National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

Model validation in the Netherlands and the MQO

Joost Wesseling,
Lan Nguyen

Content

- Introduction
- Model validation in the Netherlands
  - Indicators
  - Results NO_2, PM_{10}, $PM_{2.5}$
- Applying the FAIRMODE MQO
- Questions?

Introduction

- From time to time there are discussions in The Netherlands about the quality of the Dutch models for determining air quality and perform compliance testing.
  - Most discussions concern NO_2 near roads.
  - It is important that the models yield –on average– the correct concentrations.
  - The uncertainty of model calculations is relevant.

- Recently, uncertainty became very important as in several cases the speed limit on highways was increased while the NO_2 concentrations were already close to the limit value.

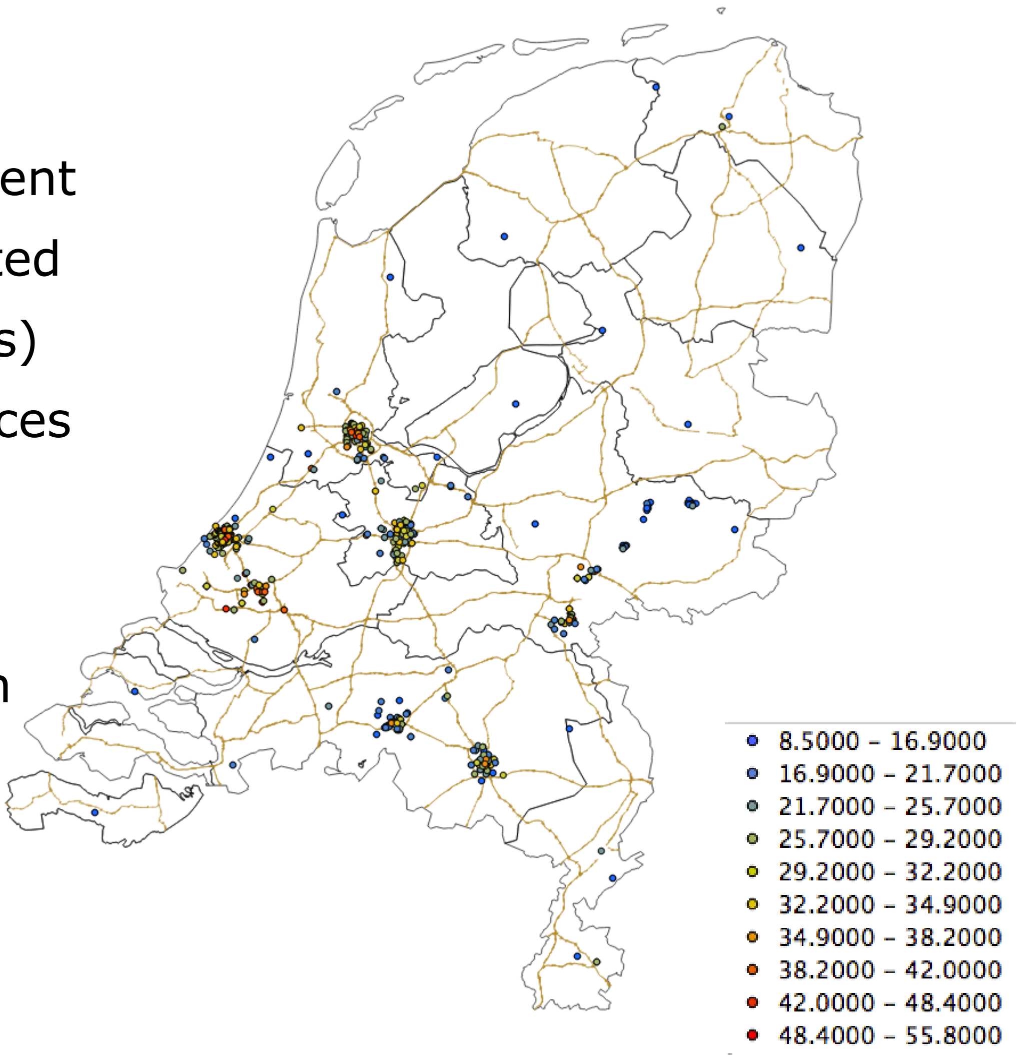
Model validation

- In 2007, 2011, 2013 and 2014 the RIVM has conducted (limited) validation tests of the Dutch Standard Calculation Methods for air quality.
- In 2015 the derogation for complying with the NO_2 limit value in the Netherlands expired.
- Several municipalities, provinces and also action groups have performed (their own) measurements.

- So, … how good are the model results?

Model validation 2016

- RIVM received NO_2 measurement results (Palmes tubes, calibrated using reference measurements) from 16 municipalities, provinces and environmental groups.
- Data covers 2010 – 2015.
- Measurements concentrated in cities with relatively poor air quality.



Model validation 2016

- For all measurement locations air quality calculations were performed using the Dutch standard models and the street/traffic data provided in the framework of the Dutch “National Cooperation on Air Quality”.
- Roughly 1950 usable data points for NO_2.
- For NO_x and PM_{10} some 190 measurements using official reference stations, for $PM_{2.5}$ some 100 measurements.
- Analyses of the total data set, for each individual year and also all datasets separately.

