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Comparability of air quality data in Europe

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Introduction

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The eruption in Eyjafjallajökull was in two phases

Phase one
March 20th – April 12th
Outside the glacier
Flow of lava - almost no ash
Small scale eruption - "tourist" eruption
Little threat more like great fireworks

By Borsteinn Johansson,
Environmental Agency, Iceland

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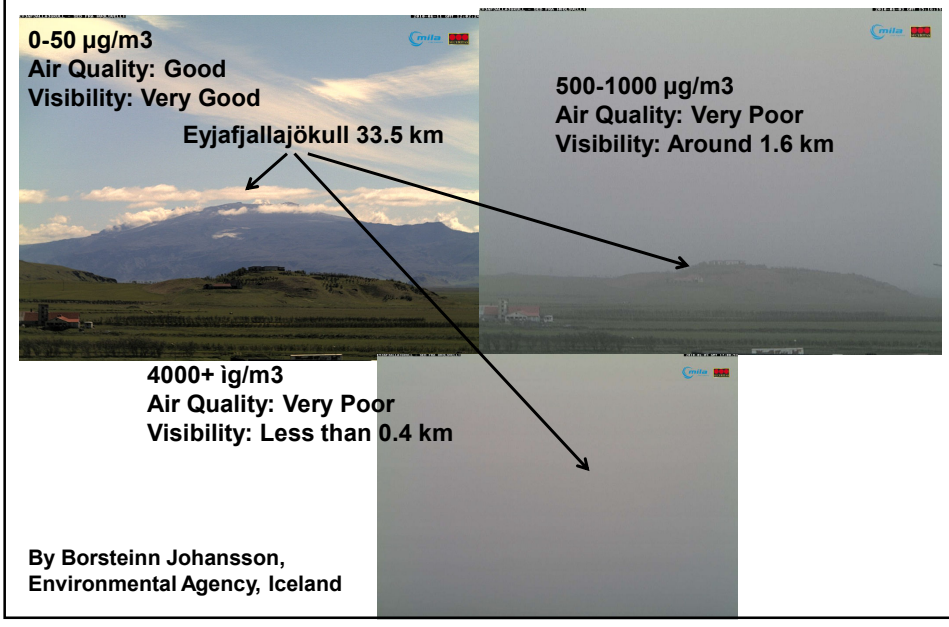

By Borsteinn Johansson,
Environmental Agency, Iceland

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Content

- EU policy on air quality measurements
- Legislation
- Measurement methods
- Comparisons
- Data availability

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Definition

Comparability

Formed from two component:

- Measurements
- Site location

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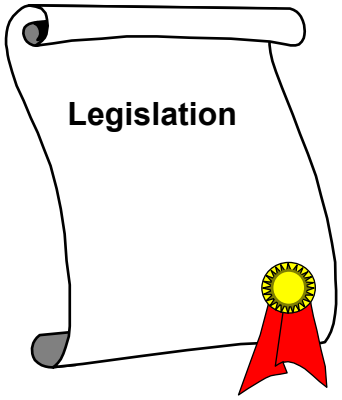

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EU-practise on the air quality policy

The 6th Environmental Action Plan (based on the 5th EAP):

- Defines the priorities and objectives of European environment policy and describes the measures to be taken to help implement its sustainable development strategy
- Has a knowledge-based approach: policies proposed are underpinned by scientific and technical knowledge
- Four priority areas:
  - climate change;
  - biodiversity;
  - environment and health;
  - sustainable management of resources and wastes

Environment and health:

- To achieve levels of air quality that do not give rise to significant negative impacts on and risks to human health and the environment

Air Quality Directive (CAFE directive)

The priorities in the CAFE programme are:

- *On the air pollutants ozone, particulate matter and nitrogen oxides, which are estimated to cause most of the damage on human health and the environment in Europe.*
- *To establish a long-term, integrated strategy to tackle air pollution and to protect against its effects on human health and the environment*

Additionally AQD:

- Require responsible authorities and bodies for specific tasks (Article 3): National Reference Laboratory
  - To attend the comparison studies organized by EC (JRC)
- Sets limit and target values for certain pollutants based on health effects and effects to the nature: balance with cost and benefit

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EU-practise on the air quality policy

Air Quality Directive (CAFE directive)

- Defines the data quality objectives (e.g. maximum uncertainty of measurements)
- Defines the reference methods
  - Task of CEN to prepare the standards (include the method, QA/QC procedures, uncertainty budget)
- Reguirements for the measurement result: traceability to national standards → **Comparability of measurement results**
- Accreditation is required from the National Refernce Laboratory for the reference methods

