

# Data for Environmental monitoring and protection: who can you trust?

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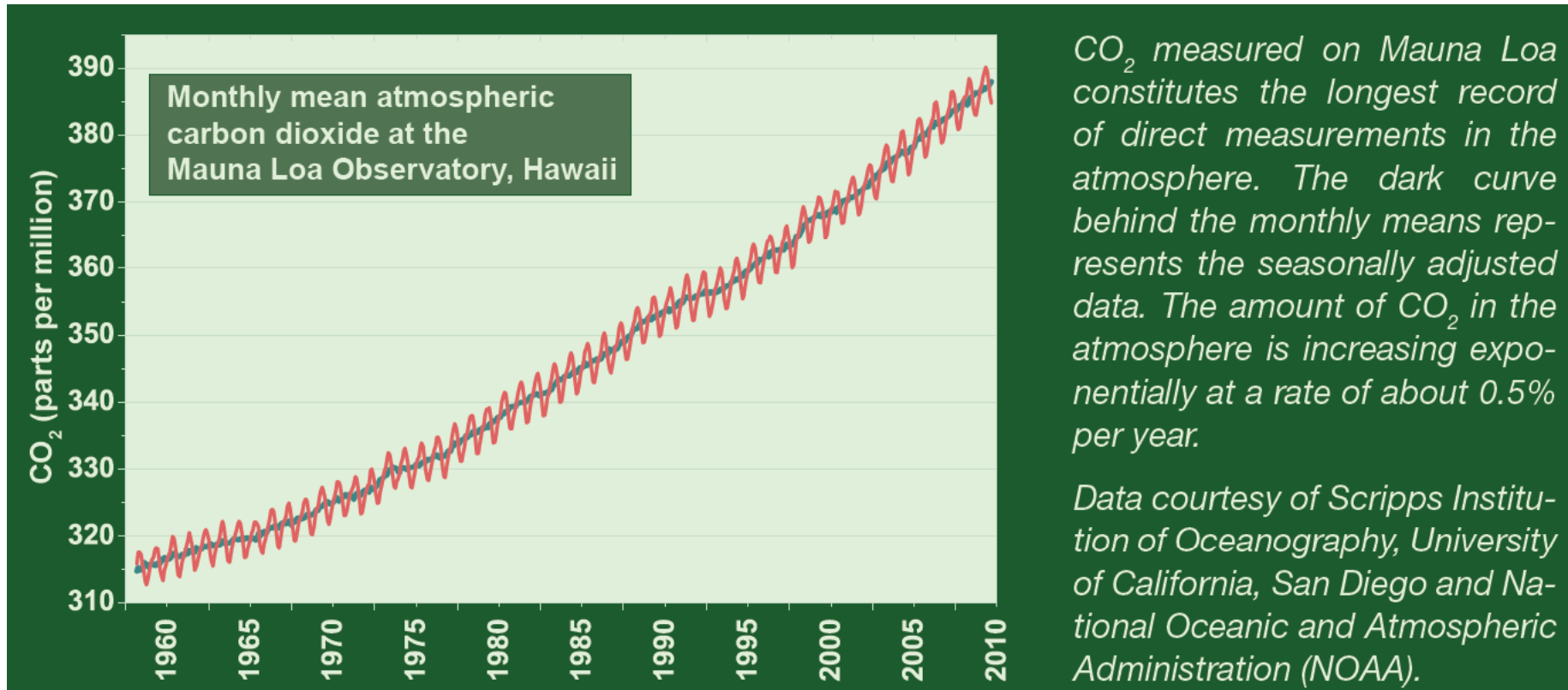
The AAAS 2011 meeting's theme — ***Science Without Borders***

