Guidance for Implementing 1-hour NO_2 NAAQS for PSD

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Outline

- Form of the 1-hour NO_2 standard
- Role of NO_x chemistry for NO_2 modeling
- Summary of existing guidance in Appendix W and clarifications issued June 2010
- Discussion of key issues addressed in March 1, 2011 guidance memo
- Summary of 1-hour NO_2 model-to-monitor comparisons

Form of 1-hour NO_2 Standard

- 1-hour NO_2 NAAQS is based on the 98^{th}-percentile of the annual distribution of daily maximum 1-hour concentrations, averaged across the number of years modeled
- Monitored design values are based on 3-year averages (see Appendix S to 40 CFR Part 50)
  - Monitoring guidance does not preempt or alter Appendix W requirement for use of 5 years of National Weather Service (NWS) meteorological data or at least 1 year of site-specific data

Form of 1-hour NO_2 Standard

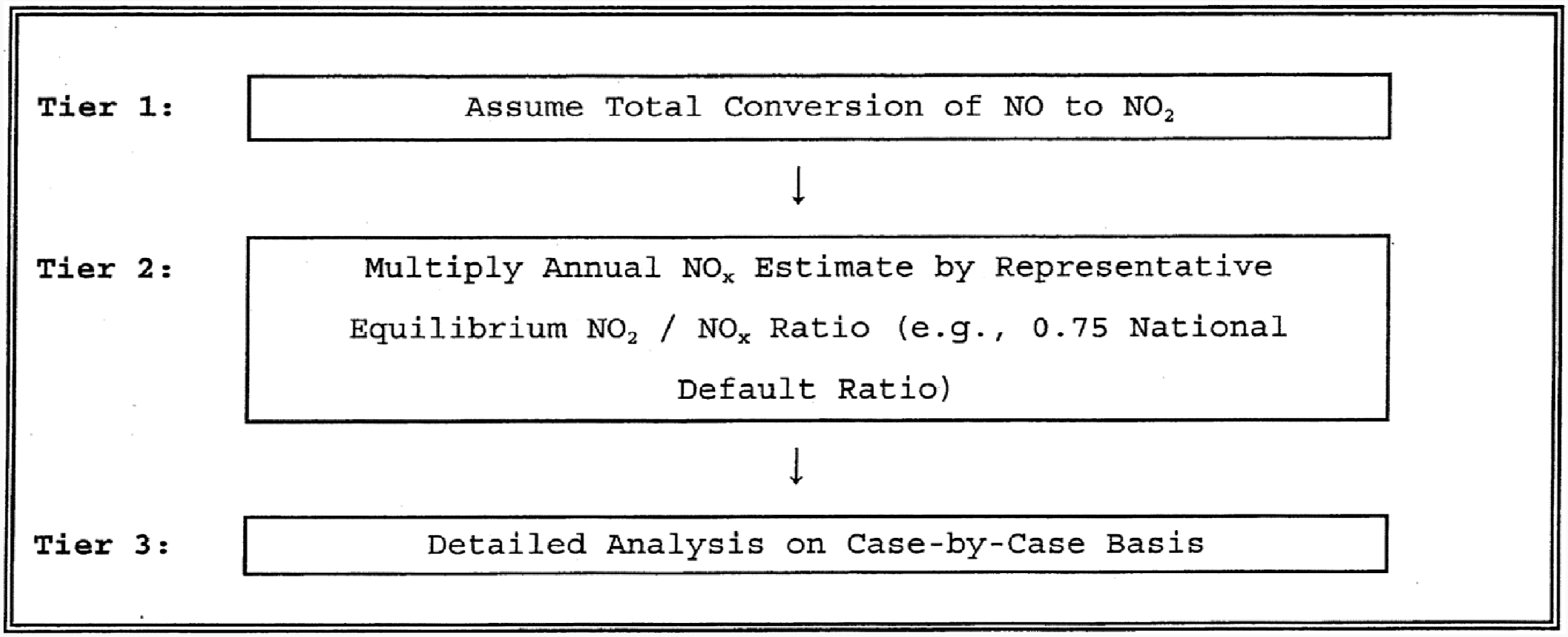
- Form of the 1-hour NO_2 NAAQS complicates aspects of modeled compliance demonstrations
  - Comparison of project impacts to interim significant impact level (SIL) of 4 ppb is based on multiyear average of highest 1-hour NO_2 concentrations at each receptor, which is consistent with the maximum contribution that a source could make at that receptor
  - Significant contribution analysis examines whether project impacts contribute significantly to modeled violations paired in time and space, including all cases where cumulative impact exceeds the NAAQS at or below the 98^{th}-percentile
  - Recent AERMOD updates support these analyses

Modeling Guidance for NO_2

- 1-hour and annual NAAQS are based on ambient concentrations of NO_2, whereas majority of NO_x emissions are in the form of NO rather than NO_2
- Modeling guidance in Appendix W (40 CFR Part 51) acknowledges that a source's impact on ambient NO_2 depends in part "*on the chemical environment into which the source's plume is to be emitted*" (see Section 5.1.j)

Figure 5–1, Section 5.2.4, Appendix W (40 CFR Part 51)

Multi-tiered Screening Approach for Estimating Annual NO_2 Concentrations from Point Sources



Modeling Guidance for NO_2

- Clarification memo on applicability of Appendix W guidance for new 1-hour NAAQS issued in June 2010
  - AERMOD is the preferred model for estimating NO_2 impacts in near-field applications (out to 50 km)
  - Three-tiered screening approach in Section 5.2.4 is generally applicable for 1-hour NO_2 modeling, with additional/different considerations:
    - Tier 1 assumes full conversion of NO to NO2;
    - Tier 2 applies ambient ratio to Tier 1 result (annual default ratio = 0.75);
    - Tier 3 “detailed screening methods” on a case-by-case basis, including OLM (ozone limiting method) and PVMRM (plume volume molar ratio method) options implemented in AERMOD

Modeling Guidance for NO_2

- Applicability of three-tiered screening approach for 1-hour NO_2 modeling:
  - Tier 1 applies to 1-hour NAAQS without additional justification;
  - Tier 2 may also apply to the 1-hour NAAQS in many cases, but additional consideration may be needed regarding appropriate ratio for peak hourly impacts since the current default ARM of 0.75 is representative of "area wide quasi-equilibrium conditions";
  - Tier 3 "detailed screening methods" such as OLM and PVMRM will be on a case-by-case basis, but representativeness of background O_3 data and in-stack NO_2/NO_x ratios will be more important for the 1-hour NAAQS.

Tier 3 Detailed Screening Methods

- OLM specifically mentioned in Appendix W under Tier 3; PVMRM is also considered in this category until more robust model evaluations can be completed
- OLM and PVMRM are available as non-regulatory-default options in AERMOD
  - Requires justification and approval from RO on case-by-case basis as alternative modeling techniques, in accordance with Section 3.2.2.e of Appendix W, but main focus should be on key input data
- Applications of OLM option in AERMOD (subject to Section 3.2.2.e) should routinely utilize the "OLMGROUP ALL" option for combining plumes

Tier 3 Detailed Screening Methods

- Several documents are available on the SCRAM website related to PVMRM and its implementation in AERMOD:
  - Sensitivity Analysis of PVMRM and OLM in AERMOD (2004)
  - Evaluation of Bias in AERMOD-PVMRM (2005)
  - Addendum to AERMOD Model Formulation Document provides technical description of implementation of PVMRM within AERMOD
- Evaluations of PVMRM show encouraging results, but the amount of data is too limited to justify categorizing PVMRM as a refined method for NO_2
- Evaluations have been updated and extended to include OLM and to examine model performance for predicting hourly NO_2 concentrations (summary provided below)

Tier 3 Detailed Screening Methods

- Recent evaluation results highlight the fact that the PVMRM option in AERMOD is not inherently superior to the OLM option and has no higher “status” than OLM
- Both options simulate same basic chemical mechanism of ozone titration, and main distinction is the approach for estimating ambient NO and O_3 concentrations for titration calculation accounting for multiple sources
- Multi-source algorithm in PVMRM has not been thoroughly validated and general acceptance of OLMGROUP ALL option with OLM removes any practical benefit of PVMRM vs. OLM related to multiple sources

Modeling Guidance for NO_2

- Additional guidance issued March 1, 2011
  - Clarifies procedures for analyzing results given form of NAAQS
  - Recommends default 1-hour Tier 2 ambient ratio of 0.80, and default in-stack NO_2/NO_x ratio for OLM and PVMRM Tier 3 options of 0.50, **in the absence of more appropriate information**
  - Addresses treatment of intermittent emissions (e.g., emergency generators) in PSD modeling demonstrations, a key issue with implementation of the 1-hour NO_2 NAAQS
  - Discussion/recommendations regarding nearby background sources to include in modeling and combining modeled+monitored contributions for cumulative analysis

Modeling Guidance for NO_2

- Treatment of intermittent emissions
  - Intermittent emission sources may present challenge for demonstrating compliance with 1-hour NO_2 NAAQS assuming continuous operation
  - Given implications of the probabilistic form of the 1-hour NO_2 NAAQS, the March 1, 2011 memo highlights a concern that "*assuming continuous operations for intermittent emissions would effectively impose an additional level of stringency beyond that intended by the level of the standard itself*."
  - Recommends that "*compliance demonstrations for the 1-hour NO_2 NAAQS be based on emission scenarios that can logically be assumed to be relatively continuous or which occur frequently enough to contribute significantly to the annual distribution of daily maximum 1-hour concentrations*."
  - May be appropriate to address emergency/unscheduled operation separately from routine testing operations which may be scheduled

Modeling Guidance for NO_2

- Determining background concentrations
  - Cumulative analyses of ambient impacts is required if emissions from new or modified source exceed the interim SIL
  - March 1, 2011 memo addresses components of cumulative impact analysis, including identification of nearby sources to include in modeled inventory and combining modeled results with monitored background concentrations
  - Reiterates caution expressed in the June 2010 memo against the "literal and uncritical application of very prescriptive procedures" such as the 1990 draft NSR Workshop Manual:
    - Use of such prescriptive procedures will generally be acceptable for permit modeling, but may be overly conservative in many cases
    - Challenge will be to find the proper balance of competing factors that contribute to the analysis, considering the degree of conservatism associated with key assumptions – more conservative assumptions are likely to be less controversial during the review process, and vice versa.
    - March 1 memo also offers suggestions on key elements of documentation to facilitate the review of modeling demonstrations.