Dutch Model validation 2013 / 2016

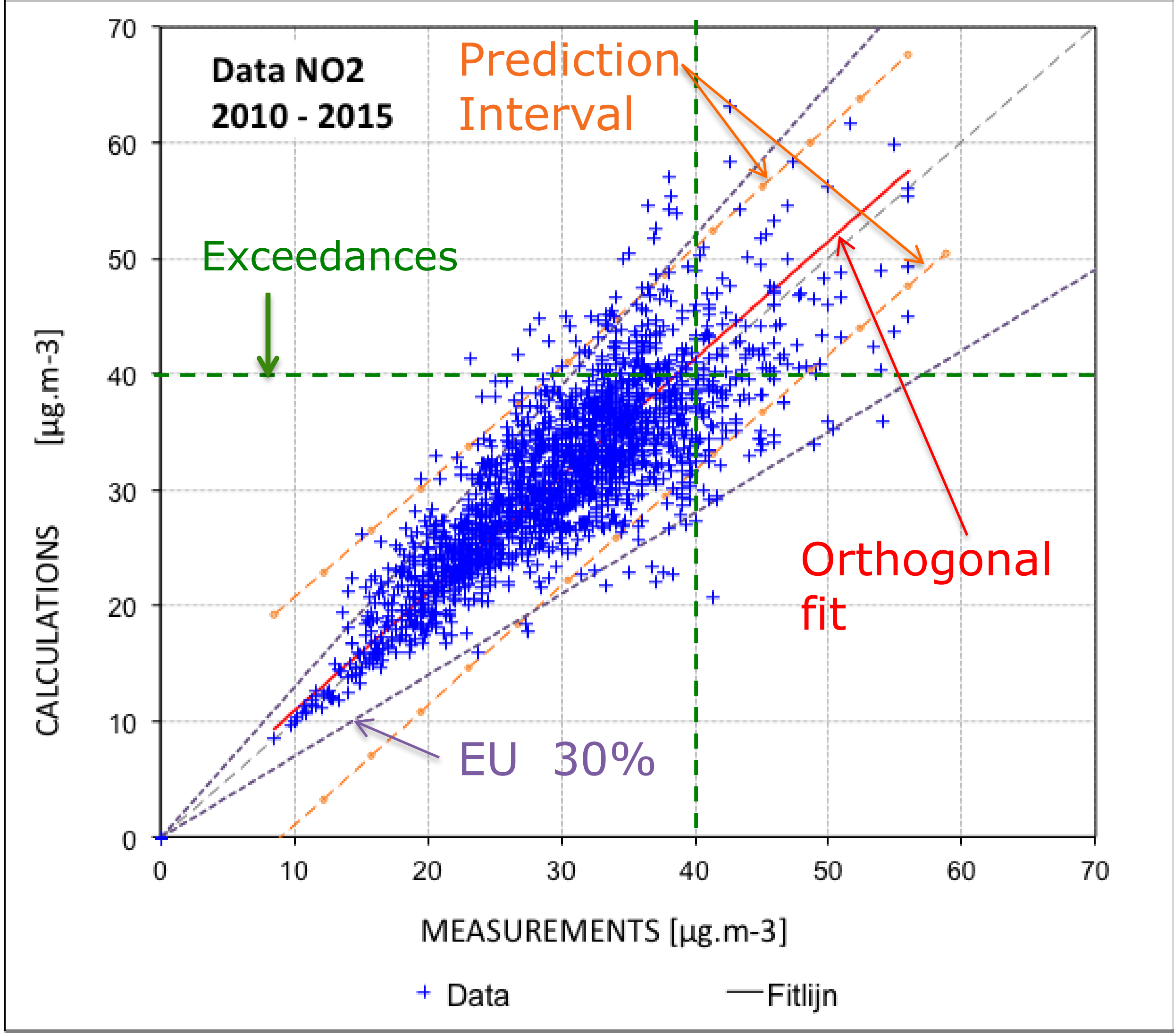
- Determine model quality:
  - Orthogonal fit of straight line → direction and offset;
  - Distribution of residues, both orthogonal and directly;
  - Bland-Altman plot;
  - Standard deviation;
  - BIAS, RMS parameters;
  - Confidence and Prediction intervals;
  - EU criteria 30% and 50%;
  - Previous checks: QQ, Bootstrap methods.

  - Extra: FAIRMODE MQO …

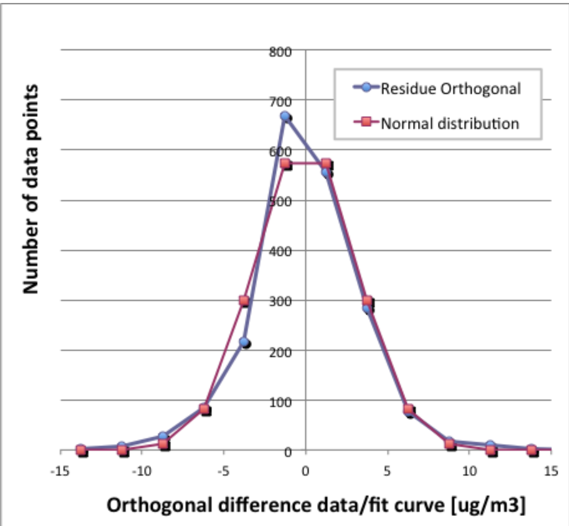
Analysis of NO_2

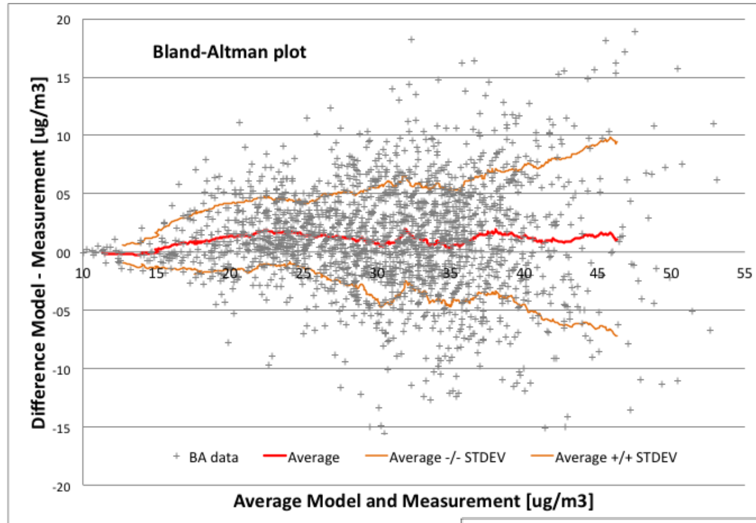
Standard analysis

Direction/BI	1.01	0.03
Offset/BI	0.8	0.8
NrPoints	1952	
F(20) / CI	21.0	0.3
F(30) / CI	31.2	0.2
F(40) / CI	41.3	0.3
F(50) / CI	51.5	0.5
Diff >30%	6.6%	128
RMSE/R^2	4.6	0.68
BIAS	1.19	
MNB/ANB	0.05	0.04
>40.5	163	230

