Activities at the CODE Analysis Center

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The CODE consortium

Four institutions compose the CODE consortium: the Astronomical Institute of the University of Bern (AIUB), Switzerland; swisstopo: the Federal Office of Topography of Switzerland; the German Federal Agency for Cartography and Geodesy (BKG) and the Institut fuer Astronomische und Physikalische Geodaesie (IAPG), Munich, Germany.

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Highlights

Rigorously combined processing of GPS and GLONASS observations has been performed since mid of 2003 as an essential step towards multi-constellation analysis (see Fig. 1 and 2).
Two consistent solution series, a **clean one-day (COF)** and a **three-day long-arc (COD)** solution, are generated in parallel.
Regular contribution to IGS MGEX since 2012 with a five-system solution: GPS + GLONASS + Galileo + BeiDou + QZSS (see presentation of Prange et al. in plenary session #02).
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 of Maier et al. in session «Orbit Modelling and Space Vehicle Dynamics»).
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).
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).
- Plane-specific ERP and satellite-specific GCC (see presentation of Scaramuzza et al. in plenary session #06).

Note: These parameters are contained in the daily NEQs that are archived. For efficiency reasons the monitoring parameters are stacked or removed from the NEQs before generating the final solution (Fig. 6).
Differential code bias (DCB) retrieval for P1-C1, P1-P2, P2-C2 with different algorithms.
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 (Dach et al., 2015) including the 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.

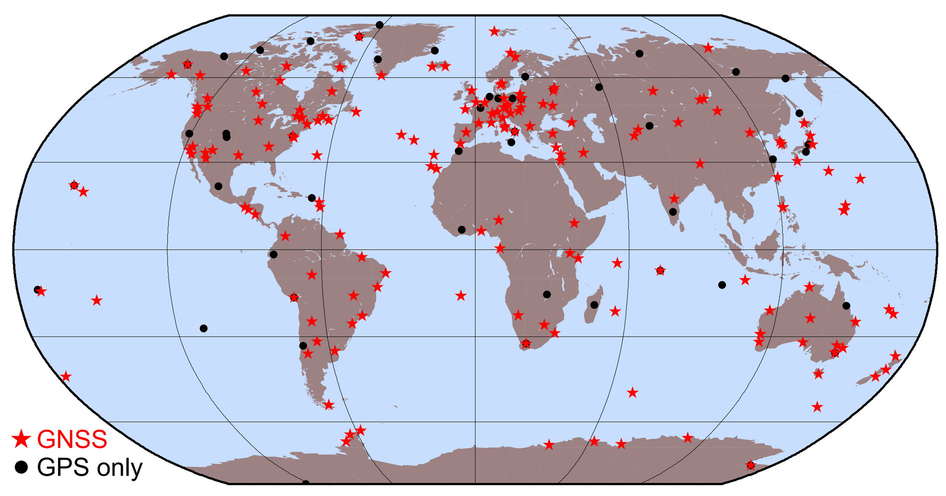

Fig. 1: Tracking network as considered in CODE's GNSS final analysis by end of 2015. About 80% of the sites support GLONASS.

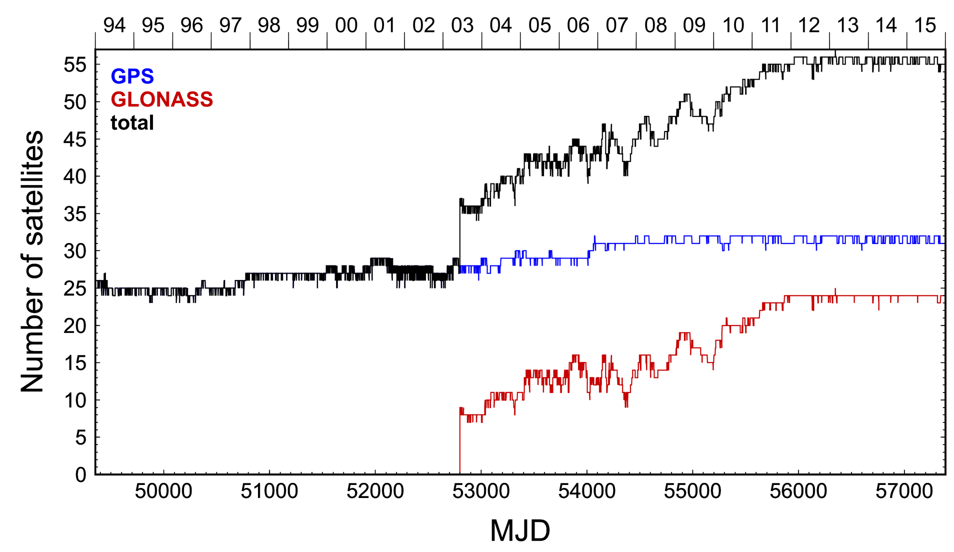

Fig. 2: Number of GNSS satellites since 1994 as considered in CODE's analysis. With a total of 56 operational GPS+GLONASS satellites, two full constellations were reached on February 2, 2012 (see IGS Mail #6538).

