Implementation of the NCAR Community Land Model (CLM) in the NASA / NCAR Finite-Volume Global Climate Model (fvGCM)

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1. INTRODUCTION

In this study, the recently developed stateof- of-the-art NCAR Community Land Model (CLM) version 2.0 land-surface model (Dai et al. 2002; Zeng et al. 2002) was integrated into theNASA/NCAR finite-volume Global Climate Model(fvGCM; Lin and Rood 2002). The CLM2 provides a comprehensive physical representation of soil/snow hydrology and thermal dynamics and biogeophysics. The CLM2 was developed collaboratively by an open interagency/university group of scientists, and based on well-proven physical parameterizations and numerical schemes that combine the best features of three previous land surface models: Biosphere-Atmosphere Transfer Scheme (BATS; Dickinson et al. 1993), the NCAR Land-surface Model (LSM; Bonan 1996), and the IAP94 snow model (Dai and Zeng 1996). The Data Assimilation Office (DAO) has collaborated with NCAR to produce the NASA/NCAR fvGCM, which is a unified climate, numerical weather prediction, and chemistrytransport model suitable for data assimilation, with the DAO's finite-volume dynamical core and NCAR's suite of physical parameterizations.

2. RESULTS

The fvGCM coupled CLM2 was run at 2 x 2.5° horizontal resolution with 55 vertical levels for a 15-year period from 1991-2006 with initial conditions based on AMIP (Atmospheric Model Intercomparison Project) and fixed sea-surface temperatures based on an annual climatology. The 10-year climate from the fvGCM CLM2 Control run was then intercompared with the climate from fvGCM LSM, the European Center for Medium-range Weather Forecasting (ECMWF) reanalysis and the National Centers for Environmental Prediction (NCEP) reanalysis. We concluded that the incorporation of CLM2 did not significantly impact the fvGCM atmospheric climate circulation from that of LSM. The most striking difference was the warm bias in the CLM2 surface skin temperature over desert regions, which was equal and opposite to the LSM cold bias (Figure 1). We determined that the warm bias can be partially attributed to the value of the drag coefficient for the soil under the canopy (csoilc), which was too small for sparsely vegetated regions resulting in a decouplingbetween the ground surface and the canopy. We also found that the canopy interception was high compared to observations in the Amazon region. We performed several experiments designed to improve the CLM2 representation of surface hydrologic processes and the model's computational performance.

The experiments (Table 1), each of which included only one of the modifications, were run for 5 years starting in January 2000. All of the experiments were intercompared with the Control (the initial test case) based on a 2000-2004 average. The following experiments were completed: the exponential csoilc scheme (Experiment I), the leaf heat capacity scheme (Experiment II), the implicit leaf temperature scheme (Experiment III), the revised interception scheme (Experiment IV), the revised interception with sub-surface runoff turned off (Experiment V), and an experiment including all of the modifications (Experiment VI).

For Experiment I, csoilc was considered a function of vegetation density as represented by the LAI (Leaf Area Index), in order to correct the warm bias resulting from the decoupling. Analysis of the results revealed that there was a substantial impact, and the warm and dry bias in the fvGCM CLM2 was significantly reduced. The global annual mean bias and standard deviation for the intercomparisons of skin temperature with NCEP reanalysis presented in Figure 1, show a reduction in the standard deviation and the bias for Experiment I compared to the Control. Experiment II, the leaf heat capacity scheme, which was shown to improve the memory of skin temperature and impact its diurnal cycle, had only a marginal impact on the annual mean (Figure 1). Experiment III included changes to the numerical scheme that solves the water and energy balance of the vegetation canopy. An implicit scheme, which is scientifically accurate and computationally more efficient, replaced the explicit scheme previously used in CLM2 (Wang et al. 2002a). While the implicit scheme saves computation time, it does not cause noticeable changes in the model results (Figure 1)

For Experiment IV, the change involved incorporating precipitation sub-grid scale variability into the canopy interception scheme, which causes a decrease of interception loss and subsequent increase in the canopy throughfall (Wang et al. 2002b). The results from the 5-year run show that the new interception

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run show that the new interception scheme causes about 0.5° in warming, which in turn increases the CLM2 warm bias when compared to NCEP (Figure 1). The positive impacts were an increase in the low-level moisture and a significant decrease in the interception loss ratio (canopy evaporation to precipitation). Experiment V included the modified interception scheme but with Z. -L. Yang and G. -Y. Niu's sub-surface runoff scheme turned off. This was done to correct some overestimation of lateral sub-surface runoff, which may have resulted from not considering the impact of topography in the runoff scheme. This produced a more realistic runoff ratio (runoff to precipitation). Inhibiting the sub-surface runoff also reduced the warming caused by the revised interception scheme (Experiment IV) and the results from Experiment V did not deviate much from the Control (Figure 1).

In Experiment VI, all of the modifications were incorporated and the largest and most beneficial change was attributed to the exponential csoilc scheme, which considerably decreased the warm bias in the CLM2 when compared to the Control. This result was expected based on Figure 1, which shows Experiment I having the most substantial impact. Also, the standard deviation from Experiment VI does not differ greatly from that of the fvGCM LSM (Figure 1).

Table 1: Description of experiments.

Experiment	Description
Control	Initial fvGCM CLM2 run
Experiment I	Exponential csoilc
Experiment II	Leaf heat capacity
Experiment III	Implicit leaf temperature
Experiment IV	Revised interception
Experiment V	Exp. IV w/o subsurface runoff
Experiment VI	All of the modifications (I-V)

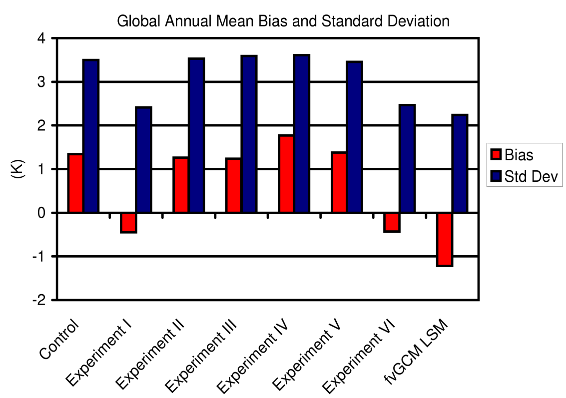

Figure 1. The global annual mean standard deviations of surface skin temperature between the Control, Experiments I-VI (Table I), and fvGCM LSM versus NCEP.

3. REFERENCES

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