

Comprehensive evaluation on air quality forecasting ability of Hi-Res in southeastern United States

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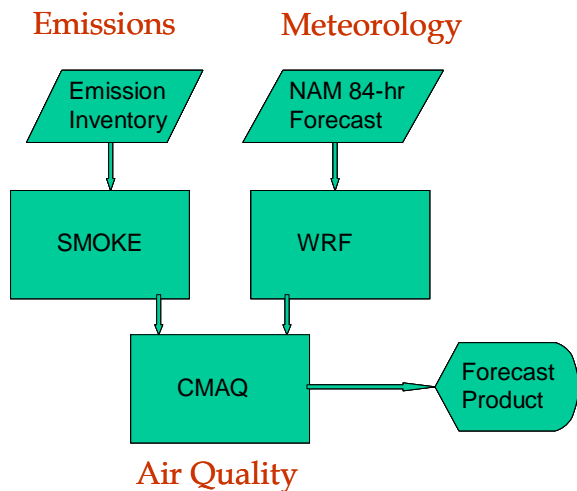
8th Annual CMAS Conference, October 19th, 2009

Outline

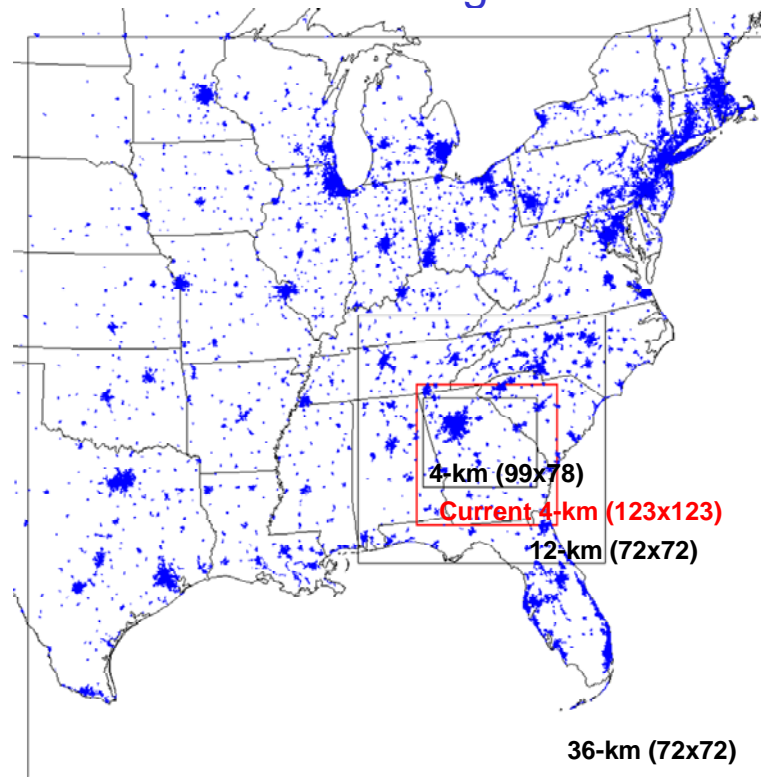
- The Hi-Res air quality forecasting system.
- 2006-2009 O₃ and PM_{2.5} performance for Atlanta metro.
- Spatial variation of forecast performance.
- Linking forecast performance to weather conditions.
- Linking forecast performance to emissions conditions.

Hi-Res: forecasting ozone and PM_{2.5} at a 4-km resolution in metro Atlanta area

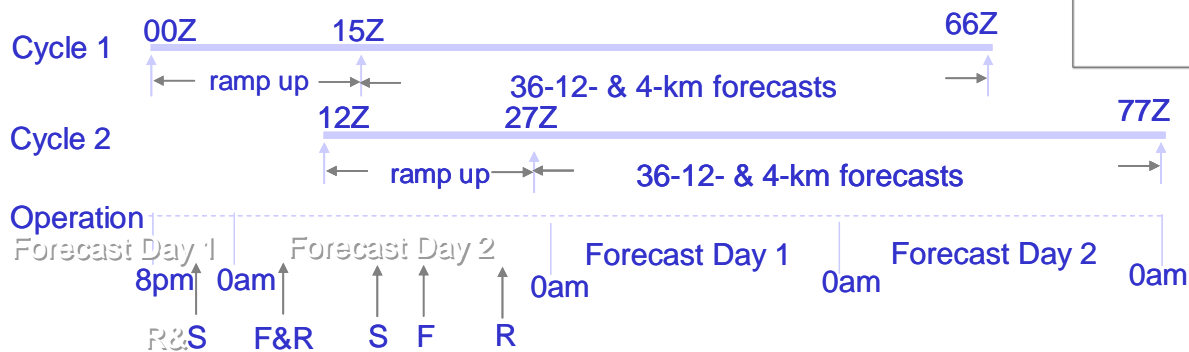
Hi-Res Air Quality Forecasting System
Serving Metro-Atlanta Area since 2006



Hi-Res Modeling Domains



Hi-Res Cycle



Hi-Res Forecast Products

- “Single Value” Report: tomorrow’s AQI, ozone and PM_{2.5} by metro area in Georgia
- Air Quality Forecasts: AQI, ozone and PM_{2.5}, 48-hrs spatial plots and station profiles
- Meteorological Forecasts: precipitation, temperature and winds, 48-hrs spatial plots and station profiles
- Performance Evaluation: time series comparison and scatter plots for the previous day

Snapshots from Hi-Res homepage: <http://forecast.ce.gatech.edu>

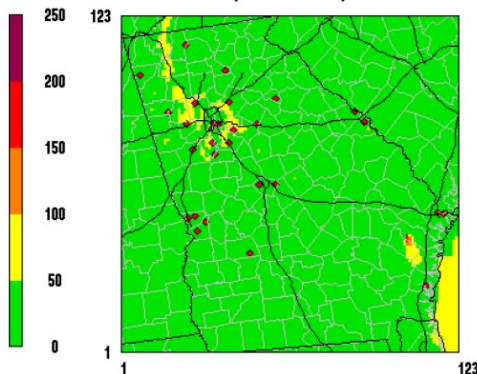
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Hi-Res Air Quality Forecast Web Site

AQI

Daily Maximum Air Quality Index

At date below
(4-km Resolution)



October 19, 2009 1:00:00 (EST)
Min= 28 at (10,65), Max= 193 at (105,43)

Technical Support Information

Technical support is offered Monday - Friday from 9 a.m. to 5 p.m. (ET).

Phone : (404) 894-2783

E-Mail : odman@gatech.edu

Forecasts

(Tomorrow's ozone and PM_{2.5} report by Metro Area)

Air Quality Forecasts

- [Air Quality Index \(AQI\)](#)
- [Ozone](#)
- [PM_{2.5}](#)

Meteorological Forecasts

- [Precipitation](#)
- [Temperature](#)
- [Winds](#)

This Web site is for air quality forecasts. We've gathered a number of resources here to help you better understand our latest improvements and our forecasting research.

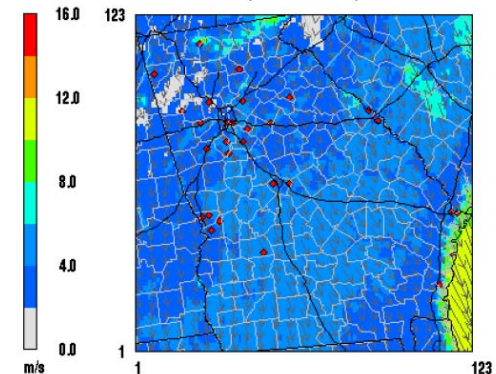
For more information on the Air Quality Index (AQI) and state-wide coverage in Georgia, click on the links below. The 2009 ozone season began on October 19, 2009.

For more information on the 2009 ozone season in the Eastern U.S., click on the link below. For more information on the 2006 Air Quality Index in Georgia, click on the link below. For more information on the 2007 & Outlook for Georgia, click on the link below.

Winds

Hourly Winds at 10m

At date & time below
(4-km Resolution)



October 19, 2009 0:00:00 (EST)
Min= 0.0 at (64,118), Max= 11.3 at (118,3)

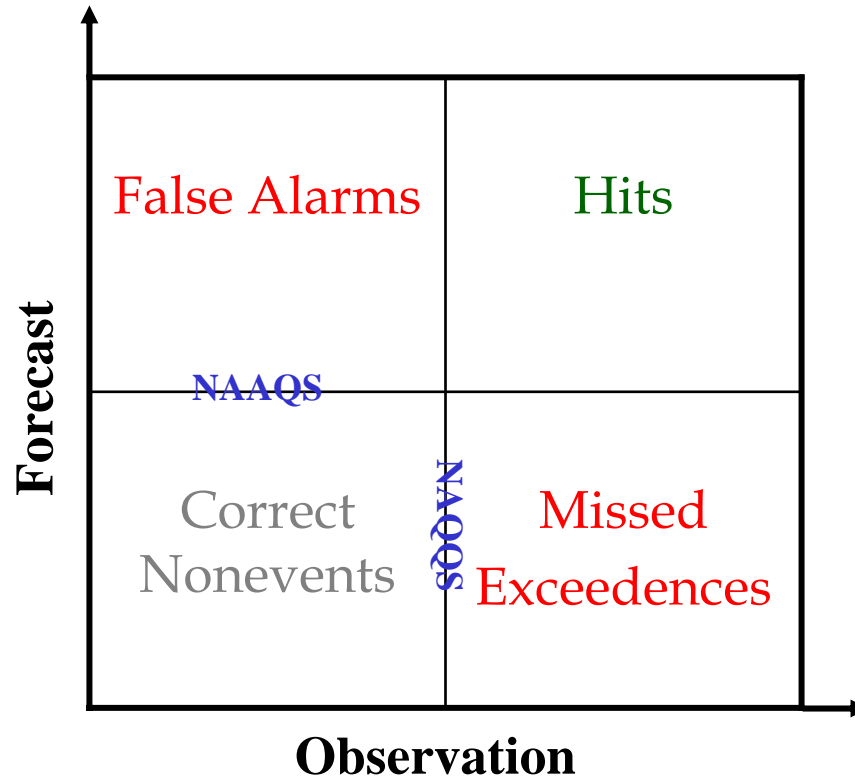
Evolving history of Hi-Res during 2006-2009

- Updated to new release of WRF each year before ozone season.
 - WRF2.1, 2.2, 3.0 and 3.1
- Projected NEI to current year in the very beginning of each year.
- Updated forecast products website each year before ozone season.
- Switched from single-cycle forecasting to two-cycles in 2008.
- Enlarged 4-km domain to cover the entire Georgia in 2009.
- Introduced Georgia Tech's new SOA module in 2009.
- Data assimilation in ozone forecasting is in experiment.

