Model Performance for PM and O3 over Multiple Years

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Purpose: PM

- How consistently does the modeling system perform from one summer to the next in the Great Lakes and Ohio Valley regions?
- Which species perform well in which seasons?
- Examine performance metrics averaged over region by month
- Examine performance consistency over the annual simulation by day of the year
- Examine performance by station averaged over each month

Background

Setup

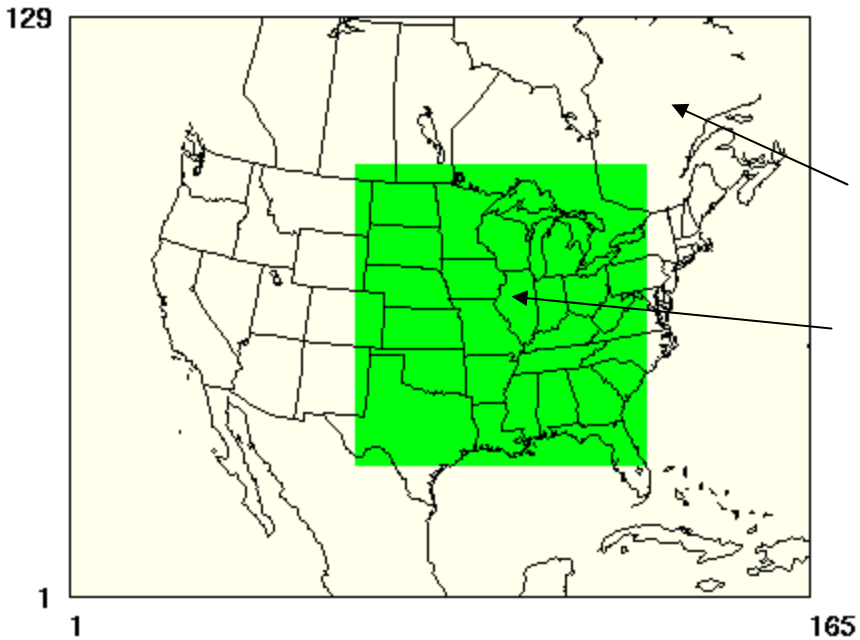
- **CAMx4.20**
- **36 km grid with 12 km nest (2-way nest)**
- **No sub-grid plume treatment**
- **Wet and dry deposition “on”**
- **RADM aqueous phase chemistry**
- **ISORROPIA inorganic thermodynamics**
- **SOAP (CMU) organic chemistry**
- **CB4 speciation**

Episodes

- 2001 36km
- 2002 36km
- 2003 36km
- 36/12km Summer modeling episodes begin June 2nd and end September 1st

Horizontal Grid Domains

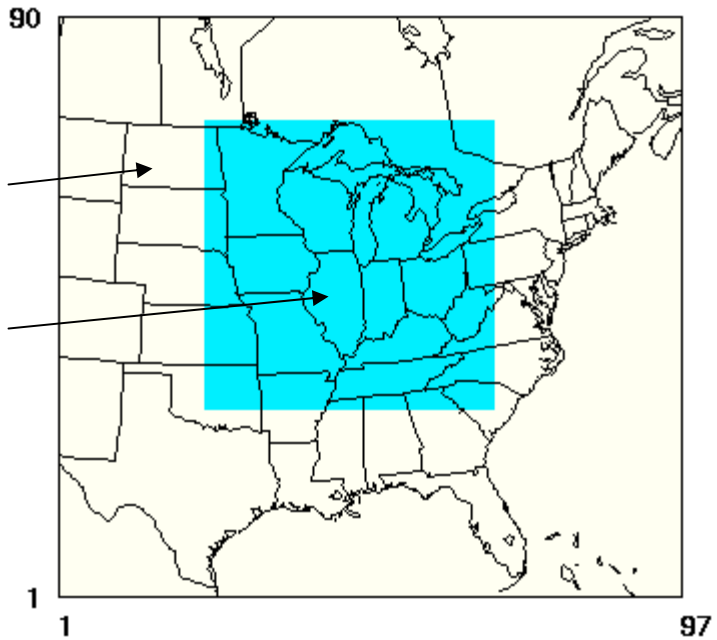
Meteorological Modeling Domains



36 KM

12 KM

Photochemical Modeling Domains



Met Modeling

MM5 Application (v3.6)

- Mixed phase moisture scheme
- Kain-Fritsh2 cumulus scheme
- RRTM radiation
- Pleim Chang PBL (ACM)
- Pleim Xiu Land Surface Model

height(m)	k(MM5)	depth(m)	k(PCM)	depth(m)
14662	34	1841	16	4535
12822	33	1466		
11356	32	1228		
10127	31	1062	15	3611
9066	30	939		
8127	29	843		
7284	28	767		
6517	27	704	14	2533
5812	26	652		
5160	25	607		
4553	24	569		
3984	23	536	13	1522
3448	22	506		
2942	21	480		
2462	20	367	12	634
2095	19	266		
1828	18	259	11	428
1569	17	169		
1400	16	166	10	329
1235	15	163		
1071	14	160	9	318
911	13	158		
753	12	78	8	155
675	11	77		
598	10	77	7	153
521	9	76		
445	8	76	6	151
369	7	75		
294	6	74	5	148
220	5	74		
146	4	37	4	37
109	3	37	3	37
73	2	36	2	36
36	1	36	1	36
--SURF--	--SURF--	--SURF--	--SURF--	--SURF--

EMS Emissions Modeling

Monthly Weekday, Saturday, Sunday

- Point source inventory based on 2002 CERR Inventory
- Onroad based on MOBILE6 with 2002 CERR VMT and Mobile6 inputs
- Nonroad2004 with midwest Vessels, Rail, Rec. Marine, Agricultural
- Area based on 2002 CERR inventory

Day Specific

- Biogenics based on BIOME3/BEIS3 with BELD3 landuse and MM5 15 m temperatures and GOES satellite PAR

Other Inputs

- Landuse: BELD3
- Seasonal variations in surface roughness length
- Ozone column data (GOES satellite data)
- Albedo data (monthly values based on GOES satellite data)
- Photolysis rates – discrete ordinate algorithm used in TUV model
- Initial & Boundary Concentrations:
  - Monthly averages based on GEOS-CHEM global model simulation

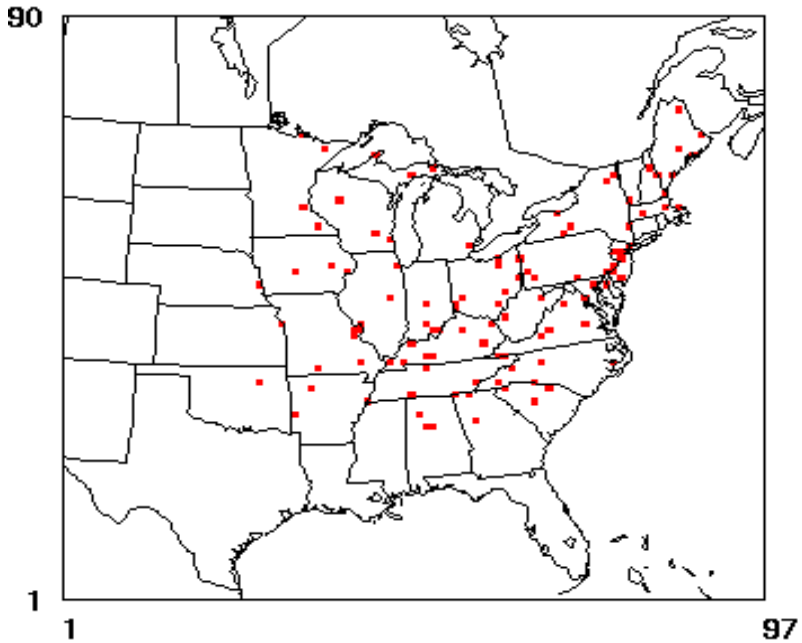
PM Model Performance

- Metrics consistent with EPA modeling guidance:
  - Bias
  - Error
  - Fractional Bias
  - Fractional Error

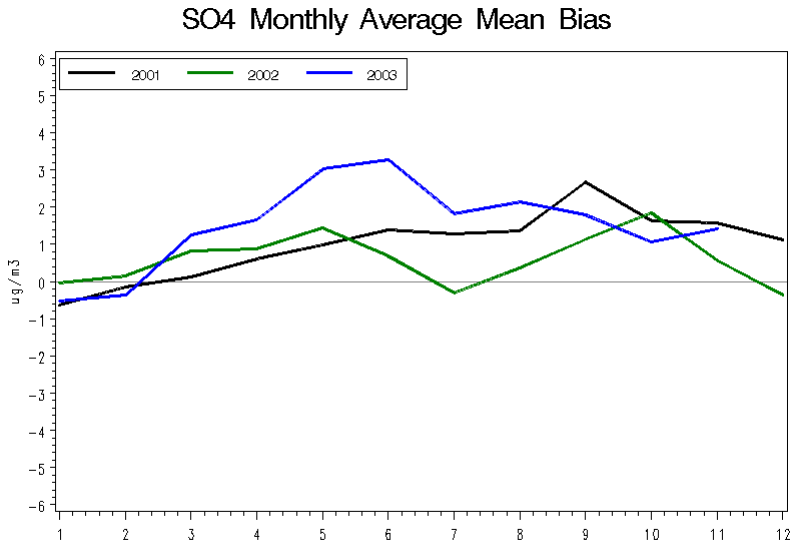
- Model performance using daily average speciated PM2.5 measurements
- IMPROVE, EPA Speciation Trends (from VIEWS)

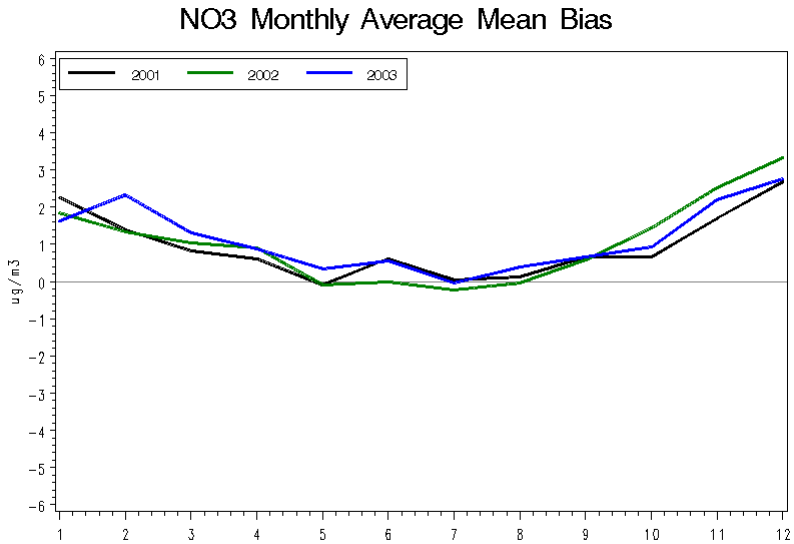
- OM/OC = 1.6 for urban and 2.1 for rural sites

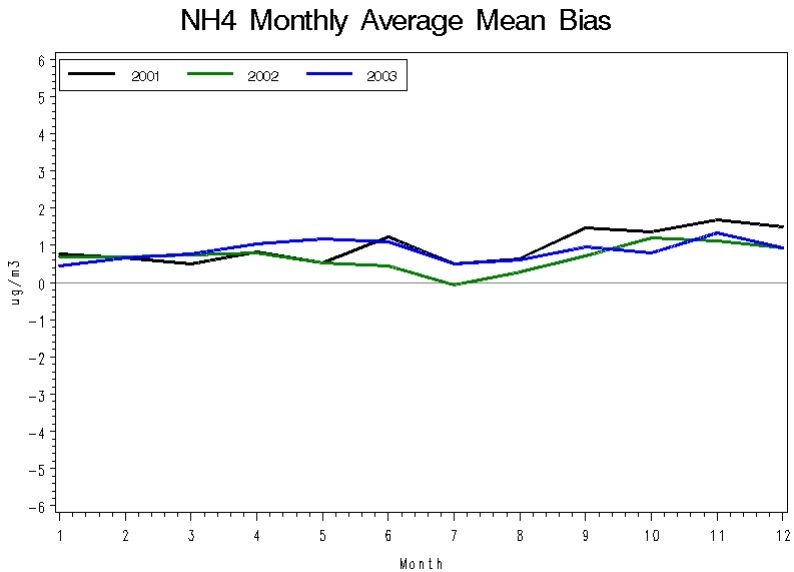
- Predictions and observations paired in time and space

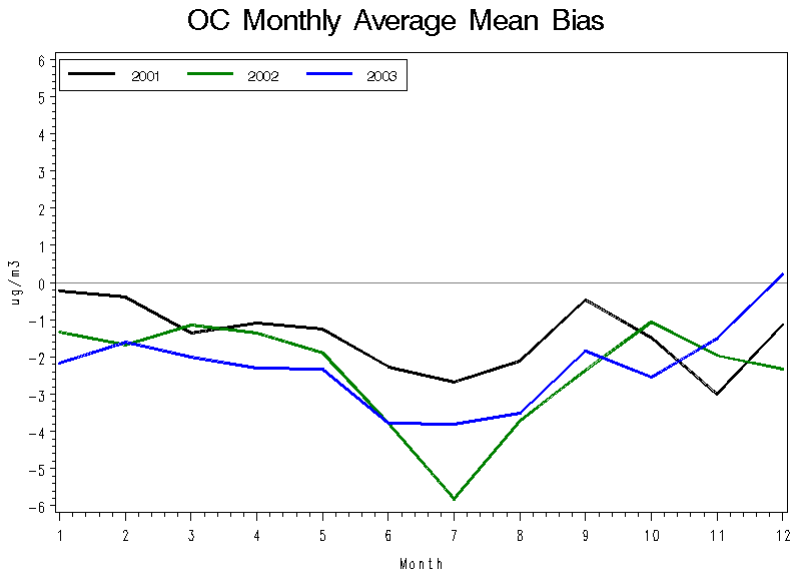


Monthly Bias for Each Annual Simulation by PM2.5 chemical specie (top left clockwise) sulfate, nitrate, organics, ammonium









