Advances in the GRACE Data Assimilation System

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The twin satellites of the NASA/German Gravity Recovery and Climate Experiment (GRACE) mission were launched just over a decade ago, in March 2002. Since that time, they have flown in Low Earth Orbit, 220 kilometers apart from one another, recording continuous, highly precise measurements of their location and the distance between them using GPS and a microwave ranging system. These measurements can be used to derive geodetic maps of Earth's gravitational field, since accelerations of the satellites relative to each other are influenced by the presence of gravitational anomalies. Changes in the gravitational field over time are associated with the movement of mass near Earth's surface, and over GRACE observed timescales—weeks to years—the movement of water constitutes a significant and quantifiable portion of this signal [1]. In this way, GRACE provides hydrogeodetic information by relating the temporal variations of the Earth's gravitational field to changes in the hydrologic cycle. Careful analysis of the GRACE signal over land yields estimates of terrestrial water storage (TWS) anomalies, a quantity that includes changes in surface water, snow and ice, vegetation water, soil moisture, and groundwater.

While the GRACE TWS estimate is an unprecedented observation that is of great value for basin scale hydrologic monitoring, many hydrology and water resources applications require water storage estimates at higher spatial resolution, greater temporal frequency, and with greater physical specificity (e.g., groundwater versus soil moisture versus snow) than GRACE can offer. The GRACE Data Assimilation System [2] was developed to skillfully merge GRACE information on large scale TWS anomalies with the physically-based hydrological simulation tools of advanced Land Surface Models in order to improve model simulation of water storage while disaggregating and downscaling the raw GRACE TWS estimate. The primary assimilation algorithm is a variant of the ensemble Kalman Smoother. In recent years the system has been applied to studies of water resources and drought monitoring in diverse climate conditions over four different continents. These experiences have led to refinements in the assimilation system that include modifications to land surface model parameters and the treatment of irrigation withdrawals, adjustments in the assimilation algorithm for snow updates, and, most recently, the implementation of a gridded observation assimilation capability that allows for a more flexible application of the system. This presentation will provide an overview of current GRACE-DAS capabilities, report on recent innovations in the modeling system, and describe future directions in GRACE data assimilation research and applications.

References

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