Purposes of Forecasting Performance Evaluation

- To hopefully have a good performance show and hence to give a good reason for being further funded.
 - It's in fact very important...
- To explore reasons for why bad forecasting so that we can improve.
 - Science? Can we blame for "Smog Alert" that reduced emissions?
- Finally for users of our forecasts: to build "quantitative" confidence in the forecasts.
 - If today is a sunny Monday how I am going to trust their "Smog Alert"?
- "Comprehensive" evaluation, preliminary results presented here.

Performance Metrics

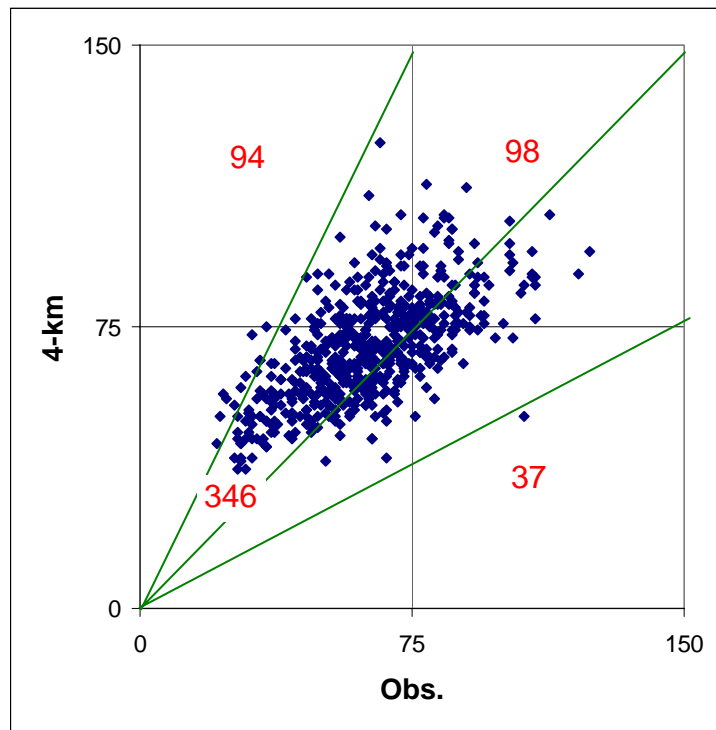


$$\text{MNB} = \frac{1}{N} \sum_{k=1}^N \frac{c_k^m - c_k^o}{c_k^o}$$

$$\text{MNE} = \frac{1}{N} \sum_{k=1}^N \frac{|c_k^m - c_k^o|}{c_k^o}$$

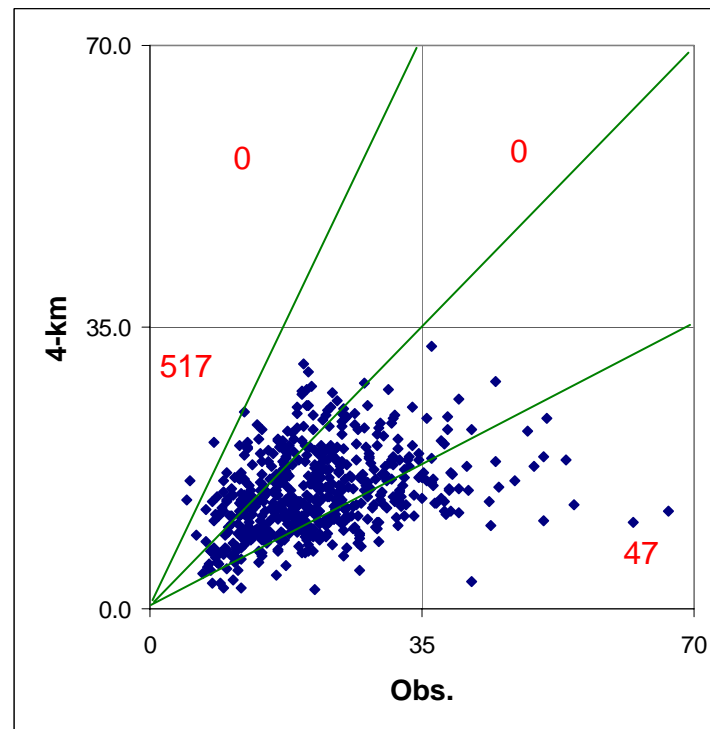
Overall 2006-2009 Performance: Atlanta Metro

