ASSESSING IMPACTS OF INTEGRATING MODIS VEGETATION DATA IN WEATHER RESEARCH FORECASTING (WRF)/NOAH COUPLED MODEL

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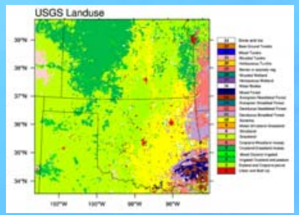
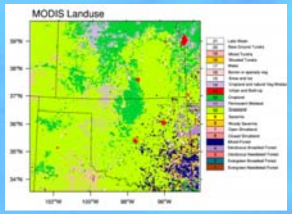
This research is supported by JCSDA

Goal: Evaluate impacts of incorporating MODIS 8-day, 1-km leaf area index (LAI), green vegetation fraction (GVF), and land-use data in WRF/Noah on regional weather prediction

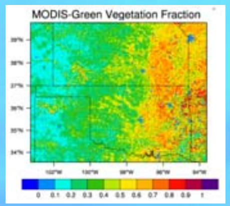
Introduction: **The MODIS products provide a number of vegetation parameters at higher spatial and temporal resolution than the AVHRR-based climatology data currently used in WRF. These high-resolution, near-real-time MODIS data are hypothesized to be more accurate to reflect variations in vegetation characteristics. We first assessed the impact of MODIS data assimilation on simulating the surface energy and water budgets within the Noah land model. We then conducted a 12-member ensemble using the coupled WRF/Noah modeling system for a typical summertime convection episode over the Southern Great Plains that occurred during the IHOP_2002 field experiment. The model was run for 28–31 May 2002 (4 days simulation). These experiments were performed with the Noah land surface model coupled to two canopy resistance schemes, namely the default Jarvis scheme and a more interactive, scheme based gas-exchange model (GEM).**

Landuse map from USGS and MODIS

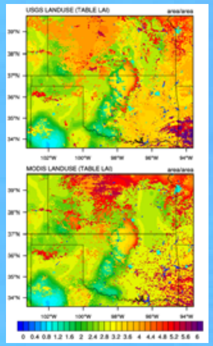




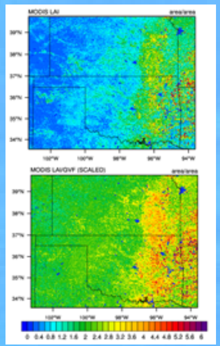
MODIS GVF



Leaf Area Index



Panel A



Panel B

Panel A: Table dependent LAI map based on USGS and MODIS landuse

Panel B: realtime MODIS-LAI and scaled MODIS-LAI using MODIS-GVF

Canopy Resistance Schemes

Jarvis Scheme:

$$R_c = \frac{R_c\_min}{LAI \times F1 \times F2 \times F3 \times F4}$$

LAI – Leaf Area Index,
F1 ~ f (amount of PAR)
F2 ~ f(air temperature: heat stress)
F3 ~ f(air humidity: dry air stress)
F4 ~ f(soil moisture: dry soil stress)

Ball-Berry scheme in GEM (Gas Exchange Model)

$$g_s = m\frac{A_n}{C_s}h_s p_s + b \qquad R_c = \frac{1}{g_s}$$

hs – relative humidity at leaf surface
ps – Surface atmospheric pressure
An – net CO2 assimilation or photosynthesis rate
Cs – CO2 concentration at leaf surface
m and b are linear coeff based on gas exchange consideration

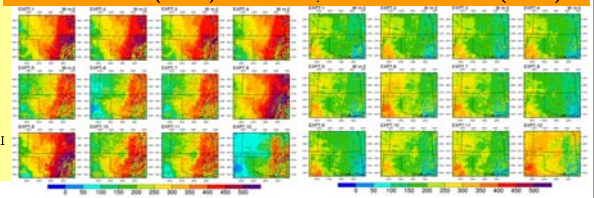
Experimental Design:

• Conducted a 12-member ensemble using latest version of WRFV3.0.1 for a typical summertime convection episode over the Southern Great Plains that occurred during the IHOP_2002 (28-31 May 2002) field experiment. WRF model was run with two nested domains at 9 and 3 km resolution and results are presented with 3 km resolution domain. The 12 ensemble experiments are as follows:

