MQO

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Status

- A formulation of the MQO based on observation uncertainty:

$$MQO_{hourly/daily} = \frac{RMSE}{RMS_U}$$

$$MQO_{yearly} = \frac{BIAS}{2U}$$

- Assumptions are made to derive a simple formulation for the observation uncertainty (e.g. data reference year)

- MQO are currently available for NO2 (h/y), O3(8h) and PM10 (d/y)

Points addressed

- *Testing the robustness of the formulation*
  - **Extended datasets**
  - **Further tests on specific hypotheses**

- *Extending the formulation to new species*

"u" formulation

European Commission

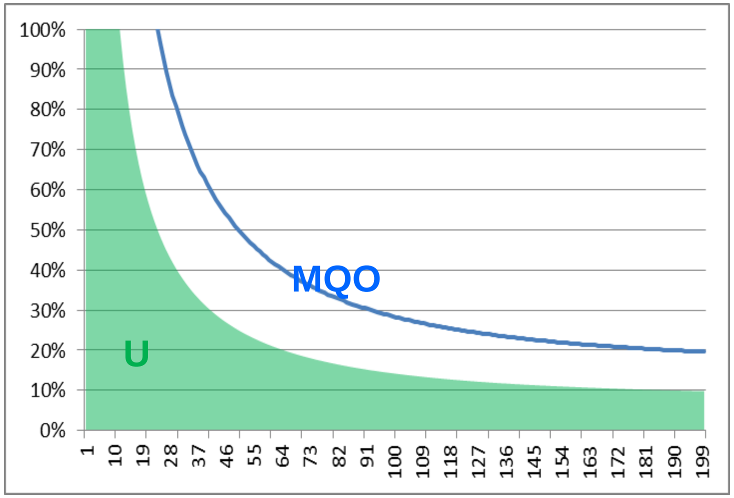
Hourly / daily

$$u^2 = u_{RV}^2 (1-\alpha) C^2 + u_{RV}^2 \alpha RV^2$$

Yearly

$$u^2 = \frac{u_{RV}^2 (1-\alpha) C^2}{N_p} + \frac{u_{RV}^2 \alpha RV^2}{N_{np}}$$

u_{RV}	Uncertainty at the reference value
α	Degree of proportionality
RV	Reference value (free user choice)
N_p, N_{np}	Yearly fitting coefficients



Concentration (ug/m3)

NO2 robustness (I)

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Hourly NO2: GUM approach

Group	Source	Hourly values, u: Min	Hourly values, u: Max	Annual values, u: Min	Annual values, u: Max	D,%rand	Ty
b_0, b_1	*NOx Zero*(0)	2/3^½	2/3^½	2/(0.5x4x3)½	2/(0.5x2x3)^½	R, R; R, R, 50%	pn
	NO Zero(0)	1/3^½	1/3^½	1/(0.5x4x3)½	1/(0.5x2x3)^½	R, R; R, R, 50%	pn
	NOx/NO Zero$_r$ (0)						
	Repeatability at zero	0.1	1/3^½	0.1/(24x3)^½	1/(4x3)^½	N,R; R, R, 100%	pn
	Long term zero drift	0.58	4/3^½	0.58/(0.5x24)^½	4/(0.5x24x3)^½	N, R; N,R, 50 %(i)	pn
b_1	*% of Span* (200,750)	1%	2.5%	1%	2.5%	N,N; N, N, 0 %	p
	% of Span$_r$ (200,750)						p
	Repeatability	0.1	0.75%	0.1/(24)^½	0.75%/(24)^½	N, N; N,N, 100%	p
	Long term span drift	1.44%	5%/3^½	0.29%	5%/(0.5x24x3)^½	N,R; N, R, 50%	p
$NO_{x,r}, NO_r$	Repeatability	0.1	0.75%	0.1/(N_{eff})^½	0.75%/(N_{eff})^½	N, 100%	p
	Lack of Fit, linearity	5/3^½	Max(5,4%)/3^½	0.18%	Max(5,4%)/N_{eff}3^½	R, 100 %	pn
	Pressure change	0.06		0.01			n
	Temperature	0.7		0.18			n
	Voltage change	0.02		0.0			n
	Sampling(ii)	2%/3^½		2%/(0.5xN_{eff}x3)^½(iii)		N, 50 %	p
	H_2O	2%+2%.(14/9)/6^½	4%+4% (14/9)/6^½	2%(iv)	4%	Mean Tr	p
$NO_{x,r}$	*PAN*(v)	1/6^½	7/6^½	0.2	1		n
	CO_2	0.35		0.13			n
	NH_3 & NHO_3	0	0	0	0		n
	HNO_2	0.5+2.2/6^½		0.5		Mean T	n
eff (0.95,1)		0.5 %	2%	0.5 %	2%	N, 0 %	p
Missing data (90%)				0%	0.5%		p

