A Generic, Interoperable, Hydrologic Data Assimilation Framework using the Land Information System

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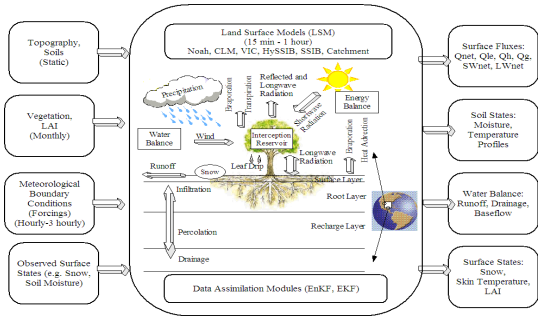
1. Overview

The Land Information System (LIS; http://lis.gsfc.nasa.gov) is a hydrologic modeling system that integrates various community land surface models, ground and satellite-based observations, and high performance computing and data management tools to enable assessment and prediction of hydrologic conditions at various spatial and temporal scales. The LIS architecture is designed using advanced software engineering principles, allowing the interoperability of land surface models, meteorological inputs, land surface parameters and observational data. In this work, we describe the extension of the LIS framework to incorporate data assimilation capabilities, through a collaborative effort. The extensible LIS data assimilation framework allows the incorporation and interplay of multiple observational sources, multiple data assimilation algorithms, and multiple land surface models. These capabilities are demonstrated using a suite of experiments that assimilate various sources observational data into different land surface models to propagate observational information in space and time. The available data assimilation algorithms include direct insertion, rule-based approaches, and ensemble Kalman Filtering (EnKF). The assimilation of soil moisture and snow water equivalent data is demonstrated using the Noah, Community Land Model (CLM), and Catchment Land Surface Model using a number of different assimilation algorithms. We will also demonstrate the ability of the system to simultaneously assimilate multiple observations. These experiments are used to demonstrate the use of the flexible, extensible LIS data assimilation framework to effectively apply hydrological observations and modeling tools to understand and improve the prediction land surface water and energy cycling.

2. Land Information System (LIS) Background



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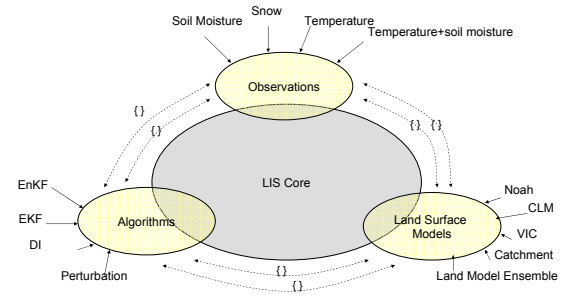
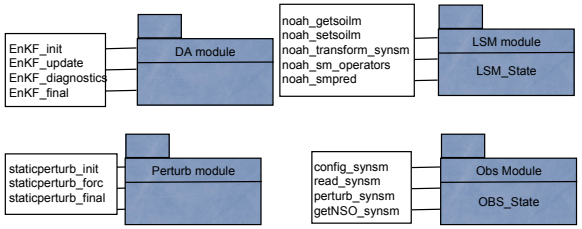
3. LIS Data Assimilation Design

- Support Multiple Data Assimilation Algorithms
  - Direct Insertion
  - Different Ensemble Kalman filter algorithms
- Support Multiple LSMs
- Support Perturbation algorithms, including perturbation frequencies, for
  - Forcing
  - Observations
  - State variables
- Support assimilation of multiple observation types
- Ability to choose spatially distributed observations for each modeling grid point
- Provide data assimilation Diagnostics (Mean, standard deviation, spread, normalized innovations)

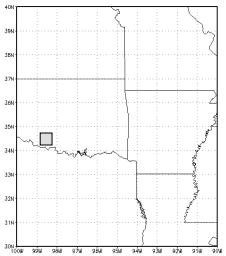
4. LIS Data Assimilation Structure



5. Data Assimilation Abstractions

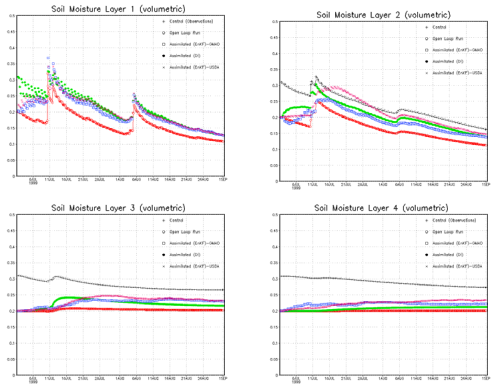


6. Soil Moisture Identical Twin Experiment (ITE)

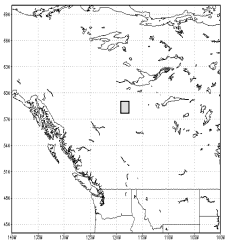


- Location :
  - Lat: 34.5 N, Lon: 98.5 W
- Noah LSM
  - 4 soil layers (10cm, 30cm, 60cm,100cm thicknesses)
- NLDAS forcing for atmospheric boundary conditions
- Control run
  - Two years of spinup leading up to July 1,1999
  - Two months of control simulations: 1 July 1999 to Aug 31, 1999.
- Open Loop Run
  - LSM simulations for July and August using a dry initial soil moisture

- Assimilating control run 10cm soil moisture every 12Z, each day into the open loop run.



7. Snow Water Equivalent Identical Twin Experiment (ITE)



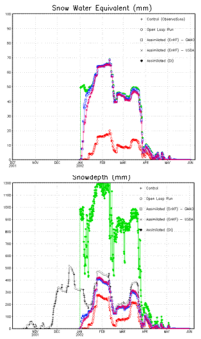
- Location
  - Lat (57-58 N), Lon (117-118W)
  - Noah LSM
  - NCEP GDAS forcing for atmospheric boundary conditions
- Control Run
  - Simulations from October 1, 2001 to June 1, 2002.
- Open Loop Run
  - Simulations from January 1, 2002 to June 30, 2002, with SWE and snowdepth initialized to zero.

Assimilation Runs

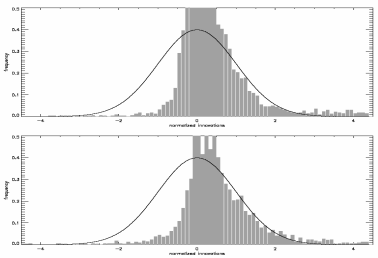
-LSM simulations from January 1, 2002 to June 30, 2002, assimilating the SWE values from the control run every day at 12Z into the open loop runs

-Simulations using Ensemble Kalman Filters.

-A direct insertion of SWE observations into the model caused the model to become unstable since the corresponding snowdepth fields was not updated automatically



8. SWE ITE Diagnostics-Normalized Innovations



9. Summary

A framework for data assimilation in LIS has been developed and demonstrated via two identical twin experiments conducted with the Noah LSM using two different EnKF implementations.

Ongoing work with AFWA, GMAO, NOAA, USDA and CREW will lead to further improvements and demonstrations including AMSR-E Soil moisture and SWE and Modis snow covered area.

Acknowledgements

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