Ozone



MNB	17%
MNE	24%

PM_{2.5}

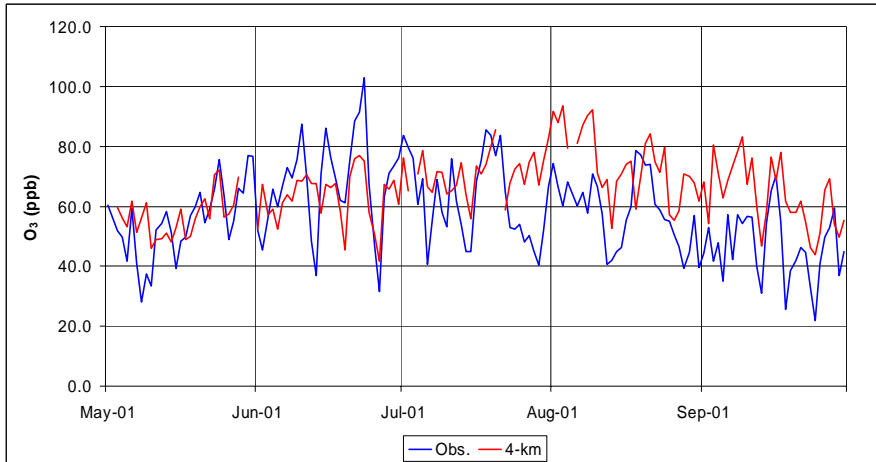


MNB	-25%
MNE	37%

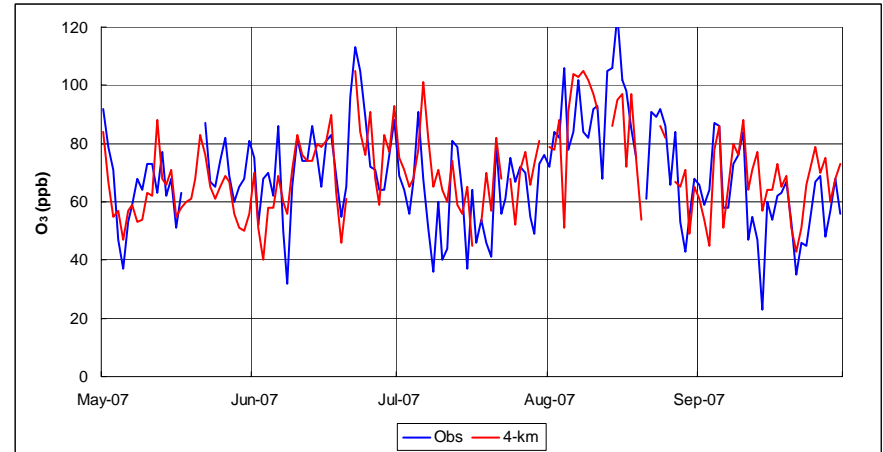
Ozone Performance

Forecast vs. Observed O₃

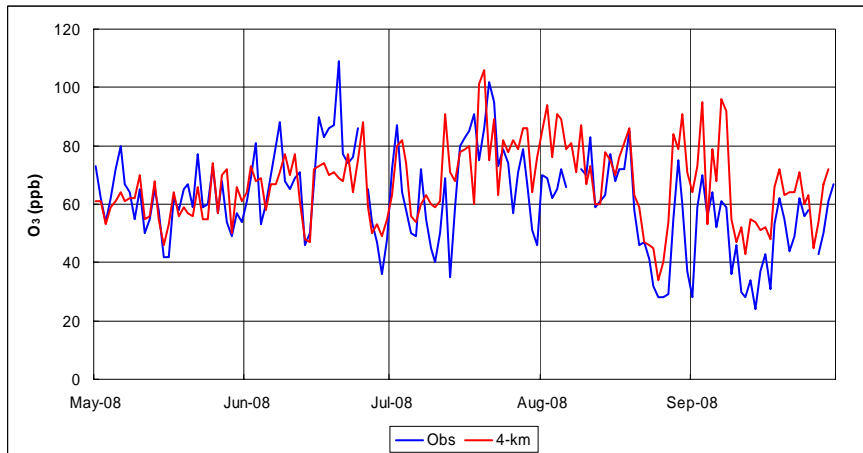
2006



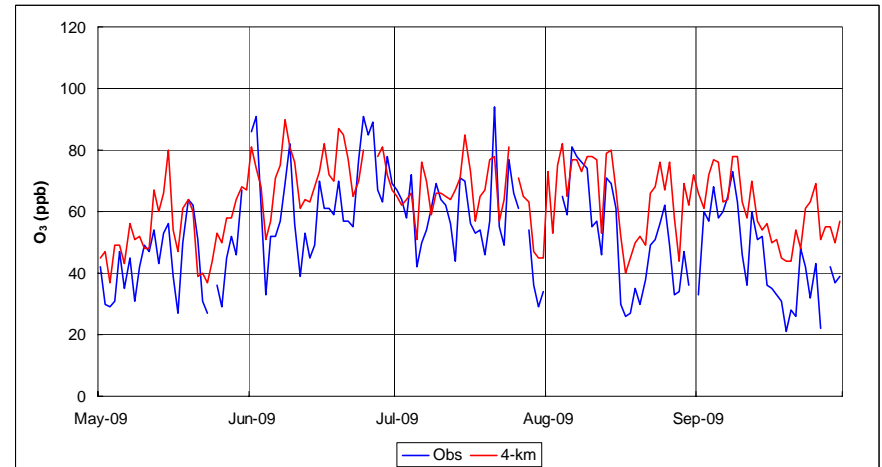
2007



2008

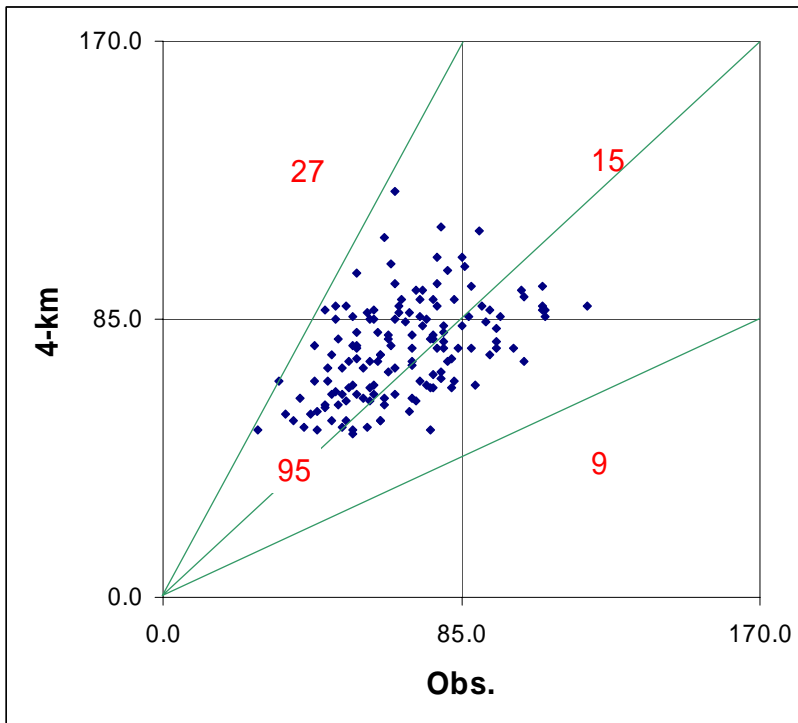


2009



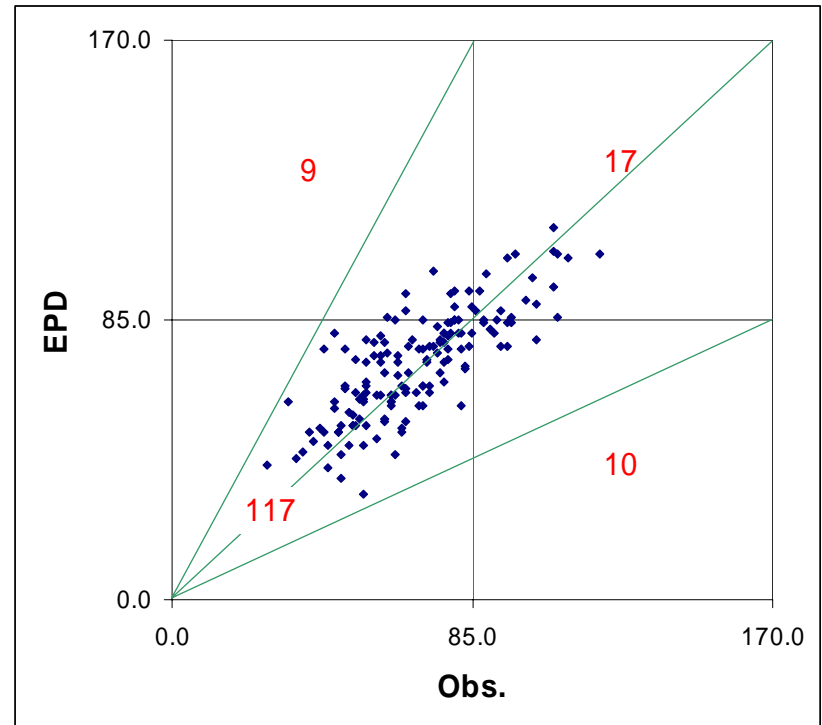
2006 O₃ Performance: Hi-Res vs. EPD's

Our 4-km Forecast



MNB	11%
MNE	29%

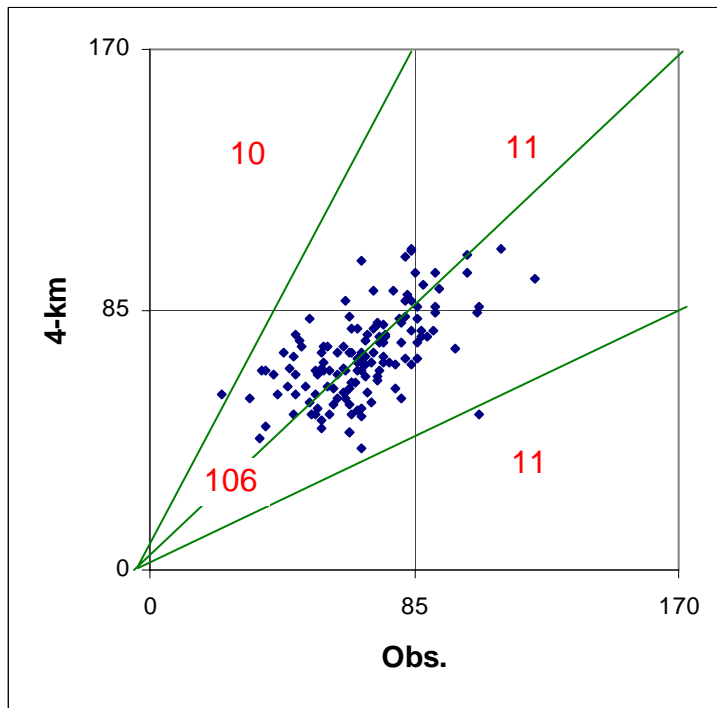
EPD Ensemble Forecast



MNB	6.2%
MNE	15%

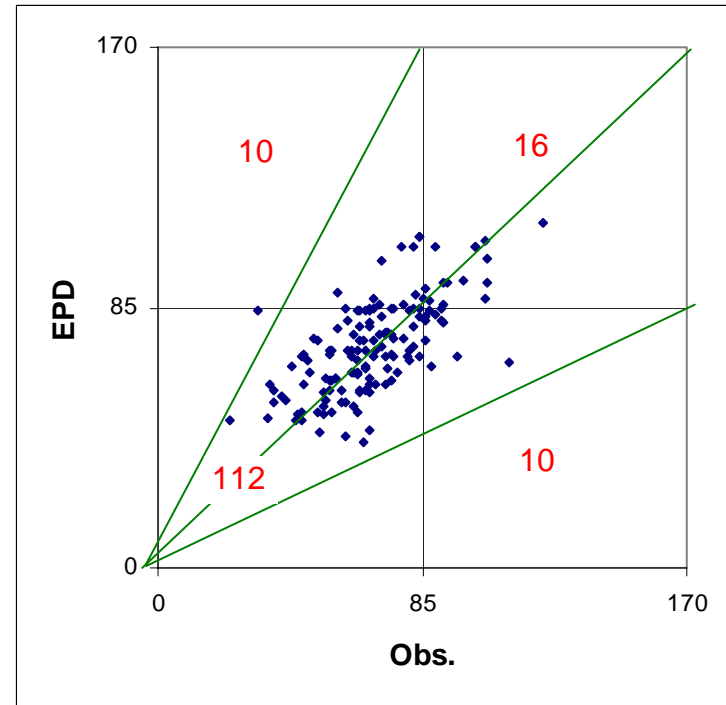
2007 O₃ Performance: Hi-Res vs. EPD's

Our 4-km Forecast