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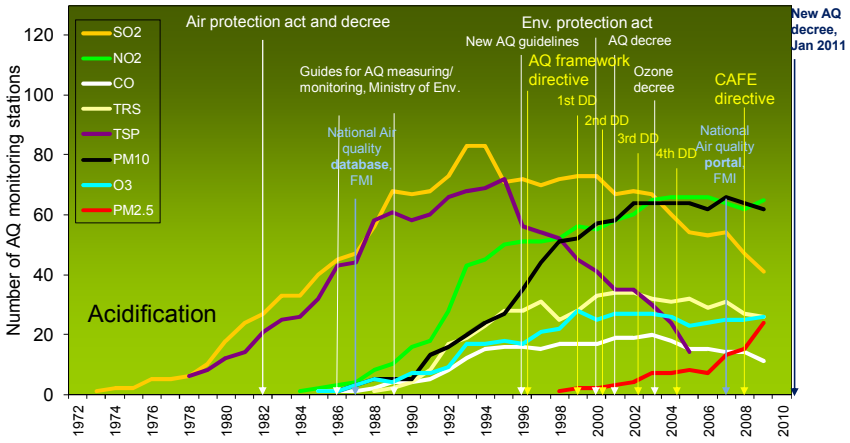
Development of AQ legislation and the number of AQ monitoring stations per pollutant in Finland



Approximately 160 measuring stations in 70 municipalities, 35 measuring organizations.
Real-time measurements at 115 stations in 57 municipalities.

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EU Directives on air quality

Air Quality Directive (CAFE) (50/2008/EC)
0n ambient air quality and cleaner air for Europe (CAFÉ)

SO_2, NO_2, CO, C6H6 , O3, PM_{10}, $PM_{2.5}$ and Pb

4th DD 2004/5
relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air

Cd, As, PAHs, Ni, Hg

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NATIONAL REFERENCE LABORATORY

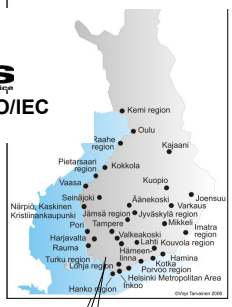
MAINTENANCE OF THE TRACEABLE CALIBRATION SERVICE

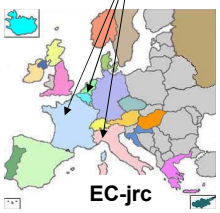
FINAS
Finnish Accreditation Service
K043 (EN ISO/IEC 17025:2005)

DEVELOPMENT OF THE CALIBRATION METHODS

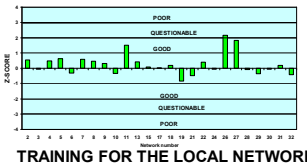
EXPERT ON THE EC WORKING GROUP

Traceability of the measurements





INTERCOMPARISON EXCERCISES FOR LOCAL NETWORKS



TRAINING FOR THE LOCAL NETWORK

INTERCOMPARISON EXPERIMENTS BY EC-JRC

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Network of National Reference Laboratories

AQUILA Air Quality Reference Laboratories

Objectives:

- to provide expert judgement on issues in Air Quality,
- to promote the harmonisation of air quality measurements among EU,
- to co-ordinate QA/QC activities, method development and validation,
- to participate in standardisation activities,
- to develop common research projects and pilot studies
- to offer a forum for information exchange in form of training courses, workshops and conferences.

Members: 28 NRL, JRC, DG/Env Associate: WHO, EEA, ETC
Observers: Croatia, FYROM, Serbia, Turkey

Steering Committee:
The current AQUILA board is composed as follows:
Francois Mathe, LCSQA (F) chair
Jari Walden, FMI (FI) chair
Annette Borowiak, JRC (EC) co-chair
Daniela Buzica, DG ENV (EC) co-chair
Peter Woods, NPL (UK) advisor to chair
Secretariat:
Annette Borowiak/ EC Joint Research Centre /Institute for Environment and Sustainability

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COMPARABILITY

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Measurement methods

- **Standardized or equivalent method**
- **Calibration method**
- **QA/QC procedures at the site**