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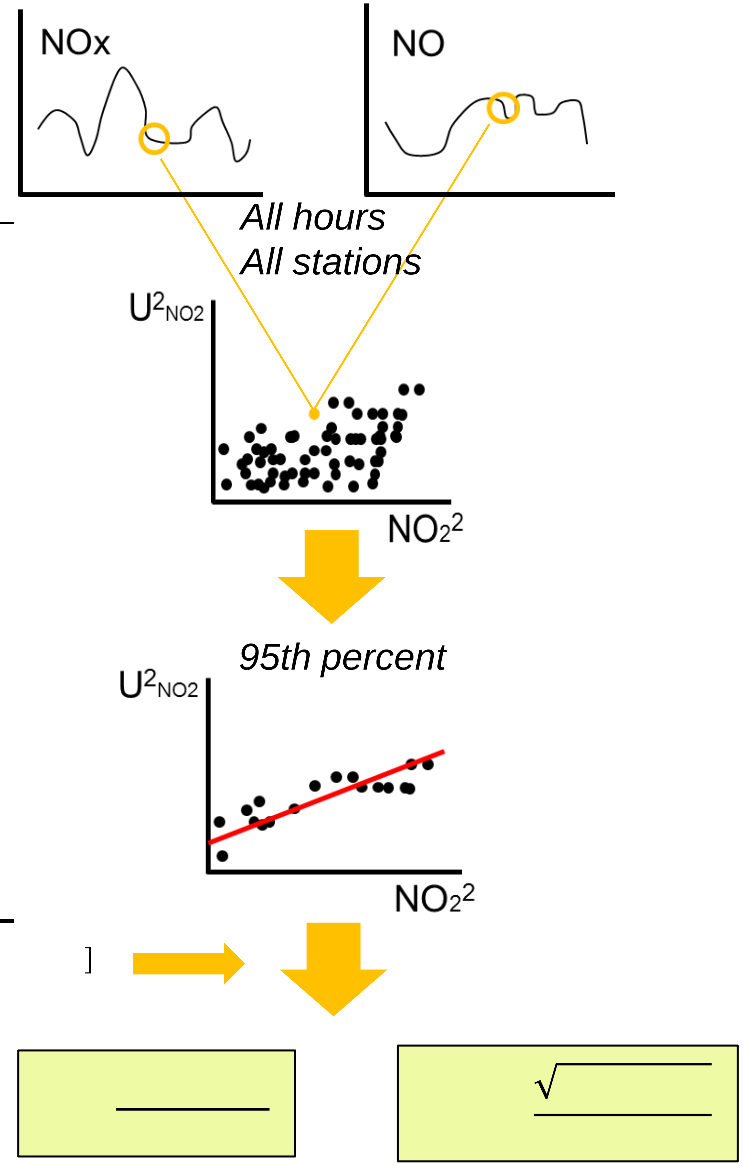

NO2 robustness (II)

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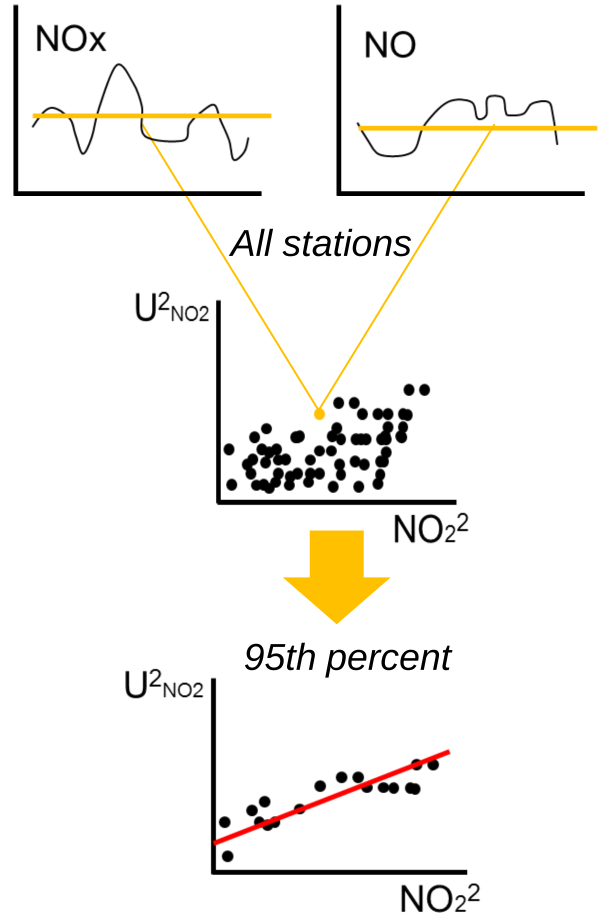
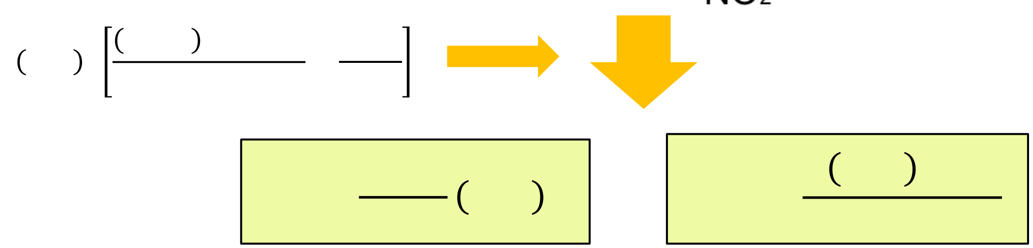
Yearly NO2: GUM approach