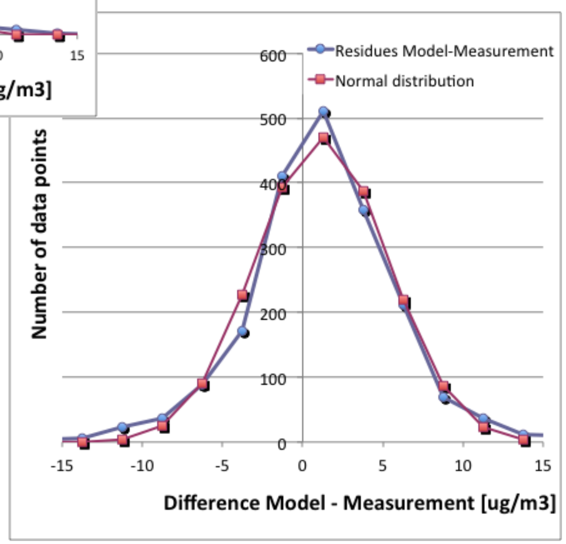


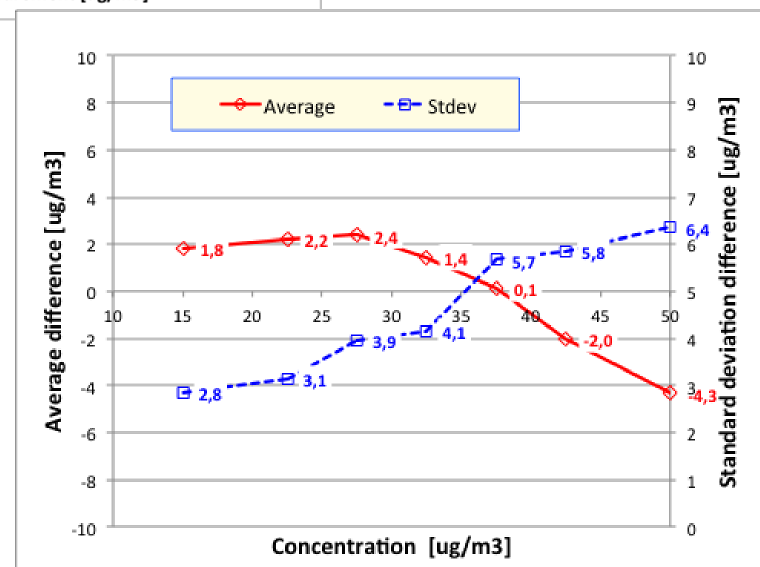
Residues NO_2





Data slightly heteroscedastic





Residues:
Normal distributions of 3.1 and 4.1 µg/m^3

MQO FAIRMODE (May 2016)

8.2.3. A MQO for yearly average model results

For air quality models that provide yearly averaged pollutant concentrations, the MQO is modified into a criterion in which the mean bias between modelled and measured concentrations is normalized by the expanded uncertainty of the mean concentration:

$$MQI = \frac{|\bar{O} - \bar{M}|}{\beta U_{95}(\bar{O})} \qquad and\ MQO: MQI \leq 1 \tag{15}$$

For this case, Pernigotti et al (2013) derive the following expression for the 95th percentile uncertainty:

$$U_{95}(\bar{O}) = U_{95,r}^{RV} \sqrt{\frac{(1-\alpha^2)}{N_p^*}(\bar{O}^2 + \sigma_o^2) + \frac{\alpha^2 . RV^2}{N_{np}}} \cong U_{95,r}^{RV} \sqrt{\frac{(1-\alpha^2)}{N_p}\bar{O}^2 + \frac{\alpha^2 . RV^2}{N_{np}}} \tag{16}$$

	β	$U_{95,r}^{RV}$	*RV*	α	N_p	N_{np}
NO2	2.00	0.25	200 µg/m3	0.20	5.2	5.5
O3	2.00	0.18	120 µg/m3	0.79	11	3
PM10	2.00	0.28	50 µg/m3	0.13	30	0.25
PM2.5	2.00	0.36	25 µg/m3	0.30	30	0.25

Table 1: List of the parameters used to calculate the uncertainty

$$\beta = \begin{cases} 2 & : \text{Interpretation EU directive.} \\ \sqrt{2} & : \text{Uncertainties model and measurement equal.} \end{cases}$$

