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The method of tailored sensitivity kernels for GRACE mass change estimates

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To infer mass changes (such as mass changes of an ice sheet) from time series of GRACE spherical harmonic solutions, two basic approaches (with many variants) exist: The regional integration approach (or direct approach) is based on surface mass changes (equivalent water height, EWH) from GRACE and integrates those with specific integration kernels. The forward modeling approach (or mascon approach, or inverse approach) prescribes a finite set of mass change patterns and adjusts the amplitudes of those patterns (in a least squares sense) to the GRACE gravity field changes.
The present study reviews the theoretical framework of both approaches. We recall that forward modeling approaches ultimately estimate mass changes by linear functionals of the gravity field changes. Therefore, they implicitly apply sensitivity kernels and may be considered as special realizations of the regional integration approach. We show examples for sensitivity kernels intrinsic to forward modeling approaches.
We then propose to directly tailor sensitivity kernels (or in other words: mass change estimators) by a formal optimization procedure that minimizes the sum of propagated GRACE solution errors and leakage errors. This approach involves the incorporation of information on the structure of GRACE errors and the structure of those mass change signals that are most relevant for leakage errors. We discuss the realization of this method, as applied within the ESA "Antarctic Ice Sheet CCI (Climate Change Initiative)" project. Finally, results for the Antarctic Ice Sheet in terms of time series of mass changes of individual drainage basins and time series of gridded EWH changes are presented.