		Hourly values, u		Annual values, u		D,%rand	Ty
		Min	Max	Min	Max		
b_0, b_1	*NOx Zero*(0)	2/3^{½}	2/3^{½}	2/(0.5x4x3)½	2/(0.5x2x3)^{½}	R, R; R, R, 50%	pn
	NO Zero(0)	1/3^{½}	1/3^{½}	1/(0.5x4x3)½	1/(0.5x2x3)^{½}	R, R; R, R, 50%	pn
	NOx/NO Zero$_r$ (0)						
	Repeatability at zero	0.1	1/3^{½}	0.1/(24x3)^{½}	1/(4x3)^{½}	N,R; R, R, 100%	pn
	Long term zero drift	0.58	4/3^{½}	0.58/(0.5x24)^{½}	4/(0.5x24x3)^{½}	N, R; N,R, 50 %$^{(i)}$	pn
b_1	*% of Span* (200,750)	1%	2.5%	1%	2.5%	N,N; N, N, 0 %	p
	% of Span$_r$ (200,750)						p
	Repeatability	0.1	0.75%	0.1/(24)^{½}	0.75%/(24)^{½}	N, N; N,N, 100%	p
	Long term span drift	1.44%	5%/3^{½}	0.29%	5%/(0.5x24x3)^{½}	N,R; N, R, 50%	p
$NO_{x,r}, NO_r$	Repeatability	0.1	0.75%	0.1/(N_{eff})^{½}	0.75%/(N_{eff})^{½}	N, 100%	p
	Lack of Fit, linearity	5/3^{½}	Max(5,4%)/3^{½}	0.18%	Max(5,4%)/N_{eff}3^{½}	R, 100 %	pn
	Pressure change	0.06		0.01			n
	Temperature	0.7		0.18			n
	Voltage change	0.02		0.0			n
	Sampling$^{(ii)}$	2%/3^{½}		2%/(0.5xN_{eff}x3)$^{½(iii)}$		N, 50 %	p
	H_2O	2%+2%.(14/9)/6^{½}	4%+4% (14/9)/6^{½}	2%$^{(iv)}$	4%	Mean Tr	p
$NO_{x,r}$	*PAN*$^{(v)}$	1/6^{½}	7/6^{½}	0.2	1		n
	CO_2	0.35		0.13			n
	NH_3 & NHO_3	0	0	0	0		n
	HNO_2	0.5+2.2/6^{½}		0.5		Mean T	n
eff (0.95,1)		0.5 %	2%	0.5 %	2%	N, 0 %	p
Missing data (90%)				0%	0.5%		p





NO2 robustness (III)

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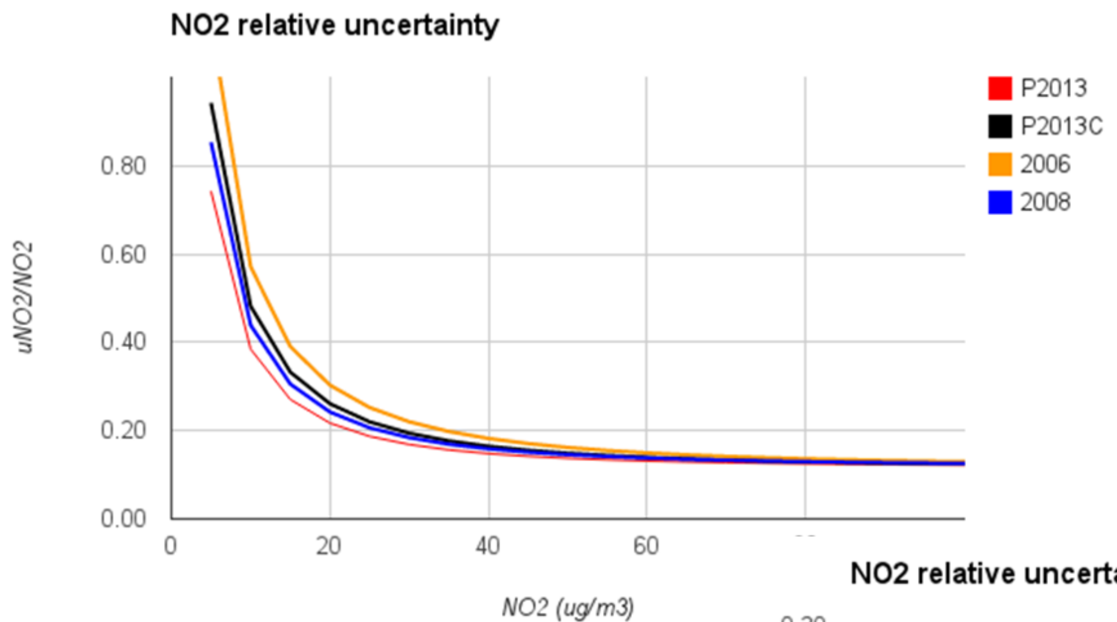
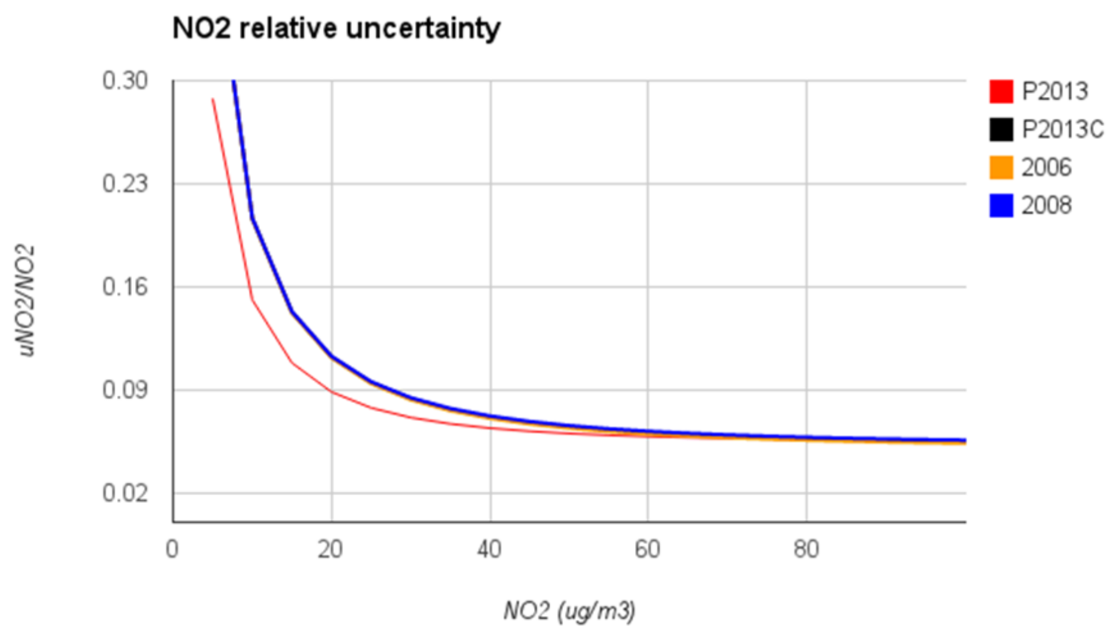


