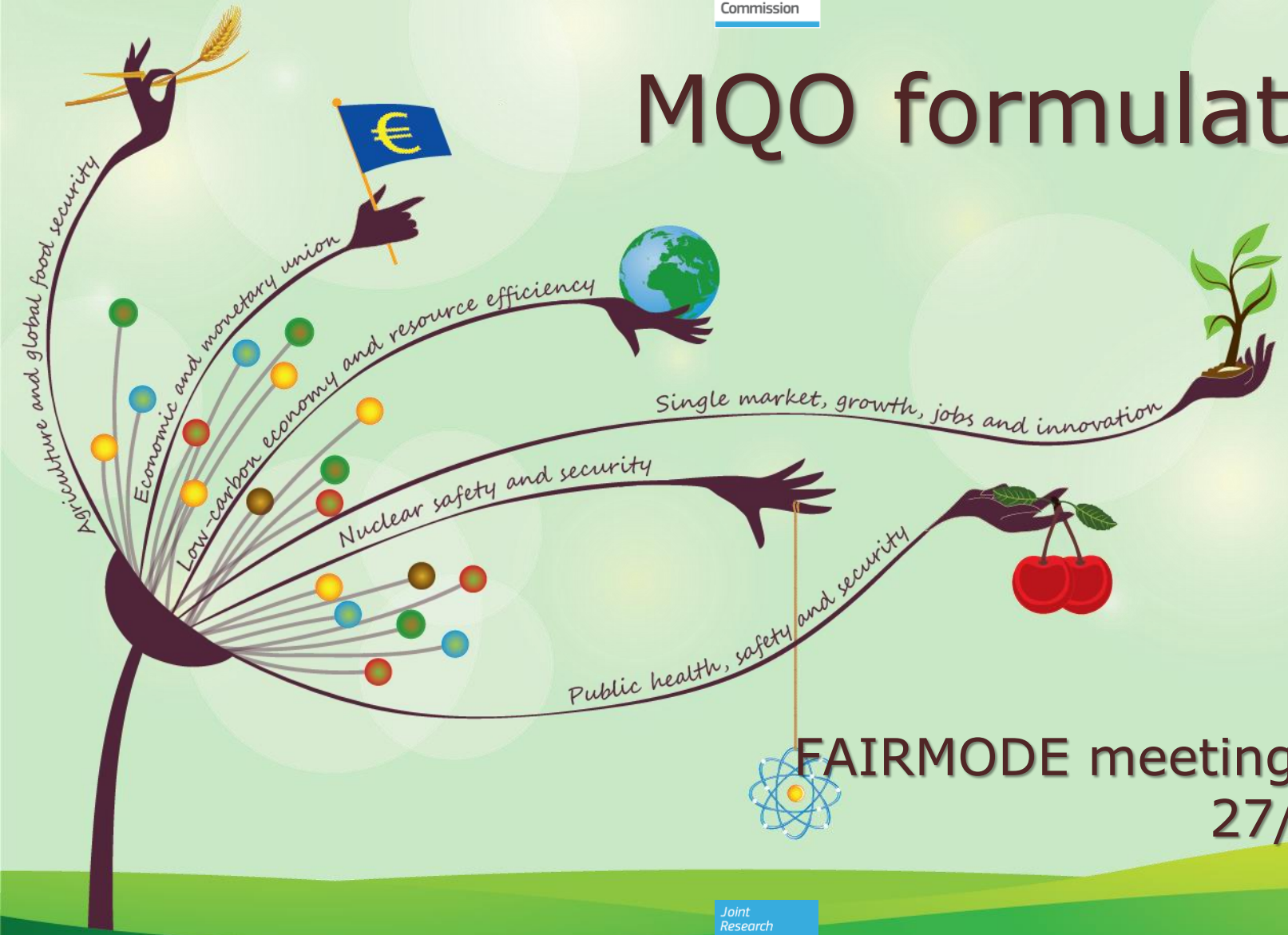
European Commission

MQO formulation



FAIRMODE meeting, Zagreb
27/06/2016

Joint Research Centre

What is in the AQD

DIRECTIVE 2008/50/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 21 May 2008

