Activities at the CODE Analysis Center

IGSWS2014-PS01
International GNSS Service
Workshop 2014
23 June - 27 June 2014, Pasadena, USA

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The CODE Consortium

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Highlights

Two consistent solution series, a **clean one-day (COF) and a three-day long-arc (COD)** solution, are generated in parallel.
Rigorously combined processing of GPS and GLONASS observations has been performed since mid of 2003 as an essential step towards multi-constellation analysis. Meanwhile the GPS-only tracking stations are in the minority in our network (see Fig. 1 and 2).
Continuous parameterization, particularly for Earth orientation parameters (EOP, Fig. 3), troposphere zenith path delays (ZPD) and horizontal gradients, as well as for ionosphere parameters (Fig. 4), allows the connection of the parameters at day boundaries.
Completion of GNSS orbit products with respect to all transmitting GPS and GLONASS satellites without exception. Reliable accuracy code information is provided.
Generation of uninterrupted orbit information for the satellites being repositioned (Fig. 5). Corresponding events are identified with a maneuver flag in the SP3c orbit files. An orbit initialization procedure is implemented for easy inclusion of brand new GNSS satellites, even if they do not provide broadcast navigation messages.
Automatic verification of IGb08 fiducial sites for consistent datum definition in the final, rapid, and ultra-rapid analysis chains.
Comprehensive CODE analysis summaries with extended orbit validation information and datum verification results.
Independent GNSS orbit validation on the basis of SLR data (see poster from Sosnica et al. in PS10).
GNSS ambiguity resolution: ambiguities are resolved for GPS **and GLONASS** observations with a self-calibrating procedure for handling of GLONASS-DPCB (differential phase-code biases).
Phase pre-processing for short(est) baselines: The test criteria for checking the geometry-free LC are a function of the baseline length. This ensures that the original L1 and L2 observations are clean for short(est) baselines (with less than 20km length).
Monitoring parameters are set up in the final solutions for internal use:

- *Satellite(-specific) antenna* offset and pattern.
- *GLONASS-GPS bias parameters* with respect to station coordinates and troposphere ZPD.
- *Scaling factors* for higher-order ionosphere (HOI) and non-tidal atmosphere pressure loading (APL) corrections.
- *Geocenter coordinates* (GCC).

Note: These parameters are contained in the daily NEQs that are archived. For efficiency reasons the monitoring parameters are removed from the NEQs before generating the final solution (see Fig. 6).
Differential code bias (DCB) retrieval for P1-C1, P1-P2, P2-C2 with different algorithms (e.g., direct and indirect P1-C1 retrieval, Fig. 7).
GLONASS frequency numbers are verified on a regular basis.
SINEX result files are generated in all processing lines: final, **rapid and even ultra-rapid**.
Fully automated GNSS data processing with the latest development version of the Bernese GNSS Software including BPE (Bernese Processing Engine). The processing is embedded in a system of Perl modules. This includes instant alerting in case of BPE processing and technical failures, general data flow problems, changes in the GNSS constellations.

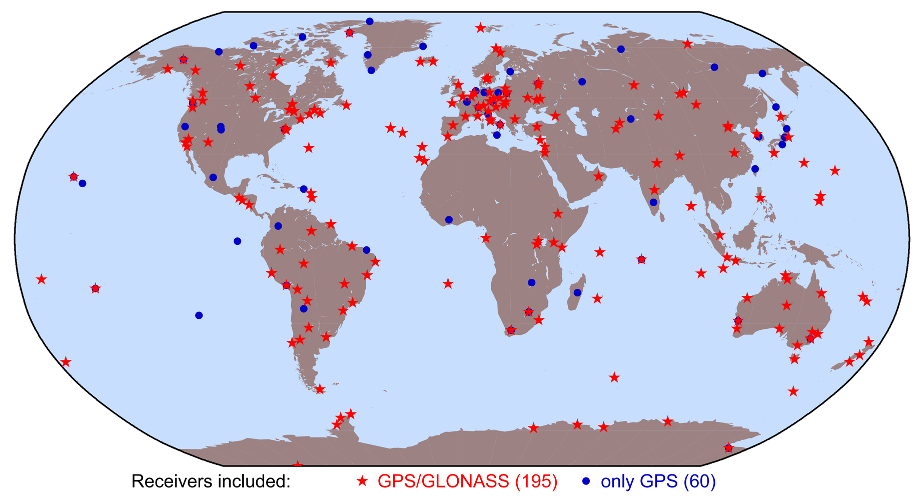

Fig. 1: Tracking network as considered in CODE's GNSS final analysis for GPS week 1795.

