

Air4EU case study Oslo II

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Case study Oslo II

◆ Motivation

- To see if a combination of modelling and monitoring can help to improve AQ-assessment close to open roads
- To see if it is possible to use observations at stations close to a road in order to better estimate model input parameters, and thereby reduce the uncertainties in the resulting model concentrations

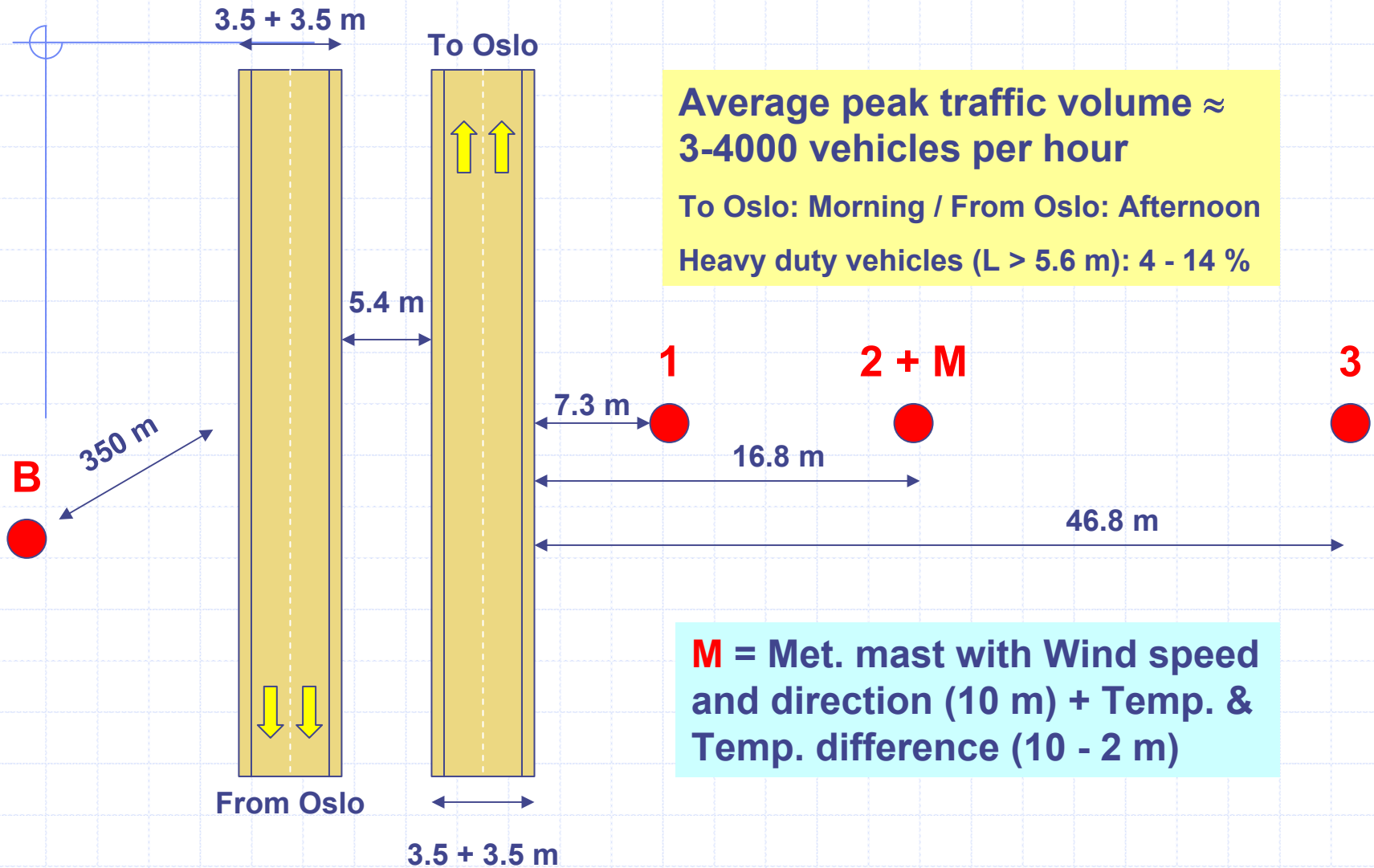
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◆ Data set used

- Nordbysletta close to Oslo
- Single 850 m long roadway with 4 separate lanes
- Measurement campaign 1 January – 15 April 2002

- Hourly data:
 - ◆ Observations of NO_x , NO_2 , O_3 and PM at three stations close to the roadway
 - ◆ Observations of background concentrations of the same species
 - ◆ Wind speed, wind direction and vertical temp. difference
 - ◆ Traffic counting of light and heavy duty vehicles

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◆ Data set filter

- Wind direction between 58 and 238 degrees, i.e., direction of wind towards the stations 1 - 3
- Wind speed above 0.5 m/s at 10 m height
- Traffic with more than 60 vehicles per hour

◆ Resulting data set

- 1038 hours of data from a total of 2520 hours

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◆ WORM – Weak Wind Open Road Model

- Gaussian integrated line source model similar to the CAR-FMI model
- Uses an accurate numerical integration scheme based on Gauss-quadrature to calculate concentrations in receptor points
- Contains a meteorological preprocessor based on Monin-Obukhov similarity theory and COST-710 recommended equations for wind, temperature and turbulence profiles, Lagrangian time scales and mixing height

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◆ WORM – Weak Wind Open Road Model

- Growth of sigma-y determined by new formula from recent article by Oettl et al., (Atm. Env. 39 (2005)) taking into account plume meandering at low wind speeds.
- Meandering parameters taken from the Graz Lagrangian model (GRAL) (function of wind speed)
- In the current version we are also using a simple minimum setting of sigma-v = 0.5 m/s

