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Stochastic modeling, variance propagation, and total least squares co-estimation of satellite orientation in GRACE processing.

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In the course of computing the ITSG-Grace2014 and ITSG-Grace2016 monthly potential time series from data at the range rate level, the K-Band antenna phase center coordinates of both GRACE-A and GRACE-B were co-estimated.

In the resulting time series of antenna phase center coordinates, two effects could be observed:
1. The length of the phase center vector shows a large standard deviation of around 15cm to 20cm. This can be adequately explained by the unfavorable measurement configuration, where the opening angle between the respective phase center vectors and the baseline between the satellites' centers of mass is very small, on the order of a few milliradians.
2. The phase center vectors show a strong bias toward zero. Where, by knowledge of the construction of the satellites, it is known that the vector should have a length of approximately 1.45m, the mean of the estimates is approximately 1.2m. This suggests that there must be an effect that is not sufficiently modeled.

Investigations revealed that this bias is due to non-consideration of the stochastic characteristics of the satellite orientation observations in our adjustment. We propagate orientation uncertainties derived from Star Camera/Angular Acceleration sensor fusion to the antenna offset correction applied to the GRACE range-rate measurement. This enables the disentanglement of the stationary noise of the K-Band system from the non-stationary noise of the antenna offset correction. Knowledge of the two separate noise sources then allows for co-estimation of improved orientation parameters in a total least squares squares for the gravity field parameters. We present results obtained using this approach using real data.