Implementation and Evaluation of PRIME in AERMOD – Panel Presentation

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Introduction

- AERMOD proposed for Guideline at 7th Modeling Conference in June 2000
- ISC-PRIME also proposed for cases where downwash is important
- PRIME incorporated into AERMOD in response to public comments
- Developmental and final evaluation of PRIME completed

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Purpose of Presentation

- Describe implementation of PRIME in AERMOD
- Present results of evaluation of AERMOD with PRIME

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Guiding Principle

- To keep PRIME algorithms as intact as possible, while maintaining improved AERMOD meteorology

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Implementation Issues

- PRIME includes gridded meteorology profiles that differ from AERMOD
- PRIME includes ambient turbulence intensities based on PG stability class
- PRIME uses Gaussian vertical distribution for unstable conditions; AERMOD includes non-Gaussian PDF
- Application of PRIME to AERMOD's three –plume approach in CBL

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Implementation Decisions

- Incorporate AERMOD meteorology profiles into PRIME
- Define ambient turbulence intensities for PRIME based on AERMOD turbulence and wind profiles
- Use PRIME estimates within wake region and transition to AERMOD estimates beyond wake region

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Implementation Decisions (cont.)

- Lateral and vertical extent of wake region are defined internally by PRIME algorithm based on building geometry
- Longitudinal extent of wake (for purposes of PRIME to AERMOD transition) defined as larger of 15R and distance where transition from wake to ambient turbulence occurs

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Implementation Decisions (cont.)

- PRIME estimate is Gaussian for all conditions
- AERMOD estimate includes three plume approach with non-Gaussian PDF for CBL, and does not include downwash
- Use exponential transition function (( ) to weight PRIME and AERMOD components

Implementation Decisions (cont.)

- Criterion for whether plume “escapes” wake was modified based on results of developmental evaluation
  - PRIME uses 45 degrees for critical plume trajectory angle at top of wake (N) to determine if wake affects plume
  - AERMOD uses 20 degrees for N based on developmental evaluation results

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Weighting Function (( )

CHI_{TOTAL} = (CHI_{PRIME} + (1- ( ) CHI_{AERMOD}

(= 1 inside wake region; beyond wake

$$\gamma = \exp\left(\frac{-(x-\sigma_{xg})^2}{2\sigma_{xg}^2} \right) \exp\left(\frac{-(y-\sigma_{yg})^2}{2\sigma_{yg}^2} \right) \exp\left(\frac{-(z-\sigma_{zg})^2}{2\sigma_{zg}^2} \right)$$

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Weighting Function (cont.)

where

x = downwind distance of receptor from upwind edge of the building;

y = lateral distance of receptor from building centerline;

z = receptor height above stack base, including terrain and flagpole;

F_{xg} = max(15R, distance to transition from wake to ambient turbulence);

F_{yg} = lateral distance from building centerline to lateral edge of the wake at receptor location; and

F_{zg} = height of the wake at the receptor location

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Developmental Data Bases

- Bowline Point Power Station database, Hudson River valley (half year of data)
- Millstone Nuclear Power Station tracer database, coastal Connecticut
- Duane Arnold Energy Center (DAEC) tracer database, rural Iowa
- Alaska North Slope tracer database, near Prudhoe Bay, Alaska

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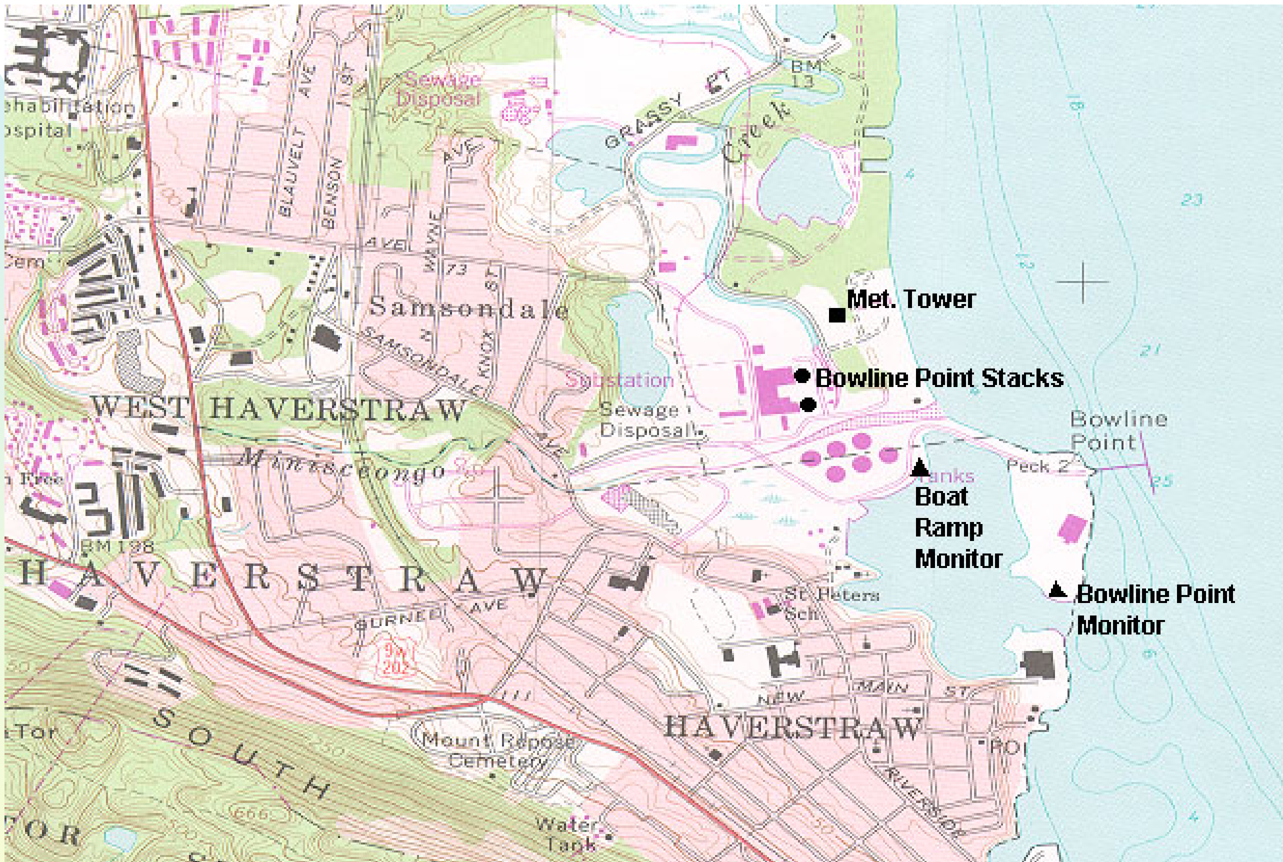
Bowline Point Study Area