EURACHEM Workshop, MIKES 20-21 May, 2013/JW

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Comparability: Measurements

Measurement methods

EU practise: AQ Directive defines reference method →
Standardized methods

Not a reference method →
Equivalent methods
PM-comparisons, DOAS etc

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Comparability: Measurements

➢ EU REFERENCE METHODS

- **EN 14212:2005 (Sulphur dioxide by ultraviolet fluorescence)**
- **EN 14211:2005 (Nitrogen dioxide and nitrogen monoxide by chemiluminescence)**
- **EN 14625:2005 (Ozone by ultraviolet photometry)**
- **EN 14626:2005 (Carbon monoxide by nondispersive infrared spectroscopy)**
- **EN 12341:1999 (PM10 mass fraction of suspended particulate matter by gravimetry)**
- **EN 14907:2005 (PM2.5 mass fraction of suspended particulate matter by gravimetry)**
- **EN 14902:2005 (Pb, Cd, As and Ni in PM10 by ICP-MS or AAS)**
- **EN 14662:2005 Parts 1, 2 and 3 (Benzene by GC)**
- **EN 15549:2008 (Benzo(a)pyrene by GC-MS)**
- **EN 15841:2009 (Pb, Cd, As, Ni in rainwater by ICP-MS or AAS)**
- **EN 15852:2010 (Total gaseous mercury by CVAAS or CVAFS)**
- **EN 15853:2010 (Mercury in deposition by CVAAS or CVAFS)**

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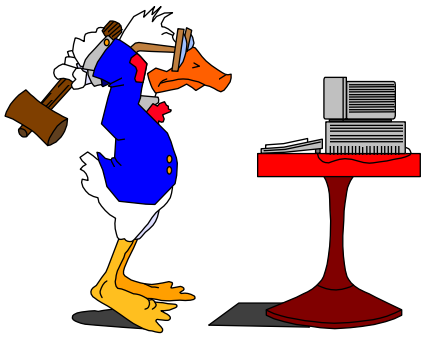
Test of instruments according CEN standard



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Performance characteristics of the analyzer

Reference method:
- type approval of instruments (accredited test laboratory)
- test of the instruments in the lab/field
- to demonstrate the instruments are working according to specifications

Other than reference method:
- equivalence procedure to fulfill the requirements for the reference method

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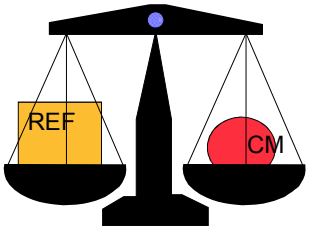
Project

Demonstration of Equivalency of the PM10 and PM2.5 measurement devices 2007 - 2008



EC air quality directive : A member state can use any other measurement method that it can demonstrate to fulfill the data quality objectives of the reference methods
Field measurement campaigns, data analysis, and reporting
EC: final acceptance of the report
Funding: governmental funding
Cooperation: Swedish national reference laboratory, Norway, Baltic countries (Estonia, Latvia and Lithuania)

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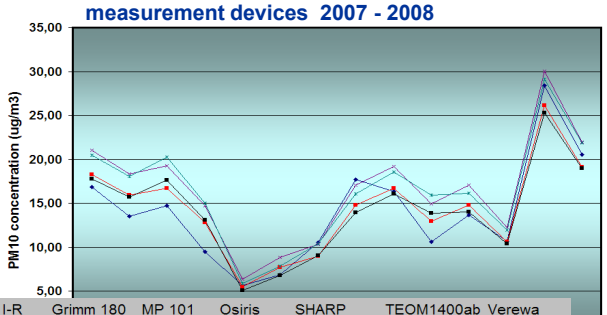
Project

Demonstration of Equivalency of the PM10 and PM2.5 measurement devices 2007 - 2008

PM10	Equivalence field	
UNCORRECTED DATA		
REGRESSION OUTPUT		
slope b	*1,17*	not significa
uncertainty of b	*0,11*	
intercept a	*2,36*	not significa
uncertainty of a	*1,59*	
EQUIVALENCE TEST RESULTS		
random term	1,72	ug/m3
bias at LV	10,74	ug/m3
combined uncertainty	10,87	ug/m3
relative uncertainty at the LV	21,75	fail
RM between-sampler uncertainty	1,50	ug/m3
SLOPE CORRECTION		
REGRESSION OUTPUT		
slope b	*0,99*	not significa
uncertainty of b	*0,09*	
intercept a	*2,14*	not significa
uncertainty of a	*1,36*	
EQUIVALENCE TEST RESULTS		