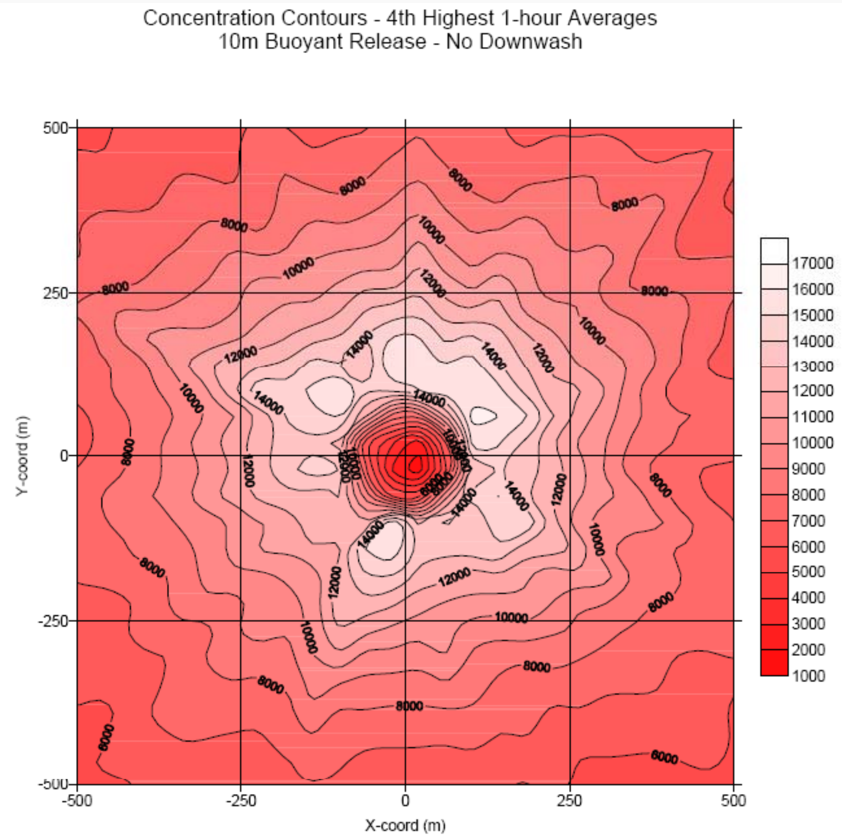
Modeling Guidance for NO_2

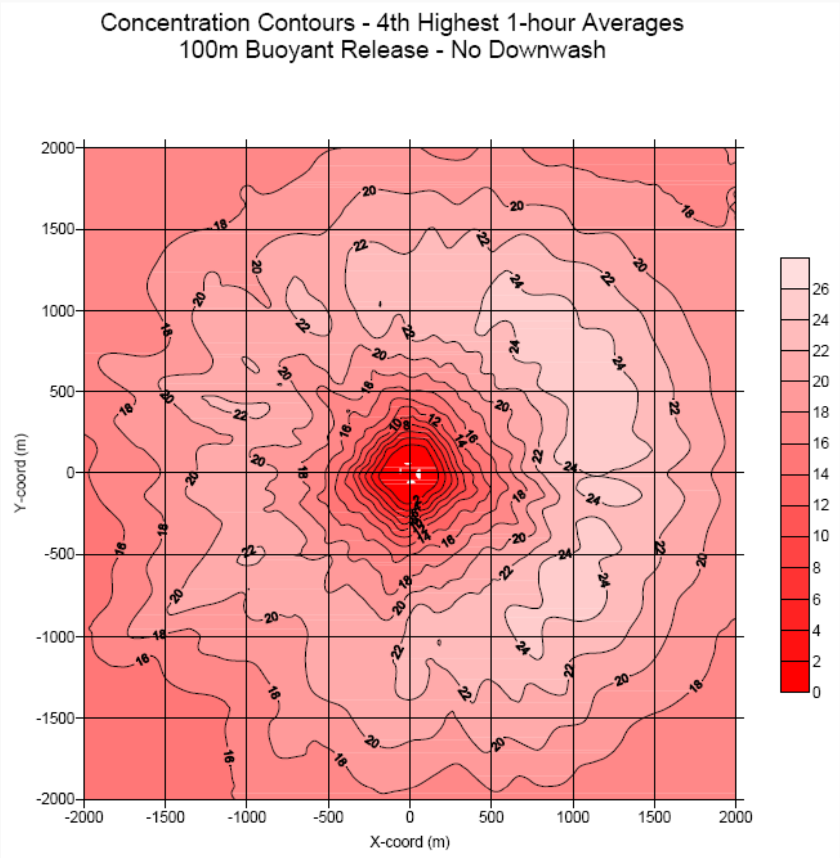
- Significant concentration gradient criterion
  - Appendix W identifies "*a significant concentration gradient in the vicinity of the source*" as the sole criterion for identifying which nearby sources to model
    - A concentration gradient is the rate of change of concentration with distance, and has two components, a longitudinal (along-wind) gradient and a lateral (cross-wind) gradient.
    - Both components are important, but the lateral gradient may be more important for this purpose.
  - Appendix W did not "*comprehensively define*" the term "*owing to both the uniqueness of each modeling situation and the large number of variables involved in identifying nearby sources*."
  - Significant concentration gradients in the vicinity of the source imply that the nearby source's potential interaction with the proposed source's impacts will not be represented well by monitored concentrations at a specific location

Modeling Guidance for NO_2

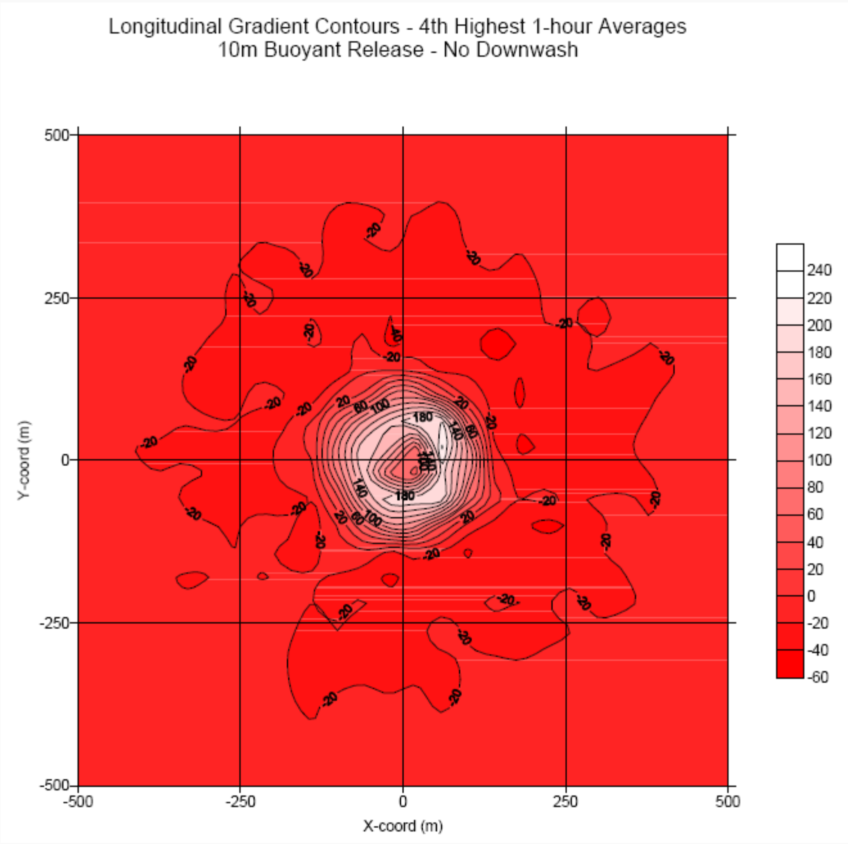
- Significant concentration gradient criterion
  - Concentration gradients are generally largest between the source and the location of maximum ground-level impacts, nominally about 10 times the release height in relatively flat terrain
  - This suggests focusing on nearby sources within about 10 kilometers of the project source in most cases
  - Every application entails case-specific considerations based on the dispersion characteristics of the project location (e.g., terrain influences), the location and characteristics of nearby sources, and the availability and representativeness of ambient monitoring data
  - Contours of high ranked 1-hour concentrations for a 10m and 100m buoyant release are shown in the next slide, followed by longitudinal and lateral concentration gradient contours

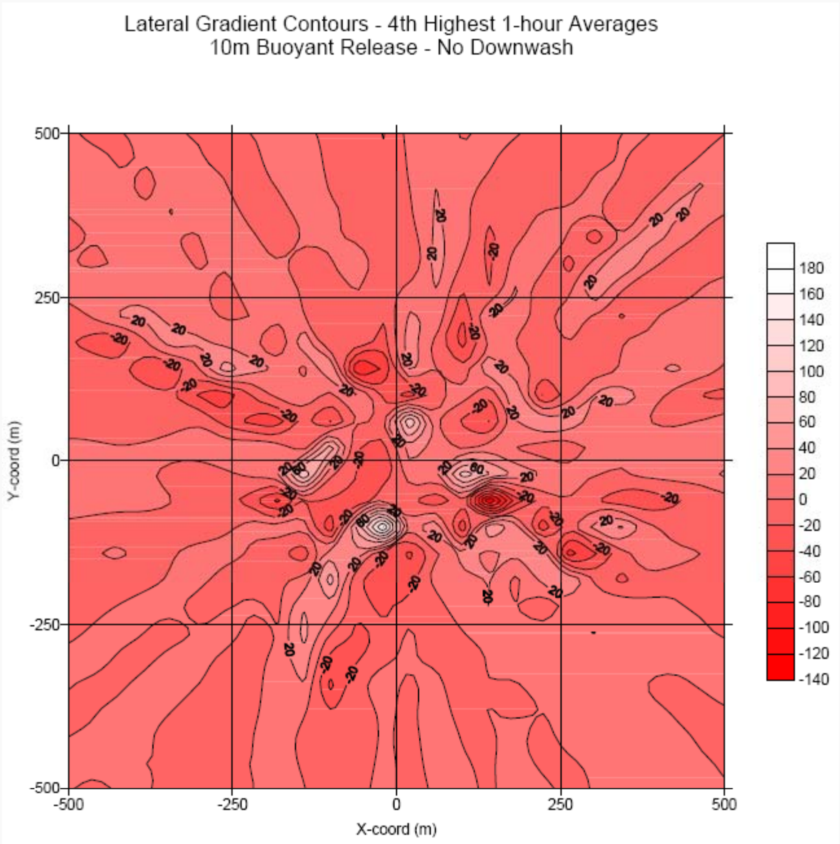
Concentration Contours – 10m & 100m Stacks



