# Low Wind and Plume Rise Developments

## EPA RSL Workshop

*U.S. EPA / OAQPS / Air Quality Modeling Group*

*Monday, June 21, 2021*

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# Plume Rise Development

# Plume Rise – Multiple Moving Pieces

- Current White Paper on Saturated Plumes
  - PLURIS is generic plume rise model that "can be applied to situations with arbitrary three-dimensional wind fields, arbitrary directions of the source exit, and to both dry and wet plumes" (Janicke & Janicke, 2001)
  - Paine et al., 2016, recommend a pre-processor to adjust POINT source temperature to account for additional buoyancy from condensation
  - If PLURIS were applied to AERMOD, would need an approach that allows for calculation in the model
  - Significant update to white paper underway, much more expansive view of the current and past science
- BLP integration and applications
  - BLP integration into AERMOD in 2017 "as is" with no scientific changes (based on PG stability)
  - BLP was formulated for "roof vents", includes buoyancy only, i.e., no momentum
  - Multiple Model Clearinghouse actions for coke ovens using a hybrid approach seeking to maximize enhanced plume rise from BLP and better dispersion estimates from AERMOD POINT/AREA sources
    - Buoyancy from generally "hot" facilities, even if not the specific emissions themselves, could be important for some sources

# Plume Rise – Multiple Moving Pieces

- Penetrated plume white paper submitted, recently updated
  - White paper pairs with on-going discussions about a permit considering an alternative model approval for penetrated plumes
- Workgroup with FAA partly focused on plume rise from aircraft
  - Potential of adding plume rise to area and/or volume sources in AERMOD
- Buoyancy from fugitives could be important for some sources
- Plume merging from nearby stacks not explicitly accounted for in AERMOD, but could be important and there have been several discussions on recent permits looking at merged plumes
- Break-out session tomorrow to review modeling flares, which is not explicitly accounted for in AERMOD
- Plume rise is calculated independently, but plume height important in interaction with downwash

# Low Wind Development

# Low Wind – Treatment Pathways

- **Goal**: to improve model predictions under low wind conditions
- Current LOW_WIND **alpha** options fit into 2 categories
  - Adjustments to turbulence parameters
    - Minimum sigma-v (SVmin, standard deviation of the horizontal component of the wind speed)
    - Minimum wind speed (WSmin, correlation between WSmin and SVmin)
    - Minimum sigma-w (SWmin, standard deviation of the vertical component of the wind speed)
  - Adjustments to the meander formulation
    - Fraction of the random plume (FRANmax, maximum weighting for the random plume)
    - Wind speed correlation time scale (BigT) at which mean wind information at the source is no longer correlated with the location of plume material at a downwind receptor
- Additional possible pathways for addressing low wind conditions
  - Adjustments to the wind profiling and wind speed averaging within AERMOD
  - Improvements to initial estimates of meteorological conditions (e.g., adjust u*)

# Low Wind - Work Needed

- Need to examine available data from field studies to clarify when and where problems are occuring
  - Critical need for datasets across a range of conditions
  - How often are low wind conditions a factor in existing datasets (e.g., stacks vs surface releases, influence of downwash)
- Initial evaluations of Project Sagebrush show mixed results
  - Phase 1 had one day of low wind conditions
  - Phase 2 more focused on low wind conditions, had an expanded receptor grid to capture more plume spread
  - Do we use this data for model formulation or model evaluation?

