Proposed Updates to AERMOD Modeling System

Roger W. Brode
U.S. EPA/OAQPS/AQAD/AQMG

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Introduction

- Beginning with version 12345, AERMOD and AERMET incorporated non-Default/BETA options to address concerns regarding model overpredictions during stable/low-wind conditions:
  - These non-Default/BETA enhancements included the LOW_WIND option in AERMOD and the ADJ_U* option in AERMET;
  - Proposed updates to these non-Default/BETA options in version 15181 are discussed here.
- Additional updates to the regulatory options in AERMOD are being proposed, including a buoyant line source option and options to model capped and horizontal stacks.
- Proposed updates are subject to public review and comment and would then be codified as part of the final rule action, as appropriate.

AERMOD Updates – Low_Wind

- Beginning with v12345, AERMOD includes non-DFAULT/BETA Low_Wind options;
  - Prior to v15181, AERMOD included a LowWind1 option and a LowWind2 option, i.e.,
    - LowWind1 eliminates the horizontal meander component and increases the minimum value of sigma-v from the default of 0.2 m/s to 0.5 m/s;
    - LowWind2 includes horizontal meander, but places an upper limit of 0.95 for the meander factor, and increases the minimum value of sigma-v from the default of 0.2 to 0.3 m/s.
  - LowWind1 and LowWind2 are mutually exclusive

AERMOD Updates – Low_Wind (cont.)

- AERMOD v15181 includes a new LowWind3 (LW3) non-DFAULT/BETA option:
  - LowWind3 increases minimum value of sigma-v from 0.2 to 0.3 m/s, consistent with the LowWind2 option, but eliminates upwind dispersion, consistent with the LowWind1 option;
  - The LowWind3 option uses an “effective” sigma-y value that replicates the centerline concentration accounting for meander, but sets concentrations to zero (0) for receptors more than 6*sigma-y off the plume centerline, similar to the FASTALL option;
  - EPA has proposed in the NPRM that the LowWind3 option be incorporated into regulatory version, while the LowWind1 and LowWind2 options are still available for testing & evaluation purposes.

AERMET/AERMOD Updates – ADJ_U*

- The Beta ADJ_U* option in AERMET associated with the Bulk Richardson Number (BULKRN) option has been modified to include a more refined method for calculating THSTAR and extending its applicability for very stable/low wind conditions, based on Luhar and Raynor (BLM, v132, 2009);
- The updated ADJ_U* option with BULKRN also includes modifications to subroutine TGINIT in AERMOD to calculate THSTAR;
- EPA has proposed in the NPRM that the ADJ_U* option (with or without BULKRN) be incorporated into the regulatory version of AERMET.

Capped and Horizontal Stacks

- A Model Clearinghouse memorandum dated July 9, 1993, provided recommendations for modeling capped and horizontal stacks:
  - Clearinghouse procedure involves setting the exit velocity (V_s) to 0.001 m/s and adjusting the stack diameter (D_s) to maintain the actual flow rate and buoyancy of the plume;
  - The PRIME numerical plume rise algorithm for building downwash uses the input D_s to define the initial radius of the plume – use of a larger effective radius may alter results in physically unrealistic ways;
  - The AERMOD Implementation Guide suggests using V_s=0.001m/s with actual D_s as an interim solution.

Capped and Horizontal Stacks (cont.)

- Draft/BETA options for capped & horizontal stacks have been incorporated in AERMOD (beginning with v06341):
  - Source types POINTCAP & POINTHOR used to trigger BETA options;
  - User inputs actual stack exit velocity (V_s) and stack diameter (D_s);
  - The Model Clearinghouse procedure is used for non-downwash sources;
  - For the POINTHOR option with downwash the exit velocity is assigned as the initial horizontal velocity of the plume;
  - For the POINTCAP option with downwash, the initial plume radius is assigned as $2*D_s$ to account for initial plume spread from the cap, and the initial horizontal velocity of the plume is assigned as the initial exit velocity specified by the user divided by 4 to account for suppressed momentum and buoyancy.

Buoyant Line Sources

- Appendix W currently recommends the use of the Buoyant Line and Point (BLP) model for buoyant line sources;
- The BLP model is based on outdated dispersion theory and the meteorological data processor for BLP, PCRAMMET, is not capable of processing the current meteorological data, including the 1-minute ASOS data;
- The BLP model also lacks the processing options to support the form of the 1-hr NO2, 1-hr SO2 and 24-hr PM2.5 NAAQS.

Buoyant Line Sources (cont.)

- Beginning with v15181, AERMOD includes an option to model buoyant line sources, using the BUOYLINE source type;
- The BUOYLINE option in AERMOD model allows for modeling of buoyant line sources using meteorological data processed through the AERMET meteorological processor;
- The BUOYLINE option in AERMOD also allows use of the processing options to support the form of the 1-hr NO2, 1-hr SO2 and 24-hr PM2.5 NAAQS.

Evaluation of AERMET/AERMOD Updates

- The proposed Beta ADJ_U* option in AERMET and Low_Wind option in AERMOD have been evaluated based on several relevant field studies, including:
  - The 1993 Cordero Rojo surface coal mine fugitive dust study in eastern Wyoming based on 24-hr PM10 concentrations (using v14134);
  - The 1974 NOAA Oak Ridge, TN, tracer study for a low-level release on the Oak Ridge peninsula 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);;
  - The 1974 NOAA Idaho Falls, ID, tracer study for a low-level release 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);

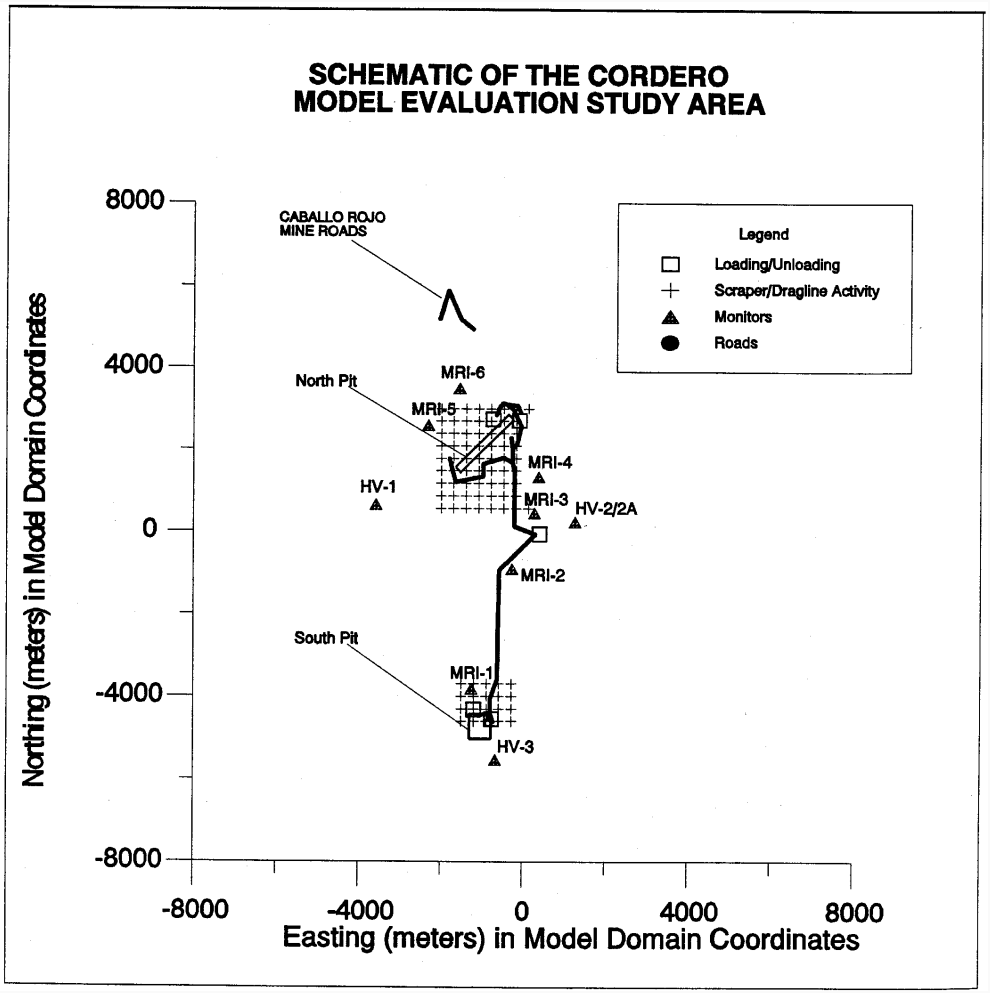
Model Evaluation Caveats

- Caveats regarding model evaluation:
  - 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.

