Assimilation of Remotely Sensed Snow Observations into the NSIPP Land Surface Model

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March 8, 2001

Introduction

Snow plays an important role in the global energy and water budgets, due to its high albedo, distinct thermal properties, and being a mid-term water store. However, it is difficult to accurately forecast snow in atmospheric and hydrologic models. The scale of its spatial variability is usually smaller than the resolution of these models, and the forcing generated by models contains error. By assimilating remotely sensed snow observations, we may correct errors from a Land Surface Model (LSM) snow initialization based on model spin-up. However, care must be taken to avoid erroneous systematic influences on the water budget as a result of the assimilation.

This project explores the assimilation of relevant remotely sensed snow observation products into the Catchment-based LSM (CLSM) that is being used by the NASA Seasonal-to-Interannual Prediction Project (NSIPP). This work focuses on a retrospective study of North America for the past 20 years using the uncoupled NSIPP LSM, with the perspective of the assimilation scheme being expanded globally and applied to the NSIPP fully coupled Global Circulation Model (GCM).

Goals

The primary goal of this project is to develop a framework for the assimilation of snow observation products into the NSIPP LSM. The specific objectives are as follows:

1) Development of a Kalman filtering scheme for snow data assimilation, which will overcome the current limitations in assimilation of snow water equivalent, snow depth, and snow cover.
2) Investigate the utility of novel snow observation products in such an assimilation strategy. Such observations include snow melt signature and fractional snow cover.
3) Provide a basis for global implementation of an assimilation scheme for snow observation products, both for near-real-time forecasting and for the accurate initialization of seasonal-to-interannual predictions in the NSIPP fully-coupled GCM.

Progress

1. Snow model development

Drs Stieglitz and Dery have been making improvements to the snow model component of the CLSM, by adding sub-catchment scale variability to the model. Whilst this work is relatively immature, since work was not commenced until December 2000, initial tests have been conducted on the model's sensitivity to varying forcing data and their effects on the evolution of the snowpack, by running the snow model for the Sleepers River catchment of Vermont. Tests are also underway to validate the snow pack simulation for catchments in northern Alaska during 1987. Concurrently, the accuracy of the European Center for Medium-Range Weather Forecasts (ECMWF) Re-Analysis (ERA) data used to force the simulation are being investigated in comparison with observations.

2. Snow observation data

Dr Foster has commenced work on the processing of SMMR and SSM/I passive microwave data for snow water equivalent observations. The daily swath data is being processed (Figure 1).

3. Data assimilation

Drs Walker, Houser and Sun have been making progress on the assimilation of snow observation data into the current snow model component of the CLSM. A one-dimensional Kalman filter is currently employed for each catchment. Since the model is nonlinear, the extended Kalman filter (EKF) is utilized – the nonlinear model is linearized around the current state value for forecasting the model error covariance, while the state itself evolves according to the nonlinear dynamics. In the future, a linear version of the snow model may be developed to ease the computing demand for numerical differentiation. Whilst this work is also relatively immature, with work not being commenced until late November 2000, significant progress is being made. The Kalman filter implementation is still being developed and tested within the framework of a synthetic identical-

Figure 1: Example of SMMR snow cover data for North America. White is snow and brown is no snow.

twin experiment. We are currently focusing on the snow water equivalent observations.

Summary and future directions

We expect that a substantial amount of the snow observation data will be processed and made available in the near future. The implementation of subcatchment scale variability within the snow model is being actively pursued and the data assimilation work is moving forward. Once the Kalman filtering scheme is tested and verified, we will assimilate actual satellite observations. We expect to be able to correct air temperature and land surface temperature biases, so as to provide more accurate and physically realistic forecasts of the snow pack.