Webinar: AERMOD Modeling System Update

U.S. EPA/OAQPS
Air Quality Modeling Group

January 14, 2014

Outline

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

AERMOD Developments

- AERMOD Version 13350:
  - Several bug fixes, including:
    - Problem with use of DAYRANGE keyword for multiple years of meteorological data where the Julian day may have been incorrect;
    - Problem with skipping the calculation of the center of the effective area source for OPENPIT sources if the first receptor was located inside the boundaries of the actual OPENPIT source;
    - Problem with “double counting” unit conversions for non-hourly background data;
  - Potentially significant bug fix/patch for some applications involving building downwash due to the initial sigma-z for the “cavity source” in PRIME being set to zero (0):
    - Significant overpredictions of about 8 times showed up in one application associated with changes in wind speed of < 0.01 m/s

AERMOD Developments

- AERMOD Version 13350 (cont.):
  - Incorporated several enhancements, including:
    - Options to vary background concentrations by wind sector for the pollutant being modeled, and/or for background O_3 data used for modeling NO_2 with the OLM and PVMRM Tier 3 BETA options:
      - » Background concentrations are selected based on flow vector (i.e., downwind direction), reflecting background levels in the direction of plume transport;
      - » Direction-varying background can be specified using any of the existing options, e.g., hourly data, values varying by month, season, season and hour-of-day, etc., and different options may be used for different sectors depending on the available data

AERMOD Developments

– AERMOD Version 13350 (cont.):

- Incorporated several enhancements, including:
  - Incorporated new options for modeling NO_2, including a new Default option for the Tier 2 Ambient Ratio Method (ARM), and a non-Default BETA option for the Ambient Ratio Method – 2 (ARM2) developed by API. Note that the ARM and ARM2 ratios are applied only to the modeled NO_x concentrations, not to the background NO_2 concentrations if provided;
    - » ARM and ARM2 have the advantage of not requiring in-stack NO_2/NO_x ratios or representative background O_3 data;
    - » ARM2 includes default maximum NO_2/NO_x ratio of 0.9 and default minimum NO_2/NO_x ratio of 0.2;
    - » Additional clarifications regarding NO_2 modeling will be issued soon.

AERMET Developments

– Version 13350:

- Incorporated AECOM's recommended corrections to theta-star under the ADJ_U* Beta option introduced in version 12345 based on Qian and Venkatram (2011);
- Incorporated the Luhar and Rayner (2009) approach for estimating U* under stable conditions as part of the ADJ_U* Beta option under the Bulk Richardson Number (BULKRN) method based on delta-T measurements for stable conditions (also included in the API/AECOM low-wind study);
- Corrected the coefficient used in calculating the mechanical mixing height from 2300 to 2400, based on original reference by Venkatram (BLM, 2009), which will slightly increase mechanical mixing heights;
- Allow for the use of ONSITE mixing heights only, without requiring upper air data, including modifications to process the previously obsolete LOCATION keyword on the METPREP (Stage 3) pathway to allow users to specify the time zone adjustment from GMT to LST;

AERMET Developments

– Version 13350 (cont.):

- Incorporated options to substitute for missing cloud cover (CCVR) and temperature (TEMP) data based on linear interpolation across 1 or 2-hour gaps;
  - Substitutions will be incorporated by default if only SURFACE or only ONSITE data are available, but options are also included to allow users to disable the substitutions;
  - Linear interpolation across short gaps is considered reasonable for these parameters;
  - Initial motivation for these options was a concern that 1 or 2-hour gaps in CCVR or TEMP near sunrise could result in all convective hours for that day being missing;
  - May also facilitate use of surface data sets that include 3-hourly CCVR data (although caution should be used)

Evaluation of Beta Options

- Updating and expanding evaluations of new Beta options in AERMET and AERMOD, based on evaluations performed by AECOM/API (results for v12345 were summarized in Appendix F of the AERMOD User's Guide Addendum);
- 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).

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

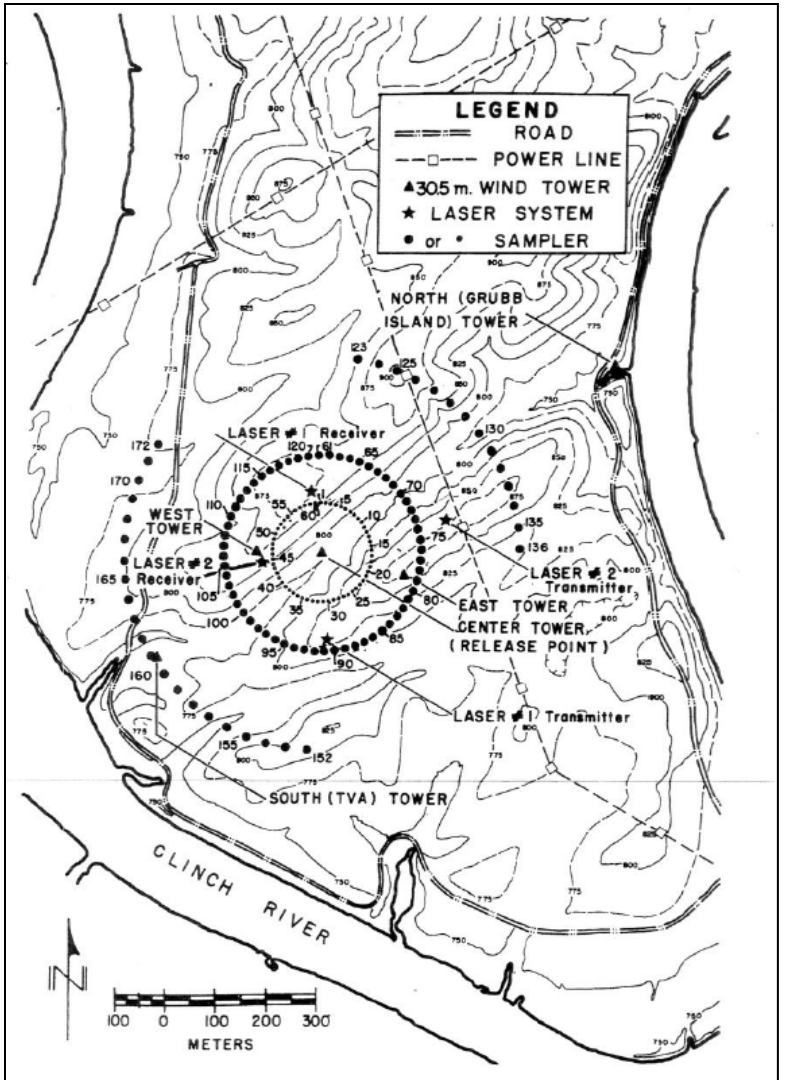
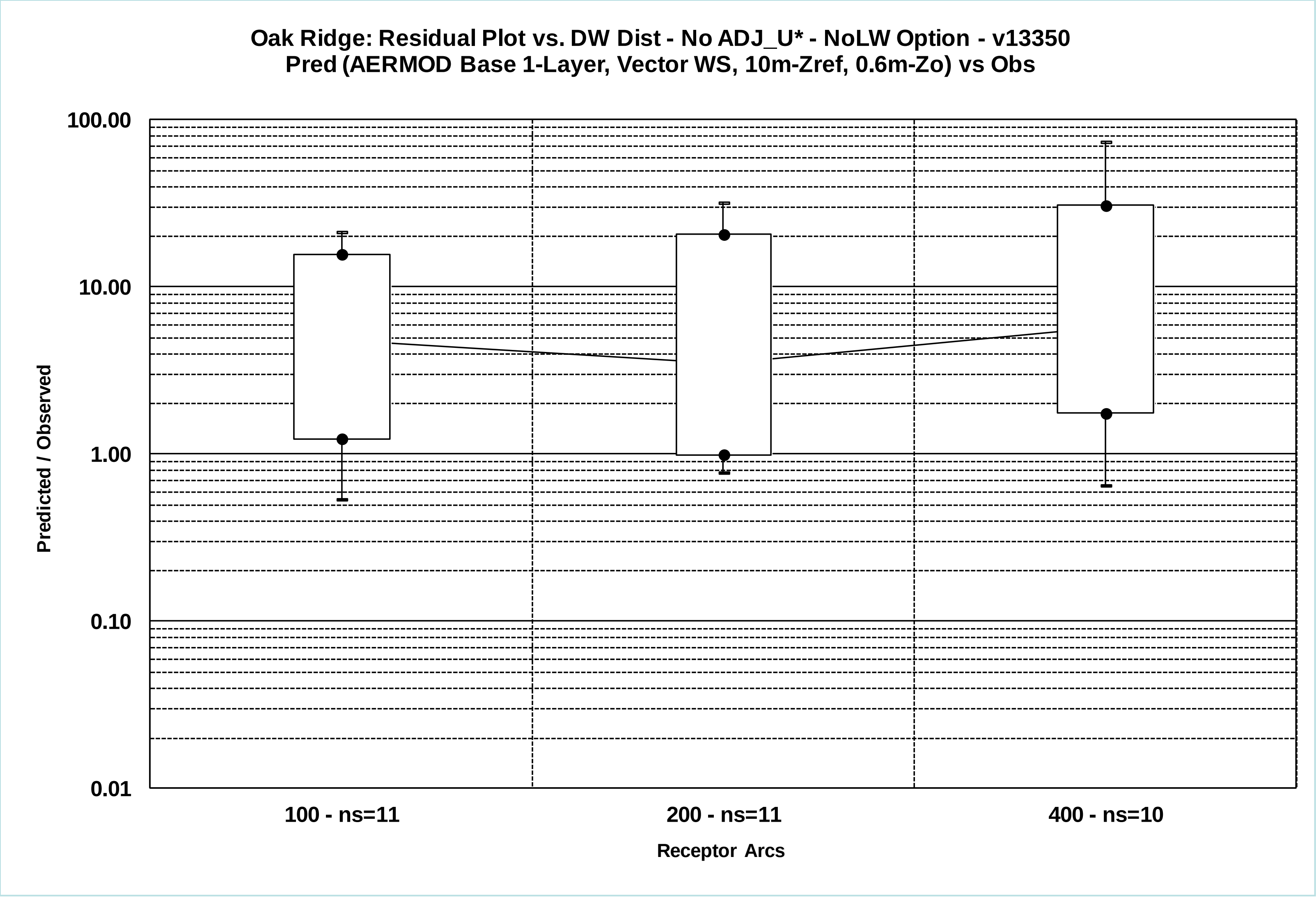