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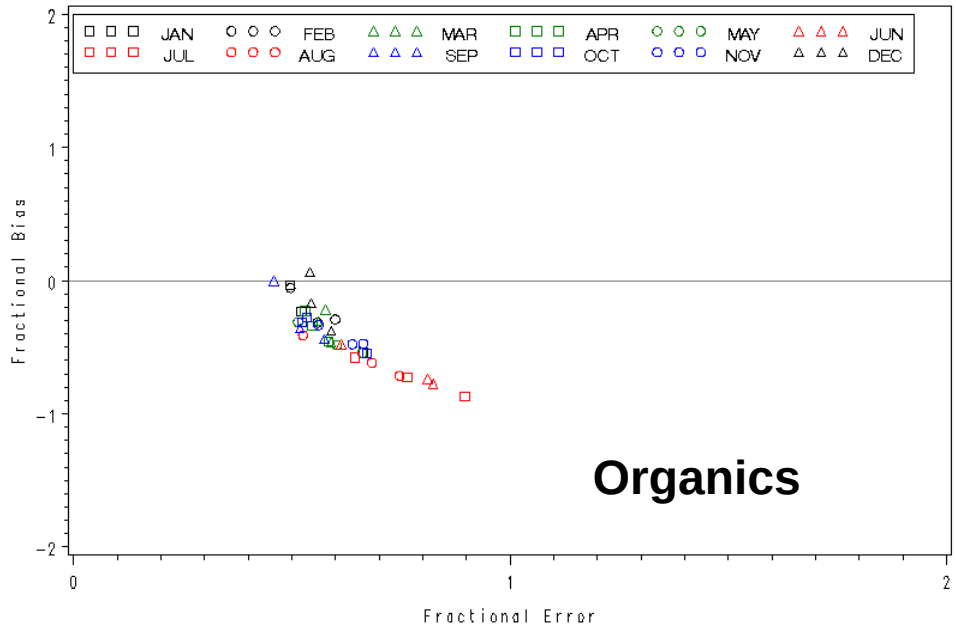
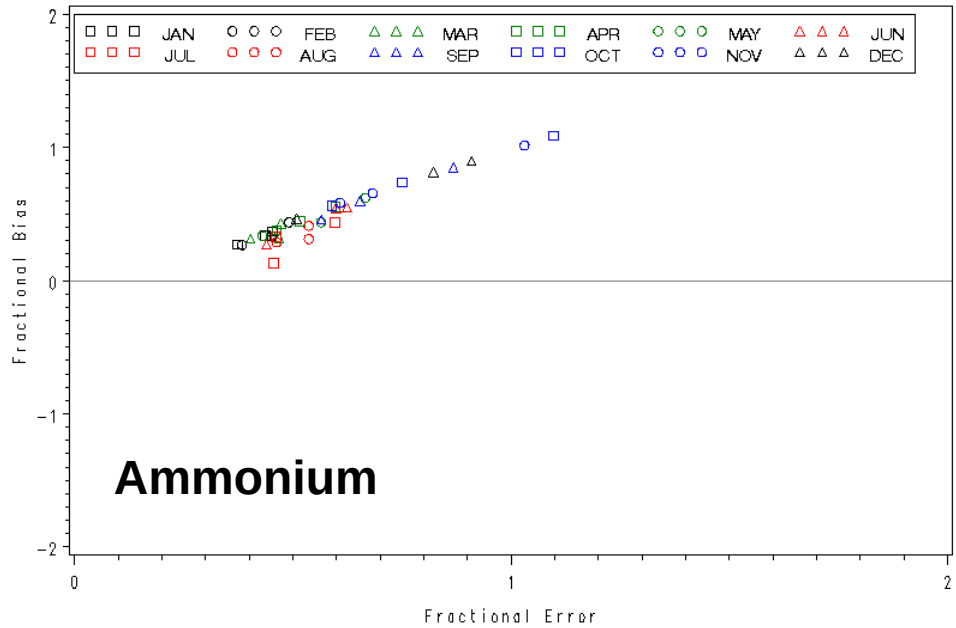
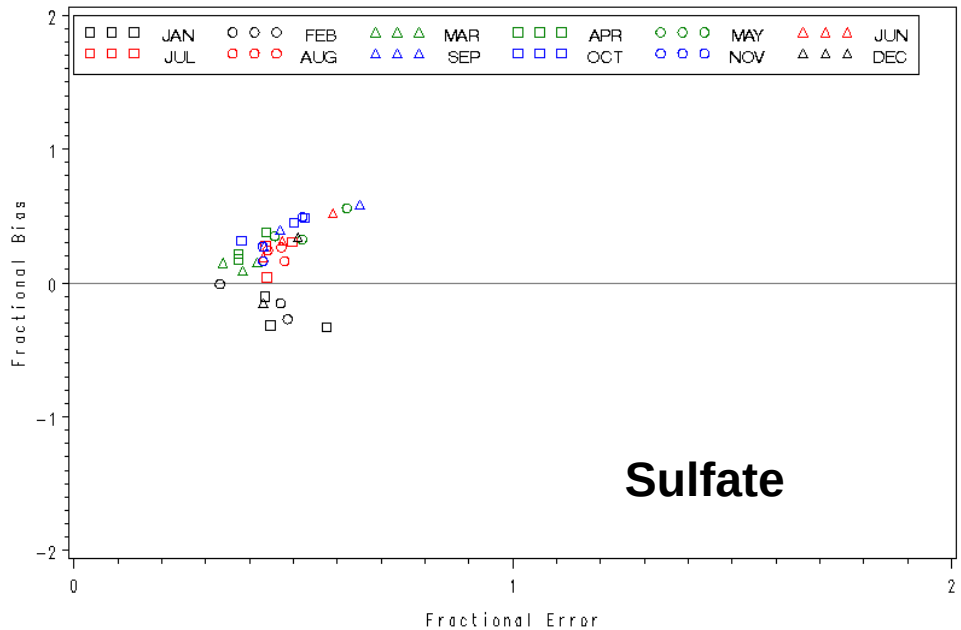
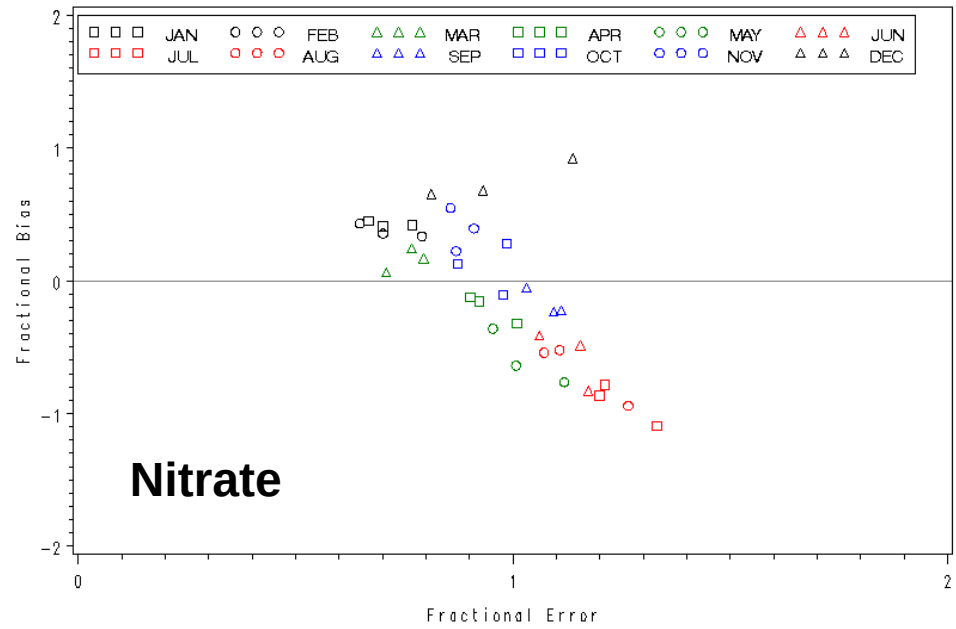
Fractional Metrics: Bias and Error

