TIGA Reprocessing at GFZ

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Introduction

The International GNSS Service (IGS) Tide Gauge Benchmark Monitoring – Working Group (TIGA-WG) is responsible for analyzing GNSS data from stations at or near tide gauges (TG) on a preferably continuous basis and to provide information specifically for the vertical rates. The position and vertical velocity results of the stations can be applied in several geodetic and geophysical studies, such as global and regional sea-level change studies, calibration of satellite altimeters and the unification of height systems.

As one of the TIGA Analysis Centers the German Research Centre for Geosciences (GFZ) is contributing to the IGS TIGA Reprocessing Campaign. After the first reprocessing the standard model of 2nd IGS reprocessing were implemented into the latest GFZ software version EPOS.P8: reference frame IGb08 based on ITRF2008, antenna calibration igs08.atx, geopotential model (IERS2010), higher-order ionosphere effects, a priori meteorological model (GPT2) and VMF mapping function etc.
The GNSS data is collected through the SONEL data centre (www.sonel.org) of the Global Sea Level Observing System (GLOSS). The data of about 800 sites for the time span from 1994 until end of 2012 are reprocessed. In this presentation the GFZ process scheme and some results of the TIGA GNSS data reprocessing are given.

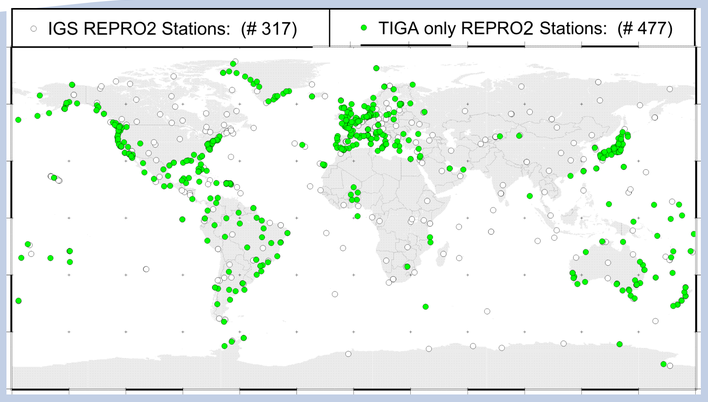

Fig. 1: *Global distribution of the TIGA reprocessed GPS stations for GFZ REPRO2 (white dots) and TIGA (green+white dots).*

Data Processing

Processing Scheme

For the TIGA Reprocessing the software package EPOS.P8 developed at the GFZ is used. The data processing is performed on a Linux cluster with a maximum number of 30 computers/servers. Using EPOS.P8 a high degree of automatization of the individual processing jobs can be achieved on the computers/servers cluster.

The TIGA data reprocessing is done in two steps, firstly precise satellite clocks, orbits, 1-day normal equations are generated from the GFZ REPRO2 using the IGS stations. In the second step the TIGA stations without the GFZ REPRO2 stations, named TIGA only stations, are processed in PPP mode using the GFZ REPRO2 satellite clock and orbit products to clean the observation data. Since the processed number of TIGA daily stations can reach up to 560 stations (Fig.2) and the EPOS.P8 can process up to 250 stations for one single job, the TIGA stations muss be processed in up to 3 sub-networks. To connect the two or three sub-networks 30 global distributed GFZ REPRO2 stations are selected and processed together with the TIGA sub-networks. The 30 connection stations are different for each sub-network and be selected automatically from GFZ REPRO2 stations for each day according to its distribution and post fit. The GFZ REPRO2 solutions would be one of TIGA sub-network solutions, if the number of TIGA REPRO2 stations larger than 250 stations.

Since the initial coordinates of most TIGA only stations have insufficient accuracy (> 2 cm) for the IGS data analysis, in the PPP data clean step the estimated station coordinates are used to generated new initial coordinates and velocities. For example, the PPP coordinates of the station AUTF are given in Fig.4, from the coordinate time series the initial coordinates and velocities can be retrieved. The IGS like data analysis for the clusters will be finish in the next months. For the GFZ IGS data analysis the used models and algorithms are listed below.