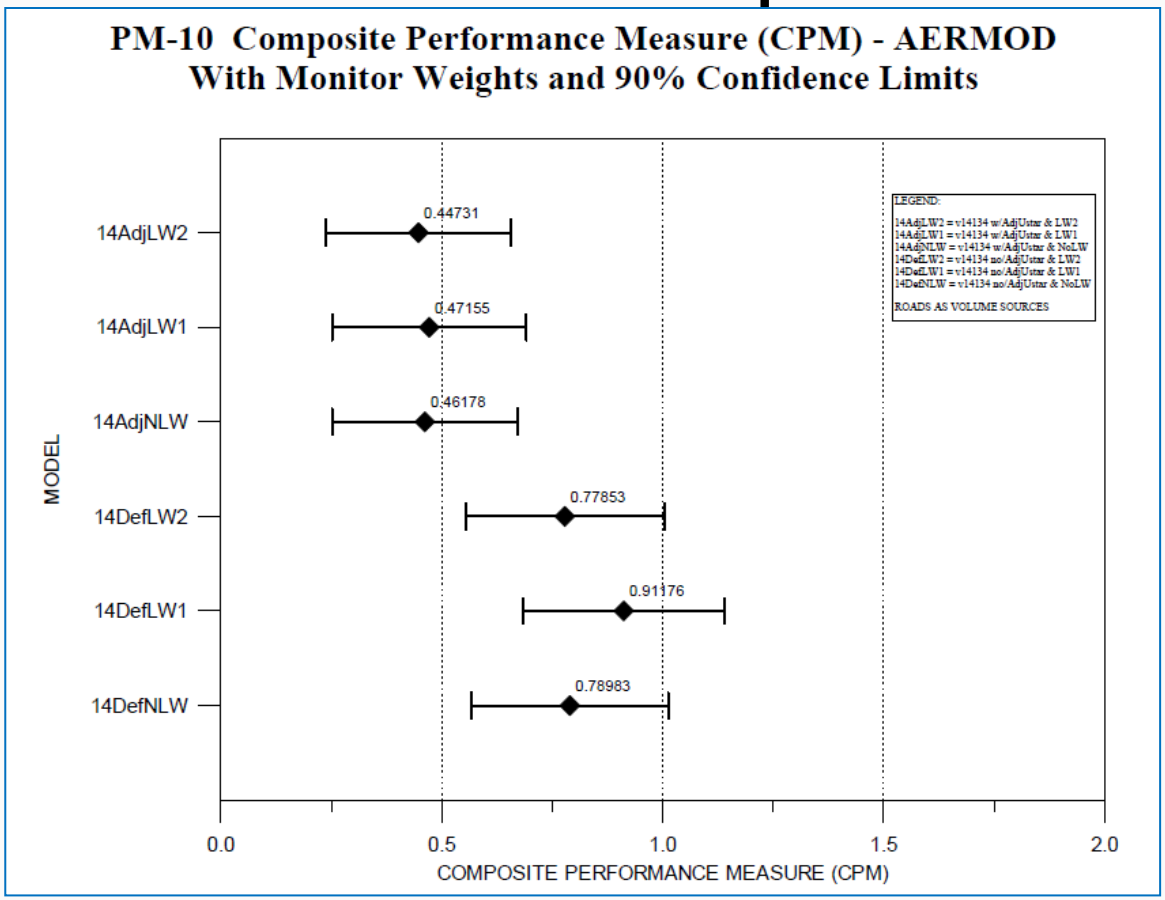
Evaluation of Beta Options

- 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
- Results presented are for ADJ_U* and LW1 and LW2 based on v14134, but are likely to be similar for v15181

Evaluation of Beta Options

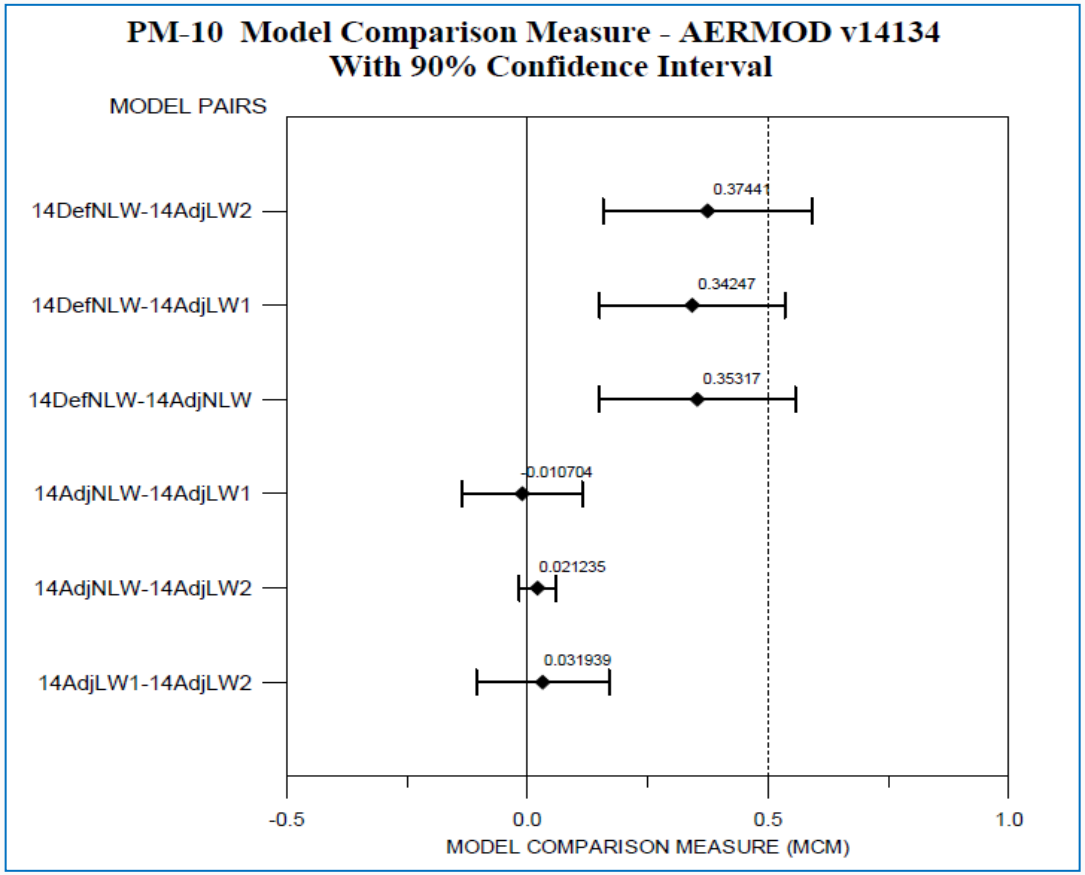


Evaluation of Beta Options – CPM



Note: Smaller value of CPM indicates “better” performance

Evaluation of Beta Options - MCM



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

Summary of Cordero PM10 Evaluation

- Use of the proposed ADJ_U* option in AERMET appears to significantly improve model performance for this study;
  - The confidence intervals for the Model Comparison Measure (MCM) do not cross zero when comparing results with ADJ_U* vs. no ADJ_U*;
  - The LW1 and LW2 options in AERMOD appear to have limited affect on modeled performance.

Oak Ridge and Idaho Falls Evaluations

- EPA's evaluations for the 19974 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 to 2m assumed by AECOM;
  - Also note that the Oak Ridge study area is located in a hilly area, with terrain elevations varying about 40m across the study area. Neither the AECOM nor EPA evaluations have incorporated terrain elevations in the analysis;
  - 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, TN, Study Area

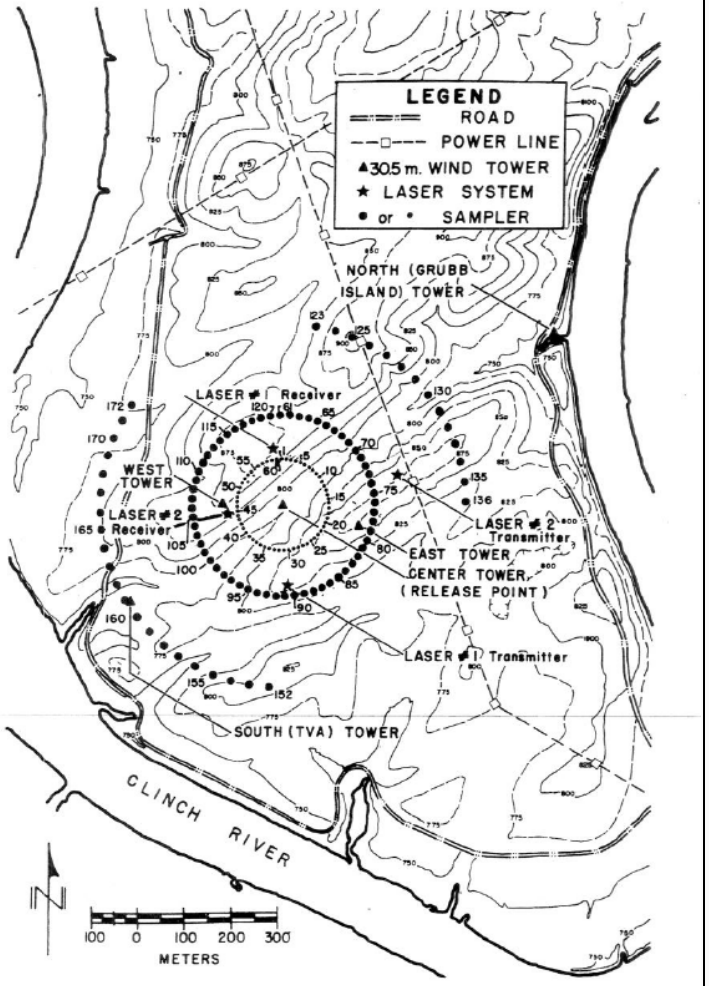
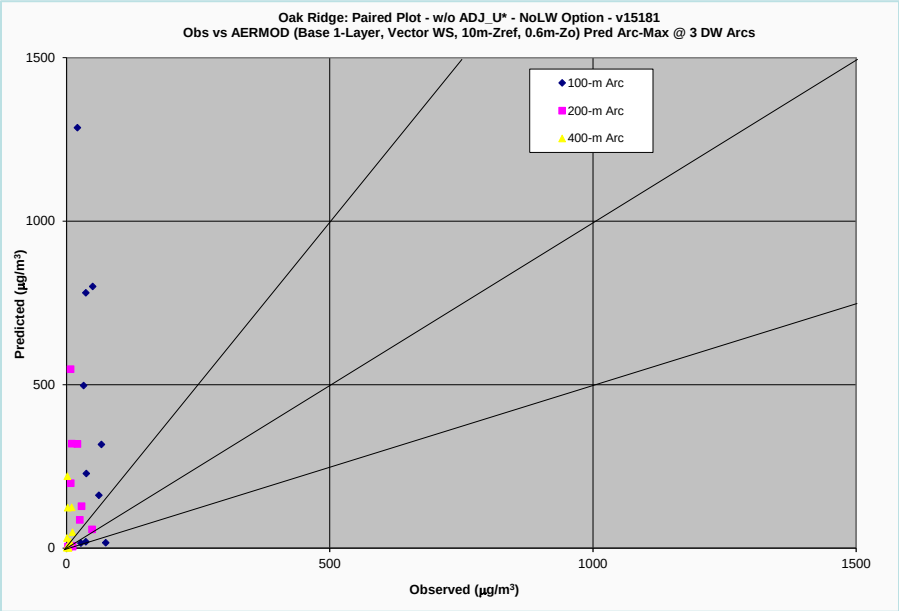


