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A comprehensive assessment of a Bayesian-based and a statistical decomposition-based framework for separating GRACE signals

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The Gravity Recovery And Climate Experiment (GRACE) global time-variable (daily-monthly) data products represent the spatial-temporal variations of the Earth's gravity caused by different phenomena including non-steric sea level changes, terrestrial (surface and sub-surface) water storage variations, ice sheet melting, post glacial rebound, etc. Although the GRACE data represent an accurate superposition of the anomalies caused by these phenomena, their separation, to estimate the contribution of each of above components, is desirable for many geodynamic and hydro-climatic applications.

Various methodologies have been developed in recent years to separate GRACE data and extract physically meaningful information from them. Most of these techniques are inversion-based and require (i) a prior information about the components of GRACE data (derived from in-situ/remote sensing data or available models), and (ii) assumptions about their error models. Properties of (i) and (ii), for example the spatial/spectral and temporal resolution mismatch of data in (i) and Gaussian/non-Gaussian errors in (ii), affect the final estimation of global/regional mass anomalies. These impacts, however, have not been systematically assessed yet.

In this study, we present (A) a statistical decomposition-based, and (B) a Bayesian-based formulation for separating GRACE signals. The formulation (in A) provides the advantage of dimension-reduction thanks to the property of the statistical decomposition techniques. However, the cross-correlations between a priori fields have often been over-looked. The Bayesian formulation (in B) mitigates the problem with cross-correlations, however it is theoretically more sensitive to the error assumptions, as well as to resolution mismatches. In order to numerically evaluate the performance of the proposed methods, realistic synthetic GRACE Total Water Storage (TWS) data will be generated and contaminated with realistic coloured noise. We will assess differences between the results of applying methods (A) and (B). Particularly, it will be shown that how selecting 1) a priori models, 2) error models, and 3) spectral truncation and spatial smoothing will change the final signal separation results.

Keywords: GRACE; Signal Separation; Bayesian Separation, Statistical Decomposition-based Signal separation; Spatial/Temporal Resolution Mismatch