New results from the GHYRAF (Gravity and Hydrology in Africa) experiment in relation to the use of ground and space geodesy to constrain water storage changes

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Hydrological time-varying processes (soil moisture, aquifers) redistribute underground water and hence lead to alter the gravity and shape of the Earth at various length scales (from very local catchment size to continental size) because of Newtonian attraction and elastic loading.

A new experiment called GHYRAF (Gravity and Hydrology in Africa) was set up in 2008 in West Africa. The first goal is to better characterize the annual cycle of water storage in West Africa and to assess the predictions of global hydrology models for this region. A by-product of this project is also to validate satellite gravity observations (GRACE) with ground gravity and GPS observations.
This multidisciplinary project (space and ground gravimetry, geodesy, subsurface geophysics, hydrology) is conducted on three distinct regions: the Sahara (Tamanrasset, South of Algeria) with almost no rainfall (20 mm), the Sahelian zone (Niamey and Diffa in Niger) with moderate and highly variable rainfall (500 mm) and, finally, the equatorial monsoon region (Djougou, Benin Republic) with heavy rainfall (1200 mm). Since gravity is sensitive to various length scales involved in hydrology, we will use satellite gravimetric observations from GRACE for the large scales and rely on dense in-situ measurements (rain gauges, piezometers, soil moisture probes) and subsurface geophysics surveys (MRS) to model the local gravity effects we measure with absolute and relative spring meters at ground.

The first yearly cycle of the project is now completed and we will report on the first results. On the semi-arid site near Niamey in Southwest Niger, we found a nice agreement between the measured surface gravity changes and the modeled ones using local piezometry observations during the 2008 monsoon. Similarly, the water storage estimates from the hydrological devices or measured by absolute gravimetry on the Djougou site (culture-fallow hillslope) are compatible. The good agreement on these two sites shows that gravimetry appears to be a promising tool to monitor the water storage variations.

The GPS data available in West Africa mainly originating from the AMMA (African Monsoon Multidisciplinary Analyses) program have been analyzed and the vertical motion of the sites clearly exhibits the annual load signature due to continental hydrology.
We will finally present some comparisons between satellite-derived gravity data (GRACE), hydrology models and hydro-meteorological data for the Niger and Chad basins.