UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
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OFFICE OF
ENVIRONMENTAL ASSESSMENT

20 October 2015

MEMORANDUM

Subject: Surface Friction Velocity (u.) Non-Default/Beta Option in AERMET Version 15181; Alternative Refined Model Demonstration

From: Herman Wong
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To: Alan Schuler
Alaska Department of Environmental Conservation, Engineer, P.E.

This U.S. Environmental Protection Agency (EPA), Region 10 (R10) memorandum serves to notify the State of Alaska, Department of Environmental Conservation (ADEC) and the Model Clearinghouse (C/H) in the EPA Office of Air Quality Planning and Standards (OAQPS) of its decision to approve the use of the surface friction velocity (u.) non-default/beta option (u. option) in Version 15181 of the American Meteorological Society/Environmental Protection Agency Regulatory Improvement Committee (AERMIC) meteorological (AERMET) preprocessor program.[1] The R10 authority for such an approval are found in Sections 3.0.b and 3.2.2.a of Appendix W[2] and in the 1988 Model C/H Operational Plan.[3]

With the *Revision to the Guideline on Air Quality Models: Enhancement to the AERMOD Dispersion Modeling System and Incorporation of Approaches to Address Ozone and Fine Particulate Matter* proposed rulemaking published in 80 FR 45340 on 29 July 2015, ADEC in its 17 September 2015 letter[4] contained in Attachment A, requested R10 approval to allow an applicant to use the u. option in the AERMET preprocessor program and the "BETA" keyword under the CO MODELOPT pathway in the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD) dispersion program under 18 AAC 50.215(c).[5] These two programs along with Version 11.103 of the AERMIC terrain preprocessor (AERMAP)

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[1] EPA. 2015. Addendum, User's Guide for the AERMOD Meteorological Preprocessor (AERMET). (EPA-454/B-03-002, November 2004). Office of Air Quality Planning and Standards, Research Triangle Park, NC. June.

[2] Code of Federal Regulations; Title 40 (Protection of Environment.), Part 51, Appendix W, Section 3,

[3] EPA. 1988. Model Clearinghouse: Operation Plan (Revised). Staff Report. Office of Air Quality Planning and Standards, Research Triangle Park, NC. June 7.

[4] Schuler, A. 2015. Request to Use Adjusted u. Option for the Dolin Gold Project. Department of Environmental Conservation, 410 Willoughby Ave, Suite 303, Juneau, AK. September 17.

[5] Alaska Air Quality Control Regulations. Title 18, Environmental Conservation - Air Quality

program[6] will be utilized to estimate the Donlin Gold Limited Liability Company (DGLLC) mine construction and mine operation air pollutant emission impacts in ambient air to determine compliance with National Ambient Air Quality Standards (NAAQS)[7] and Prevention of Significant Deterioration (PSD) air quality increments.[8] The gold mine construction and/or operation compliance demonstrations will be submitted to ADEC as part of a PSD permit application and to the U.S. Army Corps of Engineers (Lead Agency) for inclusion in an Environmental Impact Statement (EIS) under the National Environmental Policy Act (NEPA).[9] The State of Alaska (AK) administrative code stipulates that an EPA preferred model may be substituted for an alternative model provided a demonstration is made pursuant to Section 3 in Appendix W of 40 CFR 51 and is approved by the R10 Regional Administrator.

The following sections describe the proposed project and discuss the bases for the R10 approval.

A. Project Overview

The DGLLC gold mine project will be located in topographic relief on the western slopes of the Kuskokwin Mountains in the Yukon-Kuskokwin region of southwestern Alaska as shown in Figure 1. Elevations range from 500 to 2,100 feet (ft). Ridges are well rounded.

The remote project area has no existing roads, rail access, or other public infrastructure. DGLLC currently accesses the area by air, using a private airstrip that they constructed near the site. To support the major mining and processing operations, DGLLC will construct significant infrastructure that includes a natural gas pipeline, power generation sources, an onsite employee accommodation complex, roads, ports, shipping and barging facilities.

Based on existing design, DGLLC proposes to construct and operate an open-pit gold mine, tailings and waste rock facilities, a process plant with a nominal production rate of 59,000 short tons of ore per day, a 220 megawatt power plant, and various ancillary sources. DGLLC intends to characterize the air emissions, including the fugitive dust emissions from the associated haul and access roads as 80 point, 398 volume, 46 area, and one open pit source for modeling purposes.[10] Point source stack heights range from 2.0 meters (m) for the dust collectors on the Apron Feeders (which are part of the rock crushing system) to 49.0 m for the 12 Wartsila power plant engines. Volume sources include haul road segments and blasting. Haul road segments are the most numerous with a release height of 6.97 m. Blasting operations will have a release height of 75.0 m. Areas sources include tailing storage facilities and access roads. Figure 2 shows an overhead view of the emission source layout.

Surface observations from the onsite American Ridge meteorological monitoring station, upper air data from the McGrath National Weather Service (NWS) station, and cloud cover data

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[6] EPA. 2011. Addendum, User's Guide for the AERMOD Terrain Preprocessor (AERMAP) (EPA-454/B-03-003, October 2004). Office of Air Quality Planning and Standards, Research Triangle Park, NC. March.

[7] Code of Federal Regulations; Title 40 (Protection of Environment), Part 50 – National Primary and Secondary Ambient Air Quality Standards.

[8] Code of Federal Regulations; Title 40 (Protection of Environment), Part 52 – Approval and Promulgation of Implementation Plans.

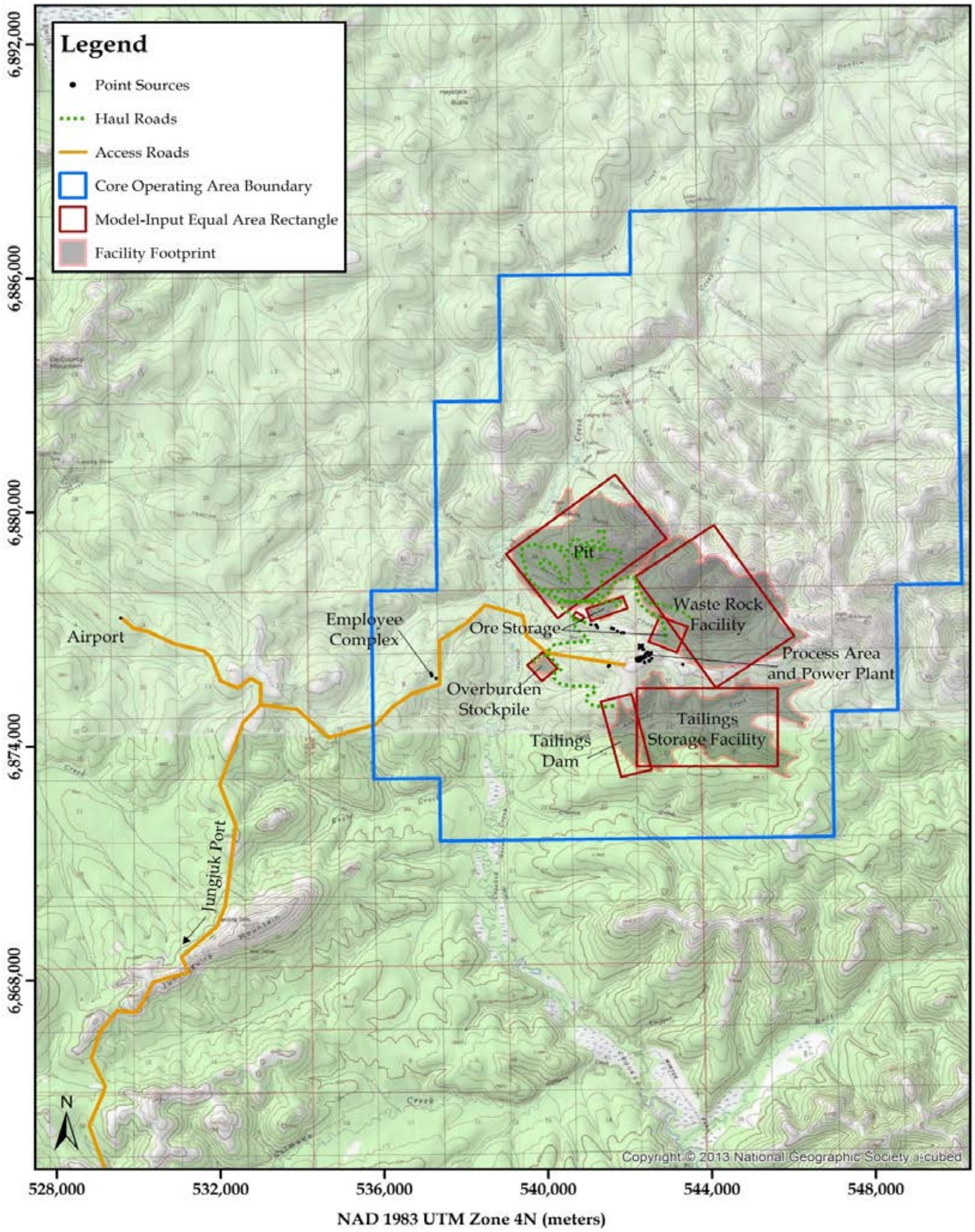
[9] 42 U.S.C. 4321

[10] Air Sciences. 2015. Class II PSD Increment and AAQS Compliance Modeling Protocol, Donlin Gold Project, Alaska. Project No. 281-15-2. Prepared for DGLLC. July.

Figure 1. Project Location.

Source: Air Sciences. 2015. Class II PSD Increment and AAQS Compliance Modeling Protocol, Donlin Gold Project, Alaska. Project No. 281-15-2. Prepared for DGLLC. July.

Figure 2. Proposed Emission Source Layout.



Source: Air Sciences. 2015. Class II PSD Increment and AAQS Compliance Modeling Protocol, Donlin Gold Project, Alaska. Project No. 281-15-2. Prepared for DGLLC. July.

from Sleetmute NWS station will be read by AERMET to build and output a surface file and a profile file for input into the AERMOD dispersion program to estimate air pollutant concentration impacts. The hourly surface observations were reviewed by ADEC and were found acceptable.[11] In lieu of the Bulk Richardson option, DGLLC will use Sleetmute cloud cover data which was determined by ADEC to be representative.[12] [13] The five year period of record for the data ranges from 1 July 2005 to 30 June 2010. Figure 3 shows the locations of the meteorological monitoring stations.

B. Regulatory Compliance and Demonstration for Use of a Non-Default/Beta Option in a Preferred Model

An alternative option in a preferred model may be used if it is found to be more appropriate than the preferred model. Section 3.2.2.b in Appendix W states that "There are three conditions under which such a model may normally be approved for use: (1) If a demonstration can be made that the model produces concentration estimates equivalent to the estimates obtained using a preferred model; (2) if a statistical performance evaluation has been conducted using measured air quality data and the result of the evaluation indicate the alternative model performs better for the given application than a comparable model in Appendix A; or (3) if the preferred model is less appropriate for the specific application, or there is no preferred model." R10 authority to accept and approve the use of an alternative option in a preferred model is given in Section 3.0.b and 3.2.2.a of Appendix W and in the 1988 revised Model Clearinghouse Plan.

In the following three subsections, four EPA Model Change Bulletins (MCB) related to the Qian and Venkatram u_* equations[14] coded into AERMET are summarized, a DGLLC demonstration consistent with Appendix W, Section 3.3.2.b(2)[15] [16] to use the u_* option in lieu of the current AERMET hard-coded u_* Default Method is presented, and a R10 description of the other meteorological variables affected by the u_* option is provided. The keyword "BETA" will be specified in MODELOPT since u_* is a non-default option in the AERMOD dispersion program per the June 2015 Addendum to the user's guide.

B.1 EPA Model Change Bulletin

In an effort to address AERMOD's propensity to overestimate concentration estimates during low wind speed stable conditions, EPA updated the AERMET source code with the Qian

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[11] Schuler, A. 2015. Approval of the July 2015 Prevention of Significant Deterioration (PSD) Modeling Protocol for the Donlin Gold Project. Department of Environmental Conservation, 410 Willoughby Ave, Suite 303, Juneau, AK. September 28.

[12] Schuler, A. 2013. Email to Robert Enos, DGLLC *Donlin May Use Sleetmute Cloud Cover Data*. Department of Environmental Conservation, 410 Willoughby Ave, Suite 303, Juneau, AK. October 1.

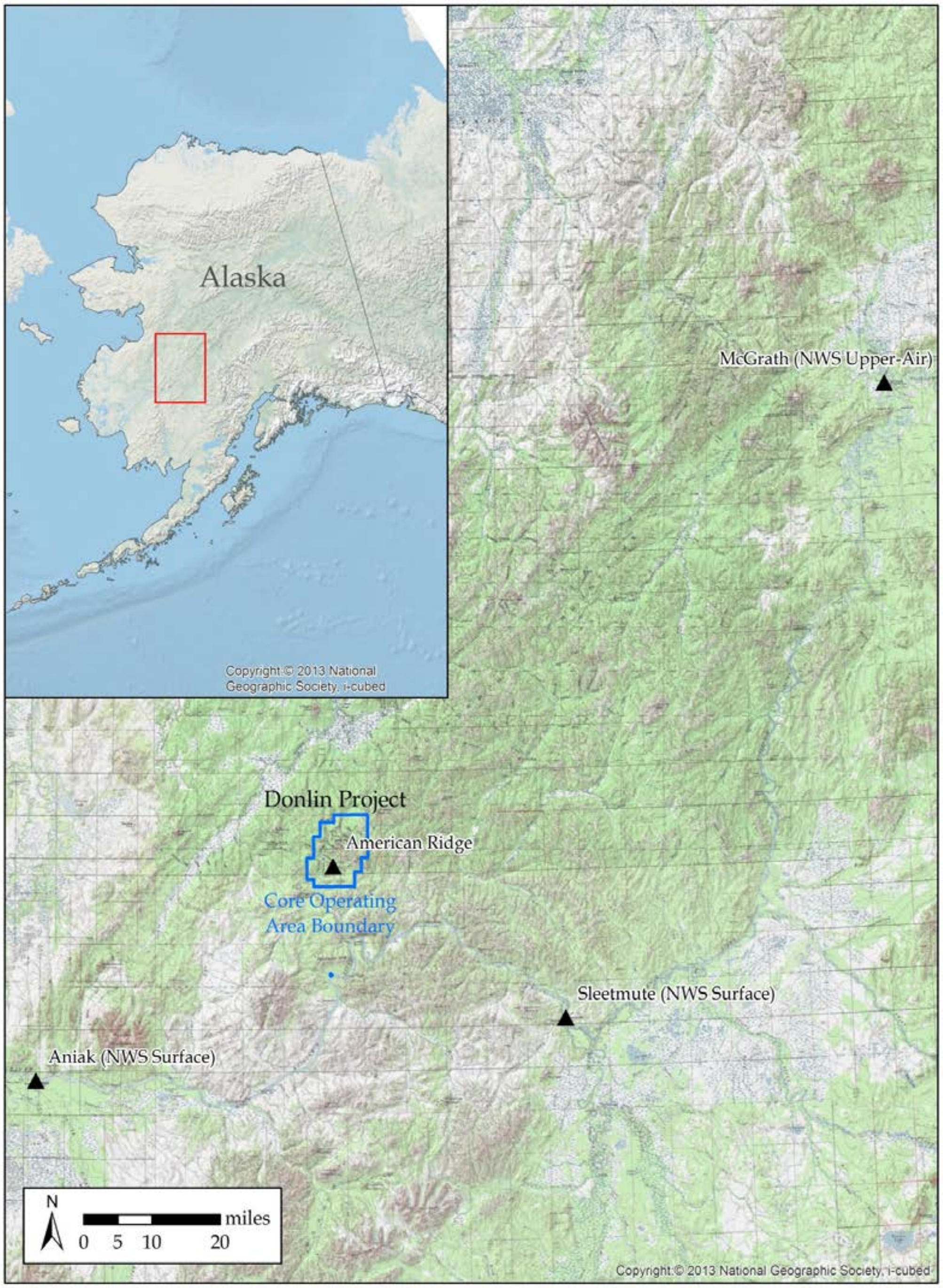
[13] Renovatio, J 2015. Email to Mike Rieser, DGLLC *FW: Cloud cover for Donlin*. Department of Environmental Conservation, 410 Willoughby Ave, Suite 303, Juneau, AK. February 3.

[14] Qian, Wenjun and Akula Venkatram. 2011. Performance of Steady-State Dispersion Models Under Low Sped Conditions. Boundary Layer Meteorology, 138:475-491.

[15] DGLLC. 2015. Additional Information Regarding DGLLC's Adj_u_* Approval Request to Alan Schuler, Alaska Department of Environmental Conservation. Donlin Gold, 4720 Business Park, Suite G-25, Anchorage, AK. August 25.

[16] DGLLC. 2015. Responses to EPA R10 Comments on DGLLC's Adj_u_* Approval Request to Alan Schuler, Alaska Department of Environmental Conservation. Donlin Gold, 4720 Business Park, Suite G-25, Anchorage, AK. September 2.

Figure 3. Meteorological Monitoring Station Location Map.



Source: Air Sciences. 2015. Class II PSD Increment and AAQS Compliance Modeling Protocol, Donlin Gold Project, Alaska. Project No. 281-15-2. Prepared for DGLLC. July.

and Venkatram equations for u_*. EPA also coded three non-default low wind options into AERMOD, any of which may be selected with or without the u_* option. However, DGLLC is not seeking R10 approval to use any of the non-default/beta low wind speed options in AERMOD.

Starting with AERMOD Version 12345, the Model C/H added the u_* option to address overpredicted concentration estimates associated with low wind speed under stable conditions (i.e., Monin-Obukhov [M-O] length > 0). This option was subsequently updated in Versions 13350, 14134 and 15181 with the latter proposed as regulatory default on 29 July 2015. The sequence of changes to AERMET are as follows:

1. Version 12345 - Model C/H first coded the u_* option into UCALST subroutine.[17]
2. Version 13350 - Model C/H modified the UCALST subroutine per AECOM recommendation to correct the scaling temperature (θ_*) in the u_* option.[18] [19] In addition, Model C/H modified the BULKRI subroutine to incorporate a Bulk Richardson (BULKRN) option for u_* based on Luhar and Raynor. [20]
3. Version 14134 - Model C/H modified BULKRI subroutine to include θ_* adjustment for low solar elevation angle and for the u_* option associated with the BULKRN option.[21]
4. Version 15181 - Modified subroutines UCALST and MPPBL to use a constant θ_* equal to 0.8, full inclusion of the displacement height, and a modified formulation of the M-O Length for u_* option based on Qian and Venkatram.[22]

With Version 15181, the Model C/H believed that there was sufficient analyses and evaluations completed internally and externally to propose the inclusion of the u_* option into Appendix W and make it a regulatory default option in AERMET.

B.2 DGLLC Demonstration to Use Adjusted u_* Option

The following paragraphs have been extracted in part from DGLLC letters dated 25 August 2015 and 2 September 2015 which are contained in Attachment B and Attachment C, respectively. DGLLC had requested R10 approval through ADEC to employ the u_* option in AERMET based on the analyses and evaluation used in the EPA Appendix W proposal.

During the January 2014 webinar, EPA presented preliminary model performance evaluation results from a low wind-speed study at Oak Ridge, TN in complex terrain. The webinar also provided results from an evaluation of the Cordero

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[17] EPA. 2012. Model Change Bulletin #3, AERMET (dated 12345). Office of Air Quality Planning and Standards, Research Triangle Park, NC. December 10.

[18] AECOM. 2012. AERMOD Low Speed Evaluation Study by Bob Paine at EPA 10th Modeling Conference. March 13.

[19] EPA. 2013. Model Change Bulletin #4, AERMET (dated 13350). Office of Air Quality Planning and Standards, Research Triangle Park, NC. December 16.

[20] Luhar, A. K. and K. N. Rayner. 2009. Methods to Estimate Surface Fluxes of Momentum and Heat from Routine Weather Observations for Dispersion Application under Stable Stratification. Boundary Layer Meteorology, 132:437-454.

[21] EPA. 2014. Model Change Bulletin #5, AERMET (dated 14134). Office of Air Quality Planning and Standards, Research Triangle Park, NC. May 14.

[22] EPA. 2014. Model Change Bulletin #6, AERMET (dated 15181). Office of Air Quality Planning and Standards, Research Triangle Park, NC. June 30.

Rojo surface coal mine study in Wyoming, examining monitored PM_{10} (particulate matter equal to or less than 10 microns in aerodynamic diameter) concentrations compared to modeled concentrations. A surface coal mine would have emission characteristics similar to those from the DGLLC project. Both studies showed that AERMOD simulations using the u_* option demonstrate significantly improved correlation to field data compared to the Default Method. Additionally in the webinar, EPA presented results from a model evaluation of the Idaho Falls tracer gas study for a low-level, non-buoyant release which also showed that the use of the u_* option improved model performance.

In the June 2015 Addendum to the AERMOD User's Guide, EPA provided model evaluation results using AERMET/AERMOD version 15181 for the Oak Ridge and Idaho Falls tracer studies. Evaluation of the u_* option applied to these studies also showed improved model performance for version 15181 compared to the Default Method. Additionally, EPA performed an evaluation of u_* as applied to a tall stack (145 meters) in complex terrain for the Lovett Power Plant, New York study. Again, the u_* option improved model performance when compared to observations. Updated results from the Cordero Rojo surface coal mine study were not included in the AERMET/AERMOD version 15181 evaluation studies. However, per a presentation at the 2015 Modeling Conference, EPA stated that it expected that the u_* evaluation results for that study "are likely to be similar for v15181". (R10 contacted the Model C/H to confirm that AERMET/AERMOD version 15181 had been run and the results were similar.[23])

For these four studies, model performance improved significantly with the use of the u_* option compared to the Default Method. These studies are relevant to the proposed DGLLC project due to similarities in terrain (complex) and emission characteristics (fugitive sources with low release heights or tall stacks, such as DGLLC's power plant stacks). Table 1 provides a summary of EPA's AERMET/AERMOD version 15181 u_* option evaluation studies in the June 2015 Addendum to the AERMOD User's Guide and the Cordero Rojo surface coal mine study presented in EPA's 2014 webinar.

DGLLC believes that the model evaluations performed by the EPA - presented in the 2014 webinar, and updated for AERMET/AERMOD version 15181 in the Users' Guide Addendum—sufficiently address the performance requirements of Sections in 3.2.2.b(2) and 3.2.2(d) for DGLLC's proposed use of the u_* option. Therefore, DGLLC seeks R10 and ADEC approval for application of the u_* option in the AERMOD modeling for the gold mine project under Section 3.2.2.b(2) of Appendix W.

DGLLC provided an AERMOD sensitivity analysis with their u_* option request. They modeled PM_{10} emissions since that would include fugitive dust sources using what they considered to be the worst-case meteorological period. Figure 4 highlights the difference in using the u_* option and the Default Method when predicting hourly concentrations for haul roads. The u_* option values are generally greater than 0.10 meters per second (m/sec) and the hourly predicted concentrations are less than 35 micrograms per cubic meter ($\mu g/m^3$). In the Default Method, u_* are as low as 0.04 m/sec with predicted hourly concentrations as high as 60 $\mu g/m^3$.

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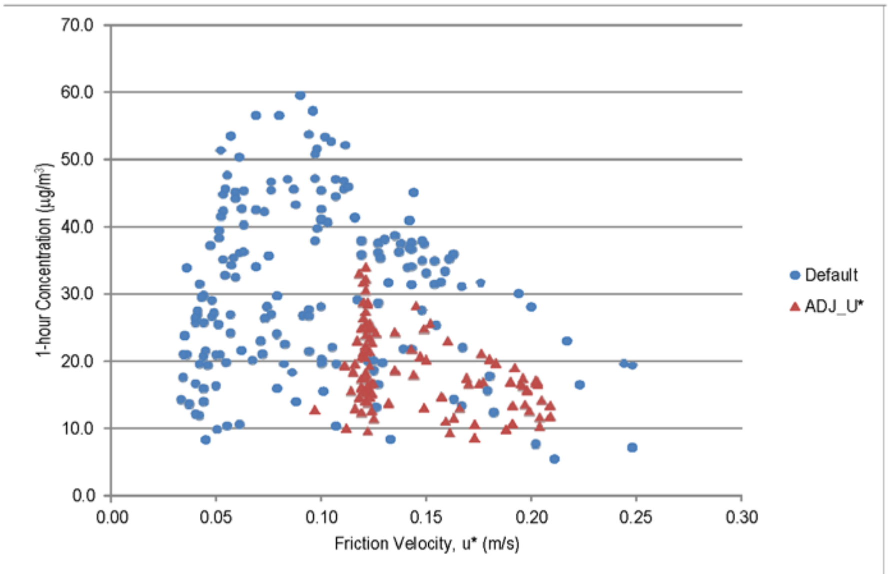
[23] Wong, H. 2015. Region 10 telephone conversation with R. Brode, EPA Model Clearinghouse. Office of Environmental Assessment, Seattle, WA. September 30.

Table 1. Summary of EPA's ADJ_U* Evaluations for AERMET/ AERMOD Version 15181

Study Name	Release Type	Terrain / Surroundings	Applicable to Donlin?	Model Performance Without ADJ_U*	Model Performance With ADJ_U*	Overall Conclusions
Oak Ridge	Low-level, non-buoyant release (1 m)	Complex terrain, Rural, Open-area	Yes - Donlin is located in complex terrain and has numerous, low-level fugitive emission sources	Model over-predicts observations by a factor of 2 to 30 (EPA 2015b, Pages F-6 and F-11)	Model agrees with observations within a factor of 1 to 2 (EPA 2015b, Pages F-8 and F-14)	"significant improvement in model performance with the ADJ_U* option in AERMET" (EPA 2015b, Page F-16).
Idaho Falls	Low-level, non-buoyant release (3 m)	Flat/even terrain, Open-area	Yes - Donlin has low-level, non-buoyant fugitive sources, but terrain is different	Model over-predicts observations by a factor of 2 (EPA 2015b, Pages F-6 and F-11)	Model agrees with observations within a factor of 1 to 2 (EPA 2015b, Pages F-25 and F-26)	Generally good model performance at receptors nearest the release. As noted by EPA, "For this type of source, i.e., a non-buoyant, ground-level or low-level source (e.g., fugitive emission), the maximum ambient impacts are likely to occur at the fenceline" (EPA 2015b, Page F-18). Relevant to DGLLC operations/modeling.
Lovett	Tall stack (145 m)	Complex terrain, Rural, Open-area	Yes - Donlin is located in complex terrain and has tall point sources such as the power plant stacks (49 m)	"Past evaluations of AERMOD have shown good performance" (EPA 2015b, Page F-33). The consideration of ADJ_U* reduces the model over-predictions slightly.		Model performance improvement when using ADJ_U* (EPA 2015b, Pages F-33 and F-34).
Cordero Rojo (Wyoming surface coal mine)	Surface mine; majority of emissions from haul roads	Flat/even terrain, Rural, Open-area	Yes - Donlin has low-level, non-buoyant fugitive sources, but terrain is different	EPA evaluated ADJ_U* for AERMOD version 14134, not for version 15181. "Use of the proposed ADJ_U* option in AERMET appears to significantly improve model performance for this study" (EPA 2015d).		Significant improvement in model performance when using ADJ_U*. The results for this study are "based on v14134, but are likely to be similar for v15181" (EPA 2015d).

Figure 4. Haul Road Source Group: u* Option and u* Default Method Comparison
(Note: 10-degree sector winds, 0 < M-O < 50 m)



B.3 R10 Analysis of Meteorological Variables Affected by the u* Option

Most, if not all of the evaluations and analyses have focused on the influence of u* on AERMOD predicted concentrations. However, no discussion or analysis was presented for heat flux, mechanical mixing height and M-O Length which uses u* to derive their numerical value. This subsection presents a comparison of these three calculated meteorological variables based on the u* option and the Default Method.

In the MPPBL subroutine of AERMET, a call is made to UCALST which calculates a u* value for a specified hour. The calculated u* then is returned to UCALST to derive heat flux, mechanical mixing height and M-O Length. Tables 2 – 8 presents a numerical comparison of these calculated four meteorological parameters using the u* option and the Default Method. Figures 5-11 presents the tabulated results graphically. These tabular and graphics summaries were based on the High, Second-High (HSH) predicted concentrations for each of the seven source groups used by DGLLC in their AERMOD sensitivity analysis.

General Observations:

1. The HSH concentrations for all seven source groups occurred during November to February. In northern latitudes, where the project is located, these months are characterized by short days with very low sun angles and very stable conditions. An example is the Power Plant Source Group presented in Table 4 and Figure 7 in which there was 24 hours of M-O > 0.
2. For all seven groups, the u* option based surface friction velocity, heat flux and mechanical mixing height are greater than those based on the Default Method.

Table 2. Affected Hourly Meteorological Variables With and Without u_* Option for HSH Concentration - All Sources/Groups

					Qian and Venkatram				Default			
YR	MO	DY	JDY	HR	H	u_*	Z_{im}	L	H	u_*	Z_{im}	L
5	12	26	360	9	-6.1	0.120	100	24.2	-2.3	0.055	31	6.1
5	12	26	360	10	-5.6	0.120	100	26.4	-1.9	0.050	27	5.6
5	12	26	360	11	-6.1	0.120	100	23.9	-2.3	0.055	31	6.1
5	12	26	360	12	-23.5	0.234	271	60.1	-9.9	0.114	92	12.7
5	12	26	360	13	-40.7	0.444	709	216.6	-27.0	0.385	574	179.4
5	12	26	360	14	-8.9	0.143	266	27.6	-2.9	0.072	260	11.0
5	12	26	360	15	-24.0	0.259	315	73.5	-11.5	0.185	192	46.8
5	12	26	360	17	-3.1	0.118	97	43.9	-0.7	0.030	12	3.1
5	12	26	360	18	-4.5	0.120	100	32.9	-0.9	0.040	19	6.3
5	12	26	360	19	-5.7	0.120	100	25.7	-1.6	0.051	28	7.4
5	12	26	360	20	-6.5	0.120	100	22.5	-2.6	0.059	34	6.5
5	12	26	360	22	-9.6	0.143	130	26.1	-3.9	0.073	47	8.3
5	12	26	360	23	-24.3	0.241	284	63.8	-10.5	0.117	96	13.1
5	12	26	360	24	-8.6	0.135	125	24.5	-3.6	0.069	43	7.6

Table 3. Affected Hourly Meteorological Variables With and Without u_* Option for HSH Concentration – Process and Auxiliary Sources

YR	MO	DY	JDY	HR	Qian and Venkatram				Default			
					H	u_*	Z_{im}	L	H	u_*	Z_{im}	L
6	1	1	1	1	-5.6	0.121	101	26.5	-1.9	0.050	27	5.5
6	1	1	1	2	-3.9	0.121	101	38.0	-0.9	0.035	16	4.1
6	1	1	1	4	-4.0	0.118	98	34.6	-1.2	0.038	18	3.9
6	1	1	1	6	-5.8	0.121	101	25.9	-2.0	0.051	28	5.8
6	1	1	1	7	-7.3	0.124	105	22.3	-3.1	0.063	38	7.0
6	1	1	1	8	-3.9	0.121	101	38.0	-0.9	0.035	16	3.9
6	1	1	1	9	-14.3	0.176	177	34.1	-5.9	0.088	62	9.7
6	1	1	1	10	-6.4	0.120	101	23.1	-2.5	0.057	33	6.3
6	1	1	1	11	-25.5	0.251	301	69.2	-11.0	0.163	157	32.9
6	1	1	1	12	-23.3	0.231	266	58.6	-9.7	0.113	91	12.5
6	1	1	1	14	-3.8	0.112	90	31.3	-0.9	0.040	19	6.1
6	1	1	1	17	-3.7	0.121	101	40.3	-0.6	0.033	14	4.7
6	1	1	1	18	-4.7	0.121	101	31.5	-1.1	0.042	21	6.0
6	1	1	1	20	-5.9	0.121	101	25.6	-1.6	0.052	29	7.4
6	1	1	1	22	-10.6	0.150	140	27.2	-4.4	0.076	50	8.3
6	1	1	1	24	-5.1	0.121	101	29.3	-1.6	0.045	23	5.0

Table 4. Affected Hourly Meteorological Variables With and Without u_* Option for HSH Concentration – Power Plant Sources

YR	MO	DY	JDY	HR	Qian and Venkatram				Default			
					H	u_*	Z_{im}	L	H	u_*	Z_{im}	L
5	12	7	341	1	-64.0	0.699	1401	538.1	-60.7	0.624	1181	340.6
5	12	7	341	2	-64.0	0.742	1531	605.7	-44.2	0.672	1319	583.0
5	12	7	341	3	-64.0	0.777	1641	664.2	-64.0	0.696	1391	445.9
5	12	7	341	4	-56.9	0.580	1106	370.1	-49.0	0.508	906	226.0
5	12	7	341	5	-56.8	0.578	1057	368.1	-48.9	0.506	864	223.7
5	12	7	341	6	-60.8	0.619	1168	422.1	-31.0	0.561	1007	479.9
5	12	7	341	7	-63.8	0.650	1257	465.3	-32.5	0.590	1085	530.0
5	12	7	341	8	-63.5	0.647	1250	461.1	-32.4	0.587	1079	524.0
5	12	7	341	9	-63.6	0.650	1259	465.3	-43.6	0.583	1067	380.1
5	12	7	341	10	-64.0	0.852	1883	809.0	-42.3	0.773	1629	915.3
5	12	7	341	11	-64.0	0.759	1602	633.1	-37.5	0.690	1387	731.2
5	12	7	341	12	-64.0	0.710	1442	553.9	-50.4	0.639	1231	432.2
5	12	7	341	13	-54.0	0.630	1210	436.4	-53.4	0.554	998	264.9
5	12	7	341	14	-64.0	0.811	1750	724.1	-36.5	0.738	1520	917.4
5	12	7	341	15	-64.0	0.950	2214	1114.7	-43.9	0.862	1915	1214.0
5	12	7	341	16	-64.0	0.894	2038	927.6	-64.0	0.804	1741	676.2
5	12	7	341	17	-64.0	0.777	1668	663.3	-45.2	0.703	1432	638.1
5	12	7	341	18	-64.0	1.073	2658	1602.6	-52.4	0.972	2295	1456.7
5	12	7	341	19	-64.0	1.038	2544	1449.6	-50.7	0.940	2195	1361.7
5	12	7	341	20	-64.0	0.968	2303	1177.3	-47.3	0.878	1986	1187.5
5	12	7	341	21	-64.0	0.968	2287	1177.3	-47.2	0.878	1974	1188.7
5	12	7	341	22	-64.0	1.024	2480	1395.2	-49.9	0.929	2141	1331.8
5	12	7	341	23	-64.0	1.014	2452	1353.4	-49.4	0.919	2116	1305.9
5	12	7	341	24	-64.0	0.837	1890	770.4	-40.9	0.760	1629	892.6

Table 5. Affected Hourly Meteorological Variables With and Without u_* Option for HSH Concentration - Haul Road Sources

YR	MO	DY	JDY	HR	Qian and Venkatram				Default			
					H	u_*	Z_{im}	L	H	u_*	Z_{IM}	L
5	12	26	360	9	-6.1	0.120	100	24.2	-2.3	0.055	31	6.1
5	12	26	360	10	-5.6	0.120	100	26.4	-1.9	0.050	27	5.6
5	12	26	360	11	-6.1	0.120	100	23.9	-2.3	0.055	31	6.1
5	12	26	360	12	-23.5	0.234	271	60.1	-9.9	0.114	92	12.7
5	12	26	360	13	-40.7	0.444	709	216.6	-27.0	0.385	574	179.4
5	12	26	360	14	-8.9	0.143	266	27.6	-2.9	0.072	260	11.0
5	12	26	360	15	-24.0	0.259	315	73.5	-11.5	0.185	192	46.8
5	12	26	360	17	-3.1	0.118	97	43.9	-0.7	0.030	12	3.1
5	12	26	360	18	-4.5	0.120	100	32.9	-0.9	0.040	19	6.3
5	12	26	360	19	-5.7	0.120	100	25.7	-1.6	0.051	28	7.4
5	12	26	360	20	-6.5	0.120	100	22.5	-2.6	0.059	34	6.5
5	12	26	360	22	-9.6	0.143	130	26.1	-3.9	0.073	47	8.3
5	12	26	360	23	-24.3	0.241	284	63.8	-10.5	0.117	96	13.1
5	12	26	360	24	-8.6	0.135	125	24.5	-3.6	0.069	43	7.6

Table 6. Affected Hourly Meteorological Variables With and Without u_* Option for HSH Concentration – Blasting Sources

YR	MO	DY	JDY	HR	Qian and Venkatram				Default			
					H	u_*	Z_{im}	L	H	u_*	Z_{im}	L
6	1	31	31	7	-4.8	0.125	106	34.9	-0.9	0.040	19	5.9
6	1	31	31	8	-3.8	0.121	101	39.4	-1.0	0.033	15	3.2
6	1	31	31	11	-4.2	0.124	105	39.2	-1.0	0.035	16	3.7
6	1	31	31	13	-14.1	0.189	198	41.1	-3.2	0.086	60	16.5
6	1	31	31	14	-6.0	0.126	109	28.9	-1.4	0.059	34	12.2
6	1	31	31	15	-4.0	0.101	77	21.8	-1.2	0.051	28	9.7
6	1	31	31	16	-5.0	0.110	88	22.7	-1.4	0.053	30	9.1
6	1	31	31	17	-29.5	0.307	409	103.8	-6.3	0.113	91	19.1
6	1	31	31	18	-46.3	0.427	669	200.3	-18.4	0.162	157	19.8
6	1	31	31	19	-9.0	0.136	247	23.8	-3.0	0.064	45	7.3
6	1	31	31	20	-7.3	0.125	109	22.7	-2.9	0.061	36	6.5
6	1	31	31	21	-6.2	0.125	106	26.7	-2.1	0.051	28	5.5
6	1	31	31	22	-12.9	0.164	159	29.5	-4.5	0.077	52	8.7
6	1	31	31	23	-9.3	0.138	123	24.0	-3.0	0.065	39	7.5
6	1	31	31	24	-26.9	0.244	290	65.7	-4.4	0.091	66	14.4

Table 7. Affected Hourly Meteorological Variables With and Without u_* Option for HSH Concentration – Inpit Loading/Unloading/Machinery Sources

					Qian and Venkatram				Default			
YR	MO	DY	JDY	HR	H	u_*	Z_{im}	L	H	u_*	Z_{im}	L
5	12	21	355	1	-6.1	0.122	102	25.1	-2.2	0.053	30	5.9
5	12	21	355	2	-3.8	0.121	101	39.4	-0.9	0.034	15	3.7
5	12	21	355	6	-5.1	0.121	101	29.3	-1.6	0.045	23	5.0
5	12	21	355	8	-6.4	0.121	101	23.5	-1.7	0.057	32	8.8
5	12	21	355	9	-6.5	0.121	101	23.0	-1.8	0.058	34	9.0
5	12	21	355	10	-11.6	0.157	150	28.5	-3.4	0.079	53	12.3
5	12	21	355	11	-17.7	0.196	209	42.3	-5.1	0.097	72	15.1
5	12	21	355	12	-21.9	0.219	246	52.9	-8.9	0.107	85	11.9
5	12	21	355	13	-21.9	0.222	252	54.4	-7.8	0.141	127	30.5
5	12	21	355	14	-20.9	0.232	267	59.0	-8.7	0.143	130	28.7
5	12	21	355	15	-18.3	0.206	224	46.5	-6.1	0.101	77	14.2
5	12	21	355	16	-18.1	0.199	213	43.6	-7.4	0.098	74	10.9
5	12	21	355	17	-23.7	0.232	268	59.3	-8.9	0.154	145	35.0
5	12	21	355	18	-14.1	0.175	176	33.5	-4.1	0.087	63	13.6
5	12	21	355	19	-11.6	0.157	150	28.6	-3.4	0.079	53	12.3
5	12	21	355	20	-23.9	0.234	271	60.0	-9.0	0.157	149	36.2
5	12	21	355	21	-17.5	0.195	207	41.7	-5.0	0.096	72	15.0
5	12	21	355	22	-19.0	0.203	220	45.5	-5.5	0.100	76	15.6
5	12	21	355	23	-20.6	0.212	234	49.5	-5.9	0.104	81	16.2
5	12	21	355	24	-7.2	0.123	107	22.0	-2.1	0.063	38	9.7

Table 8. Affected Hourly Meteorological Variables With and Without u_* Option for HSH Concentration – Waste Unloading/Machinery/Hauling Sources

YR	MO	DY	JDY	HR	Qian and Venkatram				Default			
					H	u_*	Z_{im}	L	H	u_*	Z_{im}	L
5	12	26	360	9	-6.1	0.120	100	24.2	-2.3	0.055	31	6.1
5	12	26	360	10	-5.6	0.120	100	26.4	-1.9	0.050	27	5.6
5	12	26	360	11	-6.1	0.120	100	23.9	-2.3	0.055	31	6.1
5	12	26	360	12	-23.5	0.234	271	60.1	-9.9	0.114	92	12.7
5	12	26	360	13	-40.7	0.444	709	216.6	-27.0	0.385	574	179.4
5	12	26	360	14	-8.9	0.143	266	27.6	-2.9	0.072	260	11.0
5	12	26	360	15	-24.0	0.259	315	73.5	-11.5	0.185	192	46.8
5	12	26	360	17	-3.1	0.118	97	43.9	-0.7	0.030	12	3.1
5	12	26	360	18	-4.5	0.120	100	32.9	-0.9	0.040	19	6.3
5	12	26	360	19	-5.7	0.120	100	25.7	-1.6	0.051	28	7.4
5	12	26	360	20	-6.5	0.120	100	22.5	-2.6	0.059	34	6.5
5	12	26	360	22	-9.6	0.143	130	26.1	-3.9	0.073	47	8.3
5	12	26	360	23	-24.3	0.241	284	63.8	-10.5	0.117	96	13.1
5	12	26	360	24	-8.6	0.135	125	24.5	-3.6	0.069	43	7.6

Figure 5. Affected Hourly Meteorological Variables With and Without u_* Option for HSH Concentration - All Sources/Groups

