Evaluation of OML and AERMOD

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Background for the study

- The Danish regulatory model OML was developed at NERI, basically in the 1980's.
- OML is a Gaussian model, belonging to the same family of models as AERMOD and ADMS.
- This presentation is based on a recent review of the OML model where we investigated the effects of revising the model in certain respects.
- Technical report: *OML: Review of model formulation* (available on web, reference in paper)

This presentation describes just one corner of the entire study…

- Here: Prairie Grass
- Also considered Kincaid data, Borex experiment, Copenhagen experiment
- Further, studied the building algorithm. Considered use of PRIME algorithm.
  Note: A very instructive data set on buildings was compiled by Roger Thompson. It is put in a handy form by us (Excel sheets accessible through the Atmospheric Dispersion Wiki)

Models considered

- OML: Danish regulatory model. We have examined a new 'Research Version' in parallel with the old Standard Version.
- AERMOD (version 04300)

New in the OML 'Research version'

- **More elaborate treatment of wind speed** (for plume transport). Instead of wind speed at plume centerline height, wind speed is integrated over vertical extent of the plume (most important for very low sources).
- Parameterisation of **lateral dispersion** (σ_y) revised. In the Research Version, for stable cases with low wind speed, the simulated plume is more narrow than in the standard version.

New in the OML 'Research version'

- In the standard version, **parametrisation of vertical dispersion** is purely Gaussian. In the *Research Version*, a new model formulation allows for "vertical meandering" of the plume, combined with a Gaussian shape of the basic plume.

Prairie Grass

- Classic experiment conducted in 1956.
- Source close to ground level: 46 cm
- Closely spaced monitors at arc distances of 50 m, 100 m, 200 m, 400 m, 800 m.
- Averaging time: 10 minutes
- Wind speed profile measured at heights 0.25 m, 0.5 m, 1 m, 2 m, 4 m, 8 m, 16 m
- Roughness height generally found to be 6 mm

Evaluation is not simple

- Statistical performance measures (metrics) provide only limited information.
- Need for exploratory data analysis!

Emphasis on exploratory data analysis

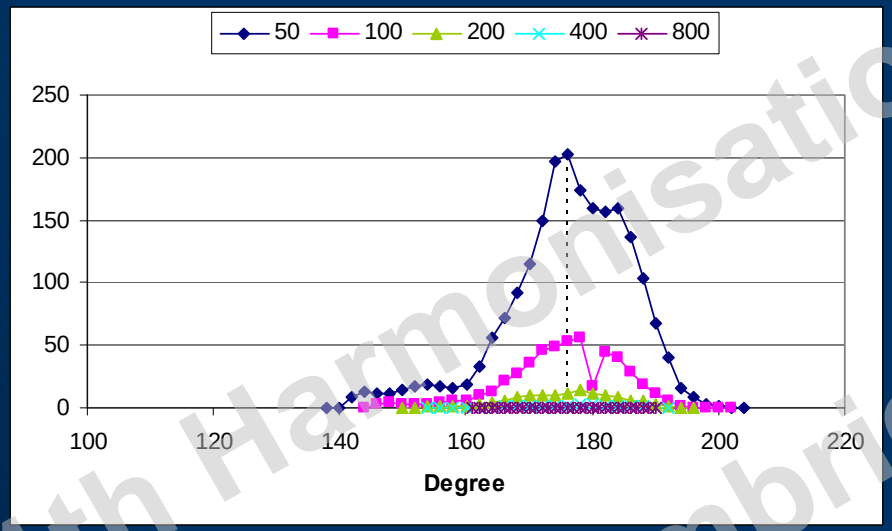
- We have pursued a very detailed approach
- Experimental data, modelled data and graphs have been collected in a single Excel file, enabling us to examine details.

Emphasis on exploratory data analysis

- Keep in mind: For an individual experiment deviations between observation and model are natural. Agreement can only be expected for an ensemble average.

Concentration along 5 arcs. Run 5

Observed concentrations



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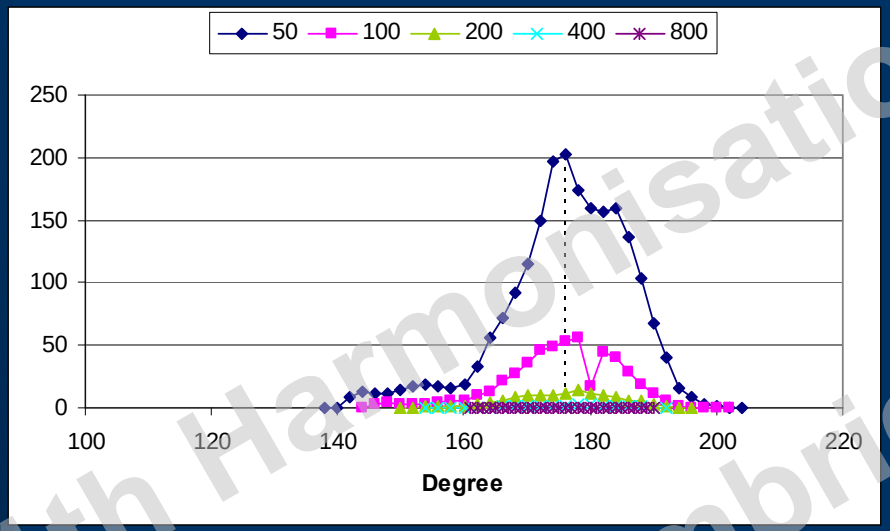
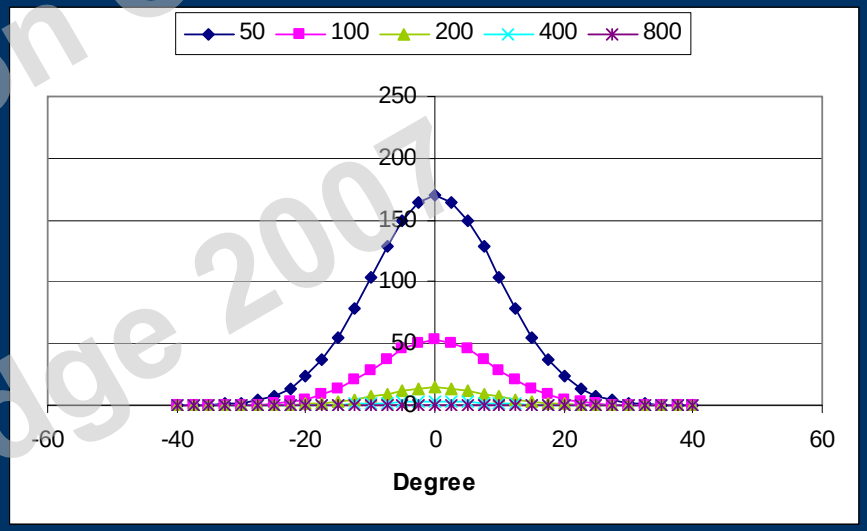


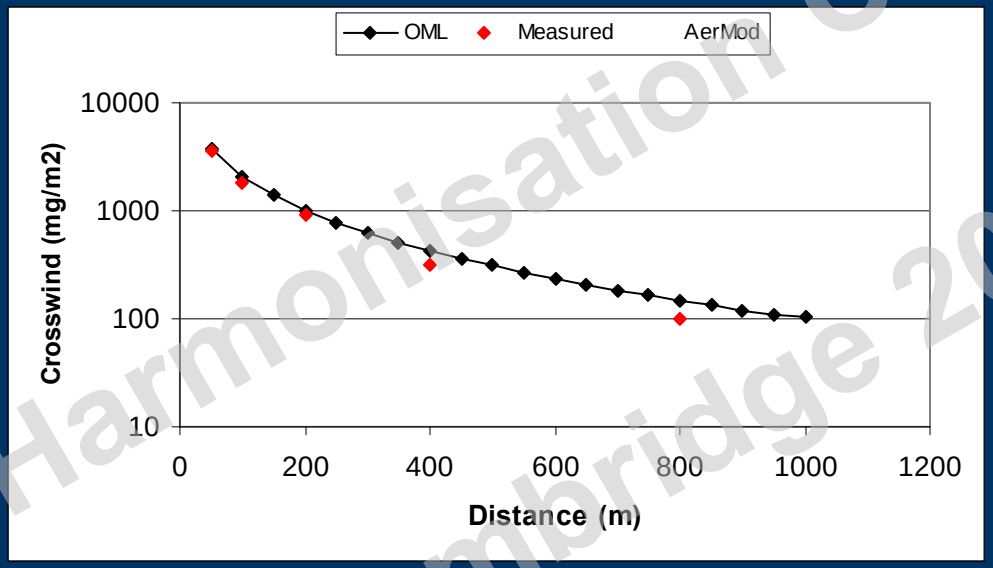
Modelled (OML Research Version)



Effect of averaging time

- A plume averaged for 10 minutes can be expected to be narrower than a plume averaged for 60 minutes.
- OML and AERMOD predict 60-minute averages. Thus, modelled plumes are expected to be wider than observed.
- To avoid this problem, here emphasis is on **cross-wind integrated concentrations.**