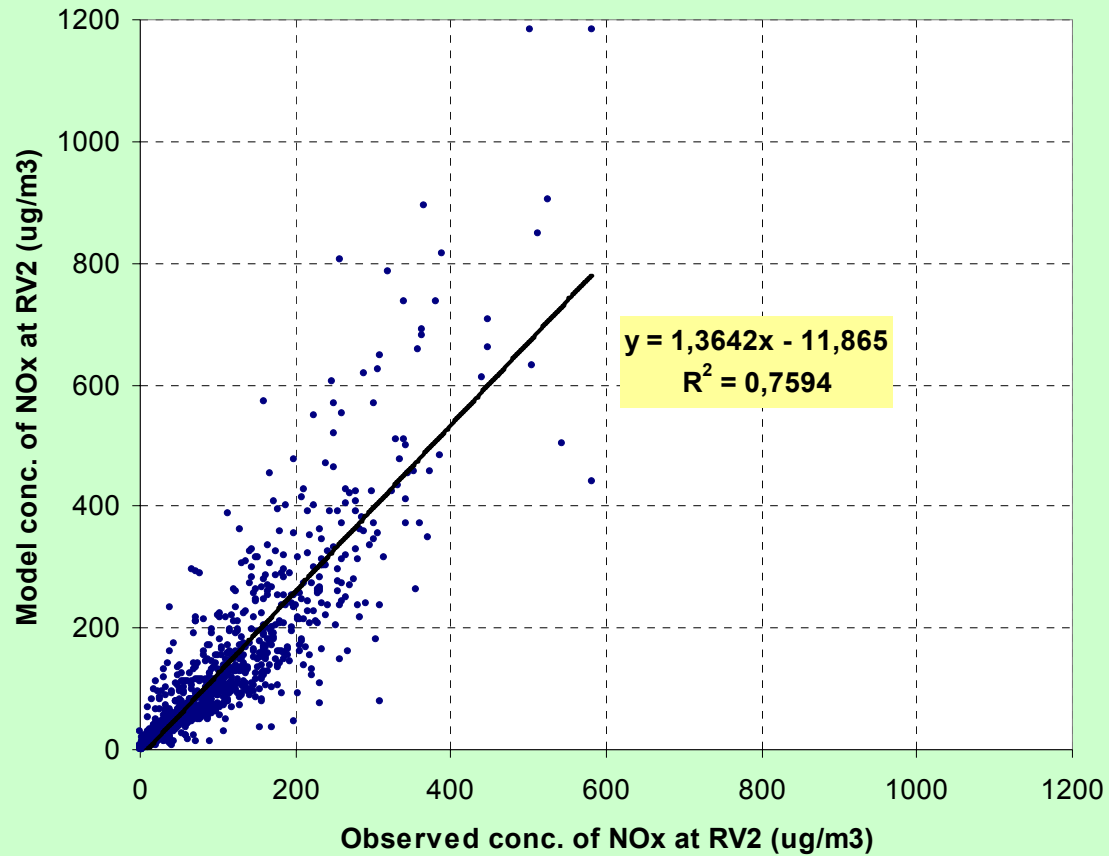
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◆ WORM model set up

- Surface roughness tentatively set to 0.25 m based on Davenport & Wieringa site classification
- Emission height = 0.5 m (lane) + 1.0 m (dam) = 1.5 m
- Initial horizontal and vertical dispersion parameters σ_y0 and σ_z0 defined as in CAR-FMI
 - ◆ $\sigma_y0 \approx 5-7$ m and $\sigma_z0 \approx 2.5-3.5$ m
- Focus on NO_x since it is the simplest component
 - ◆ No photochemical reactions, easier to estimate emissions than for PM

WORM model evaluation

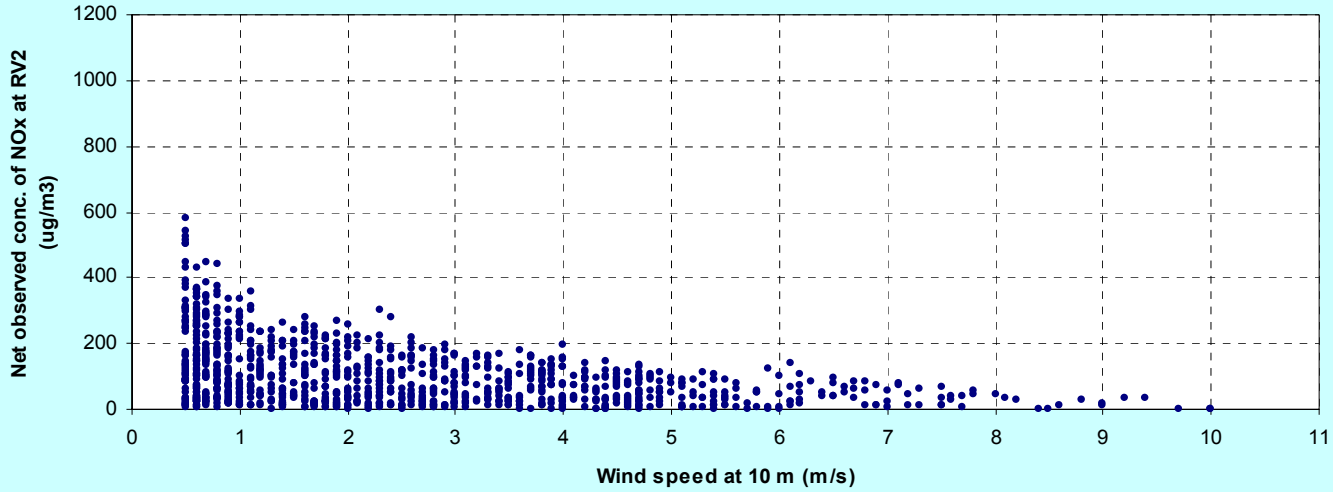
Scatter plot of model (Y) vs net observed (X) conc.
of NOx at RV2