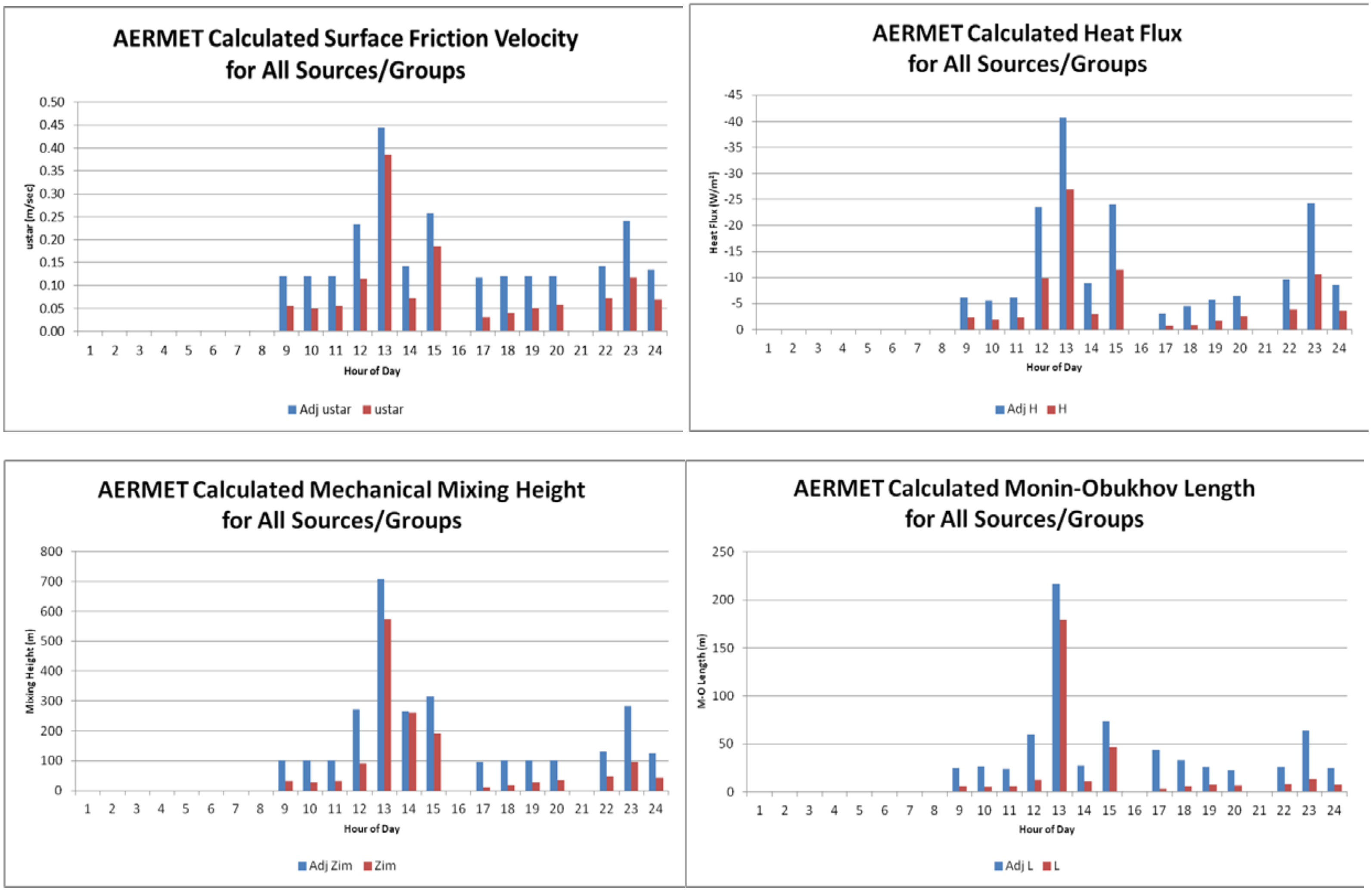


Figure 6. Affected Hourly Meteorological Variables With and Without u_* Option for HSH Concentration – Process and Auxiliary Sources

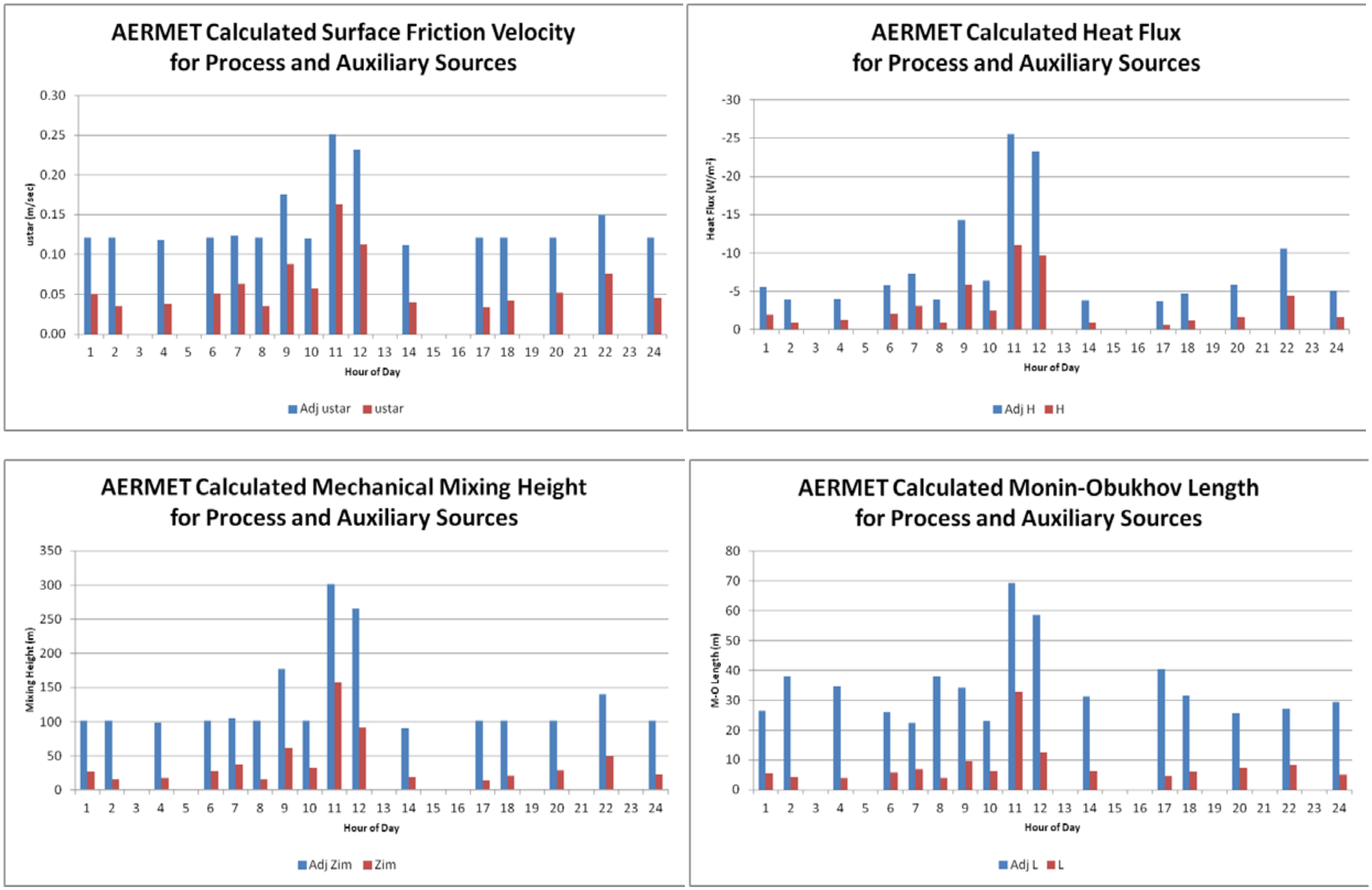


Figure 7. Affected Hourly Meteorological Variables With and Without u_* Option for HSH Concentration – Power Plant Sources

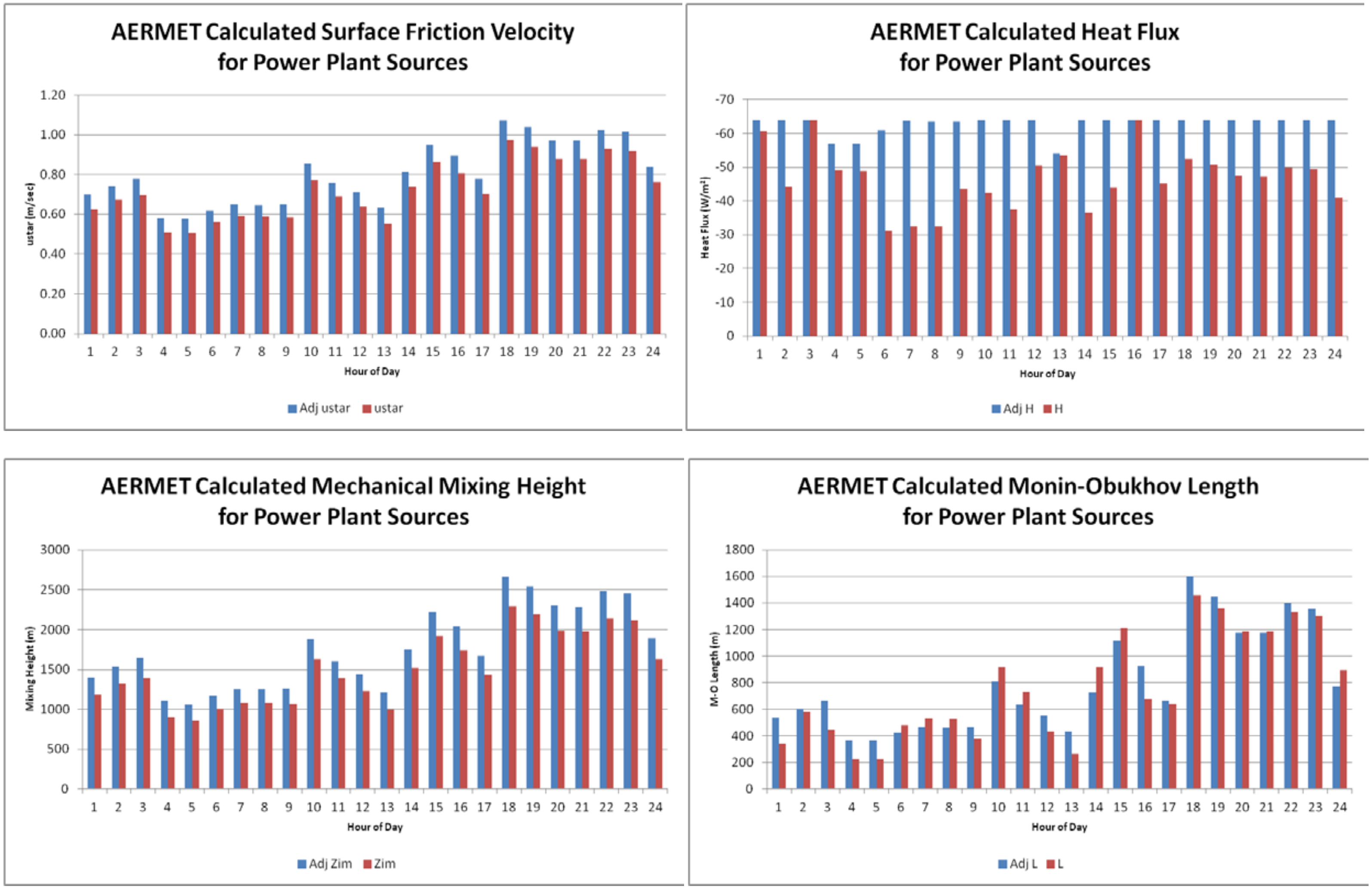


Figure 8. Affected Hourly Meteorological Variables With and Without u. Option for HSH Concentration - Haul Road Sources

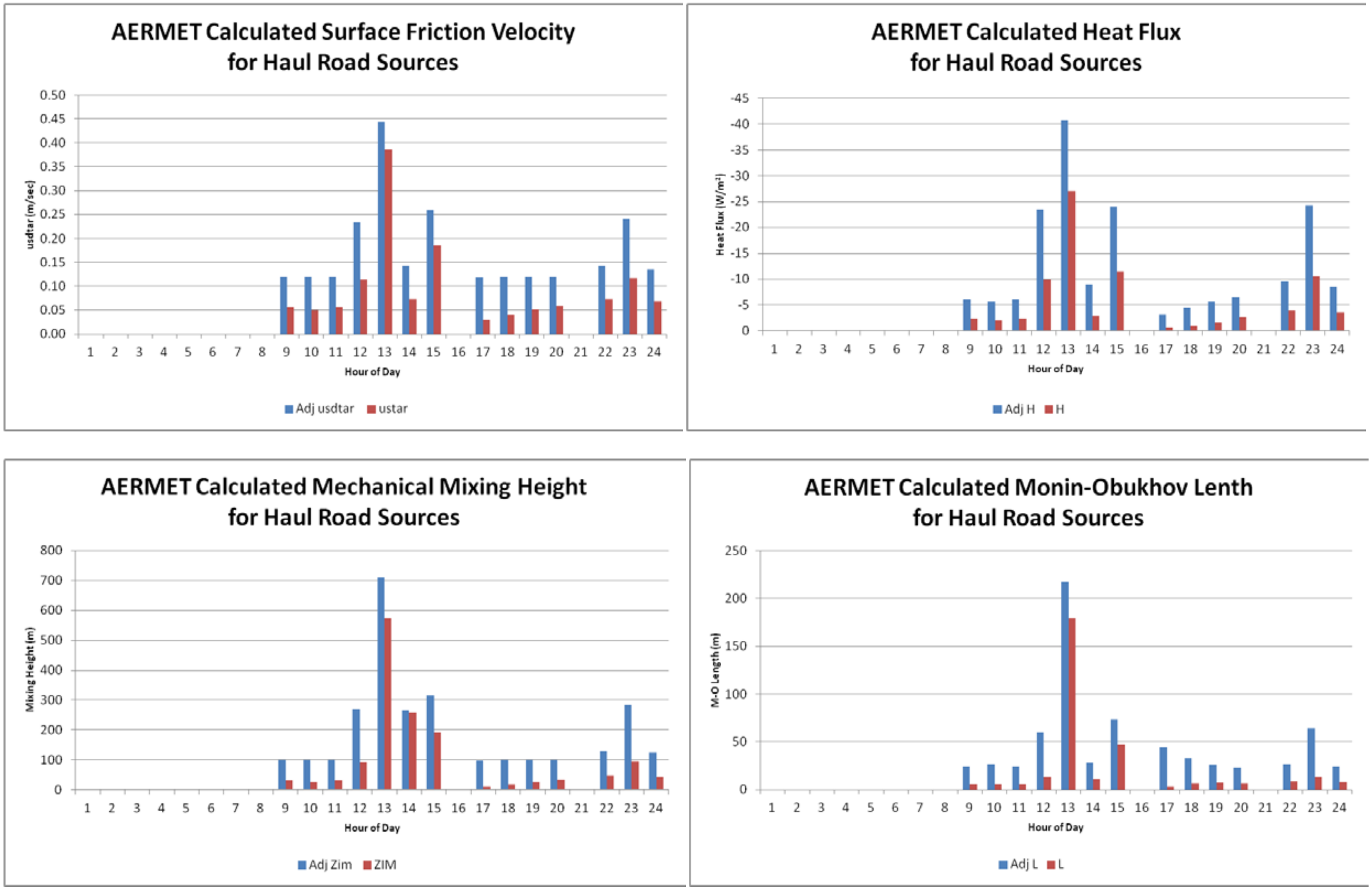


Figure 9. Affected Hourly Meteorological Variables With and Without u_* Option for HSH Concentration – Blasting Sources

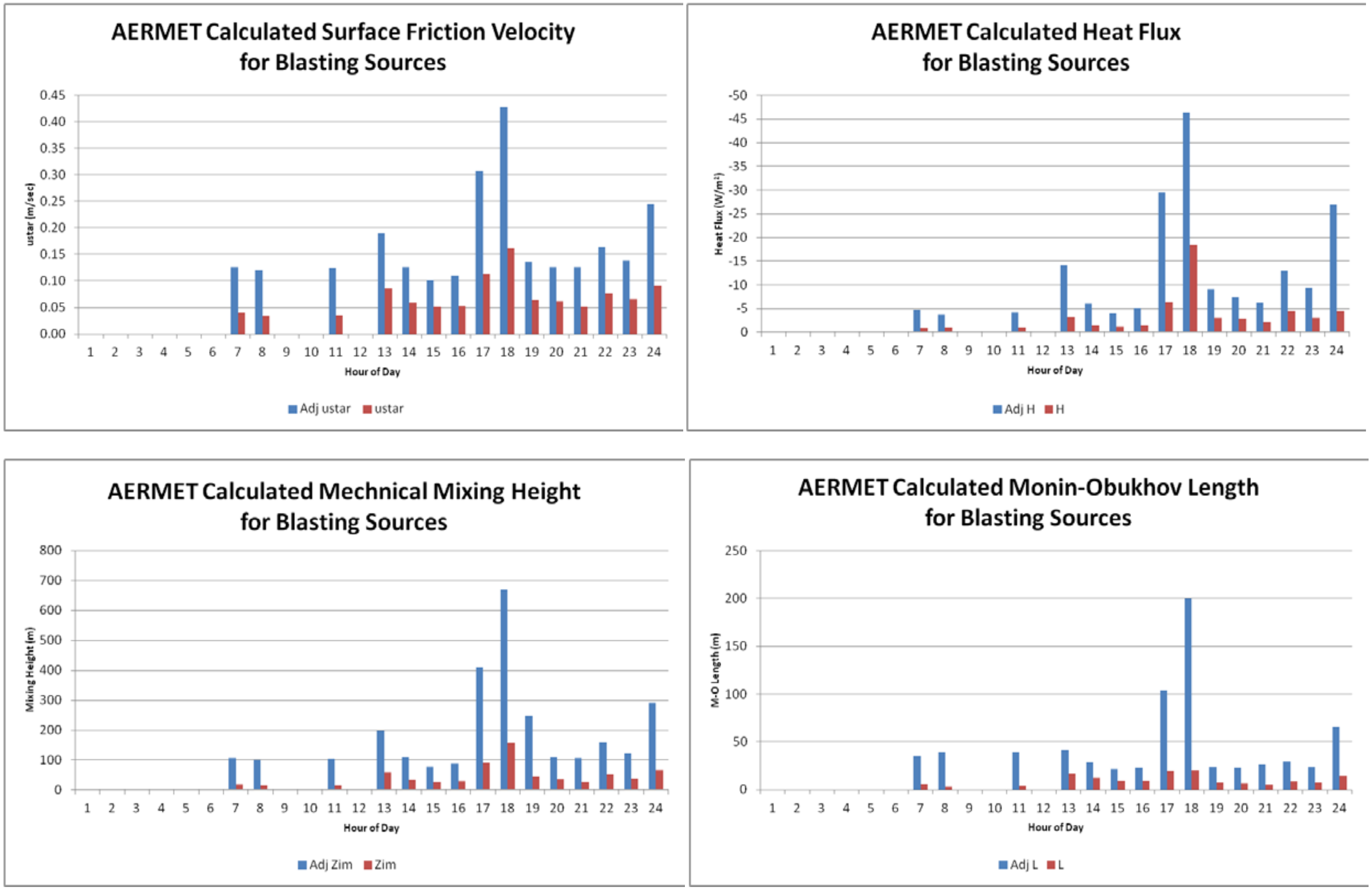


Figure 10. Affected Hourly Meteorological Variables With and Without u_* Option for HSH Concentration – Inpit Loading/Unloading/Machinery Sources

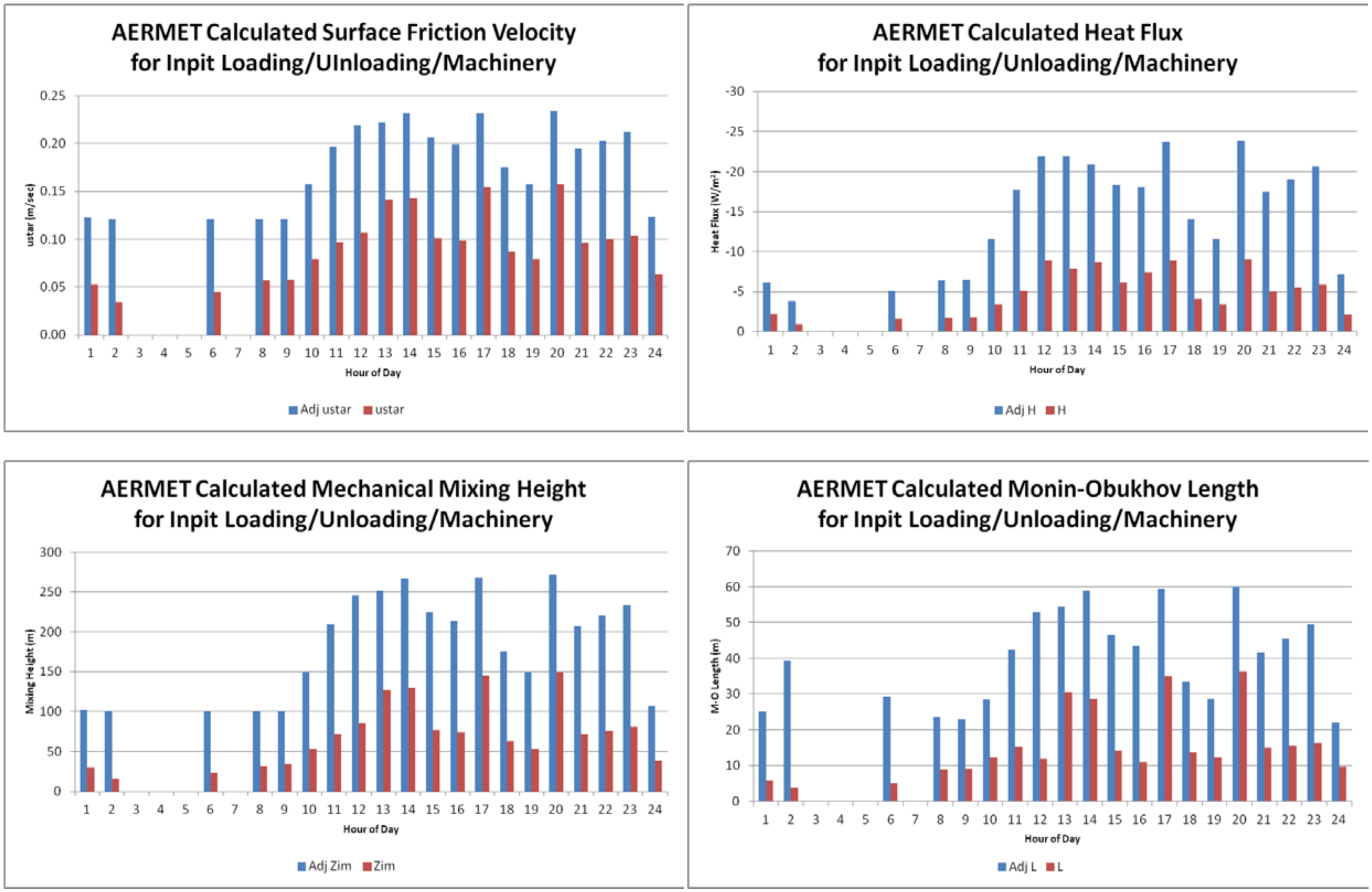
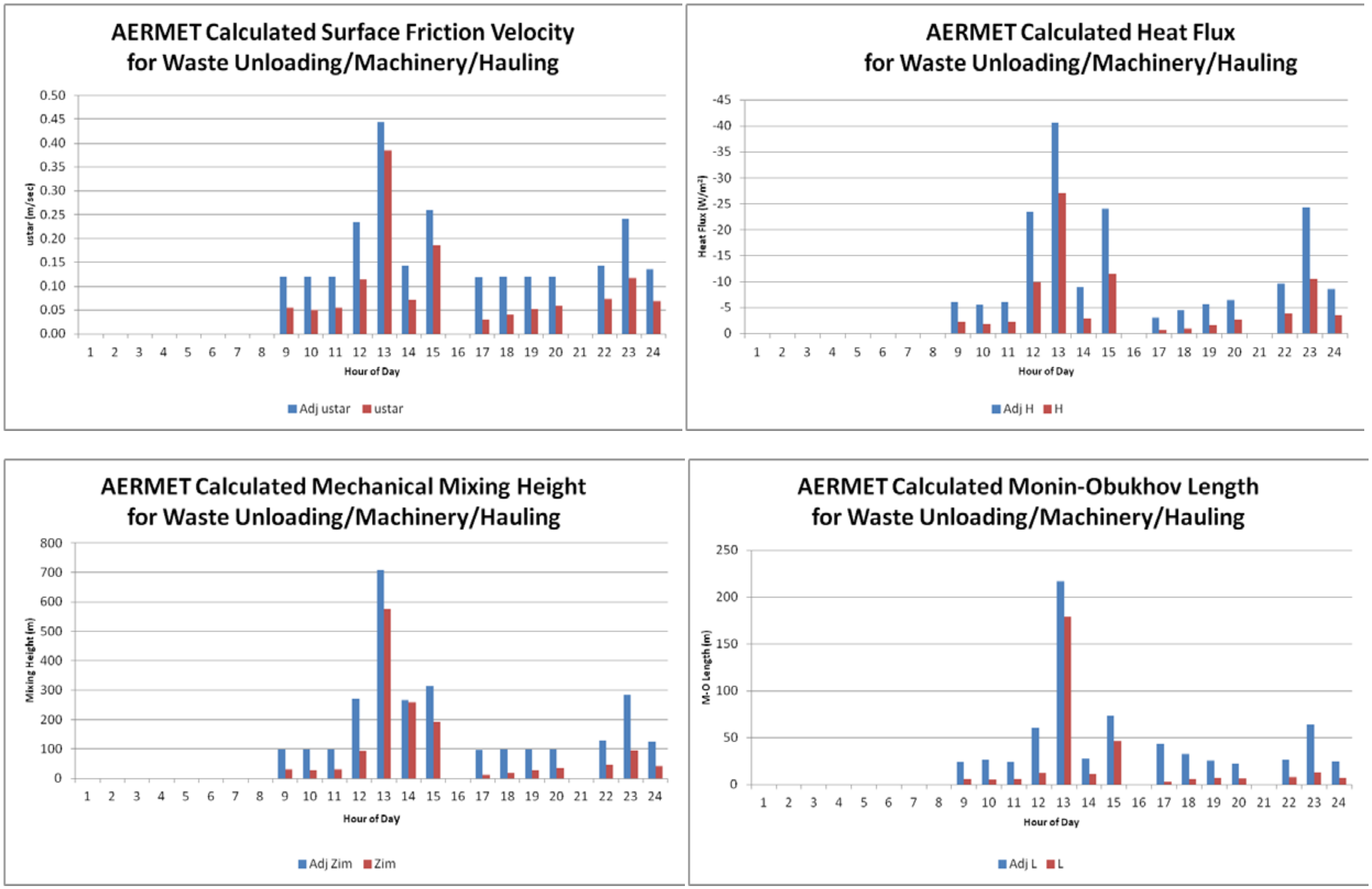


Figure 11. Affected Hourly Meteorological Variables With and Without u_* Option for HSH Concentration – Waste Unloading/Machinery/Hauling Sources



3. Except for the Power Plant Source Group, the u_* option based M-O Length are greater than those based on the Default Method. For Power Plant Source Group, M-O Length based on the Default Method for hours 6, 7, 8, 10, 11, 14, 15, 20, 21, and 24 are greater than the u_* option.
4. Only hours for the HSH day for each of the seven source groups are presented
5. For strong wind cases, the heat flux is set to -64 W/m2 to avoid becoming unrealistically large negatively.

C. Conclusions and Recommendations

C.1 Conclusions

R10 has reviewed the technical materials and presentations available from the Model C/H and the private sector as well the DGLLC technical materials provided to ADEC and R10 and has determined that the condition of Section 3.2.2.d of Appendix W in 40 CFR 51 has been adequately addressed. In addition, while the Qian and Venkatram equations coded into AERMET V15181 addresses the u_* option underpredictions during stable conditions, it also numerically improves the values of heat flux, mechanical mixing height and M-O Length. Thus, AERMET with the u_* option is a better meteorological preprocessor and makes AERMOD a better performing model.

Approval to use this alternative model option is made on a case-by-case basis until a final rulemaking is published in Federal Register that makes the Qian and Venkatram u_* option in Version 15181 a “default option” in AERMOD.

As part of the public notice and comment period, ADEC will solicit comments on the use of the u_* option to support the issuance of the draft PSD permit.

R10 is not aware of any pending AERMOD/AERMET updates, including u_* updates, from EPA. However, ADEC will need to consult with R10 if EPA does issue an update prior to an ADEC public notice of a preliminary permit decision. R10 may recommend that DGLLC revise their analysis if the update corrects a coding error that likely leads to underestimated impacts.

C.2 Recommendations.

Below are two options related to the implementation of the u_* option in AERMET that the Model C/H and R10 developed. DGLLC should select either Model Option 1 or Model Option 2 when preprocessing meteorological data.

Model Option 1 – Use of adjusted u_* (AERMET) with site specific meteorological data that does not include either (1) measured turbulence parameters (i.e., sigma-theta or sigma-w) or (2) beta LOWWIND (AERMOD) options.

Model Option 2 - Use of adjusted u_* (AERMET) with site specific meteorological data that includes measured turbulence parameters and does not include beta LOWWIND (AERMOD) options. Due to the fact that model performance evaluations for the beta LOWWIND (AERMOD) options together with the adjusted u_* option (AERMET) are inconclusive at this time, 1-year of post construction ambient monitoring may be needed should this option be employed.

The Bulk Richardson (AERMET) option can be used with either Option 1 or Option 2.

Table 4 and Figure 7 shows ten hours in which the Default Method M-O Length are greater than the u_* option based M-O Length. The u_* option and related equation in MPPBL and UCALST should be reviewed to determine if changes are necessary.

cc:
Mahbubul Islam, R10
George Bridgers, Model C/H

Attachment A: ADEC Request Letter

THE STATE of ALASKA
GOVERNOR BILL WALKER

Department of Environmental Conservation

DIVISION OF AIR QUALITY
Air Permits Program

410 Willoughby Avenue, Suite 303
Juneau, Alaska 99811-1800
PO Box 111800
Main: 907.465.5100
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Sent via E-Mail

September 17, 2015

Herman Wong, OEA-140
Office of Environmental Assessment
EPA – Region 10
1200 6th Ave., Suite 900
Seattle, WA 98101

Subject: Request to Use Adjusted_u* Option for the Donlin Gold Project

Dear Mr. Wong:

Through this letter, the Alaska Department of Environmental Conservation (ADEC) is asking the U.S. Environmental Protection Agency (EPA) Region 10 (R10) to allow Donlin Gold LLC (DGLLC) to use EPA's proposed algorithm for adjusting the surface friction velocity (ADJ_u*) within the AERMOD Modeling System. EPA proposed this algorithm as part of their July 29, 2015 revisions to their *Guideline on Air Quality Models* (Guideline).

ADEC will likely issue a preliminary decision on DGLLC's pending Prevention of Significant Deterioration (PSD) permit application before EPA finalizes their proposal. Therefore, DGLLC must follow the requirements in Section 215(c) of Chapter 50 of Title 18 of the Alaska Administrative Code (18 AAC 50.215(c)) to use this non-Guideline technique in their PSD ambient demonstration.

18 AAC 50.215(c)(1) requires applicants to demonstrate in a manner consistent with Section 3.2.2 of the Guideline that the alternative approach is more appropriate than the preferred air quality model. Section 3.2.2 states the request must meet at least one of three conditions, which are summarized below:

1. The alternative and preferred model provide equivalent estimates;

2. The alternative model outperforms the preferred model when comparing the results to actual air quality data; or

3. The preferred model is less appropriate or there is no preferred model for the given scenario.

DGLLC believes their request meets the second criteria. ADEC agrees. As discussed in DGLLC's August 25, 2015 request (enclosed), EPA has noted for the past eight years that AERMOD performs poorly during low wind speed conditions and has been developing the ADJ_u* algorithm since at least 2012 to help mitigate the problem. EPA has now formally proposed the use of this algorithm on a routine basis and has conducted a number of modeled to measured comparisons to support their proposal.

DGLLC conducted a sensitivity analysis to determine which of their emission activities would benefit from the ADJ_u* option. The option provides at least some benefit for all source categories, but the most notable benefit is a 35-percent reduction in the 24-hour coarse particulate (PM-10) impact from haul roads. This source category was included in EPA's Cordero Rojo study, where they determined, "[The] use of the proposed ADJ_U* option in AERMET appears to significantly improve model performance for this study" (EPA's *Proposed Updates to AERMOD Modeling System* presentation at the 11th Modeling Conference). DGLLC's request provides additional information regarding this study, along with other pertinent EPA studies. ADEC has reviewed the sensitivity analysis modeling files and concurs with DGLLC's findings and conclusions.

R10 stated in an August 25, 2015 e-mail[1] that the ADJ_u* option should not be used with the following calculated meteorological parameters: standard deviation of horizontal wind direction (sigma-theta); or standard deviation of vertical wind speed (sigma-w). DGLLC was originally planning to use these parameters but has agreed to exclude them per R10's request.

EPA also proposed a second modeling option (LOWWIND3) that *could be* used in conjunction with the ADJ_u* option, to further mitigate the low wind speed problem. DGLLC is not proposing to use this additional option. The studies presented by EPA show marginal benefits, if any, with the LOWWIND3 option. R10 also stated in their August 25th e-mail that the LOWWIND3 option should not be used since the model performance evaluations "are inconclusive at this time." ADEC agrees that the LOWWIND3 option should not be used at this time.

R10 also raised several preliminary questions regarding DGLLC's request in an August 27, 2015 e-mail.[2] DGLLC provided answers to R10's questions in a September 2, 2015 letter, which is also enclosed.

18 AAC 50.215(c)(2) requires approval from the R10 Administrator and the ADEC Commissioner of a non-Guideline modeling technique. The Commissioner delegated the responsibility for approving non-Guideline modeling methods to the Air Permits Program (APP) Manager on June 3, 2008. It is ADEC's understanding that the R10 Administrator has delegated his authority to you. The APP Manager, John Kuterbach, approved DGLLC's request to use the ADJ_u* algorithm on September 15, 2015. Mr. Kuterbach's approval is enclosed.

In addition to complying with ADEC's modeling requirements in 18 AAC 50.215(c), PSD applicants must also comply with the PSD modeling requirements in 40 CFR 52.21(l), per 18 AAC 50.306(b) and 18 AAC 50.040(h)(10). 40 CFR 52.21(l)(2) says the use of a non-Guideline modeling technique, "must be subject to notice and opportunity for public comment". ADEC will include a notice

[1] Herman Wong (R10) to Alan Schuler (ADEC) and Clint Bowman (Washington Department of Ecology), *R10 – MCH Interactions on Donlin and BP*, August 25, 2015

[2] Herman Wong (R10) to Alan Schuler (ADEC), *Review of Donlin's Request and your Agreement*, August 27, 2015.

regarding DGLLC's use of the ADJ_u* option in the public notice of its preliminary permit decision, if R10 grants DGLLC's request to use this modeling technique and EPA has not yet finalized the ADJ_u* proposal.

For the reasons described above and elaborated on in DGLLC's request, please grant DGLLC permission to use the ADJ_u* option in the ambient demonstration conducted in support of their pending PSD permit application.

If you have any questions regarding this request, please contact me at (623) 271-9028 or at alan.schuler@alaska.gov.

Sincerely,

Alan E. Schuler

Alan E. Schuler, P.E.
Engineer, DEC

Enclosures: DGLLC's August 25, 2015 Request to Use Adjusted_u*
DGLLC's September 2, 2015 Response to R10's Comments
APP Manager Approval to Use Adjusted_u*

cc: Patrick Dunn, ADEC/APP/Anchorage
James Renovatio, ADEC/APP/Juneau
Mike Rieser, DGLLC
Nick Enos, DGLLC

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Attachment B: DGLLC 25 August 2015 Letter

August 25, 2015

Mr. Alan Schuler
Division of Air Quality
Alaska Department of Environmental Conservation
410 Willoughby, Suite 303
PO Box 111800
Juneau, AK 99811-1800

RE: Additional Information Regarding DGLLC's ADJ_U* Approval Request

Dear Mr. Schuler,

In previous submittals, Donlin Gold LLC (DGLLC) has sought approval from the Alaska Department of Environmental Conservation (ADEC) and the U.S. Environmental Protection Agency (EPA) Region 10 (R10) for the use of a non-default adjusted surface friction velocity (ADJ_U*) option in the AERMOD modeling for its proposed Donlin project in southwestern Alaska.[1] With this submittal, DGLLC is updating this approval request as described in this letter.

Recently EPA has released a new version of its regulatory default AERMOD modeling system (v15181). EPA is also seeking and reviewing public comments on its proposed changes to the Guideline on Air Quality Models (40 CFR Part 51, Appendix W). In the wake of these developments, EPA R10 and ADEC have requested that DGLLC update its pending ADJ_U* approval request to include and/or address relevant AERMOD and 40 CFR 51, Appendix W revisions. In addition, ADEC has requested that DGLLC perform a model sensitivity study to evaluate the effects of the ADJ_U* option with the new AERMOD modeling system v15181 for its Donlin project.

This letter provides a summary of updates to DGLLC's ADJ_U* approval request and the ADJ_U* sensitivity analysis with AERMOD v15181 for the Donlin project.

It is important to note that EPA's proposal to incorporate ADJ_U* as a default regulatory option is currently under public review and comment (EPA 2015c, EPA 2015d). EPA has acknowledged that AERMOD performs poorly during low wind-speed conditions (Robinson and Brode 2007). To address this concern, EPA has evaluated the technical basis of the ADJ_U* option and has completed several model evaluation studies. The results of these evaluation studies conclude that the ADJ_U* option produces statistically significant improvement in AERMOD performance compared to the default option (EPA 2014).

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[1] The original request was submitted to EPA R10 in April 2014; it was revised and re-submitted in July 2014, and additional information was provided in October of 2014.

Donlin Gold, 4720 Business Park Blvd., Suite G-25, Anchorage, AK 99503
Tel (907) 273-0200 Fax (907) 273-0201 www.DonlinGold.com

Updated ADJ_U* Approval Request

DGLLC's revised ADJ_U* approval request for its Donlin project, dated August 24, 2015, is provided in Attachment A for ADEC's review. The criteria for approval of an alternate model are set forth in 40 CFR 51, Appendix W, Sections 3.2.2.b. through e. DGLLC has reviewed EPA's recent proposed changes to 40 CFR 51, Appendix W, and the relevant changes are addressed in the revised ADJ_U* approval request provided in Attachment A. Although DGLLC is currently required to request EPA's approval of an alternate model for the use of the ADJ_U* option, pending EPA's review of public comments related to this option, it is expected that ADJ_U* will be incorporated as a default regulatory option for AERMOD modeling (EPA 2015c, EPA 2015d).

The new AERMOD v15181 background and technical support documentation, updated user's guides (EPA 2015a, EPA 2015b), test cases, and codes/executables have been provided by EPA on the Support Center for Regulatory Atmospheric Modeling (SCRAM) webpage. Per EPA R10's request, DGLLC has reviewed this documentation and has incorporated relevant material in its revised ADJ_U* approval request provided in Attachment A.

With the release of AERMOD v15181, EPA updated the ADJ_U* field study validations (EPA 2015b) using this version for the following evaluation databases: Oak Ridge, Idaho Falls, and Lovett. EPA has not updated the recently released Cordero Rojo surface coal mine ADJ_U* evaluation study with AERMOD v15181. However, EPA states that it expected that the ADJ_U* evaluation results for the Cordero Rojo study "are likely to be similar for v15181" (EPA 2015d). The Cordero Rojo study is particularly applicable to the Donlin project because of the similarity of source and emission characteristics. These four evaluation studies show that the AERMOD model performance improved significantly with the use of ADJ_U*. Therefore, DGLLC continues to assert that EPA's existing model evaluation studies for ADJ_U* provide comprehensive and sufficiently appropriate support documentation to justify DGLLC's proposed use of ADJ_U* for the Donlin project.

ADJ_U* Sensitivity Modeling with AERMOD v15181

EPA R10 suggested that DGLLC perform an ADJ_U* sensitivity analysis using AERMOD v15181 and the Alaska tracer gas experiment provided on SCRAM. However, DGLLC and ADEC believe that the Alaska tracer study available on SCRAM will not provide evaluations that are representative of the Donlin project because the study was performed for a source in a flat-terrain, coastal setting, whereas the Donlin project is located inland in complex terrain. Furthermore, the Alaska tracer study only considered daytime hours with typically higher wind speeds and emissions from a tall stack, which are not related to the ADJ_U* option. DGLLC is not aware of additional EPA model tracer studies performed for low-release emissions and stable conditions in a complex terrain Alaskan environment.

EPA R10 initially suggested testing building downwash and NO_X chemistry modules for ADJ_U* with AERMOD v15181 for the Donlin project. However, ADEC suggested (and DGLLC concurs) that the sensitivity analysis should only focus on the most relevant aspects of modeling associated with ADJ_U*. The preliminary analyses performed for the Donlin project suggest that its primary ambient air impact issues are related to particulate concentrations from low-release fugitive emission sources occurring under low wind-speed conditions. Building downwash and NO_X

chemistry options are less pertinent to Donlin project impacts. DGLLC is not aware of any model performance issues that have arisen from the application of ADJ_U* with downwash or NO_X chemistry modules.

The application of the ADJ_U* option reduces the frequency of low surface friction velocity (u*) values that are known to result in over-predictions of modeled concentrations with AERMOD. Figure 1 provides a comparison of the u* values estimated by the AERMOD meteorological preprocessor AERMET v15181 using the default and ADJ_U* options for five years of DGLLC American Ridge meteorological station data.