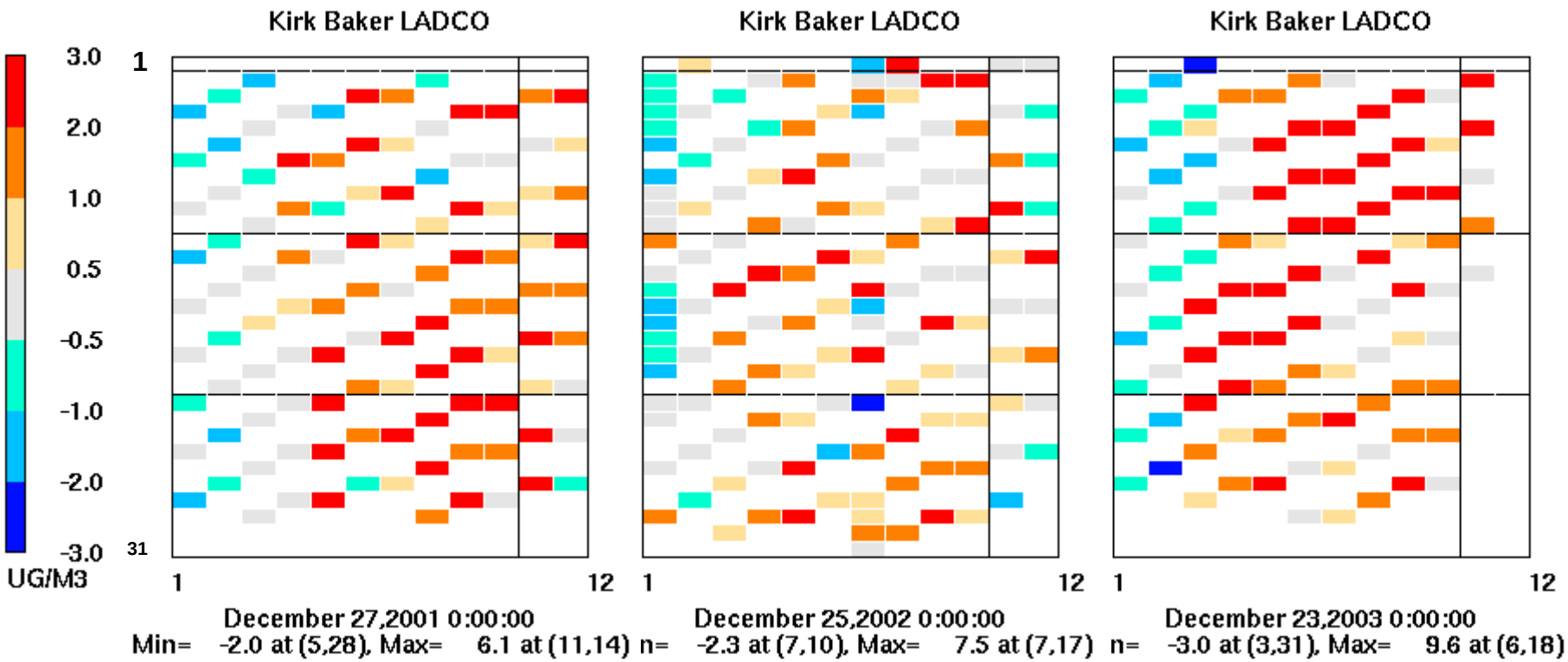




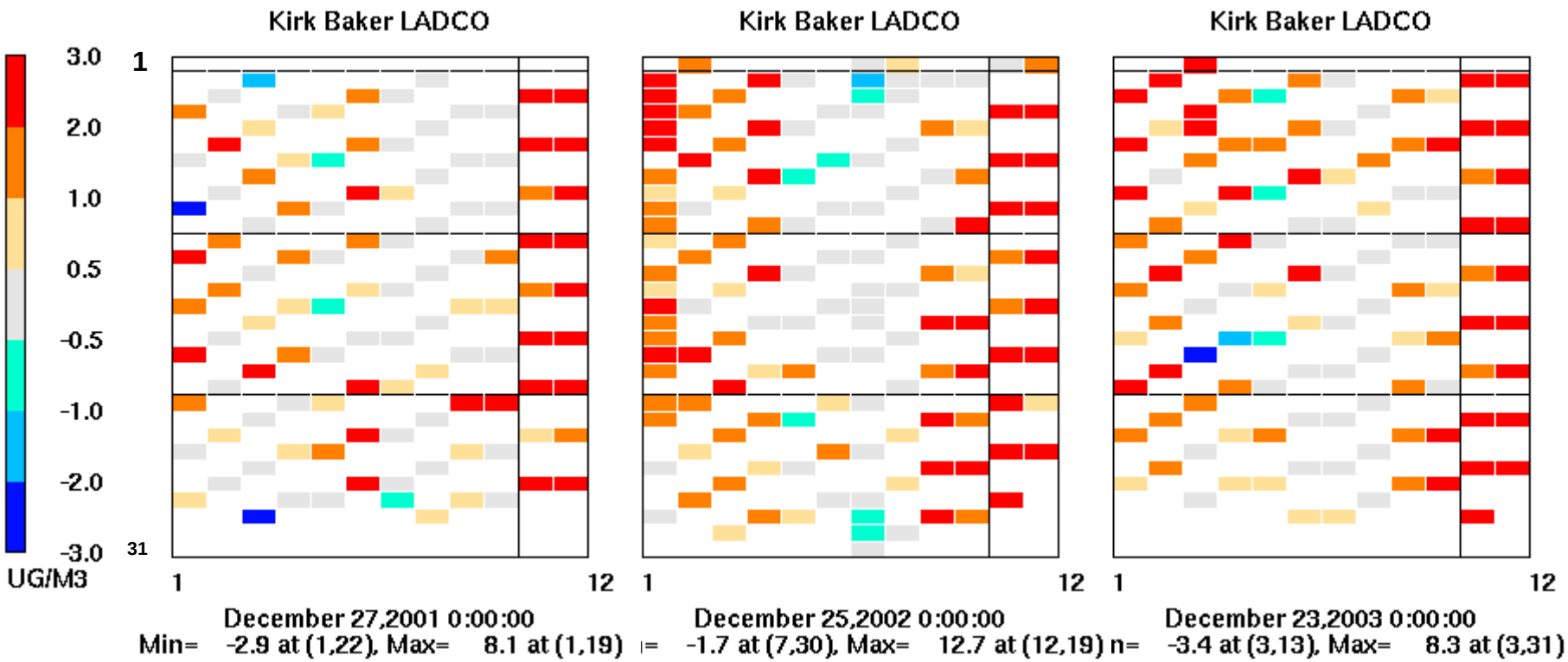




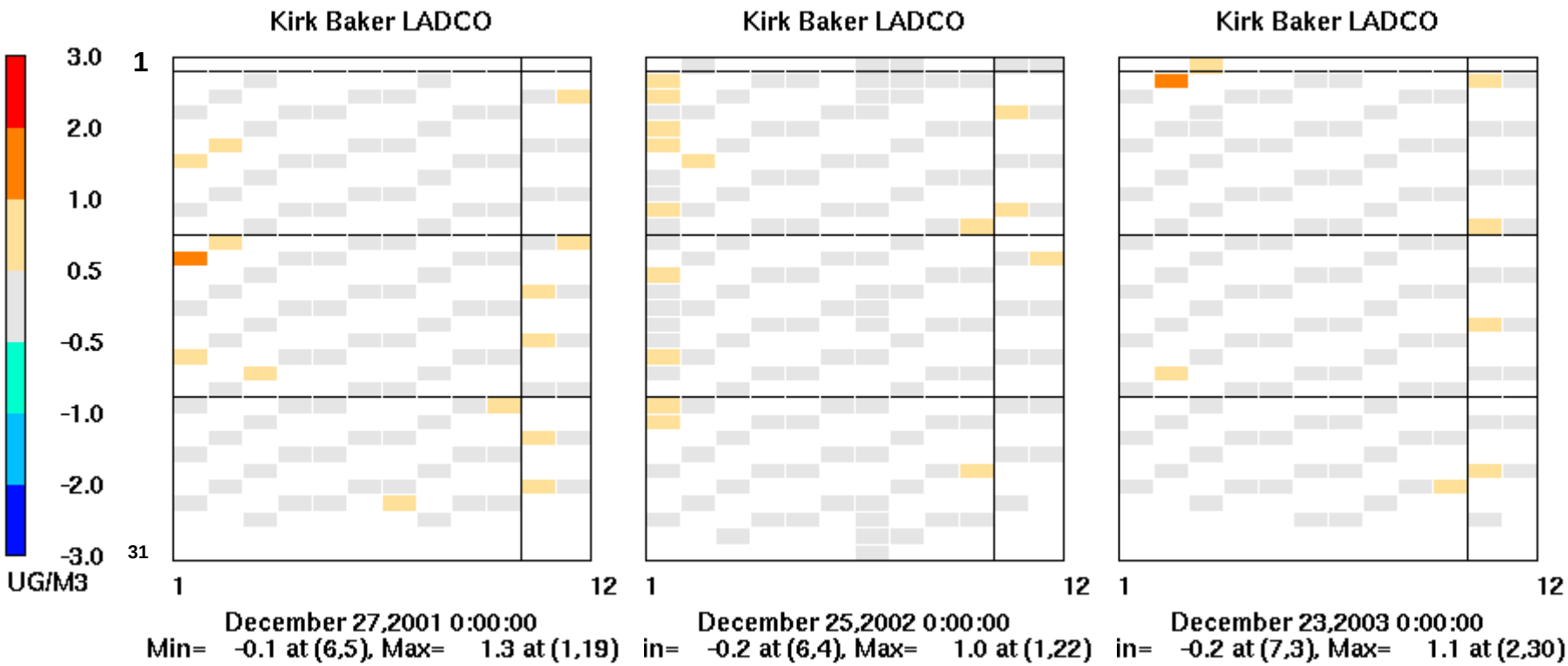
PM2.5 Sulfate Ion Daily Bias



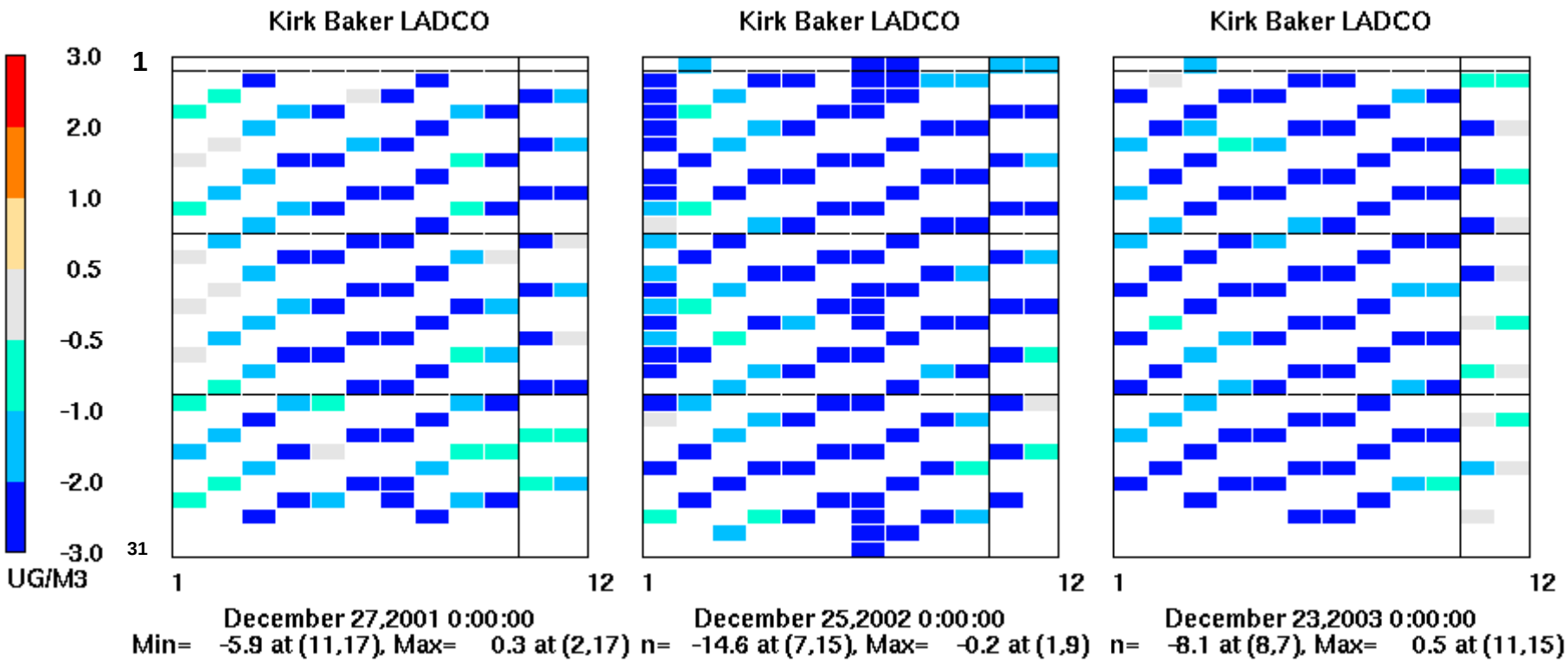
PM2.5 Nitrate Ion Daily Bias



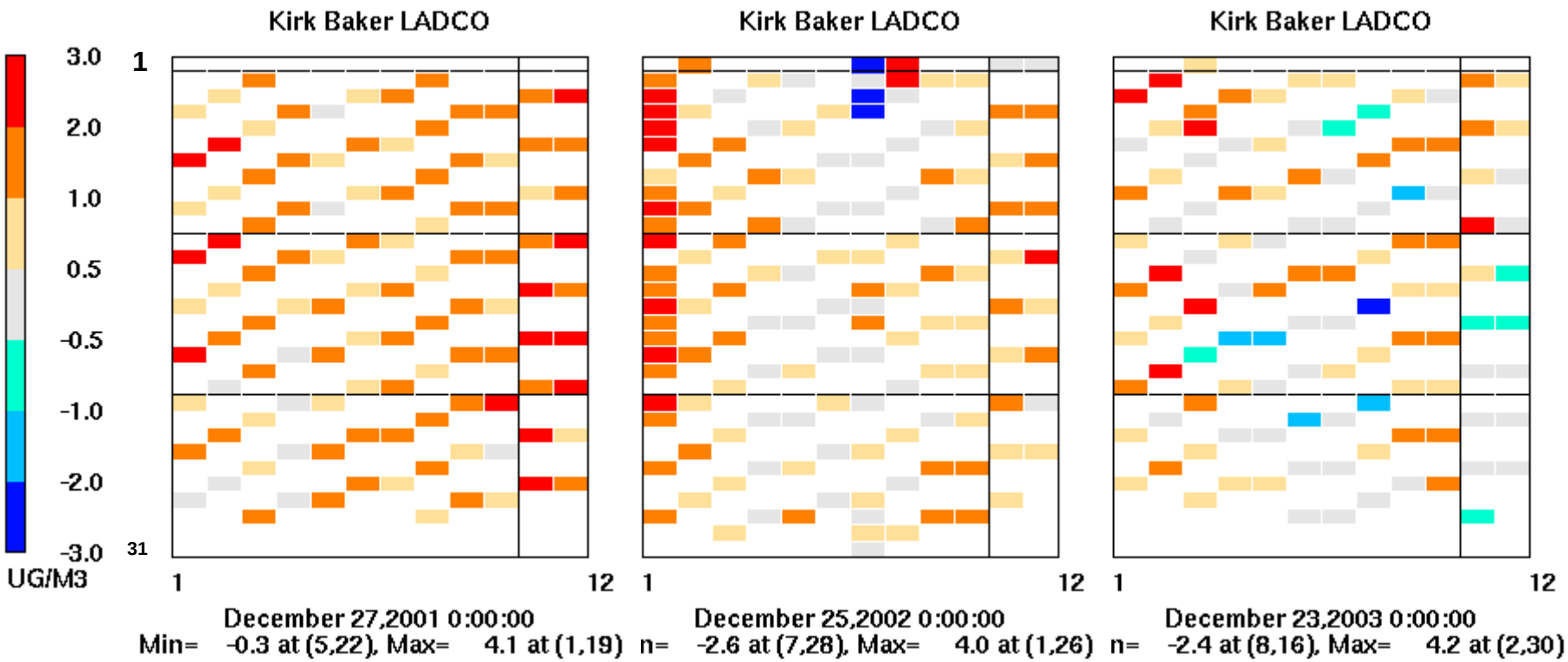
PM2.5 Elemental Carbon Daily Bias

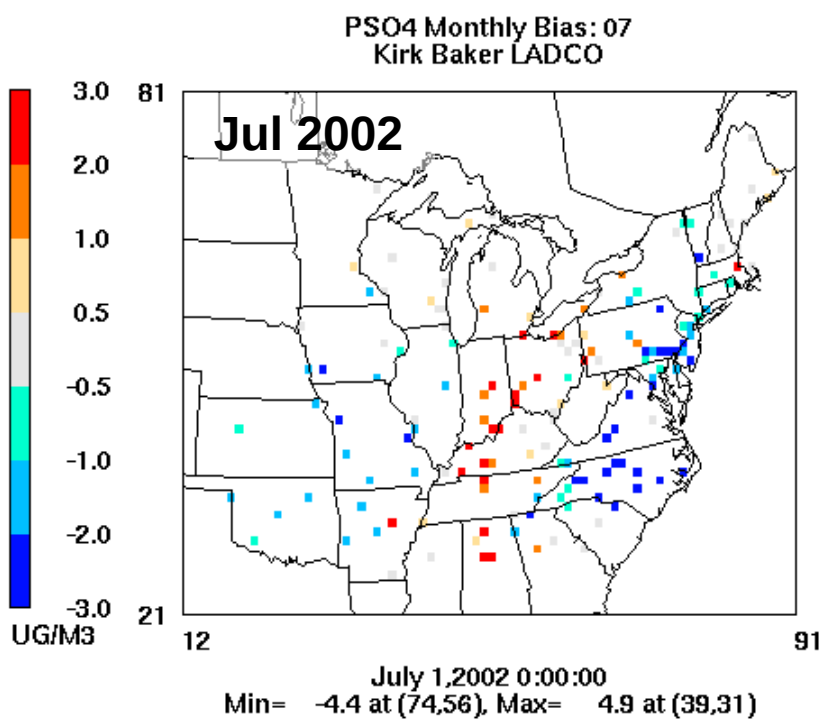


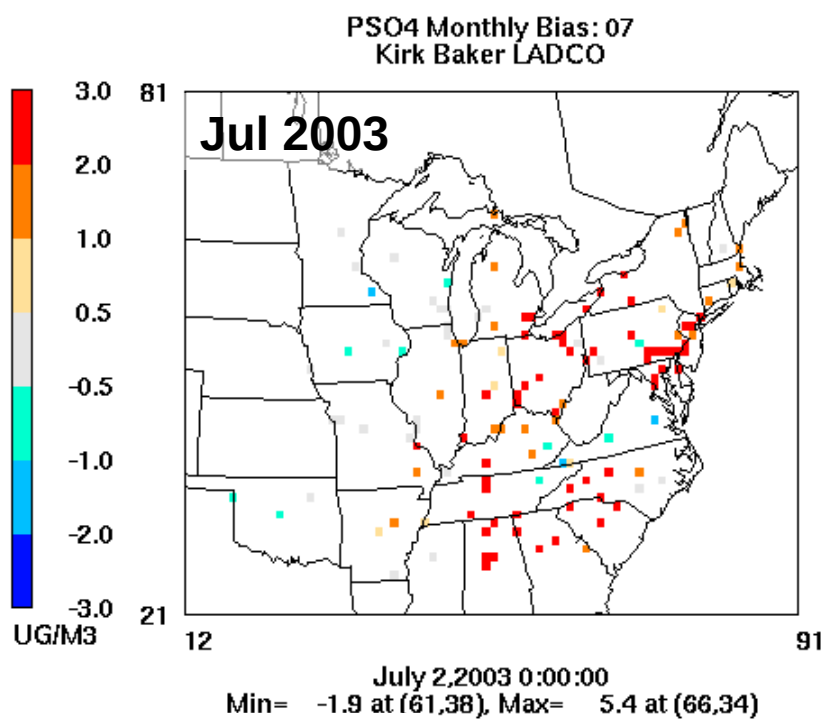
PM2.5 Organic Carbon Daily Bias



PM2.5 Soil/Crustal Daily Bias

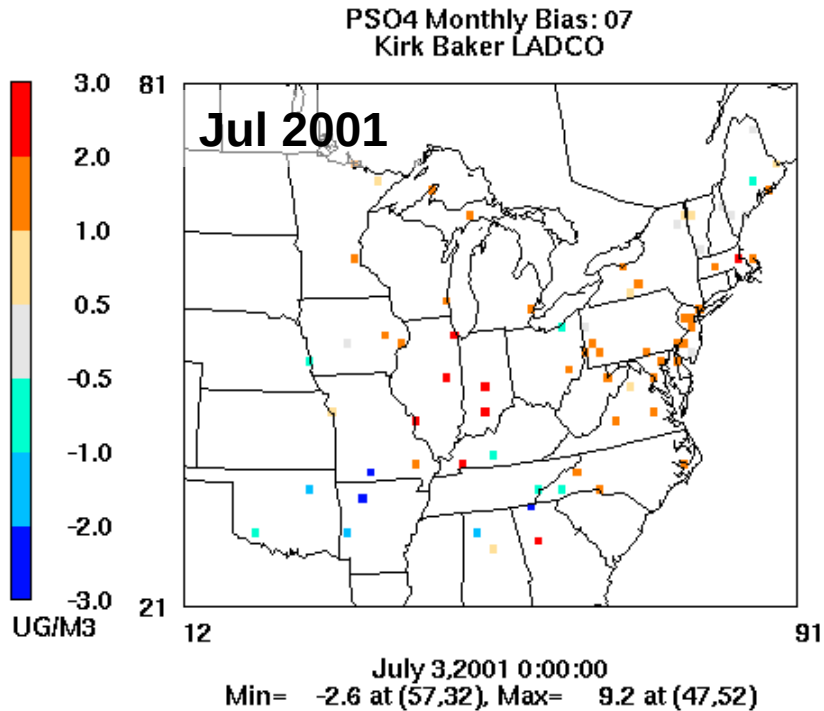




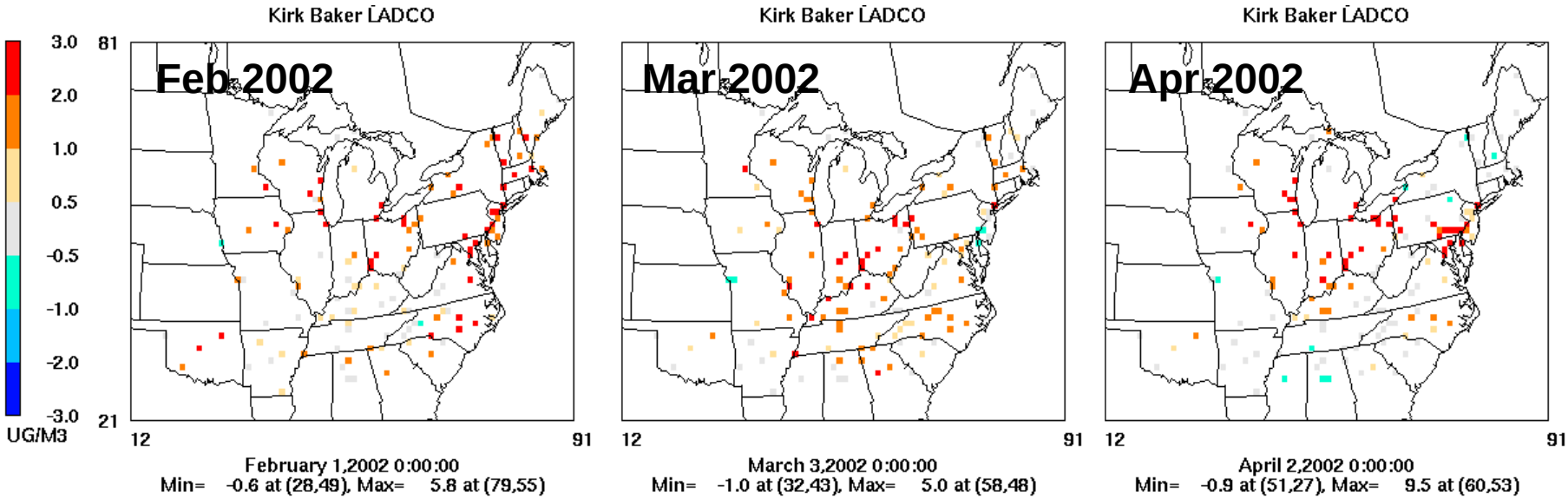


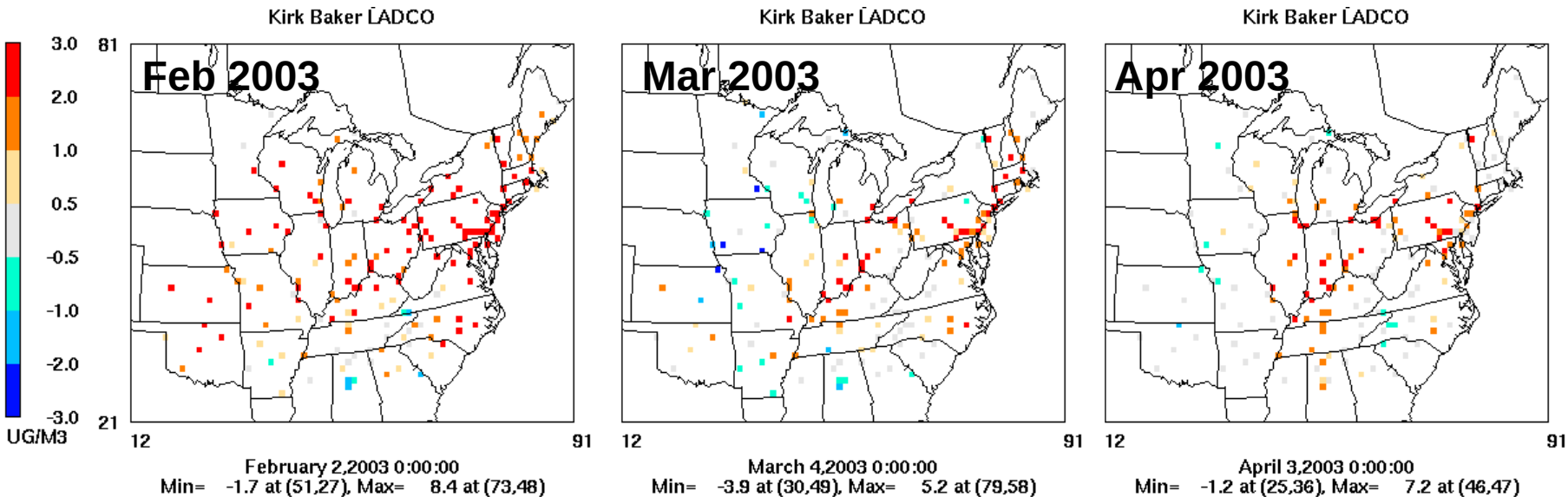
PM2.5 Sulfate Ion

Monthly Bias

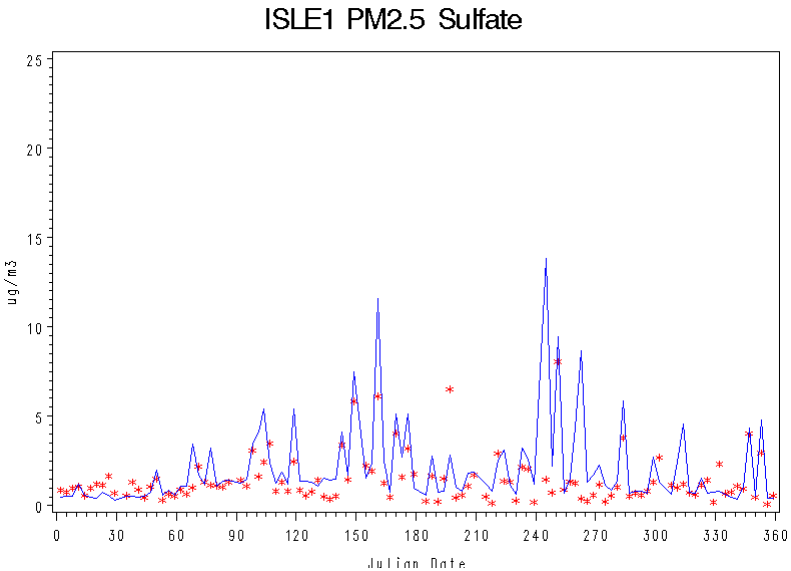


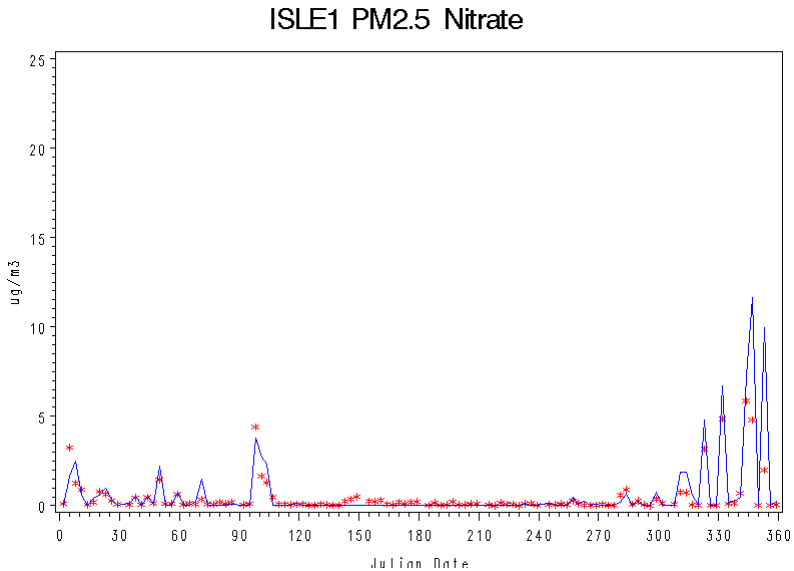
PM2.5 Nitrate Monthly Average Bias

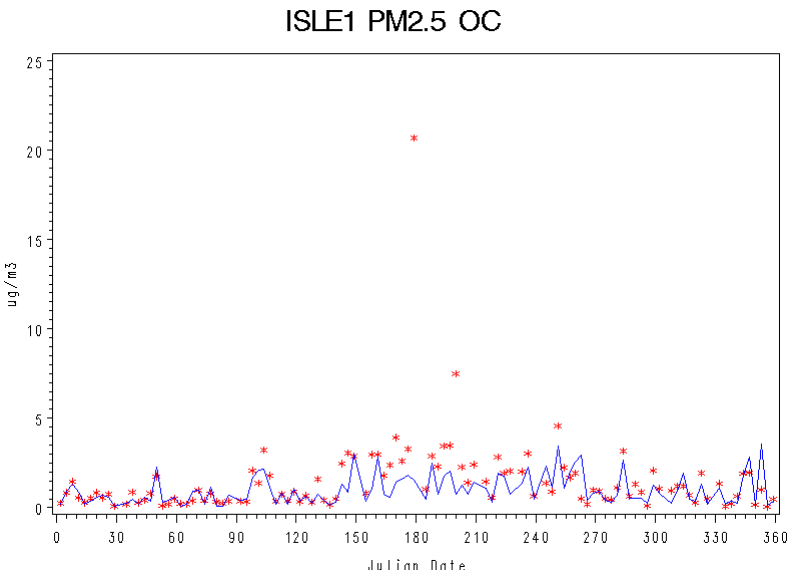


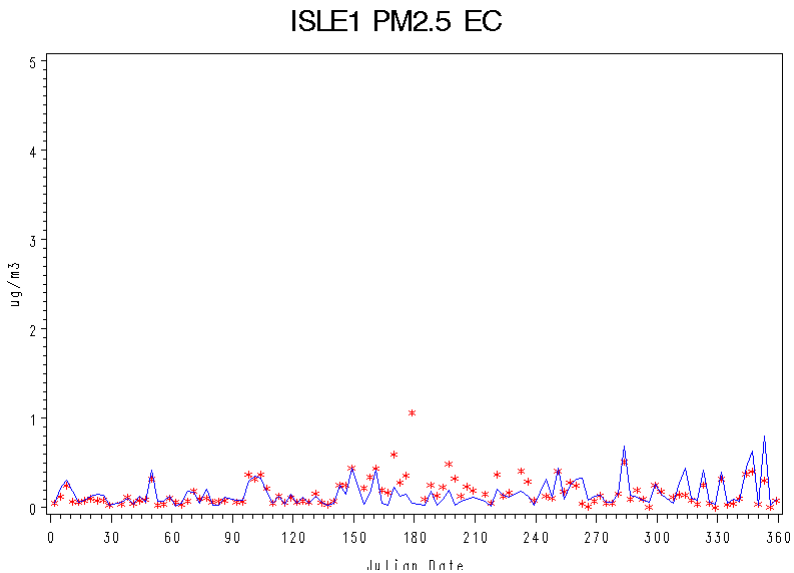