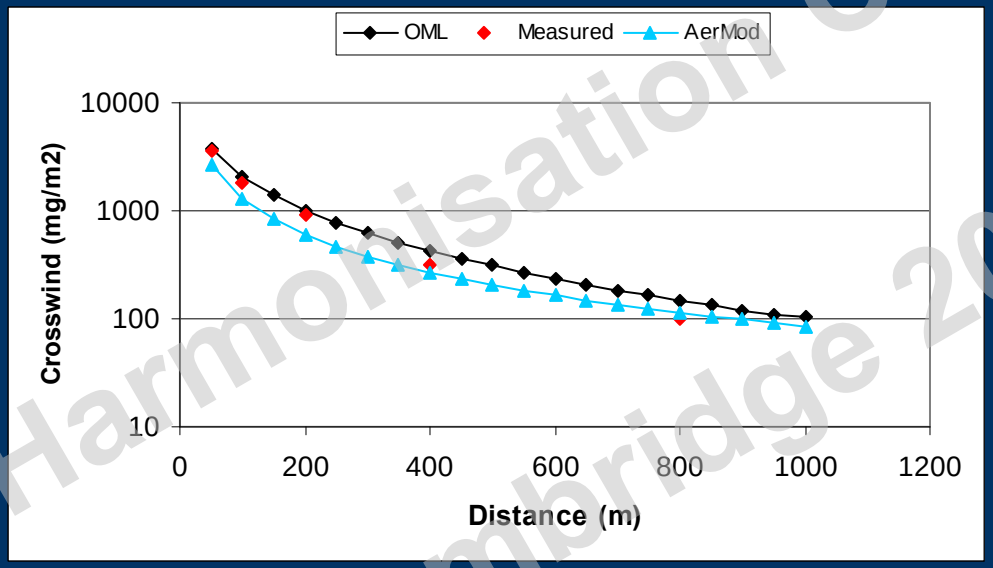
Cross-wind integrated concentration as a function of distance, run 5



OML Research Version (black line) and measurements (red)

Note that the scale is logarithmic

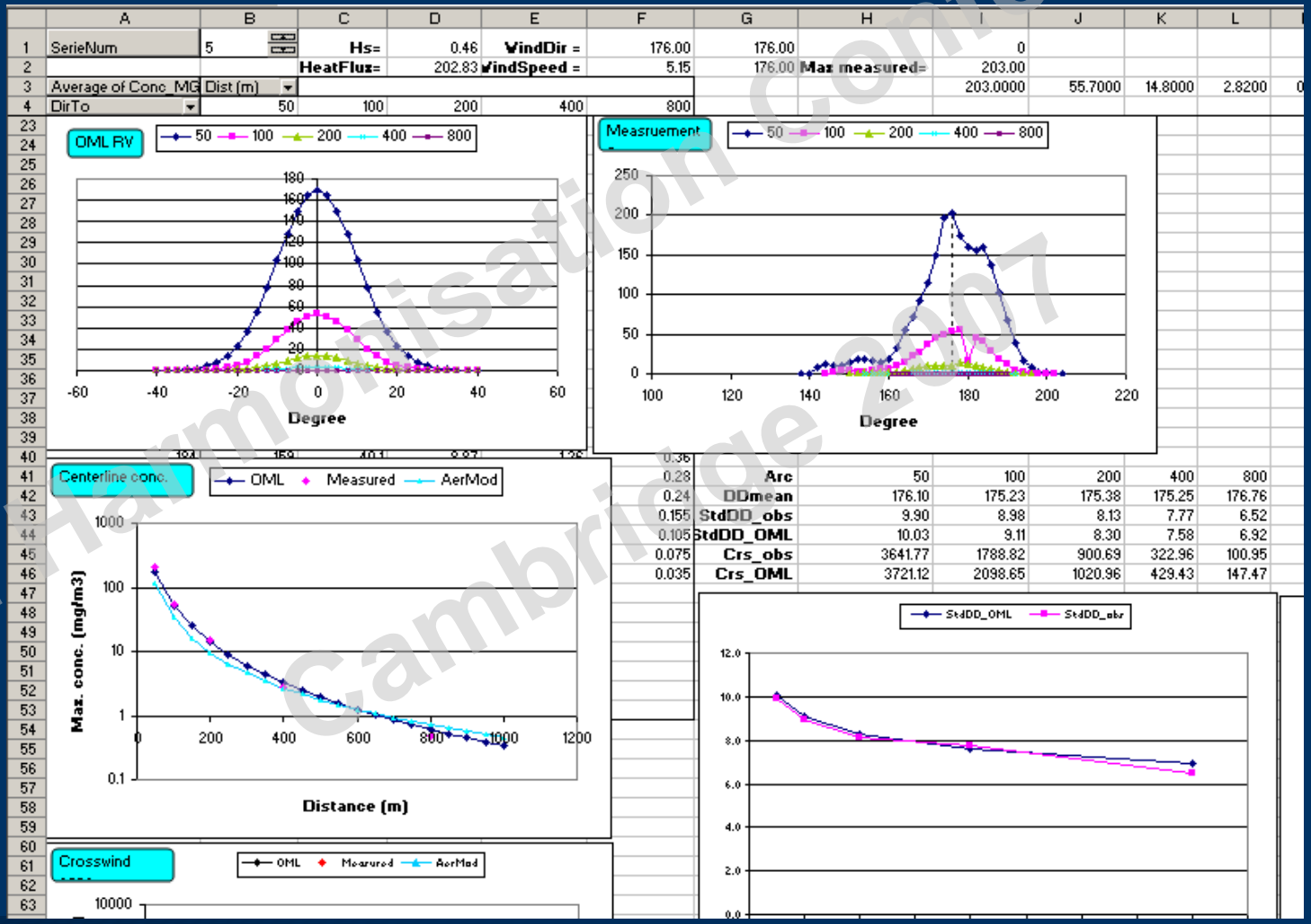
Cross-wind integrated concentration as a function of distance, run 5



OML Research Version (black line) and measurements (red)

AERMOD (light blue line) added

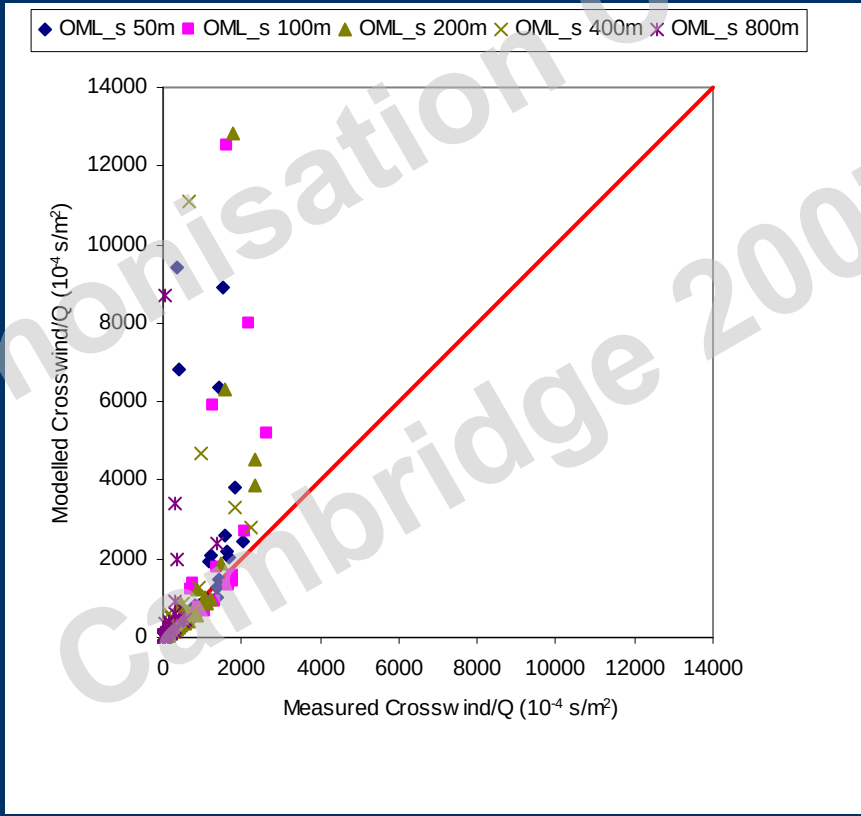
An Excel sheet gives dynamic access to several graphs



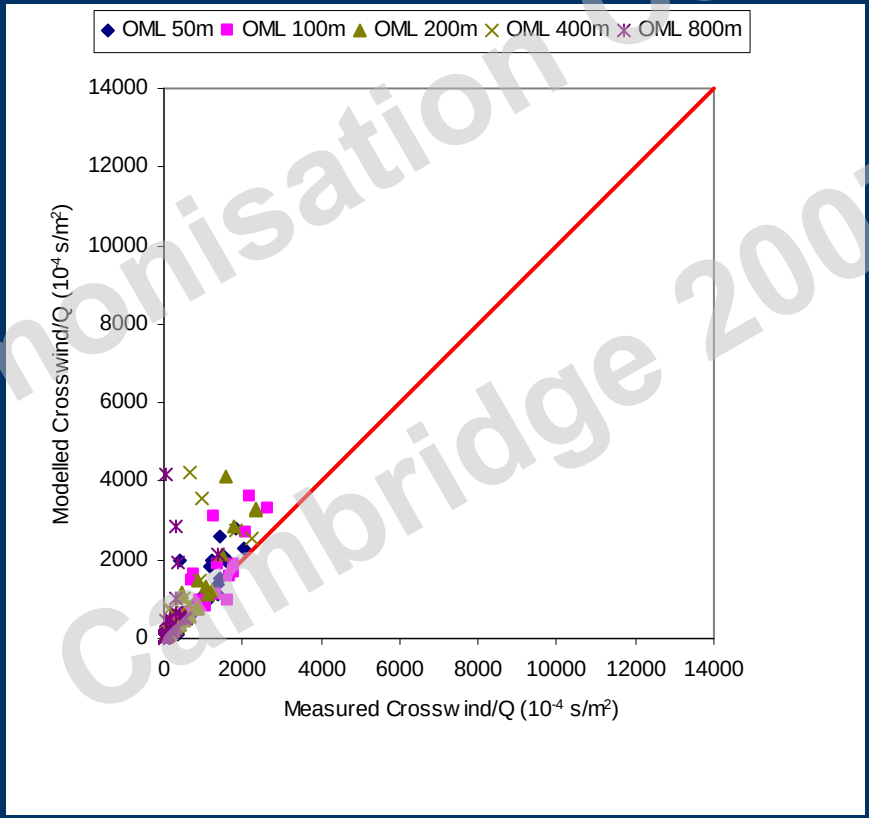
Subsets of Prairie Grass data

- 68 ten-minute experiments during July and August.
- 4 of these have non-standard release height (1.5m instead of 46 cm). This leaves 64 runs.
- Various researchers have used different subsets. The US EPA uses only 44 runs in their AERMOD evaluation.