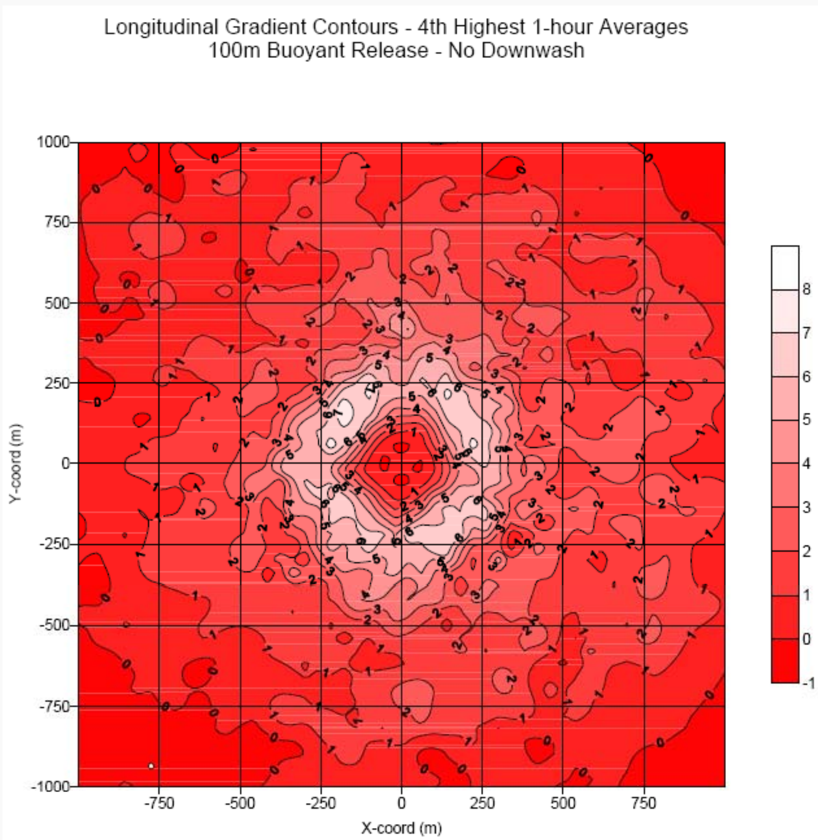


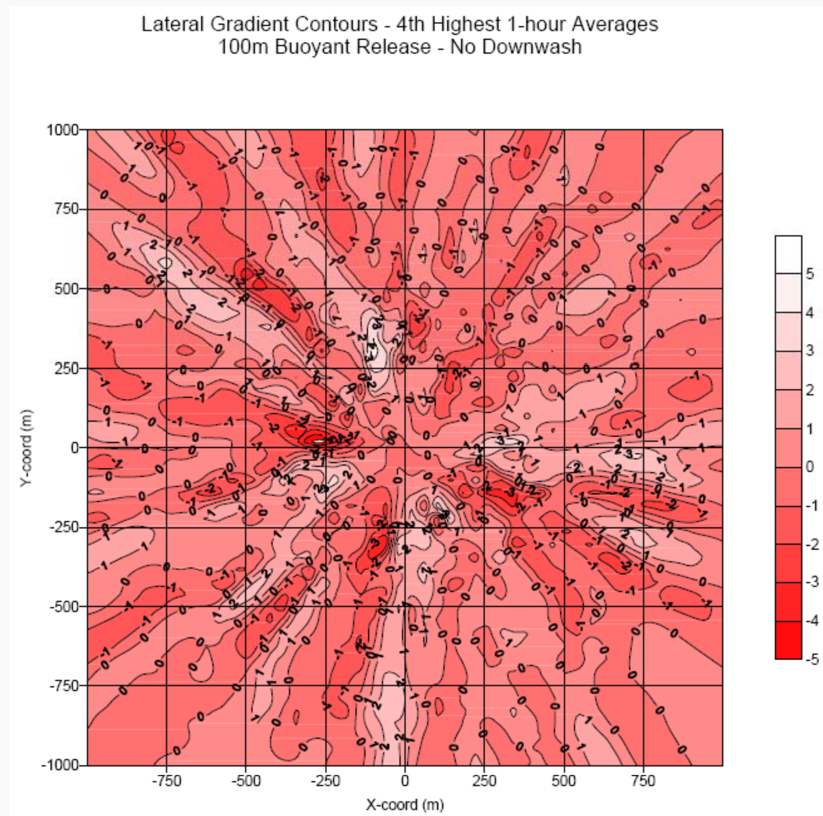
Concentration Gradients – 10m Stack





Concentration Gradients – 100m Stack





Modeling Guidance for NO_2

- Combining modeled and monitored concentrations
  - The issues of which nearby sources to include in the modeled inventory and what monitored concentration to include in the cumulative assessment are interrelated, and depend on the circumstances of the specific case
  - If a demonstrably complete inventory of background sources is included in the modeling, then less conservative assumptions regarding the monitored component may be justified to avoid double counting of modeled and monitored impacts
  - Conversely, if a demonstrably conservative monitored concentration is used, then a less extensive (i.e., less conservative) modeled inventory may be justified
  - In either case, some assessment of what sources are contributing to the monitored concentrations should be included in the justification

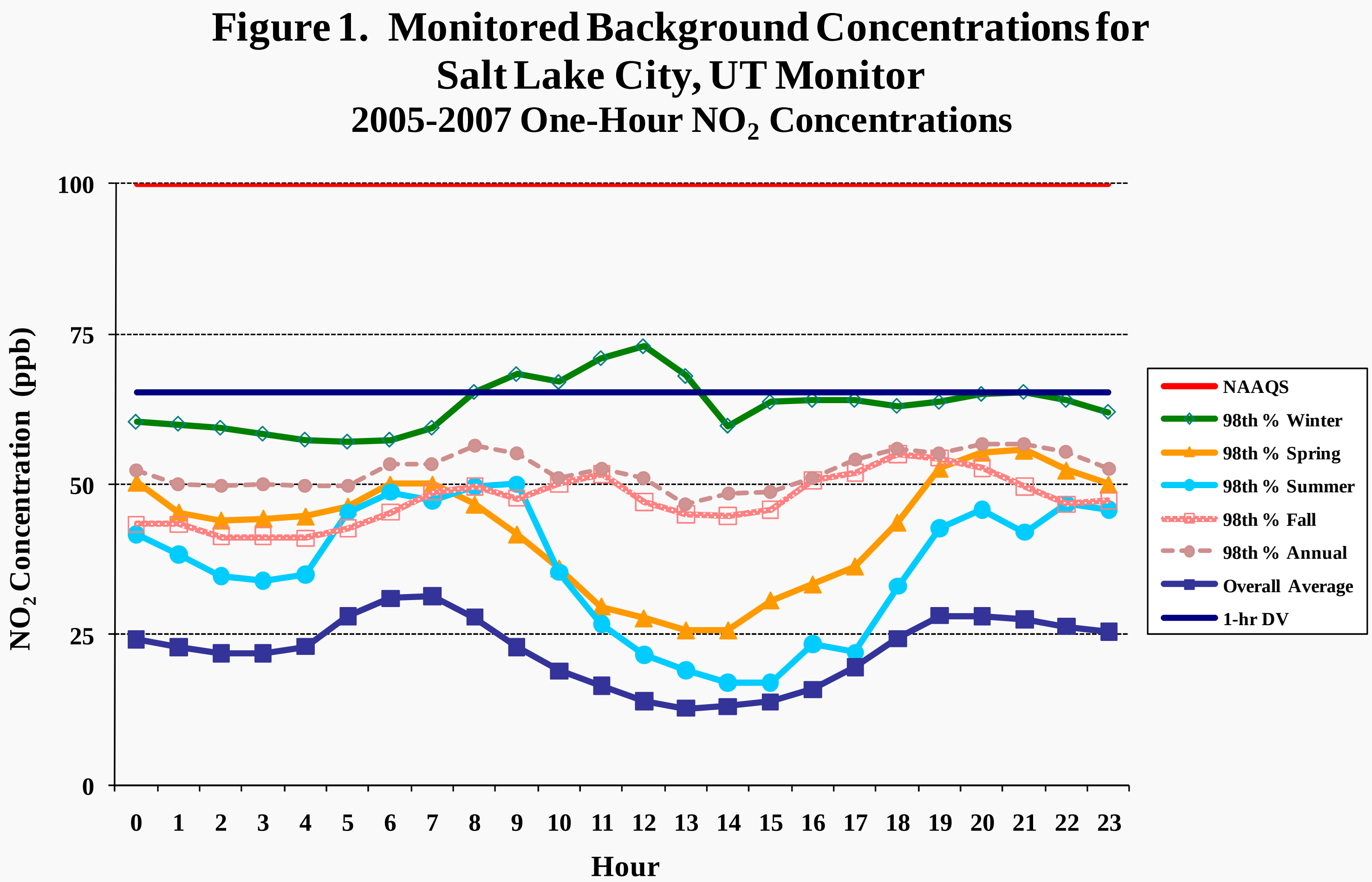
Modeling Guidance for NO_2

- Combining modeled and monitored concentrations
  - The June 29, 2010 memo identified the overall highest 1-hour monitored background NO_2 concentration as a “first tier” that should be acceptable without further justification
  - The March 1, 2011 memo suggests that the monitored design value (3-year average of the 98^{th}-percentile of the annual distribution of daily maximum 1-hour concentrations) should be acceptable as a less conservative “first tier” in most cases
  - Given the form of the 1-hour NO_2 NAAQS, and the role of background ozone concentrations in the Tier 3 OLM and PVMRM options, diurnal and seasonal patterns of concentrations, which reflect diurnal and seasonal patterns of both emissions and dispersion, may play a significant role in determining how best to combine modeled and monitored concentrations

