Webinar: AERMOD Modeling System Update

U.S. EPA/OAQPS
Air Quality Modeling Group

August 12, 2014

Outline

- Recent AERMOD modeling system developments
  - AERMOD dispersion model
  - AERMET meteorological preprocessor
- Evaluation of BETA options in AERMET and AERMOD
- Other developments
  - Upper Air data substitution tool
  - AERSURFACE and Gust Factor Tool

AERMOD Developments

– Version 14134 Bug Fixes:

- Corrected problems associated with the ARM and ARM2 options for NO_2 chemistry, especially for ANNUAL values;
- Corrected several problems associated with the PVMRM option for NO_2 chemistry;
- Modified OLM and PVMRM options to limit conversion of NO_2 to the specified equilibrium ratio for hours with missing O_3 data (formerly treated as full conversion)
- Modified subroutine O3READ to allow 0.0 as a valid O_3 value for EVENT processing;
- Corrected several problems associated with the EVENT processing mode in AERMOD, including issues associated with EVENT processing for the NO_2 chemistry options;

AERMOD Developments (cont.)

- Version 14134 Bug Fixes (cont.):
  - Corrected issues associated with cases where calculations are skipped, e.g., receptor located < 1m from source or “inside” a VOLUME source, including re-initialization of arrays associated with PVMRM calculations;
  - Corrected a problem with the sigma-z calculation for LINE sources that may have caused incorrect results in some cases;
  - Modified subroutine DEBOPT to increase the number of fields on the DEBUGOPT keyword to accommodate all applicable DEBUG options;
  - Several minor issues were also addressed.

AERMOD Developments (cont.)

- Version 14134 Enhancements:
  - Modified the POLLUTID keyword to allow users to "disable" the special processing requirements associated with the 1-hr NO_2, 1-hr SO_2, and 24-hr PM2.5 NAAQS; which are based on multi-year averages of ranked maximum daily values and require complete years of meteorological data:
    - User can specify 'H1H' or 'H2H' or 'INC' on the CO POLLUTID keyword to "disable" these requirements;
    - This facilitates the use of AERMOD for modeling PM2.5 increments, based on a deterministic "design value" which can be exceeded once per year;
    - This also facilitates evaluations of NO_2 chemistry options without the constraint of requiring full years of meteorological data.
  - Modified AERMOD to check for flags in the SURFACE file indicating that MMIF-generated inputs were used, or if the BULKRN option in AERMET was used, based on additional flags included in AERMET v14134.

AERMOD Developments (cont.)

- Version 14134 Enhancements (cont.):
  - Modified the DEBUGOPT keyword to include a new AREA/LINE debug option, with expanded debug information that also includes debug information for OPENPIT sources;
    - Also removed DEBUG information from the main AERMOD.OUT file.
  - Enhanced the DEBUG outputs for the NO_2 options:
    - Lists all of the parameters included in the hourly NO-NO_2 conversion for each source and receptor, plus the BACKGROUND contribution, and multi-hour averages for EVENT processing;
    - The enhanced NO_2 DEBUG options can also be used to determine individual source contributions on an hourly basis.

Sample from New OLM DEBUG File

```
*** AERMOD - VERSION  14134 ***   *** EMPIRE ABO NOX   NORTH MONITOR   OLMGRP RUN                          ***        05/18/14
*** AERMET - VERSION  14134 ***   *** OLM Debug File:   Hrly non-EVT results sorted by hour/rec/srcgrp/src ***        12:32:12

 OPTIONS:  NonDFAULT CONC      FLAT      OLM       BETA

   DATE    IREC    GRPID   ISRC    SRCID       IOLM    OLMID     O3CONC       OLMVAL   X   NO2Ratio  =  NO2VAL       NO_VAL      OrigConc  X  PercentNO2 =  HRVAL        AVEVAL
 93061101     1  ALL          1  EAC1             1  ALL       0.78400E+02  0.66796E+00  0.10000E+00  0.66796E-01  0.39207E+00  0.00000E+00  0.90000E+00  0.00000E+00  0.00000E+00
 93061101     1  ALL          2  EAC2             1  ALL       0.78400E+02  0.66796E+00  0.10000E+00  0.66796E-01  0.39207E+00  0.35161E-01  0.90000E+00  0.31645E-01  0.31645E-01
 93061101     1  ALL          3  EAC3             1  ALL       0.78400E+02  0.66796E+00  0.10000E+00  0.66796E-01  0.39207E+00  0.24872E-01  0.90000E+00  0.22385E-01  0.54030E-01
 93061101     1  ALL          4  EAC4             1  ALL       0.78400E+02  0.66796E+00  0.10000E+00  0.66796E-01  0.39207E+00  0.39446E-01  0.90000E+00  0.35501E-01  0.89531E-01
 93061101     1  ALL          5  EAC5             1  ALL       0.78400E+02  0.66796E+00  0.10000E+00  0.66796E-01  0.39207E+00  0.23581E-01  0.90000E+00  0.21223E-01  0.11075E+00
 93061101     1  ALL          6  EAC6             1  ALL       0.78400E+02  0.66796E+00  0.10000E+00  0.66796E-01  0.39207E+00  0.14708E-01  0.90000E+00  0.13237E-01  0.12399E+00
 93061101     1  ALL          7  EAC7             1  ALL       0.78400E+02  0.66796E+00  0.10000E+00  0.66796E-01  0.39207E+00  0.19290E-01  0.90000E+00  0.17361E-01  0.14135E+00
 93061101     1  ALL          8  EAC8A            1  ALL       0.78400E+02  0.66796E+00  0.10000E+00  0.66796E-01  0.39207E+00  0.15814E-01  0.90000E+00  0.14233E-01  0.15559E+00
 93061101     1  ALL          9  EAC8B            1  ALL       0.78400E+02  0.66796E+00  0.10000E+00  0.66796E-01  0.39207E+00  0.00000E+00  0.90000E+00  0.00000E+00  0.15559E+00
 93061101     1  ALL         10  EAC27            1  ALL       0.78400E+02  0.66796E+00  0.10000E+00  0.66796E-01  0.39207E+00  0.19919E-01  0.90000E+00  0.17927E-01  0.17351E+00
 93061101     1  ALL         11  EAC9             1  ALL       0.78400E+02  0.66796E+00  0.10000E+00  0.66796E-01  0.39207E+00  0.19767E-01  0.90000E+00  0.17790E-01  0.19130E+00
 93061101     1  ALL         12  EAC10            1  ALL       0.78400E+02  0.66796E+00  0.10000E+00  0.66796E-01  0.39207E+00  0.17392E-01  0.90000E+00  0.15652E-01  0.20696E+00
 93061101     1  ALL         13  EAC11            1  ALL       0.78400E+02  0.66796E+00  0.10000E+00  0.66796E-01  0.39207E+00  0.53126E-01  0.90000E+00  0.47814E-01  0.25477E+00
 93061101     1  ALL         14  EAC28            1  ALL       0.78400E+02  0.66796E+00  0.10000E+00  0.66796E-01  0.39207E+00  0.77982E-01  0.90000E+00  0.70184E-01  0.32495E+00
 93061101     1  ALL         15  EAC14            1  ALL       0.78400E+02  0.66796E+00  0.10000E+00  0.66796E-01  0.39207E+00  0.81555E-01  0.90000E+00  0.73400E-01  0.39835E+00
 93061101     1  ALL         16  EAH16            1  ALL       0.78400E+02  0.66796E+00  0.10000E+00  0.66796E-01  0.39207E+00  0.14424E-01  0.90000E+00  0.12982E-01  0.41133E+00
 93061101     1  ALL         17  EAH17            1  ALL       0.78400E+02  0.66796E+00  0.10000E+00  0.66796E-01  0.39207E+00  0.23155E-01  0.90000E+00  0.20839E-01  0.43217E+00
 93061101     1  ALL         18  EAB19            1  ALL       0.78400E+02  0.66796E+00  0.10000E+00  0.66796E-01  0.39207E+00  0.40243E-01  0.90000E+00  0.36219E-01  0.46839E+00
 93061101     1  ALL         19  EAB20            1  ALL       0.78400E+02  0.66796E+00  0.10000E+00  0.66796E-01  0.39207E+00  0.40254E-01  0.90000E+00  0.36228E-01  0.50462E+00
 93061101     1  ALL         20  EAB21            1  ALL       0.78400E+02  0.66796E+00  0.10000E+00  0.66796E-01  0.39207E+00  0.39162E-01  0.90000E+00  0.35245E-01  0.53987E+00
 93061101     1  ALL         21  EAB22            1  ALL       0.78400E+02  0.66796E+00  0.10000E+00  0.66796E-01  0.39207E+00  0.43025E-01  0.90000E+00  0.38723E-01  0.57859E+00
 93061101     1  ALL         22  EAB29            1  ALL       0.78400E+02  0.66796E+00  0.10000E+00  0.66796E-01  0.39207E+00  0.25088E-01  0.90000E+00  0.22579E-01  0.60117E+00
 93061101     1  ALL         23  EAI23            1  ALL       0.78400E+02  0.66796E+00  0.10000E+00  0.66796E-01  0.39207E+00  0.48460E-08  0.90000E+00  0.43614E-08  0.60117E+00
 93061101     1  ALL         24  EAF24            1  ALL       0.78400E+02  0.66796E+00  0.10000E+00  0.66796E-01  0.39207E+00  0.00000E+00  0.90000E+00  0.00000E+00  0.60117E+00
 93061101     1  ALL         25  EAF25            1  ALL       0.78400E+02  0.66796E+00  0.10000E+00  0.66796E-01  0.39207E+00  0.00000E+00  0.90000E+00  0.00000E+00  0.60117E+00
 93061101     1  ALL         26  EAP33            1  ALL       0.78400E+02  0.66796E+00  0.10000E+00  0.66796E-01  0.39207E+00  0.00000E+00  0.90000E+00  0.00000E+00  0.60117E+00
 93061101     1  ALL             BACKGROUND                                                                                                    0.22561E+01  0.28572E+01
```

AERMET Developments

– Version 14134 Bug Fixes:

- Modified subroutines SUBST and MPPBL to correct problems associated with the options introduced in v13350 to substitute for missing cloud cover (CCVR) and temperature (TEMP) by linear interpolation across 1 or 2-hour gaps;
- Modified subroutines GETTEMP and SUBST to ensure that substitutions for missing ONSITE temperatures are only based on values from the same measurement level;
- Corrected bugs which may have incorrectly indicated that ONSITE temperatures were missing, and may have caused errors in PRES and RH calculations;
- Modified subroutine MPPBL to correct problems with assigning ‘MyZone’ to determine the reference sounding time based on longitude;

AERMET Developments (cont.)

– Version 14134 Bug Fixes (cont.):

- Modified subroutine BULKRI to include the THSTAR adjustment for low solar elevation angles for the BULKRN option, including the ADJ_U* option associated with the BULKRN option;
- Addressed issues associated with use of ONSITE solar radiation and delta-T data using the BULKRN option for cases where BULKRN is being applied with ONSITE or NWS cloud cover data;
- Modified subroutines SUMHF and SUNDAT to eliminate mixed-mode integer/real calculations in summing heat fluxes and calculating sunrise/sunset times and solar elevation angles.

AERMET Developments (cont.)

– Version 14134 Enhancements:

- Incorporated an option to allow users to disable substitutions for missing CCVR and/or TEMP data that are based on persistence for hours 23 and 24, and additional flags were added to the surface file to identify when this option is applicable;
- Modified several subroutines to track the availability of ONSITE variables to determine whether substitutions for missing CCVR or TEMP data should be implemented by default, e.g., if ONSITE CCVR data is not available and options to estimate equivalent cloud cover are not included, then CCVR substitutions (based on the available NWS data) will be implemented by default;
- Modified several subroutines to track and report the use of MMIF-generated inputs, and to include a 'MMIF' flag in the surface file if MMIF-generated data are used.

Issues with v14134 Update

- AERMOD v14134 issues:
  - AERMOD incorrectly indicates that full conversion is used for NO2 if the ARM option is specified along with the regulatory DFAULT option:
    - However, model results do correctly reflect ARM;
  - Optimizations based on relative source/receptor locations has introduced a problem with collocated sources/receptors:
    - Individual hourly results may show up as Infinity or NaN (not a number), and cumulative results may be erroneous;
    - A “QSUM = 0.0” error message may also be issued if PVMRM option is used.

Issues with v14134 Update

- AERMOD v14134 issues (cont):
  - AERMOD User's Guide Addendum (Section 2.5) incorrectly states that background concentrations will automatically be included with source group ALL:
    - User must specify BACKGRND on the SRCGROUP ALL keyword to include background concentrations;
    - Note that this issue also applied to v13350, and AERMOD will automatically issue a warning message indicating whether BACKGRND is included with group ALL when the BACKGRND option is used.

Issues with v14134 Update

- AERMET v14134 issue:
  - An application using the ADJ_U* Beta option in AERMET together with the BULKRN (delta-T) option produced questionable results:
    - Unusually high concentrations occurred associated with anomalously large lapse rates (exceeding 1 K/m);
    - This is similar to an issue that occurred with v12345 using the ADJ_U* option without BULKRN that was apparently corrected in v13350;
    - However, this has prompted a more thorough review of the ADJ_U* and BULKRN options in AERMET and potential inconsistencies with the meteorological profiling in AERMOD

Evaluation of Beta Options

- Continue to update and expand evaluations of Beta options in AERMET and AERMOD;
- Two tracer field studies conducted in the 1974 by NOAA focused on dispersion of low-level releases under low-wind/stable conditions:
  - Oak Ridge, TN, included low-level and elevated releases with sampling arcs at 100m, 200m, and 400m, and wind speeds ranging from 0.15 to 0.73m/s (10 of 11 cases < 0.5m/s);
  - Idaho Falls, ID, included low-level releases with sampling arcs at 100m, 200m, and 400m, and wind speeds ranging from 0.75 to 1.93m/s (4 of 11 cases < 1.0m/s);
  - v12345 results for Idaho Falls and Oak Ridge field studies are summarized in Appendix F of the AERMOD User's Guide Addendum.

Evaluation Caveats

- The preliminary model evaluation results presented here are still under review and are subject to change;
- In addition, several caveats regarding model evaluation should be kept in mind:
  - Evaluating performance of dispersion models is a complex endeavor and results may be affected by errors or uncertainties regarding the correct model inputs, including emission rates, source characteristics, surface characteristics and meteorological data;
  - Errors or uncertainties regarding the interpretation of “observed” concentrations may also significantly affect the conclusions regarding model performance;
  - The potential impact of these caveats on conclusion regarding model performance are likely to be exaggerated in cases with very low wind speeds since results may be highly sensitive to relative small “errors” in important inputs or assumptions.

Evaluation Caveats (cont.)

- Regarding the model evaluation results presented below, the following issues should be noted:
  - EPA's evaluations for Oak Ridge and Idaho Falls deviated in some respects from the original evaluations conducted by AECOM/API:
    - EPA assumed a surface roughness of 0.6m for Oak Ridge as compared to 0.2m assumed by AECOM;
    - EPA assumed a wind measurement height of 10m for Oak Ridge (due to the fact that the observed wind speeds were derived from laser anemometry from lasers sited on the top on nearby ridges, as compared 2m assumed by AECOM;
    - EPA assumed a surface roughness of 0.08m for Idaho Falls, as compared to AECOM's assumption of 0.15m for February and 0.3m for other months (the study spanned from Feb. to May);
    - EPA assumed a release height of 3m for Idaho Falls, based on information presented in the NOAA Technical Memorandum and as assumed by other researchers, as compared to a 1.5m release height assumed by AECOM.