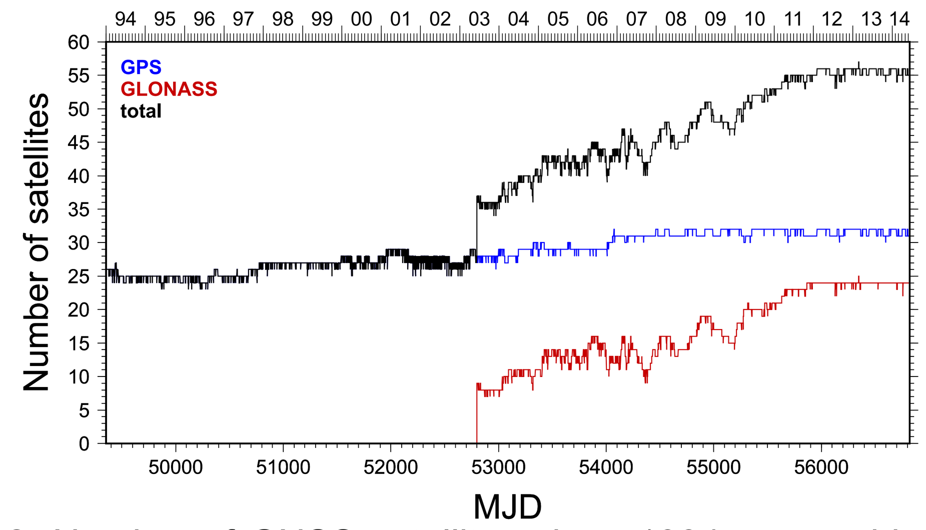

Fig. 2: Number of GNSS satellites since 1994 as considered in CODE's analysis. With a total of 56 operational GPS+GLONASS satellites, two full constellations were reached on February 2, 2012 (see IGS Mail #6538).

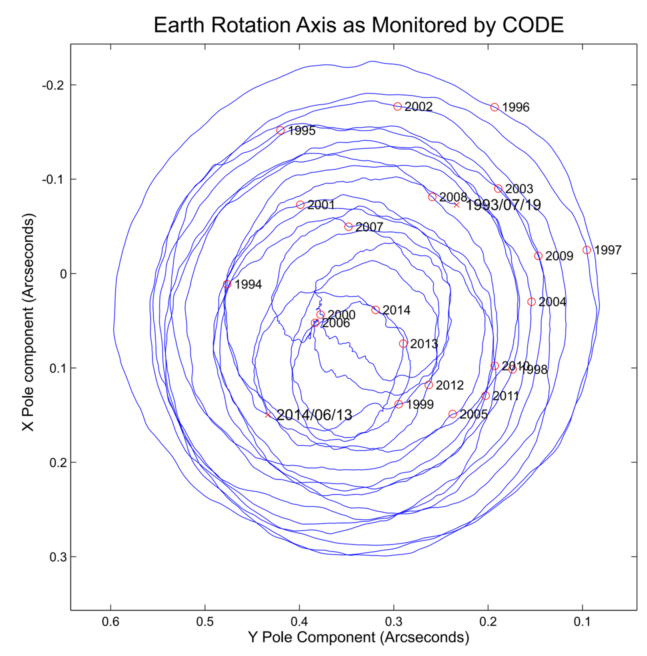

Fig. 3: Polar motion from 19-Jul-1993 to 10-Jun-2014 as monitored by CODE.