Modeling Guidance for NO_2

- Combining modeled and monitored concentrations
  - Appendix W recommends that *"[f]or shorter averaging periods, the meteorological conditions accompanying the concentrations of concern should be identified*" and that *"[c]oncentrations for meteorological conditions of concern . . . should be averaged for each separate averaging time to determine the average background concentration*." (see Section 8.2.2.b)
  - Based on this guidance, the March 1, 2011 memo suggests that the use of "multiyear averages of the 98th-percentile of the available background concentrations by season and hour-of-day" is an appropriate methodology for the 1-hour NO_2 standard (see example on next slide)
    - The March 1, 2011 memo recommends using the 3rd-highest value by season and hour-of-day to represent the 98th-percentile of the monitored data
    - Use of the 98th-percentile values by season and hour-of-day is a simple surrogate for identifying the meteorological conditions of concern. Use of the overall average by hour-of-day (also shown on the next slide) is not recommended as it will also reflect concentrations during periods not of concern.

Background Concentration Example

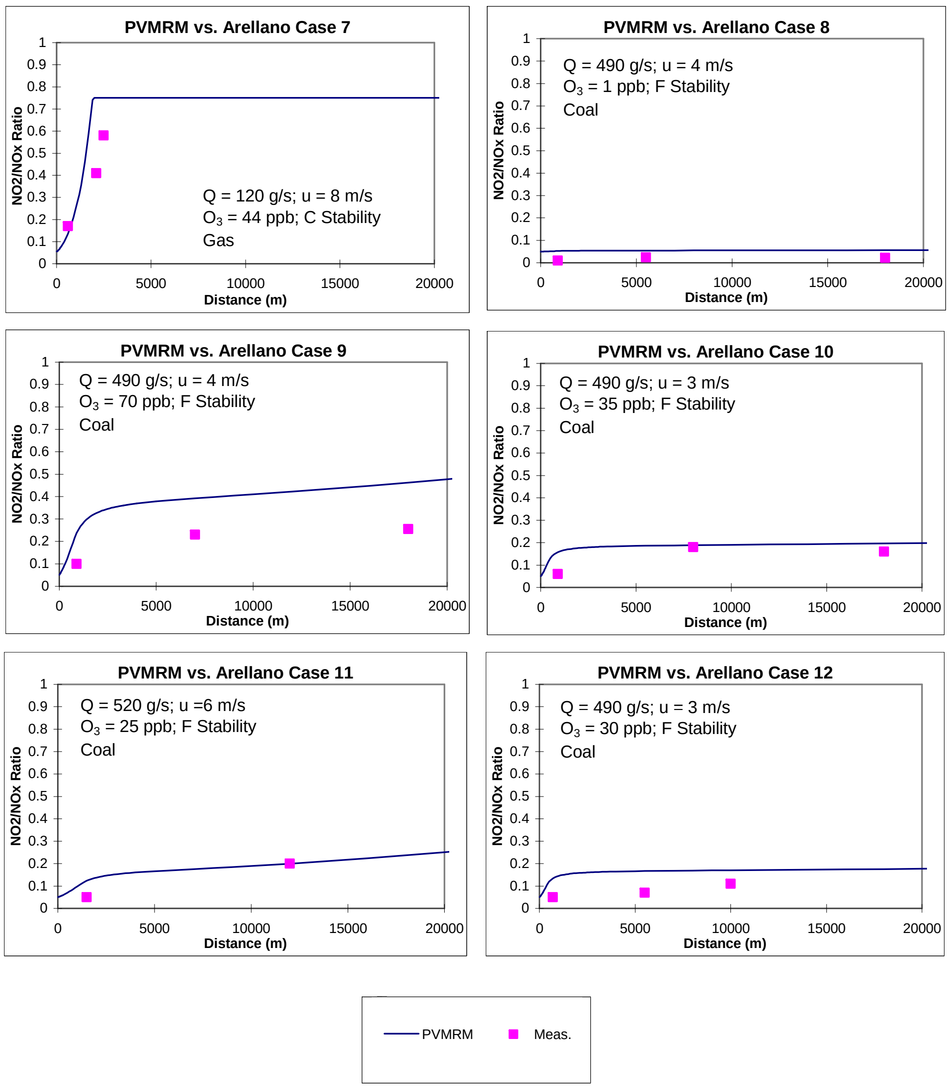


AERMOD NO_2 Evaluation Results

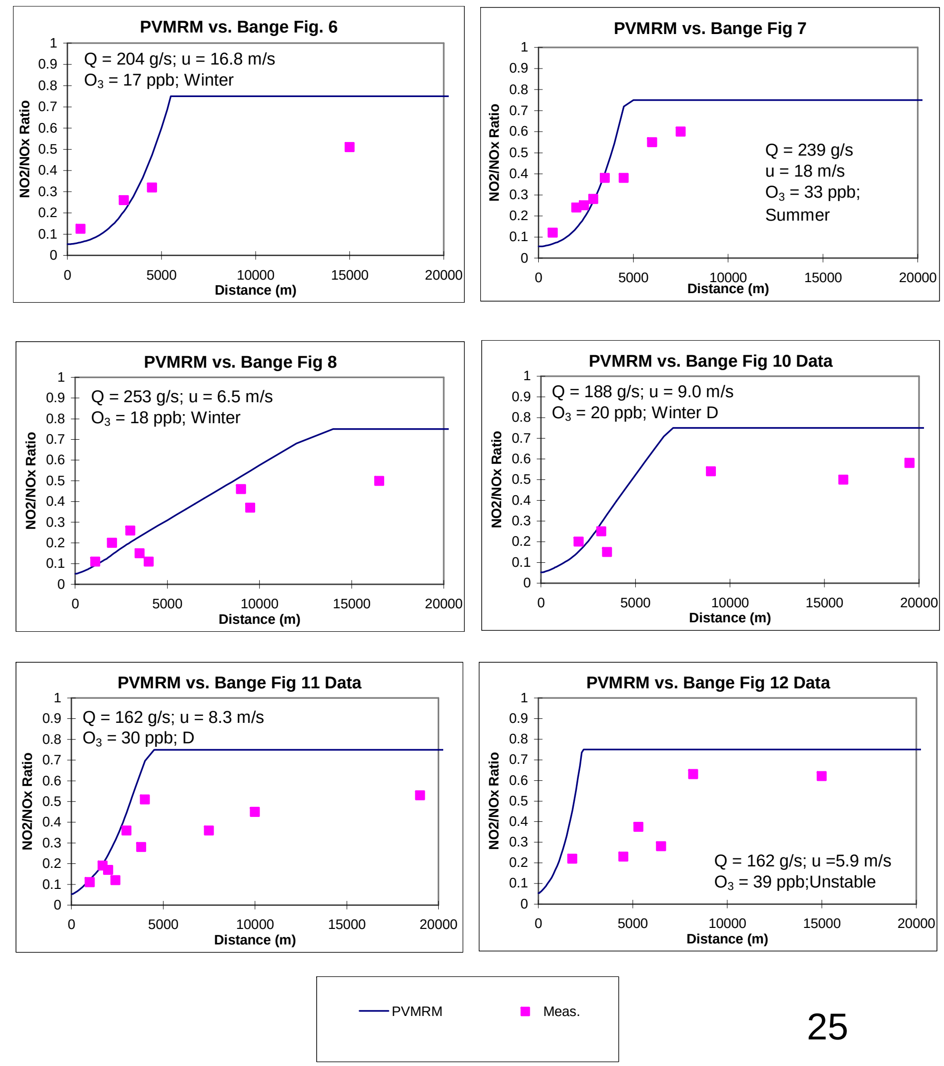
- AERMOD-PVMRM evaluated against two aircraft studies, two long-term monitoring studies, and LES model
- Evaluation results show generally good agreement with observed NO_2/NO_x ratios and ambient NO_2 concentrations
- Initial evaluation results based on default in-stack NO_2/NO_x ratio of 0.1, which may be conservative for EGUs
- Results of aircraft studies also demonstrate importance of in-stack ratios, especially under stable conditions
- Model-to-monitor comparisons from Atlanta NO_2 Risk and Exposure Assessment also show encouraging results

AERMOD-PVMRM vs. Aircraft Data
Examples of Paired NO2/NOX Ratios

NO_2/NO_x Ratio Predictions
AERMOD-PVMRM Model Predictions vs. Arellano Aircraft Data



NO_2/NO_x Ratio Predictions
AERMOD-PVMRM Model Predictions vs. Bange Aircraft Data



Long-term Monitoring Studies
1-hr NO_2 Robust Highest Concentrations

	Observed	PVMRM	OLMGRP	OLM	FULL
New Mexico Abo North Monitor RHC	117.87	116.26	108.38	444.87	449.24
New Mexico Abo South Monitor RHC	70.10	218.98	104.81	440.96	454.68
Hawaii Palaau Monitor RHC	95.42	101.57	113.18	368.57	480.38
Geometric Mean Pred/Obs RHC	---	1.486	1.177	4.510	4.993

Figure A-1. AERMOD Model Evaluation - New Mexico North Monitor - Hourly NO2 Q-Q Plot