Oak Ridge Study Area

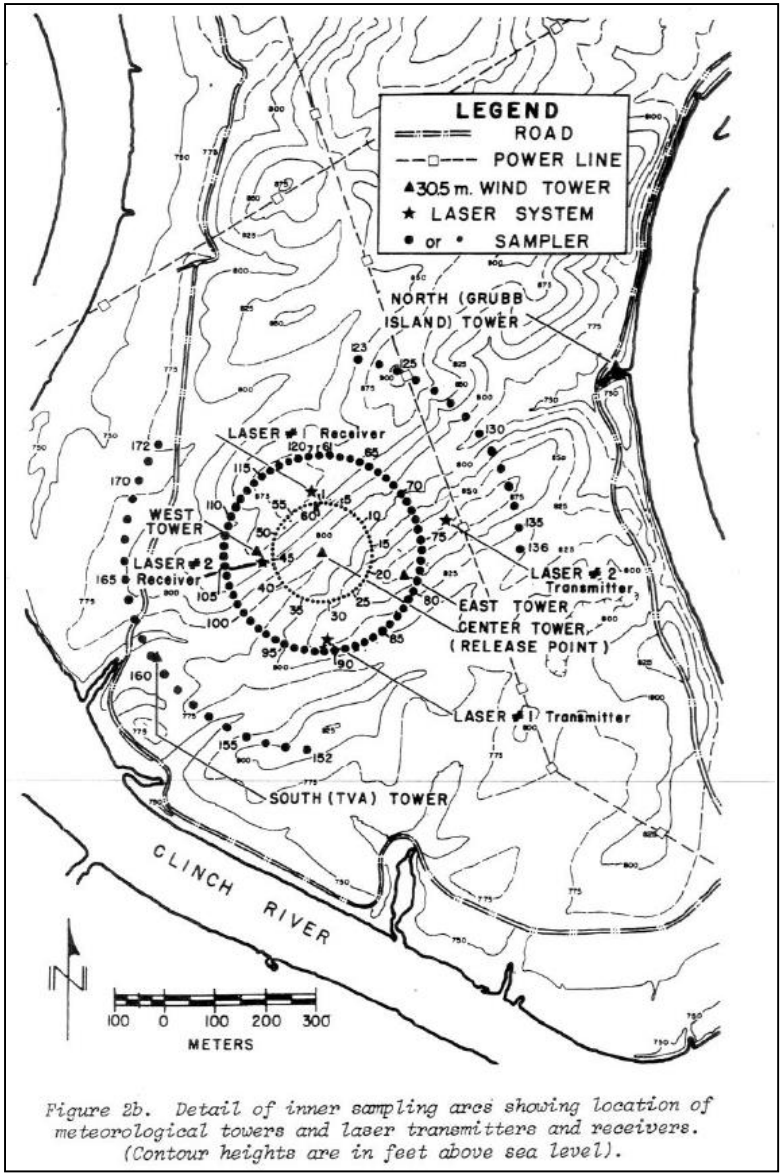
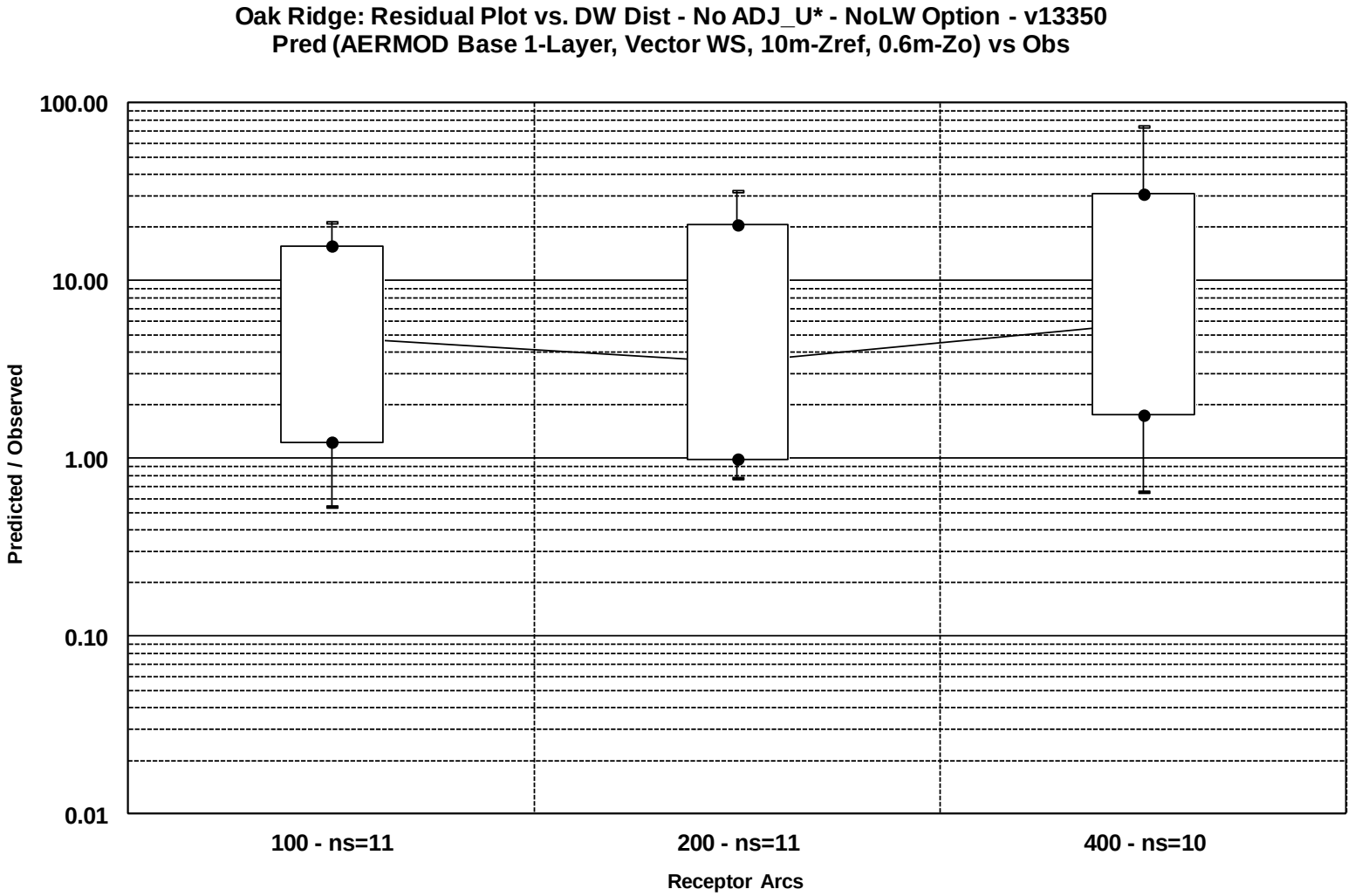


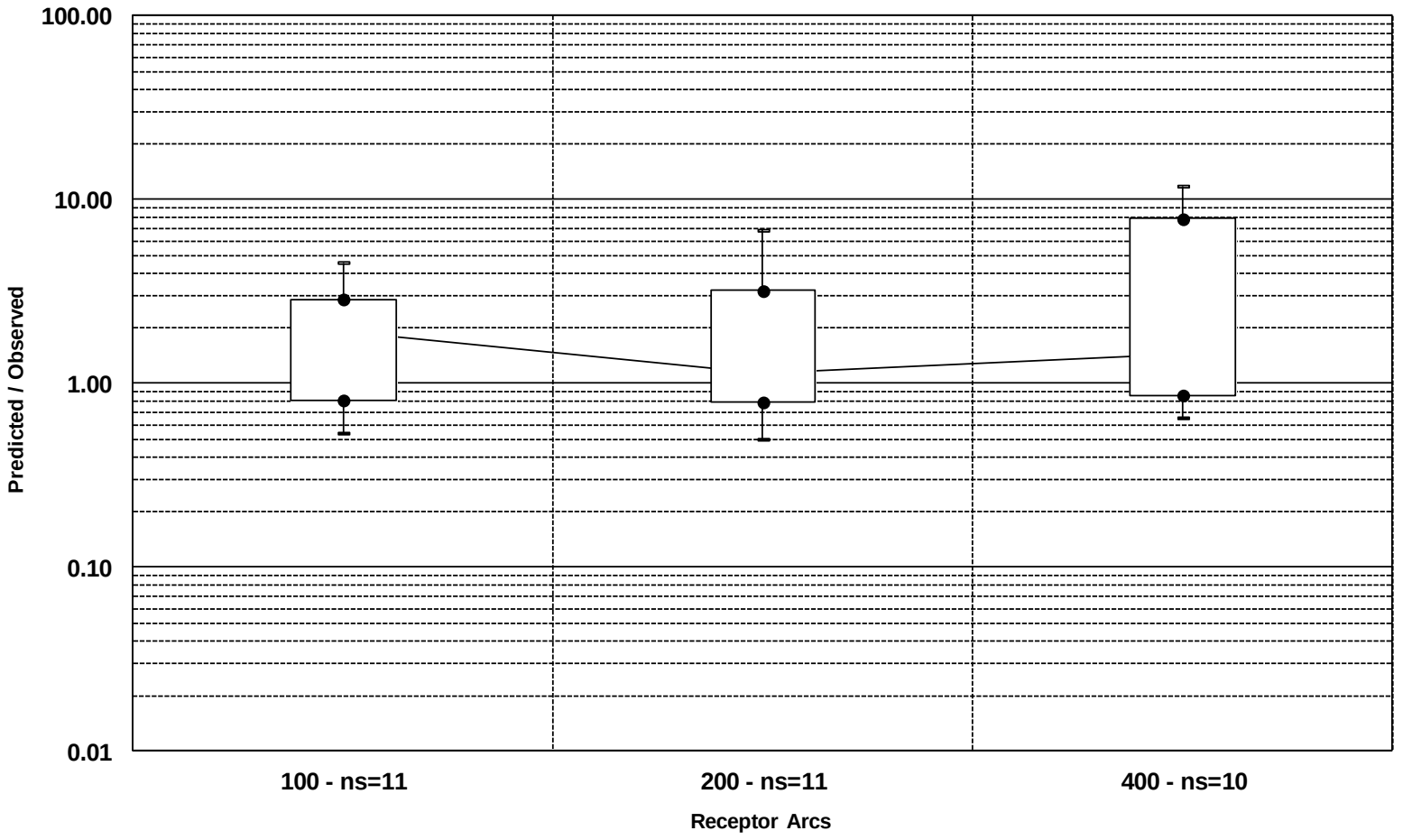
Figure 2b. Detail of inner sampling arcs showing location of meteorological towers and laser transmitters and receivers. (Contour heights are in feet above sea level).

From NOAA Technical Memorandum ERL ARL-61, 1976.

