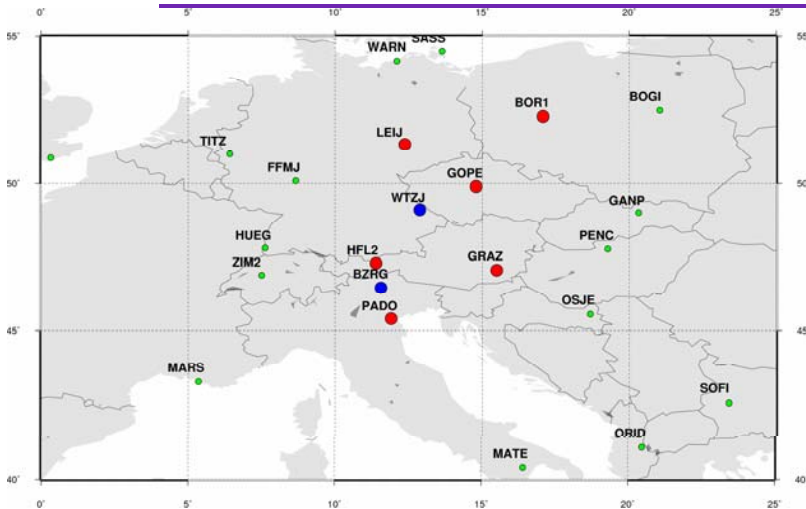
# Network solution with single frequency receiver

- 16.04.2006, sampling 30sec
- WTZS-WTZJ 700m
- Ambiguity fixing with Lambda method (L1 only)

Kinematic coordinates compared to IGS weekly solution (WTZJ)  
(5 mm in Horizontal, 1 cm in height)