# Project Sagebrush

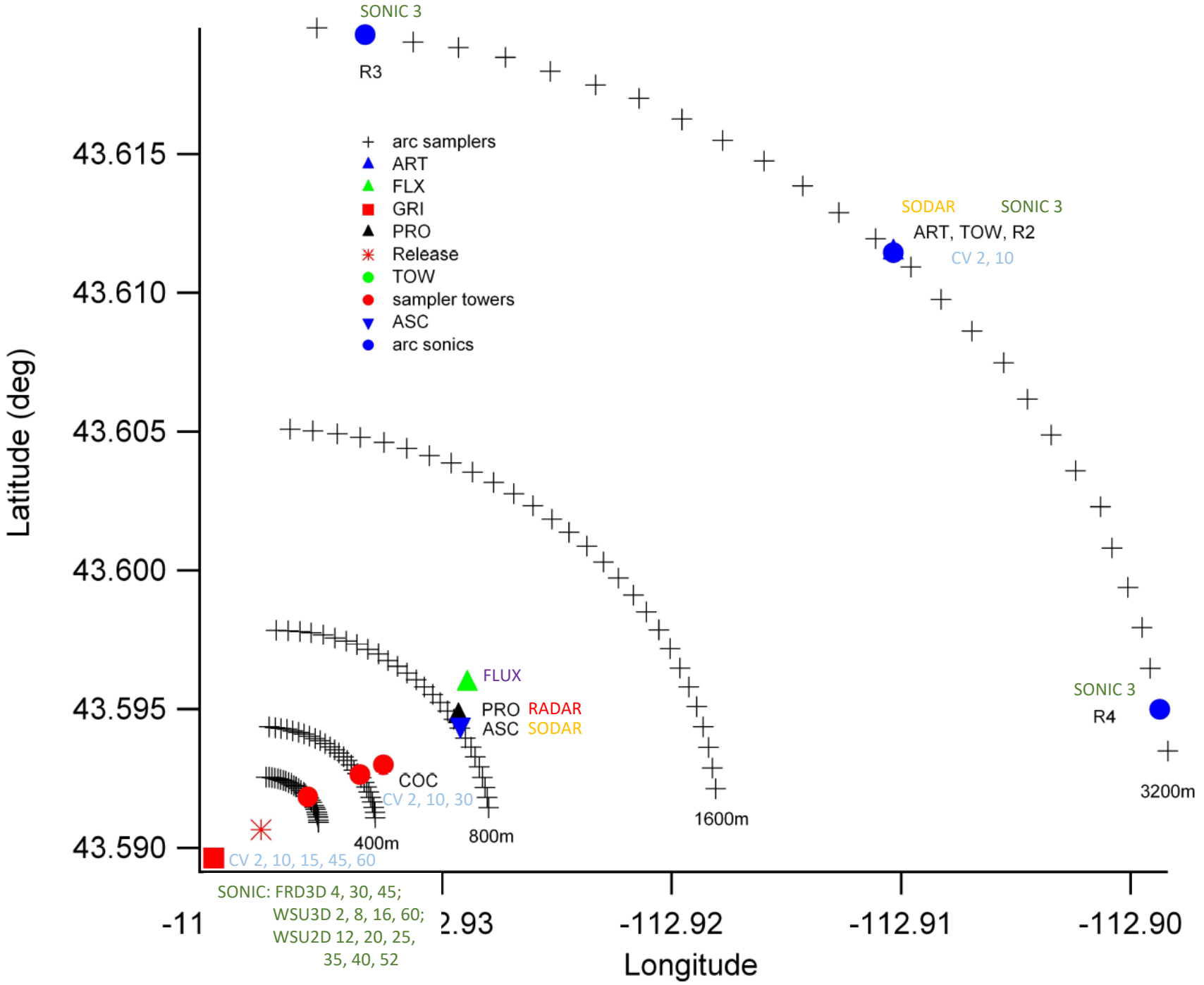
- Conducted at the Idaho National Laboratory in October 2013
- Five tests were conducted during the daytime with conditions ranging from near neutral with higher wind speeds to unstable with low wind speeds.
  - Each experimental period consisted of a continuous 2.5 hour SF6 tracer release with consecutive 10-minute average bag sampling over the last two hours of the tracer release period.
  - Bag sampling was done on four arcs of almost 90 degrees each ranging in distance from 200 to 3200 m from the source.
- An extensive suite of meteorological measurements included a 60 m tower arrayed with seven 3-d sonic anemometers and five sets of cup anemometers and wind vanes.
  - Two additional towers at 10 and 30 m height had cup and vane anemometers mounted at 2 and 3 levels, respectively.
  - Three additional sonic anemometers were arrayed on the 3200 m arc to examine the issue of horizontal homogeneity.
  - Additional meteorological measurements were made by two sodars, a radar wind profiler, and radiosondes released just prior to and just after the two-hour sampling period.
- NOAA, 2015, Project Sagebrush Phase I, Technical Memorandum OAR ARL-268

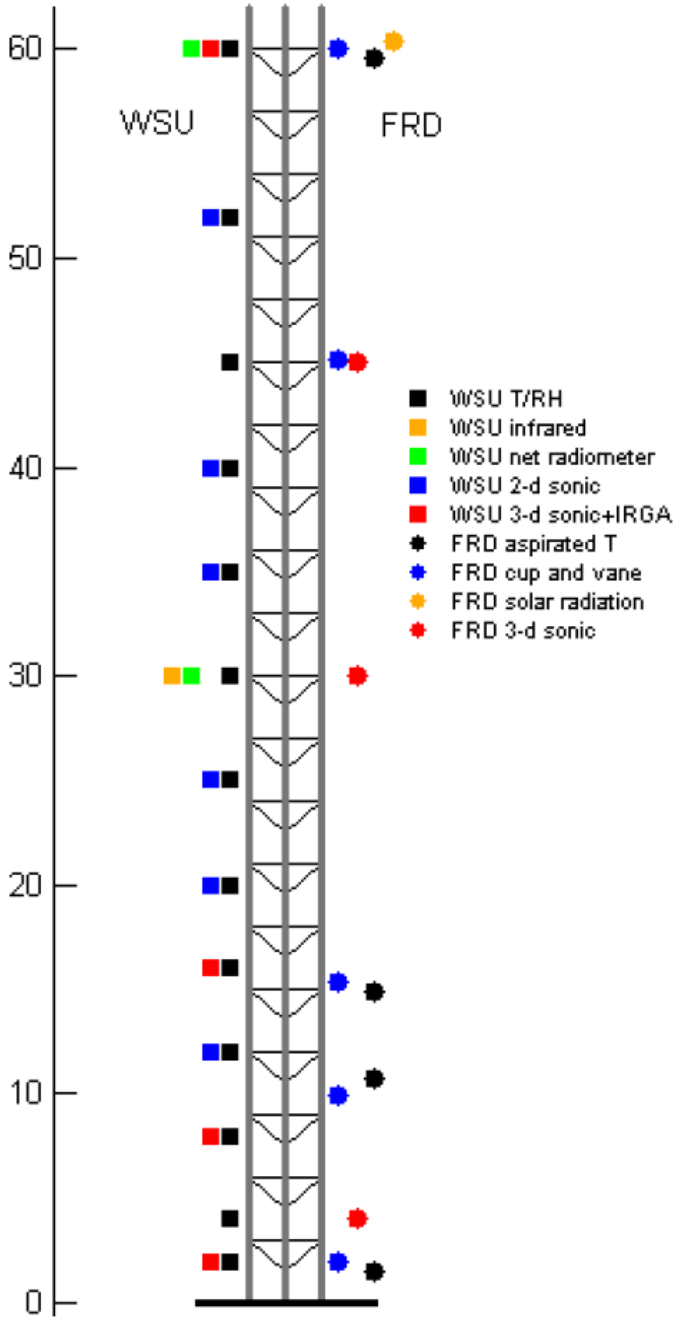
# Project Sagebrush Study Days

Table 1. IOP Summary.

