cpp

WIND ENGINEERING &
AIR QUALITY CONSULTANTS

Background Concentrations and the Need for a New System to Update AERMOD

EPA 11th Conference on Air Quality Modeling

August 13, 2015

Sergio A. Guerra, Ph.D. – CPP Inc.

Outline

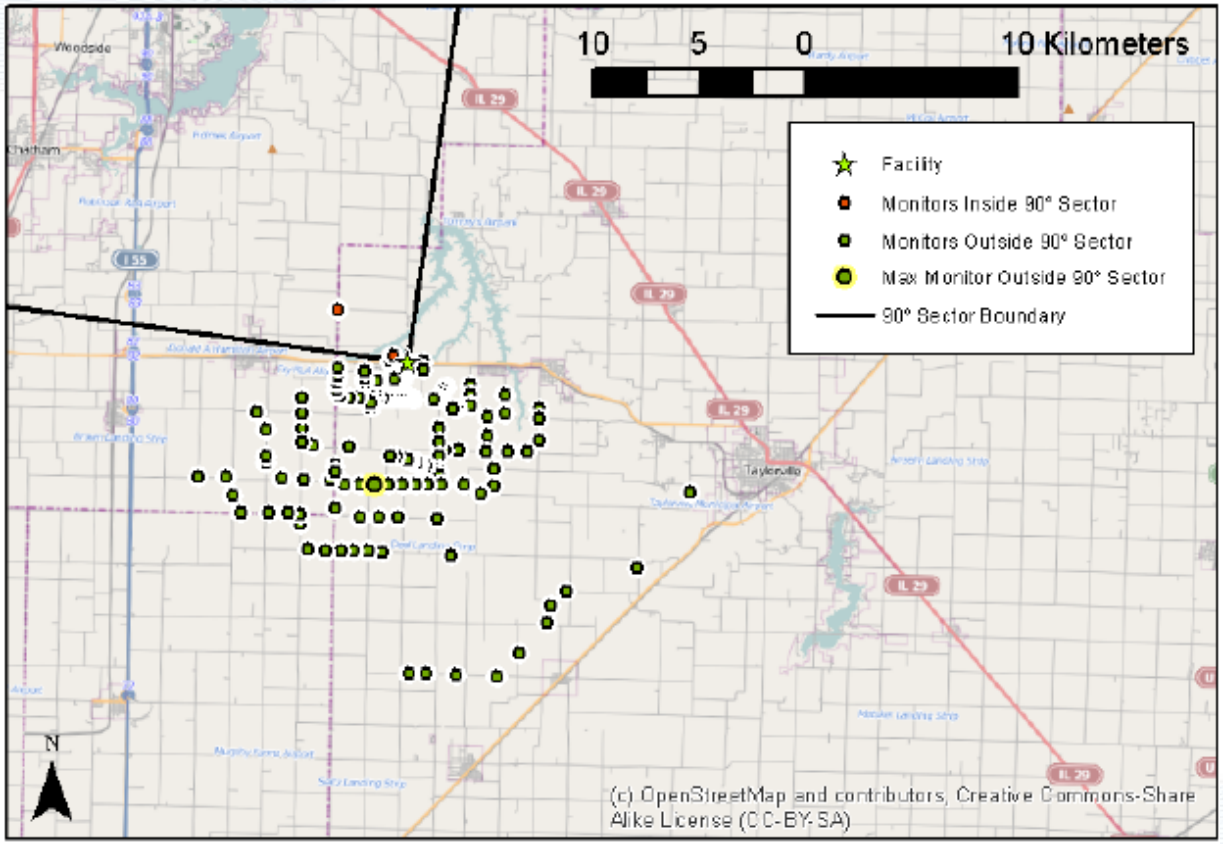
- Preliminary evaluation of methods proposed in Draft Guidance to account for background concentrations.
- Alternative approach to account for background.
- Appendix W: lessons learned and proposed framework for new/advanced modeling techniques.

Background Concentrations

In the draft Guidance EPA (Section 8.3) proposes the following:

1. Excluding the 90° downwind sector from source in question.
2. Modifying ambient data record when monitor is impacted by unusual events such as Canadian forest fires, construction, etc. This is to be accomplished by:
    1. Removing hourly or daily data,
    2. Scaling or adjusting data from specific days or hours.
3. Pairing monitoring and modeled data on a temporal basis:
    1. Season,
    2. Hour of day or,
    3. In rare cases of isolated sources, an hourly or daily pairing may be recommended.
4. Use results from a regional-scale photochemical grid model.

Excluding the 90° Downwind Sector



Probability Analyses of Combining Background Concentrations With Model-Predicted Concentrations
Douglas R. Murray and Michael B. Newman
Journal of the Air & Waste Management Association
Vol. 64, Iss. 3, 2014

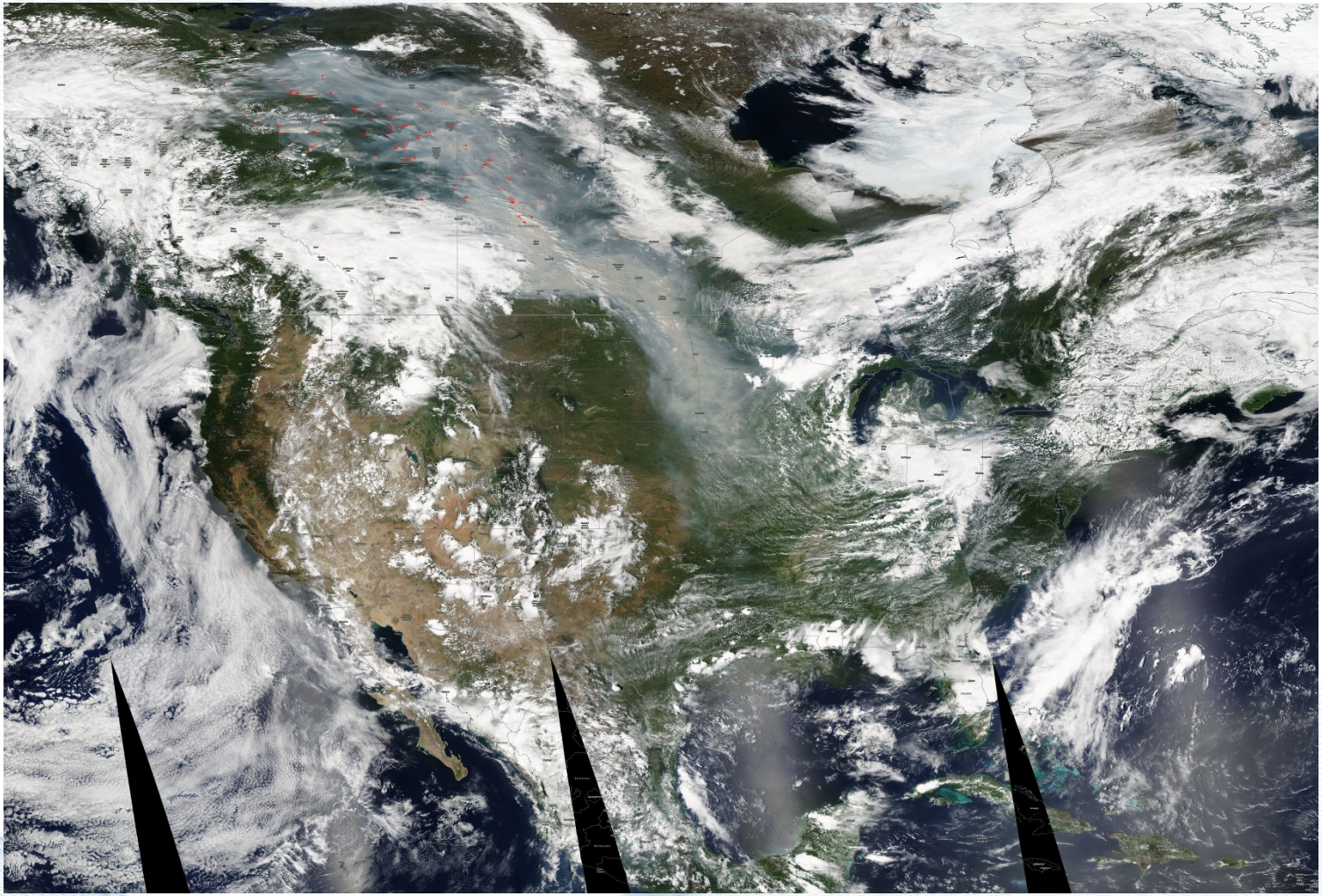
Summary of Tracer and SO_2 Observed Outside 90° Downwind Sector

