Estimating the Geocenter from GNSS Observations

Simulation scenario

The geometry from the CODE contribution to the IGS final solution has been assumed as true. A network of 90 globally distributed stations was assumed (see Figure 2).

Figure 2: Network of stations where GPS and GLONASS measurements have been simulated based on the geometry given by CODE orbit and coordinate solutions for every 10th day in the year 2013.

Measurements without noise have been simulated with the consequence that:
• phase measurements can serve for a solution where the ambiguities are freely estimated with real values.
• code measurements may be used for a solution where all ambiguities are fixed to their correct integer values.
• full ionosphere and troposphere parameters are available.

Reference solutions:

Figure 3: When analysing the simulated observations, all residues become zero if the solution is consistently generated (left panel). If the coordinates are shifted by 10 cm towards the Z component the resulting effect can be compensated by related parameters as long as they are available in the parameter estimation setup (first three lines in the right panel). Otherwise, if the ambiguity is distributed to all other parameters to be estimated (primary station coordinates, satellite orbits and clocks, see Section on Error Propagation) according to the principle of the least squares adjustment.

Inspecting the Covariance Matrix

To investigate the potential correlations between parameters of interest Figure 4 shows the posteriori covariance matrix obtained from solutions based on the simulated code observations.

Figure 4: Datum: NNR+NNT, GCC: estimated (left) and fixed (right).

Error Propagation

If the instantaneous center of mass is forced to the origin of the reference frame (Datum: NNR+NNT; GCC: fixed) there is a discrepancy with respect to a “relaxed” solution (Datum: NNR+NNT; GCC: estimated).

Conclusions

The expected correlations between satellite clock and orbit parameters are clearly visible.
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• The simulated shift of 10 cm towards the Z component from Figure 4a (note the correlation with the troposphere parameters, indicated with the red rectangle)

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Conclusions from the covariance matrices in Figures 4+5:
• The expected correlations between satellite clock and orbit parameters are clearly visible.
• The NT is essential for the datum definition, independent whether the geocenter is estimated or fixed. In particular the station coordinates become singular.
• There are high correlations between GCC parameters and satellite clock parameters. They are, on the other hand, in the same order of magnitude like the correlations between station height and troposphere, compare Figures 5a+b.

Figure 5a: Extract for the GCC parameters from the covariance matrix displayed in Figure 4a.

Figure 5b: Extract for the station coordinates (ZM2) from the covariance matrix from Figure 4a (note the correlation with the troposphere parameters, indicated with the red rectangle).

Closing Remark

• The simulated shift of 10 cm towards the Z component is about ten times larger the expected geocenter variation. It was used to increase the resolution of the numbers in the file formats.
• It is confirmed by the results from the CODE reprocesing results that the geocenter estimates for the X and Y components give reasonable values (confirmed by SLR measurements) whereas the Z component contains artifacts from the earth model (in particular for GLONASS).