on ambient air quality and cleaner air for Europe

A. **Data quality objectives for ambient air quality assessment**

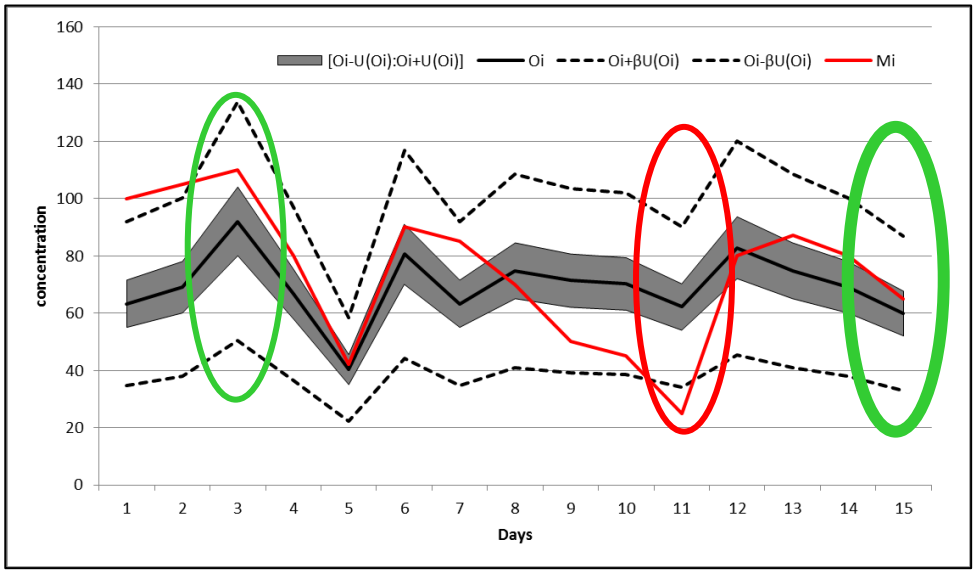
	Sulphur dioxide, nitrogen dioxide and oxides of nitrogen and carbon monoxide	Benzene	Particulate matter ($PM_{10}/PM_{2,5}$) and lead	Ozone and related NO and NO_2
Fixed measurements (1)				
O Uncertainty	15 %	25 %	25 %	15 %
Modelling uncertainty:				
M Hourly	50 %	—	—	50 %
Eight-hour averages	50 %	—	—	50 %
Daily averages	50 %	—	not yet defined	—
Annual averages	30 %	50 %	50 %	—

Proposed Indicators

$$I = \frac{|O_{LV} - M_{LV}|}{LV} \quad \rightarrow \quad I = \frac{|O(i) - M(i)|}{\beta\, U(i)}$$

- Only valid around the Limit Value
- Timing of the events not considered
- Not available for all time averages

- Valid over the concentration range
- Timing of the events is considered
- Available for different time averages



$|O(i) - M(i)| \leq \beta\, U(i)$ $|O(i) - M(i)| > \beta\, U(i)$ $|O(i) - M(i)| \leq \quad U(i)$

Joint Research Centre

Definitions

Modelling Quality Indicator (MQI): Statistical indicator calculated on the basis of measurements and modelling results.

Modelling Quality Objective (MQO): Criteria for the value of the MQI. The MQO is said to be fulfilled if MQI is less than or equal to unity.

Modelling Quality Indicator (MPI): Statistical indicators calculated on the basis of measurements and modelling results. Each of the MPI describes a certain aspect of the discrepancy between measurement and modelling results.

Modelling Performance Criteria (MPC) Criteria that MPI are expected to fulfil. They are necessary, but not sufficient criteria to determine whether the MQO are fulfilled.

