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FORCING A GLOBAL, OFFLINE LAND SURFACE MODELING SYSTEM WITH OBSERVATION-BASED FIELDS

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1. Introduction

Satellite remote sensing of hydrometeorological states and fluxes has improved steadily over the past two decades. At the same time, increases in supercomputing power and affordability have allowed atmospheric and land surface models to gain complexity and resolution. These models have the ability to fill in observational gaps, so that incorporating data from advanced observing systems into models as forcings and constraints maximizes our knowledge of the processes and resulting states of the Earth system.

The Global Land Data Assimilation System (GLDAS), which is being developed jointly at NASA's Goddard Space Flight Center and NOAA's National Centers for Environmental Prediction, enables users to run multiple, state-of-the-art land surface models (LSMs) using a combination of modeled and observation-based forcing fields (Houser et al., 2001). Drivers have been installed for Mosaic (Koster and Suarez, 1992), the Common Land Model (Dai et al., 2001), the Catchment LSM (Koster, et al., 2000), and NOAA's NOAH LSM. The primary goal of GLDAS is to produce global, high resolution (0.25^o), near-real time fields of land surface states and fluxes. These will be used to initialize weather and climate prediction models and to facilitate flood and drought prediction, agricultural productivity forecasting, water resources decision-making, and a variety of studies in the Earth sciences.

By utilizing data from advanced observing systems, GLDAS can avoid systematic biases which arise in atmospheric model-based precipitation and radiation forcing fields and accumulate in land surface moisture and temperature states. GLDAS is enhanced further by the capability of running the one dimensional LSMs on subgrid tiles, which are based on a 1 *km* global vegetation dataset, an elevation correction based on the GTOPO30 global digital elevation model, and a soil parameterization based on Reynolds, Jackson, and Rawls (1999) 5' global soils information. Future enhancements will include satellite observation-based vegetation updates, a runoff routing scheme, and assimilation of satellite-derived snow (MODIS), soil temperature and moisture (AMSR), and terrestrial water storage (GRACE) observations.

2. Methods

GLDAS began running in near-real time on 1 March 2001, with Mosaic as the operational LSM. The spatial resolution was set to 0.25^o, with one vegetation tile per grid square, 30 minutes was the length of each time step, and Mosaic's original soil scheme was used. Surface state variables were initialized based on fields from NOAA's global, 4DDA, real time meteorological modeling system (GDAS). GDAS also provided all of the forcing data. By 30 July 2001 the time step had been shortened to 15 minutes and the primary source of forcing data had been changed to NASA's GEOS 3.24 global, 4DDA, real time meteorological modeling system. Temporal and spatial interpolation has been required to derive forcing from the GDAS and GEOS files, which are produced every three hours at 0.7^o and 1.0^o resolutions, respectively.

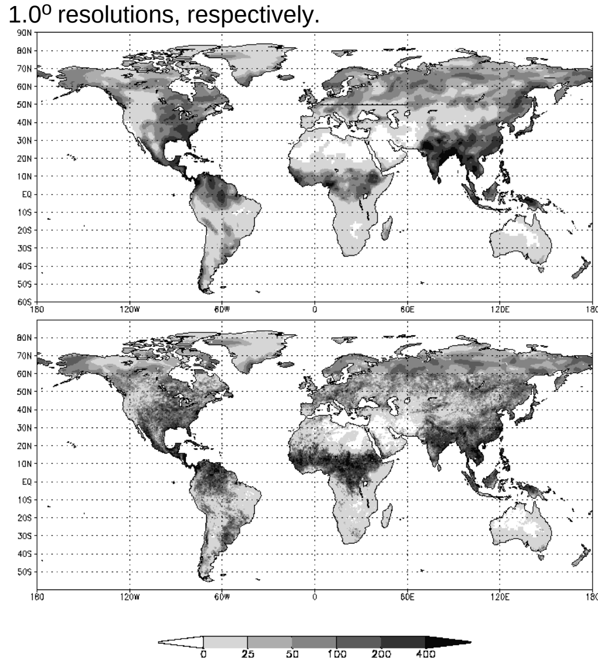

Figure 1: Monthly total precipitation [mm], August 2001. Top: GEOS model. Bottom: Combination of NRL satellite-derived precipitation and GEOS.

Since 31 July 2001, geostationary satellite infrared (IR) and TRMM / SSM/I microwave-based, 0.25^o, 6-hourly mean rain rate fields from the U.S. Naval Research Laboratory (NRL) have been incorporated into the forcing. NRL does not generate precipitation estimates poleward of 60^o, and TRMM / SSM/I coverage is incomplete at 6-hourly resolution. Therefore GLDAS uses GEOS precipitation as a base, overlays NRL IR-based rain, and overlays the result with NRL microwave-based rain.