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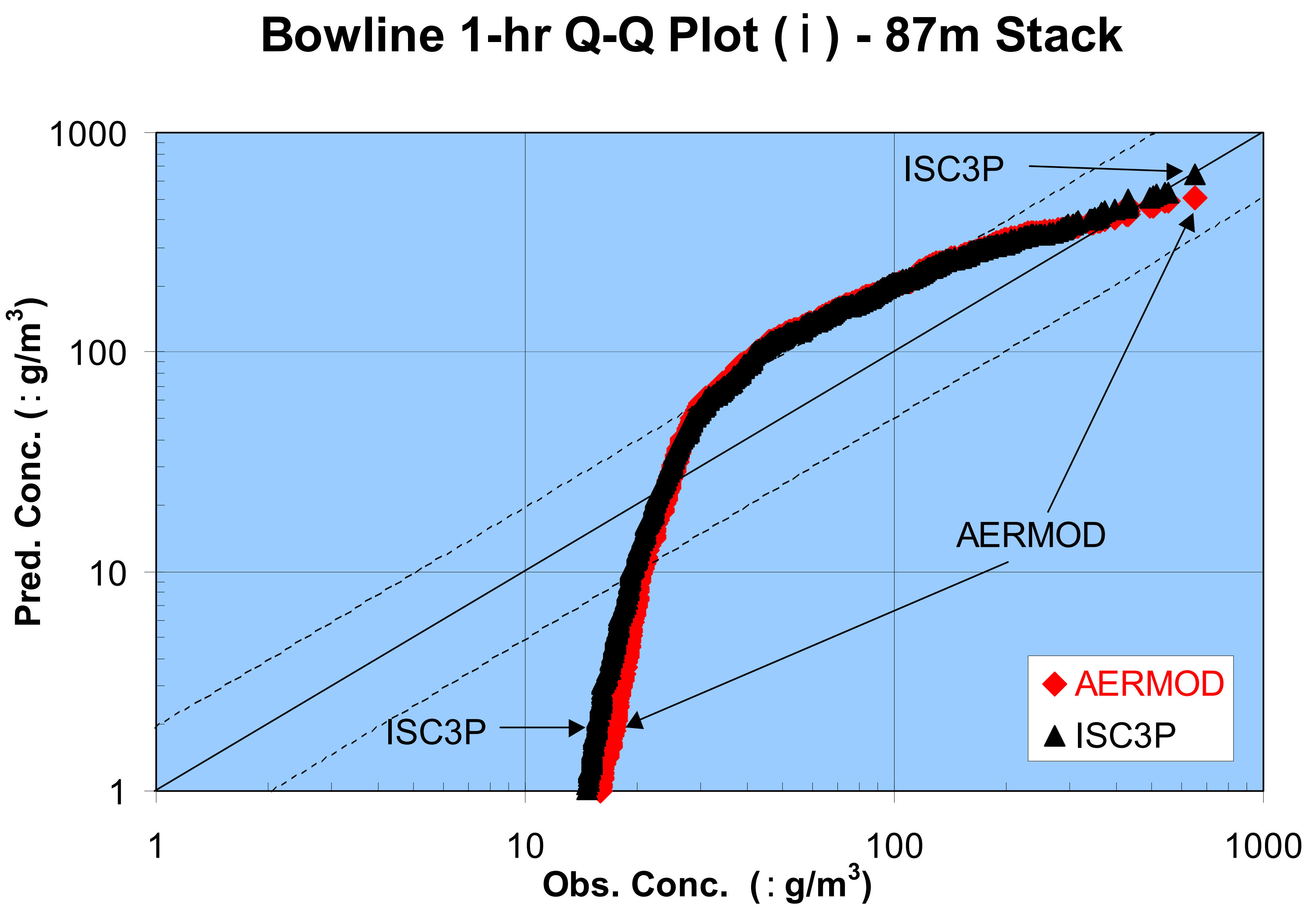
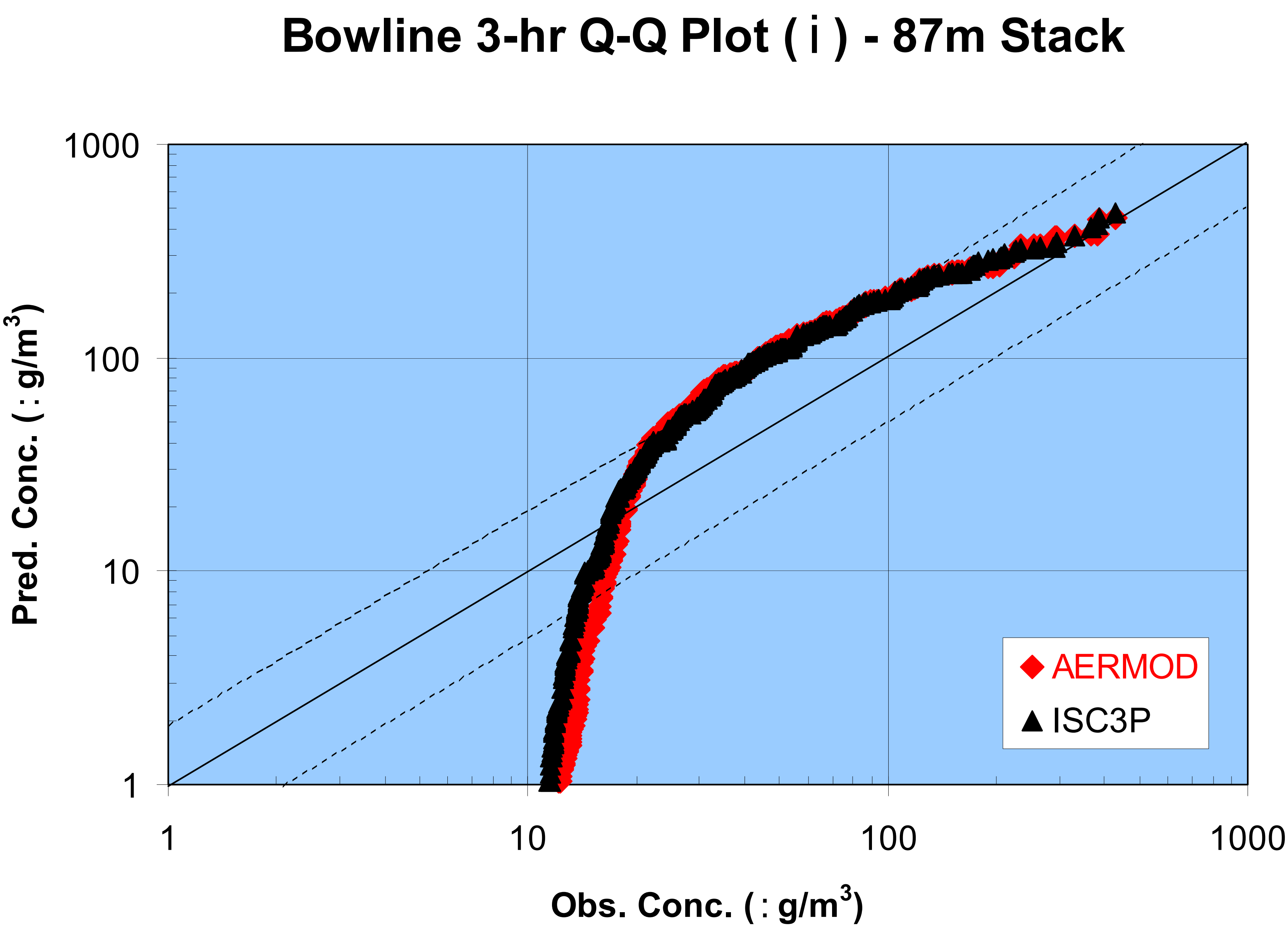
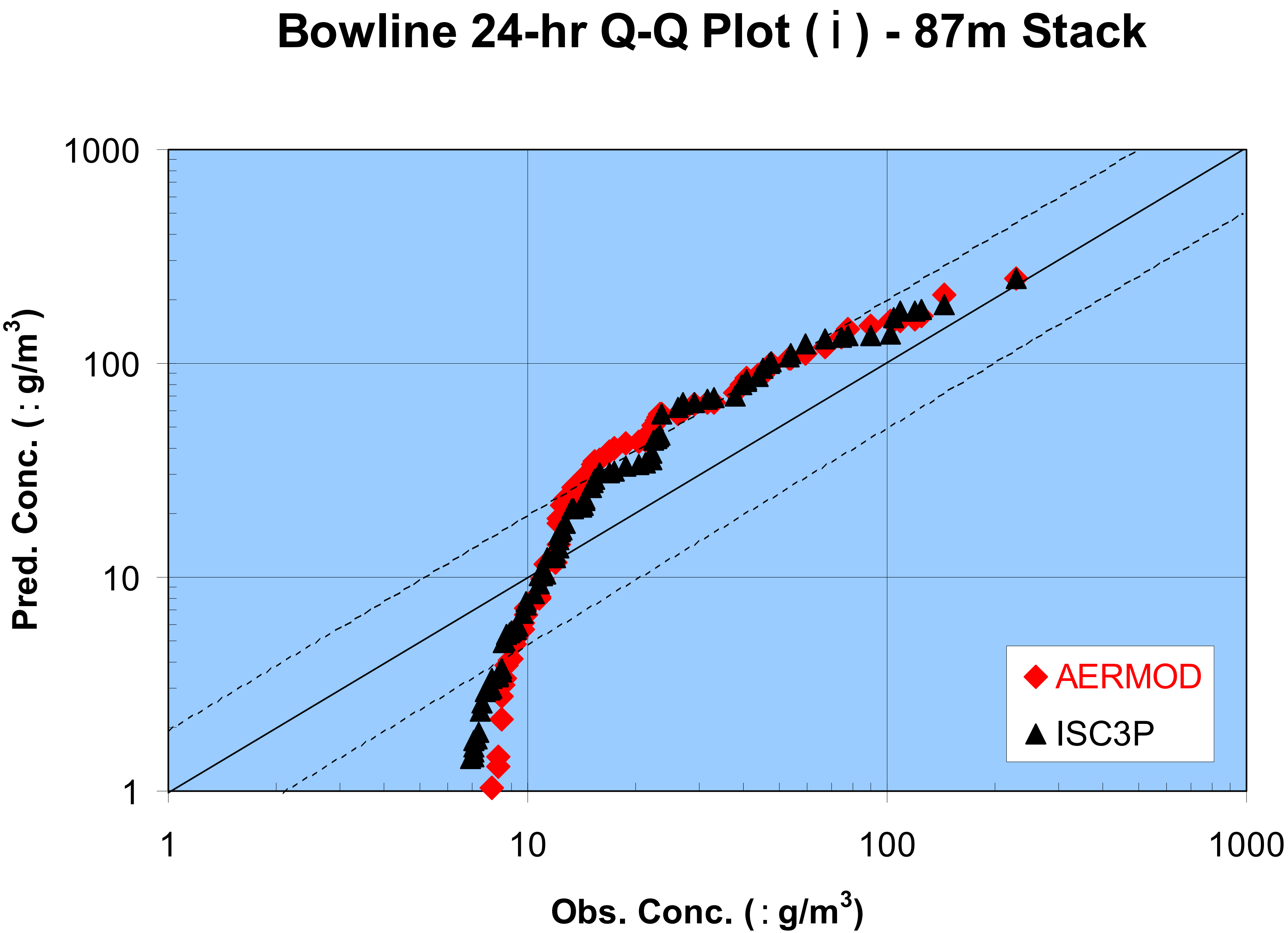


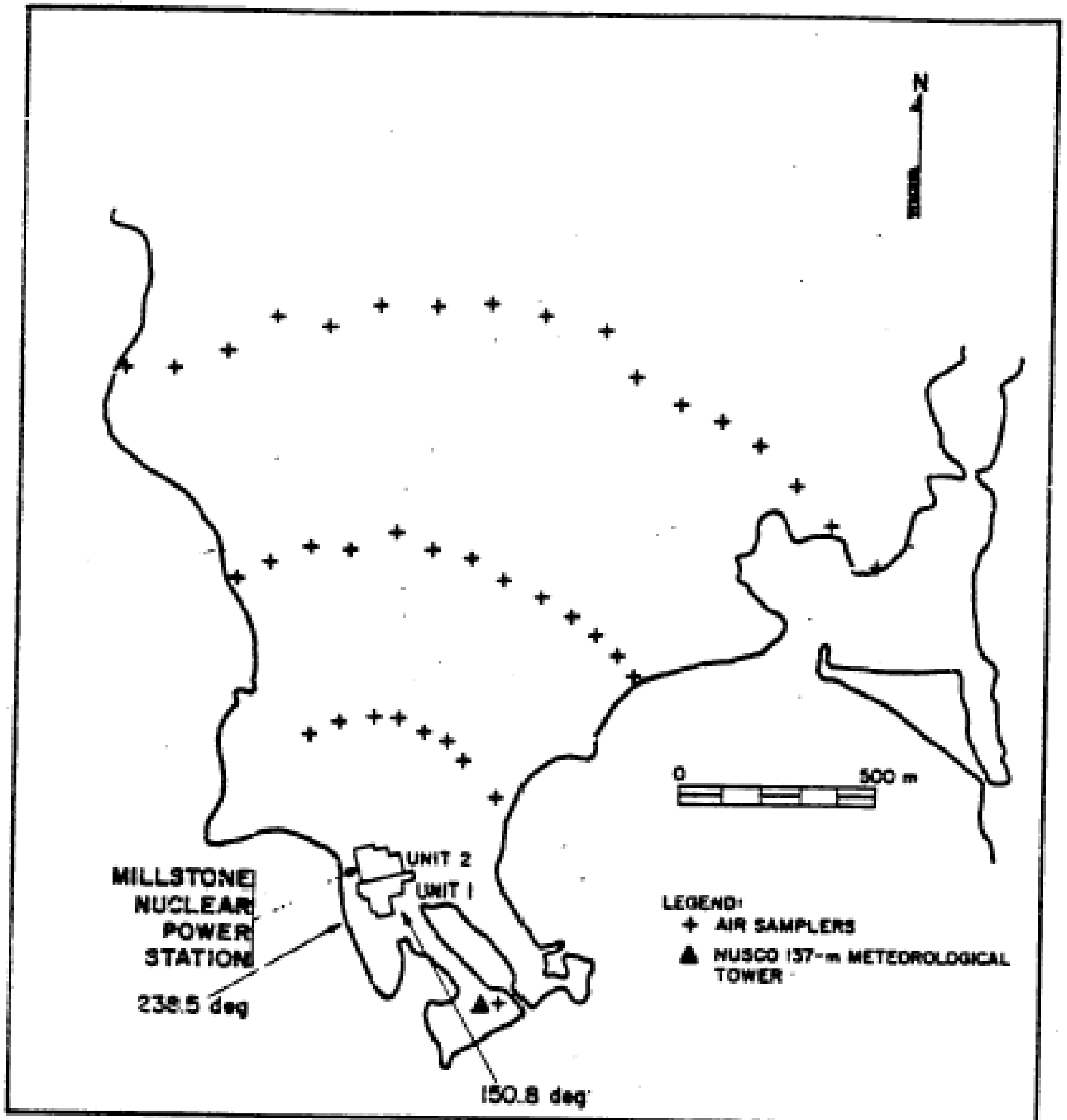
Bowline 1-hr Q-Q Plot (i) - 87m Stack
Pred. Conc. (: g/m3)
Obs. Conc. (: g/m3)
1000
100
10
1
1
10
100
1000
ISC3P
AERMOD
ISC3P
AERMOD
ISC3P