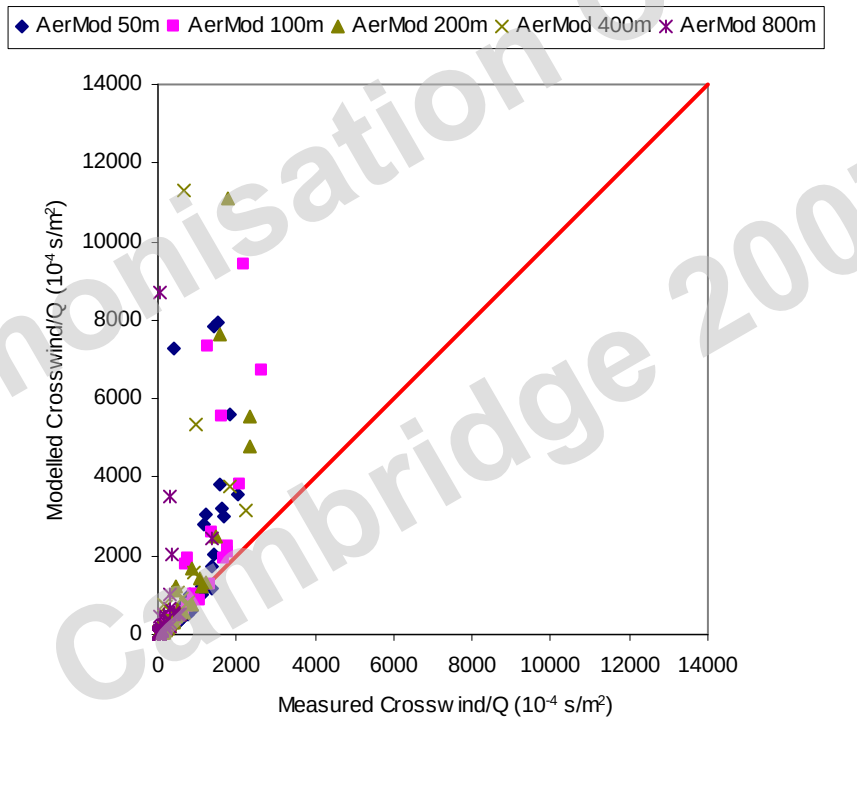
OML, standard version. All 64 runs.



OML research version. All 64 runs

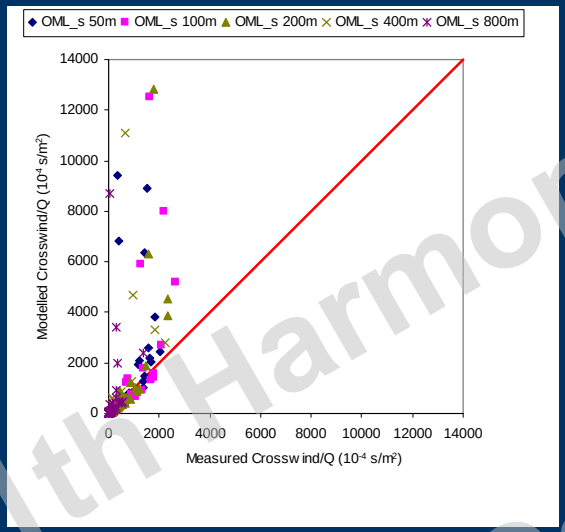


AERMOD. All 64 runs



64 runs, all 3 models

OML standard



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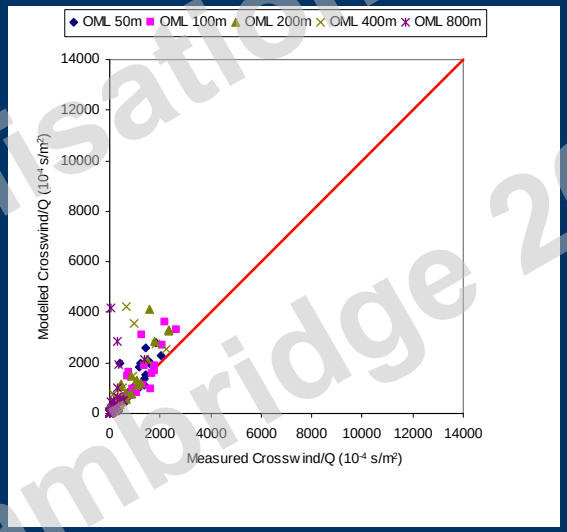
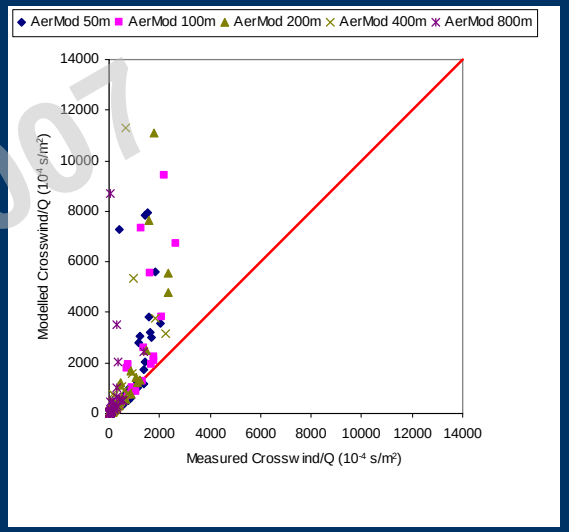


AERMOD



Detective work on the outliers

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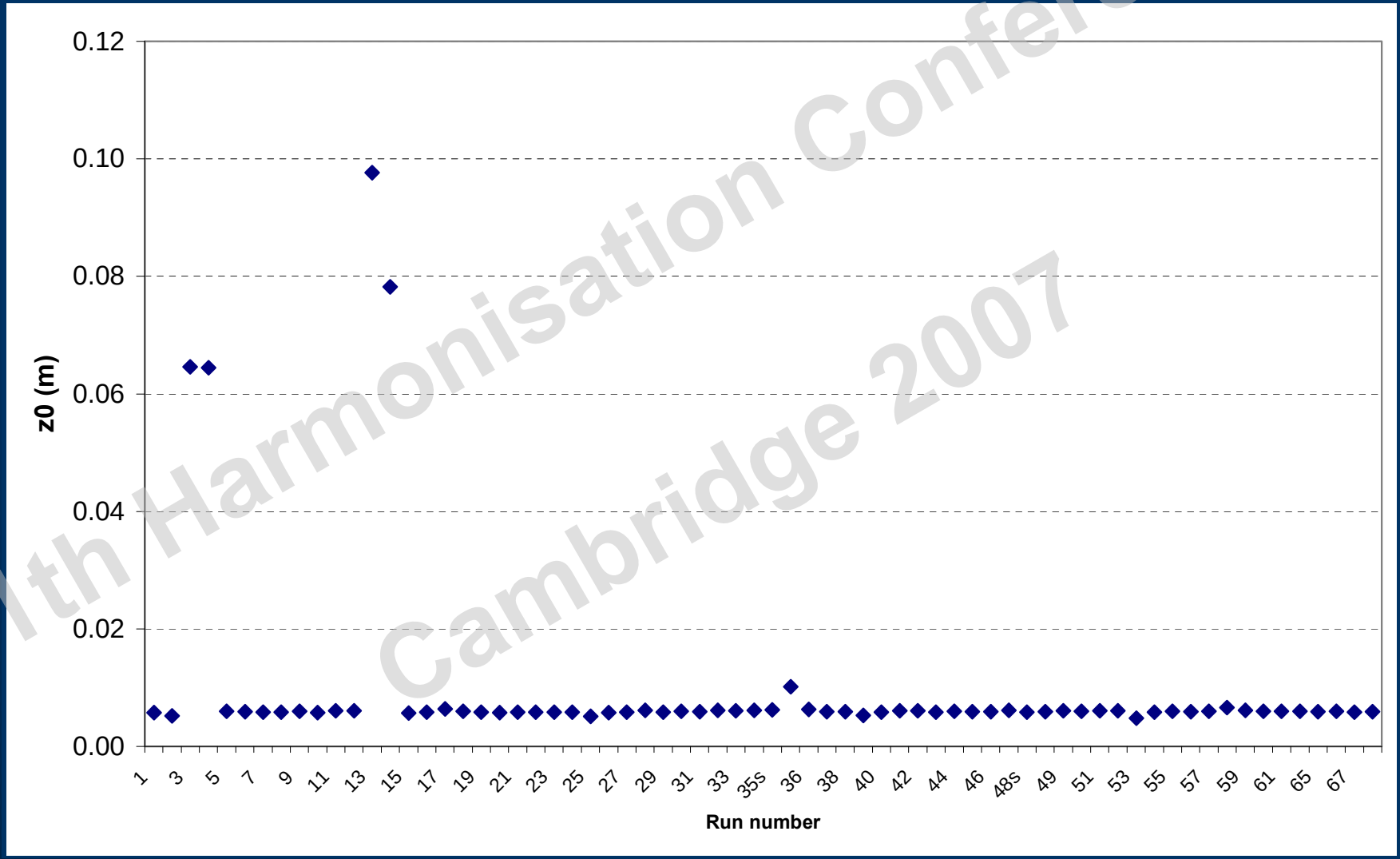
- Very stable conditions
- Let's look at meteorology...

