Evaluation of CMAQ Ozone and Aerosol Forecasts

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MDL AQ web site:
http://slosh.nws.noaa.gov/aqverif
Username: aqverif
Password: ozone

September 7, 2006

Goals: Air Quality Verification

- Compare 5x model performance on 3x domain to 3x model.
- Performance metrics:

  H (% Correct), TS, POD, FAR,

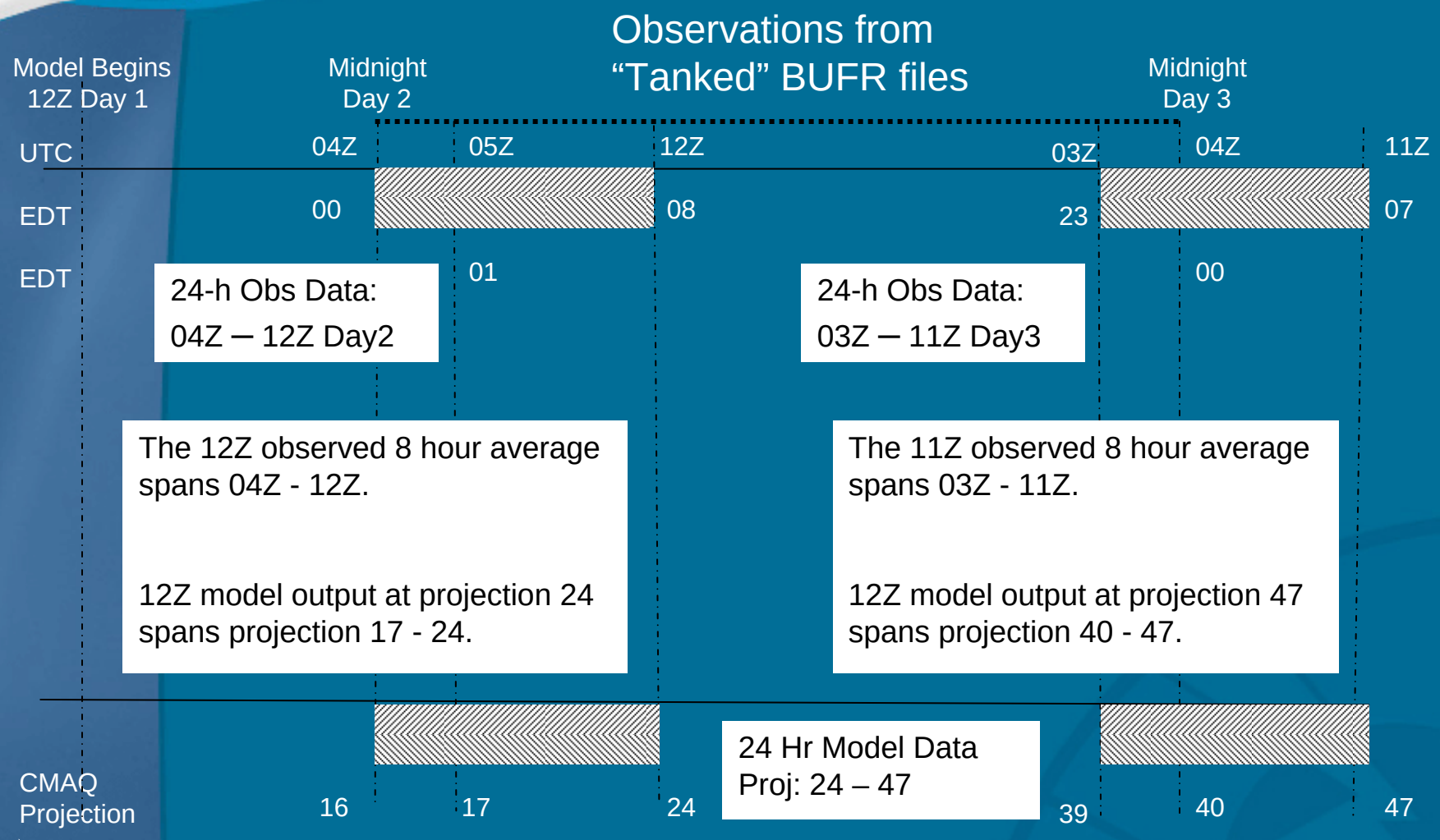
  MAE, ME/Bias.
- Use spatial maps to complement performance measures.
- Preliminary 1-h aerosol spatial maps and statistics.

Definitions of Statistical Terms

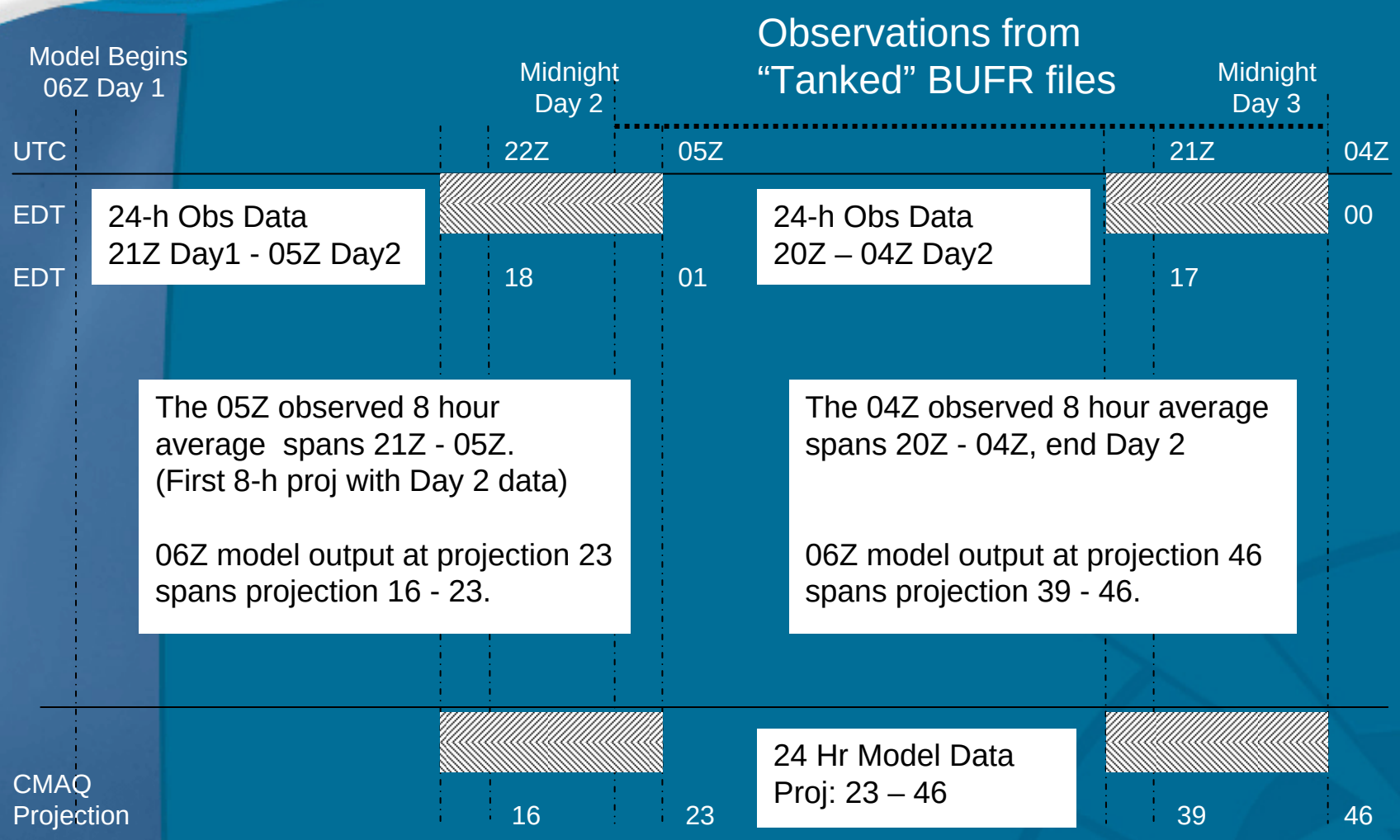
		OBSERVED	
		Y	N
FORECAST	Y	a	b
	N	c	d

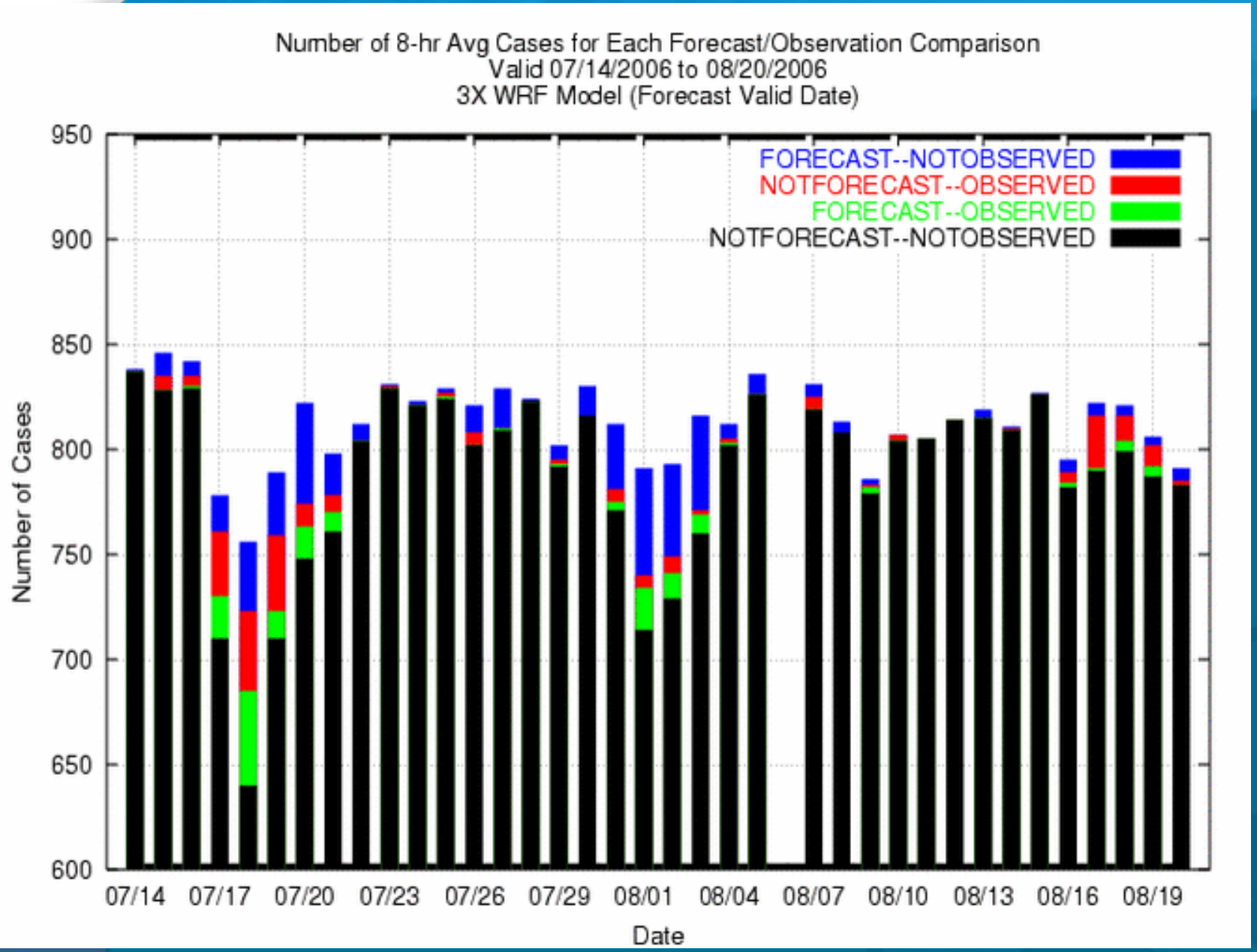
(H) FRACTION CORRECT = (a+d) / (a+b+c+d)
(TS) THREAT SCORE = a / (a+b+c)
POD = a / (a+c)
FAR = b / (a+b)

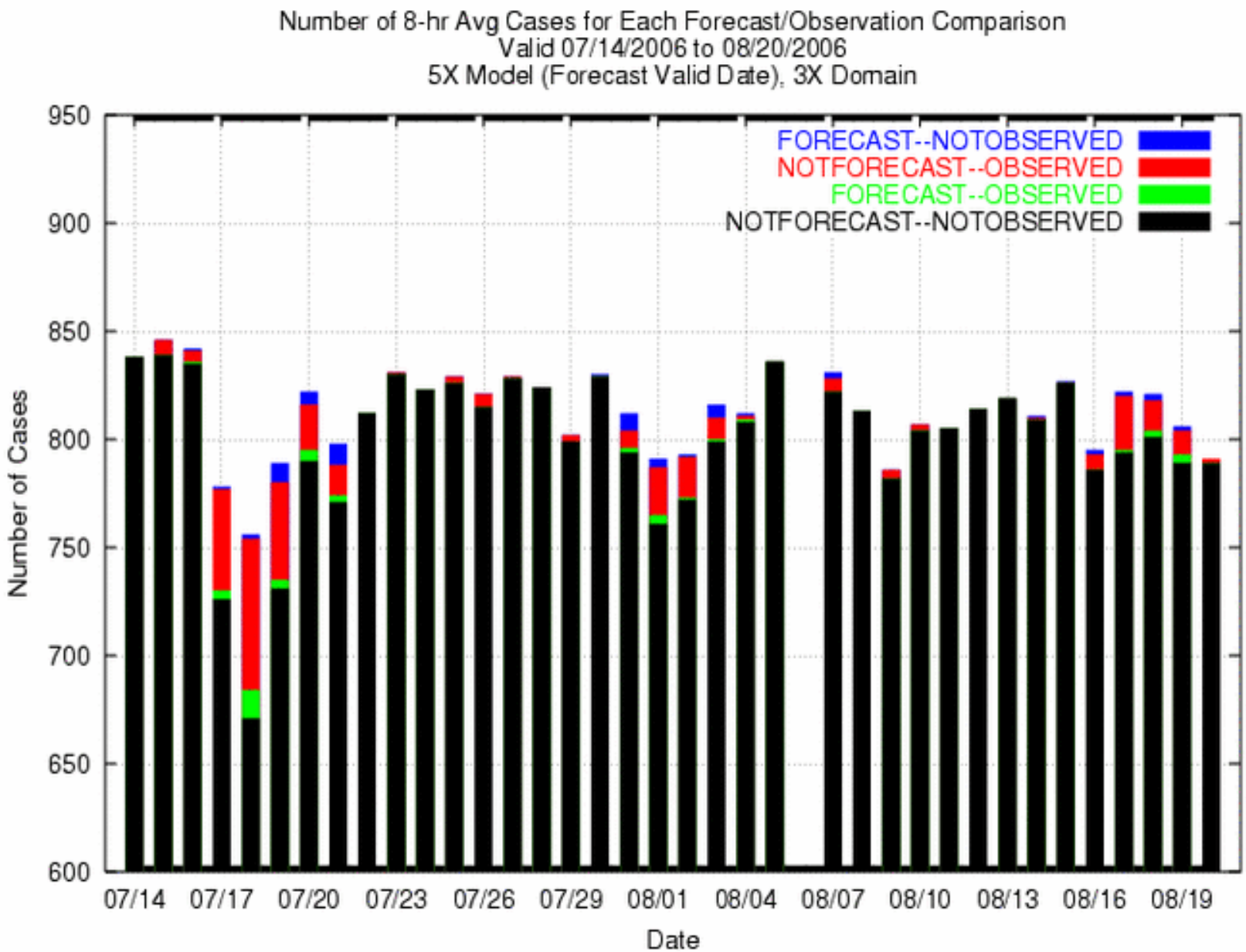
Timing for 8-h 12Z Ozone Concentrations 2006 Season