Bowline 3-hr Q-Q Plot (ì) - 87m Stack
1000
100
10
1
1
10
100
1000
Pred. Conc. (: g/m3)
Obs. Conc. (: g/m3)
AERMOD
ISC3P

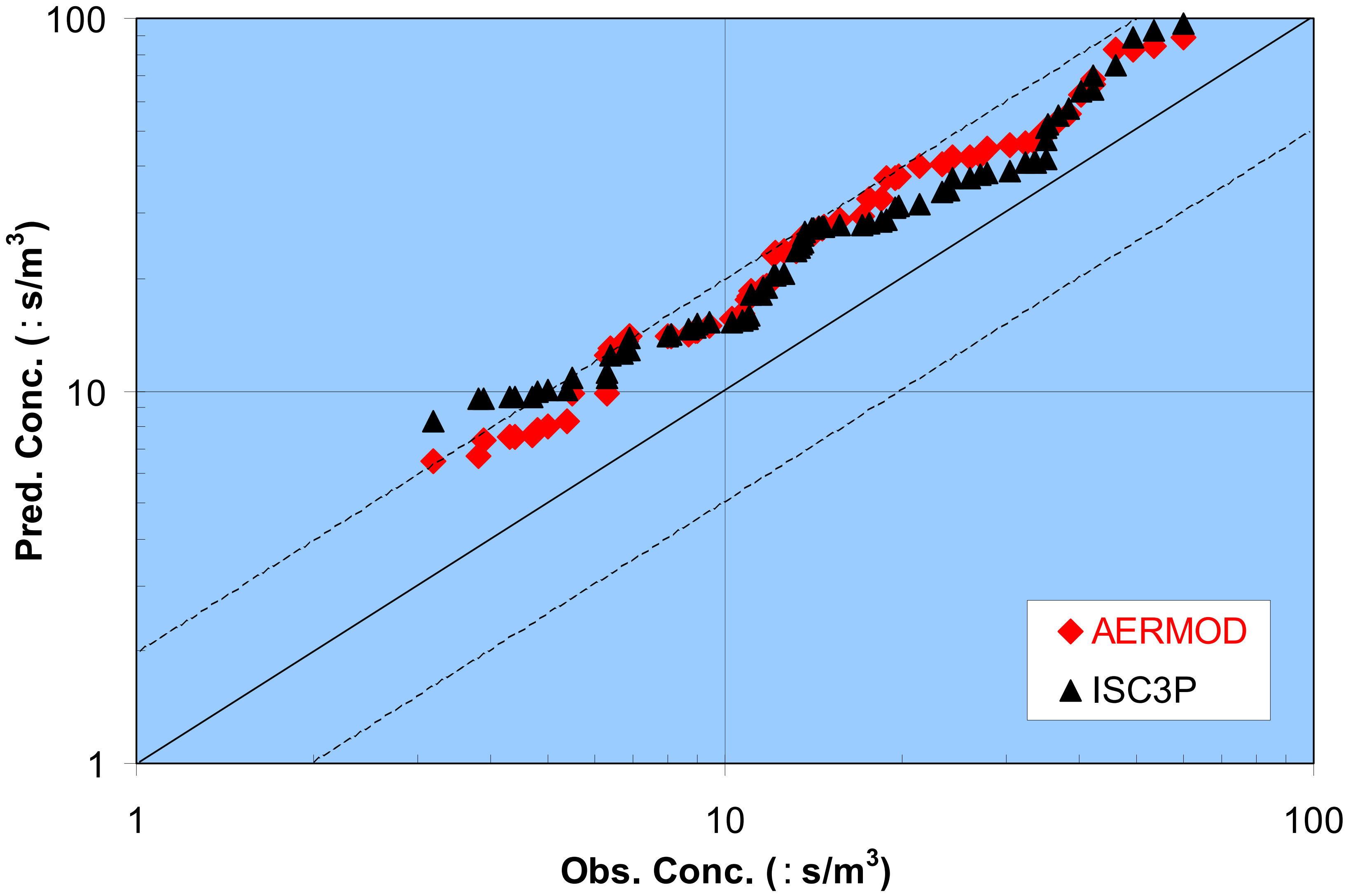


Bowline 24-hr Q-Q Plot (i) - 87m Stack
1000
100
10
1
Pred. Conc. (: g/m3)
1
10
100
1000
Obs. Conc. (: g/m3)
AERMOD
ISC3P

