Towards Improvement of the NCEP Noah LSM in the NLDAS during the Warm Season

Helin Wei, Kenneth Mitchell, Michael EK and Youlong Xia

NOAA National Centers for Environmental Prediction, Camp Springs, Maryland

Abstract

The NCEP Noah land surface model (LSM) has been extensively evaluated with in situ observations over the southern Great Plains during the North American Land Data Assimilation System (NLDAS) Phase I simulation periods (May - September of 1998 and 1999). The model does a fairly good job but still some discrepancies in the surface energy partition between model and observations. The Bowen ratio is too low in the spring and too high in the summer. To improve the performance, we have further refined some parameters particularly those related to the calculation of canopy resistance such as the soil moisture stress function, vapor pressure deficit function, and minimum canopy resistance values. Varied LAI and root fraction have been applied as well to reflect its seasonal variation which has significant consequence on the temporal evolution of surface fluxes.

The new version of Noah LSM has been used to rerun NLDAS Phase I 3-year core period as well as some sensitivity tests. These results have been validated against some observation data. It is found that the high/low latent heat flux biases during the spring/summer have been reduced in the new version. Also the surface skin temperature and the surface water budget have been improved significantly.

Experimental Design

CNTR Constant LAI=3

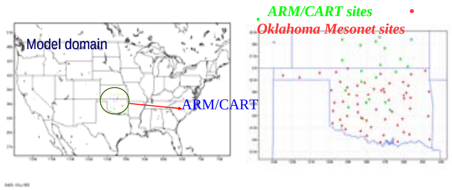
SLAI Seasonal LAI

Seasonal LAI Approach

$$LAI = LAI_{min} + (LAI_{max} - LAI_{min}) * \alpha$$

$$\text{where } \alpha = (f - f_{min})/(f_{max} - f_{min})$$

LAI_{min} and LAI_{max} are from Brian Cosgrove's table.



simulation period: Oct.,1996 - Sep.,1999

RTDS Seasonal LAI & Root Fraction + Vapor Pressure Deficit Function + more

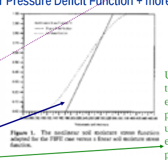
$$R_c = \frac{R_{cmin}}{LAI\,F_1 F_2 F_3 F_4}$$

$$F_1 = \frac{R_{cmin}/R_{cmax} + f}{1 + f} \quad \text{where } f = 0.55\frac{R_g}{R_{gl}}\frac{2}{LAI}$$

$$F_2 = \frac{1}{1 + h_s[q_s(T_a) - q_a]}$$

$$F_3 = 1 - 0.0016(T_{ref} - T_a)^2, \quad \text{and}$$

$$F_4 = \sum_{i=1}^{n} \frac{(\Theta_i - \Theta_w) d_i}{(\Theta_{ref} - \Theta_w)(d_1 + d_2 + \dots)}$$

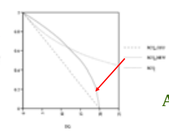


Using a narrow range of this tends to overestimate the evaporation during wet periods (spring) and underestimate the evaporation during dry periods (summer).