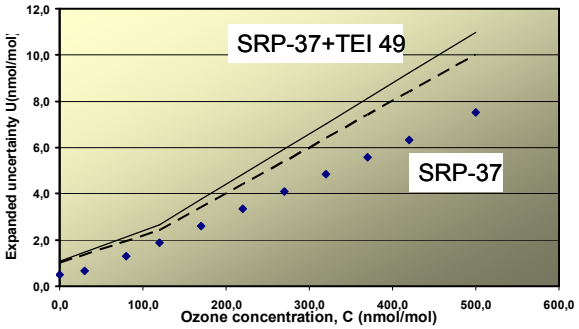


Test $PM_{2.5}$	Dekati PM10	FH 62 I-R	Grimm 180	MP 101	Osiris	SHARP	TEOM1400ab	Verewa
Calibration range (µg/m3)		0 - 55	0 - 55	0 - 55		0 - 55	0 - 55	0 - 55
Calibration equation								
Slope	0.89	1.35	0.75	1.92	2.15	1.09	1.28	1.39
Intercept (µg/m³)	-0.95	-0.73	-0.31	0.98	-1.7		1.7	-1.1
Relative combined standard uncertainty (%)	10.2	3.1	3.8	6.7	16.8	0.7	8.2	6.9
Test PM_{10}								
Calibration range (µg/m3)		0 - 36	0 - 36	0 - 36	10 - 36	0 - 36	0 - 36	10 - 36
Calibration equation								
Slope		1.25	0.71	1.85	1.42	Not needed	1.12	1.30
Intercept (µg/m³)		-0.50	1.45	1.10	-1.10	Not needed	1.26	-0.61
Relative combined standard uncertainty (%)		1.2	1.2	3.2	3.4	4.0	3.4	5.6

14

Uncertainty due to calibration:

For ozone: SRP-37 + transfer standard (TEI49 CPS)



$$u_{cal} = \left(\frac{r_{std}}{100} \cdot hlv \right) / 2 = \left(\frac{3}{100} \cdot 120 \right) / 2 = 1.8\, ppb$$

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Comparability: Measurements

Characteristics	Symbol		crit.	res.			u(p)	u(p)^2
							nmol/mol	(nmol/mo
Repeatability at zero	rl,z		1,0	0,40	nmol/mol		0,40	0,16
Repeatability at span	rl,s		3,0	2,0	nmol/mol		0,12	0,01
Linearity	Xl		5,0	2,0	%		1,39	1,9
Dependence on pressure	bsp		8,0	0,40	nmol/mol/kPa		**3,30**	10,9
Dependence on temperature	bgt		3,00	0,32	nmol/mol/K		**2,60**	6,8
Environment temperature			3,00	0,25	nmol/mol/K		1,00	1,0
Dependence on line voltage	bV-		0,30	0,30	nmol/mol/V		0,65	0,42
Interferences								
H2O at 18.000 mmol/mol	XH2O,z		5	-2,0	nmol/mol		**1,90**	3,6
H2O konsentraatiossa 21.	XH2O, c(t)		5	-2,5	nmol/mol		**1,90**	3,6
Averaging error	Xav		7,0	4,5	% measured value		1,30	1,69
Repeatability on field	rf		5,0	2,0	% 3 kk:n k		0,80	0,64
Long term drift at zero	Dl,z		5,0	**5,0**	nmol/mol		**2,89**	8,33
Long term drift at span	Dl,lv		5,0	**5,0**	% mean over 3monthl		**3,46**	12,00
Calibration uncertainty	**X(cg)**		**5,0**	**5,0**	% measured value		**3,00**	9,00
Combined standard uncertai	u(c)(abs)			7,62	nmol/mol			
Expanded uncertainty	U(c)(abs)			15,2	nmol/mol			
Expanded relative un	**U(c)(rel)**			**12,7**	**%**	**less than 15%**		

Combined standard uncertainty:

$$u_c = \sqrt{u_{r,z}^2 + u_{r,lv}^2 + u_{l,lv}^2 + u_{gp}^2 + u_{gt}^2 + u_{st}^2 + u_V^2 + u_{H_2O}^2 + (u_{int,pos}^2 \text{ or } u_{int,neg}^2) + u_{av}^2 + u_{Dsc}^2 + u_{cg}^2}$$

Expanded uncertainty:

$$U_c = k \, x \, u_c$$

$$U_{c,rel} = \frac{U_c}{hlv} x100$$

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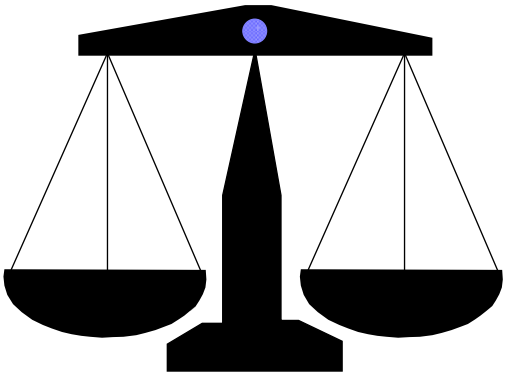
Traceability of standards

