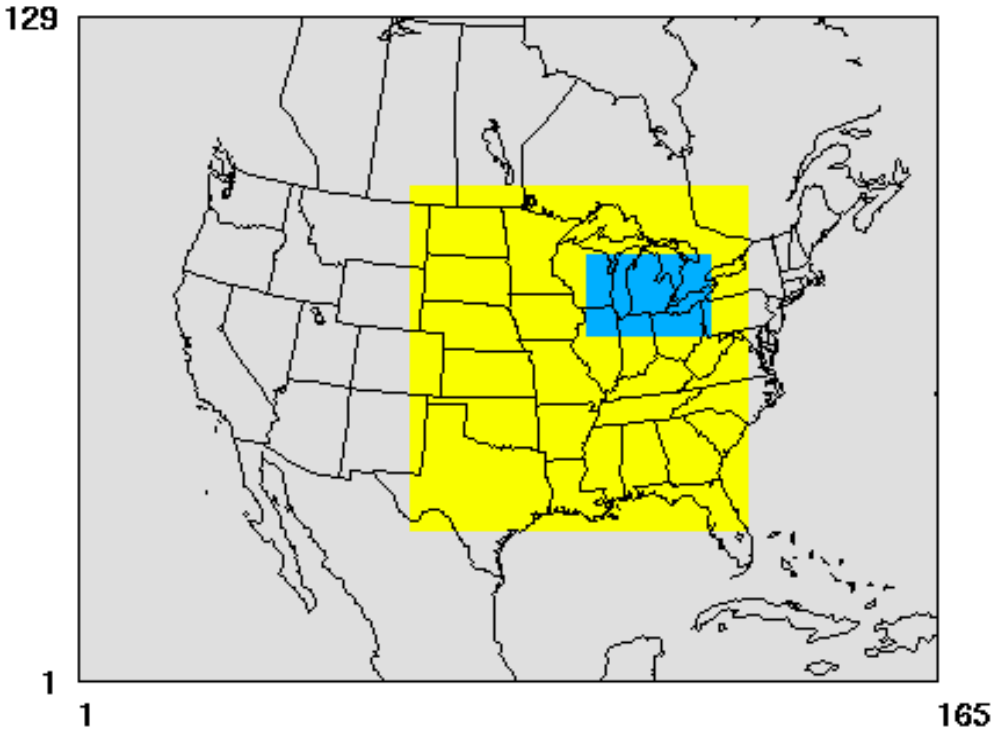
2007 Ad-Hoc Meteorological Modeling Meeting

Boulder, CO

Kirk Baker

Lake Michigan Air Directors Consortium

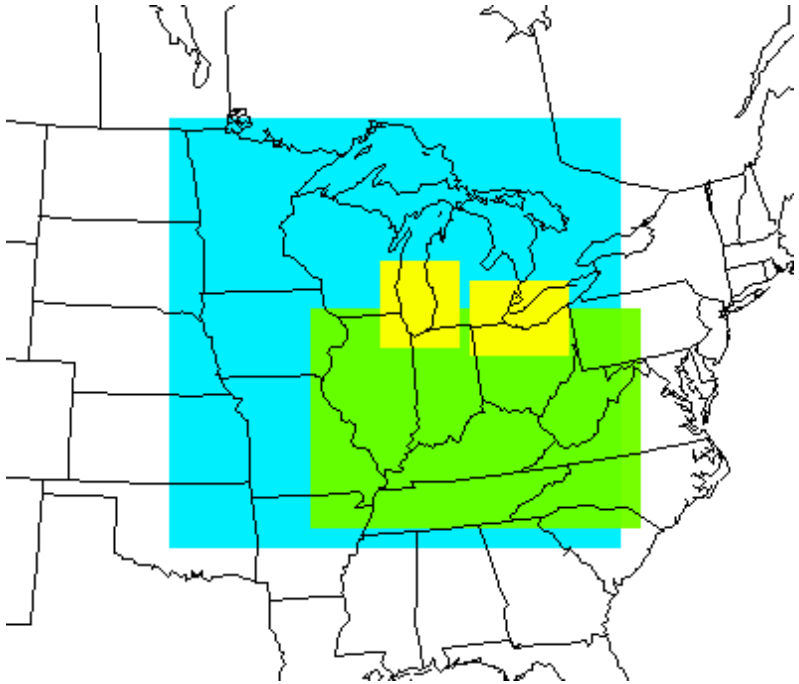


Configuration	All Domains
Explicit Moisture	Mixed Phase (Reisner I)
Cumulus	Kain-Fritsch 2
PBL	Pleim-Chang (ACM)
Radiation	RRTM
Multi-Layer Soil Model	Pleim-Xiu
Shallow convection	No
4-D Data Assimilation	Analysis nudging on above PBL
Moist Physics Table	No

k(MM5)	sigma	press.(mb)	height(m)	depth(m)
34	0.000	10000	14662	1841
33	0.050	14500	12822	1466
32	0.100	19000	11356	1228
31	0.150	23500	10127	1062
30	0.200	28000	9066	939
29	0.250	32500	8127	843
28	0.300	37000	7284	767
27	0.350	41500	6517	704
26	0.400	46000	5812	652
25	0.450	50500	5160	607
24	0.500	55000	4553	569
23	0.550	59500	3984	536
22	0.600	64000	3448	506
21	0.650	68500	2942	480
20	0.700	73000	2462	367
19	0.740	76600	2095	266
18	0.770	79300	1828	259
17	0.800	82000	1569	169
16	0.820	83800	1400	166
15	0.840	85600	1235	163
14	0.860	87400	1071	160
13	0.880	89200	911	158
12	0.900	91000	753	78
11	0.910	91900	675	77
10	0.920	92800	598	77
9	0.930	93700	521	76
8	0.940	94600	445	76
7	0.950	95500	369	75
6	0.960	96400	294	74
5	0.970	97300	220	74
4	0.980	98200	146	37
3	0.985	98650	109	37
2	0.990	99100	73	36
1	0.995	99550	36	36
0	1.000	100000	0	--SURF--