Pollutant	Basis:	Maximum Per Hour			Average Per Hour		Minimum Per Hour
	Wind Direction	99th % Observed (10^{-9} s/m³)	99th % Outside Sector (10^{-9} s/m³)	% hours outside sector > 10 % hourly max	99th % Outside Sector (10^{-9} s/m³)	% hours outside sector > 10 % hourly max	Average Observed (10^{-9} s/m³)
SF_6	National Wx Service	247.2	188.0	60.3%	23.9	6.5%	0.00
	100 m Onsite	247.2	147.3	53.1%	16.5	3.9%	0.00
	10 m Onsite	247.2	116.3	55.7%	13.0	3.9%	0.00

Pollutant	Basis:	Maximum Per Hour			Average Per Hour		Minimum Per Hour
	Wind Direction	99th % Observed (µg/m³)	99th % Outside Sector (µg/m³)	% hours outside sector > 10 % hourly max	99th % Outside Sector (µg/m³)	% hours outside sector > 10 % hourly max	Average Observed (µg/m³)
SO_2	National Wx Service	504.6	366.1	90.8%	65.9	59.9%	0.02
	100 m Onsite	507.3	300.7	90.1%	57.2	57.8%	0.02
	10 m Onsite	507.3	287.6	91.3%	58.0	58.6%	0.02

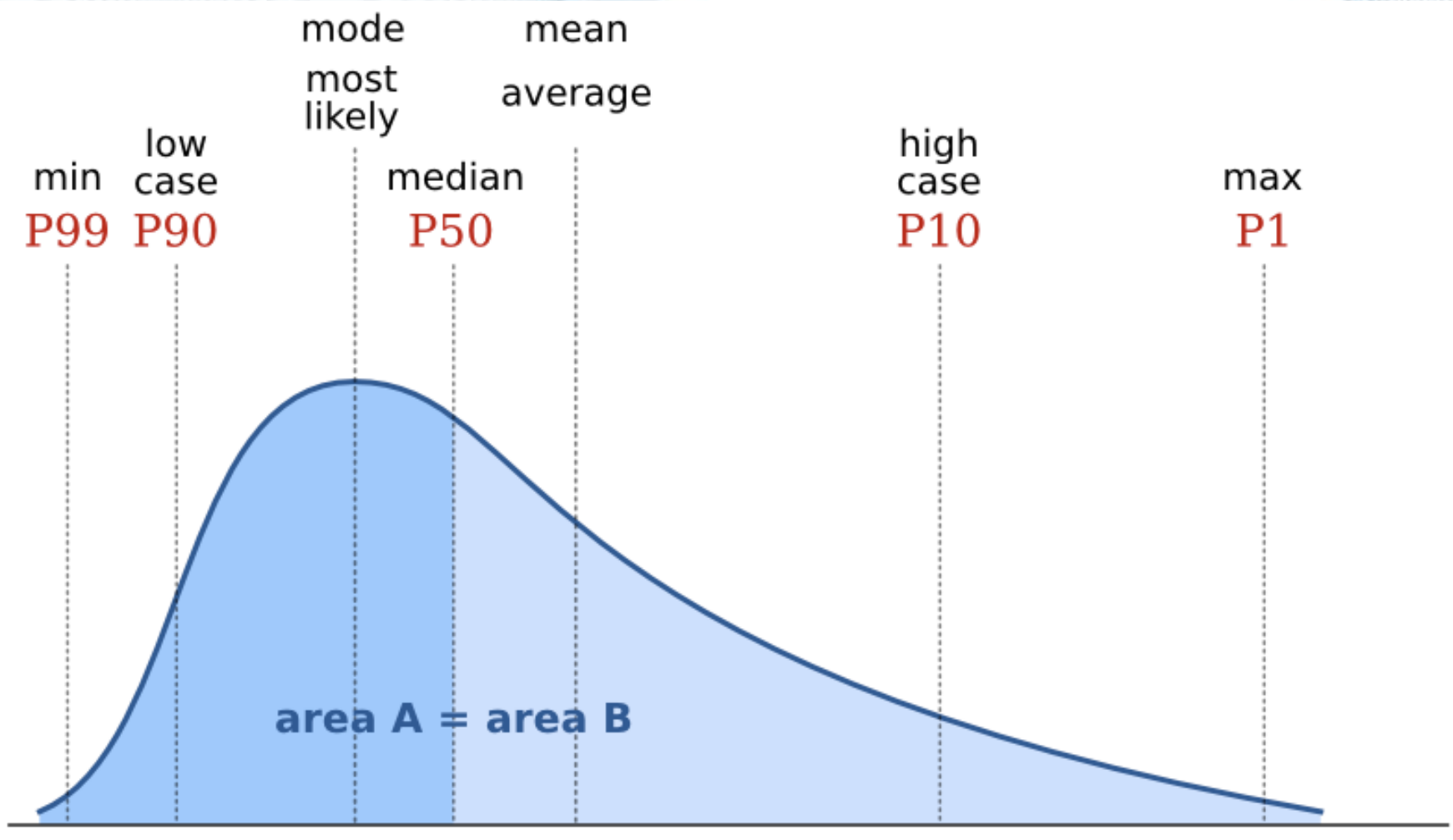
Probability Analyses of Combining Background Concentrations With Model-Predicted Concentrations
Douglas R. Murray and Michael B. Newman
Journal of the Air & Waste Management Association
Vol. 64, Iss. 3, 2014