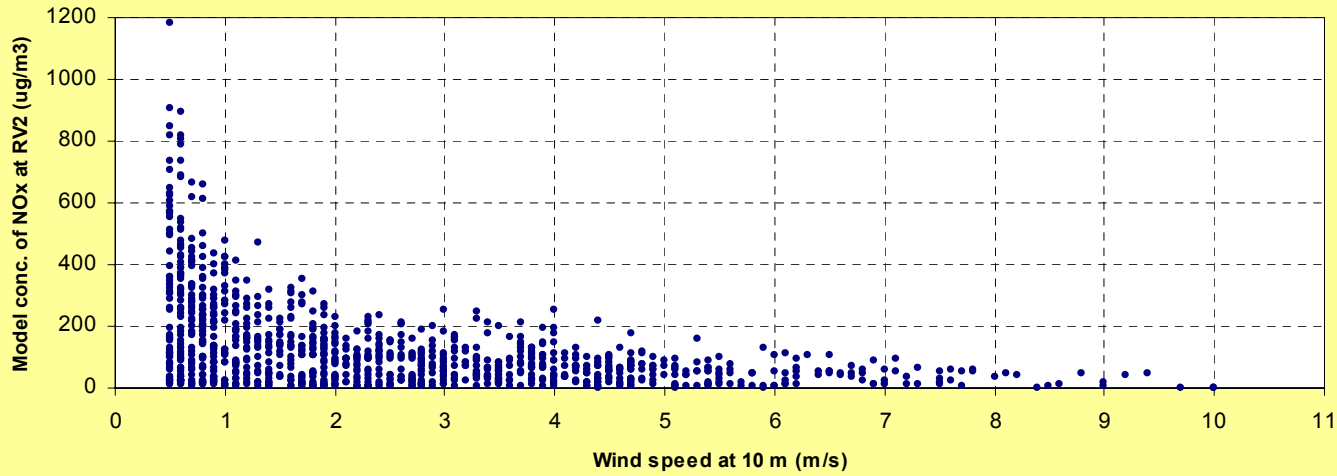
WORM model evaluation

N = 1038	Obs 1	Mod 1	Obs 2	Mod 2	Obs 3	Mod 3
AVER	137	148	103	129	67	99
SDEV	120	162	93	144	67	119
MAX	722	1336	581	1185	463	979
RMSE		82		82		78
RMSS		25		42		48
CORR		0.88		0.87		0.86

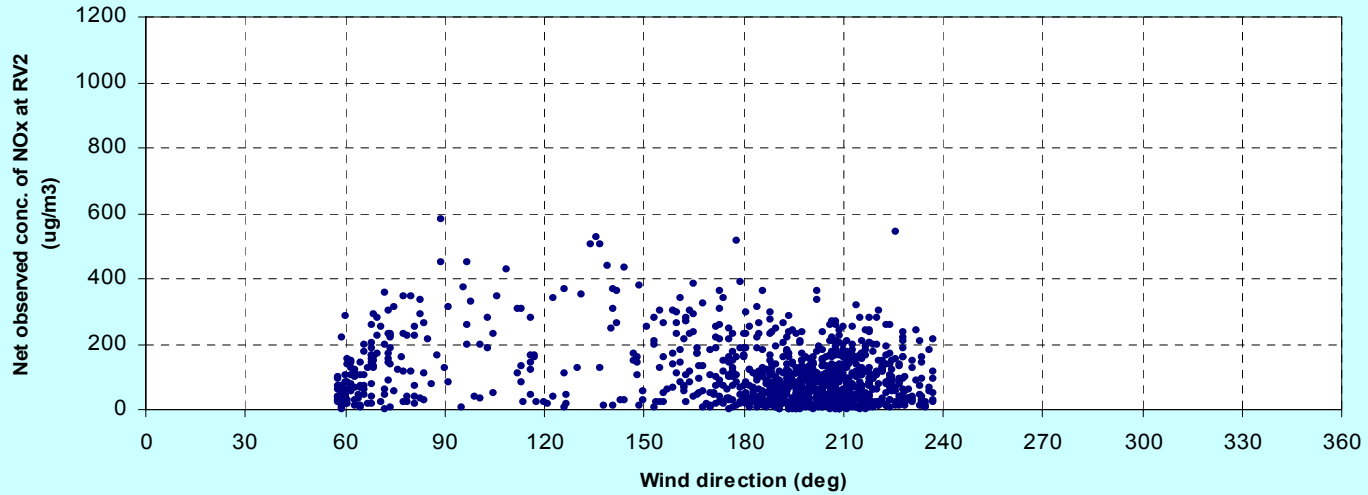
Net observed NOx conc. at RV2
depending on wind speed



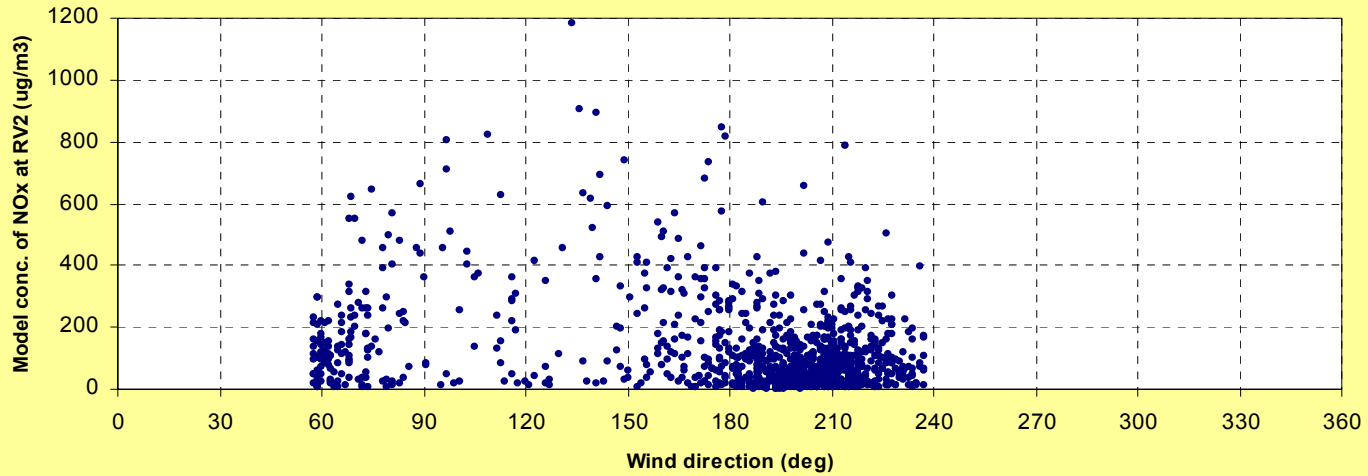
Model conc. of NOx at RV2
depending on wind speed