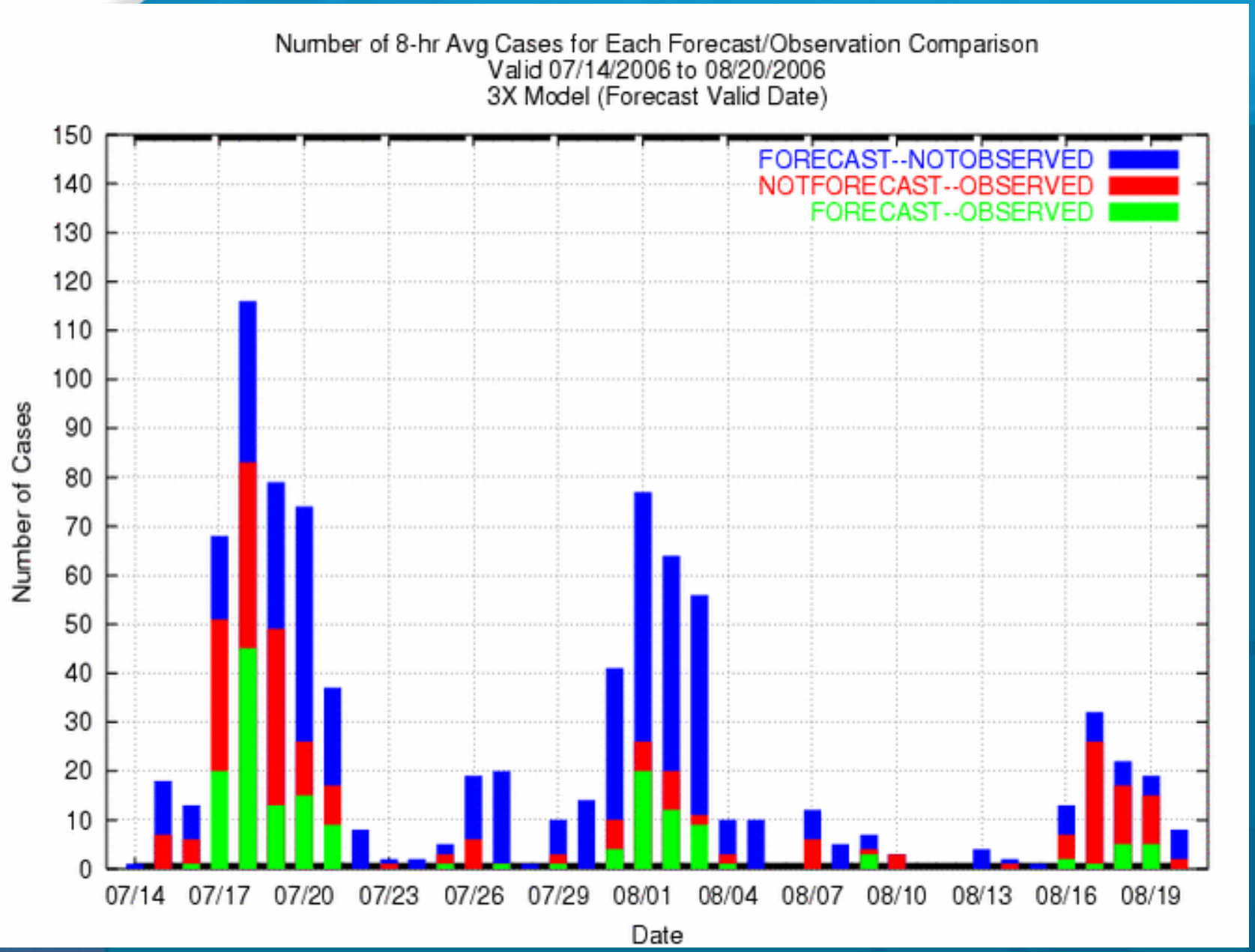


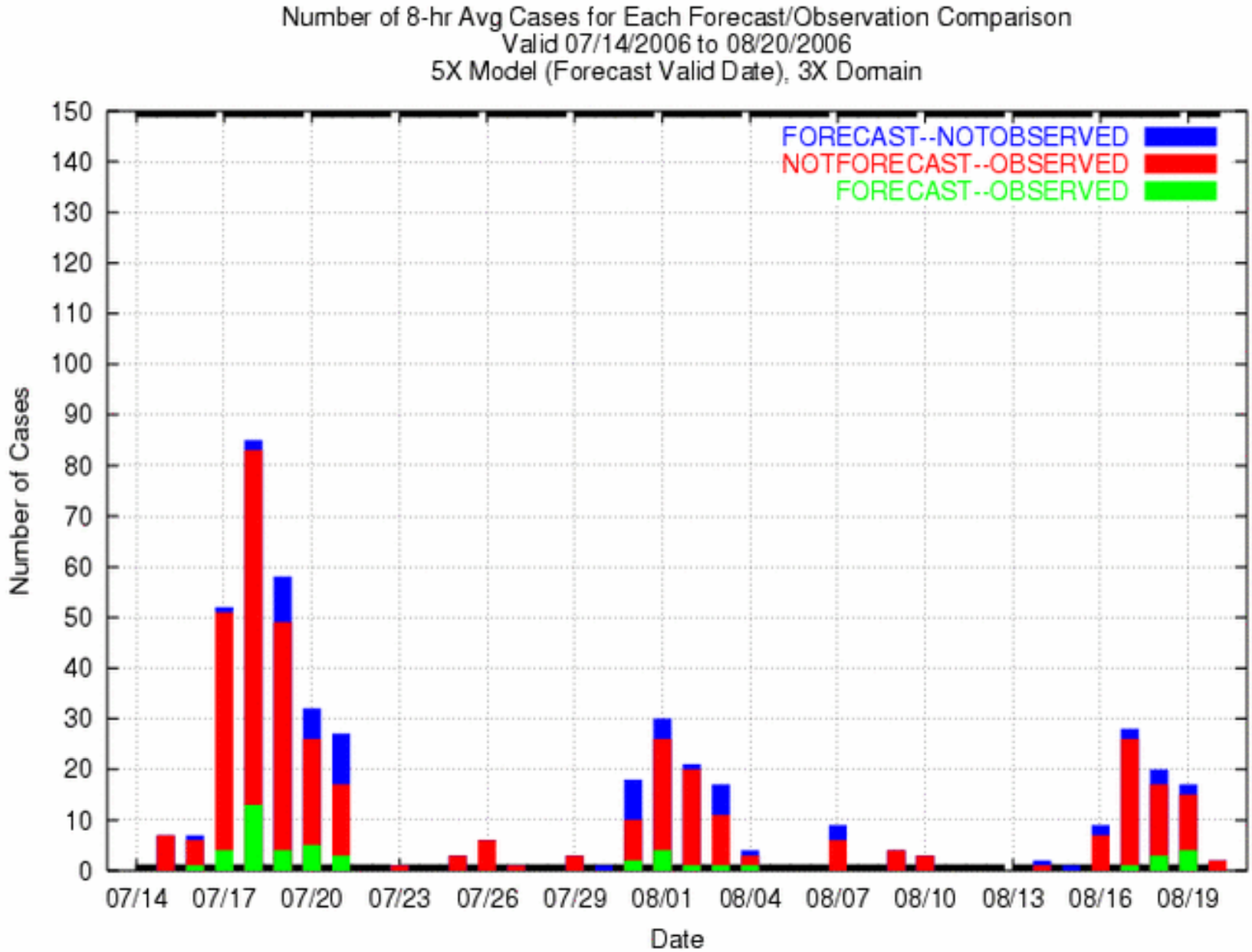
Timing for 8-h 06Z Ozone Concentrations 2006 Season

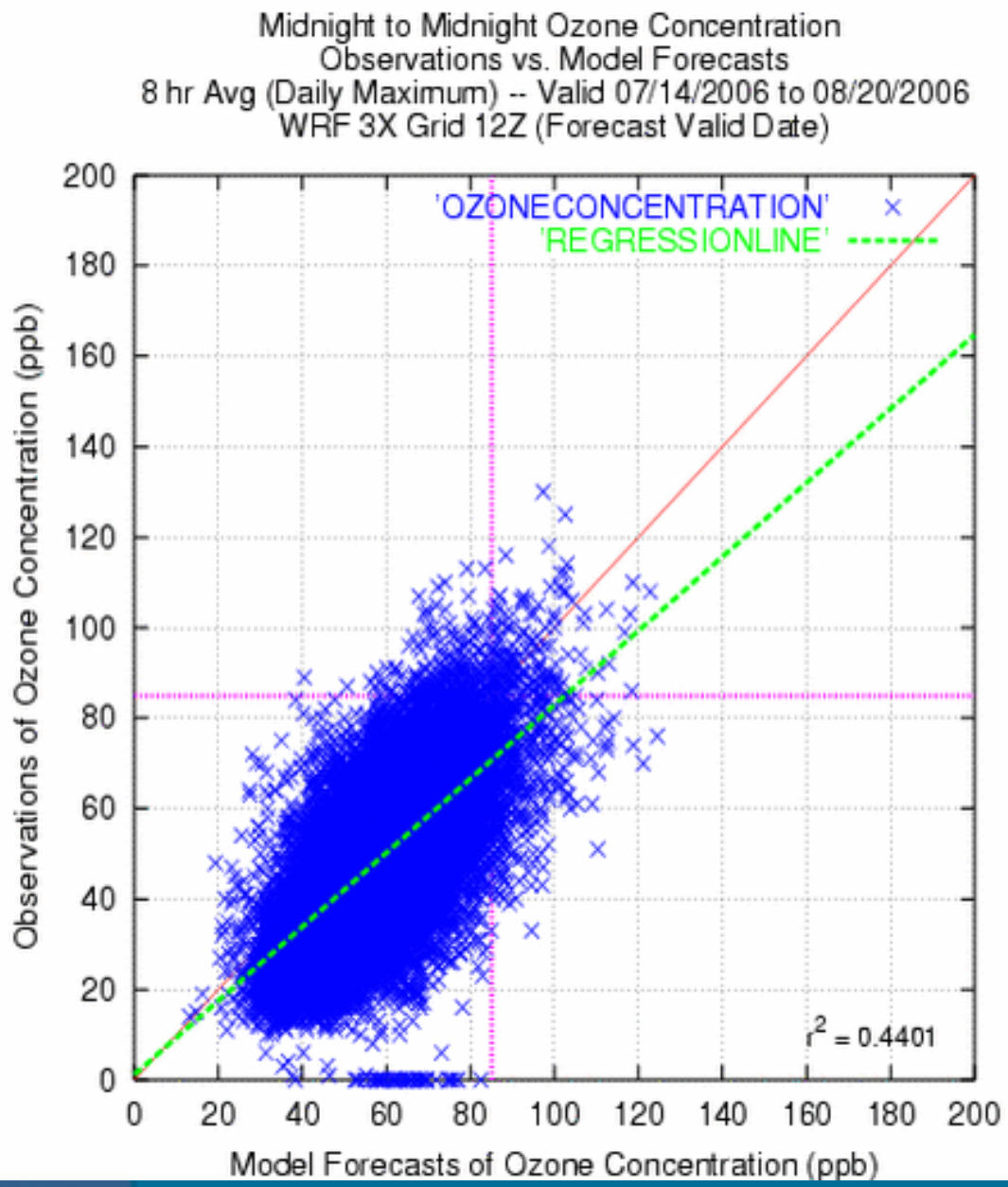


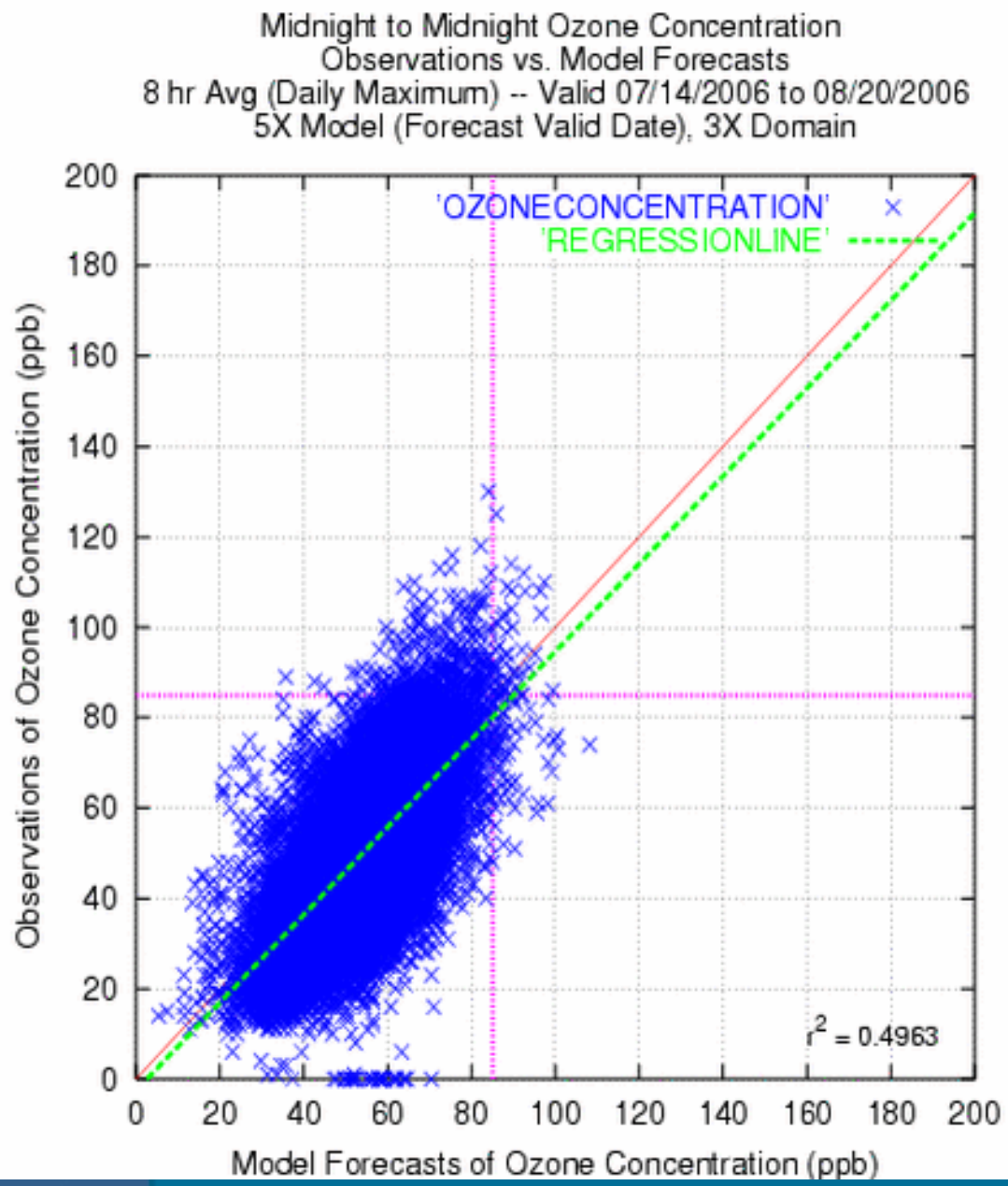

Number of 8-hr Avg Cases for Each Forecast/Observation Comparison
Valid 07/14/2006 to 08/20/2006
3X WRF Model (Forecast Valid Date)
FORECAST--NOTOBSERVED
NOTFORECAST--OBSERVED
FORECAST--OBSERVED
NOTFORECAST--NOTOBSERVED
Number of Cases
950
900
850
800
750
700
650
600
07/14
07/17
07/20
07/23
07/26
07/29
08/01
08/04
08/07
08/10
08/13
08/16
08/19
Date

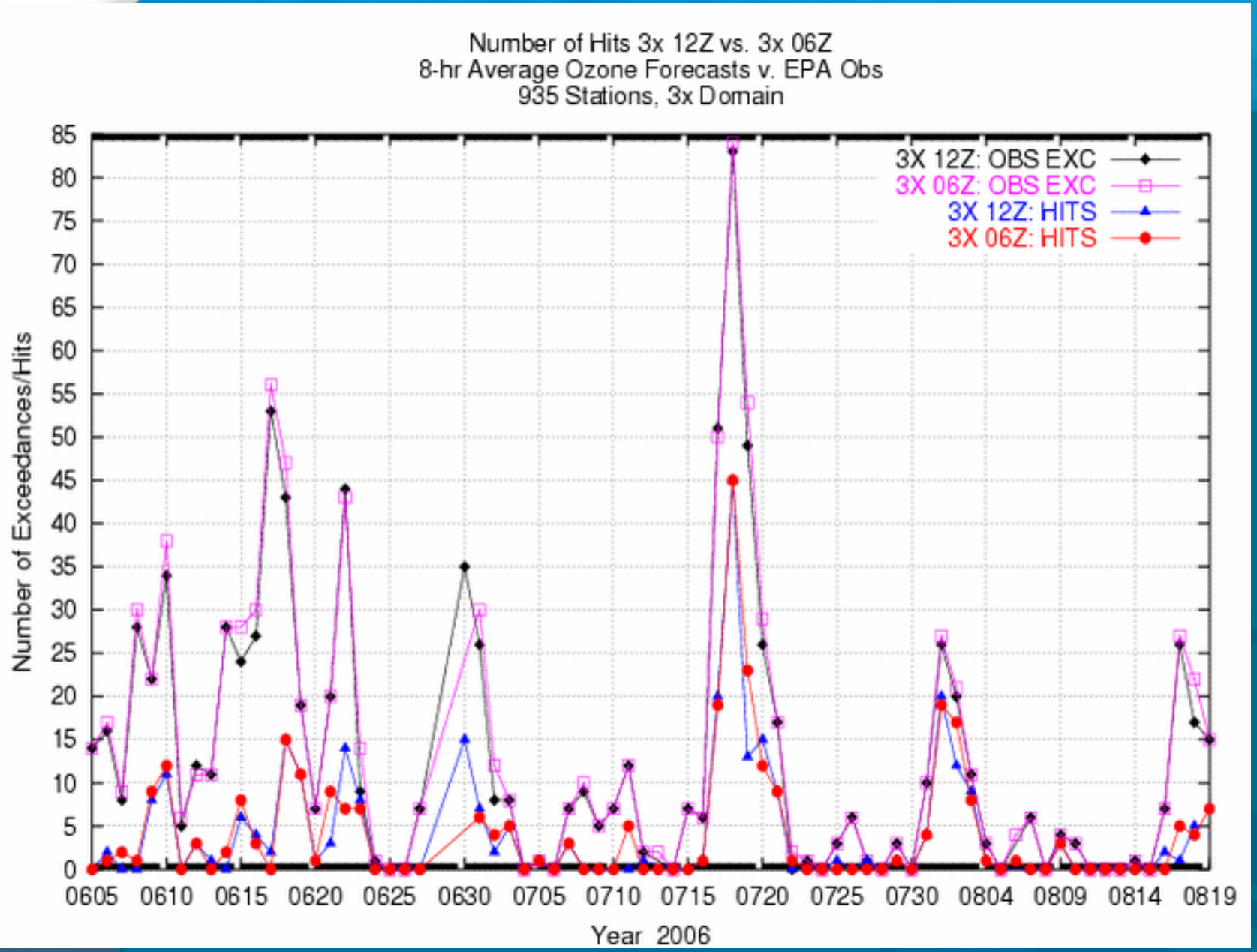

Number of 8-hr Avg Cases for Each Forecast/Observation Comparison
Valid 07/14/2006 to 08/20/2006
5X Model (Forecast Valid Date), 3X Domain
FORECAST--NOTOBSERVED
NOTFORECAST--OBSERVED
FORECAST--OBSERVED
NOTFORECAST--NOTOBSERVED
Number of Cases
950
900
850
800
750
700
650
600
07/14
07/17
07/20
07/23
07/26
07/29
08/01
08/04
08/07
08/10
08/13
08/16
08/19
Date