| IOP | Date | Start Time (MST) | Release Rate ($g\ s^{-1}$) | Stability | Aircraft | Meteorological Summary |
|---|---|---|---|---|---|---|
| 1 | 02-Oct-13 | 1430 | 10.177 | Unstable[a] | Yes | Mostly sunny with cirrostratus haze. Very light and variable winds. |
| 2 | 05-Oct-13 | 1300 | 9.986 | Unstable[a] | Yes | Mostly sunny. Light-moderate SW winds. |
| 3 | 07-Oct-13 | 1300 | 9.930 | Neutral | Yes | Mostly sunny. Moderate-strong SW winds. |
| 4 | 11-Oct-13 | 1400 | 1.043 | Weakly Unstable | No | Mostly sunny. Moderate SW winds. |
| 5 | 18-Oct-13 | 1300 | 1.030 | Weakly Unstable | No | Mostly sunny. Moderate SW winds. |

a. Estimates of stability vary.


SONIC 3
R3
arc samplers
ART
FLX
GRI
PRO
Release
TOW
sampler towers
ASC
arc sonics
SODAR
SONIC 3
ART, TOW, R2
CV 2, 10
FLUX
PRO RADAR
ASC SODAR
COC
CV 2, 10, 30
400m
800m
1600m
SONIC 3
R4
3200m
CV 2, 10, 15, 45, 60
SONIC: FRD3D 4, 30, 45;
WSU3D 2, 8, 16, 60;
WSU2D 12, 20, 25,
35, 40, 52
Latitude (deg)
43.615
43.610
43.605
43.600
43.595
43.590
-11
2.93
-112.92
-112.91
-112.90
Longitude