Excluding Unusual Events



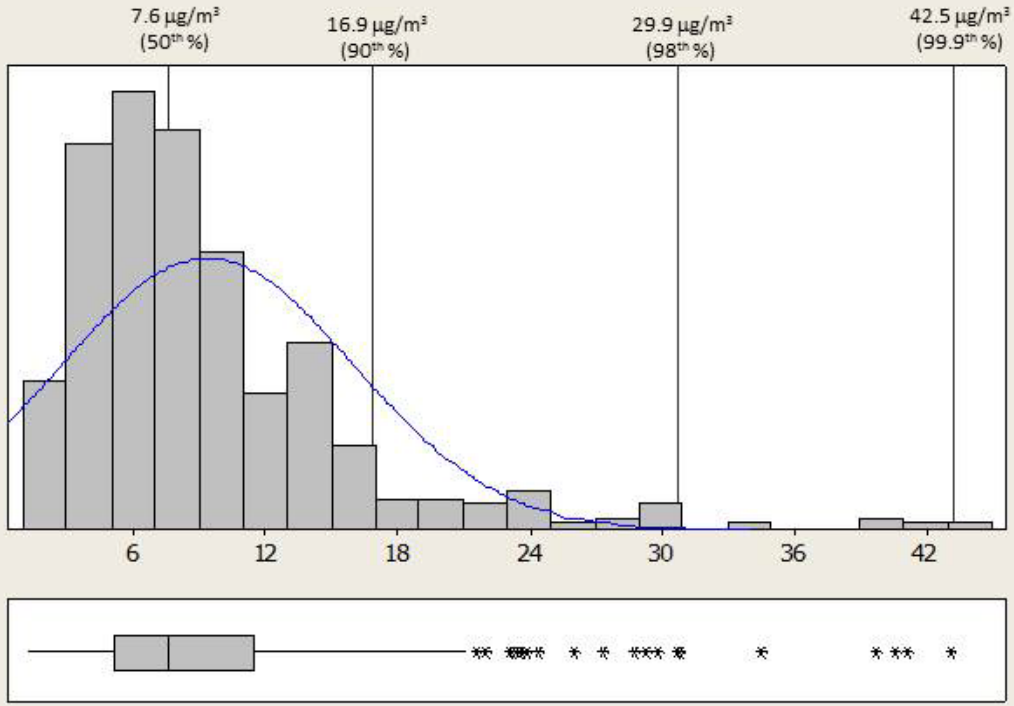
NASA's Earth Observatory
http://earthobservatory.nasa.gov

Positively Skewed Distribution



http://www.agilegeoscience.com

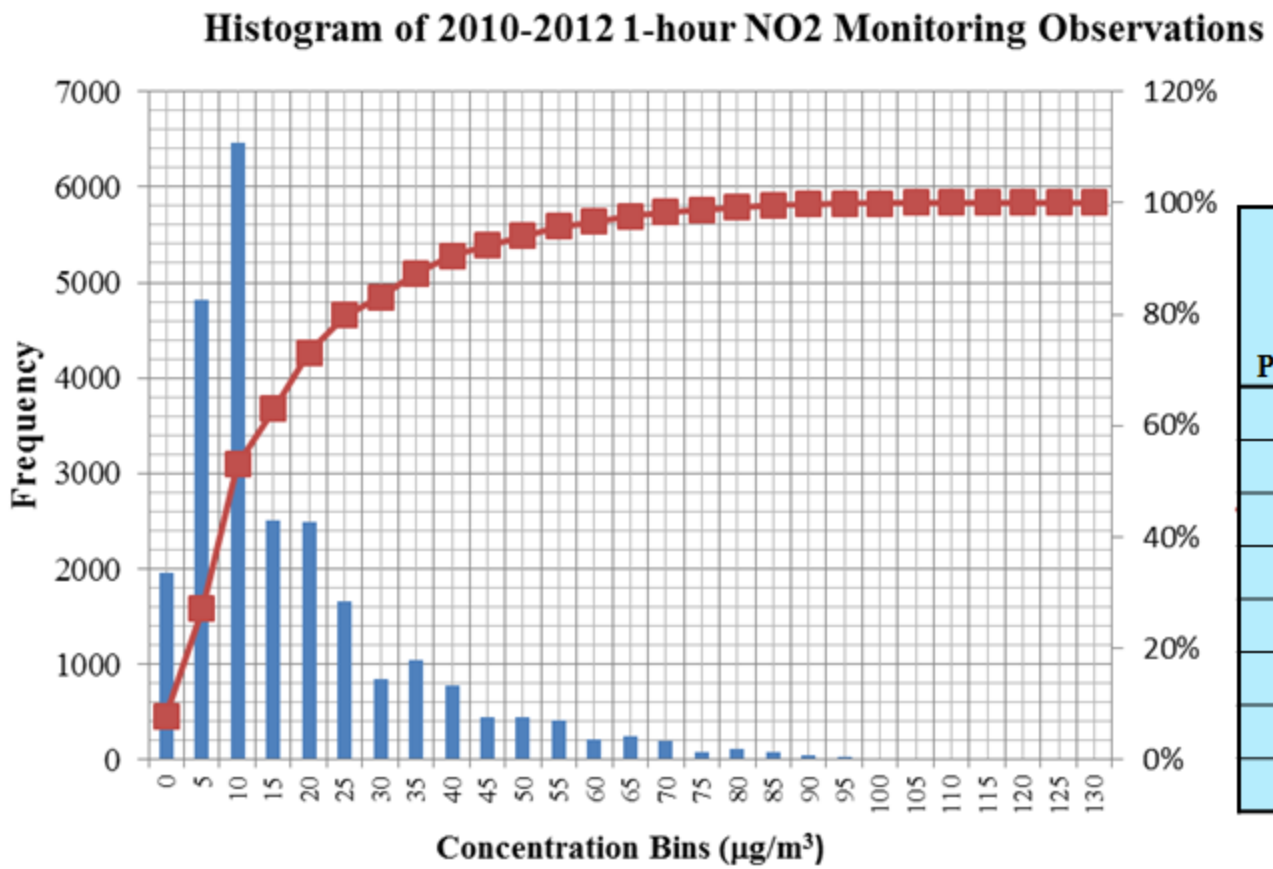
24-hr $PM_{2.5}$ Observations



Percentile	BG µg/m³	Max. Available based on NAAQS µg/m³
50th	7.6	27.4
60th	8.7	26.3
70th	10.3	24.7
80th	13.2	21.8
90th	16.9	18.1
95th	22.6	12.4
98th	29.9	5.1
99.9th	42.5	**Exceeds!**

Evaluation of the SO_2 and NO_X offset ratio method to account for secondary $PM_{2.5}$ formation
Sergio A. Guerra, Shannon R. Olsen, Jared J. Anderson
Journal of the Air & Waste Management Association
Vol. 64, Iss. 3, 2014