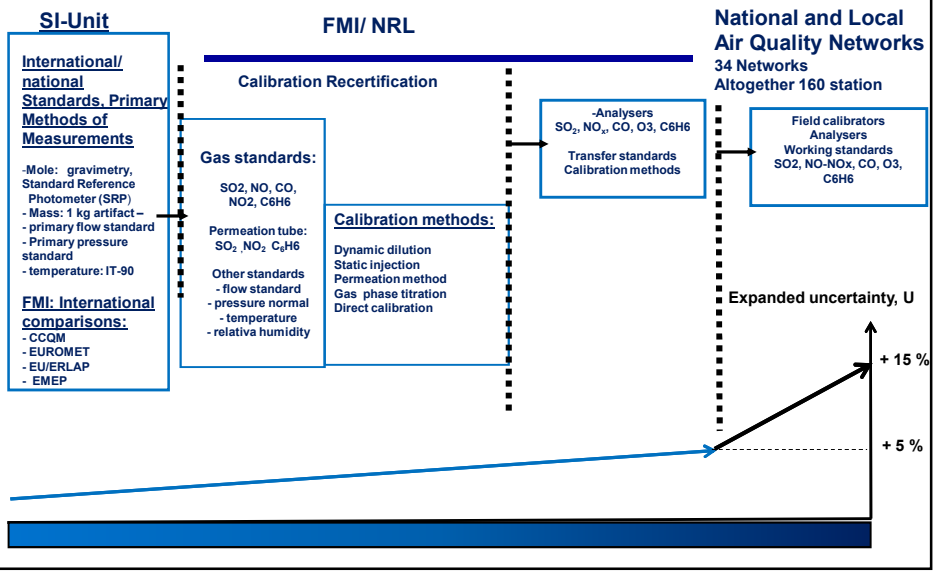


Traceable Calibration

AQ Directive: *State that all measurements undertaken in relation to the assessment of ambient air quality pursuant to Articles 6 and 9 are traceable in accordance with the requirements set out in Section 5.6.2.2 of the ISO/IEC 17025:2005*

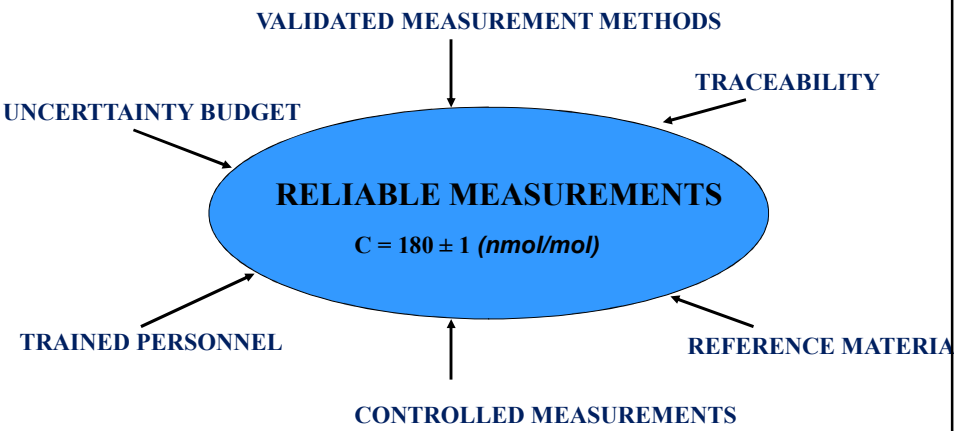
EN standards: *test and calibration gases shall be traceable to (inter)nationally accepted standards*

Traceability and propagation of uncertainty of measurement results



QA/QC Programme

RELIABLE MEASUREMENTS



QA/QC procedures

EU practise:

- *that institutions operating networks and individual stations have an established quality assurance and quality control system which provides for regular maintenance to assure the accuracy of measuring devices,*
- *that a quality assurance/quality control process is established for the process of data collection and reporting and that institutions appointed for this task actively participate in the related Community-wide quality assurance programmes*

EN-standards: The designated body responsible for QA/QC of the monitoring station is responsible for producing valid data.