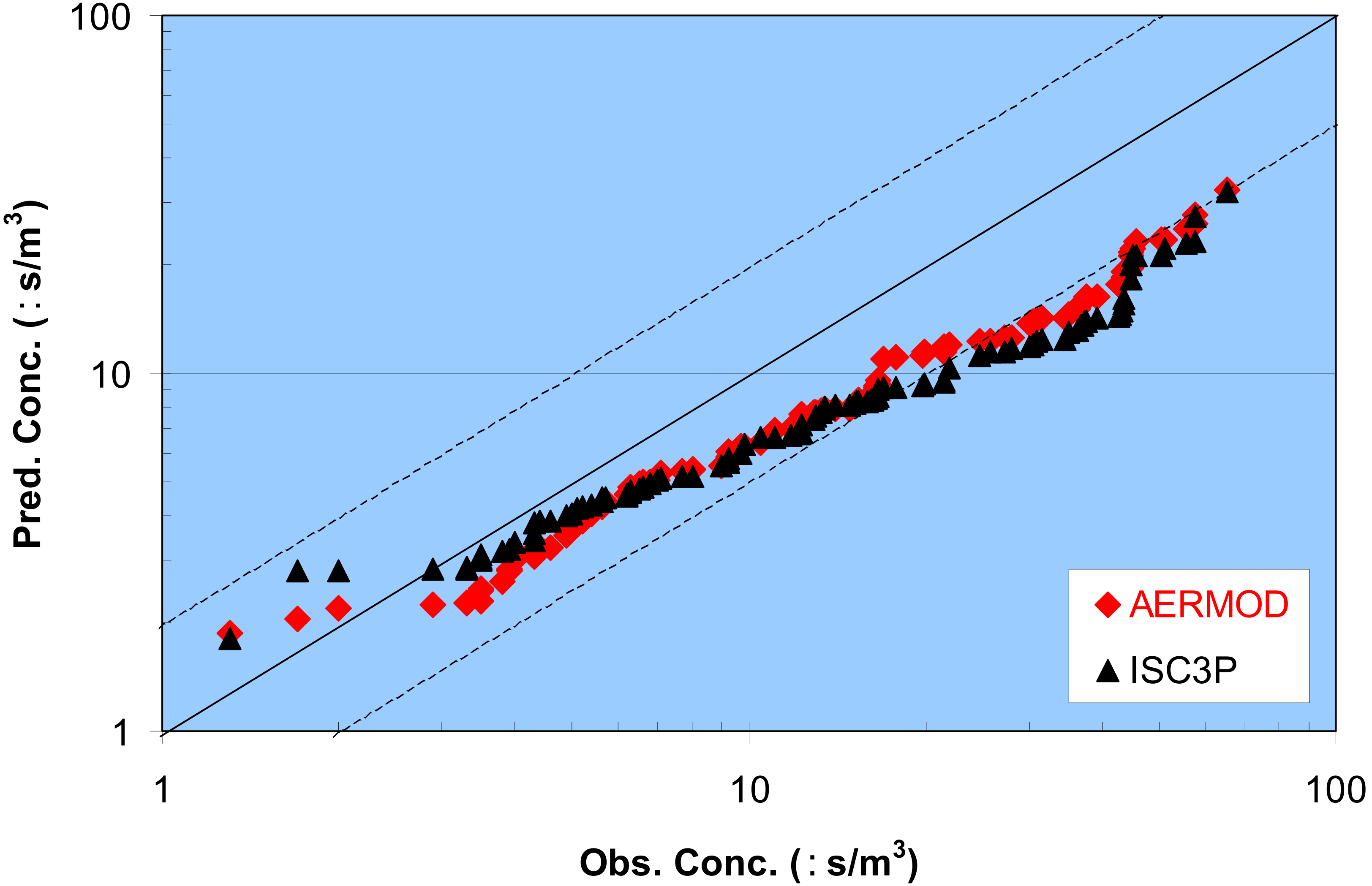
Millstone Study Area



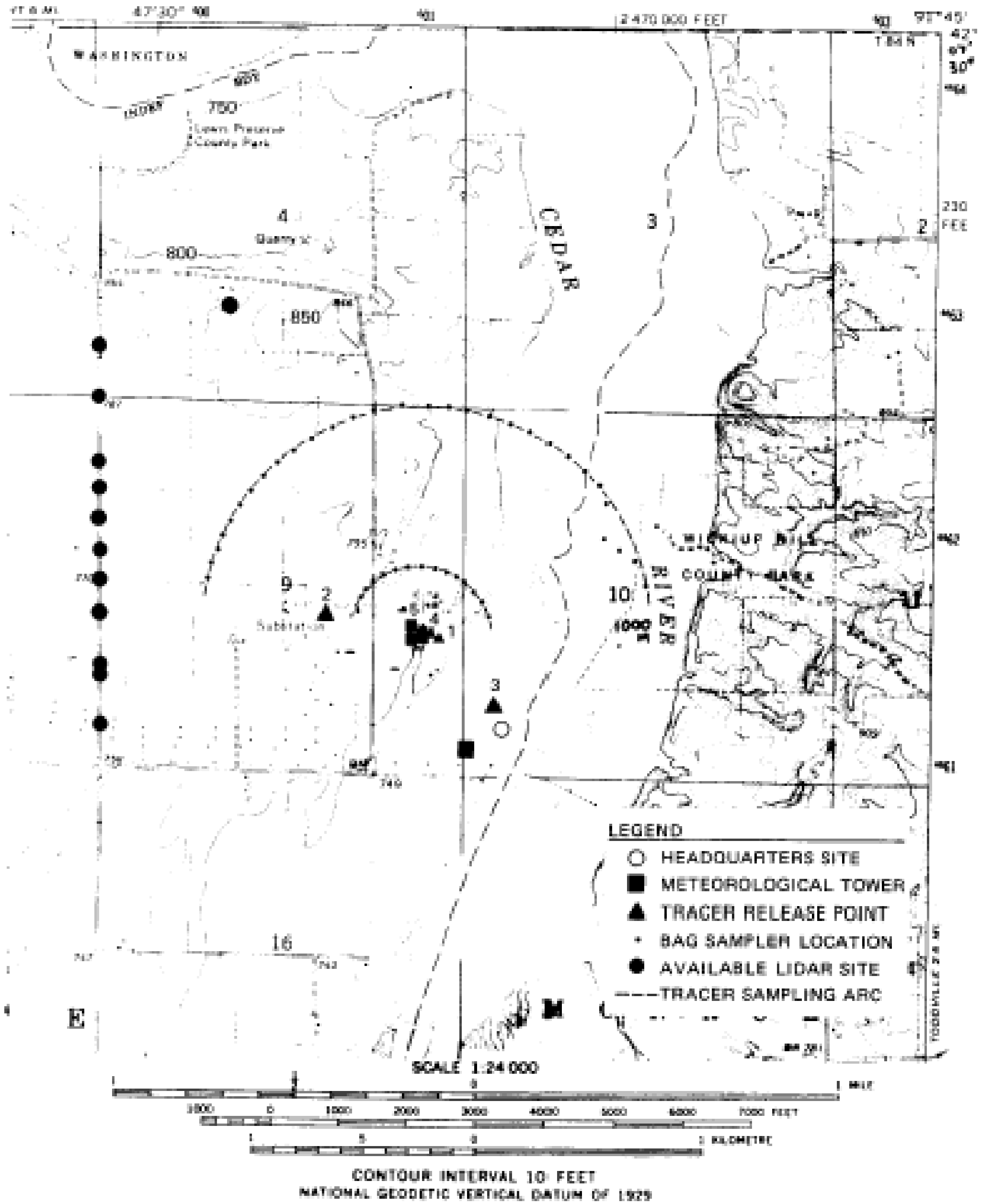
Millstone Freon 1-hr Q-Q Plot (i /Q) - 29m Stack