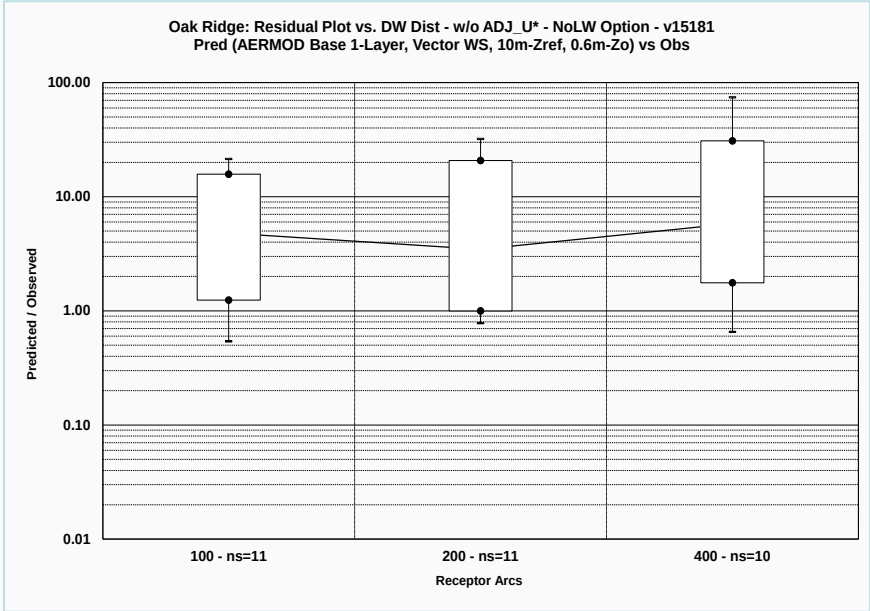
Figure 2b. Detail of inner sampling arcs showing location of meteorological towers and laser transmitters and receivers. (Contour heights are in feet above sea level).

