Assimilation of GRACE Terrestrial Water Storage for Improving Land Surface Processes and Drought Monitoring

Bailing Li[1], Matthew Rodell[2] and Hiroko Beaudoing[1]

[1] Earth System Science Interdisciplinary Center, University of Maryland

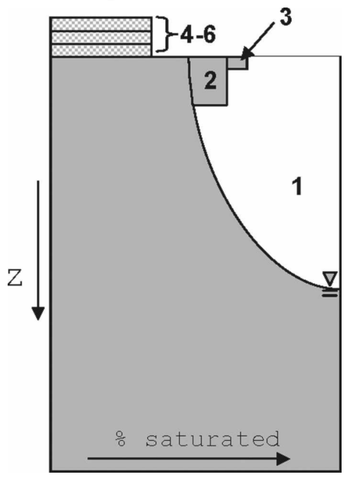
[2]Hydrological Sciences Laboratory, NASA Goddard Space Flight Center

Introduction

The Gravity Recovery and Climate Experiment (GRACE) satellite system maps temporal variations of Earth's gravity field from which monthly terrestrial water storage (TWS) anomalies (relative to a long time mean) can be inferred. GRACE derived TWS represents the sum of soil moisture, groundwater, snow and surface water and is provided at coarse temporal and spatial resolutions. Other than in large-scale water balance studies, spatial and temporal downscaling and vertical disaggregation of GRACE TWS are often needed to make the observation more useful for process scale studies and practical applications. Here we present some results on using an ensemble Kalman smoother (EnKS) to assimilate GRACE derived TWS and on the application of GRACE assimilated soil moisture and groundwater storage for drought monitoring.

The NASA Catchment model (Koster et al, 2000)

The EnKS was implemented in the Catchment land surface model which simulates 6 states related to water storage changes in snow, soil moisture and groundwater table.



1: catchment deficit (CatDef)
2: root zone excess (rtzEx)
3: surface excess (sfEx)
4-6: SWE

Model estimated TWS is derived from CatDef, rtzEx and SWE as well as catchment parameters such as maximum capacity for water in a catchment.

The assimilation method (Zaitchik et al, 2008)

The ensemble Kalman smoother (EnKS) implemented in our studies can be represented using the following update equation:

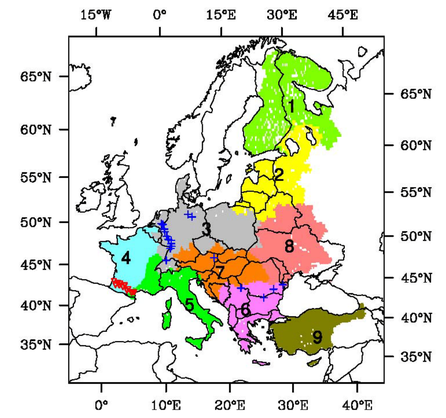
$$X_a = X_f + K(TWS_{GRACE} - TWS_{MODEL})$$

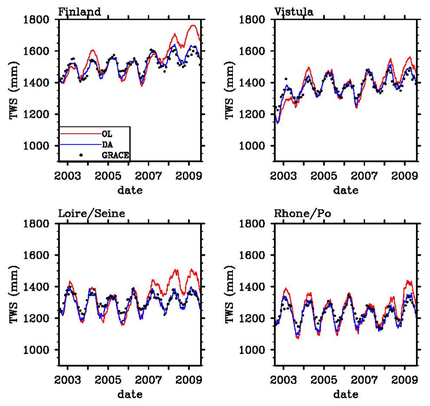
where X_a represents the analysis of daily states and X_f represents the daily forecast; **K** is the Kalman gain matrix which is integrated once per month; TWS represent monthly model and GRACE derived TWS.

Because GRACE TWS provides monthly average values, the EnKS is performed in two iterations: first, the ensemble is propagated forward to the end of the month and the monthly mean of modeled TWS is obtained; second, the ensemble is re-integrated from the beginning of the month with an update for each state and each member of the ensemble.