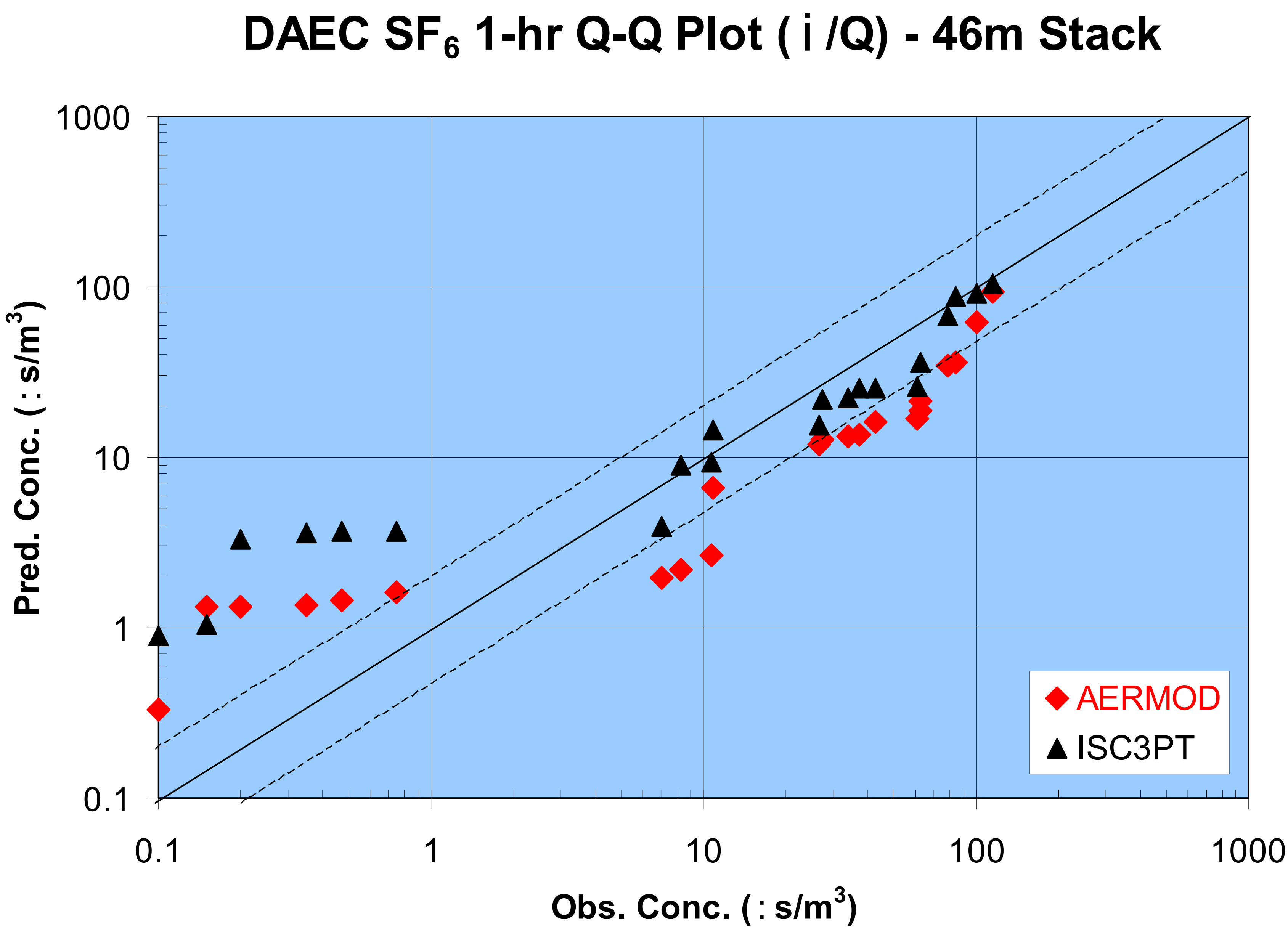


Millstone SF_6 1-hr Q-Q Plot (ì /Q) - 48m Stack



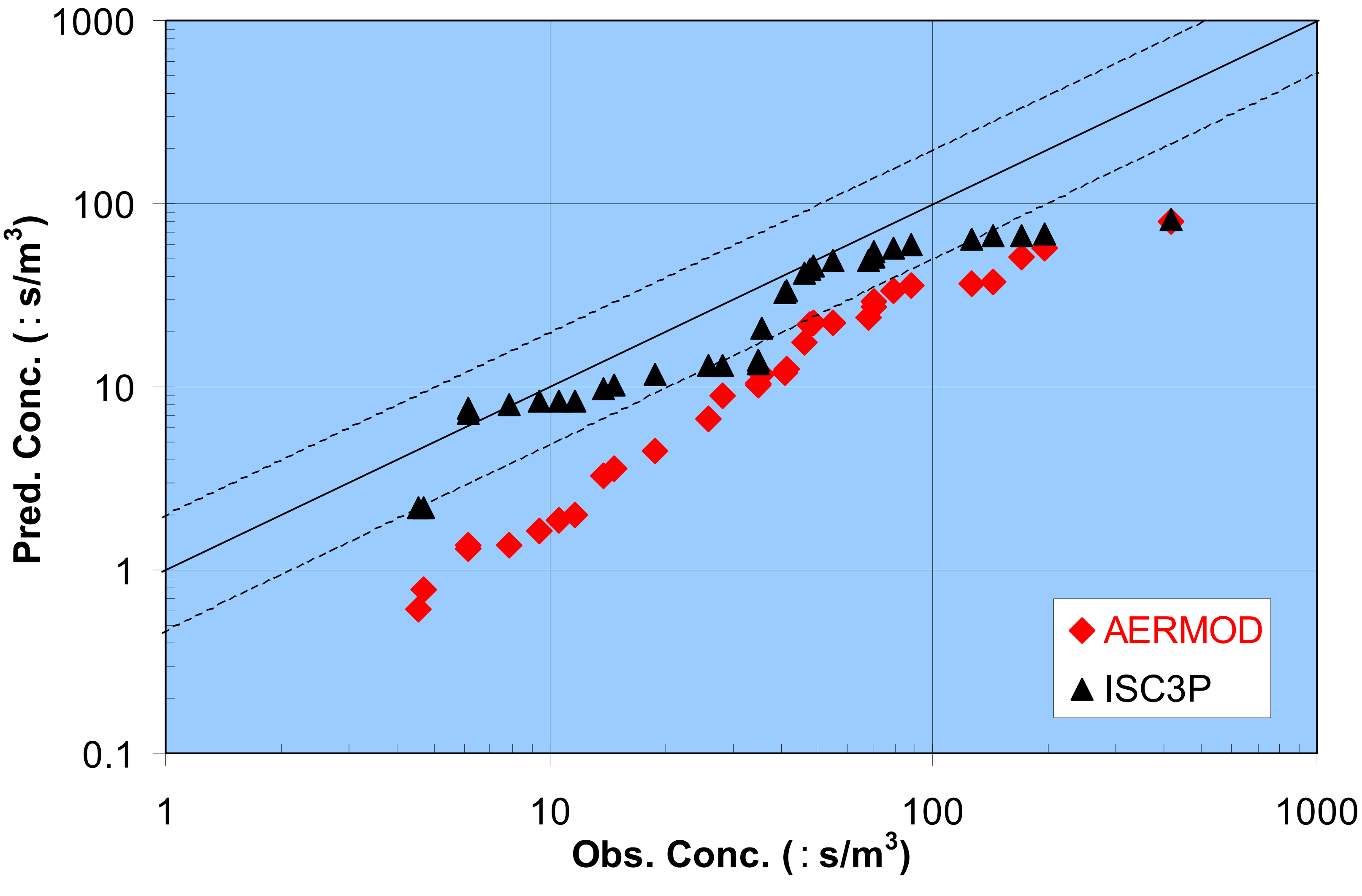
DAEC Study Area

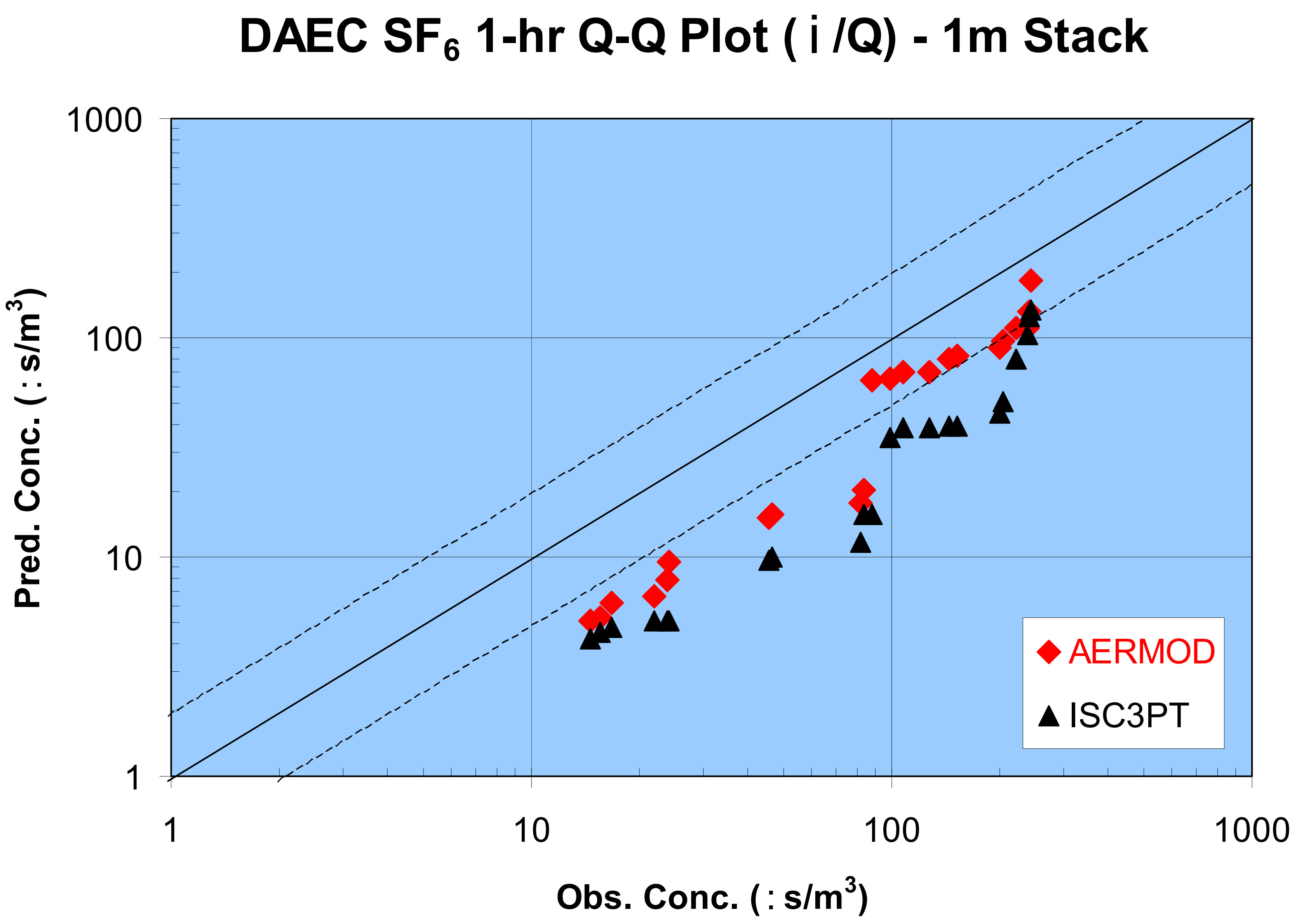




DAEC SF6 1-hr Q-Q Plot (i /Q) - 46m Stack
Pred. Conc. (: s/m3)
Obs. Conc. (: s/m3)
1000
100
10
1
0.1
0.1
1
10
100
1000
AERMOD
ISC3PT

DAEC SF_6 1-hr Q-Q Plot (i /Q) - 24m Stack




DAEC SF6 1-hr Q-Q Plot (i /Q) - 1m Stack
Pred. Conc. (: s/m3)
Obs. Conc. (: s/m3)
1000
100
10
1
1
10
100
1000
AERMOD
ISC3PT

Alaska North Slope Study Area

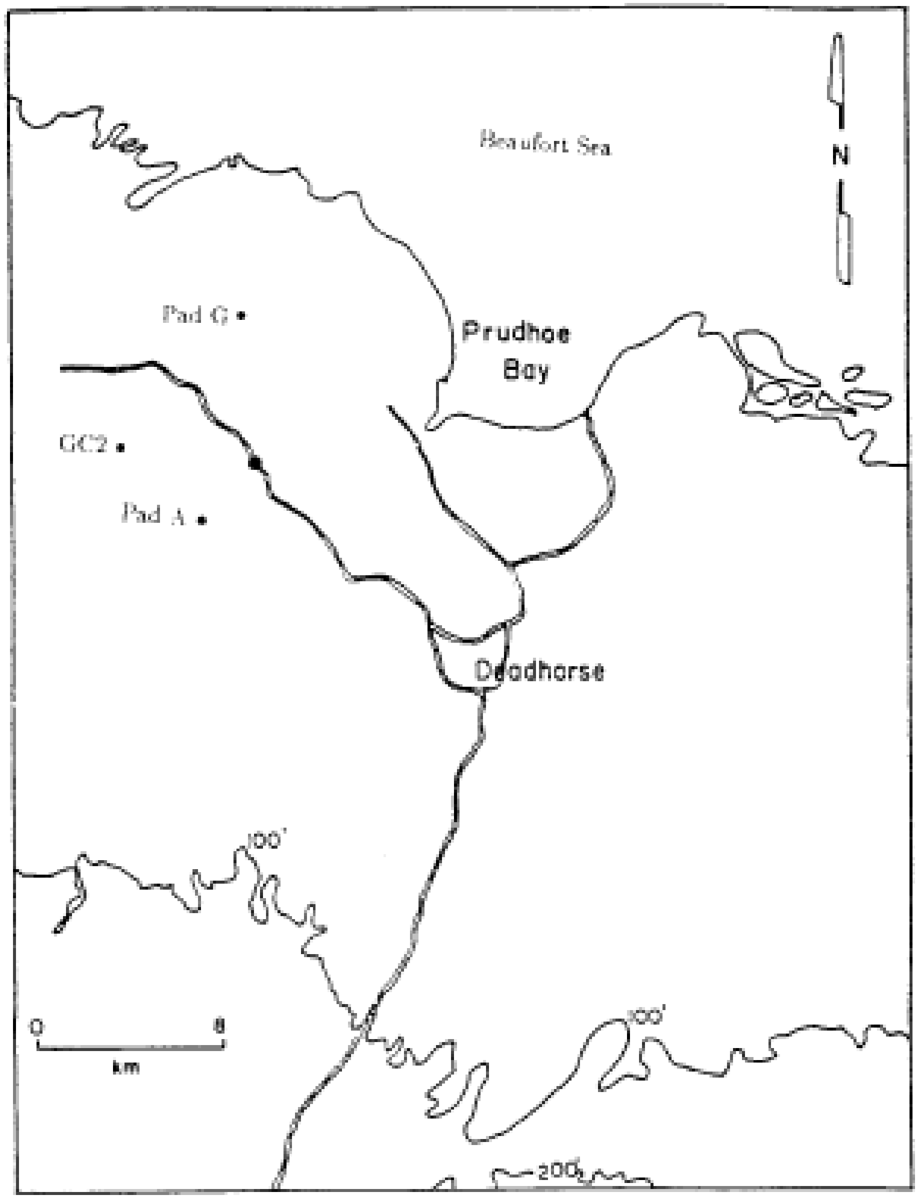
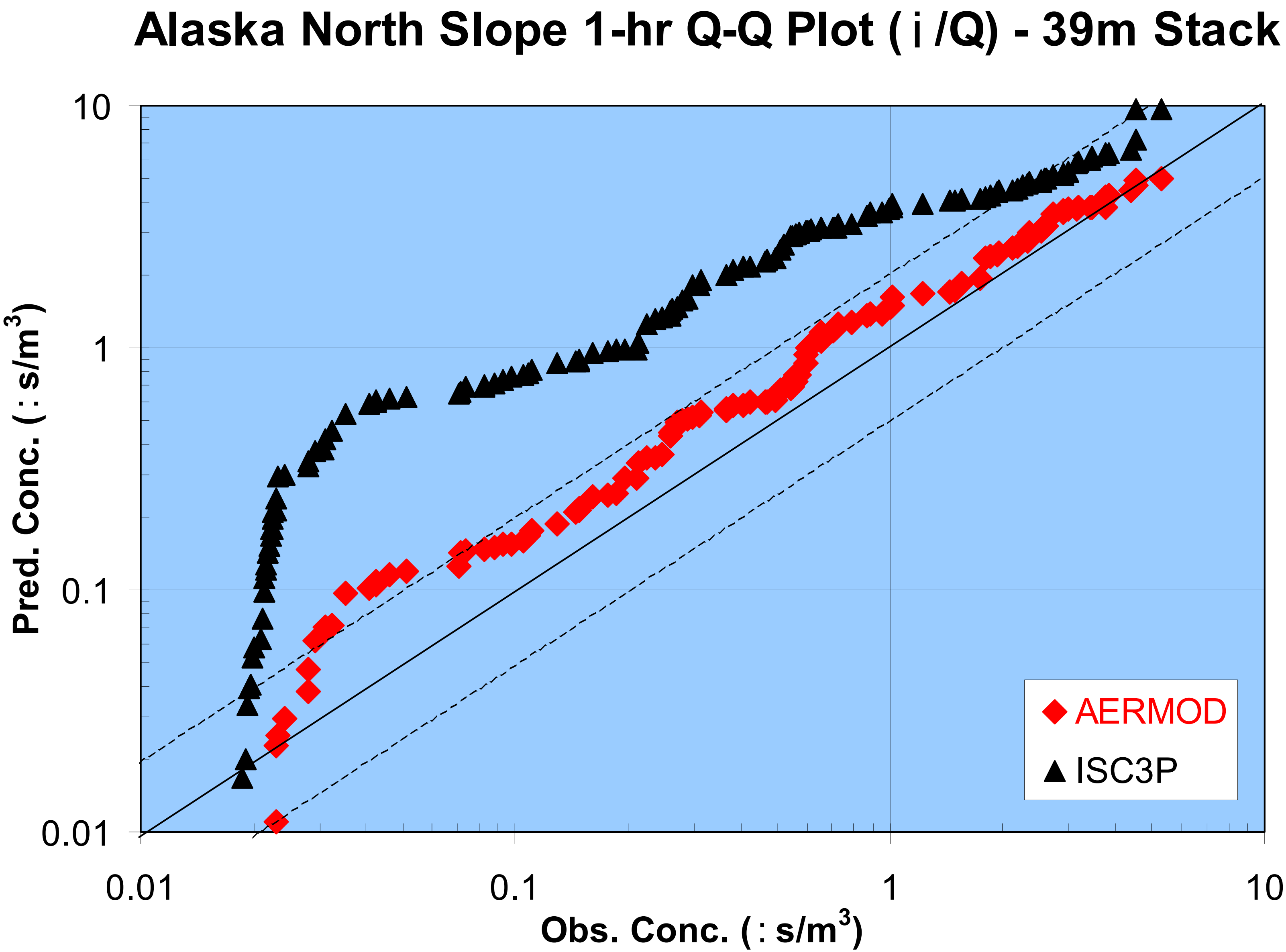


