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Application of EOF/PCA-based methods in the post-processing of GRACE derived water variations

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Abstract

Two problems that users of monthly GRACE gravity field solutions face are 1) the presence of correlated noise in the Stokes coefficients that increases with harmonic degree and causes 'striping', and 2) the fact that different physical signals are overlaid and difficult to separate from each other in the data. These problems are termed the signal-noise separation problem and the signal-signal separation problem. Methods that are based on principal component analysis and empirical orthogonal functions (PCA/EOF) have been frequently proposed to deal with these problems for GRACE. However, different strategies have been applied to different (spatial: global/regional, spectral: global/order-wise, geoid/equivalent water height) representations of the GRACE level 2 data products, leading to differing results and a general feeling that PCA/EOF-based methods are to be applied 'with care'. In addition, it is known that conventional EOF/PCA methods force separated modes to be orthogonal, and that, on the other hand, to either EOFs or PCs an arbitrary orthogonal rotation can be applied.

The aim of this paper is to provide a common theoretical framework and to study the application of PCA/EOF-based methods as a signal separation tool due to post-process GRACE data products. In order to investigate and illustrate the applicability of PCA/EOF-based methods, we have employed them on GRACE level 2 monthly solutions based on the Center for Space Research, University of Texas (CSR/UT) RL04 products and on the ITG-GRACE03 solutions from the University of Bonn, and on various representations of them. Our results show that EOF modes do reveal the dominating annual, semiannual and also long-periodic signals in the global water storage variations, but they also show how choosing different strategies changes the outcome and may lead to unexpected results.