Assimilation of the MODIS Snow Cover Fraction Dataset through the Coupled Data Assimilation Research Testbed and the Community Land Model

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An accurate estimate of snowpack is very important to the regions where people live on the snowmelt. Hundreds of millions of people are affected by the ice and snow that accumulate in mountain regions. Snow data is also a key input to the hydrologic and climatic models and it will influence the predictability of these models. So high-quality, spatially and temporally continuous snow product is eagerly needed. Assimilating satellite snow estimates and in-situ measurements into land surface models, which integrates the advantages of varies data sources, is proposed to address this problem.

The Data Assimilation Research Testbed (DART) is being extended to support the Community Land Model (CLM 4.0) to assimilate observations of land-based quantities such as snow cover, soil moisture, and soil temperature. This is the first effort linking DART and a land surface model. The major obstacle is to communicate a heterogeneous set of state information and metadata between CLM4.0 and DART, and to accommodate the use of multiple instances of CLM within the Community Earth System Model (CESM 1.0). The DART facility allows extensible support for additional observation types with a small amount of effort and provides a rich suite of assimilation algorithms and diagnostic tools.

Experience with other models has shown that the spread of the ensemble of CLM states is more likely to be maintained if each ensemble member has a distinct meteorological forcing. A freely available ensemble of reanalysis data created by DART and the Community Atmospheric Model (CAM) v. 4.0 is used. The ensemble of CAM reanalysis data, serving as the forcings for the ensemble CLM members , provide a reasonable spread which is critical to obtaining a good data assimilation result. However, the CAM reanalysis data may inherit systematic biases commonly found in climate models. CAM tends to have code bias and excessive precipitation in the Arctic region. This fact can partly explain that the snow depth from the CLM case driven by the CAM reanalysis forcing is deeper. The advantages and disadvantages of using this dataset will be further discussed.

As the first application of the coupled DART and CLM framework, this work is focused on assimilating the Moderate Resolution Imaging Spectroradiometer (MODIS) snow cover fraction dataset with the purpose of improving the performance of CLM on snow simulation. A test case has been made and the results show that the coupled DART and CLM tends to adjust the SWE fields where the largest snow variability exists. And the assimilation within this framework is properly reducing the Root Mean Square Error of SWE at each assimilation step.

The effectiveness of the assimilation is further assessed by evaluating the 24-hour forecasts against the observations before they are assimilated. This framework is also sustainable to assimilate ground-based observations, for example, the SNOwpack TELemetry (or SNOTEL) SWE measurements.

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