- *The assessment shall be repeated at least every year using actual values of uncertainty contributions estimated from information gained during ongoing QA/QC*
- *Established QA/QC procedures to be followed at the field station*

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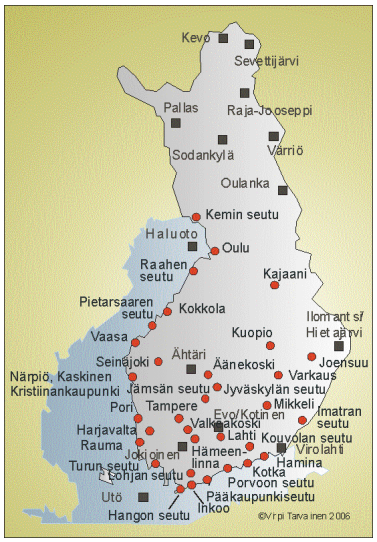
Comparability: Measurements



Air Quality Networks in Finland

- 34 local networks, 160 measurement sites
  SO_2, NO_X, PM_{10}, $PM_{2.5}$, TSP, O_3, CO, TRS, heavy metals, PAH, VOC
- National/International background air quality network, 18 measurement sites, run by FMI
  SO_2, NO_X, O_3, VOC, Hg, PM_{10}, $PM_{2.5}$, SO_4, heavy metals, PAH, pH, conductivity, main ions, heavy metals, HNO_3+NO_3, NH_3+NH_4

QA/QC Procedures by CEN Requirements for Gases:

Span and zero checks: daily/weekly
Sampling lines: cleaning 6 month
Particulate filters: change according experience, 2 week - 3 month
Linearity check (once a year + after repair)
Calibration at least every 3-months
Check site calibration standards (6-month)
Test sample manifold (3-years+ < 2% loss)

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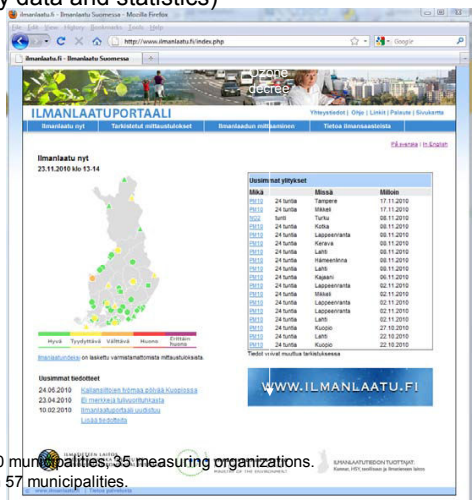
National Air Quality Portal -content

- Real-time air quality information (hourly data)
- Validated air quality information (hourly data and statistics)
- Air quality bulletins

airquality.fi



Information about air pollutants and their effects

•

Information about air quality legislation

•

Information about measuring networks, instruments, and methods

•

Information about the AQ Reference Laboratory and link to them

•

Links to air quality research and other topical pages.

Approximately 160 measuring stations in 70 municipalities, 35 measuring organizations.
Real-time measurements at 115 stations in 57 municipalities.

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Comparison studies

CCQM level

Some of CCQM Key comparison studies has been focussed based on EU directives e.g.

- CCQM 26 a/b: NO/SO2 concentration at ambient level
- CCQM K51: Carbon monoxide (CO) in nitrogen (5 µmol.mol-1)
- CCQM K84: Carbon monoxide in Synthetic air at ambient level
- BIPM.QM-K1, Ozone at ambient level

Comparison studies

EURAMET level

- EURAMET 1183 NO at ambient level, started 2012, not completed

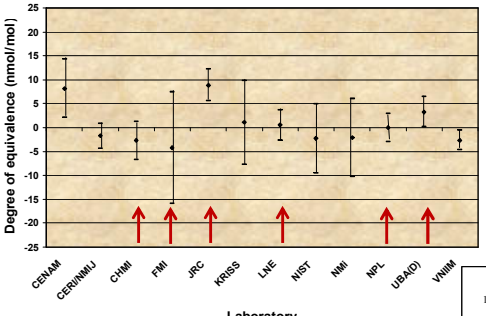
EU level

- EC/JRC organizes on-going comparison events for the compounds which EU has set limit values

WHO

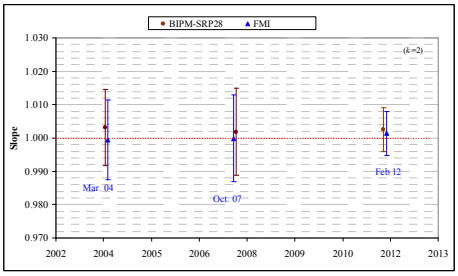
- Joint comparison experiments in inorganic gas coumpounds with the EC/JRC