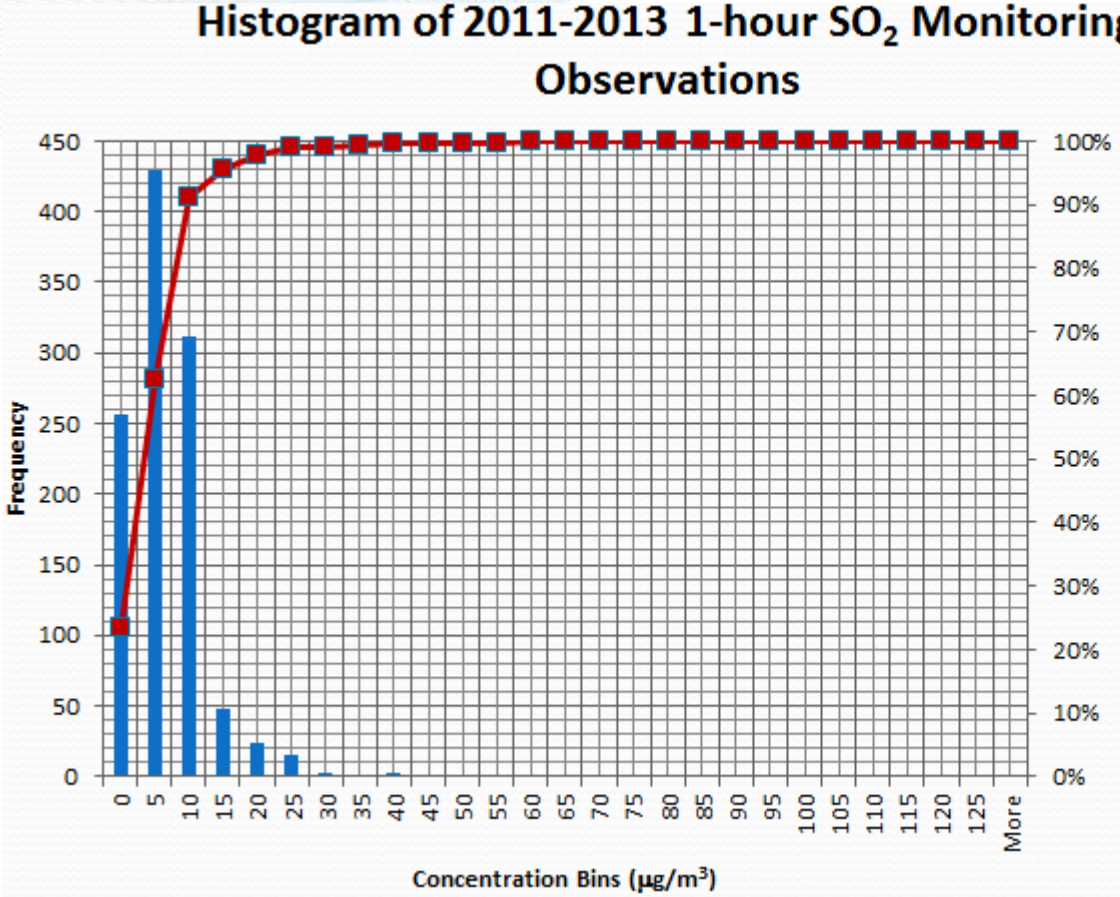
1-hr NO_2 Observations



Percentile	BG µg/m³	Max. Available based on NAAQS µg/m³
50th	9.4	178.6
60th	13.2	174.8
70th	16.9	171.1
80th	26.4	161.6
90th	39.5	148.5
95th	52.7	135.3
98th	67.7	120.3
99.9th	97.8	90.2

Innovative Dispersion Modeling Practices to Achieve a Reasonable Level of Conservatism in AERMOD Modeling Demonstrations.
Sergio A. Guerra
A&WMA 107th Annual Conference and Exhibition, June 26, 2014.

1-hr SO_2 Observations



Percentile	BG µg/m³	Max. Available based on NAAQS µg/m³
50th	2.6	193.4
60th	3.5	192.5
70th	5.2	190.8
80th	6.1	189.9
90th	9.6	186.4
95th	12.9	183.1
98th	20.1	175.9
99th	25.6	170.4
99.9th	69.5	126.5
99.99th	84.7	111.3

Innovative Dispersion Modeling Practices to Achieve a Reasonable Level of Conservatism in AERMOD Modeling Demonstrations.
Sergio A. Guerra
EM Magazine, December 2014.

Excluding Unusual Events

Considerations:

- Meteorological data is necessary but seldom collected at monitoring sites.
- Alternative methods are necessary when no meteorological data are available.
- Data handling can be challenging.
- Difficult to identify all unusual events impacting monitor.

