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Using the Multiplicative Schwarz Alternating Algorithm (MSAA) for Solving the Large Linear System of Equations Related to Global Gravity Field Recovery up to Degree and Order 120

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The GRACE mission has substantiated the low–low satellite-to-satellite tracking (LL-SST) concept. The LL-SST configuration can be combined with the previously realized high–low SST concept in the CHAMP mission to provide a much higher accuracy. The line of sight (LOS) acceleration difference between the GRACE satellite pair is the mostly used observable for mapping the global gravity field of the Earth in terms of spherical harmonic coefficients. In this paper, mathematical formulae for LOS acceleration difference observations have been derived and the corresponding linear system of equations has been set up for spherical harmonic up to degree and order 120. The total number of unknowns is 14641. Such a linear equation system can be solved with iterative solvers or direct solvers. However, the runtime of direct methods or that of iterative solvers without a suitable preconditioner increases tremendously. This is the reason why we need a more sophisticated method to solve the linear system of problems with a large number of unknowns.
Multiplicative variant of the Schwarz alternating algorithm is a domain decomposition method, which allows it to split the normal matrix of the system into several smaller overlaped submatrices. In each iteration step the multiplicative variant of the Schwarz alternating algorithm solves linear systems with the matrices obtained from the splitting successively. It reduces both runtime and memory requirements drastically.
In this paper we propose the Multiplicative Schwarz Alternating Algorithm (MSAA) for solving the large linear system of gravity field recovery. The proposed algorithm has been tested on the International Association of Geodesy (IAG)-simulated data of the GRACE mission. The achieved results indicate the validity and efficiency of the proposed algorithm in solving the linear system of equations from accuracy and runtime points of view.

Keywords: Gravity field recovery, Multiplicative Schwarz Alternating Algorithm, Low-Low Satellite-to-Satellite Tracking