Daily / Hourly MQO & MPC

European Commission

	MQI	MQO	MPI	MPC
RMSE	$\frac{RMSE}{\beta\ RMS_U}$	$MQI \leq 1$		
BIAS			$\frac{\lvert\bar{M}-\bar{O}\rvert}{\beta\ RMS_U}$	$MPI \leq 1$
R			$\frac{\sqrt{2\sigma_O\sigma_M(1-R)}}{\beta RMS_U}$	
SD			$\frac{\lvert\sigma_M-\sigma_O\rvert}{\beta\ RMS_U}$	
Spatial R			$\frac{\sqrt{2\sigma_O\sigma_M(1-R)}}{\beta RMS_{\bar{U}}}$	$MPI \leq 1$
Spatial SD			$\frac{\lvert\sigma_M-\sigma_O\rvert}{\beta\ RMS_{\bar{U}}}$	
Exceedances			$\frac{\lvert M_{perc}-O_{perc}\rvert}{\beta\ (O_{perc})}$	$MPI \leq 1$

Joint Research Centre

Yearly MQO & MPC

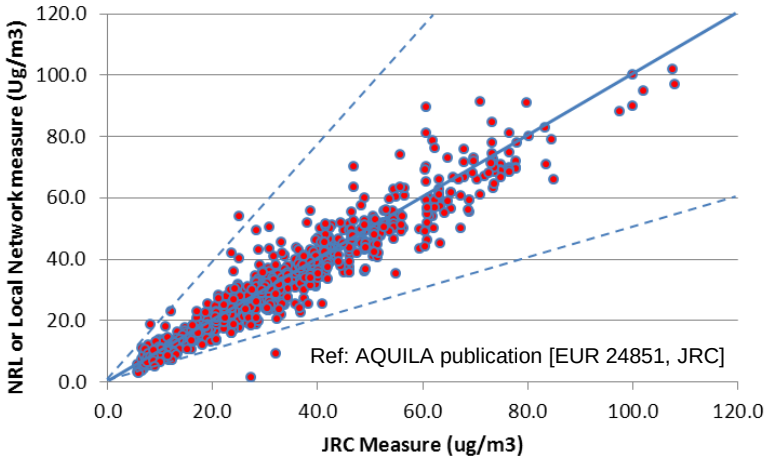
European Commission

	MQI	MQO	MPI	MPC
RMSE	$\frac{\lvert\bar{M}-\bar{O}\rvert}{\beta\ RMS_U}$	$MQI \leq 1$		
Spatial R			$\frac{\sqrt{2\sigma_O\sigma_M(1-R)}}{\beta RMS_{\bar{U}}}$	$MPI \leq 1$
Spatial SD			$\frac{\lvert\sigma_M-\sigma_O\rvert}{\beta\ RMS_{\bar{U}}}$	

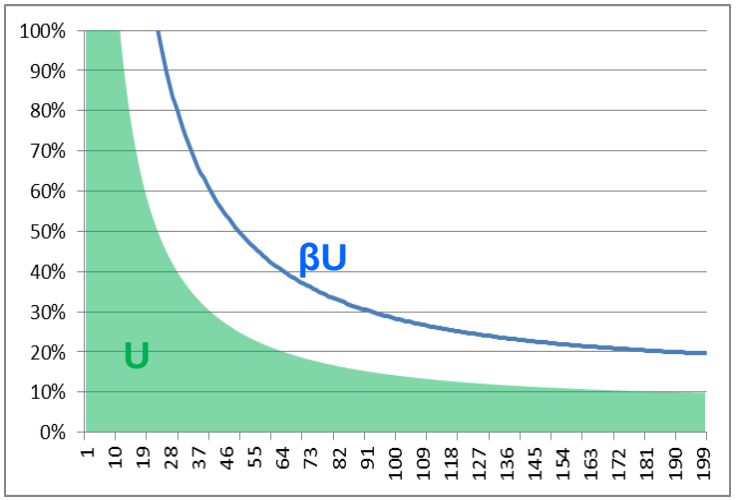
What value for $U_o(i)$

European Commission

Intercomparisons



PM10



Uncertainty budget (GUM)