MNB	8.5%
MNE	19%

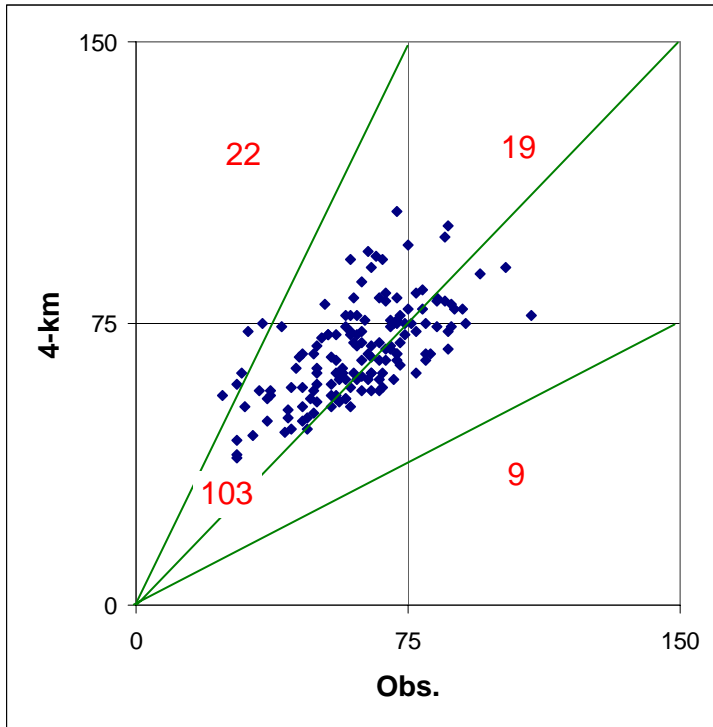
EPD Ensemble Forecast



MNB	9.0%
MNE	18%

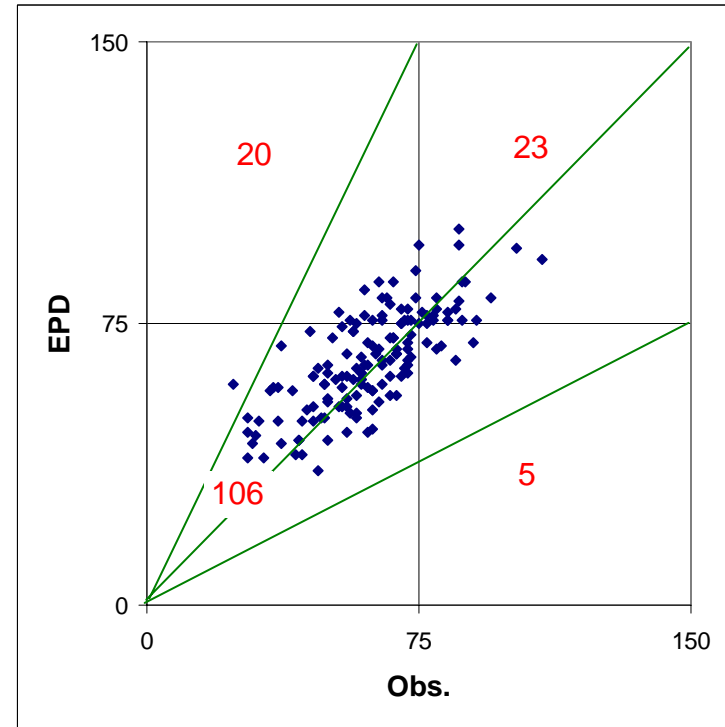
2008 O₃ Performance: Hi-Res vs. EPD's

Our 4-km Forecast



MNB	17%
MNE	23%

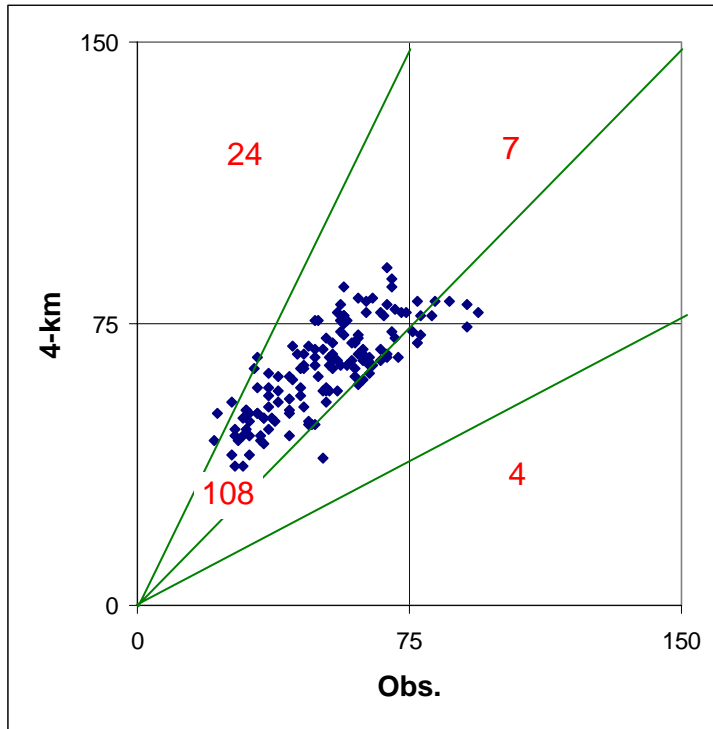
EPD Ensemble Forecast



MNB	11%
MNE	19%

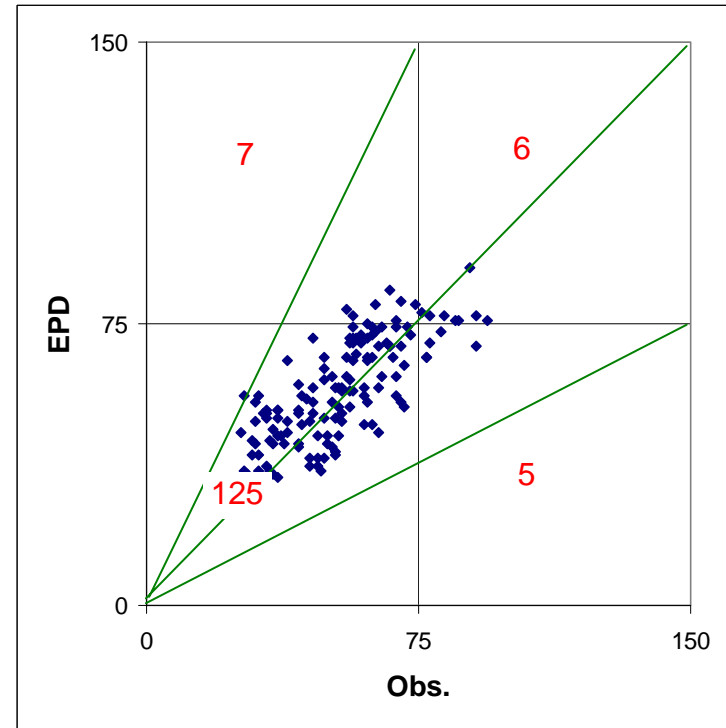
2009 O₃ Performance: Hi-Res vs. EPD's

Our 4-km Forecast



MNB	28%
MNE	30%

EPD Ensemble Forecast



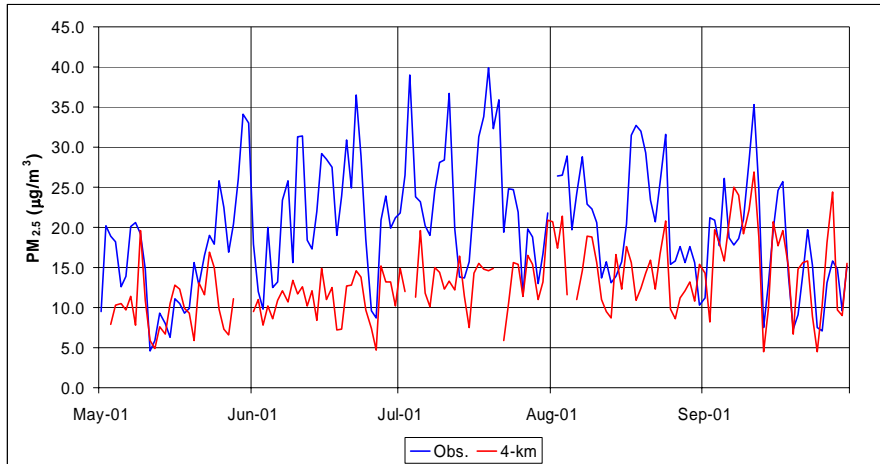
MNB	13%
MNE	21%

Particulate Matter Performance

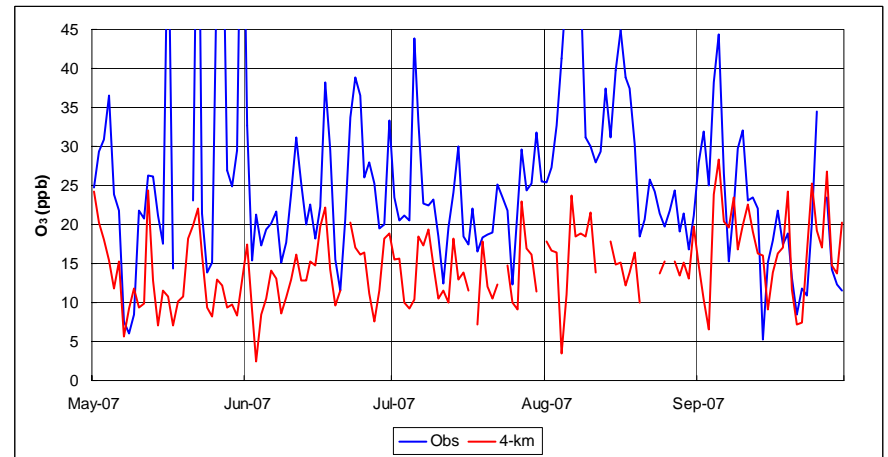
Summer

Forecast vs. Observed PM_{2.5}

