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Assimilating multi-sensor satellite observations for initializing hydrologic and agricultural forecasts

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The application of data assimilation techniques in hydrologic studies has been gaining traction in the last 10-15 years. Most of these studies have focused on a single water cycle component, while few studies have examined methods of assimilating multiple observations from different sensors and of different hydrologic variables. The latter is challenging since any potential disparities in the observations could lead to suboptimal estimates after assimilation. The optimal estimates of hydrologic states, such as soil moisture, can be used as initial conditions for hydrologic forecasting systems. A multi-sensor and multivariate data assimilation forecast system has been developed at JPL (RHEAS, Regional Hydrologic Extremes Assessment System) with an initial focus on forecasting drought characteristics. The core of RHEAS is the VIC hydrology model, which has been widely used for many water resources applications. Apart from hydrologic forecasts, RHEAS can produce agricultural forecasts by coupling VIC with the DSSAT crop growth model. The modeling system is supported by a spatial database component, which provides access to multiple in-situ and satellite observations and allows data to be delivered to users through web-GIS or mobile application interfaces. The satellite observations, which include soil moisture, water storage, evapotranspiration, and snow cover, are assimilated into the VIC model to update the initial state of seasonal hydrologic and crop growth forecasts. We demonstrate the value of ingesting satellite observations by performing a series of hindcast experiments over both the United States (California and Upper Colorado basins) and Kenya (Nzoia basin). In-situ measurements along with a simulation with the best available datasets are used as the benchmark to evaluate the hindcasts against. The impact of each observation type or sensor is quantified, allowing for evaluating their relative contribution to improving the forecast skill. Particular case studies that are discussed in more detail include the ongoing California as well as the 2011 East Africa droughts.