In the framework of the Multi-GNSS Experiment (MGEX) a number of Analysis Centers (ACs) extended their software capabilities to process signals from the BeiDou, Galileo, and GLONASS systems in addition to the well established systems GPS and GLONASS. Combined orbits and clocks, from GPS and GLONASS represent core products of the IGS. The presence of the newly developing GNSS and the fact that a number of individual MGEX-AC products are already available asks also for associated combined MGEX products. This poster provides preliminary results from a multi-GNSS orbit and clock combination.

Abstract

In the framework of the Multi-GNSS Experiment (MGEX) a number of Analysis Centers (ACs) extended their software capabilities to process signals from the BeiDou, Galileo, and GLONASS systems in addition to the well established systems GPS and GLONASS. Combined orbits and clocks, from GPS and GLONASS represent core products of the IGS. The presence of the newly developing GNSS and the fact that a number of individual MGEX-AC products are already available asks also for associated combined MGEX products. This poster provides preliminary results from a multi-GNSS orbit and clock combination.

Orbit and Clock Combination Procedure

A generalized workflow for the multi-GNSS orbit combination is illustrated in Fig. 2 (left). The detailed procedure is adapted from that applied within the IGS. The AC-individual orbit frames are aligned w.r.t. each other using the GPS constellation only. The finally combined solution is a weighted average for all GNSS included. Fig. 4 shows selected transformation parameters resulting from the orbit frame alignment. Fig. 4 (top) shows the agreement with the combined MGEX solution for GPS satellites in terms of the weighted RMS of orbit differences. The workflow for the multi-GNSS clock combination is illustrated in Fig. 2 (right). It basically follows the IGS strategy including additional steps to cope with different inter-system bias setups among the ACs. In particular, additional clock offsets and linear drifts are estimated for all non-GPS satellite clocks w.r.t. a selected reference AC. Generally, all satellite and receiver clock parameters are assumed to refer to GPS time scale. For GPS satellites, Fig. 4 (bottom) shows the agreement between the combined MGEX and the Final IGS solution in terms of the standard deviation of clock differences. The qdf solution was excluded from the combination due to generally large deviations and kept for comparisons only. Likewise, the bpm solution was excluded due to the absence of the GPS part. Final IGS GPS orbits are included with zero weight for comparison purposes. The table below provides an overview of the AC in/exclusion from the combination.

GLONASS, Galileo, BeiDou and QZSS Combination Results

Orbit and clock comparison results of individual AC solutions w.r.t. the MGEX-combined solution are shown in Fig. 5 for GLONASS, Fig. 6 for Galileo, Fig. 7 for QZSS, and Fig. 8 for BeiDou. WRMS values derived from orbit differences (each subfigure) are also shown for satellites which have been excluded from the combination. Combined satellite clocks are available only if at least two submissions are present. General remarks:

• Comparison for comb shows systematic orbit differences for GLONASS constellation w.r.t. average of remaining ACs.
• Satellite attitude modelling issues visible for QZSS and BeiDou, e.g. switch from yaw-steering to orbit normal mode (1).
• Solution shows generally larger discrepancy for Galileo satellites probably due to the missing orbit alignment.
• Largest orbit differences are identified for BeiDou L1/L2/G1 (C01...C05) satellites (only two ACs!)

Outlook

• Fix remaining format issues for MGEX product files.
• Make use of operational AC submissions for cross-check analysis.
• Incorporate IGS Final GLONASS product (IGV) into comparison.
• Unification of inter-system bias (ISB) level for Galileo and BeiDou required, if multiple reference ACs have been selected for same GNSS.
• Elaborate possible unified processing standards in order to minimize/eliminate systematic AC-specific differences for non-GPS parameters.
• Encourage ACs to provide full set of products files, i.e. to complete product portfolio.