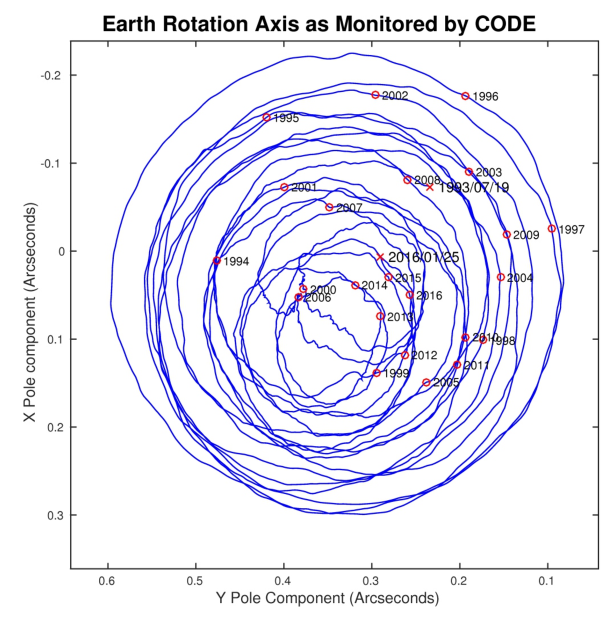

Fig. 3: Polar motion from 19-Jul-1993 to 25-Jan-2016 as monitored by CODE.

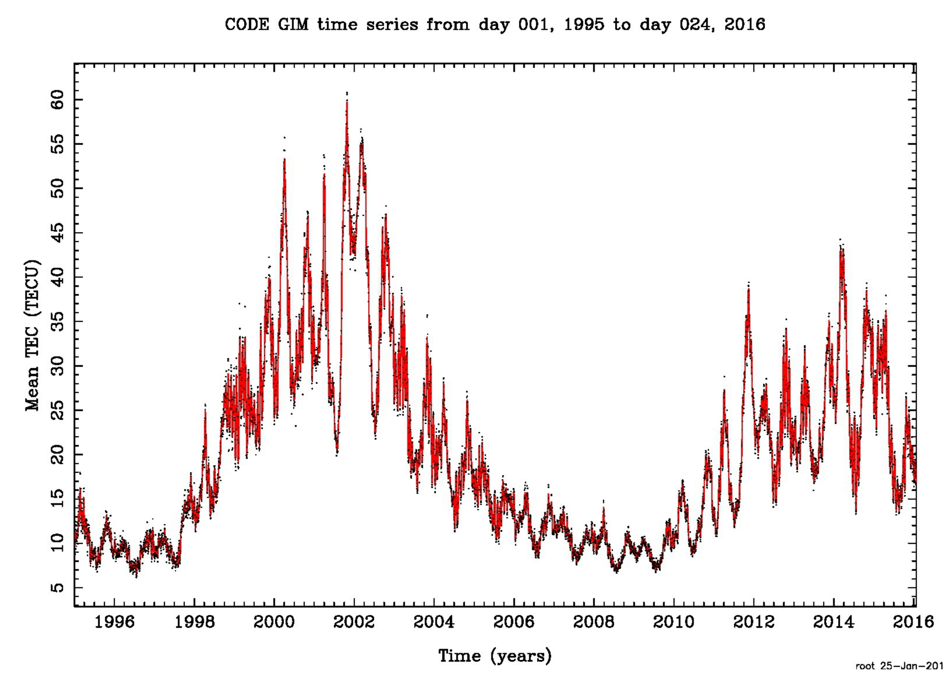

Fig. 4: Global mean TEC extracted from the Global Ionosphere Maps (GIMs) produced by CODE covering almost two solar cycles. The red curve shows the interpolated mean TEC based on a least-squares collocation. The daily averaged mean TEC values, namely the zero-degree coefficients of the spherical harmonic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

