1.1 OPTIMAL LAND INITIALIZATION FOR THE NCEP GLOBAL FORECAST SYSTEM USING THE NASA LAND INFORMATION SYSTEM

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1. INTRODUCTION

Accurate initialization of land states, namely, soil moisture, soil temperature, and snowpack, is critical in numerical weather and climate prediction systems because of their regulation of simulated water and energy fluxes between the land surface and atmosphere over a variety of time scales. Currently, land states in prediction systems are often found to have substantial errors owing to bias in the land surface forcing of the coupled systems, mainly in precipitation and surface radiation. A research project is ongoing in close collaboration between NASA and NOAA using the NASA Land Information System (LIS, http://lis.gsfc.nasa.gov/) to generate alternative land initial conditions for the NOAA NCEP Global Forecast System (GFS). The goal is to investigate the influence of enhanced land initial conditions on the prediction system. A LIS infrastructure has been built on the NCEP supercomputer where the operational GFS is executed. At this development stage, this system is configured identically to the seasonal forecast mode of GFS including the same T62 gaussian grid projection (1.875° resolution), land-sea mask, terrain height, and soil and vegetation specifications. A baseline GFS simulation that uses the NCEP Noah land surface model (Ek et al., 2003) will be executed as the control run also providing the baseline atmospheric forcing. The same version of Noah will be used in this LIS simulation. Observation based, both in situ and satellite driven, precipitation and surface radiation are used as alternative forcing. With the advantage of its high performance parallel computing technique, LIS is able to generate offline uncoupled land initial conditions ensemble in a prompt manner.

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In this paper, the simulated land states and fluxes corresponding to the alternative land surface forcing will be compared to the corresponding baseline GFS fields. The translation from the perturbation in the forcing to that in the resulting land states will be quantified. Selected observations from the Coordinated Enhanced Observing Period (CEOP) reference sites will be used for evaluation.

2. METHODOLOGY AND DATA

The baseline GFS simulation used in this study is an experimental version (Lu and Mitchell, 2004) that utilizes the Noah land surface model as part of NCEP efforts to unify the land-model component in all NCEP global and regional models and their associated 4-dimentional data assimilation systems. The LIS experiments are conducted with the one-time identical initial GFS soil temperature and moisture for the four soil layers (0-10, 10-40, 40-100, 100-200 cm), and the identical atmospheric forcing from the GFS forecast fields with optional alternative observation based precipitation and surface radiation. The focus in this paper is to evaluate the impact of the alternative forcing on the time scale of one to a few months.

The NCEP Climate Prediction Center (CPC) product of pentad CMAP (CPC Merged Analysis of Precipitation, Xie and Arkin, 1997) is used as the alternative precipitation forcing. CMAP merges gauge measurements and satellite estimates including GPI, OPI, and SSM/I, to produce a global 2.5° pentad precipitation analysis. In this study, the baseline GFS forecast precipitation field is constrained that the 5-day accumulation over the 2.5° area average will be conserved to the corresponding CMAP, while retaining the original GFS spatial and temporal resolutions.

The radiation algorithm from the United States Air Force Weather Agency (AFWA) AGRMET global land surface modeling system (Shapiro, 1987) is used as the alternative radiation forcing.

AGRMET uses the AFWA World Wide Merged Cloud Analysis (WWMCA, previous known as RTNEPH, Hamill et al., 1992) as the primary input to calculate surface radiation. WWMCA/RTNEPH is derived from the satellite images from the geostationary and polar-orbiting satellites of the NOAA satellite systems and the Defense Meteorological Satellite Program (DMSP). We have acquired the cloud analysis and radiation code from AFWA for the on site execution to calculate surface radiation at a 24 km spatial resolution and an hourly temporal resolution. The calculated AGRMET radiation will be then interpolated to the GFS spatial resolution.

The simulations start at 00Z August 1, 2003, using the identical initial land conditions obtained from the baseline GFS fields. The LIS/Noah executions integrate for one month through 00Z, September 1, 2003, using baseline and alternative forcing.

3. PRELIMINARY RESULTS

Figure 1 shows the difference in the August 2003 monthly accumulate precipitation between the GFS forecast and CMAP analysis over the region of the continental United States. GFS in general has more precipitation in the extension from the Rockies to Texas and northern Mexico, and along the Atlantic coast, with only a few grid points exception. The scale of 60 kg m^{-2} can be converted to approximately 2.5 inches.