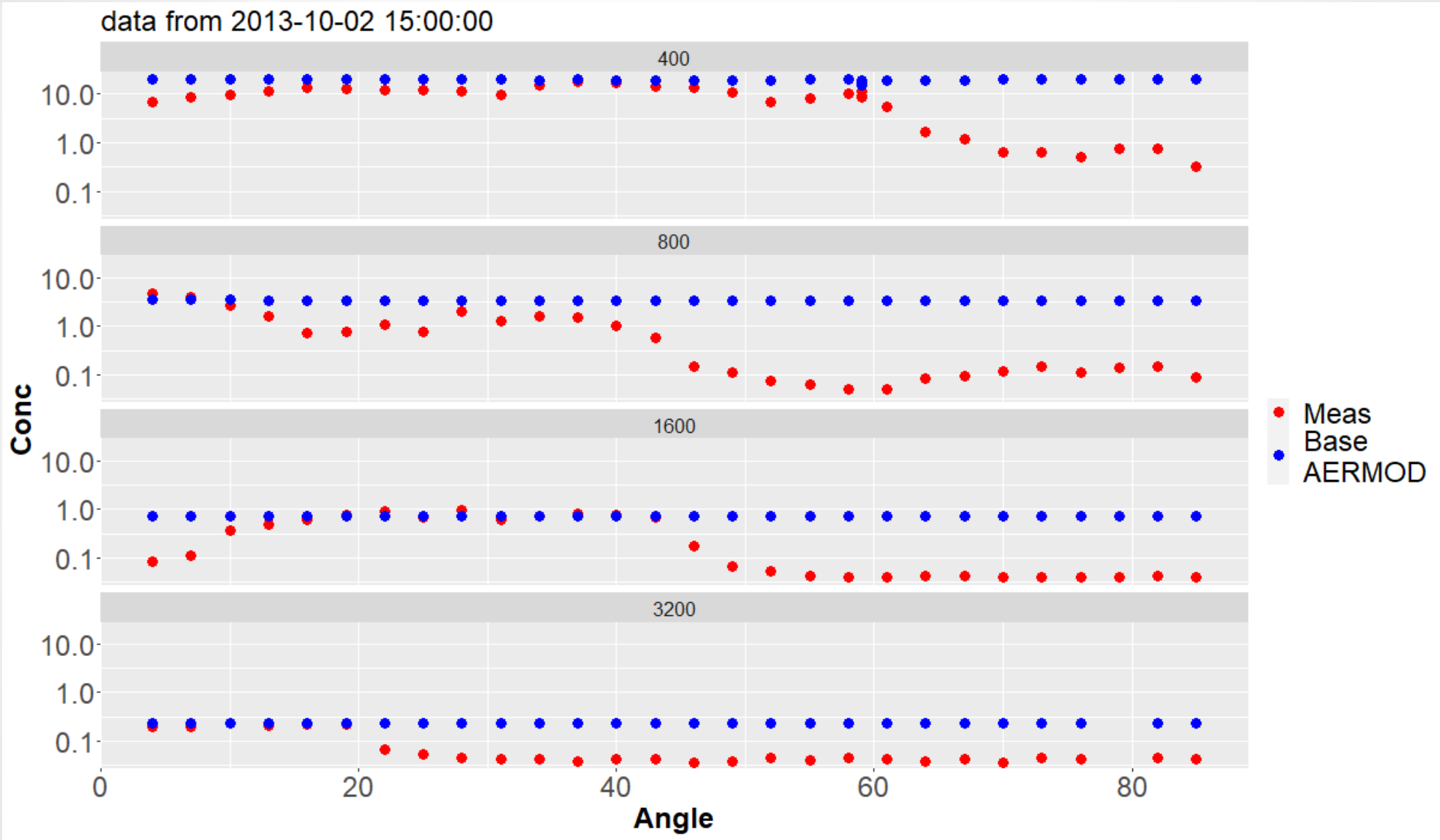



| | |
|---|---|
| WS/WD | C&V (GRI): 2, 10, 15, 45, 60<br>3D Sonic FRD (G1, G2, R1) and WSU: 2, 4, 8, 16, 30, 45, 60<br>2D Sonic (RM): 12, 20, 25, 35, 40, 52 |
| SigA | C&V (GRI): 2, 10, 15, 45, 60<br>3D Sonic FRD (G1, G2, R1): 4, 30, 45 |
| SigW | 3D Sonic FRD (G1, G2, R1) and WSU: 2, 4, 8, 16, 30, 45, 60 |
| Temp | RM: 2, 4, 8, 12, 16, 20, 25, 30, 35, 40, 45, 52, 60<br>GRI: 2, 10, 15, 60<br>3D Sonic FRD (G1, G2, R1): 4, 30, 45<br>Flux: 2 |
| Dew-point Temp | WSU: 2, 8, 16, 60 |
| RH | RM: 2, 4, 8, 12, 16, 20, 25, 30, 35, 40, 45, 52, 60<br>GRI: 2; Flux: 2 |
| Pressure | WSU: 2, 8, 16, 60<br>RM: Surface and 30m<br>GRI: Barometric; Flux |
| Net Radiation | Flux; RM: 30, 60 |
| Insolation | Flux; GRI |
| Precip | GRI |
| u* | 3D Sonic WSU: 2, 10, 15, 60<br>3D Sonic FRD (G1, G2, R1): 4, 30, 45 |

