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Evaluation of groundwater storage variations in various large aquifers using GRACE data

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In many regions of the world where strong water depletion occurs, surface water stocks are often insufficient to satisfy the population domestic needs and irrigation requirements. When large aquifers are present, groundwater pumping may be used to fulfill these needs. Yet, flows in aquifer systems are largely slower than in the surface layers, and high abstraction combined with low natural recharge may lead to groundwater depletion (decreasing trend of water table level). Despite the importance of integrating water stored in the aquifers into water management, groundwater monitoring suffers from scarce direct measurements. Hydrology models may provide an alternative way to estimate groundwater variations but they need data to be calibrated. In that sense, even if they are generally quite relevant to represent surface and near surface storage (rivers, lakes, reservoirs, soil moisture and evapotranspiration), they also suffer from the lack of groundwater measurements.

Since 2002, the GRACE mission has provided, all over the world, monthly estimates of the vertically integrated water storage, also named Total Water Storage (TWS). In this study, we first compare the GRACE inferred TWS to the climate forcing (precipitation) in some of the greatest aquifers of the world (among others, the Guarani, California and Canning aquifers). This comparison shows quite limited correlations in space and time variability, which seems to indicate the presence of a non-negligible anthropogenic component.

Groundwater storage variations are then calculated by subtracting modeled land surface storage to the GRACE-derived TWS. Different models (GLDAS, WGHM, ISBA and LaD) are used in order to estimate their uncertainties, for example on the "surface to ground" vertical water distribution. In some cases, in situ water table variations are available and then used to validate the method. Other ancillary data, such as volume of groundwater pumping, are also used as validation materials. Results show a quite good agreement between direct measurements and GRACE-derived groundwater storage variations, which confirms the potential of satellite Gravimetry for the monitoring and possibly the management of groundwater in large aquifers.