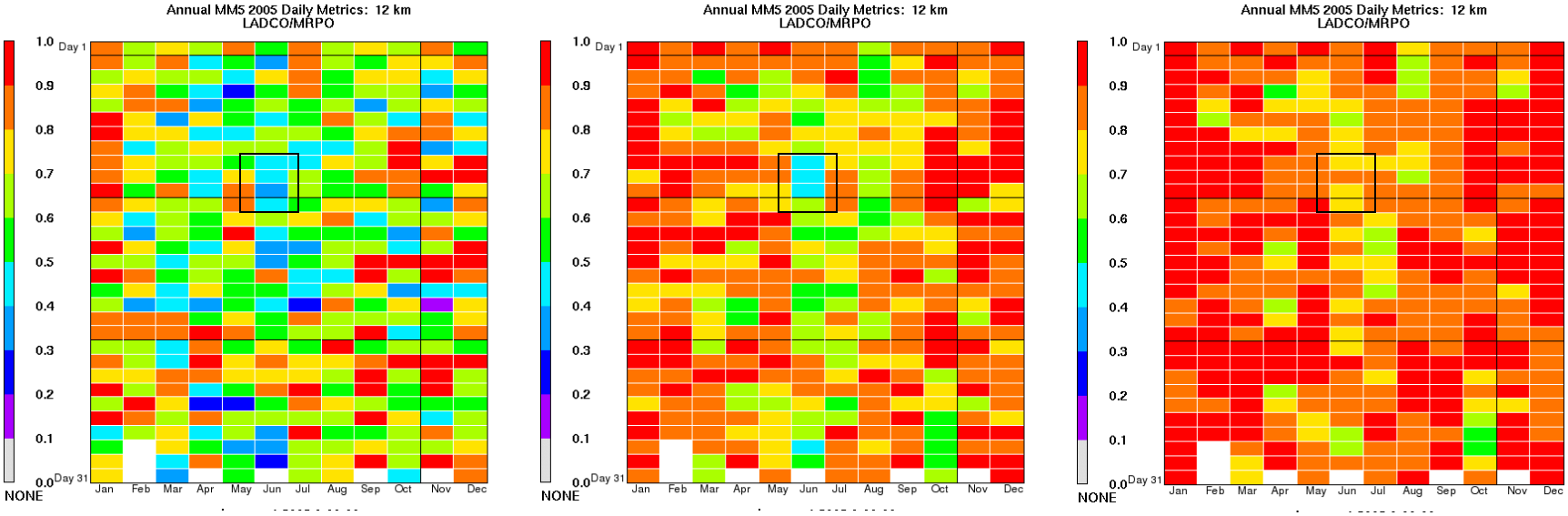
Index of Agreement

- Comment on the index of agreement metric
- Metric used to assess how well the predictions and observations agree over some spatial domain
- Metric is largely a direct function of the number of prediction-observation pairs
- Not very useful metric



Index of Agreement

- Humidity Index of Agreement at 12 km
- the Detroit-Cleveland region (left), Ohio Valley region (center), and Upper Midwest region (right)



Performance for Variables Important in Biogenic Emissions Modeling

PAR

- Photosynthetically Activated Radiation (PAR)
- It is this fraction of the total short-wave downward radiation which causes photosynthesis in plants and the resulting emission of isoprene
- Isoprene plays an important role in regional ozone formation in the Midwest United States (and other places)
- Comparison for entire year of 2005 using 36 km estimates from a variety of methodologies to surface measurements (SURFRAD network)

PAR

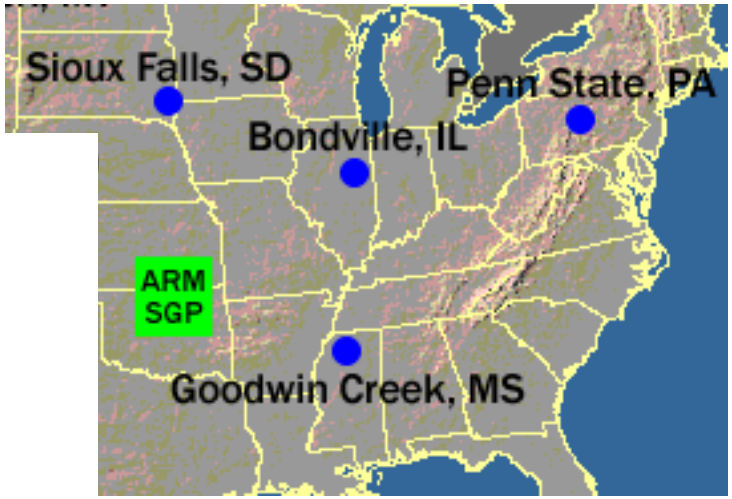
Estimate Methods:

- Satellite (GOES)
- MM5
- BEIS2
- BEIS3

- All units are watts/m^2

SURFRAD sites used:

- Sioux Falls
- Bondville
- Goodwin Creek
- PSU



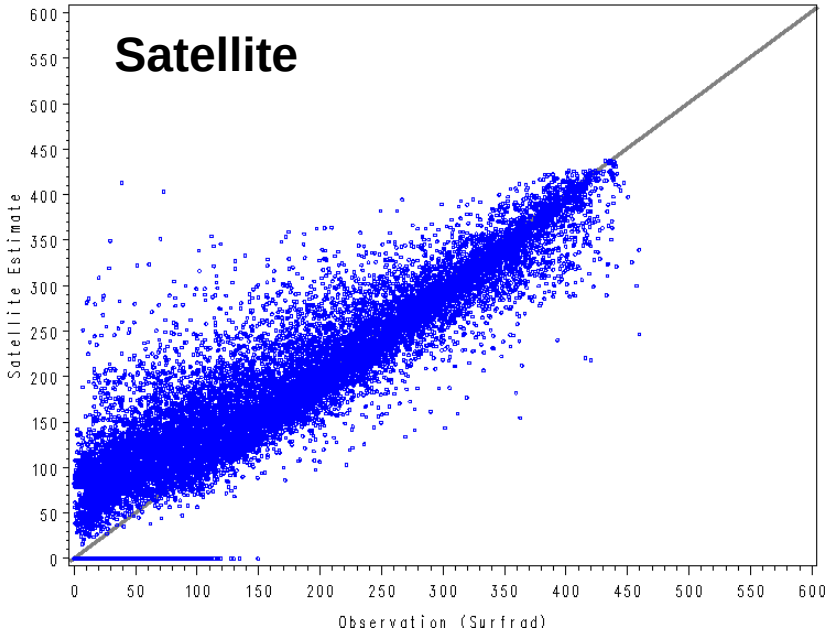
Satellite Estimates of PAR

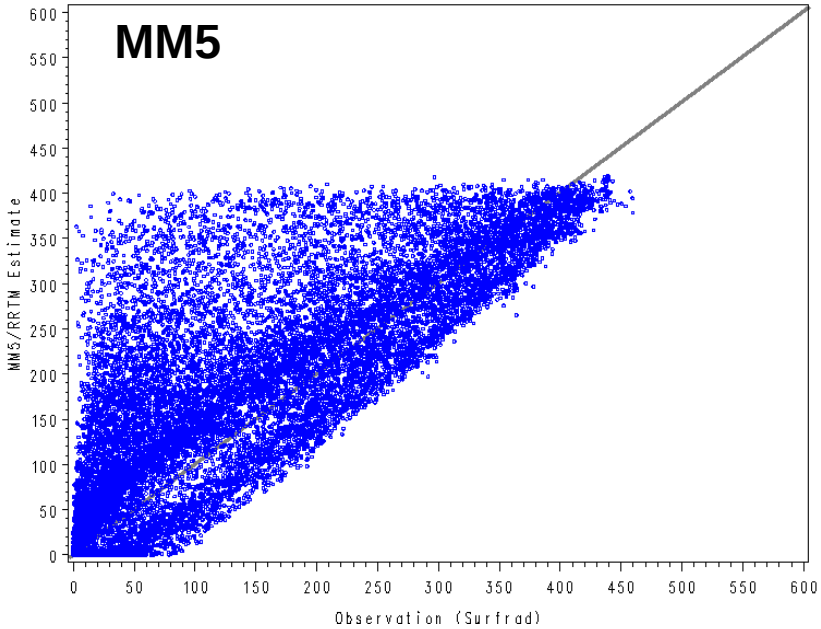
http://www.atmos.umd.edu/~srb/par/03satellite.htm

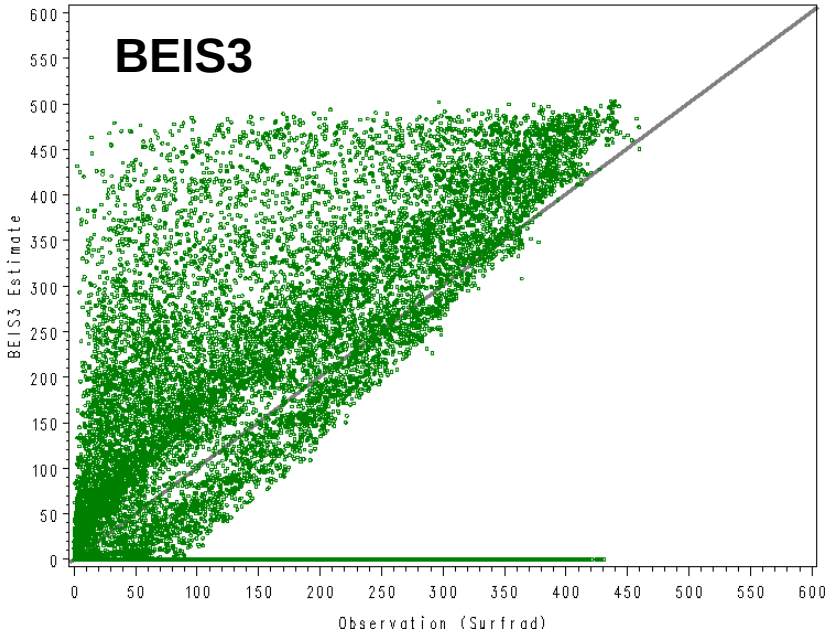
- The approach is based on a physical inference scheme to derive surface spectral radiatiative components from satellite observations at the top of atmosphere
- A modified version of the Global Energy and Water Cycle Experiment (GEWEX) /Surface Radiation Budget (SRB) model (Whitlock et al., 1995; Pinker et al., 1995)

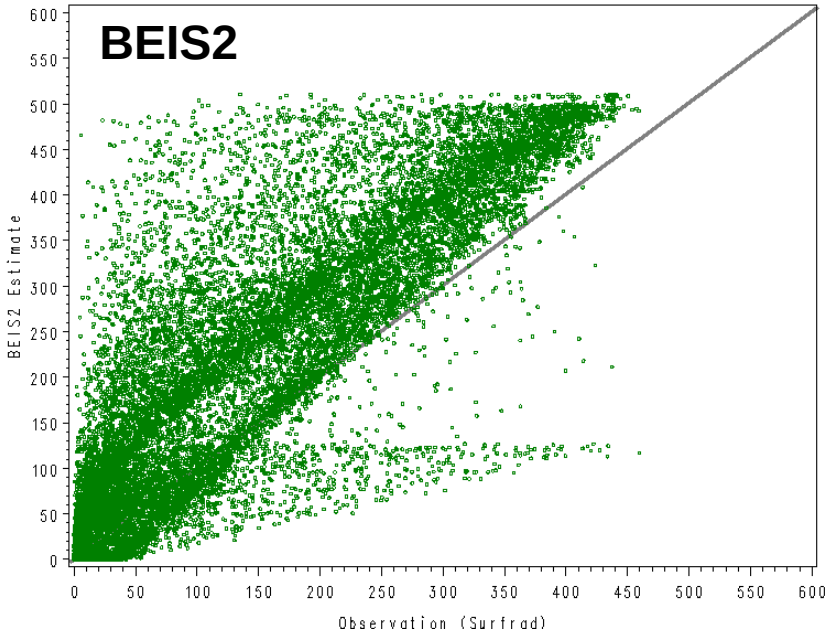
Other Estimates of PAR

- The MM5 estimate of PAR is the total shortwave downward radiation (SWDOWN) multiplied by .45, which is an estimate of the PAR fraction of short-wave downward radiation
- BEIS methods essentially use angle of the sun and cloud cover variables from MM5 to estimate total shortwave downward radiation


Satellite
Satellite Estimate
Observation (Surfrad)
0 50 100 150 200 250 300 350 400 450 500 550 600


MM5
MM5/RRTM Estimate
Observation (Surfrad)
0 50 100 150 200 250 300 350 400 450 500 550 600


BEIS3
BEIS3 Estimate
Observation (Surfrad)
0 50 100 150 200 250 300 350 400 450 500 550 600


BEIS2
BEIS2 Estimate
Observation (Surfrad)
0 50 100 150 200 250 300 350 400 450 500 550 600