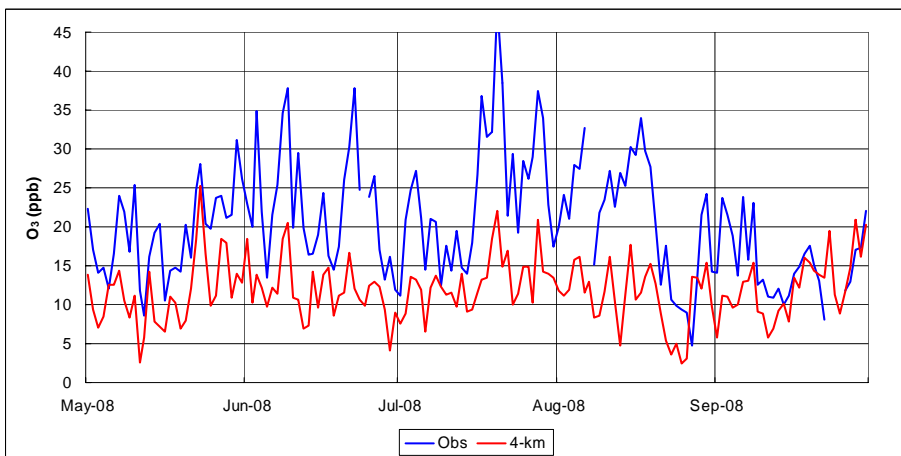
2006



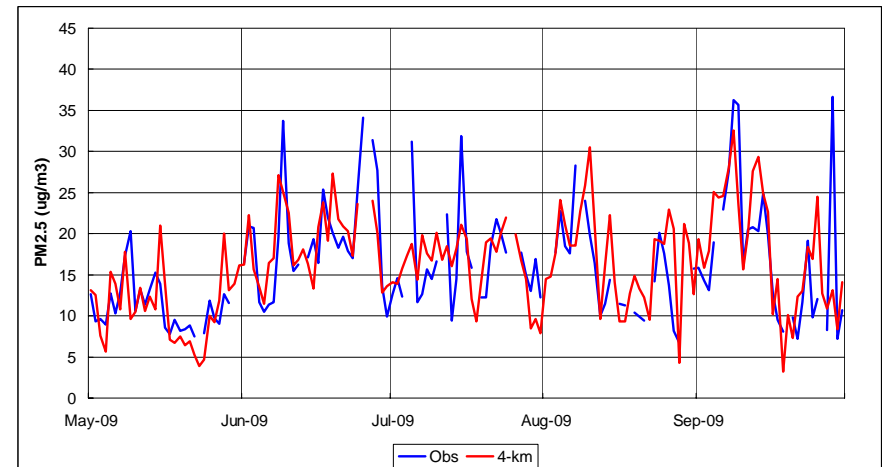
2007



2008

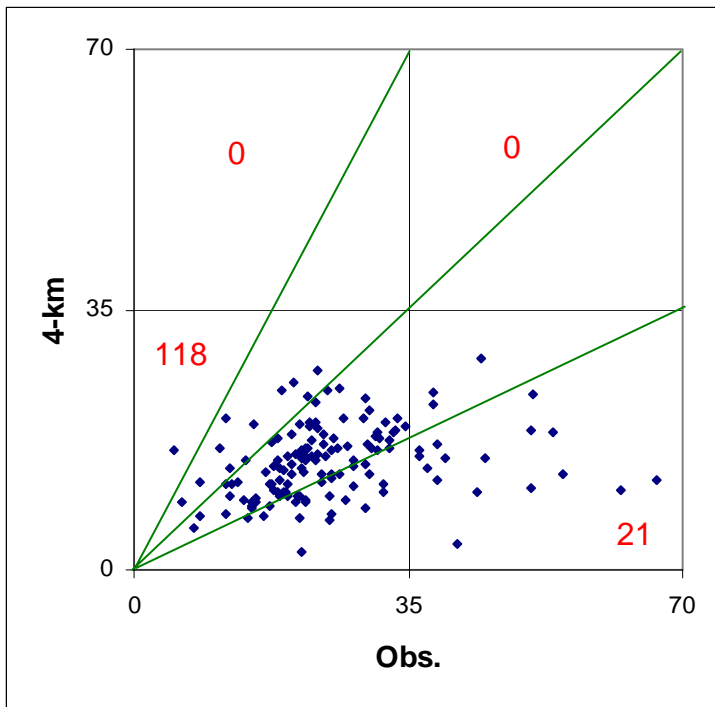


2009

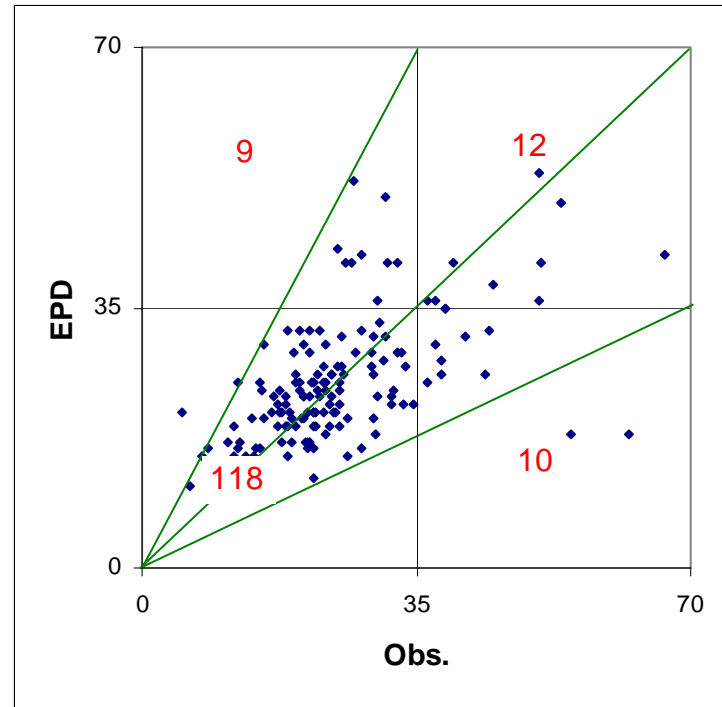


2007 PM_{2.5} Performance: 4-km vs. EPD's

Our 4-km Forecast



EPD Ensemble Forecast

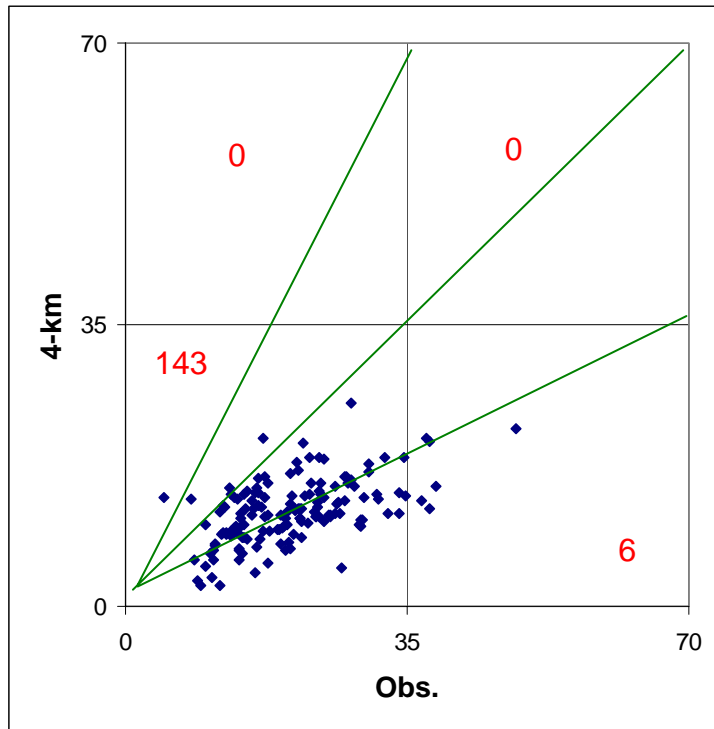


MNB	-37%
MNE	44%

MNB	8.6%
MNE	28%

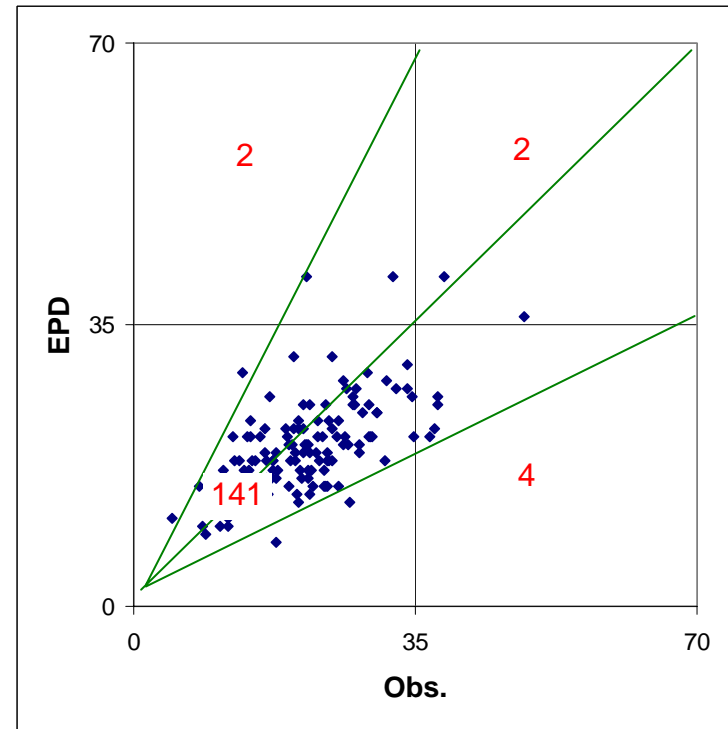
2008 PM_{2.5} Performance: 4-km vs. EPD's

Our 4-km Forecast



MNB	-38%
MNE	42%

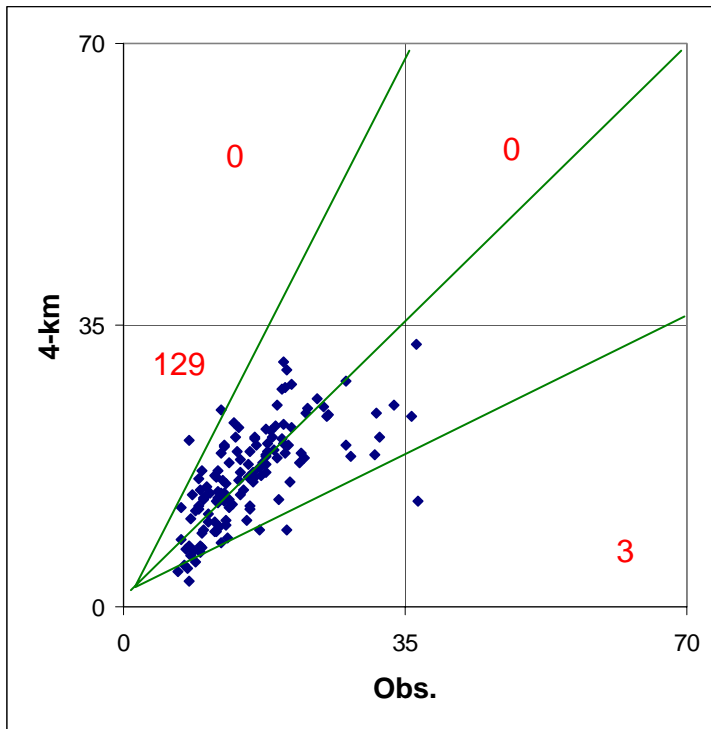
EPD Ensemble Forecast



MNB	-0.2%
MNE	22%

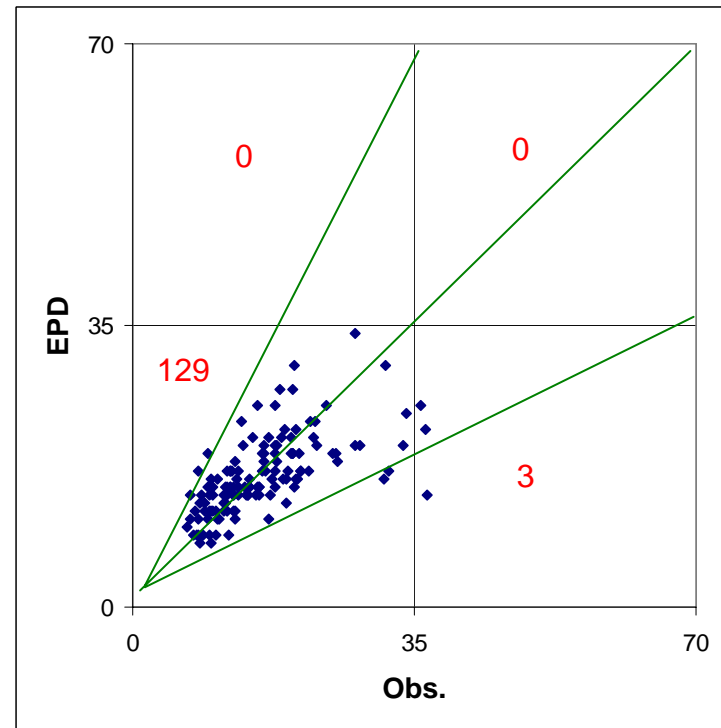
2009 PM_{2.5} Performance: 4-km vs. EPD's