Temporal Pairing of Bkg Values

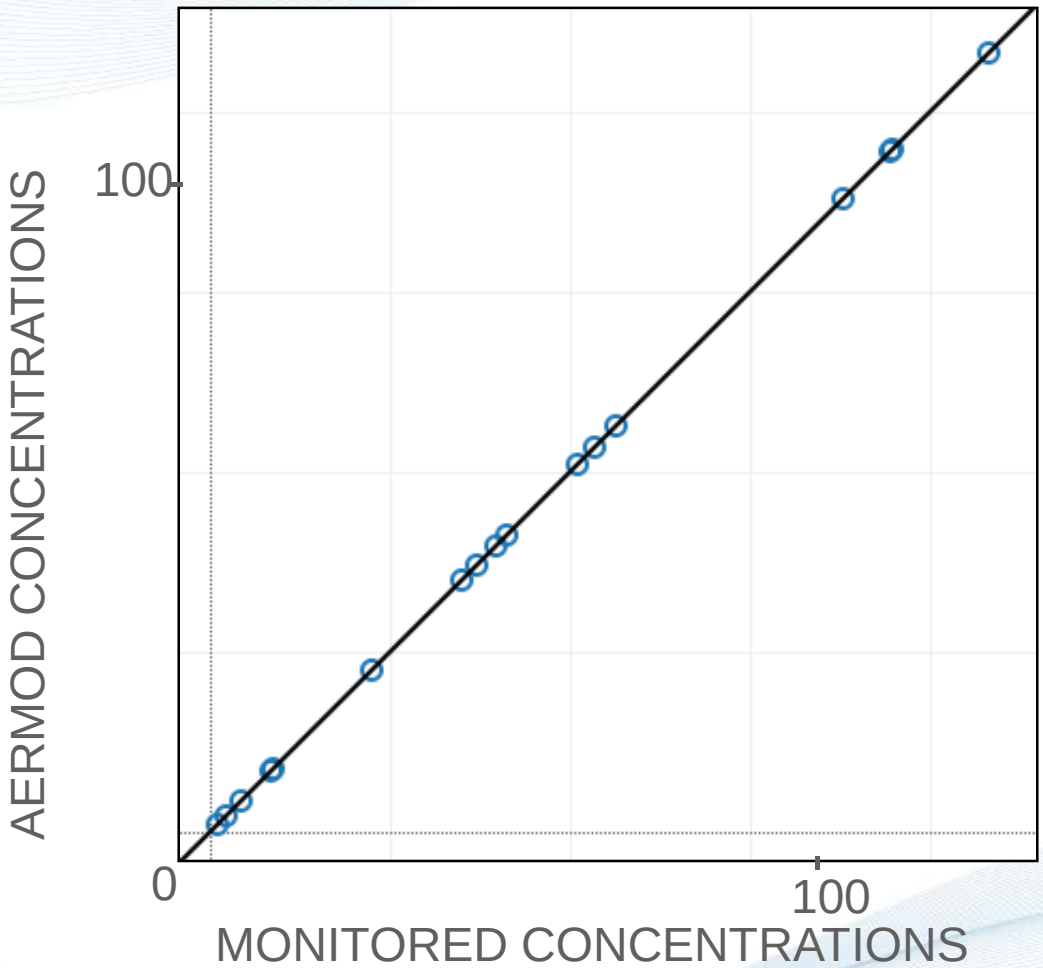
Model's Accuracy

Appendix W: *9.1.2 Studies of Model Accuracy*

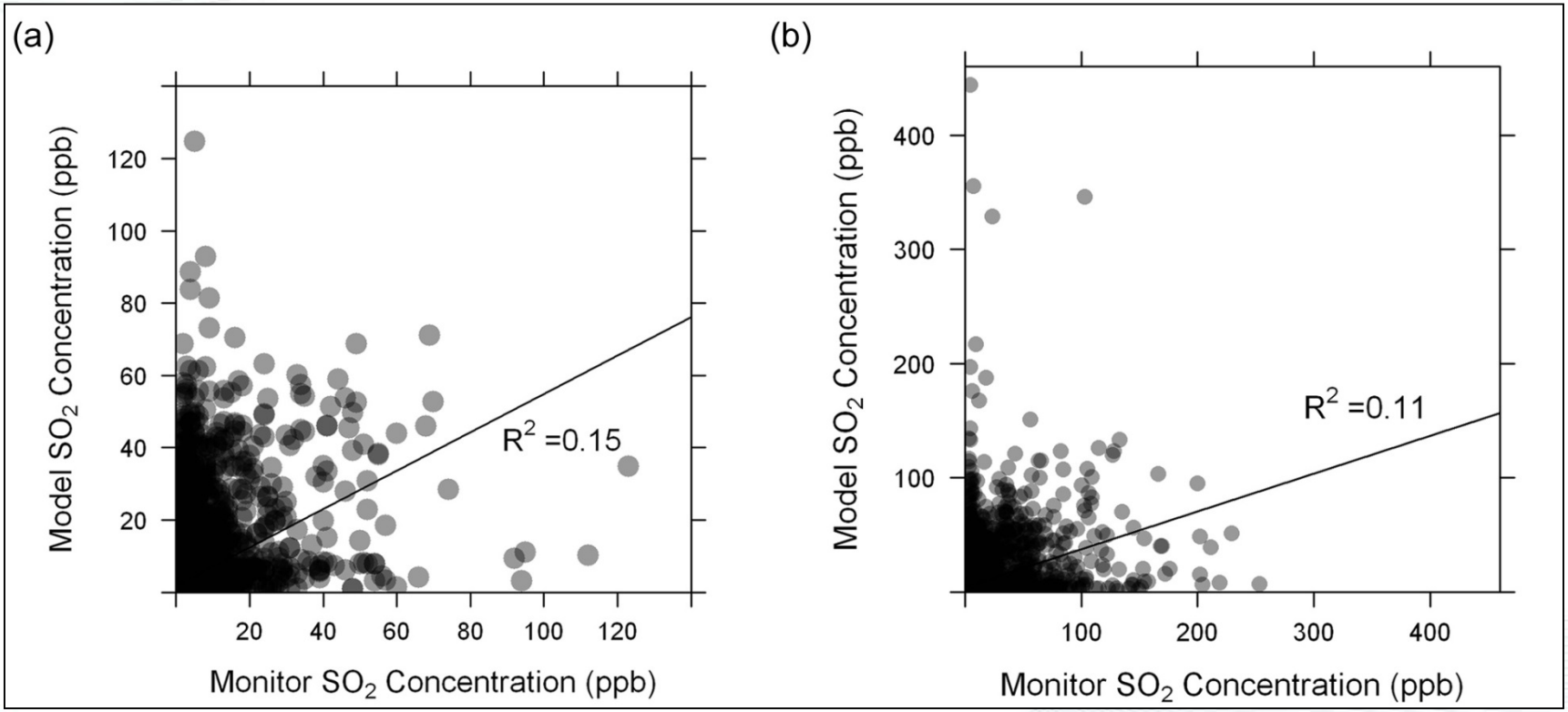
a. *A number of studies have been conducted to examine model accuracy, particularly with respect to the reliability of short-term concentrations required for ambient standard and increment evaluations. The results of these studies are not surprising. Basically, they confirm what expert atmospheric scientists have said for some time: (1)* ***Models are more reliable for estimating longer time-averaged concentrations than for estimating short-term concentrations at specific locations; and (2) the models are reasonably reliable in estimating the magnitude of highest concentrations occurring sometime, somewhere within an area.*** *For example, errors in highest estimated concentrations of ± 10 to 40 percent are found to be typical, i.e., certainly well within the often quoted factor-of-two accuracy that has long been recognized for these models. However, estimates of concentrations that occur at a specific time and site, are poorly correlated with actually observed concentrations and are much less reliable.*

- Bowne, N.E. and R.J. Londergan, 1983. Overview, Results, and Conclusions for the EPRI Plume Model Validation and Development Project: Plains Site. EPRI EA–3074. Electric Power Research Institute, Palo Alto, CA.
- Moore, G.E., T.E. Stoeckenius and D.A. Stewart, 1982. A Survey of Statistical Measures of Model Performance and Accuracy for Several Air Quality Models. Publication No. EPA–450/4–83–001. Office of Air Quality Planning & Standards, Research Triangle Park, NC.