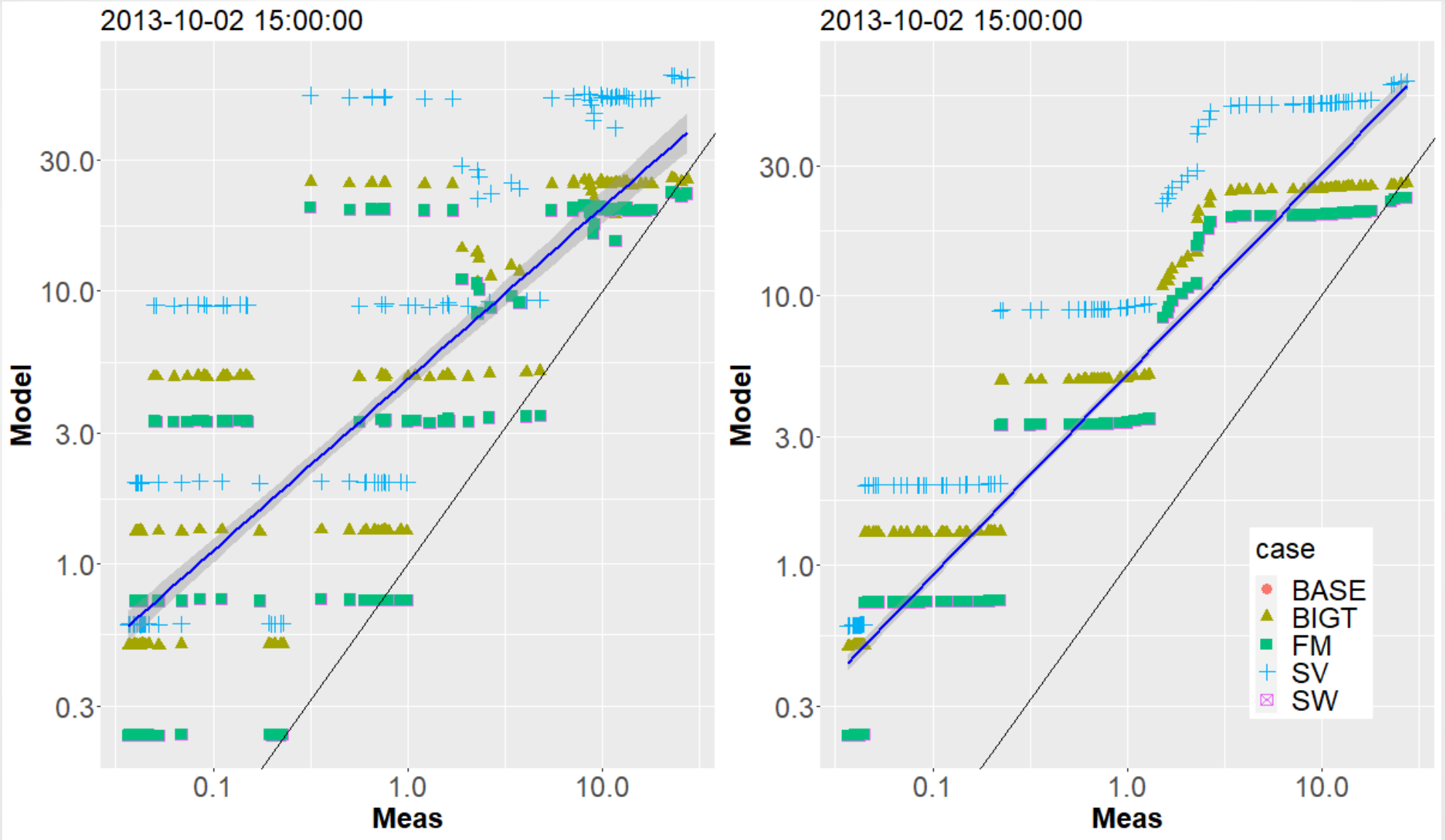
# Sagebrush Low Wind Test Cases

- 10-minute bag samples averaged up to 30-minute samples
- Each 30-minute period modeled as 1-hour in AERMOD
- On-site meteorology used from sonics at the main 60 m GRI tower