Oak Ridge Results with v15181 Default Options

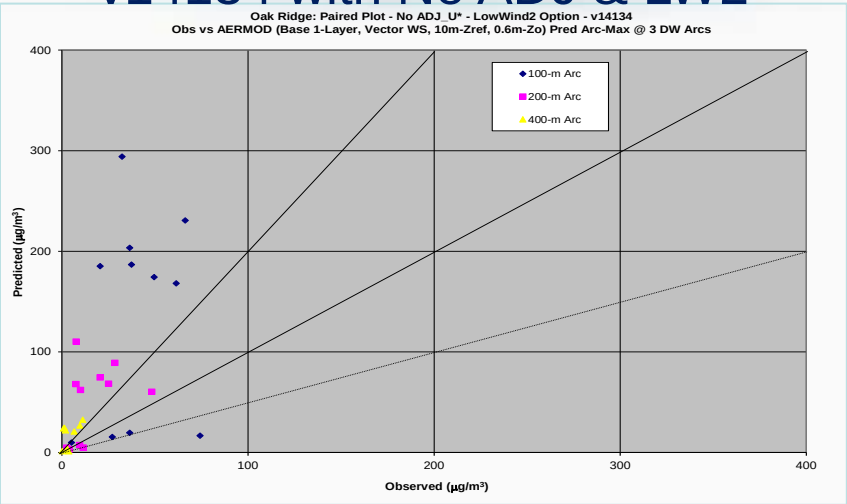
Paired Conc by Arc



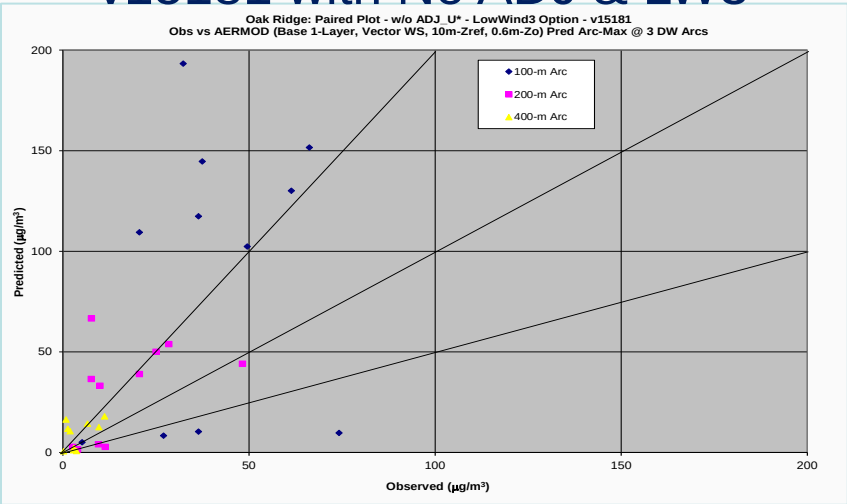
Pred/Obs by Arc

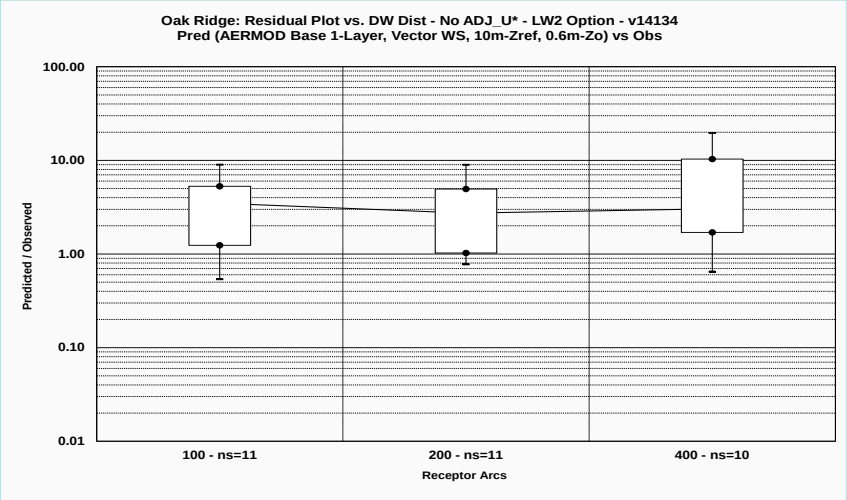


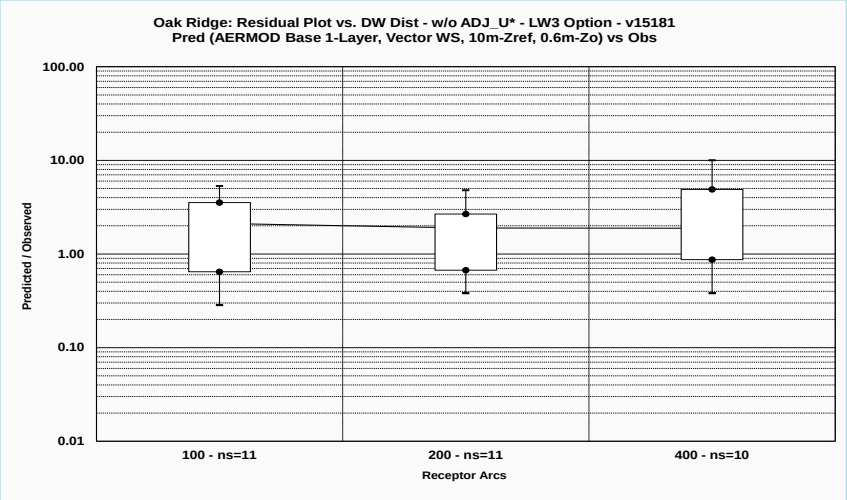
v14134 with No ADJ & LW2



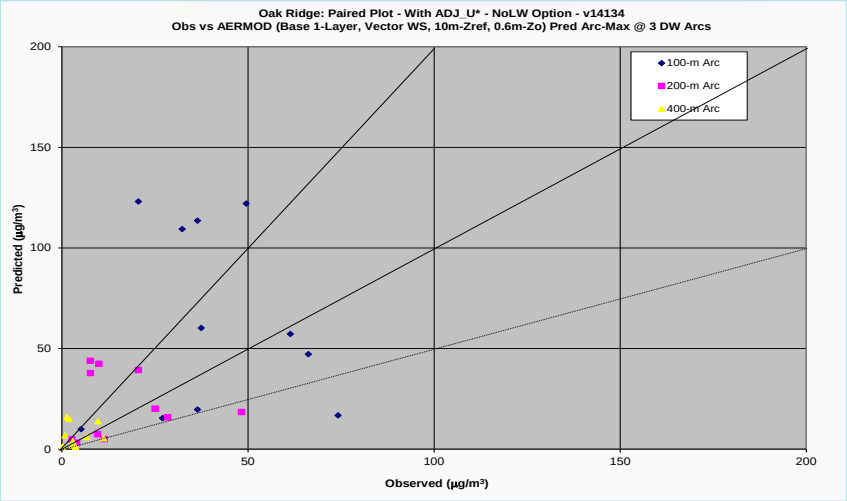
v15181 with No ADJ & LW3

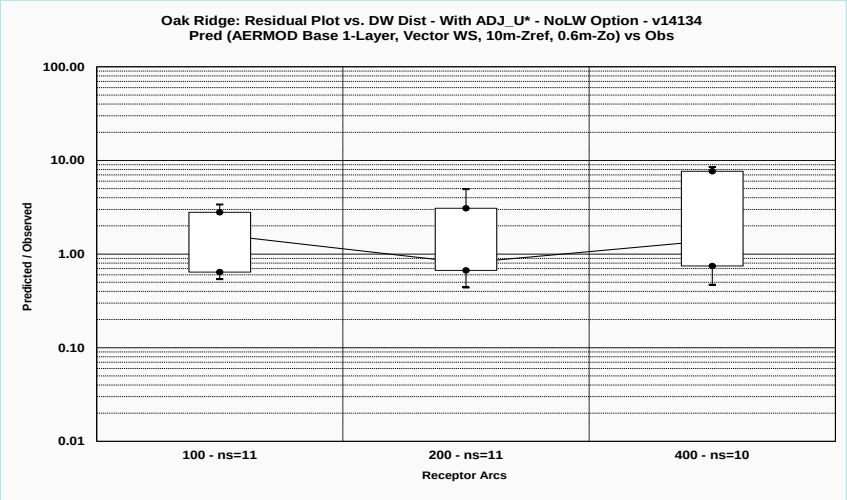




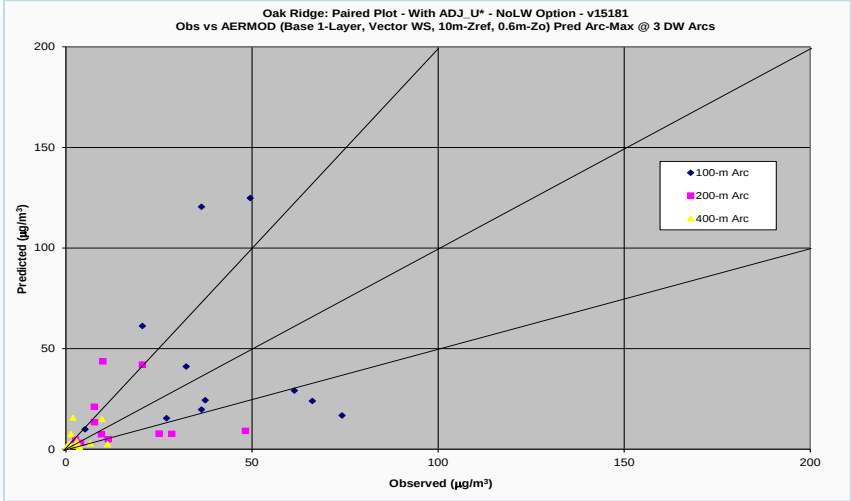


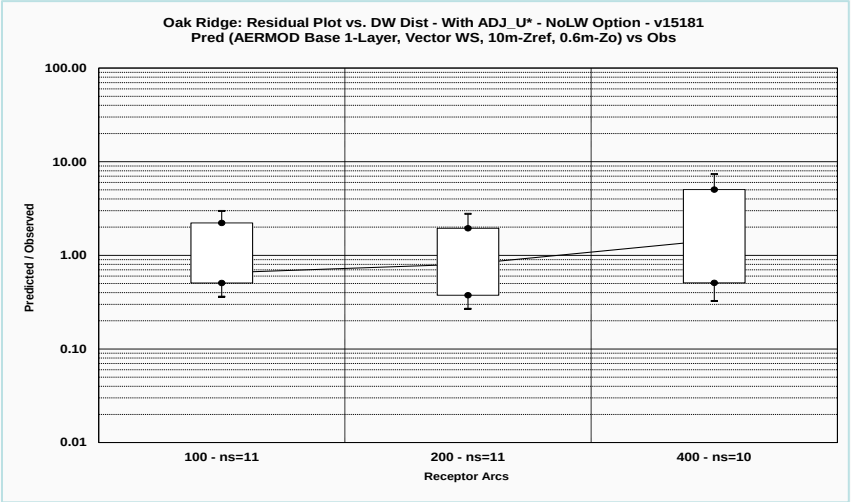
