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Stochastic noise modelling of kinematic orbit positions in the celestial mechanics approach (CMA)

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We study gravity field determination from high-low GPS satellite-to-satellite tracking using kinematic positions of the GRACE satellites as pseudo-observations. In our celestial mechanics approach, we so far employed a simplified stochastic model based on epoch-wise covariance information, which may be efficiently derived in the kinematic point positioning process. A natural extension of this approach is to not only use the epoch-wise covariance information but the fully populated covariance matrices covering longer time spans, e.g., of up to about half of the satellites' revolution period. These purely mathematical error propagations, however, are not sufficient to ensure a realistic noise characterisation of the results, since the mathematical description of the stochastic behaviour in the least squares estimation does not fully reflect the noise characteristics of the data. As a further step of sophistication, we introduce empirical covariances derived from the residuals of a reduced-dynamic orbit fit of the kinematic positions to weight our observations. Such empirically obtained covariances may be derived with or without taking the mathematical error propagations from the kinematic point positioning into account. We validate the performance of the above outlined strategies to model the stochastic behaviour of the kinematic positions by performing K-band validation of the resulting (GPS-only) derived orbits, by analysing the residuals of combined orbits calculated using both kinematic positions and K-band data, and by analysing the quality of co-estimated gravity field solutions. Eventually, we assess if the use of undifferenced ambiguity-fixed kinematic positions is beneficial as compared to the use of ambiguity float solutions for the above mentioned gravity field recoveries, especially in view of a commonly observed discrepancy between GPS and K-band observations, which usually asks to additionally (artificially) down-weight the GPS observations with respect to the K-band observations.