From Chen et al. 1996

SMHIGH and SMLOW

BXEXP



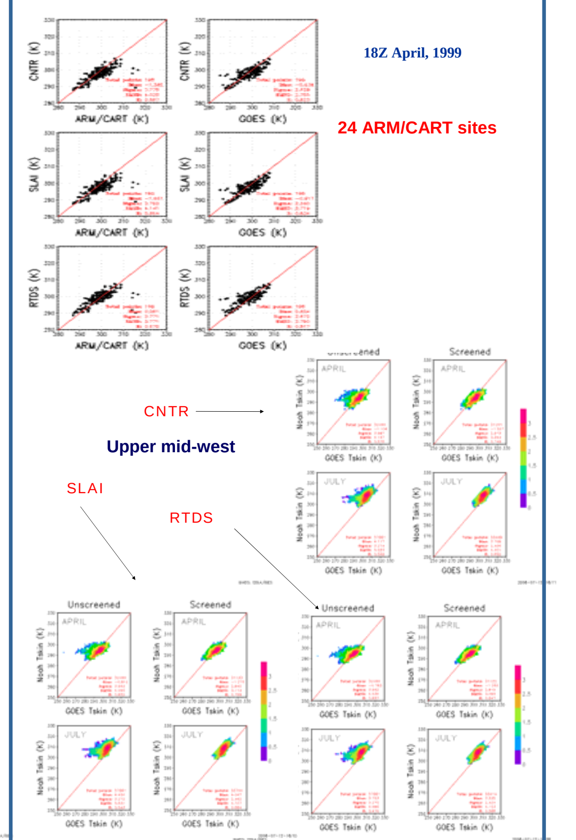
Adding a seasonal factor to root distribution:

$$f = 1 - 0.0016*(T_{opt} - T_{gm})^2$$

Topt: Optimum root growth temperature (298 K)

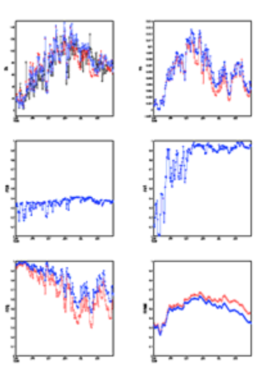
T_{gm}: mean soil temp over the root zone

Results (Surface Skin Temp)



Sensitivity Tests of Canopy Resistance Factors

Averaged over 24 ARM/CART sites



One example of many sensitivity tests

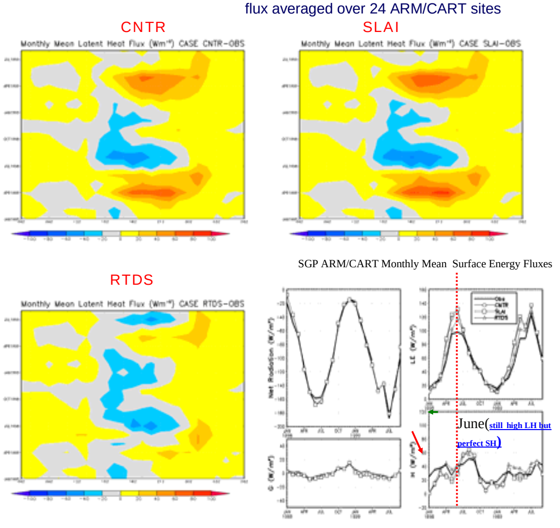
Black: Obs

Red: CNTR

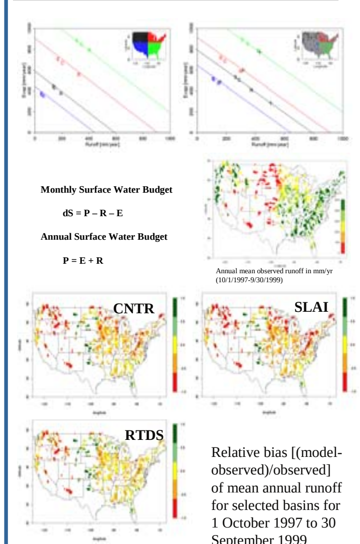
Blue: Sensi

Results (surface fluxes)

Monthly mean diurnal cycle of latent heat flux averaged over 24 ARM/CART sites



Surface Water Budget



Relative bias [(model-observed)/observed] of mean annual runoff for selected basins for 1 October 1997 to 30 September 1999

Conclusions

- Seasonal LAI and root fraction have been implemented to Noah LSM.
- Some parameters have been retuned especially for those related to computing canopy resistance (vapor pressure deficit function, soil moisture function).
- The new version of Noah LSM has yielded better surface fluxes, particularly both the high LH bias during the spring and the low LH bias during the summer have been reduced.
- The warm bias of the surface skin temperature has been reduced.
- The new version of Noah LSM produces better surface water budget, i.e. surface runoff.