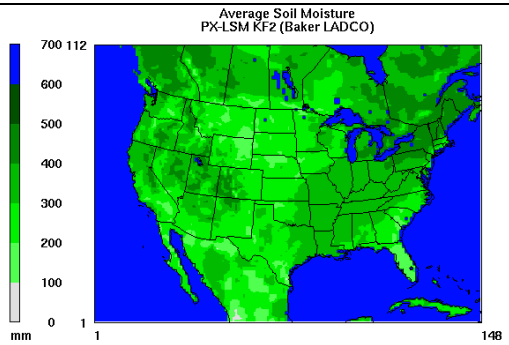
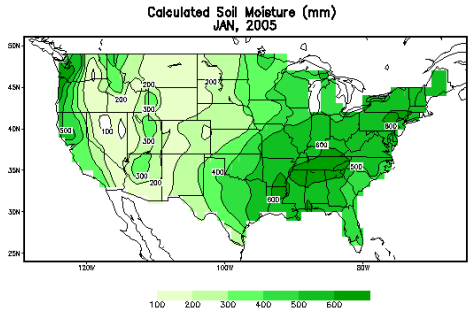
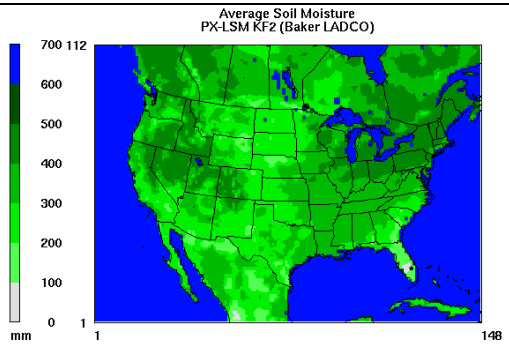
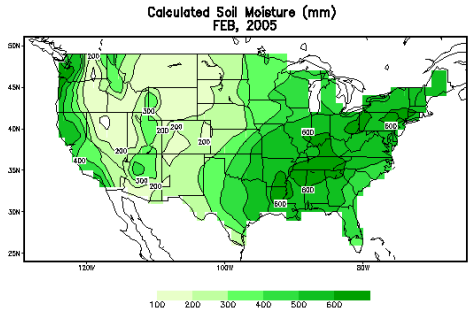
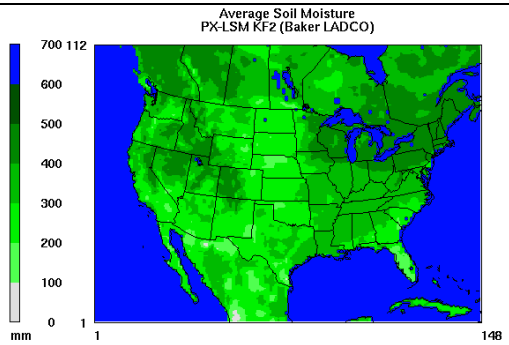
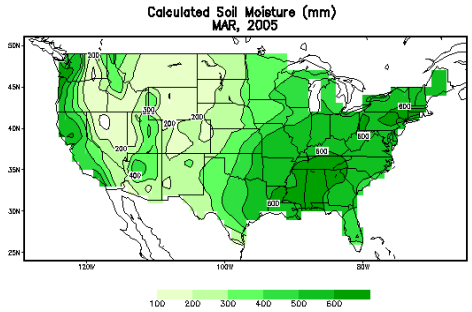
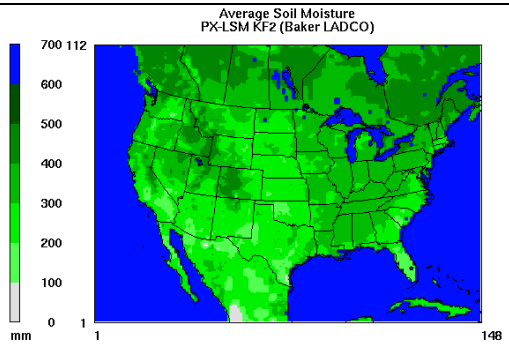
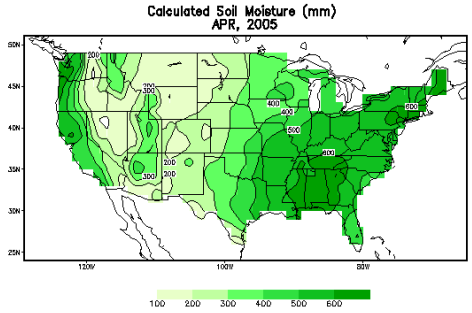
Soil Moisture