v14134 with ADJ & NoLW



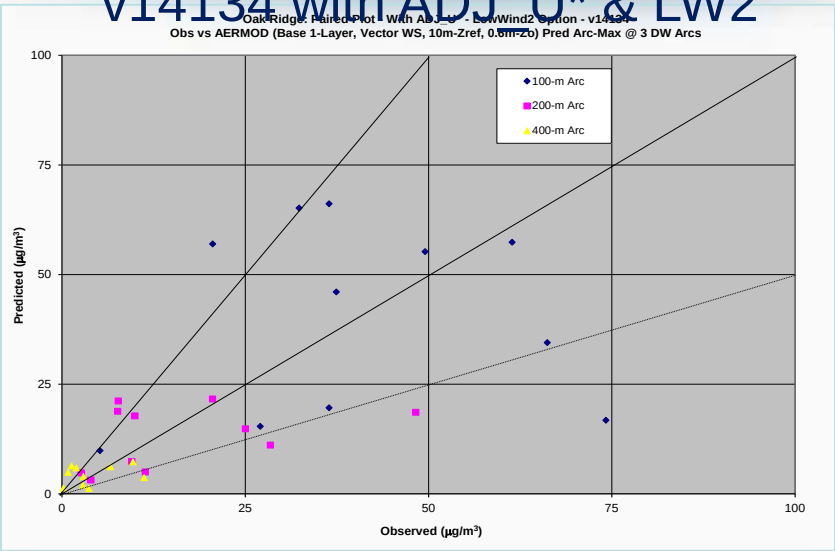


v15181 with ADJ & NoLW

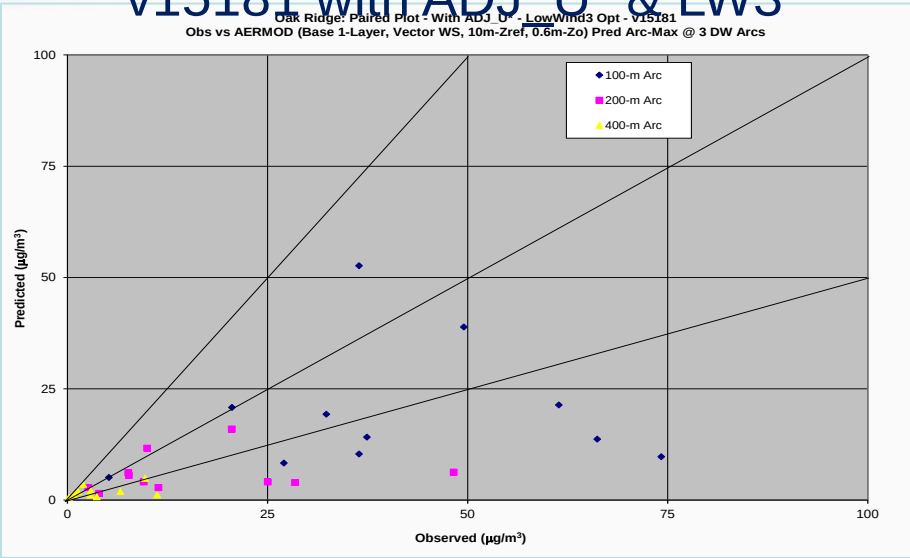


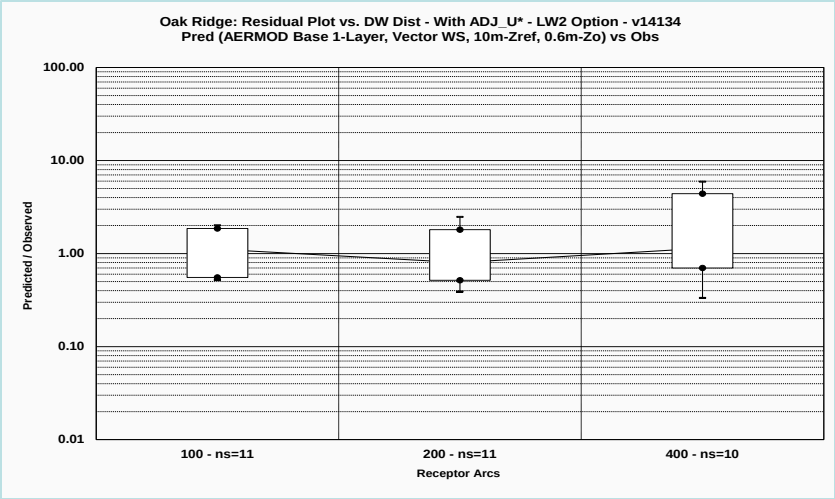


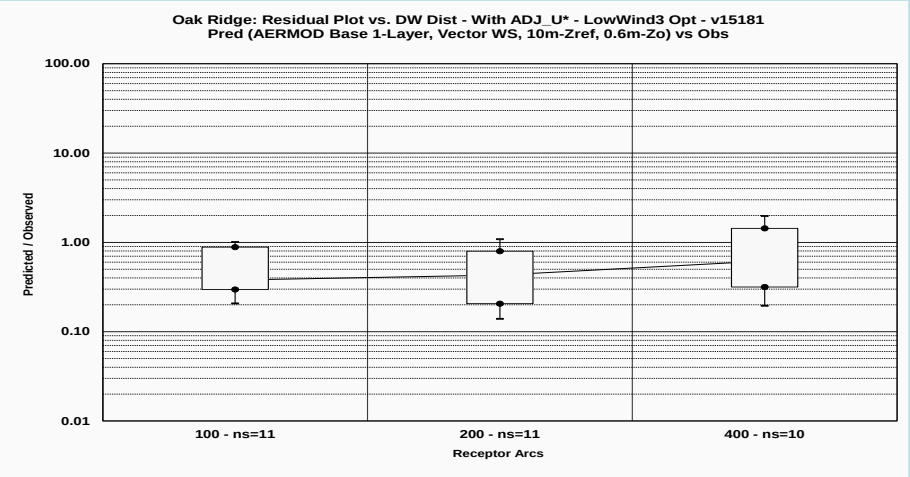
v14134 with ADJ_U* & LW2



v15181 with ADJ_U* & LW3







Idaho Falls, ID,
Study Area

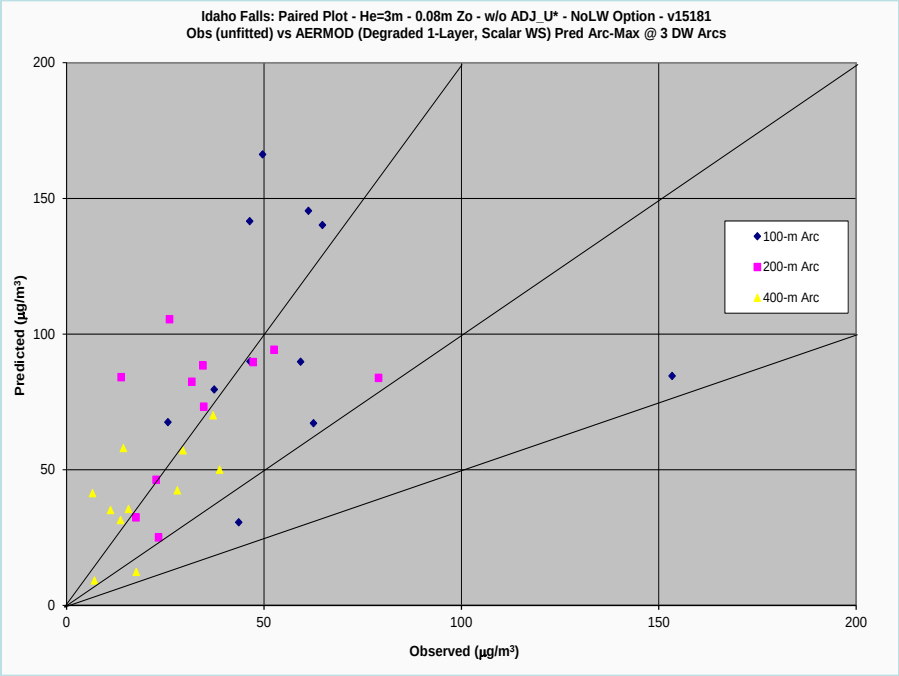
8/12/2015

Google earth

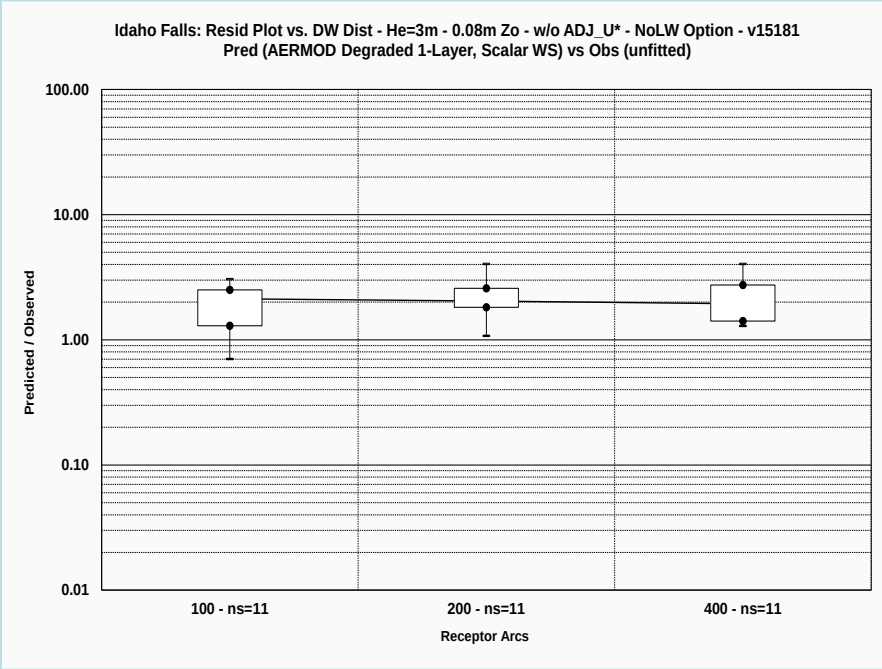
feet 1000
meters 600

Idaho Falls Results with v15181 Default Options

Paired Conc by Arc

