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Water storage variations extracted from GRACE data by combination of multi-resolution representation (MRR) and principal component analysis (PCA)

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Regionally changing hydrological conditions and their link to the availability of water for human consumption and agriculture is a challenging topic in the context of global change that is receiving increasing attention. Gravity field changes related to signals of land hydrology have been observed by the Gravity Recovery And Climate Experiment (GRACE) satellite mission over a period of more than 12 years. These changes are being analysed in our studies with respect to changing hydrological conditions, especially as a consequence of extreme weather situations and/or a change of climatic conditions.

Typically, variations of the Earth's gravity field are modeled as a series expansion in terms of global spherical harmonics with time dependent harmonic coefficients. In order to investigate specific structures in the signal we alternatively apply a wavelet-based multi-resolution technique for the determination of regional spatiotemporal variations of the Earth's gravitational potential in combination with principal component analysis (PCA) for detailed evaluation of these structures.

The multi-resolution representation (MRR) i.e. the composition of a signal considering different resolution levels is a suitable approach for spatial gravity modeling especially in case of inhomogeneous distribution of observation data on the one hand and because of the inhomogeneous structure of the Earth's gravity field itself on the other hand. In the MRR the signal is split into detail signals by applying low- and band-pass filters realized e.g. by spherical scaling and wavelet functions. Each detail signal is related to a specific resolution level and covers a certain part of the signal spectrum. Principal component analysis (PCA) enables for revealing specific signal patterns in the space as well as the time domain like trends and seasonal as well as semi seasonal variations.

We apply the above mentioned combined technique to GRACE L1C residual potential differences that have been derived directly from GRACE inter-satellite range-rate observations, spanning the time interval between 04/2002 and 05/2014. Scaling coefficients for the radial basis functions are computed via variance component estimation. Since the GRACE L1C residual potential differences, serving as input for our regional gravity modeling routines, are already corrected for time variable gravity effects of atmosphere, oceans and tides the output mainly reflects hydrological variations in the area of interest. Our study area is the northern part of South America including the Amazon region. We take the detail signals of selected resolution levels computed by the MRR as input for the time series analysis. PCA is thus conducted for each resolution level separately. Following the analysis by means of principal components and empirical orthogonal functions our results will be interpreted and validated with reference data.