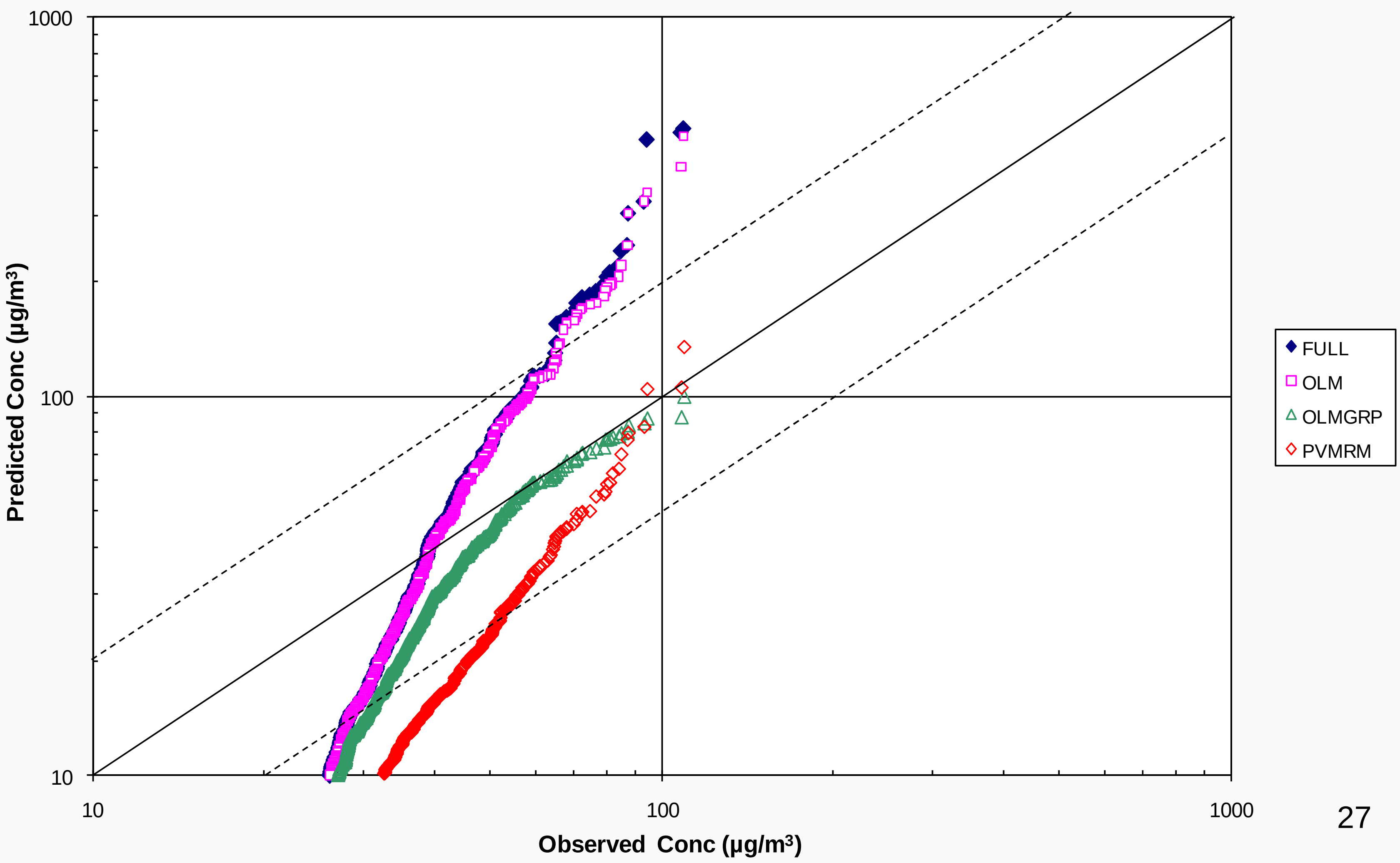


Figure A-2. AERMOD Model Evaluation - New Mexico South Monitor - Hourly NO2 Q-Q Plot

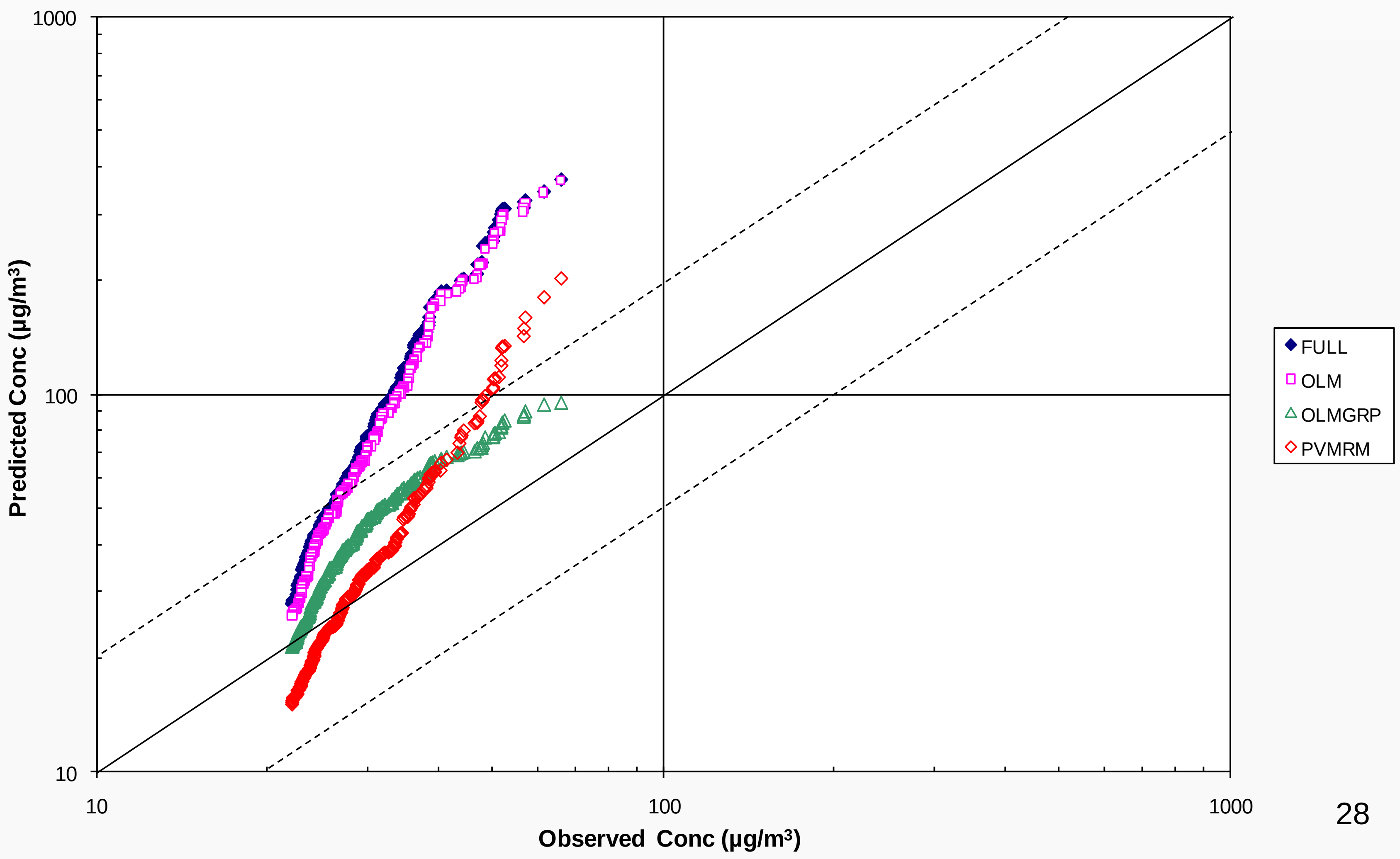
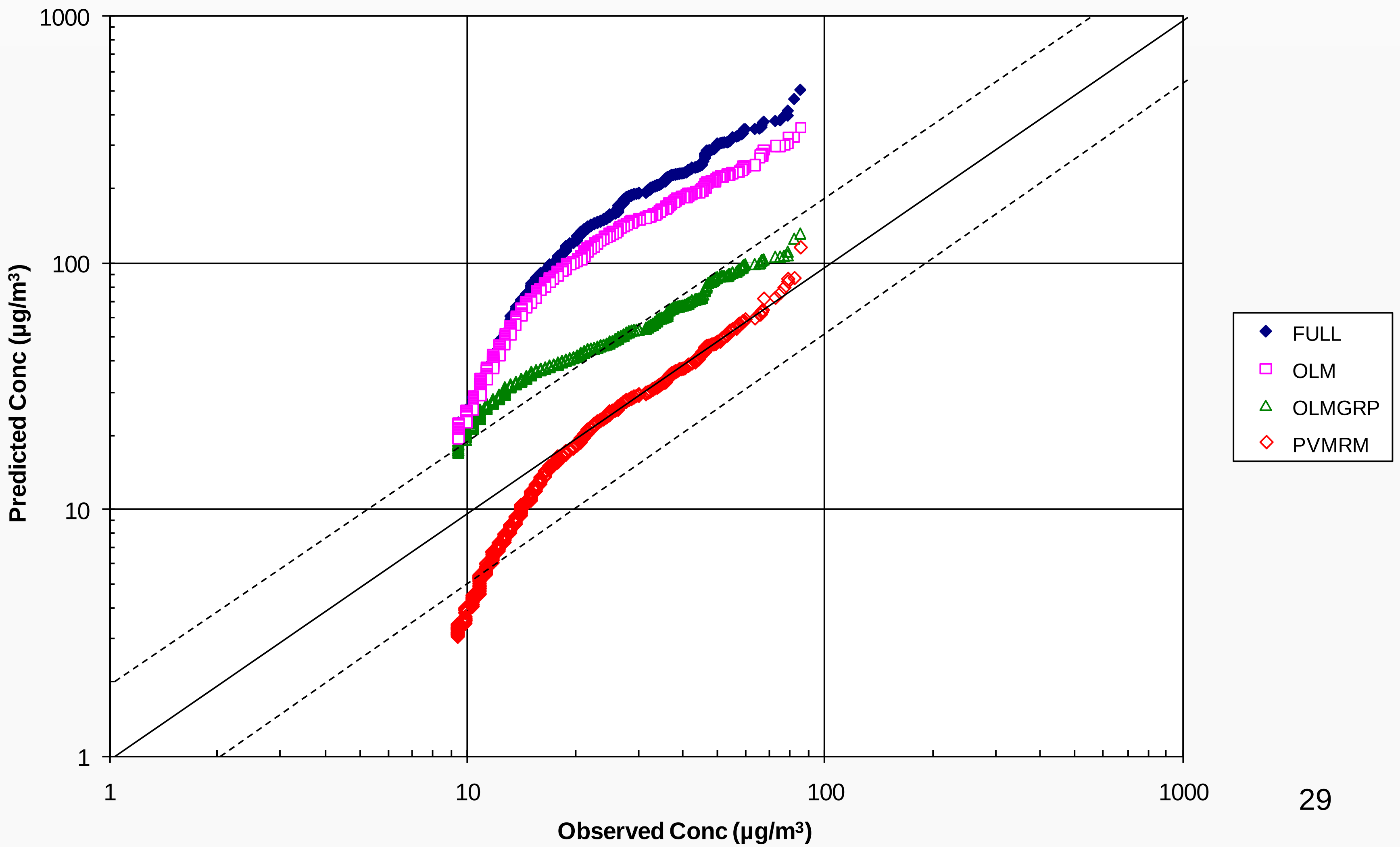


