# IGS Analysis Center at GFZ: Activities and Developments

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## Abstract

GFZ operates an active IGS Analysis Center. This poster presents recent activities regarding the transition to IGS14, important modelling changes of the routine products, the quality and consistency of the GFZ products, the status of our multi-GNSS analysis and MGEX-related products, and the plans for future developments.

## Operational Data Processing and Recent Modelling Changes

EPOS.P8 is following the IERS Conventions 2010 (Petit and Luzum, 2010). The global station network used in the processing is presented in Figure 1. About 200, 140, and 100 sites are used for the IGS Final, Rapid and Ultra-Rapid, respectively. Table 1 gives further information regarding these processing lines. With a larger number of sites providing also GLONASS data, estimated GLONASS orbit and clock products have been provided routinely since 2010 (Figure 2). Latest changes in the routine processing are listed in Table 2. A comparison of GFZ final orbits and clock products with respect to the IGS combined solution is shown in Figure 3.

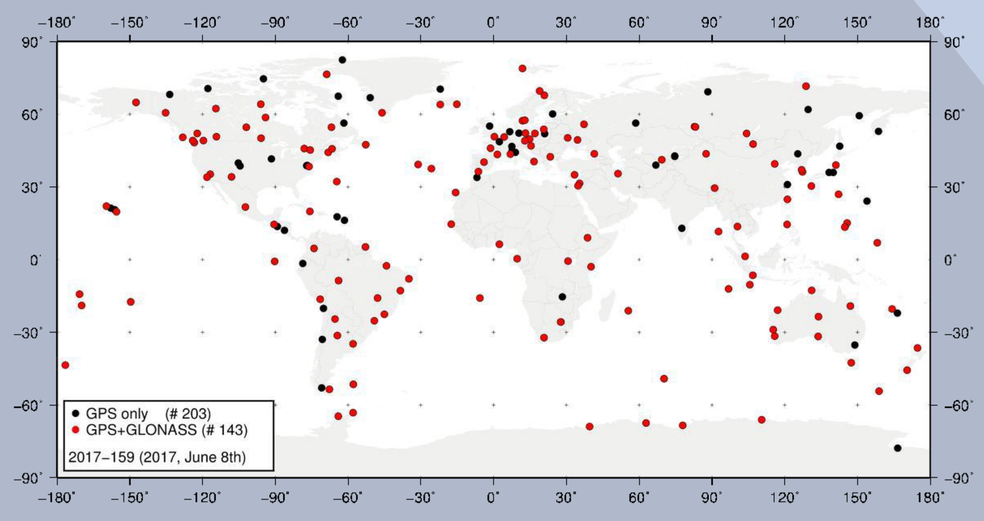


***Fig. 1*** *Global network of IGS stations used for combined GPS+GLONASS data processing.*

***Tab. 1*** *Number of stations and processing time for different GFZ products.*

| IGS Product | #Sites | #Sites GLO | Duration [min] |
|---|---|---|---|
| Ultra-Rapid | 100 | 70 | ~ 30 |
| Rapid | 140 | 100 | ~ 90 |
| Final | 200 | 140 | ~ 210 |

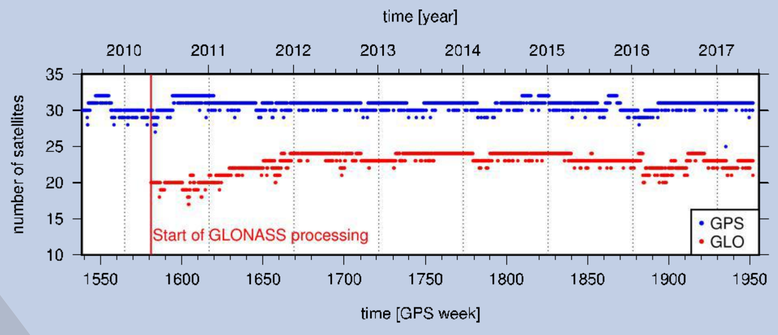


***Fig. 2*** *Number of GPS and GLONASS satellites since 2010 as considered for the final GFZ analysis.*

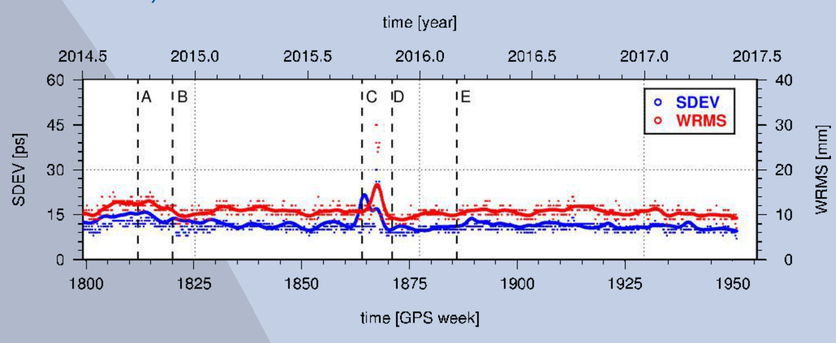


***Fig. 3*** *Comparison of GFZ final orbits and clocks w.r.t. IGS combined solution. Processing changes are reported in Tab 2. A:1812, B:1820, C:1864, D:1872, E:1886*

