Multi-satellite Land Data Assimilation

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Global monitoring of soil moisture, snow, vegetation, and groundwater is now available through various satellite observations from optical, microwave, and gravitational sensors. However, very few modeling frameworks exist that conjointly use the above sensors to produce mutually and physically consistent earth system records. To this goal, a prototype of multi-satellite land data assimilation system is developed by linking the Community Land Model version 4 (CLM4) and a series of forward models with the Data Assimilation Research Testbed (DART).

The deterministic Ensemble Adjustment Kalman Filter (EAKF) within the DART is utilized to estimate global soil moisture and snow by assimilating brightness temperature, snow cover fraction, and daily total water storage observations from the Advanced Microwave Scanning Radiometer for Earth Observing System (AMSR-E), Moderate Resolution Imaging Spectroradiometer (MODIS), and Gravity Recovery and Climate Experiment (GRACE), respectively. A 40-member of Community Atmosphere Model version 4 (CAM4) reanalysis is adopted to introduce ensemble spread in CLM4 land states and some methods are used to reduce the computational load. Data assimilation with different combinations of sensors is implemented for 2003–2009 to investigate individual contributions from different satellite observations. Evaluation results and cross-comparison of open-loop and data assimilation cases suggest that 1) assimilation of MODIS snow cover fraction slightly improves snow estimation in mid and high latitudes; 2) lower and higher frequencies of AMSR-E brightness temperature play complementary roles in improving global soil moisture and snow estimation; 3) assimilation of GRACE tends to degrade soil moisture estimation but poses potential in improving snow depth estimation in most high-latitude regions. Generally, the combination of MODIS, GRACE, and AMSR-E observations with regard to spatial locations holds promise to provide a robust global soil moisture, snow, and streamflow estimation through the multi-satellite land data assimilation system. The land DA products are used for the first time to systematically understand the monsoon forecast skill from multi-satellite DA perspectives.

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