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Continental scale atmospheric and terrestrial water budget modeling and comparison to GRACE

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Estimation of large scale water balances is still an unsolved challenge in hydrological sciences, particularly for data spare regions. The GRACE satellite mission (launched in 2002) provides a completely new opportunity to investigate seasonal large scale water mass changes based on measurements of gravitational acceleration differences.

Our study aims at determining the potential of GRACE data for hydrological applications. Our approach assumes that vertically integrated atmospheric moisture convergence equals 1) precipitated minus evapotranspired water masses and therefore equals 2) aggregated surface runoff minus water storage changes. Using observed basin runoff, this interrelation allows us to compare GRACE derived water storage changes with modeled atmospheric moisture convergences. As regional atmospheric modeling is expected to yield more accurate meteorological fields than global model results, we use the WRF model for a dynamic downscaling of global atmospheric fields and hence derive high resolution fields of air pressure, horizontal moisture flux divergence, precipitation minus evapotranspiration, soil water storage, etc.

Our study focuses on sensitivities and uncertainties of regionally modeled atmospheric mass and moisture fluxes due to specific model setup, origin of global driving data (NCEP vs. ECMWF) and spatial resolution. This is performed for four regions: Australia, Sahara, Siberia and the Amazon. The first three regions are characterized by a simplified hydrological mass balance, i.e. either evaporation or precipitation is close to zero. Central Australia represents a region with no outlet, meaning runoff is negligible. The Sahara also has zero runoff and for the dry periods evapotranspiration is close to zero. Siberia, comprising the catchments of Lena and Yenisei has negligible evapotranspiration for the winter months. The basin of the Amazon is representative for regions with high precipitation and evaporation terms.

For the years 2003 to 2008, correlations between monthly GRACE derived and regionally modeled water storage changes are shown for the mentioned areas. Also, the uncertainty bounds of the atmospheric moisture flux computations that arise from different atmospheric driving data (NCEP Reanalysis, ECMWF Operational Analysis, ECMWF ERA-INTERIM) are estimated. Also, the effects of different sea surface temperature data and nudging towards global datasets will be depicted.

Furthermore, the estimated water budgets are compared to weekly GRACE solutions that have become available in late 2008 by GFZ Potsdam.