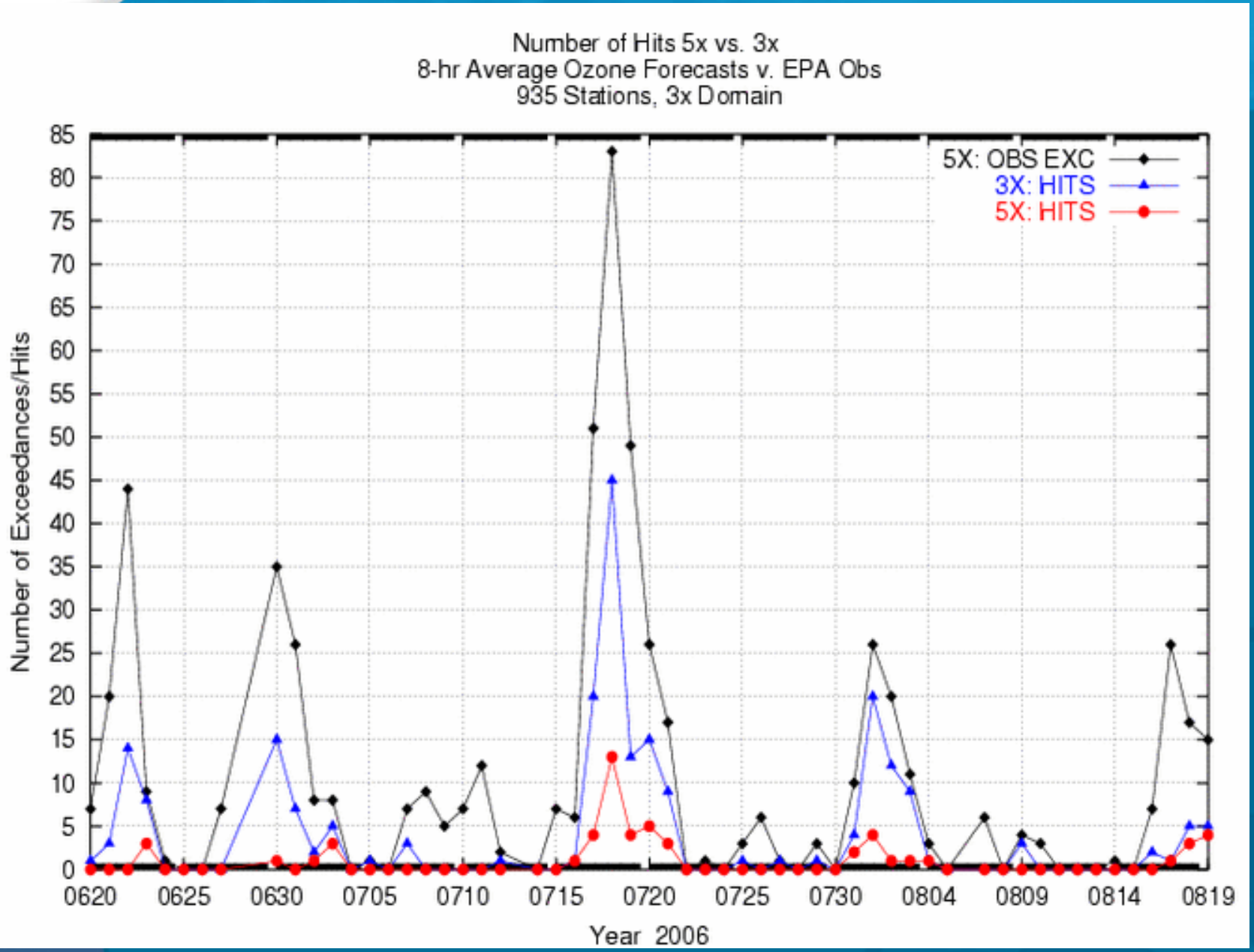

Number of 8-hr Avg Cases for Each Forecast/Observation Comparison
Valid 07/14/2006 to 08/20/2006
3X Model (Forecast Valid Date)
FORECAST--NOTOBSERVED
NOTFORECAST--OBSERVED
FORECAST--OBSERVED
Number of Cases
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
07/14
07/17
07/20
07/23
07/26
07/29
08/01
08/04
08/07
08/10
08/13
08/16
08/19
Date

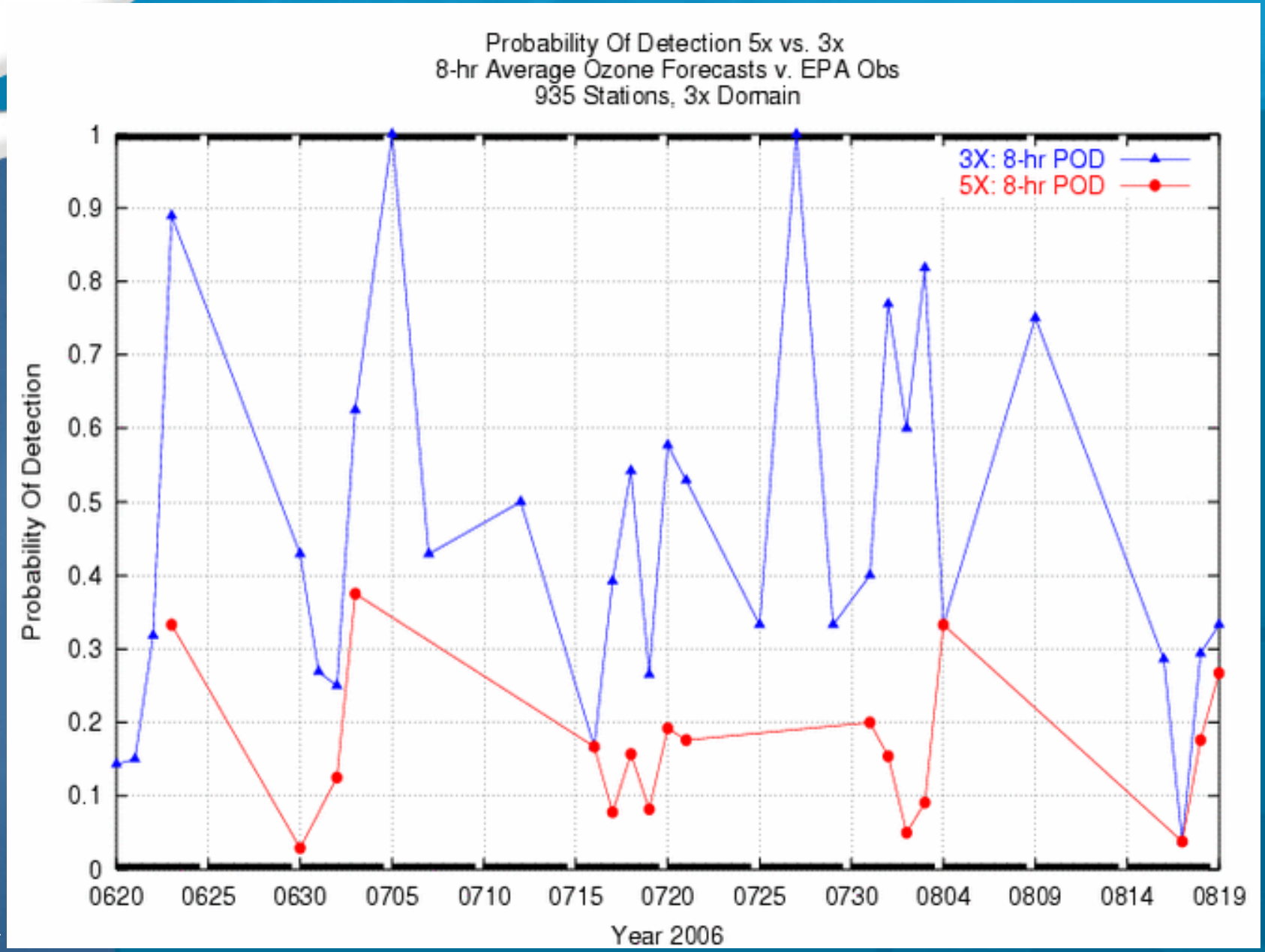

Number of 8-hr Avg Cases for Each Forecast/Observation Comparison
Valid 07/14/2006 to 08/20/2006
5X Model (Forecast Valid Date), 3X Domain
FORECAST--NOTOBSERVED
NOTFORECAST--OBSERVED
FORECAST--OBSERVED
Number of Cases
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
07/14
07/17
07/20
07/23
07/26
07/29
08/01
08/04
08/07
08/10
08/13
08/16
08/19
Date

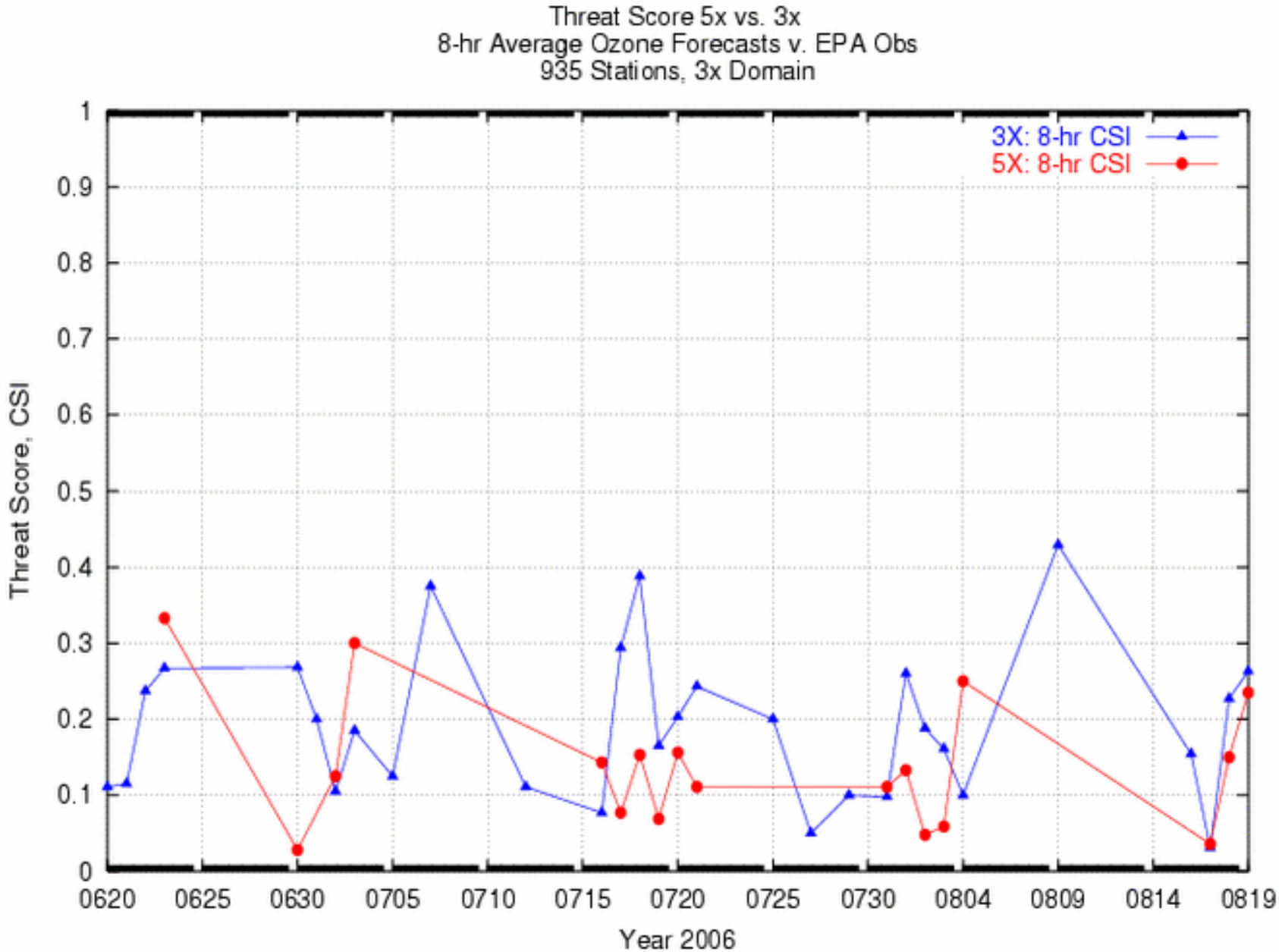

Midnight to Midnight Ozone Concentration
Observations vs. Model Forecasts
8 hr Avg (Daily Maximum) -- Valid 07/14/2006 to 08/20/2006
WRF 3X Grid 12Z (Forecast Valid Date)
'OZONECONCENTRATION'
'REGRESSIONLINE'
r^2 = 0.4401
Observations of Ozone Concentration (ppb)
Model Forecasts of Ozone Concentration (ppb)
0
20
40
60
80
100
120
140
160
180
200