Roughness length for each run



The four peculiar runs

- Runs 3, 4, 13 and 14 have abnormal meteorology.
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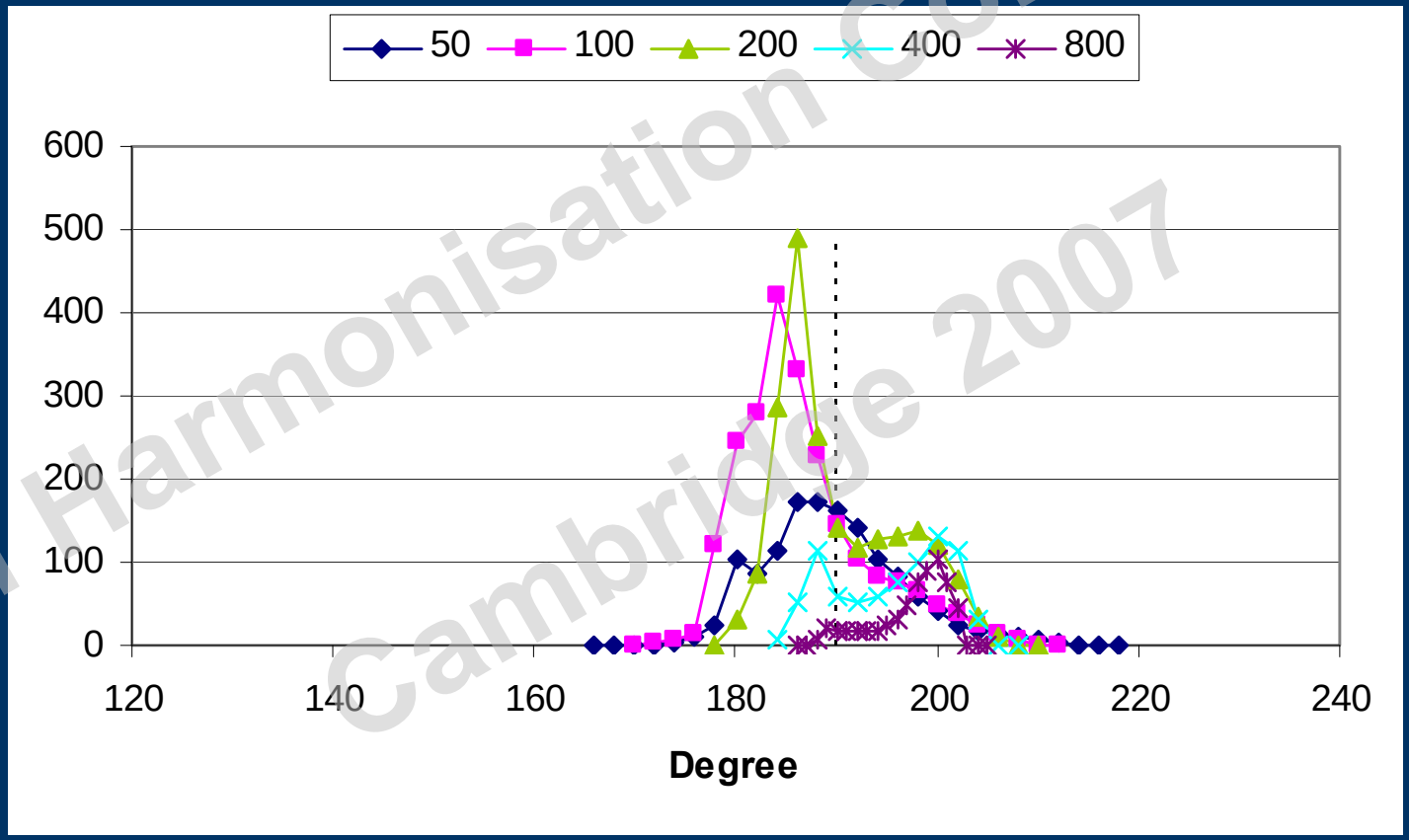
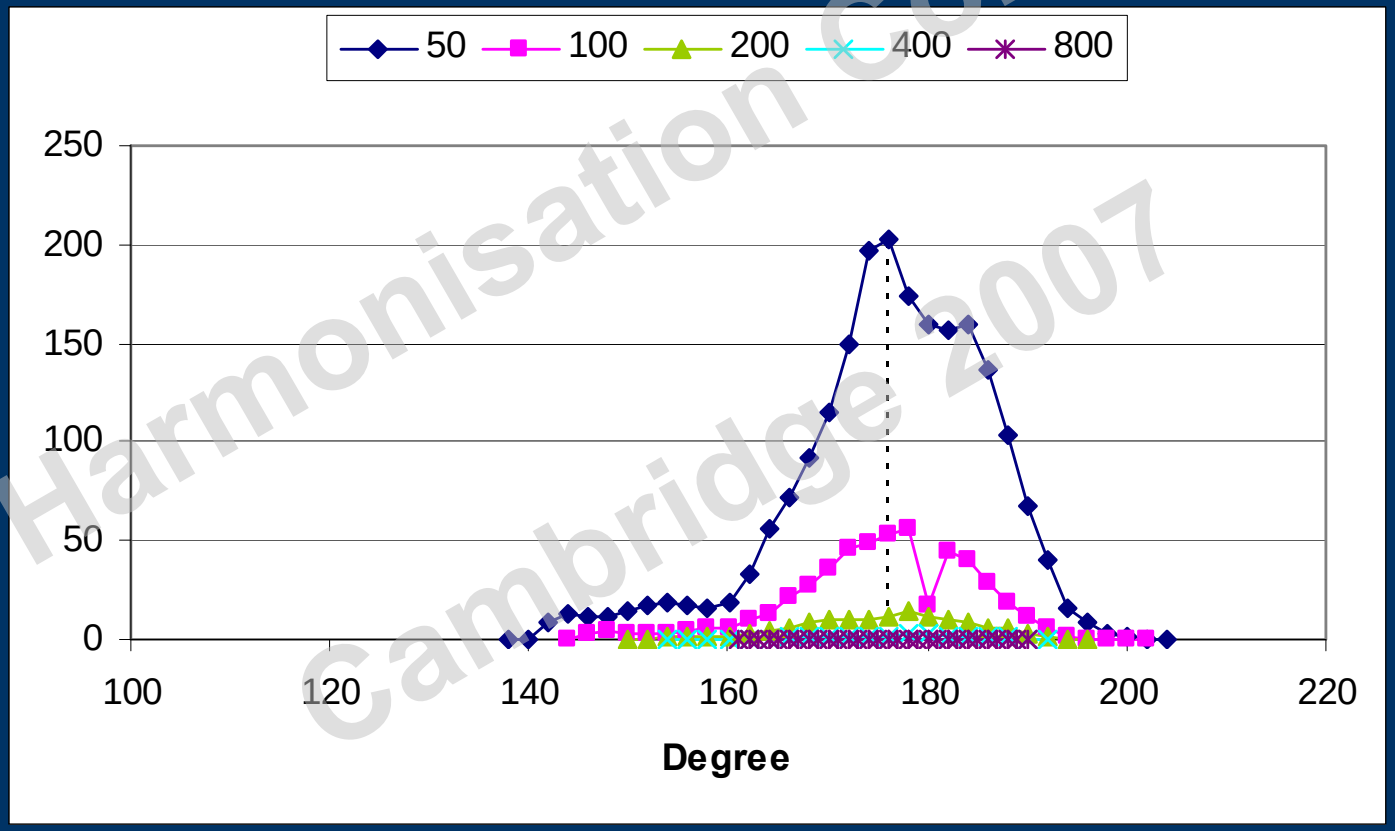
- For these runs roughness height is above 6 cm instead of 6 mm.
- Let's look closely at concentrations