  - Turbulence data from tower included in model run
- Low wind model runs
  - $\sigma_{v,min}$ = 0.5 m/s & min windspeed = 0.707 m/s
  - $\sigma_{w,min}$ = 0.1 m/s
  - BIGT = 1.0 hrs
  - FRAN_MAX = 0.7

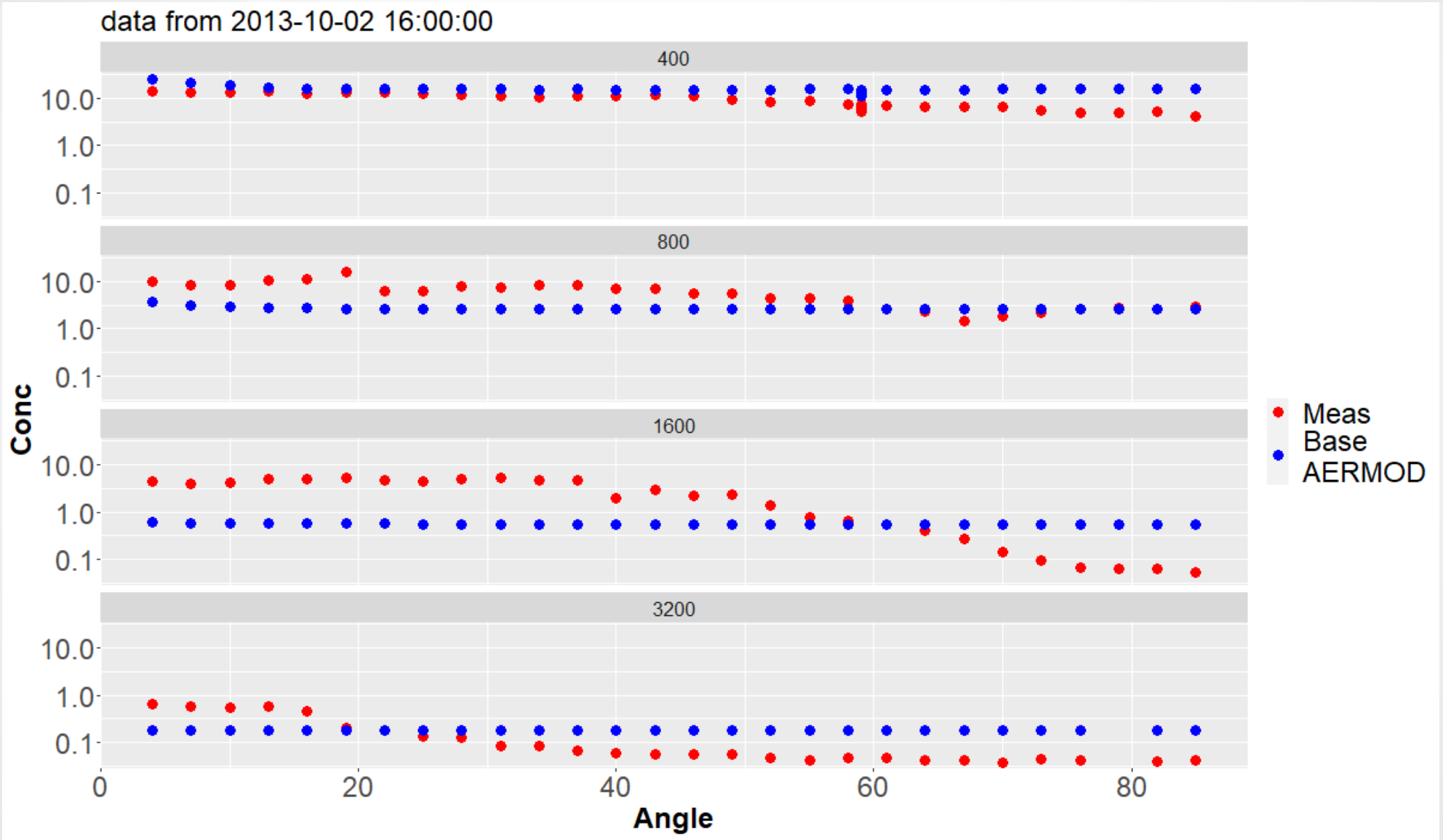
# Day 1a Results, Unstable, Very Light Winds