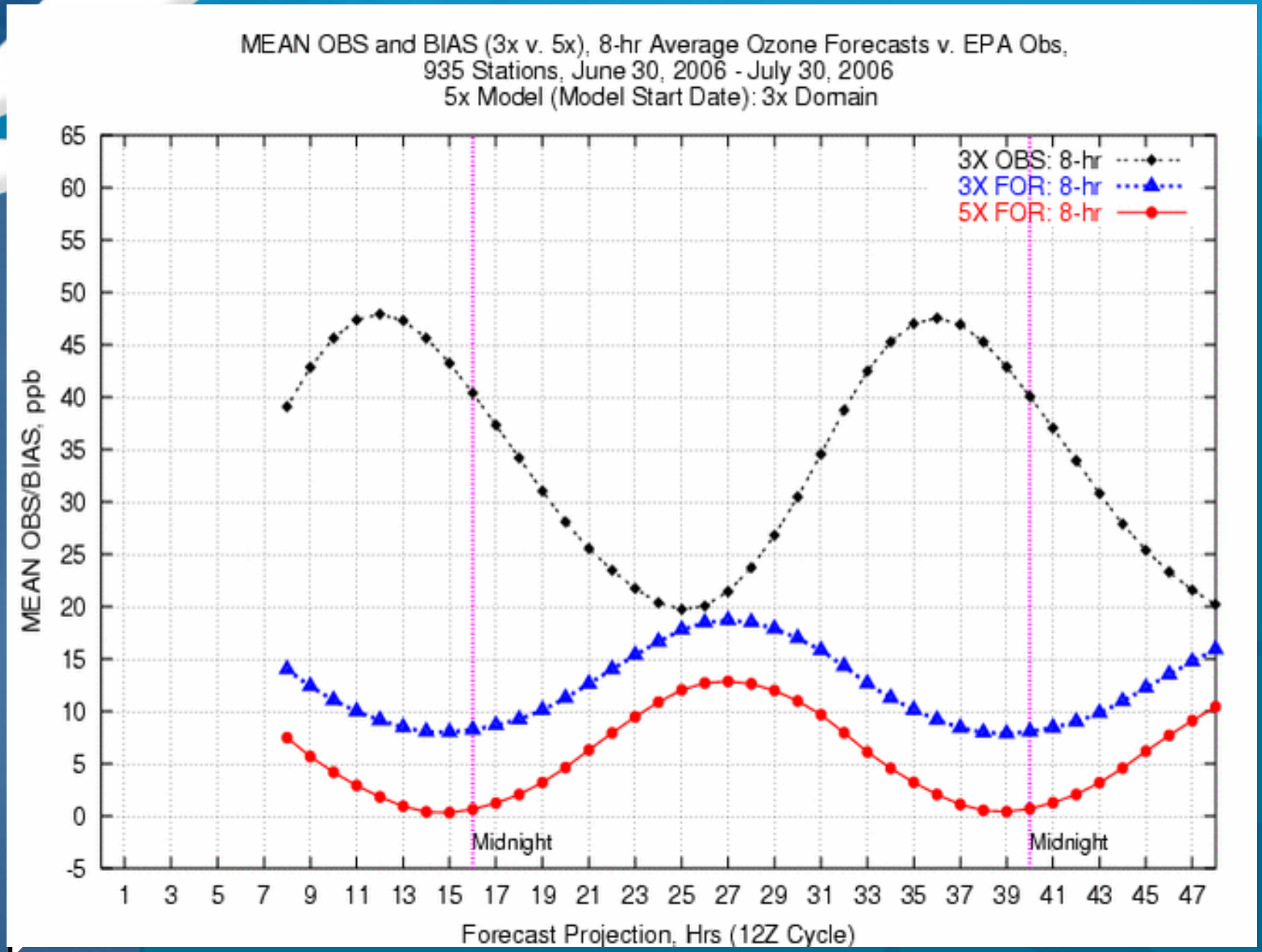

Midnight to Midnight Ozone Concentration
Observations vs. Model Forecasts
8 hr Avg (Daily Maximum) -- Valid 07/14/2006 to 08/20/2006
5X Model (Forecast Valid Date), 3X Domain
'OZONECONCENTRATION'
'REGRESSIONLINE'
r^2 = 0.4963
Observations of Ozone Concentration (ppb)
Model Forecasts of Ozone Concentration (ppb)
0
20
40
60
80
100
120
140
160
180
200

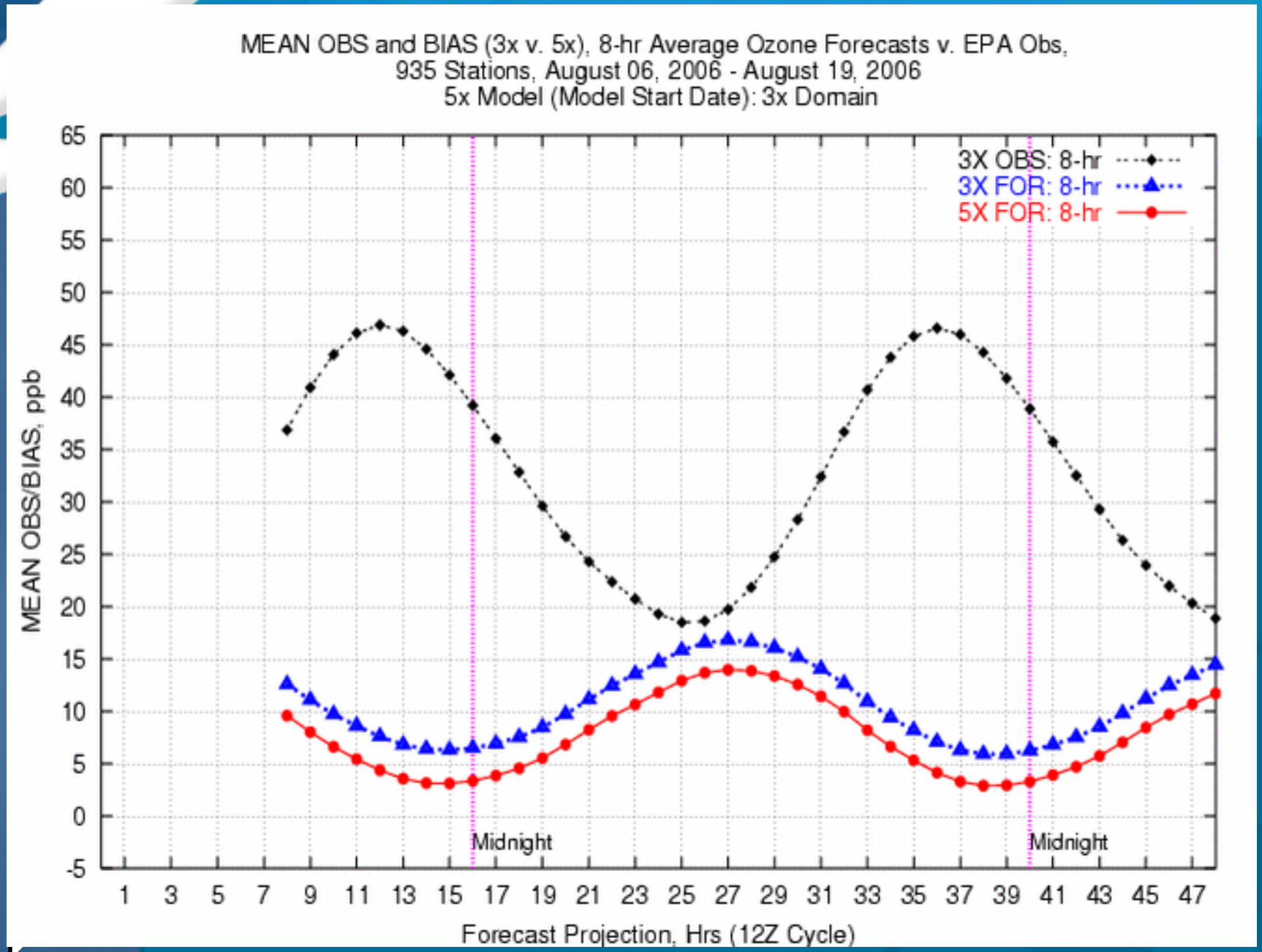

Number of Hits 3x 12Z vs. 3x 06Z
8-hr Average Ozone Forecasts v. EPA Obs
935 Stations, 3x Domain
3X 12Z: OBS EXC
3X 06Z: OBS EXC
3X 12Z: HITS
3X 06Z: HITS
Number of Exceedances/Hits
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
0605
0610
0615
0620
0625
0630
0705
0710
0715
0720
0725
0730
0804
0809
0814
0819
Year 2006

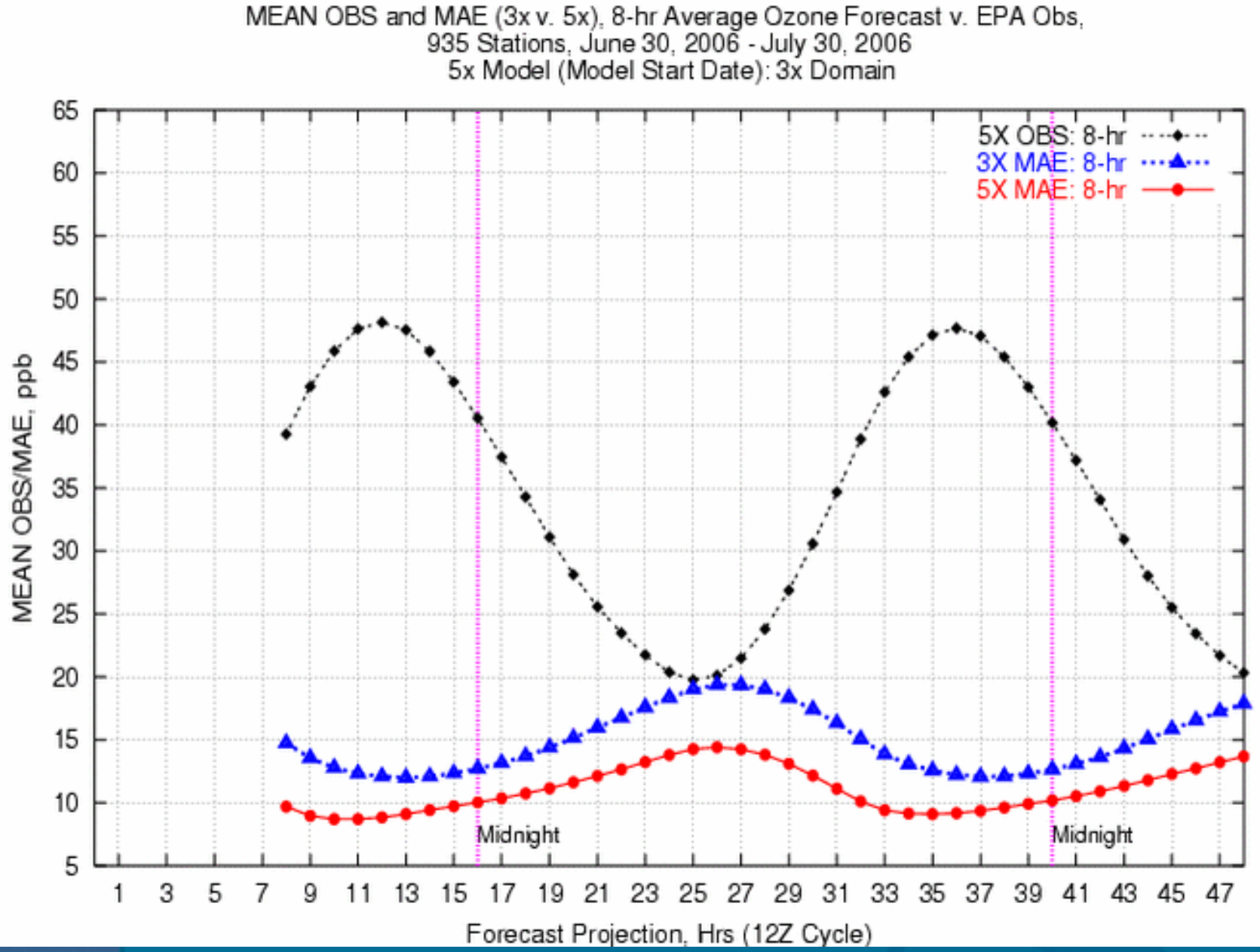

Number of Hits 5x vs. 3x
8-hr Average Ozone Forecasts v. EPA Obs
935 Stations, 3x Domain
5X: OBS EXC
3X: HITS
5X: HITS
Number of Exceedances/Hits
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
0620
0625
0630
0705
0710
0715
0720
0725
0730
0804
0809
0814
0819
Year 2006

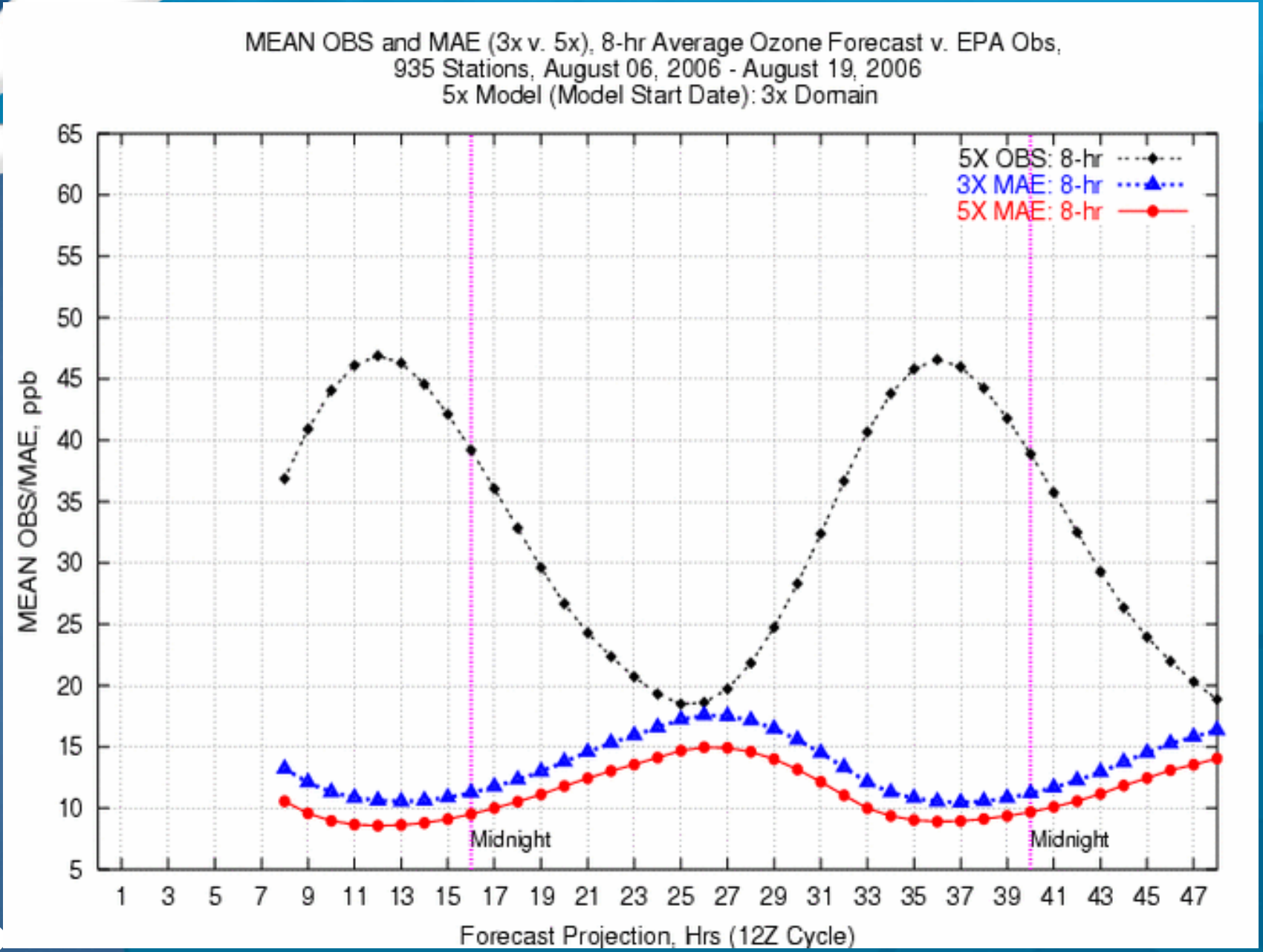

Probability Of Detection 5x vs. 3x
8-hr Average Ozone Forecasts v. EPA Obs
935 Stations, 3x Domain
3X: 8-hr POD
5X: 8-hr POD
Probability Of Detection
Year 2006
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0620
0625
0630
0705
0710
0715
0720
0725
0730
0804
0809
0814
0819

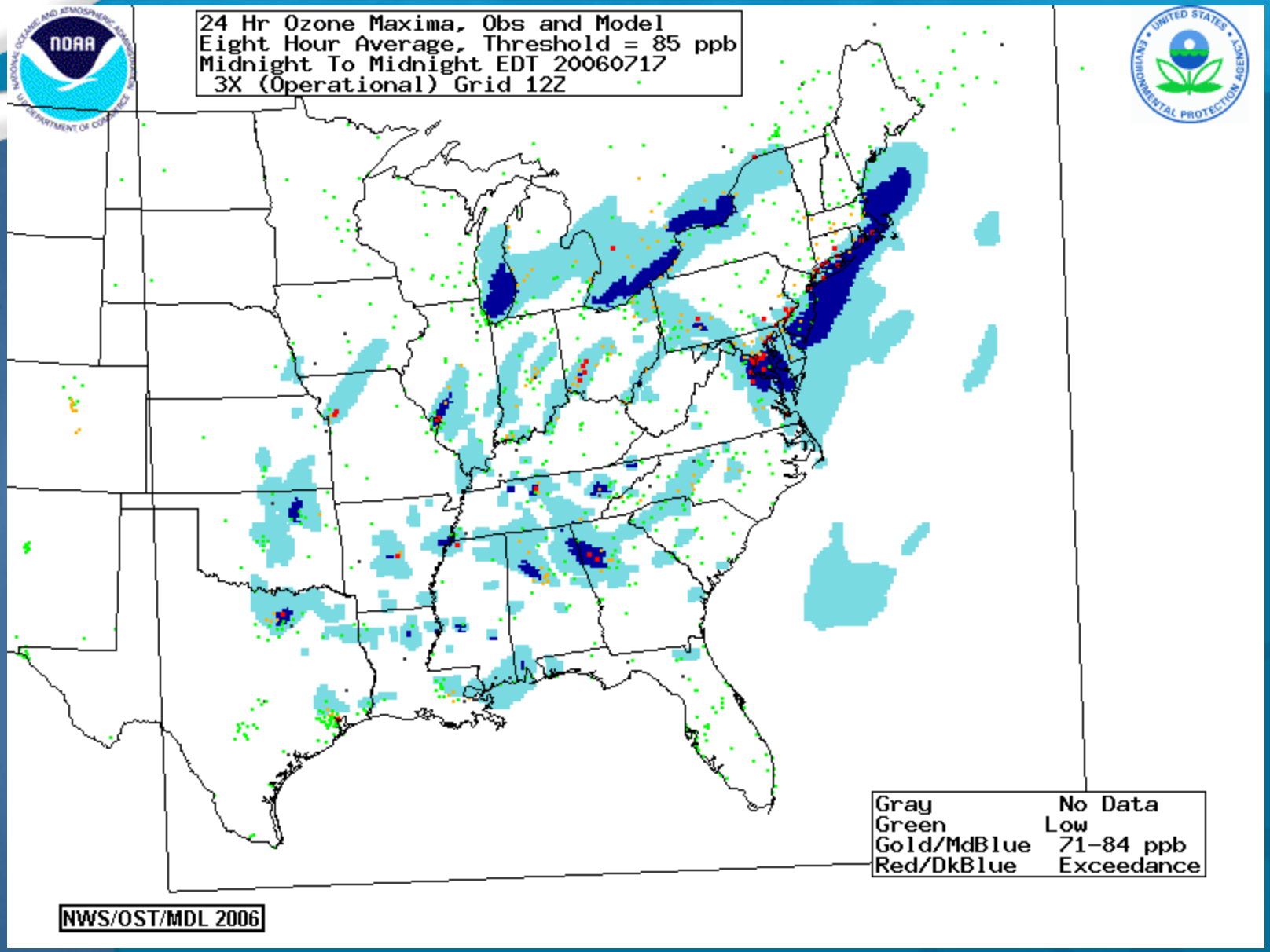

Threat Score 5x vs. 3x
8-hr Average Ozone Forecasts v. EPA Obs
935 Stations, 3x Domain
3X: 8-hr CSI
5X: 8-hr CSI
Threat Score, CSI
Year 2006
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0620
0625
0630
0705
0710
0715
0720
0725
0730
0804
0809
0814
0819

