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The GHYRAF (Gravity and Hydrology in Africa) experiment: first results from GPS, GRACE and surface gravity observations in relation to 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 effects to continental size) because of Newtonian attraction and elastic loading. We present here a new experiment set up in 2008 in West Africa called GHYRAF (Gravity and Hydrology in 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 (GLDAS, LadWorld) for this region. Our project will also help to validate satellite gravity observations (GRACE) with ground gravity and GPS observations. This project is multidisciplinary (gravimetry, geodesy, subsurface geophysics, hydrology) and allows several French and African teams to work together in order to better understand the changes in water storage by using different types of observations. This research program mainly concentrates geographically on three distinct regions: the Sahara (Tamanrasset, South of Algeria) with almost no rainfall, the Sahelian zone (Niamey and Diffa in Niger) with moderate and highly variable rainfall and the equatorial monsoon band (Djougou, Benin Republic) with heavy rainfall. Different kinds of surface gravity measurements are involved: the repetition several times a year with an absolute gravimeter (FG5) at the 4 above-mentioned specific sites; complementary measurements with a portable A10 absolute meter and measurements on dense repetition networks with microgravimeters (Scintrex). The main gravity stations are collocated with permanent GPS stations in order to independently estimate the gravity contribution due to vertical motion of the ground. Since gravity is sensitive to various length scales involved in hydrology, we will rely on dense in-situ measurements (rain gauges, piezometers, soil moisture probes) and subsurface geophysics (MRS) to model local gravity effects.
We will report on preliminary results of the GHYRAF experiment based on the repetition of the first FG5 AG measurements in Niger and Benin and their relation to local water content changes. We will also show the results from a preliminary treatment of the available GPS data mainly originating from the AMMA (African Monsoon Multidisciplinary Analyses) program and their comparison with theoretical predictions for the continental scale hydrological loading. We will finally present some comparisons between GRACE data, hydrology models and hydro-meteorological data for the Niger and Chad basins.