Perfect Model

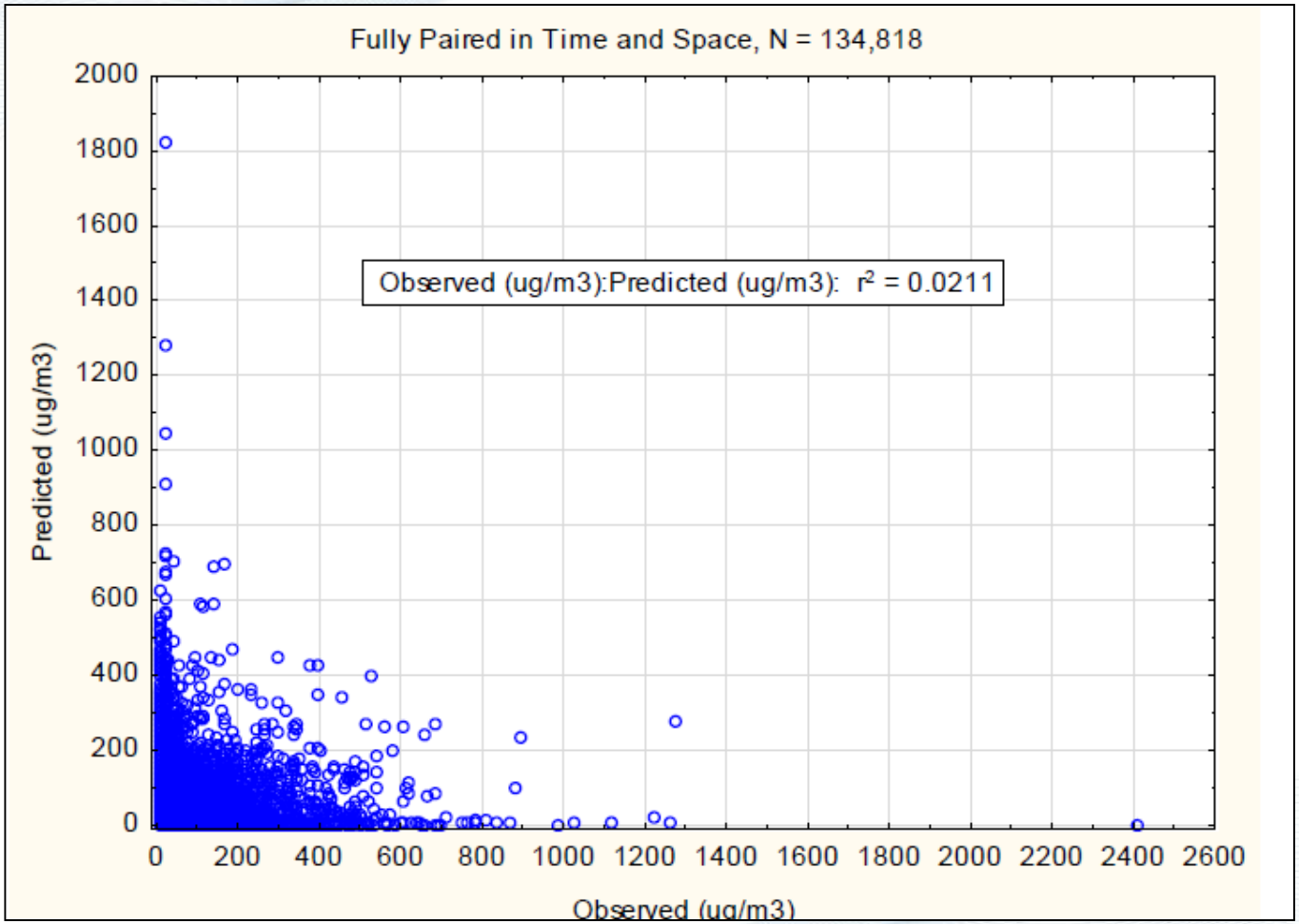


Monitored vs Modeled Data: Paired in Time and Space



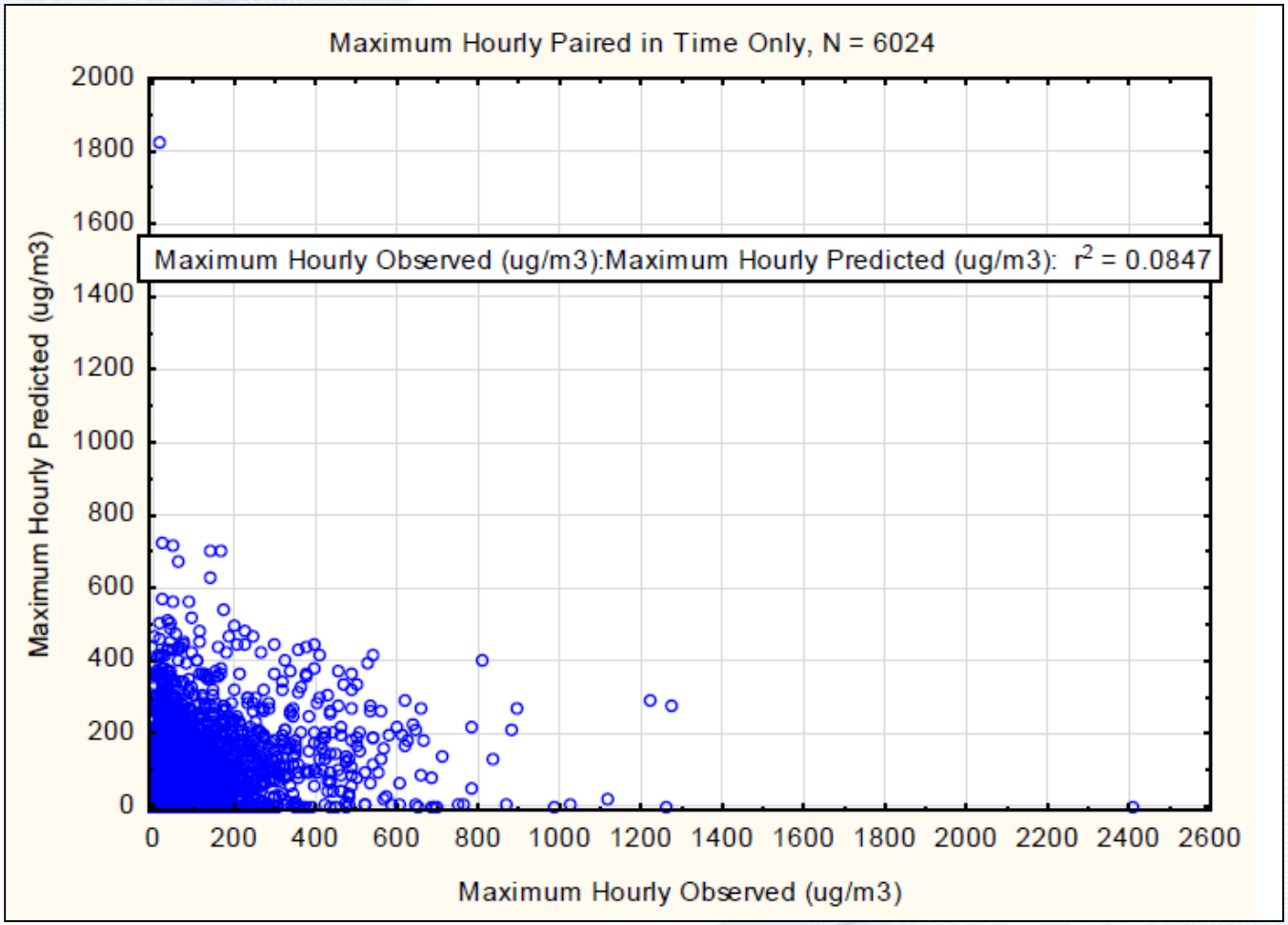
AERMOD performance evaluation of three coal-fired electrical generating units in Southwest Indiana
Kali D. Frost
Journal of the Air & Waste Management Association
Vol. 64, Iss. 3, 2014