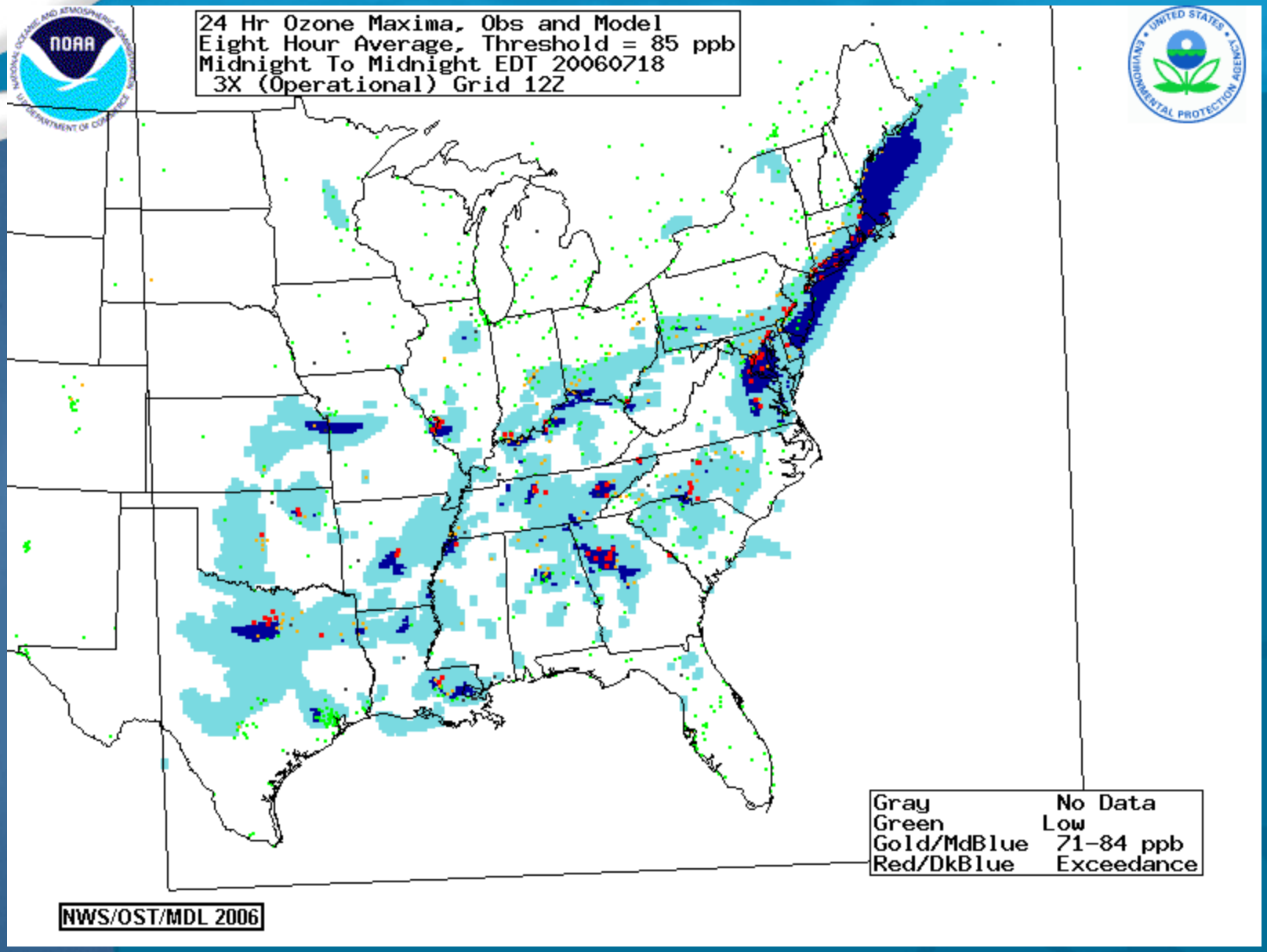

MEAN OBS and BIAS (3x v. 5x), 8-hr Average Ozone Forecasts v. EPA Obs,
935 Stations, June 30, 2006 - July 30, 2006
5x Model (Model Start Date): 3x Domain
3X OBS: 8-hr
3X FOR: 8-hr
5X FOR: 8-hr
MEAN OBS/BIAS, ppb
65
60
55
50
45
40
35
30
25
20
15
10
5
0
-5
Midnight
Midnight
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47
Forecast Projection, Hrs (12Z Cycle)

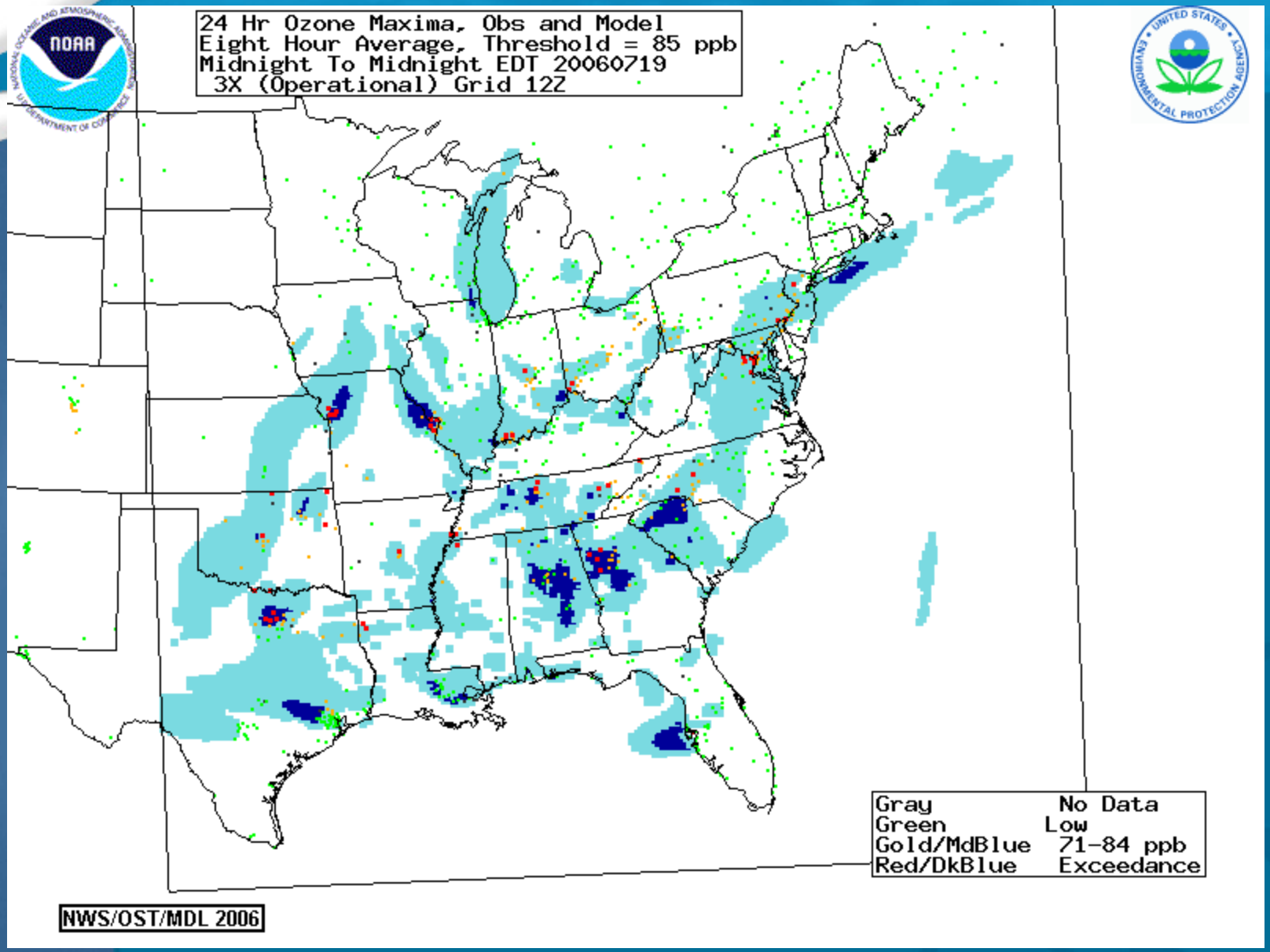

MEAN OBS and BIAS (3x v. 5x), 8-hr Average Ozone Forecasts v. EPA Obs,
935 Stations, August 06, 2006 - August 19, 2006
5x Model (Model Start Date): 3x Domain
3X OBS: 8-hr
3X FOR: 8-hr
5X FOR: 8-hr
MEAN OBS/BIAS, ppb
65
60
55
50
45
40
35
30
25
20
15
10
5
0
-5
Midnight
Midnight
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47
Forecast Projection, Hrs (12Z Cycle)

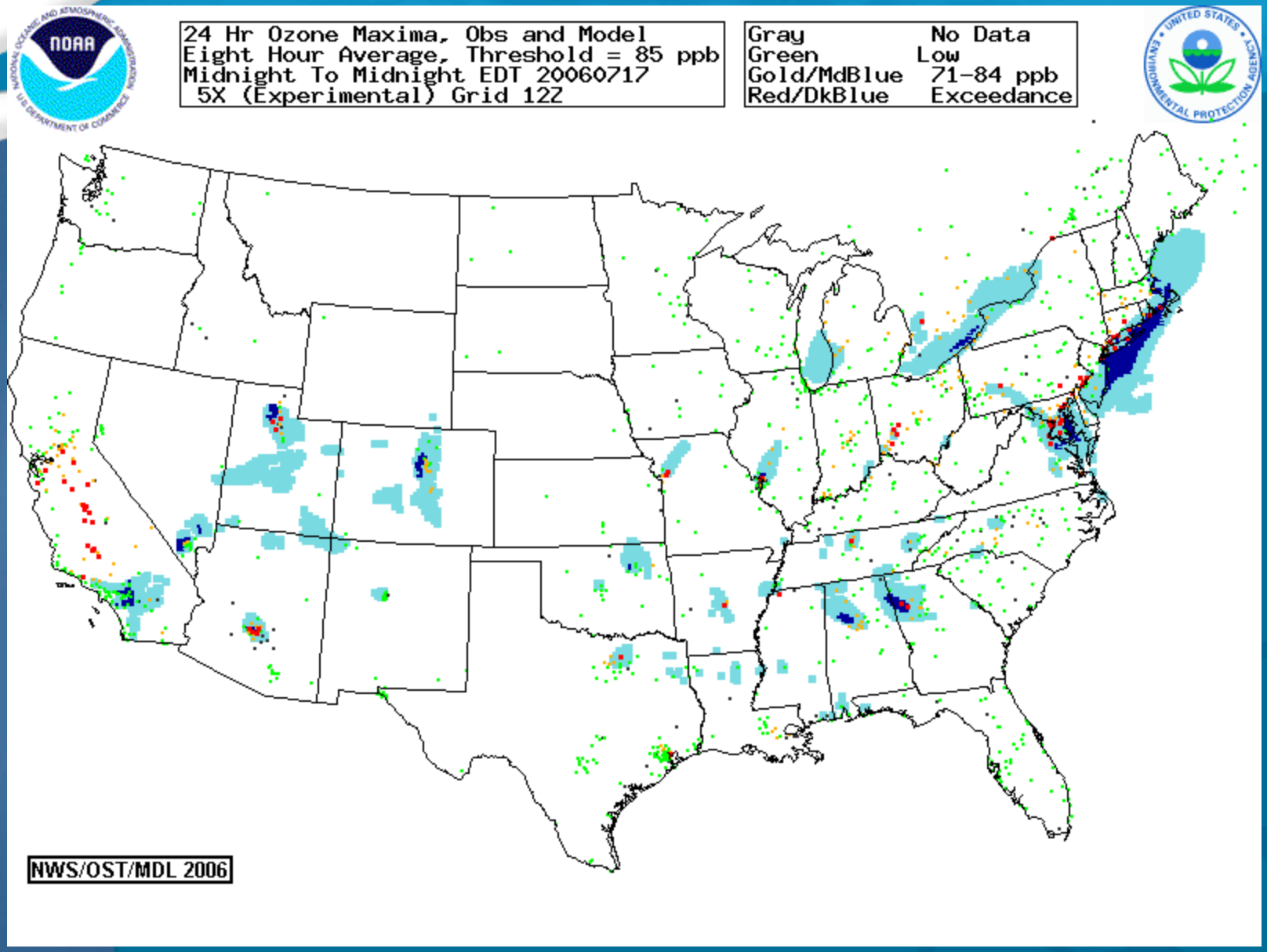

MEAN OBS and MAE (3x v. 5x), 8-hr Average Ozone Forecast v. EPA Obs,
935 Stations, June 30, 2006 - July 30, 2006
5x Model (Model Start Date): 3x Domain
5X OBS: 8-hr
3X MAE: 8-hr
5X MAE: 8-hr
MEAN OBS/MAE, ppb
65
60
55
50
45
40
35
30
25
20
15
10
5
Midnight
Midnight
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47
Forecast Projection, Hrs (12Z Cycle)

