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Combination of kinematic orbit and analytical perturbation theory for the determination of precise orbit and gravity field

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Based on GPS measurements from the LEO satellite and kinematic precise orbit determination (POD), it is possible to estimate or measure an orbit in a pure geometrical manner without using any information on satellite dynamics. Such an orbit is represented using satellite positions to an accuracy of 1-2 cm, given with a high sample rate, and provided together with variance-covariance information. However, the kinematic orbit is highly sensitive to the performance of the GPS receiver and the number of GPS satellites being tracked.

Several methods to extract gravity field information from the LEO kinematic positions, and additional measurements such as KBR, have been demonstrated over the last several years. Although spherical harmonics are a standard way to represent gravity fields, this is not the case with the orbit determination model, which is based solely on numerical integration of equation of motion. Analytical perturbation theory avoids the use of numerical integration, representing an orbit using spherical harmonics. However the main disadvantage of this purely analytically computed orbit is its inaccuracy, which increases with the orbit arc length.

Kinematic POD has enabled us for the first time to obtain positions of the satellite independently of any dynamical model. Here we presented a method to combine kinematic POD and analytical perturbations in a consistent reference frame, considering all relevant forces such as tides or accelerometer measurements. Compared to the standard inclination function, we consider a consistent modeling of the Earth rotation and describe an alternative way to represent the rotation of satellite orbit. The idea is to determine the orbit and gravity field using a method that optimally combines kinematic positions, accelerometer measurements and highly accurate KBR measurements. We present and discuss the first results using the new orbital model and make comparison with standard kinematic and so-called reduced-kinematic POD.