# Land Surface Processes Simulated from the NCEP GFS Coupled with the Noah LSM: A Comparative Study using the CEOP EOP-1 In-situ Observations

**Cheng-Hsuan Lu [1,2] and Kenneth Mitchell [2]**
**[1] RS Information Systems Inc, McLean, VA**
**[2] Environmental Modeling Center, NOAA/NWS/NCEP, Camp Springs, MD**

**Abstract**

In situ surface and sub-surface observations obtained from the Coordinated Enhanced Observing Period (CEOP) EOP-1 are used to evaluate land surface processes simulated in the NCEP Global Forecast System (GFS). Two sets of GFS simulations are analyzed, one is based on the operational version and the other uses the experimental version coupled with the Noah Land Surface Model (LSM).

## 1. Introduction

In this study, the Coordinated Enhanced Observing Period (CEOP) EOP-1 in situ observations are used to evaluate land surface processes simulated in the NCEP Global Forecast System (GFS). The fields of interest are surface meteorology and fluxes (near-surface temperature, humidity, sensible heat flux, and latent heat flux) and sub-surface fields (soil heat flux, soil temperature, and soil moisture). Among 41 reference sites in the CEOP network, only 10 sites contain both surface and sub-surface observations. This study, therefore, focuses on data from selected sites where multi-layer soil temperature and moisture observations are available.

## 2. Model and Experiment Setup

The model used for this study is a global spectral model with T42 resolution (~ 300km) in the horizontal and 28 levels in the vertical. It is a slightly modified version of the GFS used for medium range weather forecasting at the NCEP. Key model physical parameterizations include the Relaxed Arakawa Schubert convection, long wave and short wave radiation, explicit cloud microphysics, non-local vertical diffusion and gravity wave drag.

The operational version of GFS utilizes the Oregon State University (OSU) LSM (Pan and Mahrt, 1987). As part of the efforts to unify land model in all NCEP global and regional models and their associated data assimilation systems, NCEP community Noah LSM (Mitchell et al., 2002) has been implemented into the test bed for the NCEP Global Forecast System (GFS) in late 2002.

In this study, two versions of GFS are used, one is the operational version using the OSU LSM and the other is the experimental version coupled with the Noah LSM. A series of 5 day forecast with hourly output throughout the CEOP EOP-1 (covers the time period from 1 July, 2001 to 30 Sept, 2001) is conducted. The initial conditions are taken from NCEP Global Data Assimilation System (GDAS) analysis at 00Z. In this study, results from day 1 forecast are presented.

## 3. CEOP Reference Sites

The Coordinated Enhanced Observing Period (CEOP) is a coordinated international activity aimed to establish an integrated global observing system for the water cycle. It contains satellite data, model and assimilation output, and in situ observations, with a focus on hydrometeorological processes in the atmosphere and land surface.

There are 41 CEOP reference sites distributed around the globe. Data sets sampled at these references sites include: (1) hourly surface meteorology, flux, and radiation, and (2) hourly soil heat flux, moisture, and temperature. However, only 10 stations contain both surface and sub-surface data (Figure 1). Sites selected for this study are grouped according to their associated experiments, including BALTEX (The Baltic Sea Experiment), CAMP (CEOP Asia Monsoon Exp), LBA (The Large Scale Biosphere-Atmosphere Experiment in Amazonia), MAGS (The Mackenzie Gewex Study), and GAPP (Gewex American Prediction Project).

## 4. Results

Figures 2 presents the near surface temperature comparison between CEOP observations and GFS results at 4 CEOP reference sites, e.g., Pantanal of central Brazil, Mongolia, Lindenberg of German, and Southern Great Plains (SGP) stations. The agreements between GFS-simulated and CEOP-observed temperature are reasonable at these sites except for Pantanal where significant differences up to 6-7 degree are found. In general, GFS employed the OSU LSM leads to a slighter higher temperature than that using the Noah LSM.

Figures 3 and 4 show the comparisons for sensible and latent heat flux at SGP, Pantanal, and Lindenberg sites. Note that surface heat fluxes are not sampled at the Mongolia site. Sensible hear fluxes [latent heat fluxes] simulated by the experimental version of GFS (using the Noah LSM) are lower [greater] than those simulated from the operational GFS (using the OSU LSM). The discrepancy between GFS simulated and CEOP observed fluxes can be partially attributed to the positive bias in incoming solar insolation in the NCEP GFS (shown in Figure 5).

