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Status of IGS Orbit Modeling and Areas for Improvement

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While the overall mean inaccuracy of the recent Final orbits of the International GNSS Service (IGS) is estimated to be about 2 cm (1D RMS), three aspects of the orbit modeling can probably be significantly improved: 1) ensure consistent and accurate modeling of satellite attitude variations; 2) mitigate spurious rotations of the constellations; and 3) add accelerations due to Earth radiation pressure. The errors associated with these are all highly systematic, not random.

Reliable models for the attitude control of the older GPS satellites have been published for some years. Recently new models have been developed for GLONASS and the newest generation of GPS satellites as well. However, the implementation of these models among IGS Analysis Centers (ACs) is not consistent. Partly this is probably because the GPS Block IIR spacecraft were designed in such a way that attitude effects were nearly benign, so the major analysis errors were for the older, dwindling generations. However, with newer constellations and GPS Blocks the attitude variations probably cannot be treated so simply for high-accuracy results. The impact on user products is mostly on satellite clock variations and therefore on precise point positioning (PPP) results. So it is vital to ensure overall consistency by the IGS ACs adopting common models to generate combined products and by users implementing the same models in their PPP solutions.

A leading error in the current IGS orbits is spurious net rotations of the constellation. It was learned in the early years of the IGS that once-per-revolution empirical parameters (or similar) were needed to model subdaily effects of solar radiation pressure. Failing to do so caused mainly large translational offsets in the Y component of the GPS orbit origin. But even with the higher-order parameterizations, much smaller rotational errors remain. The spectral features of these seem strongest near odd multiples of the GPS draconitic frequency (1.04 cycles per year) and probably also near fortnightly periods. Deficiencies in the widespread once-per-rev empirical modeling are likely to be responsible for these rotational errors.

Most IGS ACs neglect the satellite accelerations due to reflected and thermally emitted radiation from the Earth as well as recoil thrust from the GNSS transmitters, largely because an accepted model for GNSS spacecraft is not yet available. Studies indicate that including at least the Earth albedo effect could remove most of the observed 2 cm bias between IGS orbits and satellite laser ranging. So developing an acceptable model and implementing it should be a high near-term priority for the IGS.