AIRBASE
1y All EU

NO2

O3

$$U^2 = U_{RV}^2(1-\alpha^2)C^2 + U_{RV}^2\alpha^2 RV^2$$

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

Joint Research Centre

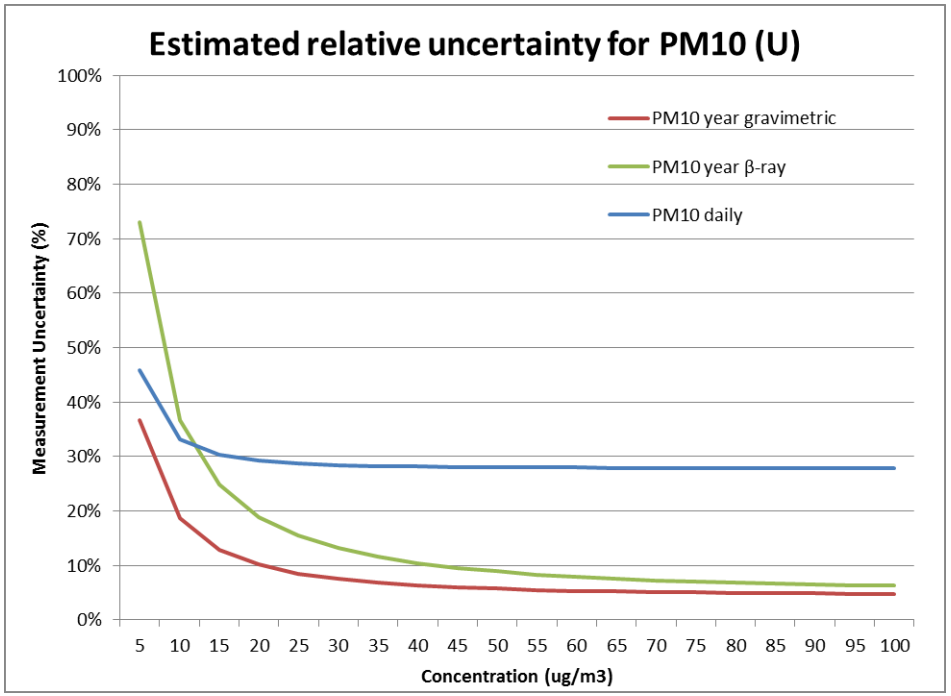
About U

European Commission

	β	U_r^{RV}	RV	α	N_p	N_{np}
NO_2	2	0.25	200 µg/m^3	0.20	5.2	5.5
O_3	2	0.18	120 µg/m^3	0.79	11	3
PM_{10}	2	0.28	50 µg/m^3	0.13	30	0.25
$PM_{2.5}$	2	0.36	25 µg/m^3	0.30	30	0.25

Joint Research Centre

Relation between short- and long-term uncertainties (PM)



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

The 90% principle

The AQD approach is currently used, i.e. the MQO must be fulfilled for at least 90% of the available stations.

		MQI
8	Stat 4	**1.45**
7	Stat 2	**1.32**
6	Stat 8	**1.11**
5	Stat 7	**1.05**
4	Stat 5	**0.90**
3	Stat 1	**0.80**
2	Stat 6	**0.70**
1	Stat 3	**0.65**

METHOD 1:

Percentage of stations fulfilling the MQO = **50%**

METHOD 2: interpolation

Stat90 = fix(nstat*0.9) = fix(7.2)=7
Dist = nstat*0.9-stat90=0.2

$$\mathrm{MQI}_{90\mathrm{th}} = \mathrm{MQI}(\mathrm{stat}_{90}) + [\mathrm{MQI}(\mathrm{stat}_{90}+1) - \mathrm{MQI}(\mathrm{stat}_{90})] * \mathrm{dist}$$

$$\mathrm{MQI}_{90\mathrm{th}} = 1.32 + [1.45 - 1.32] * 0.2 = \mathbf{1.35}$$

$$\mathrm{MQO}: \quad \mathrm{MQI}_{90\mathrm{th}} \leq 1$$

The 90% principle

		MQI
8	Stat 4	**1.45**
7	Stat 2	**1.02**
6	Stat 8	**1.01**
5	Stat 7	**1.01**
4	Stat 5	**0.90**
3	Stat 1	**0.80**
2	Stat 6	**0.70**
1	Stat 3	**0.65**

Meth. 1: 50%
Meth. 2: 1.10

		MQI
2	Stat 6	**1.20**
1	Stat 3	**0.65**

Method 1: 50%
Method 2: 1.09

The choice of the method does not change the final result (fail or pass) but modifies the interpretation in case of close-by cases, especially when few stations are available. Method 2 is then more precise.