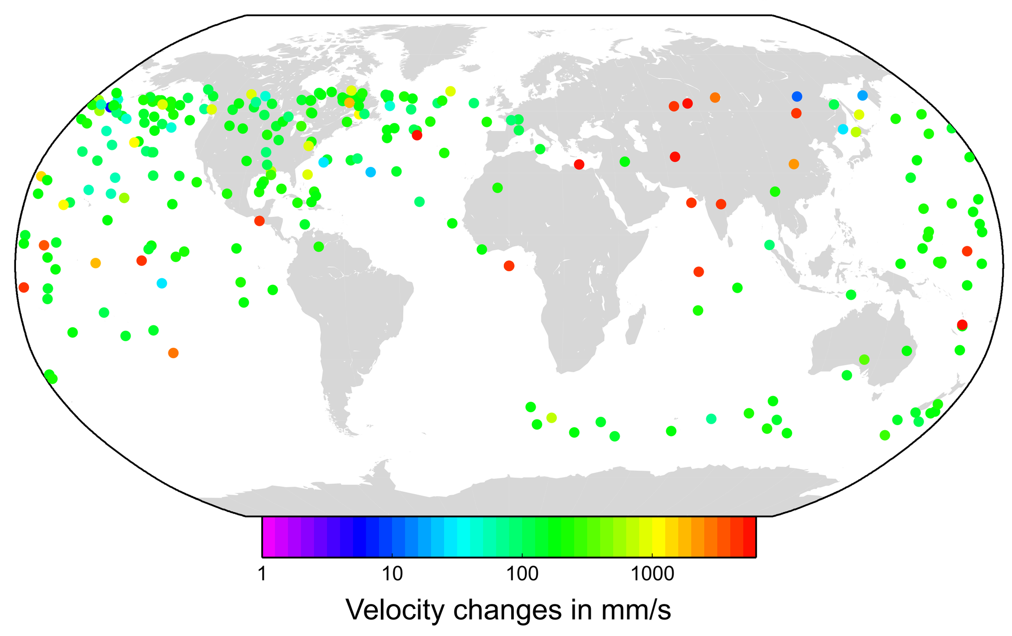

Fig. 5: Geographical locations of all repositioning events of GPS satellites since 2004 as determined by CODE.

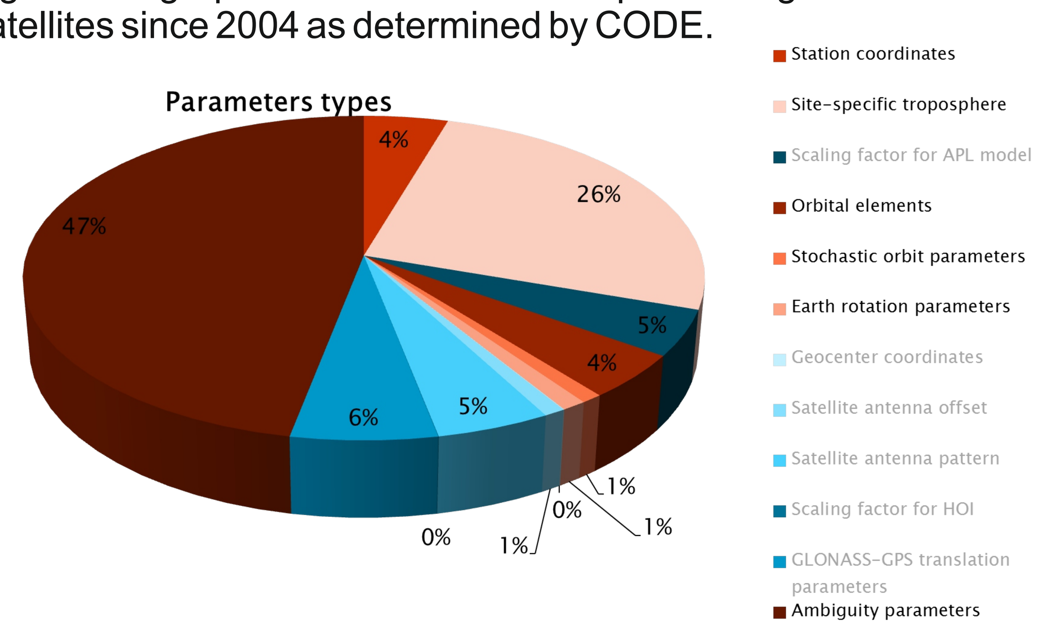

Fig. 6: Parameter types in the CODE final solution (about 24,000); the gray shaded parameters are so-called monitoring parameters that are removed from the NEQs before generating the final solution (in order to avoid potential numerical problems and to speed up the computation).

Most important new developments and model changes

- Major revision of the ultra-rapid (Lutz et al. 2014) and rapid products generation.