A restart file was used to initiate a run of GLDAS which paralleled the operational run between 31 July and 31 August 2001. All parameters were identical in the two runs, except that NRL observation-based rain was not used in the test run. The hypothesis was that

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using observation-based precipitation forcing has a positive effect on the modeled state of the land surface.

3. Results

Figure 1 contrasts the August 2001 total precipitation produced by the GEOS operational atmospheric model with that derived from satellite observations by NRL. The general global patterns and quantities are similar, which suggests that neither product is wildly unrealistic. The principle discrepancy is in the small scale variability of rainfall accumulations. On a 6-hourly timescale (not shown), GEOS tends to generate lighter rain with broader regional coverage as compared to the more localized and intense storm bursts in the NRL fields. For August 2001 these localized bursts summed to produce coverage which was similar to GEOS precipitation. However, the spotty nature of the NRL precipitation is manifested in the fine scale heterogeneity of the monthly total field.

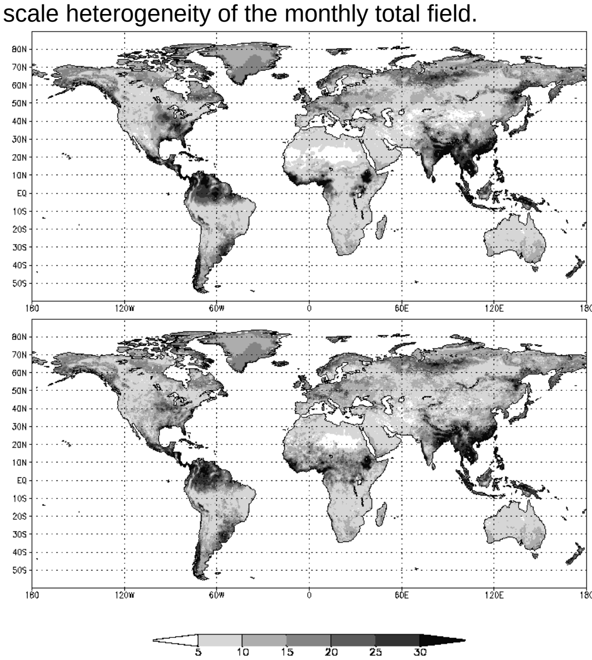

Figure 2: Volumetric soil water content (upper 1 m) [%] output from GLDAS (Mosaic), 21Z 31 August 2001. Top: Forced by GEOS. Bottom: Forced using NRL satellite-derived precipitation.

Figure 2 compares the GLDAS output soil moisture from the end of the two runs (31 August 2001). The soil moisture field from the observation-forced run displays more fine scale heterogeneity than that from the model-forced run. Surface runoff (not shown) was generally greater in the operational run as well. These results stand to reason given that the GEOS precipitation is generally lighter and more homogenous. Figures 1 and 2 also reveal discrepancies between the two types of precipitation forcing. In particular, the observation-based forcing makes central Africa wetter and the southeastern United States dryer. Further study will be required to determine whether these differences persist and which product is more realistic.

4. Discussion

A major theme of the GLDAS project is the utilization of observation-based fields for forcing and constraining land surface models. The results of this investigation support the feasibility of that approach by demonstrating that 1) observation-based develop similar large scale patterns of precipitation accumulation over the course of a month, and 2) believable patterns of soil moisture develop when the observation-based precipitation fields are used as forcing. Furthermore, the small scale heterogeneity seen in the observation-based precipitation fields and resultant soil moisture output fields is likely to be more realistic than the spatial uniformity produced by the modeled forcing. When GLDAS output fields of land surface states are used to reinitialize global coupled meteorological models, the small scale heterogeneity in soil moisture, to which the atmosphere is sensitive, may feed back to have a positive effect on those model simulations.

During the period of study, TRMM / SSM/I rain was not available for 108 non-consecutive hours and IR rain was not available for 114 non-consecutive hours. These data gaps overlapped for 90 hours, during which time GLDAS relied on GEOS forcing exclusively. Therefore the observed precipitation field in Figure 1 (and likewise the output in Figure 2) might be slightly more similar to GEOS field than it otherwise would be. Data gaps are likely to be unavoidable when modeling in near-real time, so the results shown here can be considered representative of GLDAS.

For more results and a detailed description of the GLDAS project, please visit http://ldas.gsfc.nasa.gov.

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