Finally, results from sensitivity studies are presented in Figure 6. Four sets of GFS simulations (from 00Z07Jul to 23Z12Jul) are conducted, one uses the operational version and the other three use the experimental version (with varying model configuration: T62 L28, T62 L64, T254 L64). In general, model results show weak sensitivity to the model configuration at these sites except for the Pantanal site.

## 5. Conclusions

This study presents the comparison results between in situ observations and GFS model results at CEOP reference sites. Two sets of GFS runs are conducted, one is based on the operational version and the other is an experimental version that coupled with the Noah LSM.

The agreement between GFS simulated and CEOP observed fields are found to vary among reference sites. Caveats to LSM assessment encountered in this study are: (a) positive solar insolation bias in parent atmospheric model; (b) fair evaluation of Noah LSM awaits use of continuously cycled Noah LSM land states in GDAS.

To achieve a comprehensive assessment, future studies are needed. A brief list is given below:

- Extend the number of reference sites
- Include the sub-surface fields in the comparison study
- Analyze the partition of energy balance
- Initialize from GDAS cycled with Noah LSM

## References

Mitchell et al., 2002: Recent GCIP-sponsored advancements in coupled land-surface modeling and data assimilation in the NCEP Eta Mesoscale Model, *Reprints, 15th Conf. On Hydrology*, AMS, Long Beach, CA, 180-183.

Pan and Mahrt, 1987: Interaction between soil hydrology and boundary layer developments, *Boundary Layer Meteorol.*, **38**, 185-202.

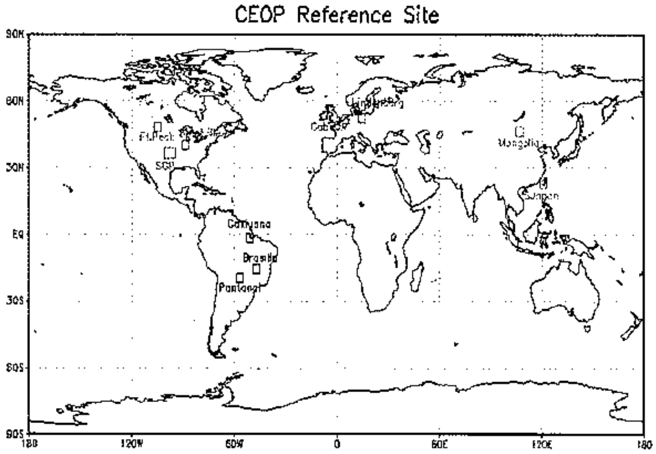


Figure 1. Distributions of CEOP reference sites selected in this study. Sites marked by red, blue, cyan, green, and yellow are associated with BALTEX, LBA, CAMP, GAPP, and MAGS, respectively.

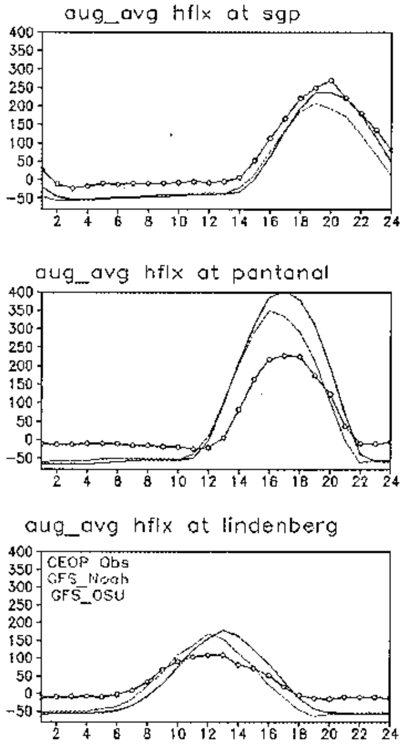


Figure 3. Surface sensible heat flux (in W/m$^2$), averaged over 2001 August, at SGP (top), Pantanal (middle), and Lindenberg (bottom). In situ observations, GFS_Noah run, and GFS_OSU runs are marked by red, green, and blue, respectively.

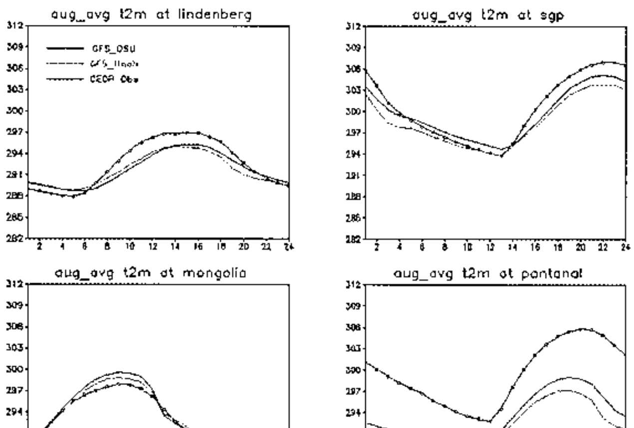


Figure 2. Near surface temperature time series (in K), averaged over 2001 August, at Lindenberg (top-left), SGP (top-right), Mongolia (bottom-left), and Pantanal (bottom-right). In situ observations are marked by red and GFS runs are marked by green (Noah LSM) and blue (OSU LSM).