Isle Royale (MI) Time Series for 2002

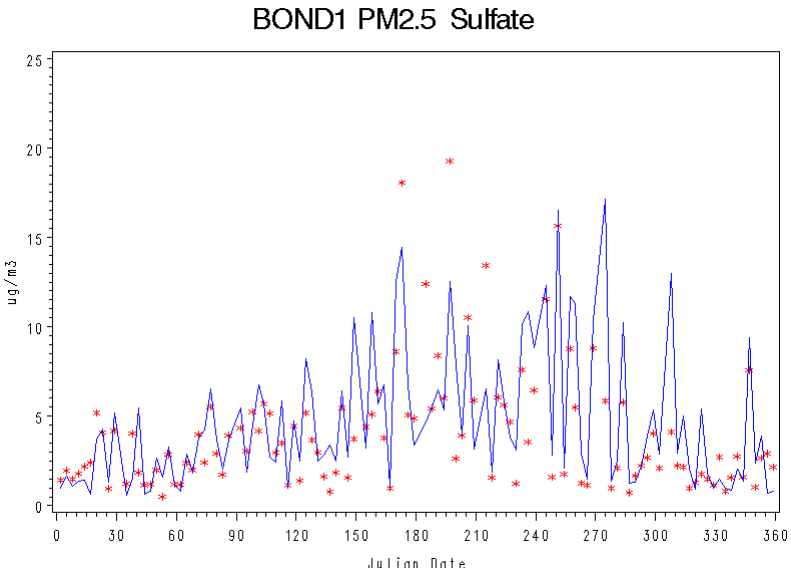


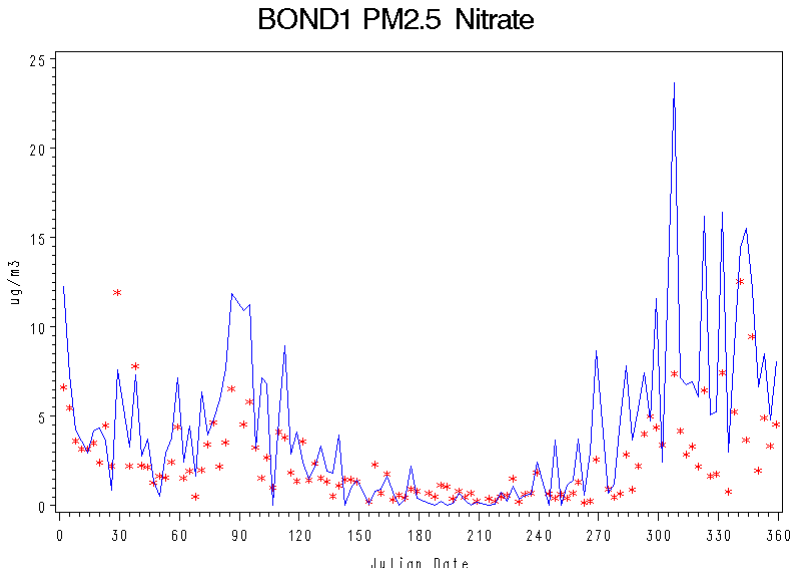


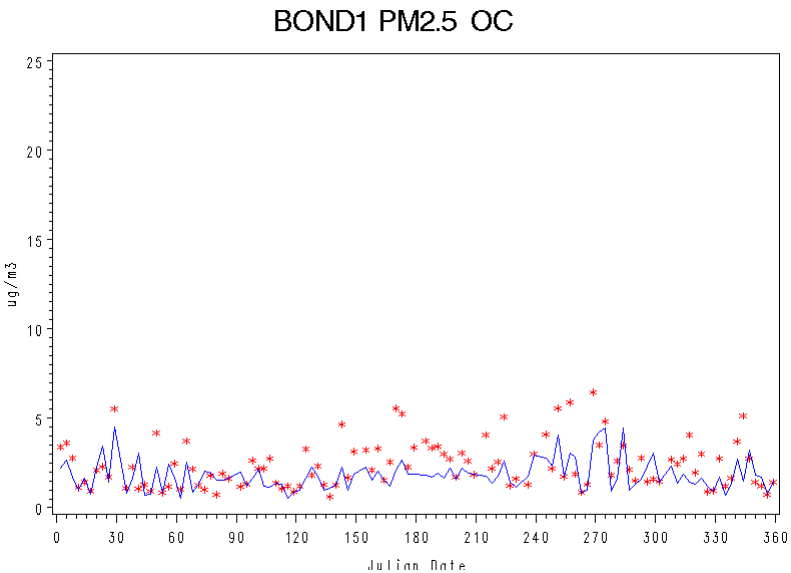


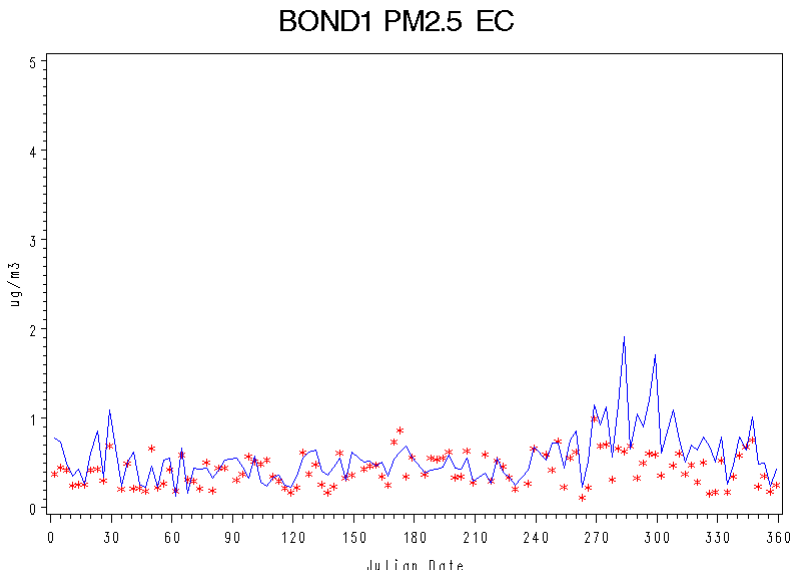


Bondville (IL) Time Series for 2002









Remarks: PM

- Performance by chemical specie very consistent from year to year
- Sulfate ion most variation between years, likely due to sulfate formation link to atmospheric water content
- Modeling system performs best for sulfate ion and elemental carbon
- Performance worst for organic carbon during the summer months
- Nitrate performance needs additional evaluation

Purpose: Ozone

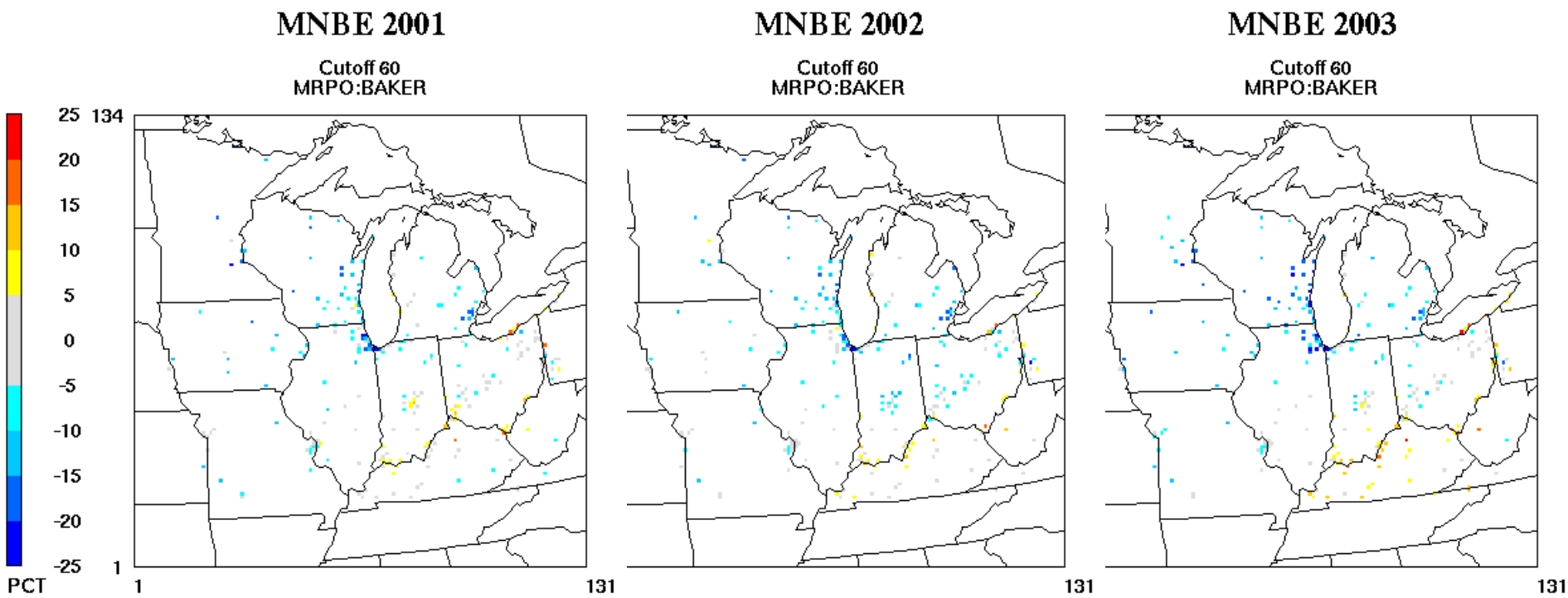
- How consistently does the modeling system perform from one summer to the next in the Great Lakes and Ohio Valley regions?