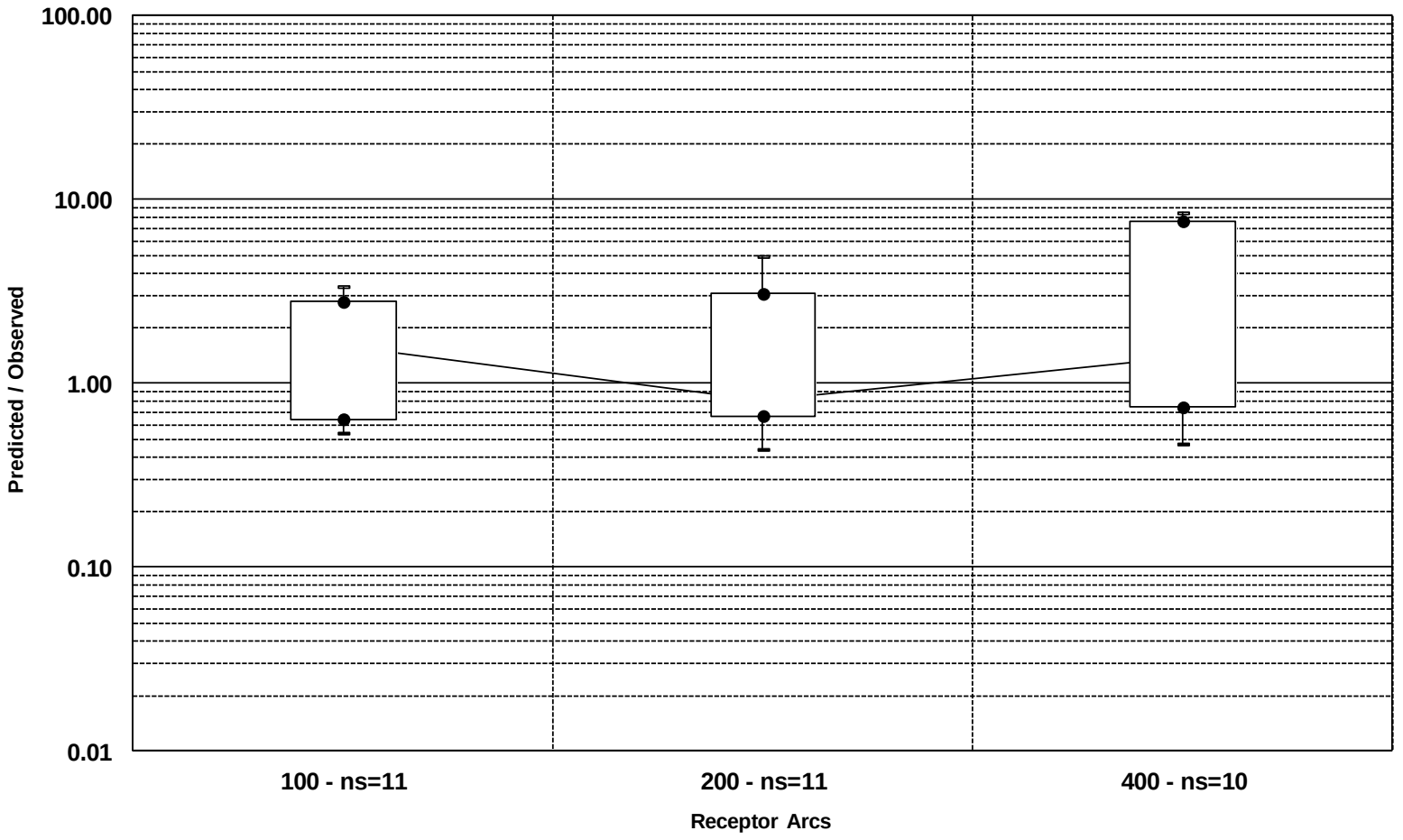
Oak Ridge – Base Model



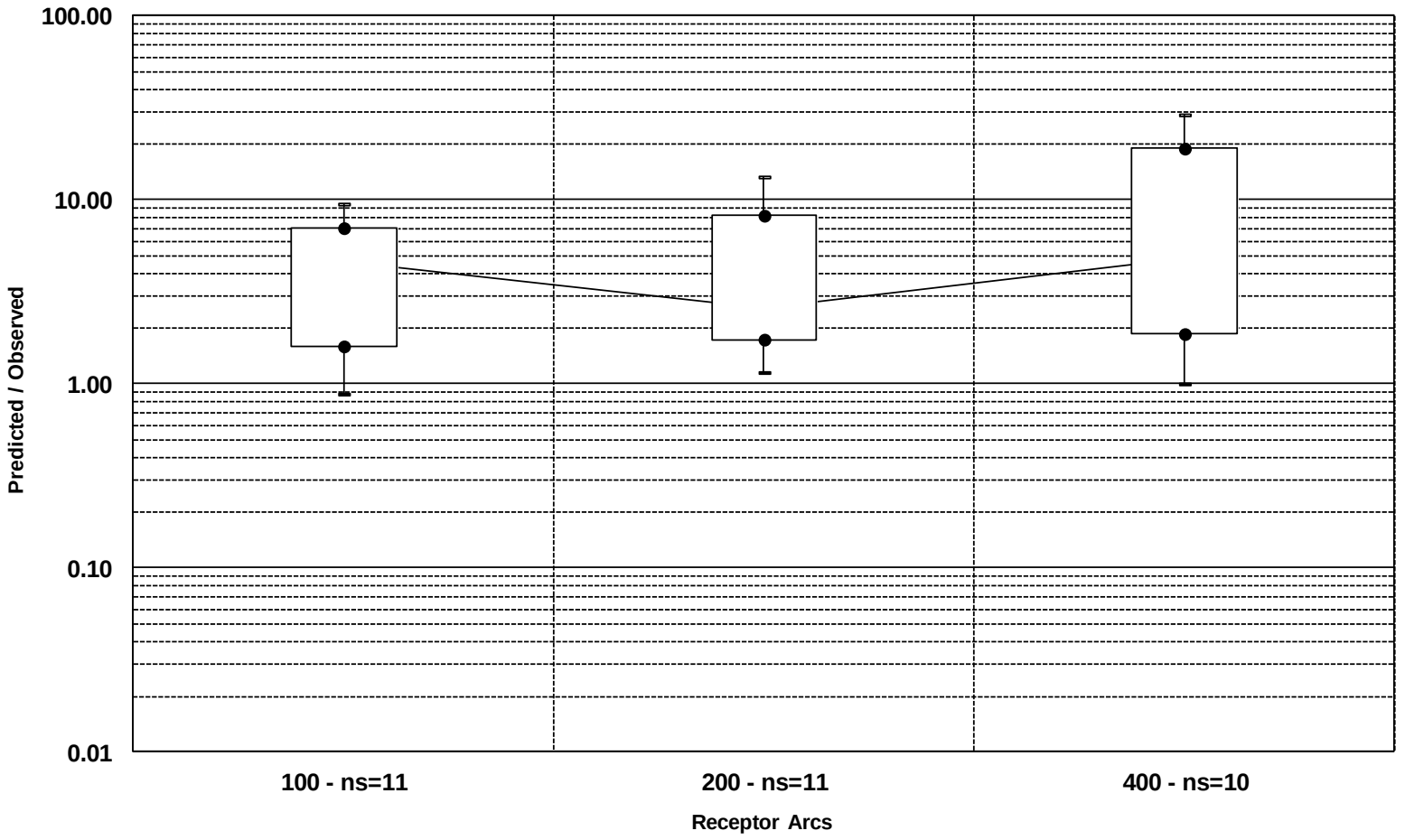
Oak Ridge – ADJ_U* Option



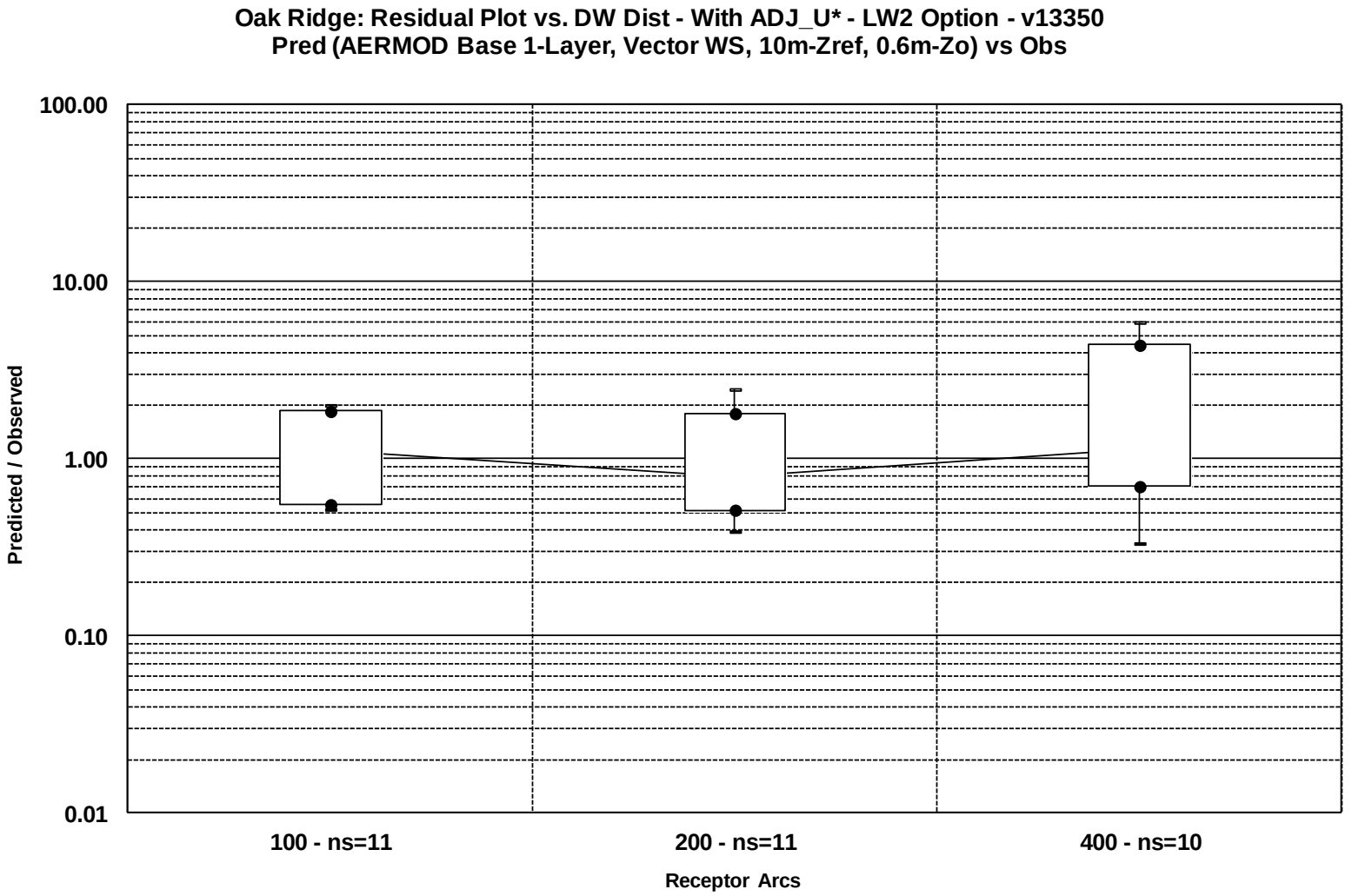
Oak Ridge – ADJ_U* Option



Oak Ridge – ADJ_U* Option



Oak Ridge – ADJ_U* Option



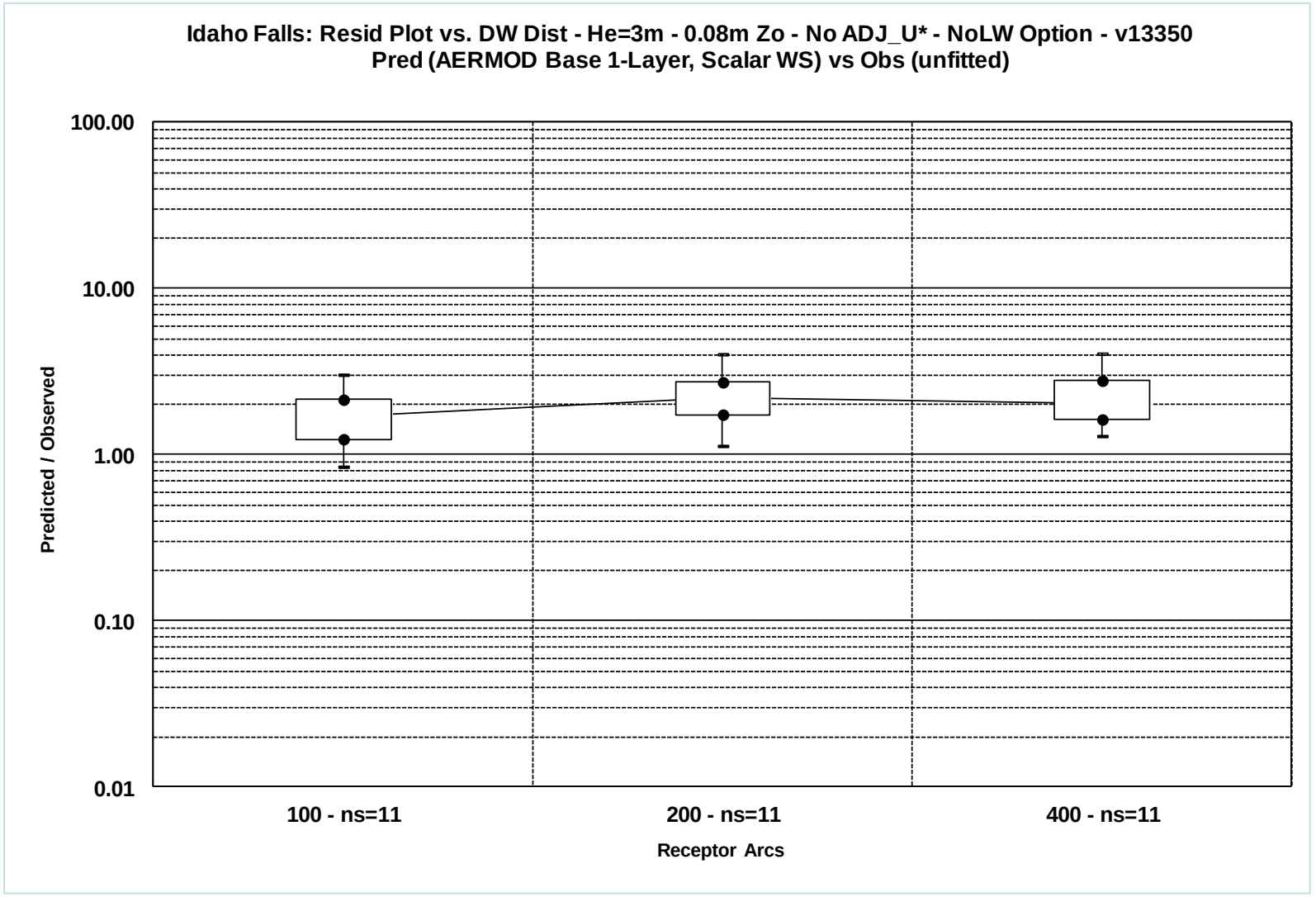
Idaho Falls Study Area

Google earth

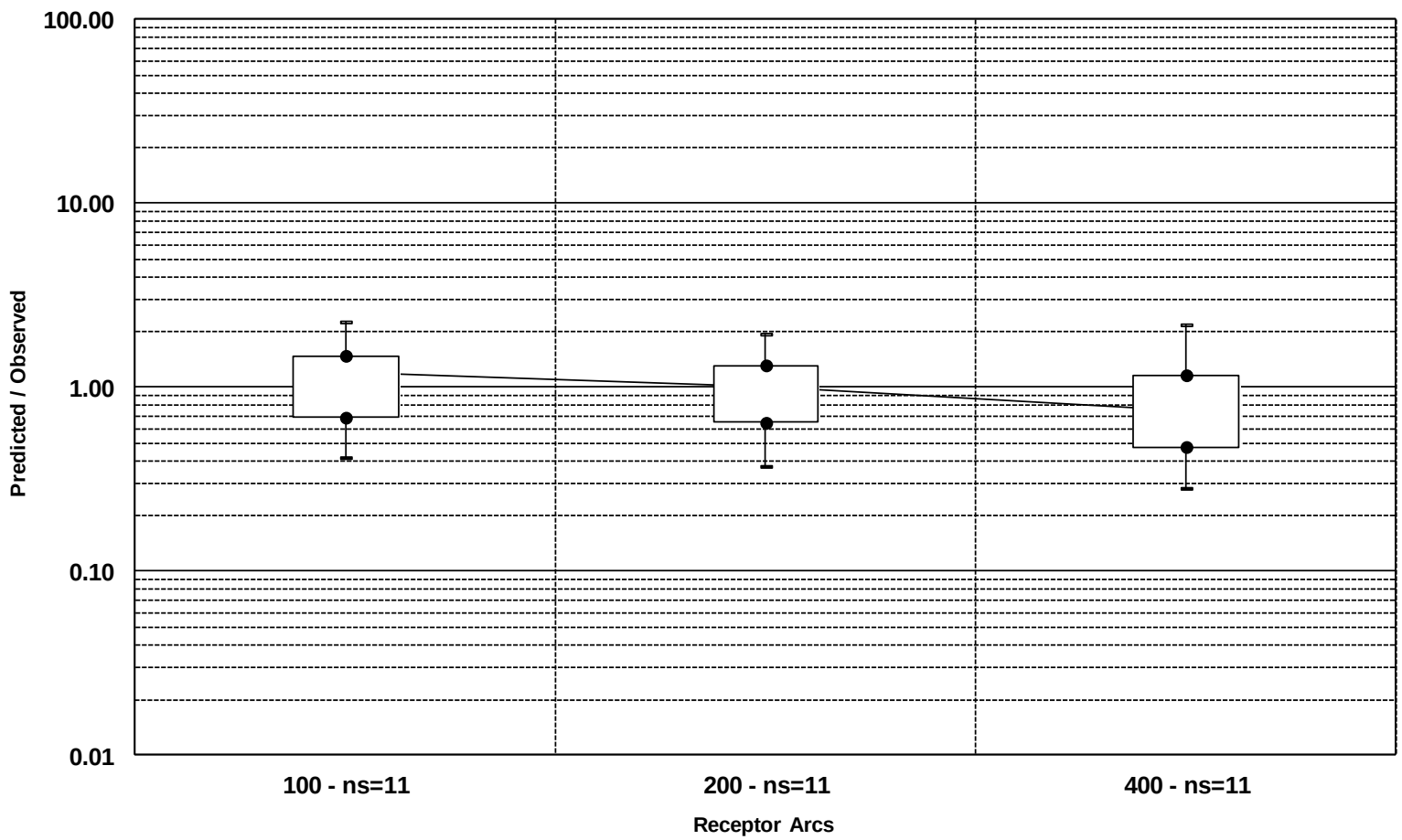
feet 1000

meters 600

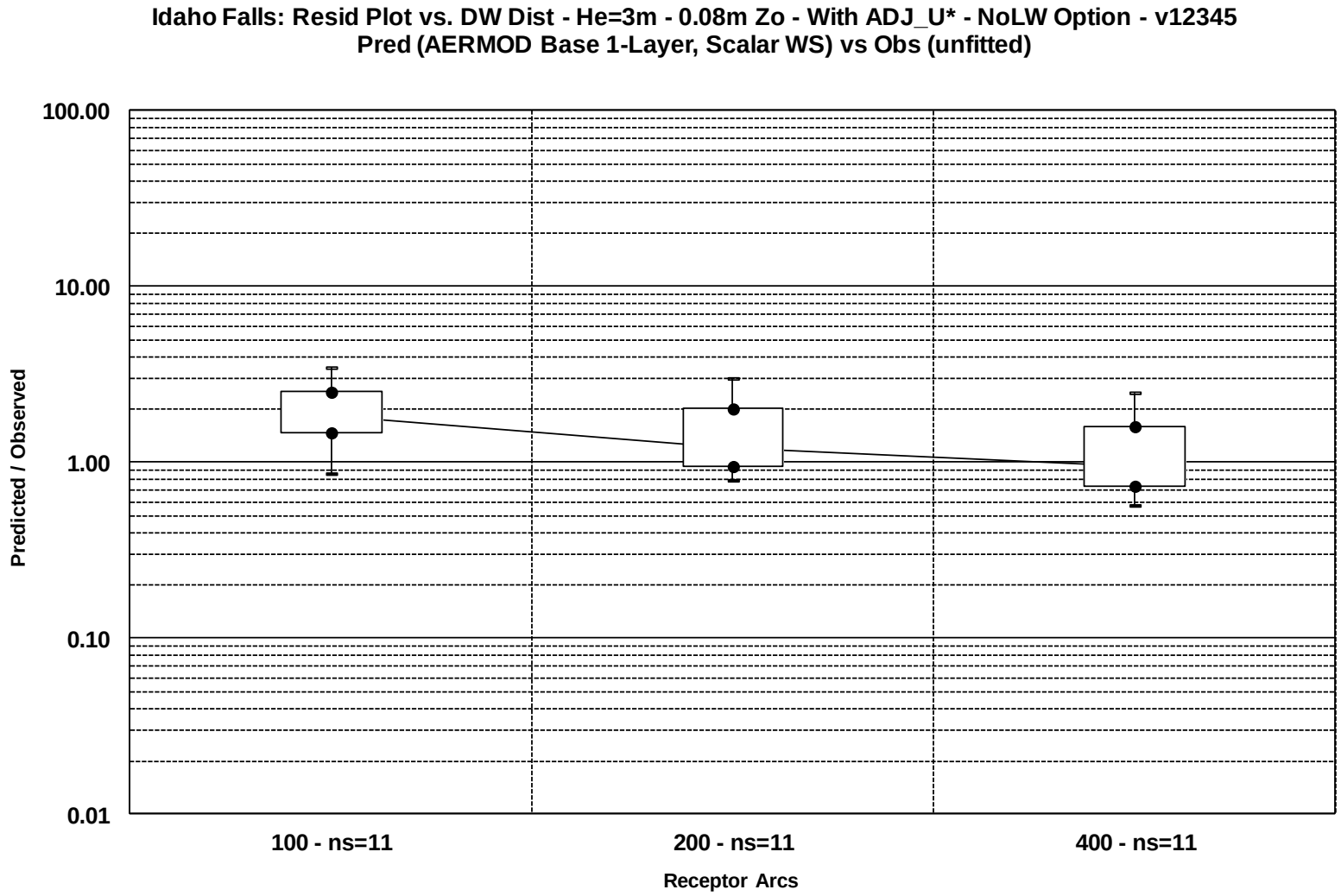
Idaho Falls – Base Model



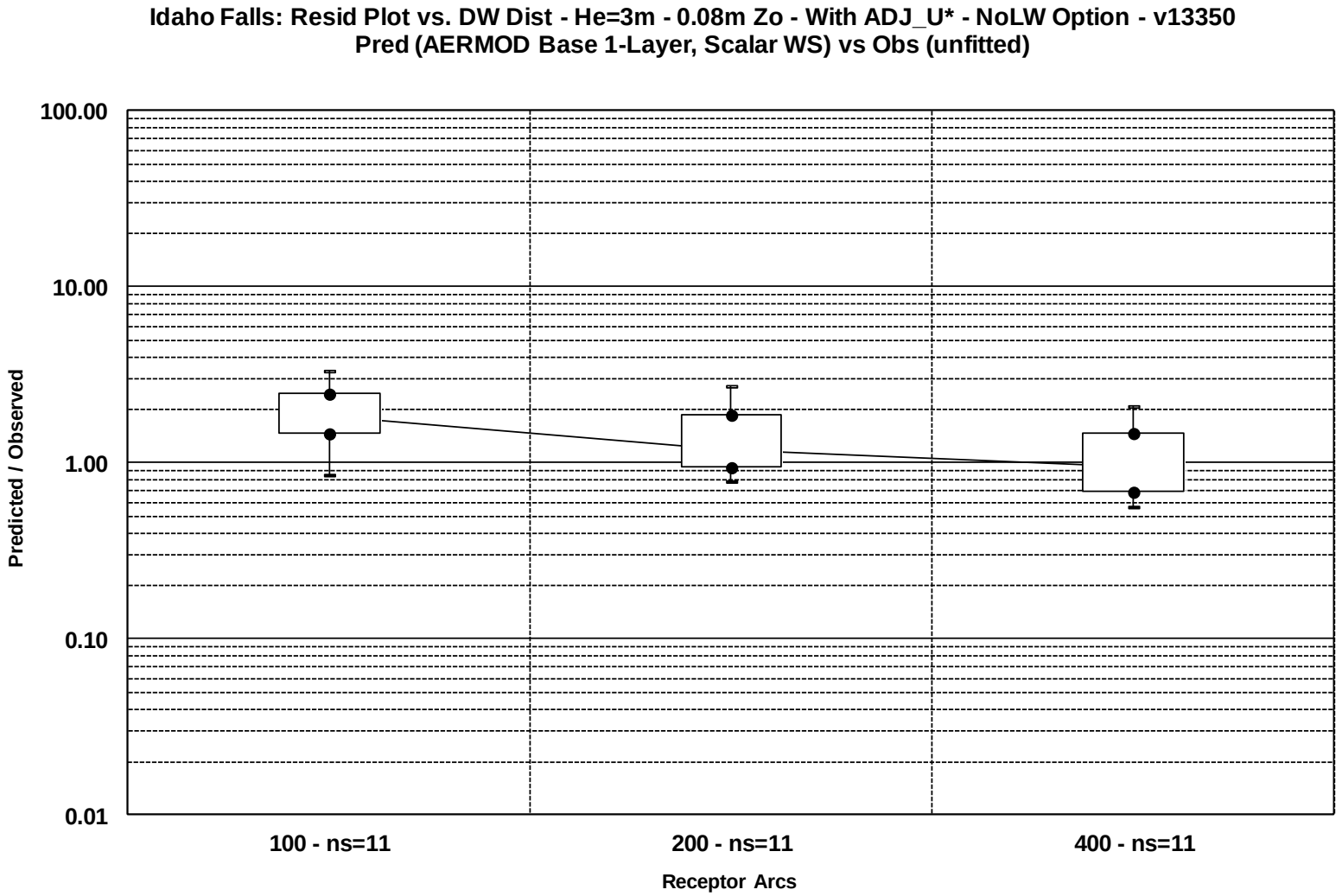
Idaho Falls – ADJ_U* w/BULKRN



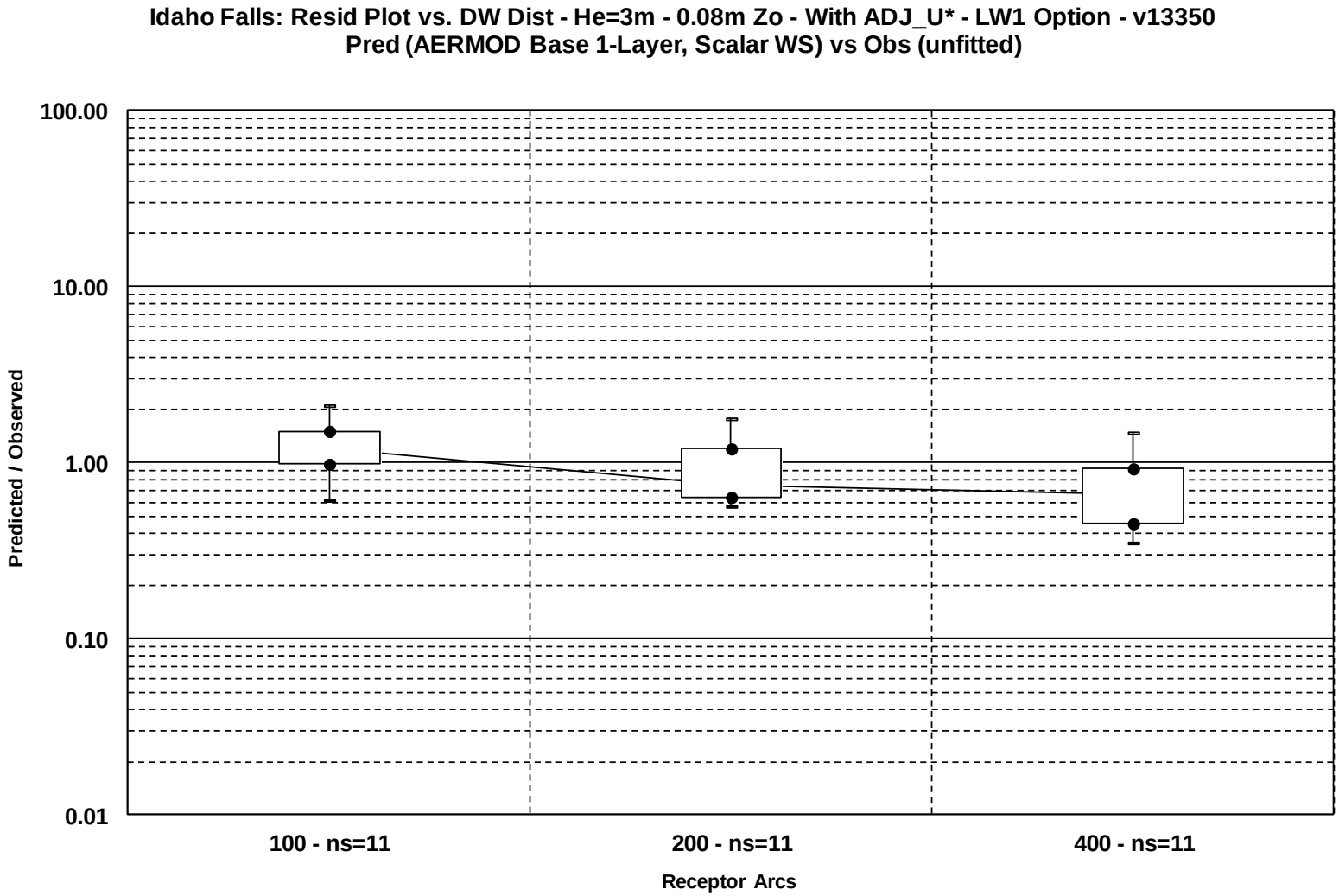
Idaho Falls – ADJ_U* Option



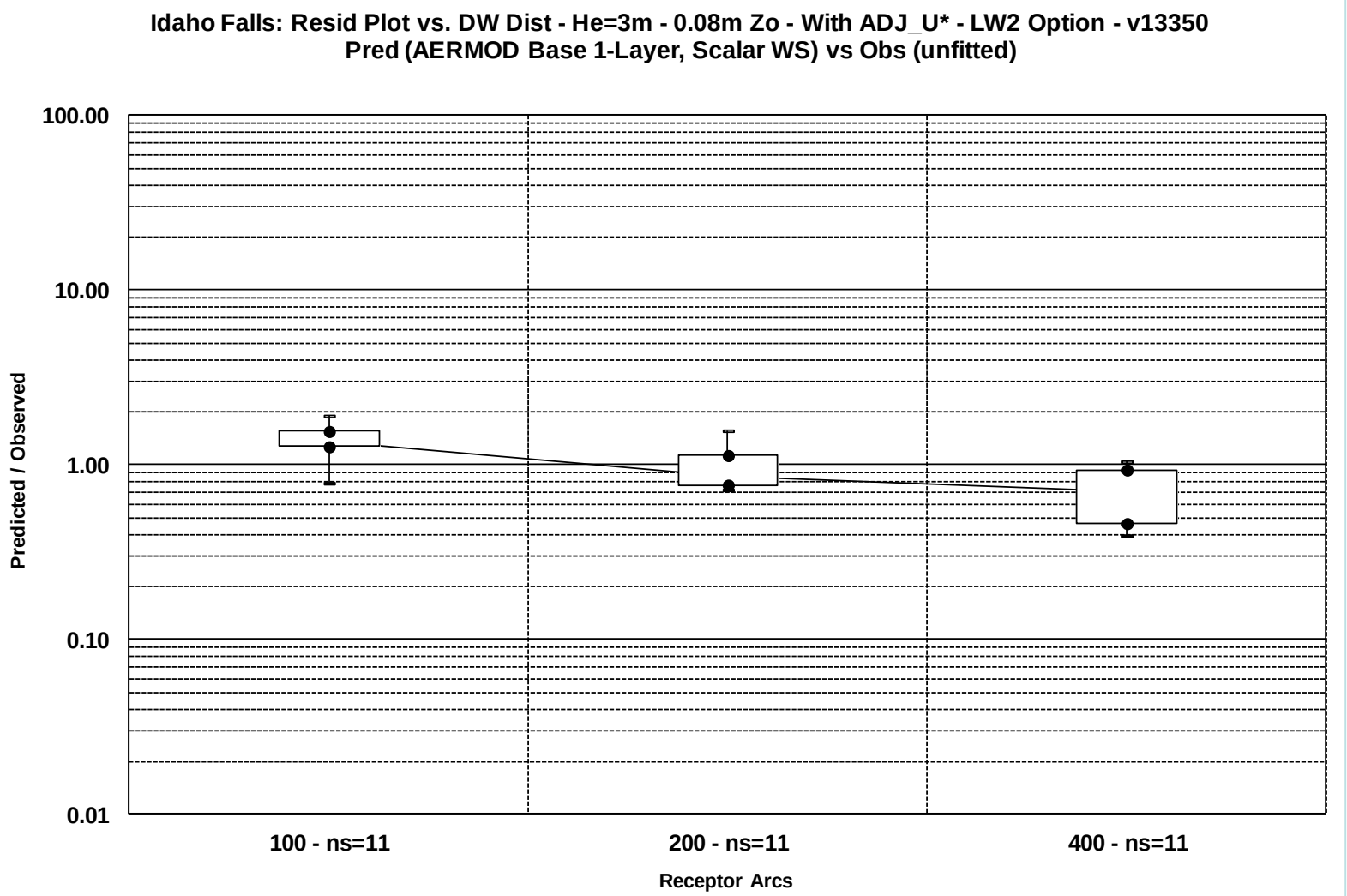
Idaho Falls – ADJ_U* Option



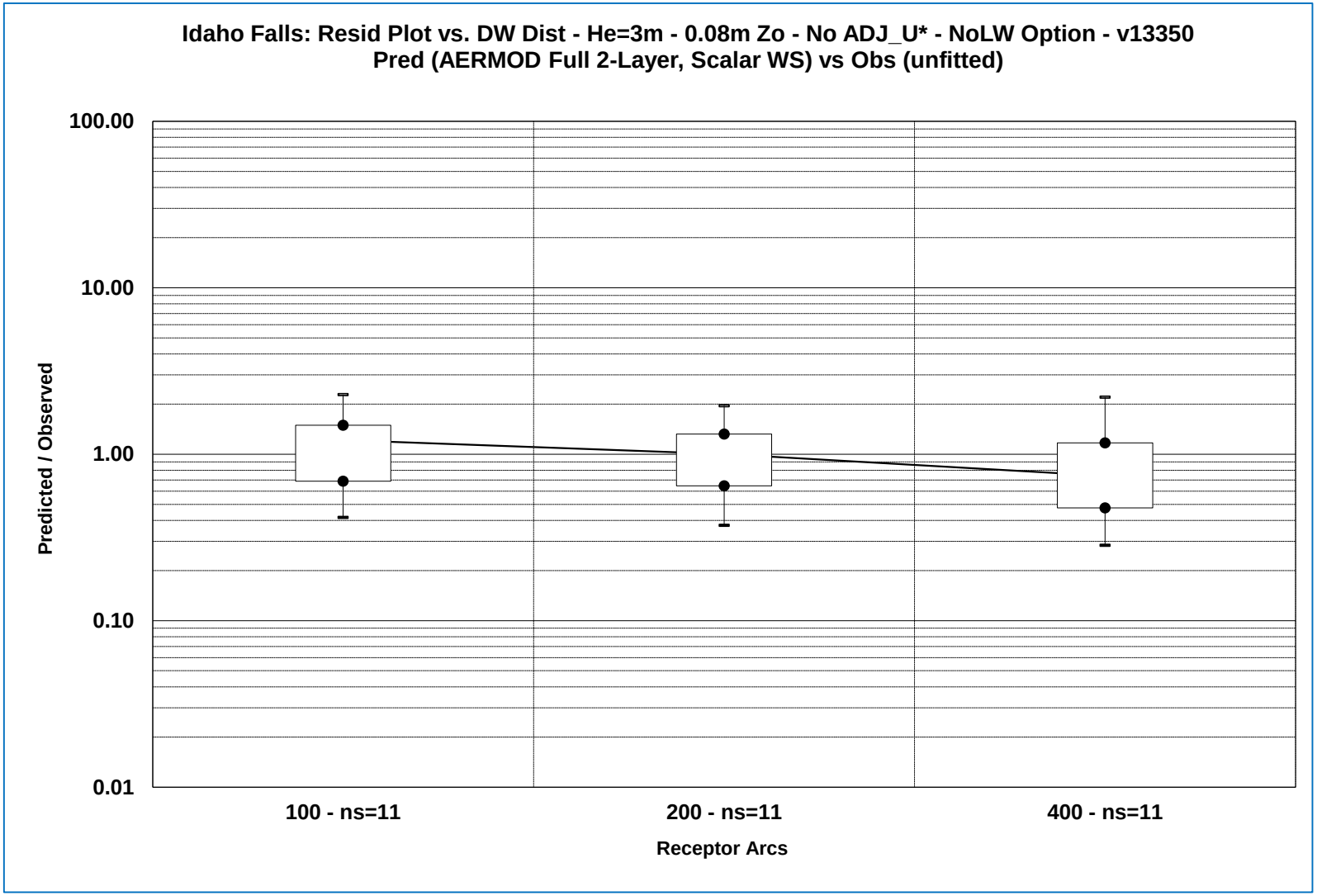
Idaho Falls – ADJ_U* Option



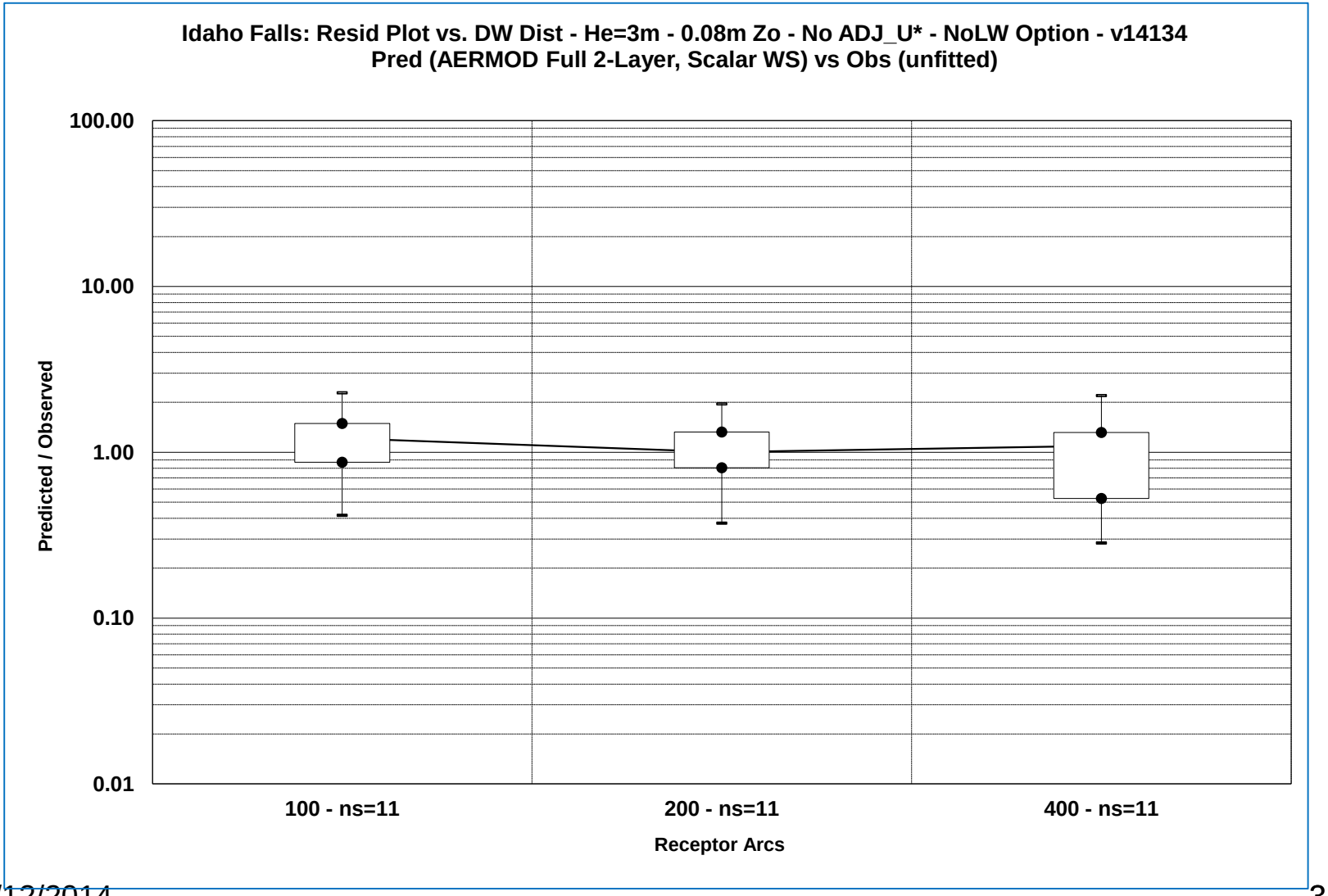
Idaho Falls – ADJ_U* Option



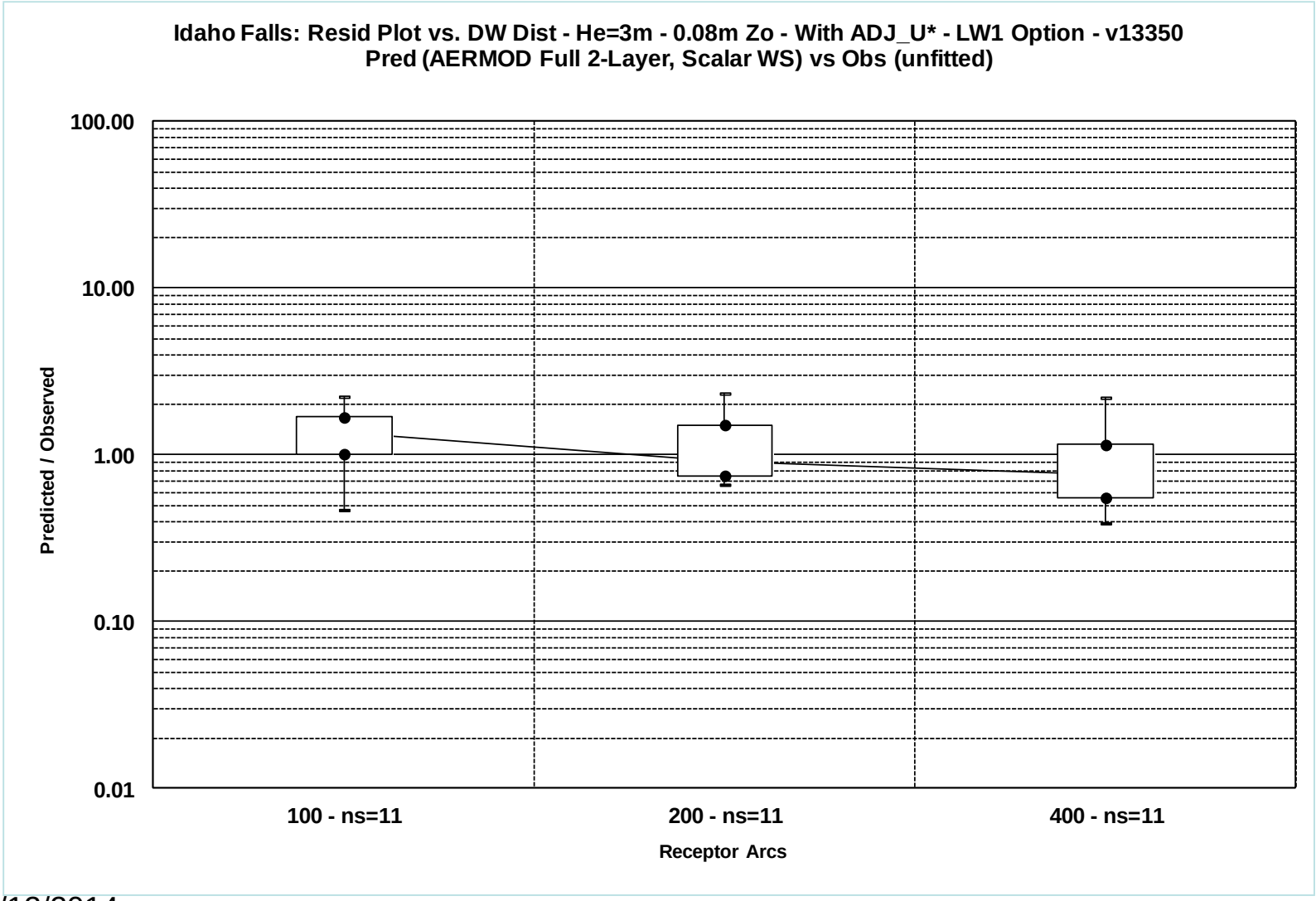
Idaho Falls – ADJ_U* w/BULKRN



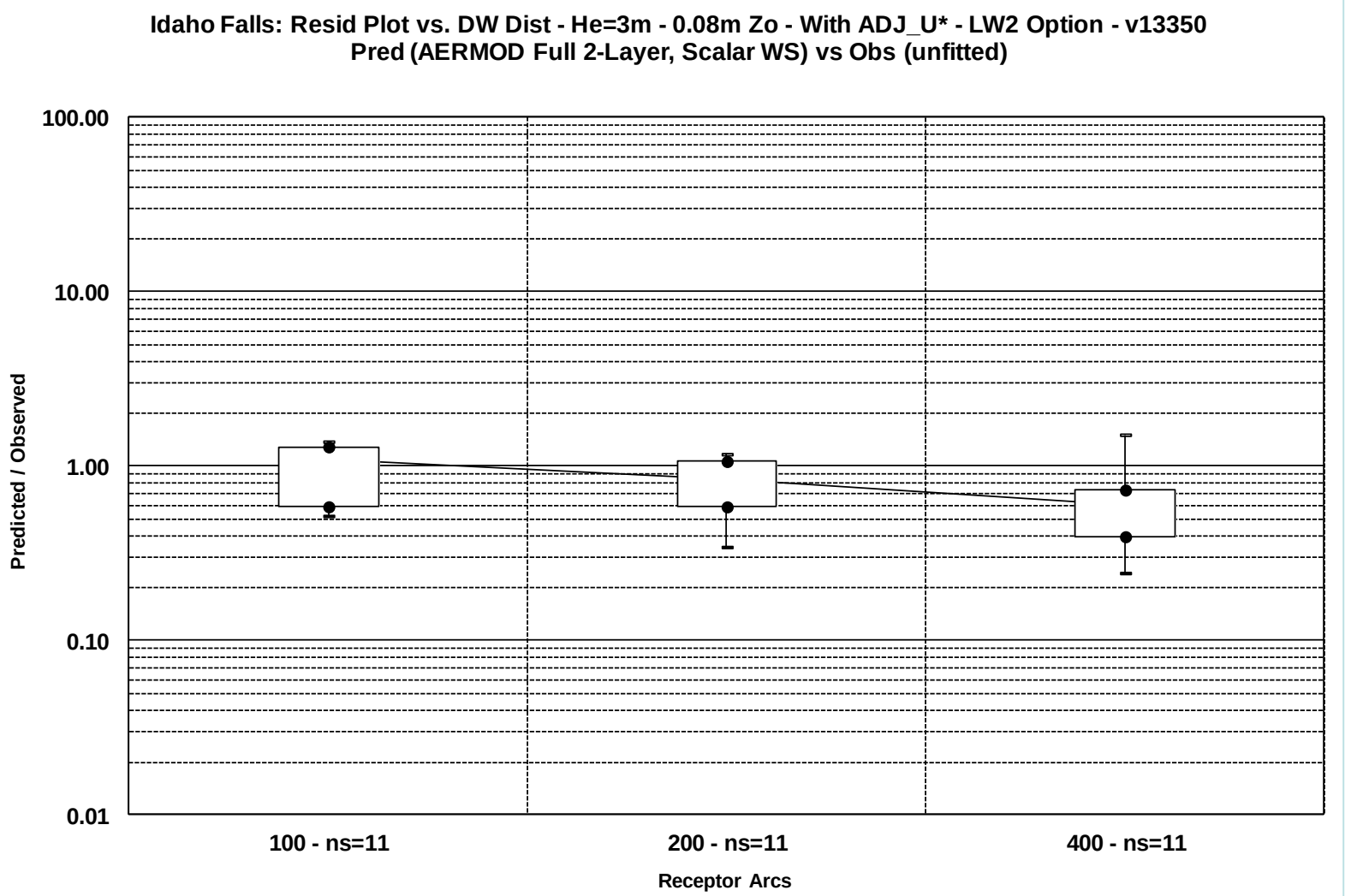
