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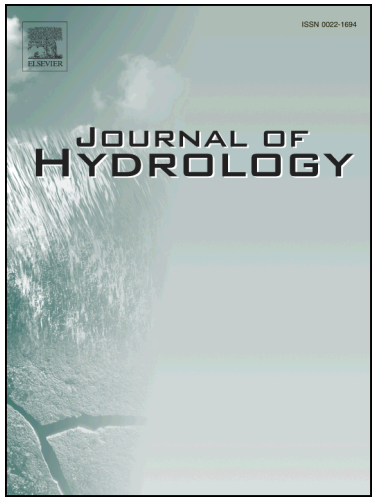

Research papers

A Two-update Ensemble Kalman Filter for Land Hydrological Data Assimilation with an Uncertain Constraint

M. Khaki, B. Ait-El-Fquih, I. Hoteit, E. Forootan, J. Awange, M. Kuhn

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ACCEPTED MANUSCRIPT

A Two-update Ensemble Kalman Filter for Land Hydrological Data Assimilation with an Uncertain Constraint

M. Khaki[a,1], B. Ait-El-Fquih[b], I. Hoteit[b], E. Forootan[c], J. Awange[a], M. Kuhn[a]

[a] *Department of Spatial Sciences, Curtin University, Perth, Australia.*

[b] *King Abdullah University of Science and Technology (KAUST), Thuwal, Saudi Arabia.*

[c] *School of Earth and Ocean Sciences, Cardiff University, Cardiff, UK.*

Abstract

Assimilating Gravity Recovery And Climate Experiment (GRACE) data into land hydrological models provides a valuable opportunity to improve the models' forecasts and increases our knowledge of terrestrial water storages (TWS). The assimilation, however, may harm the consistency between hydrological water fluxes, namely precipitation, evaporation, discharge, and water storage changes. To address this issue, we propose a weak constrained ensemble Kalman filter (WCEnKF) that maintains estimated water budgets in balance with other water fluxes. Therefore, in this study, GRACE terrestrial water storages data are assimilated into the World-Wide Water Resources Assessment (W3RA) hydrological model over the Earth's land areas covering 2002 – 2012. Multi-mission remotely sensed precipitation measurements from the Tropical Rainfall Measuring Mission (TRMM) and evaporation products from the Moderate Resolution Imaging Spectroradiometer (MODIS), as well as ground-based water discharge measurements are applied to close the water balance equation. The proposed WCEnKF contains two update steps; first, it incorporates observations from GRACE to improve model simulations of water storages, and second, uses the additional observations of precipitation, evaporation, and water discharge to establish the water budget closure. These steps are designed to account for error information associated with the included observation sets during the assimilation process. In order to evaluate the assimilation results, in addition to monitoring the water budget closure errors, in-situ groundwater measurements over the Mississippi River Basin in the US and the Murray-Darling Basin in Australia are used. Our results indicate approximately 24% improvement in the WCEnKF groundwater estimates over both basins compared to the use of (constraint-free) EnKF. WCEnKF also further reduces imbalance errors by approximately 82.53% (on average) and at the same time increases the correlations between the assimilation solutions and the water fluxes.

Email address: Mehdi.Khaki@postgrad.curtin.edu.au (M. Khaki)

[1]Contact details: Department of Spatial Sciences, Curtin University, Perth, Australia, Email: Mehdi.Khaki@postgrad.curtin.edu.au, Tel: 0061410620379

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