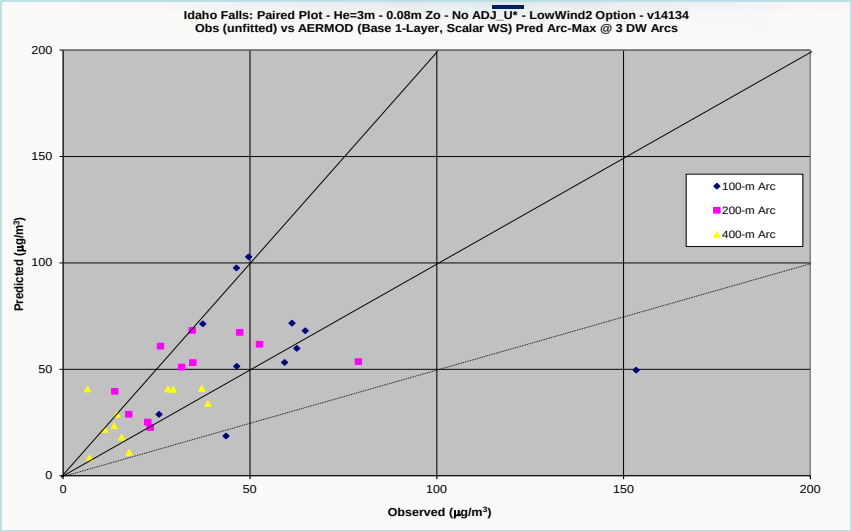


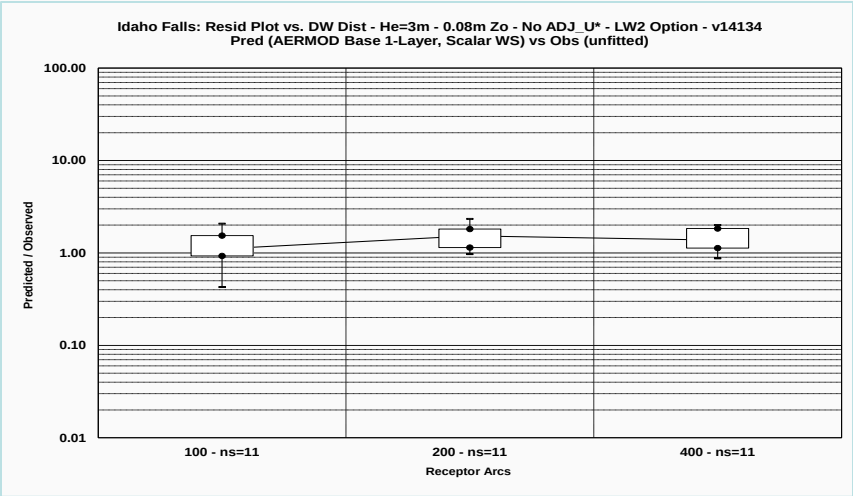
Pred/Obs by Arc



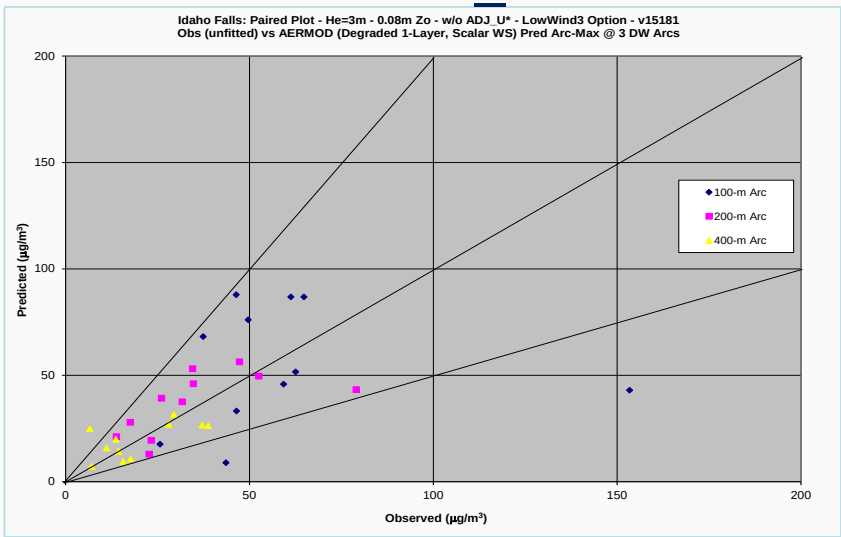
Degraded 1-layer
No Delta_T and No SA

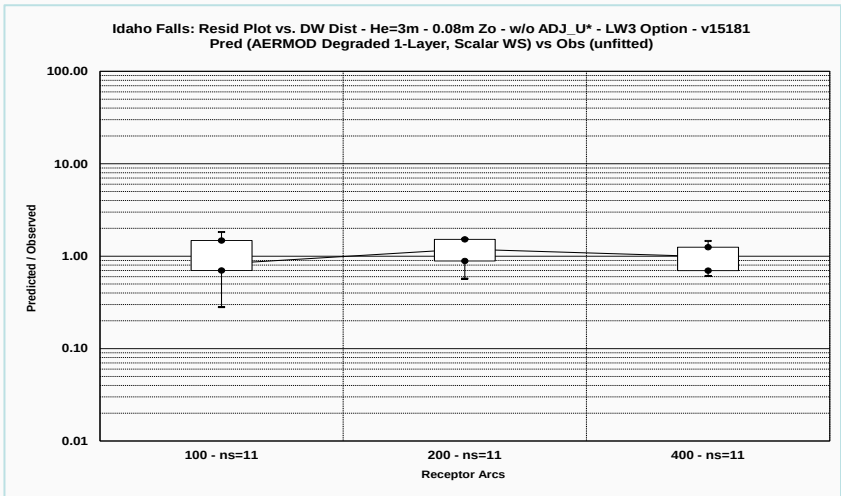
v14134 w/o ADJ_U* & LW2





v15181 w/o ADJ_U* & LW3





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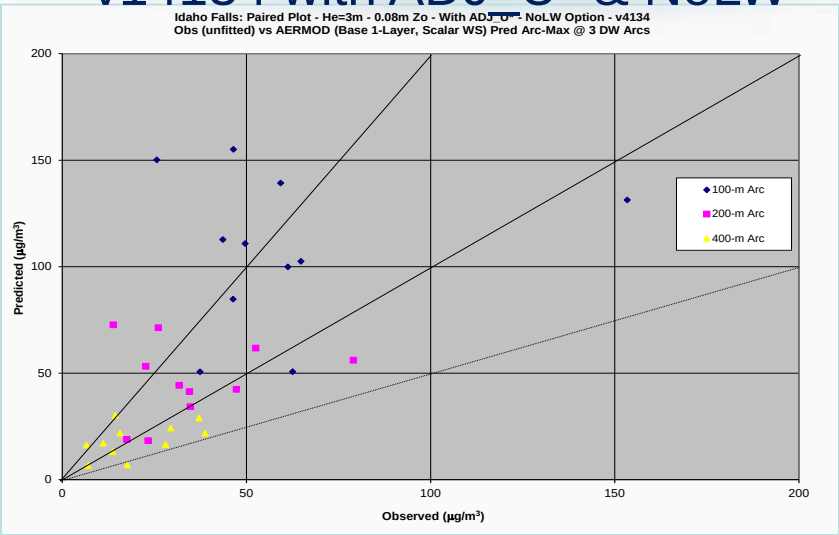
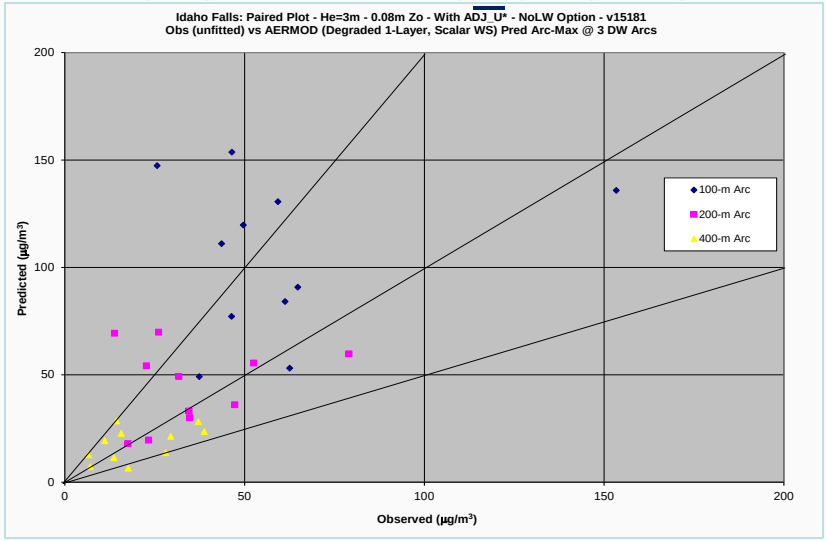
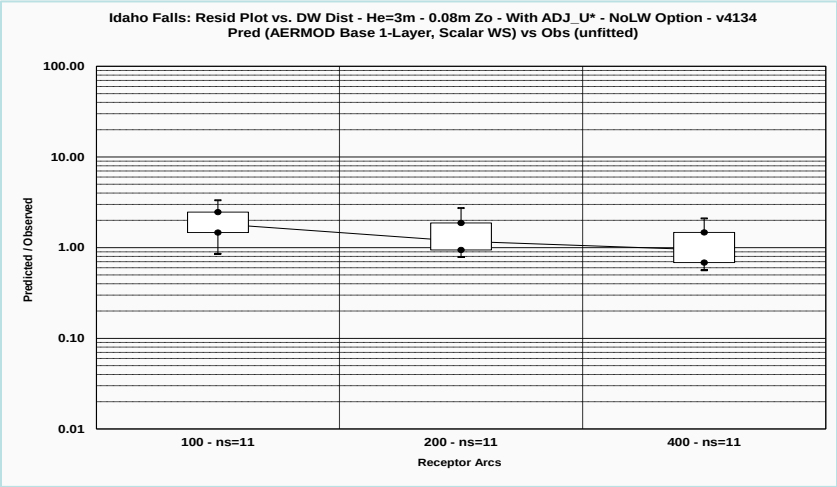
No Delta_T and No SA