Idaho Falls – ADJ_U* w/BULKRN



Idaho Falls – ADJ_U* w/BULKRN



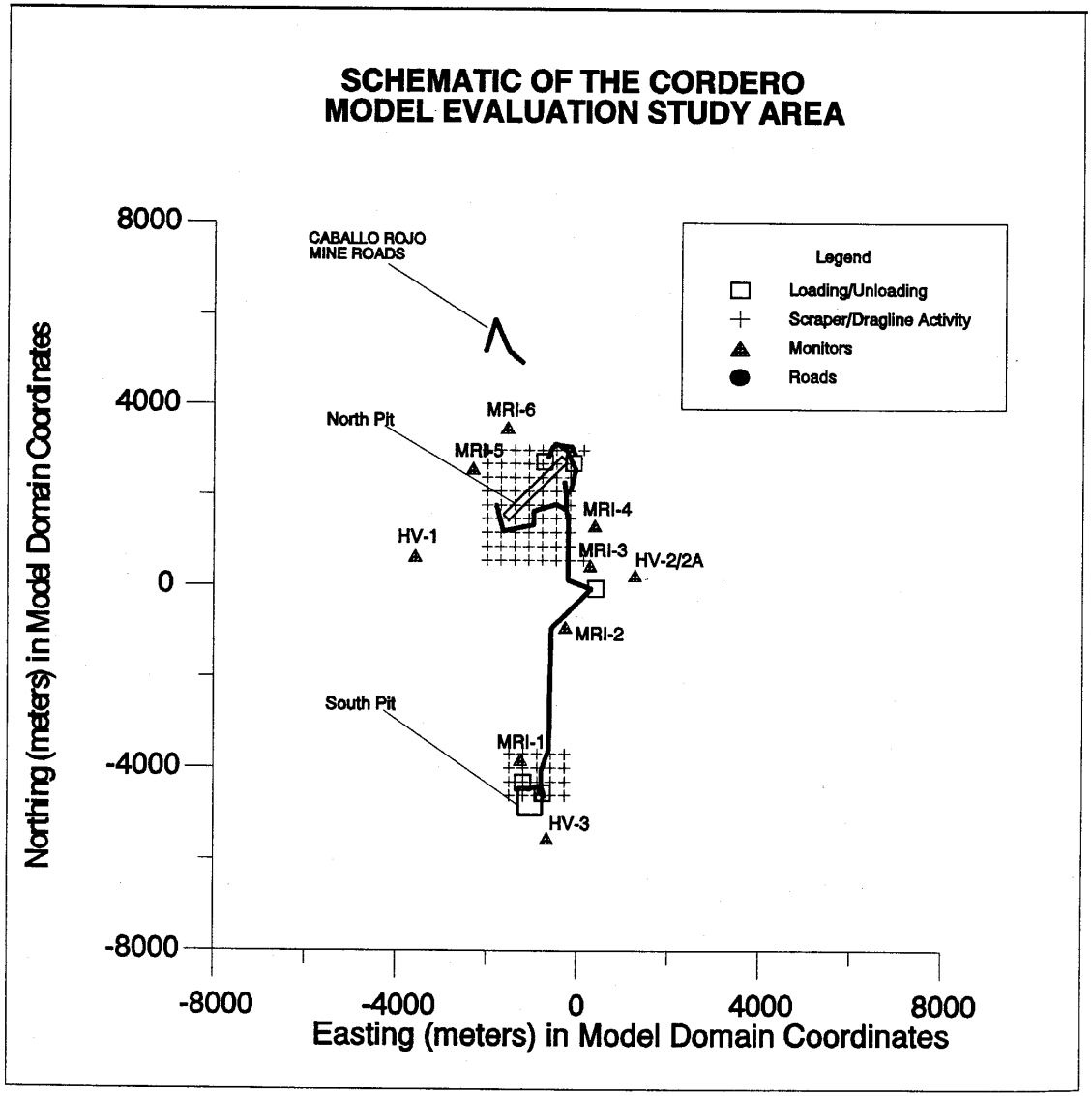
Idaho Falls – ADJ_U* w/BULKRN



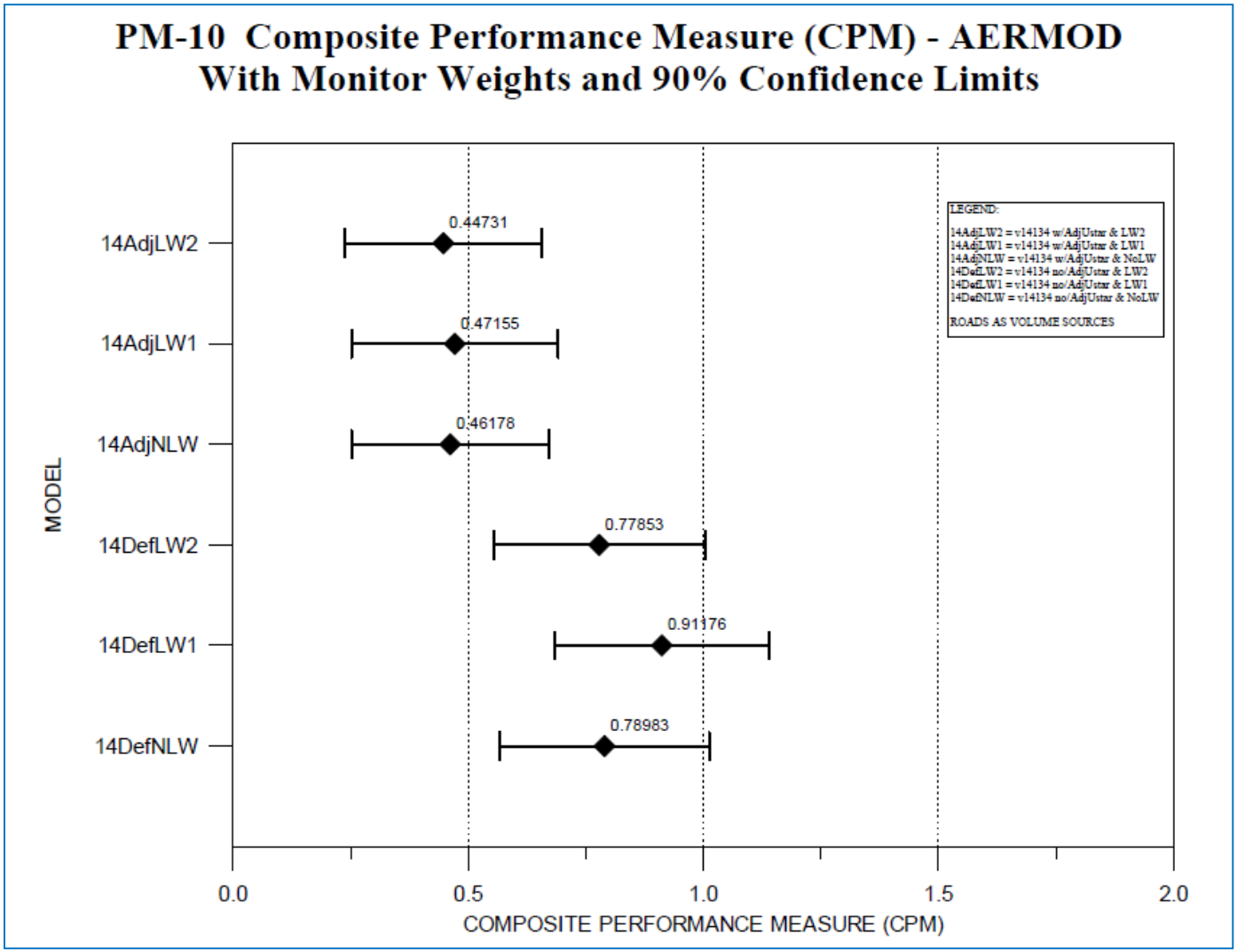
Evaluation of Beta Options

- Surface Coal Mine PM10 Study
  - Cordero Rojo Mine in eastern Wyoming
  - Two-month Field Study in 1993 to evaluate new emission factor and dispersion model options
  - Evaluated 24-hour averages for PM-10 and TSP
  - Majority of emissions (~75%) from roadways
  - Cox-Tikvart protocol for determining the “best performing” model applied to give “confidence intervals” on model performance

Evaluation of Beta Options

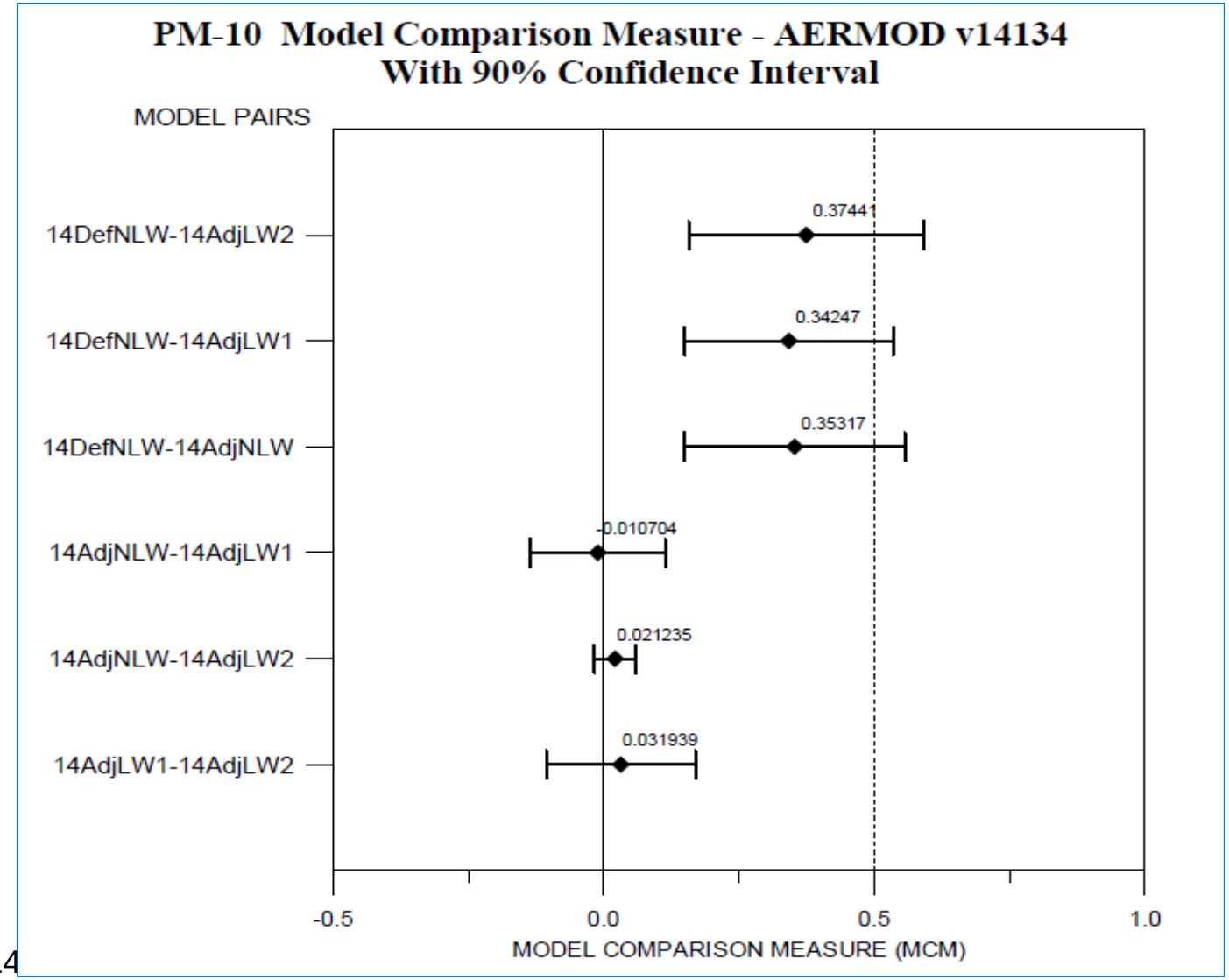


Evaluation of Beta Options



Note: Smaller value of CPM indicates “better” performance”

Evaluation of Beta Options



Note: If MCM confidence interval spans zero performance differences not statistically significant

Future Plans for AERSURFACE