Hourly



Yearly

NO2 robustness (IV)

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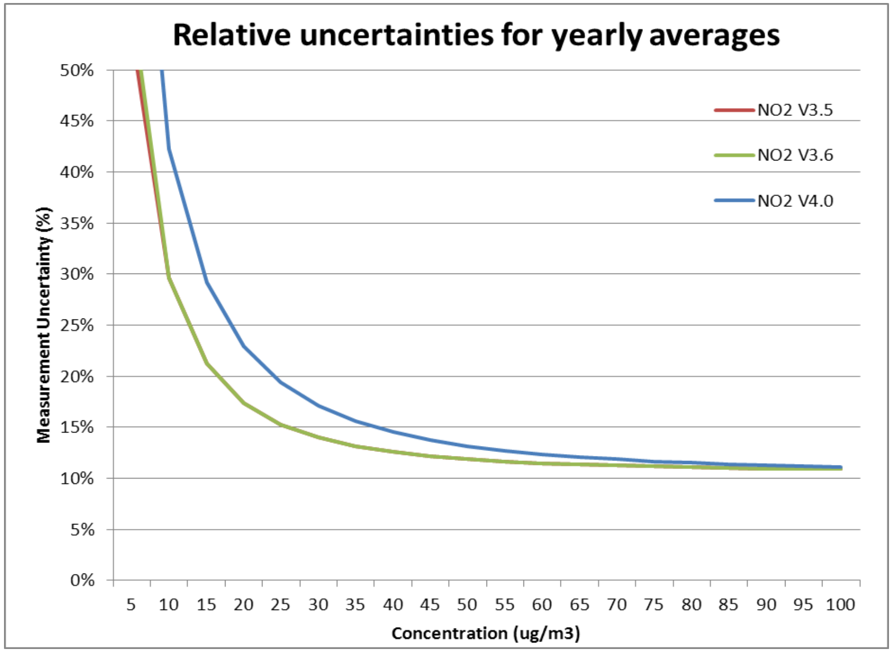
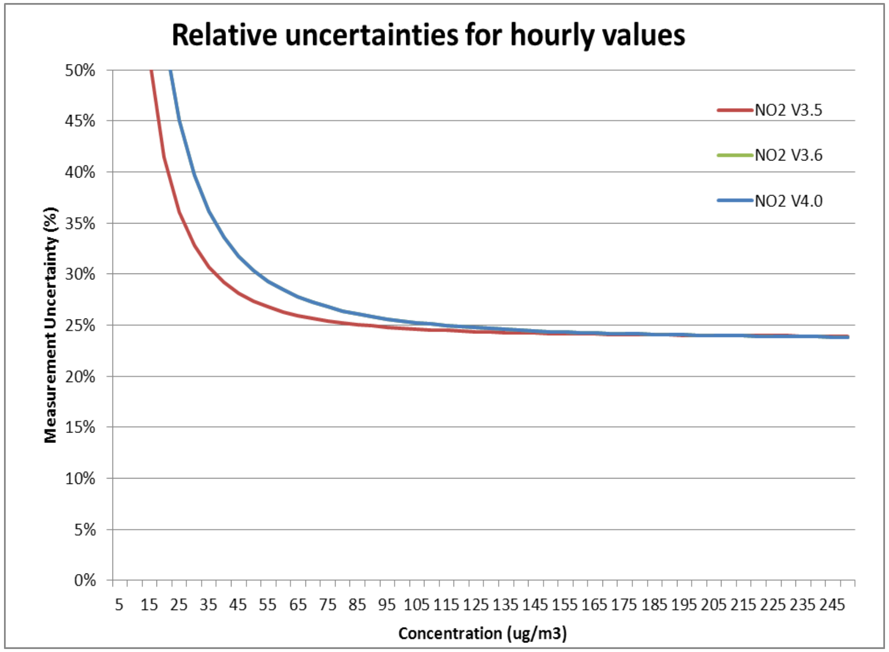
Yearly

	k	UrLV	alpha	LV	Np	Nnp
NO2 V3.5	2	0.12	0.02	200	4.7	6.7
NO2 V3.6	2	0.12	0.04	200	5	12
NO2 V4.0	2	0.12	0.04	200	5.2	5.5

Hourly

	k	UrLV	alpha	LV
NO2 V3.5	2	0.12	0.02	200
NO2 V3.6	2	0.12	0.04	200
NO2 V4.0	2	0.12	0.04	200





