Geophysical Research Abstracts
Vol. 20, EGU2018-13611, 2018
EGU General Assembly 2018

Extracting geophysical signals from GRACE using an objective spatio-temporal filter

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Measurements of the spatio-temporal variations of Earth's gravity field from the Gravity Recovery and Climate Experiment (GRACE) mission have led to unprecedented insights into large spatial mass redistribution at secular, seasonal, and sub-seasonal time scales. However, GRACE solutions from various processing centers, using different processing strategies, result in estimates that include errors, or "noise", with specific spatial and temporal patterns.

In order to extract geophysical signals from noise in the GRACE measurement, several methods have been proposed. However, previous attempts based on filtering techniques required a priori assumptions on the spatio-temporal noise characteristics. Here we explore an alternative approach, using an objective spatio-temporal filter. We rely on the Multichannel Singular Spectrum Analysis (MSSA), which is a data-adaptive, multivariate, and non-parametric method that simultaneously exploits the spatial and temporal correlations of geophysical fields to extract common modes of variability.

We perform an MSSA on 13 years of GRACE spherical harmonics solutions from 5 centers of analysis simultaneously. We show that the method allows for the extraction of common modes of variability between solutions, and removal of the solution-specific spatio-temporal noise pattern that arises from processing strategies. In particular, the method filters out efficiently the spurious north-south stripes, most likely caused by aliasing of geophysical signals that were imperfectly modeled. Finally, we compare our GRACE solution – based on extracting common signals in space and time from 5 existing solutions – to mass concentration (MASCON) solutions that allow for the application of a priori information derived from near-global geophysical models to prevent striping in the solutions.