The potential for improving terrestrial water storage estimates through assimilation of GRACE data into a hydrological model

S.Tian[a], A.I.J.M. van Dijk[b], and P.Tregoning[a]

[a] *Research School of Earth Sciences, The Australia National University, Canberra, Australia*
[b] *Fenner School of Environment & Society, The Australia National University, Canberra, Australia*
Email: siyuan.tian@anu.edu.au

Abstract: The lateral and vertical distribution of terrestrial water interacts with Earth's climate system, controlling over water, energy and biogeochemical fluxes，thus having a critical role in characterizing water availability, hydrologic extremes such as drought and flood. Traditional monitoring of terrestrial water change mainly depends on model simulation. Although hydrological models solve the problems in describing water storage change, the lack of systematic global fine-scale hydrological measurements increases the model uncertainty and lowers the simulation accuracy.

Terrestrial water storage (TWS) includes all forms of water stored above and underneath the surface of the earth (e.g. surface water, soil moisture, groundwater, as well as snow and ice). Recently, the combination of remote sensing technology, observation network and hydrological models shows its significant potential in terrestrial hydrology studies. However, ground or satellite based techniques can only provide the measurements of some individual components like surface water and hardly be applied to subsurface water. The problem of the absence of integrated TWS measurements was resolved by the launch of Gravity Recovery and Climate Experiment (GRACE) with unprecedented accuracy for the entire globe. The TWS estimates from GRACE is on the basis of 1 month or 10 days, with a horizontal resolution of about 150 000 km^2. Vertically, GRACE's TWS observations mostly reflect the change in land water storage and ice mass and it integrates changes in groundwater, soil moisture, snow and ice sheets, surface water, and vegetation, after removing the changes in atmospheric and ocean mass.

In this study, a statistical comparison of GRACE and TWS estimates from the World Wide Water Resource Assessment (W3RA) model was conducted to investigate the potential for identifying and diminishing model deficiencies. GRACE TWS estimates agree well with the W3RA model outputs in most of the continents, and the difference indicates the uncertainty of GRACE data and the limitation of the model structure. The discrepancy in Amazon and northwest Australia shows the potential for using GRACE to improve TWS estimates in the area requiring better rainfall estimation. In addition, the model appeared to underestimate the TWS amplitude, which suggests the modeled soil, groundwater and/or surface water systems drain too quickly. Therefore, a model sensitivity study needs to be conducted to investigate the impact of different meteorology forcing datasets (e.g. precipitation, temperature and radiation) on improving the model estimates. Estimates in individual water storage are expected to be improved by the constraints from GRACE TWS estimates in the way of disaggregating GRACE TWS anomalies into individual components.

To isolate individual components from GRACE TWS data, auxiliary information in each component is needed, such as using ground-based measurements or satellite-based retrievals of soil moisture to obtain groundwater storage change. Another approach is to merge GRACE TWS through simulation by a hydrological model via data assimilation. Therefore, the aim of this study is to improve the global TWS estimates through assimilating both GRACE-derived TWS and auxiliary information about individual water storage components into W3RA model. Near surface soil moisture retrievals from Soil Moisture and Ocean Salinity (SMOS) or Advanced Microwave Scanning Radiometer-EOS (AMSR-E) is considered due to the vital role of soil moisture in the estimation of evapotranspiration and runoff.

The improved estimation of TWS by the developed data assimilation system will offer a new perspective on monitoring global water cycle and especially subsurface water storage variation. It will also contribute to drought and flood prediction and management.

Keywords: *GRACE, data assimilation, World Wide Water Resources Assessment (W3RA), total water storage, soil moisture*