***Tab. 2*** *Recent processing changes*

| Date (GPS week) | Change |
|---|---|
| **2014-09-03 (1807)** | Introduced 2nd order ionosphere correction and VMF-1 mapping function for tropo-sphere modeling in IGS final processing |
| **2014-10-15 (1812)** | Switch to EGM2008 and FES2004 |
| **2014-12-02 (1820)** | Bug fix: C20 term in EGM2008 |
| **2015-02-13 (1831)** | Bug fix: use updated GPS P1-C1 differential code biases |
| **2015-10-05 (1864)** | Switch to 12th generation of IGRF; allow ISB reference receiver be different from clock reference receiver; switch from CODE TEC maps to IGS TEC maps |
| **2015-12-02 (1872)** | Fix clock reference selection procedure |
| **2016-02-02 (1881)** | Switch meteo model from NOM to GPT2 and mapping function from GMF to VMF in the processing of 30 sec clock corrections |
| **2016-03-01 (1886)** | Skip bad satellites from constellation mean calculation |
| **2016-05-25 (1896)** | Inclusion of RINEX 3 data |
| **2017-01-29 (1933)** | Switch from IG08 to IGS2014 and from IGS08.atx to IGS14.atx |

## Transition from IGb08 to IGS14

In preparation of the switch from IGb08 to IGS14 we performed an IGS14-based test processing between GPS weeks 1913 and 1933. The parallel processing with respect to IGb08 and IGS14 allows to assess the effect IGS14 has on derived products. Figure 4 shows the orbit comparison between the orbits computed in the operational mode (IGb08) and in the experimental chain (IGS14) as mean RMS of position differences. This comparison was done without (*blue*) and with (*red*) estimating Helmert transformation parameters. Mean RMS values of the differences were found to be around 4 mm and around 6 mm, respectively. Figure 5 presents the estimated transformation parameters, which are rather stable over time, except for some small variations in the z-translation between week 1922 and 1924. For the rotation around the y-axis an offset of 2 mm was detected.

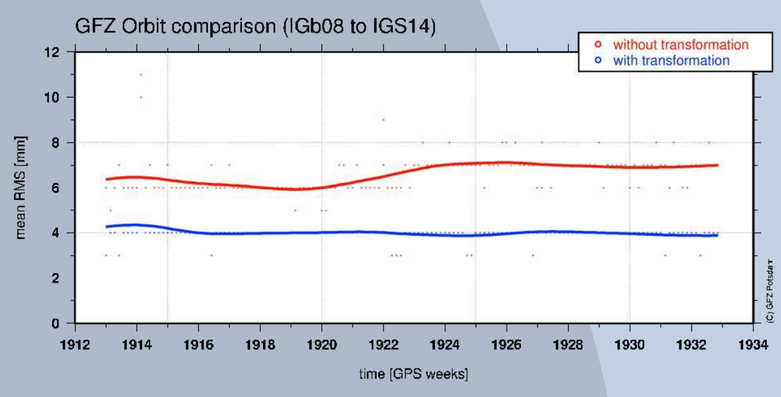


***Fig. 4*** *Orbit comparison between GFZ orbits based on IGb08 and on IGS14 (mean 3D RMS over all satellites)*

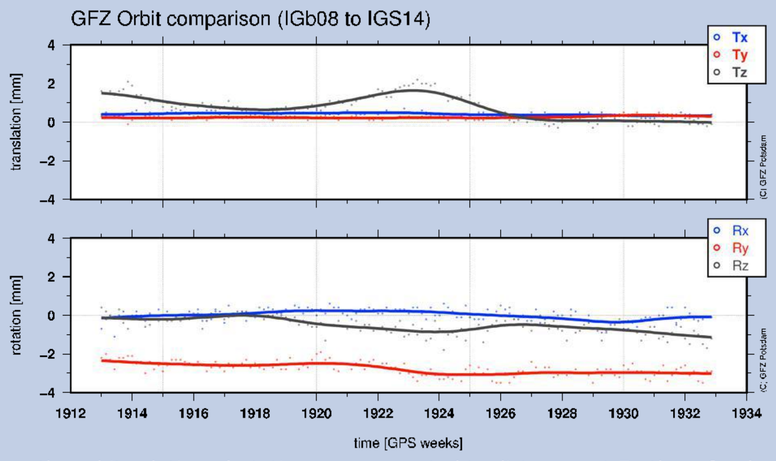


***Fig. 5*** *Helmert transformation parameters estimated between the orbit solutions (rotations are converted to distances at Earth surface)*