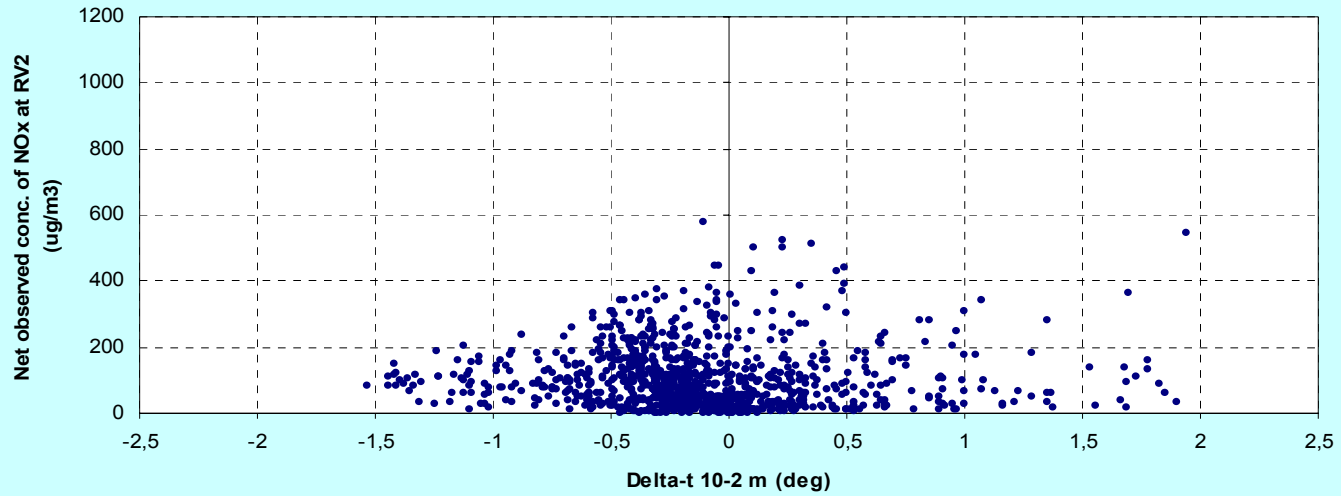
**Net observed NOx conc. at RV2
depending on wind direction**



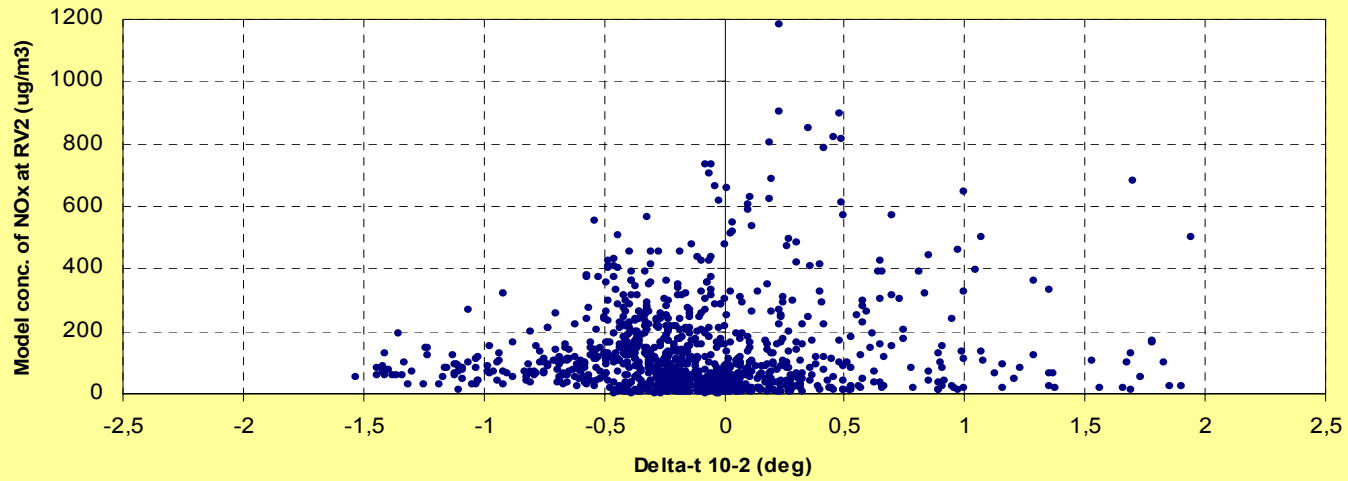
**Model conc. of NOx at RV2
depending on wind direction**



**Net observed NOx conc. at RV2
depending on delta-t 10-2 m**



**Model conc. of NOx at RV2
depending on delta-t 10-2 m**



Classification of WORM model variables

	Q	Z 0	H	U 1 0	U H	D 10	D H	D T	SY 0	SZ 0	TL Y	TL Z	U *	T *	L	H M	TH V	TH W	S V	S W
Obs.	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification
Uno.	Classification	Classification	Classification	Classification	Tentative variables for assimilation	Classification	Classification	Classification	Tentative variables for assimilation	Tentative variables for assimilation	Classification	Classification	Classification	Classification	Classification	Classification	Tentative variables for assimilation	Classification	Tentative variables for assimilation	Classification
Pri.	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Tentative variables for assimilation	Tentative variables for assimilation	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification
Sec.	Classification	Classification	Classification	Classification	Tentative variables for assimilation	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Tentative variables for assimilation	Classification	Tentative variables for assimilation	Classification
Dir.	Classification	Classification	Classification	Classification	Tentative variables for assimilation	Classification	Classification	Classification	Tentative variables for assimilation	Tentative variables for assimilation	Classification	Classification	Classification	Classification	Classification	Classification	Tentative variables for assimilation	Classification	Tentative variables for assimilation	Classification
Indir.	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification	Classification

