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Refinement of the differential gravimetry approach for future intersatellite observations

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The differential gravimetry approach can be used to connect intersatellite range, range-rate and range-acceleration observations to the relative gradient of the gravitational potential at the locations of the two satellites and thus enables the gravity field recovery from satellite mission like e.g. GRACE. Therein, range-accelerations need to be combined with the relative velocity of the two satellites which, consequently, needs to be known with the same accuracy as the range observations in order to take full advantage of the accuracy of the range observations. In the practical implementation of GRACE, the highly precise K-Band observation can only be combined with the less accurate GPS-observations, which is a major setback of the method, but it can be circumvented by introducing a reference orbit derived from an a priori gravity field. The observations are reduced to a residual quantity and the velocity term can be neglected if the reference orbit is sufficiently accurate. Corrections to the a priori gravity field can then be estimated from the residual observation. By repeated iteration, a similar quality of the solution can be achieved as in the case of the typically used approaches based on variational equations. However, simulations indicate that this iterative approximation of the velocity term fails if the accuracy of the range observation is increased as it is expected for the laser-based range observation of upcoming satellite mission, i.e. the contribution of the residual velocity term can no longer be neglected. This contribution presents the refinement of the approach by introducing the first order term of a Taylor expansion of the relative velocity term. As a consequence, the approach needs to employ variational equations as well, in order to include the contribution of the relative velocity term in the design matrix. Yet, the design matrix is not solely based on the variational equations. The major contribution still comes from the direct connection of the range acceleration to the relative gravitational gradient. It can be seen as type of "hybrid" approach where parts of the (residual) signal are connected directly and others through the variational equations. Consequently, the computational effort increases but the demands to the evaluation of the variational equations are less stringent. Additionally, the question of a determination of the initial conditions of the two satellites with sufficient accuracy will be addressed. Even with an increased range observation, the determination of the initial conditions is still based on GPS-observations. It is investigated if their determination is sufficiently accurate in order to take full advantage of the improved intersatellite observations.