- Release Beta version of AERSURFACE with Effective Roughness Method based on IBL approach:
  - Supports 1992, 2001 and 2006 NLCD data, supplemented by 2001/2006 Impervious and 2001 Canopy data;
  - Based on evaluation results, IBL approach shows better performance vs. IBL estimates than current approach with default 1km radius; however IBL/GFM results suggest that 1km is a reasonable default;
  - Beta version will utilize a pathway/keyword user interface, similar to AERMOD, and will include an option to specify different locations and separate data files for surface roughness vs. Bowen ratio and albedo, as discussed in Section 3.1.2 of AERMOD Implementation Guide;
  - Option to specify “airport” vs. “non-airport” by sector is also included for cases where buildings are located close to tower location.

Future Plans for AERSURFACE

- Release Gust Factor (GF) Tool for use with 1-min ASOS wind data:
  - GF Tool may provide a useful QA check for results based on AERSURFACE, potentially identifying issues with temporal representativeness of NLCD data, misclassified land cover categories, and/or errors in tower location;
  - GF Tool may also serve as an alternative source of surface roughness inputs to AERMET in some cases.

Upper Air Data Substitution

- An UA data substitution tool has been developed to facilitate the use of more than one representative upper air data source (undergoing internal review);
- When UA data is missing, all convective hours for that day will be missing:
  - This may introduce a bias in modeled results, and users may not be aware of how often this occurs;
- Since UA data is typically representative of a large area, multiple UA stations may be adequately representative for a given application;
- The tool “splices” together UA data from a primary station and up to two alternative stations; substituted days are identified in AERMET Stage 1 report file.