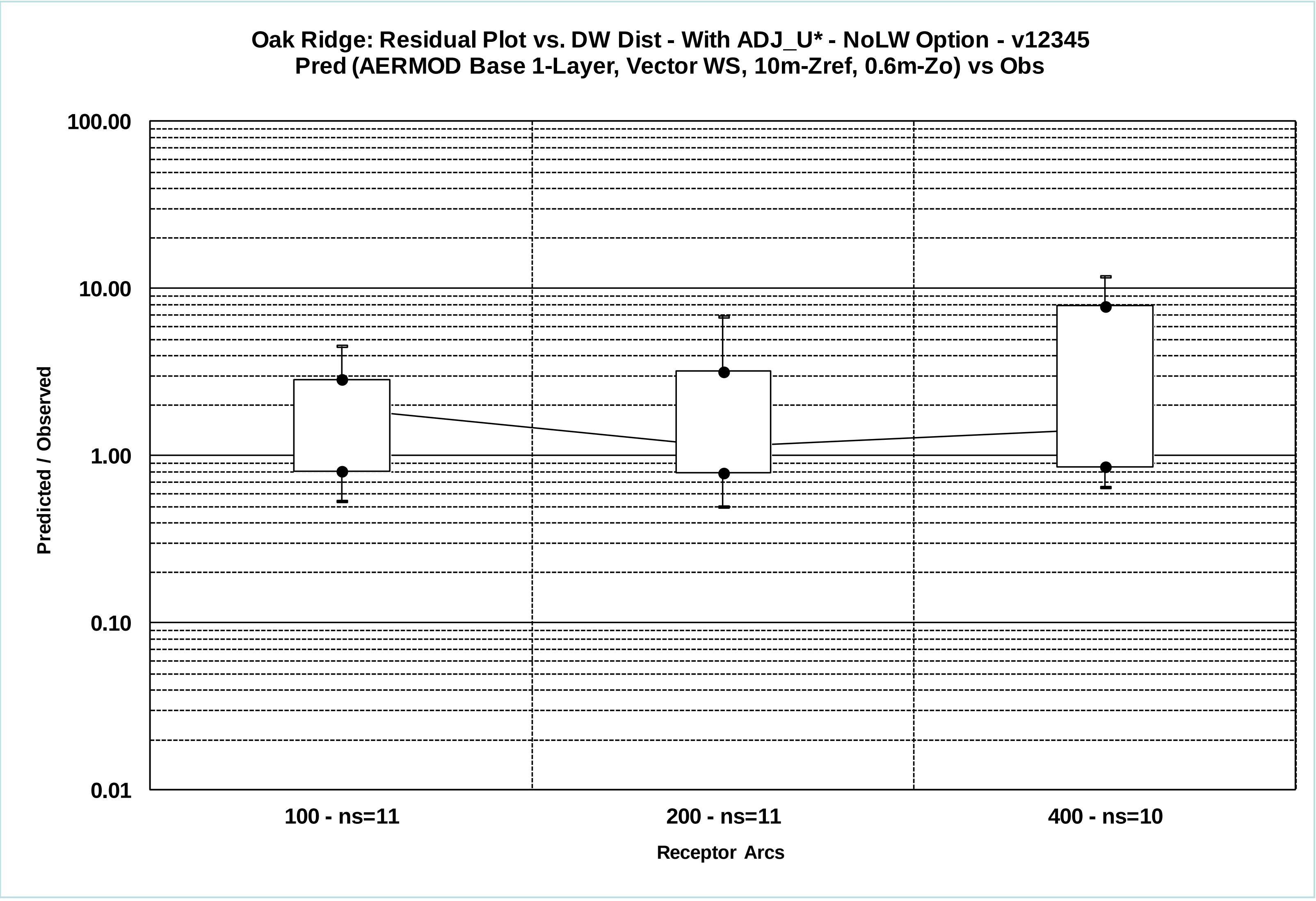
Figure 2b. Detail of inner sampling arcs showing location of meteorological towers and laser transmitters and receivers. (Contour heights are in feet above sea level).

From NOAA Technical Memorandum ERL ARL-61, 1976.

