Mapping North American Snow Water Equivalent by Assimilating GRACE and MODIS into CLM

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Large scale snow water equivalent (SWE) mapping is important to climate trend detection, regional hydrological prediction, and land-atmosphere-ocean interaction analyses. Because of the dearth of ground based SWE measurements, satellite based information is increasingly utilized in mapping SWE. This research consists of two parts of investigations towards an enhanced estimation of continental scale SWE by assimilating different satellite observations into the Community Land Model (CLM) in North America. First we applied a newly developed snow cover fraction (SCF) parameterization into the ensemble Kalman filter (EnKF) system, and incorporated MODIS SCF data to optimally adjust the SWE simulations from the CLM driven by the Global Land Data Assimilation System (GLDAS). It was found that integrating MODIS information significantly improved the quality of SWE data in many areas, especially in the Northern Great Plains, western mountainous regions, and costal regions in high latitudes. The second part of work continued to quantify the incremental value of multi-sensor assimilation in SWE estimation, i.e., the adjunct assimilation of MODIS SCF data and GRACE terrestrial water storage (TWS) change data. This work was motivated partly by the limitations in MODIS (single-sensor) data assimilation. The limitations included (1) the SCF signal saturation (nearly 100%) in many high latitude regions in winter (especially in boreal forest and tundra regions); (2) the parameters uncertainty in the observational operator; and (3) the uncertain error magnitude of MODIS SCF data in the forest and mountainous regions. The data assimilation cycle consisted of two components: the MODIS update (designed in the same way as the previous work) and the GRACE update. The monthly GRACE TWS change data were assimilated into the CLM through the ensemble Kalman smoother (EnKS), which optimally distributed the water storage information to each daily SWE estimation according to the correlation matrix calculated from the ensemble simulation. Preliminary results from the multi-sensor data assimilation demonstrated that incorporating the GRACE signal largely complemented the MODIS update, and significantly improved the SWE estimation in boreal forest, tundra, and other high latitude regions where the contribution of MODIS information was limited.