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Spatial and Temporal Gravity Data Used for Hydrological Model Calibration: Field Study of a Recharge Event in the Okavango Delta, Botswana

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Hydrological models are traditionally calibrated using point data from e.g. piezometers, discharge stations and infiltrometers, which characterize water levels and water flows in the modeled system. Changes in total water storage in the ground is often not well constrained by this type of data because it depends on the drainable porosity (specific yield) of the aquifer. Time-lapse micro-gravimetry can detect changes in water mass (volume) in the ground and can thus help constrain the mass balance in a groundwater model, potentially leading to better estimates of e.g. specific yield and hydraulic river bed conductance. Field test have so far been limited, but with the emergence of better gravimeters over the past years, the interest in hydro-gravimetry is growing. The Okavango Delta, Botswana, has an annual flood cycle resulting in large (two meters or more) variations in groundwater table along the peripheral rivers of the wetland. Combined with a generally sandy soil, this provides good conditions for field tests of hydro-gravimetry. During the flooding of a previously dry river bed in July – August 2008, shallow groundwater wells along two transects were monitored and relative micro-gravity data collected with at temporal and spatial distribution using a Scintrex CG-5 relative gravimeter. Changes in gravity of up to 30μGal were observed with uncertainties down to 4μGal. The traditional approach of considering the groundwater as a horizontal slab fails to give consistent values for specific yield. A MODFLOW groundwater model for the site is build and calibrated, using both water level and gravity data. To facilitate this, a forward gravity code has been developed in the HYDROGRAV research group which calculates the gravity response from a modeled change in groundwater level. We see that the inclusion of gravity data significantly decreases parameter uncertainty. Moreover, we assess to what extent gravity data can substitute the more expensive drilling of boreholes.