PM10 robustness

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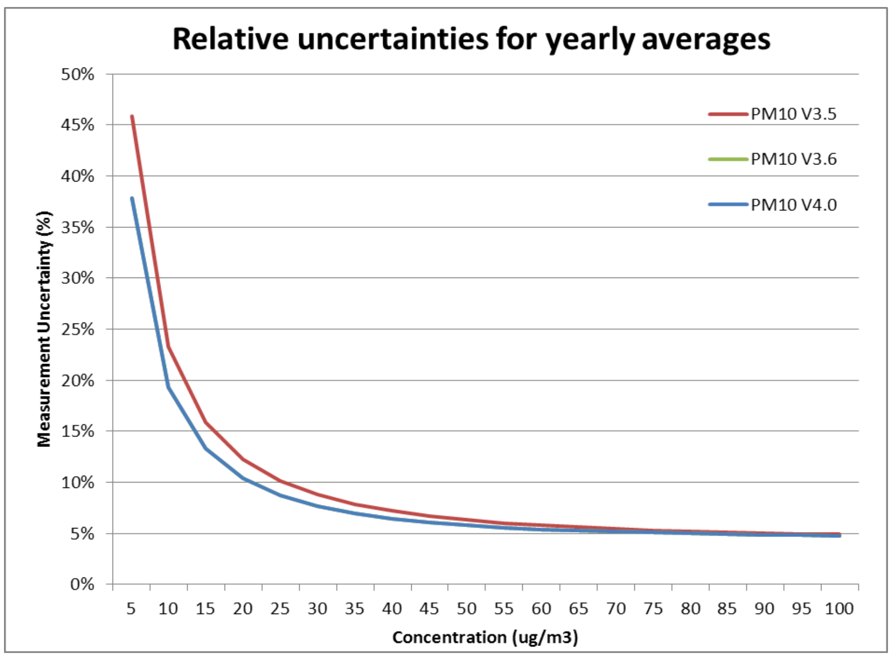
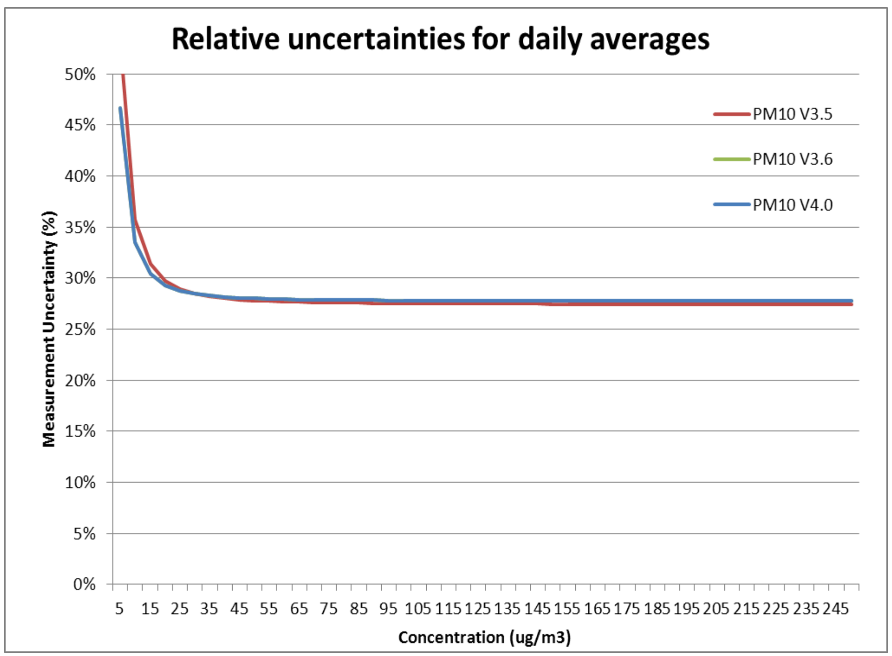
Yearly

	k	UrLV	alpha	LV	Np	Nnp
PM10 V3.5	2	0.139	0.027	50	40	1
PM10 V3.6	2	0.14	0.018	50	40	1
PM10 V4.0	2	0.14	0.018	50	40	1



Daily

	k	UrLV	alpha	LV
PM10 V3.5	2	0.139	0.027	50
PM10 V3.6	2	0.14	0.018	50
PM10 V4.0	2	0.14	0.018	50



Robustness of the assumptions (I)

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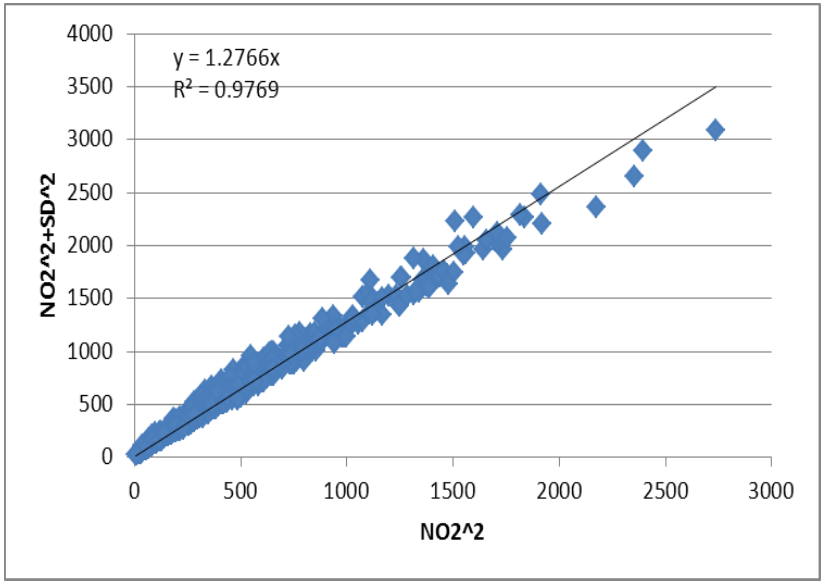
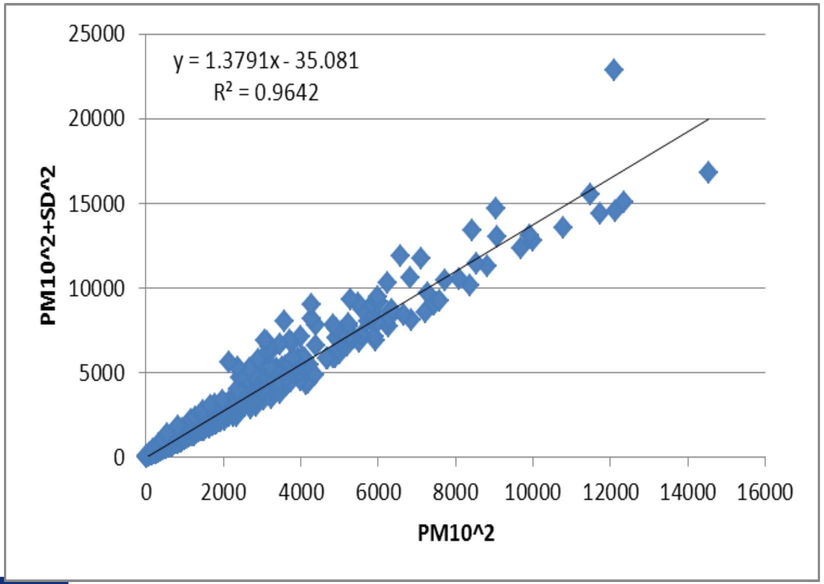
- *Linearization of the standard deviation term*

