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Numerically stable approach for high-precision orbit integration using Encke's method and equinoctial elements

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Future gravity missions like GRACE-FO and beyond will deliver low-low satellite-to-satellite (ll-sst) ranging measurements of much increased precision. This necessitates a re-evaluation of the processes used in gravity field determination with an eye to numerical stability.

When computing gravity fields from ll-sst data, precise positions of both satellites are needed in the setup of the observation equations. These positions thus have an immediate effect on the sought-after gravity field parameters. We use reduced-dynamic orbits which are computed through integration of all accelerations experienced by the satellite, as determined through a priori models and observed through the accelerometer.

Our simulations showed that computing the orbit of the satellite through complete integration of all acting forces leads to numeric instabilities magnitudes larger than the expected ranging accuracy.

We introduce a numerically stable approach employing a best-fit keplerian reference orbit based on Encke's method. Our investigations revealed that using canonical formulations for the evaluation of the reference keplerian orbit and accelerations lead to insufficient precision, necessitating an alternative formulation like the equinoctial elements.