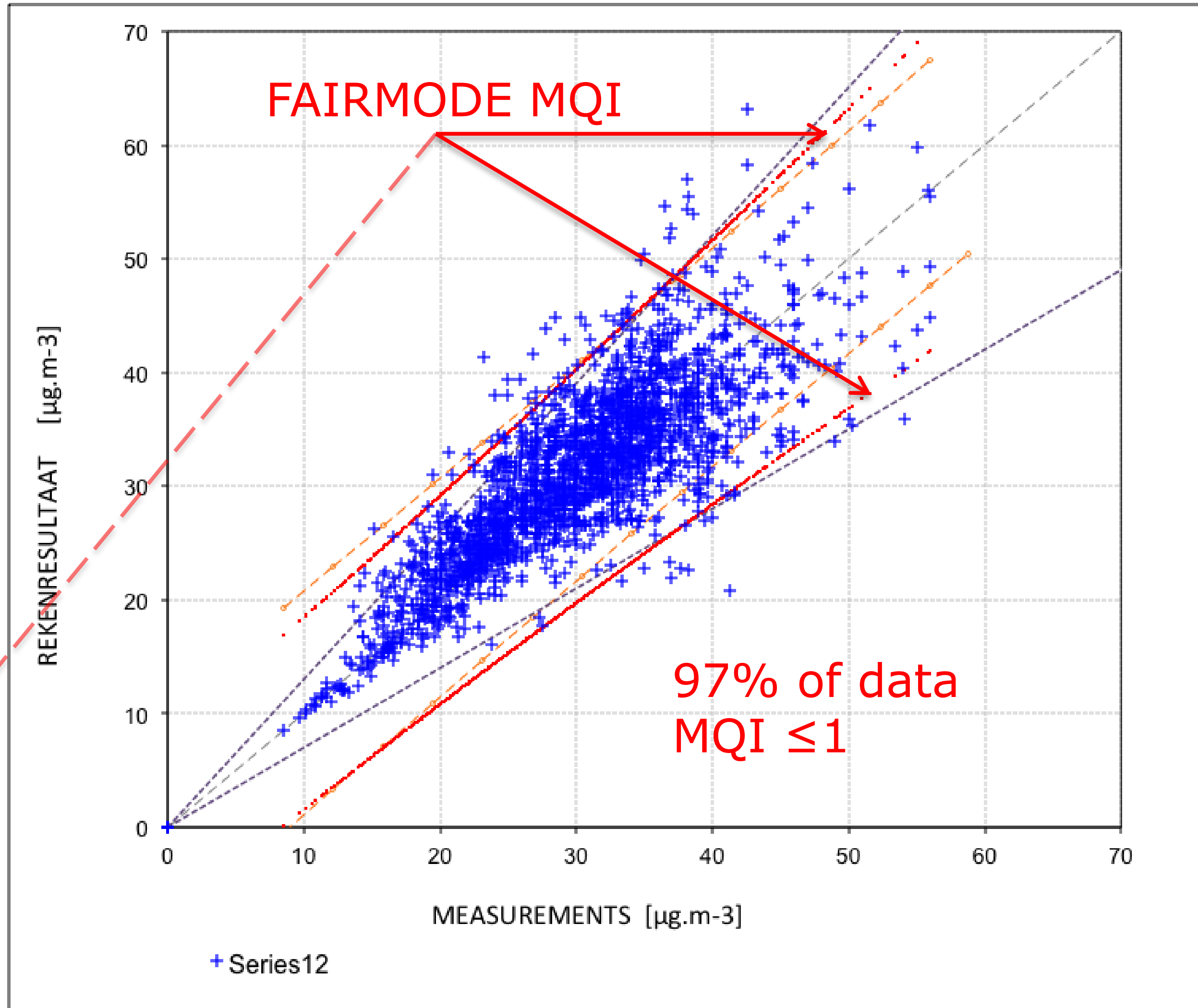
Analysis of NO_2

Standard analysis

MQO, FAIRMODE U0, β = 2.

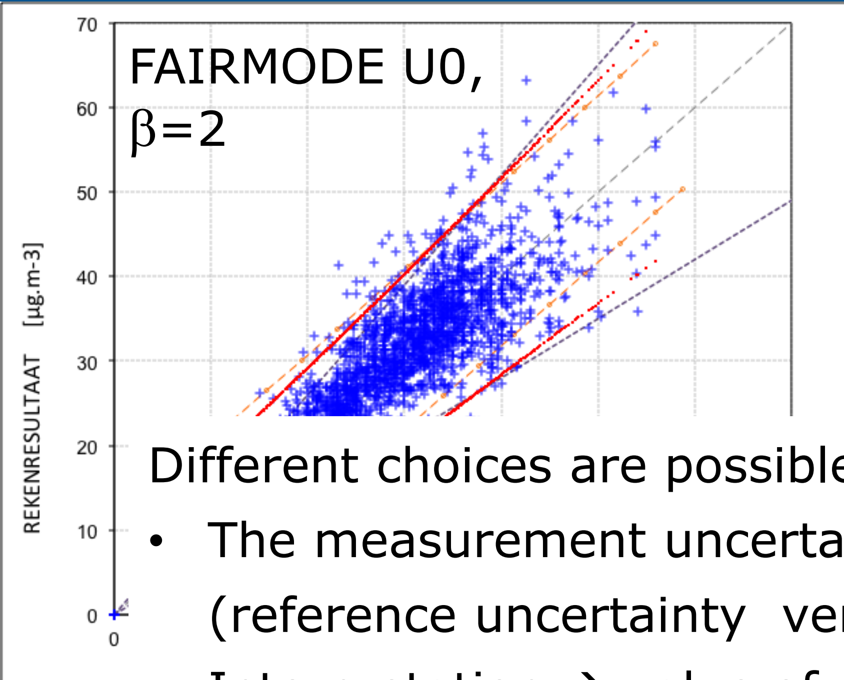
Direction/BI	1.01	0.03
Offset/BI	0.8	0.8
NrPoints	1952	
F(20) / CI	21.0	0.3
F(30) / CI	31.2	0.2
F(40) / CI	41.3	0.3
F(50) / CI	51.5	0.5
Diff >30%	6.6%	128
RMSE/R^2	4.6	0.68
BIAS	1.19	
MNB/ANB	0.05	0.04
>40.5	163	230