Observation data:

- Ionosphere-free linear combination, undifferenced carrier phase and pseudo-range observables
- Sampling rate: 5 minutes
- Elevation cut-off angle: 7°
- Elevation depended weighting: 1/2sin(e) for e<30°

Measurement models:

- Updated satellite & ground antenna phase center offsets (PCOs) & phase center variations (PCVs) in IGS08_1730.ATX file.
- Ocean tide loading: FES2004 (CoM corr. applied)
- Loading due to S1 & S2 atmosphere pressure tides Tidal effects: IERS Conventions 2010
- ARP eccentricities from site-logs/igs.snx
- Troposphere: a priori zenith delay from Saastamoinen, Global Pressure & Temperature model (GPT2) and Vienna Mapping Function (VMF)
- Ionosphere: include 2nd order ionosphere correction

Reference frames:

- Terrestrial: IGS realization of ITRF2008 (IGb08)
- IAU 2000A Precision-Nutation model
- Bulletin A EOPs as a priori values

Orbit models:

- Gravity field: EGM2008 (12x12) with temporal variations
- Geopotential ocean tide model: FES2004
- Third-Body: JPL Planetary ephemeris DE405
- Solar radiation pressure: a priori none
- Albedo Acceleration: model from C.J. Rodriguez-Solano
- Earth shadow model: penumbra
- Attitude model: Bar-Sever, based on nom. yaw- rates
- Relativistic effects: Schwarzschild and Lense-Thirring dynamical correction and gravitational time delay

Estimated parameters (Least Square Adj.):

- Coordinates of stations
- Clocks of satellites and receivers per epoch
- Orbits (position, velocity, SRP, stochastic impulses, y-bias, yaw-rate) per day
- Troposphere: ZTD per hour, gradients per 24 h
- Ambiguities: fixed
- ERPs: pole coordinates and rates, LOD per day

Since the IGS REPRO2 combination solutions are not available, the quality of the reprocessed GPS and IGS Final orbits by 7-parameter similarity transformations. The mean RMS of the transformed reprocessed orbits w.r.t. the REPRO1/IGS orbits is shown in Fig. 5. The RMS decreases rapidly from about 15 cm in 1994 to about 2 cm in the mid of 1995.

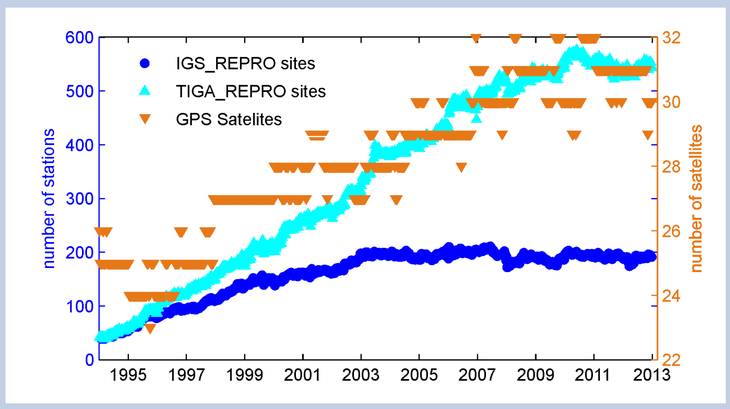

Fig. 2: *Weekly Number of stations and satellites included in the GFZ REPRO2 and TIGA REPRO2. TIGA REPRO2 is based on the same set of GFZ REPRO2 stations, so that the difference to IGS_REPRO2 shows the number of processed TIGA only stations.*