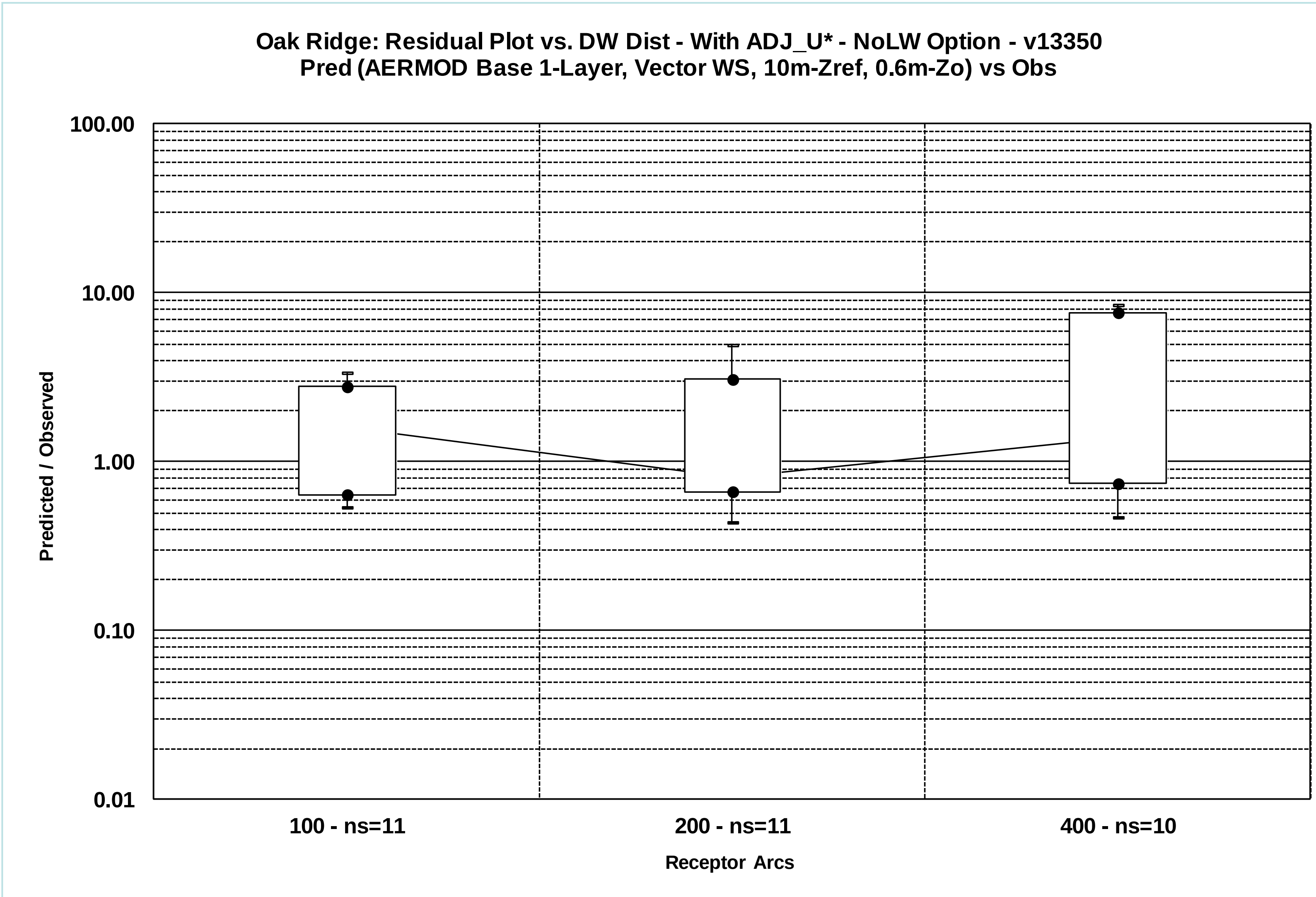
Oak Ridge – Base Model



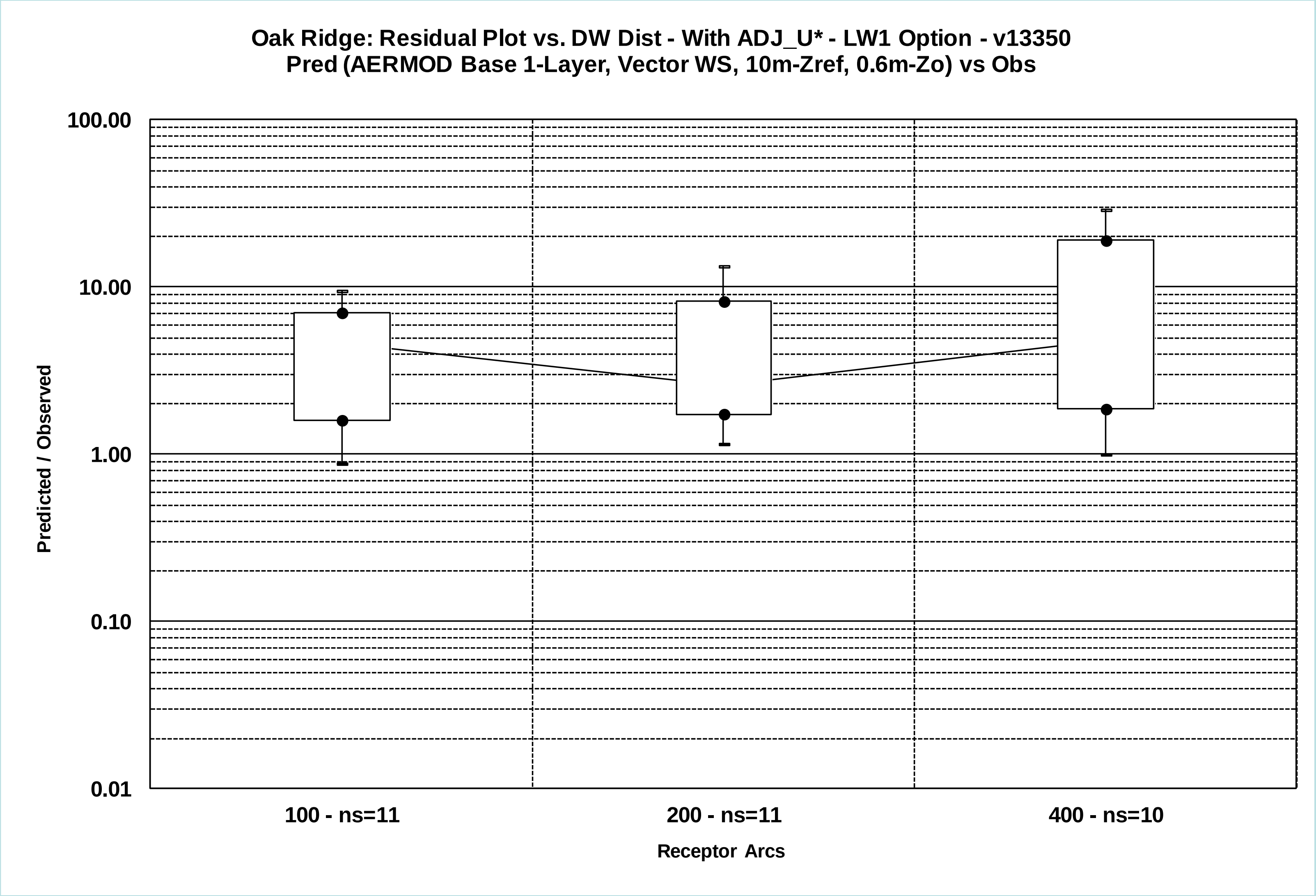
Oak Ridge – ADJ_U* Option



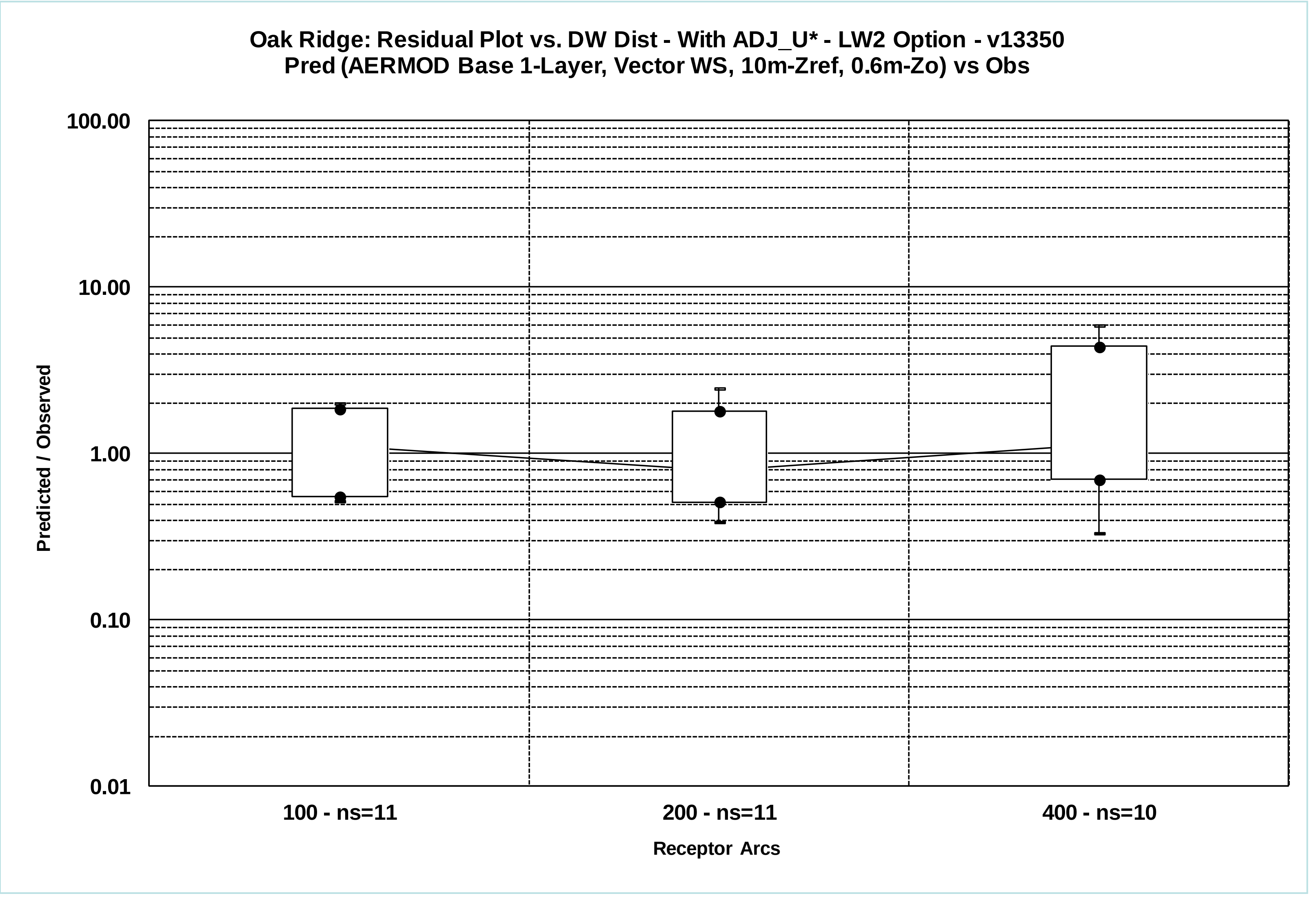
Oak Ridge – ADJ_U* Option



Oak Ridge – ADJ_U* Option



Oak Ridge – ADJ_U* Option

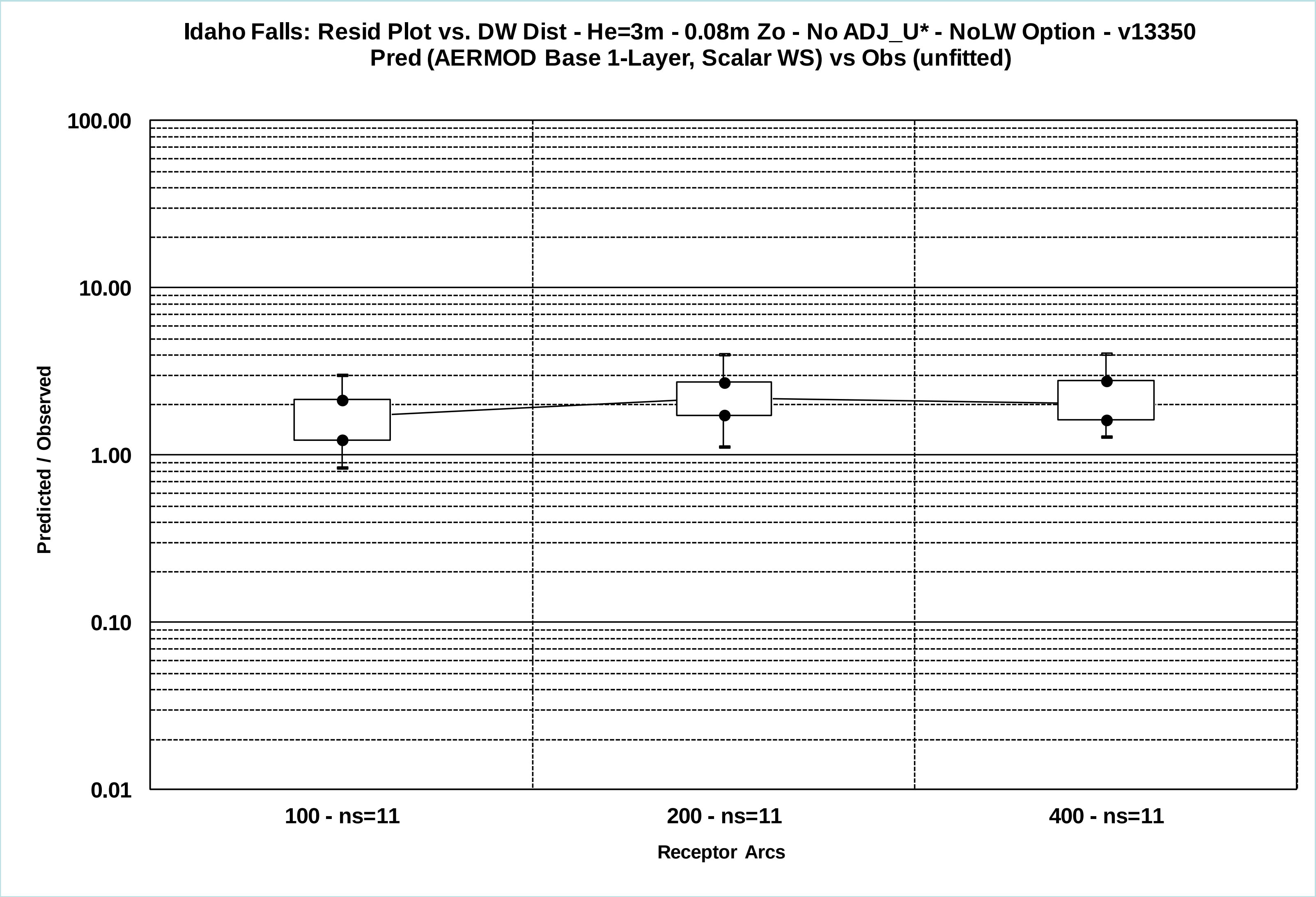


Idaho Falls Study Area

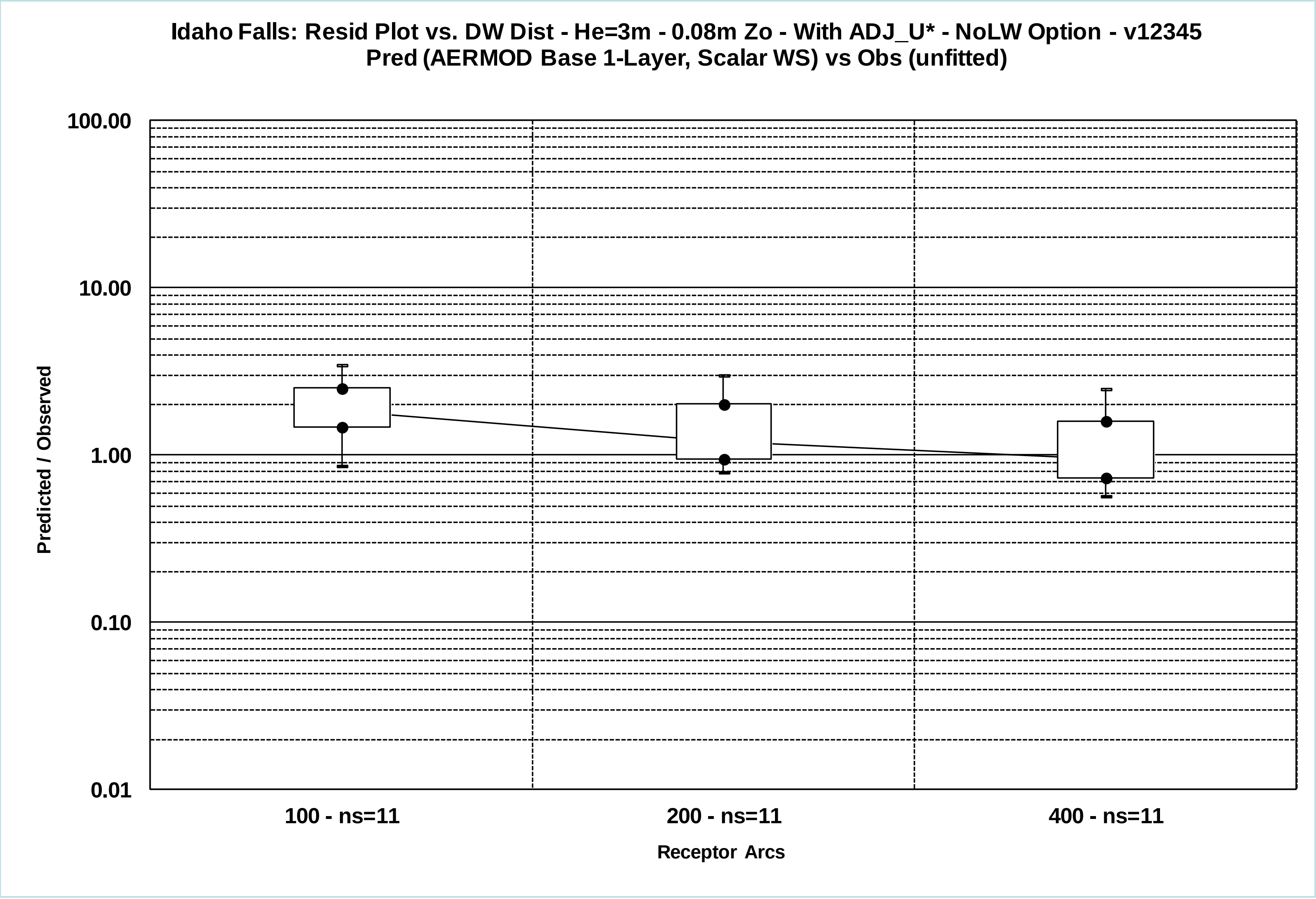
Google earth

feet 1000
meters 600

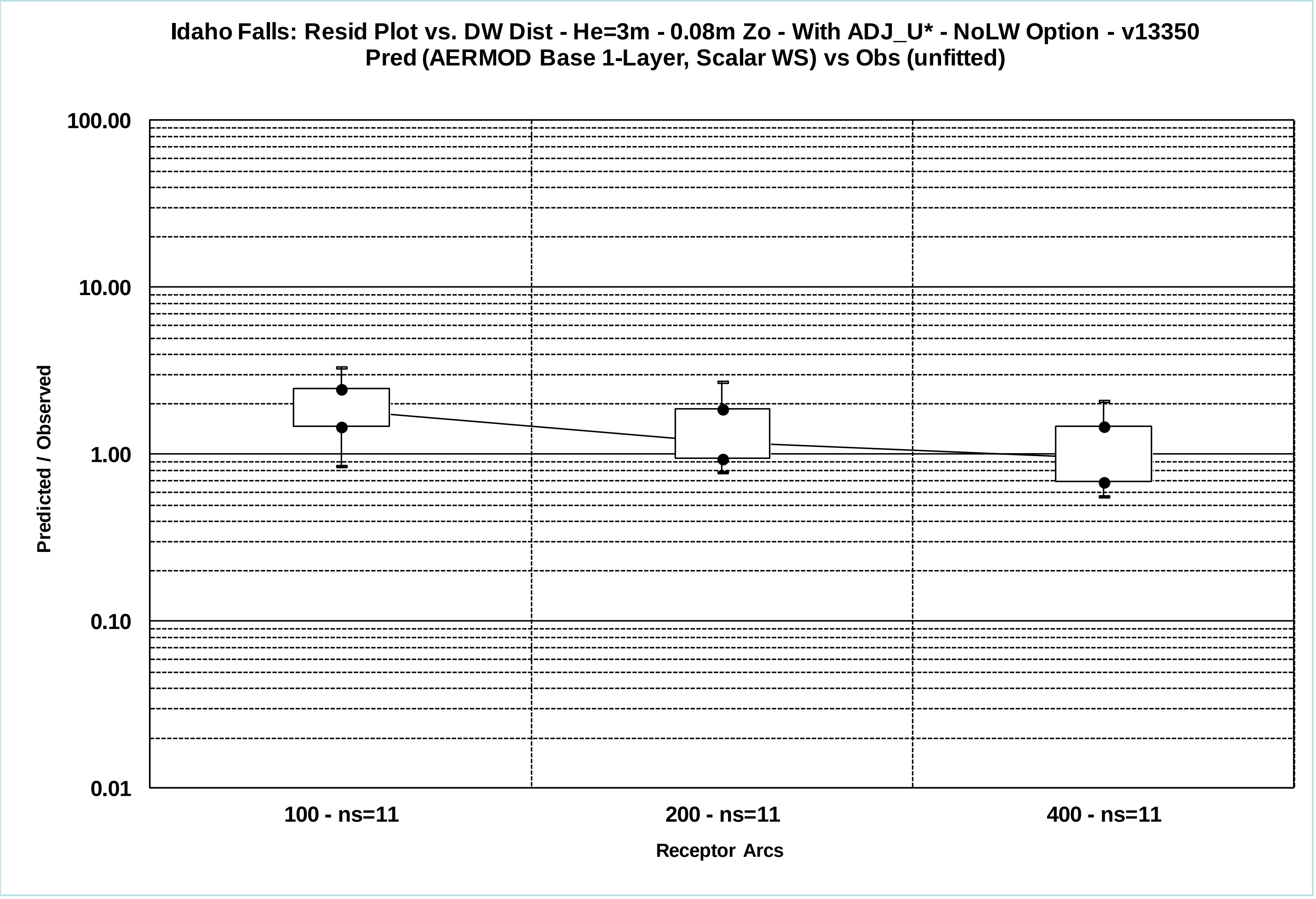
Idaho Falls – Base Model



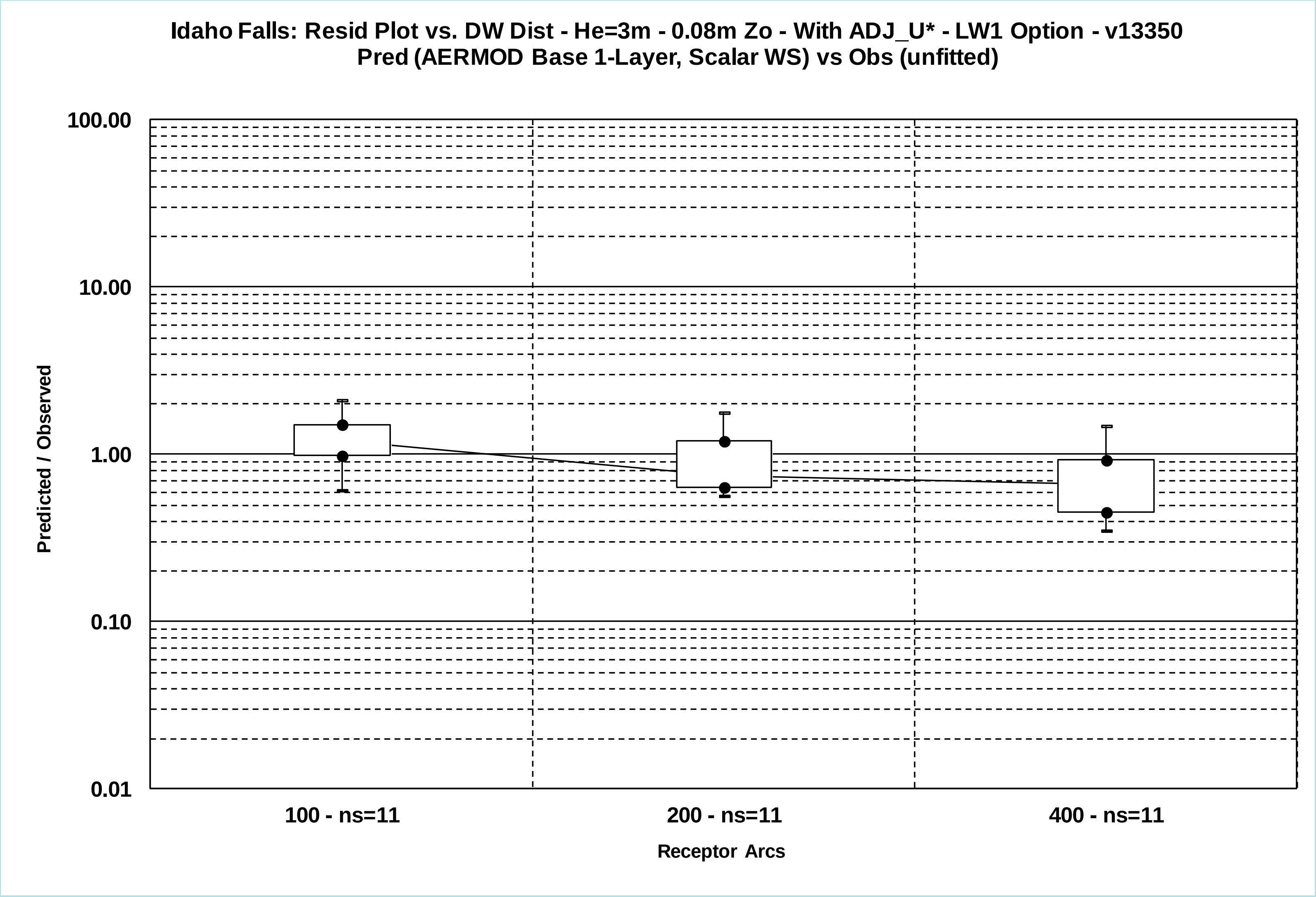
Idaho Falls – ADJ_U* Option



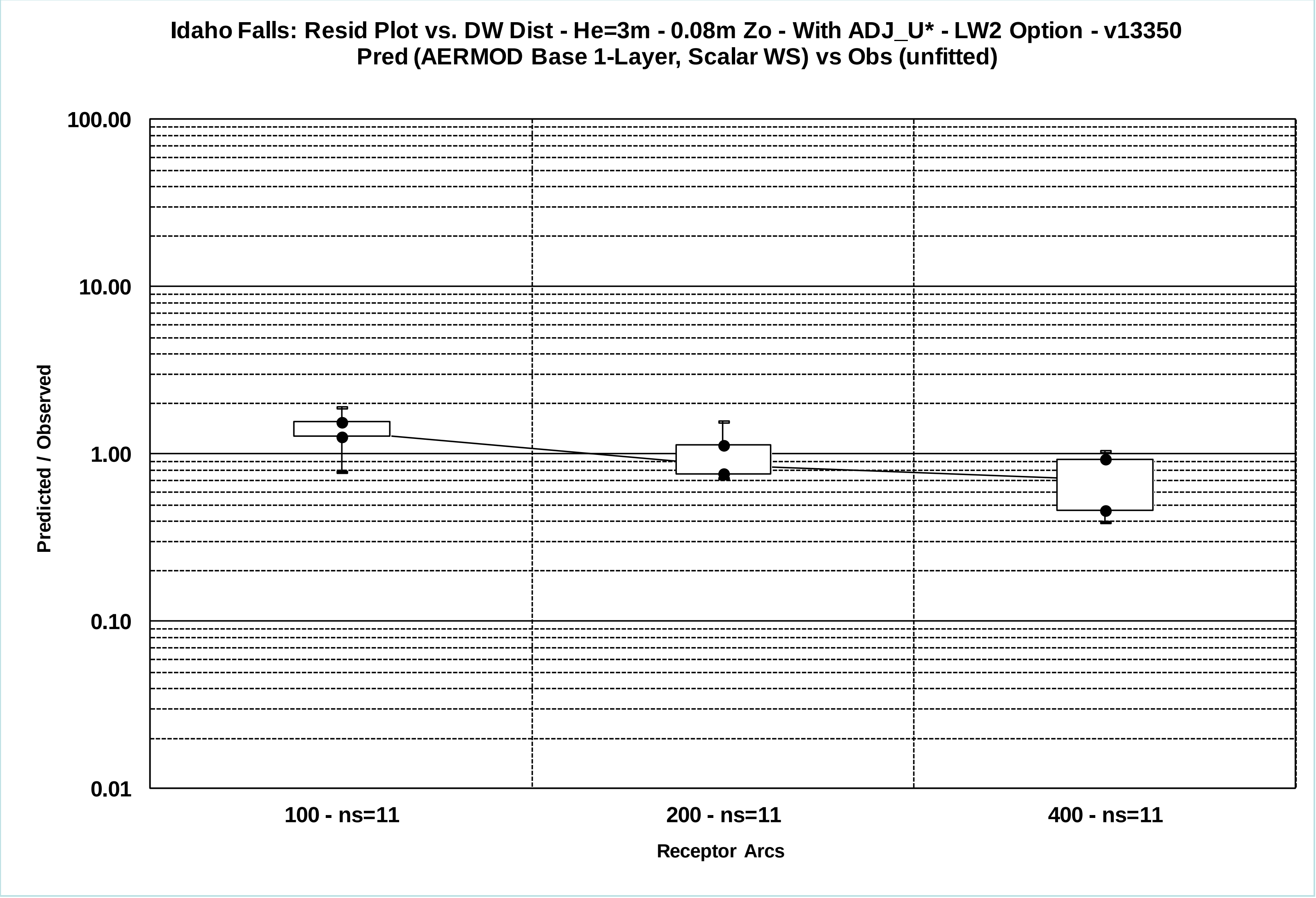
Idaho Falls – ADJ_U* Option