New NO_2 Modeling Guidance

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OAR/OAQPS/AQAD/AQMG

Outline

- Summary of current guidance
- ARM
- ARM2
  - Summary of API report
  - EPA analysis
  - Recommended approval scenarios
- NO2/NOx in-stack ratios (ISR)
- Selection of Tier 3 methods
- Selection of background monitoring data

Summary of current guidance

- Tier 1 – assume full conversion of NO to NO_2
- Tier 2 – multiply Tier 1 results by empirically derived NO_2/NO_x ratios
  - 0.75 as the national default ratio for annual
  - 0.80 as the national default ratio for hourly
- Tier 3 – detailed screening methods
  - Ozone Limiting Method (OLM, Cole and Summerhays, 1979)
  - Plume Volume Molar Ratio Method (PVMRM, Hanrahan, 1999)

Summary of current guidance

- Tier 3 methods are non-default and require approval by permitting authority
- All methods are screening
  - Cannot use negative emissions for annual increment/offset analysis

Tier 2 methods: ARM

- Ambient ratio method (ARM) now available in AERMOD
  - CO ARMRATIO used to modify annual and hourly default ratios
  - BACKGRND is included in the SRCGROUP ALL in order to automatically add background in model computations

Tier 2 methods: ARM2

- New Tier 2 method, ARM2
  - Based off analysis of EPA's Air Quality System (AQS) record of ambient air quality data
  - ARM2 equation derived from highest NO_2/NO_x ratio in bins of AQS data
  - 6^{th} order polynomial to fit data, with maximum and minimum ratios set to 0.9 and 0.2
  - Non-default beta option, requires approval for use
  - Full documentation in API report:

    http://www.epa.gov/ttn/scram/models/aermod/ARM2_Development_and_Evaluation_Report-September_20_2013.pdf

Figure 1– NO_2/NO_X Ratios for All AQS Monitoring Sites for 2001-2010

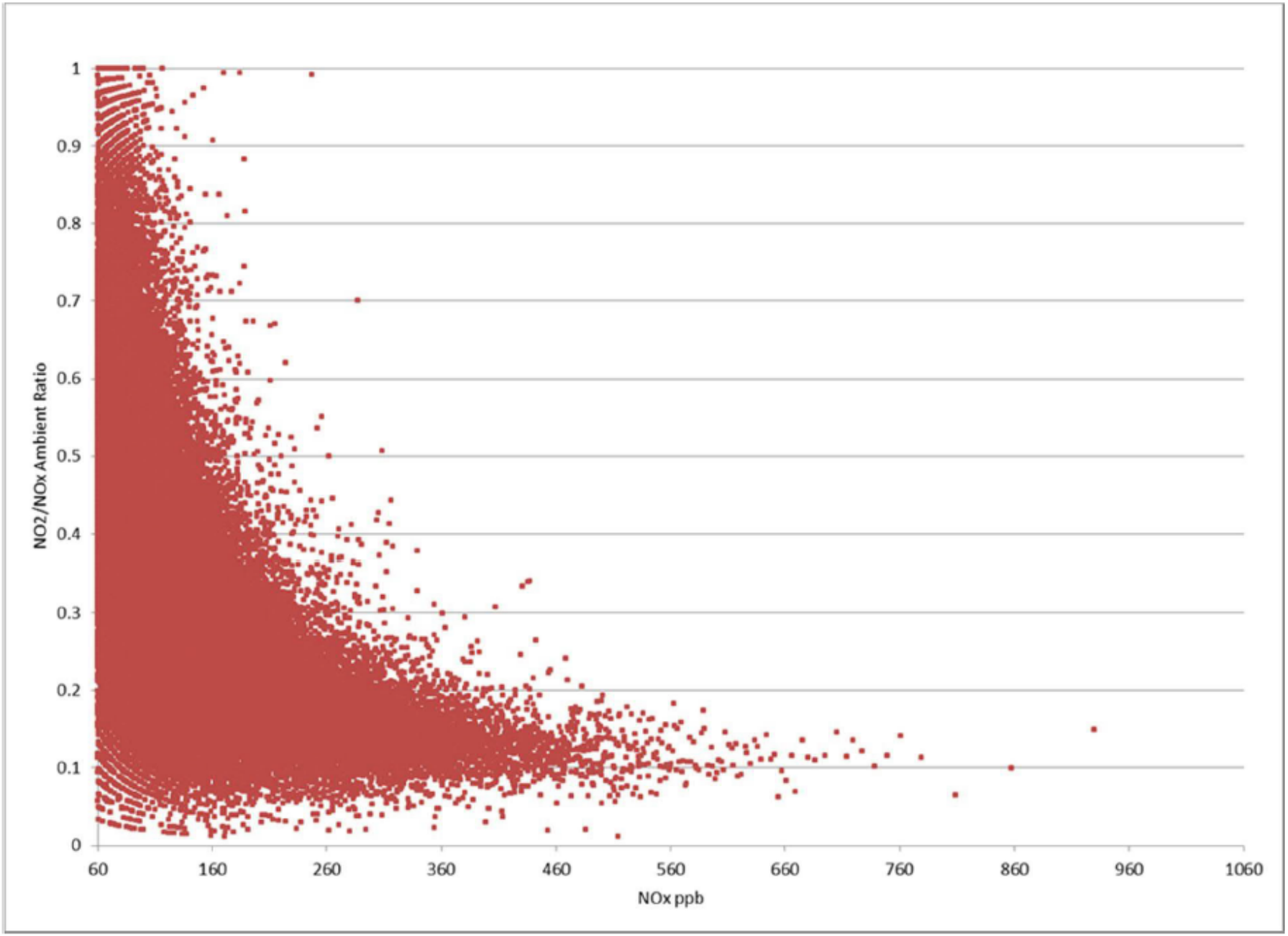


Figure 4 – 98th Percentile Ambient Ratios and ARM2 Equation for "All AQS Sites" Data

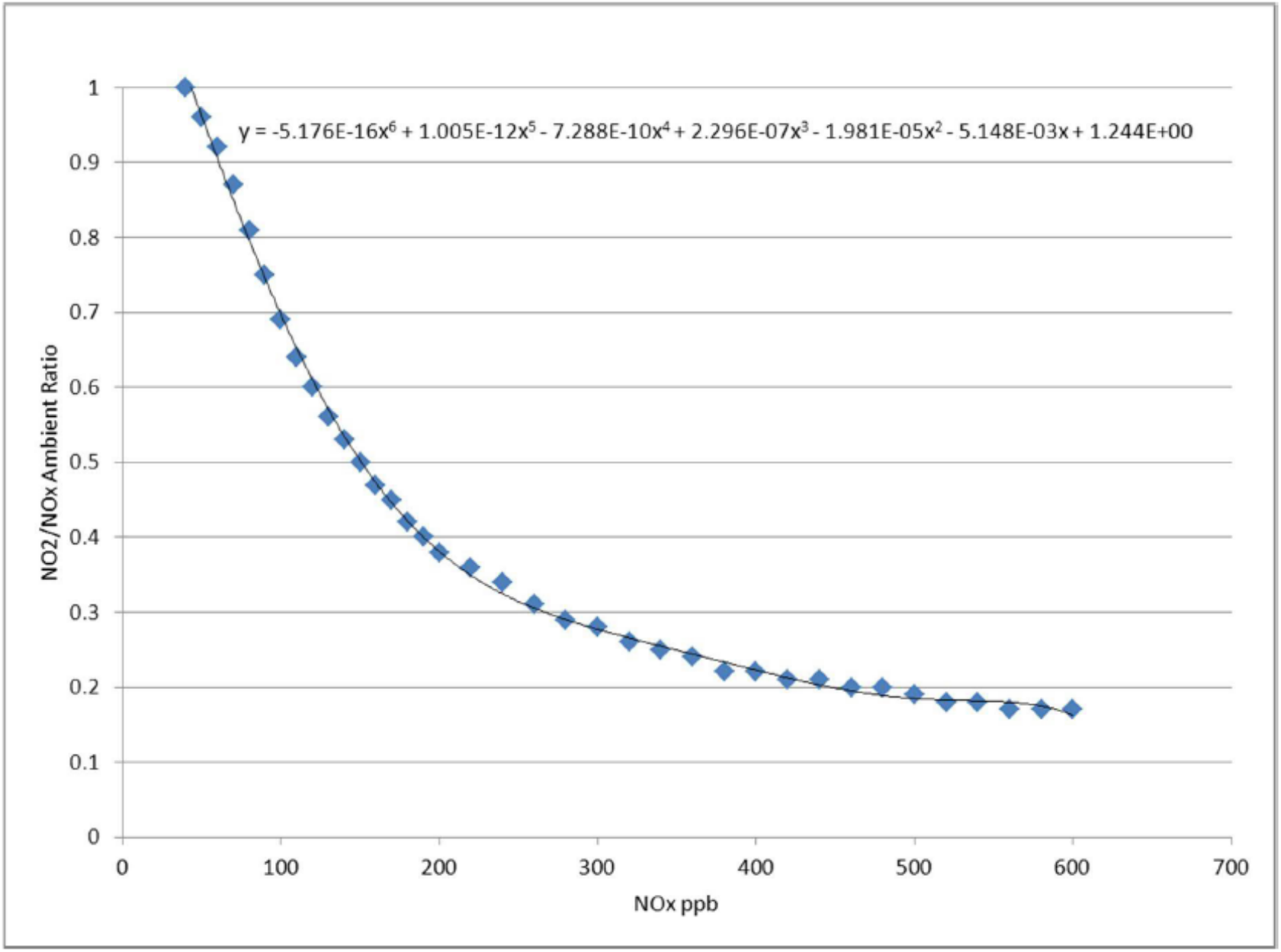


Figure 8 –Plot of NO_2/NO_X Ratio vs NO_X for Empire Abo North Data Set

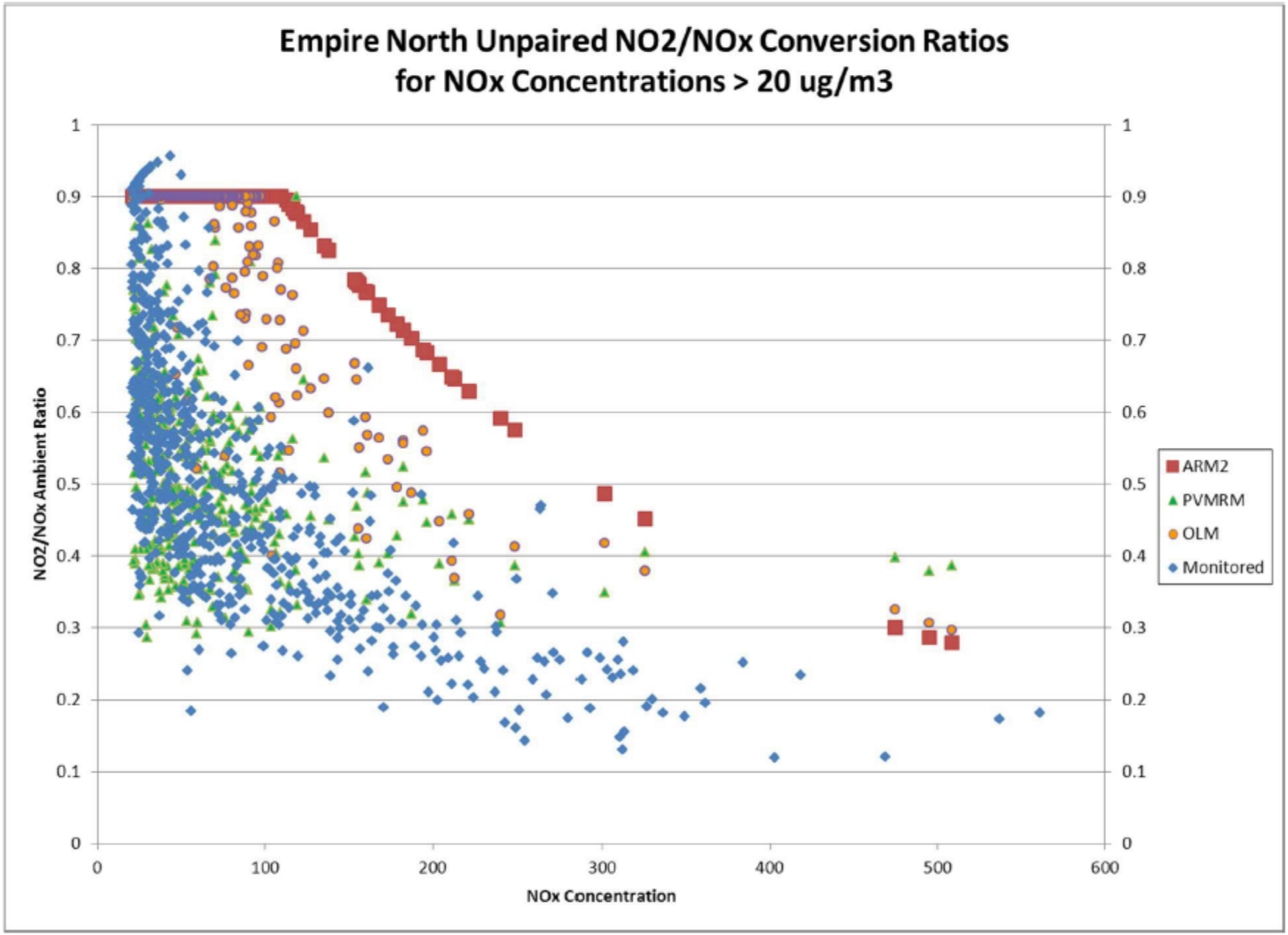
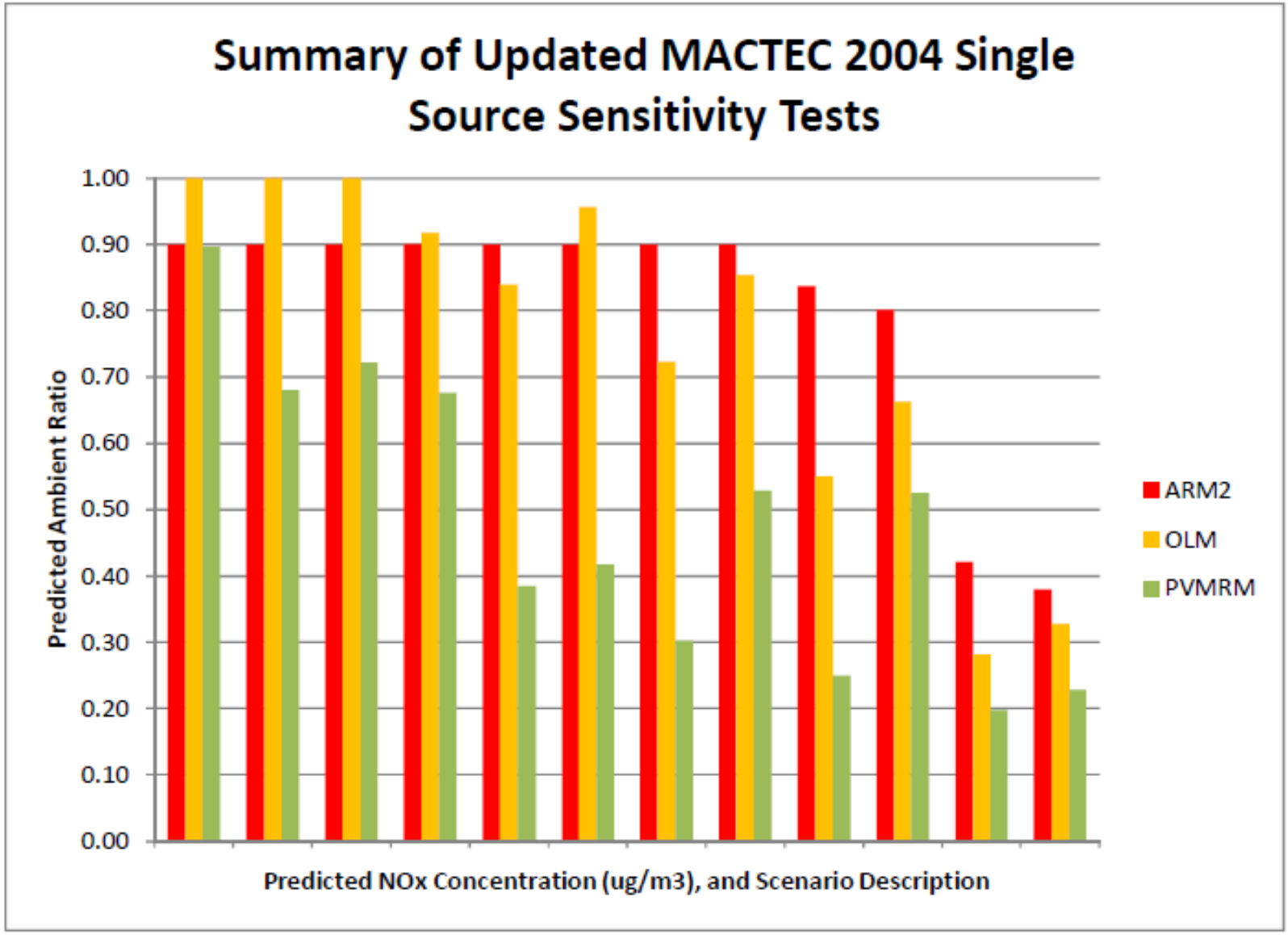