Figure 1. Comparison of u* Values with AERMET Default and ADJ_U* Options: American Ridge Data Set (July 1, 2005 – June 30, 2010)

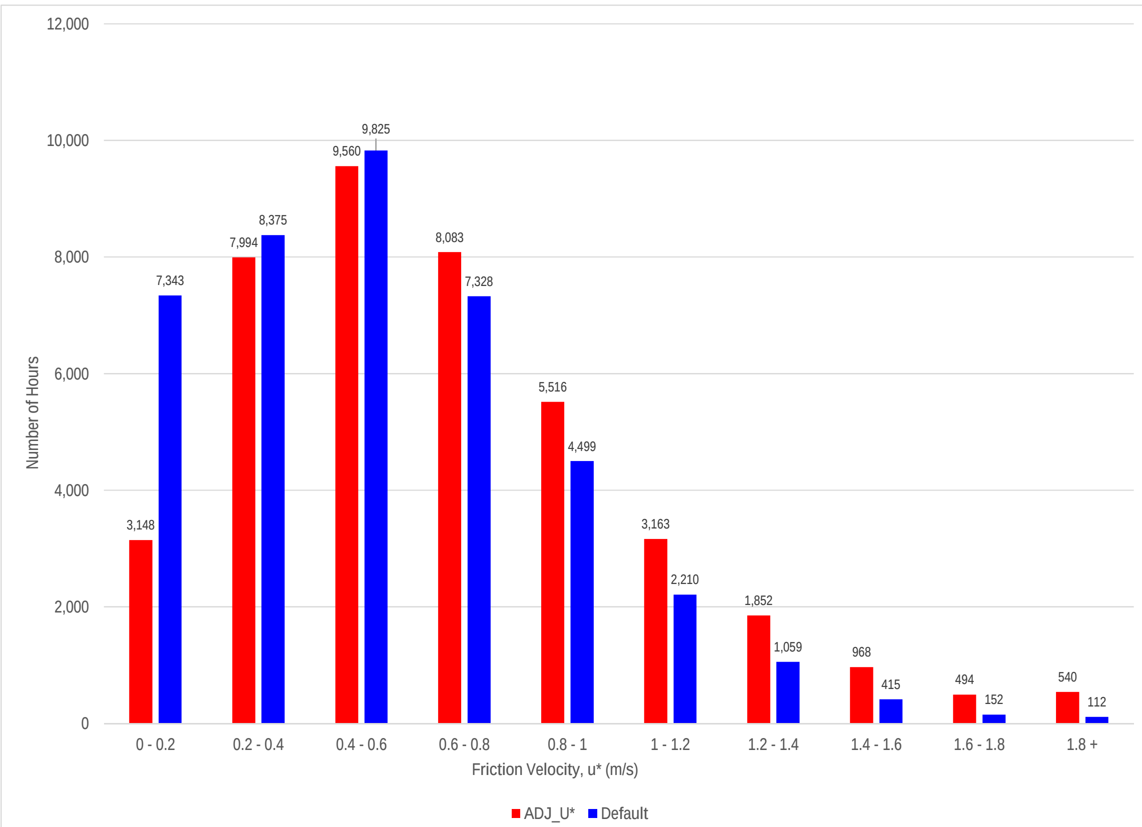


Figure 1 shows that the ADJ_U* option significantly reduces (from 7,343 to 3,148) the occurrence of low u* values (up to 0.2 meters per second) when applied for the American Ridge data set.

Following ADEC's suggestion, the AERMOD v15181 sensitivity study described herein includes the following:

- Six project-specific source groups (listed in Table 1) that are expected to significantly influence the modeled concentrations (based on preliminary analyses)

- 24-hour PM_{10} emissions and modeling options
- One year (2005) of the worst-case site-specific (American Ridge) meteorological data set, which excludes site-specific sigma data for the ADJ_U* option
- One ambient air receptor in a location at or near the maximum 24-hour PM_{10} design concentration (high-second-high [H2H]) as determined from preliminary analyses

The H2H 24-hour PM_{10} results of the Donlin project's ADJ_U* sensitivity analysis are summarized in Table 1.

Table 1. Summary of Donlin Project's ADJ_U* Sensitivity Modeling

	H2H 24-hour PM_{10} Concentration ($\mu g/m^3$)	
Source Group Description	Default	ADJ_U*
Process and Ancillary Sources, Excluding Power Plant	7.70	2.87
Power Plant	0.77	0.59
All Haul Roads	21.15	13.78
Blasting	2.48	1.42
In-pit, Excluding Hauling and Blasting	9.44	4.49
Waste Rock Storage	3.15	1.35

As shown in Table 1, results of the sensitivity analysis indicate that the use of ADJ_U* reduces maximum 24-hour PM_{10} modeled concentrations. The results of this analysis also highlight that the low-release, fugitive haul road emissions are expected to be the most significant contributor to the Donlin project's overall PM_{10} impacts. When applying ADJ_U*, the largest concentration reduction (7.4 $\mu g/m^3$) is associated with the haul roads.

The modeled 24-hour PM_{10} concentration plots for each source group listed in Table 1 are provided in Figures 2 through 7. These plots present the modeled concentrations (364 values starting with the H2H) for both default and ADJ_U* cases, as a function of 24-hour average u* values.

Figure 2. 24-Hour Modeled Concentrations vs. u* Values – Source Group: Process and Ancillary Sources, Excluding Power Plant

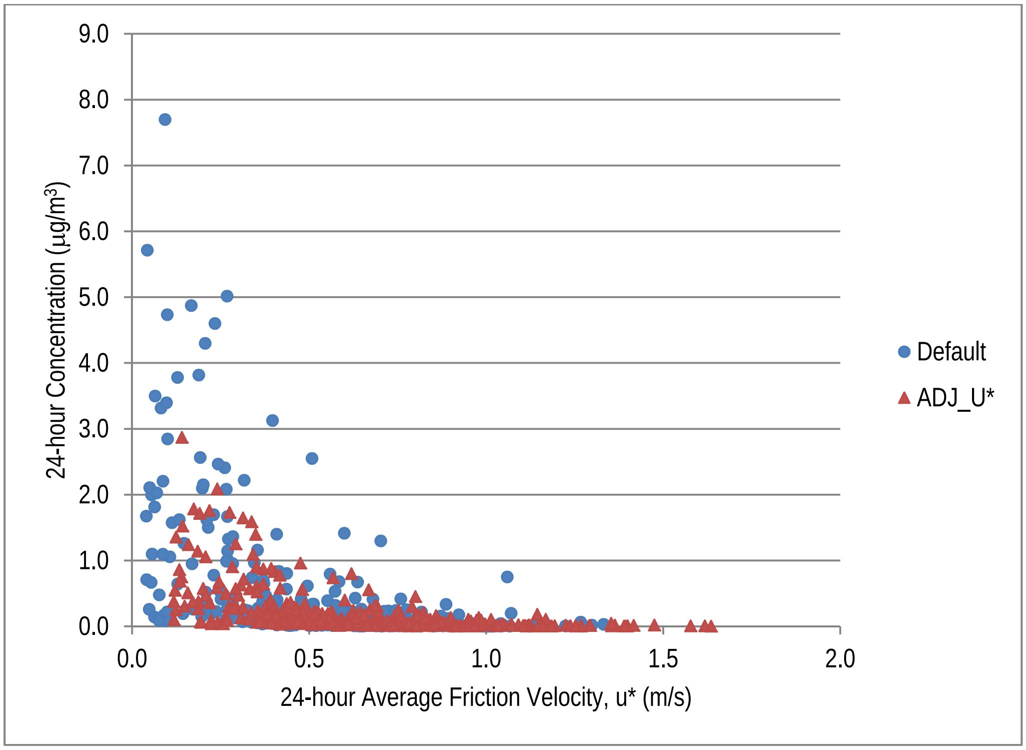


Figure 3. 24-Hour Modeled Concentrations vs. u* Values – Source Group: Power Plant

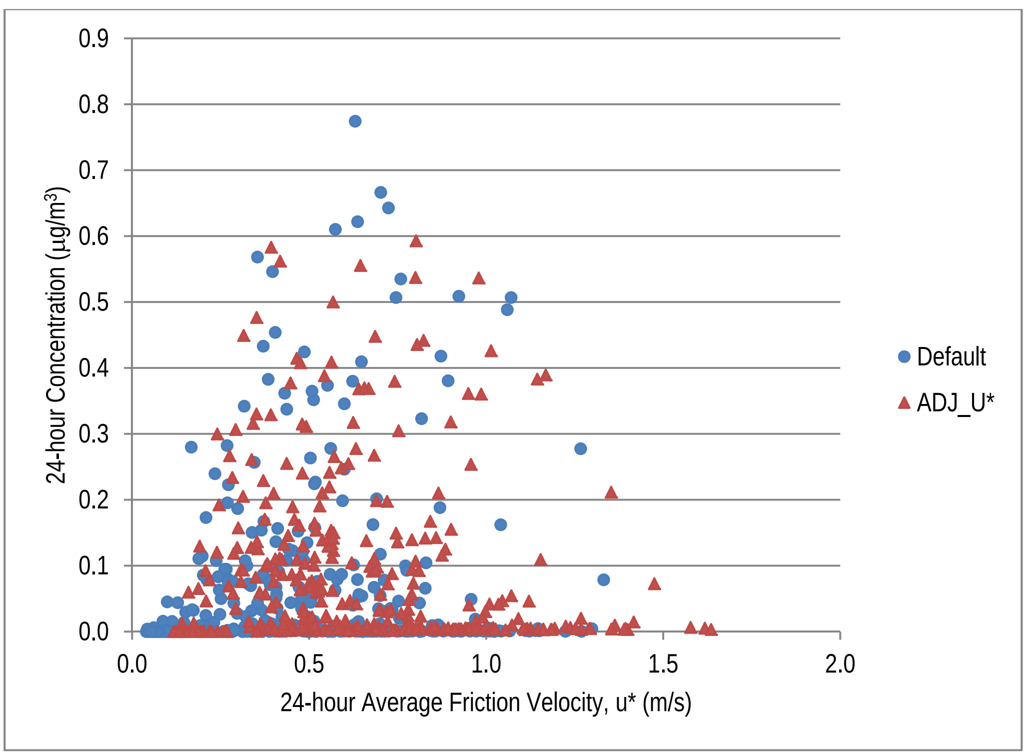


Figure 4. 24-Hour Modeled Concentrations vs. u* Values – Source Group: All Haul Roads

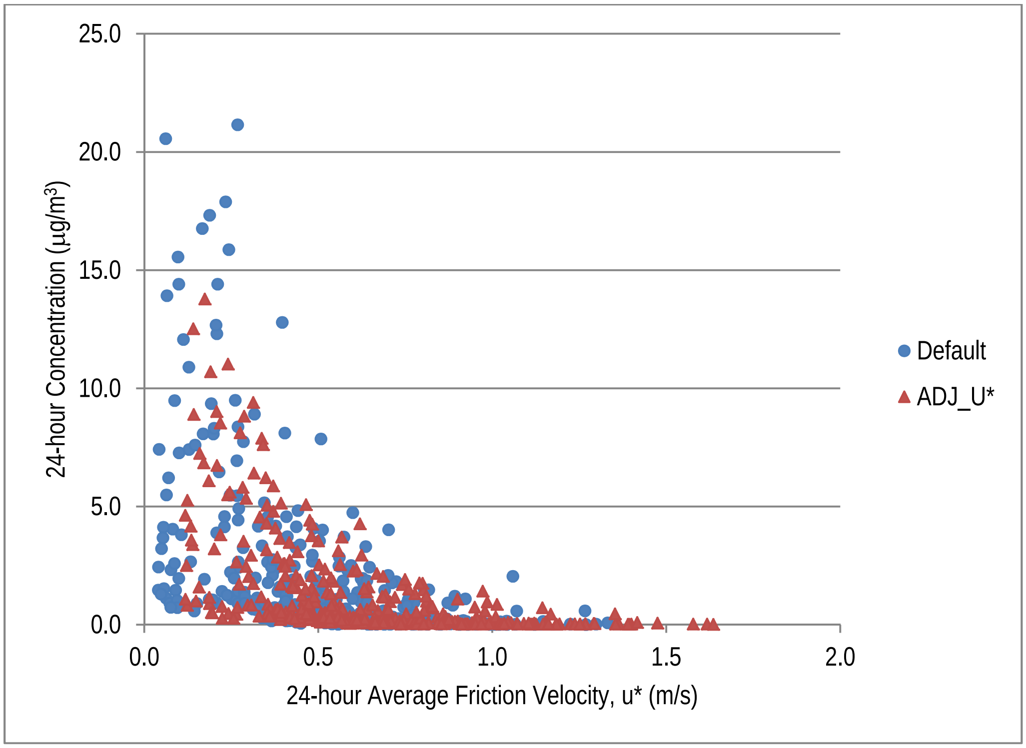


Figure 5. 24-Hour Modeled Concentrations vs. u* Values – Source Group: Blasting

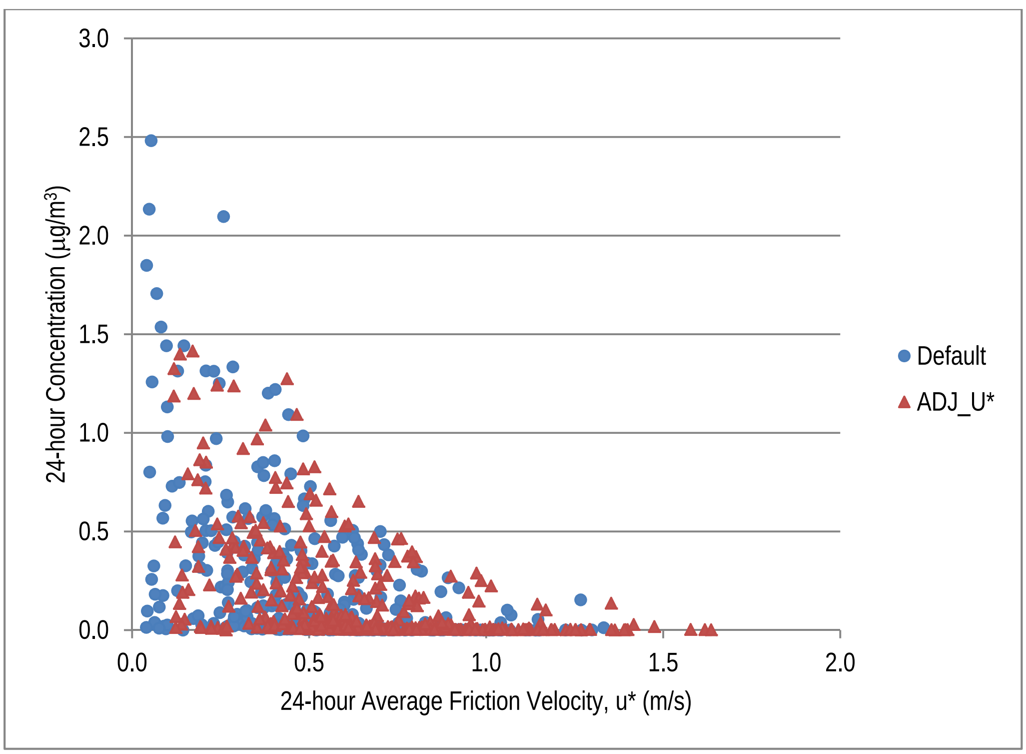


Figure 6. 24-Hour Modeled Concentrations vs. u* Values – Source Group: In-pit, Excluding Hauling and Blasting

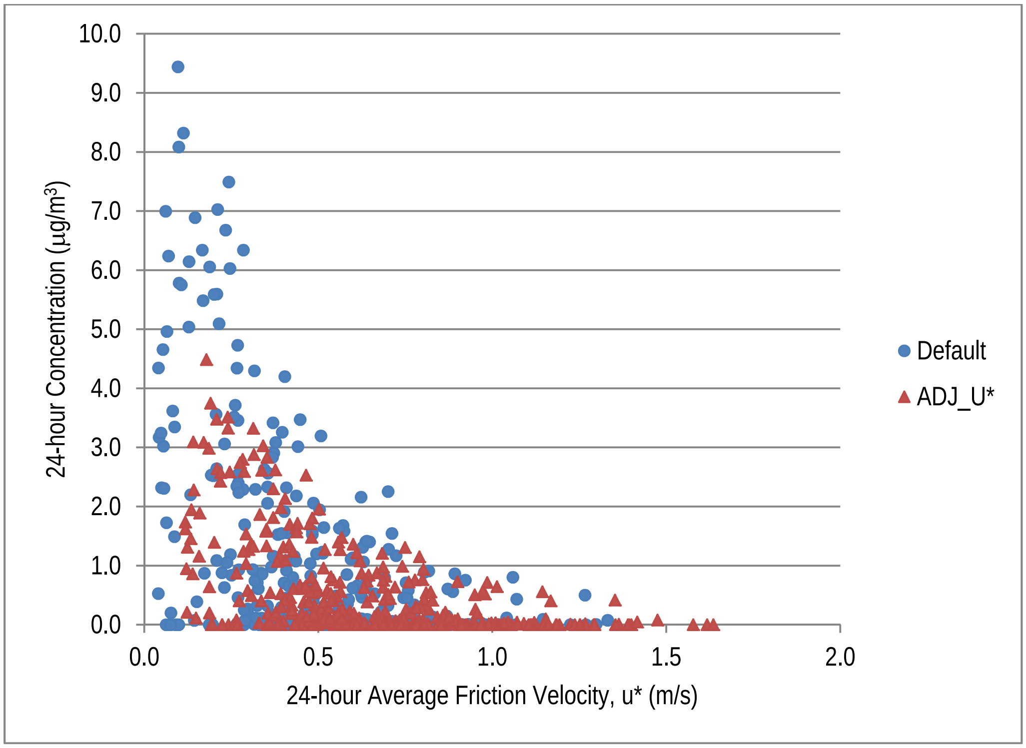
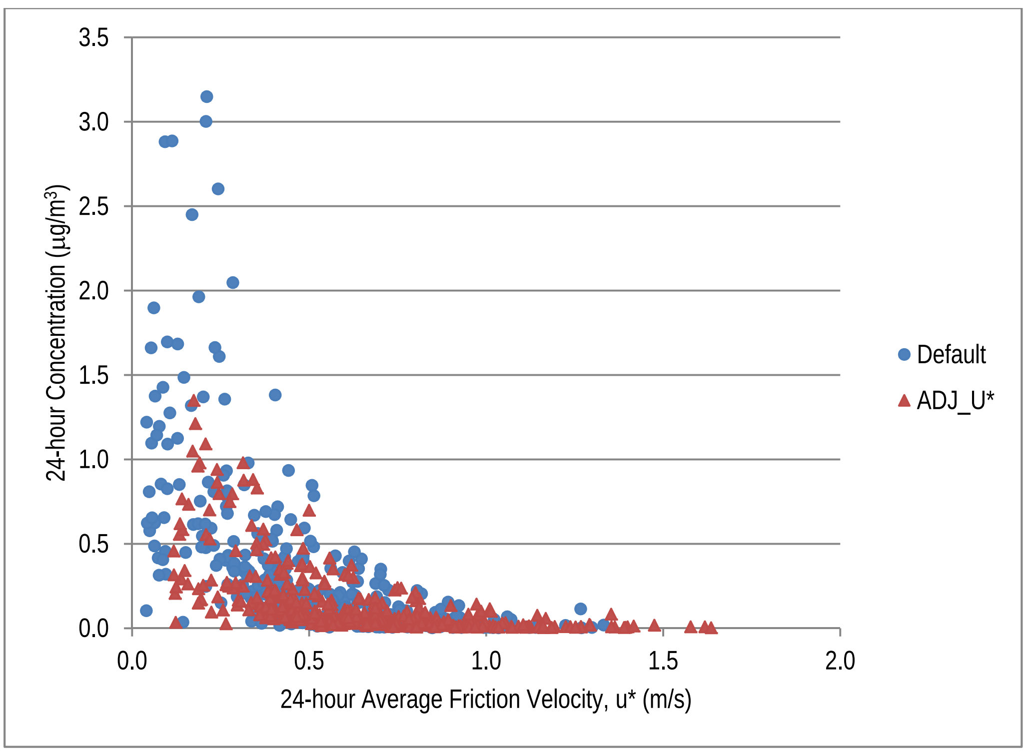


Figure 7. 24-Hour Modeled Concentrations vs. u* Values – Source Group: Waste Rock Storage



DGLLC asserts that application of the ADJ_U* option for the Donlin project is appropriate and essential in order to predict reasonable modeled impacts, due to prevailing low wind-speed conditions and dominant low-release emissions. As shown in this analysis, the use of the ADJ_U* option with AERMOD v15181 significantly reduces the frequency of low u* values, which are known to contribute to unreasonably high modeled concentrations.

Please contact me should you have any questions or require additional information.

Sincerely,

Michael Rieser
Senior Environmental Engineer

Attachments:

Attachment A – Request for Approval to use ADJ_U*

cc by e-mail:

Patrick Dunn, Division of Air Quality, ADEC
James Renovatio, Division of Air Quality, ADEC
Robert (Nick) Enos, Donlin Gold LLC

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Robinson, R. and R. Brode. 2007. "AERMOD Implementation Workgroup." Presentation at EPA Regional/State/Local Modelers Workshop. Virginia Beach, VA. May 15-17, 2007. Accessed August 24, 2015. http://www.cleanairinfo.com/regionalstatelocalmodelingworkshop/archive/2007/presentations/Tuesday%20-%20May%2015%202007/AERMOD_Implementation_Workgroup.pdf.

TECHNICAL MEMORANDUM

AIR SCIENCES INC.
DENVER • PORTLAND • LOS ANGELES

REQUEST FOR APPROVAL TO USE ADJ_U*

PREPARED FOR: Alaska Department of Environmental Conservation

PREPARED BY: Donlin Gold LLC and Air Sciences Inc.

PROJECT NO.: 281-15-2

DATE: August 25, 2015

TABLE OF CONTENTS

1.0 Introduction

The purpose of this memorandum is to seek approval from the Alaska Department of Environmental Conservation (ADEC) and the U.S. Environmental Protection Agency (EPA) for application of the non-default adjusted surface friction velocity (ADJ_U*) option in the AERMOD modeling for Donlin Gold LLC's (DGLLC) proposed Donlin project in southwestern Alaska. This request is submitted pursuant to Section 3.2 of the Guideline on Air Quality Models (the Guideline; EPA 2005). Additionally, the July 29, 2015, proposed revisions to Section 3.2 of the Guideline (EPA 2015e) regarding the ADJ_U* option are addressed in this memorandum.

DGLLC believes that the application of the ADJ_U* option is appropriate in the AERMOD modeling analysis for the Donlin project because of the frequent occurrence of low wind speed stable conditions, under which the default option (i.e., no low wind-speed correction) in

AERMOD is known to over-predict ambient concentrations. The ADJ_U* option is intended to significantly improve AERMOD's performance, compared to the default option, including the performance for sites and sources similar to the Donlin project where emissions are released at low heights (typical of surface mining sources) and the project is located in a region with complex terrain.

2.0 Background

2.1 ADJ_U* Intended as Regulatory Default Option

In the proposed revisions to the Guideline (EPA 2015e), EPA intends for the ADJ_U* option to be part of the regulatory default model. EPA made this proposal in the preamble to the proposed changes to the Guideline, referred to below as Notice of Public Rule Making (NPRM). Due to several initial comments from stakeholders, members of the EPA modeling group provided clarifications (EPA 2015c and 2015d) that reinforced EPA's intent to include ADJ_U* as a regulatory default option. These clarifications were provided during EPA's 11th Conference on Air Quality Modeling and Public Hearing for the Proposed Revisions to the Guideline held on August 12–13, 2015 (2015 Conference). EPA's statements regarding the ADJ_U* option as presented in the NPRM and the 2015 Conference are provided below.

From NPRM section IV.A.2., "Updates to EPA's AERMOD Modeling System" (EPA 2015e):

> *"Based on studies presented and discussed at the Tenth Modeling Conference, and additional relevant research since 2010, the EPA and other researchers have conducted additional model evaluations and developed changes to the model formulation of the AERMOD modeling system to improve model performance in its regulatory applications. We propose the following updates to the AERMOD modeling system to address a number of technical concerns expressed by stakeholders:*
>
> > 1. *A proposed option incorporated in AERMET to adjust the surface friction velocity (u*) to address issues with AERMOD model overprediction under stable, low wind speed conditions. This proposed option is selected by the user with the METHOD STABLEBL ADJ_U* record in the AERMET Stage 3 input file."*

As presented on the public record at the 2015 Conference by Tyler Fox in his presentation "Overview of Proposed Revisions to Appendix W" (EPA 2015c):

> *"In the NPRM, EPA has proposed to incorporate specific updates to the regulatory version that are the subject of public review and comment and then would be codified as part of the final rule action, as appropriate.*
>
> *– These options have thus remained "beta" in v15181 to allow for public testing & evaluation"*

As presented on the public record at the 2015 Conference by Roger Brode in his presentation "Proposed Updates to AERMOD Modeling System" (EPA 2015d):

> *"EPA has proposed in the NPRM that the ADJ_U* option (with or without BULKRN) be incorporated into the regulatory version of AERMET."*

It is clear that EPA, pending review and comments during the public comment period, intends to incorporate ADJ_U* as a regulatory default option. At this time, ADJ_U* remains a non-default option and requires approval from EPA for use in modeling compliance demonstrations. According to statements at the 2015 Conference, the proposed revisions to the Guideline are expected to be finalized by the spring of 2016 (EPA 2015c).

2.2 Development of ADJ_U* to Improve AERMOD Performance

EPA has acknowledged poor AERMOD performance during low wind-speed conditions (Robinson and Brode 2007). Qian and Venkatram (2010) demonstrated that the AERMOD meteorological preprocessor (AERMET) tends to grossly under-predict surface friction velocity (u*) under low wind-speed conditions (less than two meters per second). When simulating low release height emission sources with AERMOD, the under-prediction of u* leads to inappropriately low mechanical mixing heights, consequently resulting in overly conservative (excessively high) ambient concentration estimations (EPA 2015b; Paine and Connors 2013; Qian and Venkatram 2010).

Qian and Venkatram (2010) suggested a new method for calculating u* and showed results that support improved u* and model concentration predictions in the low wind-speed regime. EPA has incorporated this calculation methodology in AERMET as ADJ_U* (EPA 2013), most recently in AERMET version 15181. The ADJ_U* method is a processing option for calculating u* for low wind speeds during stable (nighttime) conditions (EPA 2015a). Several study results support the conclusion that the application of the ADJ_U* option significantly improves AERMOD performance for low wind-speed conditions while maintaining a conservatively high bias in predicted concentrations (EPA 2013; EPA 2015b; EPA 2014; Paine and Connors 2013). These studies indicate that the ADJ_U* option has been sufficiently peer-reviewed.

2.3 Donlin Project Characteristics

The proposed Donlin project is located in the Yukon–Kuskokwim region of southwestern Alaska, a remote, mountainous area. It is approximately 280 miles west of Anchorage, 155 miles northeast of Bethel, and 10 miles north of the village of Crooked Creek. The project area is one of low topographic relief on the western flank of the Kuskokwim Mountains. Elevations in the project area range from 500 to 2,100 feet.

Typically, air quality analyses for surface mine projects like Donlin are predominantly driven by fugitive emissions associated with mining activities such as material extraction and hauling; mobile machinery tailpipes; maintenance equipment; and wind erosion of exposed surfaces. Activities like these are characterized in AERMOD by emission sources with low release heights (less than 10 meters).

The use of the ADJ_U* option is particularly appropriate when processing meteorological data at high-latitude Alaskan sites, due to the long winter nights and frequent cloudy conditions that tend to cause sustained low wind speeds and stable conditions. For the meteorological data proposed for the Donlin project air quality analysis, 22.4 percent of the hourly wind speeds are less than two meters per second, and over 50 percent of these low wind speeds occur during the winter months.

3.0 Request for ADJ_U* Approval

3.1 Guideline Criteria for Alternative Models

The criteria for approval of an alternative model are set forth in Sections 3.2.2(b) through (e) of the Guideline (EPA 2005), which state the following:

> "*b. An alternative model should be evaluated from both a theoretical and a performance perspective before it is selected for use. There are three separate conditions under which such a model may normally be approved for use: (1) If a demonstration can be made that the model produces concentration estimates equivalent to the estimates obtained using a preferred model; (2) if a statistical performance evaluation has been conducted using measured air quality data and the results of that evaluation indicate the alternative model performs better for the given application than a comparable model in Appendix A; or (3) if the preferred model is less appropriate for the specific application, or there is no preferred model. Any one of these three separate conditions may make use of an alternative model acceptable. Some known alternative models that are applicable for selected situations are listed on EPA's SCRAM Internet Web site (subsection 2.3). However, inclusion there does not confer any unique status relative to other alternative models that are being or will be developed in the future.*
>
> *c. Equivalency, condition (1) in paragraph (b) of this subsection, is established by demonstrating that the maximum or highest, second highest concentrations are within 2 percent of the estimates obtained from the preferred model. The option to show equivalency is intended as a simple demonstration of acceptability for an alternative model that is so nearly identical (or contains options that can make it identical) to a preferred model that it can be treated for practical purposes as the preferred model. Two percent was selected as the basis for equivalency since it is a rough approximation of the fraction that PSD Class I increments are of the NAAQS for SO_2, i.e., the difference in concentrations that is judged to be significant. However, notwithstanding this*

demonstration, models that are not equivalent may be used when one of the two other conditions described in paragraphs (d) and (e) of this subsection are satisfied.

d. For condition (2) in paragraph (b) of this subsection, established procedures and techniques[...] for determining the acceptability of a model for an individual case based on superior performance should be followed, as appropriate. Preparation and implementation of an evaluation protocol which is acceptable to both control agencies and regulated industry is an important element in such an evaluation.

e. Finally, for condition (3) in paragraph (b) of this subsection, an alternative refined model may be used provided that:

i. The model has received a scientific peer review;

ii. The model can be demonstrated to be applicable to the problem on a theoretical basis;

iii. The data bases which are necessary to perform the analysis are available and adequate;

iv. Appropriate performance evaluations of the model have shown that the model is not biased toward underestimates; and

v. A protocol on methods and procedures to be followed has been established."

DGLLC asserts that its request to use the ADJ_U* option in the AERMOD modeling system can be considered under either Section 3.2.2(b)(2) or 3.2.2(b)(3) for the Donlin project under the current Guideline rules (EPA 2005). Section 3.2.2(b)(3) of the current Guideline (EPA 2005) and of the proposed Guideline revisions (EPA 2015e) lists one of the conditions under which an alternative model may be approved. Under the current Guideline (EPA 2005), Section 3.2.2(b)(3) reads:

"(3) if the preferred model is less appropriate for the specific application, or there is no preferred model."

In the proposed revisions (EPA 2015e), Section 3.2.2(b)(3) reads:

"(3) If there is no preferred model."

Given the language changes in the proposed revisions (EPA 2015e), DGLLC is not considering Section 3.2.2(b)(3) for this request.

However, the request for ADJ_U* can still be considered under 3.2.2(b)(2), which is the same under the current Guideline (EPA 2005) and the proposed Guideline revisions (EPA 2015e).

Thus, until EPA approves ADJ_U* as the default option in AERMOD, DGLLC requests EPA's approval of the use of ADJ_U* under condition 3.2.2(b)(2).

3.2 Request for Approval Under Section 3.2.2(b)(2)

Sections 3.2.2(b)(2) and 3.2.2(d) of the current Guideline (EPA 2005) state the following criteria for alternative model approval:

> 3.2.2(b)(2):
> *"if a statistical performance evaluation has been conducted using measured air quality data and the results of that evaluation indicate the alternative model performs better for the given application than a comparable model in Appendix A;"*

> 3.2.2(d):
> *"For condition (2) in paragraph (b) of this subsection, established procedures and techniques[...] for determining the acceptability of a model for an individual case based on superior performance should be followed, as appropriate. Preparation and implementation of an evaluation protocol which is acceptable to both control agencies and regulated industry is an important element in such an evaluation."*

Regarding Section 3.2.2(b)(2), the improved performance of AERMOD with the ADJ_U* option compared to the default method was initially presented by EPA in their January 2014 AERMOD Modeling System Update Webinar (EPA 2014). During the webinar, EPA presented preliminary model performance evaluation results from a low wind-speed study at Oak Ridge, TN in complex terrain. The webinar also provided results from an evaluation of the Cordero Rojo surface coal mine study in Wyoming, examining monitored PM_{10} (particulate matter less than 10 microns in diameter) concentrations compared to modeled concentrations. A surface coal mine would have emission characteristics similar to those from the Donlin project. Both studies showed that AERMOD simulations using the ADJ_U* option demonstrate significantly improved correlation to field data compared to the default method (EPA 2014). Additionally in the webinar, EPA presented results from a model evaluation of the Idaho Falls tracer gas study for a low-level, non-buoyant release, which also showed that the use of ADJ_U* improved model performance.

In the June 2015 Addendum to the AERMOD User's Guide (EPA 2015b), EPA provided model evaluation results using AERMET/AERMOD version 15181 for the Oak Ridge and Idaho Falls tracer studies. Evaluation of the ADJ_U* option applied to these studies also showed improved model performance for version 15181, compared to the default method. Additionally, EPA performed an evaluation of ADJ_U* as applied to a tall stack (145 meters) in complex terrain for the Lovett Power Plant, New York study. Again, the ADJ_U* option improved model performance when compared to observations. Updated results from the Cordero Rojo surface coal mine study were not included in the AERMET/AERMOD version 15181 evaluation studies. However, per an EPA presentation at the 2015 Conference, EPA stated that it expected that the ADJ_U* evaluation results for that study "are likely to be similar for v15181" (EPA 2015d).

For these four studies, model performance improved significantly with the use of the ADJ_U* option compared to the default method. These studies are relevant to the proposed Donlin project due to similarities in terrain (complex) and emission characteristics (fugitive sources with low release heights or tall stacks, such as DGLLC's power plant stacks). Table 1 provides a summary of EPA's AERMET/AERMOD version 15181 ADJ_U* evaluation studies in the June 2015 Addendum to the AERMOD User's Guide (EPA 2015b) and the Cordero Rojo surface coal mine study presented in EPA's 2014 webinar.

DGLLC believes that the model evaluations performed by the EPA—presented in the 2014 webinar, and updated for AERMET/AERMOD version 15181 in the Users' Guide Addendums (EPA 2015a and 2015b)—sufficiently address the requirements of Section 3.2.2(d) for DGLLC's proposed use of the ADJ_U* option. Therefore, DGLLC seeks EPA and ADEC approval for application of the non-default ADJ_U* option in the AERMOD modeling for the Donlin project under Section 3.2.2(b)(2) of the Guideline.

3.3 Site-Specific Sigma Meteorological Data

On August 20, 2015, it was brought to DGLLC's attention by ADEC that EPA had recently expressed concern with the use of site-specific sigma meteorological data in conjunction with ADJ_U*. Therefore, DGLLC is open to an approval of the ADJ_U* option that may include conditions regarding the use of site-specific sigma meteorological data in conjunction with ADJ_U*.

Table 1. Summary of EPA's ADJ_U* Evaluations for AERMET/ AERMOD Version 15181

Study Name	Release Type	Terrain / Surroundings	Applicable to Donlin?	Model Performance Without ADJ_U*	Model Performance With ADJ_U*	Overall Conclusions
Oak Ridge	Low-level, non-buoyant release (1 m)	Complex terrain, Rural, Open-area	Yes - Donlin is located in complex terrain and has numerous, low-level fugitive emission sources	Model over-predicts observations by a factor of 2 to 30 (EPA 2015b, Pages F-6 and F-11)	Model agrees with observations within a factor of 1 to 2 (EPA 2015b, Pages F-8 and F-14)	"significant improvement in model performance with the ADJ_U* option in AERMET" (EPA 2015b, Page F-16).
Idaho Falls	Low-level, non-buoyant release (3 m)	Flat/even terrain, Open-area	Yes - Donlin has low-level, non-buoyant fugitive sources, but terrain is different	Model over-predicts observations by a factor of 2 (EPA 2015b, Pages F-6 and F-11)	Model agrees with observations within a factor of 1 to 2 (EPA 2015b, Pages F-25 and F-26)	Generally good model performance at receptors nearest the release. As noted by EPA, "For this type of source, i.e., a non-buoyant, ground-level or low-level source (e.g., fugitive emission), the maximum ambient impacts are likely to occur at the fenceline" (EPA 2015b, Page F-18). Relevant to DGLLC operations/modeling.
Lovett	Tall stack (145 m)	Complex terrain, Rural, Open-area	Yes - Donlin is located in complex terrain and has tall point sources such as the power plant stacks (49 m)	"Past evaluations of AERMOD have shown good performance" (EPA 2015b, Page F-33). The consideration of ADJ_U* reduces the model over-predictions slightly.		Model performance improvement when using ADJ_U* (EPA 2015b, Pages F-33 and F-34).
Cordero Rojo (Wyoming surface coal mine)	Surface mine; majority of emissions from haul roads	Flat/even terrain, Rural, Open-area	Yes - Donlin has low-level, non-buoyant fugitive sources, but terrain is different	EPA evaluated ADJ_U* for AERMOD version 14134, not for version 15181. "Use of the proposed ADJ_U* option in AERMET appears to significantly improve model performance for this study" (EPA 2015d).		Significant improvement in model performance when using ADJ_U*. The results for this study are "based on v14134, but are likely to be similar for v15181" (EPA 2015d).

4.0 References

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Attachment C: DGLLC 2 September 2015 Letter

September 2, 2015

Mr. Alan Schuler
Division of Air Quality
Alaska Department of Environmental Conservation (ADEC)
410 Willoughby Avenue, Suite 303
PO Box 111800
Juneau, AK 99811-1800

RE: Responses to EPA R10 Comments on DGLLC's ADJ_U* Approval Request

Dear Mr. Schuler,

This letter provides responses to comments from the U.S. Environmental Protection Agency (EPA) Region 10 (R10) email dated August 27, 2015, regarding the Donlin Gold LLC (DGLLC) request to use a non-default adjusted surface friction velocity (ADJ_U*) option in the AERMOD modeling for the proposed Donlin project in southwestern Alaska.

Each comment from EPA R10 (except for Comment 1, which requires a response from ADEC) is reiterated herein, followed by a DGLLC response.

EPA R10's Comments 2-5 and DGLLC's Responses

Comment 2.
Figure 1 plots Option 1 and default u_*. The total hours do not total five years. Are those American Ridge hours missing and/or bad data?

Response to Comment 2.
The friction velocity (u*) frequency chart provided in Figure 1 was based on five years (July 1, 2005 – June 30, 2010) of American Ridge meteorological data. This data period consists of a total of 43,824 hours (including a leap year). There is a total of 41,318 hourly u* values provided in Figure 1 for each option (default and ADJ_U*). There are 2,506 hours in this data set for which AERMET did not calculate u* due to missing/calm winds or other missing parameters.

Comment 3.
AERMOD and AERMET input files should be provided for us to review and accept, and made part of the public record.

Response to Comment 3.
Electronic AERMOD and AERMET input and output files will be provided via the DGLLC ftp site (https://ftp.donlingold.com). User name, password and folder information will be provided by e-mail.

Comment 4.
Figure 2 – Figure 7 shows 24-hour average friction velocity vs 24-hour concentrations for six source groups.

a. *Explain 24-hour emissions.*

b. *Is each filled in circle or triangle representative of a day in the year?*

c. *R10 suggest that Donlin provide a similar plot of the haul roads but for default u*, Adj_u*, 0 < L < 50 m, and wind direction (+/-5 degrees) from the haul roads to the receptor.*

Response to Comment 4.

a. Table A provides the modeled emissions rates in grams per second (g/s) for the six source groups (listed in Table 1) that were used to estimate the 24-hour concentrations presented in Figures 2 through 7.

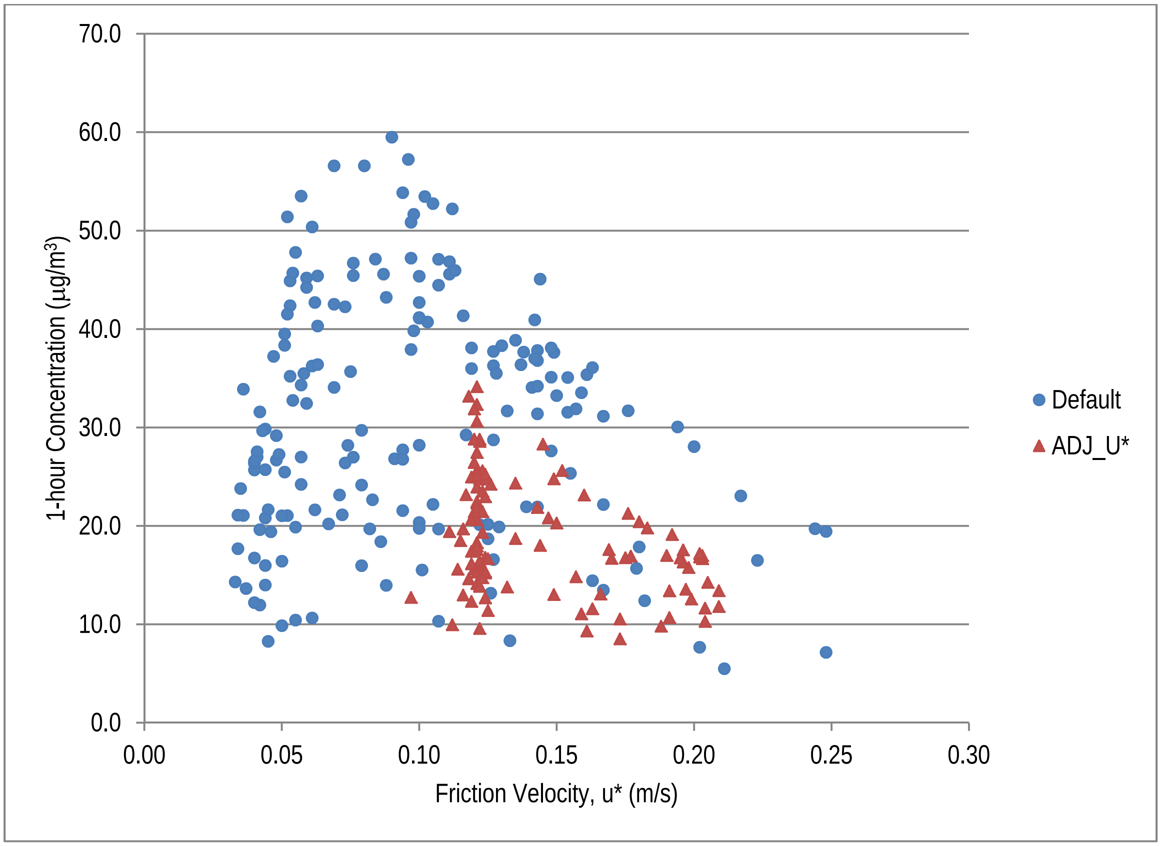
Table A. Modeled Emission Rates

Source Group Description	Modeled Emissions (g/s)
Process and Ancillary Sources, Excluding Power Plant	3.153
Power Plant	8.393
All Haul Roads	19.240
Blasting	5.809
In-pit, Excluding Hauling and Blasting	8.403
Waste Rock Storage	8.525

b. Confirmed, each blue circle and red triangle represents a 24-hour modeled concentration for the default and ADJ_U* options, respectively.

c. The requested hourly concentration plot for the haul road source group is provided in Figure A. This plot presents the hourly modeled concentrations for both the default and ADJ_U* options, as a function of hourly u* values. This plot only includes hours when winds are blowing within a 10-degree sector (+/- 5 degrees) from the haul road network toward the modeled receptor, and the Monin-Obukhov Length (L) values are between 0 to 50 meters (m).