SO_2 Concentrations Paired in Time & Space



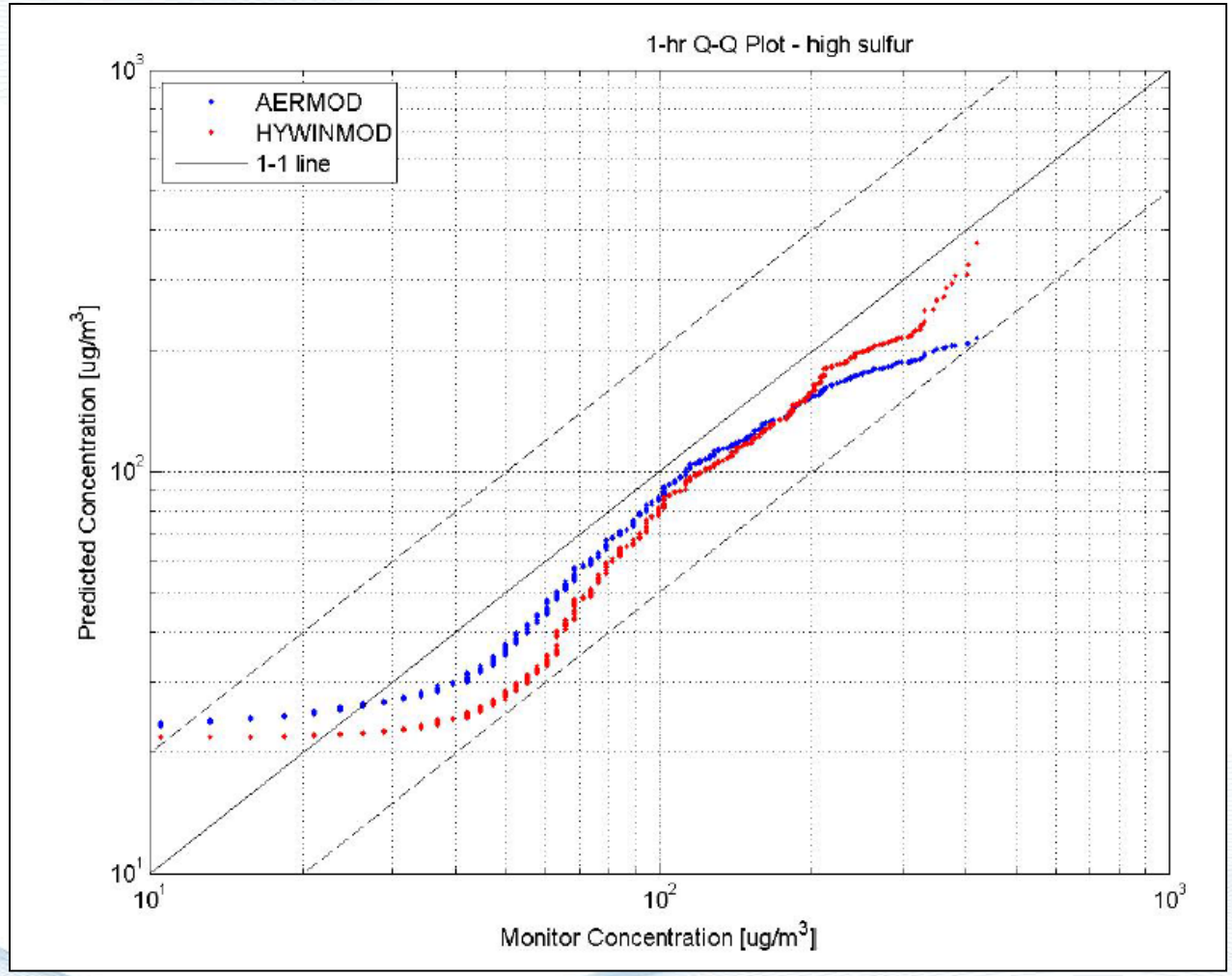
Probability analyses of combining background concentrations with model-predicted concentrations
Douglas R. Murray, Michael B. Newman
Journal of the Air & Waste Management Association
Vol. 64, Iss. 3, 2014

SO_2 Concentrations Paired in Time Only



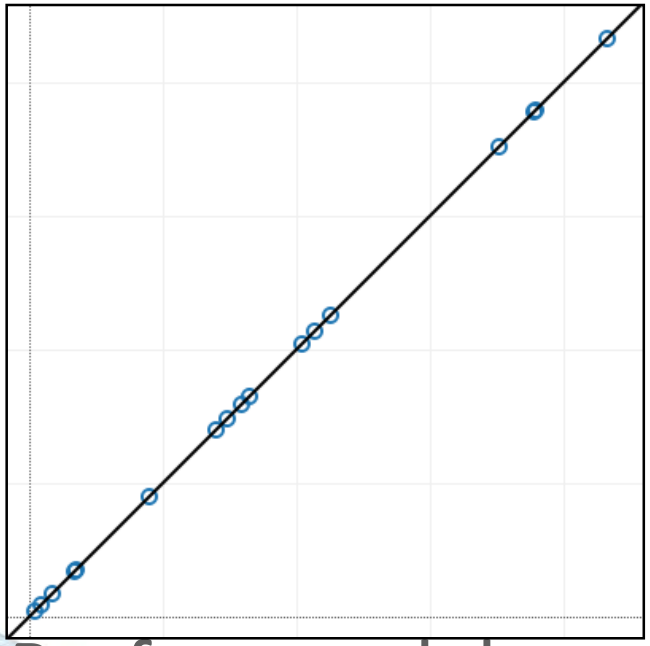
Probability analyses of combining background concentrations with model-predicted concentrations
Douglas R. Murray, Michael B. Newman
Journal of the Air & Waste Management Association
Vol. 64, Iss. 3, 2014

AERMOD's Evaluation

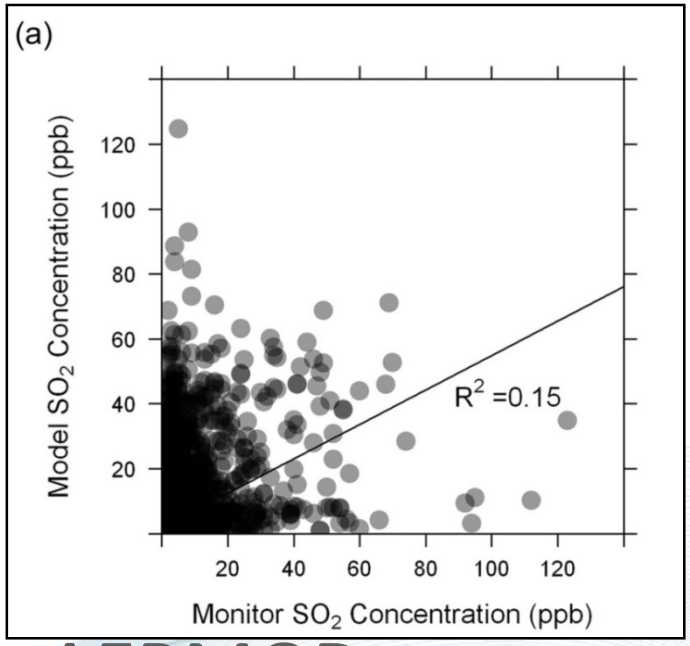


Temporal Matching is Not Justifiable

- AERMOD cannot accurately predict concentrations on a temporal (or spatial) basis.
- Therefore, such pairing should be avoided.