FEW RESULTS FROM COMPARISONS



CCQM-K26a, Nitric oxide NO

BIPM.QM-K1, Ozone at ambient level



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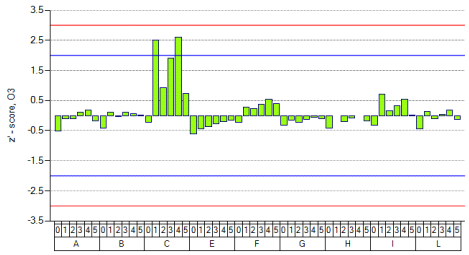
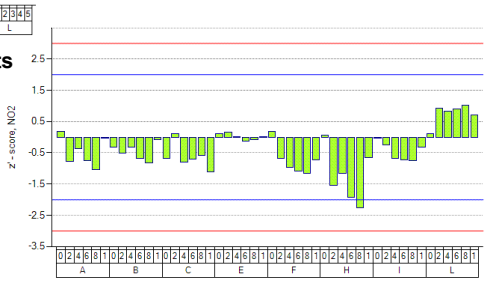
FEW RESULTS FROM COMPARISONS



The z'-score evaluations of O3 measurements

The evaluation of the Interlaboratory comparison Exercise for SO2, CO, O3, NO and NO2
14.- 17. June 2010
Organized by EC/JRC



The z'-score evaluations of NO2 measurements

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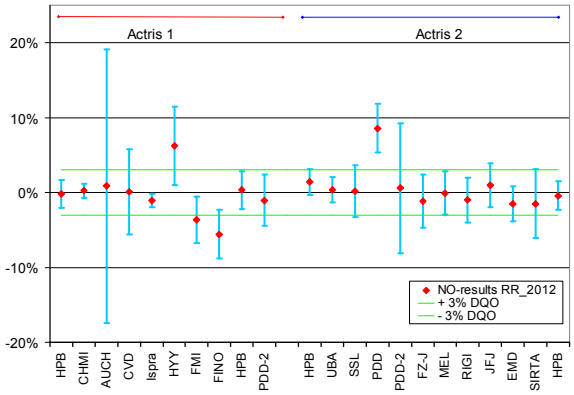
FEW RESULTS FROM COMPARISONS

ACTRIS Aerosols, Clouds, and Trace Gases Research Infrastructure Network



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Station/Site classification

EU practise: *Ambient air quality shall be assessed in all zones and agglomerations in accordance with the specific criteria*

Measurements shall be taken in particular in urban or suburban areas at any monitoring site set up in accordance with the requirements of this Directive and considered appropriate with regard to the monitoring objectives

1. Protection of human health
2. Protection of vegetation and natural ecosystems

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Assessment on measurement sites

Guidance document on:

- siting criteria for AQ monitoring sites
- classification of AQ monitoring sites
- representativeness of AQ monitoring sites

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Siting criteria

The siting criteria for AQ monitoring sites laid down in AQ legislation are basic provisions which shall ensure:

- harmonized AQ assessment through the EU
- provide comparable assessment data.
- Macro-scale siting criteria provide
  - minimum requirements on the types of locations where AQ assessment has to be performed
- Micro-scale siting criteria shall ensure:
  - free air flow around the sampling inlet – as a basic requirement for ensuring measurement representative for a defined area
  - provide minimum requirements for sampling near major roads.

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Classification of monitoring stations

Classification" of AQ monitoring sites is a prerequisite for any interpretation of AQ data.

Two different spatial scales exists:

- Type of area" ("urban", "suburban", "rural") refers to the environment on a scale of several kilometers
- Type of station" ("traffic", "industrial", "background") refers to the impact (or absence) of near-by emissions (and is pollutant-specific in 2011/850/EU).

Classification of monitoring stations is required for
Macro-scale siting criteria
Reporting of assessment meta-data (2011/850/EU)
Assessment of representativeness, assessment of exposure, model evaluation, source apportionment, etc.

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Classification of monitoring stations

Classification of monitoring stations is required for:

- Macro-scale siting criteria
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- assessment of exposure, model evaluation,
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Spatial representativeness of monitoring stations

Information about the representative area of monitoring stations is required for the following tasks:

- The design of monitoring networks
  knowledge about the spatial distribution of pollution levels in a zone, and some knowledge about the representative area of specific monitoring sites (e.g. the exposure of the general population, hot-spots)
- Is closely related to the site classification “Type of area” and “Classification of the Station in relation to predominant emission sources relevant for the measurement configuration for each pollutant” in the Implementing Decision for Reporting.

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COMPARABILITY OF RESULTS – WHAT THEN?

What we achieve from the comparability of results ?

