Updating the CODE ultra-rapid procedure

Introduction

The International GNSS Service (IGS) issues four sets of so-called ultra-rapid products per day, including satellite orbits and Earth Rotation Parameters (ERPs). The CODE ultra-rapid product is derived from observations for the current day. The first half is based on observational data up to 6, 12, 18, or 24 UTC of the current day for the corresponding set. The second half is a prediction for real-time applications. The IGS ultra-rapid product combines the contributions from individual IGS Analysis Centers. Last year, the submissions from the Center for Orbit Determination in Europe (CODE) were revised and updated. This poster highlights the transition from the old to the new CODE ultra-rapid product and the associated improvement in reliability and performance.

The old CODE ultra-rapid procedure

Until summer 2013, the CODE ultra-rapid product was based on the output of the last two CODE rapid analyses and a 3-day solution, in which the last day contained 6, 12, 18, or 24 hours of observations. The ERPs were modeled as piece-wise linear over one calendar day, for the predicted part they were derived from IERS Bulletin-A. The daily orbit positions emerging from the three solutions were fed into a parameter estimation program of the Bernese GNSS Software package (Dach et al. 2007) using an orbit parameterization especially designed for prediction.

The new CODE ultra-rapid procedure

The current CODE ultra-rapid product was developed in 2013 and has been submitted to the IGS since November 2013. Other than the old procedure, the new CODE ultra-rapid solution is based on the output of exactly one 3-day analysis, containing between 54 and 72 hours of observations. The parameterization of the ERPs was modified to avoid estimates relying only on short data sets. A priori ERP information for the prediction is no longer required.

Fig. 1: Origin of orbit positions in the old CODE ultra-rapid product (here a solution for t0=18UTC). Green: orbital positions originating from the most recent two complete CODE rapid 3-day solutions; Magenta: most recent long arc solution based on the two most recent daily rapid normal equations files (NEQs) and the NEO from the un-complete current day; Red: composed orbit arcs from parameter estimation processes (green and magenta) used as the basis to fit the long arc; Black: 72-hour orbit positions from the orbit positions from the most recent rapid and ultra-rapid solutions (red); start of predicted part is shown, as well.

The use of the estimated ERPs referring to the previous day for the following 24 hours led to unrealistic results for prediction. Therefore, the a priori ERPs from the most recent Bulletin-A were used in the CODE ultra-rapid for ERP prediction after some point in time.

Fig. 2: Estimated and a priori x-coordinate of the pole (de-trended) for a 6 UTC ultra-rapid solution. Blue: old CODE ultra-rapid; Magenta solid: Bulletin-A available at the time of generating the ultra-rapid; Magenta dash-dot: Bulletin-A available one day after generating the ultra-rapid; Green + signs: IGS ultra-rapid (igu) pole positions (estimated and predicted); Red: new CODE ultra-rapid for comparison (description in the middle section).

Note that the ERPs of the old CODE ultra-rapid product are continuous at the boundary of days 3 and 4, because the corresponding ERP values stem from the same 3-day solution (magenta line in Fig. 1). They are not continuous at the other two boundary times (in black).

Eventually, after 10-Jul-2013, the estimated and shifted a priori ERPs of the old procedure were made to coincide at the beginning of the last day, but the shifted a priori ERPs were used only after the end of the last day. This measure slightly improved the CODE ultra-rapid orbit predictions. The impact of the change is barely visible in the x- and y-rotations of the CODE orbit estimates w.r.t. the IGS ultra-rapid product, whereas a clear improvement is visible in the rotations about the z-axis (see Fig. 6).

Comparison with the IGS product

Until summer 2013, the CODE ultra-rapid product was based on the output of the last two CODE rapid analyses and a 3-day solution, in which the last day contained 6, 12, 18, or 24 hours of observations. The ERPs were modeled as piece-wise linear over one calendar day, for the predicted part they were derived from IERS Bulletin-A. The daily orbit positions emerging from the three solutions were fed into a parameter estimation program of the Bernese GNSS Software package (Dach et al. 2007) using an orbit parameterization especially designed for prediction.

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• The observed part of the new ultra-rapid product does not refer to three different 3-day solutions, but to exactly one, where three NEQs of three consecutive days (two complete and the current one) are used.
• Weekly determined orbit and ERP parameters referring to the last 24 hours of the observed part of the ultra-rapid products are avoided.
• The ERPs in the predicted part of the ultra-rapid product are defined by the two ERP parameters referring to the last 24 hours covered by observations.

The CODE orbit model allows estimating the following parameters for each orbital arc:
• Set of six osculating orbital elements
• At maximum nine empirical orbit parameters (three constant accelerations in three orthogonal directions, three once-per-rev. accelerations in the same directions) of the Empirical CODE Orbit Model (ECOM, Beutler et al. 1994)
• Pseudo-stochastic pulses in radial direction R, in along-track direction S, and in out-of-plane direction W at 12 hours intervals (noon and midnight of each calendar day)

Conclusions

• A fully consistent multi-day solution for orbits and ERPs is the basis for a successful orbit prediction over a period of 24 or more hours, e.g. for BLR predictions.
• The orbit parameterization is different for parameter estimation and for orbit prediction. Stronger pulses (introduced to absorb potential deficiencies of the dynamic orbit model) should be avoided for orbit prediction.
• As the deadlines of the IGS ultra-rapid products are not synchronized with the update schedule of Bulletin-A, a simple linear extrapolation of the ERPs is more appropriate for a one to few days prediction. For longer intervals, the sophisticated background models of Bulletin-A may be preferable for ERP prediction.

References


Contact address

1 Astronomical Institute, University of Bern, Bern, Switzerland
2 Federal Office of Topography swisstopo, Wabern, Switzerland

Poster compiled by: S. Lutz, June 2014
Astronomical Institute of the University of Bern
Simon.Lutz@aiub.unibe.ch
Sidlerstrasse 5
3012 Bern (Switzerland)
Simon.Lutz@aiub.unibe.ch