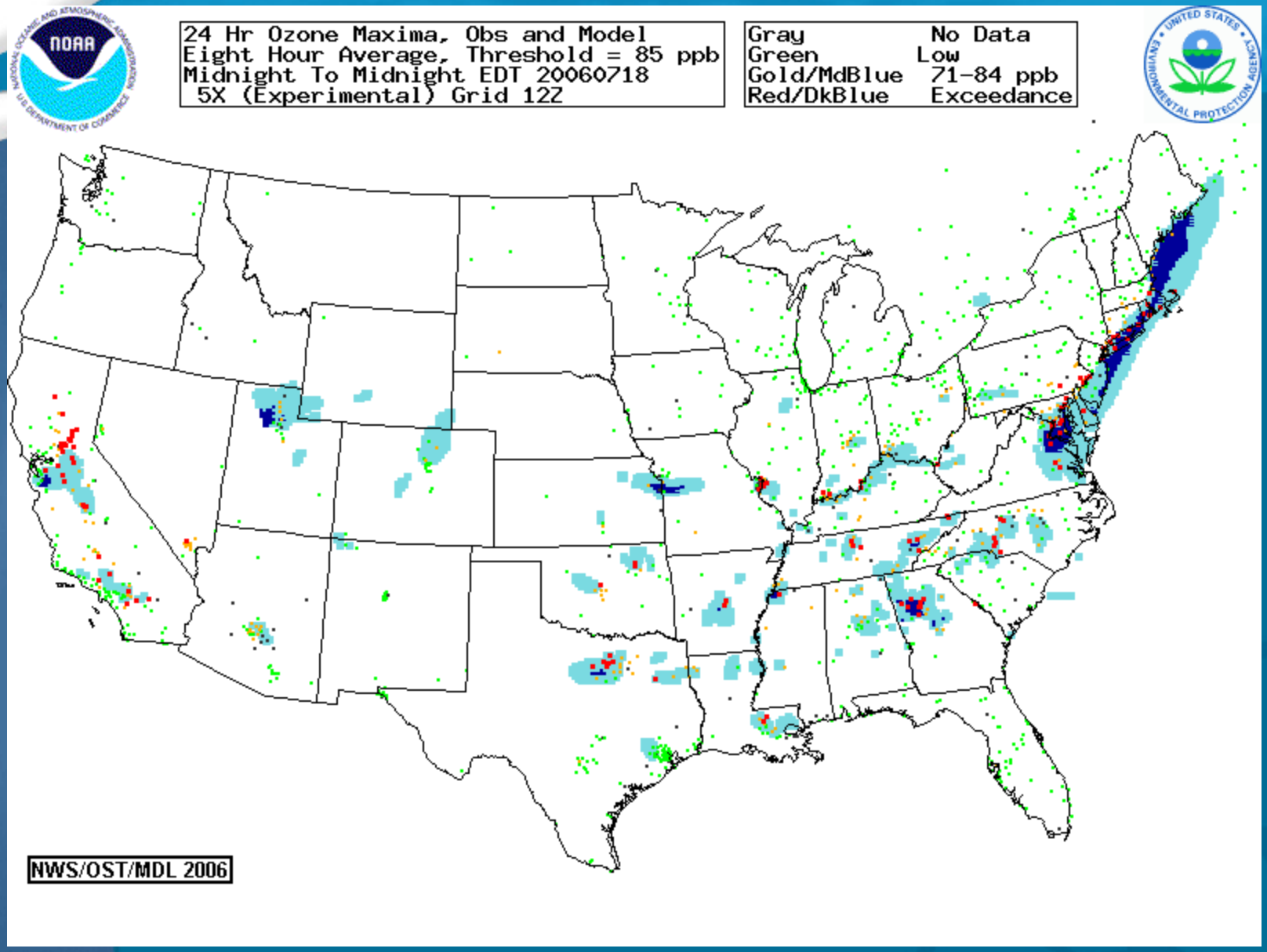

MEAN OBS and MAE (3x v. 5x), 8-hr Average Ozone Forecast v. EPA Obs,
935 Stations, August 06, 2006 - August 19, 2006
5x Model (Model Start Date): 3x Domain
5X OBS: 8-hr
3X MAE: 8-hr
5X MAE: 8-hr
MEAN OBS/MAE, ppb
65
60
55
50
45
40
35
30
25
20
15
10
5
Midnight
Midnight
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47
Forecast Projection, Hrs (12Z Cycle)

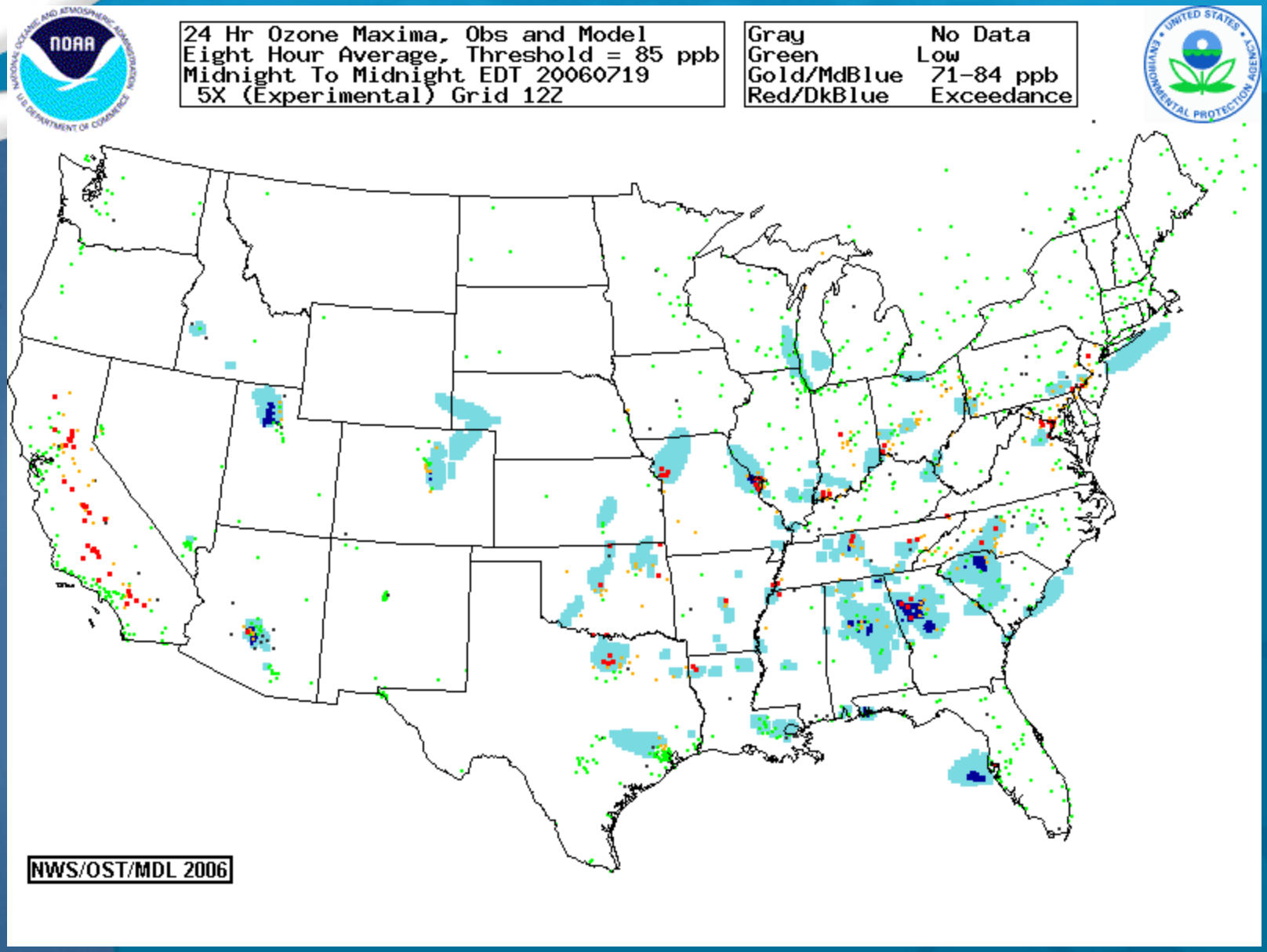

24 Hr Ozone Maxima, Obs and Model
Eight Hour Average, Threshold = 85 ppb
Midnight To Midnight EDT 20060717
3X (Operational) Grid 12Z
Gray No Data
Green Low
Gold/MdBlue 71-84 ppb
Red/DkBlue Exceedance
NWS/OST/MDL 2006

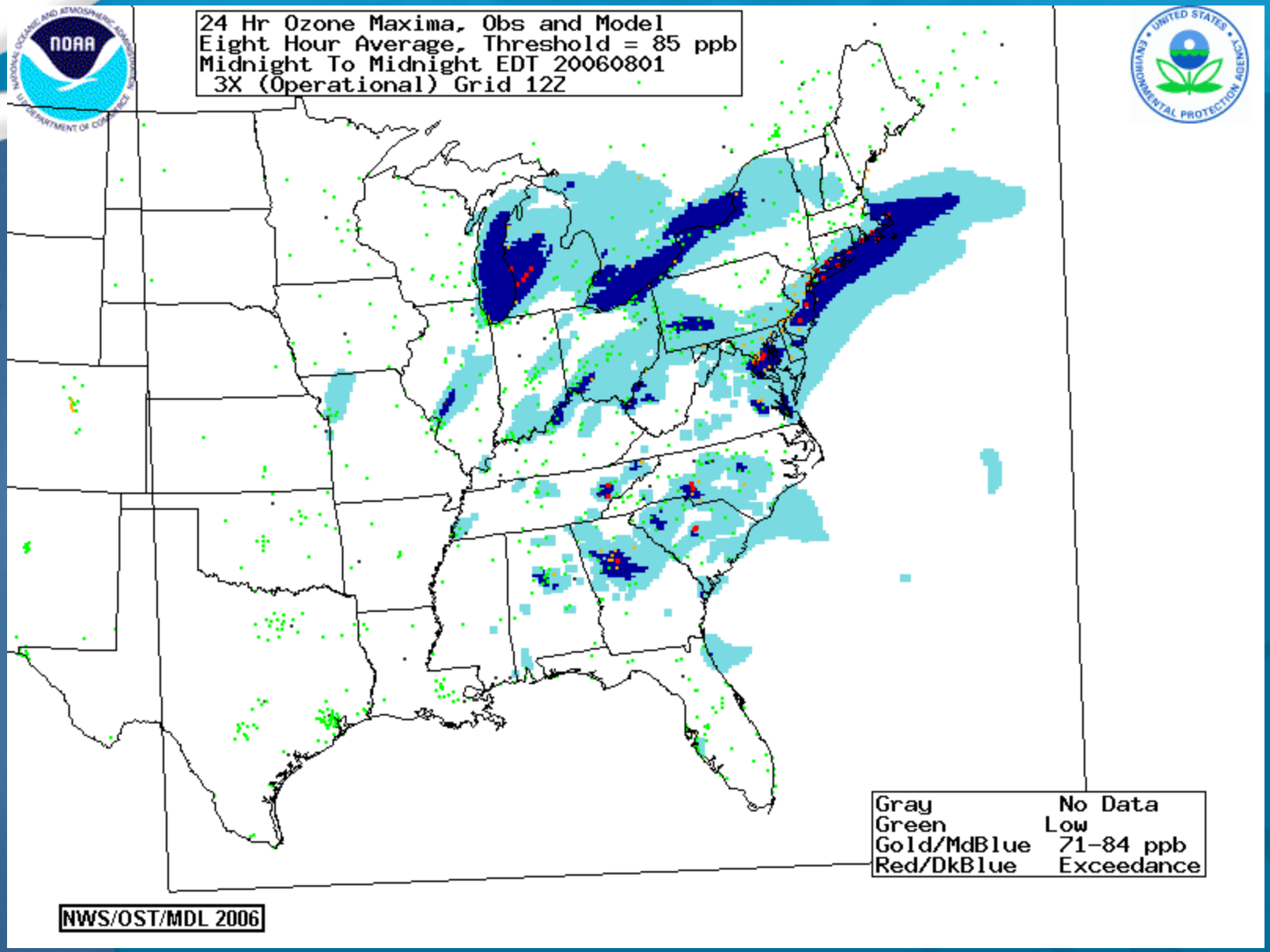

24 Hr Ozone Maxima, Obs and Model
Eight Hour Average, Threshold = 85 ppb
Midnight To Midnight EDT 20060718
3X (Operational) Grid 12Z
Gray No Data
Green Low
Gold/MdBlue 71-84 ppb
Red/DkBlue Exceedance
NWS/OST/MDL 2006

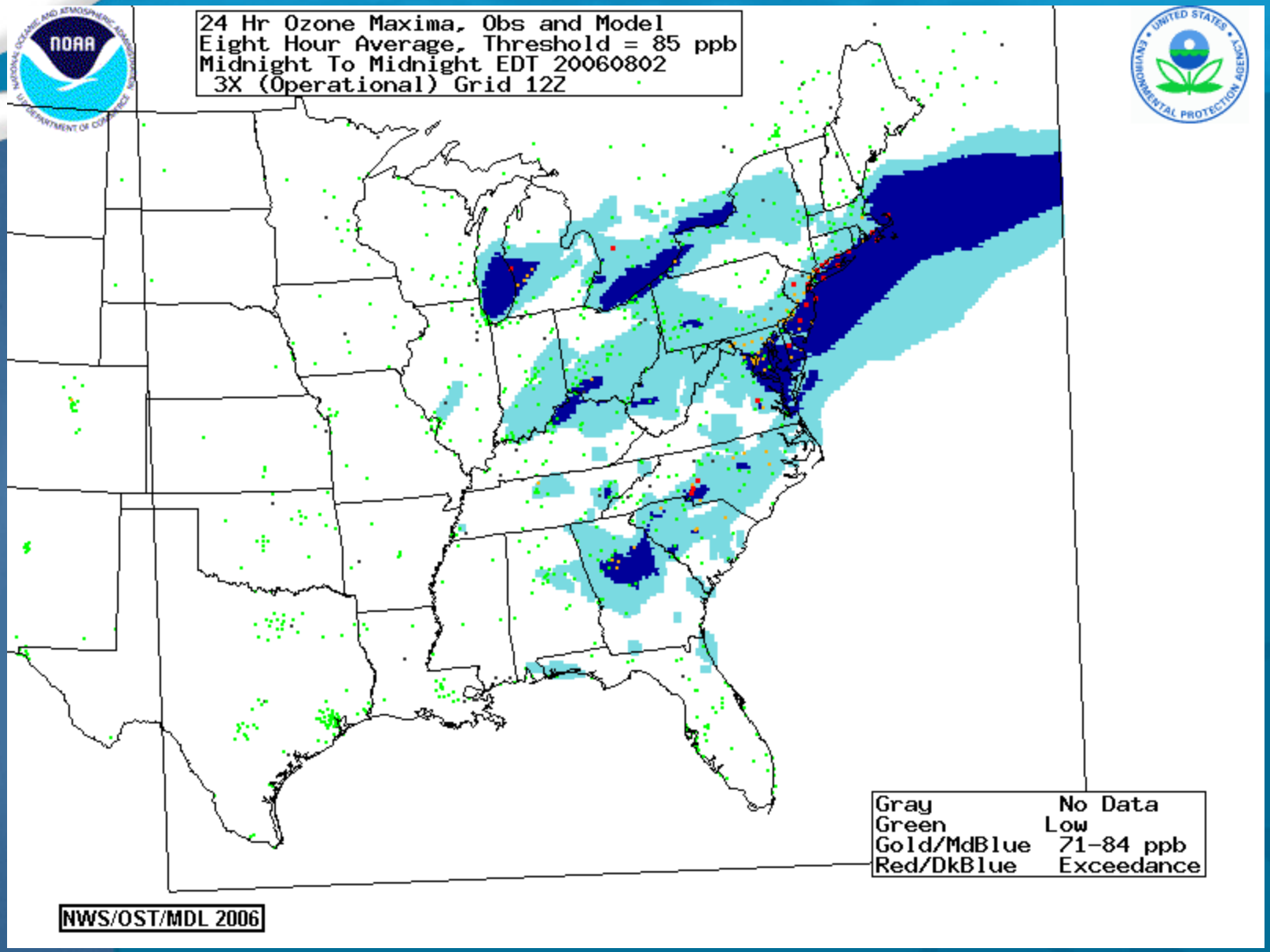

24 Hr Ozone Maxima, Obs and Model
Eight Hour Average, Threshold = 85 ppb
Midnight To Midnight EDT 20060719
3X (Operational) Grid 12Z
Gray No Data
Green Low
Gold/MdBlue 71-84 ppb
Red/DkBlue Exceedance
NWS/OST/MDL 2006

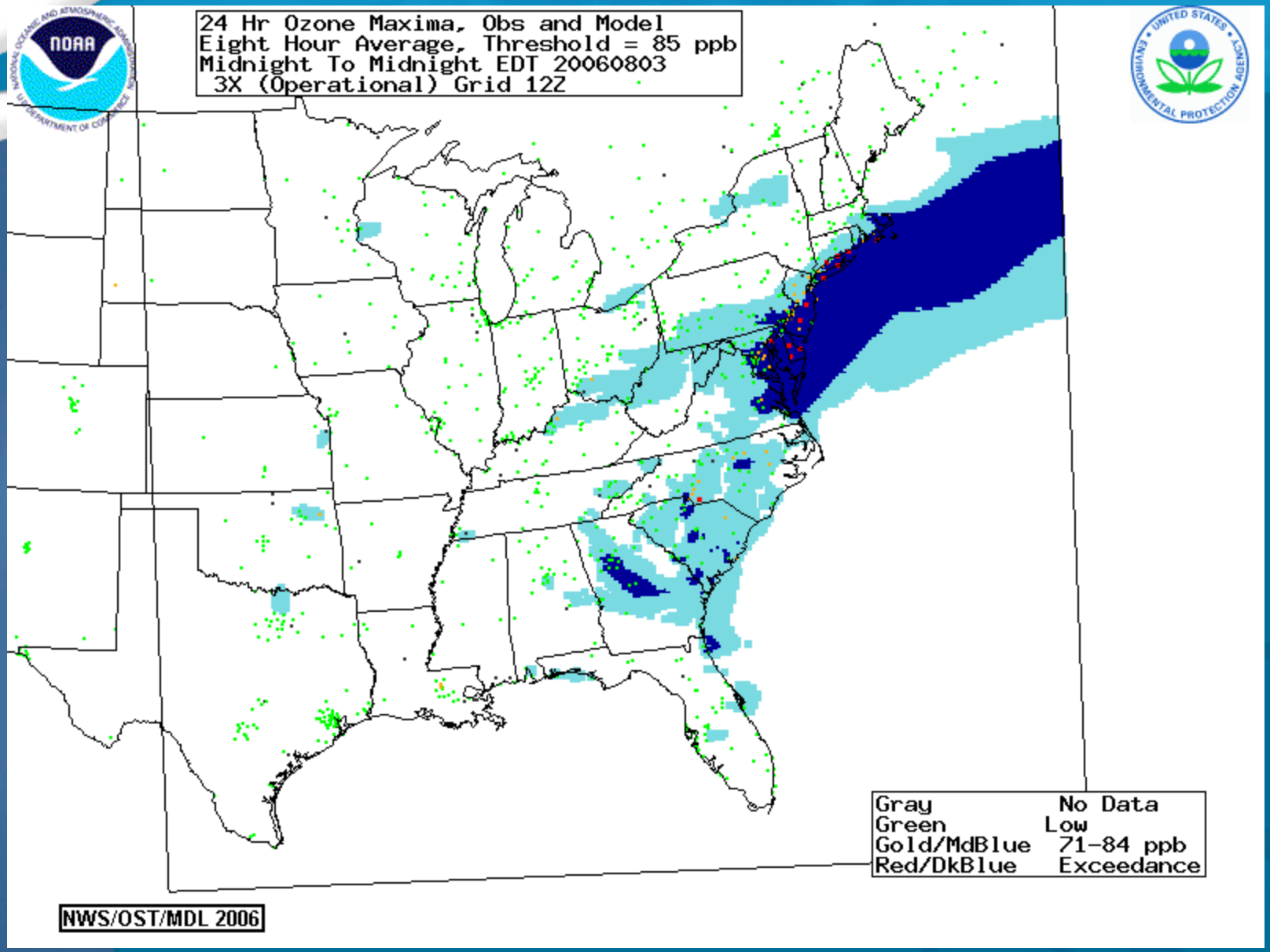

24 Hr Ozone Maxima, Obs and Model
Eight Hour Average, Threshold = 85 ppb
Midnight To Midnight EDT 20060717
5X (Experimental) Grid 12Z
Gray No Data
Green Low
Gold/MdBlue 71-84 ppb
Red/DkBlue Exceedance
NWS/OST/MDL 2006