GRACE data assimilation in Western and Central Europe (Li et al., 2012)

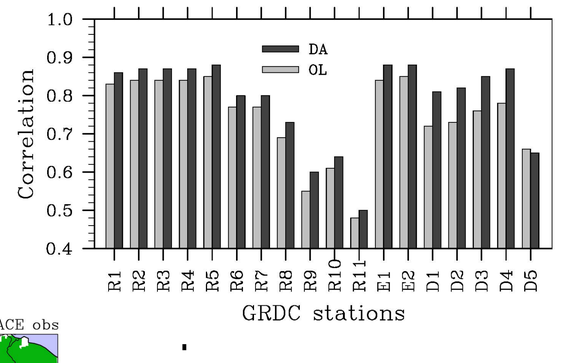
Nine major basins were created for GRACE data assimilation. GRACE observations in each basin were derived from the gridded GREACE TWS product. Stream flow data (marked by blue "x") were used to evaluate the impact of GRACE data assimilation.

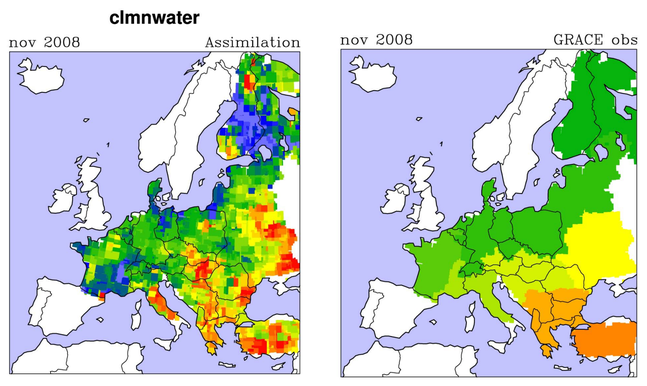




Daily TWS from the open loop (OL, in red) and data assimilation (DA, in blue) runs in four basins. Monthly GRACE derived TWS are represented in black dots

GRACE DA improved runoff correlations with gauged data.

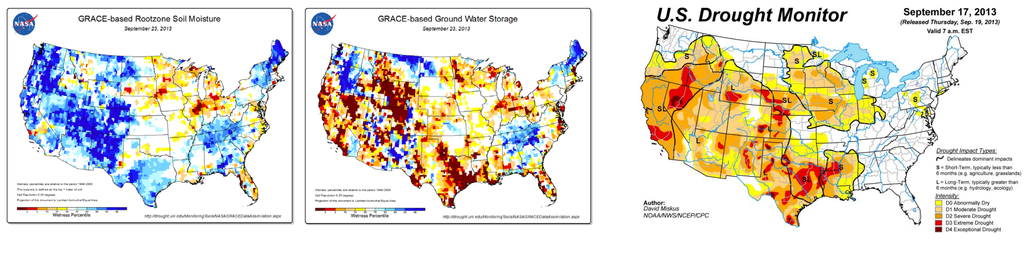




Comparison of downscaled TWS (left) with basin-scale GRACE derived TWS (right).

Assimilation of GRACE derived TWS for drought monitoring (Houborg et al, 2012)

Wetness indices created from GRACE assimilated soil moisture and groundwater storage fields, in comparison with the US Drought Monitor:



GRACE assimilation wetness indices were calculated based on a 60-year Catchment simulation driven by the Princeton forcing data set. The near-real time GRACE data assimilation is driven by the NLDAS-2 forcing data set which has been biased corrected against Princeton.

References

Koster et al, 2000: A catchment-based approach to modeling land surface processes in general circulation model, 1, model structure, JGR, **105**,24809-24822.

Zaitchik et al, 2008: Assimilation of GRACE terrestrial water storage data into a land surface model: results for the Mississippi river basin, JHM,**9**,535-549.

Li et al., 2012: Assimilation of GRACE terrestrial water storage into a land surface model: evaluation and potential for drought monitoring in Western and Central Europe, J. Hydro., **446-447**,103-115

Houborg et al., 2012: Drought indicators based model assimilated Gravity Recovery and Climate Experiment (GRACE) terrestrial water storage observations, WRR, **48**,W07525.