Figure A. 10-Degree Sector Winds, 0 < L < 50 m: Concentrations vs. u* Values – Source Group: Haul Roads



Comment 5.
In the Technical Memorandum,

a. *Page 4, second paragraph, what is reference for the phrase "frequent cloudy conditions"?*

b. *Page 4, second paragraph, what is the period of record for the meteorology which I assume is American Ridge?*

c. *Page 6, Section 3.2, second full paragraph. Reference is made to the Oak Ridge, TN, Cordero Rojo surface mine in Wyoming, Idaho Falls, and Lovett Power Plant, New York studies. These four references should be included as an appendix if they apply directly to this request.*

Response to Comment 5.

a. The term "frequent cloudy conditions" is used to describe generally occurring cloud conditions in the region where the Donlin project is located. A review of Sleetmute National Weather Service station historical (2006 – 2012) records[1] shows that partly cloudy to overcast conditions existed 95 percent of the time.

b. The period of record is July 1, 2005 – June 30, 2010 for the American Ridge meteorological data set.

c. The cited evaluation studies (excerpts from EPA 2015a and EPA 2015d) are provided in Appendix A to this letter.

Please contact me should you have any questions or require additional information.

Sincerely,

Michael Rieser
Senior Environmental Engineer

Attachments:
Appendix A – ADJ_U* Evaluation Studies

cc by e-mail:
Patrick Dunn, Division of Air Quality, ADEC
James Renovatio, Division of Air Quality, ADEC
Robert (Nick) Enos, DGLLC

[1] https://weatherspark.com/averages/33057/Sleetmute-Alaska-United-States. Accessed August 28, 2015.

Appendix A – ADJ_U* Evaluation Studies

ADDENDUM

USER'S GUIDE FOR THE AMS/EPA REGULATORY MODEL - AERMOD (EPA-454/B-03-001, September 2004)

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air Quality Planning and Standards
Air Quality Assessment Division
Research Triangle Park, North Carolina 27711

June 2015

APPENDIX F. EVALUATION OF LOW WIND BETA OPTIONS

Beginning with version 12345, AERMOD includes non-default BETA options to address concerns regarding model performance under low wind speed conditions. This included the LOWWIND1 and LOWWIND2 BETA options on the MODELOPT keyword in AERMOD, and the ADJ_U* option included in Stage 3 of the AERMET meteorological processor. Beginning with version 15181 a new LOWWIND3 BETA option was incorporated into AERMOD. The LOWWIND3 option increases the 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 that are more than 6*sigma-y off the plume centerline, similar to the FASTALL option.

Updated evaluation results for these BETA options based on version 15181 of AERMOD are presented below for two field studies conducted in 1974 by the Air Resources Laboratory of the National Oceanic and Atmospheric Administration (NOAA) to investigate diffusion under low wind speed conditions at Idaho Falls (NOAA, 1974) and Oak Ridge (NOAA, 1976). These two field studies were used in the API-sponsored evaluations of AERMOD conducted by AECOM (AECOM, 2009), that were subsequently submitted as part of API’s public comments on EPA’s 10th Conference on Air Quality Models held in March 2012. Each of these studies used tracer releases with three arcs of samplers located at 100m, 200m, and 400m from the release point. Diagrams for each of the study areas are presented below.

In addition, since the ADJ_U* option in AERMET and the LowWind option in AERMOD are focused on improving model performance during periods of stable/low-wind conditions, additional evaluations are presented below for the Lovett evaluation database, a tall stack located in complex terrain where stable/low-wind conditions can also be important.

The evaluation results presented here for the Idaho Falls and Oak Ridge studies were based in part on the information included in the AECOMs 2009 report and data files subsequently provided by AECOM. However, some adjustments to inputs were made based on an independent assessment of the surface roughness for each of the study locations, an adjustment to the effective tracer release height at Idaho Falls from 1.5 to 3m based on information provided on page 24 of the NOAA Technical Memorandum for Idaho Falls (NOAA, 1974), and adjustments to the wind measurement height for Oak Ridge based on the discussion in Section 2.2 and information provided in Table 1 of the NOAA Technical Memorandum for Oak Ridge (NOAA, 1976).

The AECOM evaluation for Oak Ridge assumed a 2m wind measurement height, whereas page 8 of the NOAA report for Oak Ridge indicated that the wind measurements were “accomplished by laser anemometry” because wind speeds were “below the threshold of standard cup anemometers.” Footnotes in Table 1 also confirm that wind speeds were “measured by laser anemometers” for all tests, except for Test 11 where the wind speed was measured at the 30.5m level on one of meteorological towers included in the study. Given that the transmitters and receivers for the laser anemometer were located on the hills on either side of the valley where the tracer was released, at elevations between 50 to 100 feet higher than the elevation at the release point (based on Figure 2b of the NOAA report), a 2m wind measurement height may not be appropriate. However, the NOAA report does not indicate an "effective" measurement height above ground for the wind speeds measured by the laser anemometers. Another aspect of the use of laser anemometry that complicates the determination of an appropriate measurement height is that the "measured" wind speeds may represent more of a volume average than a point measurement. Since the wind speeds estimated by laser anemometry are likely to be more representative of vector averaged wind speeds than scalar averages the VECTORWS option in AERMOD was used for the Oak Ridge evaluations.

Based on these considerations, the evaluation results presented here were based on an "effective" wind measurement height of 10m, and the winds were also assumed to represent vector mean wind speeds. In addition to the different assumptions regarding the appropriate measurement height to assign to the observed wind speeds at Oak Ridge, the results presented below are based on a surface roughness length of 0.6m, consistent with the forest covering most of the study area at the time. The AECOM study assumed a much smaller roughness length of 0.2m.

A series of figures is provided below for each site, starting with the Oak Ridge study followed by the Idaho Falls study. For each site a series of Q-Q plots (results paired by rank), plots of concentrations paired in time, and residual plots showing the distribution of predicted/observed concentration ratios versus downwind distance are provided. Results are shown for the following scenarios:

- Current regulatory default options, i.e., no adjustments (No ADJ_U*/No LowWind)
- U* adjustment with no low wind options (ADJ_U*/No_LowWind)
- U* adjustment with LOWWIND1 (ADJ_U*/LowWind1)
- U* adjustment with LOWWIND2 (ADJ_U*/LowWind2)
- U* adjustment with LOWWIND3 (ADJ_U*/LowWind3)

Based on the limited meteorological data available for the Oak Ridge study, a single set of model comparisons is presented. Given the more robust meteorological data available from the Idaho Falls study, including multiple levels of wind speed, direction, temperature, and sigma-theta, several sets of meteorological inputs are evaluated, including the use of delta-T data with the Bulk Richardson Number (BULKRN) option available in AERMET.

Another important difference between these two field studies is that the Oak Ridge site was located in a hilly area on the Oak Ridge peninsula, with terrain elevations varying about 40m across the study area, with the tracer release point located near the center of the valley that cuts across the peninsula. Given the very low wind speeds during the study period, drainage flows and valley channeling may have influenced plume dispersion. The influence of terrain on low-level non-buoyant releases in AERMOD has not been assessed, and neither the AECOM nor EPA results for Oak Ridge have incorporated terrain elevations in their respective evaluations. As a result, the evaluations based on the Idaho Falls are likely to be more robust than the evaluations based on Oak Ridge.

As noted above, the Oak Ridge evaluations are based on a single set of meteorological inputs, whereas the Idaho Falls evaluation are based on a range of options given the more robust data available. These various sets of meteorological inputs for Idaho Falls are referred to in the figure captions as follows:

1. Base 1-level: no delta-T or turbulence (i.e., sigma-theta) data included;

2. Full 1-level: no delta-T data with sigma-theta data;
3. Base 2-level: delta-T data used with BULKRN option without sigma-theta;
4. Full 2-level: delta-T data used with BULKRN option with sigma-theta

Each of these data sets were used with and without the ADJ_U* option in AERMET and also with and without the LowWind options. For purposes of assessing the proposed BETA options, including the ADJ_U* option in AERMET and the LowWind options in AERMOD, the comparisons below are limited to the current default options, i.e., without ADJ_U* and without the LowWind option (labeled as NoADJ and NoLW), and the proposed options of ADJ_U* and LowWind3 (labeled as ADJ and LW3).

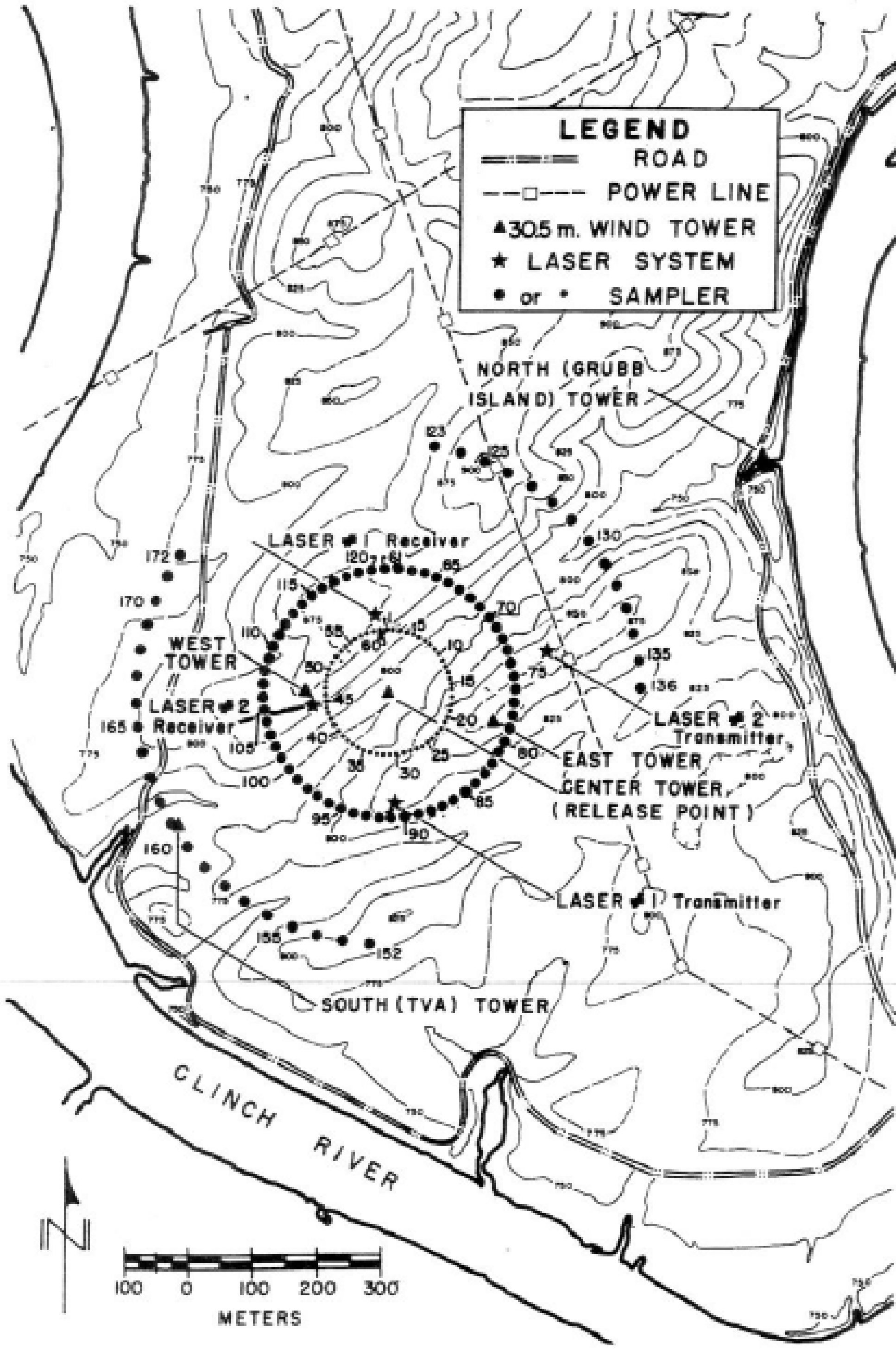
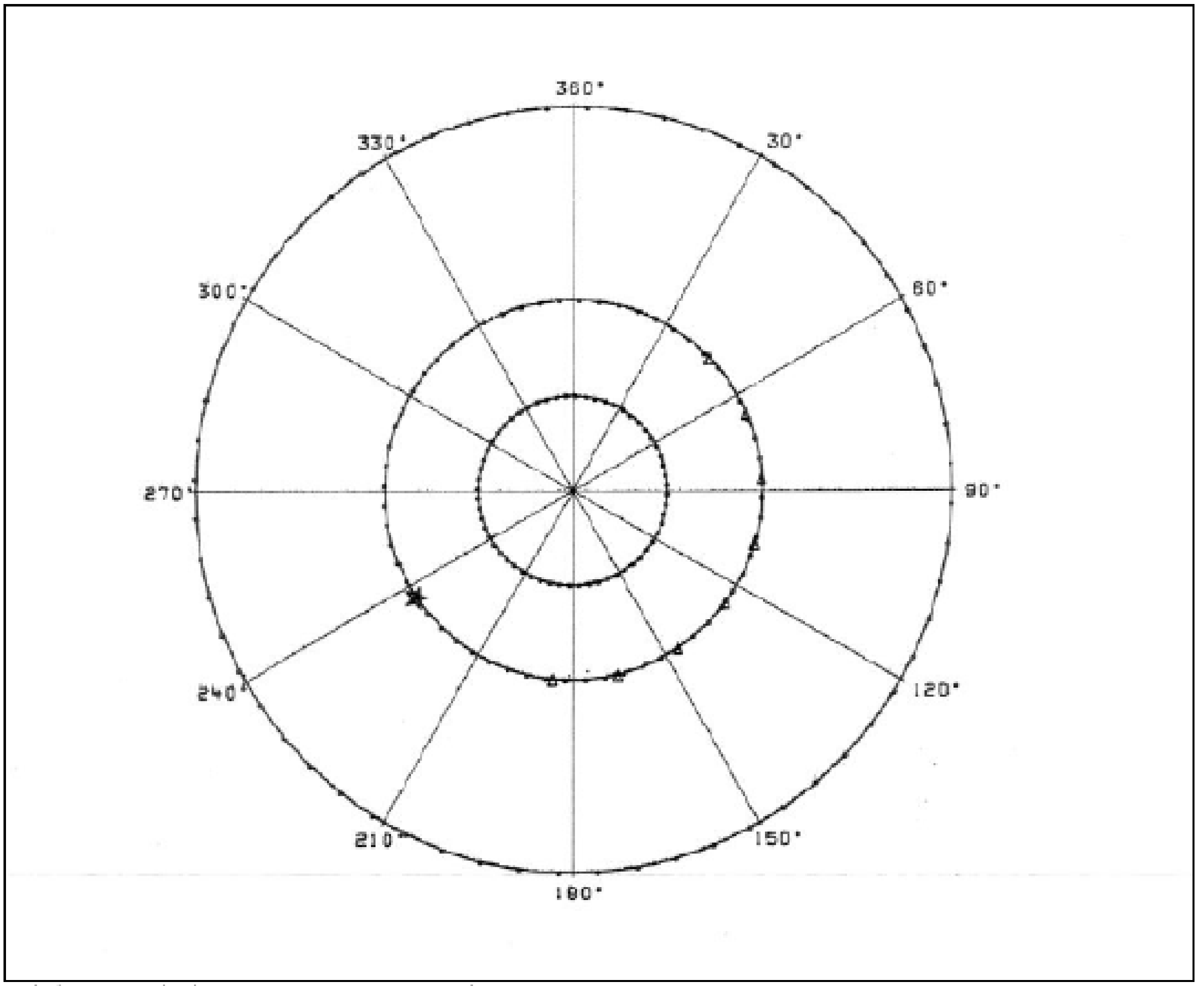


Figure 2b. Detail of inner sampling arcs showing location of meteorological towers and laser transmitters and receivers. (Contour heights are in feet above sea level).

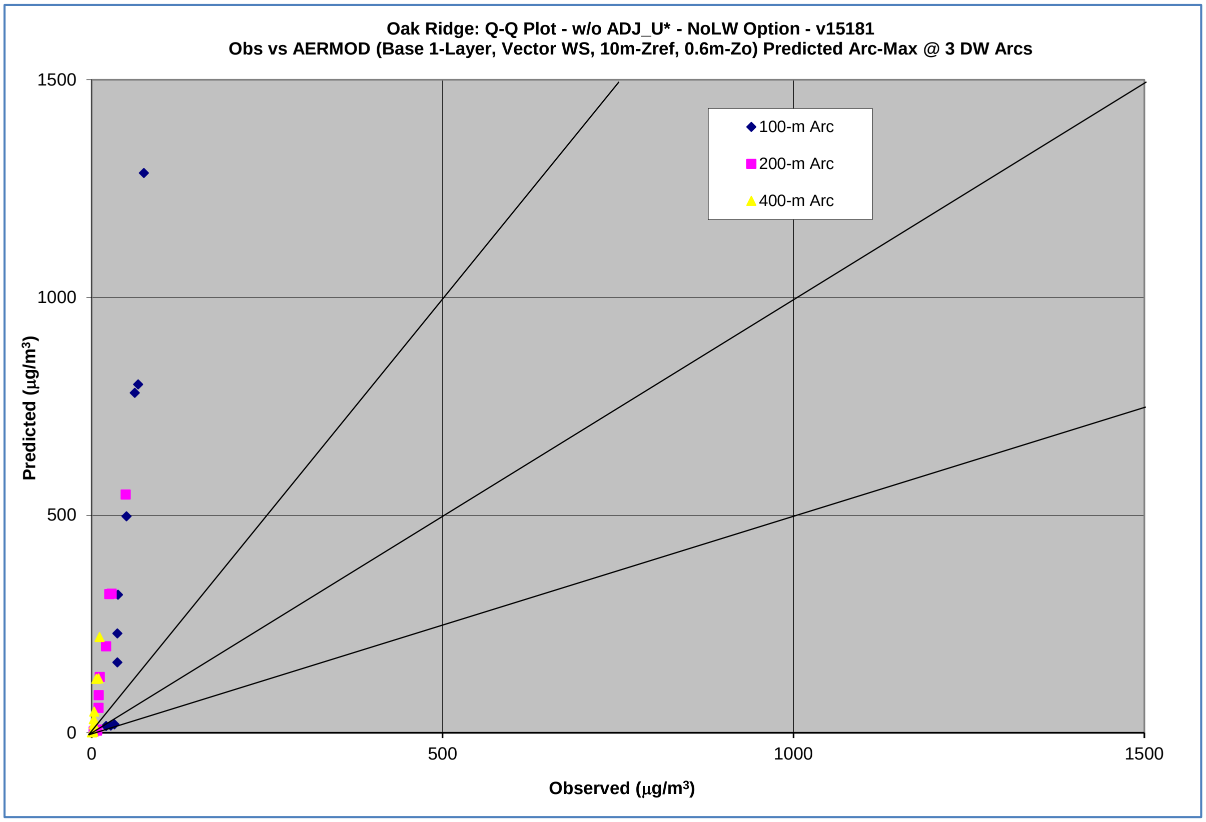
Figure 9-4: Depiction of Sampler Array for Idaho Falls

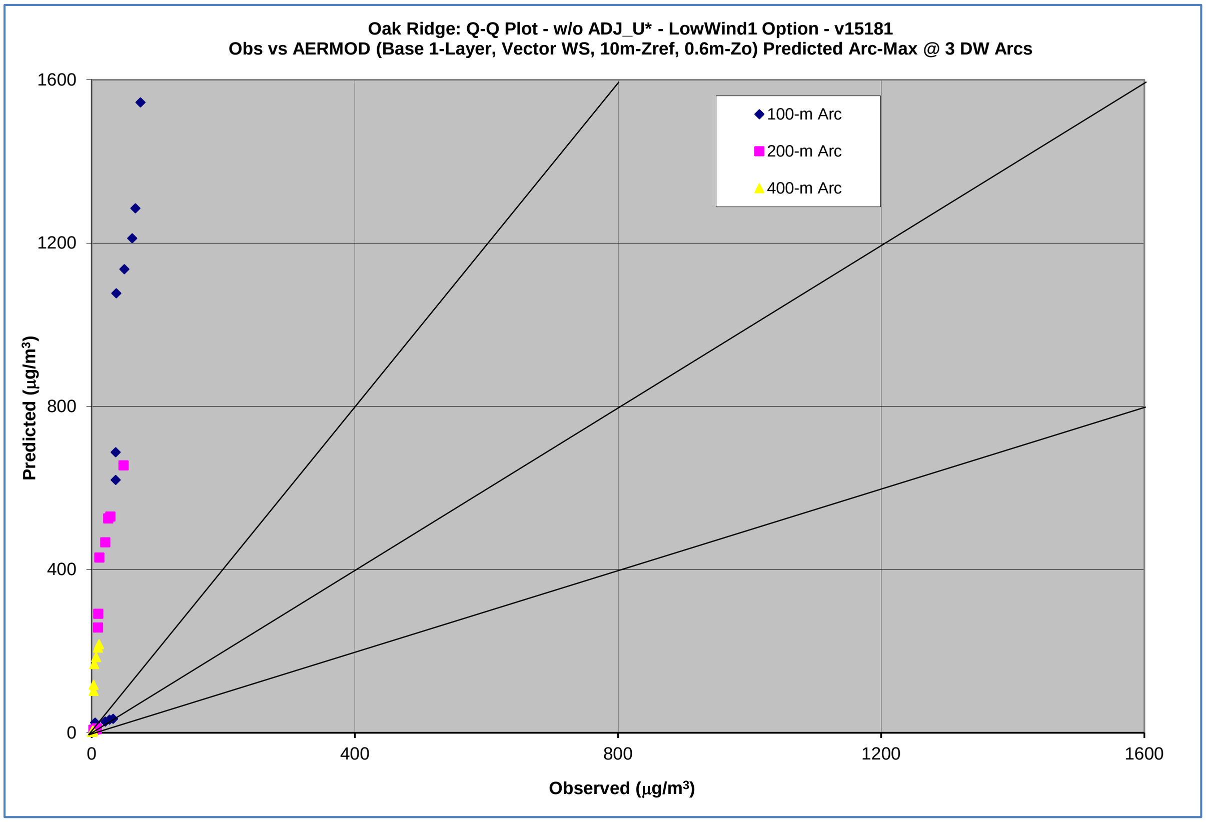


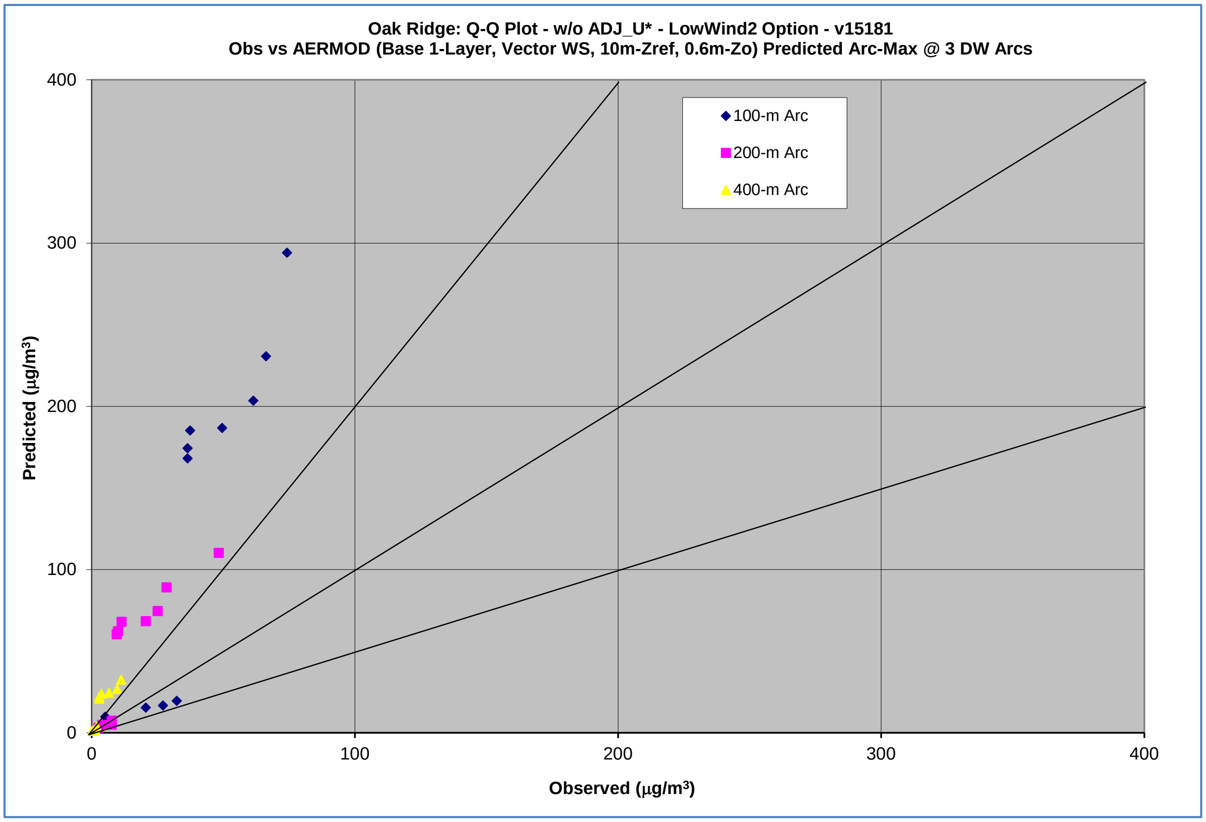
Note: the arcs are at distances of 100, 200, and 400 m from the source.

A series of figures is provided below for each site, starting with the Oak Ridge study followed by the Idaho Falls study. For each site, a series of **Q-Q plots** (i.e., results paired by rank and arc distance), **paired plots** (i.e., results paired in time and arc distance), and **residual plots** (showing the distribution of Pred/Obs ratios by distance) are shown in the following order:

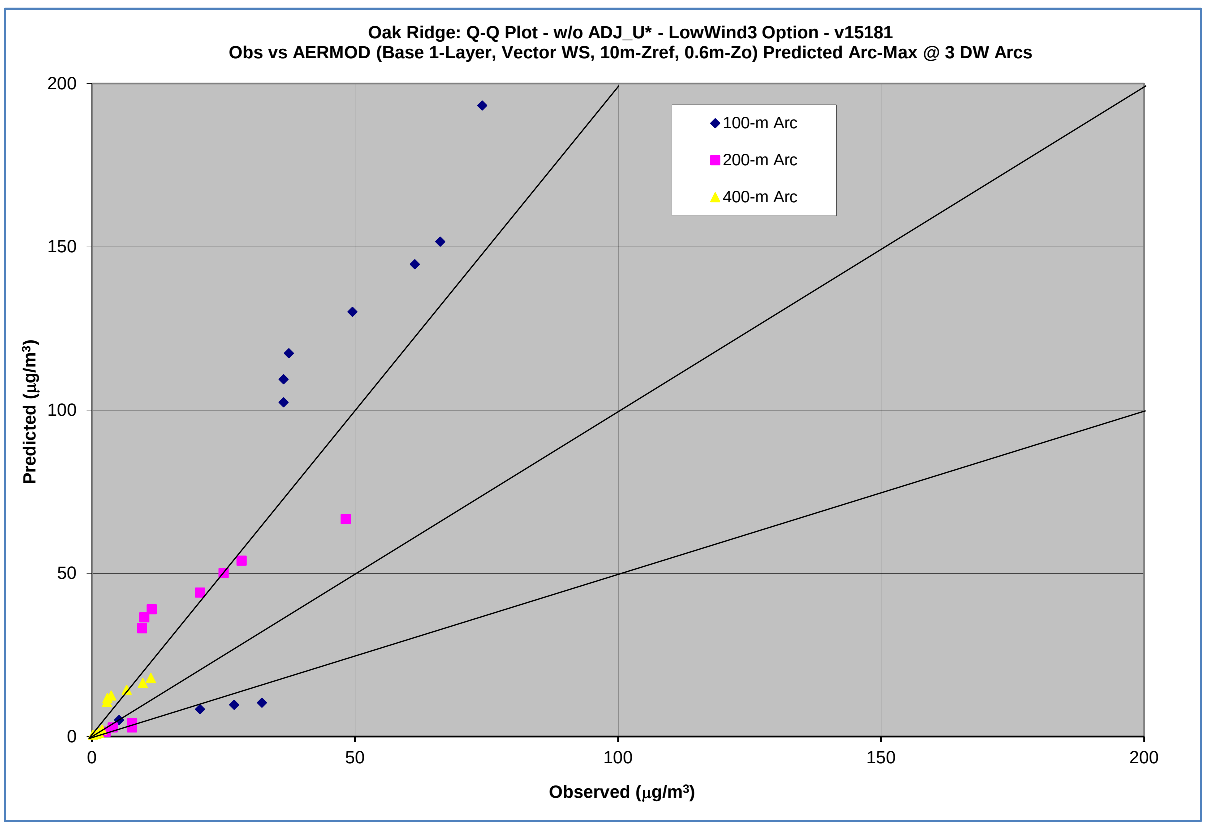
No ADJ_U* / No LowWind Option;
No ADJ_U* / LowWind1 Option;
No ADJ_U* / LowWind2 Option;
No ADJ_U* / LowWind3 Option;
ADJ_U* / No LowWind Option;
ADJ_U* / LowWind1 Option;
ADJ_U* / LowWind2 Option; and
ADJ_U* / LowWind3 Option.


Oak Ridge: Q-Q Plot - w/o ADJ_U* - NoLW Option - v15181
Obs vs AERMOD (Base 1-Layer, Vector WS, 10m-Zref, 0.6m-Zo) Predicted Arc-Max @ 3 DW Arcs
Predicted (μg/m³)
Observed (μg/m³)
100-m Arc
200-m Arc
400-m Arc
0
500
1000
1500

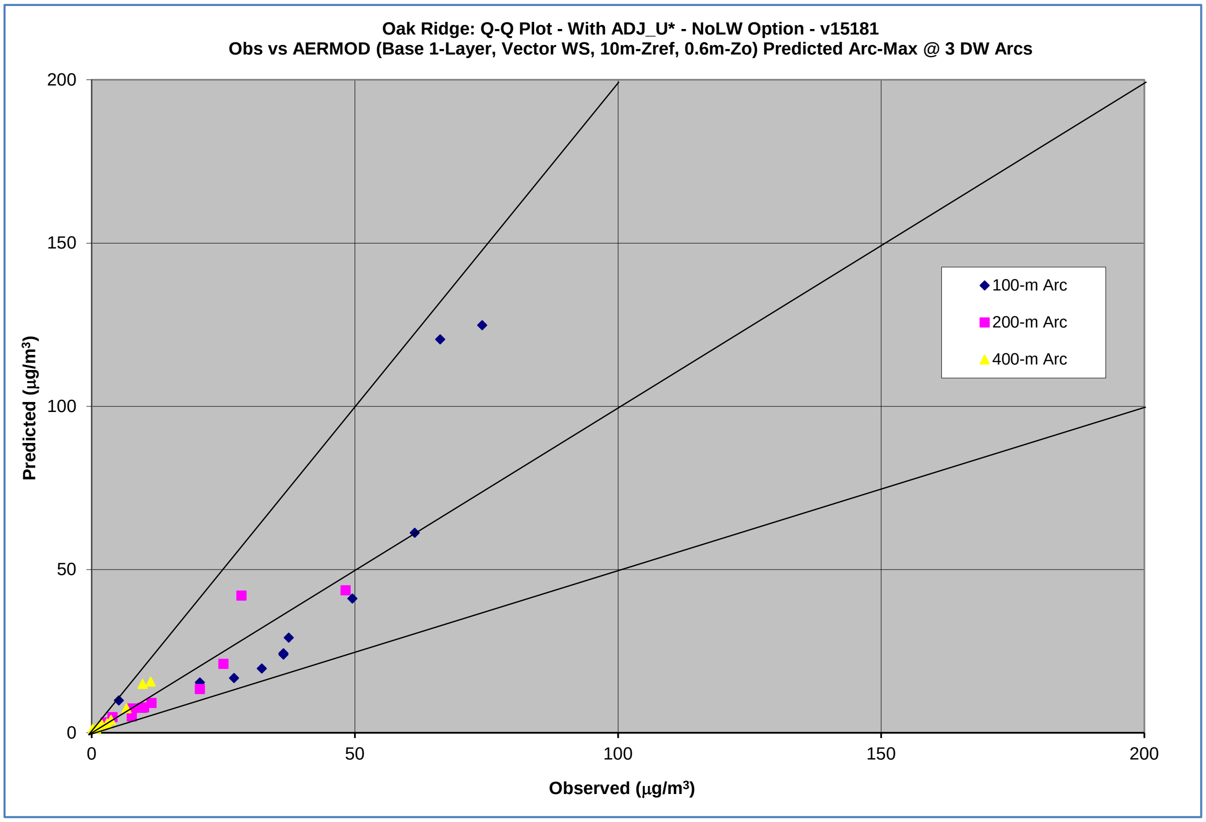

Oak Ridge: Q-Q Plot - w/o ADJ_U* - LowWind1 Option - v15181
Obs vs AERMOD (Base 1-Layer, Vector WS, 10m-Zref, 0.6m-Zo) Predicted Arc-Max @ 3 DW Arcs
Predicted (μg/m³)
Observed (μg/m³)
100-m Arc
200-m Arc
400-m Arc
0
400
800
1200
1600

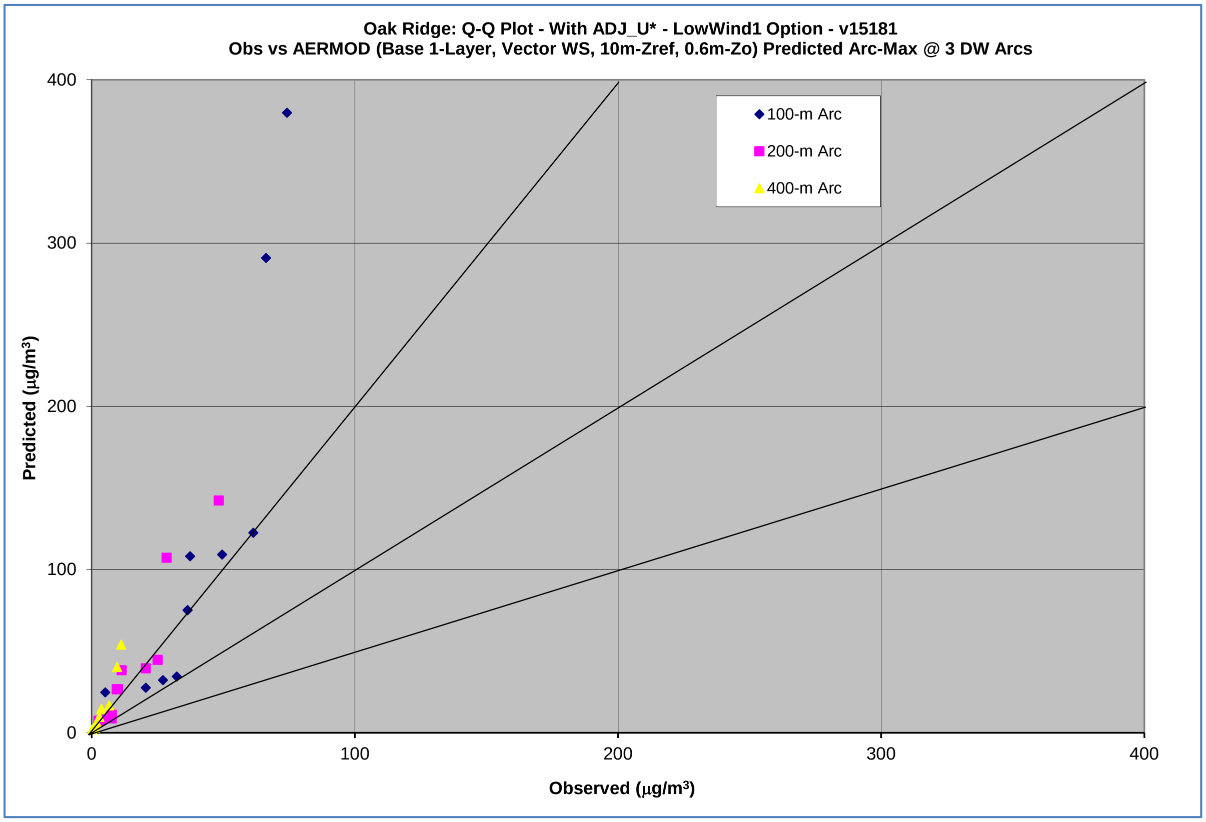


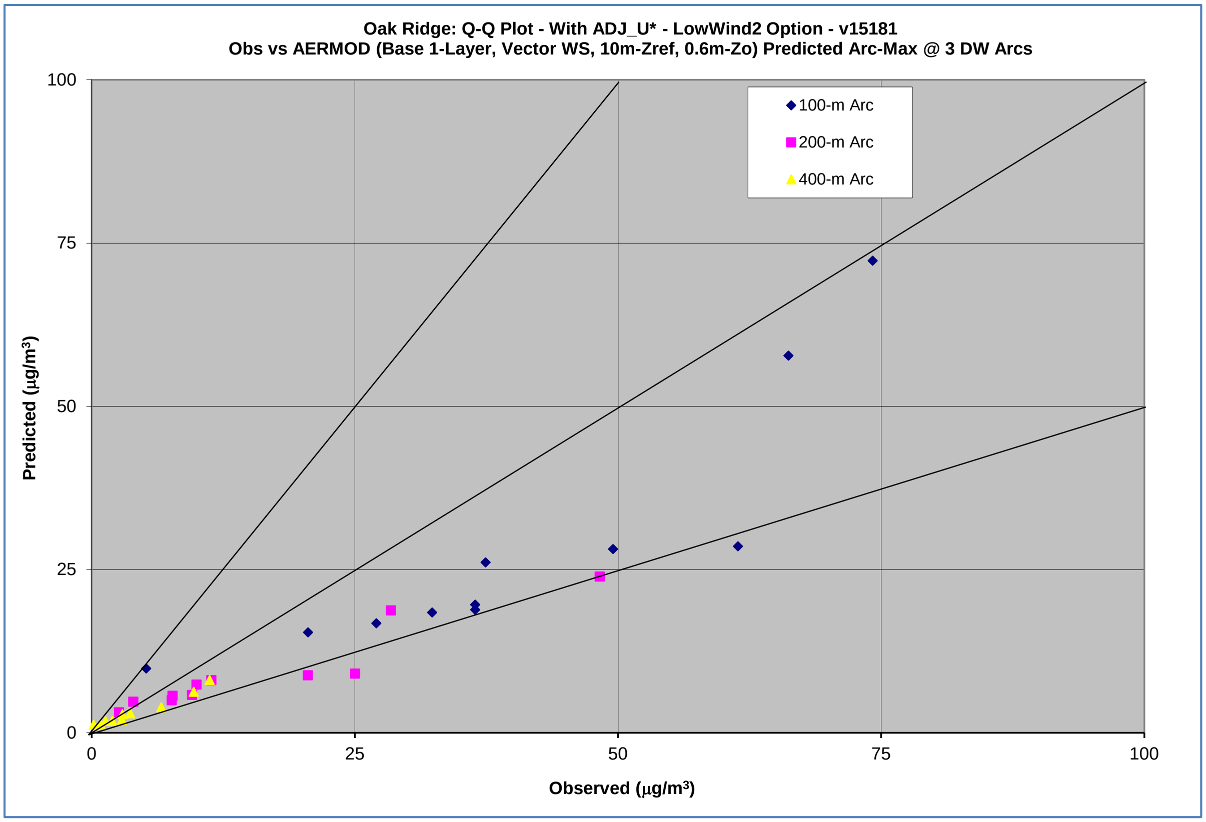
Oak Ridge: Q-Q Plot - w/o ADJ_U* - LowWind2 Option - v15181
Obs vs AERMOD (Base 1-Layer, Vector WS, 10m-Zref, 0.6m-Zo) Predicted Arc-Max @ 3 DW Arcs
Predicted (µg/m³)
Observed (µg/m³)
100-m Arc
200-m Arc
400-m Arc
0
100
200
300
400



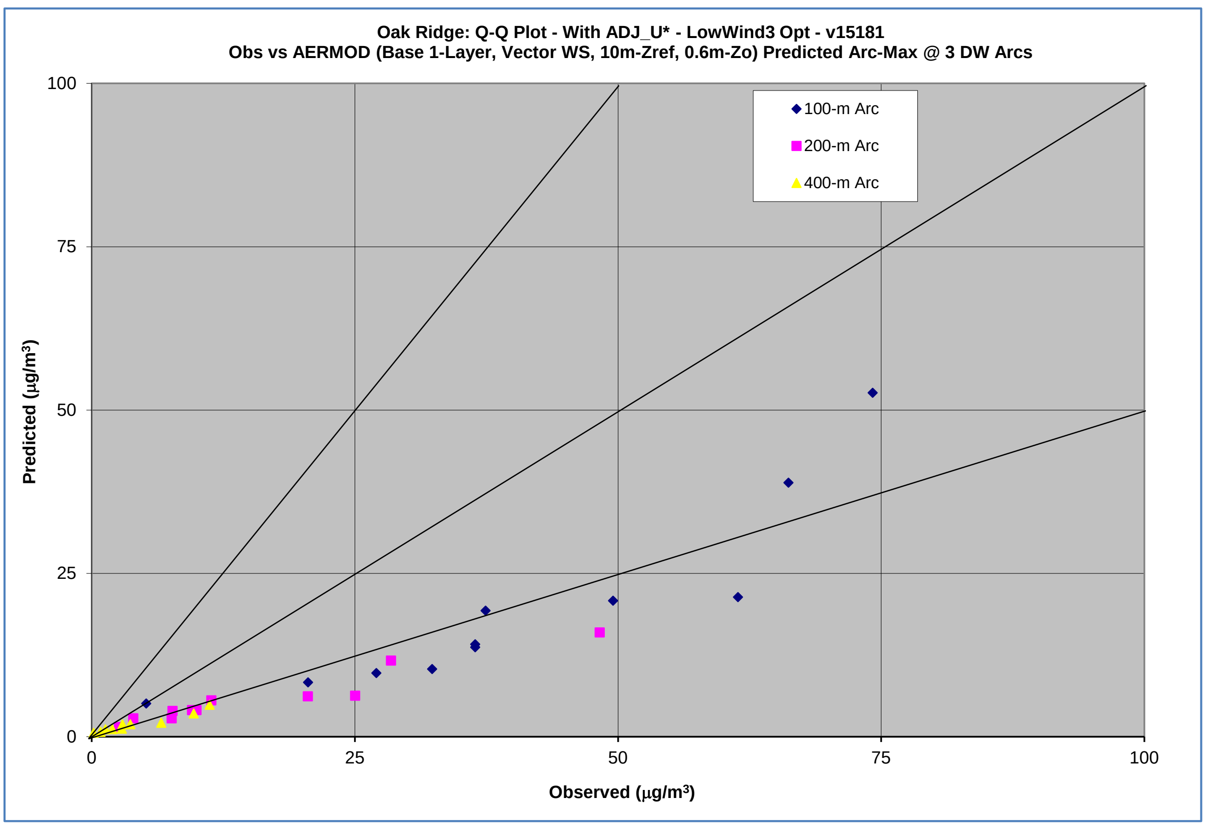
Oak Ridge: Q-Q Plot - w/o ADJ_U* - LowWind3 Option - v15181
Obs vs AERMOD (Base 1-Layer, Vector WS, 10m-Zref, 0.6m-Zo) Predicted Arc-Max @ 3 DW Arcs
Predicted (µg/m³)
Observed (µg/m³)
100-m Arc
200-m Arc
400-m Arc
0
50
100
150
200