24 Hr Ozone Maxima, Obs and Model
Eight Hour Average, Threshold = 85 ppb
Midnight To Midnight EDT 20060718
5X (Experimental) Grid 12Z
Gray No Data
Green Low
Gold/MdBlue 71-84 ppb
Red/DkBlue Exceedance
NWS/OST/MDL 2006


24 Hr Ozone Maxima, Obs and Model
Eight Hour Average, Threshold = 85 ppb
Midnight To Midnight EDT 20060719
5X (Experimental) Grid 12Z
Gray No Data
Green Low
Gold/MdBlue 71-84 ppb
Red/DkBlue Exceedance
NWS/OST/MDL 2006

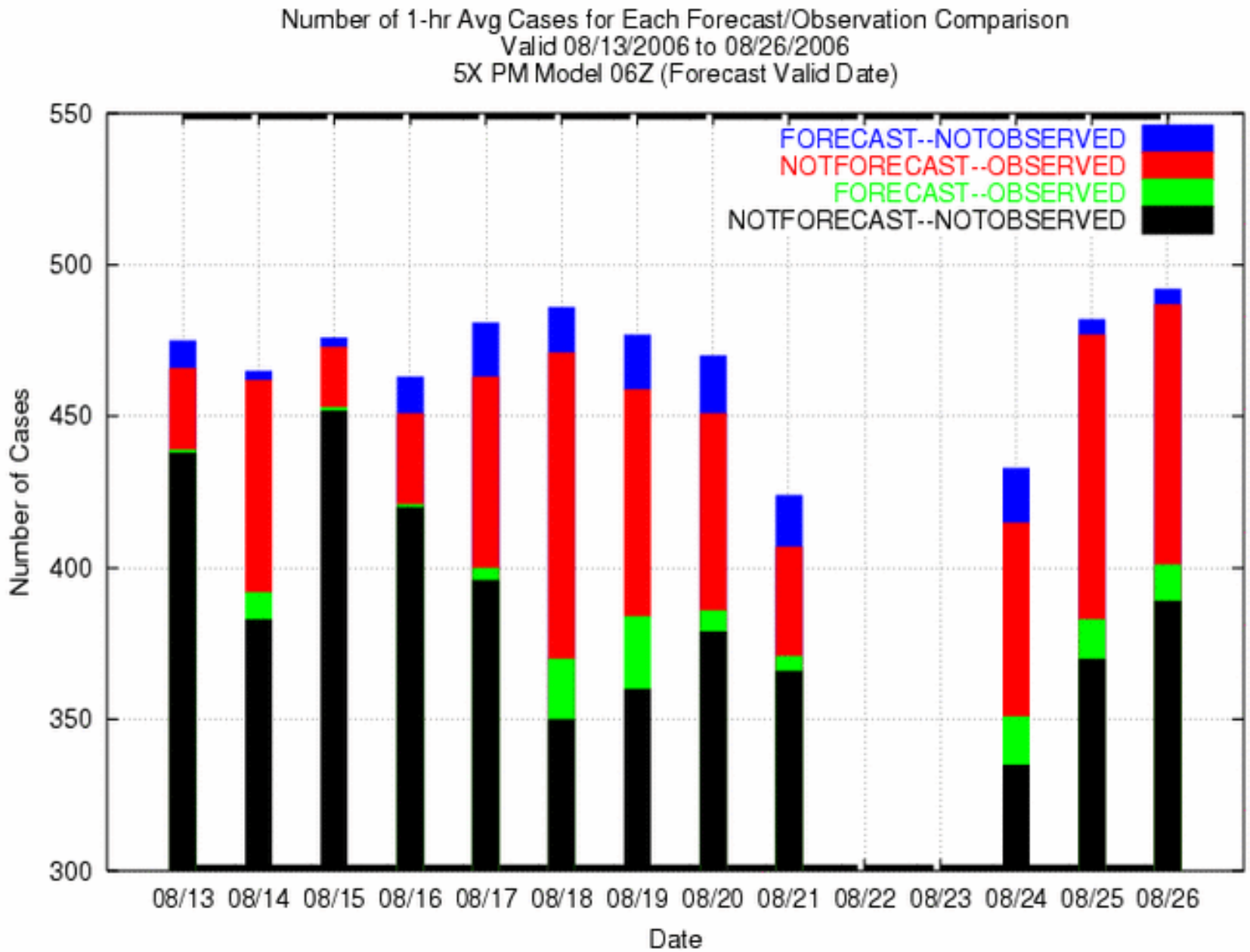

24 Hr Ozone Maxima, Obs and Model
Eight Hour Average, Threshold = 85 ppb
Midnight To Midnight EDT 20060801
3X (Operational) Grid 12Z
Gray No Data
Green Low
Gold/MdBlue 71-84 ppb
Red/DkBlue Exceedance
NWS/OST/MDL 2006

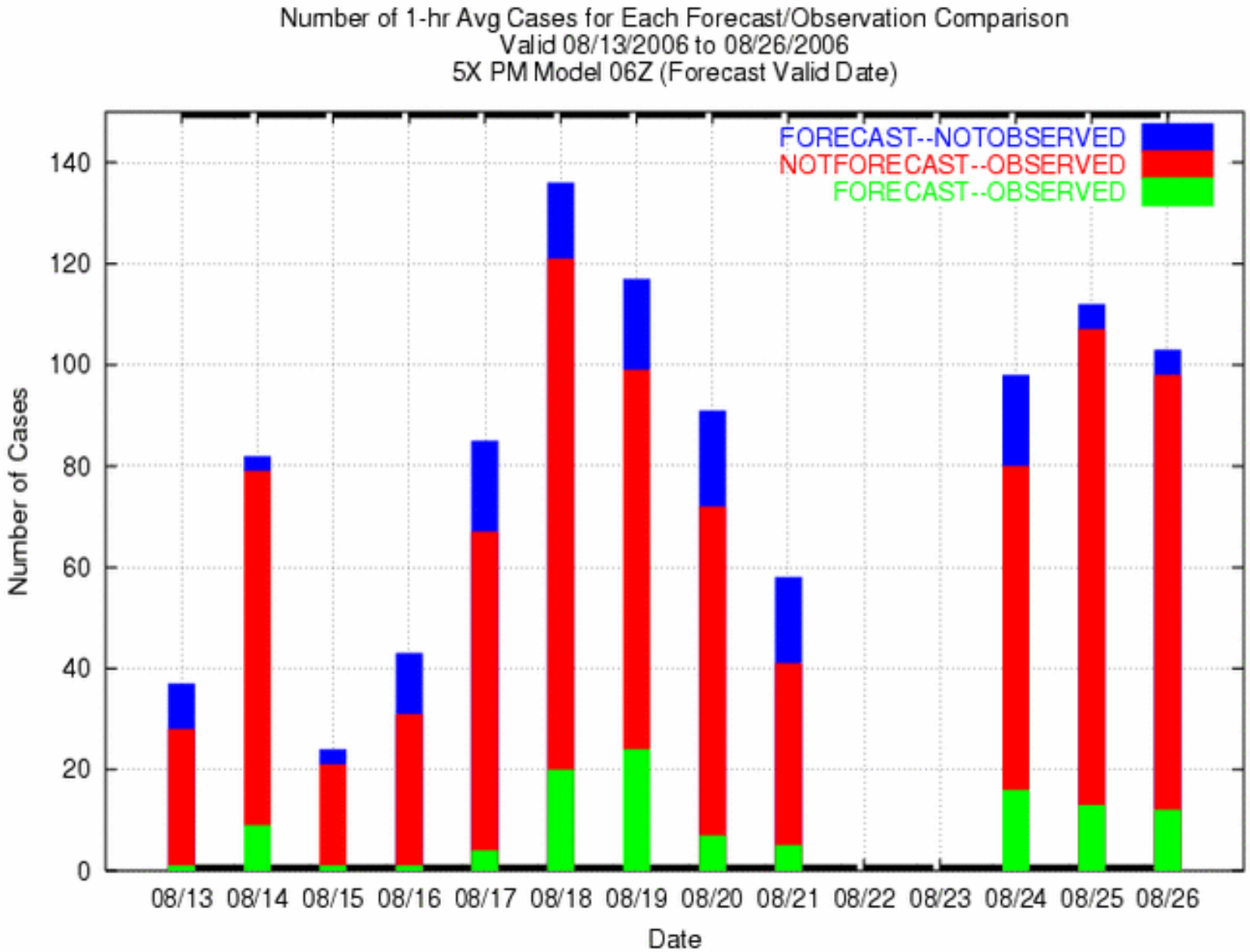

24 Hr Ozone Maxima, Obs and Model
Eight Hour Average, Threshold = 85 ppb
Midnight To Midnight EDT 20060802
3X (Operational) Grid 12Z
Gray No Data
Green Low
Gold/MdBlue 71-84 ppb
Red/DkBlue Exceedance
NWS/OST/MDL 2006

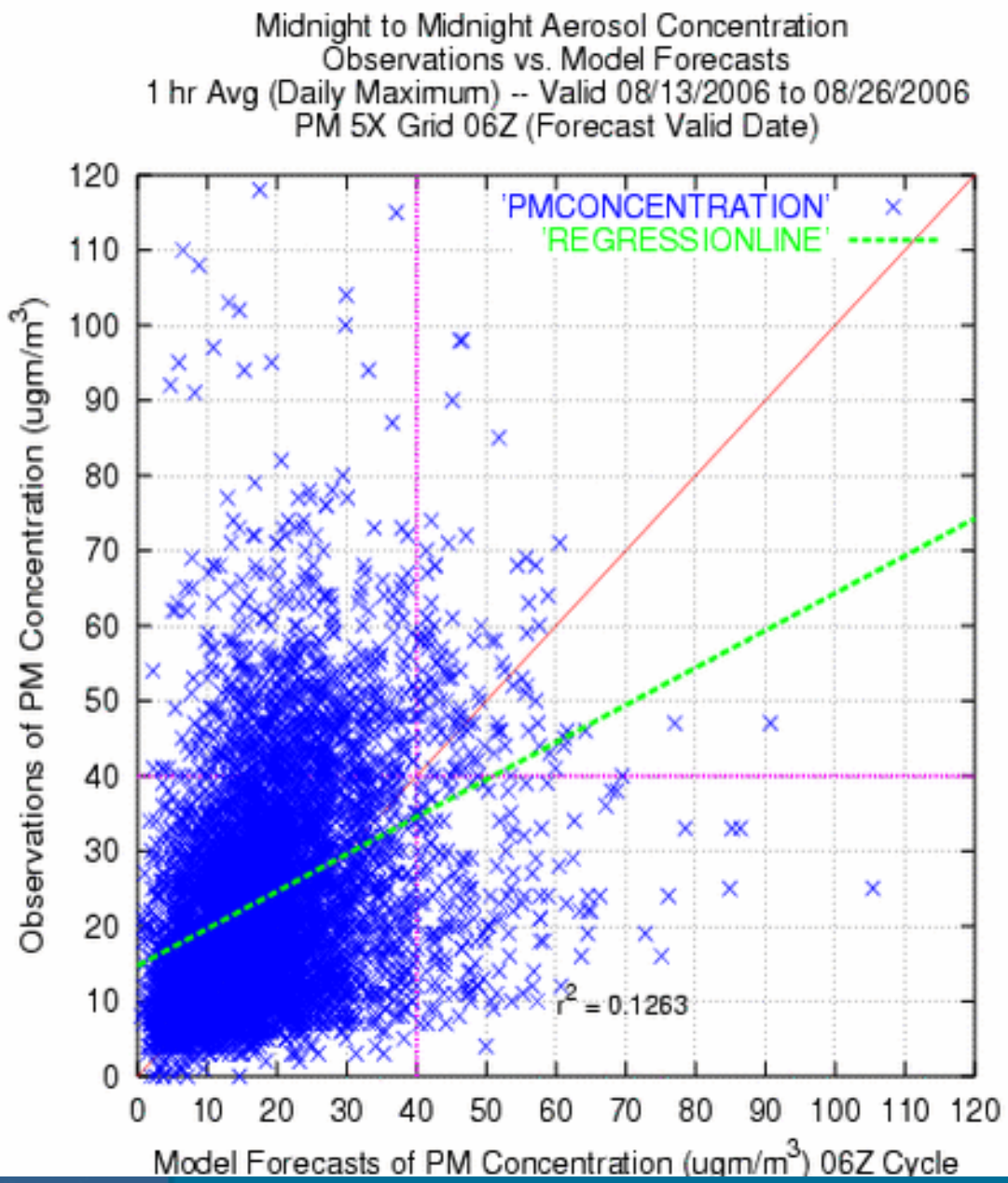

24 Hr Ozone Maxima, Obs and Model
Eight Hour Average, Threshold = 85 ppb
Midnight To Midnight EDT 20060803
3X (Operational) Grid 12Z
Gray No Data
Green Low
Gold/MdBlue 71-84 ppb
Red/DkBlue Exceedance
NWS/OST/MDL 2006

