CODE Contribution to the 2nd IGS Reprocessing

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Introduction

The Center for Orbit Determination in Europe (CODE) is one of the global analysis centers participating in the reprocessing efforts of the International GNSS Service (IGS). Major motivation for the 2nd IGS reprocessing campaign (repro2) is the preparation of a new release of the International Terrestrial Reference Frame, namely ITRF2013. The CODE contribution to IGS repro2 covers the time period from January 1994 to December 2013 (7305 days) and includes a total of 372 stations. The number of stations per day varies between 40 in 1994 and 290 in 2010. Whereas only GPS is considered in the first eight years, GLONASS starts contributing in January 2002.

As for the operational final processing for the IGS, two different product lines were generated: a clean 1-day solution (COF/CF2) as well as a 3-day long-arc solution (COD/CO2). This poster presents the processing strategy of the CODE reprocessing and evaluates the quality of the two different solutions as regards station coordinates and satellite orbits.

Processing Strategy

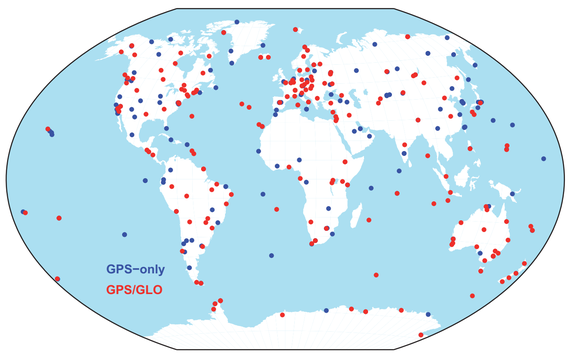

FIGURE 1: Stations used for the CODE contribution to the 2nd IGS reprocessing campaign repro2. The availability of GLONASS-capable receivers refers to 1 January 2013 for active stations and to the last receiver for inactive stations.
The station selection is based on the priority list of the IGS reference frame coordinator. However, in particular additional GPS/GLONASS stations were included to improve the GLONASS coverage.

The CODE contribution to IGS repro2 was computed with the development version 5.3 of the Bernese GNSS Software on the Linux Cluster of the Leibniz Supercomputing Centre of the Bavarian Academy of Sciences and Humanities. The processing strategy, algorithms, and options were synchronized with the operational final CODE-solution in June 2013 before the computations have been started. Important changes w.r.t. the CODE contribution to the 1st IGS reprocessing include:

- Inclusion of GLONASS (starting with 2002)
- IGb08 reference frame and IGS08 antenna phase center model
- IERS 2010 conventions
- Vienna Mapping Function 1 (VMF1) and ECMWF a priori troposphere delays
- Chen & Herring troposphere gradient mapping
- No a priori radiation pressure model
- Albedo and antenna thrust (block-specific for GPS, 100 W for GLONASS)

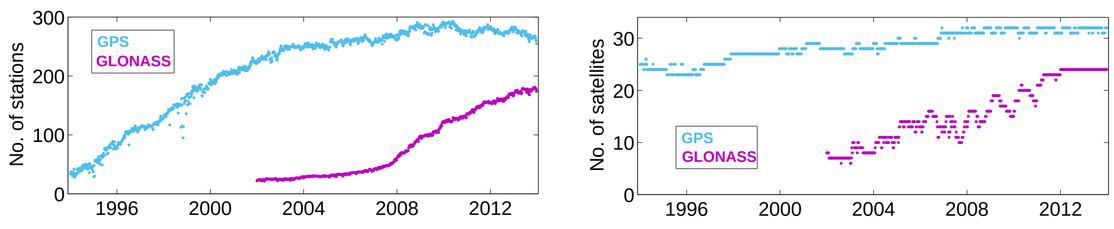

FIGURE 2: Number of GPS and GLONASS stations and satellites. Sufficient global GLONASS coverage is reached around 2009 with approximately 100 tracking stations.

