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Assimilation of basin-scale estimates of terrestrial water storage variations in a catchment-based land surface model

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Terrestrial water storage (mostly encompassing soil moisture, groundwater, snow, and surface water) is a key climatic variable relevant both for short-term and seasonal forecasting, as well as for long-term climate modeling. Despite its importance, it is not routinely measured and observations of its individual components are scarce. A possible approach for deriving large-scale (10^5-10^6 km^2) estimates of this quantity is the use of combined terrestrial and atmospheric water-balance computations based on moisture flux convergence, changes in atmospheric moisture content, and river runoff. Recently, estimates derived with this methodology using ERA-40 reanalysis data and observed runoff were shown to compare well with available ground observations in Illinois (Seneviratne et al. 2004), and a new dataset of monthly terrestrial water storage variations has been subsequently derived with the same approach for various river basins of the mid-latitudes (Hirschi et al. 2005). In the present study, we address the possible assimilation of this derived basin-scale terrestrial water-storage dataset in the National Aeronautics and Space Administration (NASA) Catchment Land Surface Model (CLSM, Koster et al. 2000), a recently developed land surface scheme which uses the hydrological catchment as basic computational unit.

Intercomparisons of the water-balance estimates and the land surface model output with ground observations show that both the water-balance and model estimates are

similarly skillful on average, but that their performances significantly differ in some regions, possibly dependent on the quality of the precipitation forcing used to drive the land surface model. Their skill appears in part complementary: They perform best in different regions (North America for the land surface model and Northern Russia for the water-balance estimates), and also capture different features from the observations, the water-balance estimates being more skillful at capturing the inter-annual variability of the observations. An assimilation approach using an ensemble Kalman filter and spatially auto-correlated forcing perturbations (Reichle and Koster 2005) for the propagation of the ensemble simulations is tested for the Volga river basin. The tested approach is shown to be successful for the assimilation of summer soil moisture variations and yields estimates of terrestrial water storage of higher quality than both the water-balance estimates and the original land surface model output. These preliminary results are particularly interesting given the scale discrepancy between the water-balance estimates and the land surface model, and could possibly be of relevance for the assimilation of measurements from the Gravity Recovery and Climate Experiment (GRACE).

References:

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