Figure 18 – Results from Single Source Sensitivity Analyses



Summary of API report findings

- ARM2 was conservative relative to measurements and Tier 3 methods for field studies
- ARM2 was usually conservative relative to Tier 3 methods for sensitivity studies
  - Cases where OLM or PVMRM might be expected to over predict NO conversion to NO_2

EPA analysis

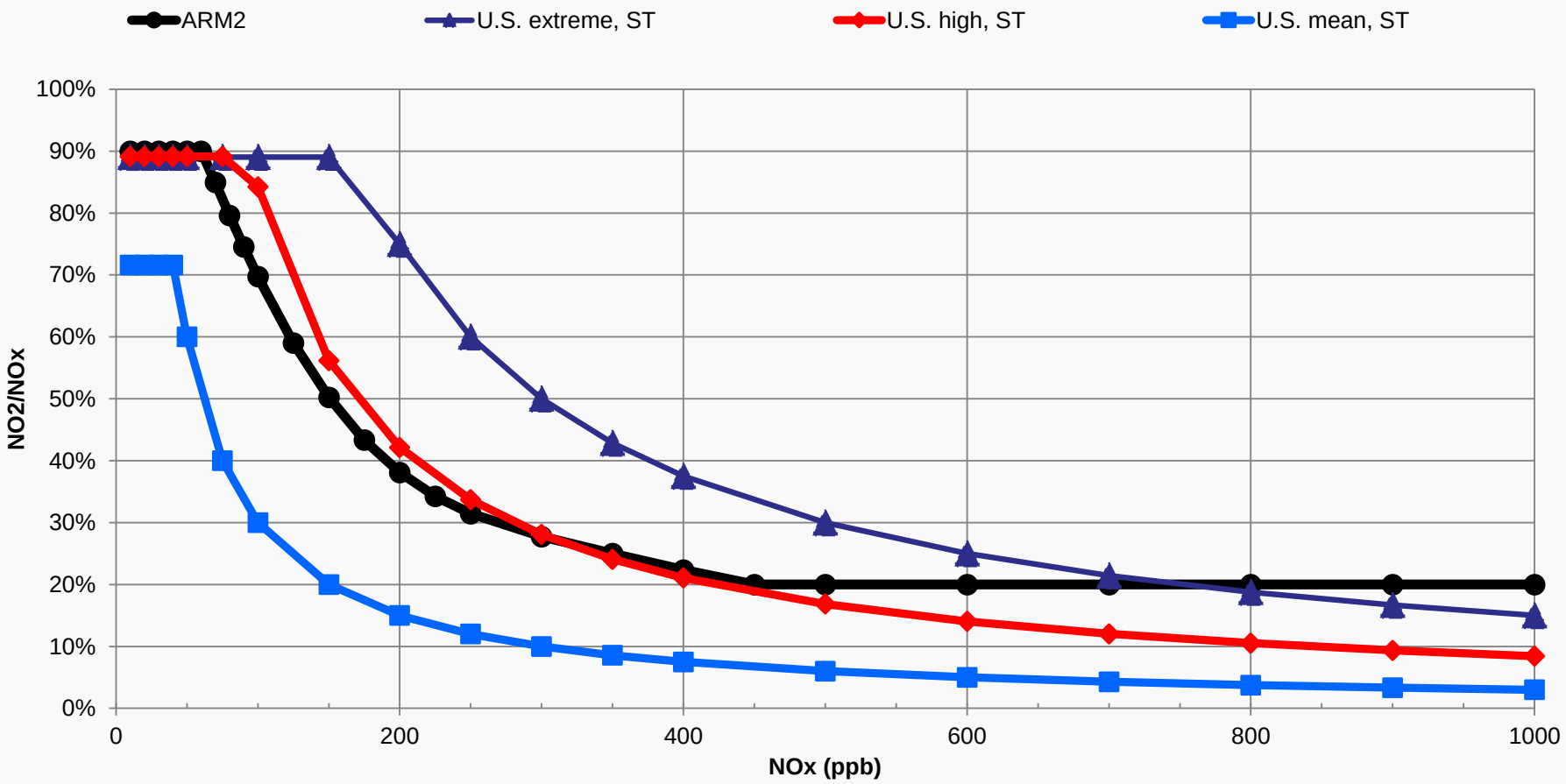
- API analysis had 2 major shortcomings:
  - Sources in field studies and sensitivity tests had ISR < 0.2
  - Not clear that the AQS data reflects direct impacts of major sources with a high ISR
- EPA analysis focused on understanding ARM2 performance when modeling high ISRs

EPA analysis: theoretical cases

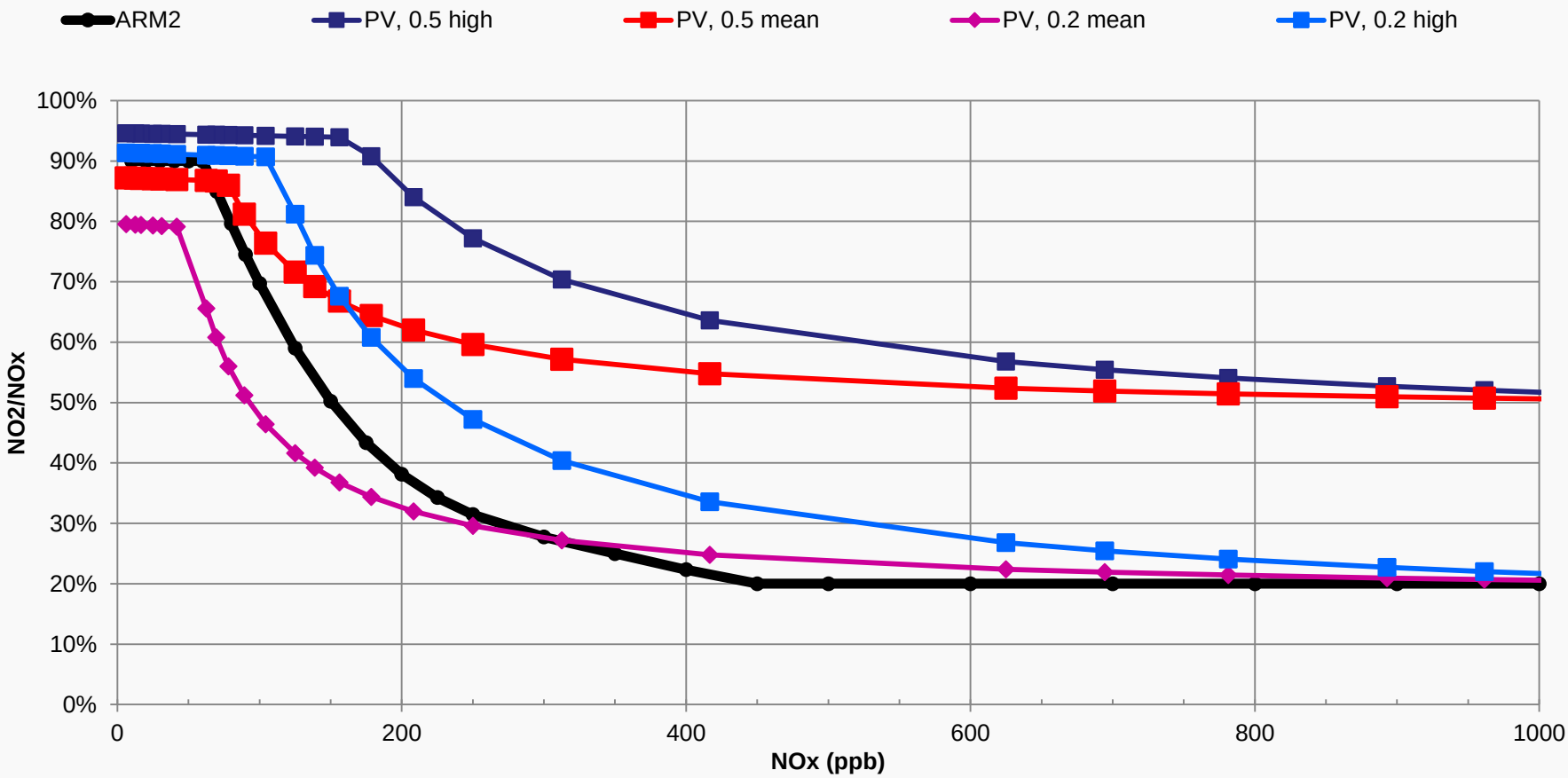
- Combinations of
  - complete titration of NO by ozone
  - pseudo-steady state approximation between NO, NO_2 and ozone
- Considered ranges of ambient conditions

ISR	Ozone (ppb)	Temp (F)	Solar zenith angle (degrees)	Cloud cover
0.0	150	97	25 (Texas or Florida)	0%
0.0	30	56	37.5 (e.g., Kansas)	50%
0.0	84	76	37.5 (e.g., Kansas)	50%
0.2	30	76	37.5 (e.g., Kansas)	50%
0.5	30	76	37.5 (e.g., Kansas)	50%

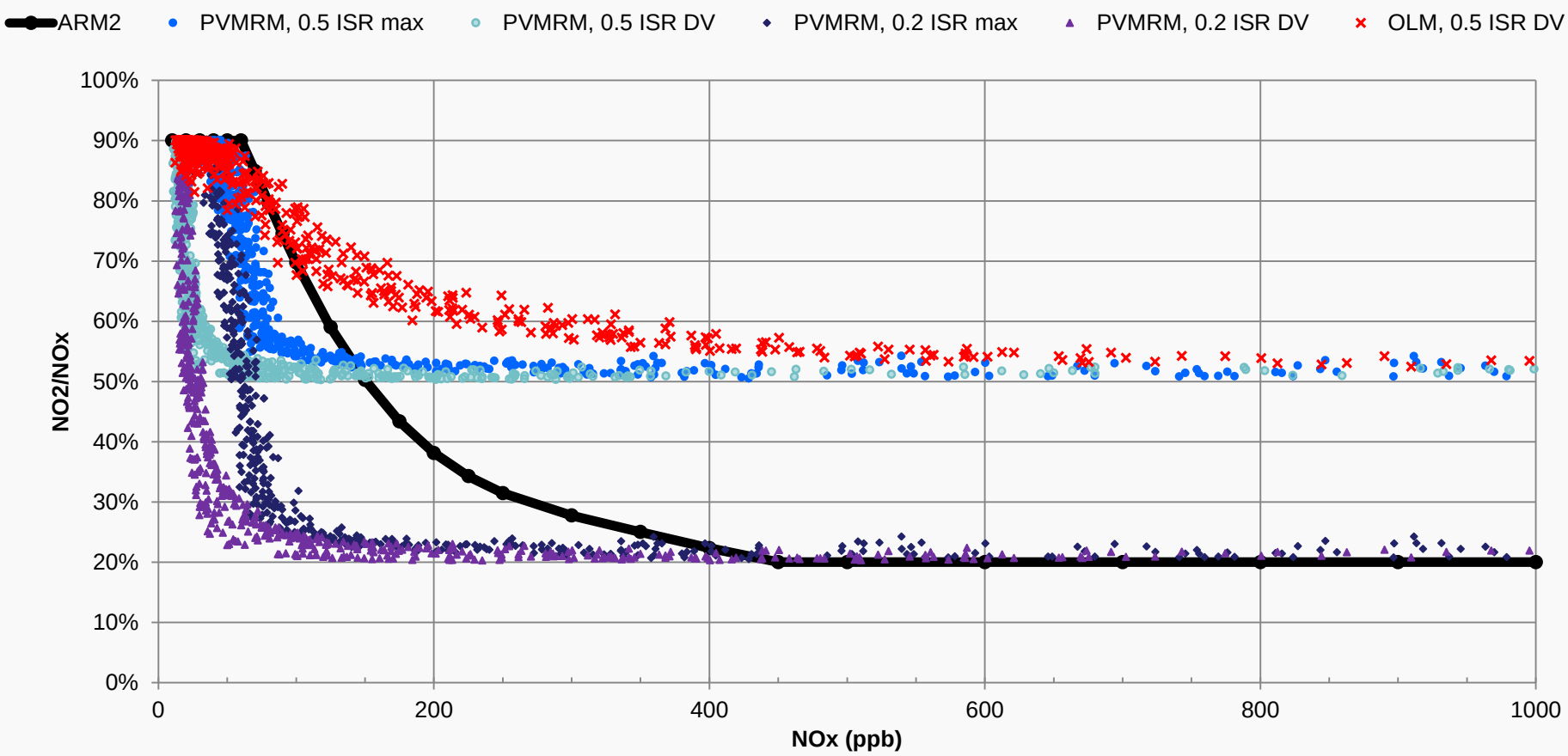
EPA analysis: theoretical cases with 0.0 ISR



EPA analysis: cases with 0.2, 0.5 ISR



EPA analysis: PVMRM, 0.2, 0.5 ISR



Recommendations for ARM2

- General recommendation for approval if
  - Tier 1 results from primary source less than threshold of 150-200 ppb NO_x, depending on general ozone levels
- If Tier 1 results greater than threshold:
  - Use ARM2 with demonstration that ISR < 0.2
  - Use ARM2 with alternate minimum ratio
  - Higher threshold if background NO_2 higher
- Recommend caution if particularly high background ozone levels

In-stack ratios (ISR)

- Traditionally only needed for Tier 3 NO_2 methods
- Important consideration for ARM2 approval
- Recommend permits include ISR submission to EPA database:

  http://www.epa.gov/scram001/no2_isr_database.htm
- New default ISR for “nearby sources” of 0.2
  - Sources greater than 1-3 km, depending on relative source strength and stack height

Tier 3 recommendations

- PVMRM works best for relatively isolated, elevated point sources.
- PVMRM may have problems with:
  - Surface release
  - Area sources
  - Groups of moderately spaced sources
  - In these cases, use OLM with “OLMGROUP ALL”
- OLM can be used for area sources, roadway sources

Background monitoring data

- AERMOD now includes direction-varying background option
  - Implemented in the SO BGSECTOR and CO O3SECTOR keywords
  - Multiple background files allowed; AERMOD selects file based on wind direction in surface file
  - Applicable sector is based on flow vector (downwind direction)
  - If downwind monitor is not appropriate, can adjust sector definitions by 180 degrees to select upwind monitor

Summary

- ARM2 acceptable in many cases, including:
  - Demonstration that source's ISR < 0.2
  - Tier 1 results < 150-200 ppb NO_x
  - Background ozone is not persistently high
- ISR important consideration
  - New default for "nearby sources" of 0.2
  - EPA recommends submission of ISR data to database whenever possible

  http://www.epa.gov/scram001/no2_isr_database.htm

Summary

- OLM and PVMRM can be used for area sources and roadways
  - But PVMRM may not perform well
    - Surface release
    - Large area sources
    - Moderately spaces sources
- New option in AERMOD of direction-varying background data