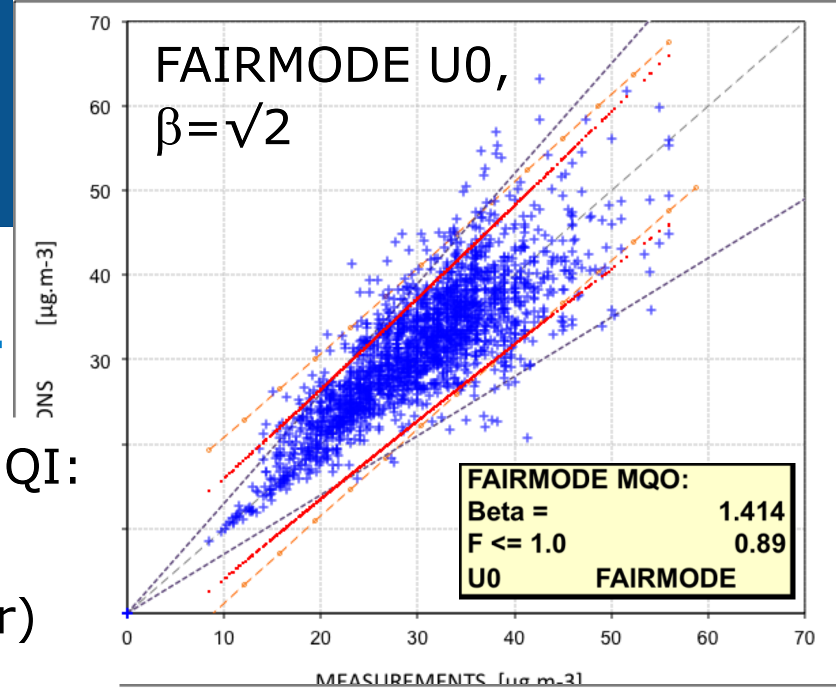
FAIRMODE MQO:	
Beta =	2.000
F <= 1.0	0.97
U0	FAIRMODE



Measurement uncertainty …

- Of the 1950 data points, some 200 are measured using reference equipment, all the others are measured using Palmes tubes.
- Palmes tubes calibrated using official measurements.
- Estimated uncertainty of Palmes tubes roughly 17-18% (95%CI).
- The uncertainty of the Palmes tubes should be used in the model assessment.

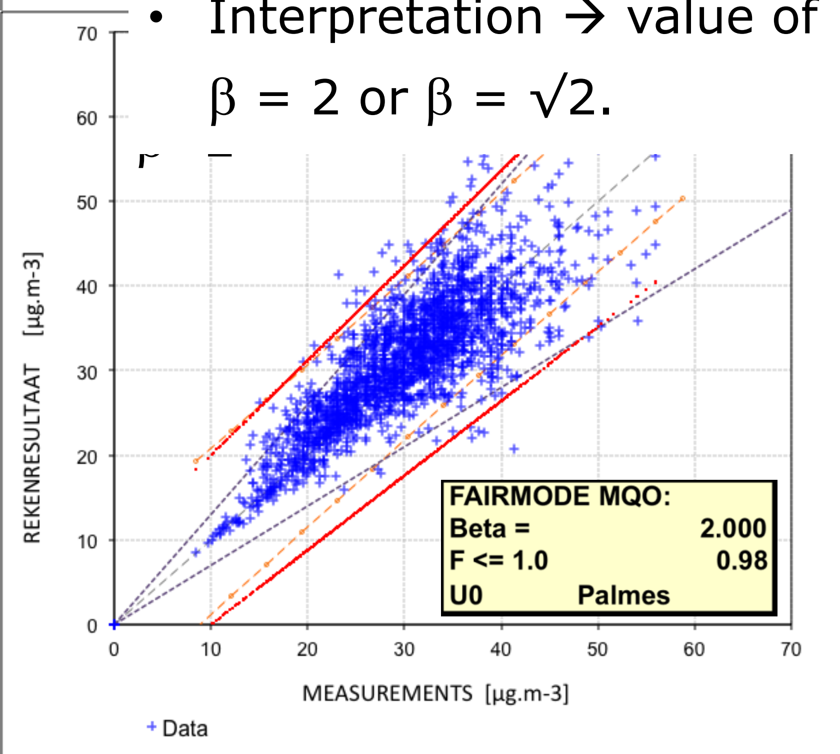


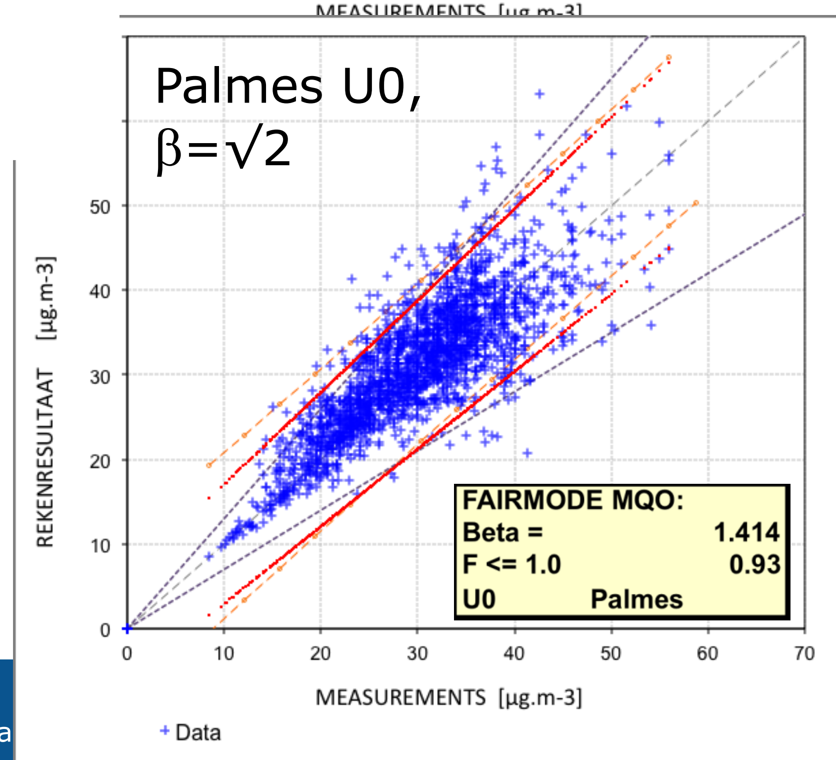


ainty ..