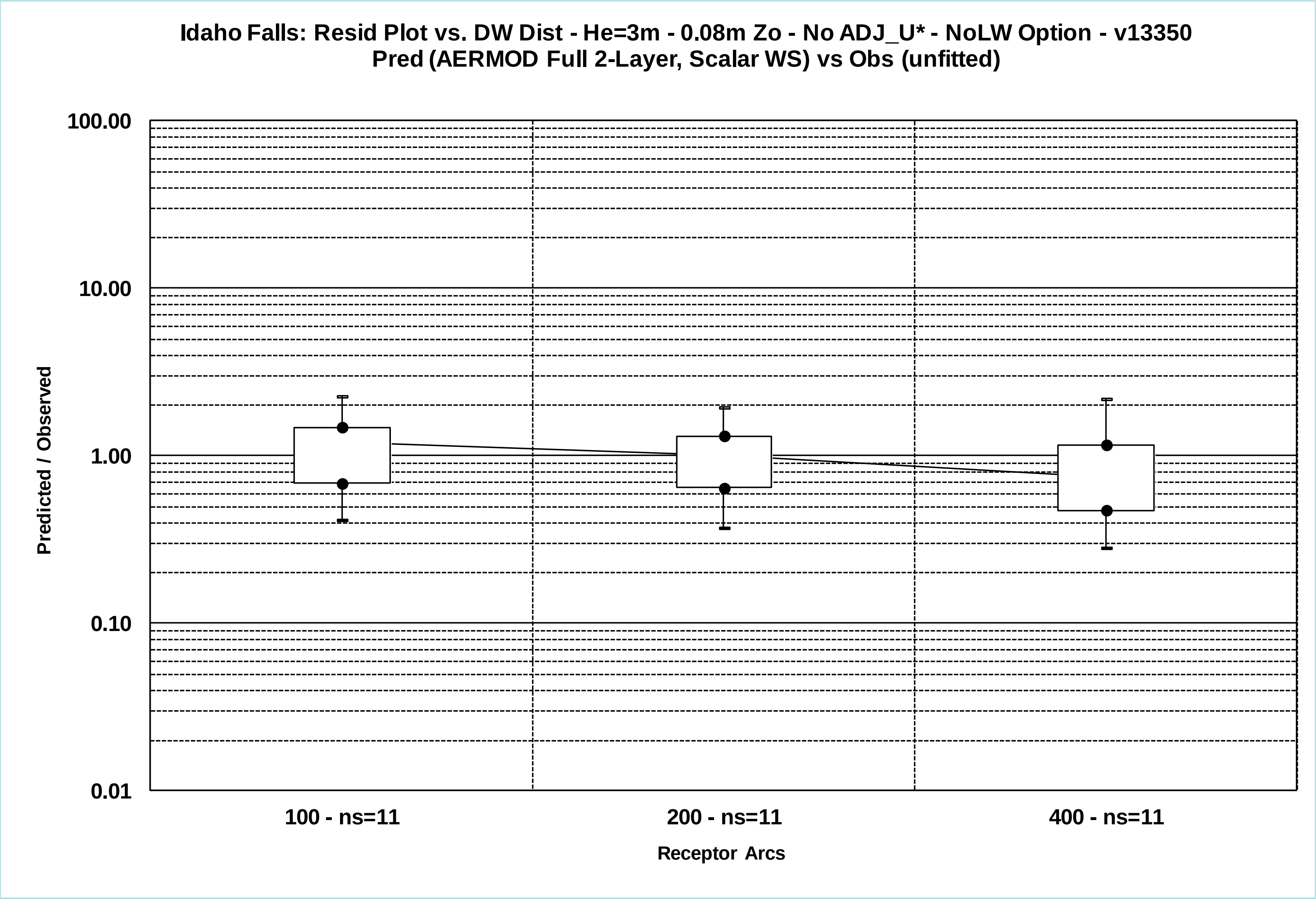
Idaho Falls – ADJ_U* Option



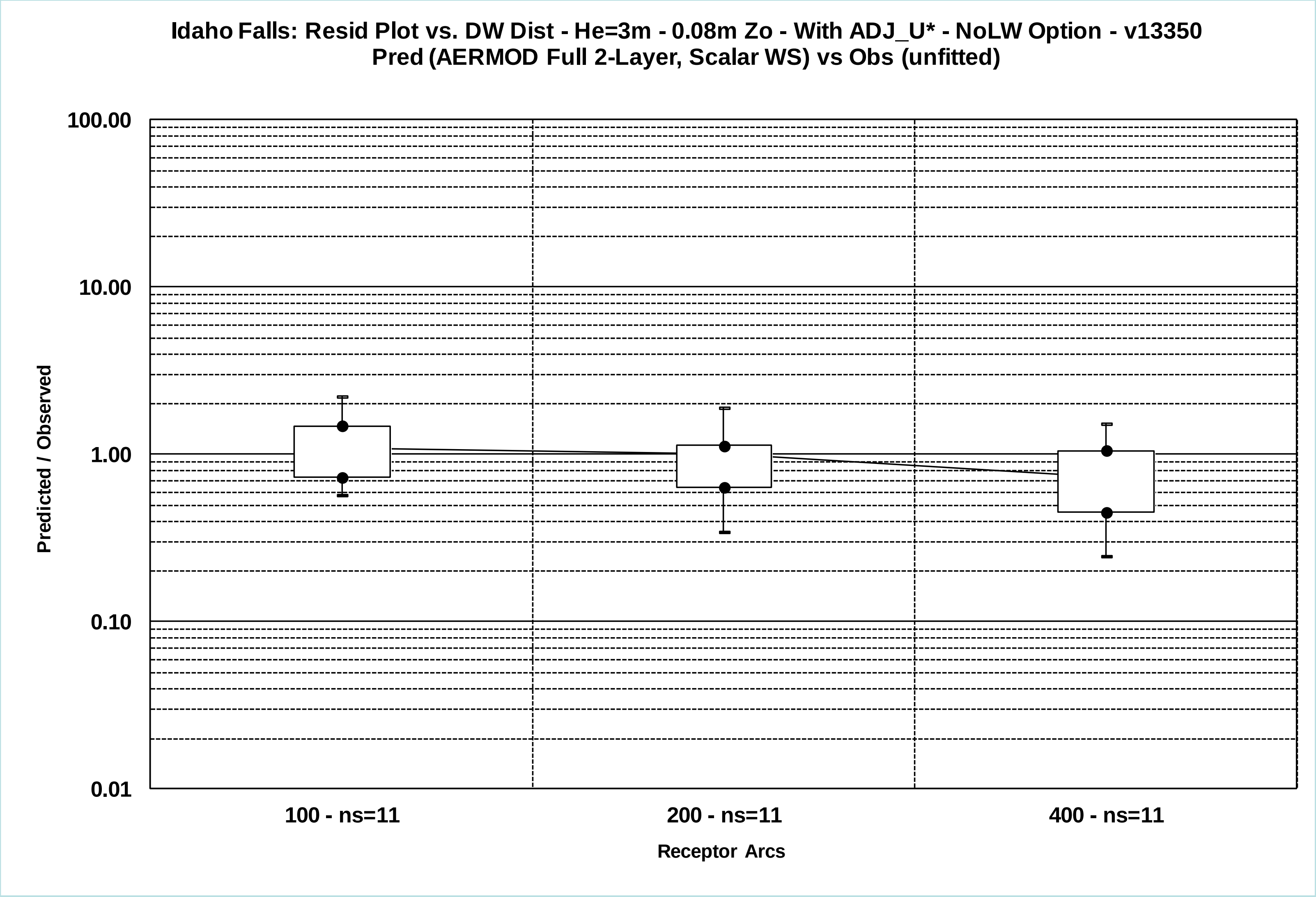
Idaho Falls – ADJ_U* Option



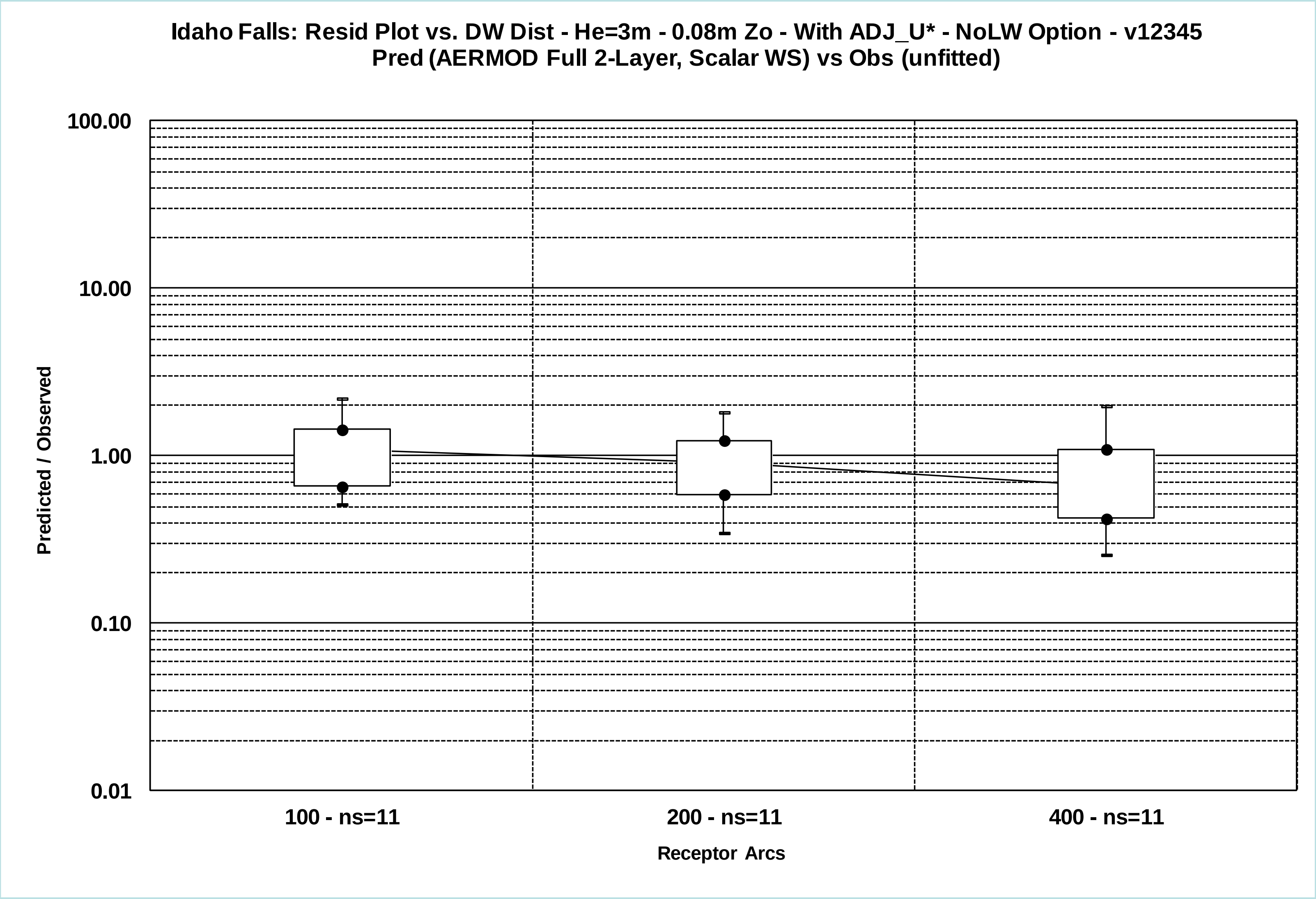
Idaho Falls – ADJ_U* w/BULKRN



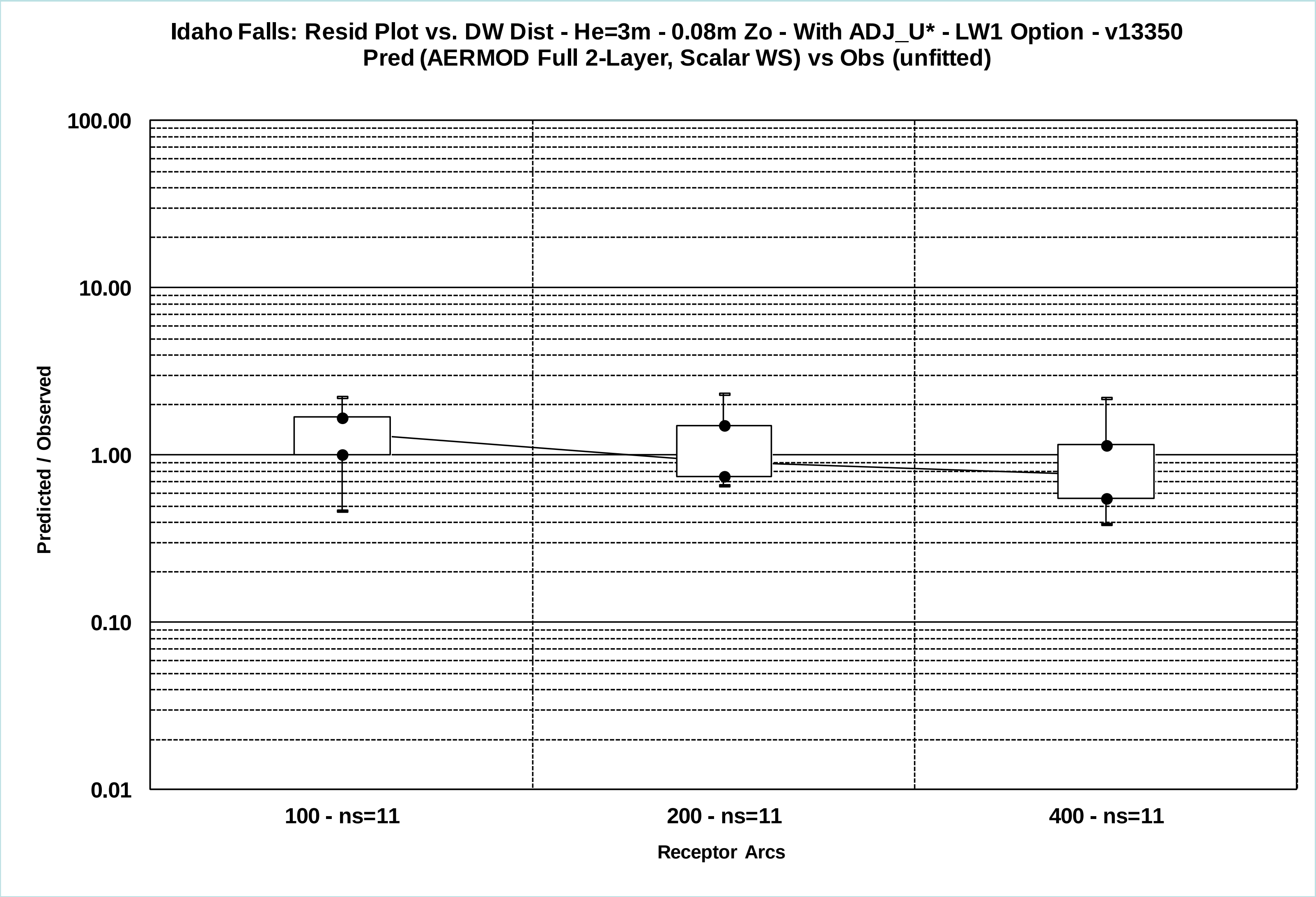
Idaho Falls – ADJ_U* w/BULKRN



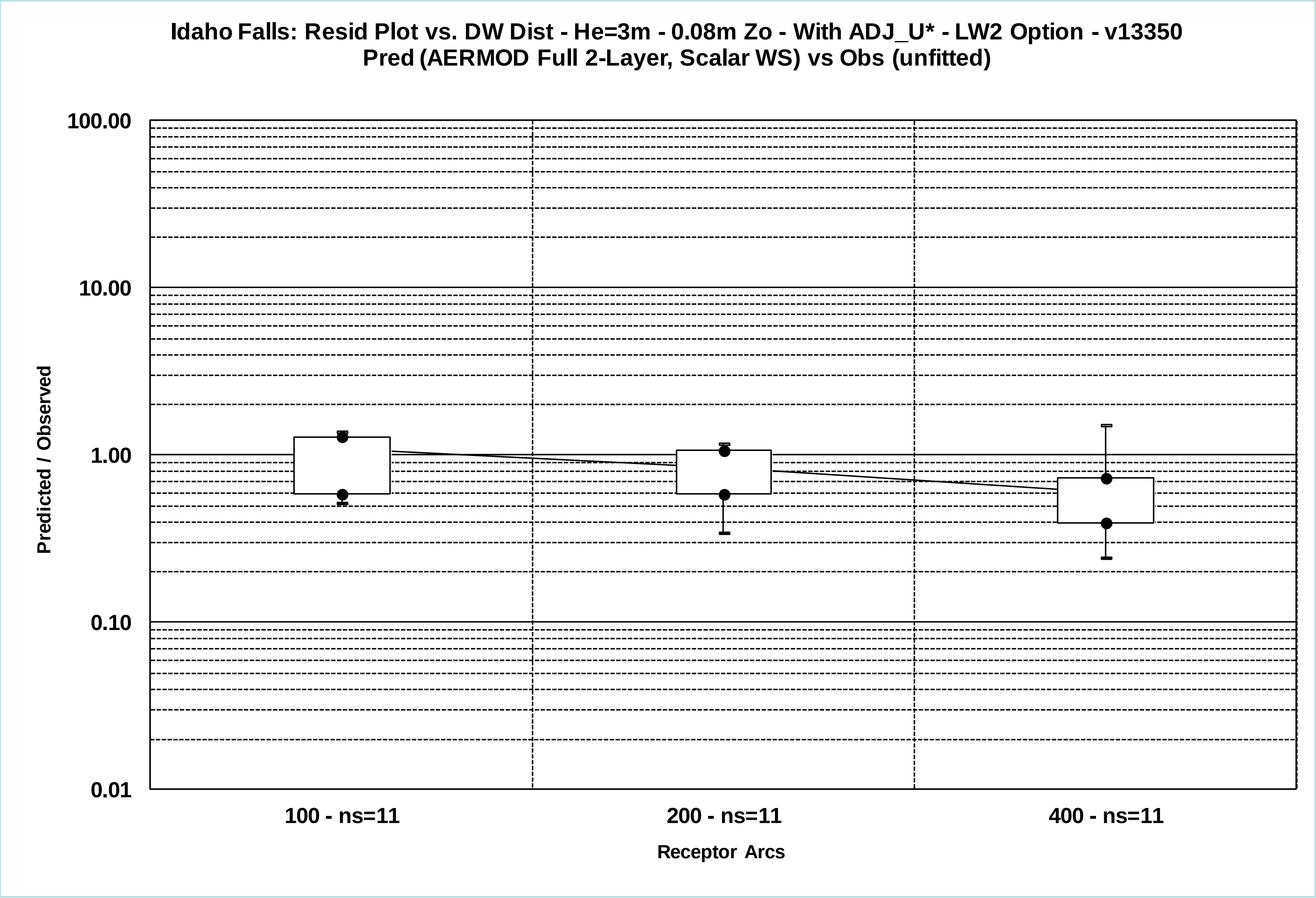
Idaho Falls – ADJ_U* w/BULKRN



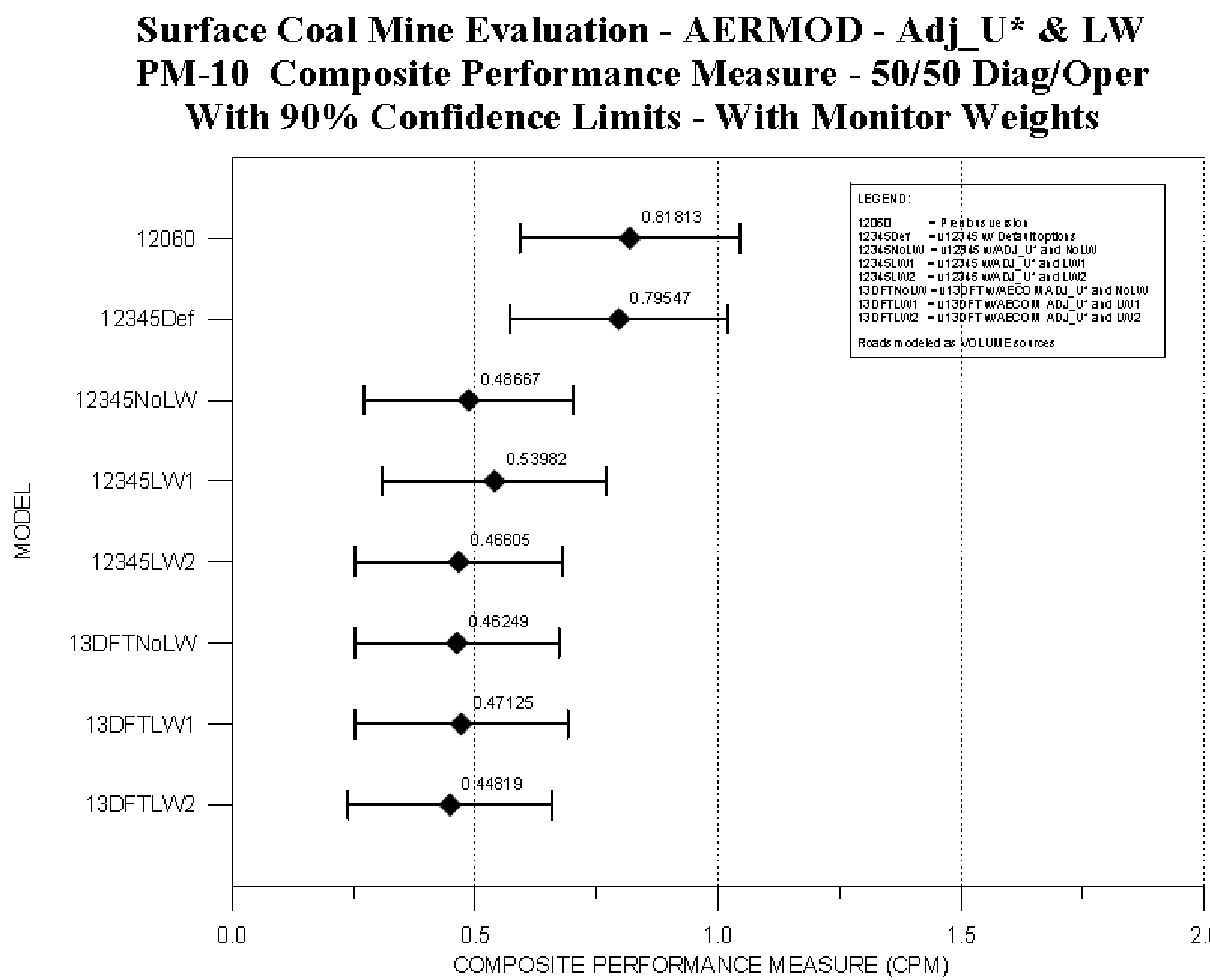
Idaho Falls – ADJ_U* w/BULKRN



Idaho Falls – ADJ_U* w/BULKRN

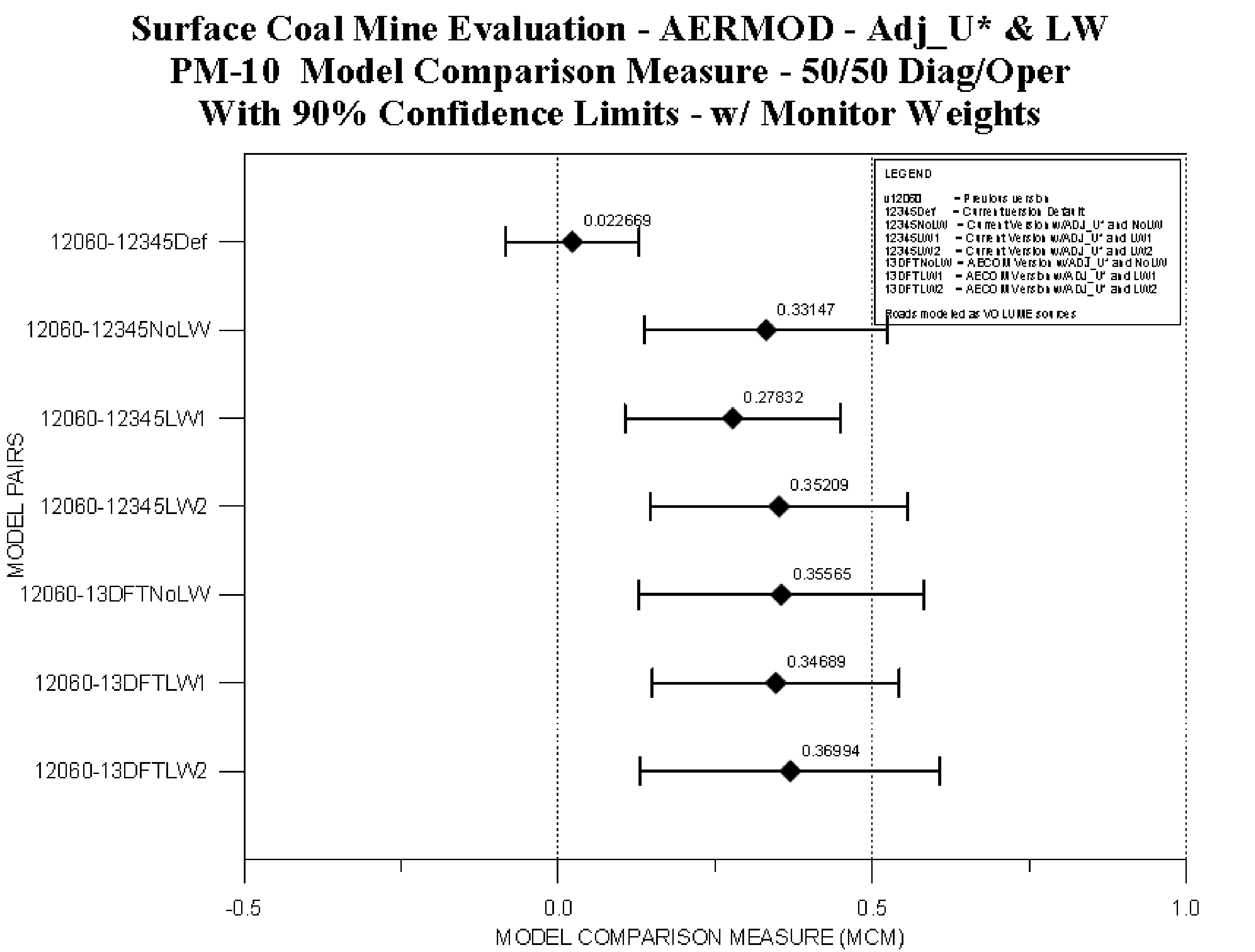


Evaluation of Beta Options*



* These are preliminary results based on an early draft of v13350

Evaluation of Beta Options*