		MQI
8	Stat 4	**3.45**
7	Stat 2	**0.98**
6	Stat 8	**0.97**
5	Stat 7	**0.92**
4	Stat 5	**0.90**
3	Stat 1	**0.80**
2	Stat 6	**0.70**
1	Stat 3	**0.65**

Meth. 1: 88%
Meth. 2: 1.47

		MQI
1	Stat 3	**0.65**

Method 1: 100%
Method 2: 0.58

An additional output: model uncertainty

The normalized deviation indicator (ISO 13528) scales the model-observation difference with the measurement and modeling uncertainties [$U(Oi)$ and $U(Mi)$] associated to this difference:

$$E_n = \frac{|O_i - M_i|}{\sqrt{U(O_i)^2 + U(M_i)^2}}$$

E_n equals to unity implies that the model and measured uncertainties are compatible with the model-observation bias. We use this relation, i.e. E_n=1, in DELTA to estimate the minimum model uncertainty compatible with the resulting model-observation bias as follows:

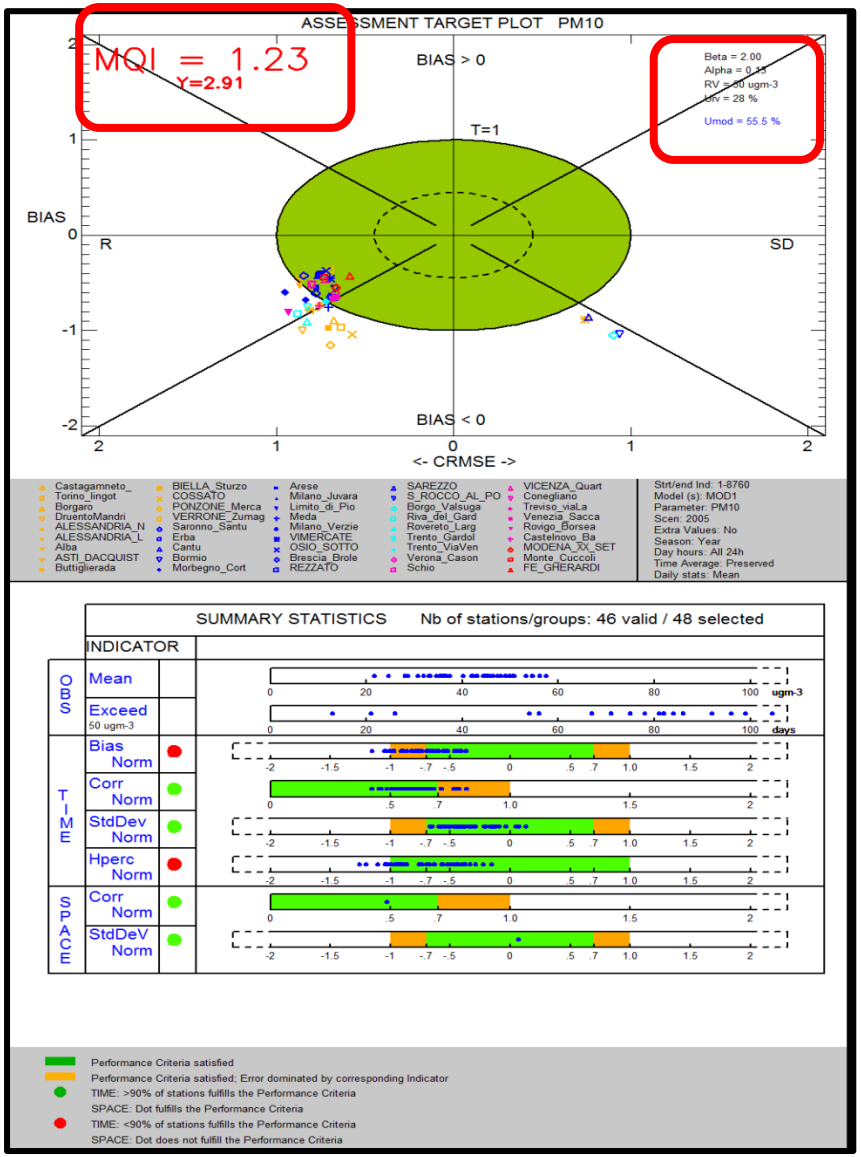
$$E_n = 1 \Rightarrow U(M_i) = U(O_i)\sqrt{\left(\frac{O_i - M_i}{U(O_i)}\right)^2 - 1}$$

