1. Introduction

The network configuration affects the quality of the products delivered from the global GNSS processing. Nowadays, international GNSS service (IGS) has the well-developed and a global coverage network of multi-GNSS receivers. However, most of the operational solutions performed by IGS Analysis Centers are based on the network, also serving other purposes instead resulting in an inhomogeneous density of stations. The purpose of this study is to analyze the difference between GNSS products, such as orbits and geodetic parameters delivered in the double-difference multi-GNSS processing, which may arise from different sets of global GNSS networks. Moreover, different approaches to the definition of datum have been tested. We checked how the estimation of the geocenter coordinates with a simultaneous No-Net-Translation condition affects the network configuration.

2. Network and processing

We have prepared two solutions with different configurations of global multi-GNSS stations: (1) SOLA stations, homogeneously distributed – SOL (2) 206 stations with representative geographical distribution (Asia-Pacific Region – SOL2 (see Fig. 1,2), All stations from SOL2 are also considered in SOL, thus are denoted as “common stations.” All the selected stations track GP, GLONASS, and Galileo that are used in the processing. The analysis considered the whole period (2017), using 36, 48 and 56 epochs. We examined the RMS consistent with the current processing scheme used in the Center for Orbit Determination in Europe (CODE) IGS14 operational solutions. In the prepared solutions following the stations are set up and estimated: station coordinates, troposphere parameters, geocenter coordinates. Earth rotation parameters, orbit parameters. On average, 70 satellites were available.

3. Datum definition

Datum definition has been realized using minimum constraints based on Helmert parameters imposed on the network. Only common stations which participated in the realization of IGS14 were used for the datum definition, whereas the coordinates of remaining stations were freely estimated in the solutions without any constraints. A No-Net-Translation condition was applied. Solution A is similar to standard IGS processing routine, with geocenter coordinates fixed to the origin of IGS14. In Solution B, geocenter coordinates and No-Net-Translation condition was imposed on the network.

4. Station coordinates

We have prepared two solutions with different configurations of global multi-GNSS stations: (1) SOLA stations, homogeneously distributed – SOL (2) 206 stations with representative geographical distribution (Asia-Pacific Region – SOL2 (see Fig. 1,2). All stations from SOL2 are also considered in SOL, thus are denoted as “common stations.” All the selected stations track GP, GLONASS, and Galileo that are used in the processing. The analysis considered the whole period (2017), using 36, 48 and 56 epochs. We examined the RMS consistent with the current processing scheme used in the Center for Orbit Determination in Europe (CODE) IGS14 operational solutions. In the prepared solutions following the stations are set up and estimated: station coordinates, troposphere parameters, geocenter coordinates. Earth rotation parameters, orbit parameters. On average, 70 satellites were available.

5. Geocenter coordinates

Figure 9 shows the geocenter coordinates delivered in SOL2 and SOL3 compared to the 7-day SLR solution based on Lagoons-1/2 satellites. The formal errors of each coordinate for SOL2 is about 10% lesser compared to SOL1. The main signal is consistent between IGS14 and SLR at the level of a few cm, especially for the X coordinate. In case of the Y coordinate, the time series derived from SOL1 is shifted in reference to SOL2, although SOL2 is more consistent with SLR solution. The enhanced consistency between SOL2 and SLR may indicate a consequence of uneven distribution of the stations. Similarly to SLR in SOL2 we have more observations from Europe and Asia which can improve the solution. The dominant signal is about 10 cm above the noise level in the spectrum may be caused by (1) modeling of GNSS-orns and correlation between 2 coordinate of the geocenter and IGS14, SOL2 and SLR, (2) major depression of the CODE (as noted by [11,12]), (3) a strong dependency of the geocenter 2-coordinate on the X-Y angle and mutual geometry of orbital planes (as noted by [3]).

6. Summary and discussion

Using only homogeneously distributed set of stations we can achieve the quality of station and geocenter coordinates at the comparable level as with the subset of stations that include more dense distribution in some regions of the globe. Imposing a No-Net-Translation condition on the network and estimation of the geocenter coordinates as the unconstrained parameters are beneficial for estimation of stations coordinates when estimated together with GNSS satellite orbits. It both stabilizes the coordinate reproducibility and improves the consistency between estimated coordinates and IGS14 coordinates. The impact of such a parametrisation should be further investigated, especially in the context of other global geodetic parameters and orbits. There is not yet a proper answer to the question “How the geocenter should be handled in global GNSS processing?” That analysis partially proves that the geocenter has to be correctly considered. The one idea is to estimate it just like other parameters. However, there are some clear limits e.g. the 2 coordinates are correlated to widely different parameters (see Fig. 9). Therefore, it could be also beneficial for the solution to introduce an external geocenter parameter (e.g. geophysical model or SLR product) to the processing and make the datum with a No-Net-Translation condition. However, we cannot treat SLR-based geocenter as flawless. We see the instability of formal errors and possibility of “network effect” in SOL2/SLR geocentre.