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GOCE Satellite Orbit in a Computational Aspect

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The presented work plays an important role in research of possibility of the Gravity Field and Steady-State Ocean Circulation Explorer Mission (GOCE) satellite orbit improvement using a combination of satellite to satellite tracking high-low (SST- hl) observations and gravity gradient tensor (GGT) measurements. The orbit improvement process will be started from a computed orbit, which should be close to a reference ("true") orbit as much as possible. To realize this objective, various variants of GOCE orbit were generated by means of the Torun Orbit Processor (TOP) software package. The TOP software is based on the Cowell 8th order numerical integration method. This package computes a satellite orbit in the field of gravitational and non-gravitational forces (including the relativistic and empirical accelerations). The three sets of 1-day orbital arcs were computed using selected geopotential models and additional accelerations generated by the Moon, the Sun, the planets, the Earth and ocean tides, the relativity effects. Selected gravity field models include, among other things, the recent models from the GOCE mission and the models such as EIGEN-6S, EIGEN-5S, EIGEN-51C, ITG-GRACE2010S, EGM2008, EGM96. Each set of 1-day orbital arcs corresponds to the GOCE orbit for arbitrary chosen date. The obtained orbits were compared to the GOCE reference orbits (Precise Science Orbits of the GOCE satellite delivered by the European Space Agency) using the root mean squares (RMS) of the differences between the satellite positions in the computed orbits and in the reference ones. These RMS values are a measure of performance of selected geopotential models in terms of GOCE orbit computation. The RMS values are given for the truncated and whole geopotential models. For the three variants with the best fit to the reference orbits, the empirical acceleration models were added to the satellite motion model. It allowed for further improving the fitting of computed orbits to the reference orbits. A linear and non-linear model of empirical accelerations was used. After using the non-linear model, the RMS values were reduced by the factor from about 2 to 3 compared with the linear model. A general form of the non-linear model of empirical accelerations is shown in this work. This model can be scaled to a given set of dynamical data for orbit determination by estimating of 192 parameters.
The comparison between the computed orbits and the reference ones was performed with respect to the inertial reference frame (IRF) at J2000.0 epoch. Thus, the given GOCE reference orbits were transformed from ITRF2005 reference frame into IRF frame. It is shown that the velocity components of GOCE reference orbits must be transformed into IRF frame using the full rotation vector of the Earth. In such a case RMS values reach a level of meters.