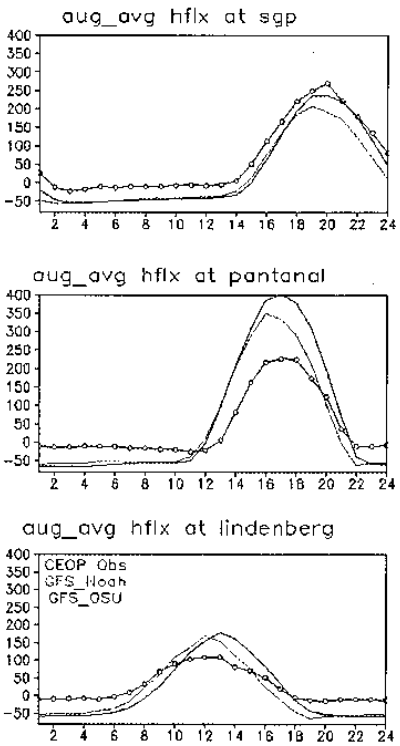


Figure 4. Same as Figure 3, except for latent heat fluxes (in W/m$^2$).

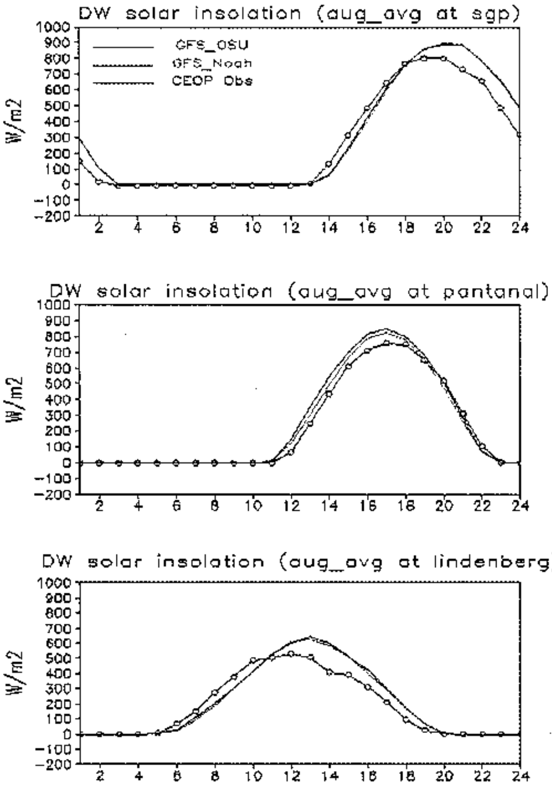


Figure 5. Same as Figure 3, except for downward solar insolation (in W/m$^2$).

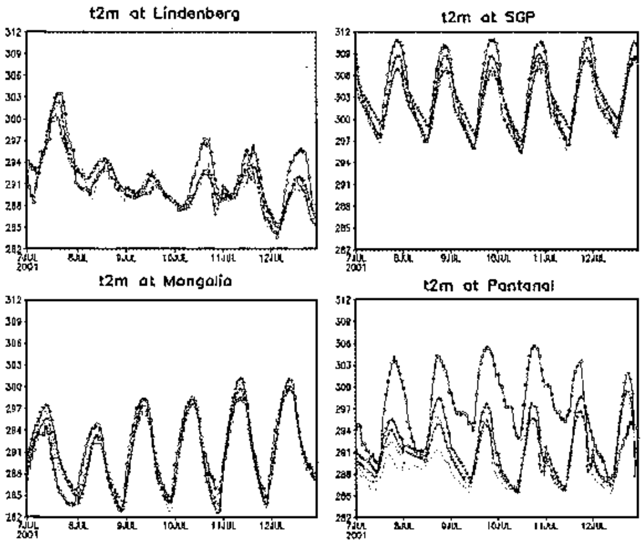


Figure 6. Time series (00Z07Jul to 23Z12Jul) from CEOP Observations (red), GFS_OSU runs (blue) and GFS_Noah runs using three model configurations: T62L28 (green), T62L6 (magenta), T254 L64 (brown).