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Enhanced numerical precision for processing of future gravity satellite mission simulations of low-low SST type

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A future low-low Satellite-to-Satellite tracking (LL-SST) mission principally aims to recover the temporal variations of the Earth's gravity field with an unprecedented precision. In order to achieve this goal, the science and mission requirements concerning the satellite sensor accuracies have been considerably raised. Consequently, the processing method for gravity field recovery has to meet the performance requirements of those new sensors to deliver the most precise gravity field possible.

This study focuses on numerical investigations of Earth's gravity field recovery using a realistic simulation environment for LL-SST gravity field recovery. Full numerical closed-loop simulations are performed by using the Integral Equation approach for several future gravity field mission scenarios where inter-satellite ranges or range-rates are used as observables. Each part of the processing is validated separately with special emphasis on numerical errors, i.e. the orbit simulation part (where the dynamic orbits are generated) through testing of the integrator, the parameter estimation part through examination of the pre-fit residuals and the gravity field adjustment part through degree RMS curves, formal error estimates and geoid height representations. The modeled accuracy is tested against the sensor precisions of a K-band microwave and an interferometric laser ranging instrument. This is achieved by comparing the "error-free" with the "white-noise" case in which the accuracy of the instruments is randomized into white noise and then propagated into the observations. The major error sources and their contributions to the error budget are examined through "colored-noise" propagation (e.g. accelerometer errors) and "true" vs. "nominal" case comparisons (ex. background field errors). The colored noise is then properly assessed by stochastic modeling.

Finally, in order to meet the performance requirements of laser interferometry and thus to analyze the impact of numerical processing errors, experiments of performing all main steps with quadruple precision are carried out which also help understanding the reasons behind some specific error behaviors. It will be demonstrated that the reduction of numerical processing errors is a prerequisite to make full benefit from the increased sensor performance of a laser link. The numerical investigations performed in this study are the foundations for a realistic simulation environment which will serve for the design, planning and mission performance analysis of future gravity satellite missions.