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Draconitic, tidal, and orbital aliasing signals in multi-GNSS solutions

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Abstract. The time series of geodetic parameters based on Global Navigation Satellite Systems (GNSS) are contaminated by various systematic errors emerging from: errors in the background tidal models, resonances between the revolution period of GNSS constellations and the Earth rotation, as well as orbit modeling errors, especially those related to the direct solar radiation pressure. We derive Earth rotation parameters with daily and sub-daily resolutions and station coordinates from network solutions and Precise Point Positioning (PPP) based on GPS-only, GLONASS-only, Galileo-only, as well as multi-GNSS data. We identify systematic errors in the station and pole coordinates and length-of-day time series with the distinction between orbital artifacts due to satellite revolution periods, tidal-related errors, aliasing between Earth rotation and tides, as well as orbit modeling errors with the occurrence of the draconitic year and its harmonics.

Most of the systematic errors in GNSS time series are different for GPS, GLONASS, and Galileo constellations due to different revolution periods of satellites, and thus, can be mitigated by generating a multi-GNSS combination. However, some effects, such as the aliasing of the errors in tidal models in daily solutions detected in the length-of-day series, are common for all GNSS constellations and cannot be handled by combining various GNSS systems. The lengths of the draconitic years are similar for GPS, GLONASS, and Galileo, however, their harmonics reveal different amplitudes because of different numbers of orbital planes for each constellation: 6, 3, and 3 (+1 eccentric), respectively. We found that the dominating errors in Galileo solutions repeat every 14.08 h, 34.20 h, 2.49 d, and ~3.4 d, whereas the corresponding periods for GLONASS are 5.63 h, 10.64 h, 21.26 h, 3.99 d, and ~8 d due to the resonances between Earth rotation and satellite revolution periods. GLONASS introduces large-scale noise into the sub-daily Earth rotation parameters and PPP solutions due to orbit modeling issues. For GPS, there are very strong orbital resonances at the periods close to a sidereal day, which are close to major tidal constituents, such as K1. Therefore, GPS does not allow for a separation of the tidal errors from orbit-related artifacts, whereas Galileo can successfully be employed for such a separation. Moreover, the accumulated length-of-day values based on GPS show a large secular drift, which is up to fourteen times smaller in Galileo-based solutions. Despite that Galileo has not reached yet the full operational capability, it can successfully be employed for the recovery of fundamental geodetic parameters.