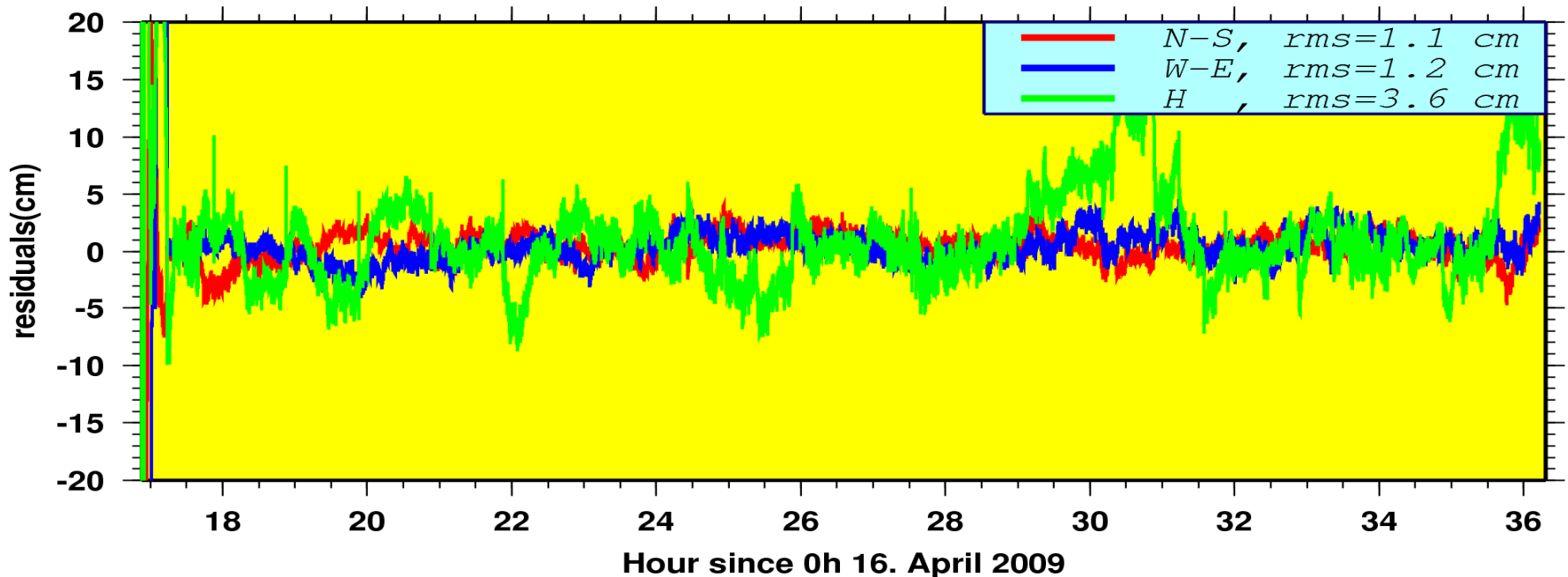


# Real-Time Network solution



- Data from BKG NTRIP Streaming: 1 hz, 8 stations (6 fixed, 2 kinematic) 16-17, April, 2009
- Ambiguity fixing with Lambda method
- GFZ ultra-rapid orbit (no update of orbits)

**Kinematic coordinates compared to IGS weekly solution (BZRG)**



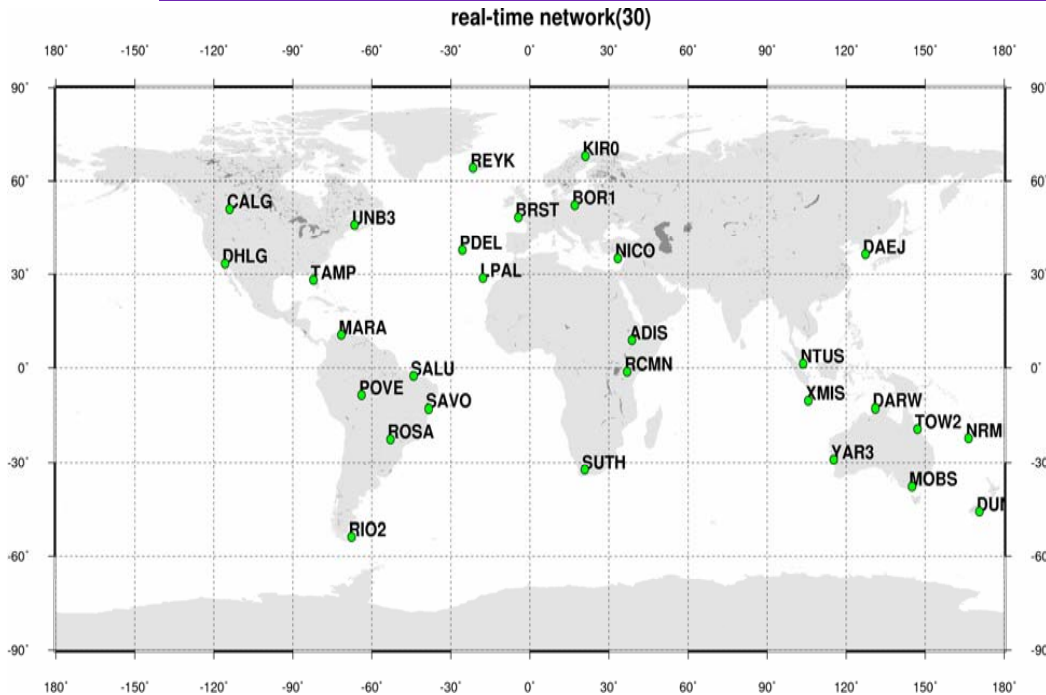
# *Investigation of IGS-RTTP*

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**Status of IGS-RTTP, satellite clock: 0.3ns  
compared to IGR clock (but we have 0.1 ns)**

- **Network reason??**
- **Orbit update strategy??**

# Network effect



- Orbits&ERP fixed to GFZ ultr-rapid products (predicted part, session from 02h-08h)
- **Different networks**
- Comparison with IGS Final Clock