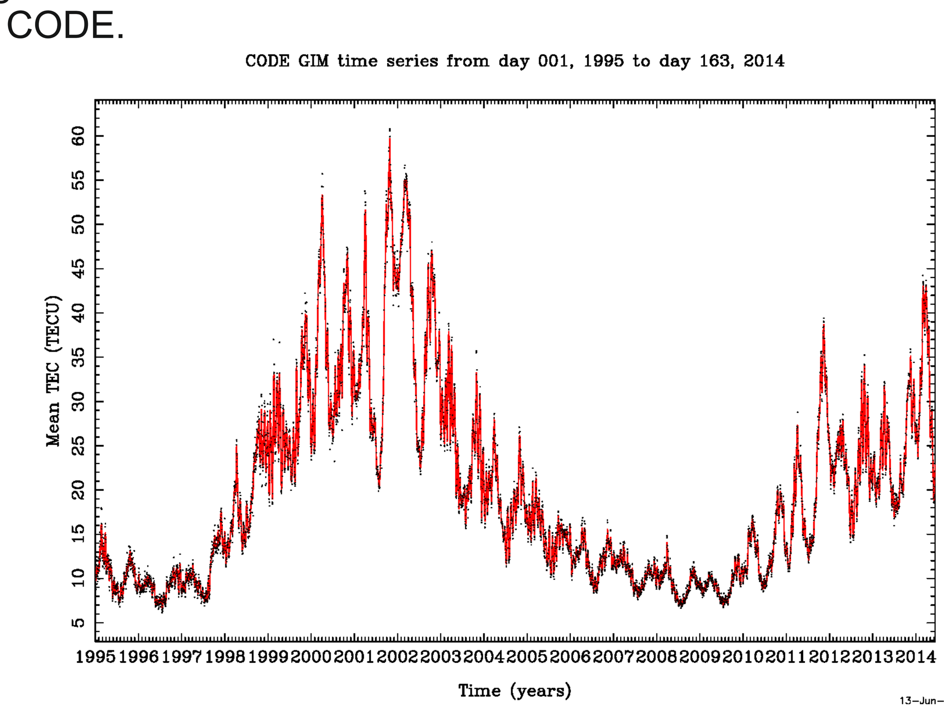

Fig. 4: Global mean TEC extracted from the Global Ionosphere Maps (GIMs) produced by CODE covering almost two solar cycles. The red curve shows the interpolated mean TEC based on a least-squares collocation. The daily averaged mean TEC values, namely the zero-degree coefficients of the spherical harmonic expansion used to represent the global TEC, are indicated by black dots.

Most important new developments and model changes

are reported in **poster contributions for this IGS workshop** (same session):

- Lutz et al.:
  Updating the CODE ultra-rapid procedure
- Steigenberger et al.:
  CODE Contribution to the 2nd IGS Reprocessing

See also: **IGS technical reports 2012 and 2013.**

RINEX issue in final clock procedure

In 2013, the IGS final clock combination revealed some recurrent problems with the contribution from CODE, resulting in a high number of exclusions in the IGS combination protocol. After some investigations, it appeared that the problem was due to unexpectedly different contents of the RINEX files for one and the same station and time interval from different sources: either downloaded directly as daily/hourly RINEX files with a sampling of 30 s or reconstructed from the 15-minutes RINEX files with the 1 Hz sampling based on real-time stream data. The latter ones are used at CODE to produce the 5 s clock product. The clock procedure was therefore adapted to guarantee that the 1 Hz data is only used to densify the clocks down to 5 s but not for generating the 30 s products.