* These are preliminary results based on an early draft of v13350

AERSURFACE Developments

- AERSURFACE tool:
  - Note that AERSURFACE is still <u>not</u> part of the AERMOD regulatory modeling system:
    - Due in part to issues and limitations of available NLCD data
  - Several implementation issues for AERSURFACE have been identified:
    - Uncertainties regarding ASOS tower locations based on information available from NCDC;
    - NLCD land cover categories are not ideal for estimating surface roughness;
    - Temporal representativeness of 1992 NLCD may be in issue for some locations;
    - Misclassification of land cover categories may also affect representativeness in come cases.

“Validating” AERSURFACE Roughness Estimates

- AERSURFACE roughness values have been compared with Gust Factor Method (GFM):
  - GFM based on Wieringa (BAMS, 1980) using 1-minute ASOS wind data provides a method to “validate” AERSURFACE
- Findings from application of GFM:
  - GFM roughness estimates appear to be reasonable based on actual site characteristics;
  - Results generally compare well with AERSURFACE estimates when land cover is “well-defined” by the NLCD data;
  - Results show significant impact of temporal variation in land cover for some sites relative to the data period being processed, as noted in 2009 Model Clearinghouse memorandum;
  - Results also highlight problems with land cover definitions for some sites and may flag potential errors in tower location

Description of Gust Factor Method

- Gust Factor Method (GFM) for estimating surface roughness presented by Wieringa in BAMS (1980) and QJROC (1976):

$$G = 1 + (1.42 + 0.3 \ln [(10^3/Ut) - 4])/\ln (z/z_0)$$

where G = gust factor

U_t = gust wavelength (m); function of anemometer specs and sampling time

z = anemometer height (m)

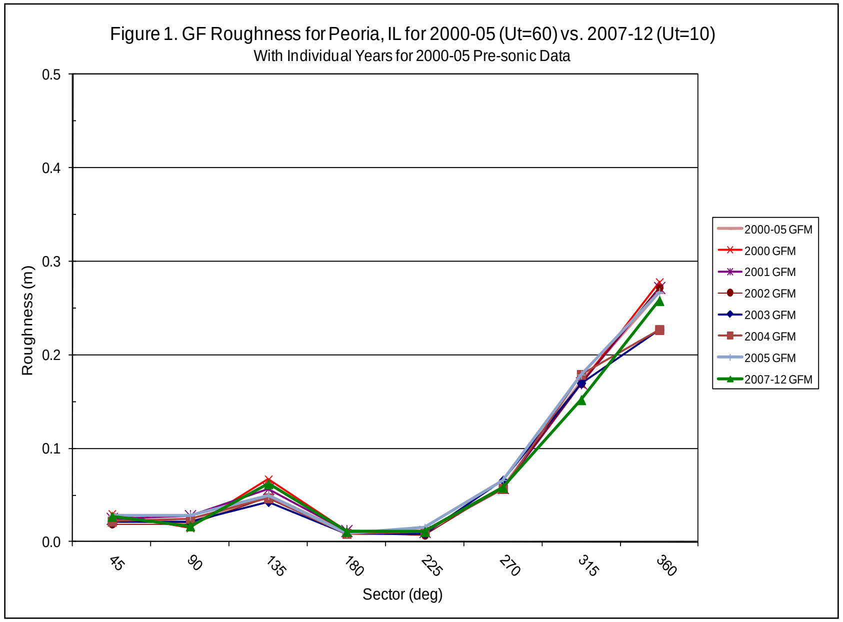
z_0 = effective surface roughness (m)