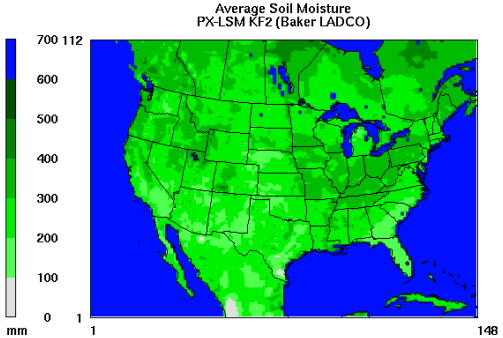
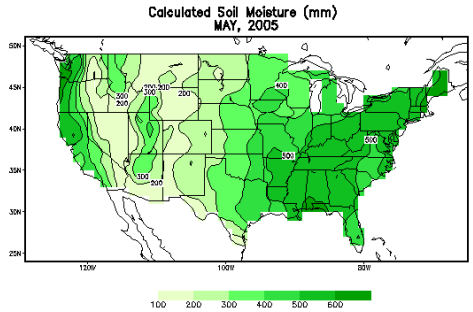
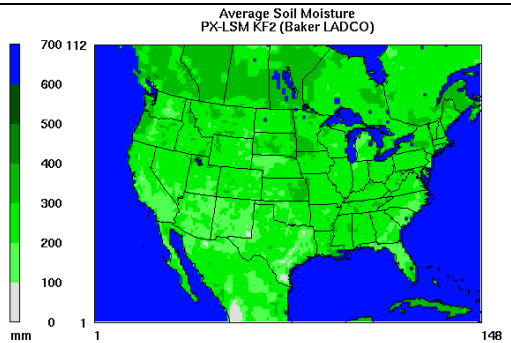
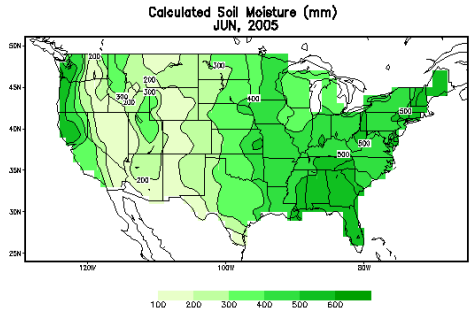
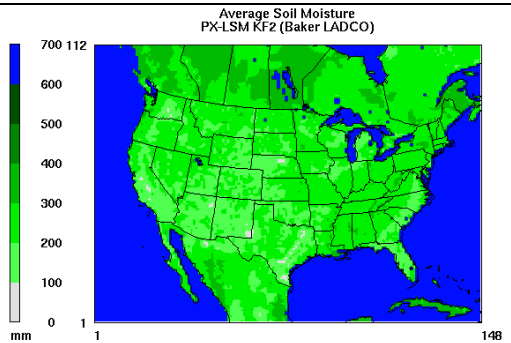
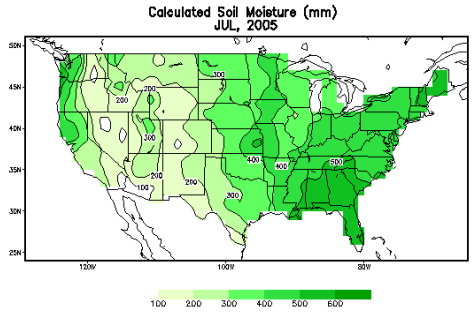
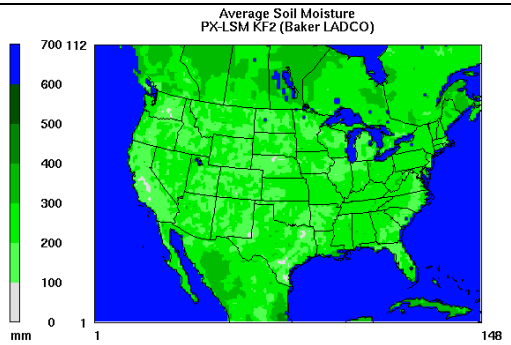
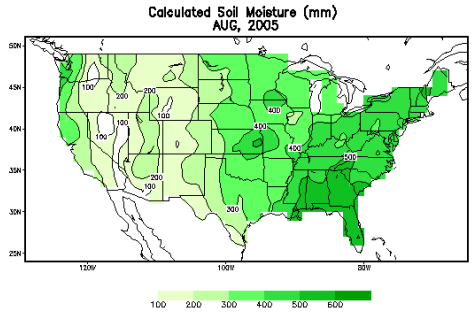
- When using the MEGAN model to estimate biogenic isoprene, soil moisture impacts emissions estimates
- Using PX LSM soil moisture estimates as input to the MEGAN emissions model
- Extract “SOIL M 2” for 2nd layer soil moisture (expressed as mixing ratio)
- DO NOT use surface soil moisture!
- Convert mixing ratio to mm to compare with CPC model estimate
  - SM (mm) = SM (m^3/m^3) * 1 meter soil depth * (1000 mm / 1 m)

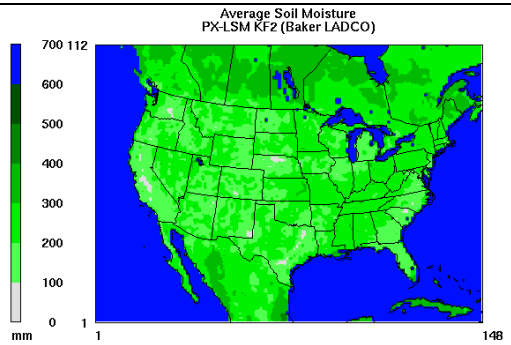
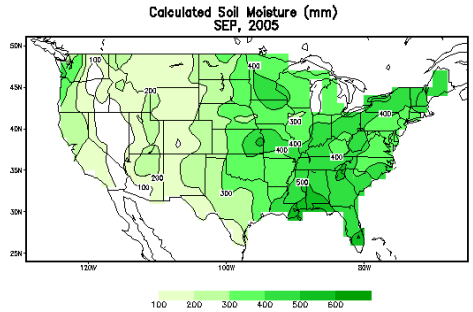
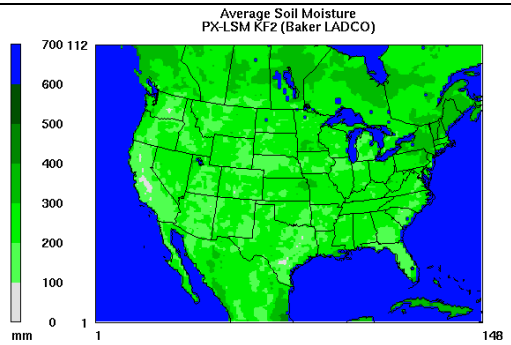
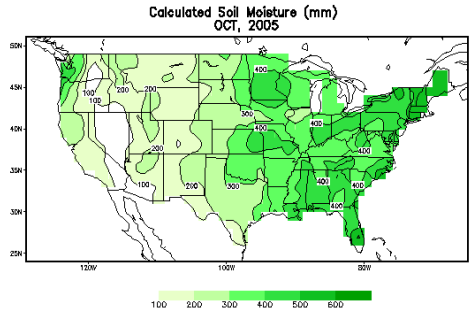
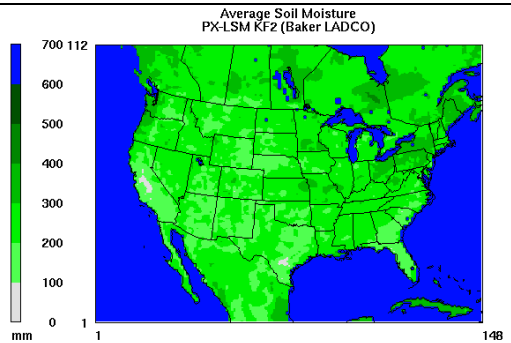
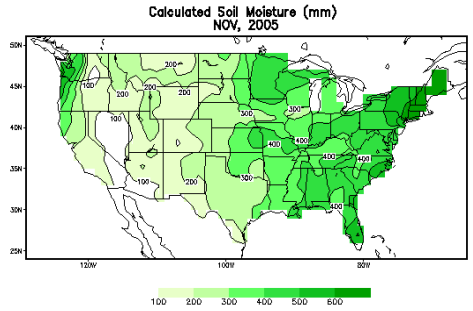
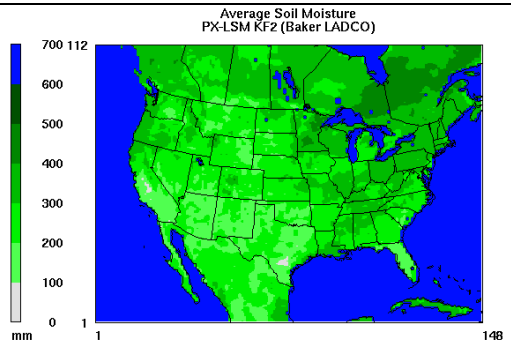
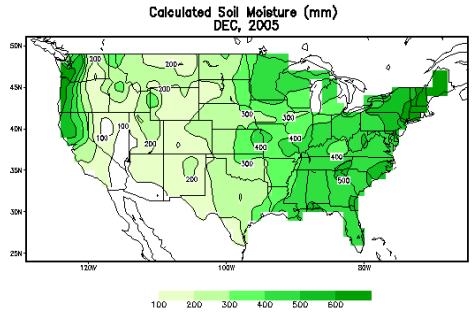
Soil Moisture “Observations”

