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A non-Gaussian decomposition of GRACE-derived climate signals, using Independent Component Analysis (ICA)

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Due to the non-Gaussian nature of global water variations signals, the principal component analysis (PCA) method that has been frequently used to analyze the products of GRACE (Gravity Recovery and Climate Experiment) mission suffers from the inability to separate the observed signals into their statistically independent sources. The problem is due to the fact that the PCA method uses only the second order information contained in the auto covariance or correlation matrix of data to explain the maximum amount of variance in the data set. This arises the question, whether conventional orthogonal based methods are suitable to find the meaningful representation from those complex data?

To answer this question, we have investigated the performance of conventional PCA and its extension VARIMAX rotation on the simulated and real GRACE derived water variations signals. Furthermore, we have also extended the conventional PCA method toward an Independent Component Analysis (ICA) method to benefit from the higher order statistic information. The results of this analysis on the real data cover the GRACE level 2 monthly solutions based on the three official data centers (GFZ, CSR and JPL) and also ITG 2010 solutions from the University of Bonn. Our results are also evaluated using the WGHM global hydrological model.

Compared to the PCA and its rotated extension, the results of ICA shows a remarkable improvement in the separation of independent components even for such regions that exhibit different overlapping modes (e.g. Amazon, Greenland). Using an ICA algorithm, we were able to separate the annual signal, long-term trend and inter-annual variations within the separated modes.

Keywords: PCA, ICA, GRACE