Oak Ridge: Q-Q Plot - With ADJ_U* - NoLW Option - v15181
Obs vs AERMOD (Base 1-Layer, Vector WS, 10m-Zref, 0.6m-Zo) Predicted Arc-Max @ 3 DW Arcs
Predicted (µg/m³)
Observed (µg/m³)
100-m Arc
200-m Arc
400-m Arc
0
50
100
150
200

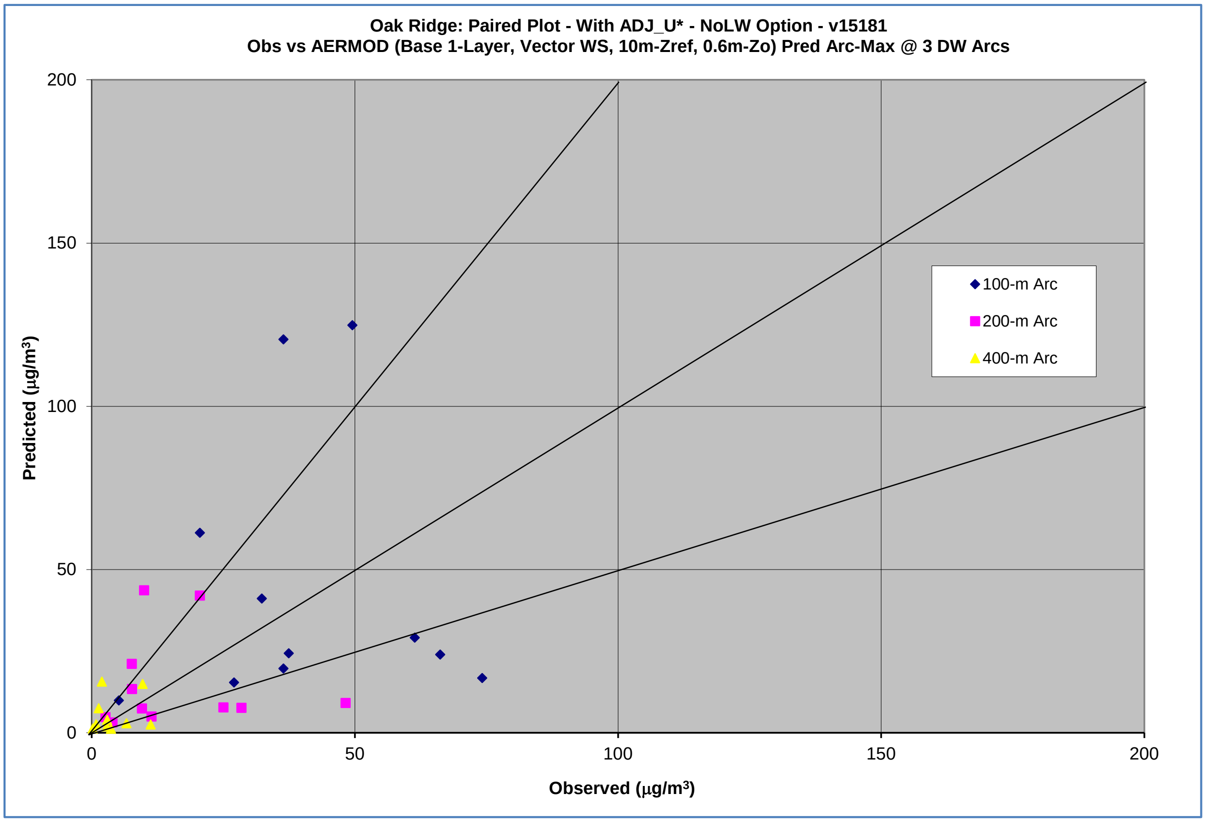

Oak Ridge: Q-Q Plot - With ADJ_U* - LowWind1 Option - v15181
Obs vs AERMOD (Base 1-Layer, Vector WS, 10m-Zref, 0.6m-Zo) Predicted Arc-Max @ 3 DW Arcs
Predicted (µg/m³)
Observed (µg/m³)
100-m Arc
200-m Arc
400-m Arc
0
100
200
300
400

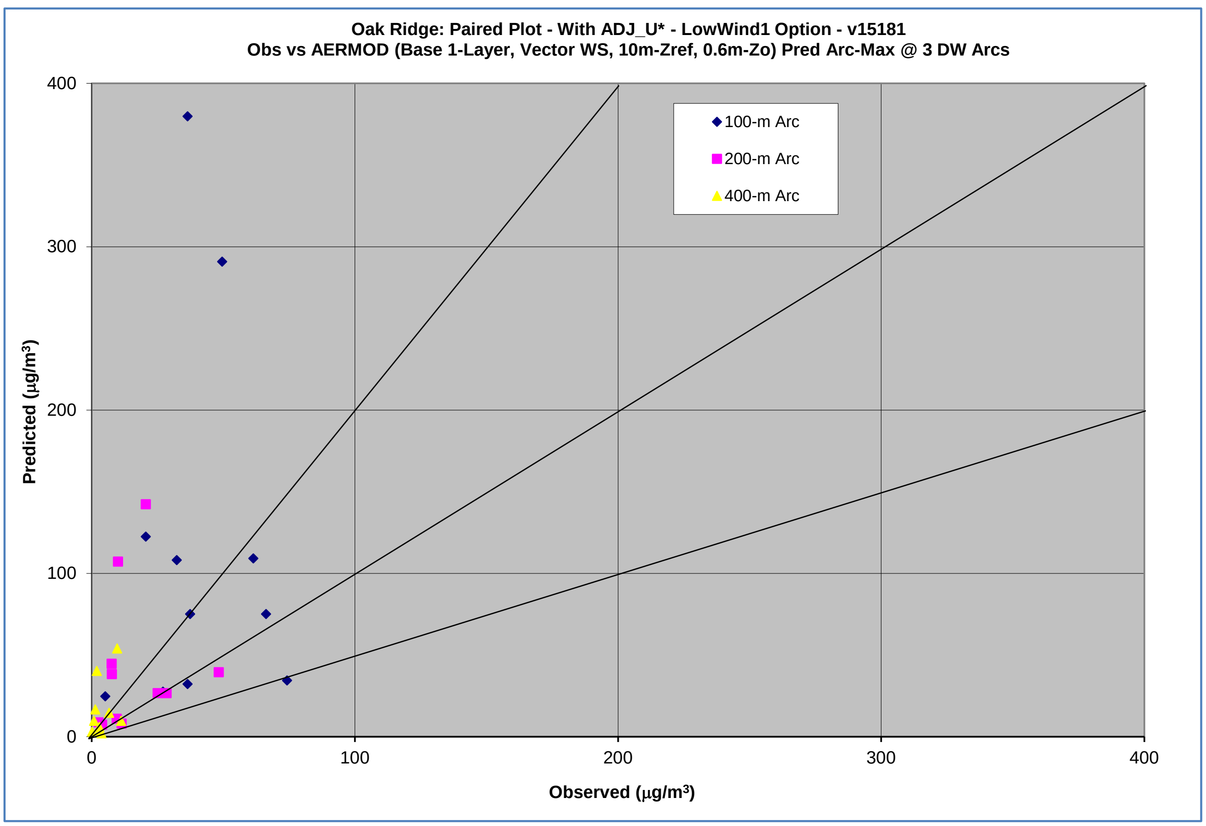


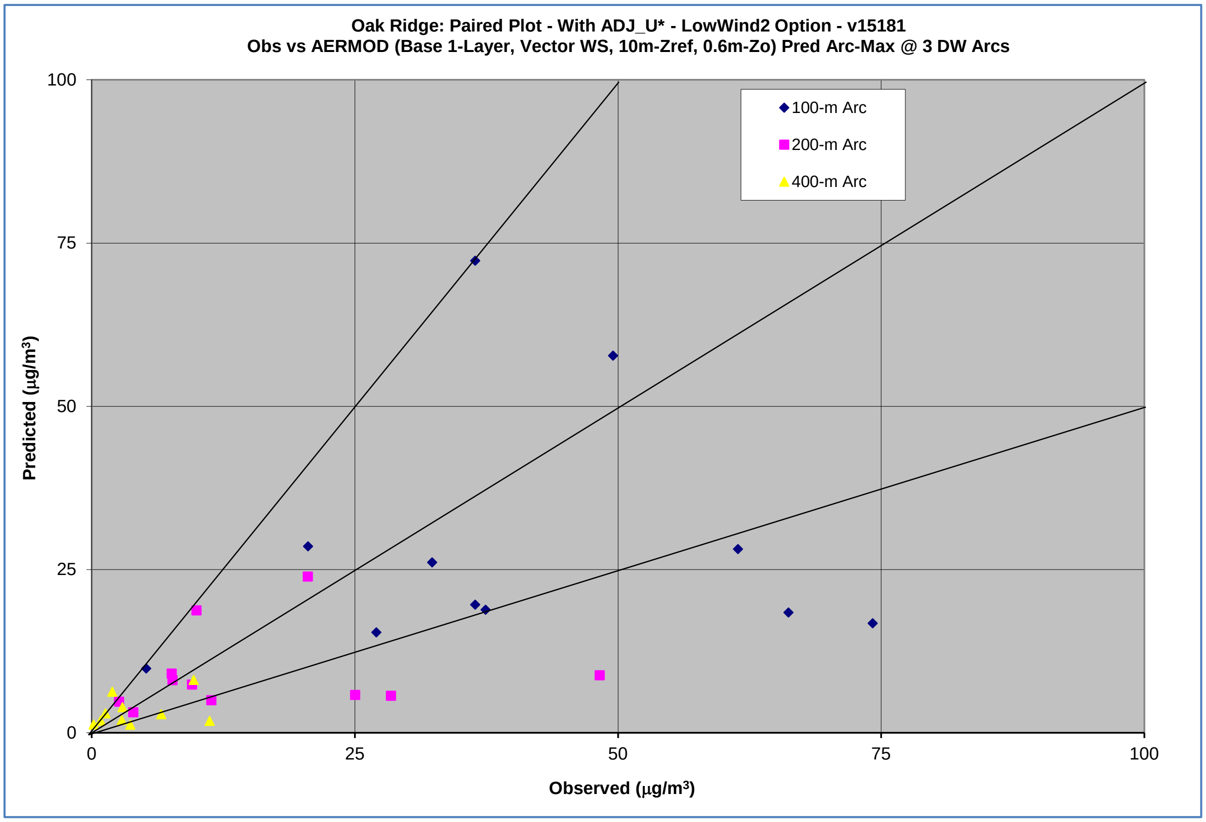
Oak Ridge: Q-Q Plot - With ADJ_U* - LowWind2 Option - v15181
Obs vs AERMOD (Base 1-Layer, Vector WS, 10m-Zref, 0.6m-Zo) Predicted Arc-Max @ 3 DW Arcs
100-m Arc
200-m Arc
400-m Arc
Predicted (µg/m³)
Observed (µg/m³)
0
25
50
75
100

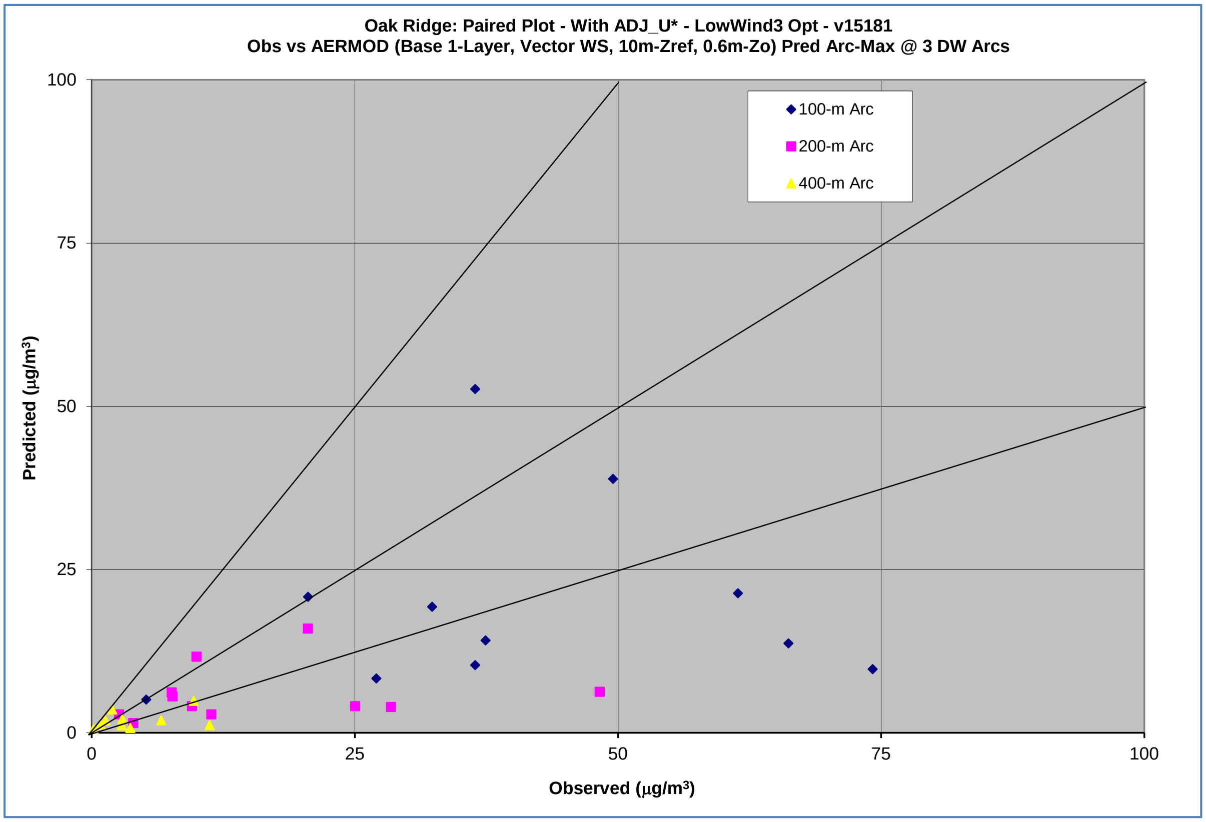


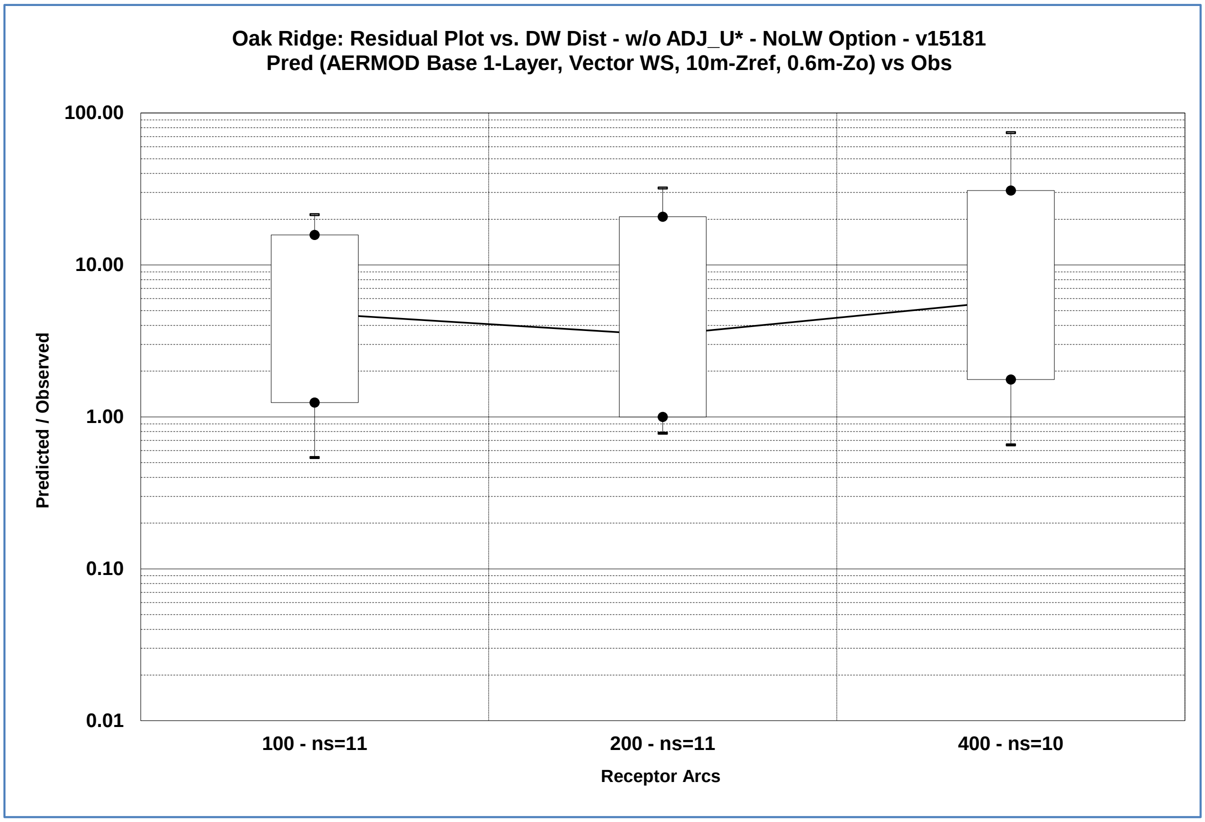
Oak Ridge: Q-Q Plot - With ADJ_U* - LowWind3 Opt - v15181
Obs vs AERMOD (Base 1-Layer, Vector WS, 10m-Zref, 0.6m-Zo) Predicted Arc-Max @ 3 DW Arcs
100-m Arc
200-m Arc
400-m Arc
Predicted (µg/m³)
Observed (µg/m³)
0
25
50
75
100

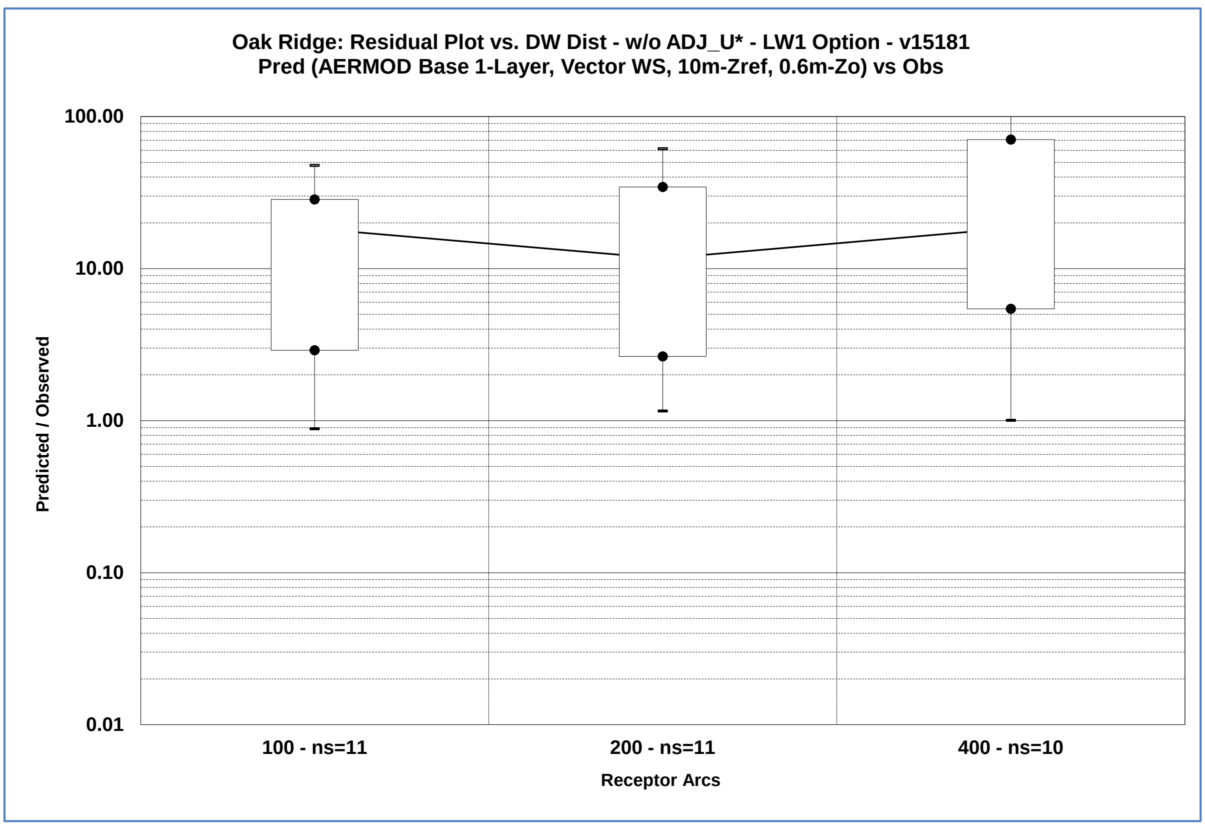

Oak Ridge: Paired Plot - With ADJ_U* - NoLW Option - v15181
Obs vs AERMOD (Base 1-Layer, Vector WS, 10m-Zref, 0.6m-Zo) Pred Arc-Max @ 3 DW Arcs
Predicted (µg/m³)
Observed (µg/m³)
100-m Arc
200-m Arc
400-m Arc
0
50
100
150
200

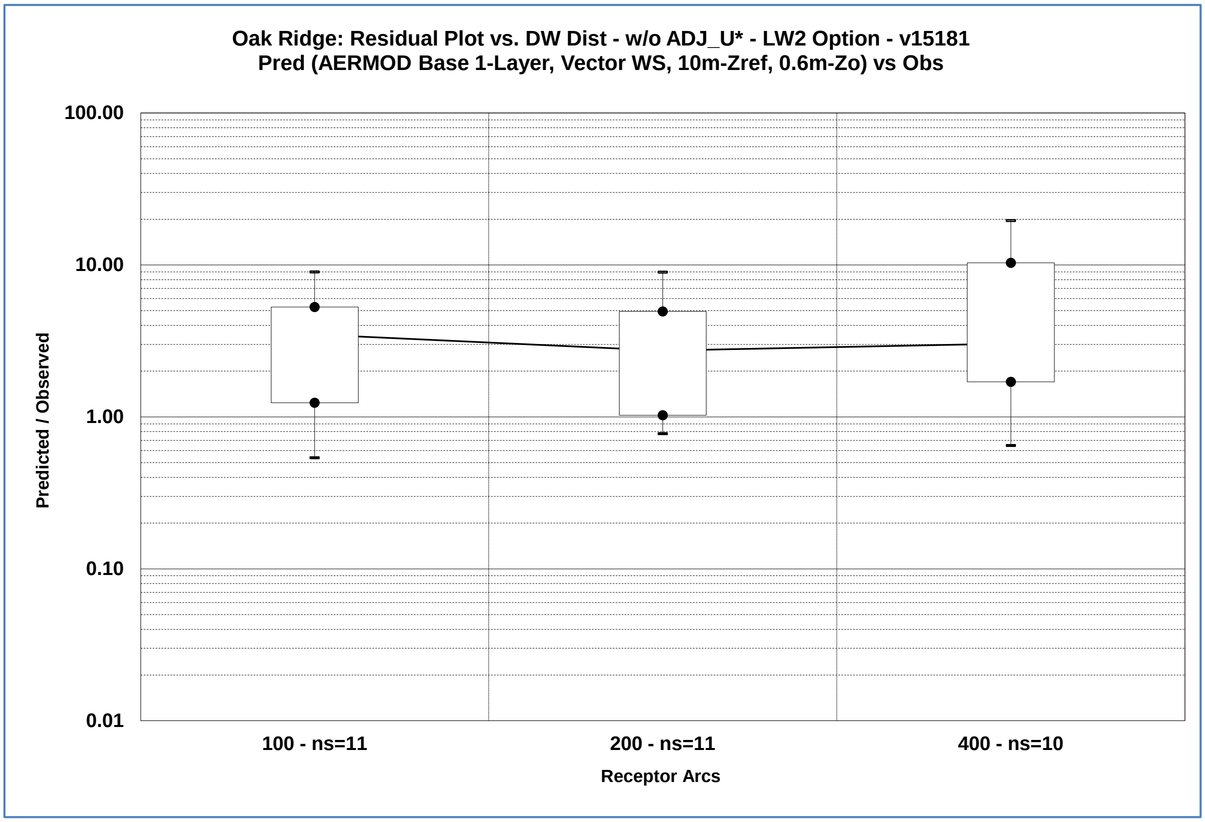

Oak Ridge: Paired Plot - With ADJ_U* - LowWind1 Option - v15181
Obs vs AERMOD (Base 1-Layer, Vector WS, 10m-Zref, 0.6m-Zo) Pred Arc-Max @ 3 DW Arcs
Predicted (µg/m³)
Observed (µg/m³)
100-m Arc
200-m Arc
400-m Arc
0
100
200
300
400

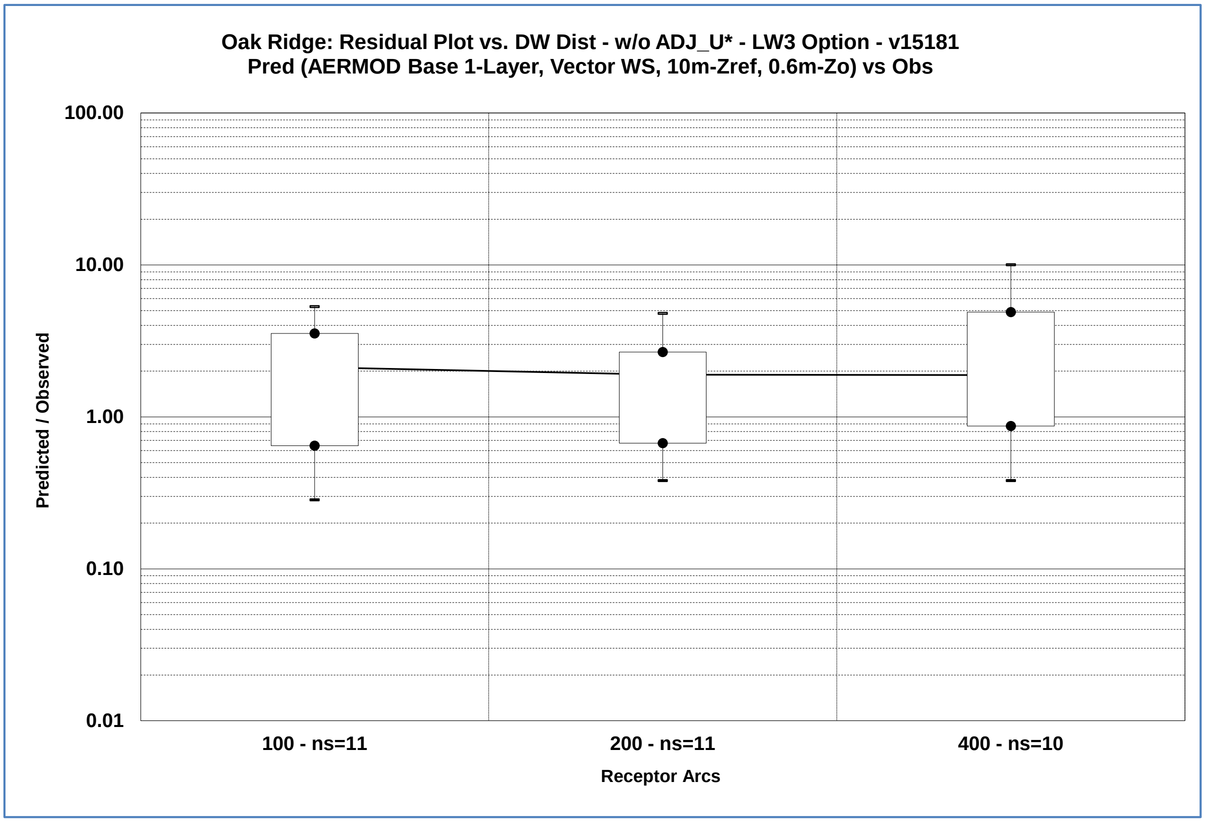

Oak Ridge: Paired Plot - With ADJ_U* - LowWind2 Option - v15181
Obs vs AERMOD (Base 1-Layer, Vector WS, 10m-Zref, 0.6m-Zo) Pred Arc-Max @ 3 DW Arcs
100-m Arc
200-m Arc
400-m Arc
Predicted (µg/m³)
Observed (µg/m³)
0
25
50
75
100

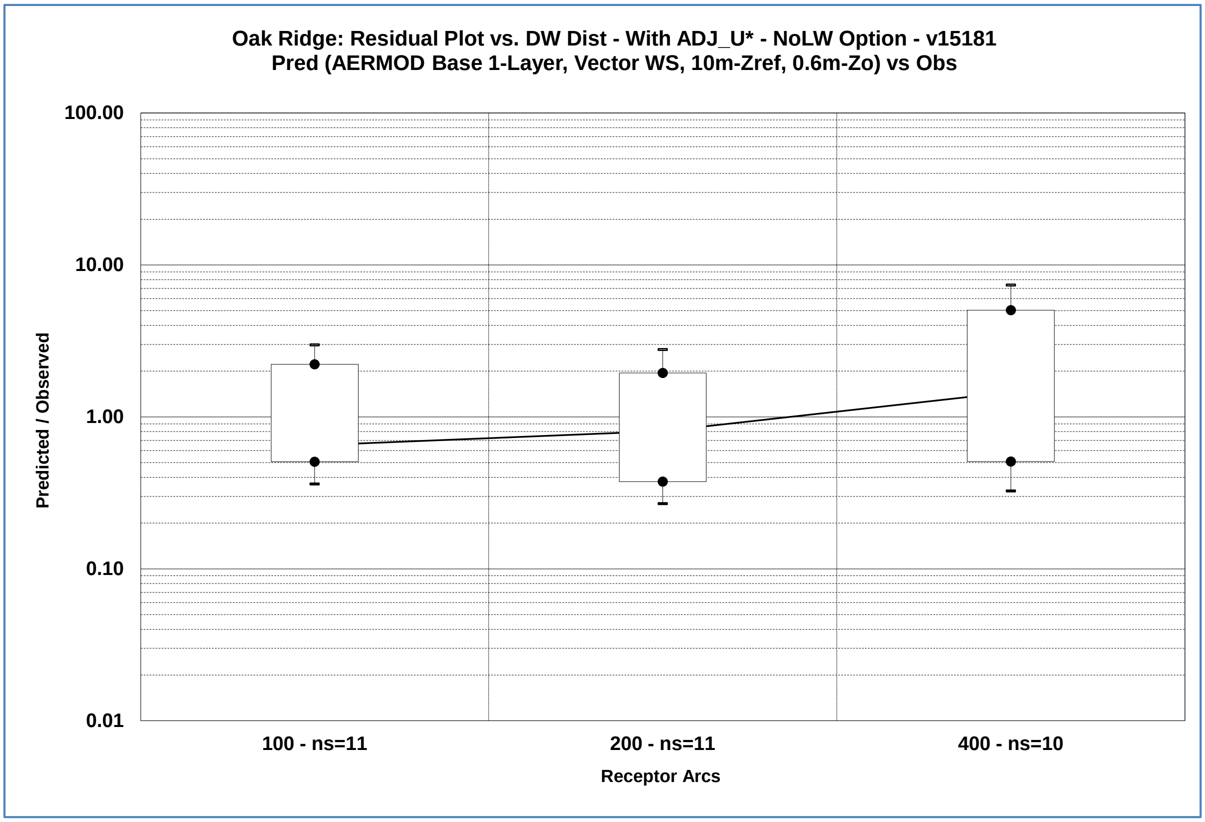

Oak Ridge: Paired Plot - With ADJ_U* - LowWind3 Opt - v15181
Obs vs AERMOD (Base 1-Layer, Vector WS, 10m-Zref, 0.6m-Zo) Pred Arc-Max @ 3 DW Arcs
100-m Arc
200-m Arc
400-m Arc
Predicted (µg/m³)
Observed (µg/m³)
0
25
50
75
100

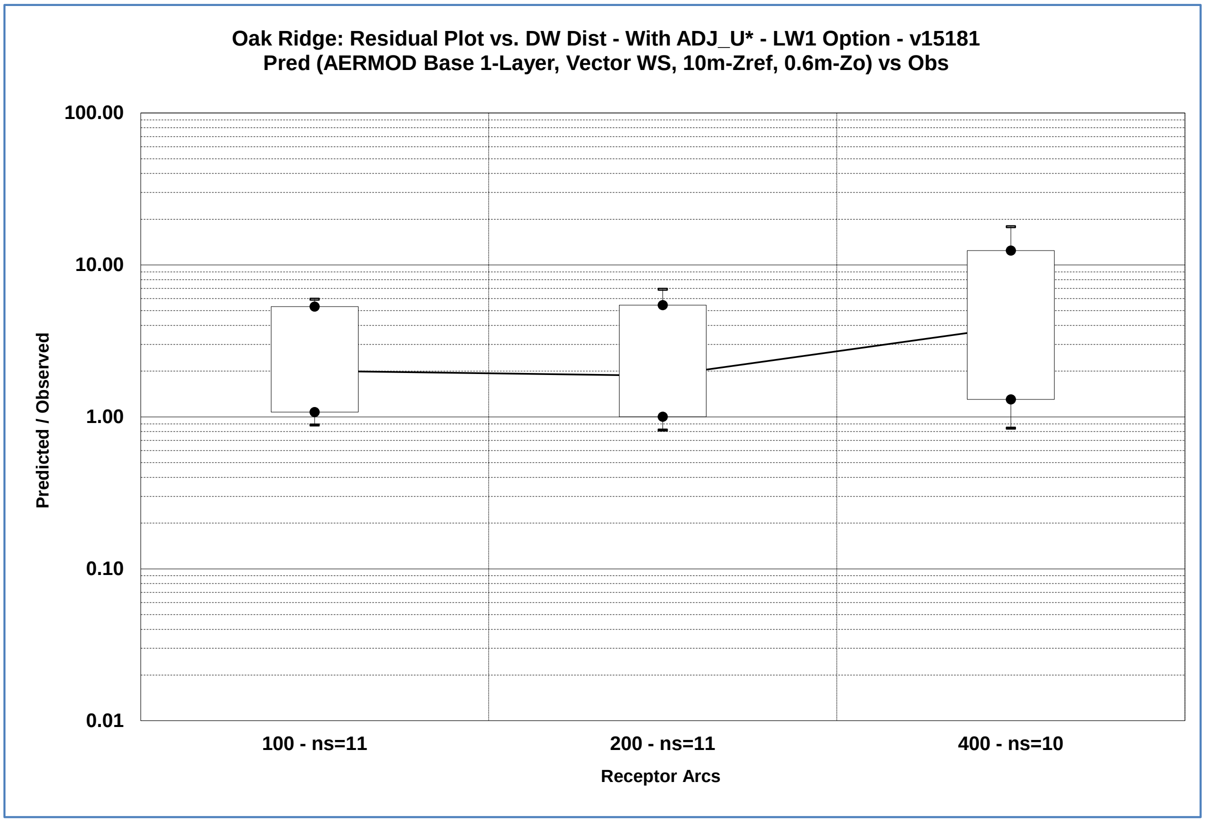

Oak Ridge: Residual Plot vs. DW Dist - w/o ADJ_U* - NoLW Option - v15181
Pred (AERMOD Base 1-Layer, Vector WS, 10m-Zref, 0.6m-Zo) vs Obs
100.00
10.00
1.00
0.10
0.01
Predicted / Observed
100 - ns=11
200 - ns=11
400 - ns=10
Receptor Arcs

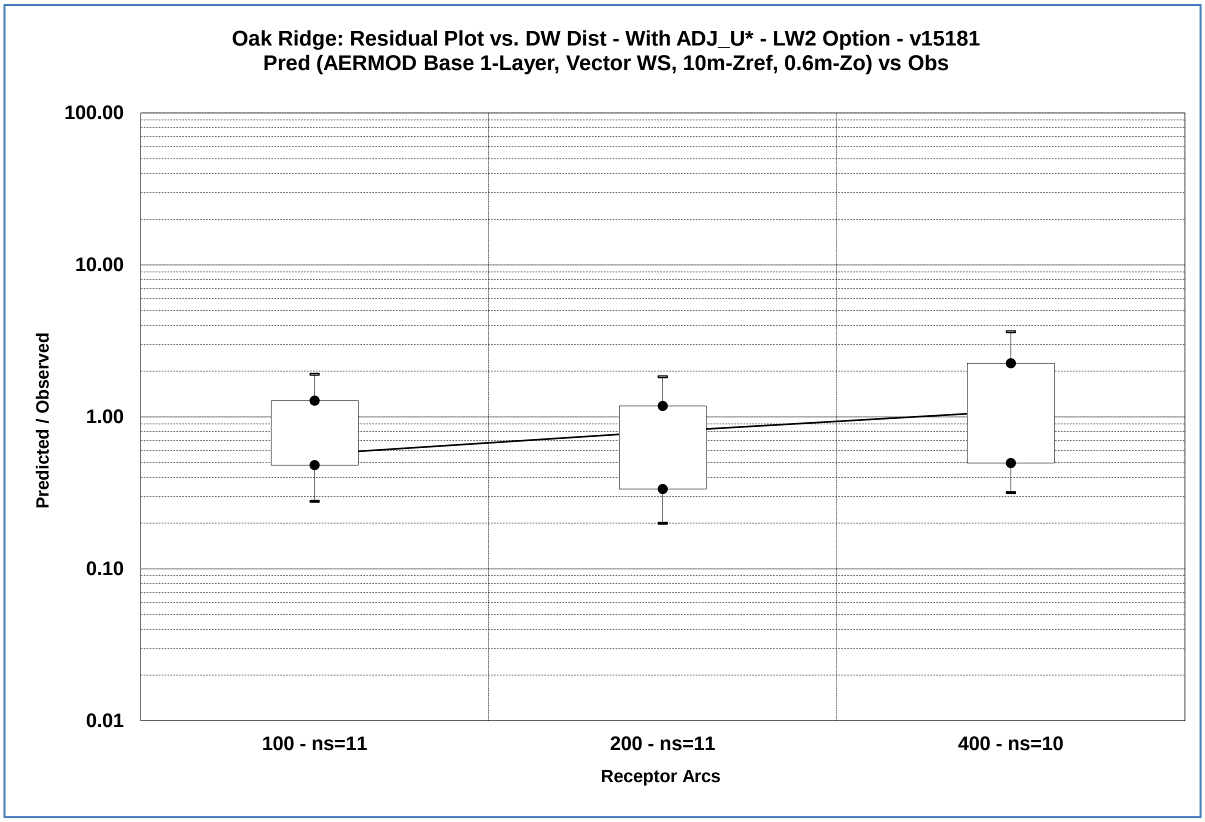

Oak Ridge: Residual Plot vs. DW Dist - w/o ADJ_U* - LW1 Option - v15181
Pred (AERMOD Base 1-Layer, Vector WS, 10m-Zref, 0.6m-Zo) vs Obs
100.00
10.00
1.00
0.10
0.01
Predicted / Observed
100 - ns=11
200 - ns=11
400 - ns=10
Receptor Arcs

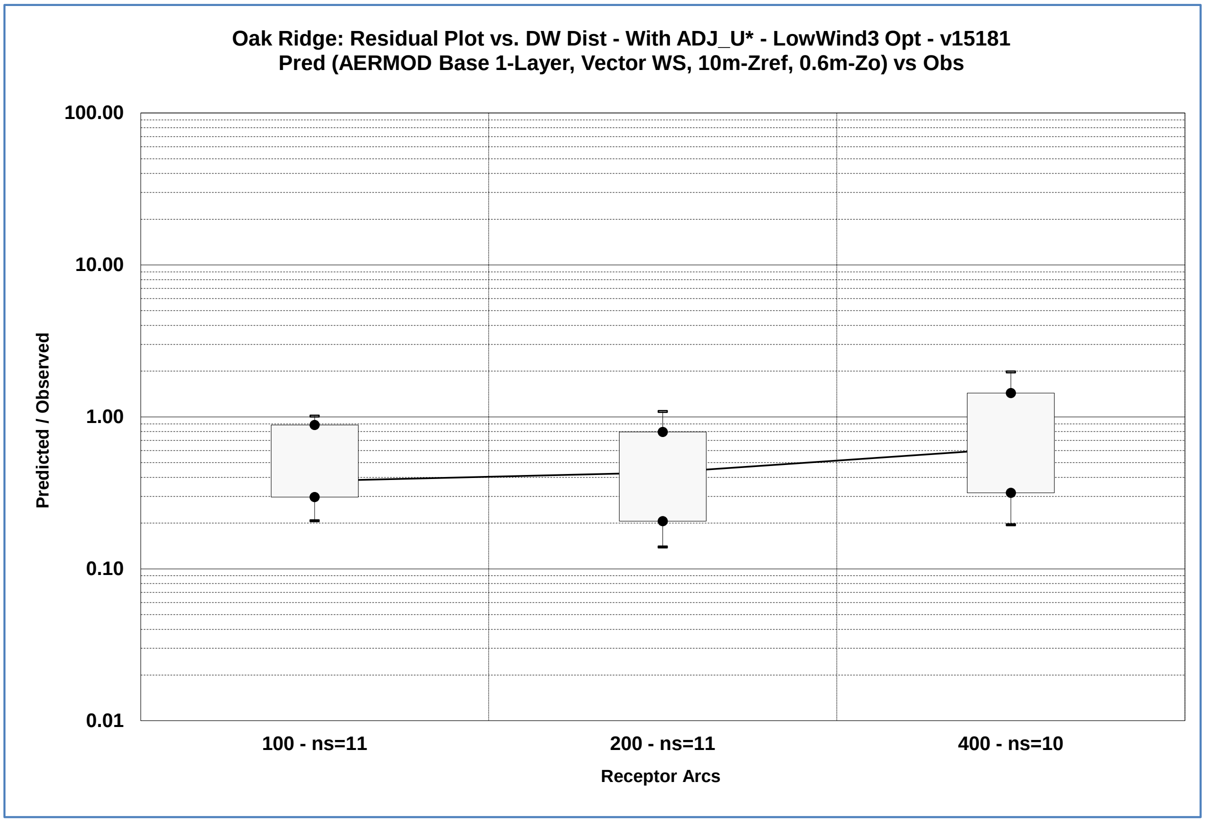

Oak Ridge: Residual Plot vs. DW Dist - w/o ADJ_U* - LW2 Option - v15181
Pred (AERMOD Base 1-Layer, Vector WS, 10m-Zref, 0.6m-Zo) vs Obs
100.00
10.00
1.00
0.10
0.01
Predicted / Observed
100 - ns=11
200 - ns=11
400 - ns=10
Receptor Arcs


Oak Ridge: Residual Plot vs. DW Dist - w/o ADJ_U* - LW3 Option - v15181
Pred (AERMOD Base 1-Layer, Vector WS, 10m-Zref, 0.6m-Zo) vs Obs
100.00
10.00
1.00
0.10
0.01
Predicted / Observed
100 - ns=11
200 - ns=11
400 - ns=10
Receptor Arcs


Oak Ridge: Residual Plot vs. DW Dist - With ADJ_U* - NoLW Option - v15181
Pred (AERMOD Base 1-Layer, Vector WS, 10m-Zref, 0.6m-Zo) vs Obs
100.00
10.00
1.00
0.10
0.01
Predicted / Observed
100 - ns=11
200 - ns=11
400 - ns=10
Receptor Arcs


Oak Ridge: Residual Plot vs. DW Dist - With ADJ_U* - LW1 Option - v15181
Pred (AERMOD Base 1-Layer, Vector WS, 10m-Zref, 0.6m-Zo) vs Obs
100.00
10.00
1.00
0.10
0.01
Predicted / Observed
100 - ns=11
200 - ns=11
400 - ns=10
Receptor Arcs


Oak Ridge: Residual Plot vs. DW Dist - With ADJ_U* - LW2 Option - v15181
Pred (AERMOD Base 1-Layer, Vector WS, 10m-Zref, 0.6m-Zo) vs Obs
100.00
10.00
1.00
0.10
0.01
Predicted / Observed
100 - ns=11
200 - ns=11
400 - ns=10
Receptor Arcs


Oak Ridge: Residual Plot vs. DW Dist - With ADJ_U* - LowWind3 Opt - v15181
Pred (AERMOD Base 1-Layer, Vector WS, 10m-Zref, 0.6m-Zo) vs Obs
100.00
10.00
1.00
0.10
0.01
Predicted / Observed
100 - ns=11
200 - ns=11
400 - ns=10
Receptor Arcs

The figures shown above for the Oak Ridge field study show significant overprediction with the current default options in AERMET and AERMOD. The LowWind2 and LowWind3 options without the ADJ_U* option exhibit much better performance, with LowWind3 showing the best results, but both options still show significant overpredictions. The LowWind1 option actually degrades model performance relative to the default options. These figures also show significant improvement in model performance with the ADJ_U* option in AERMET with and without the LowWind options. The LowWind2 option with ADJ_U* appears to show the best overall performance, with the LownWind3/ADJ_U* option showing some bias toward underprediction. However, as noted above, the evaluation results presented here do not account for the potential influence of terrain on modeled concentrations. Given the potential for valley channeling and drainage flows one might expect modeling results based on an assumption of flat terrain to underestimate concentrations for this study. Figure 7 from the NOAA Technical Memorandum shows horizontal isopleths of concentrations for Test #6 which appears to be stretched along the axis of the valley where the tracer was released. A similar pattern shows up with other tests.