- Examine performance consistency over the summer by monitor location, by episode day
- Also examine performance over all ozone concentrations and higher ozone concentrations (> 60 ppb)
- Examine the limited amount of non-surface model performance
- Predictions and observations paired in time and space

Ozone Model Performance

- Presenting normalized bias (MNBE) and normalized error (MNGE) metrics consistent with EPA modeling guidance
- Metrics are estimated using 3 minimum thresholds: 20 ppb, 40 ppb, and 60 ppb
- These thresholds represent nearly the entire prediction-observation distribution (>20), inclusion of the lowest and middle values (>40), and the higher more policy relevant values (>60)
- Metrics all using **8-hr** average ozone

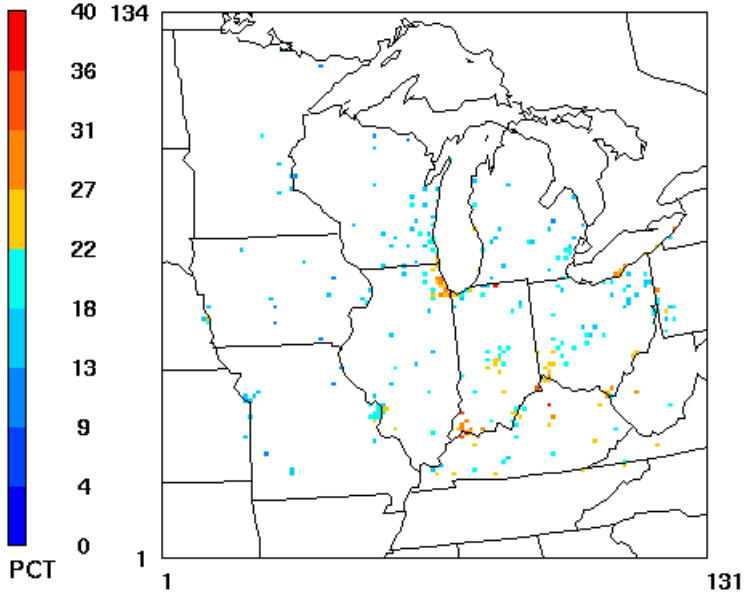
Metrics by Site Averaged over Summer Period

