# Impact of Upgrading the Land Surface Model and the Land Surface Initial Conditions in Experimental Hindcasts of the NCEP Climate Forecast System (CFS)

*Kenneth Mitchell, Rongqian Yang, Jesse Meng*

NOAA National Centers for Environmental Prediction, Camp Springs, Maryland

## CFS Improvement Thrusts at NCEP

**Higher resolution**

T126 vs T62 (about 1-deg vs. 2-deg)

**Improved physics**

Atmosphere:improved radiation

Ocean: MOM-4 replaces MOM-3

Sea ice: new sea ice model

**Land: Noah LSM replaces OSU LSM**

**Improved initial analysis / data assimilation**

Atmosphere: GSI replaces SSI

Ocean: GODAS added

**Land: Global Land Data Assimilation**

## Noah LSM vs. OSU LSM in NCEP Global Model

- 4 soil layers (10,30,60,100 cm) vs. 2 soil layers (10, 190 cm)
- land surface evaporation: *reduced high bias in warm-season*
- vegetation cover: *improved properties and seasonality*
  - improved seasonal cycle of green vegetation fraction
  - spatially varying root depth (1-2 m) vs. constant 2 m
- add frozen soil physics (freeze/thaw latent heat, limit infiltration)
- snowpack physics improvements: *greatly reduced early melt bias*
  - add snow density state variable (retain SWE)
  - retain some snowmelt in snowpack and allow refreezing
  - refine functions for snow cover fraction and snow albedo
  - add patchy snow cover treatments to snow sublimation, sensible & ground heat flux, skin temp
  - improved numerics/robustness for very shallow snow
- transpiration: refine soil moisture threshold for stress onset
- direct soil evaporation: revise dependence on soil moisture
- smaller ground heat flux bias especially: wet soil, under snowpack, under dense vegetation
  - new functions for soil thermal diffusivity and soil heat capacity

**Conclusion: The Noah LSM exhibits promising indication of improving CFS summer season forecasts of precipitation over CONUS if Noah LSM compatible initial land states are provided by GLDAS/Noah.**

## Land Models in the Current & New CFS

| | New CFS | Current CFS |
|---|---|---|
| Horizontal Resolution | T126 ( ~1° global, 384 X 190 ) | T62 ( ~2° global, 192 X 94 ) |
| Soil Layers | 4 layers ( 10, 30, 60, 100 cm ) | 2 layers ( 10, 190 cm ) |
| Land Surface Model | Noah<br>• addition of frozen soil physics<br>• improved physics:<br>– snowpack<br>– evaporation<br>– ground heat flux<br>– infiltration & runoff | OSU |
| Land Initial Conditions | GLDAS/ LIS/Noah | Global Reanalysis 2/OSU |

## T126 CFS Land Experiments (8) with CFS/Noah & CFS/OSU

| Choice of Land Model | CFS/Noah | CFS/OSU |
|---|---|---|
| Choice of Land Initial Conditions | ▶ GLDAS/Noah | GLDAS/Noah |
| | GLDAS/Noah Climatology | GLDAS/Noah Climatology |
| | GR2/OSU | ▶ GR2/OSU |
| | GR2/OSU Climatology | GR2/OSU Climatology |

**Experiment Goal:**

10 years x 2 seasons (winter/summer) x 10 members x **8** Experiments

**Experiments Completed to date:**

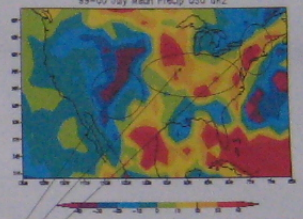
2 years X 10 members x the 3 experiments denoted above by "▶"--

Two Summers: 1999 (wet U.S. monsoon), 2000 (dry U.S. monsoon)

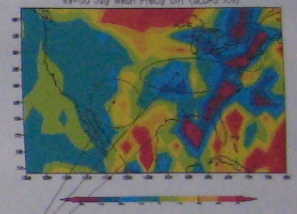
## Interannual Precipitation Difference (mm): July1999-minus-July2000

10-member CFS Ensemble Mean Fcst initialized from mid June

CFS Control: T126 CFS / OSU / GR2



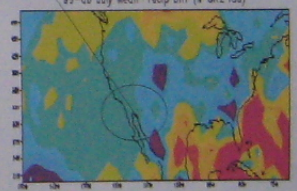
CFS Test 1: T126 CFS / Noah / GLDAS



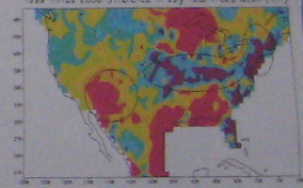
Wrong sign of interannual difference

Correct sign of interannual difference

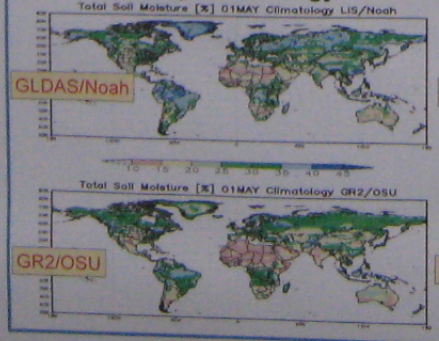
CFS Test 2: T126 CFS / Noah / GR2



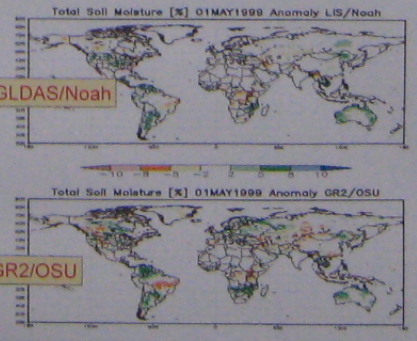
OBSERVED



## 2-m total soil moisture [%]: 01 May Climatology




## 2-m total soil moisture [%]: 01 May 1999 Anomaly




## Illinois 2-meter Soil Moisture [mm] 1985-2004