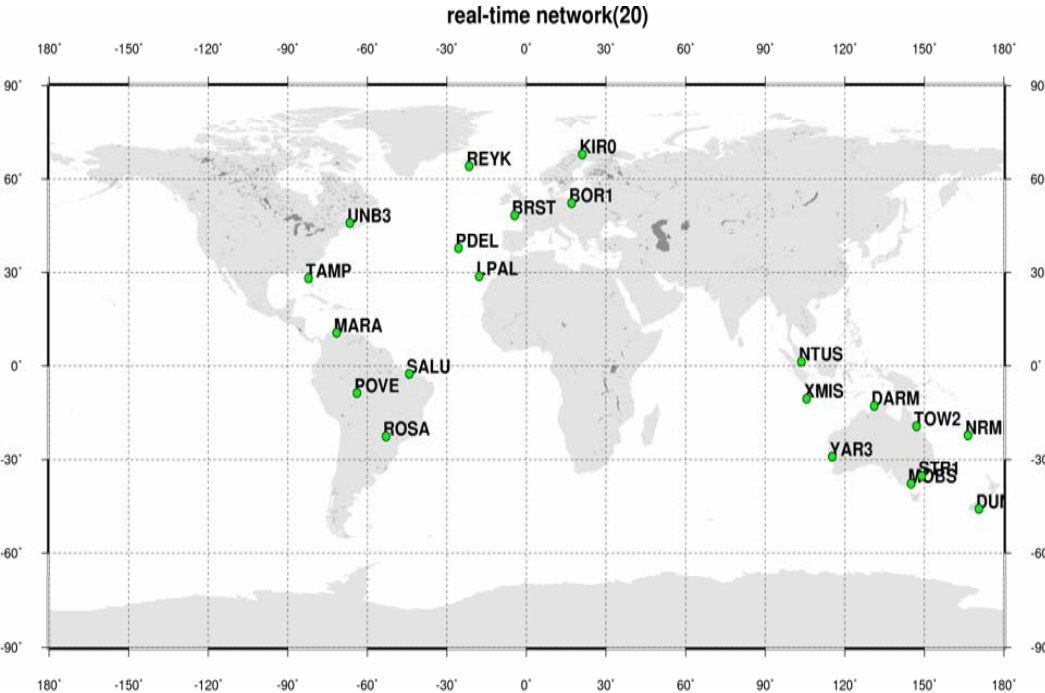
Num.	85	70	60	50	40	30	20*
bias(ns)	-0.25	-0.25	-0.25	-0.25	-0.24	-0.24	-0.34
STD(ns)	0.10	0.10	0.10	0.10	0.11	0.11	0.17

➤ **No difference when station number more than 30 (globally well distributed)**

\* Satellite G15 lose tracking in the first few hours



# Network effect



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# Orbit update

- Orbits&ERP fixed to GFZ ultral-rapid products (predicted part)
- Network with 30 globally distributed real-time station
- Comparison with IGS Final Clock
- **Clock estimation using different orbits**

Orbit	igu 00-03h	igu 01-04h	igu 02-08h	igu 00-24h	igr 00-24
bias(ns)	1.23	0.54	-0.24	1.41	1.20
STD(ns)	0.10	0.10	0.11	0.20	0.12

- **Significant improvement using updated orbits**
- **Similar precision: < 6h predicted orbits and estimated orbits**
- **No big difference between orbit updating every 3h and every 6h**

## ➤ **New concepts are implemented**

- No difference between handling of different systems and techniques

## ➤ **Performance of EPOS-RT**

- Satellite clock estimation precision :

~**0.03ns** (post-processing.GFZ igr network)

~**0.10ns** (real-time. igs real-time network)

- PPP kinematic coordinate precision: **Horizontal 1~2 cm, 3D <4 cm**

- Kinematic coordinate in network solution: **Horizontal ~1 cm, Height 2-3 cm**

## ➤ **Investigation of the status of IGS RTPP**

- No difference in clock estimation using all or a part of existing globally distributed network
- No difference with different orbit update interval (6 hour is sufficient)

## ➤ **Follow-on**

- Co-operate with partners and implement in Tectonic active area.

***Thank you!***