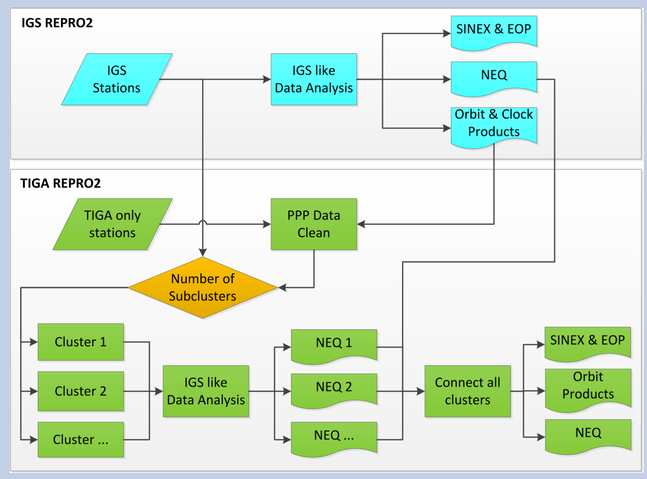

Fig. 3: *The solution IGS RERPO2 has a processing scheme similar to GFZ routine analysis. Its orbit and clock products were introduced and fixed for TIGA REPRO2 to clean the data using PPP mode. The final TIGA solution is the result of a Normal Equation (NEQ) stacking (clusters + IGS REPRO2).*

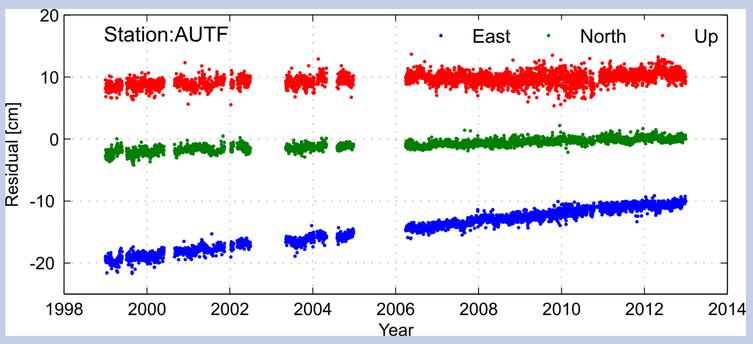

Fig. 4: *The time series of coordinates residuals in East, North and Up for TIGA only station AUFT. The coordinates are estimated in PPP mode.*

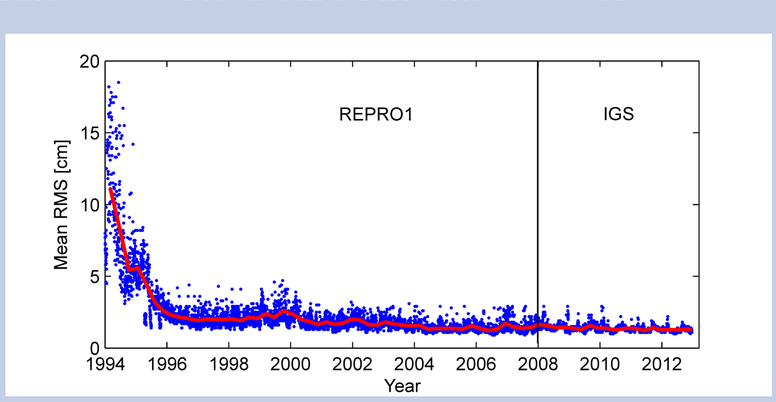

Fig. 4: *Mean RMS of transformed GFZ TIGA Repro2 orbits w.r.t. the Repro1(1994.0 - 2008.0) and the IGS Final orbits (2008.0 - 2013.0). The red solid line represents a 100-day median.*

Summary

GFZ is contributing to the IGS TIGA Reprocessing Campaign. The GPS data of the globally distributed tracking network of 794 stations for the time span from 1994 until end of 2012 has been reprocessed with up-to-date models and processing strategies. The GFZ TIGA products are now available at GFZ TIGA FTP and CDDIS FTP. The GFZ FTP stores the daily & weekly SNX, orbit SP3 and ERP files. Beside the coordinate and orbit products we have troposphere parameters as by products, which can be used for climate studies.

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