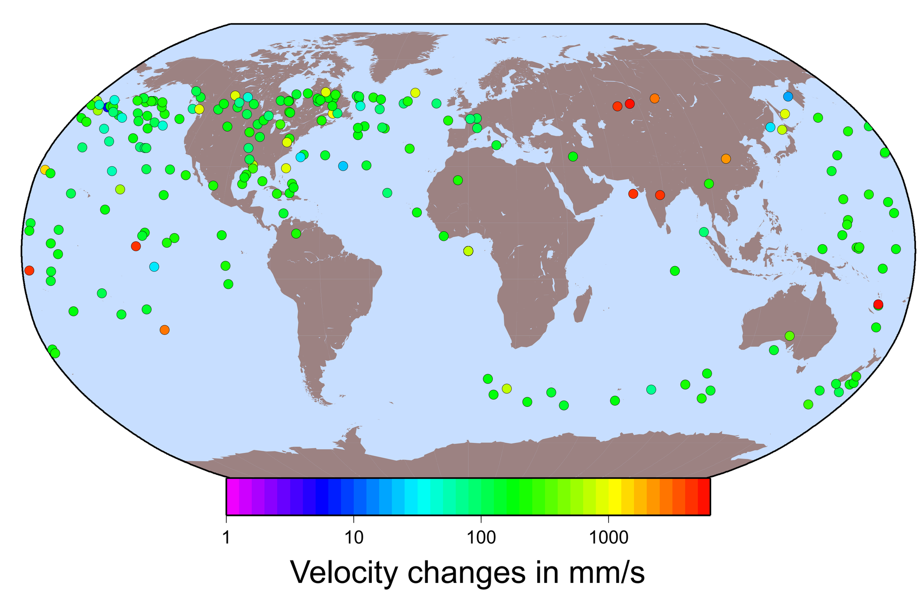

Fig. 5: Geographical locations (subprints) of all repositioning events of GPS satellites since 2004 as determined by CODE.

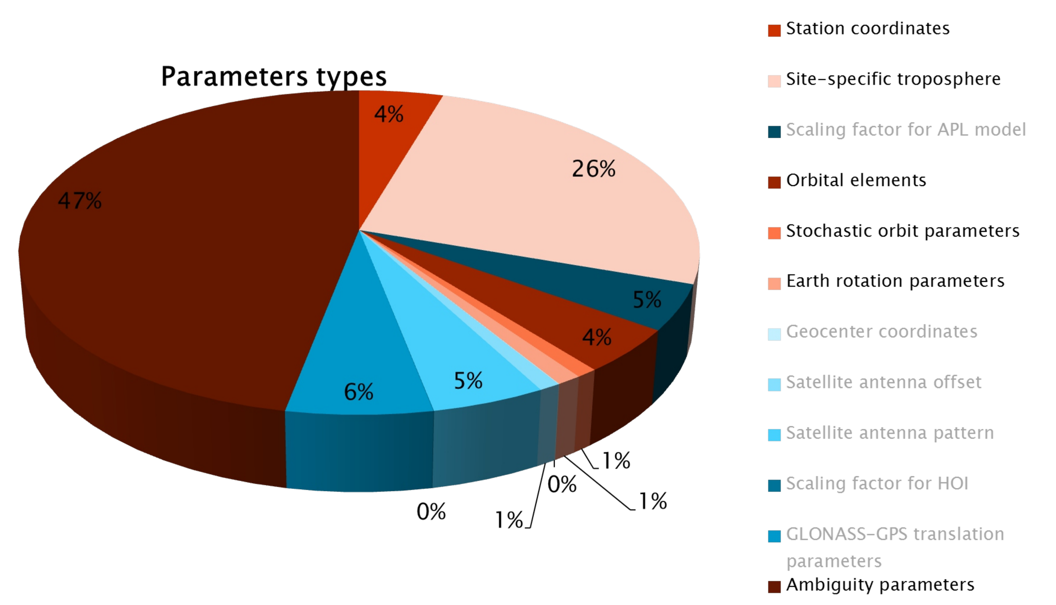

Fig. 6: Parameter types in the CODE final solution; the gray shaded parameters are so-called monitoring parameters that are removed from the NEQs before generating the final solution (in order to avoid potential numerical problems and to speed up the computation).