The theme of my presentation — ***Our eco system does not have Borders.***

*Better Standards, Better Life !*

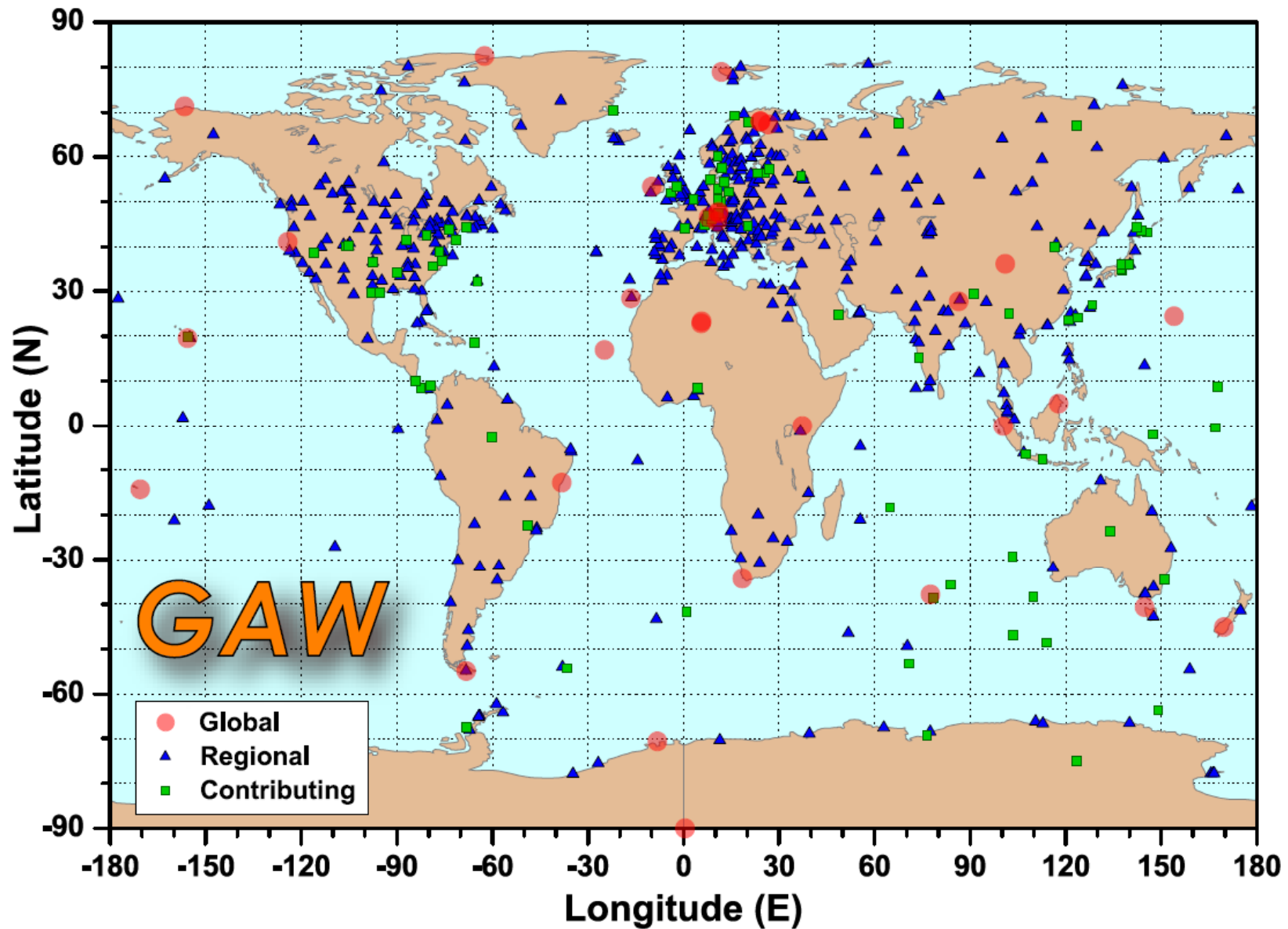
# Spatiotemporal stability of reference

KRISS



WMO Greenhouse Gas Bulletin 2008

Long term measurement requires stable reference standards and calibration infrastructure



