



# Collaboration points AQUILA-FAIRMODE

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Joint  
Research  
Centre

# Model Quality Objectives – reference measurements 2013

## FAIRMODE MQO

$$MQO = \frac{1 \text{ RMSE}}{2 \text{ RMS}_U} = \frac{1}{2} \frac{\sqrt{\sum_{i=1}^N (m_i - x_i)^2}}{\sqrt{\sum_{i=1}^N U^2(x_i)}} \leq 1$$

## FAIRMODE simplified equation

$$u_c(x_i) = u_r^{RV} \sqrt{(1 - \alpha)x_i^2 + \alpha RV^2}$$

proportional      Constant

This equation needs to adapt to:

- Technological progress?
- Change in legislation (DQOs)?
- New pollutants?

## Aquila uncertainty budget O<sub>3</sub>, NO<sub>2</sub>, PM<sub>10</sub>

Parameters	u, hourly values		u, annual values		D, %rand	Ty	
	Min	Max	Min	Max			
u(b <sub>0</sub> ), u(b <sub>1</sub> )	<b>Zero</b> (0), u( <b>Zero</b> ) for NO <sub>x</sub>	2/3 <sup>1/2</sup>	2/3 <sup>1/2</sup>	2/(0.5 × 4 × 3) <sup>1/2</sup>	2/(0.5 × 2 × 3) <sup>1/2</sup>	R, 50%	pn
	<b>Zero</b> (0), u( <b>Zero</b> ) for NO	1/3 <sup>1/2</sup>	1/3 <sup>1/2</sup>	1/(0.5 × 4 × 3) <sup>1/2</sup>	1/(0.5 × 2 × 3) <sup>1/2</sup>	R, 50%	pn
u(b <sub>1</sub> )	<b>Zero</b> , (0) u( <b>Zero</b> ), <b>NO</b>	0.1	1/3 <sup>1/2</sup>	0.1/(24 × 3) <sup>1/2</sup>	1/(4 × 3) <sup>1/2</sup>	N,R; R, R, 100%	pn
	Repeatability at zero	0.58	4/3 <sup>1/2</sup>	0.58/(0.5 × 24) <sup>1/2</sup>	4/(0.5 × 24 × 3) <sup>1/2</sup>	N, R; N,R, 50 % <sup>a</sup>	pn
	Long term zero drift	1%	2.5%	1%	2.5%	N, 0%	p
	<b>Span</b> , (200,750), u(Span <sub>z</sub> )						p
	Repeatability	0.1	0.75%	0.1/(24) <sup>1/2</sup>	0.75%/(24) <sup>1/2</sup>	N, 100%	p
u(NO <sub>x</sub> ), u(NO <sub>x,r</sub> )	Long term span drift	1.44%	5%/3 <sup>1/2</sup>	0.29%	5%/(0.5 × 24 × 3) <sup>1/2</sup>	N,R; N, R, 50%	p
	Repeatability	0.1	0.75%	0.1/(N <sub>eff</sub> ) <sup>1/2</sup>	0.75%/(N <sub>eff</sub> ) <sup>1/2</sup>	N, 100%	p
	Lack of Fit, linearity	5/3 <sup>1/2</sup>	Max (5, 4%)/3 <sup>1/2</sup>	0.18%	Max (5,4%)/(N <sub>eff</sub> × 3) <sup>1/2</sup>	R, 100%	pn
	Pressure change	0.06	0.06	0.01	0.01		n
	Temperature	0.7	0.7	0.18	0.18		n
	Voltage change	0.02	0.02	0.0	0.0		n
	Sampling <sup>b</sup>	2%/3 <sup>1/2</sup>	2%/3 <sup>1/2</sup>	2%/(0.5 × N <sub>eff</sub> × 3) <sup>1/2</sup>	2%/(0.5 × N <sub>eff</sub> × 3) <sup>1/2</sup>	N, 50%	p
	H <sub>2</sub> O	2% + 2% (14/9)/6 <sup>1/2</sup>	4% + 4% (14/9)/6 <sup>1/2</sup>	2% <sup>c</sup>	4%	Mean + Tr	p
	PANi <sup>d</sup>	1/6 <sup>1/2</sup>	7/6 <sup>1/2</sup>	0.2	1		n
	CO <sub>2</sub>	0.35	0.35	0.13	0.13		n
u(NO <sub>x,r</sub> )	NH <sub>3</sub> & NHO <sub>3</sub>	0	0	0			n
	HNO <sub>2</sub>	0.5 + 2.2/6 <sup>1/2</sup>	0.5 + 2.2/6 <sup>1/2</sup>	0.5	0.5	Mean + Tr	n
	eff (1), u(eff)	0.5%	2%	0.5%	2%	N, 0%	p
Missing data (90%)			0%	0.5%		p	