Classification

Tentative variables for assimilation

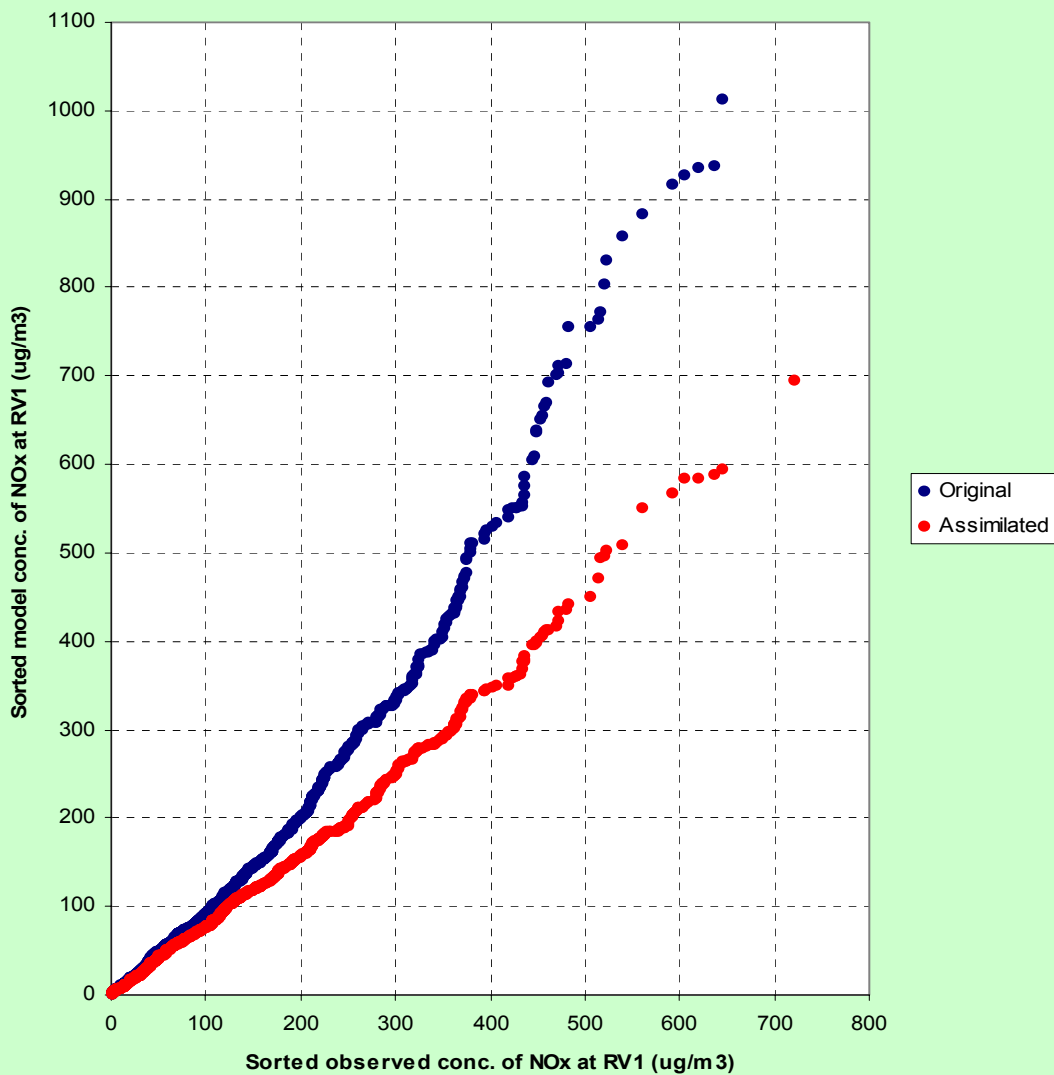
WORM model assimilation setup

- ◆ Use observations of NO_x at station 2 to estimate sigma-v (theta-v) and sigma-z0 (sigma-y0) on an hourly basis
- ◆ Use a sequential Monte-Carlo method known as SIR (Sequential Importance Re-sampling) to estimate the parameters
 - Based on a Gaussian likelihood function for the parameters assuming that the AQ observations have 5% relative error
- ◆ Create ensembles of N = 2500 modelled NO_x conc. at each station for each hour by randomly drawing input parameters
 - $\sigma\text{-v} \sim U(\sigma\text{-v}0, 2)$ $\theta\text{-v} = \text{atan}(\sigma\text{-v}/u\text{h})$
 - $\sigma\text{-z}0 \sim N(\sigma\text{-z}0, 1.5)$ $\sigma\text{-y}0 = 2*\sigma\text{-z}0$