Different choices are possible in the MQI:

- The measurement uncertainty (reference uncertainty versus other)
- Interpretation → value of β = 2 or β = √2.



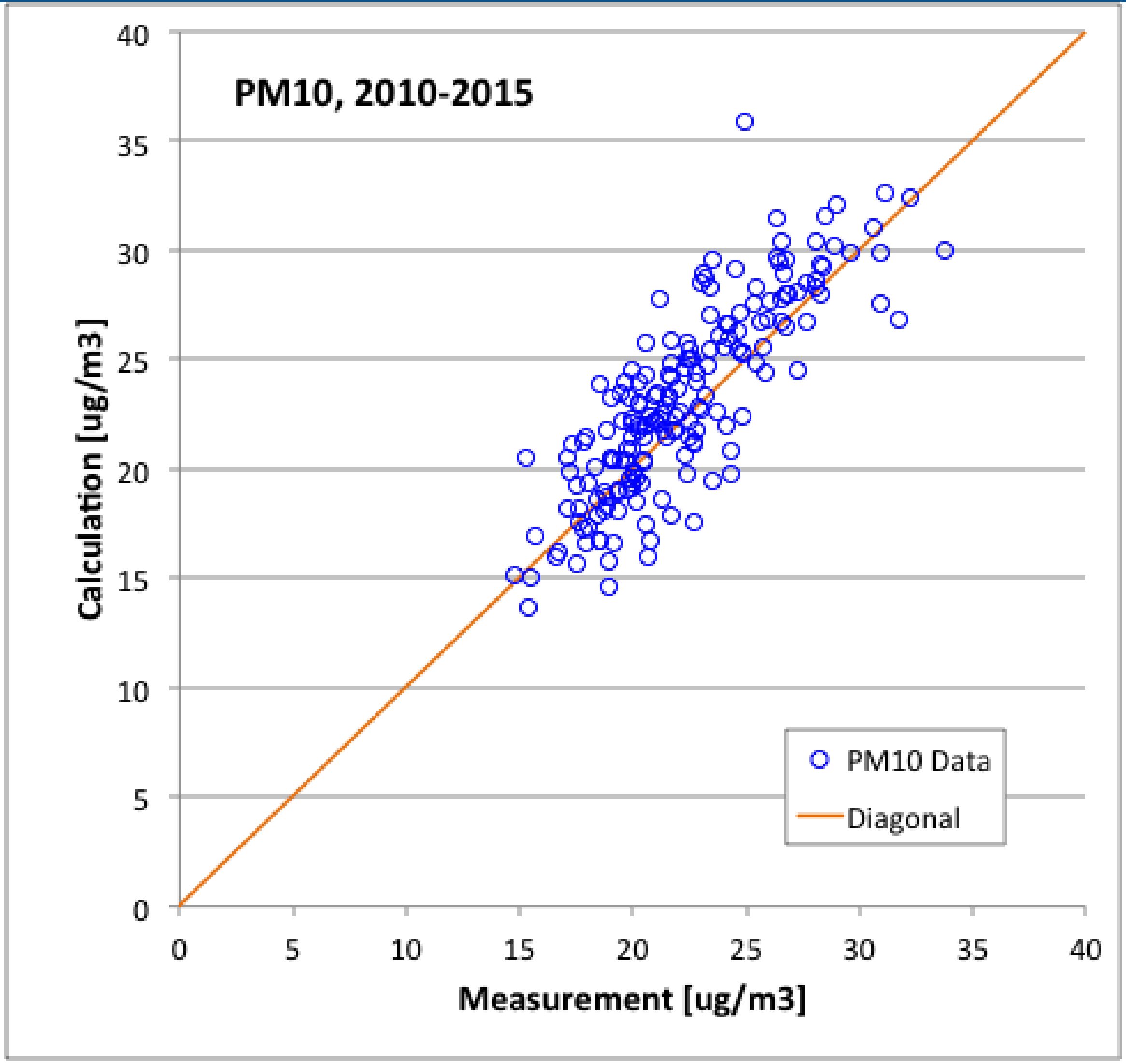


Analysis of PM_{10} and $PM_{2.5}$

- Until recently, the uncertainty derived for reference measuremens was used in FAIRMODE model evaluation for PM_{10}.
- In the Netherlands most PM_{10} measurements are performed using beta-ray methods (mostly FH 62 I-R/I-N, later BAM) that have been shown to be equivalent.
- A parameterization of uncertainties of beta-ray measurements as a function of yearly average concentration level was provided by RIVM.
- Both the U0 based on reference as well as equivalent methods have been used in the analysis.