Thunis, P., Pernigotti, D. & Gerboles, M. Model quality objectives based on measurement uncertainty. Part I: Ozone. *Atmospheric Environment* **79**, 861–868 (2013)

Pernigotti, D., Gerboles, M., Belis, C. A. & Thunis, P. Model quality objectives based on measurement uncertainty. PartII: NO2 and PM10. *Atmospheric Environment* **79**, 869–878 (2013)

# Reference measurements – new Directive

## FAIRMODE MQO

$$\text{MQO} = \frac{1 \text{ RMSE}}{2 \text{ RMS}_U} = \frac{1}{2} \frac{\sqrt{\sum_{i=1}^N (m_i - x_i)^2}}{\sqrt{\sum_{i=1}^N U^2(x_i)}} \leq 1$$

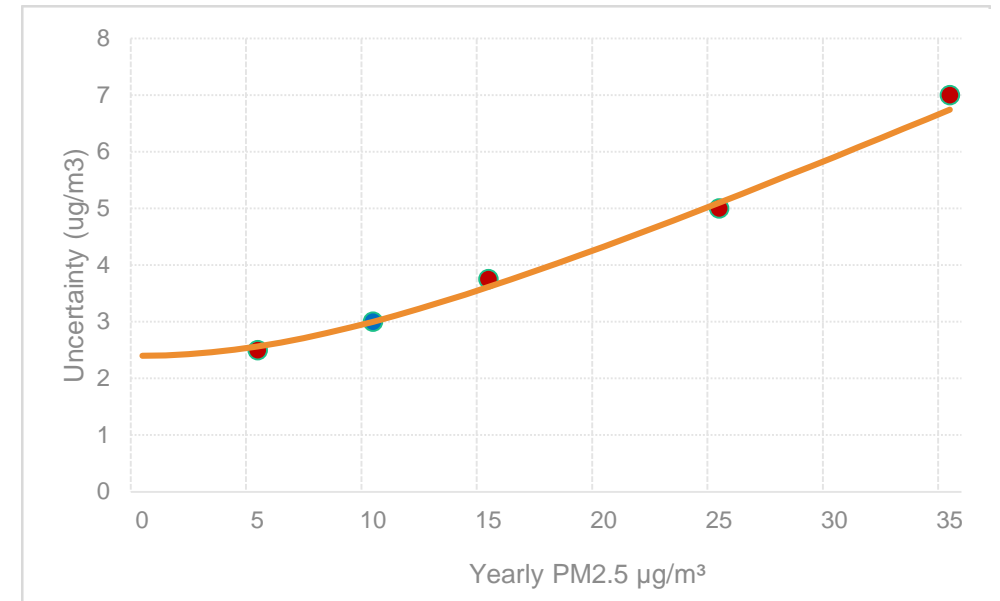


**FAIRMODE**  
simplified equation

$$U(x_i) = U_r(LV) \sqrt{(1-\alpha^2)x_i^2 + \alpha^2 LV^2} \quad \rightarrow$$

Fitting of  $\alpha$   $\leftarrow$

**Aquila** new uncertainties for all pollutants



# Model Quality Objectives – indicative measurements

## FAIRMODE MQO

$$MQO = \frac{1}{2} \frac{RMSE}{RMS_U} = \frac{1}{2} \frac{\sqrt{\sum_{i=1}^N (m_i - x_i)^2}}{\sqrt{\sum_{i=1}^N U^2(x_i)}} \leq 1$$