- Overall concentration maps over Europe
- Estimation of health effects (exposure charts, effects)
- Action to decrease the level of concentrations where exceedences occur

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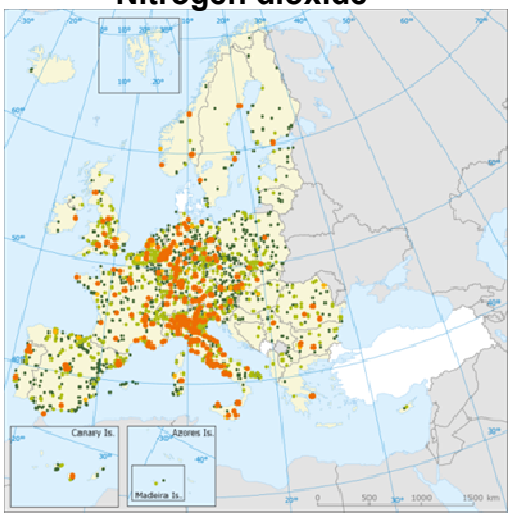
Nitrogen dioxide



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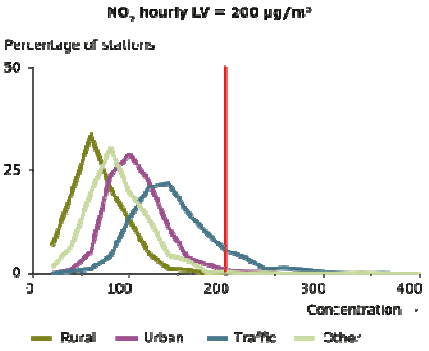

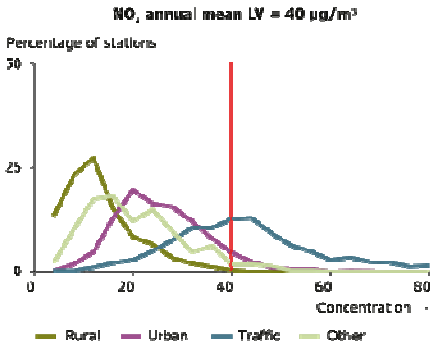

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http://www.eea.europa.eu/publications/air-quality-in-europe-2011

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European Environment Agency

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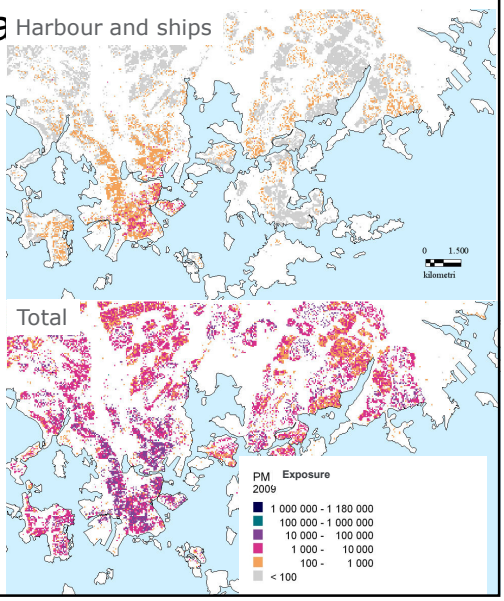
Exposure to air pollutа

- **Concentrations and activity are combined**
- **Most of $PM_{2.5}$ is long range transported**
  - Harbour activity and ships responsible of 2 % total $PM_{2.5}$ exposure
  - Vehicular traffic 12 % of total $PM_{2.5}$ exposure
  - Point sources 0.1%
- **SO_2 is mostly local**
  - Harbour activity and ships are responsible of 42 % total SO_2 exposure
  - Vehicular traffic 6 % of total SO_2 exposure
  - Point sources 6 %



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Conclusion

Concern of air quality in Europe is at high priority and it reflects on EU regulations which the member states must implement into their legislation

Limit values, data quality objectives, reference methods are to be controlled, fulfilled and followed

QA/QC procedures for the accurate measurements are included in the EN standards

The role of NRLs is to help but also responsible for the quality providing traceable standards, training, (inter)comparison exercises, information

Classification of monitoring station need to be more prerequisite for any interpretation of AQ data

At the end the measurement results are comparable within the uncertainty: usefull for modelling, exposure studies for estimation of the health effects and damages for environment

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THANK YOU

LRT episode in Helsinki 9 August, 2006. $PM_{2.5}$ concentration 70-80 µg/m^3 during the episode (left) and 1-2 µg/m^3 after the episode (right).