Figure A-3. AERMOD Model Evaluation - Palaau, HI - Hourly NO2 Q-Q Plot



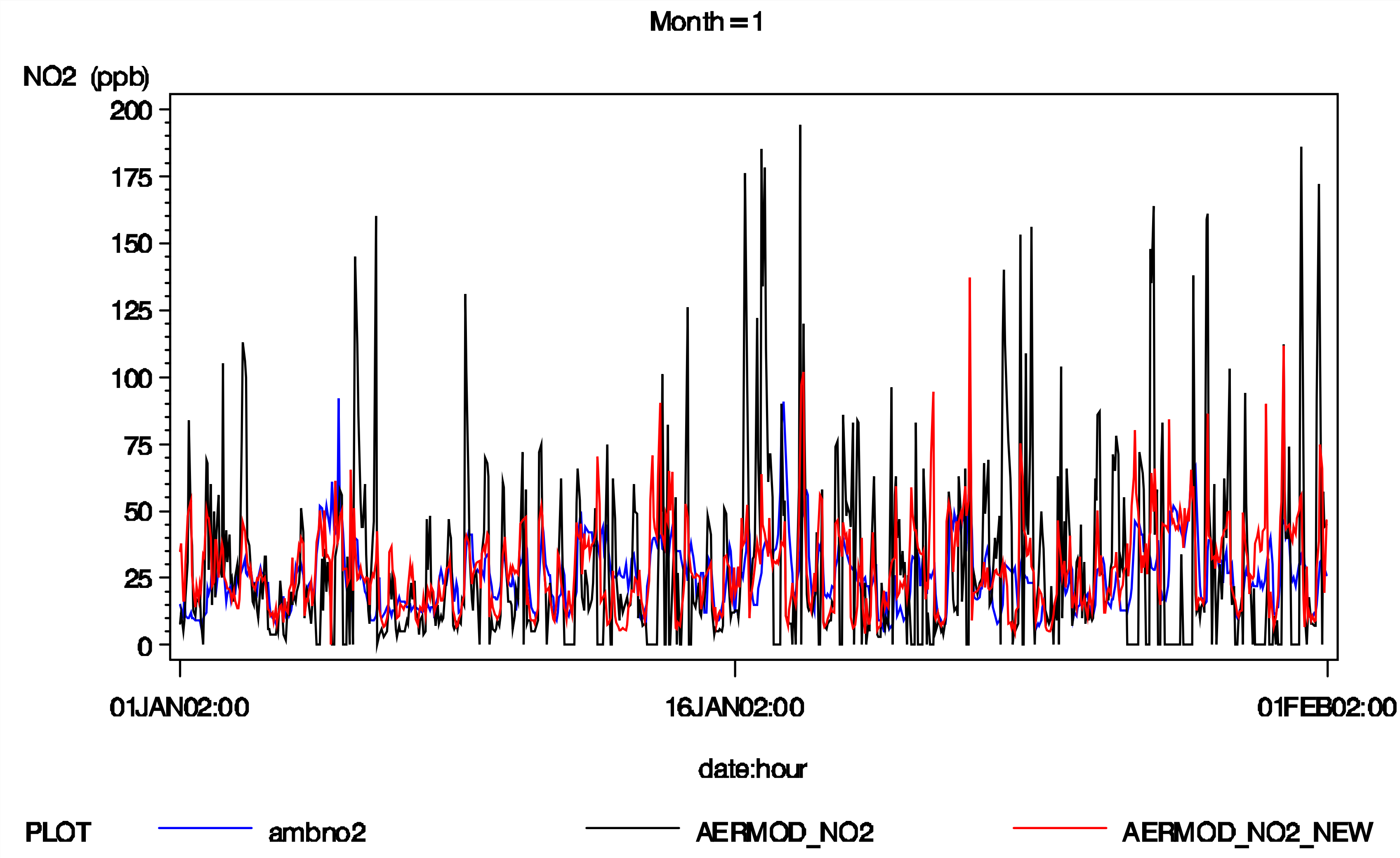
Example from NO_2 NAAQS Review

- AERMOD was applied in the REA for the Atlanta area to support recent NO_2 NAAQS review, focused on hourly impacts
- Majority of NO_2 impacts attributed to mobile sources
- Initial model-to-monitor comparisons showed AERMOD concentrations significantly exceeding monitored NO_2 concentrations at 3 Atlanta monitors
- Initial assessment by contractor was that low surface roughness used to process airport data was not representative of roughness typical of source locations, and suggestion was to re-process airport data with 1m roughness

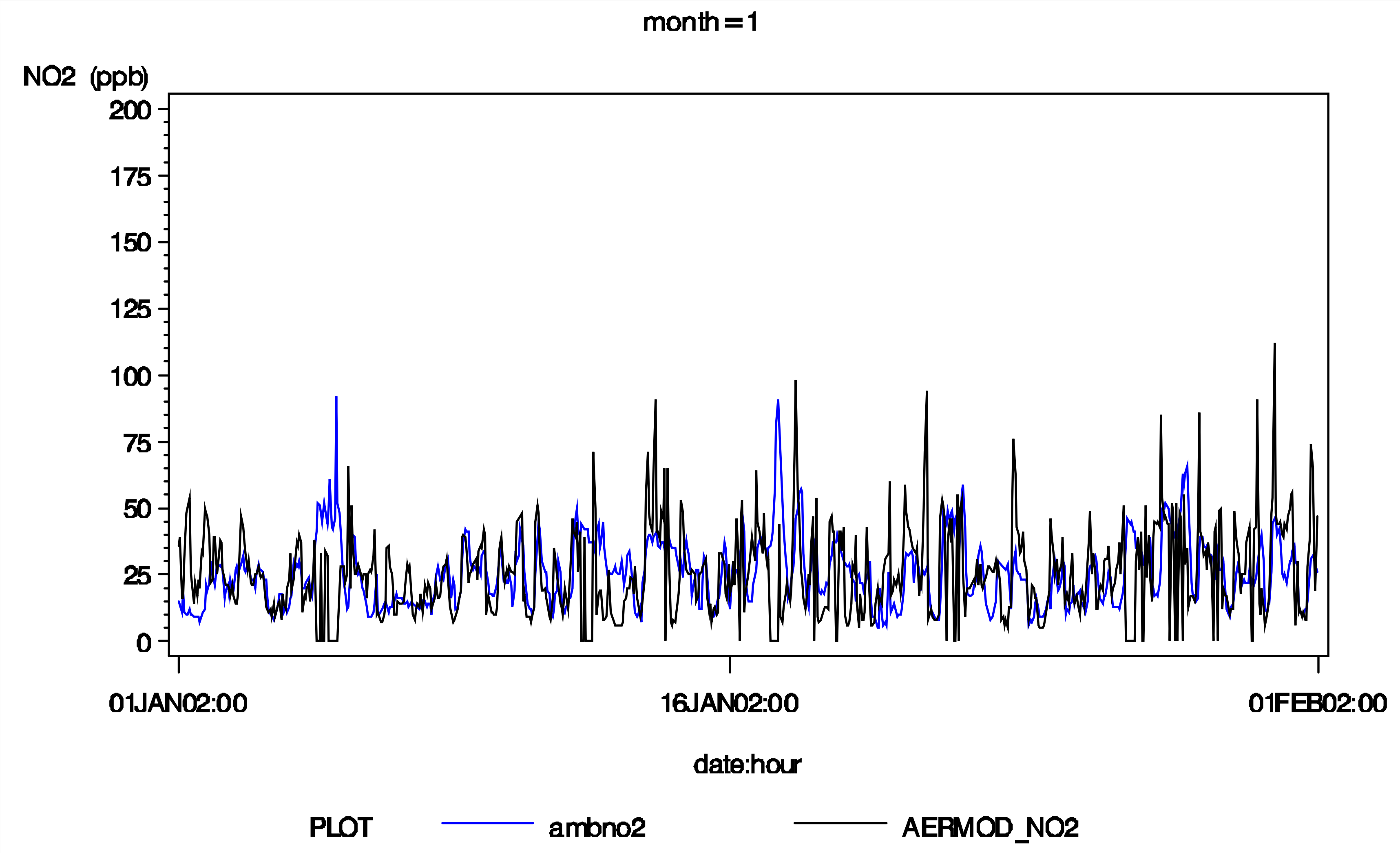
Example from NO_2 NAAQS Review

- Based on broader assessment of modeling analysis, recommendations were made to
  - Acquire and process SEARCH met data as more representative of surface characteristics for mobile source emissions
  - Apply OLMGROUP ALL option within Ozone Limiting Method to better account for NO to NO_2 conversion
  - Modify source characteristics for mobile source emissions to better account for vehicle induced turbulence
- Next slides show time-series comparisons of hourly NO_2 "before" and "after" adjustments to modeling analysis. Use of OLMGROUP ALL was one of the key factors in the improved model performance.
  - "Before" slide shows ambient NO_2 in blue, initial AERMOD results in black, and AERMOD results with SEARCH met data in red;
  - "After" slide shows ambient NO_2 in blue and final AERMOD results in black.