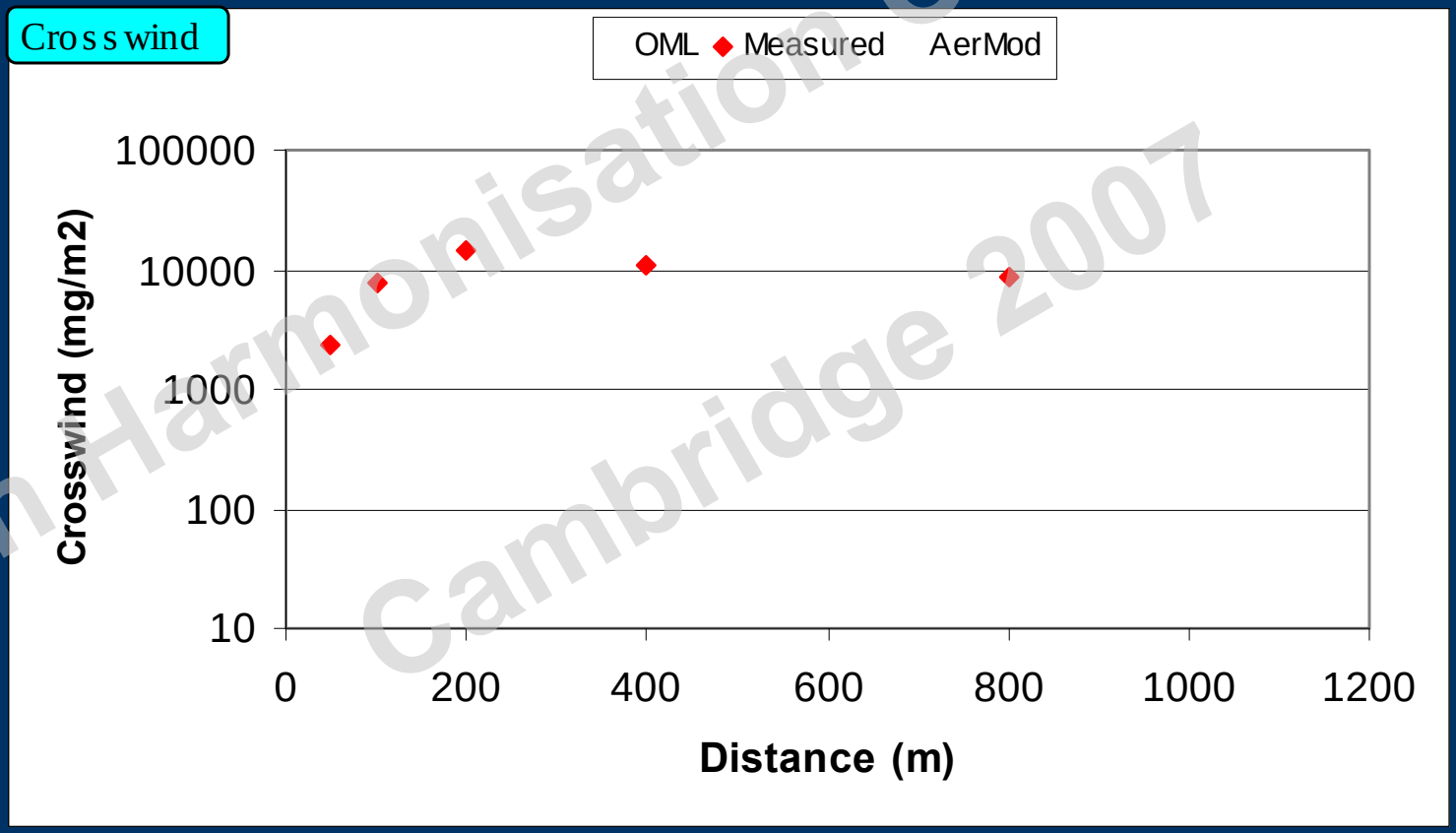
Run 13 – concentration



Run 5 once more – concentration



Run 13 – variation with distance



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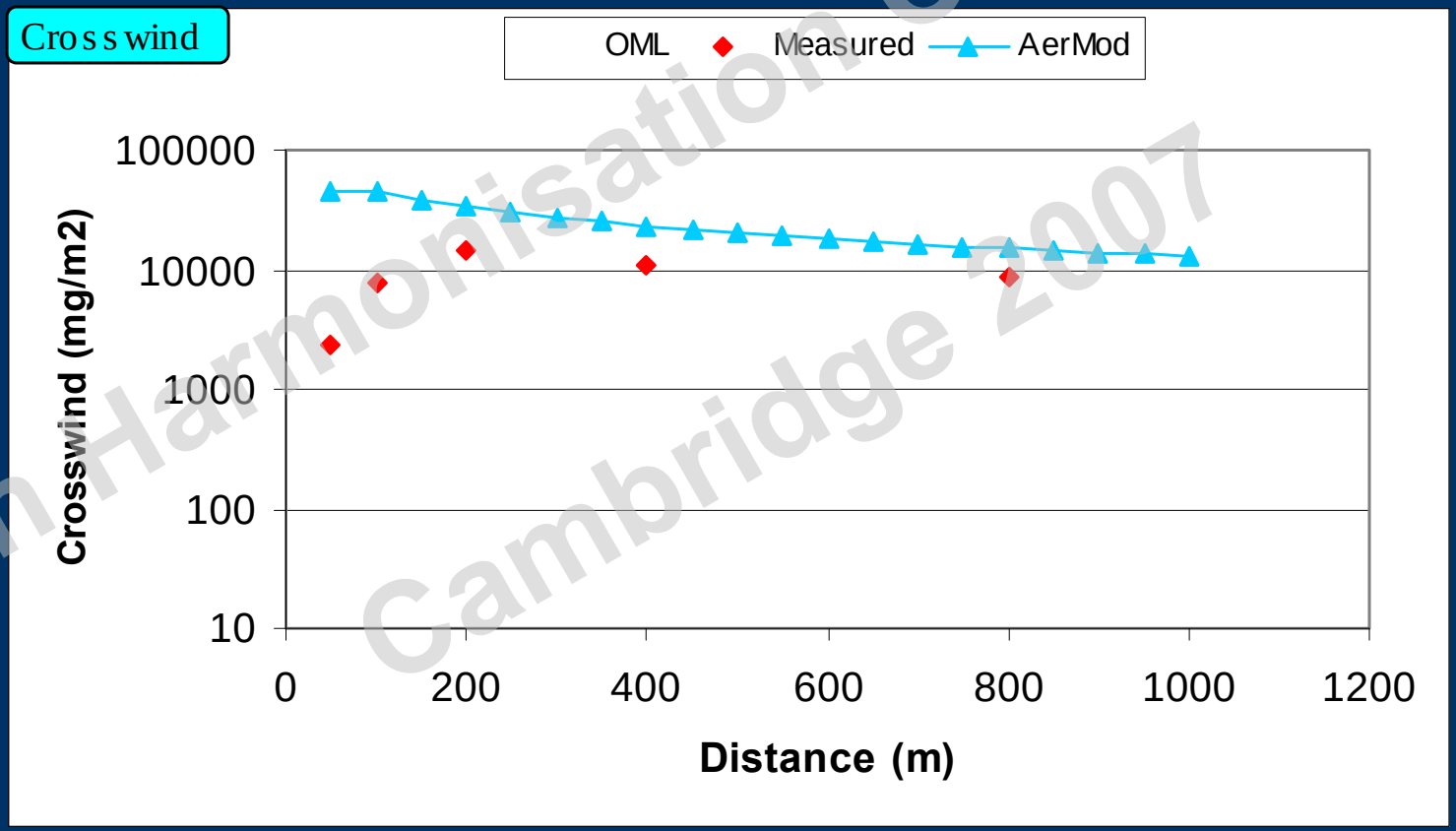

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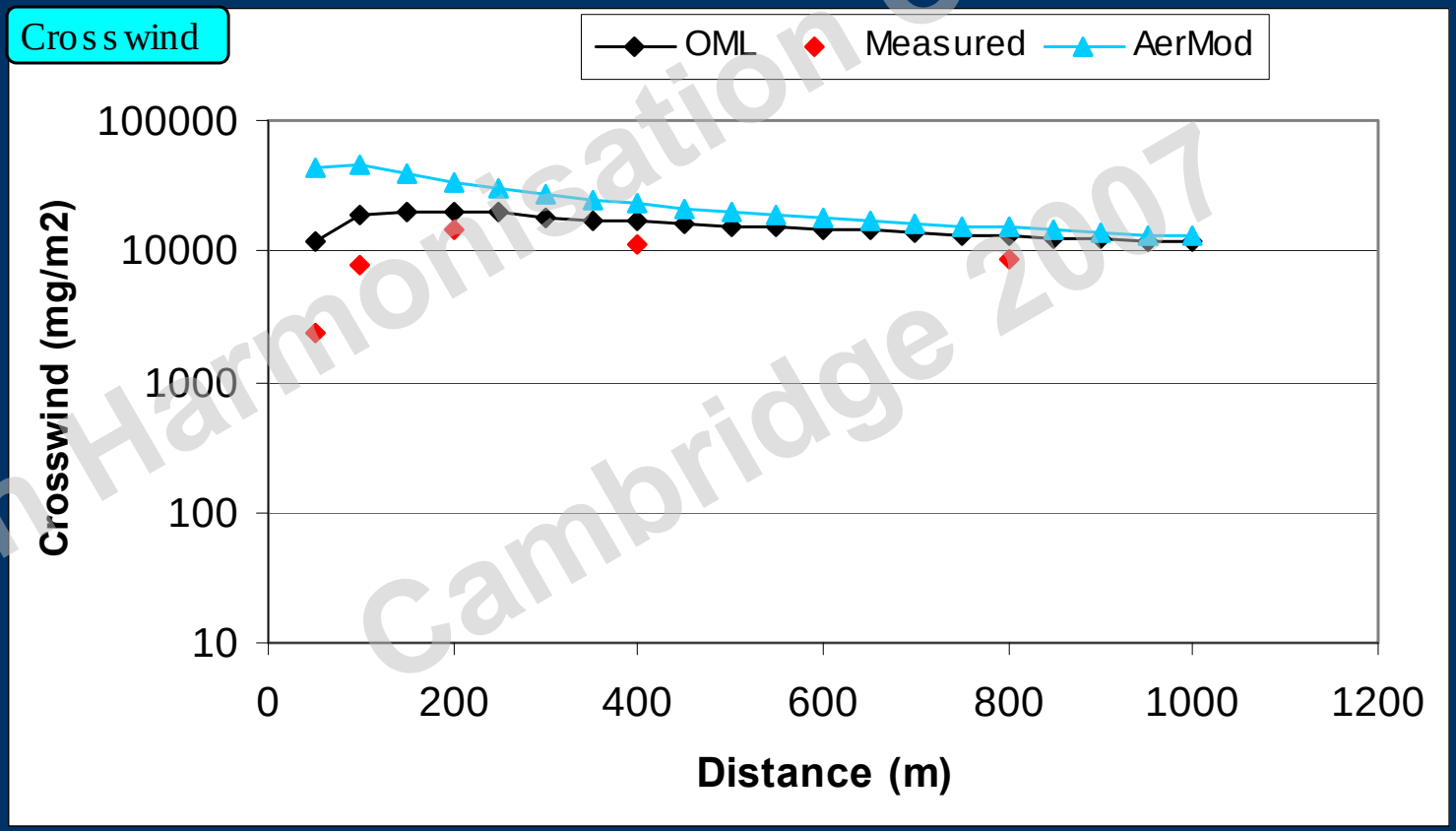