Analysis of PM_{10}

100% of data complies with EU directive



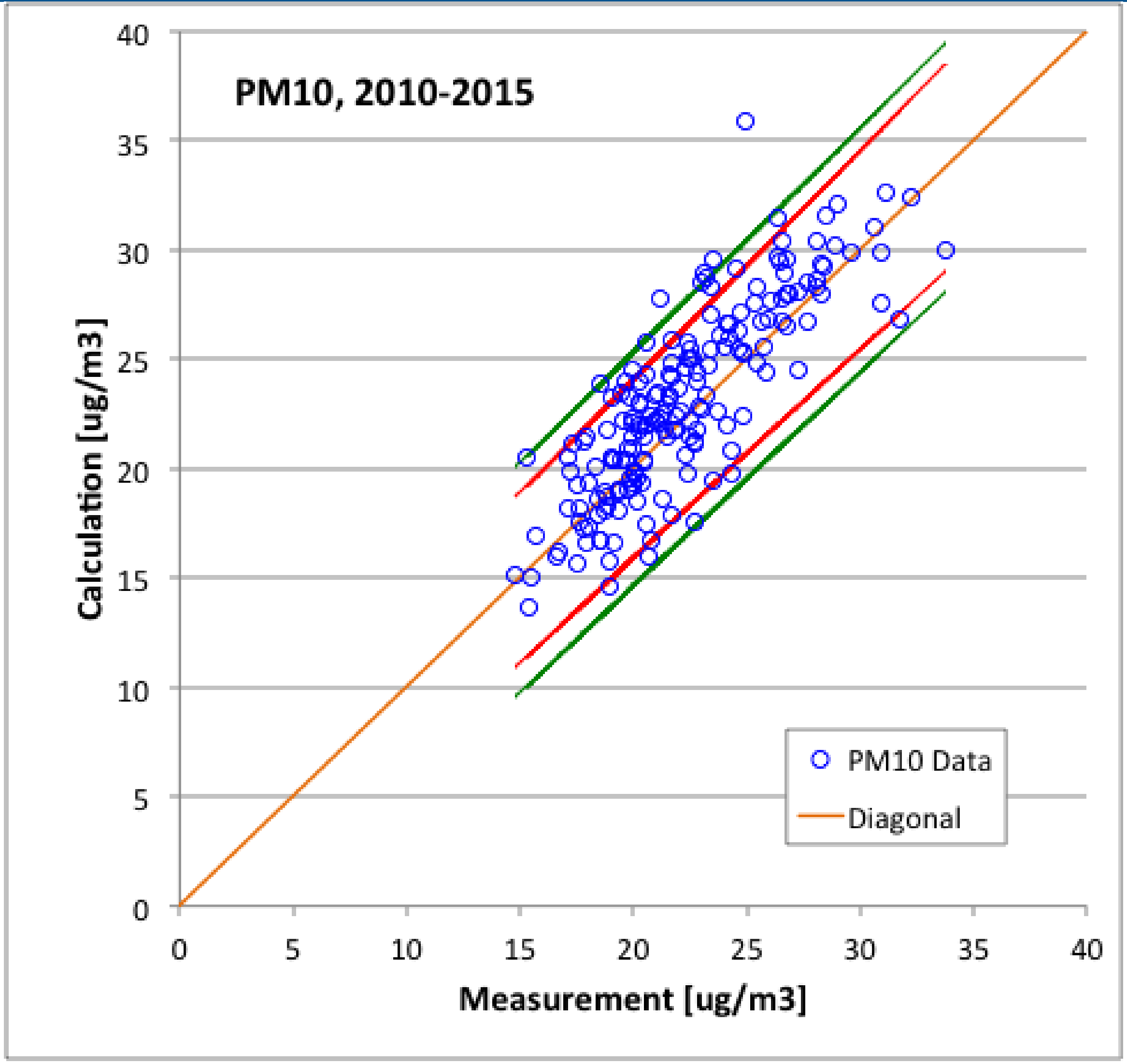
Analysis of PM_{10}

100% of data complies with EU directive

FAIRMODE:

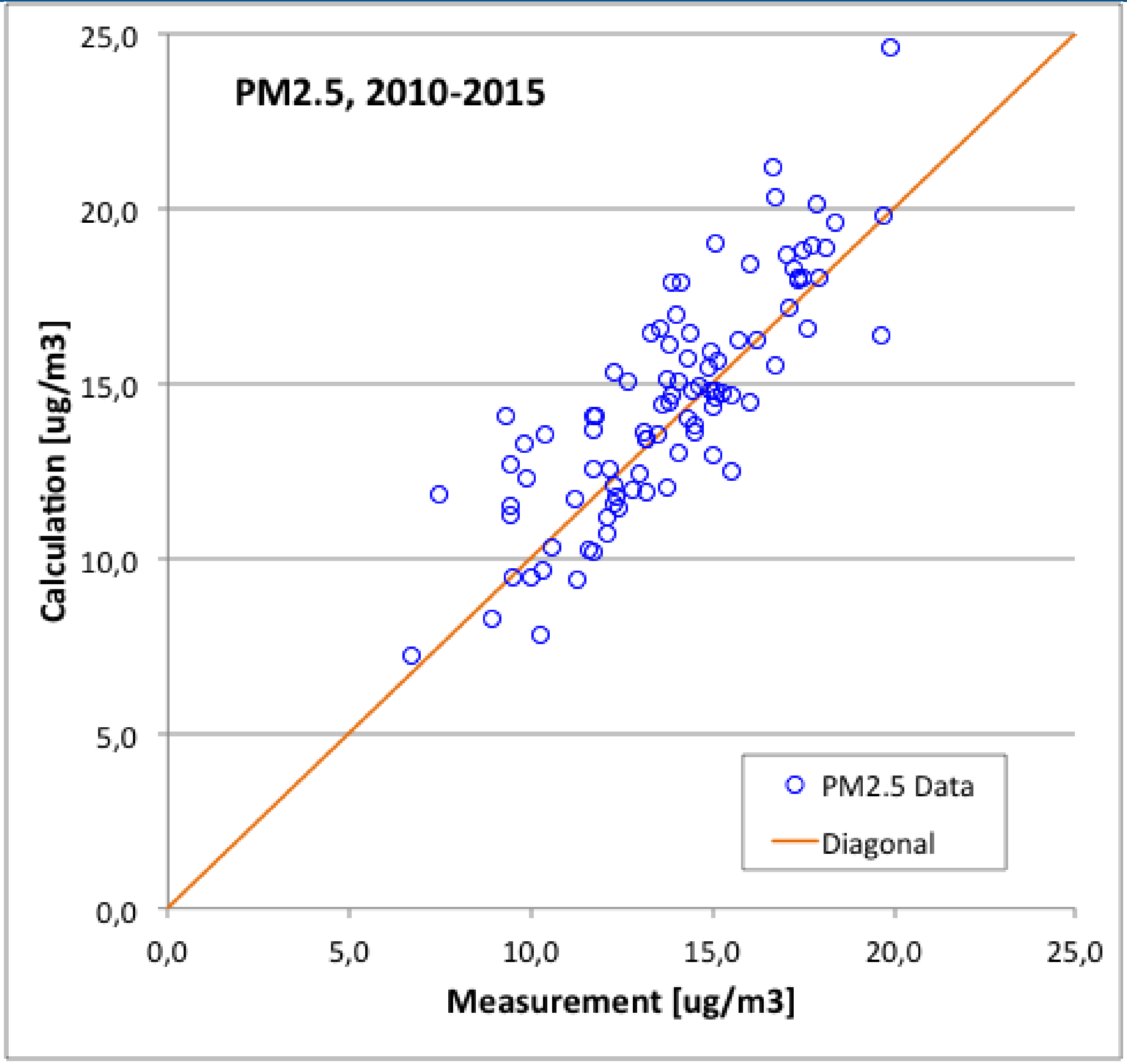
Red curves
Reference uncertainty
$\beta = 2$
88% of data complies