http://www.cpc.ncep.noaa.gov/soilmst/index_jh.html

- Soil moisture is estimated by a one-layer hydrological model (Huang et al., 1996, van den Dool et al., 2003)
- The model takes observed precipitation and temperature and calculates soil moisture, evaporation and runoff
- Qualitatively compared monthly averaged soil moisture from CPC with MM5 (PX LSM) estimates

	MM5	CPC Estimate
Jan		
Feb		
Mar		
Apr		

	MM5	CPC Estimate
May		
Jun		
Jul		
Aug		

	MM5	CPC Estimate
Sep		
Oct		
Nov		
Dec		

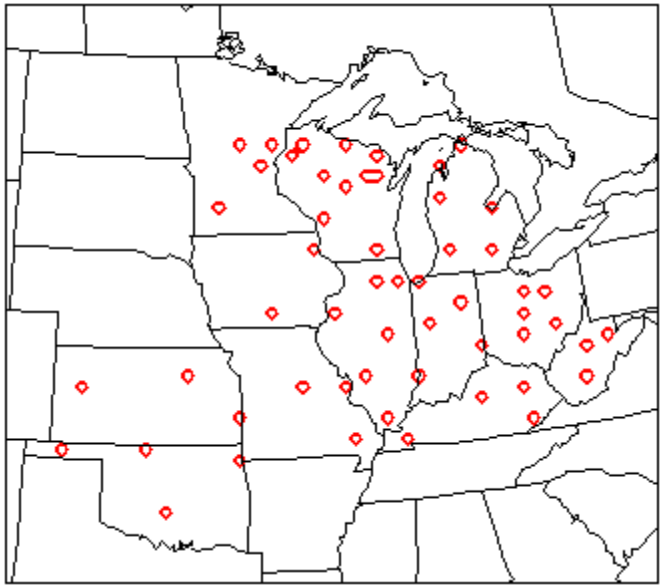
Remarks

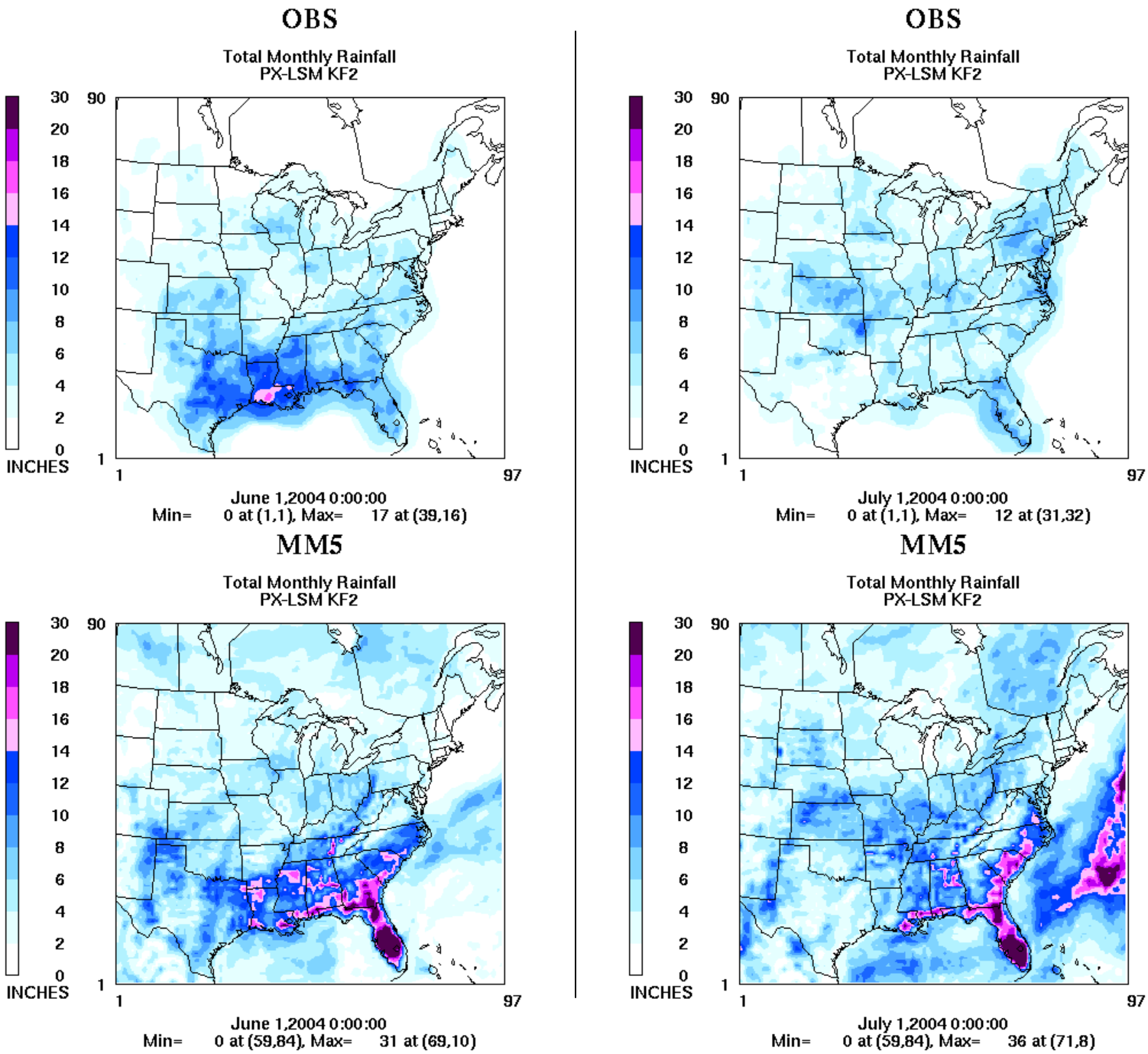
- MM5 PX/LSM seems to capture the monthly average 1 m soil moisture spatial variability seen in CPC estimates
- Satellite estimates of PAR clearly best choice to use as input to biogenic emissions models
- The other key variables input to the biogenics models such as temperature and wind speed have been extensively examined for model performance