Fig. 1. Map of the Prudhoe Bay oilfield.



Alaska North Slope 1-hr Q-Q Plot (¡/Q) - 39m Stack
Pred. Conc. (: s/m3)
Obs. Conc. (: s/m3)
10
1
0.1
0.01
0.01
0.1
1
10
AERMOD
ISC3P

Final Evaluation Databases

- Bowline Point Power Station database, Hudson River Valley (full year of data)
- AGA tracer databases in Texas and Kansas
- EOCR tracer database for Test Reactor Building in Idaho
- Wind tunnel database for Lee Power Plant

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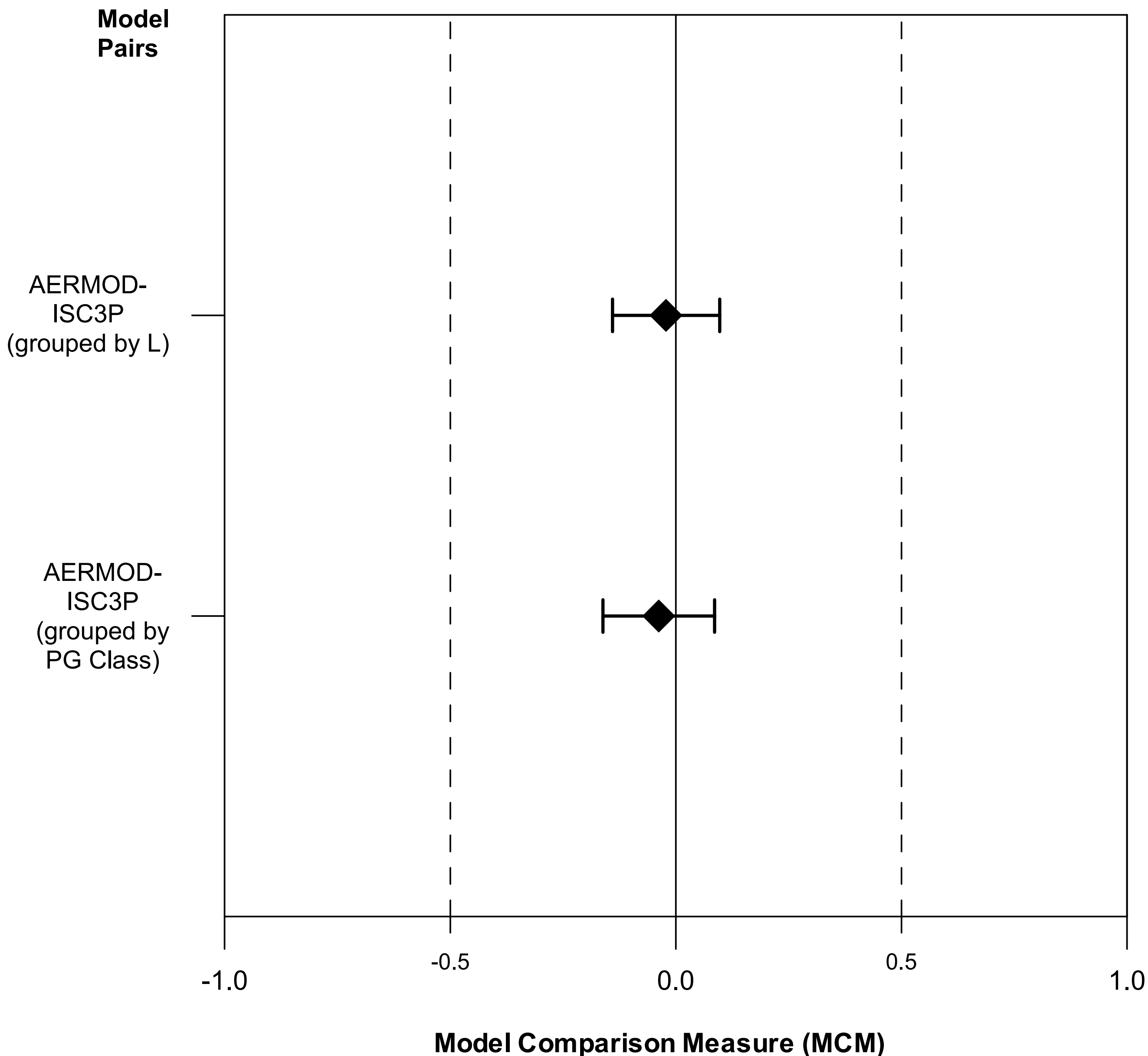
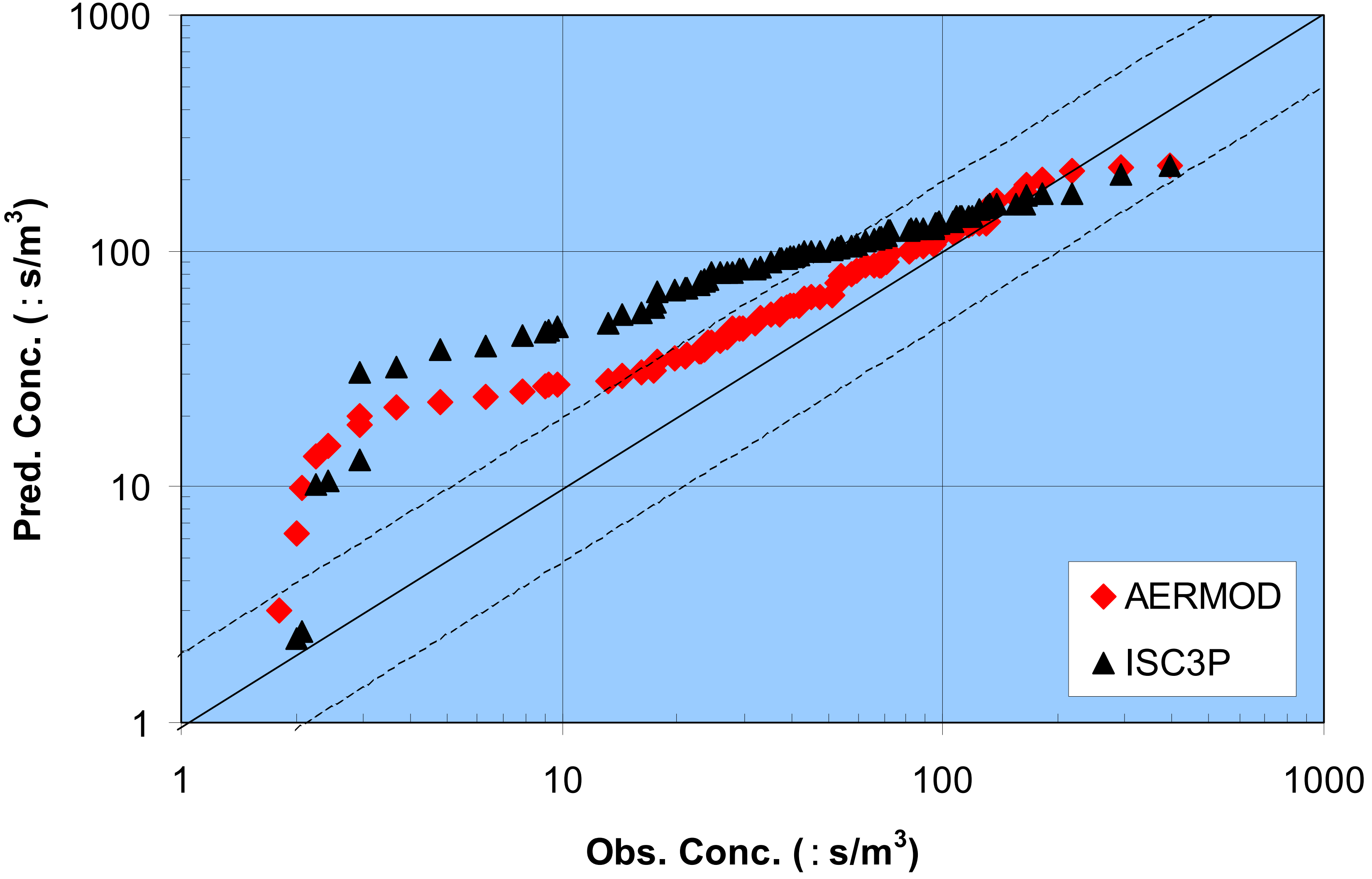
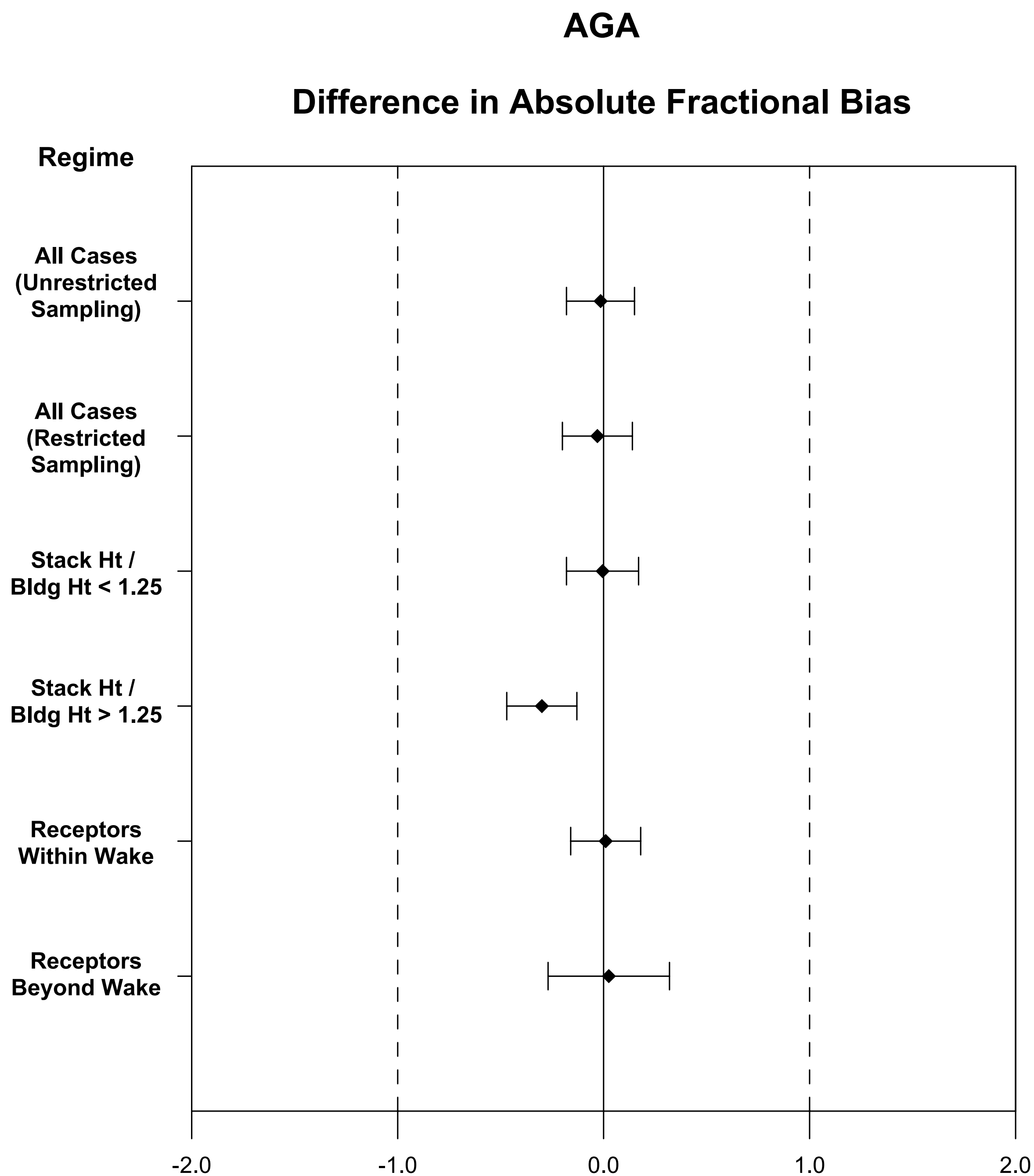
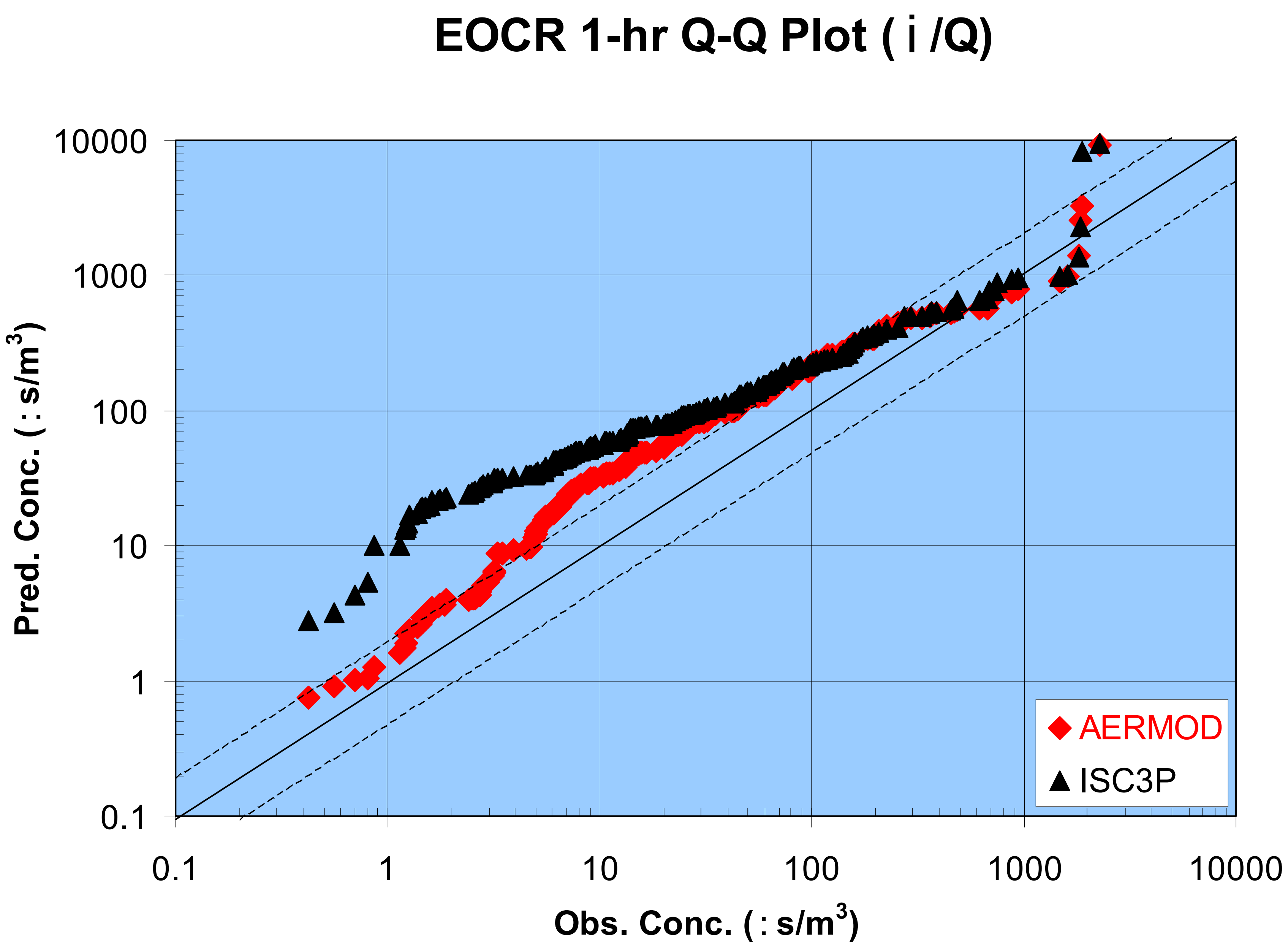
Bowline SO_2 Model Comparison Measures With 95% Confidence Intervals