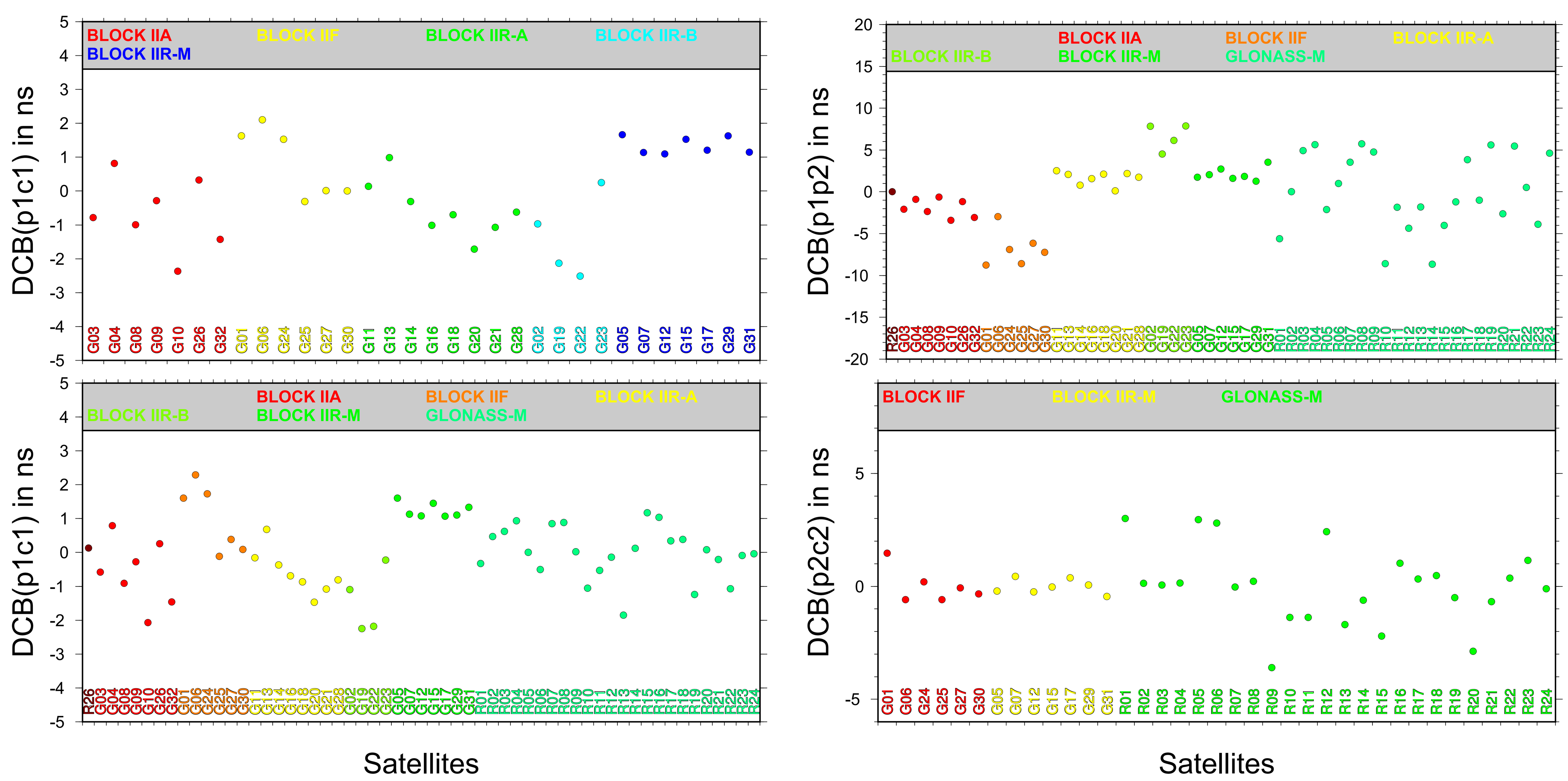

Fig. 7: Differential code biases (DCB) results as computed at CODE: GPS P1-C1 from indirect estimation (as provided to the IGS, top left), GNSS P1-C1 from the direct approach (bottom left), GNSS P2-C2 from direct approach (bottom right), and GNSS P1-P2 from the ionosphere analysis (top right).

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