Perfect model



AERMOD

Bkg from Regional-Scale Photochemical Grid Model

- Estimates from AERMOD and photochemical grid models are not equivalent.
- Each calculates impacts in a very different way and at different scales.
- EPA guidance states that absolute model output from photochemical grid-based models should be used in a relative fashion due to the effects of uneven performance and possible major bias in predicting absolute concentrations of one or more components (EPA, 2007a).

"Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM2.5, and Regional Haze." EPA-454/B-07-002, April 2007.

Alternative Pairing of Bkg and Pred

Combining 98th Percentile AERMOD and Bkg

P (AERMOD and Bkg) = P(AERMOD) * P(Bkg)

98% percentile is 2 out of 100 days, or

= (0.02) * (0.02)

= 0.0004 = 1 out of 2,500 days

Equivalent to one exceedance every **<u>6.8 years</u>**!

= 99.96th percentile of the combined probability

Combining 99th percentile AERMOD and Bkg

P (AERMOD and Bkg) = P(AERMOD) * P(Bkg)

99% percentile is 1 out of 100 days, or

= (0.01) * (0.01)

= 0.0001 = 1 out of 10,000 days

Equivalent to one exceedance every **<u>27 years</u>**!

= 99.99th percentile of the combined probability

Combining 98th AERMOD and 50th Bkg

P (AERMOD and Bkg) = P(AERMOD) * P(Bkg)

= (1-0.98) * (1-0.50)

= (0.02) * (0.50)

= 0.01 = 1 of 100 days

Equivalent to 3.6 exceedances every year

= 99th percentile of the combined probability

Evaluation of the SO_2 and NO_X offset ratio method to account for secondary $PM_{2.5}$ formation
Sergio A. Guerra, Shannon R. Olsen, Jared J. Anderson
Journal of the Air & Waste Management Association
Vol. 64, Iss. 3, 2014

Combining 99th AERMOD and 50th Bkg

P (AERMOD and Bkg) = P(AERMOD) * P(Bkg)

= (1-0.99) * (1-0.50)

= (0.01) * (0.50)

= 0.005 = 1 of 200 days

Equivalent to 1.8 exceedances every year

= 99.5th percentile of the combined probability

Evaluation of the SO_2 and NO_X offset ratio method to account for secondary $PM_{2.5}$ formation
Sergio A. Guerra, Shannon R. Olsen, Jared J. Anderson
Journal of the Air & Waste Management Association
Vol. 64, Iss. 3, 2014

Guideline on Air Quality Models

- Appendix W from 40 CFR Part 51: Guideline on Air Quality Modeling.
- Originally published in 1978 and periodically revised to ensure that new model developments or expanded regulatory requirements are incorporated.
- Purpose is to streamline dispersion modeling techniques across the country.
- Defines the accepted regulatory models.
- Critics stated that rigidity of rules would inhibit innovation and would render Guidance obsolete as technology and science advanced.

App. W Reset

- App. W needs to establish a Technical Review Advisory Committee (TRAC) with the ability to evaluate, approve, and incorporate new methods without the need to undergo a long and infrequent rulemaking process.
- TRAC composed of leading experts from EPA, industry, and academia.
- Purpose is to evaluate new dispersion modeling techniques and incorporate scientifically valid methods to the regulatory model in an expedient manner.
- APM Committee from AWMA can provide a good framework for TRAC.

Why an App. W Reset?

Timing:

- Updates to guidance require long and complicated rulemaking process.
- Current system results in a lengthy time gap between proposal of new/advanced methods and their implementation for widespread use.
- Current mechanism does not allow for an expedient update of the model to incorporate “fixes” (e.g., AERMET’s adjusted u-star option) and new techniques (e.g., ARM2) that science develops.

Why an App. W Reset?

Rulemaking Process:

- To keep up with new methods and science, EPA was supposed to update Guidance through rulemaking process (i.e., formal public comment).
- Instead, EPA has issued "non binding" guidance (or TAD) without formal evaluation process or public involvement
- However, the courts have stated that:

  > If an agency acts as if a document issued at headquarters is controlling in the field …if it leads private parties or State permitting authorities to believe that it will declare permits invalid unless they comply with the terms of the document, then the agency's document is for all practical purposes "binding."
  >
  > Appalachian Power Co. V. EPA, 208 F.3d 1015, 1021 (D.C. Cir., 2000)

- In reality, rulemaking /evaluation process has been circumvented.

Why an App. W Reset?

- Action:
  - Science is constantly advancing new methods and refinements in dispersion modeling.
  - We must recognize that the current system needs to be more efficient.
  - Stakeholders need to change paradigm and embrace collaboration.

Why an App. W Reset?

- Consistency:
  - EPA has incorporated "Beta" options in AERMOD to add new methods and refinements to the model.
  - EPA has updated AERMOD and its pre-processors on a regular basis:
    - AERMOD (11), AERSCREEN (5), AERMET(6), AERMAP (3), AERMINUTE (3), AERSURFACE (1), BPIP (0)
  - Types of updates include enhancements, bug fixes, and miscellaneous changes (e.g., adding downwash above GEP height in #3 of MCB4).
  - Updates and new modeling techniques originating outside of EPA have to wait for App. W revisions before they can be available as "default" options.
  - It is not clear what changes can be made by EPA and what changes need to wait until rulemaking to be effective.

App. W Makeover

- Technical Review Advisory Committee (TRAC) will
  - Promote collaboration,
  - Share responsibility,
  - Result in a more efficient process,
  - Improve timing of implementation of new science,
  - Create consistency.
- APM committee from AWMA would be ideal framework- major players are part of it already.
- As technology/science advance and evolve; so does our professional framework.
- Let's prove the critics of 1978 wrong, let's update App. W so it can work as efficiently as it was intended.

Summary of Comments

1. Excluding monitored values from the 90° downwind sector does not avoid double counting of ambient impacts.
2. Unusual events should be excluded from monitoring data but alternative methods that do not depend on met data need to also be considered.
3. The pairing of modeled values with lower monitored percentiles (i.e., 50th percentile) should be considered.
4. Statements about model accuracy for long and short term averages should remain in the updated Guidance. Otherwise, evidence should be provided that these statements are no longer valid.
5. Temporal matching is not justifiable because AERMOD's accuracy is suspect on a temporal basis.
6. Background values from photochemical grid modeling should be reconsidered.
7. The formation of a Technical Review Advisory Committee with the ability to evaluate and approve changes to the model is urgently needed.

Thank You!

Sergio A. Guerra, PhD

sguerra@cppwind.com

Direct: + 970 360 6020

www.SergioAGuerra.com

CPP, Inc.

2400 Midpoint Drive, Suite 190

Fort Collins, CO 80525

+ 970 221 3371

www.cppwind.com **@CPPWindExperts**