$$u\left(\overline{C}\right) = u^{RV}\sqrt{\frac{(1-\alpha)\left(\overline{C}^2+\sigma^2\right)}{N_p^*}+\frac{\alpha\, RV^2}{N_{np}}} \cong u^{RV}\sqrt{\frac{(1-\alpha)\,k\overline{C}^2}{N_p^*}+\frac{\alpha\, RV^2}{N_{np}}} \cong u^{RV}\sqrt{\frac{(1-\alpha)\,\overline{C}^2}{N_p}+\frac{\alpha\, RV^2}{N_{np}}}$$

$$\left[NO_2\right]^2 = k\left(\left[NO_2\right]^2+\sigma_{NO_2}^2\right) \qquad \left[\mathrm{PM}_{10}\right]^2 = k\left(\left[\mathrm{PM}_{10}\right]^2+\sigma_{\mathrm{PM}_{10}}^2\right)$$



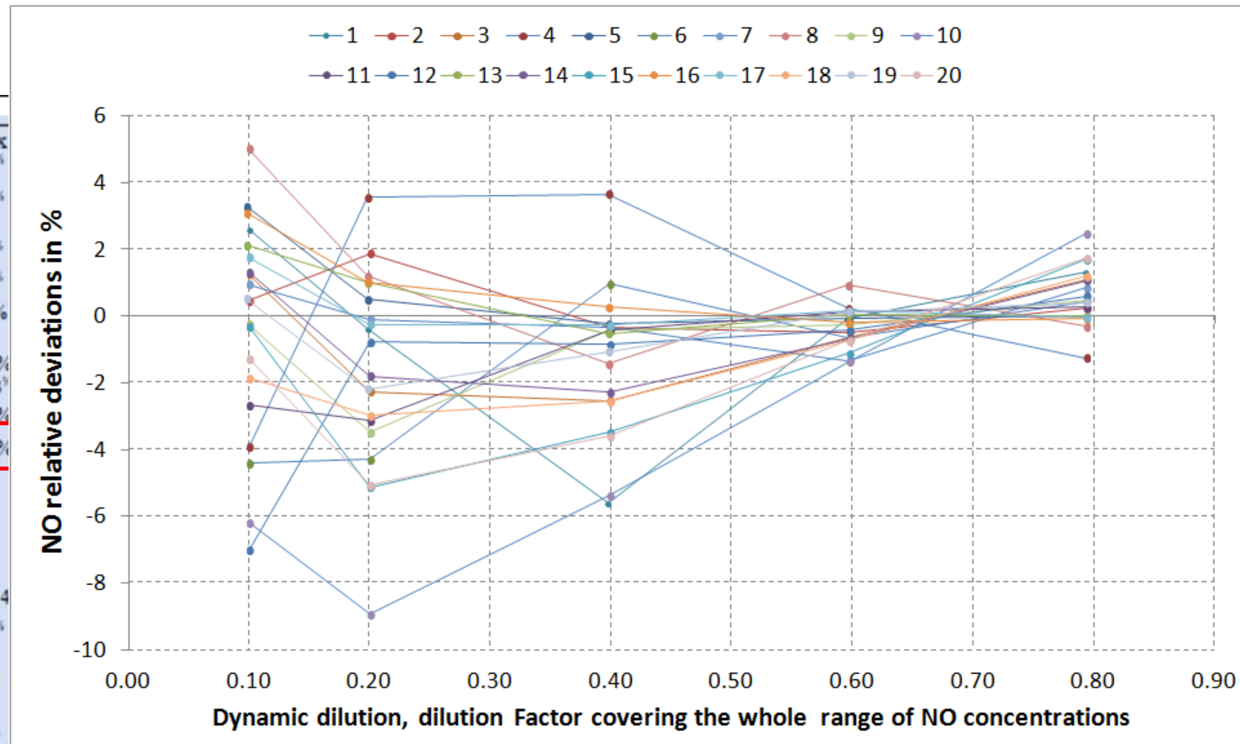


Robustness of the assumptions (II)

European Commission

- ***Linearity of NO2 automatic analysers - check of the randomness of the linearity deviations***

		Hourly values, u				
		Min	Max			
b_0, b_1	*NOx Zero*(0)	$2/3^{1/2}$	$2/3^{1/2}$			
	NO Zero(0)	$1/3^{1/2}$	$1/3^{1/2}$			
	NOx/NO Zero, (0) Repeatability at zero	0.1	$1/3^{1/2}$			
	Long term zero drift	0.58	$4/3^{1/2}$			
b_1	*% of Span* (200,750)	1%	2.5%			
	% of Span, (200,750) Repeatability	0.1	0.75%			
	Long term span drift	1.44%	$5\%/3^{1/2}$			
$NO_{x,r}, NO_r$	Repeatability	0.1	0.75%			
	Lack of Fit, linearity	$5/3^{1/2}$	Max(5,4%			
	Pressure change	0.06				
	Temperature	0.7				
	Voltage change	0.02				
	Sampling(ii)	$2\%/3^{1/2}$				
	H_2O	$2\%+2\%.(14/9)/6^{1/2}$	4%+4% (14			
$NO_{x,r}$	PAN(i)	$1/6^{1/2}$	$7/6^{1/2}$			
	CO_2	0.35				
	NH_3 & NHO_3	0	0			
	HNO_2	$0.5+2.2/6^{1/2}$				
eff (0.95,1)		0.5 %	2%			
Missing data (90%)				0%	0.5%	p