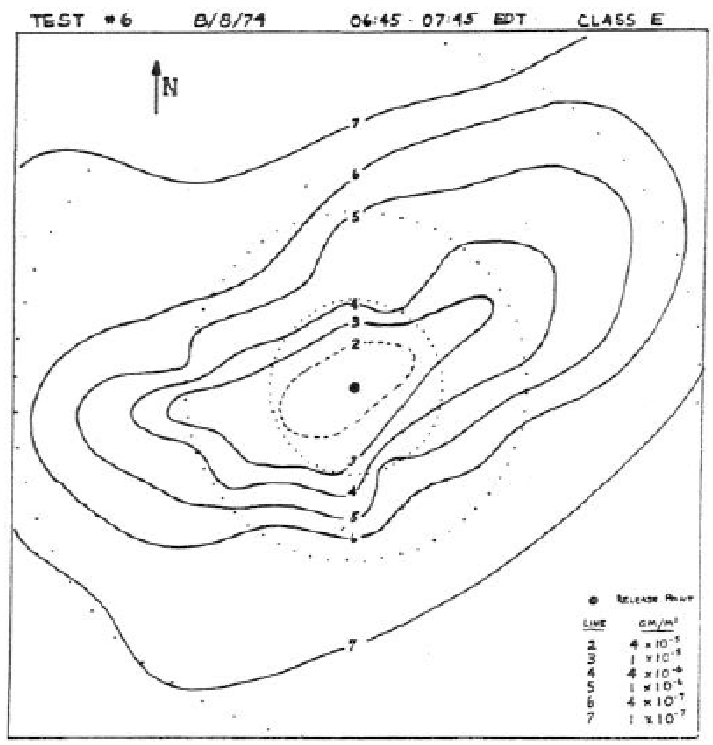
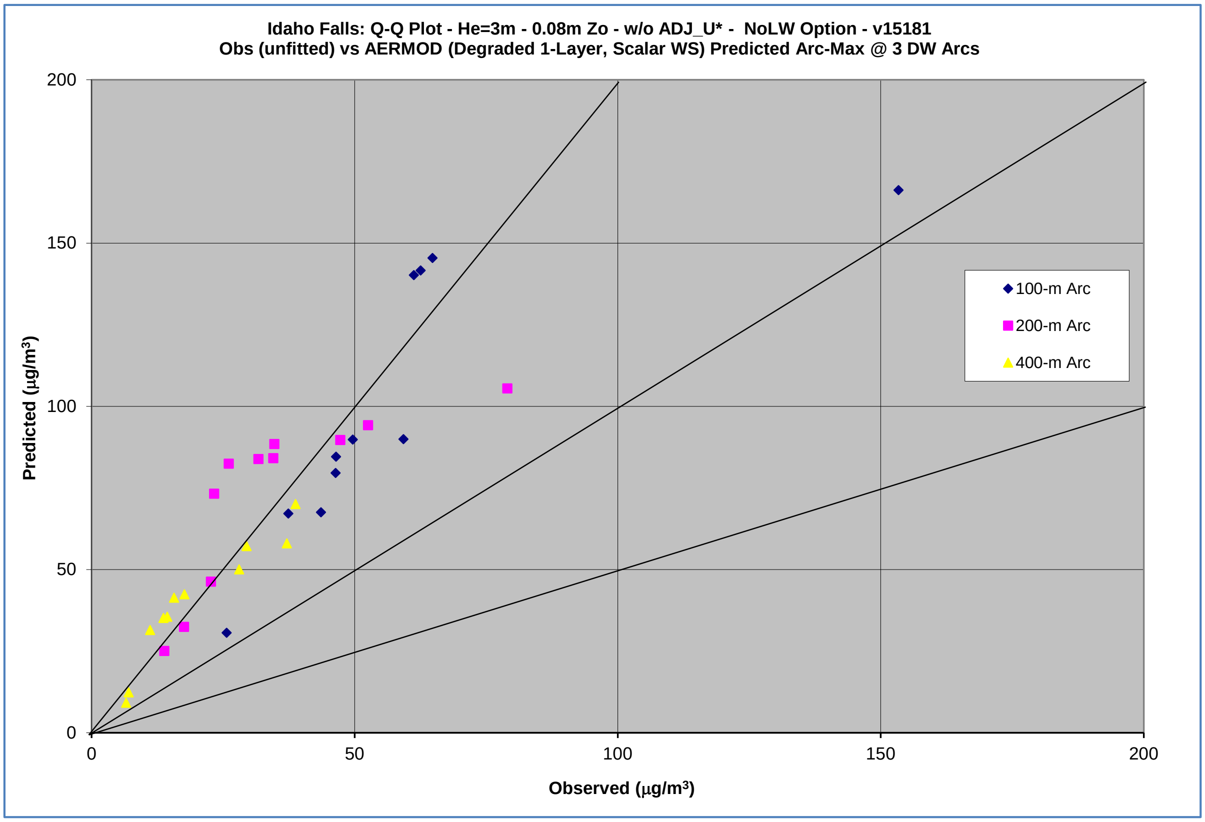
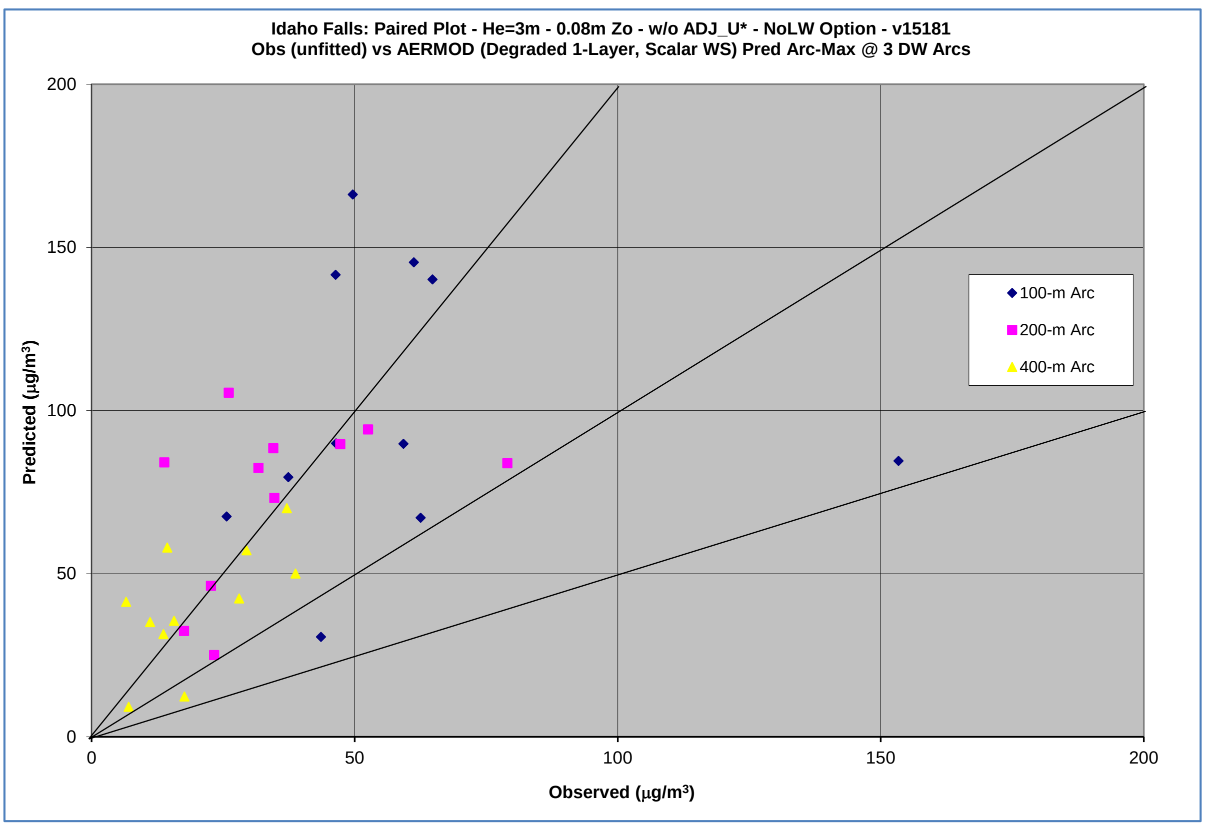
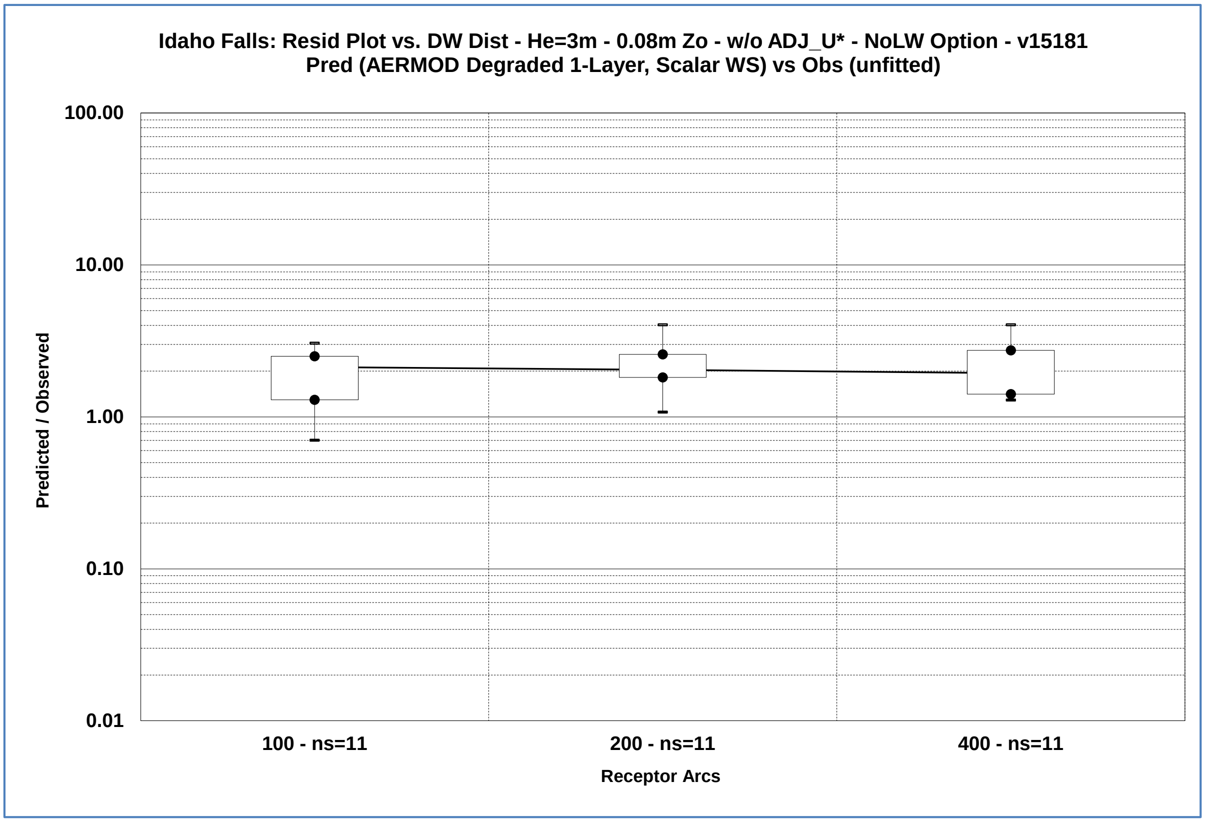


Figure 7. Horizontal isopleths of concentration for test 6 showing the typical 360° spread of gaseous tracer.

The next series of figures shows evaluation results for Idaho Falls based on the degraded 1-layer meteorological data (i.e., no delta-T data for the BULKRN option and no sigma-theta data, starting with the DFAULT option (without ADJ_U* and NoLW), followed by the LowWind1, LowWind2, and LowWind3 option, followed by the results with the ADJ_U* option.

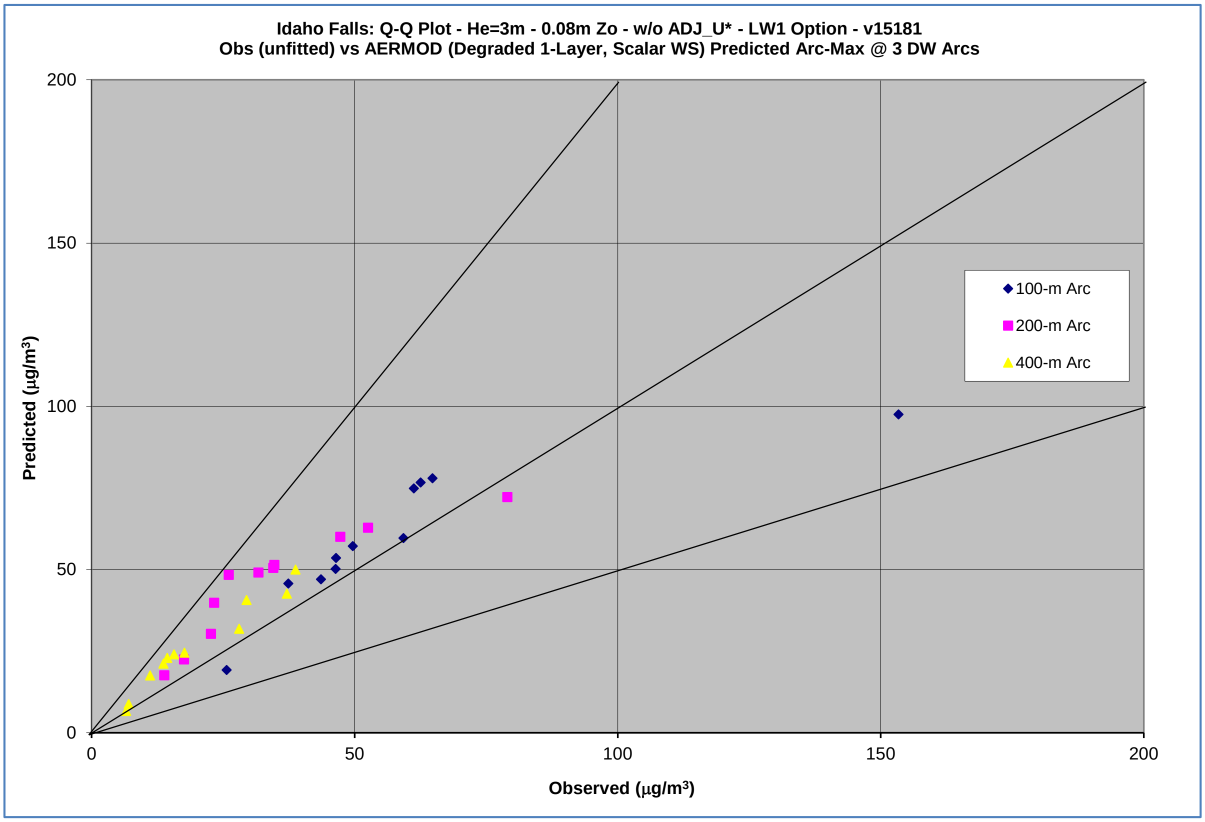

Idaho Falls: Q-Q Plot - He=3m - 0.08m Zo - w/o ADJ_U* - NoLW Option - v15181
Obs (unfitted) vs AERMOD (Degraded 1-Layer, Scalar WS) Predicted Arc-Max @ 3 DW Arcs
Predicted (µg/m³)
Observed (µg/m³)
0
50
100
150
200
100-m Arc
200-m Arc
400-m Arc


Idaho Falls: Paired Plot - He=3m - 0.08m Zo - w/o ADJ_U* - NoLW Option - v15181
Obs (unfitted) vs AERMOD (Degraded 1-Layer, Scalar WS) Pred Arc-Max @ 3 DW Arcs
Predicted (µg/m³)
Observed (µg/m³)
0
50
100
150
200
100-m Arc
200-m Arc
400-m Arc

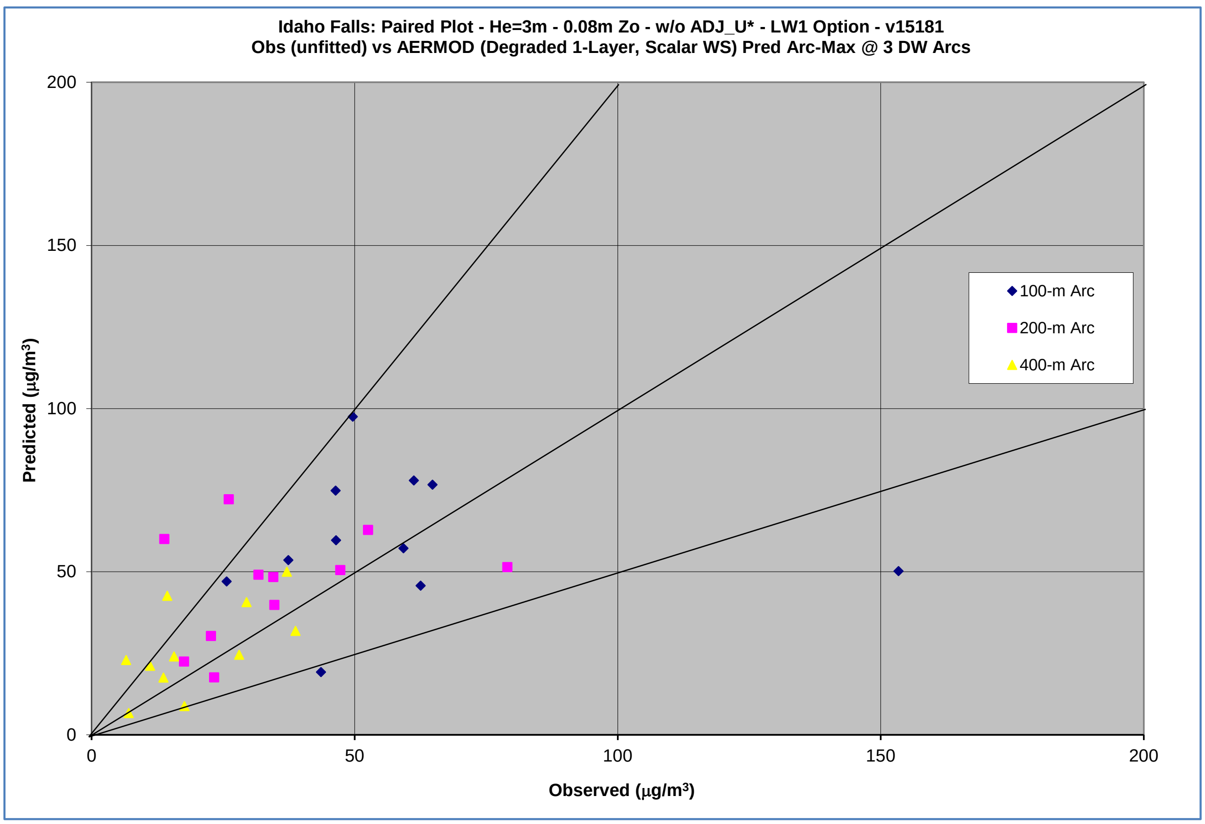


The results for Idaho Falls based on the default options in AERMET and AERMOD exhibit overprediction of the observed concentrations of approximately a factor of 2, with is a much smaller bias than for the Oak Ridge study. As shown below, the bias toward overprediction is largely eliminated with the LowWind options in AERMOD, without the ADJ_U* option in AERMET. The average Pred/Obs concentration ratios are also generally consistent with downwind distance.

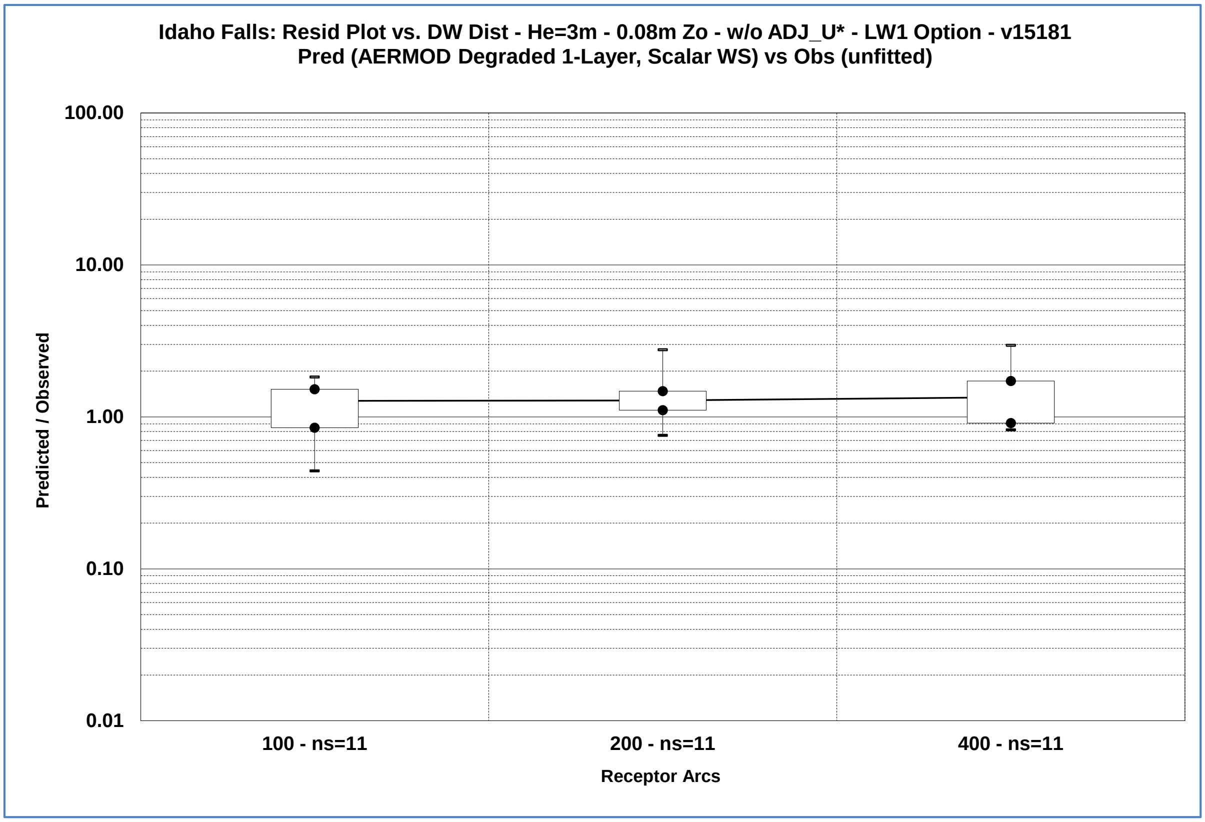
The results for Idaho Falls with the ADJ_U* option in AERMET also show generally good performance at the first arc of receptors at 100m downwind, with some tendency toward underprediction further downwind, especially when the LowWind options are also used. For this type of source, i.e., a non-buoyant, ground-level or low-level source (e.g., fugitive emission), the maximum ambient impacts are likely to occur at the fenceline.

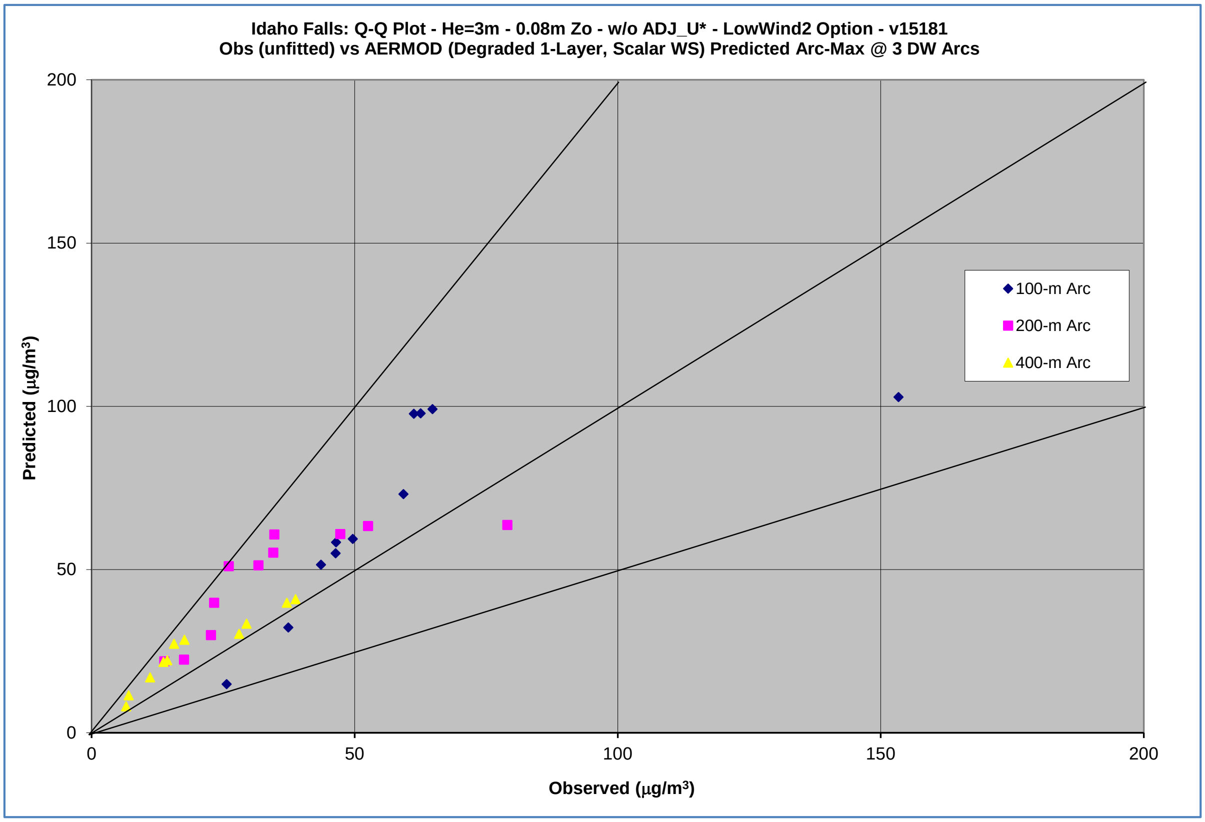


Idaho Falls: Q-Q Plot - He=3m - 0.08m Zo - w/o ADJ_U* - LW1 Option - v15181
Obs (unfitted) vs AERMOD (Degraded 1-Layer, Scalar WS) Predicted Arc-Max @ 3 DW Arcs
Predicted (μg/m³)
Observed (μg/m³)
100-m Arc
200-m Arc
400-m Arc
0
50
100
150
200

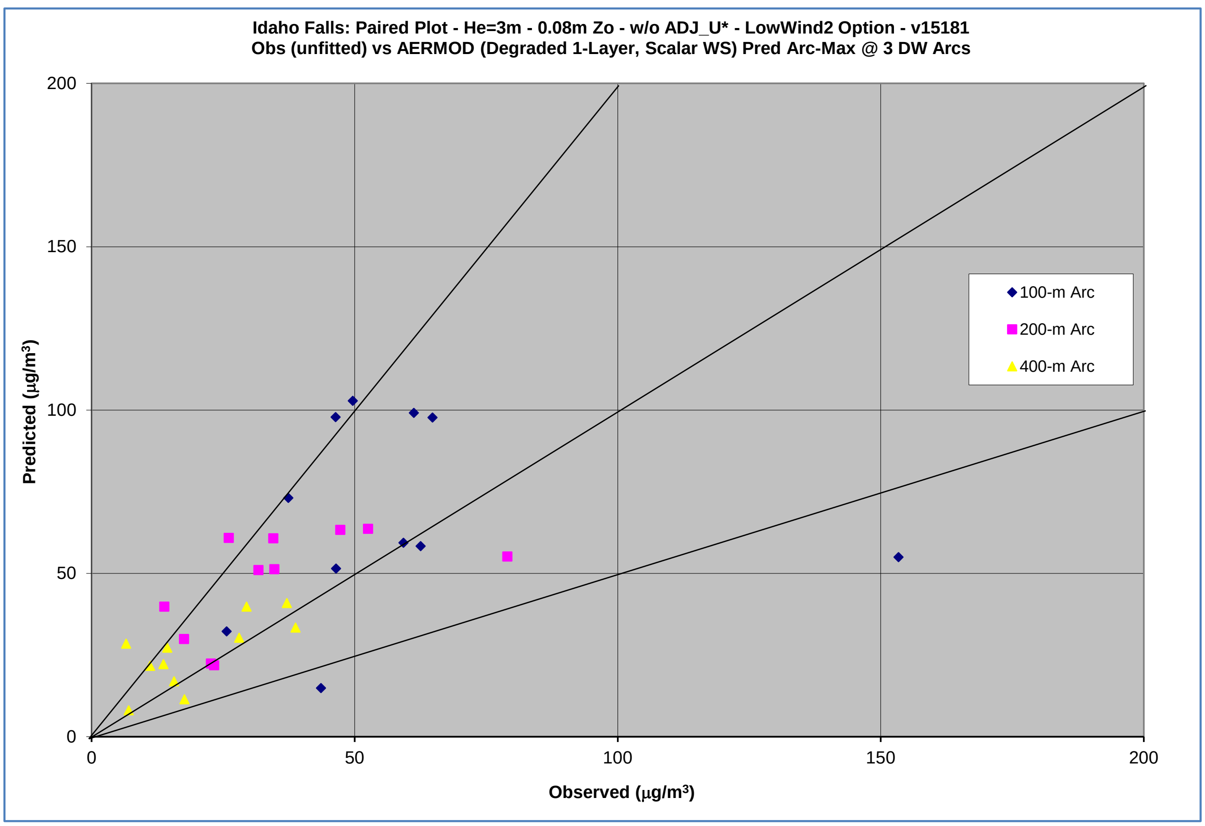


Idaho Falls: Paired Plot - He=3m - 0.08m Zo - w/o ADJ_U* - LW1 Option - v15181
Obs (unfitted) vs AERMOD (Degraded 1-Layer, Scalar WS) Pred Arc-Max @ 3 DW Arcs
Predicted (μg/m³)
Observed (μg/m³)
100-m Arc
200-m Arc
400-m Arc
0
50
100
150
200

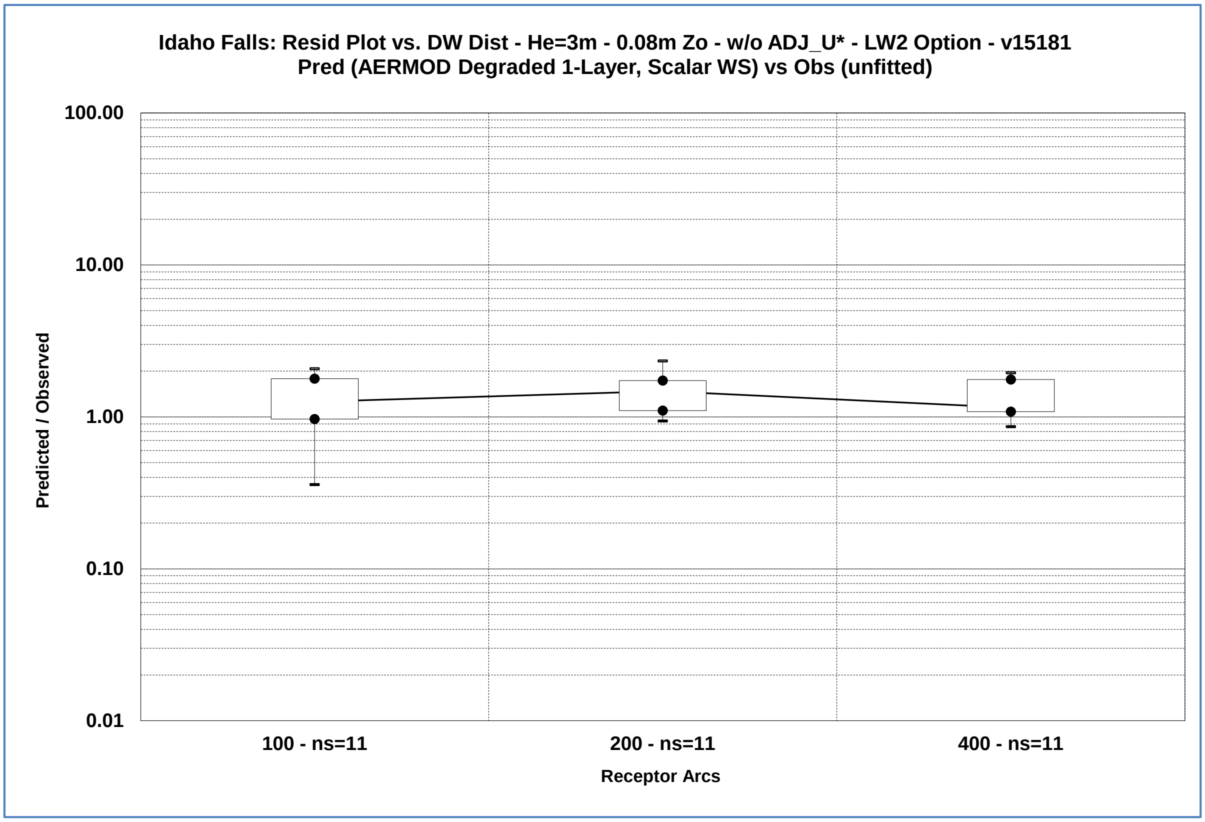

Idaho Falls: Resid Plot vs. DW Dist - He=3m - 0.08m Zo - w/o ADJ_U* - LW1 Option - v15181
Pred (AERMOD Degraded 1-Layer, Scalar WS) vs Obs (unfitted)
100.00
10.00
1.00
0.10
0.01
Predicted / Observed
100 - ns=11
200 - ns=11
400 - ns=11
Receptor Arcs

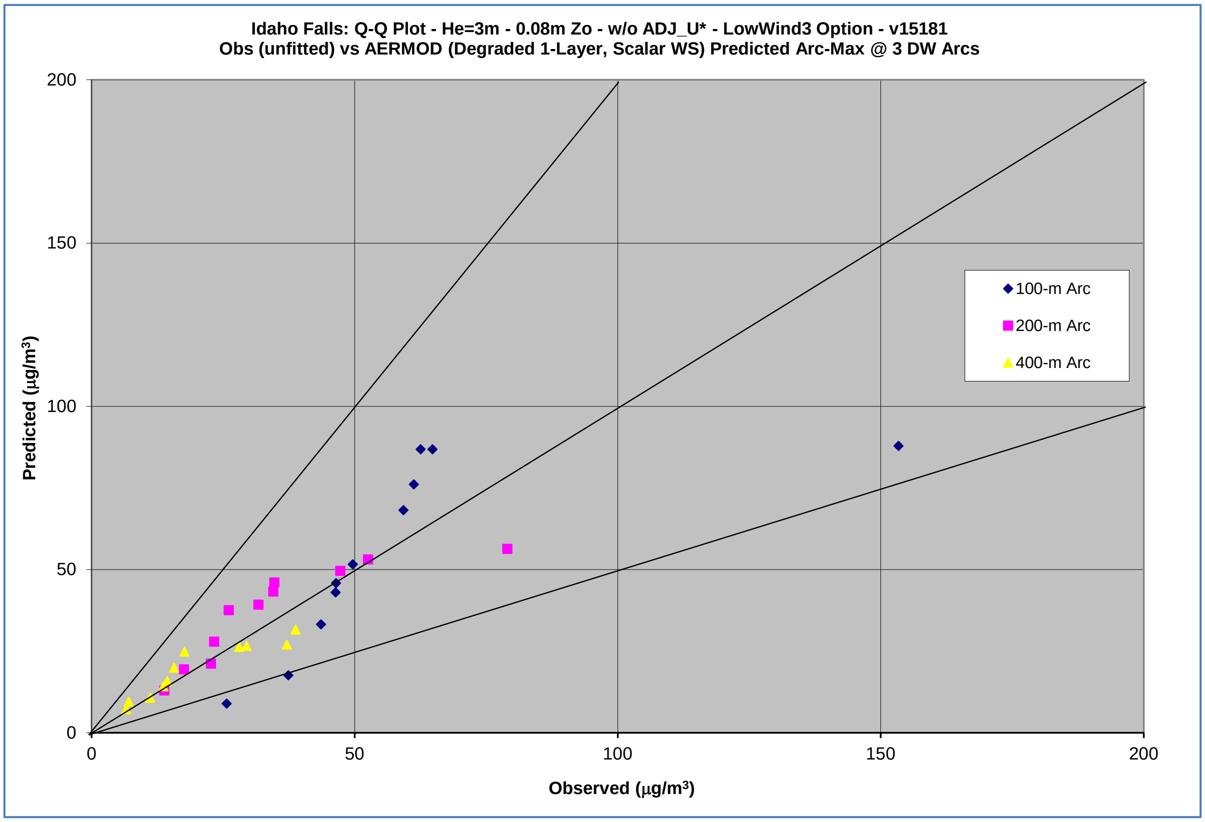


Idaho Falls: Q-Q Plot - He=3m - 0.08m Zo - w/o ADJ_U* - LowWind2 Option - v15181
Obs (unfitted) vs AERMOD (Degraded 1-Layer, Scalar WS) Predicted Arc-Max @ 3 DW Arcs
Predicted (µg/m³)
Observed (µg/m³)
0
50
100
150
200
100-m Arc
200-m Arc
400-m Arc