Prairie Grass: Release and monitors

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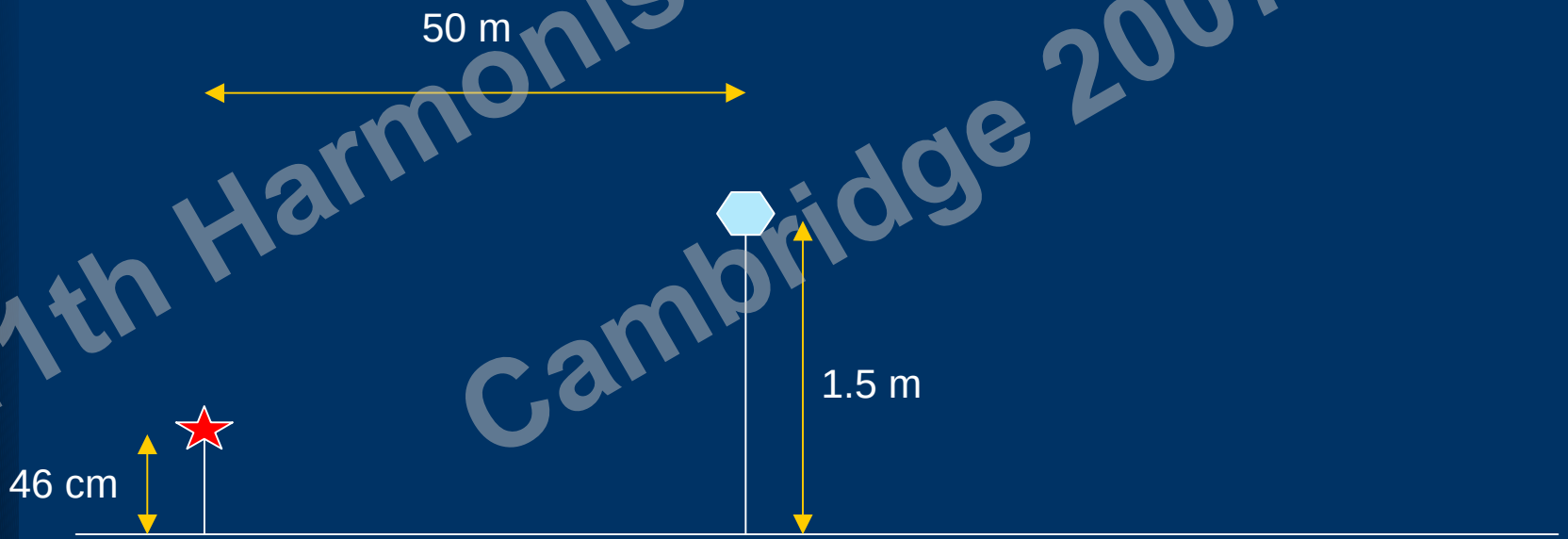

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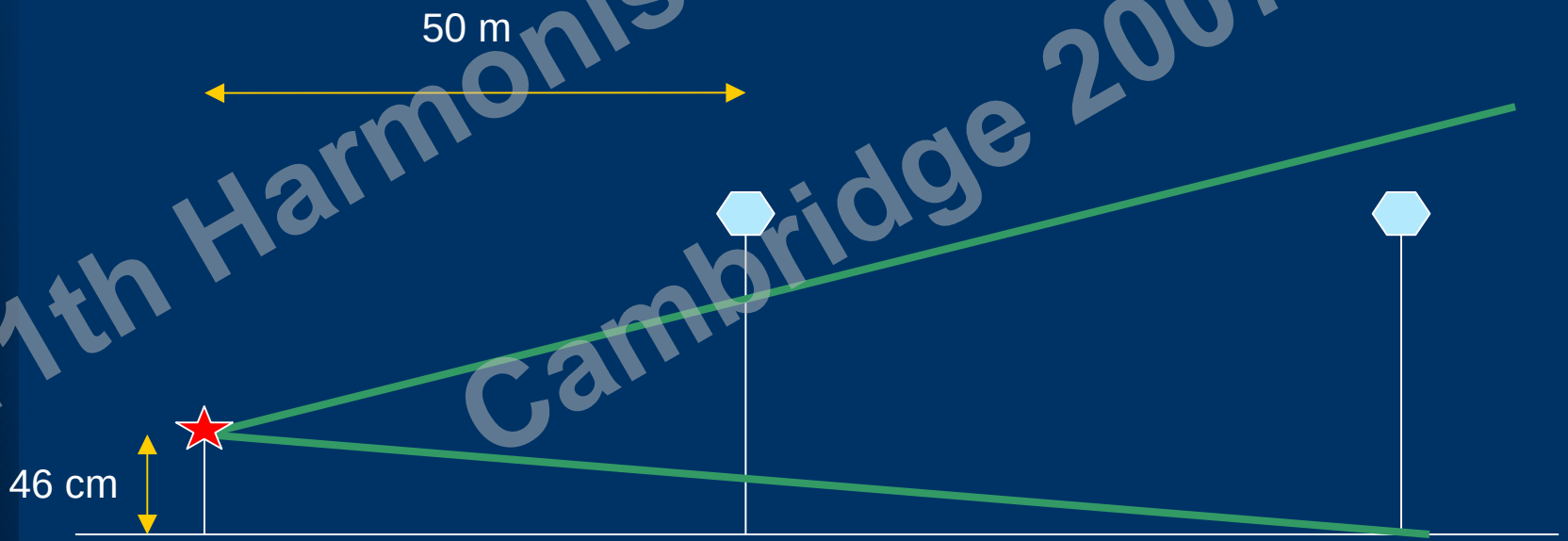
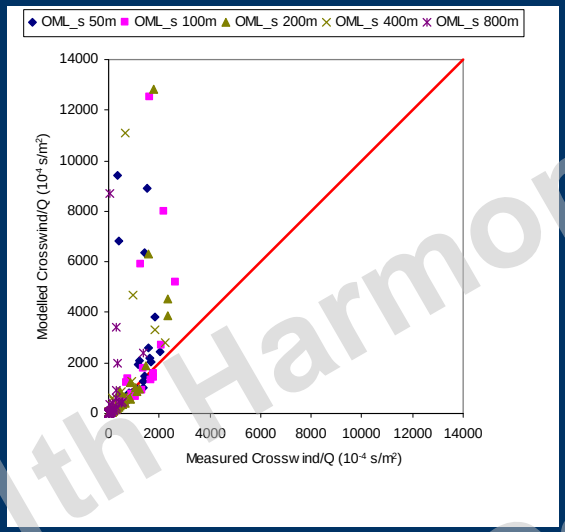


64 runs, all 3 models

OML standard



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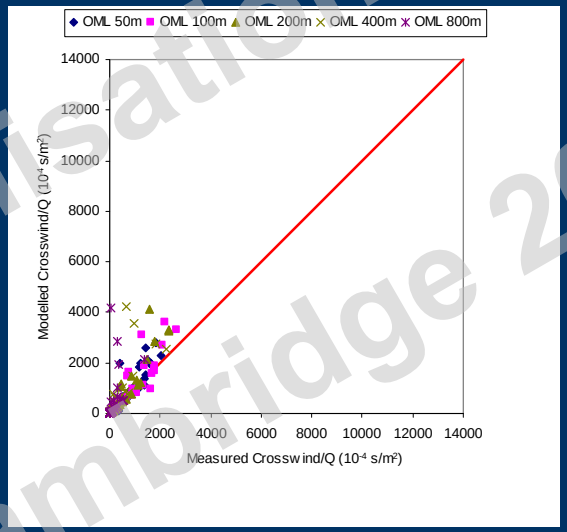
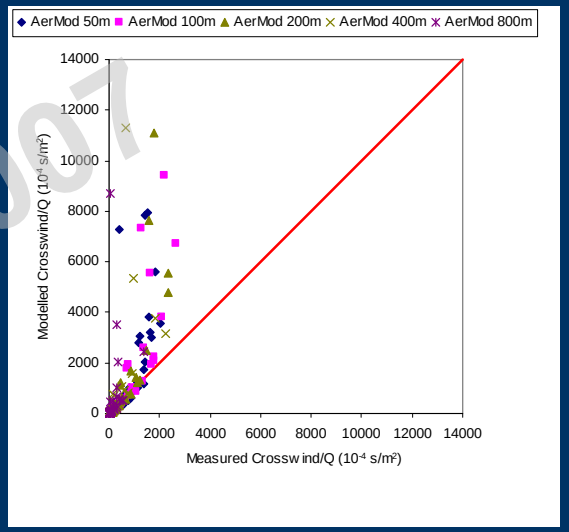


AERMOD



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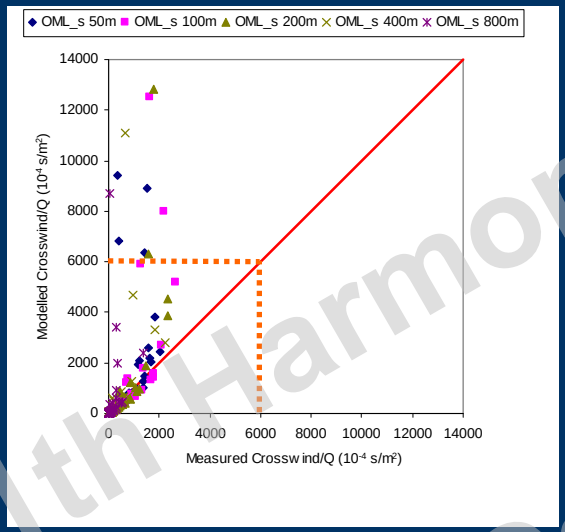

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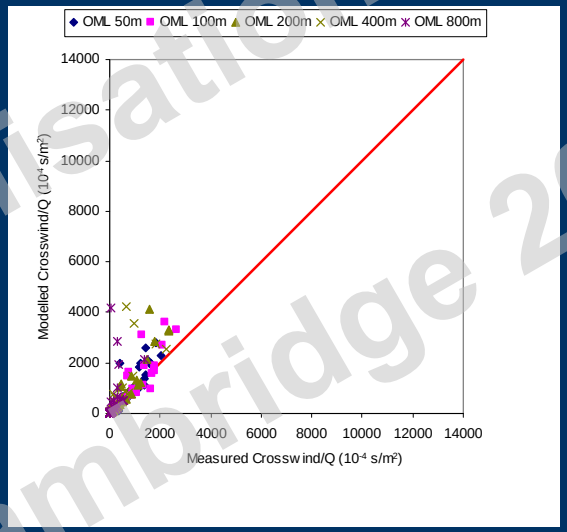

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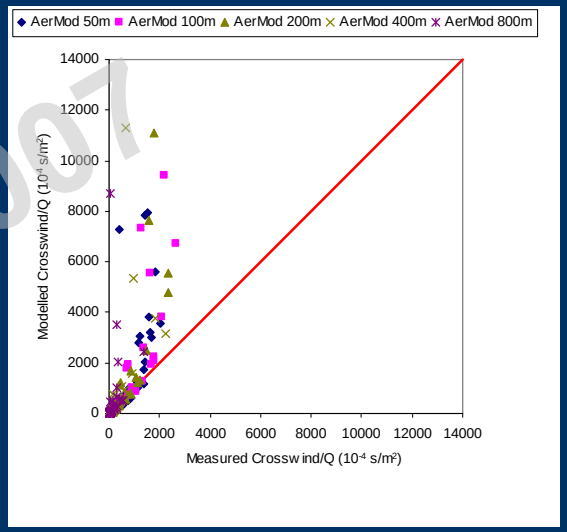
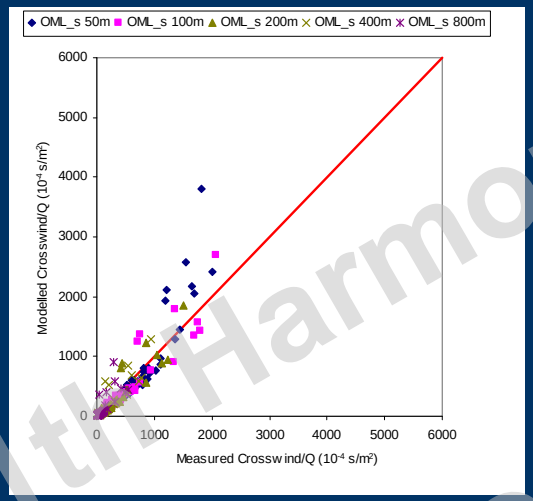


The 'gang of four' omitted. 60 runs. Note the scale.

