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(In)sensitivity of GNSS techniques to geocenter motion

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As a satellite-based technique, GNSS should be sensitive to motions of the Earth's center of mass (CM) with respect to the Earth's crust. In theory, the weekly solutions of the IGS Analysis Centers (ACs) should indeed have the "instantaneous" CM as their origin, and the net translations between the weekly AC frames and a secular frame such as ITRF2008 should thus approximate the non-linear motion of CM with respect to the Earth's center of figure. However, the comparison of the AC translation time series with each other, with SLR geocenter estimates or with geophysical models reveals that this way of observing geocenter motion with GNSS currently gives unreliable results.

The fact that the origin of the weekly AC solutions shoud be CM stems from the satellite equations of motion, in which no degree-1 Stokes coefficients are included. It is therefore reasonable to think that any mis-modeling or uncertainty about the forces acting on GNSS satellites can potentially offset the network origin from CM. That is why defects in radiation pressure modeling have long been assumed to be the main origin of the GNSS geocenter errors. In particular, Meindl et al. (2012) incriminate the correlation between the Z component of the origin and the direct radiation pressure parameters D0.

We review here the sensitivity of GNSS techniques to geocenter motion from a different perspective. Our approach consists in determining the signature of a geocenter error on GNSS observations, and seeing how and how well such an error can be compensated by all other usual GNSS parameters. (In other words, we look for the linear combinations of parameters which have the maximal partial correlations with each of the 3 components of the origin, and evaluate these maximal partial correlations.)

Without setting up any empirical radiation pressure parameter, we obtain maximal partial correlations of 99.98 % for all 3 components of the origin: a geocenter error can almost perfectly be absorbed by the other GNSS parameters. Satellite clock offsets, if estimated epoch-wise, especially devastate the sensitivity of GNSS to geocenter motion. The numerous station-related parameters (station positions, station clock offsets, ZWDs and horizontal tropospheric gradients) do the rest of the job.

The maximal partial correlations increase a bit more when the classic "ECOM" set of 5 radiation pressure parameters is set up for each satellite. But this increase is almost fully attributable to the once-per-revolution parameters BC & BS. In particular, we do not find the direct radiation pressure parameters D0 to play a predominant role in the GNSS geocenter determination problem.