Example:	INPUT:	PM_{10}, U_O=5 µg/m^3, $\|O - M\| = 15 \mu g/m^3$
	OUTPUT:	MQO=15/10=1.5 (not fulfilling) $U_M = 2.82U_O = 2.82 * 28\% = 79\%$

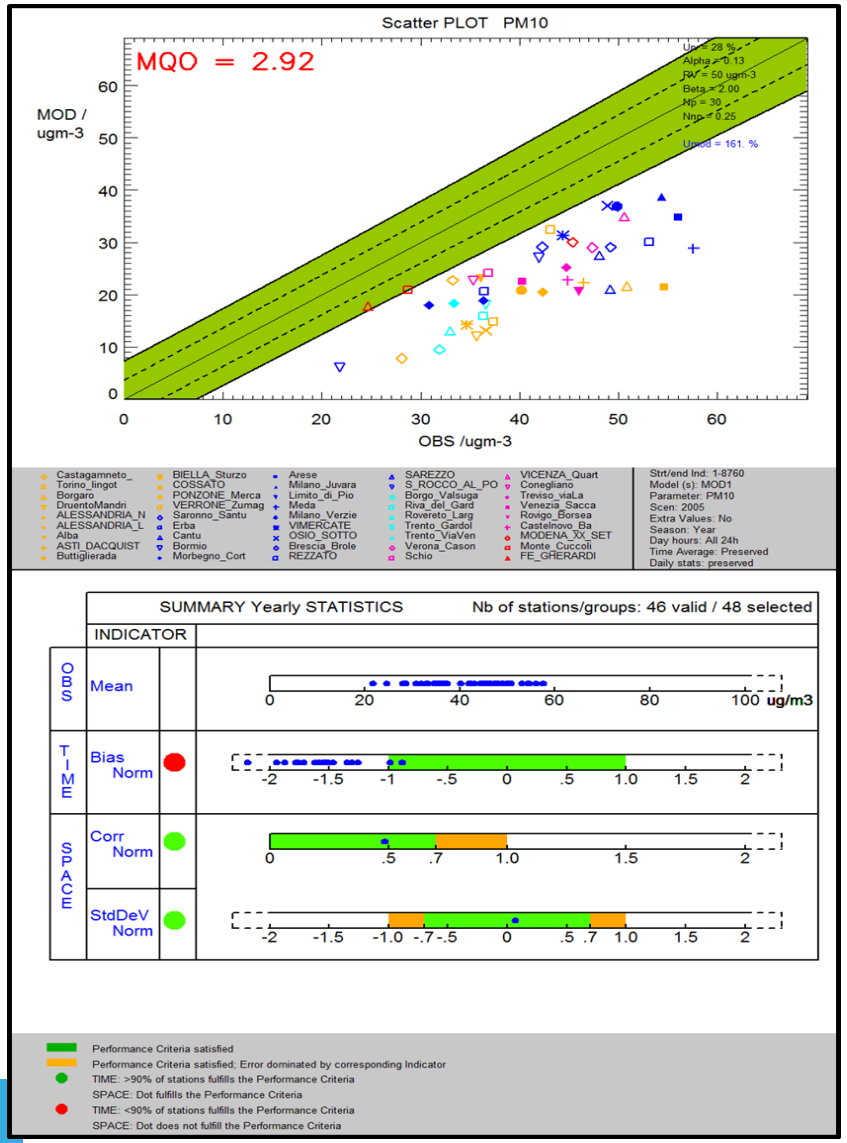
Report template

European Commission

Hourly/daily frequency



Yearly frequency



Joint Research Centre

Main updates

- Introduction of β in the MQI formulation (β =2)
- Change in the implementation of the 90th percentile constraint
- Both yearly and hourly/daily MQO are indicated in perf. Reports
- Update of the attenuation parameters for yearly PM_{10} and PM_{25}
- New attenuation parameter for O_3 long term (for spatial MPI)
- Introduction of the model uncertainty as one report's output
- Efforts have been made on definitions & concepts (CEN TC264/43)