MNBE = mean normalized bias error

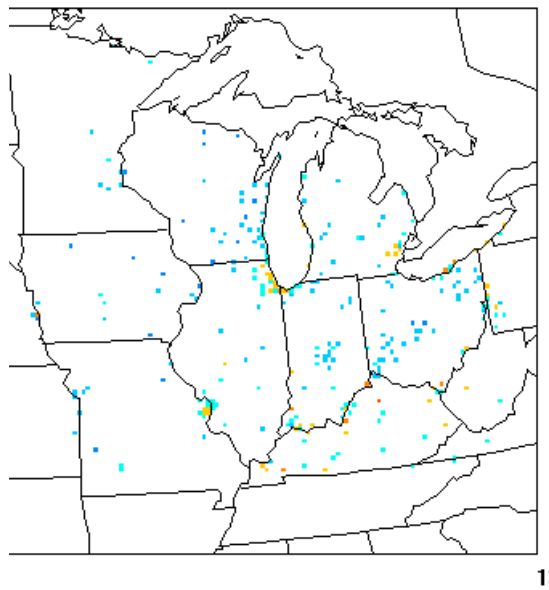


60 ppb metric cutoff

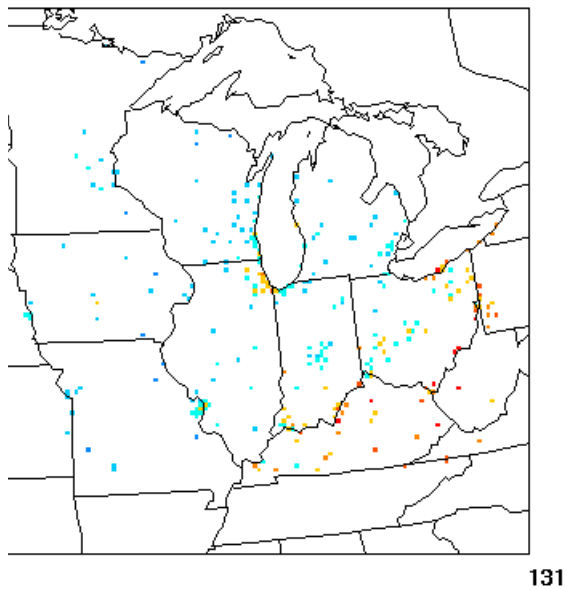
MNGE; 2001; cutoff 40



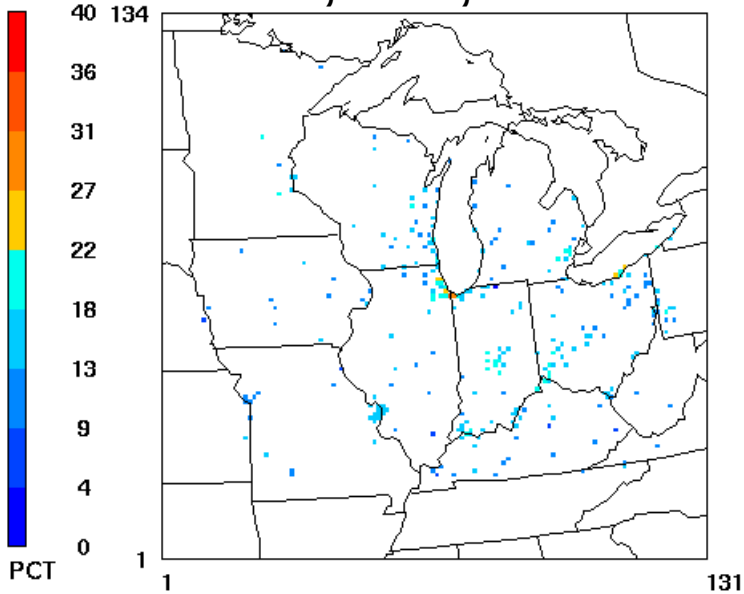
MNGE; 2002; cutoff 40



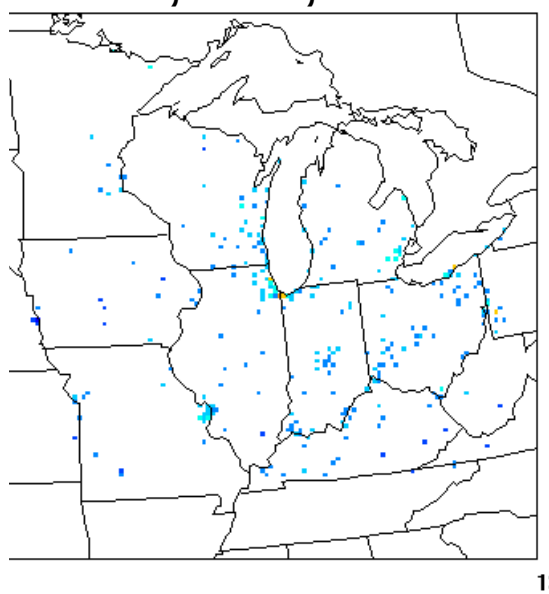
MNGE; 2003; cutoff 40



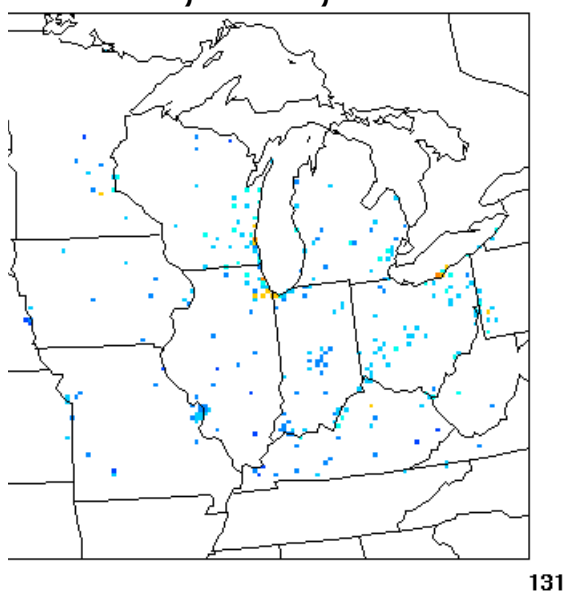
MNGE; 2001; cutoff 60

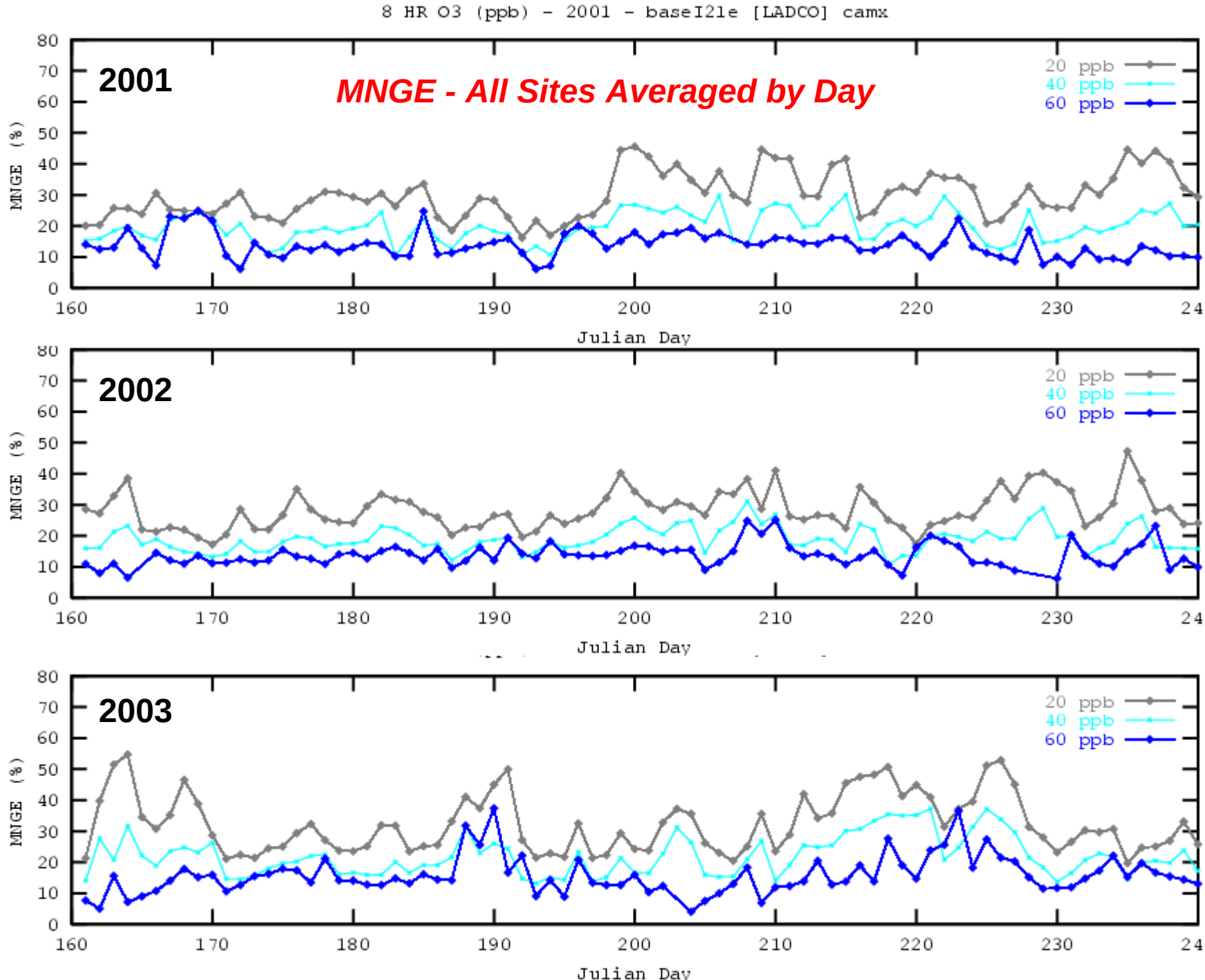


MNGE; 2002; cutoff 60

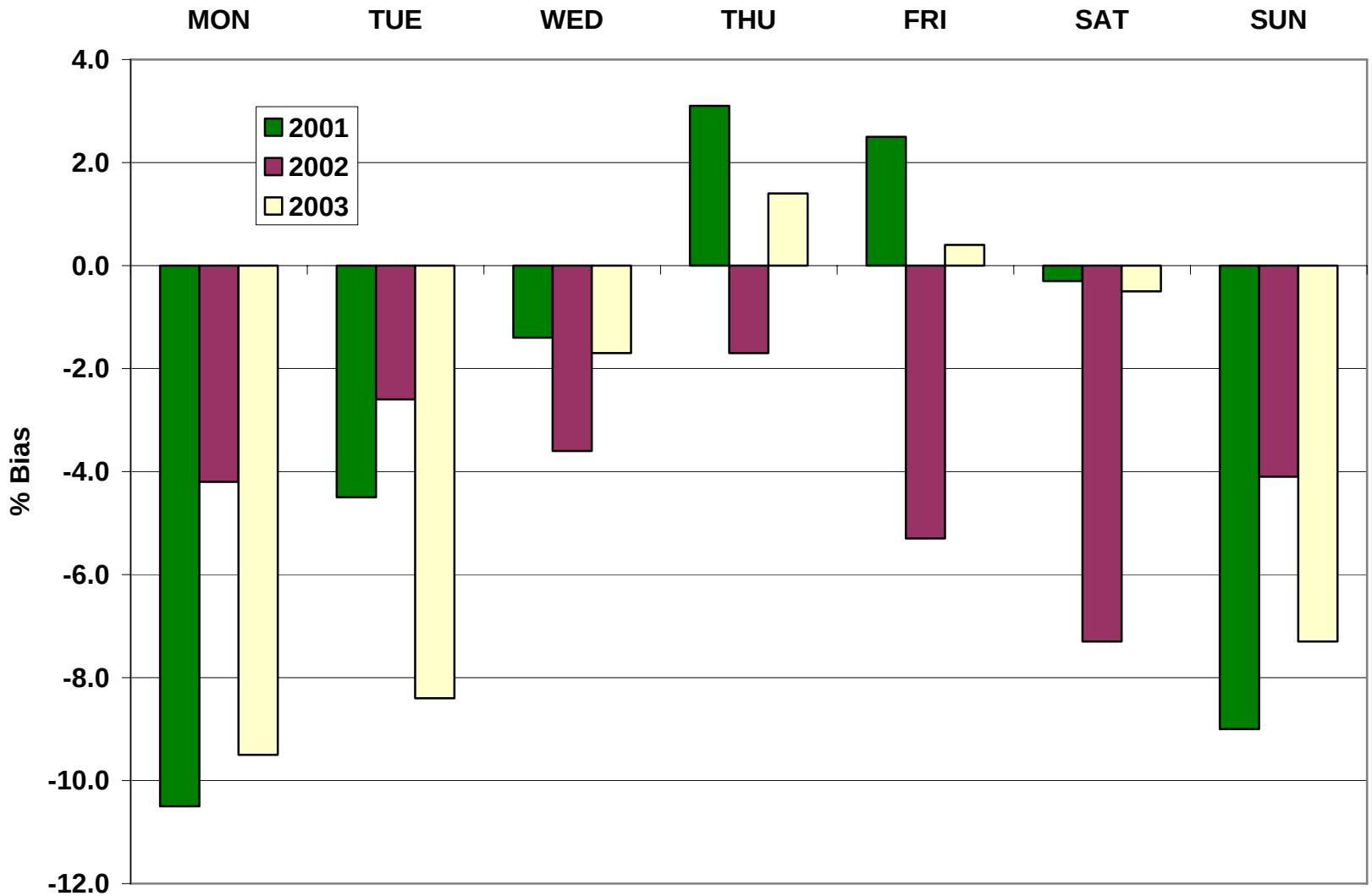


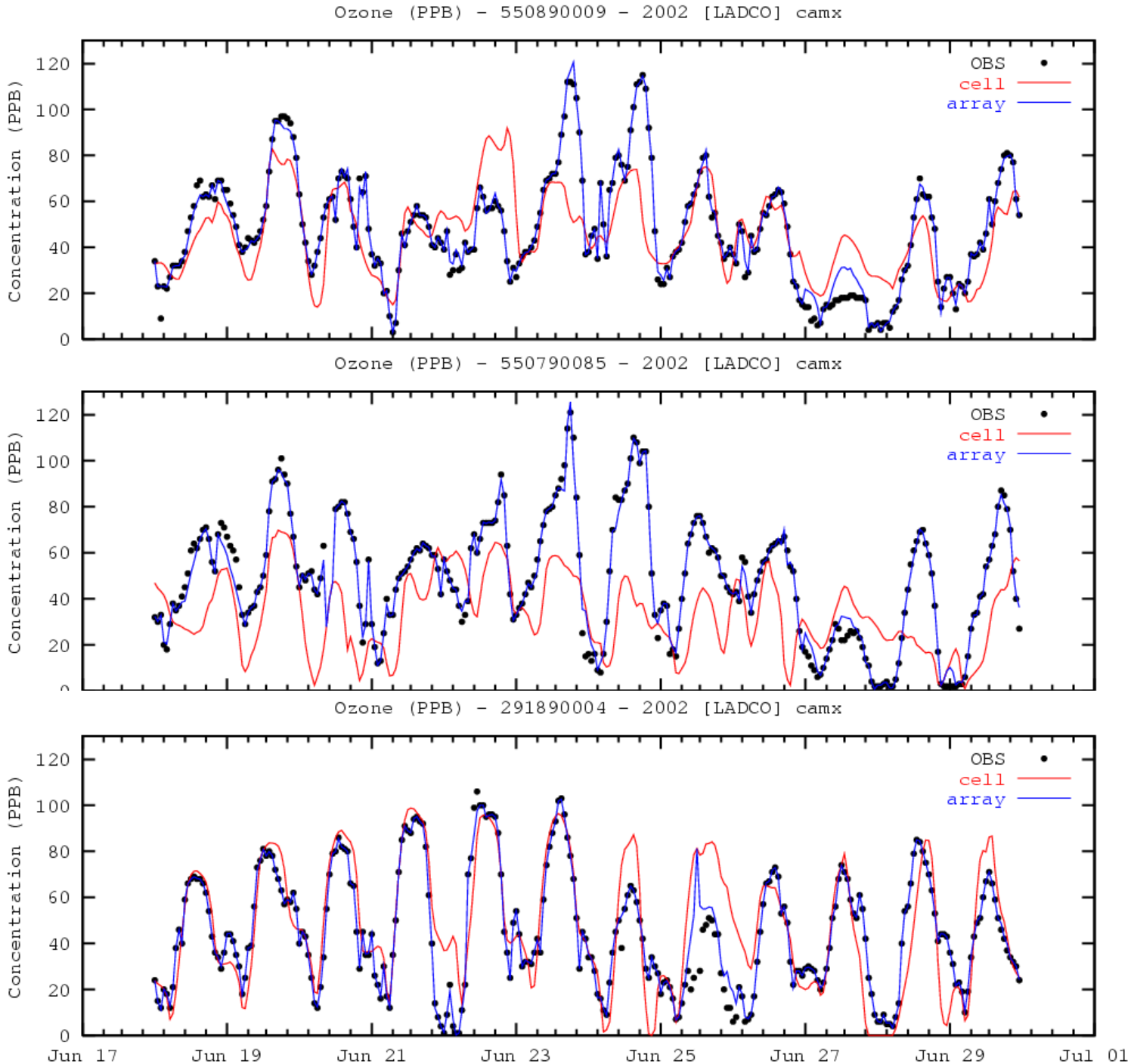
MNGE; 2003; cutoff 60



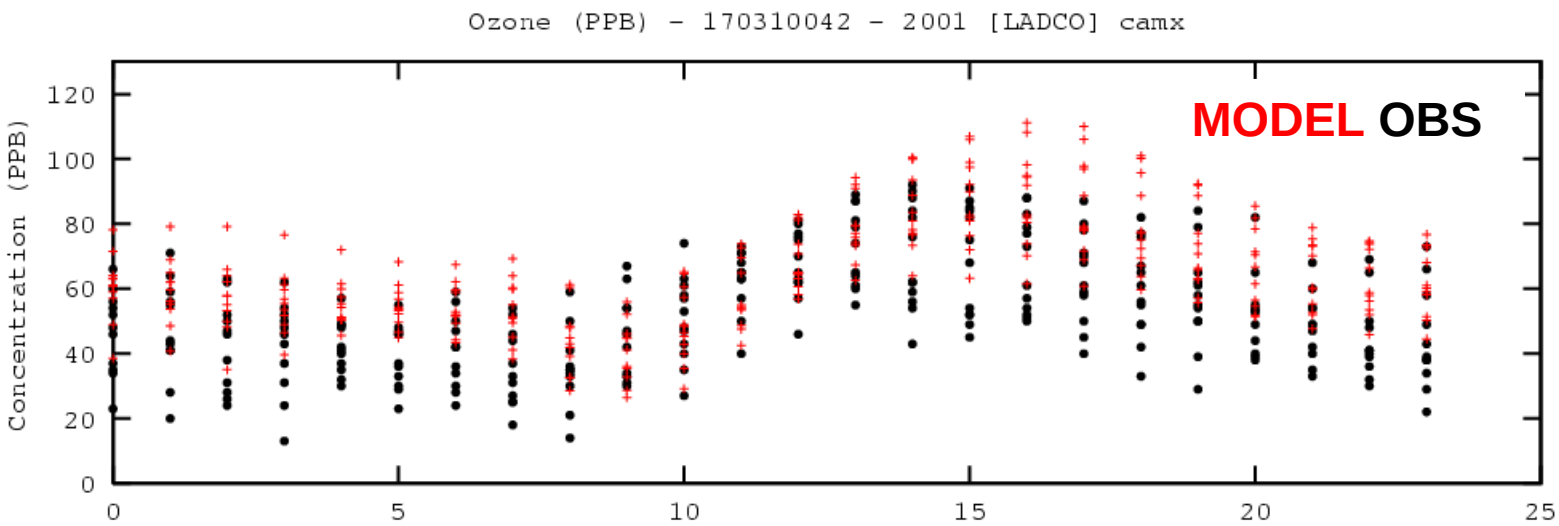

8 HR O3 (ppb) - 2001 - baseI21e [LADCO] camx
2001
MNGE - All Sites Averaged by Day
20 ppb
40 ppb
60 ppb
MNGE (%)
Julian Day
2002
2003

Hourly MNBE Metrics Averaged by Day of Week

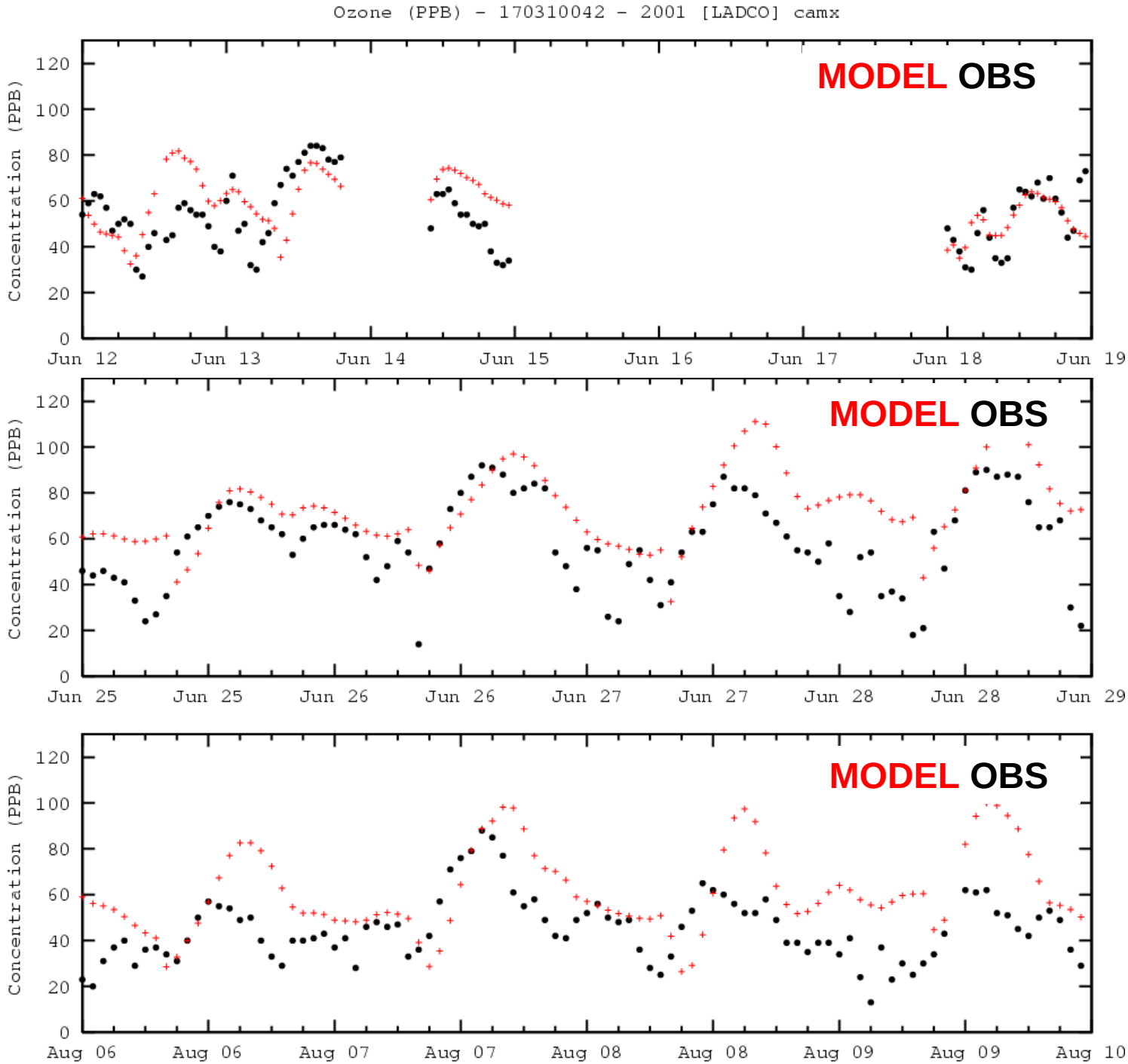