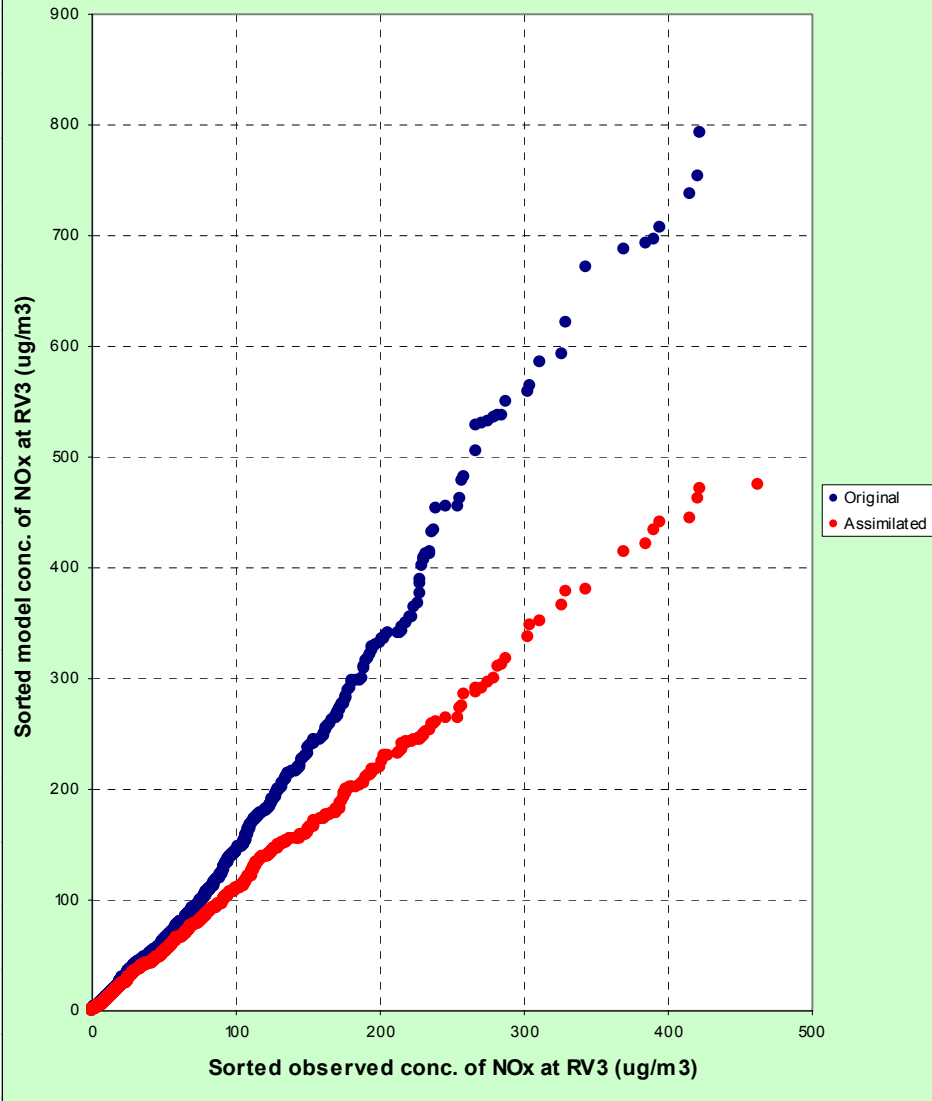
WORM assimilation results

N = 1038	Obs 1	Mod 1	Obs 2	Mod 2	Obs 3	Mod 3
AVER	137	111 148	103	96 129	67	73 99
SDEV	120	105 162	93	92 144	67	74 119
MAX	722	695 1337	581	583 1185	463	475 979
RMSE		43 82		23 82		25 78
RMSS		32 25		8 42		7 48
CORR		0.96 0.88		0.98 0.88		0.95 0.86