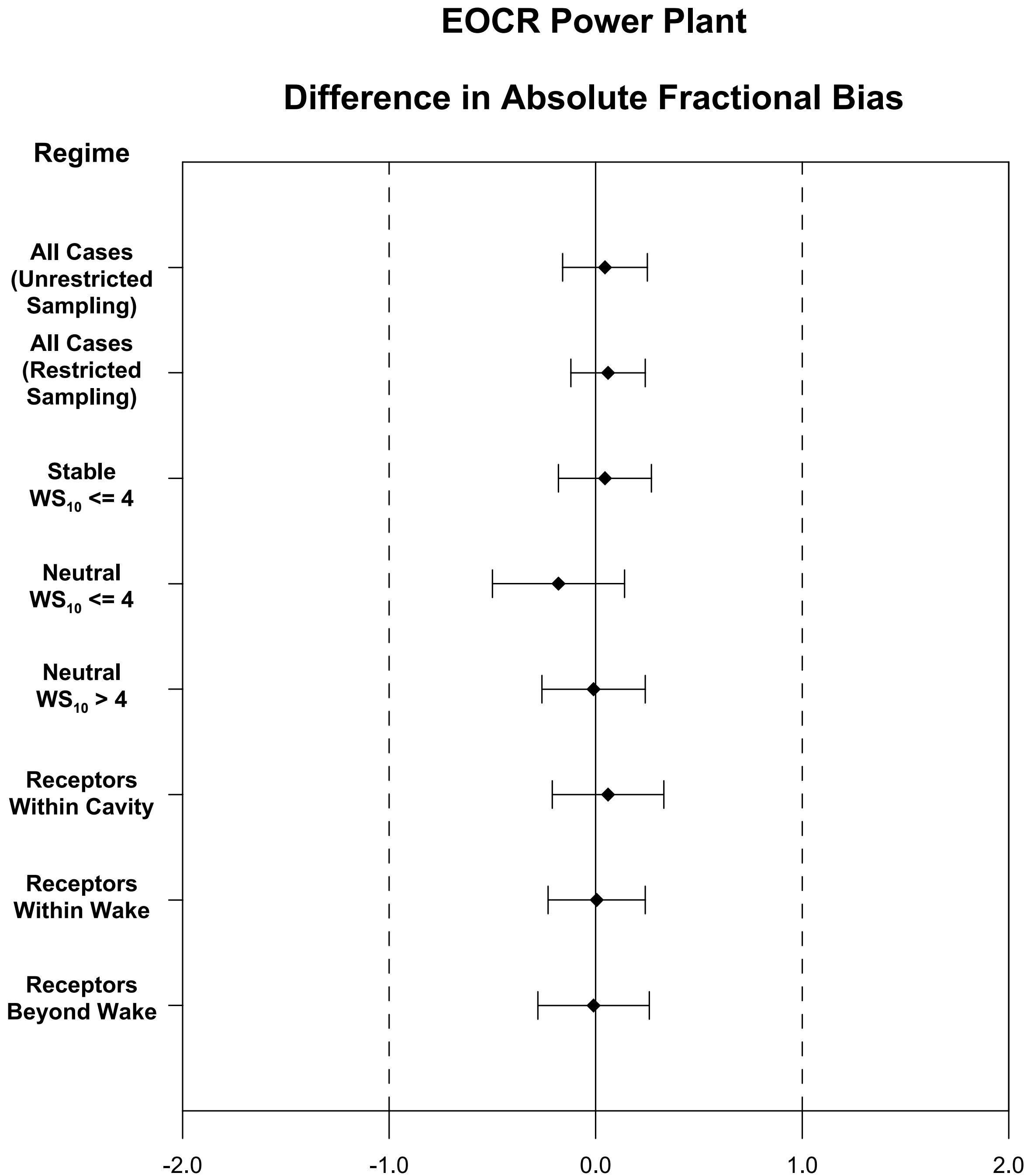


AGA 1-hr Q-Q Plot (i /Q)