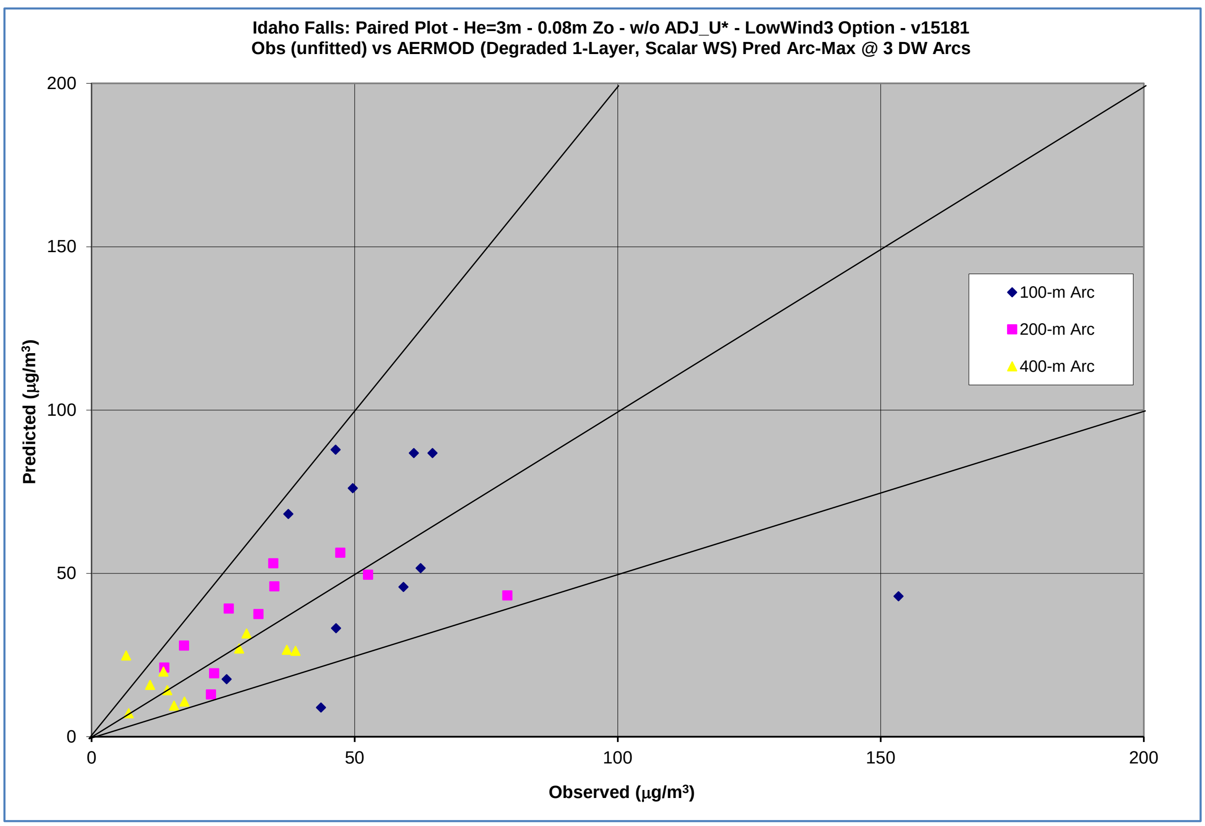


Idaho Falls: Paired Plot - He=3m - 0.08m Zo - w/o ADJ_U* - LowWind2 Option - v15181
Obs (unfitted) vs AERMOD (Degraded 1-Layer, Scalar WS) Pred Arc-Max @ 3 DW Arcs
Predicted (µg/m³)
Observed (µg/m³)
0
50
100
150
200
100-m Arc
200-m Arc
400-m Arc

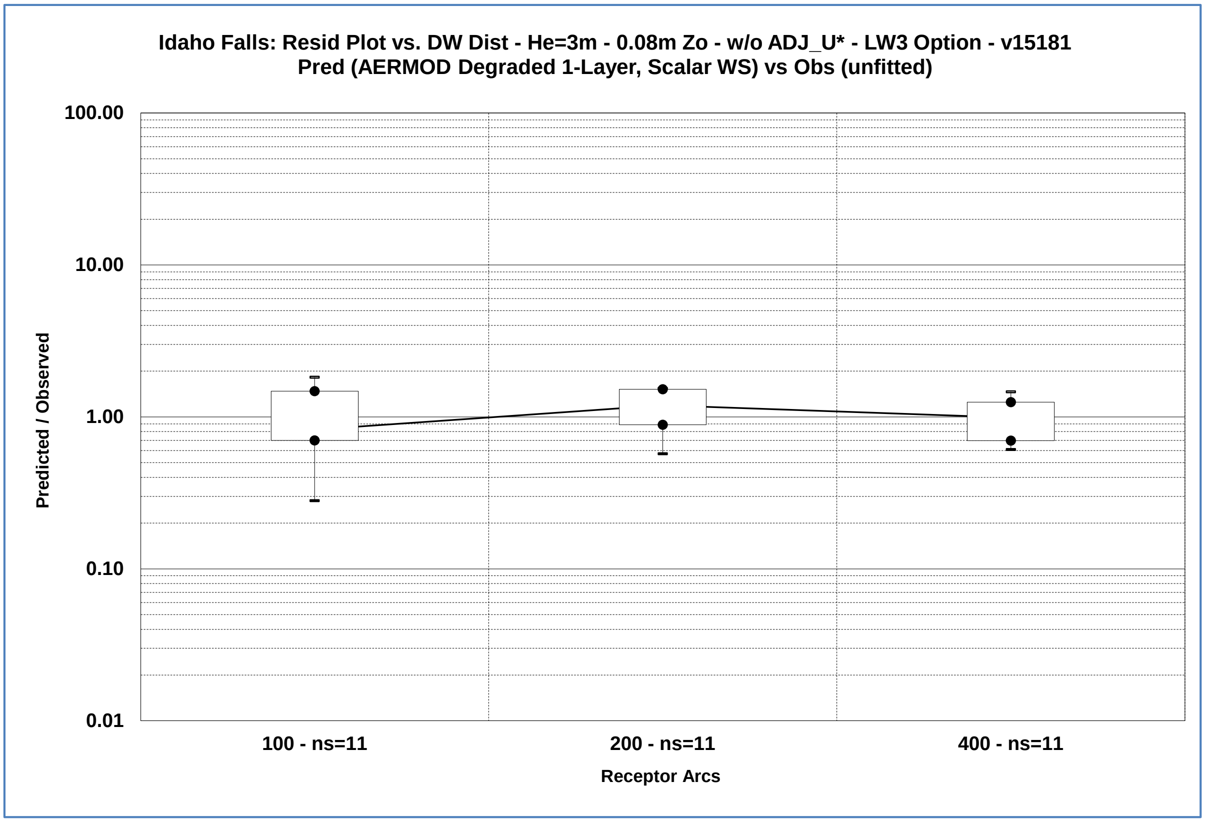

Idaho Falls: Resid Plot vs. DW Dist - He=3m - 0.08m Zo - w/o ADJ_U* - LW2 Option - v15181
Pred (AERMOD Degraded 1-Layer, Scalar WS) vs Obs (unfitted)
100.00
10.00
1.00
0.10
0.01
Predicted / Observed
100 - ns=11
200 - ns=11
400 - ns=11
Receptor Arcs

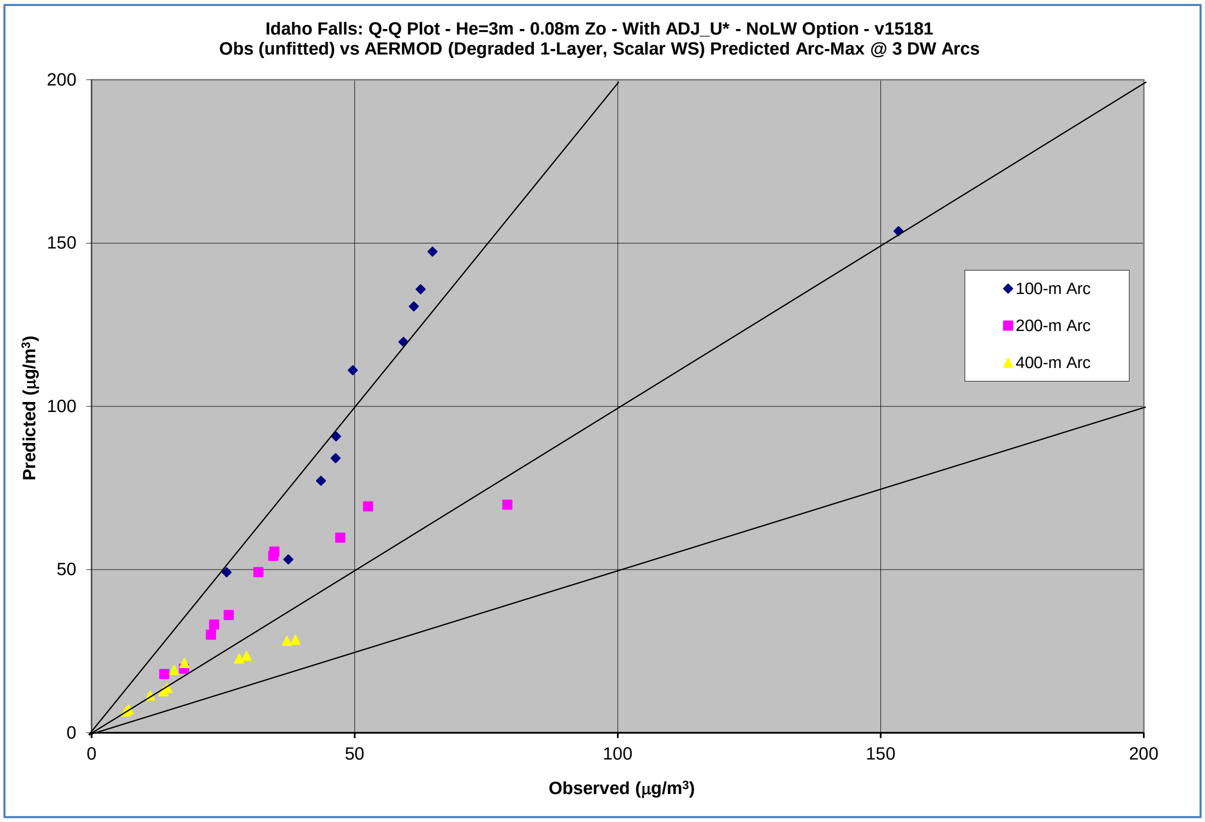


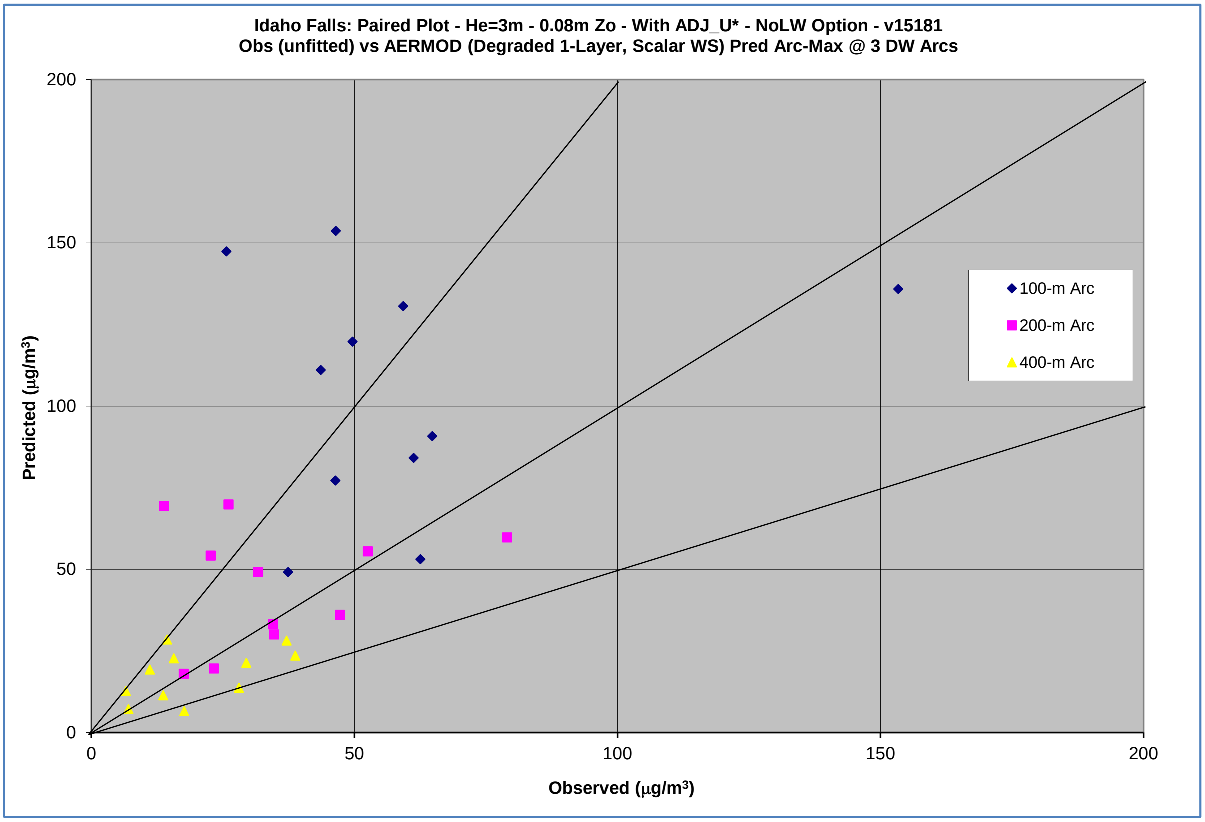
Idaho Falls: Q-Q Plot - He=3m - 0.08m Zo - w/o ADJ_U* - LowWind3 Option - v15181
Obs (unfitted) vs AERMOD (Degraded 1-Layer, Scalar WS) Predicted Arc-Max @ 3 DW Arcs
Predicted (μg/m³)
Observed (μg/m³)
0
50
100
150
200
100-m Arc
200-m Arc
400-m Arc

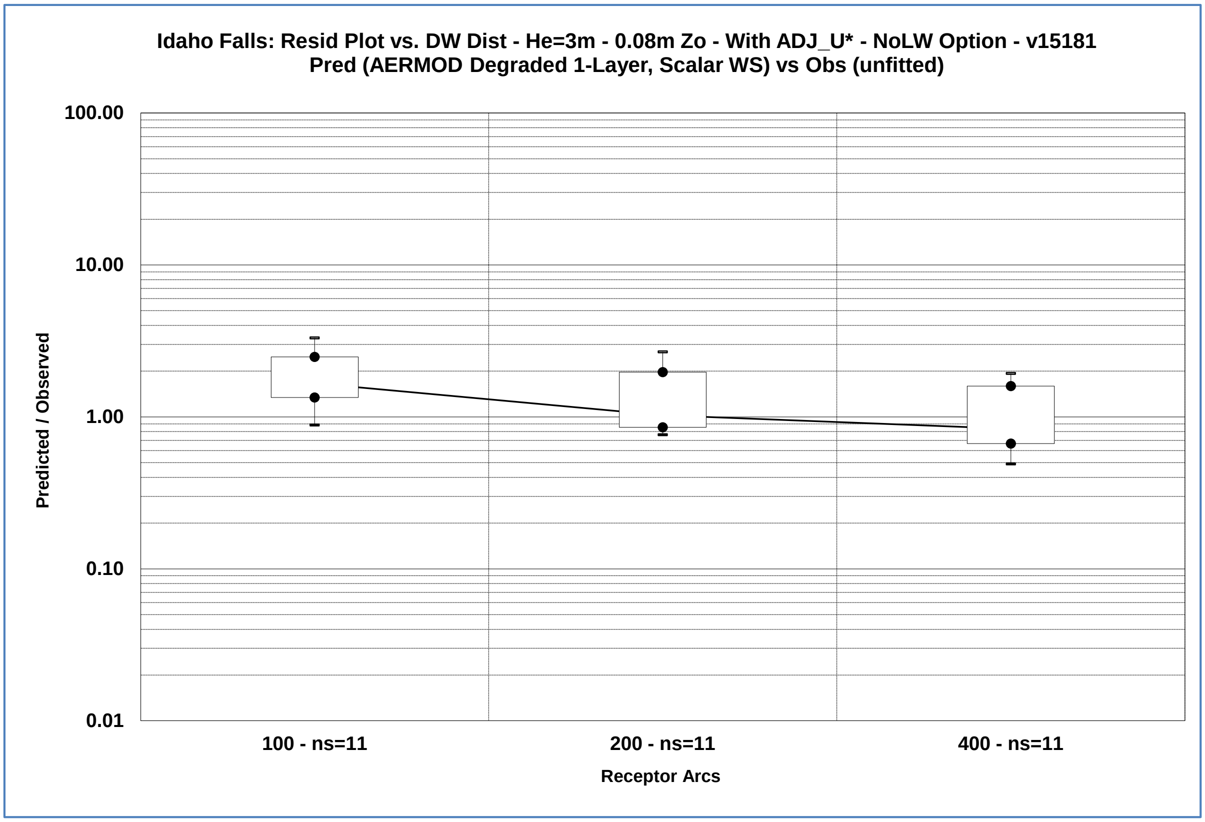


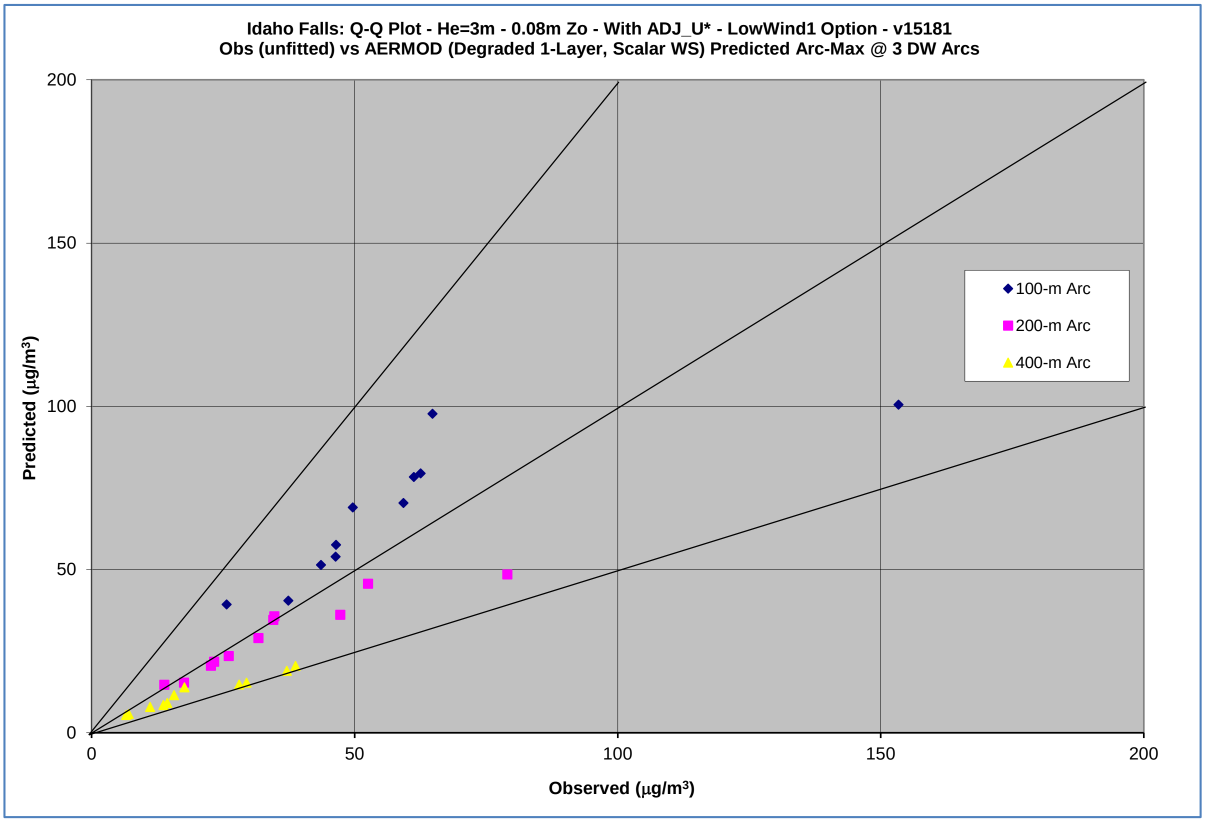
Idaho Falls: Paired Plot - He=3m - 0.08m Zo - w/o ADJ_U* - LowWind3 Option - v15181
Obs (unfitted) vs AERMOD (Degraded 1-Layer, Scalar WS) Pred Arc-Max @ 3 DW Arcs
Predicted (μg/m³)
Observed (μg/m³)
0
50
100
150
200
100-m Arc
200-m Arc
400-m Arc

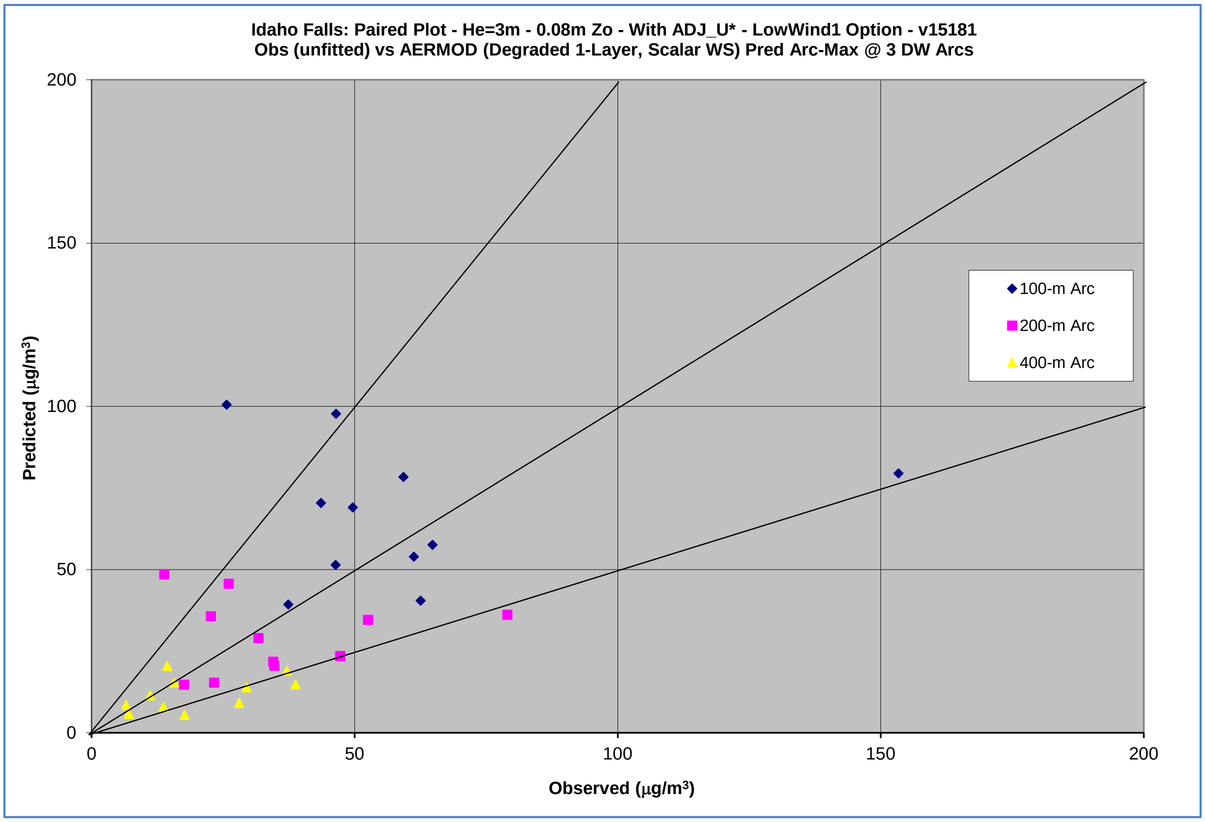

Idaho Falls: Resid Plot vs. DW Dist - He=3m - 0.08m Zo - w/o ADJ_U* - LW3 Option - v15181
Pred (AERMOD Degraded 1-Layer, Scalar WS) vs Obs (unfitted)
100.00
10.00
1.00
0.10
0.01
Predicted / Observed
100 - ns=11
200 - ns=11
400 - ns=11
Receptor Arcs

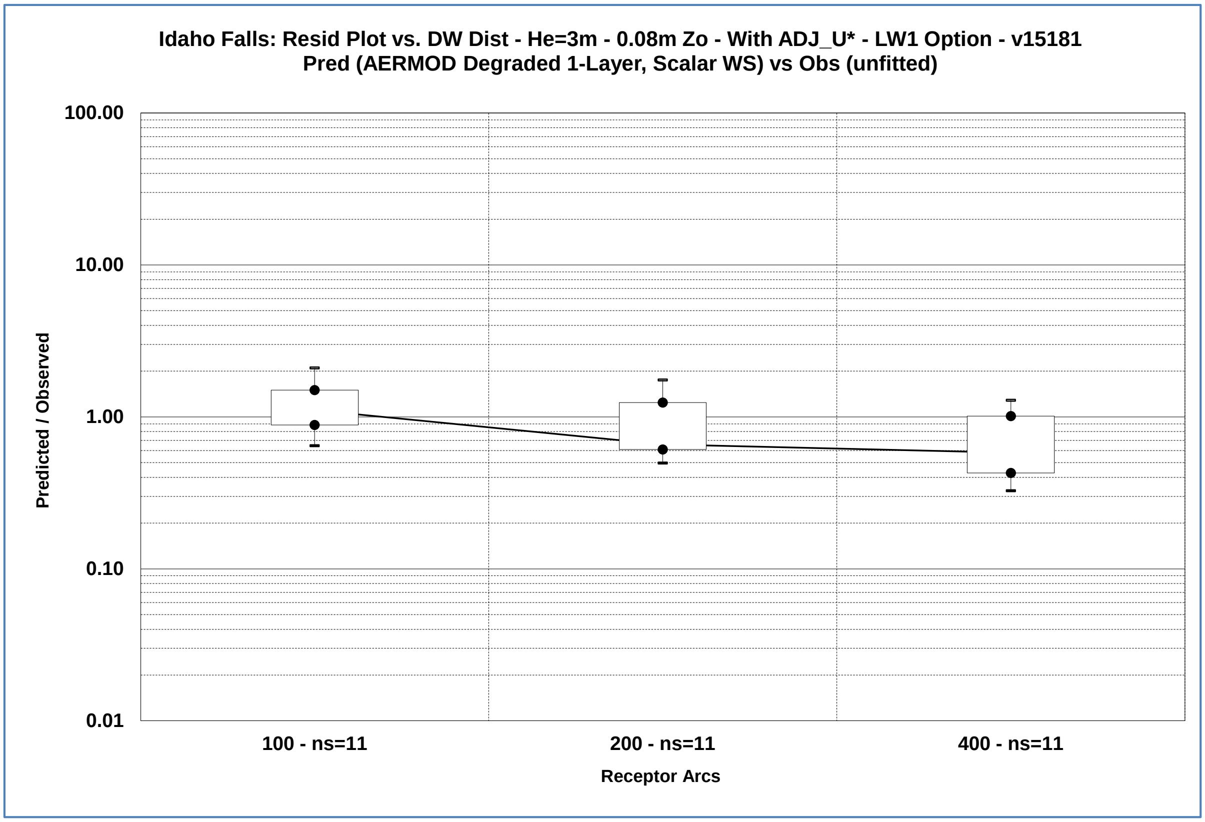

Idaho Falls: Q-Q Plot - He=3m - 0.08m Zo - With ADJ_U* - NoLW Option - v15181
Obs (unfitted) vs AERMOD (Degraded 1-Layer, Scalar WS) Predicted Arc-Max @ 3 DW Arcs
Predicted (µg/m³)
Observed (µg/m³)
0
50
100
150
200
100-m Arc
200-m Arc
400-m Arc

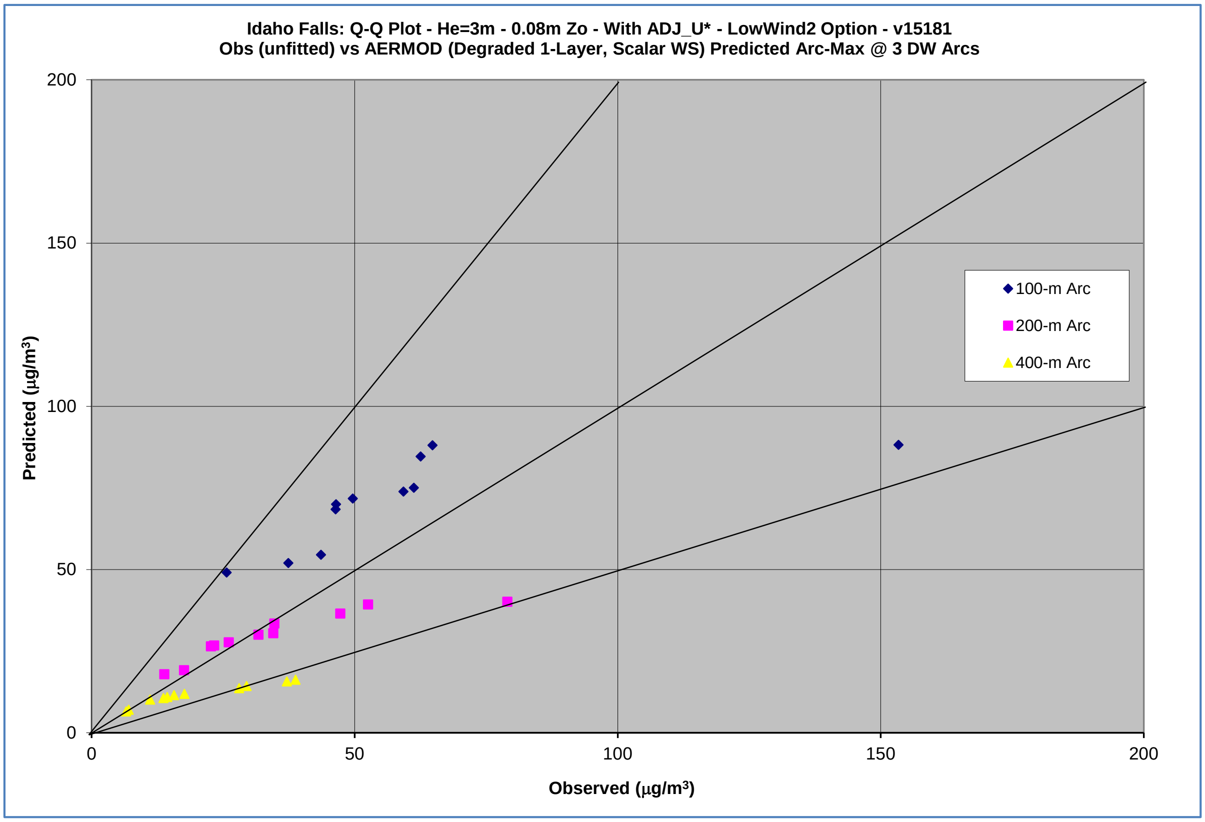

Idaho Falls: Paired Plot - He=3m - 0.08m Zo - With ADJ_U* - NoLW Option - v15181
Obs (unfitted) vs AERMOD (Degraded 1-Layer, Scalar WS) Pred Arc-Max @ 3 DW Arcs
Predicted (µg/m³)
Observed (µg/m³)
0
50
100
150
200
100-m Arc
200-m Arc
400-m Arc

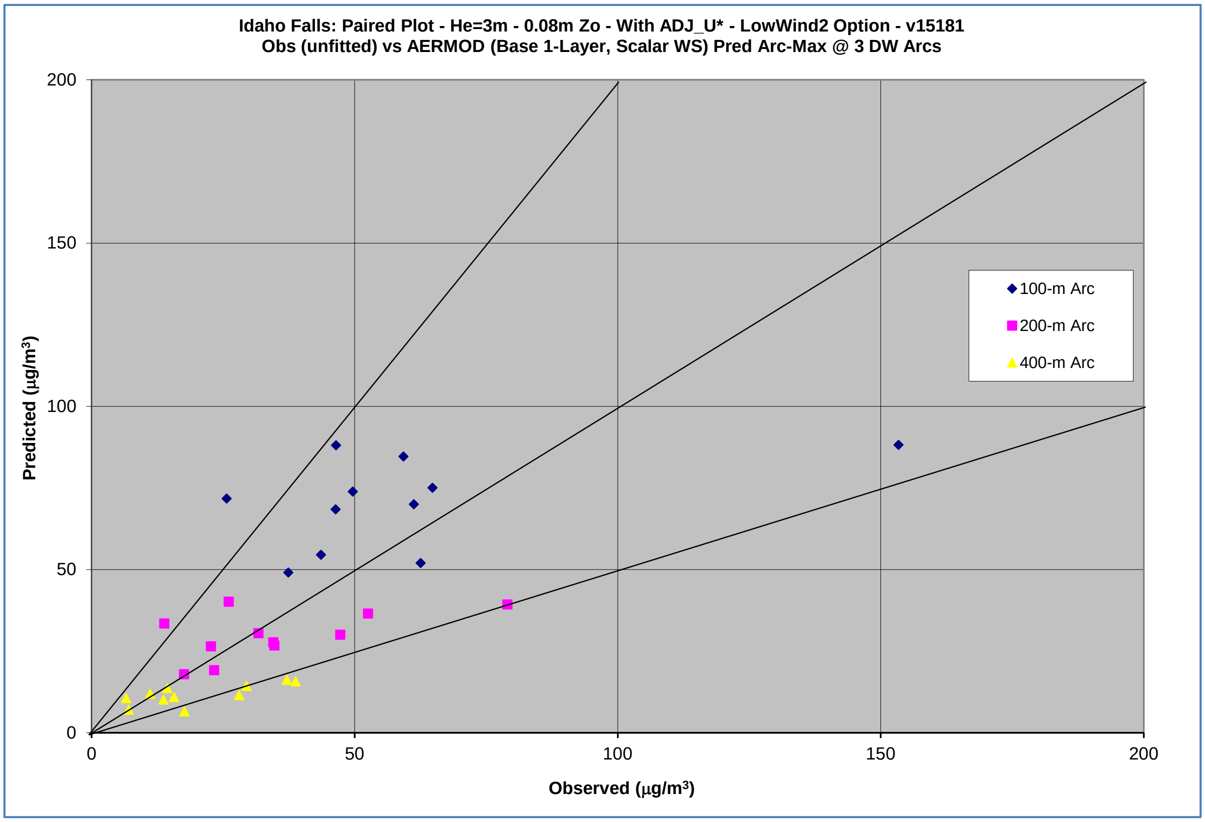

Idaho Falls: Resid Plot vs. DW Dist - He=3m - 0.08m Zo - With ADJ_U* - NoLW Option - v15181
Pred (AERMOD Degraded 1-Layer, Scalar WS) vs Obs (unfitted)
100.00
10.00
1.00
0.10
0.01
Predicted / Observed
100 - ns=11
200 - ns=11
400 - ns=11
Receptor Arcs

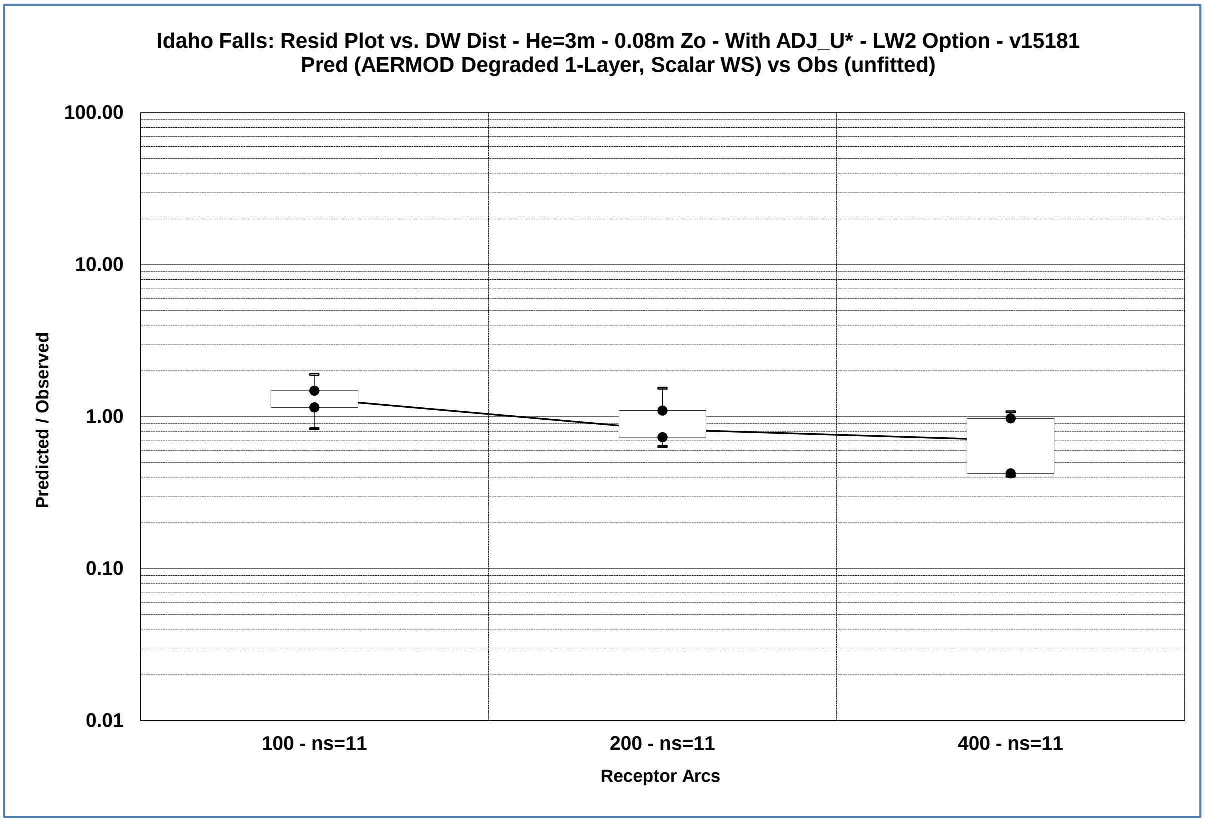

Idaho Falls: Q-Q Plot - He=3m - 0.08m Zo - With ADJ_U* - LowWind1 Option - v15181
Obs (unfitted) vs AERMOD (Degraded 1-Layer, Scalar WS) Predicted Arc-Max @ 3 DW Arcs
Predicted (µg/m3)
Observed (µg/m3)
100-m Arc
200-m Arc
400-m Arc
0
50
100
150
200


Idaho Falls: Paired Plot - He=3m - 0.08m Zo - With ADJ_U* - LowWind1 Option - v15181
Obs (unfitted) vs AERMOD (Degraded 1-Layer, Scalar WS) Pred Arc-Max @ 3 DW Arcs
Predicted (µg/m3)
Observed (µg/m3)
100-m Arc
200-m Arc
400-m Arc
0
50
100
150
200

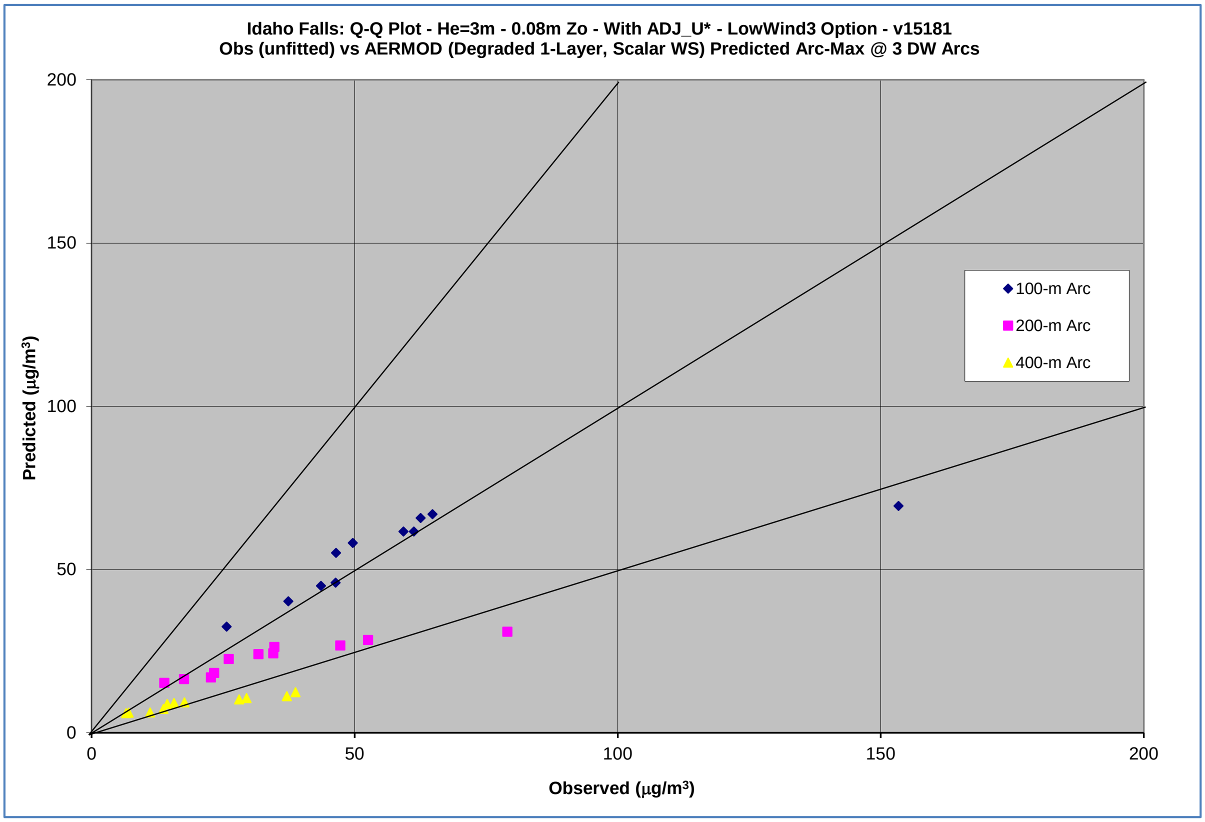

Idaho Falls: Resid Plot vs. DW Dist - He=3m - 0.08m Zo - With ADJ_U* - LW1 Option - v15181
Pred (AERMOD Degraded 1-Layer, Scalar WS) vs Obs (unfitted)
100.00
10.00
1.00
0.10
0.01
Predicted / Observed
100 - ns=11
200 - ns=11
400 - ns=11
Receptor Arcs