OML standard



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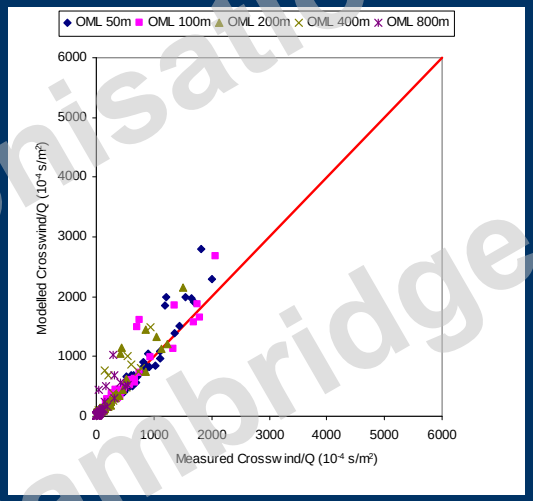

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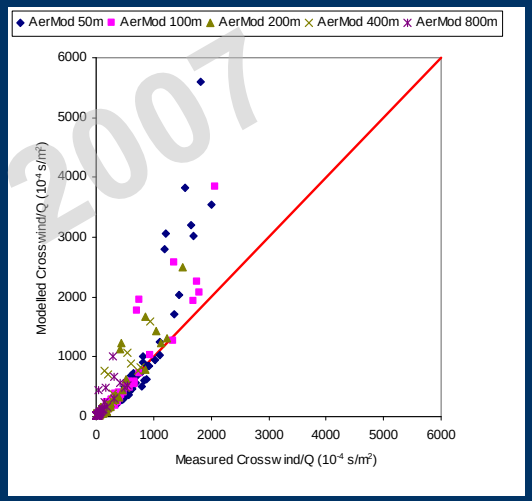


Metrics: Fractional Bias

$$FB = \frac{\left(\overline{C_o} - \overline{C_p}\right)}{0.5\left(\overline{C_o} + \overline{C_p}\right)}$$

Fractional bias, measuring systematic error on a linear scale

FB is bounded between -2 and +2.

FB = -0.67 for a factor of two overprediction

Metrics: Fractional Bias

	OML St.	OML Rv	AERMOD
64 runs	-0.55	-0.28	-0.61

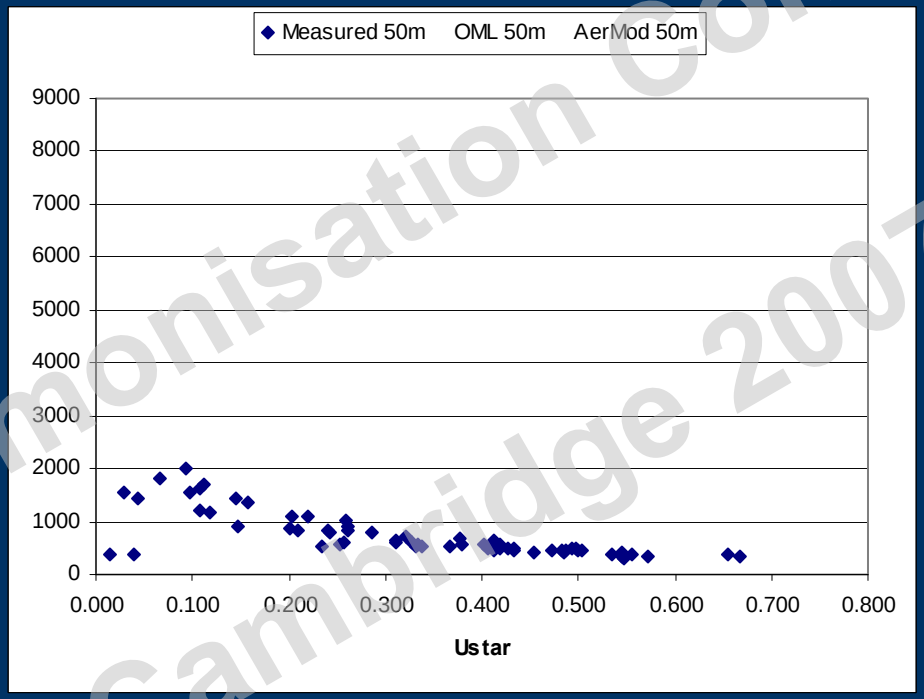
Metrics: Fractional Bias

	OML St.	OML Rv	AERMOD
64 runs	-0.55	-0.28	-0.61
60 runs	0.03	-0.13	-0.17

Comment

- **Be careful about metrics!**
  For metrics to be meaningful you must know a lot about the underlying data.
  Metrics should be computed on exactly the same basis if several models are involved.

50 m arc. 64 runs.
Measurements and simulations as function of u_*.
OML Research Version and AERMOD.



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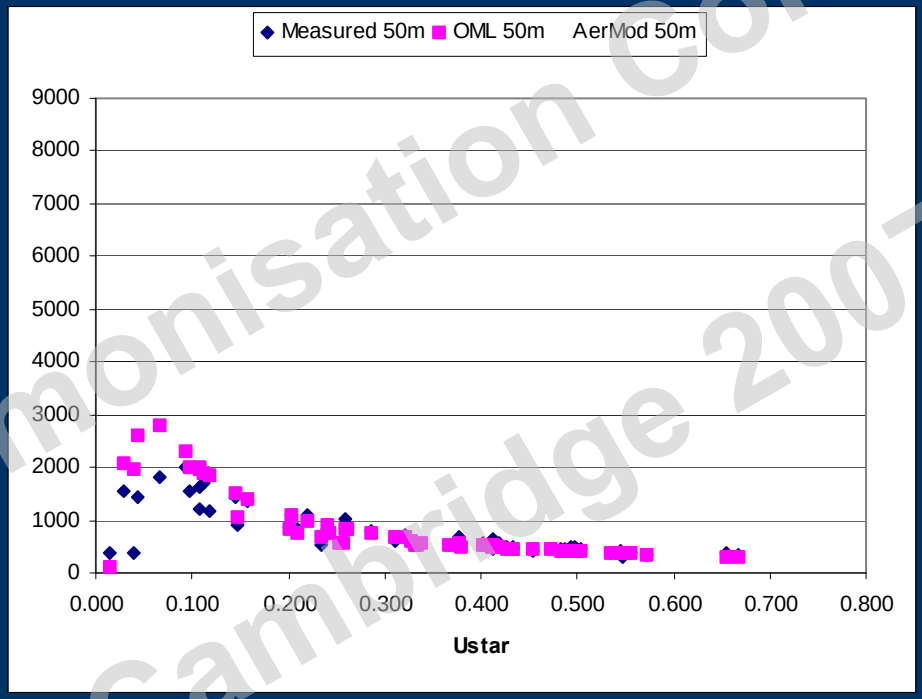

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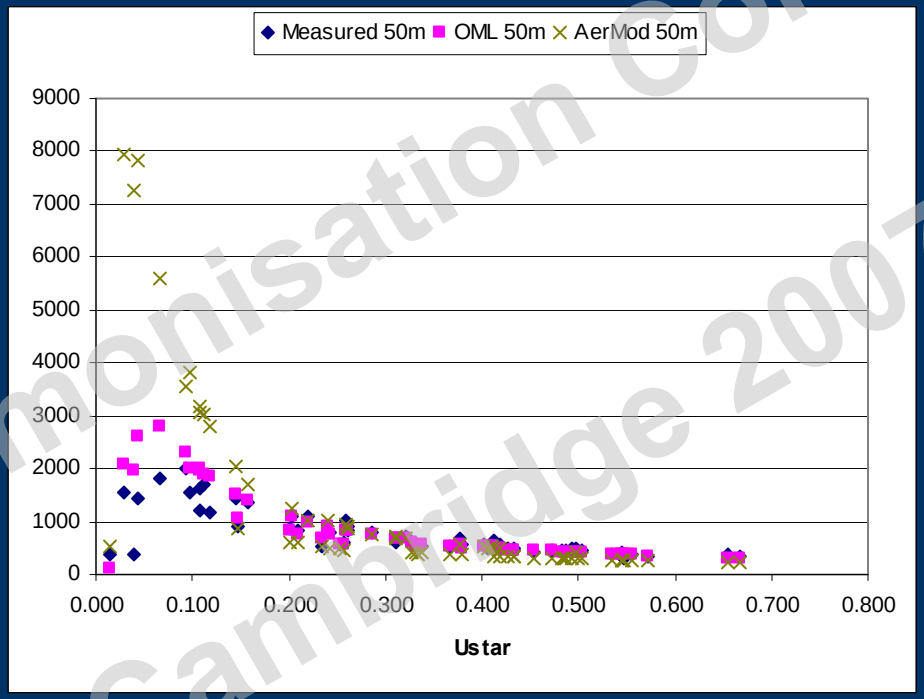


Comment

- We can put the data from 'the gang of four' aside, and for a while focus on other data to assure that our model performs well for these.
- However, it remains a problem that the models are very sensitive and can give extreme results for stable cases with small u_*.