Our 4-km Forecast



MNB	8%
MNE	25%

EPD Ensemble Forecast

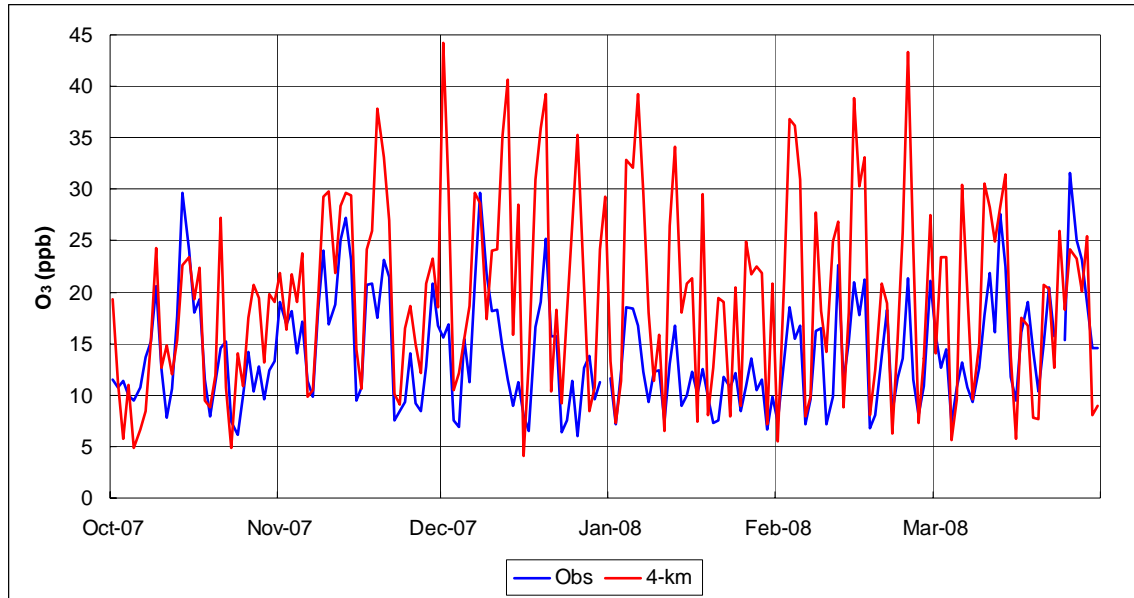


MNB	11%
MNE	24%

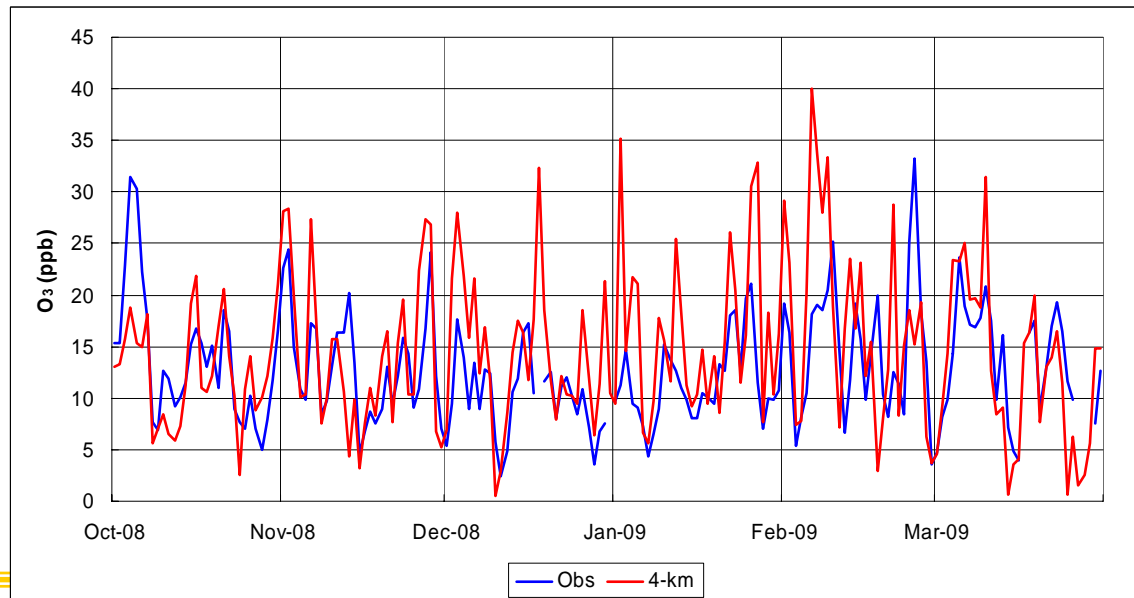
Winter

Forecasted vs. Observed $PM_{2.5}$

2007

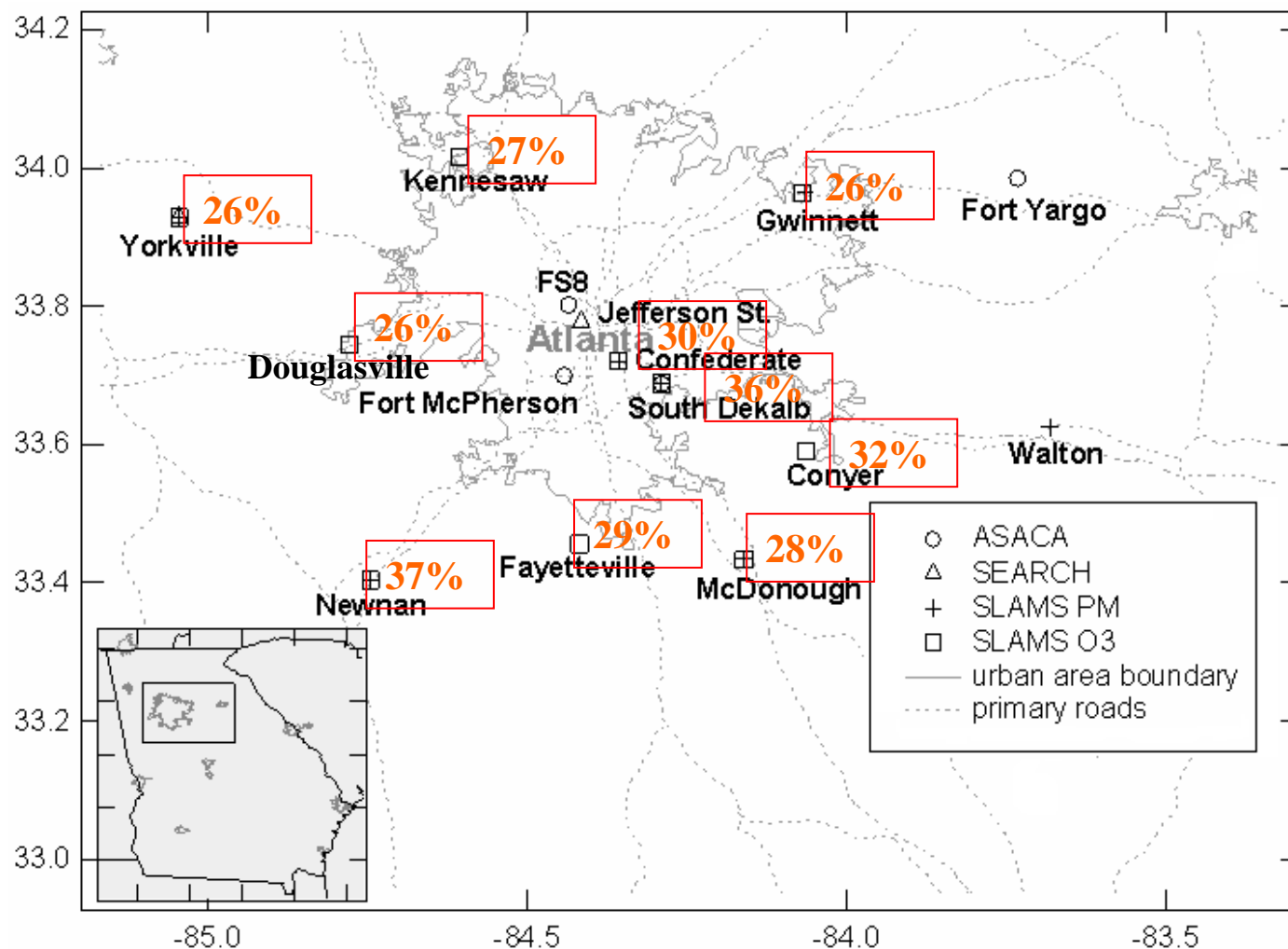


2008



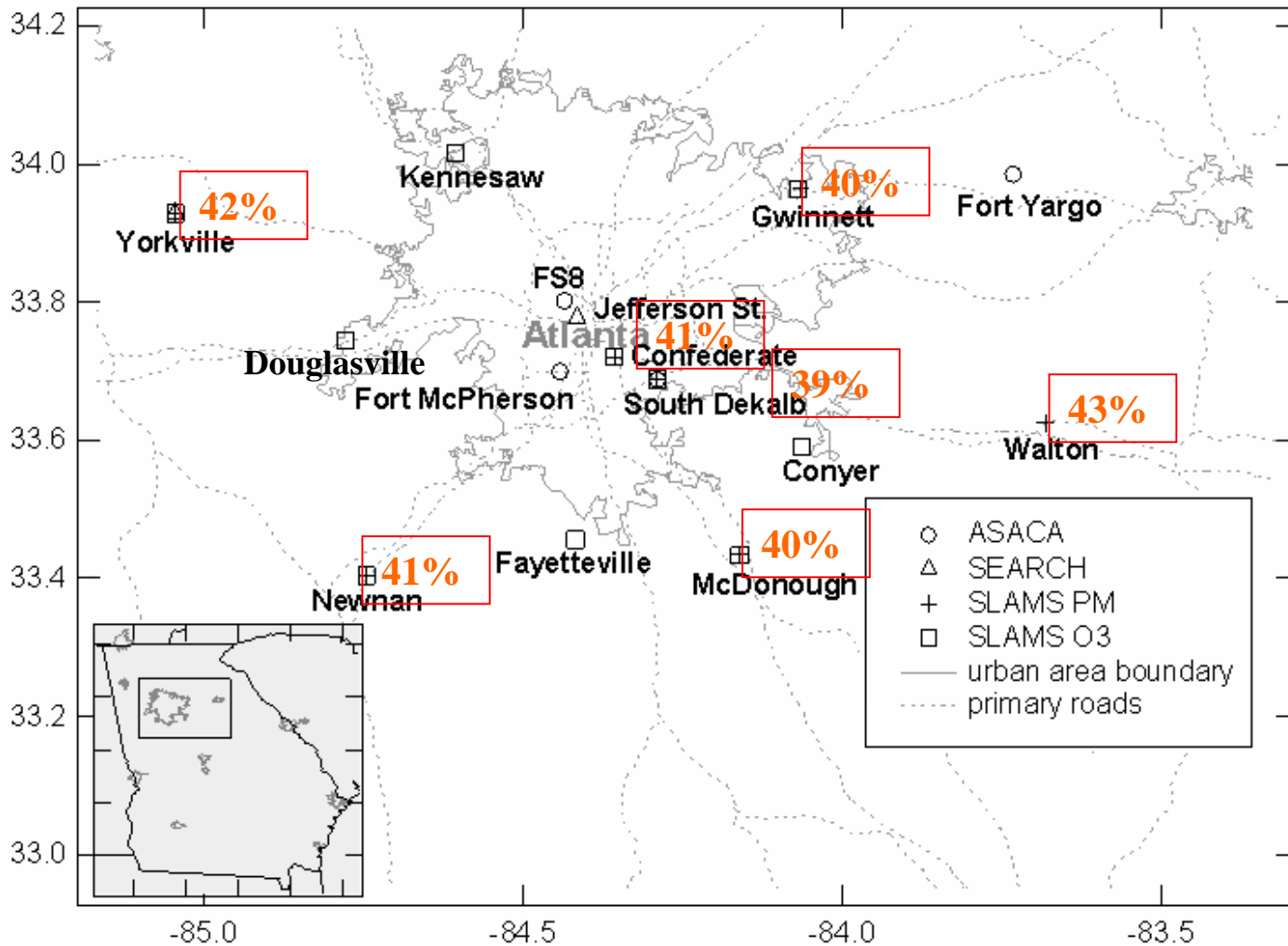
Spatial Variation of Performance: Ozone

“Single value” forecast for Atlanta metro has a MNE as 24%



Spatial Variation of Performance: PM_{2.5}

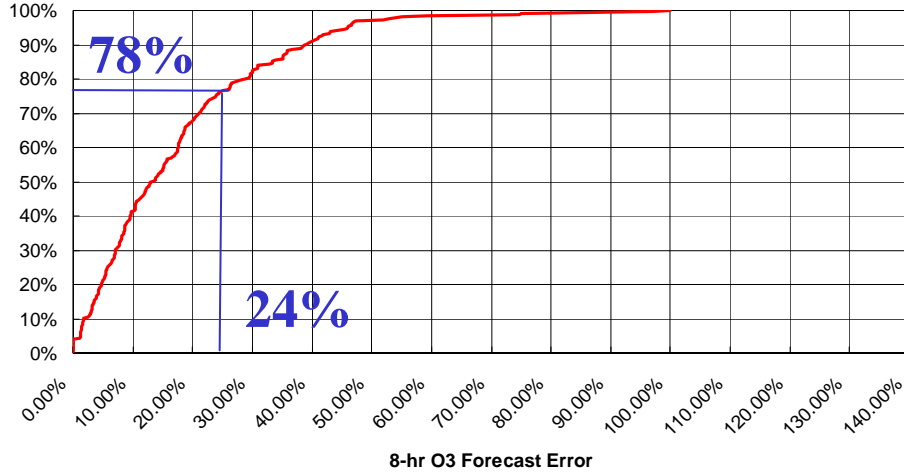
“Single value” forecast for Atlanta metro has a MNE as 37%