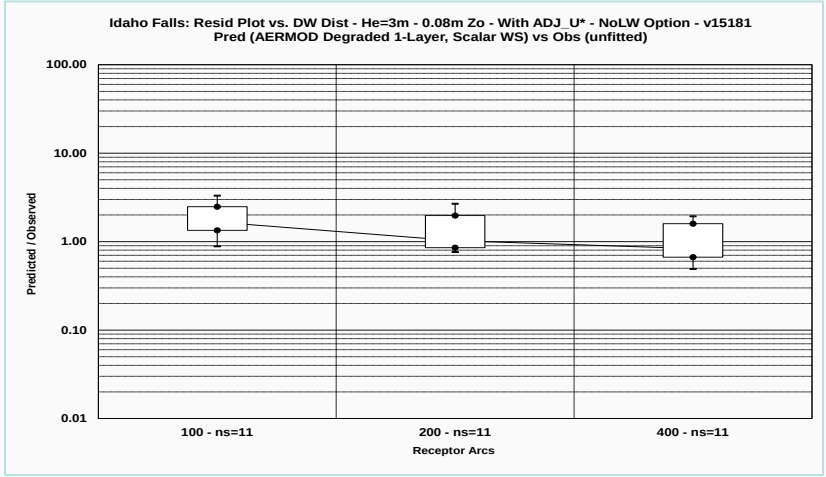
v14134 with ADJ_U* & NoLW



v15181 with ADJ_U* & NoLW







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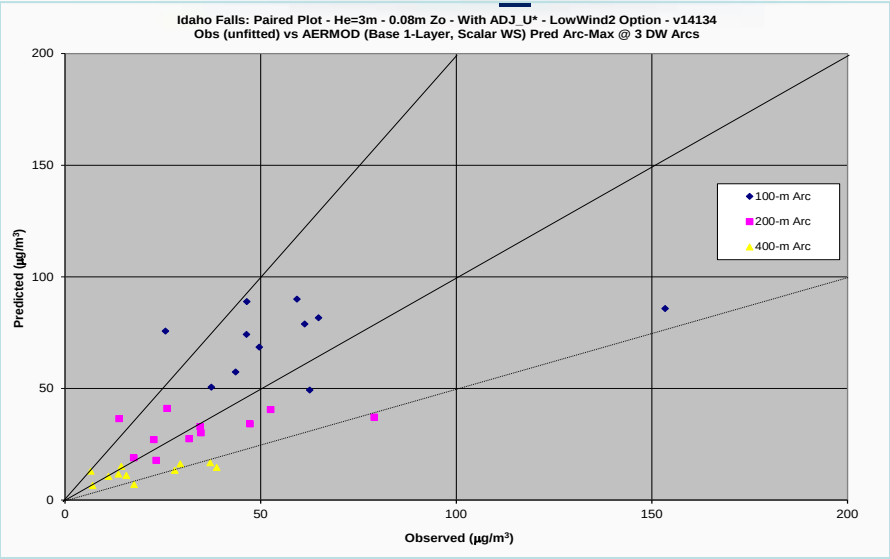
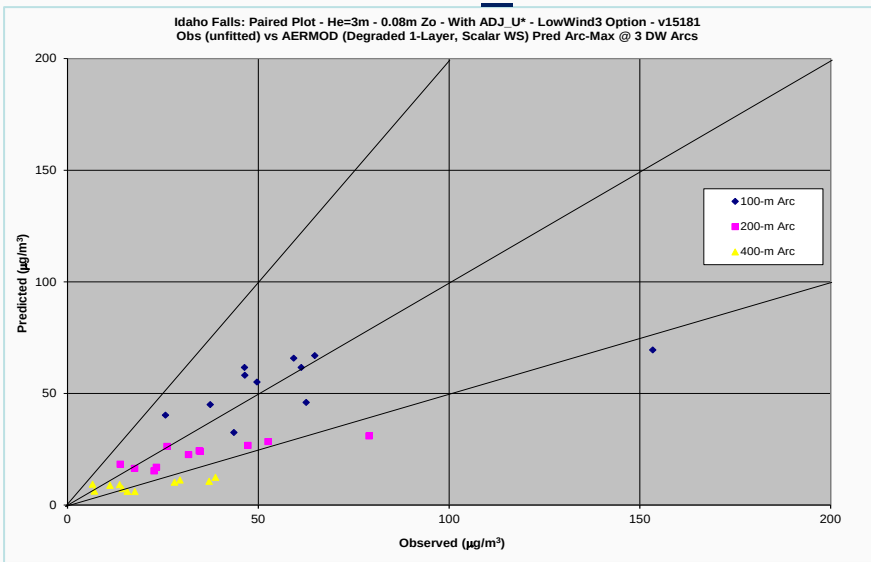
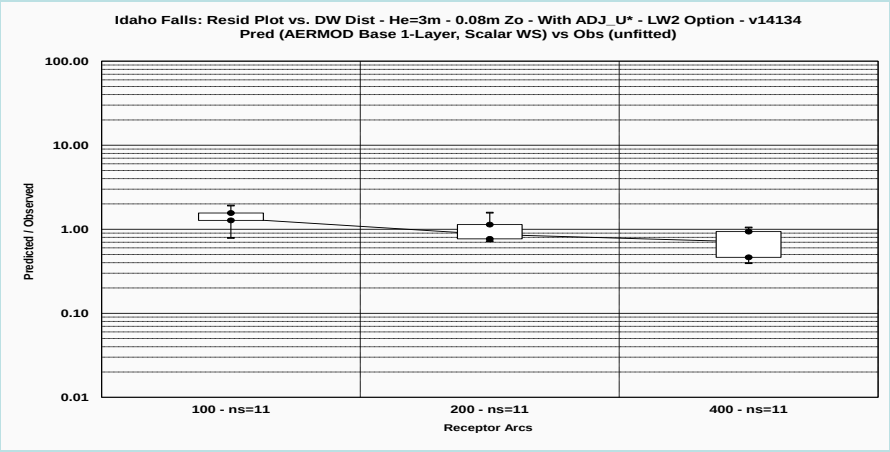
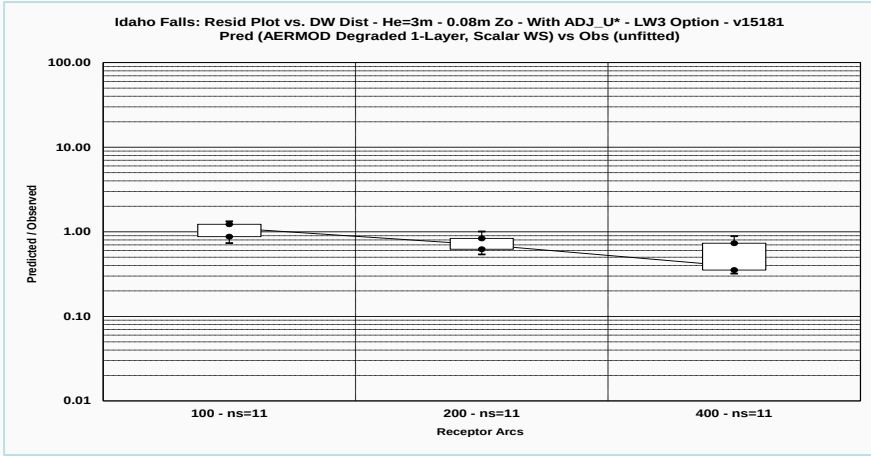
v14134 with ADJ_U* & LW2



v15181 with ADJ_U* & LW3







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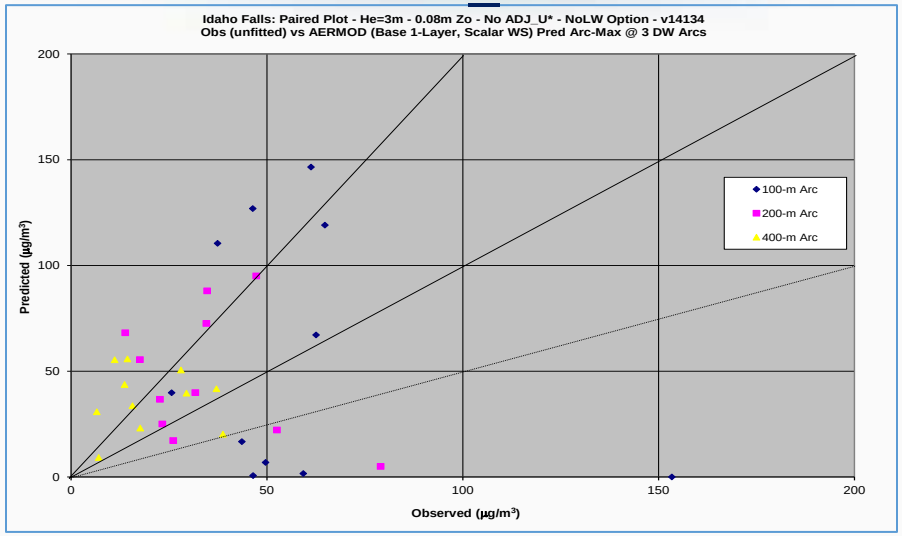
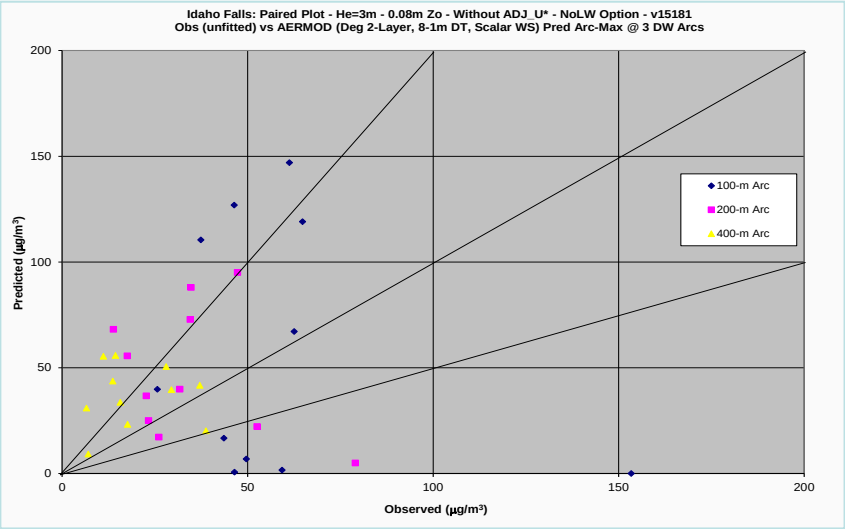
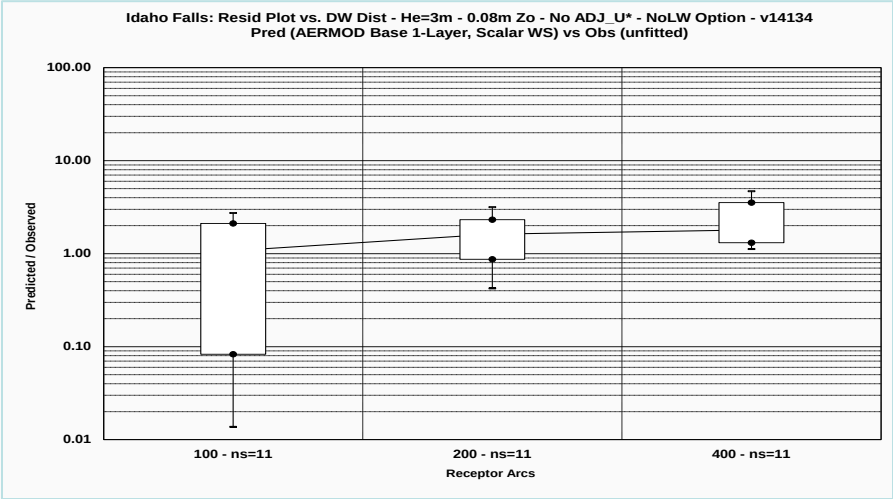
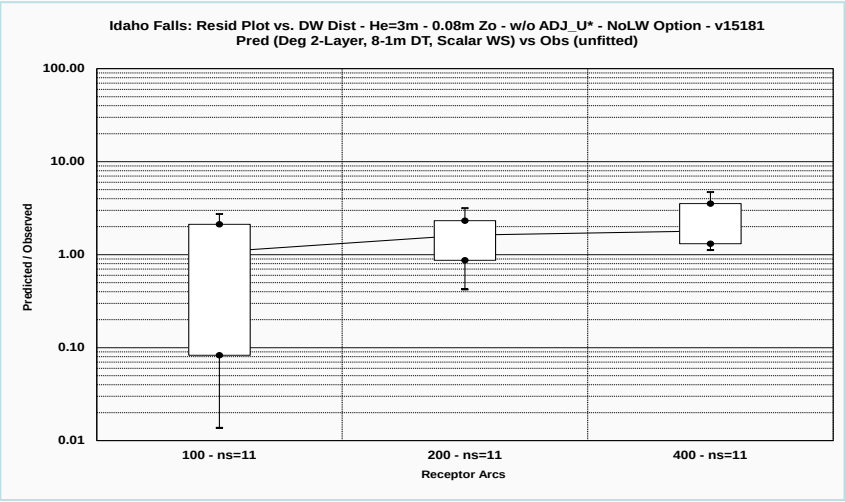
v14134 w/o ADJ_U* & NoLW



