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Identifying presence of correlated errors in GRACE monthly harmonic coefficients using machine learning algorithms

Dimitrios Piretzidis (1), Gurveer Sra (1), George Karantaidis (2), and Michael G. Sideris (1)

(1) Department of Geomatics Engineering, The University of Calgary, Calgary, Canada (dimitrios.piretzidis@ucalgary.ca), (2) School of Informatics, Aristotle University of Thessaloniki, Thessaloniki, Greece (gkarantai@csd.auth.gr)

A new method for identifying correlated errors in Gravity Recovery and Climate Experiment (GRACE) monthly harmonic coefficients has been developed and tested. Correlated errors are present in the differences between monthly GRACE solutions, and can be suppressed using a de-correlation filter. In principle, the de-correlation filter should be implemented only on coefficient series with correlated errors to avoid losing useful geophysical information. In previous studies, two main methods of implementing the de-correlation filter have been utilized. In the first one, the de-correlation filter is implemented starting from a specific minimum order until the maximum order of the monthly solution examined. In the second one, the de-correlation filter is implemented only on specific coefficient series, the selection of which is based on statistical testing. The method proposed in the present study exploits the capabilities of supervised machine learning algorithms such as neural networks and support vector machines (SVMs).

The pattern of correlated errors can be described by several numerical and geometric features of the harmonic coefficient series. The features of extreme cases of both correlated and uncorrelated coefficients are extracted and used for the training of the machine learning algorithms. The trained machine learning algorithms are later used to identify correlated errors and provide the probability of a coefficient series to be correlated. Regarding SVMs algorithms, an extensive study is performed with various kernel functions in order to find the optimal training model for prediction. The selection of the optimal training model is based on the classification accuracy of the trained SVM algorithm on the same samples used for training.

Results show excellent performance of all algorithms with a classification accuracy of 97% - 100% on a pre-selected set of training samples, both in the validation stage of the training procedure and in the subsequent use of the trained algorithms to classify independent coefficients. This accuracy is also confirmed by the external validation of the trained algorithms using the hydrology model GLDAS NOAH. The proposed method meet the requirement of identifying and de-correlating only coefficients with correlated errors. Also, there is no need of applying statistical testing or other techniques that require prior de-correlation of the harmonic coefficients.