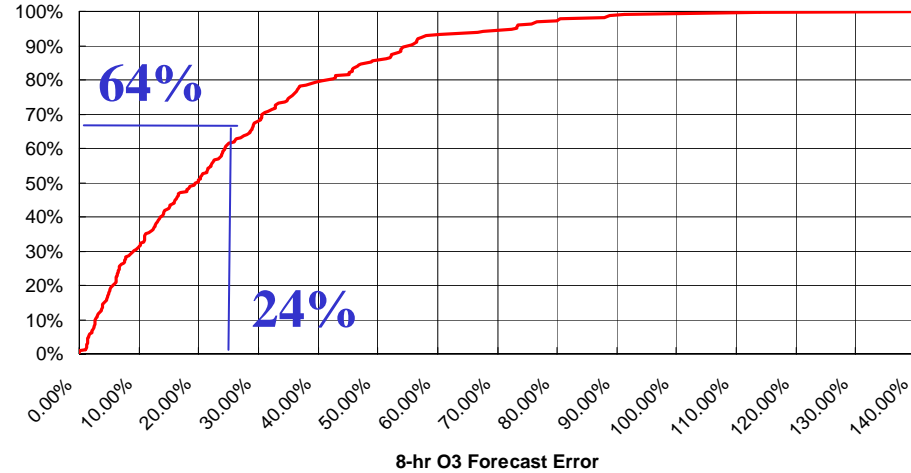
Linking Performance to Weather Conditions: (1)

Ozone

Mostly Sunny

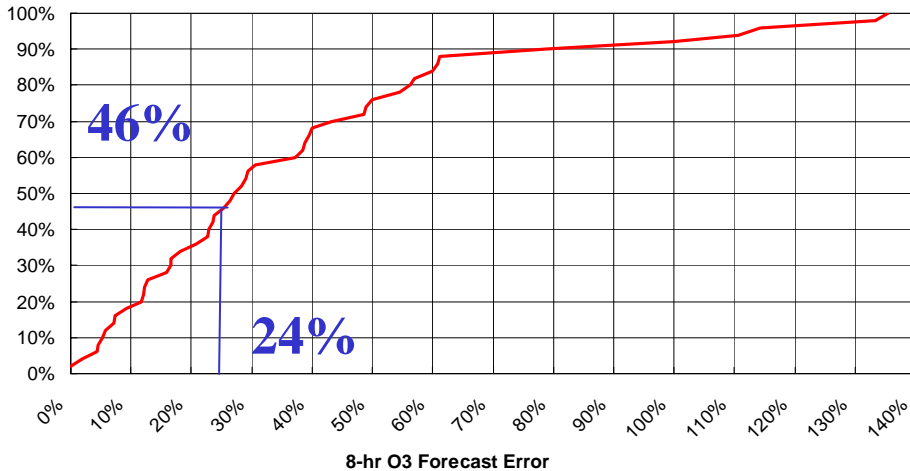


Partly Cloudy/Sunny

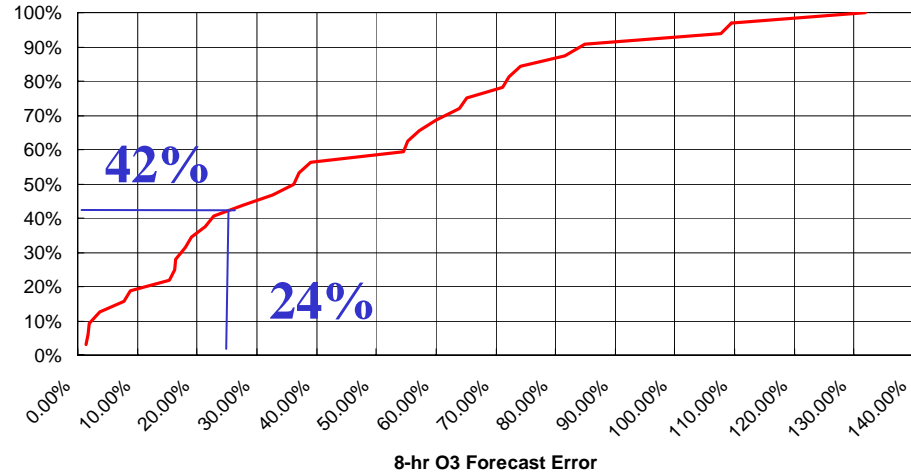


This means a 78% chance that a 8-hr O3 forecasts error in a sunny day is less than 24%

Cloudy



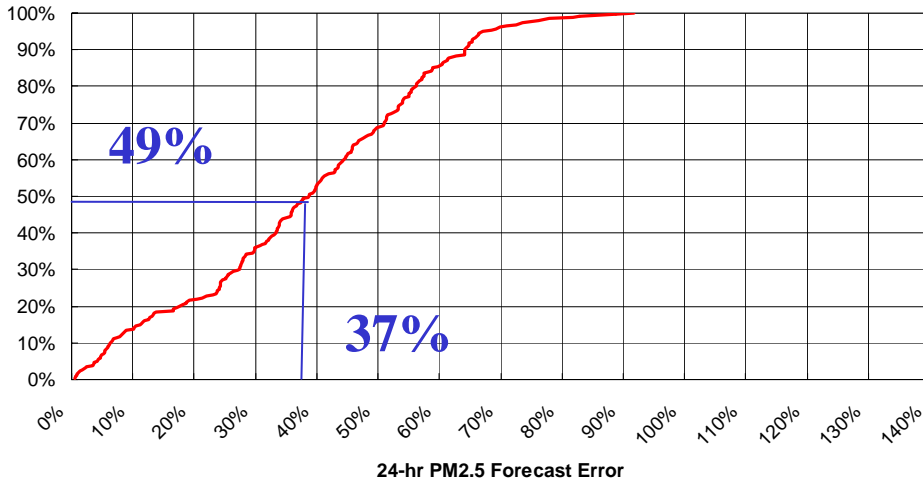
Rain



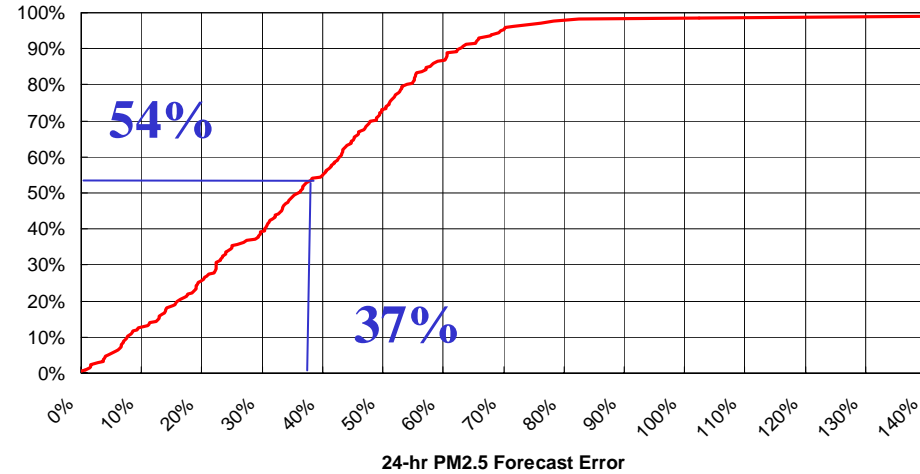
Linking Performance to Weather Conditions: (2)