# Atmospheric radiative forcing, relative to 1750

KRISS

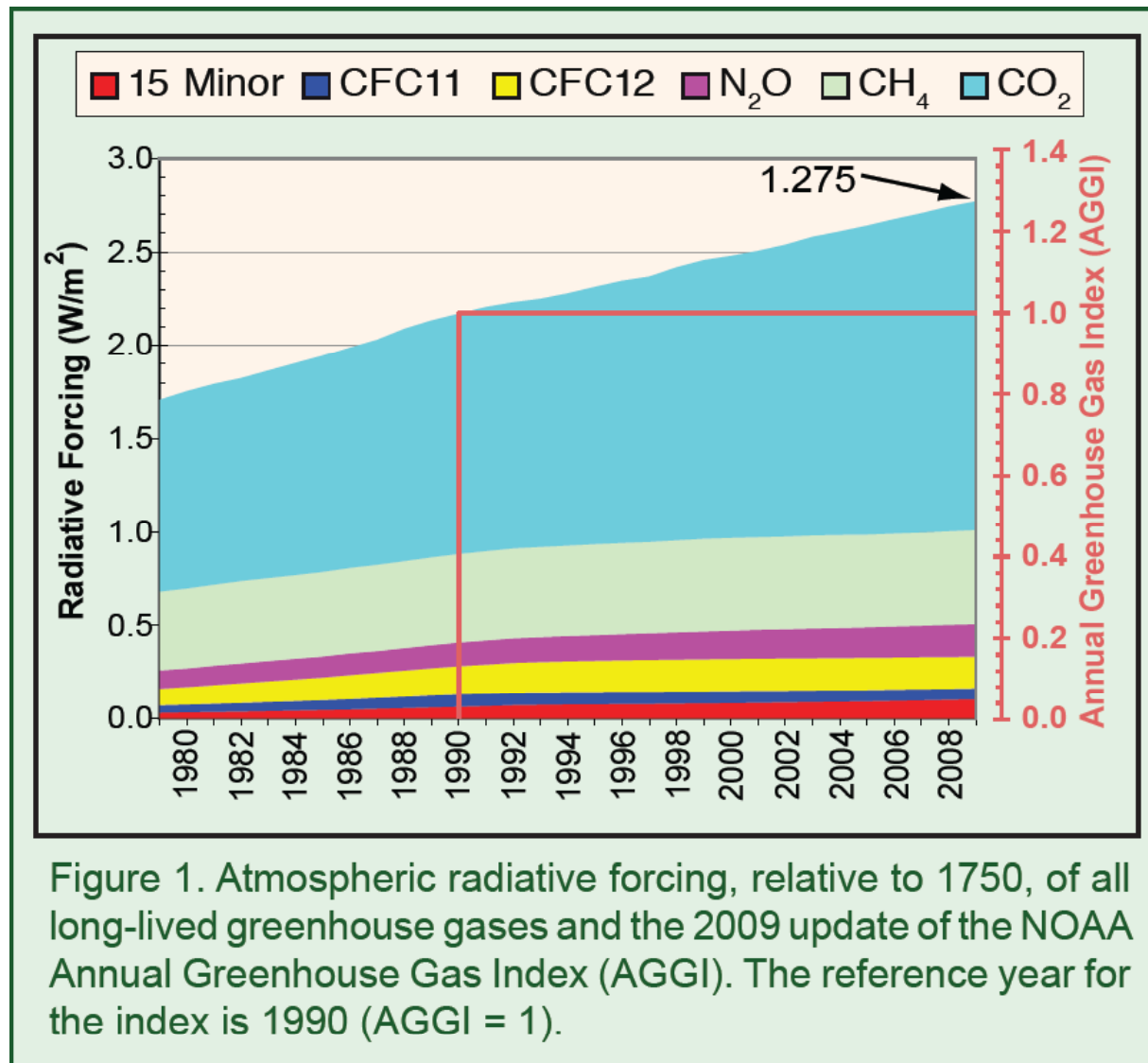


Figure 1. Atmospheric radiative forcing, relative to 1750, of all long-lived greenhouse gases and the 2009 update of the NOAA Annual Greenhouse Gas Index (AGGI). The reference year for the index is 1990 (AGGI = 1).

# Changes in key greenhouse gases

	CO <sub>2</sub> (ppm)	CH <sub>4</sub> (ppb)	N <sub>2</sub> O (ppb)
Global abundance in 2009	386.8	1803	322.5
Increase since 1750 <sup>(1)</sup>	38 %	158 %	19 %
2008–09 absolute increase	1.6	5	0.6
2008–09 relative increase	0.42 %	0.28 %	0.19 %
Mean annual absolute increase during last 10 years	1.88	2.2	0.77

<sup>1</sup> Assuming a pre-industrial mixing ratio of 280 ppm for CO<sub>2</sub>, 700 ppb for CH<sub>4</sub> and 270 ppb for N<sub>2</sub>O.

# Changes of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O

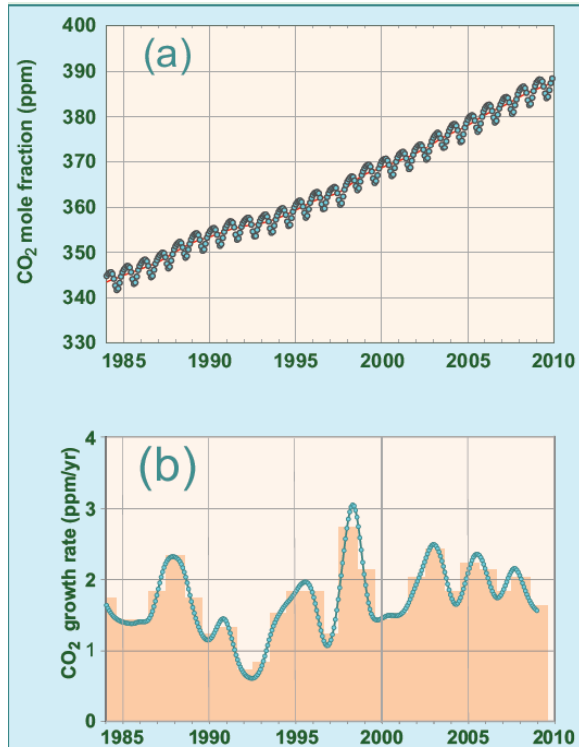


Figure 3. Globally averaged CO<sub>2</sub> mole fraction (a) and its growth rate (b) from 1984 to 2009. Annually averaged growth rate is shown by columns at (b).