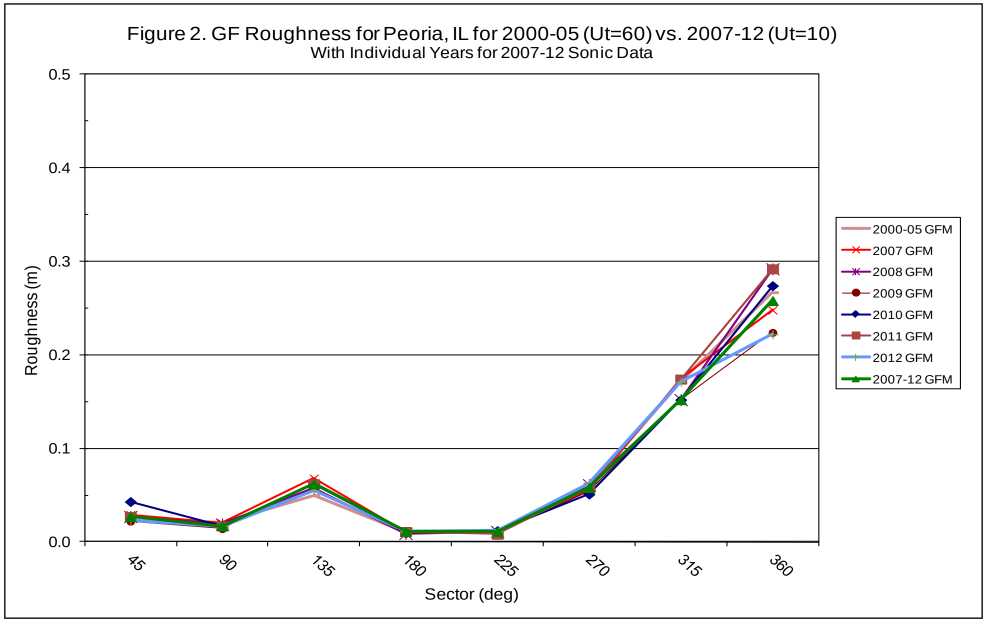
Wieringa recommends using peak and mean wind speeds over 10-minute period for cases where average WS > 10 kt

- Verkaik and Holtslag (BLM, 2007) revisited Cabauw data and found good results from GFM

AERSURFACE Developments

- The figures below compare GF roughness estimates by year and across 6 years for PIA based on pre-sonic data (2000-2005) with U_t = 60m vs. sonic data (2007-2012) with U_t = 10m for PIA airport (U_t is the gust wavelength):





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.

Future Plans for AERSURFACE

- Release Beta version of AERSURFACE with Effective Roughness Methods 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.

Upper Air Data Substitution

- An upper air data substitution tool is being developed to facilitate the use of more than one representative upper air data source;
- When upper 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 upper air data is typically representative of a large area, multiple upper air stations may be adequately representative for a given application;
- The tool will “splice” together upper air data from a primary station and up to two alternative stations.

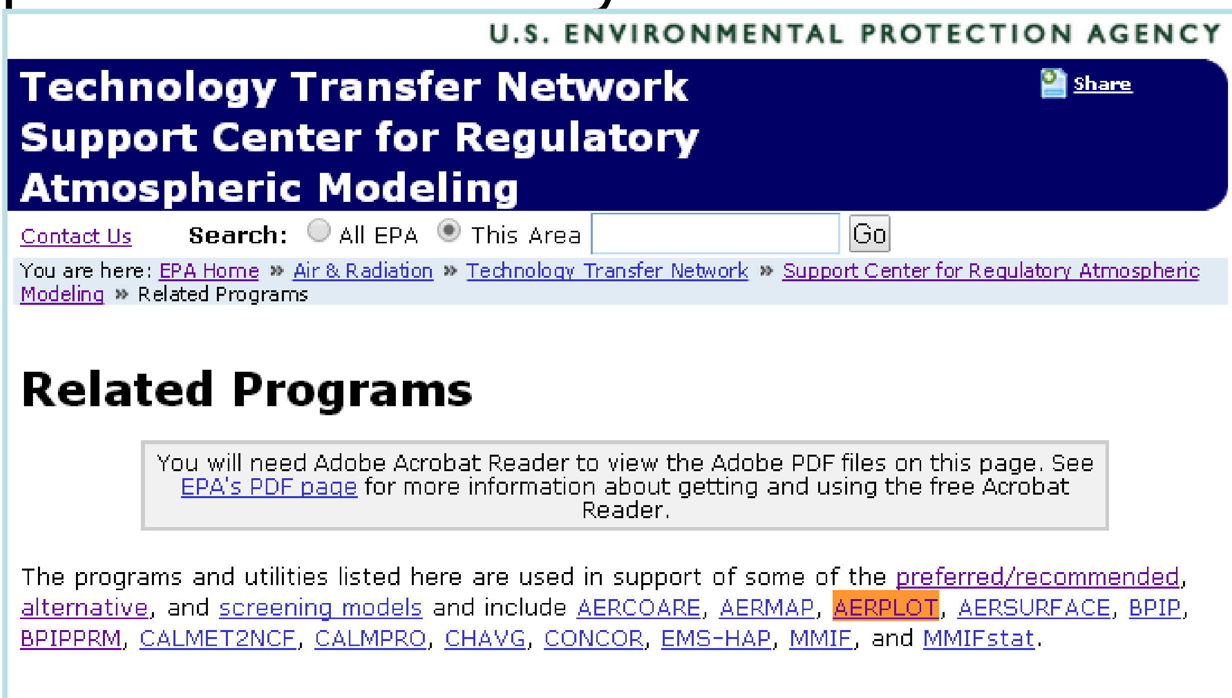
AERPLOT

- AERMOD visualization tool

AERMOD plot file + control file

Google earth kml

Receptors color coded by concentration + contours


U.S. ENVIRONMENTAL PROTECTION AGENCY

Technology Transfer Network
Support Center for Regulatory Atmospheric Modeling

Share

Contact Us Search: All EPA This Area Go

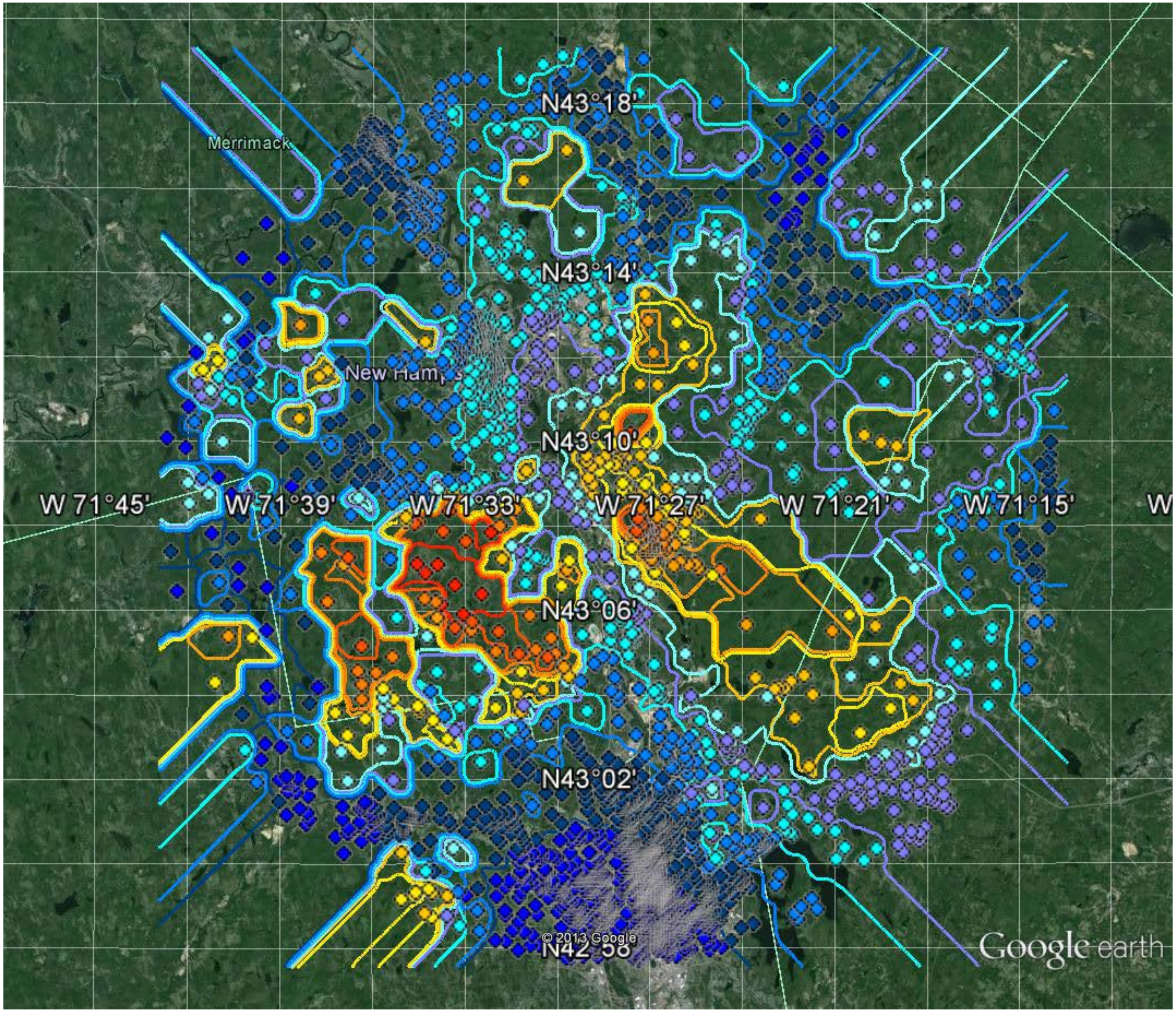
You are here: EPA Home » Air & Radiation » Technology Transfer Network » Support Center for Regulatory Atmospheric Modeling » Related Programs

Related Programs

You will need Adobe Acrobat Reader to view the Adobe PDF files on this page. See EPA's PDF page for more information about getting and using the free Acrobat Reader.

The programs and utilities listed here are used in support of some of the preferred/recommended, alternative, and screening models and include AERCOARE, AERMAP, AERPLOT, AERSURFACE, BPIP, BPIPPRM, CALMET2NCF, CALMPRO, CHAVG, CONCOR, EMS-HAP, MMIF, and MMIFstat.

Sample plot


N43°18'
Merrimack
N43°14'
New Hamp
N43°10'
W 71°45'
W 71°39'
W 71°33'
W 71°27'
W 71°21'
W 71°15'
W
N43°06'
N43°02'
© 2013 Google
N42°58'
Google earth

AERPLOT Options

- Basic control options for input/output file names, etc.
- Controls for project location
  - Assumes coordinates in UTM, requires setting the UTM zone
  - Can adjust project for generic display (relative coordinates)
- Custom controls for display properties
  - Icon size
  - color schemes
  - log vs linear color scale
  - Max/min values
  - Contour controls

Questions?

- For 1:00pm EST Webinar, call 866-299-3188, conference code 919-541-1850
- For 2:30pm EST Webinar, call 866-299-3188, conference code 919-541-5265
- Callers should turn off their speakers to prevent audio feedback!