Quantile-Quantile plot of NOx at RV1

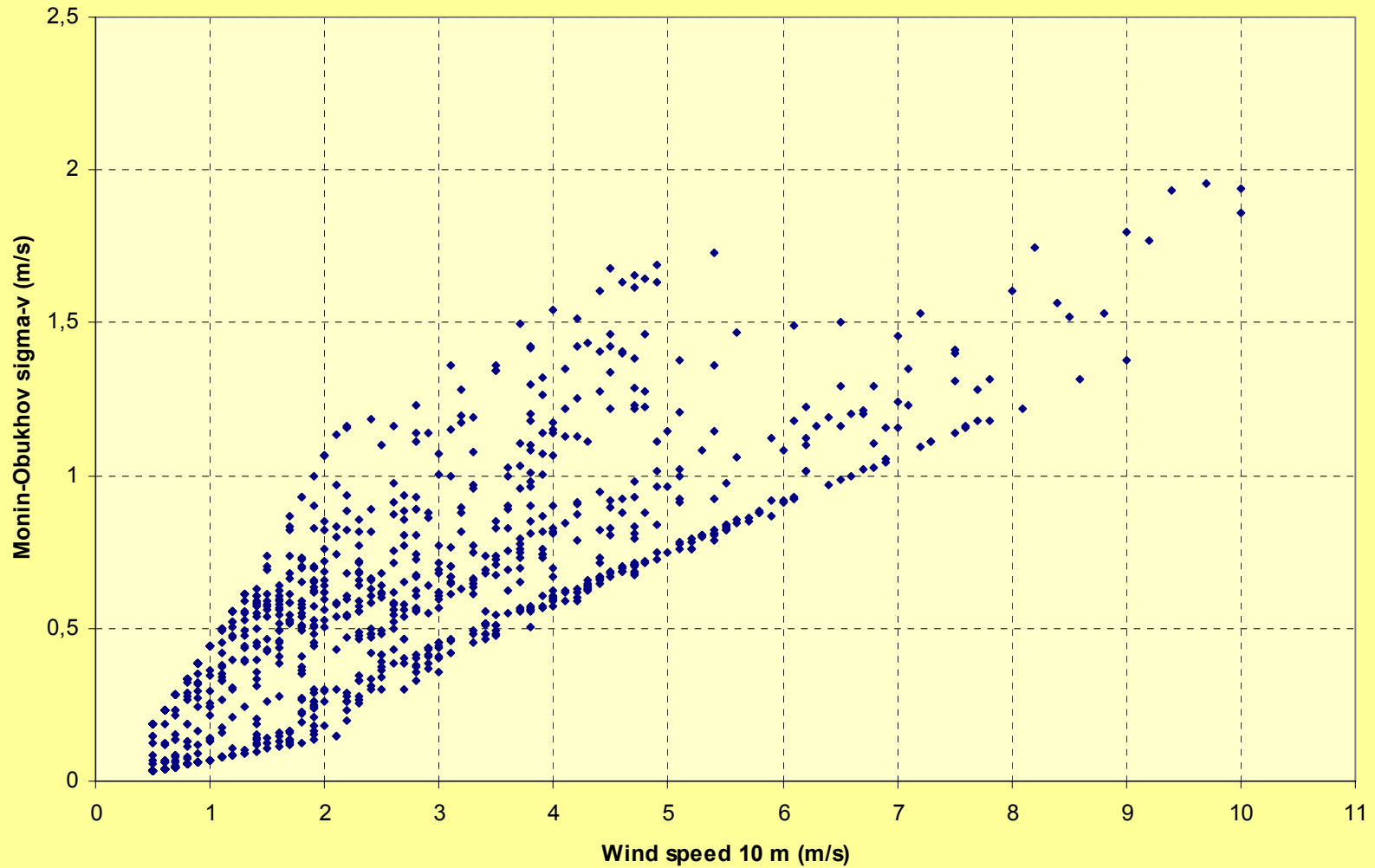


Quantile-Quantile plot of NOx at RV3

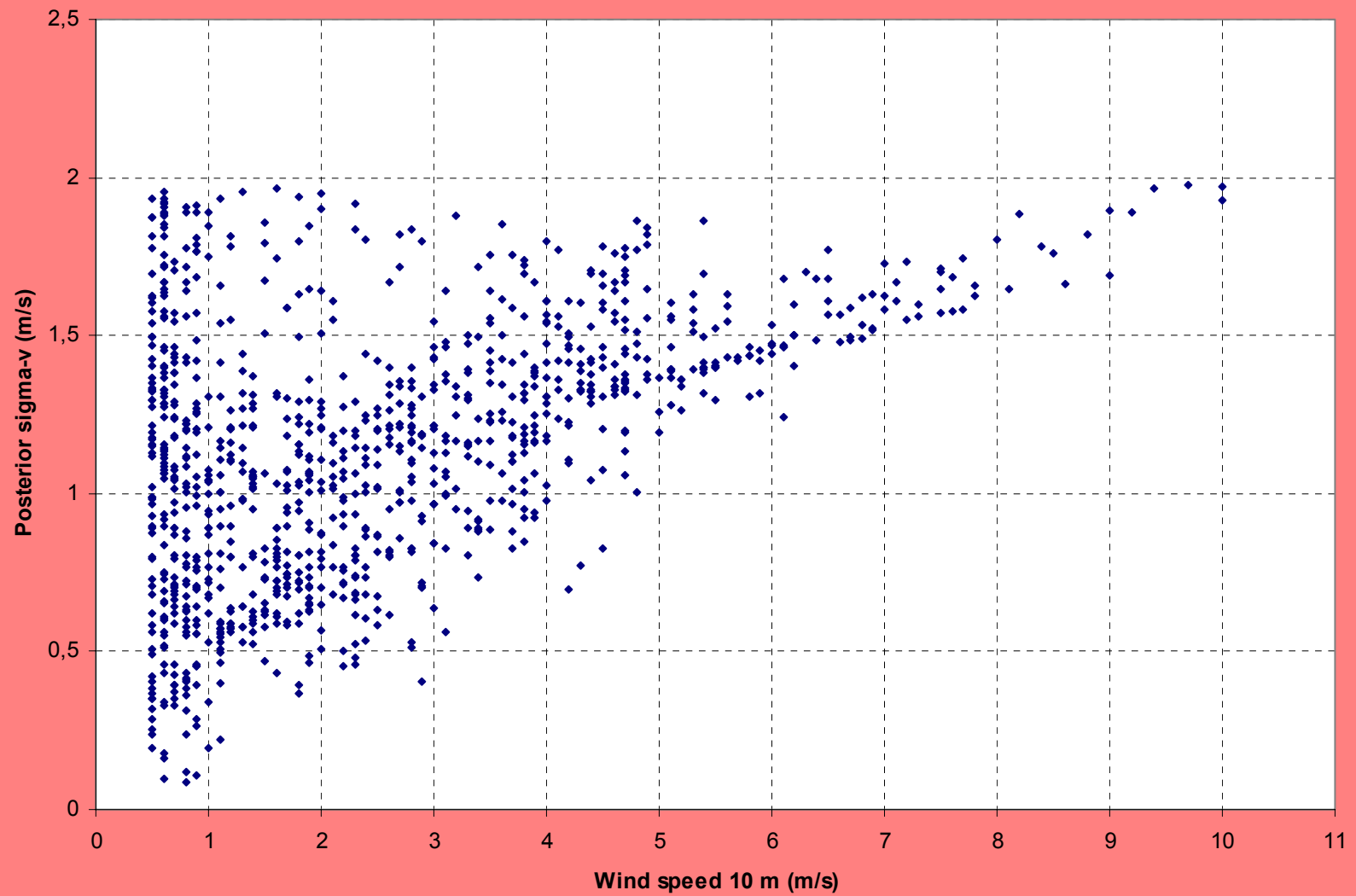


Nominal sigma-v vs. wind speed at 10 m

Based on Monin-Obukhov theory and COST-710 equations

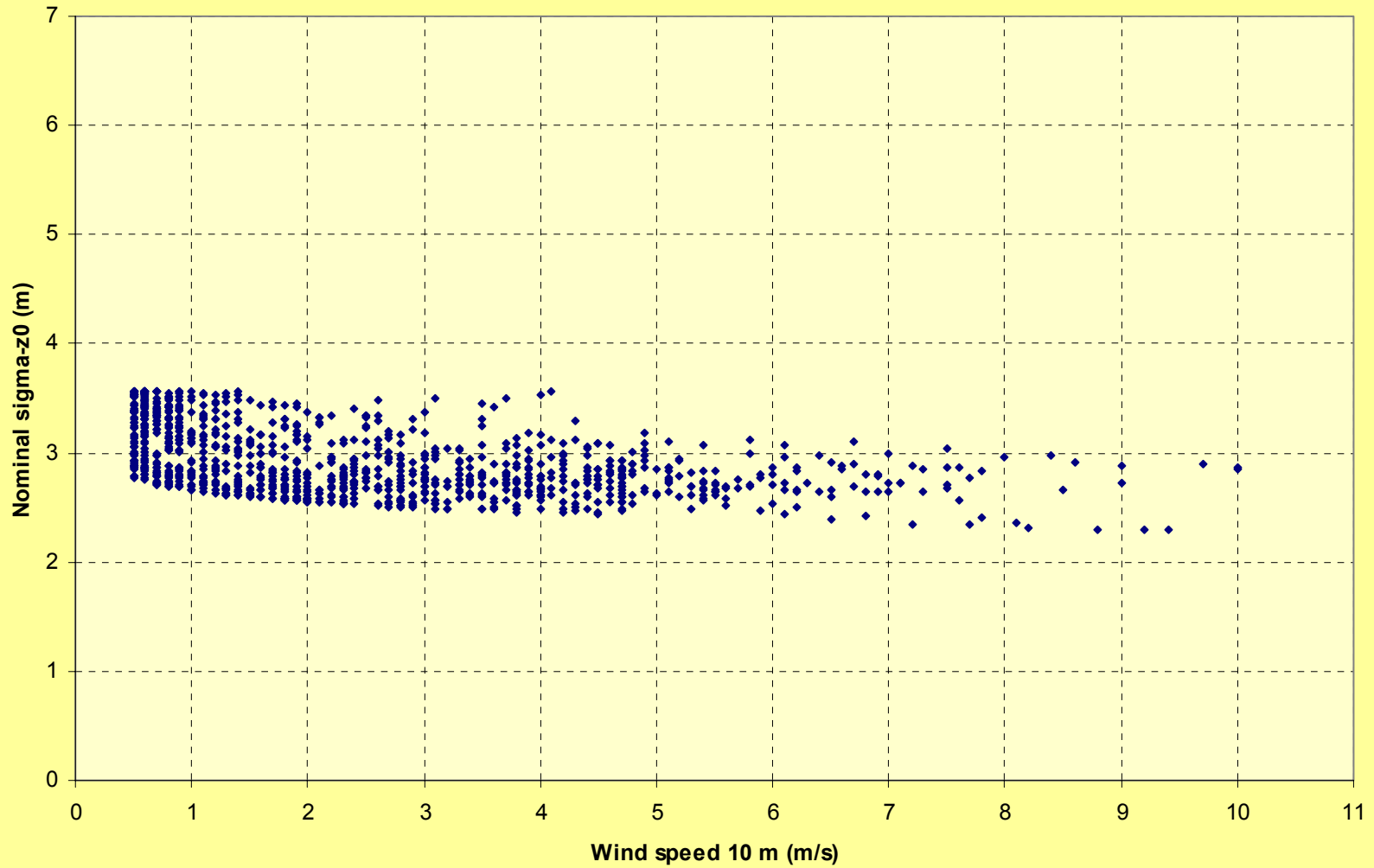


Assimilated sigma-v vs. wind speed at 10 m

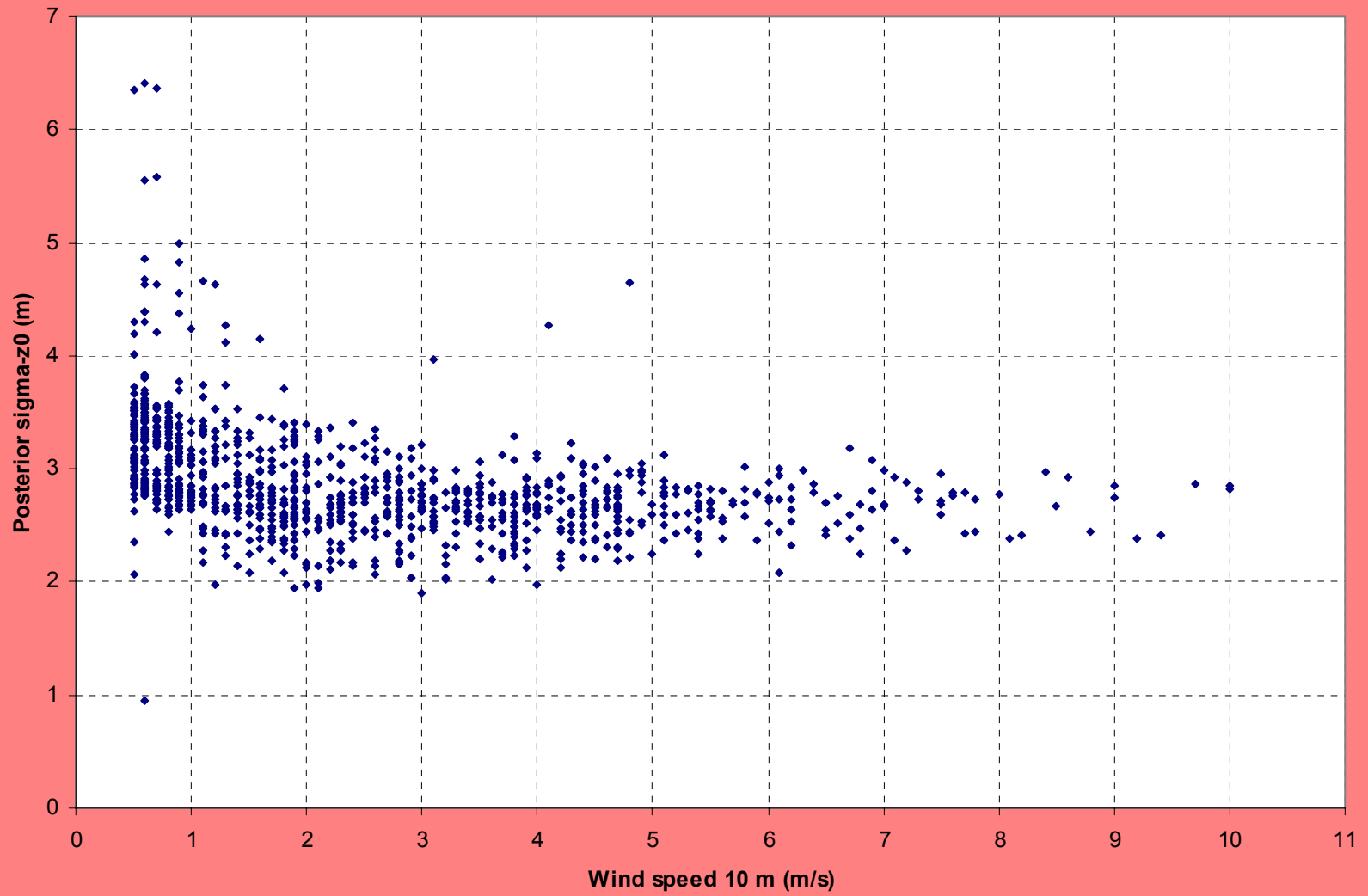


Nominal sigma-z0 vs. wind speed at 10 m

Based on same equation as CAR-FMI



Assimilated sigma-z0 vs. wind speed at 10 m



WORM assimilation results

N = 2500	Sigma-v	Sigma-v	Sigma-z0	Sigma-z0
AVER	0.55	1.14 0.22	2.92	2.86 0.74
SDEV	0.41	0.41 0.14	0.31	0.49 0.10
MIN	0.03	0.08 0.003	2.30	0.95 0.04
MAX	1.95	1.98 0.59	3.57	6.41 2.33

Original

Assimilated

Average effective sample size = 1235

Case study Oslo II – Conclusions (so far)

- ◆ Gaussian integrated lines source models can clearly be improved by assimilation of roadside AQ observations
- ◆ Estimation of horizontal diffusion and initial size of plume can be used to correct for systematic errors in the high percentiles of the model concentration distribution
- ◆ Other results in this case study show that
 - Using more than one station helps to improve the model further but at a slower pace
 - Vertical processes are more easy to estimate than horizontal
 - It is notoriously difficult to estimate Lagrangian time scales

Case study Oslo II – Future work

- ◆ Other parameters that could be important to include in the assimilation procedure
 - Effective height and wind speed for the dispersion
 - Vertical diffusion and Lagrangian time scale (?)
- ◆ Setting proper prior probability distributions for the selected parameters
- ◆ Due to the inevitable uncertainties involved, line source modelling should perhaps be more based on using ensembles