## Multi-GNSS Processing at GFZ

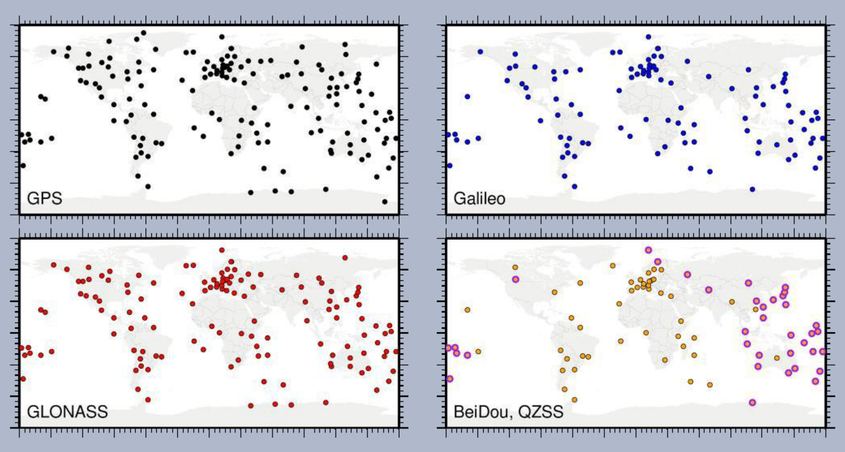


***Fig. 6*** *Processed station network for the systems contained in the gbm MGEX products (June, 8th 2017), QZSS capable stations are identified by purple circles*

Since May 2015 GFZ routinely generates IGR-like products for the five GNSS constellations GPS, GLONASS, Galileo, BeiDou, and QZSS. Figure 6 shows the considered station networks for all five systems, average station numbers are 160, 140, 110, 80, 40 sites for GPS, GLONASS, Galileo, BeiDou, and QZSS, respectively. The development of the different systems is visible in the number of processed satellites (Figure 7). As an orbit quality measure, the RMS values of the position differences from overlapping orbit arcs are estimated for each individual satellite (Figure 8). RMS values below 10 cm are achieved for GPS, Galileo, and most of the GLONASS satellites. For the geostationary BeiDou satellites RMS values of up to 2 m were found. The inclined geostationary (IGSO) satellites show RMS values between 15 and 20 cm. For the geostationary QZSS satellite a RMS value of 90 cm was derived.

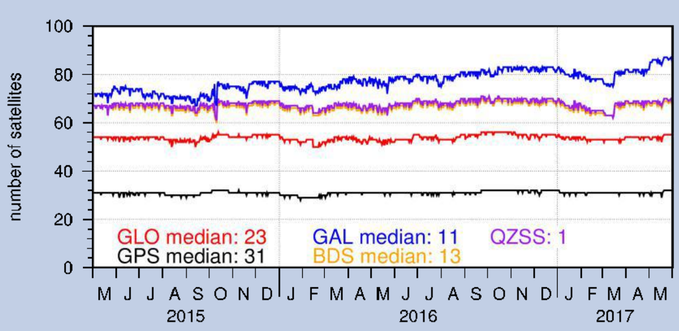


***Fig. 7*** *Number of satellites included in the gbm products between May 2015 and June 2017*

- GFZ rapid & ultra-rapid MGEX products are available via: ftp://ftp.gfz-potsdam.de/pub/pub/GNSS/products/mgnss/ (please register in order to get the most recent products)

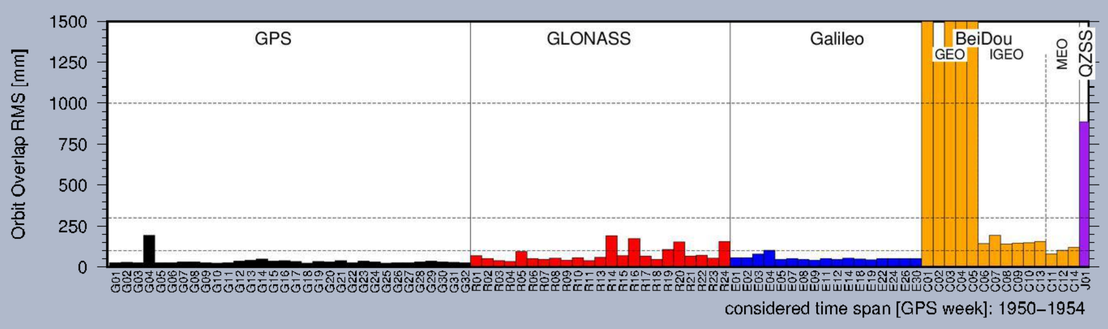


***Fig. 8*** *Daily mean RMS values of the differences from overlapping orbit positions (3 hours interval) for the five systems contained in the gbm products; for geostationary BeiDou satellites overlap RMS values of up to 2 m were found; time period: May 21 – June 24, 2017*

## Outlook

- Modernization of the EPOS.P8 processing software is ongoing
  - Increase flexibility regarding parameter setup and parameter constraining
  - Development of a web-based facility for GNSS processing (PPP and network analysis)
- Preliminary results for ongoing studies regarding orbit and clock predictions show significant improvements when using clock residual information in the orbit prediction step
- Transition to new setup for the Operational Data Center (see PS02-04, Bradke et al.) which will allow to monitor data availability, latency, data quality, and station misbehaviors in a fully automated way with web-based configuration interfaces