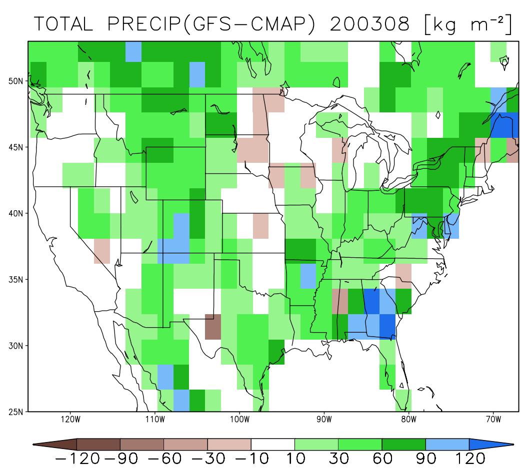

Figure 1. Difference in the August 2003 monthly accumulate precipitation between GFS and CMAP.

Figure 2 shows the difference in the simulated 2 meters column total soil moisture at the end of the one month integration between the executions using baseline and alternative forcing. Not surprisingly, the higher precipitation from GFS leads to the wetter soil in areas where the precipitation differences are significant. The high spatial correlation between Figure 2 and Figure 1 is expected since the quantity shown in Figure 2 can be also interpreted as the differences in the soil water storage changes from the beginning to the end of simulation between the two executions.

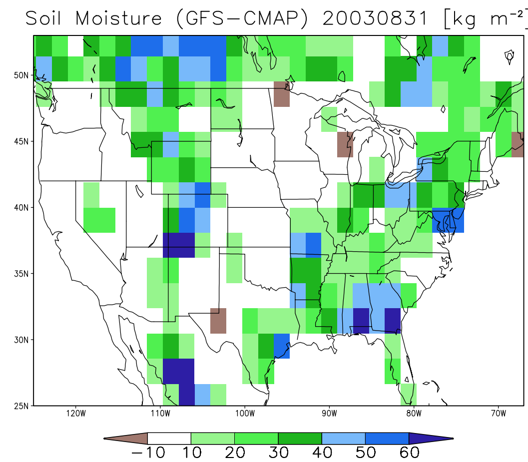

Figure 2. Difference in the simulated 2 meters column soil moisture from two LIS/Noah executions on August 31, 2003. The first execution used the baseline GFS forcing, and the second one uses the alternative forcing.

In situ observations of CEOP are widely used for climate analysis and model evaluation. There are about 40 CEOP reference sites around the globe to collect and integrate high quality measurements including near surface meteorology, surface energy and water cycles components, and soil moisture and temperature. Those valuable data will be used for continuous evaluation for the current and future experiments through this project.

Figure 3 shows the August 2003 monthly mean diurnal cycles of simulated surface latent heat fluxes against observation at the CEOP reference site of Bondville, Illinois. The baseline GFS forecasts a much higher peak value as compared to the observation. The LIS/Noah execution with alternative forcing, however, simulates a lower peak that is closer to the observation. It is worth noting that this is a comparison between point measurement and model grid value over an area of approximately 200×200 km^2. There is a lot uncertainty within the model grid associated with sub-grid scale heterogeneity. LIS has the capability to perform a global execution on a high spatial resolution of 1 km. We have learned during the LIS development that results from the 1 km execution are generally in good agreement against in situ observations.

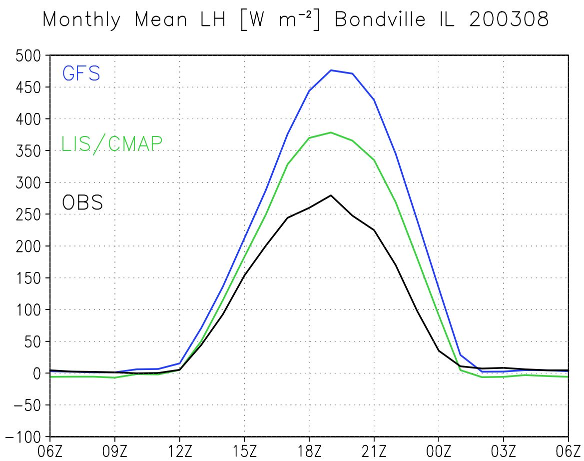

Figure 3. August 2003 monthly mean diurnal cycles of simulated surface latent heat fluxes against observation at the CEOP reference site of Bondville, Illinois. Blue is the baseline GFS forecast. Green is the LIS simulation with alternative forcing. Black is the observation.

4. CONCLUSIONS

A LIS infrastructure has been built on the NCEP supercomputer and configured to the identical land component of the seasonal forecasting mode of GFS to perform off line execution of the Noah land surface model. The interface has been established to use the GFS forecast as the baseline forcing with optional observation based alternative forcing. Preliminary results show that the impact of the alternative forcing on the simulated land states can be quantitatively identified. It is also encouraging to see a better agreement between the simulation and in situ observation when the lower biased alternative forcing is used. The next step of this project is to establish the interface to deliver the off line LIS/Noah simulated land states back to GFS to perform sensitivity experiments of its impact on the consequent GFS forecast.

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