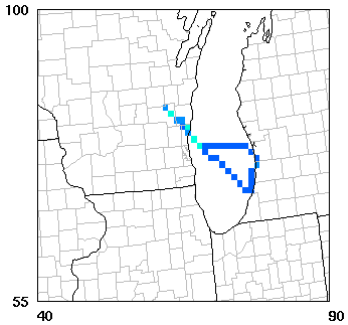

Ozone (PPB) - 550890009 - 2002 [LADCO] camx
Concentration (PPB)
OBS
cell
array
Ozone (PPB) - 550790085 - 2002 [LADCO] camx
Concentration (PPB)
OBS
cell
array
Ozone (PPB) - 291890004 - 2002 [LADCO] camx
Concentration (PPB)
OBS
cell
array
0
20
40
60
80
100
120
Jun 17
Jun 19
Jun 21
Jun 23
Jun 25
Jun 27
Jun 29
Jul 01

Non-Surface Model Performance

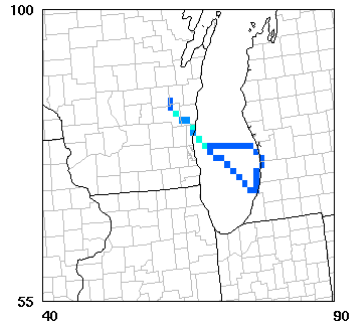


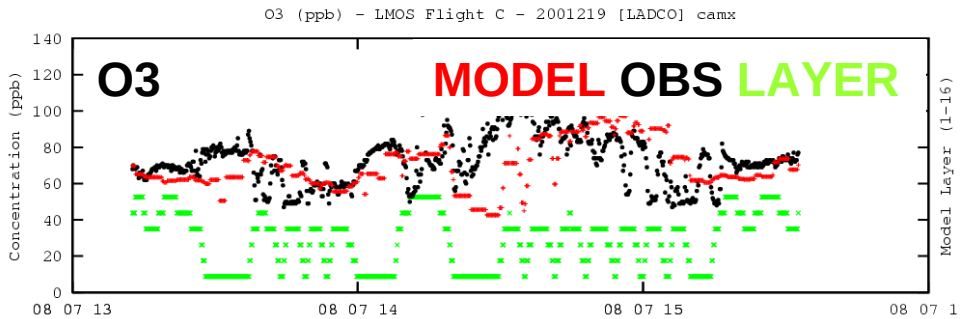
- 8-hourly averaged O3 distribution for Sear's Tower (model layer 5)
- Select days from 2001; same days as WDNR flights
- Time series shown on next slide (3 separate periods)
- Model performs fairly well during transition periods; tends to over-predict mid-day concentrations; often over-predicts nighttime lows

