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On the gravity field processing of next generation satellite gravity missions

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Dedicated gravity field missions delivering observations for a period longer than 16 years have drastically contributed in improving our knowledge of mass transport processes in the Earth system. At the same time, they have left a precious heritage for the design of next generation satellite gravity missions to be launched in the mid-term future.

Main subject of this study is the gravity field processing of future Low-Low Satellite-to-Satellite Tracking (LL-SST) missions. We perform assessment of the contribution of all error sources and develop methods for reducing their effect at the level of gravity field processing. Advances in metrology of sensors such as the inter-satellite ranging instrument, may raise the demands for processing accuracy. We show that gravity field processing with double precision may be a limiting factor for exploiting the nm-level accuracy of a laser interferometer that future missions are expected to carry. An enhanced numerical precision processing scheme is proposed instead, where double and quadruple precision is used in different parts of the processing chain. It is demonstrated that processing with enhanced precision can efficiently handle laser measurements and take full advantage of their accuracy, while keeping the computational times within reasonable levels (Daras, 2015). However, error sources of considerably larger impact are expected to affect future missions, with the accelerometer instrument noise and temporal aliasing effects being the most significant ones. The effect of time-correlated noise such as the one present in accelerometer measurements can be efficiently handled by frequency dependent data weighting. Residual time series that contain the effect of system errors and propagated accelerometer and laser noise, is considered as a noise realization with stationary stochastic properties. The weight matrix is constructed from the auto-correlation functions of these residuals. Applying the weight matrix to a noise case considering all error sources leads to reduction of the error level over the complete spectral bandwidth. The method of co-estimating empirical accelerations for reducing the remaining noise is also investigated.

Previous studies for future satellite gravity missions have already showcased the importance of using dual pair satellite formations (e.g. Bender-type) for reducing temporal aliasing effects. However, temporal aliasing remains one of the largest contributors to the error budget. We demonstrate a further reduction of non-tidal aliasing effects by applying to our Bender-type formation the so-called “Wiese” parameterization (Wiese et al, 2011), which suggests co-estimating low resolution gravity fields at short time intervals in order to directly estimate the short-term signals that alias into the combined solution. In order to maximize the effectiveness of the method, we fine-tune options such as the duration and the resolution of the gravity field solutions estimated at high frequency. As a step forward, we experiment with alternative parameterizations that combine low and medium gravity field solutions at different time intervals (Daras, 2015). Finally, we present the optimized parameterization options for our selected orbit setup and summarize the concluding remarks.