- Traditional «early» rapid solution (orbit extracted from the end of a long-arc solution) is now updated by the «final» rapid solution, extracted from the middle part of long-arc solution where the last day´s NEQ is taken from the ultra-rapid computation of 12:00 UTC (Fig. 7).

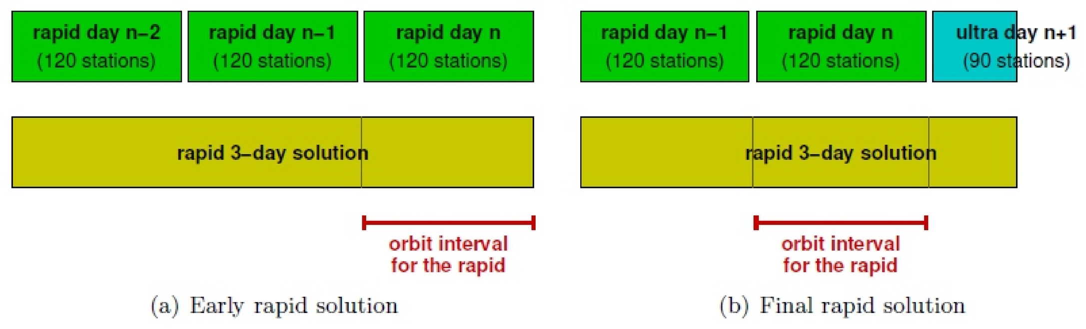

Fig. 7: «Early» versus «final» rapid solution generation schemes.

- Activation of the extended ECOM (Arnold et al., 2015) on GPS week 1826. Compared to the old ECOM, the extended one has an additional 2/rev term in the D-component, considerabling reducing shortcomings of the old ECOM for satellites with bodies of ellongated shape.

- CODE contribution to the MGEX is now regularly submitted on a weekly basis with a latency of 2 weeks and consists of a fully integrated solution from 5 GNSS: GPS, GLONASS, Galileo, BeiDou and QZSS.

- On GPS week 1851 the 4/rev term in D-component of the extended ECOM was disabled as it was degrading some of the GLONASS orbits.

- On day 202/2015, the data download procedure was upgraded to support RINEX3 files with long filenames. The following priority (in descending order) is respected in case several RINEX files are available for the same station:

1. RINEX3 file created by the receiver
2. RINEX3 file created from streamed data
3. RINEX3 file with unknown source or short filename
4. RINEX2 file

- On day 214/2015, a new multi-GNSS rapid clock procedure was activated to support GPS and GLONASS. It replaces the old GPS-only procedure and runs twice a day: a first time based on the «early» rapid orbit solution, and a second time based on the «final» rapid orbit solution.

More details on the CODE AC products, procedures and recent developments will be made available in the IGS technical report 2015.

Referencing CODE products

The products from CODE (ultra-rapid, rapid, final, MGEX and repro02 series) have recently been registered and became referable as:

Dach, R., Schaer, S., Arnold, D., Orliac, E., Prange, L., Sušnik, A., Villiger, A. and Jäggi, A. (2016). CODE ultra-rapid product series for the IGS. Published by Astronomical Institute, University of Bern.
URL: http://www.aiub.unibe.ch/download/CODE
DOI: 10.7892/boris.75676

Dach, R., Schaer, S., Arnold, D., Orliac, E., Prange, L., Sušnik, A., Villiger, A. and Jäggi, A. (2016). CODE rapid product series for the IGS. Published by Astronomical Institute, University of Bern.
URL: http://www.aiub.unibe.ch/download/CODE
DOI: 10.7892/boris.75854

Dach, R., Schaer, S., Arnold, D., Orliac, E., Prange, L., Sušnik, A., Villiger, A. and Jäggi, A. (2016). CODE final product series for the IGS. Published by Astronomical Institute, University of Bern.
URL: http://www.aiub.unibe.ch/download/CODE
DOI: 10.7892/boris.75876

Prange, L., Orliac, E., Dach, R., Schaer, S., Arnold, D. and Jäggi, A. (2016). CODE product series for the IGS MGEX project. Published by Astronomical Institute, University of Bern.
URL: http://www.aiub.unibe.ch/download/CODE_MGEX
DOI: 10.7892/boris.75882

Steigenberger, P., Lutz, S., Dach, R., Schaer, S., Jäggi, A. (2014). CODE repro2 product series for the IGS. Published by Astronomical Institute, University of Bern.
URL: http://www.aiub.unibe.ch/download/REPRO_2013
DOI: 10.7892/boris.75680

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