Green curves
Equivalent uncertainty
$\beta = \sqrt{2}$
96% of data complies



Analysis of $PM_{2.5}$

98% of data complies with EU directive



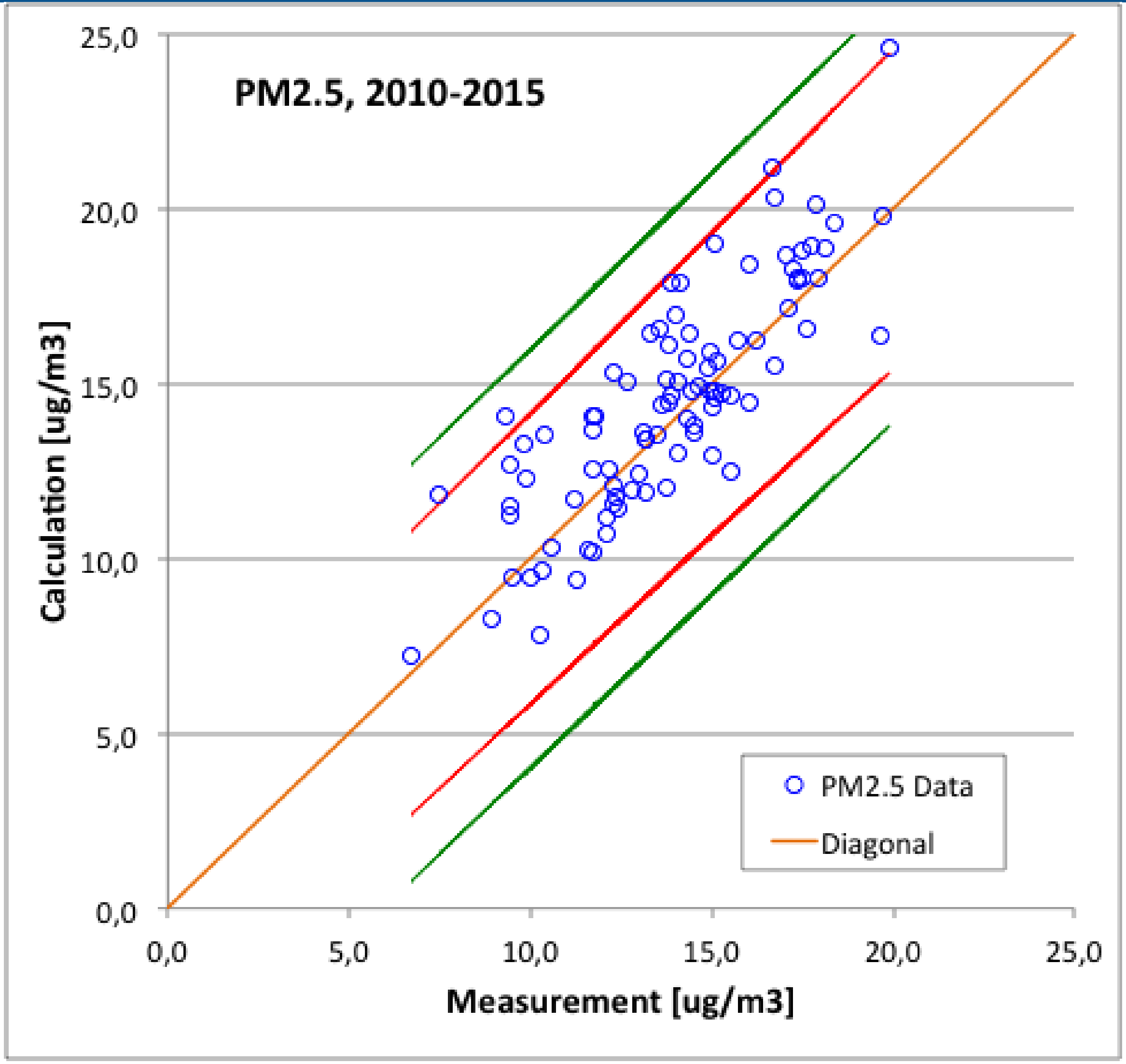
Analysis of $PM_{2.5}$

98% of data complies with EU directive

FAIRMODE:

<u>Red curves</u>
Reference uncertainty
$\beta = 2$
96% of data complies

<u>Green curves</u>
Equivalent uncertainty
$\beta = \sqrt{2}$
100% of data complies



Conclusions

- Results of the Dutch standard methods for calculating air quality were compared to measured NO_x, NO_2, PM_{10} and $PM_{2.5}$ concentrations.
- Overall, a satisfactory agreement was observed.
- In applying the FAIRMODE definition(s) for a MQO several choices are possible regarding the measurement uncertainty and the interpretation of the EU directive.

QUESTIONS …

… ANYONE?