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Global Scale Determination of “Drainable” Water Resources by GRACE and/or Runoff

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In the context of water resources management and climate change there is an ongoing discussion on how to assess available water resources. A rate based definition for a sustainable use of water resources (given by long term recharge) (Sophocleous 1997, Bredehoeft 2002, Zhou 2009) does not help to determine the absolute volume of available resources. Thus the attempt was made to estimate the volume of the respective groundwater resources based on homogeneous assumptions for aquifers with respect to thickness, porosity and accessibility (Nace [1969] and Korzun [1978]). As ground based measurements of storage compartments like groundwater, surface water, snow water equivalent and soil moisture are point measurements the determination of total water storage is still quite inaccurate and unreliable on large spatial scales.

Recent GRACE measurements allow to determine mass variations of global scale catchments. These mass variations do not directly represent the absolute storage volumes, which could be considerably larger than the mass variations themselves, yet cannot be recognized by GRACE, as they correspond to a static mass offset. In addition the mass variations comprise all storage compartments and thus do not allow to distinguish different storage compartments such as hydraulically coupled components contributing to river runoff and those which are not coupled like isolated surface water, soil moisture and snow / ice. Investigations of the Runoff - Storage relationship by GRACE and remote sensing however allow to discriminate between coupled / uncoupled storage components of a catchment (Riegger & Tourian. 2014).

The linear relationship found between runoff and the coupled storage components allows to determine the respective hydraulic time constant and - based on the reasonable assumption of proportionality - to quantify the respective mass offset, which corresponds to the mean drainable water storage. Thus the total "Drainable Storage" i.e. the absolute water volume, which can freely drain to the river system by gravity, is then given by the mass offset plus the GRACE mass deviation.

According to the available data the time constant can be taken either from simultaneous or from asynchronous averaged measurements of runoff and GRACE. A simulation of storage mass by an integration of time variable recharge and an adaption to coupled storage determined by GRACE and remote sensing provides a very reasonable estimation of drainable storage even for ungauged catchments.

Based on this, the new approach allows to determine the actual volume of drainable water storages on a global scale directly from time dependent GRACE measurements, and thus to integrate climatic as well as management aspects into an assessment of resources even under future changes in climatic conditions.

References: Riegger, J., and M. J. Tourian (2014), Characterization of runoff-storage relationships by satellite gravimetry and remote sensing. Water Resour. Res., 50, doi:10.1002/2013WR013847.