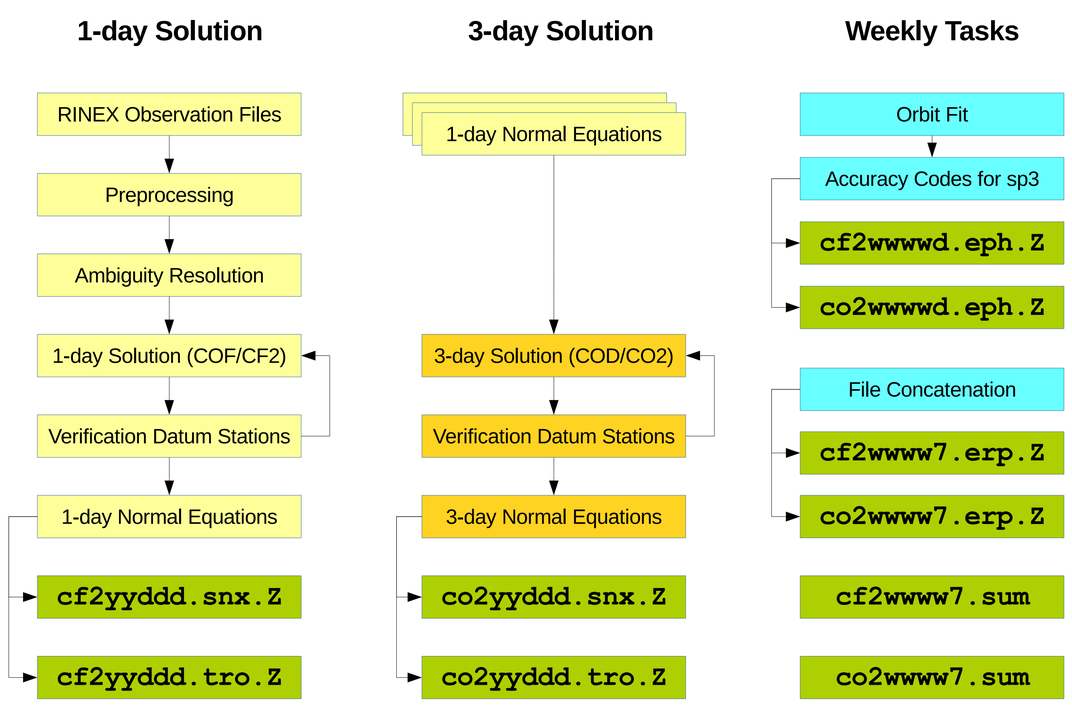

FIGURE 3: Flow chart of the product generation of the CODE reprocessing. Abbreviations:

`cf2`	CODE 1-day solution repro2	`co2`	CODE 3-day solution repro2
`yy`	2-digit year	`ddd`	Day of year
`wwww`	GPS week	`d`	Day of week
`snx`	Daily SINEX files	`tro`	Daily troposphere SINEX files
`eph`	Daily satellite orbit files	`erp`	Weekly Earth rotation parameter files
`sum`	Weekly summary files		

The `co2` orbit files contain only the middle day of the 3-day arc.

Station Coordinates

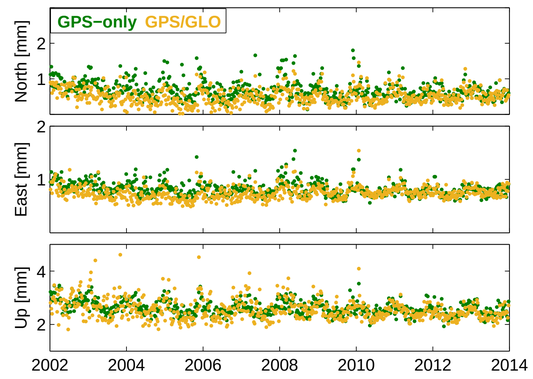

FIGURE 4: Repeatabilites of weekly coordinates computed from 3-day solutions.

Sol.	Receiver	North	East	Up
1-day	GPS-only	1.38	1.37	4.38
	GPS/GLO	1.27	1.27	4.06
3-day	GPS-only	0.81	0.80	2.56
	GPS/GLO	0.74	0.74	2.47

TABLE 1: Median repeatabilites of weekly station coordinates for GPS-only and combined GPS/GLONASS tracking stations in millimeters for the time period 2002.0 until 2014.0. The GPS/GLONASS receivers have slightly better repeatabilities compared to the GPS-only receivers, in particular for the Up component.

Satellite Orbits

The RMS of a 3-day arc fitted through three consecutive 1-day arcs (only the middle day is used for the 3-day solution) serves as quality indicator for the satellite orbits. The sparse networks in the early years of GPS and GLONASS are responsible for RMS values above 5 and 10 cm for the 1-day solutions of the GPS and GLONASS orbits, respectively. Until 2008 the GLONASS orbit fit RMS values of the 1-day solutions are more than a factor of two worse compared to the 3-day solutions.

