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Coping with "real" versus "apparent" geocenter motions

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The origin of a global coordinate frame realized from a short duration (typically one day or one week) of satellite-tracking data will generally appear displaced from the origin of a long-term integrated frame. If measured with respect to the secular origin of the International Terrestrial Reference Frame (ITRF), which has been aligned to Earth's center of mass using satellite laser ranging (SLR) data, then the time-varying displacements are known as "apparent geocenter motions". Small displacements of this type are expected geophysically due to the mass movement of planetary fluids (atmosphere, oceans, surface hydrology, ice mass, etc) relative to the solid Earth crust.

There has recently been considerable discussion about how best to deal with geocenter motions. Traditionally, a Helmert transformation has been used to compute the translations between a time series of near-instantaneous frames and the ITRF origin; the observed translations are usually called geocenter motions. In practice, this approach can be weak if the network of comparison sites is not globally well distributed (nearly uniform). Alternatively, under the assumption that frame displacements are dominantly related to global fluid movements, D. Lavallee et al. have argued for a more general treatment that simultaneously considers the accompanying crustal surface deformations. Their method does indeed appear more robust in detecting genuine geocenter motions, that is, those related to redistribution of surface fluids (assuming mass movements inside the Earth are not important).

On the other hand, for GPS the geocenter can be considered as much an "orbital parameter" as a geophysical effect [U. Hugentobler, 2005]. There are strong correlations between distortions of the terrestrial and celestial frames with empirical GPS orbit parameterizations. Different analysis groups, using different methods, yield very different estimates for apparent geocenter motions. Technique-related effects probably dominate also for DORIS, but are evidently less significant for SLR.

With regard to "stacking" multi-analysis and multi-technique results to form combinations, such as ITRF, we argue that the traditional Helmert approach is superior to Lavallee's generalization because it is important to remove all sources of apparent geocenter motion, as much as possible, not just the geophysical causes. For robust results, the Helmert reference network should be as dense and uniformly distributed as possible. Similarly, when intercomparing residual height time series (whether geodetic or geophysical), the respective whole-frame apparent geocenter motions should also be removed by Helmert translations prior to comparison. Only in the case where one wishes to isolate and study the purely geophysical loading component of apparent geocenter motions is the Lavallee method more appropriate.