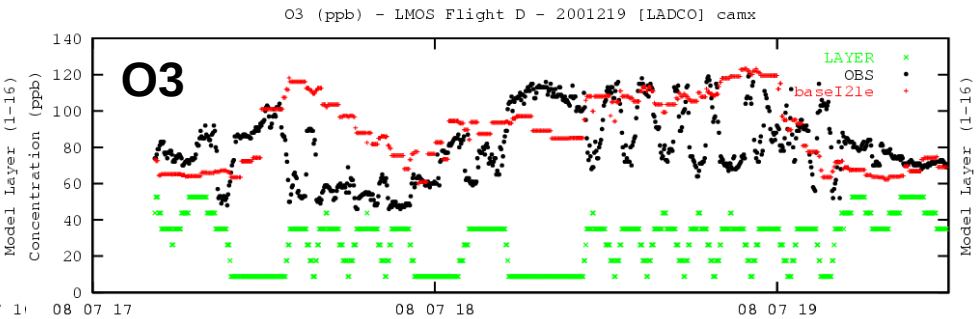

Ozone (PPB) - 170310042 - 2001 [LADCO] camx
MODEL OBS
Concentration (PPB)
0
20
40
60
80
100
120
Jun 12
Jun 13
Jun 14
Jun 15
Jun 16
Jun 17
Jun 18
Jun 19
MODEL OBS
Concentration (PPB)
Jun 25
Jun 25
Jun 26
Jun 26
Jun 27
Jun 27
Jun 28
Jun 28
Jun 29
MODEL OBS
Concentration (PPB)
Aug 06
Aug 06
Aug 07
Aug 07
Aug 08
Aug 08
Aug 09
Aug 09
Aug 10

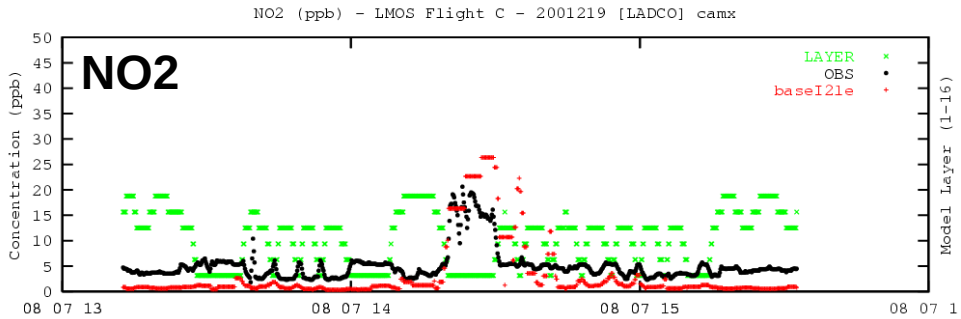


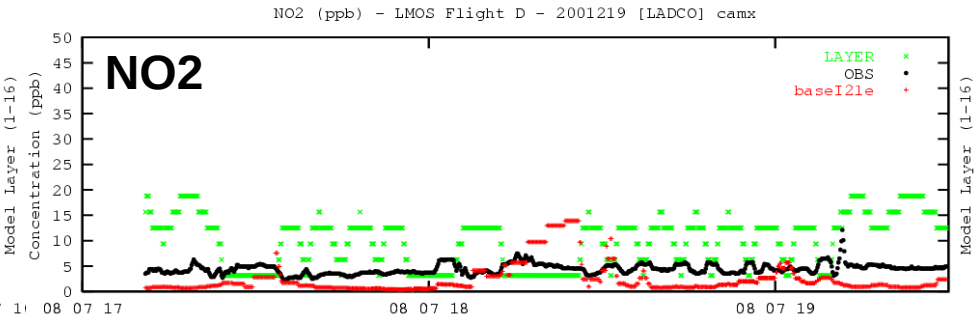
*Plots show flight paths and number of prediction-observation pairs in each grid cell

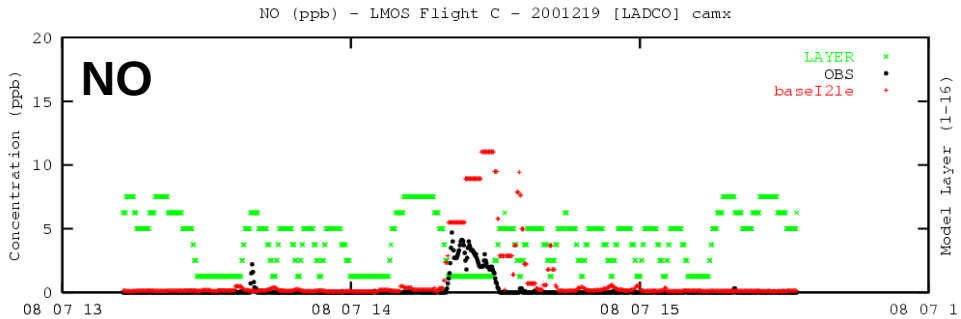


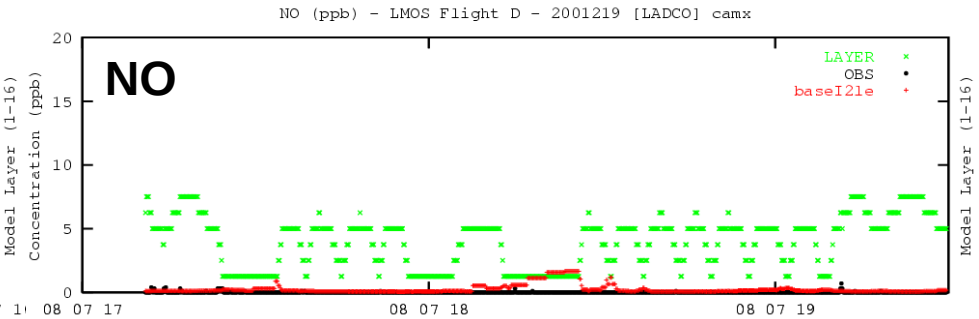


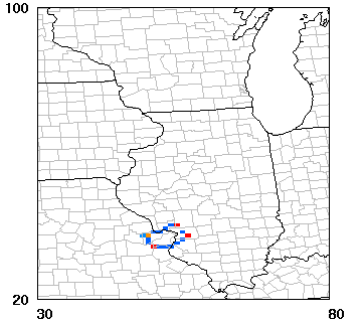




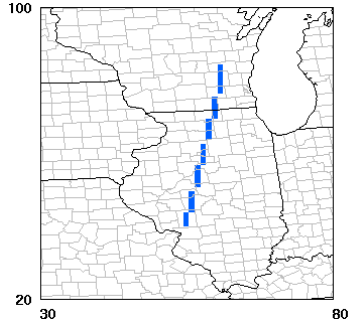


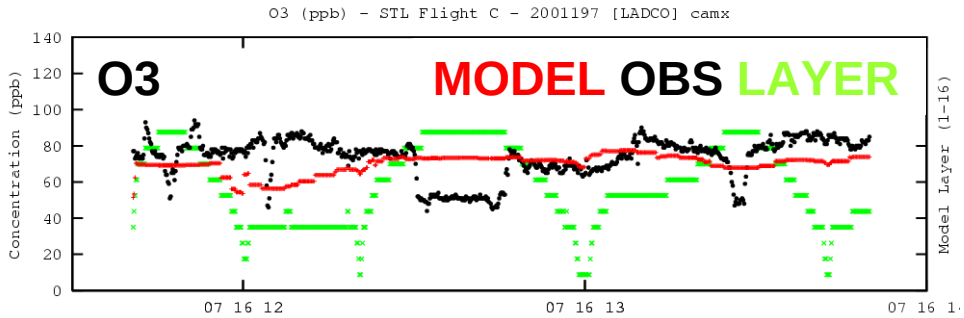


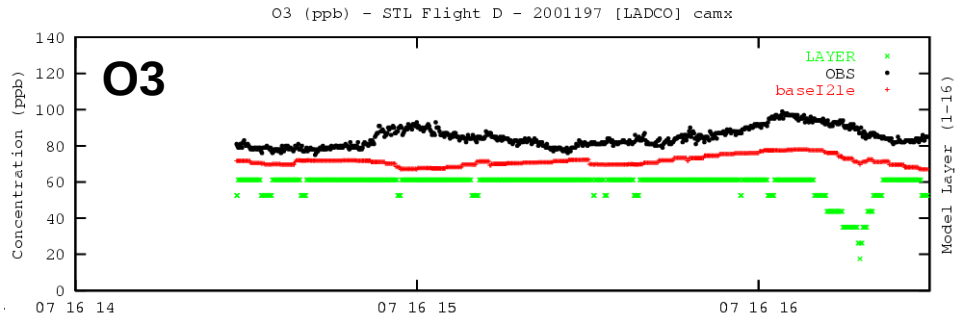


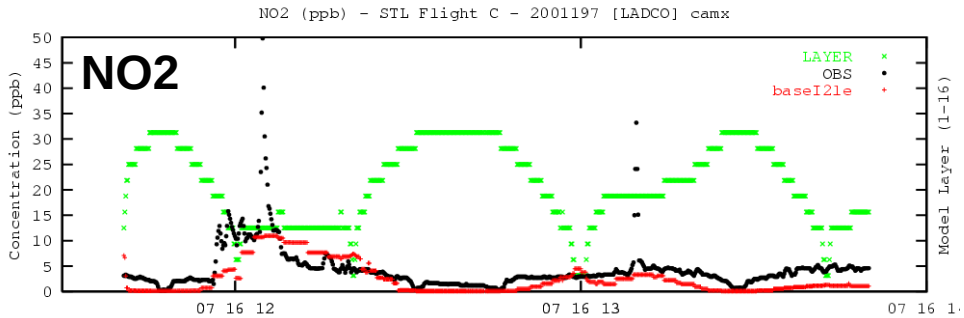


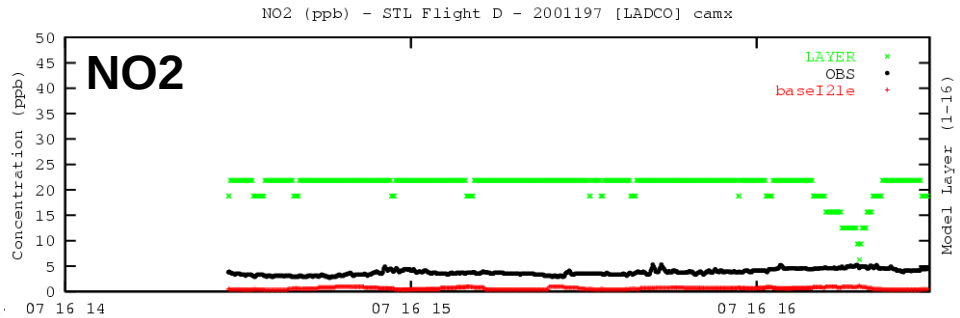
*Plots show flight paths and number of prediction-observation pairs in each grid cell

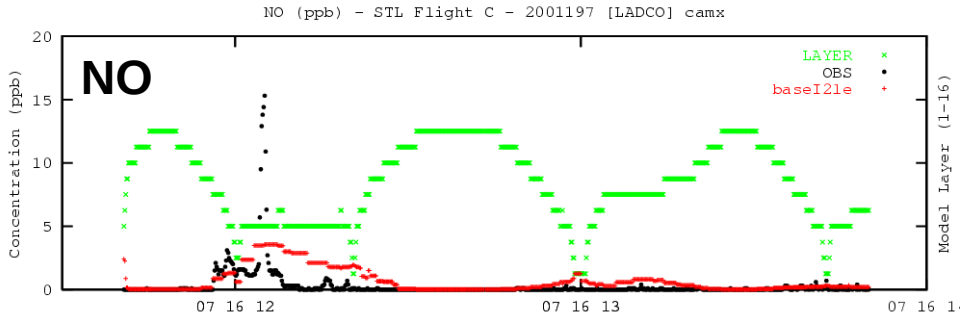


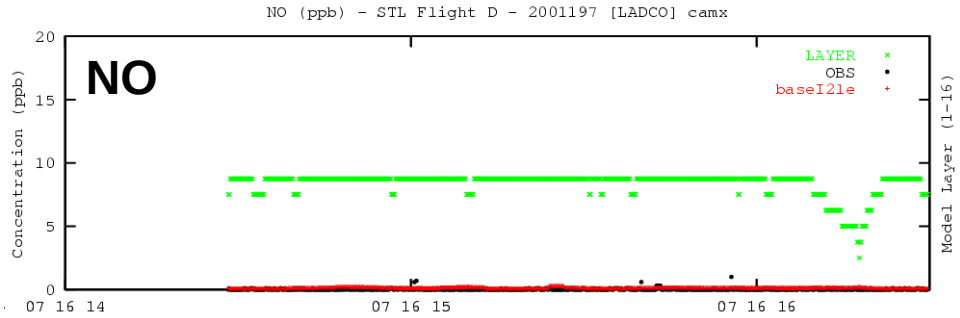












Remarks: O3

- Model performance very consistent from one summer to the next
- Model performance best for higher (> 60 ppb) ozone concentrations
- Non-surface performance open to interpretation
- Next steps: examine O3 performance for O3 > 80 for purely regulatory focus