Extension to new species (I)

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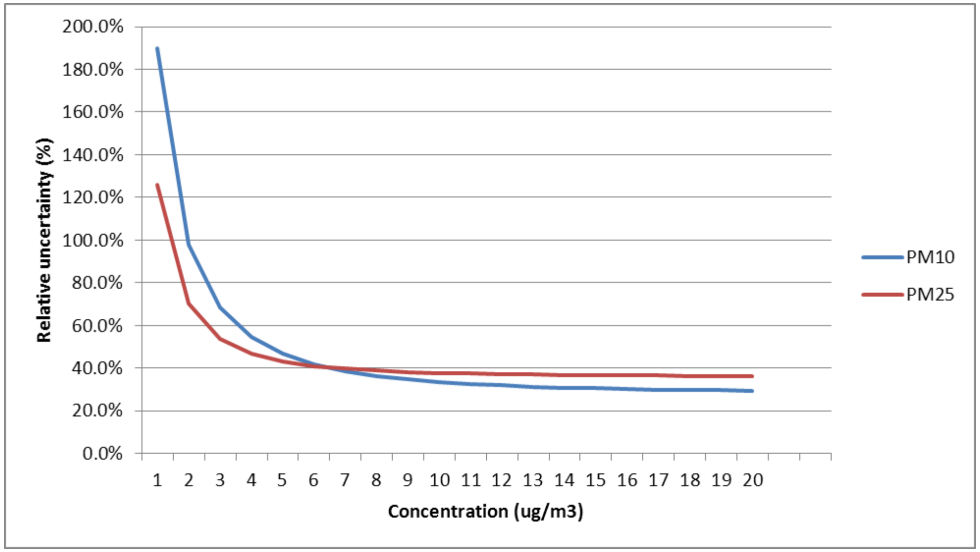
Commission

PM2.5

- *Based on 140 days of gravimetric measurements (JRC inter-comparison exercise)*
- *No significant results for TEOM and beta-ray (not enough measurements!)*

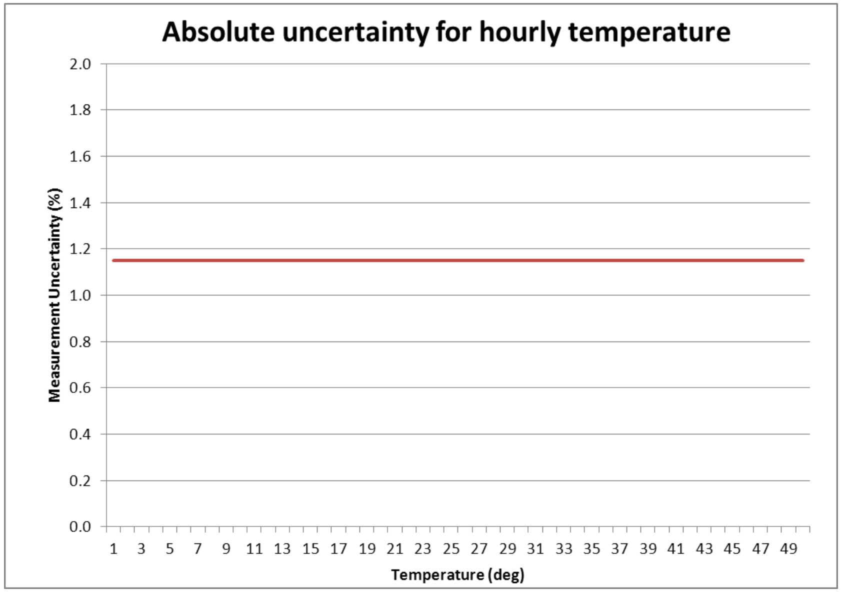


	RV	UrRV	alpha
PM10	50	0.14	0.018
PM2.5	25	0.18	0.018

Extension to new species (II)

Temperature

- *Instrument uncertainty is extremely low (0.1 degree)*
- *Shield structure leads to larger error around one degree (Leroy 2002)*
- *Assumption made: equi-probable uncertainty (rectangular distribution) leading to u=0.57 C*