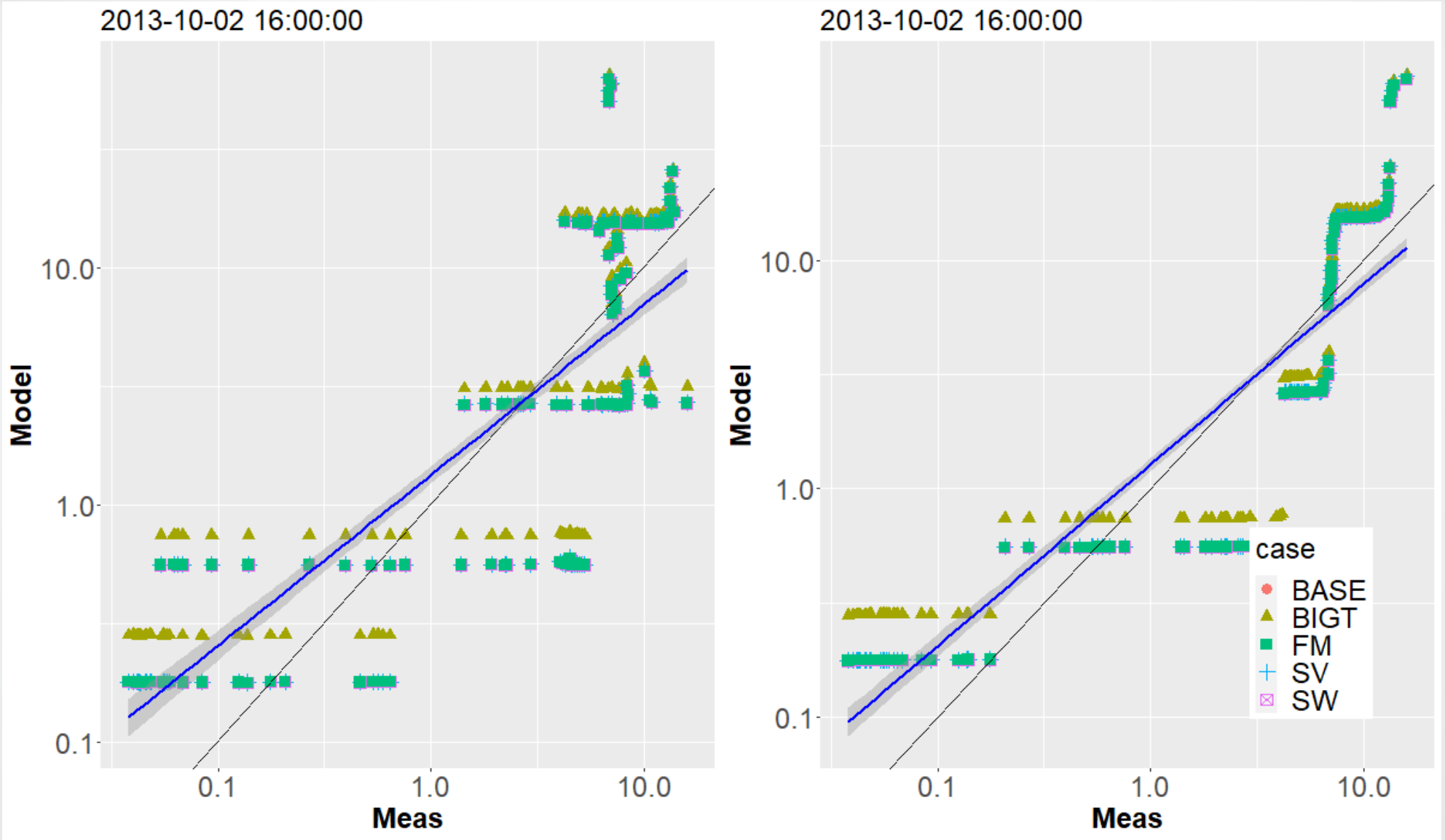
# Day 1a Results, Low Wind Options



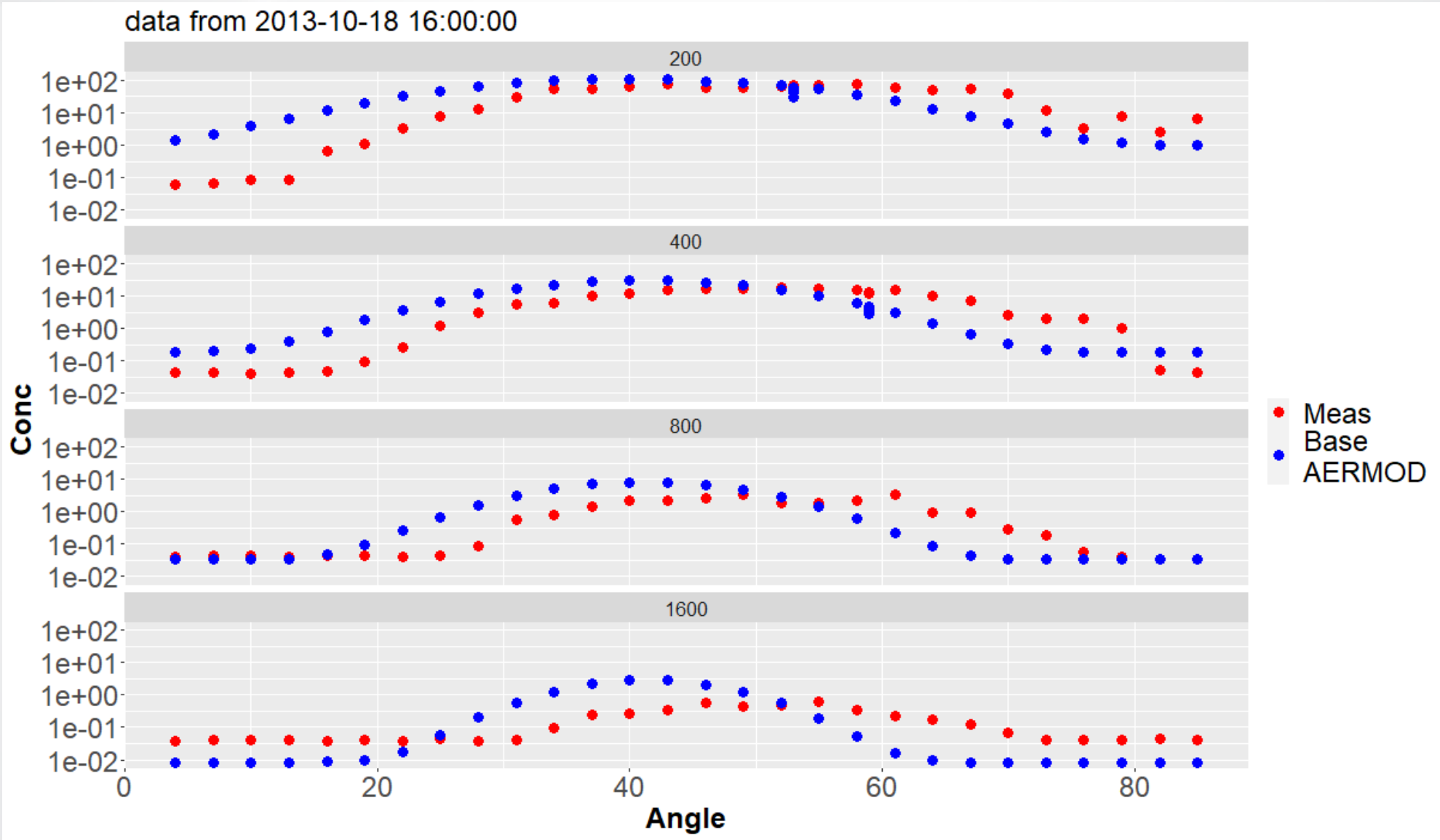
# Day 1b Results, Unstable, Very Light Winds