PM_{2.5}

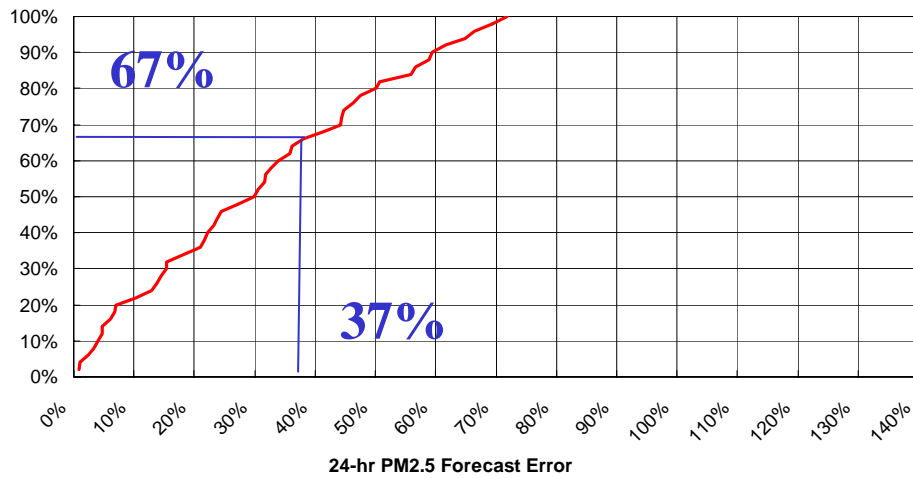
Mostly Sunny



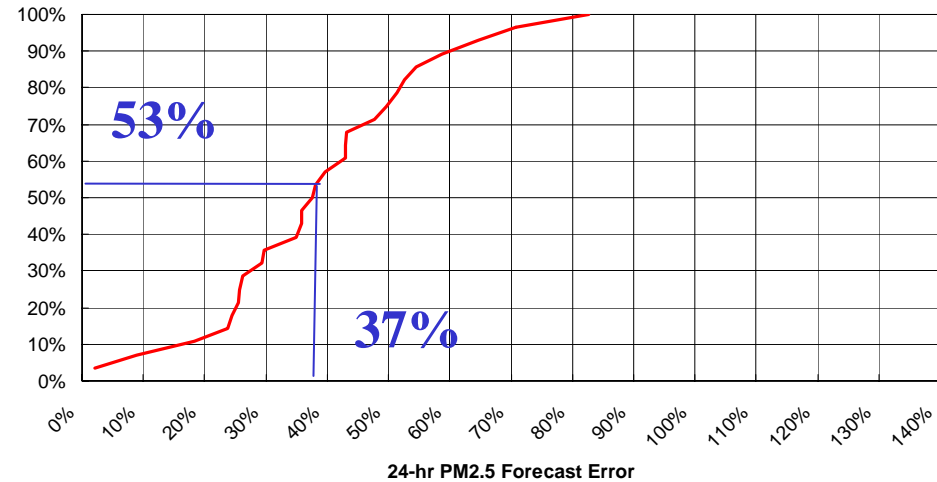
Partly Cloudy/Sunny



Cloudy



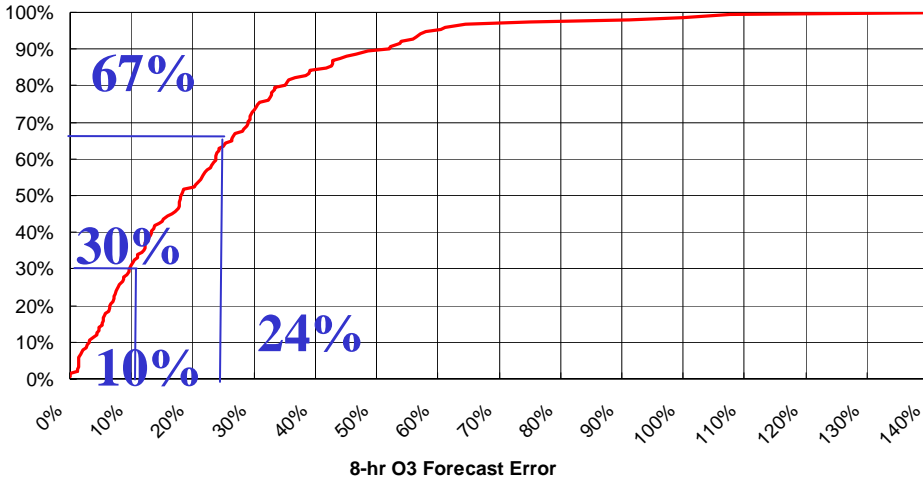
Rain



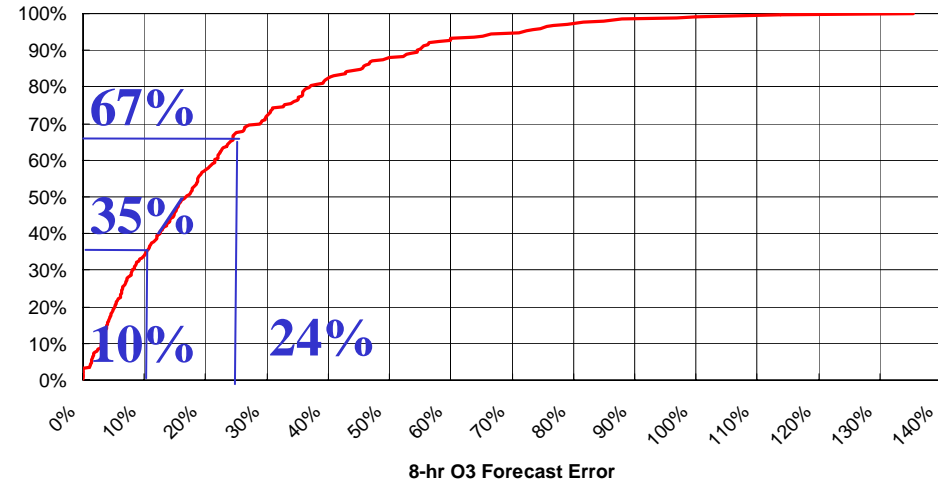
Linking Performance to Emissions Conditions: (1)

Ozone

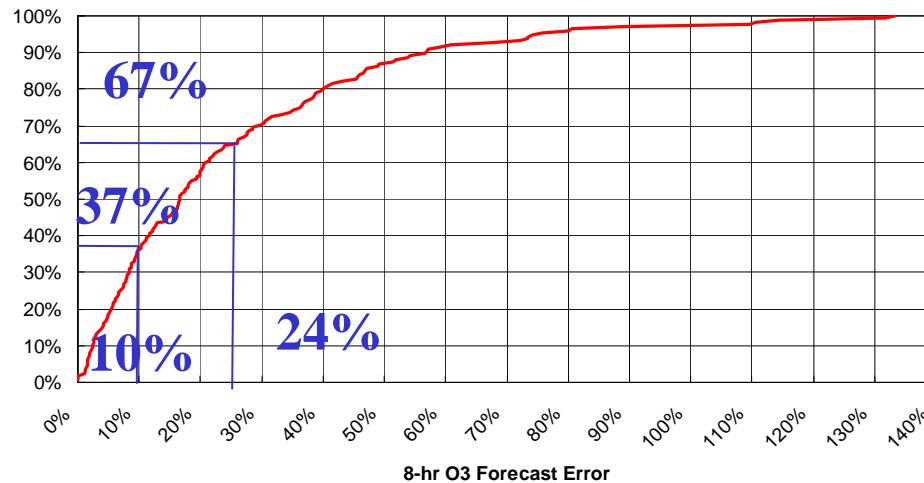
Monday and Friday



Tuesday, Wednesday and Thursday



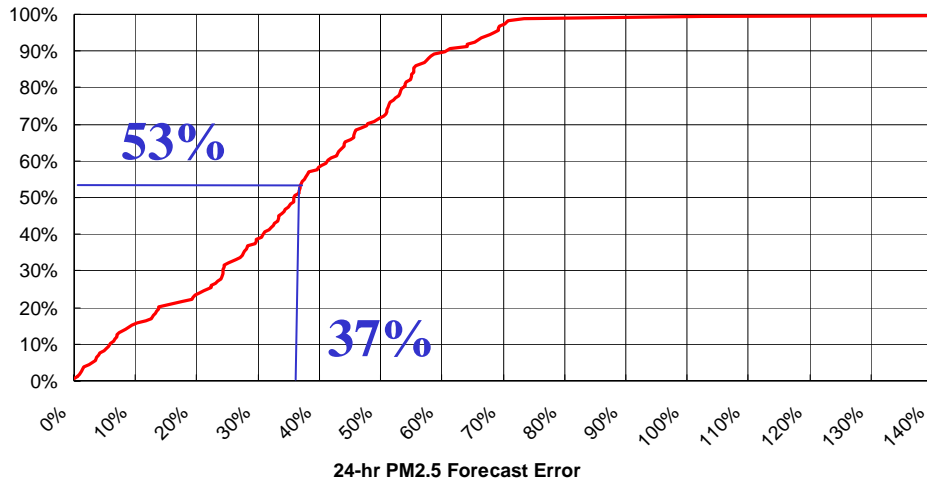
Weekends and Holidays



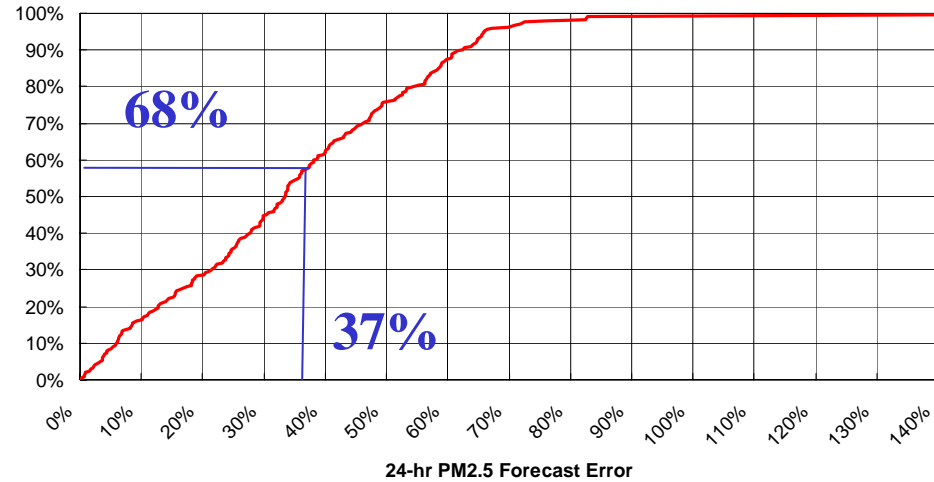
Linking Performance to Emissions Conditions: (2)

PM_{2.5}

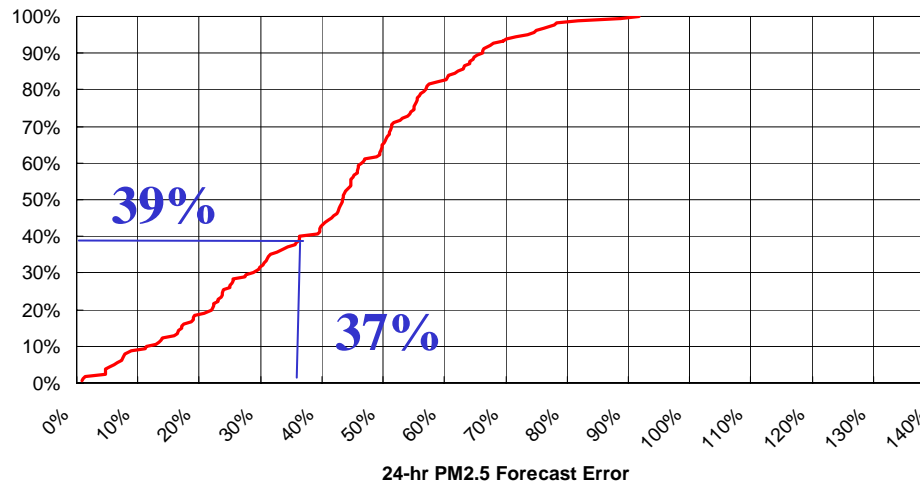
Monday and Friday



Tuesday, Wednesday and Thursday



Weekends and Holidays



Summary

- 2006-2009 Ozone forecasts are good.
 - Overall bias is +17% and error is 24%
- 2006-2009 PM_{2.5} forecasts are not very accurate.
 - May-September bias is -25% and error is 37%
- The new SOA module helped a much better 2009 PM_{2.5} performance
 - May-September bias is 8% and error is 25%
- “Single Value” forecasts for Atlanta metro is slightly in better performance than specific station forecasts.
 - Larger spatial variance for ozone performance, PM_{2.5} performance is more uniform spatially.
- Less cloud coverage, better ozone performance, but worse PM_{2.5} performance
- Worse PM_{2.5} performance in weekends and holidays
 - But not seen for ozone performance.

Acknowledgements

**We thank Georgia EPD for funding the Hi-Res forecasts,
Dr. Jaemeen Baek of our group for the new SOA module,
Dr. Carlos Cardelino of Georgia Tech for team forecasts.**