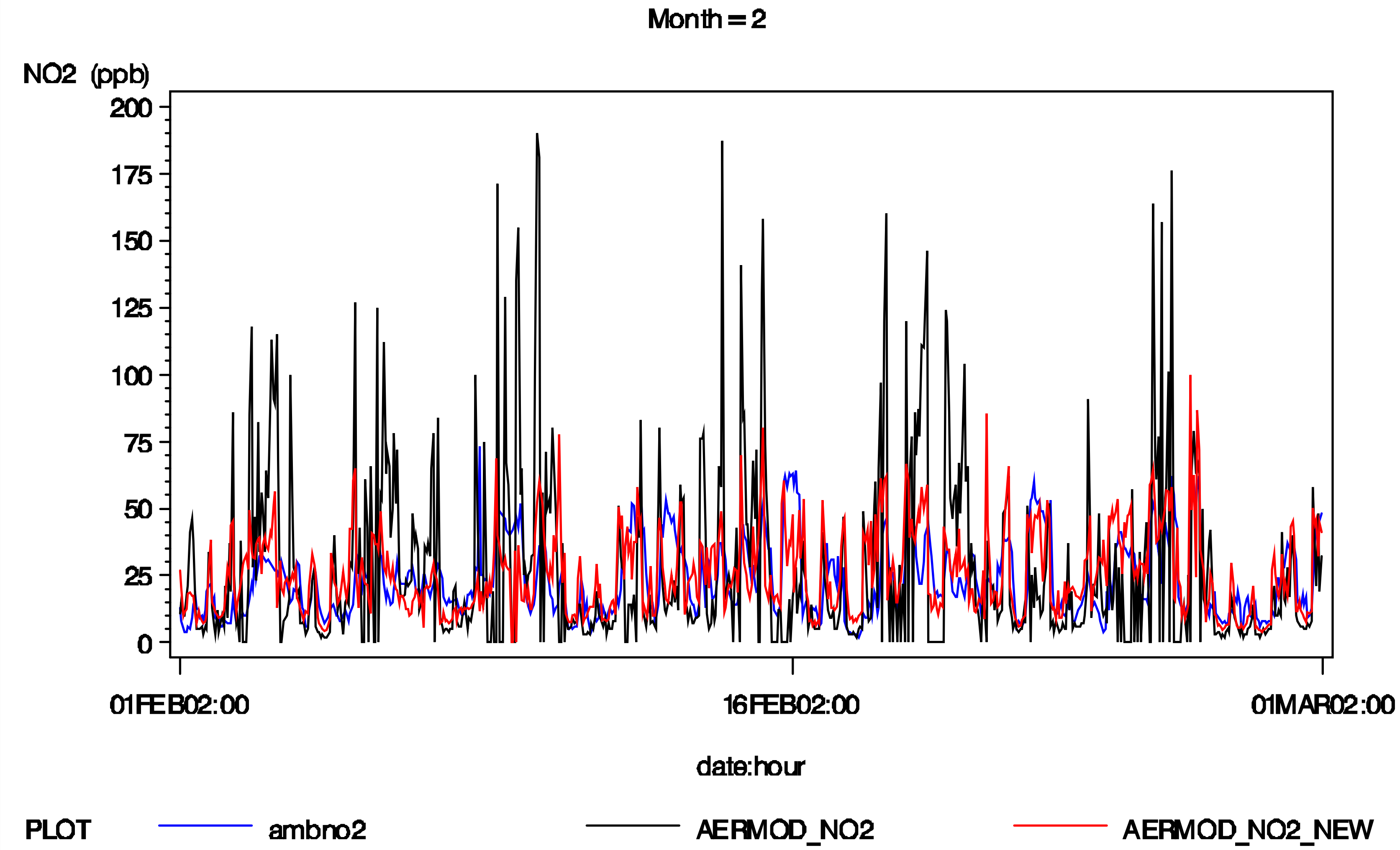
Model-to-Monitor Comparison - Before



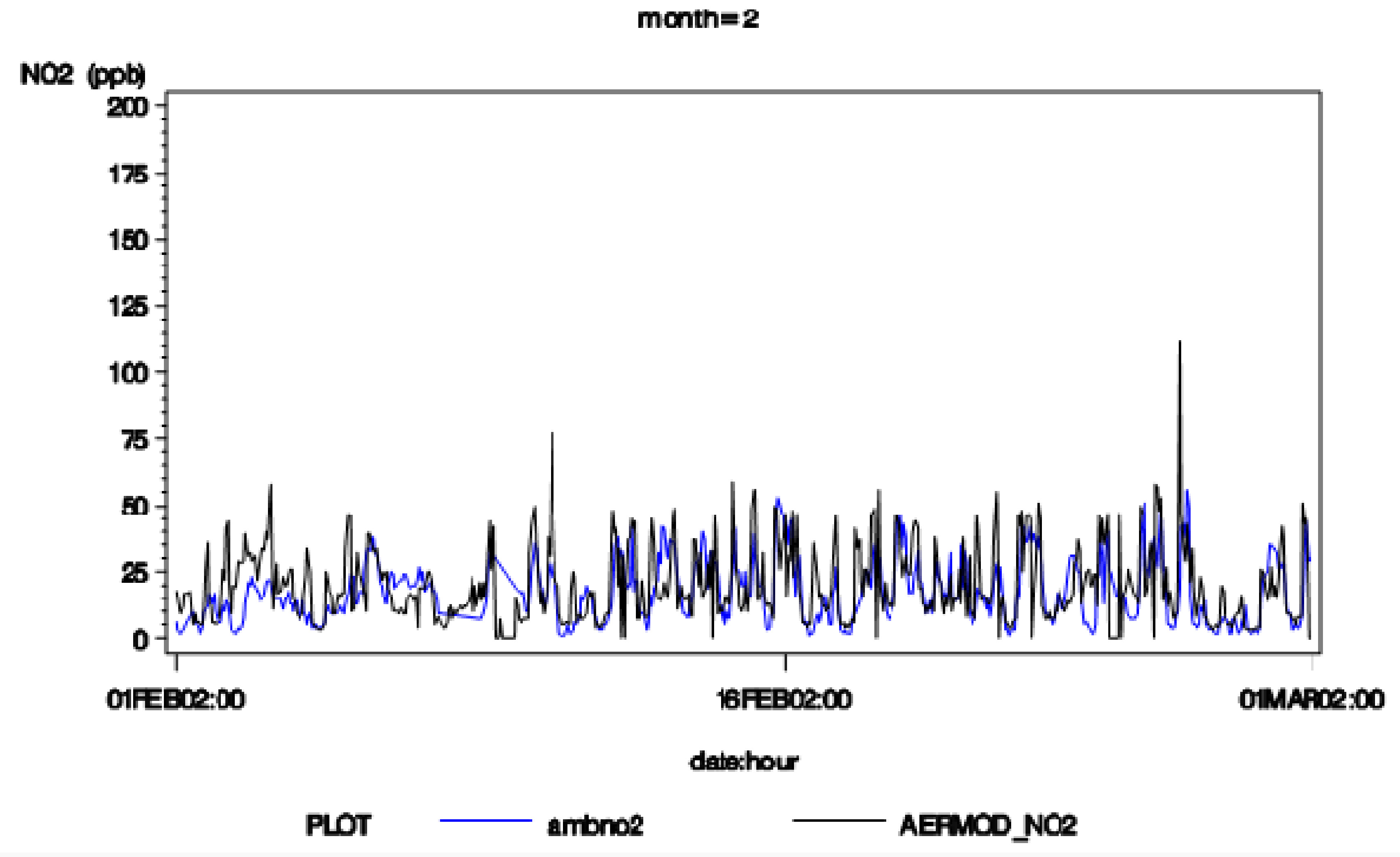
Model-to-Monitor Comparison - After



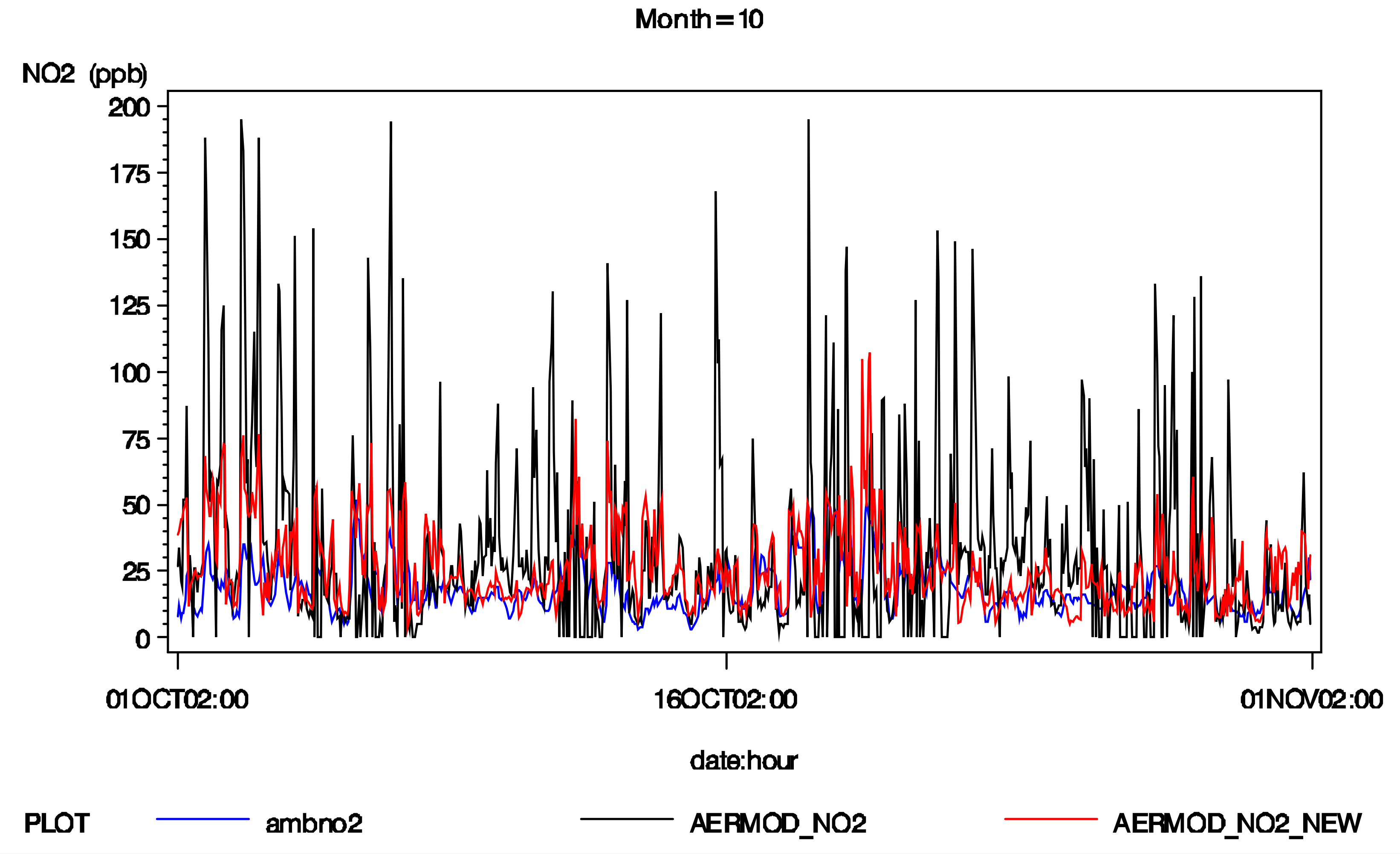
Model-to-Monitor Comparison - Before



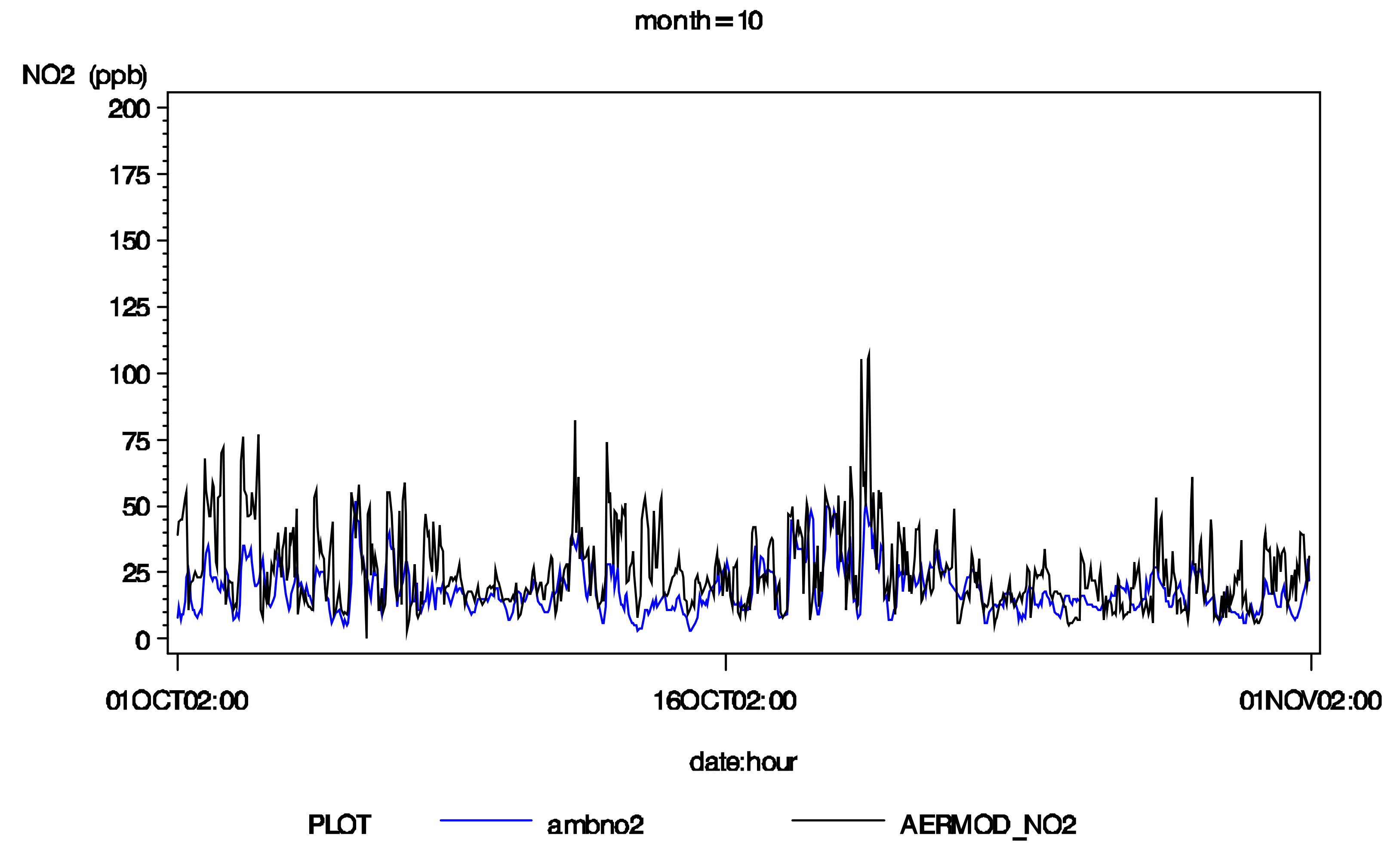
Model-to-Monitor Comparisons - After



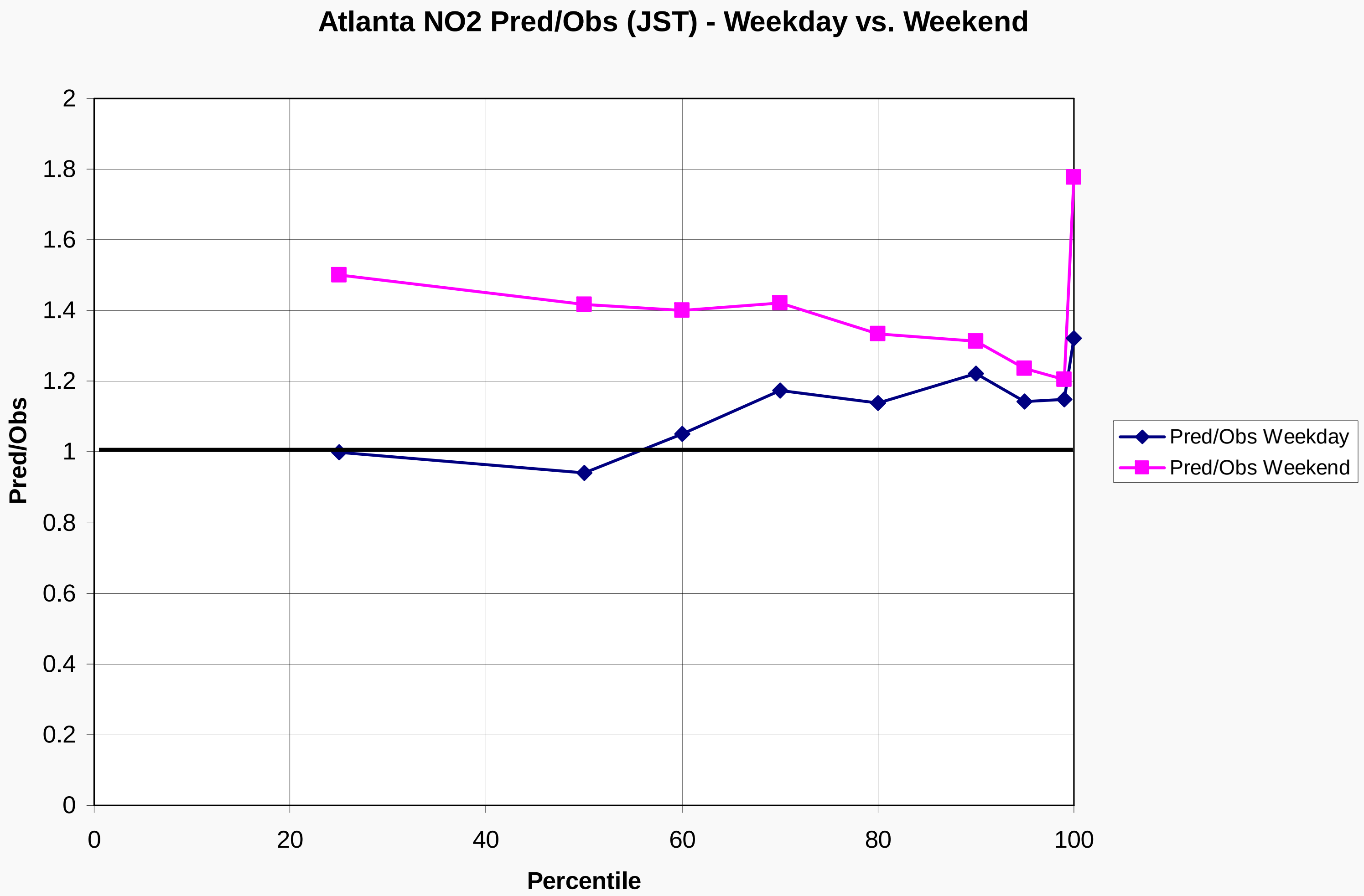
Model-to-Monitor Comparisons - Before



Model-to-Monitor Comparisons - After



Average Pred/Obs 1-hr NO2 Concentrations by Percentile Rank for JST Monitor – Weekday vs. Weekend



Contact Information

- For follow-up questions regarding NO_2 modeling guidance, contact:

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