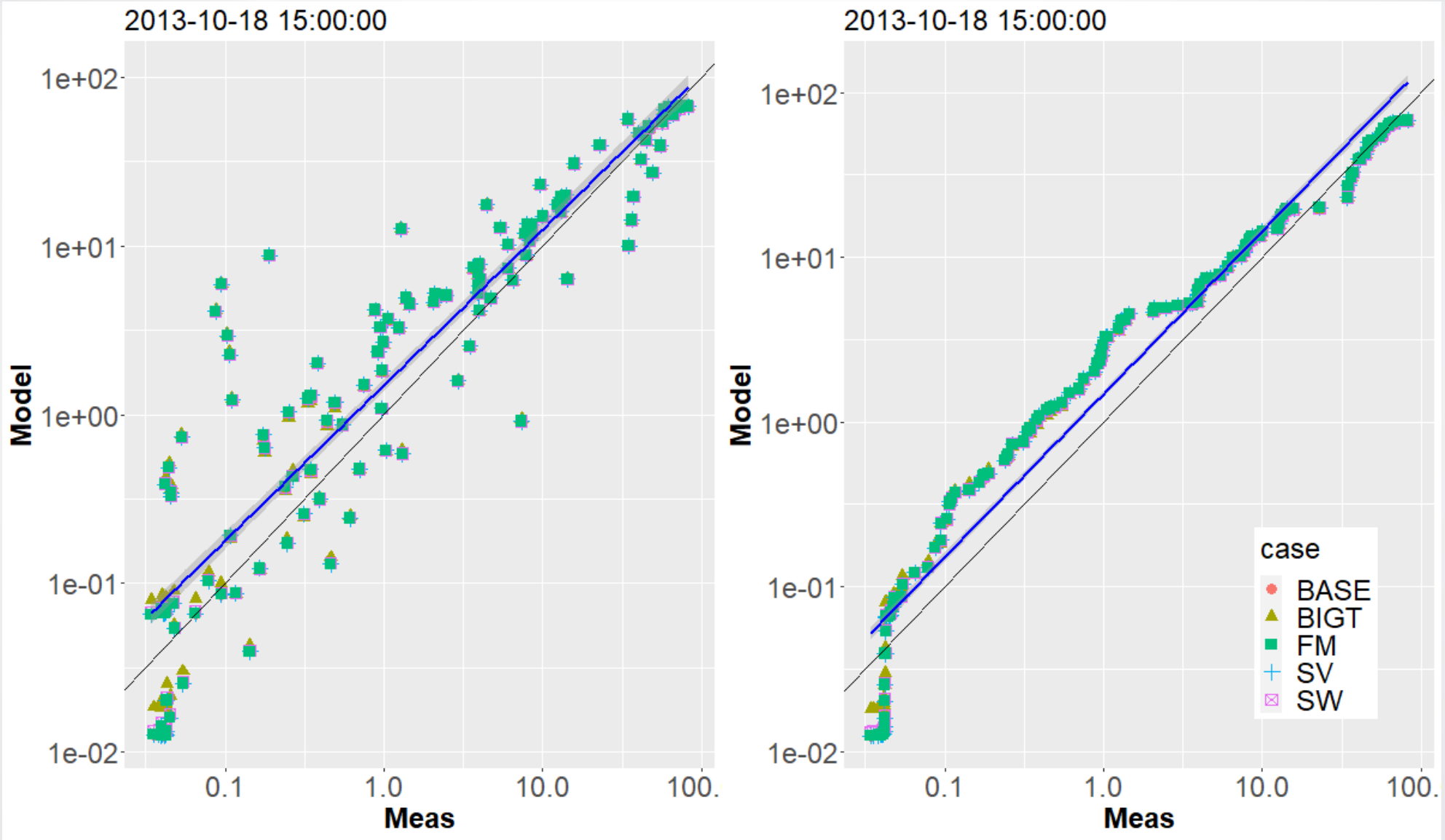
# Day 1b Results, Low Wind Options



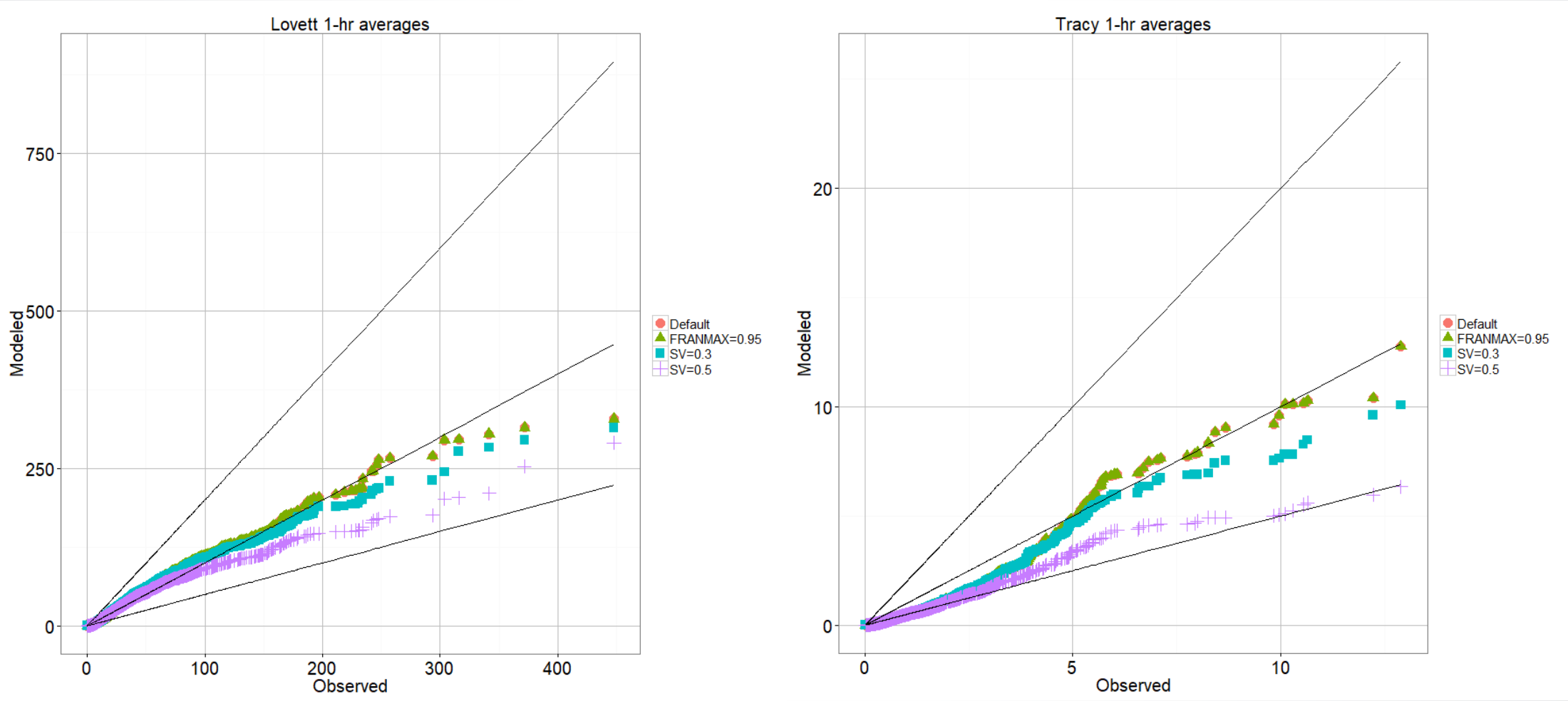
# Day 5, Weakly Unstable, Moderate Winds



# Day 5, Weakly Unstable, Low Wind Options



# Previous Work With Existing LW Options




Owen, et al, Adjustments to improve AERMOD performance during low wind conditions, Harmo Conference, Bruges, Belgium, June, 2019