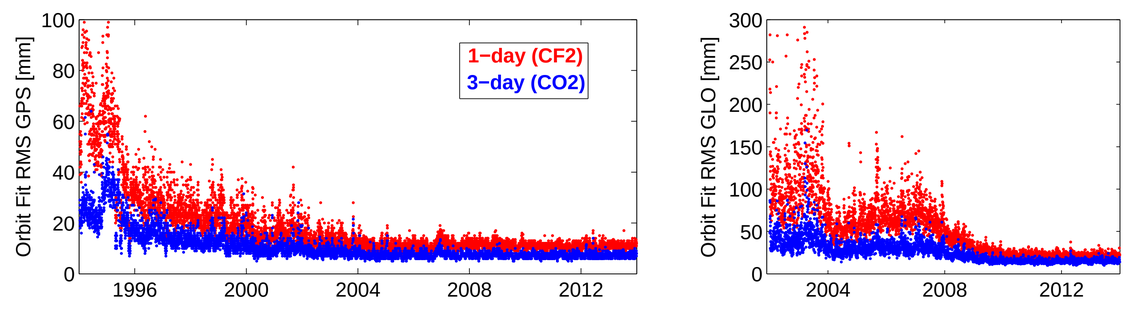

FIGURE 5: Median orbit fit RMS values of 1-day (CF2) and 3-day (CO2) solutions for GPS and GLONASS.

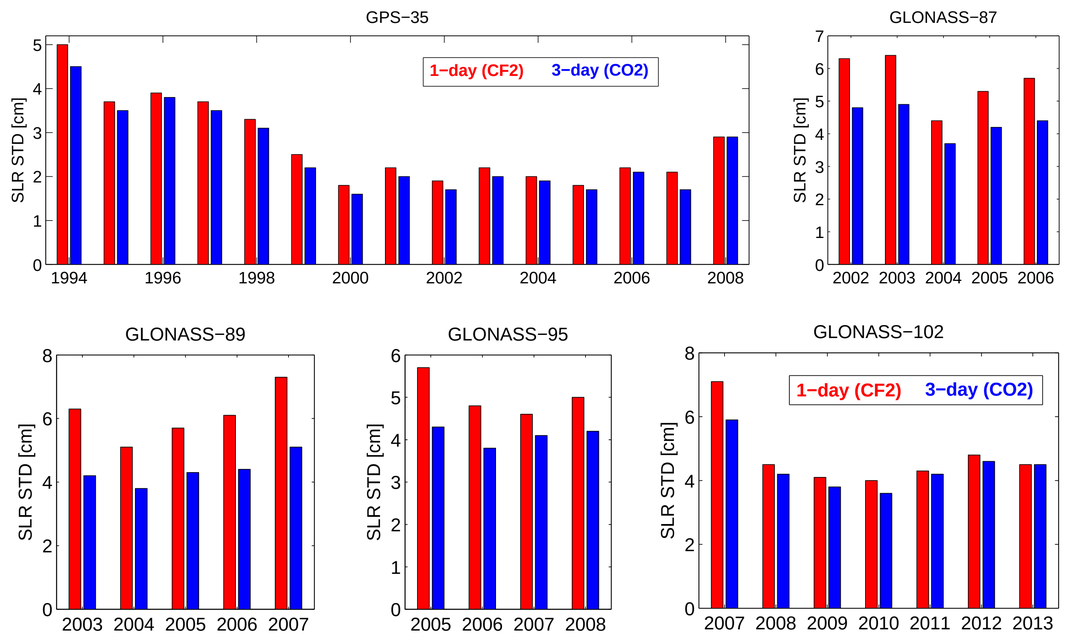

FIGURE 6: Standard deviations (STDs) of yearly batches of Satellite Laser Ranging (SLR) residuals for one GPS and four GLONASS satellites. SLR allows for an independent validation of the GNSS orbits determined from microwave observations. The GPS SLR STDs of the 3-day solution are in general 5 – 10 % smaller compared to the 1-day solution. GPS-35 data after 2009 has been excluded due to sparse transmissions. In the early years the GLONASS SLR STDs of the 1-day solution are larger by 30 – 50 % compared to the 3-day solution. For recent years, almost no differences between 1-day and 3-day solutions are visible.

Summary

- CODE contributes two full sets of global GPS/GLONASS solutions for IGS repro2:
  - clean 1-day solution CF2 (equivalent to operational COF series)
  - 3-day long-arc solution CO2 (equivalent to operational COD series)
- 3-day orbits provide an improved quality, in particular for sparse GPS and GLONASS tracking networks.
- This issue is also important for the emerging GNSS BeiDou and Galileo as the situation regarding stations tracking these GNSS is similar to the early years of GPS and GLONASS.
- The CODE IGS repro2 products are available at the global IGS data centers, e.g., at `ftp://cddis.gsfc.nasa.gov/gps/products/repro2`
- Additional Bernese-specific files are available at `ftp://ftp.unibe.ch/aiub/REPRO_2013`