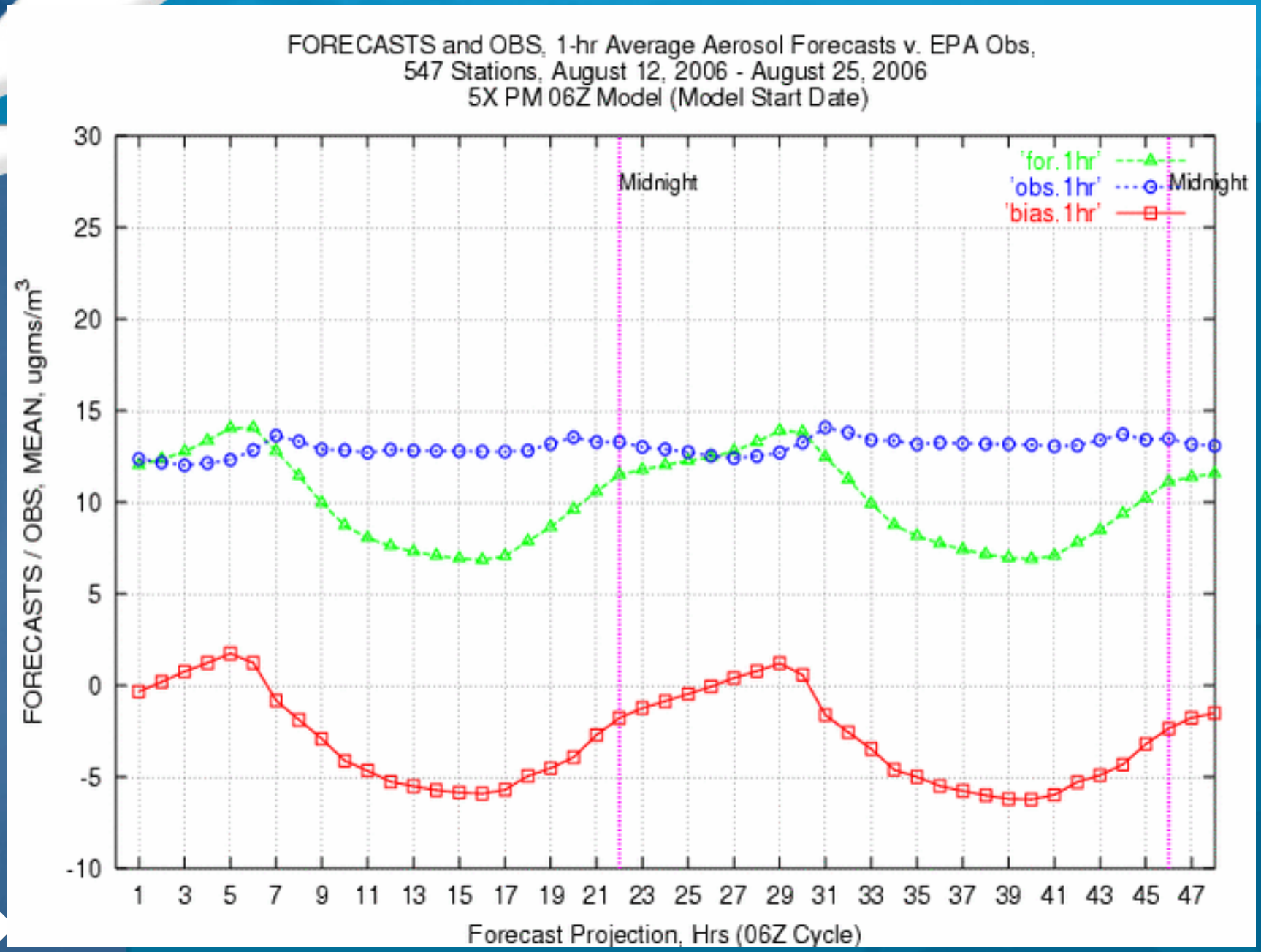
Preliminary Aerosol Verification

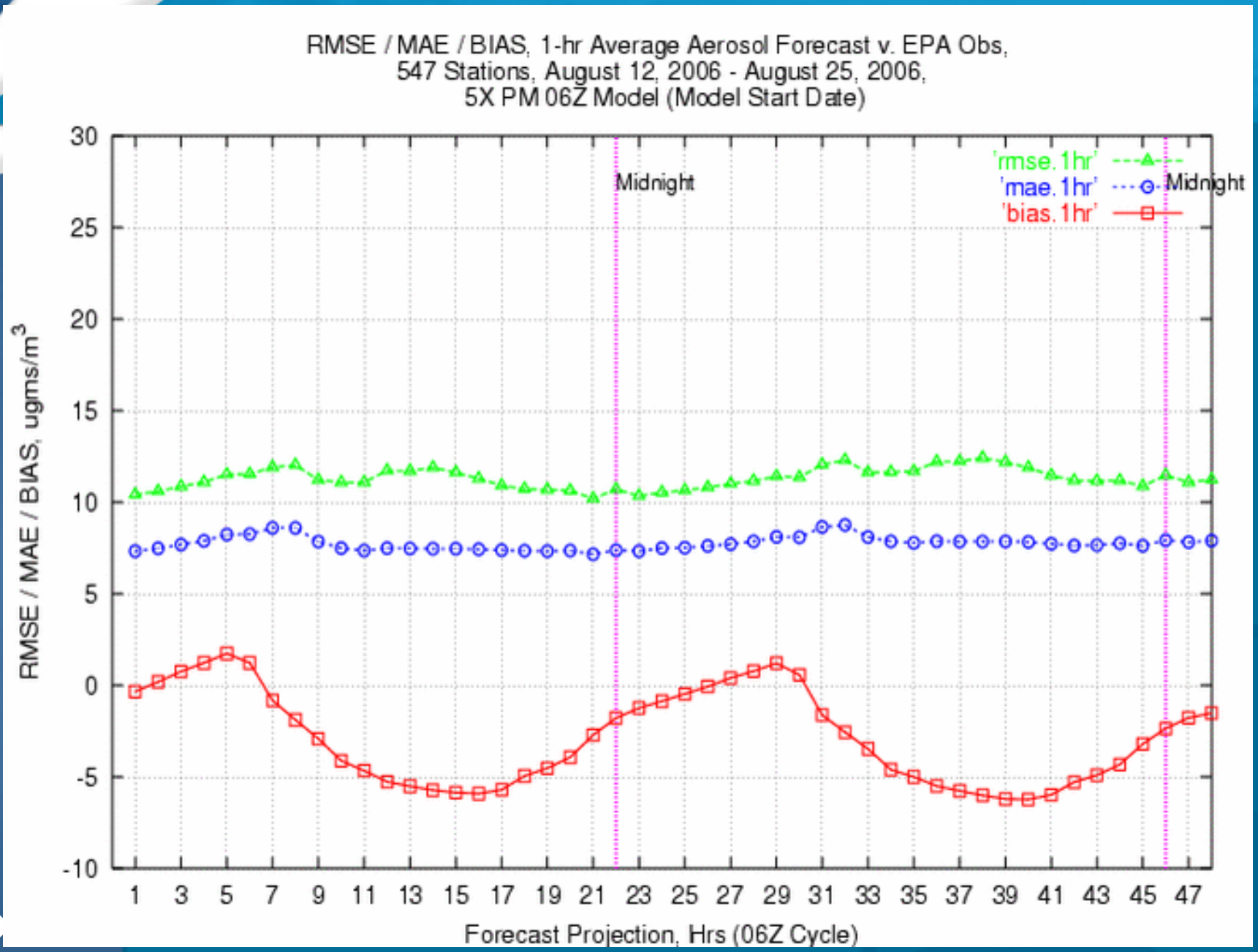
- Bar charts
- Scatter plots
- MAE/bias/rmse plots
- Spatial maps, daily 1-h max
- Daily statistics

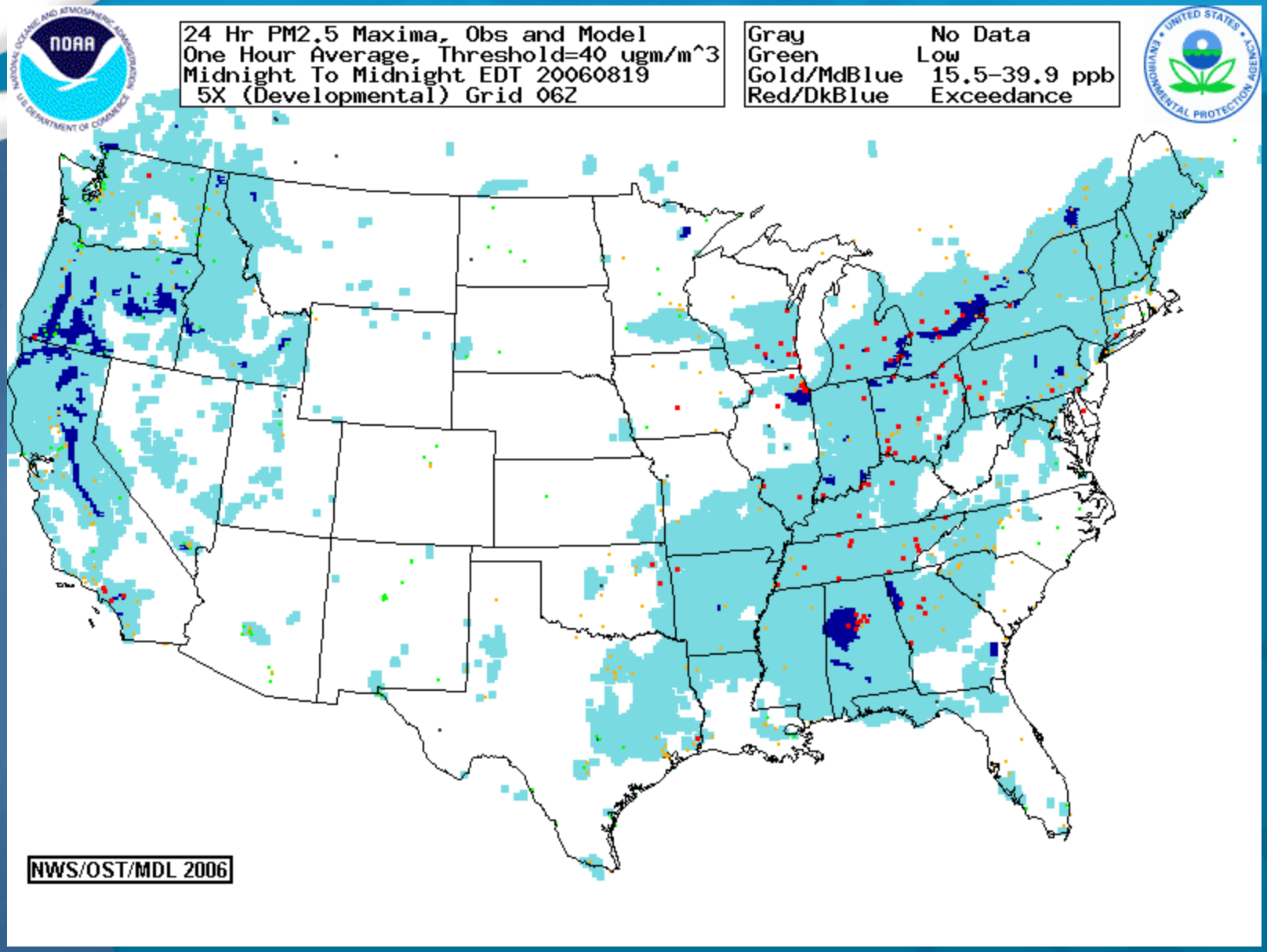

Number of 1-hr Avg Cases for Each Forecast/Observation Comparison
Valid 08/13/2006 to 08/26/2006
5X PM Model 06Z (Forecast Valid Date)
FORECAST--NOTOBSERVED
NOTFORECAST--OBSERVED
FORECAST--OBSERVED
NOTFORECAST--NOTOBSERVED
Number of Cases
550
500
450
400
350
300
08/13 08/14 08/15 08/16 08/17 08/18 08/19 08/20 08/21 08/22 08/23 08/24 08/25 08/26
Date

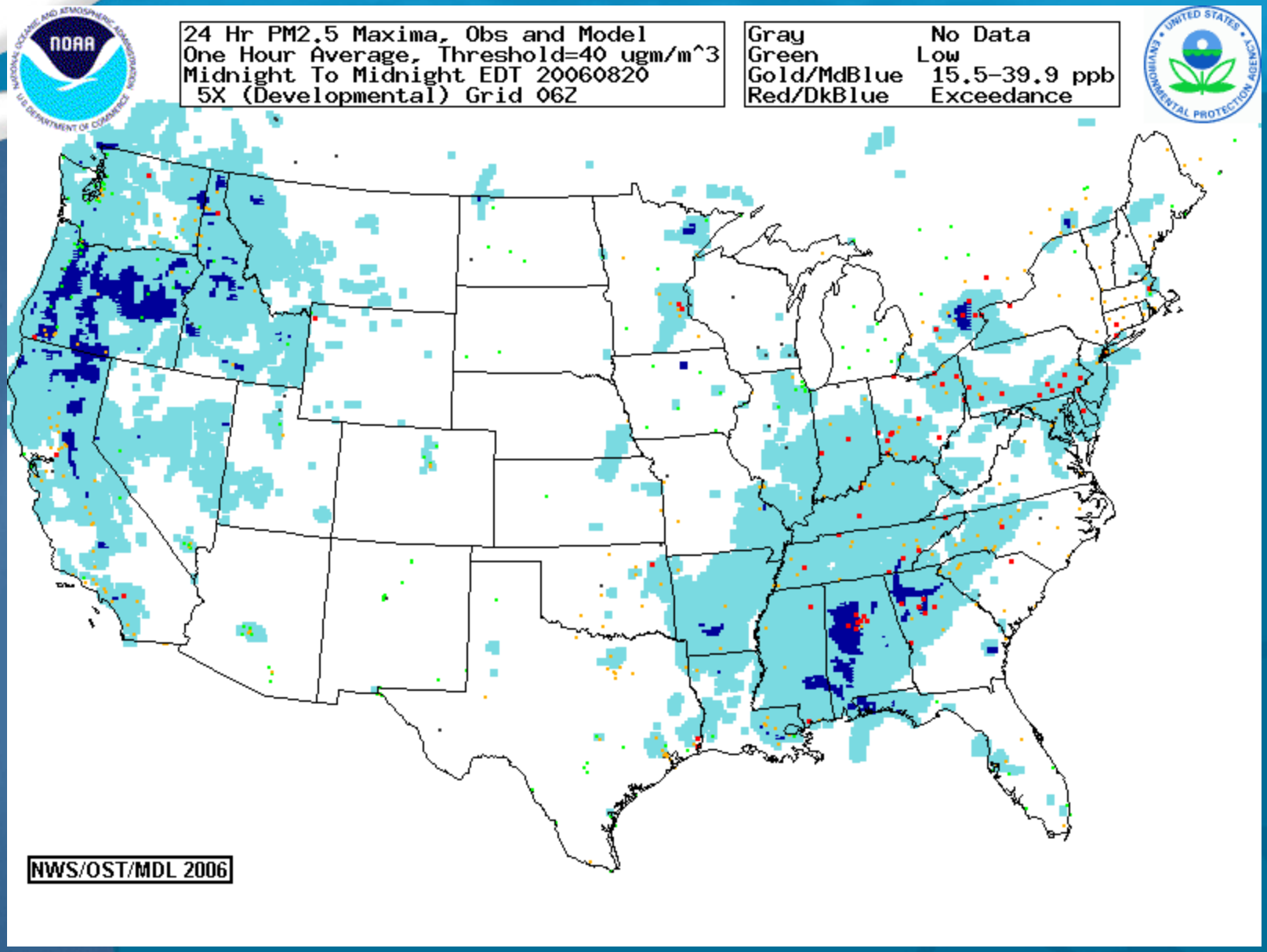

Number of 1-hr Avg Cases for Each Forecast/Observation Comparison
Valid 08/13/2006 to 08/26/2006
5X PM Model 06Z (Forecast Valid Date)
FORECAST--NOTOBSERVED
NOTFORECAST--OBSERVED
FORECAST--OBSERVED
Number of Cases
0
20
40
60
80
100
120
140
08/13
08/14
08/15
08/16
08/17
08/18
08/19
08/20
08/21
08/22
08/23
08/24
08/25
08/26
Date


Midnight to Midnight Aerosol Concentration
Observations vs. Model Forecasts
1 hr Avg (Daily Maximum) -- Valid 08/13/2006 to 08/26/2006
PM 5X Grid 06Z (Forecast Valid Date)
'PMCONCENTRATION'
'REGRESSIONLINE'
r^2 = 0.1263
Observations of PM Concentration (ugm/m^3)
Model Forecasts of PM Concentration (ugm/m^3) 06Z Cycle
0
10
20
30
40
50
60
70
80
90
100
110
120


FORECASTS and OBS, 1-hr Average Aerosol Forecasts v. EPA Obs,
547 Stations, August 12, 2006 - August 25, 2006
5X PM 06Z Model (Model Start Date)
FORECASTS / OBS, MEAN, ugms/m3
Forecast Projection, Hrs (06Z Cycle)
Midnight
Midnight
'for.1hr'
'obs.1hr'
'bias.1hr'
30
25
20
15
10
5
0
-5
-10
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47


RMSE / MAE / BIAS, 1-hr Average Aerosol Forecast v. EPA Obs,
547 Stations, August 12, 2006 - August 25, 2006,
5X PM 06Z Model (Model Start Date)
RMSE / MAE / BIAS, ugms/m3
Forecast Projection, Hrs (06Z Cycle)
Midnight
Midnight
'rmse.1hr'
'mae.1hr'
'bias.1hr'
30
25
20
15
10
5
0
-5
-10
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47


24 Hr PM2.5 Maxima, Obs and Model
One Hour Average, Threshold=40 ugm/m^3
Midnight To Midnight EDT 20060819
5X (Developmental) Grid 06Z
Gray No Data
Green Low
Gold/MdBlue 15.5-39.9 ppb
Red/DkBlue Exceedance
NWS/OST/MDL 2006


24 Hr PM2.5 Maxima, Obs and Model
One Hour Average, Threshold=40 ugm/m^3
Midnight To Midnight EDT 20060820
5X (Developmental) Grid 06Z
Gray No Data
Green Low
Gold/MdBlue 15.5-39.9 ppb
Red/DkBlue Exceedance
NWS/OST/MDL 2006

Comments, 2006

- Lower POD and FAR for 5x compared to 3x, lower 5x TS during high ozone episodes.
- 5x MAE/bias lower than for 3x.
- 5x model on CONUS grid: Consistent under-forecasting, especially in California.
- 1-h PM results: Under-forecasting, forecasted diurnal drop not observed.