Systematic errors in GPS position estimates

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Nearly all GPS sites display height variations with significant non-random power. Annual periods are most prominent, but other harmonics are also seen. (Annual signals are common in horizontal components, as well.) Sources of non-random temporal variations can be considered of two classes: external, unmodeled geophysical effects that influence individual site motions (after accounting for known and tidal variations in the data analysis); and internal, unrecognized errors related to the GPS technique. There is mounting interest in using the observed non-linear GPS motions, either for individual stations or for networks, to better characterize certain geophysical processes, especially transport of fluid mass loads within the Earth system. Doing so reliably, however, requires that the technique errors be reasonably well understood and not too large.

The weekly global coordinate frames from the International GNSS Service (IGS) can be used to assess the significance of technique errors relative to geophysical effects. Many IGS sites show height variations that correlate closely with the data-quality metrics generated by the TEQC utility. The MP1 and MP2 measures of pseudorange multipath variability, for instance, often track the annual variations of heights. Abrupt changes in both height and TEQC metric variations are sometimes found to correlate with changes in station tracking hardware.

Rather than suggest that the TEQC metrics directly cause correlated position variations, or vice versa, it seems more likely that a common instrumental response may arise due to some underlying seasonal forcing. While there is a wide range of possible driving mechanisms, including mismodelings in the data analysis, an under-appreciated possibility is near-field multipath that could introduce slowly varying biases into the GPS position estimates. This hypothesis is strongly supported by the observed correlation of RMS dU variations with RMS clock jumps at day boundaries (for those IGS reference frame stations equipped with H-masers). The latter is a sensitive measure of local long-wavelength (i.e., near-field) pseudorange multipath conditions and is highly variable across the IGS network. The correlation with height variability indicates that near-field phase multipath (which is otherwise undetectable because it is well absorbed into the geodetic parameters) is probably widespread at IGS sites. This, in turn, points to basic problems in the design and installation of antenna mounts at most sites, which may give rise to artifactual signals that overwhelm large-scale geophysical loading signals. Any prospects for improved detectability in the future will require major infrastructure upgrades in the IGS reference frame network.