- EXPT-1: WRF+USGS LANDUSE+CONST_LAI=4
- EXPT-2: WRF+USGS LANDUSE+TABLE_LAI
- EXPT-3: WRF+MODIS LANDUSE+CONST_LAI=4
- EXPT-4: WRF+MODIS LANDUSE+TABLE_LAI
- EXPT-5: WRF+MODIS LANDUSE+MODIS_GVF+CONSTANT_LAI
- EXPT-6: WRF+MODIS LANDUSE+MODIS_GVF+MODIS_LAI
- EXPT-7: WRF+MODIS +MODIS_GVF+MODIS_LAI/GVF (Scaled LAI)
- EXPT-8: WRF_GEM+USGS LANDUSE+CONST_LAI=4
- EXPT-9: WRF_GEM+USGS LANDUSE+TABLE_LAI=4
- EXPT-10: WRF_GEM+MODIS LANDUSE+MODIS_GVF+CONSTANT_LAI
- EXPT-11: WRF_GEM+MODIS LANDUSE+MODIS_GVF+TABLE_LAI
- EXPT-12: WRF_GEM+MODIS LANDUSE+MODIS_GVF+MODIS_LAI

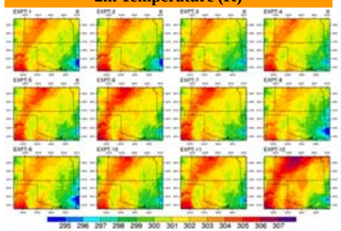
WRF: WRF +Jarvis Scheme
WRF_GEM: WRF + Ball-Berry Scheme (GEM)

Latent Heat flux (W m-2) **1800 UTC 30 May 2002** **Sensible heat flux (W m-2)**



• Pronounced systematic regional differences between all 12 model experiments.
• Assimilated MODIS LAI and GVF experiments shows decrease in latent heat flux over east side of domain significantly.
• Default WRF with MODIS products shows similar results as with WRF_GEM with Table and constant LAI
• Overall results suggest that WRF with MODIS based LAI and GVF reduced latent heat flux roughly 100-150 W m-2 over east side of domain in comparison with USGS landuse + Table LAI experiments done with WRF.

2m Temperature (K)



1 to 2 degree kelvin difference found between USGS and MODIS landuse experiments. Simulations with MODIS landuse, LAI and GVF shows 1-2 degree kelvin warmer than USGS landuse based simulations.

Bias and RMSE analysis

We used 18 UTC 30 May 2002 NWS surface observations from 71 sites across simulation domain to calculate average errors of temperature and mixing ratio.

Experiments	Temperature (K) Bias with 95% C.I	Temperature RMSE (K)	Mixing ratio (g/kg) Bias with 95% C.I	Mixing ratio RMSE g/kg
EXPT-1	-0.48	1.27	-1.24	2.01
EXPT-2	-0.38	1.23	-1.34	2.05
EXPT-3	-0.82	1.37	-0.99	1.98
EXPT-4	-0.68	1.28	-1.13	2.05
EXPT-5	-0.32	1.24	-1.53	2.32
EXPT-6	-0.04	1.20	-1.92	2.62
EXPT-7	-0.19	1.15	-1.66	2.42
EXPT-8	-1.14	1.58	-0.56	1.64
EXPT-9	-0.85	1.44	-0.83	1.82
EXPT-10	-0.51	1.20	-1.35	2.34
EXPT-11	-0.23	1.16	-1.62	2.45
EXPT-12	0.77	1.55	-2.65	3.33

Summary and Future Work

- **The coupled WRF/Noah ensemble approach was used to assess the impact of MODIS Landuse, LAI and GVF with two different canopy resistance.**
- **Analysis from 12 experiments shows that assimilation of MODIS products reduced the surface temperature bias and resulted in large difference as compared with USGS based simulations. Significant difference found in simulated surface heat fluxes and 2-m air temperature when using Ball-Berry canopy resistance scheme together with MODIS products.**
- **Future work will analyze the role of more realistic LAI and GVF from MODIS and its impact on WRF simulated boundary layer (ABL) structures.**

References:

• **Chen, F., and J. Dudhia, 2000: Coupling an advanced land-surface/hydrology model with the Penn State/NCAR MM5 modeling system. Part I: Model implementation and sensitivity. *Mon. Wea. Rev.*, 129, 569-585**
• **Kumar A, F. Chen, D. Niyogi, K. Manning, J. Alfieri, M. Ek, K. Mitchell, Evaluation of a photosynthesis based canopy resistance formulation within Noah land surface model. (Submitted)**
• **Yang W, Shabanov NV, Huang D, Wang W, Dickinson RE, Nemani RR, Knyazikhin Y, Myneni RB (2006). Analysis of leaf area index products from combination of MODIS Terra and Aqua data. Remote Sensing of Environment, 104(3), 297-312**