How about unstable cases?

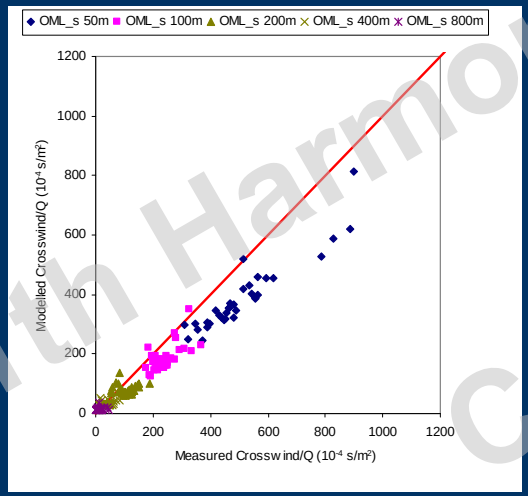
- **Stable cases dominate metrics and graphs.**

How about unstable cases?

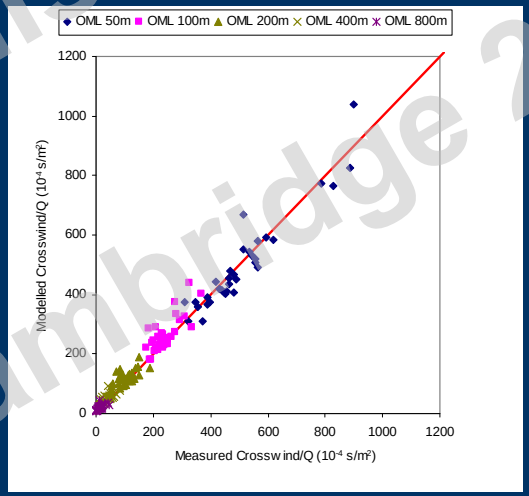
- Stable cases dominate metrics and graphs.
- Let's now focus on unstable cases.

Unstable, 34 runs. The dominating effect from stable runs is eliminated

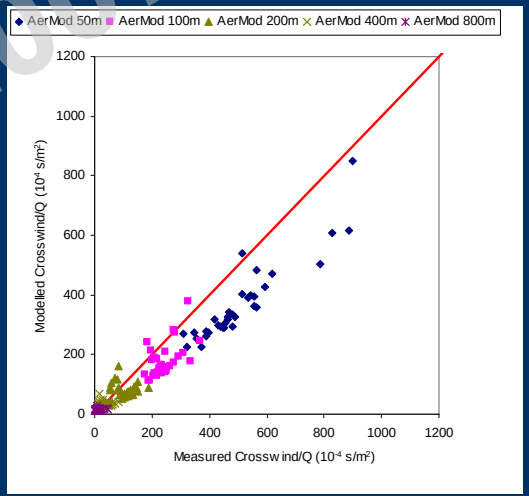
OML standard



OML Research Vers



AERMOD



Statistics, unstable runs

	OML St.	OML RV	AERMOD
FB	0.26	-0.04	0.30

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Statistics, unstable runs

	OML St.	OML RV	AERMOD
FB	0.26	-0.04	0.30
NMSE	0.19	0.03	0.26
FA2	0.89	0.89	0.85

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The Atmospheric Dispersion Wiki

- A potential focal point to pool and communicate experiences on such data sets as Prairie Grass

Page on Prairie Grass data

Hro my talk my preferences my watchlist my contributions

article | discussion | edit | history | protect | delete | move | watch

Prairie Grass

Contents [hide]

The Prairie Grass data set [edit]

Basic information on the data set [edit]

The Prairie Grass experiment is a classic experiment conducted in July-August 1956. A release took place from a point source close to ground level (46 cm height). SO2 was used as a tracer, and concentrations were measured on arcs at distances of 50 m, 100 m, 200 m, 400 m and 800 m. The duration of each of the 68 sampling periods was 10 minutes. The original data were published in a paper report (Barad, 1958).

Many researchers have used the data, but there is no official, digital version of the data.

Experiences with the data set [edit]

There is a total of 68 runs (10-minute sampling periods) from the months of July and August. 4 runs had a non-standard release height. A subset of 4 experiments: no. 3, no. 4, no. 13 and 14 - deserve special treatment. These runs are very stable and the meteorological data are not well-behaved. Thus, whereas roughness length z0 is found to be around 6 mm in general, for these 4 runs an estimate based on wind profile data gives a roughness length that is more than 10 times as large. When using AERMOD and to some extent OML the subset of these 4 runs result in very large modelled concentrations. See the conference paper by Olesen et al. (2007) for more details.

Availability of the data set and access to validation studies [edit]

- A package with materials concerning the ASTM Standard Guide for Statistical Evaluation of Atmospheric Dispersion

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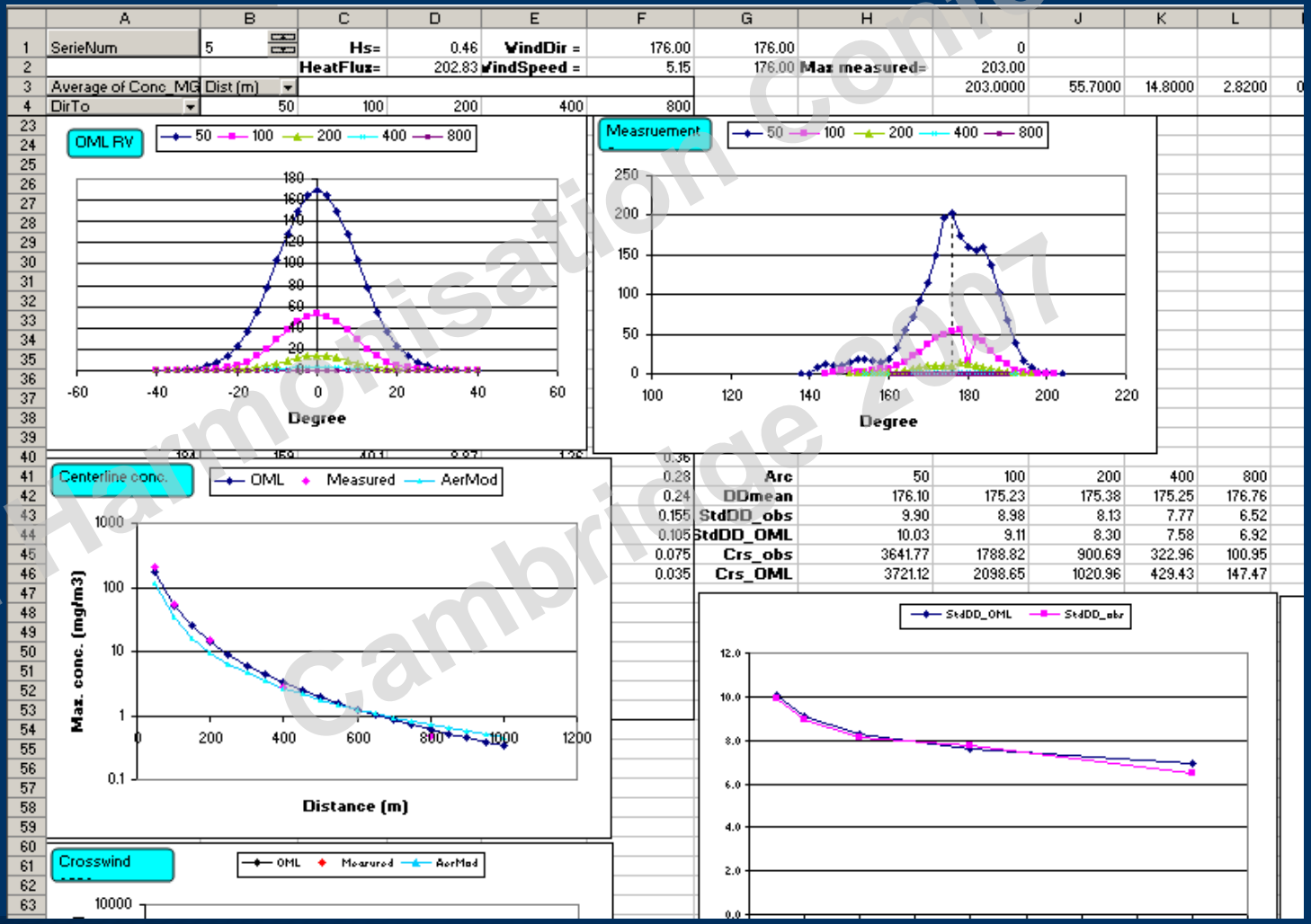
Link to the Excel sheet which gives dynamic access to graphs



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- Four Prairie Grass runs deserve special treatment – they have tremendous influence on evaluation metrics or graphs.
- Very stable cases can give extremely high modelled concentrations.
- For unstable cases, Standard OML and AERMOD tend to underpredict. This is resolved for OML Research Version.
- Generally, OML Research Version gives some improvement over the Standard version.

More conclusions...

- **Be careful about metrics!**
  For metrics to be meaningful you must know a lot about the underlying data. Metrics should be computed on exactly the same basis if several models are involved.
- When preparing evaluation data sets, it is useful to establish **well-defined subsets of data** - otherwise each modeller will create his own, arbitrary subsets.

Concluding...

- The present study is an example of the need to communicate experiences on data sets.
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- The present study is an example of the need to communicate experiences on data sets.
  In the Prairie Grass data set there are peculiarities that users should be aware of.
- The **Atmospheric Dispersion Wiki is a possible focal point in this context**.

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