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GRACE gravity field recovery using refined acceleration approach

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Since 2002, the GRACE mission has yielded monthly gravity field solutions with such a high level of quality that we have been able to observe so many changes to the Earth mass system. Based on GRACE L1B observations, a number of official monthly gravity field models have been developed and published using different methods, e.g. the CSR RL05, JPL RL05, and GFZ RL05 are being computed by a dynamic approach, the ITSG and Tongji GRACE are generated using what is known as the short-arc approach, the AIUB models are computed using celestial mechanics approach, and the DMT-1 model is calculated by means of an acceleration approach. Different from the DMT-1 model, which links the gravity field parameters directly to the bias-corrected range measurements at three adjacent epochs, in this work we present an alternative acceleration approach which connects range accelerations and velocity differences to the gradient of the gravitational potential. Due to the fact that GPS derived velocity difference is provided at a lower precision, we must reduce this approach to residual quantities using an a priori gravity field which allows us to subsequently neglect the residual velocity difference term. We find that this assumption would cause a problem in the low-degree gravity field coefficient, particularly for degree 2 and also from degree 16 to 26. To solve this problem, we present a new way of handling the residual velocity difference term, that is to treat this residual velocity difference term as unknown but estimable quantity, as it depends on the unknown residual gravity field parameters and initial conditions. In other word, we regard the kinematic orbit position vectors as pseudo observations, and the corrections of orbits are estimated together with both the geopotential coefficients and the accelerometer scale/bias by using a weighted least square adjustment. The new approach is therefore a refinement of the existing approach but offers a better approximation to reality. This result is especially important in view of the upcoming GRACE Follow-On mission, which will be equipped with a laser ranging instrument offering a higher precision. Our validation results show that this refined acceleration approach could produce monthly GRACE gravity solutions at the same level of precision as the other approaches.