## Guide for demonstration of Equivalence

$$U(x_i) = k \times \sqrt{(RMSE) + [a + (b - 1)x_i]^2}$$

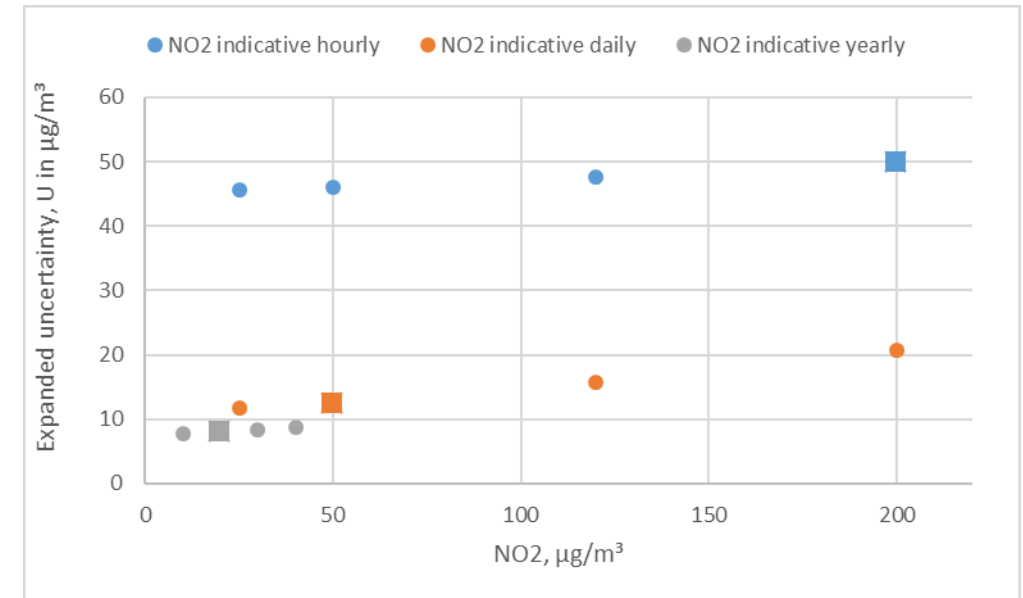
Random errors  
60 – 80%

Bias  
20-40%

Fitting of RMSE, a and b  
**Criteria:** expert judgement  
And consistency of hourly,  
daily and yearly uncertainties

## ■ DQO of the Directive

## ● Aquila additional uncertainties



# Aquila activity on representativeness of sampling points

- The Directive sets some requirement about the spatial representativeness of sampling points in relation to modelling and indicative measurements (art.8, 9, annex 4.B and 4.D, sampling points)
- Members of AQUILA were involved into early working groups about representativeness launched by DG ENV, not under the umbrella of AQUILA
- Since the FAIRMODE intercomparison study (2015-2017), AQUILA have does not carry out activities on the evaluation of the spatial representativeness of sampling points

# Aquila activity on network design evaluation

- Directive Annex 4, D.9: *“At least every 5 years the ... network design ... defined by **the competent authorities** ... shall be reviewed to ensure they remain valid and optimal overtime ... at least by either modelling applications or indicative measurements”.*
- AQUILA is the network of National Reference Laboratory (NRLs), responsible for the accuracy of measurements of the air quality monitoring network. In the Directive the network design evaluation is not under the responsibility of the NRLS (see Annex 5.F on DQOs and responsibilities).

# AQUILA activity on Low-cost sensors

- In the Directive, low-cost sensors measurements would fall under the category “indicative measurements” used for several purposes
- At the workshop on low-cost sensors, Sep. 2024, AQUILA decided not to include low-cost sensors in the JRC/AQUILA intercomparisons, seen its lack of use for monitoring in the EU Member States, likely because:
  - doubts on accuracy of low-cost sensors
  - difficulty to demonstrate that the DQOs of indicative methods are met
  - AQUILA members support benchmarking of sensors and AQUILA will facilitate the exchange of information on sensors
- CEN TC 264 WG42 deals with standardisation of low-cost sensors

# CEN TC 264 WG42 Low-cost sensors

- WG 42 has published 2 protocols for the evaluation of individual sensors, to demonstrate meeting the of the DQO for “indicative measurements” and “objective estimations”: TS 17660-1 and -2
- Being Technical Specifications (TS) and not full European Standards (EN), sensor manufacturers are reluctant to engage into the process of sensor classification of TS17660→Low-cost sensors are not much used
- DG ENV has launched a call for tender for pre-normative work to convert TSs into EN 17660 ...
- WG 42 is about to launch drafting of a new document for the QA/QC at sampling point both for individual sensors and sensor networks



# On-going Aquila work relevant for FAIRMODE

- The Guide for the Demonstration of Equivalence of Measurement Methods (GDE) is under a major revision under DG ENV – AQUILA
- The GDE is used for the evaluation of the Model Quality Objective of indicative measurements
- **My first guess:** the equation of the GDE used for the MQO of indicative methods should not change → Still to be check and confirmed when the new GDE is published.

# Thank you



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