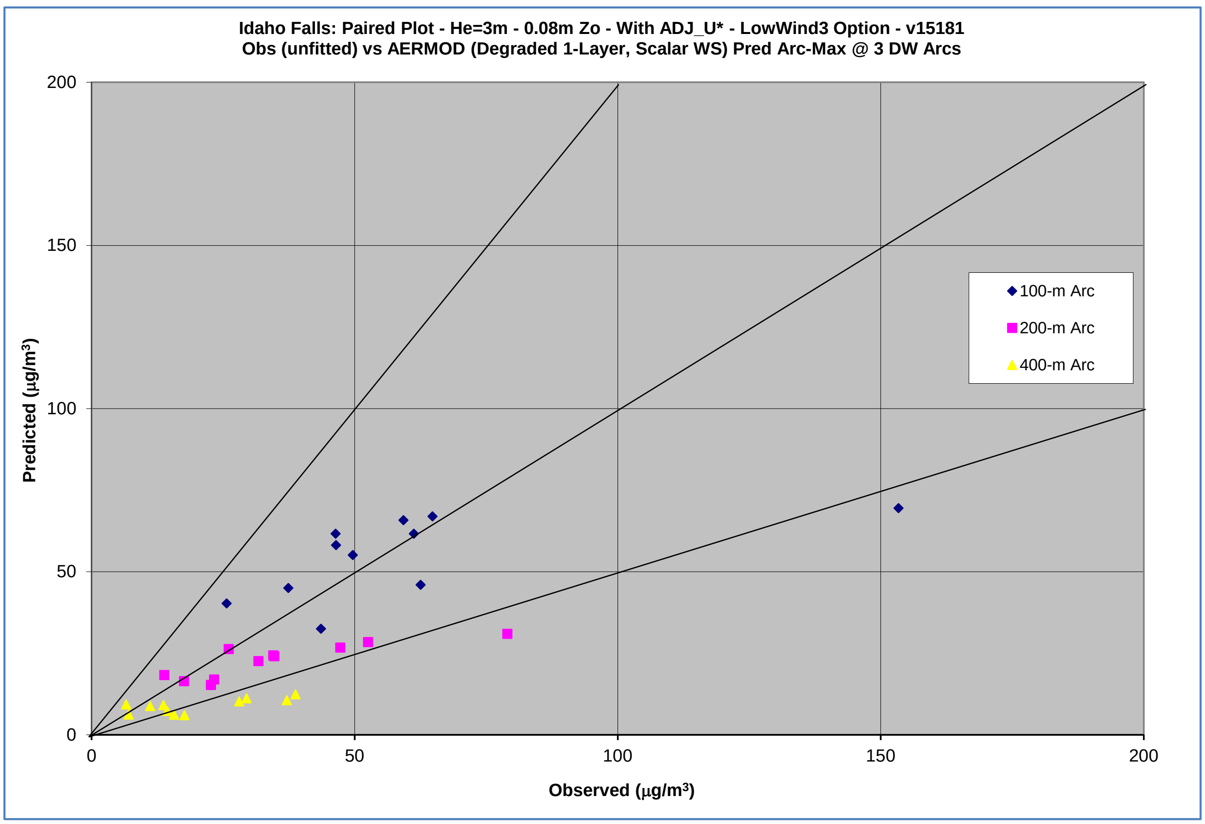

Idaho Falls: Q-Q Plot - He=3m - 0.08m Zo - With ADJ_U* - LowWind2 Option - v15181
Obs (unfitted) vs AERMOD (Degraded 1-Layer, Scalar WS) Predicted Arc-Max @ 3 DW Arcs
Predicted (µg/m³)
Observed (µg/m³)
100-m Arc
200-m Arc
400-m Arc
0
50
100
150
200

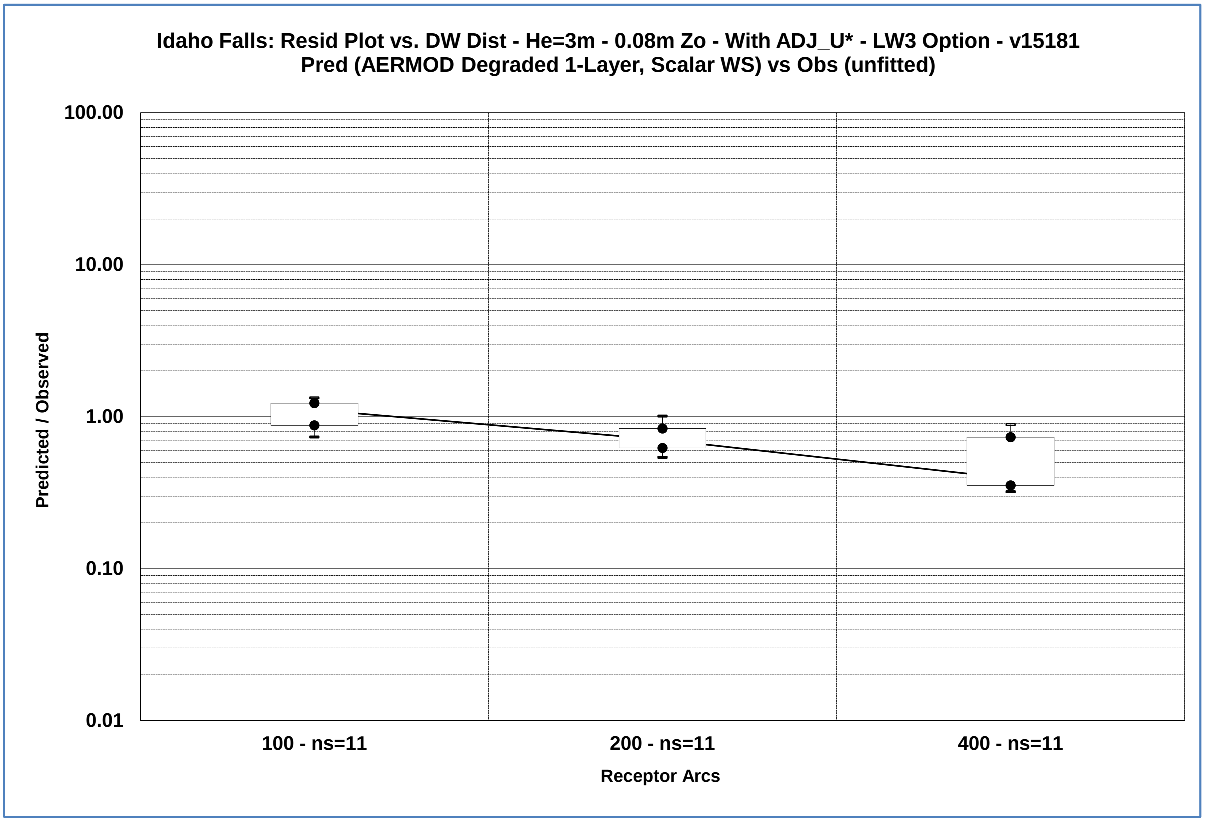

Idaho Falls: Paired Plot - He=3m - 0.08m Zo - With ADJ_U* - LowWind2 Option - v15181
Obs (unfitted) vs AERMOD (Base 1-Layer, Scalar WS) Pred Arc-Max @ 3 DW Arcs
Predicted (µg/m³)
Observed (µg/m³)
100-m Arc
200-m Arc
400-m Arc
0
50
100
150
200



Idaho Falls: Resid Plot vs. DW Dist - He=3m - 0.08m Zo - With ADJ_U* - LW2 Option - v15181
Pred (AERMOD Degraded 1-Layer, Scalar WS) vs Obs (unfitted)
100.00
10.00
1.00
0.10
0.01
Predicted / Observed
100 - ns=11
200 - ns=11
400 - ns=11
Receptor Arcs


Idaho Falls: Q-Q Plot - He=3m - 0.08m Zo - With ADJ_U* - LowWind3 Option - v15181
Obs (unfitted) vs AERMOD (Degraded 1-Layer, Scalar WS) Predicted Arc-Max @ 3 DW Arcs
Predicted (µg/m³)
Observed (µg/m³)
100-m Arc
200-m Arc
400-m Arc
0
50
100
150
200


Idaho Falls: Paired Plot - He=3m - 0.08m Zo - With ADJ_U* - LowWind3 Option - v15181
Obs (unfitted) vs AERMOD (Degraded 1-Layer, Scalar WS) Pred Arc-Max @ 3 DW Arcs
Predicted (µg/m³)
Observed (µg/m³)
100-m Arc
200-m Arc
400-m Arc
0
50
100
150
200



Idaho Falls: Resid Plot vs. DW Dist - He=3m - 0.08m Zo - With ADJ_U* - LW3 Option - v15181
Pred (AERMOD Degraded 1-Layer, Scalar WS) vs Obs (unfitted)
100.00
10.00
1.00
0.10
0.01
Predicted / Observed
100 - ns=11
200 - ns=11
400 - ns=11
Receptor Arcs

The Lovett data base includes a single 145m stack located within a few kilometers of complex terrain. The site area is shown below:

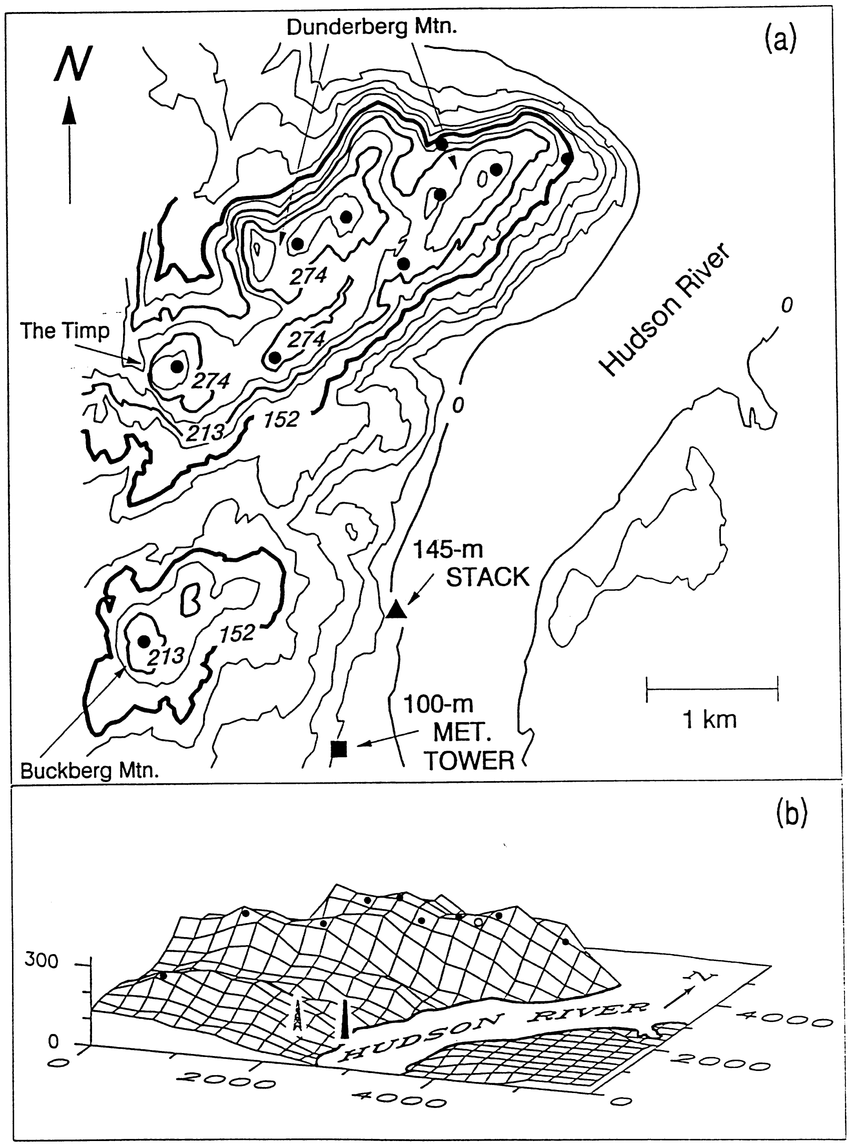
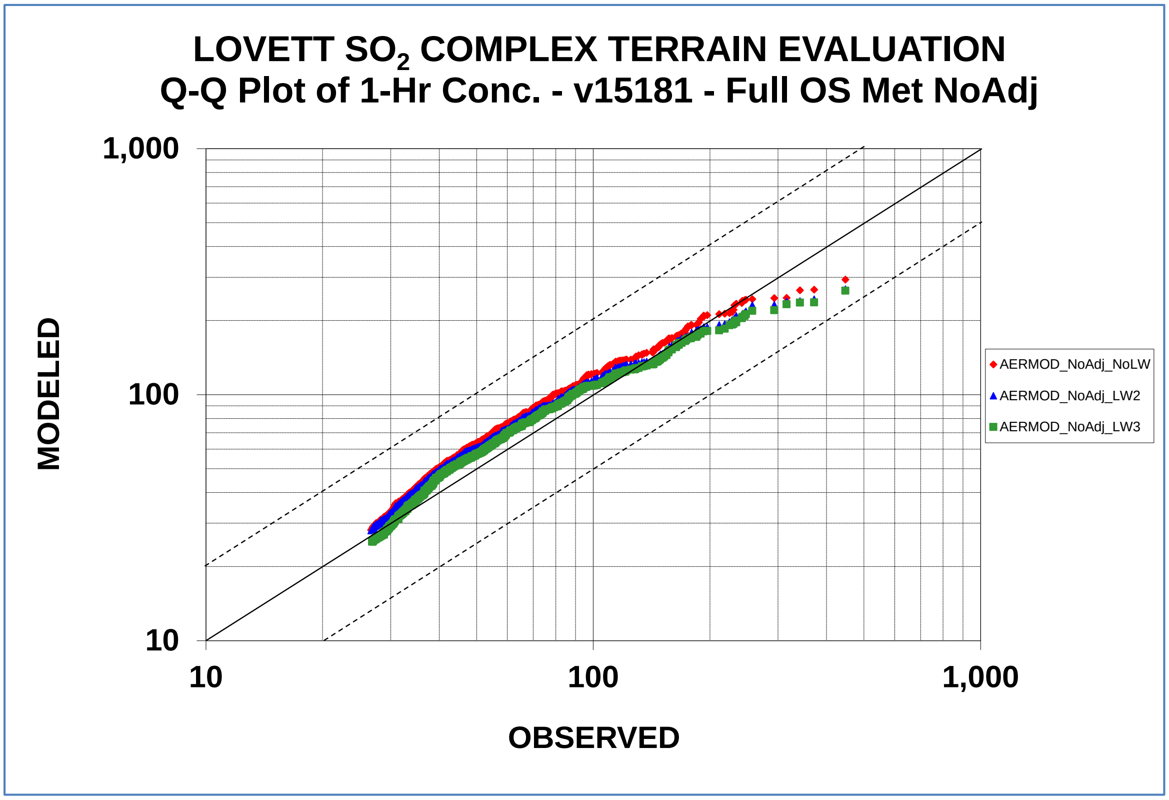
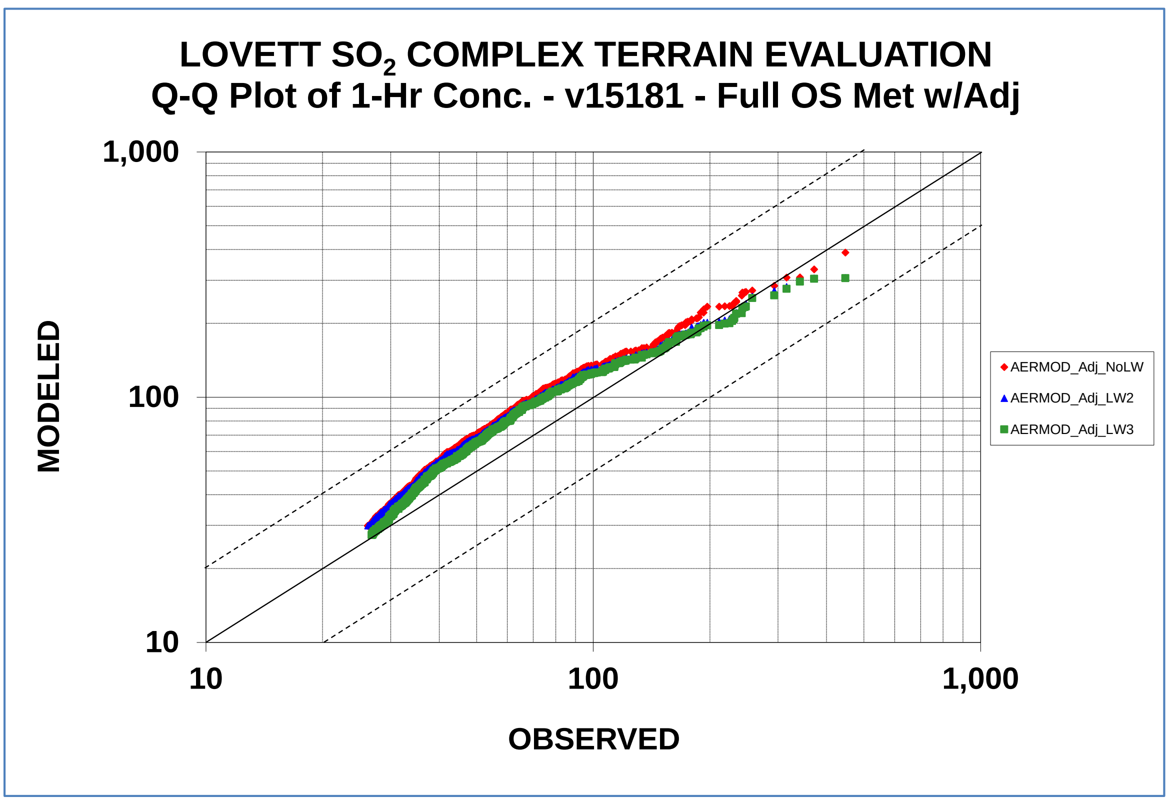


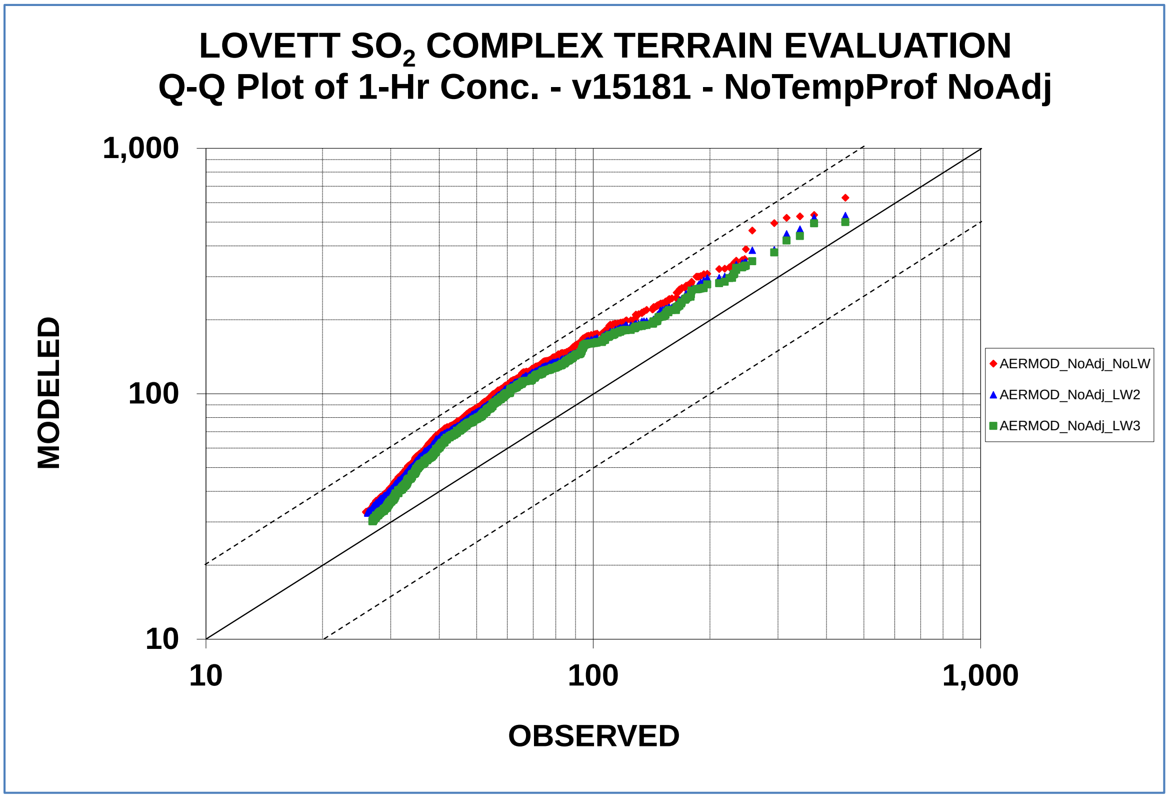
Figure 7 **Depiction of the Monitoring Network Used for the Lovett Complex Terrain Model Evaluation Study**

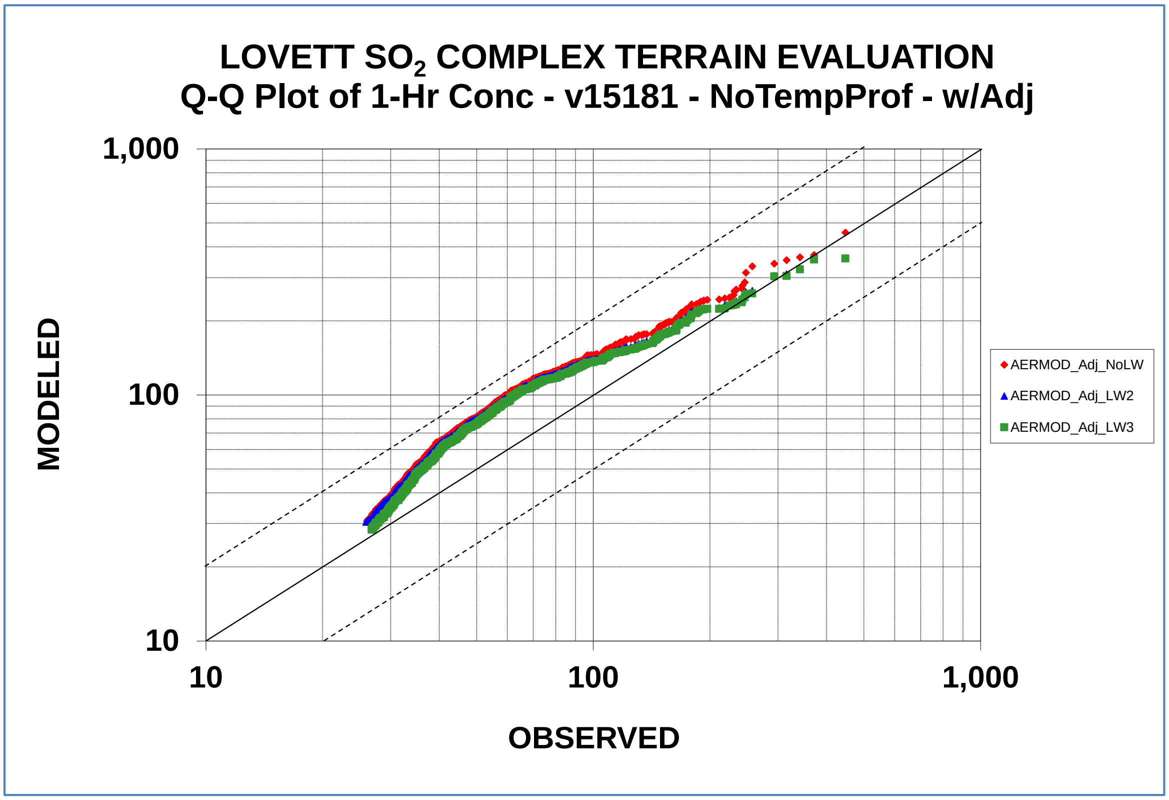
The Lovett data base includes a 100m meteorological tower with wind speed, wind direction, sigma-theta and temperature collected at the 10m, 50m, and 100m levels. In addition, sigma-w was also collected at the 10m and 100m levels. Past evaluations of AERMOD have shown good performance. Updated 1-hour results are presented below comparing model performance with full onsite meteorological data with and without the ADJ_U* and LowWind options, followed by comparisons with and without the ADJ_U* and LowWind options using degraded meteorological data inputs. Including the ADJ_U* option with full onsite meteorological data shows a slight improvement in model performance without the LowWind options, and little difference in performance for the LowWind2 compared to LowWind3 (the LowWind1 option was not included in this study.

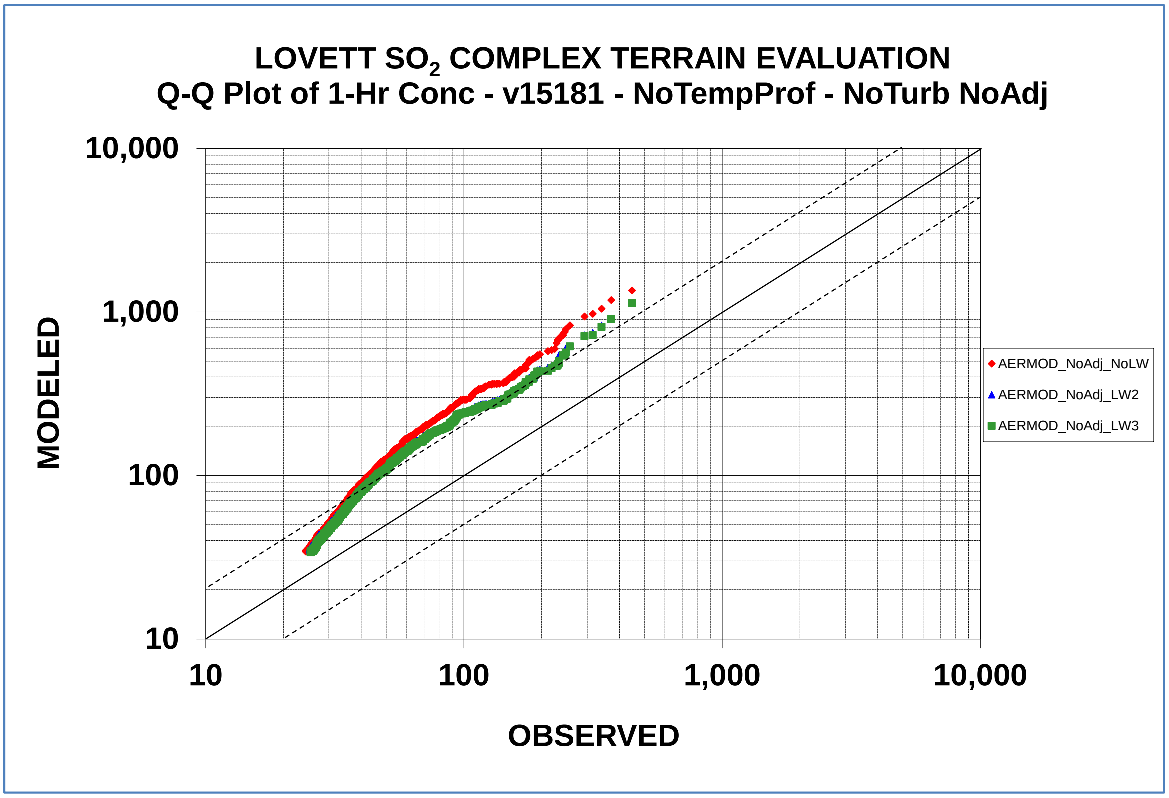
The next set of comparisons are based on no temperature profile in the Lovett site-specific meteorological data. The model shows some overprediction without the temperature profile and without the ADJ_U* option, especially without the LowWind options. The model overprediction without the temperature profile is noticeably reduced when the ADJ_U* option is used. The modeled results shows more significant overprediction when the meteorological data is further degraded by eliminating the turbulence data (i.e., sigma-theta and sigma-w), with the overprediction bias exceeding a factor of 2. The overprediction without the temperature profile and turbulence data is significantly reduced when the ADJ_U* and LowWind options are used. It’s also worth noting that results for the LowWind2 (LW2) and LowWind3 (LW3) options are nearly indistinguishable in this case.

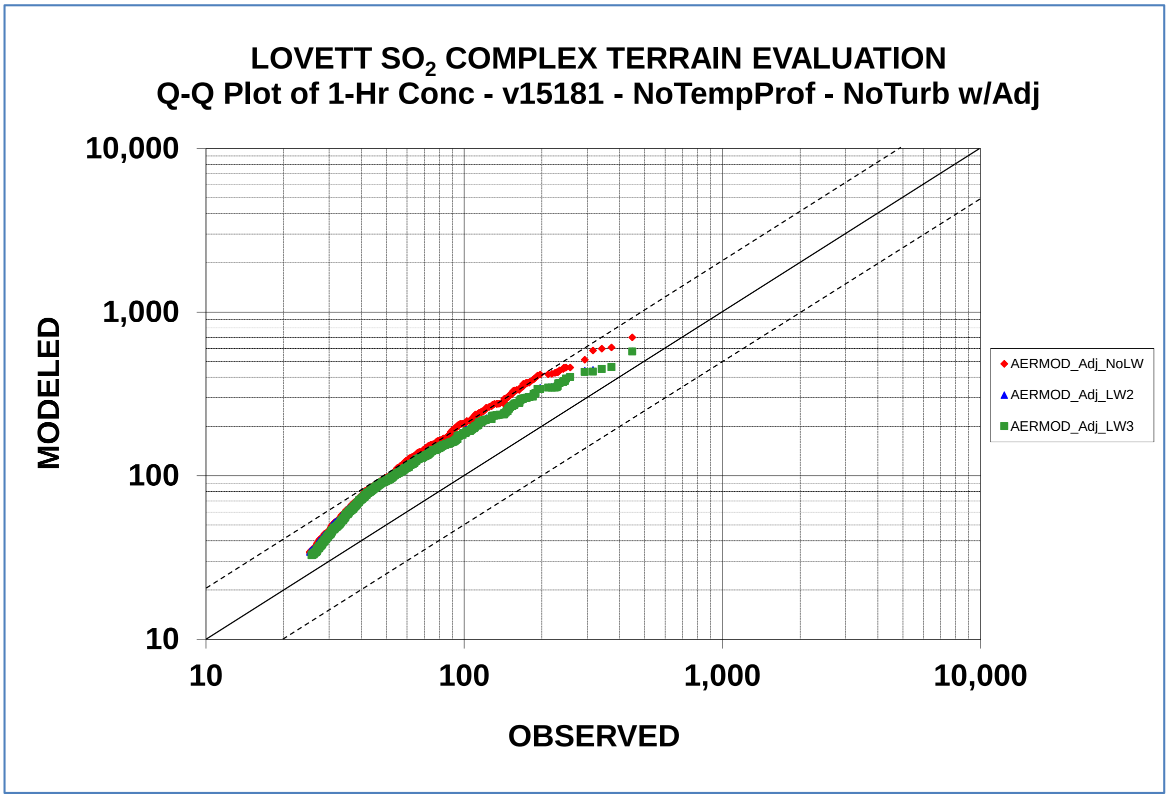

LOVETT SO2 COMPLEX TERRAIN EVALUATION
Q-Q Plot of 1-Hr Conc. - v15181 - Full OS Met NoAdj
MODELED
OBSERVED
1,000
100
10
10
100
1,000
AERMOD_NoAdj_NoLW
AERMOD_NoAdj_LW2
AERMOD_NoAdj_LW3


LOVETT SO2 COMPLEX TERRAIN EVALUATION
Q-Q Plot of 1-Hr Conc. - v15181 - Full OS Met w/Adj
MODELED
OBSERVED
1,000
100
10
10
100
1,000
AERMOD_Adj_NoLW
AERMOD_Adj_LW2
AERMOD_Adj_LW3


LOVETT SO_2 COMPLEX TERRAIN EVALUATION
Q-Q Plot of 1-Hr Conc. - v15181 - NoTempProf NoAdj
1,000
100
10
10
100
1,000
MODELED
OBSERVED
AERMOD_NoAdj_NoLW
AERMOD_NoAdj_LW2
AERMOD_NoAdj_LW3


LOVETT SO_2 COMPLEX TERRAIN EVALUATION
Q-Q Plot of 1-Hr Conc - v15181 - NoTempProf - w/Adj
1,000
100
10
10
100
1,000
MODELED
OBSERVED
AERMOD_Adj_NoLW
AERMOD_Adj_LW2
AERMOD_Adj_LW3


LOVETT SO_2 COMPLEX TERRAIN EVALUATION
Q-Q Plot of 1-Hr Conc - v15181 - NoTempProf - NoTurb NoAdj
MODELED
10,000
1,000
100
10
10
100
1,000
10,000
OBSERVED
AERMOD_NoAdj_NoLW
AERMOD_NoAdj_LW2
AERMOD_NoAdj_LW3


LOVETT SO_2 COMPLEX TERRAIN EVALUATION
Q-Q Plot of 1-Hr Conc - v15181 - NoTempProf - NoTurb w/Adj
MODELED
10,000
1,000
100
10
10
100
1,000
10,000
OBSERVED
AERMOD_Adj_NoLW
AERMOD_Adj_LW2
AERMOD_Adj_LW3

Proposed Updates to AERMOD Modeling System

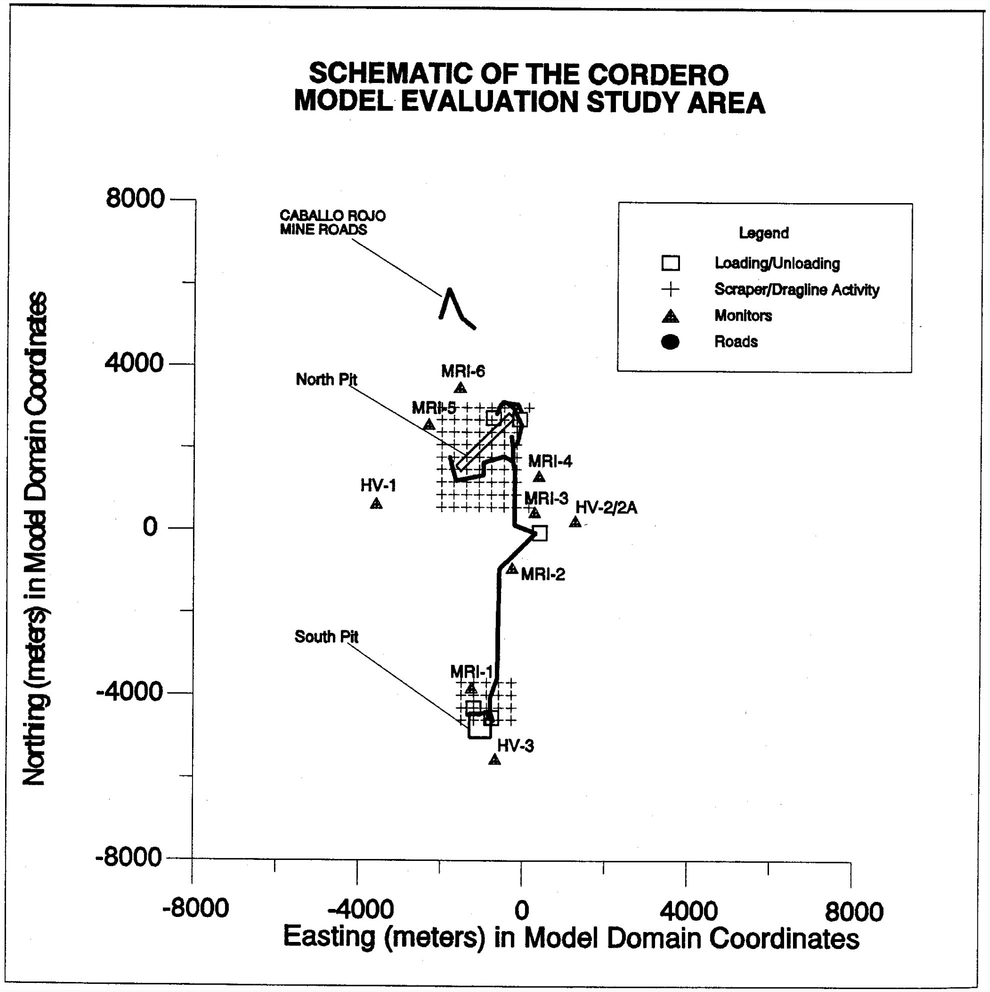
Roger W. Brode
U.S. EPA/OAQPS/AQAD/AQMG

11th Modeling Conference
Research Triangle Park, NC
August 12, 2015

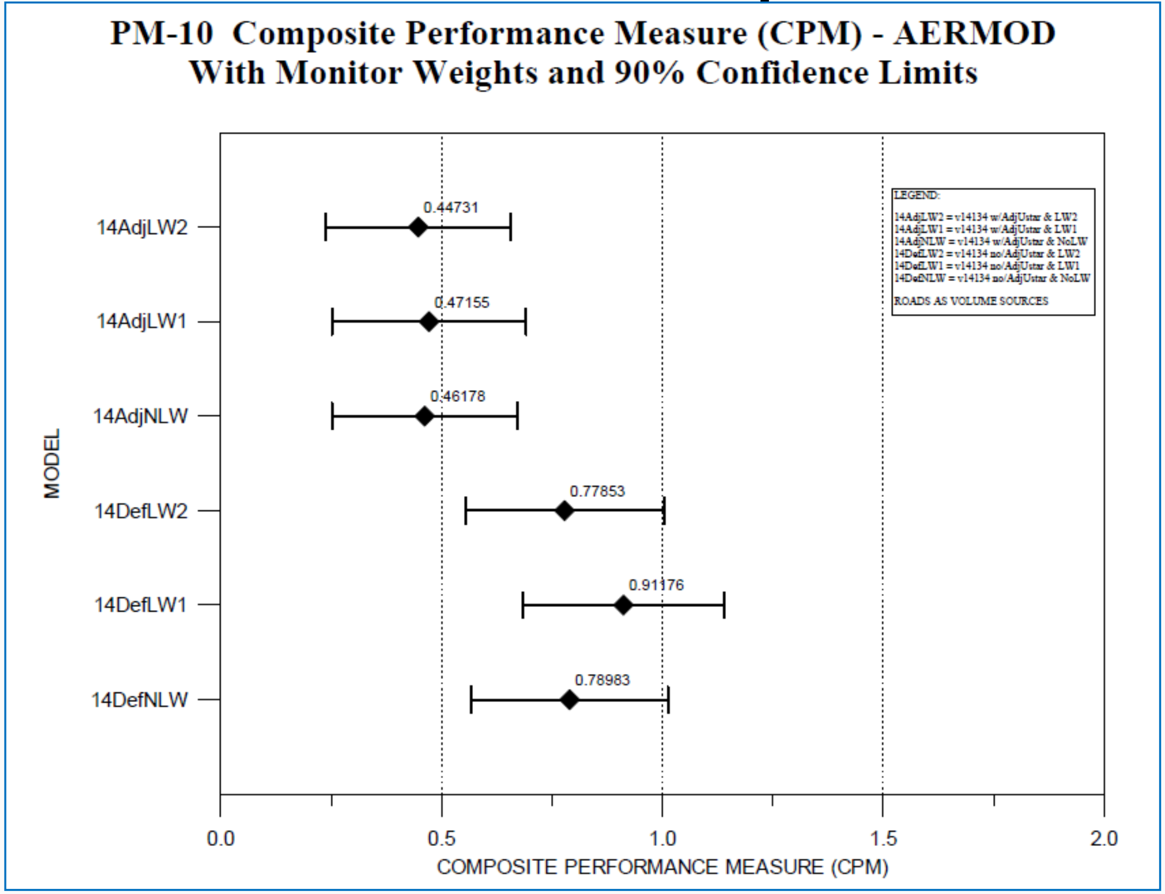
Evaluation of Beta Options

- 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

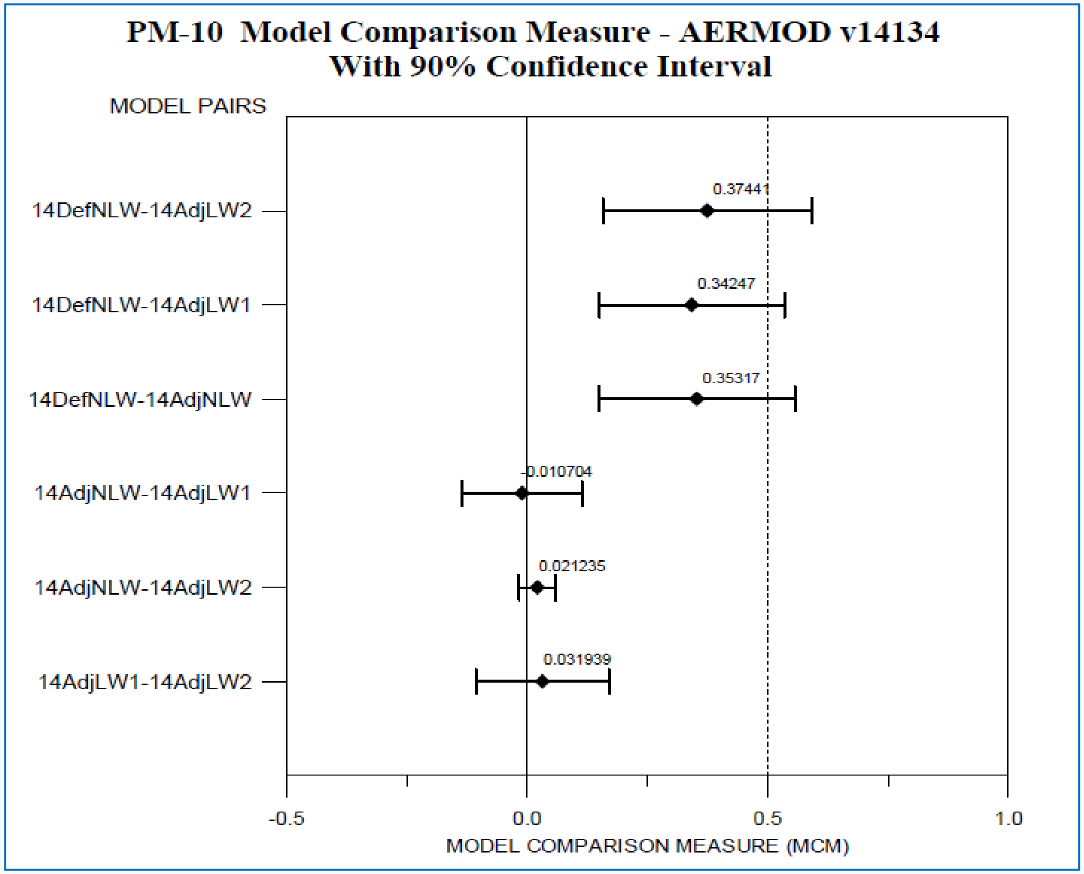


Evaluation of Beta Options – CPM



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.