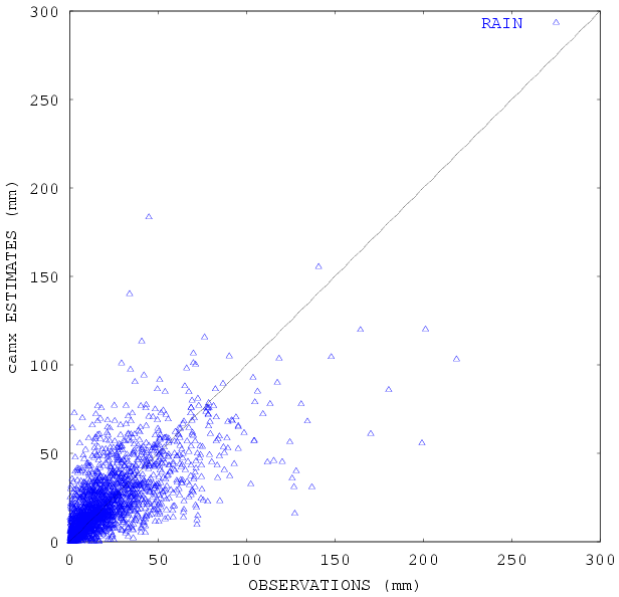
Relating Meteorological and Photochemical Performance

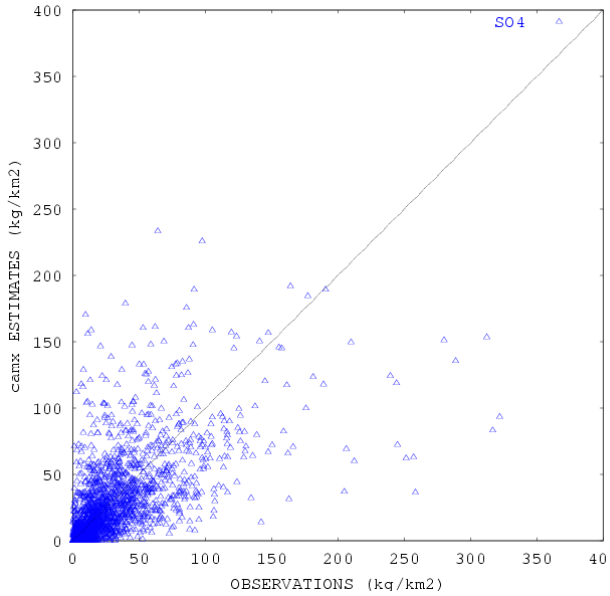
Rainfall and Wet Deposition

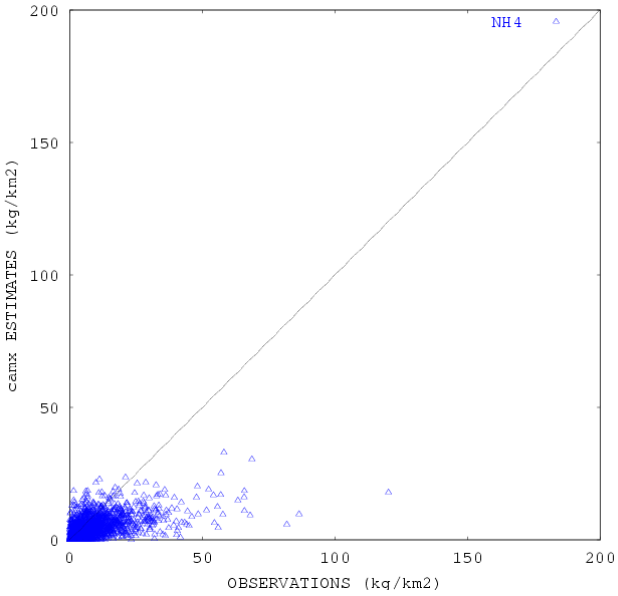
- Seem to grossly over-predict rainfall in MM5
- How does this impact wet deposition in the photochemical transport model?
- Evaluation at Midwest United States NADP monitors for entire year of 2004
- Comparing weekly total rainfall and wet deposition