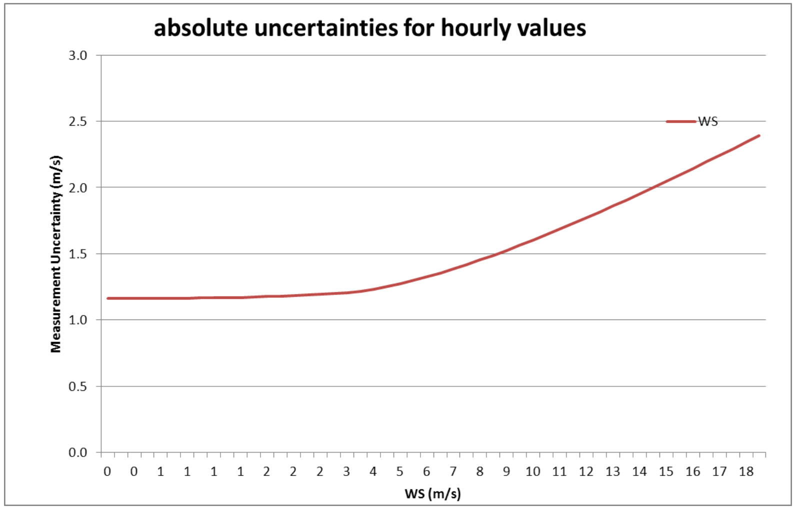
	RV	UrRV	alpha
TEMP	25	0.023	1

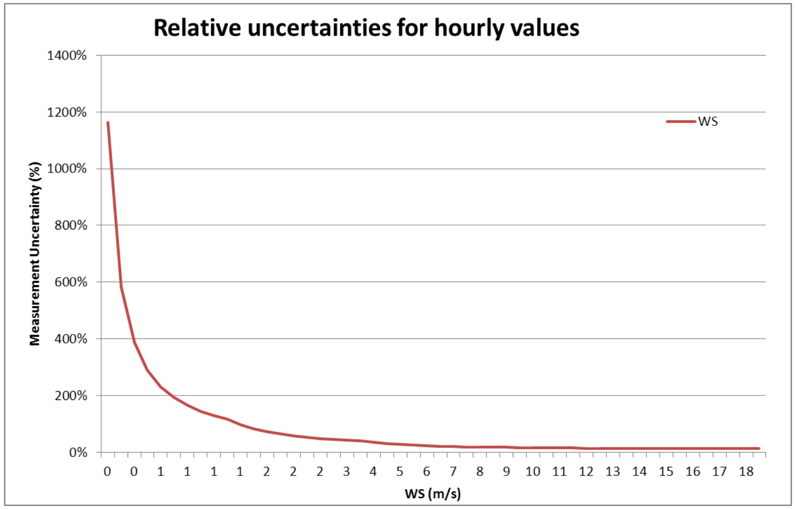
Extension to new species (III)

Wind-speed

	RV	UrRV	alpha
TEMP	5	0.13	0.8

- *Difficulty to use real datasets*
- *Assumption WMO taken as basis (0.5 fixed below 5 m/s and proportional 10% above.*
- *In addition: equi-probable 0.5 m/s due to integer rounding*





Extension to new species (IV)

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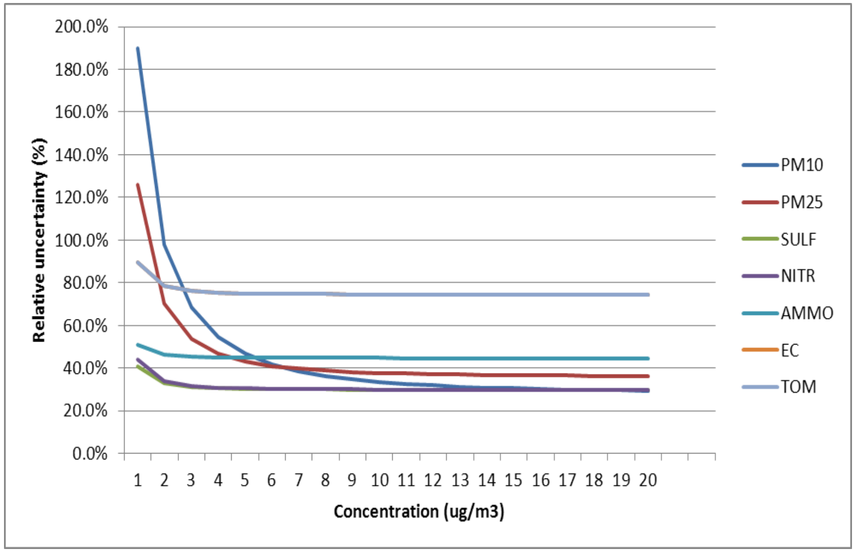
PM components

- *RV and urRV from expert judgments*
- *Alpha, Np and Nnp similar to PM10 and PM2.5*



	RV	UrRV	α	Np	Nnp
SO4	7	0.15	0.018	40	1
NO3	8	0.15			
NH4	4	0.225			
EC	5	0.375			
TOM	10	0.375			

Conclusions (I)

European Commission

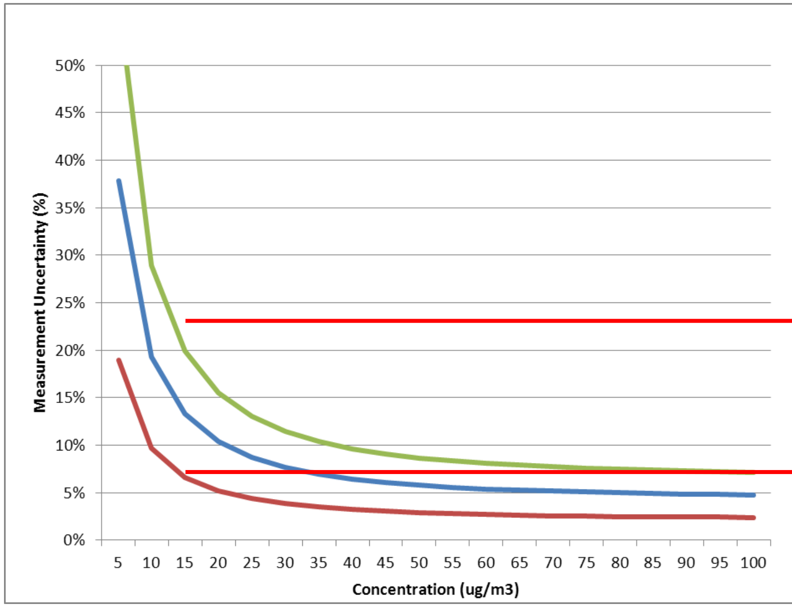
- *NO2 and PM10 MQO seem to be robust as well as underlying assumptions*

- *A new MQO is available for testing (PM2.5)*

- *Other MQO (WS, TEMP, PM components) have been derived for other projects. Of interest to FAIRMODE?*

Conclusions (II)

European
Commission



MQO is not ambitious enough
Everybody succeeds – Useless

MQO is too ambitious
Nobody succeeds – Useless

- *What is important is to relate the model error to the observation uncertainty and assume a realistic functional relationship (U)*
- *Ways exist to tune the MQO to an adequate compromise in terms of stringency (coverage factor (K), max. vs. mean uncertainty…)*