v15181 w/o ADJ_U* & NoLW







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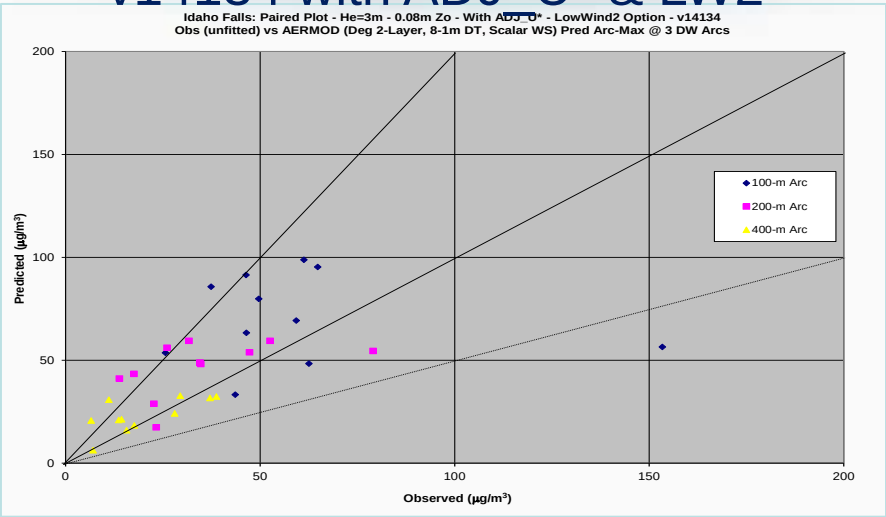
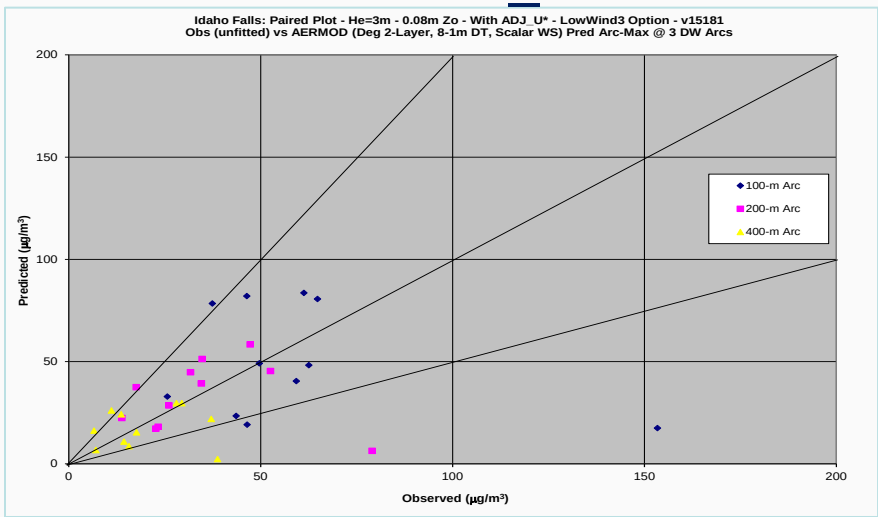
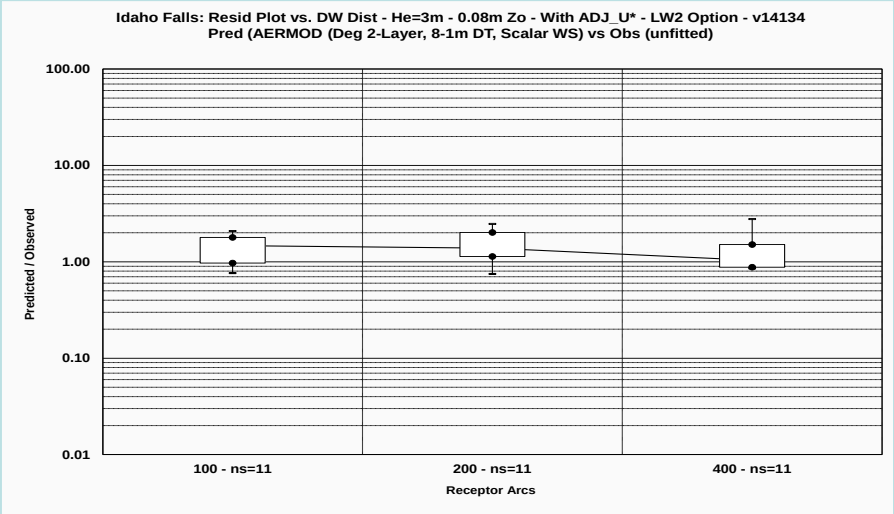
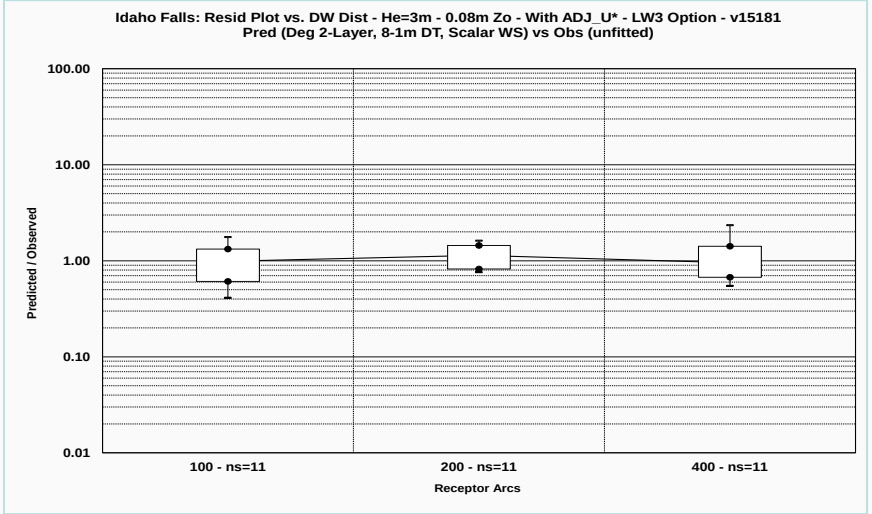
v14134 with ADJ_U* & LW2



v15181 with ADJ_U* & LW3







Summary

- EPA has proposed in the NPRM that the following options be incorporated into the regulatory versions of AERMOD and AERMET:
  - The ADJ_U* option in AERMET;
  - The LowWind3 option in AERMOD;
  - The BUOYLINE option in AERMOD for modeling buoyant line sources; and
  - The POINTCAP and POINTHOR source type options in AERMOD to model capped and horizontal stacks.