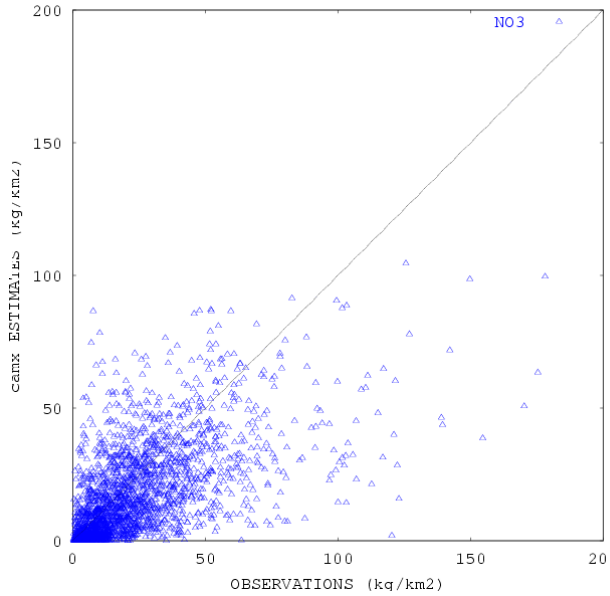


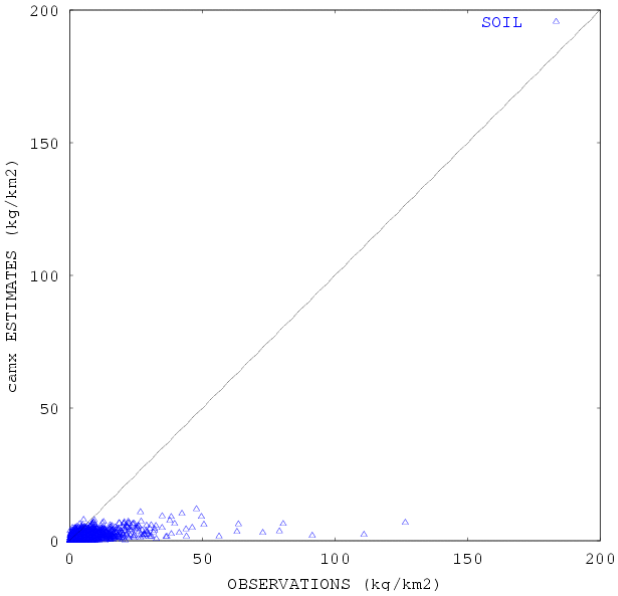

OBS
Total Monthly Rainfall
PX-LSM KF2
30
20
18
16
14
12
10
8
6
4
2
0
INCHES
90
1
1
97
June 1,2004 0:00:00
Min= 0 at (1,1), Max= 17 at (39,16)
OBS
Total Monthly Rainfall
PX-LSM KF2
July 1,2004 0:00:00
Min= 0 at (1,1), Max= 12 at (31,32)
MM5
Total Monthly Rainfall
PX-LSM KF2
June 1,2004 0:00:00
Min= 0 at (59,84), Max= 31 at (69,10)
MM5
Total Monthly Rainfall
PX-LSM KF2
July 1,2004 0:00:00
Min= 0 at (59,84), Max= 36 at (71,8)


RAIN
camx ESTIMATES (mm)
OBSERVATIONS (mm)
0
50
100
150
200
250
300


SO4
camx ESTIMATES (kg/km2)
OBSERVATIONS (kg/km2)
0
50
100
150
200
250
300
350
400


NH4
camx ESTIMATES (kg/km2)
OBSERVATIONS (kg/km2)
0
50
100
150
200


NO3
OBSERVATIONS (kg/km2)
0
50
100
150
200

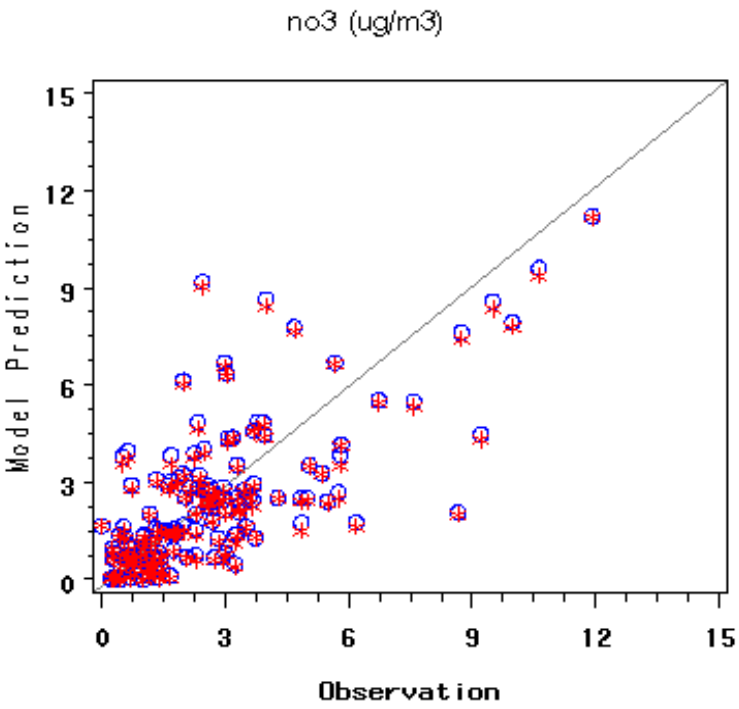

SOIL
camx ESTIMATES (kg/km2)
OBSERVATIONS (kg/km2)
0
50
100
150
200

Seasonal Metrics

		Fractional Bias				Fractional Error			
Season	N	NO_3^-	$SO_4^=$	NH_4^+	Precip.	NO_3^-	$SO_4^=$	NH_4^+	Precip.
Winter	496	-73	-91	-113	10	92	108	122	52
Spring	535	-27	-9	-50	13	64	64	81	58
Summer	493	-14	14	-19	14	70	74	78	74
Fall	458	-28	-48	-64	0	68	81	87	50

- Rainfall has little seasonal bias in the Midwest; error is highest in the Summer
- Total nitrate, sulfate, and ammonium bias and error do not seem to have a strong relationship to rainfall bias and error by season

CAMx	MM5	N	RSQ	MONTH
Error NH4	Error RH	37	0.36	1
Error NH4	Error T	30	0.30	11
Error NH3	Error T	35	0.30	1
Error SO2	Error RH	45	0.27	3
Bias NH4	Bias T	30	0.27	11
Bias NO3	Bias T	43	0.25	12
Error HNO3	Error T	30	0.25	12
Bias HNO3	Bias RH	26	0.24	11
Error NO3	Error WS	26	0.23	9
Bias SO2	Bias RH	35	0.23	11
Bias HNO3	Bias T	35	0.23	1
Bias NH4	Bias RH	45	0.21	2
Error SO4	Error T	36	0.21	11
Error HNO3	Error WS	26	0.20	11

	Bias NO_3^- Condition		
Metric	< -0.5	-0.5 > 0.5	> 0.5
N	104	234	150
Bias NO_3^- ($\mu g/m^3$)	-1.51	-0.04	2.38
Bias RH (%)	1.42	-2.12	0.03
Bias Temperature (F)	-0.19	0.77	-1.47
Bias Wind Speed (m/s)	0.42	0.37	0.16

Predictions of PM2.5 nitrate ion for standard model run (circle) and systematic adjustment to temperature (star) for October, November, and December