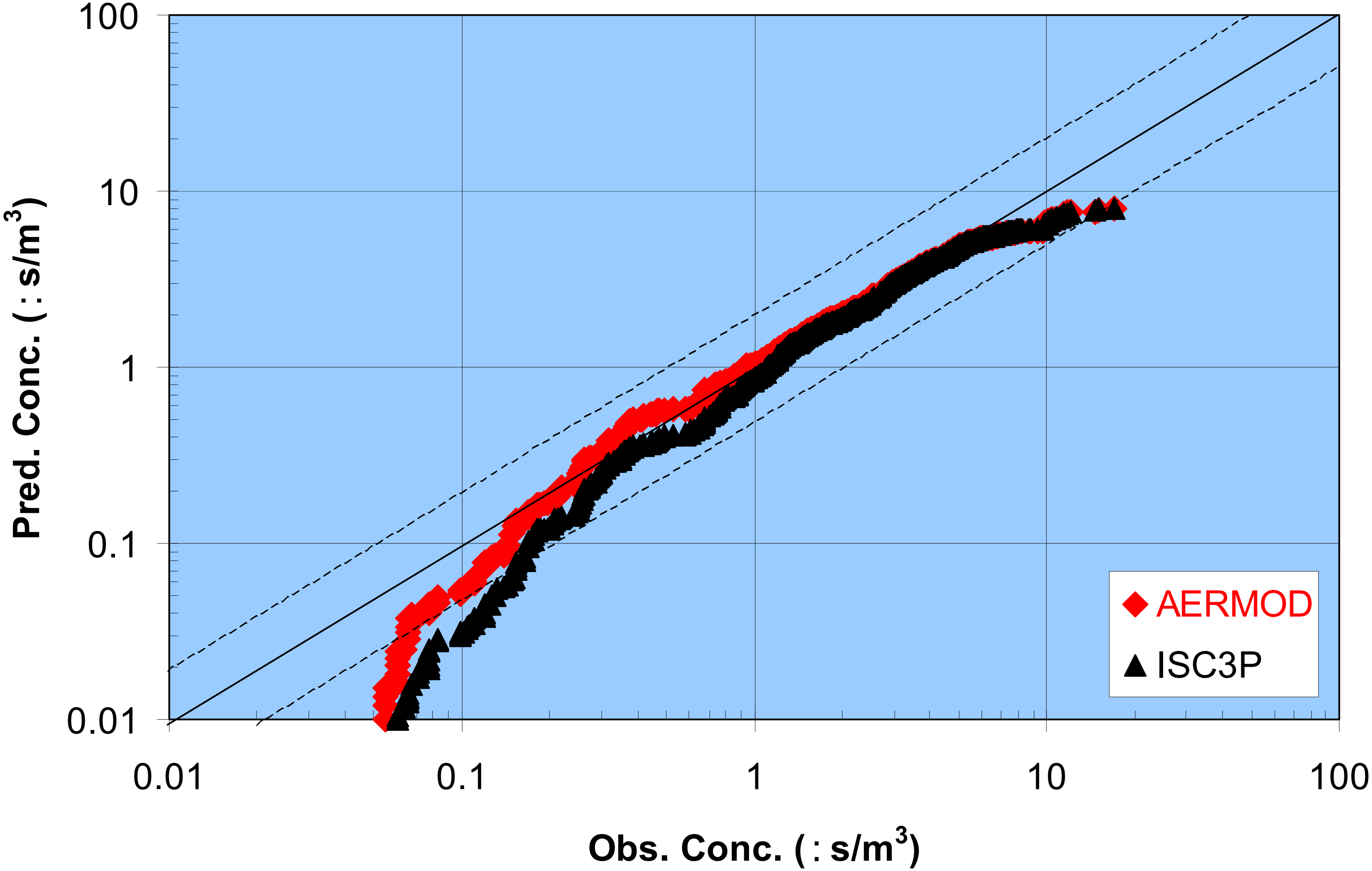


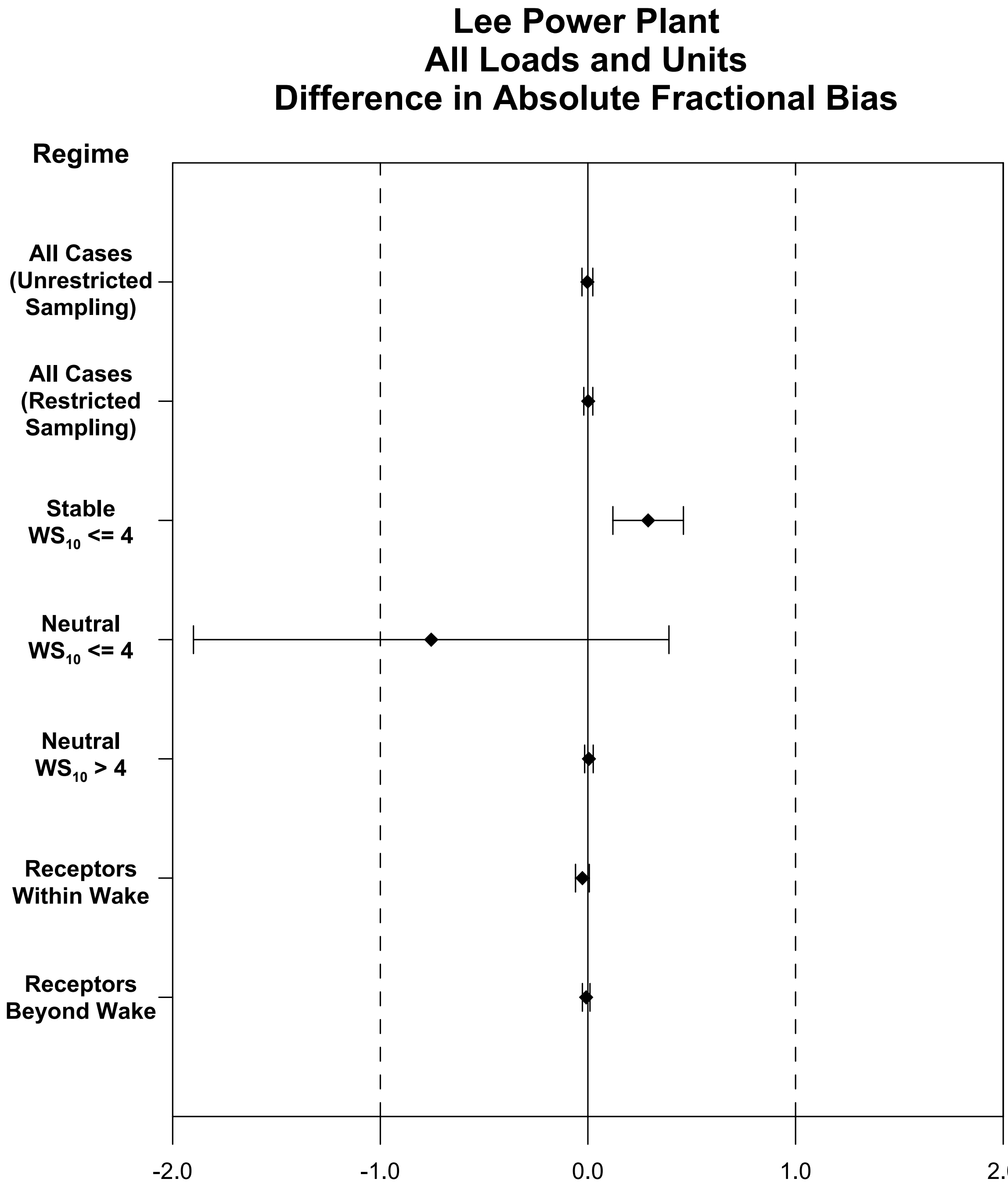

AGA
Difference in Absolute Fractional Bias
Regime
All Cases (Unrestricted Sampling)
All Cases (Restricted Sampling)
Stack Ht / Bldg Ht < 1.25
Stack Ht / Bldg Ht > 1.25
Receptors Within Wake
Receptors Beyond Wake
-2.0
-1.0
0.0
1.0
2.0


EOCR 1-hr Q-Q Plot (ì /Q)
Pred. Conc. (: s/m3)
Obs. Conc. (: s/m3)
10000
1000
100
10
1
0.1
0.1
1
10
100
1000
10000
AERMOD
ISC3P


EOCR Power Plant
Difference in Absolute Fractional Bias
Regime
All Cases (Unrestricted Sampling)
All Cases (Restricted Sampling)
Stable WS_{10} <= 4
Neutral WS_{10} <= 4
Neutral WS_{10} > 4
Receptors Within Cavity
Receptors Within Wake
Receptors Beyond Wake
-2.0
-1.0
0.0
1.0
2.0

Lee Wind Tunnel 1-hr Q-Q Plot (i /Q)




Lee Power Plant
All Loads and Units
Difference in Absolute Fractional Bias
Regime
All Cases
(Unrestricted
Sampling)
All Cases
(Restricted
Sampling)
Stable
WS10 <= 4
Neutral
WS10 <= 4
Neutral
WS10 > 4
Receptors
Within Wake
Receptors
Beyond Wake
-2.0
-1.0
0.0
1.0
2.0

Summary of Results

- Overall results for AERMOD with PRIME similar to or better than results for ISC-PRIME