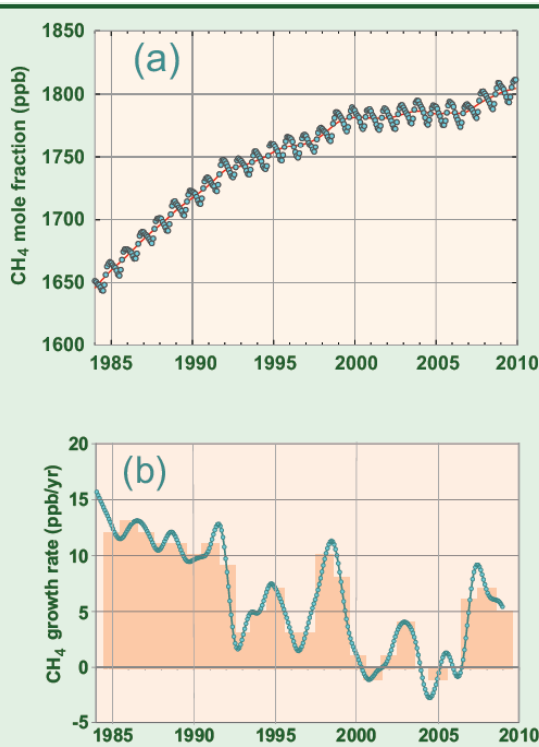


Figure 4. Globally averaged CH<sub>4</sub> mole fraction (a) and its growth rate (b) from 1984 to 2009. Annually averaged growth rate is shown by columns at (b).

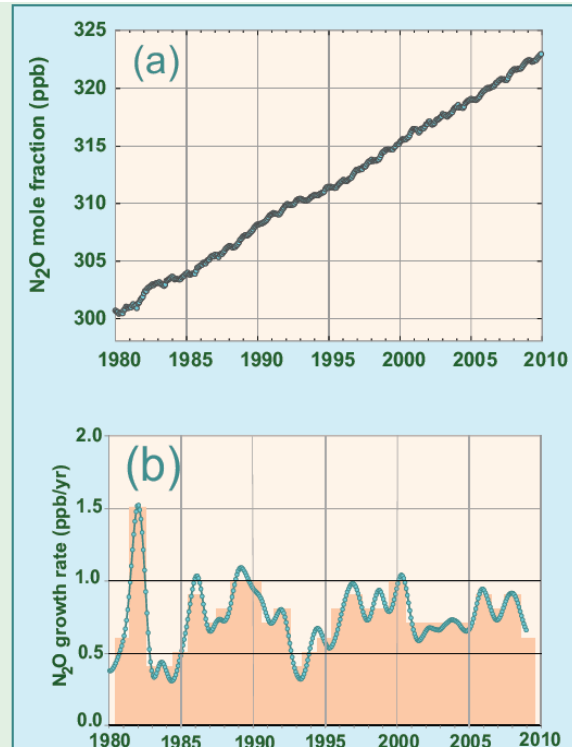


Figure 5. Globally averaged N<sub>2</sub>O mole fraction (a) and its growth rate (b) from 1980 to 2009. Annually averaged growth rate is shown by columns at (b).

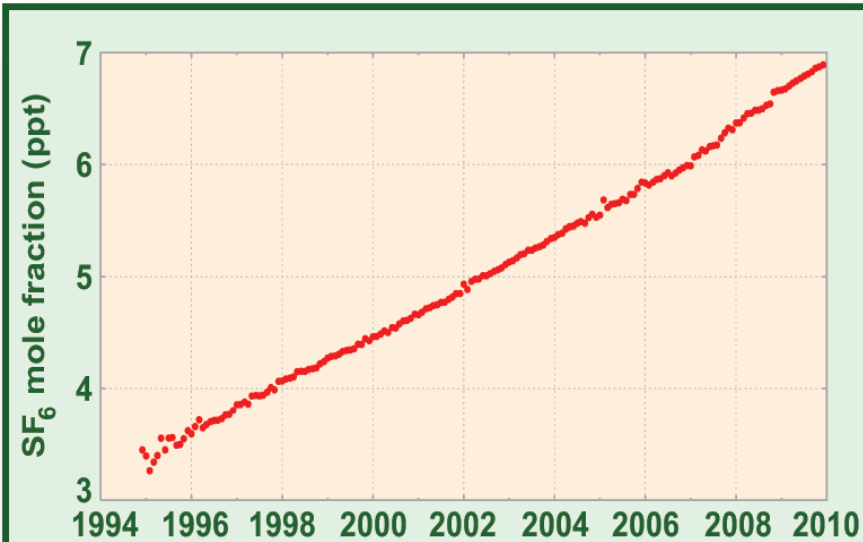


Figure 6. Monthly mean mole fraction of sulphur hexafluoride (SF<sub>6</sub>) from 1995 to 2009 averaged over 15 stations.

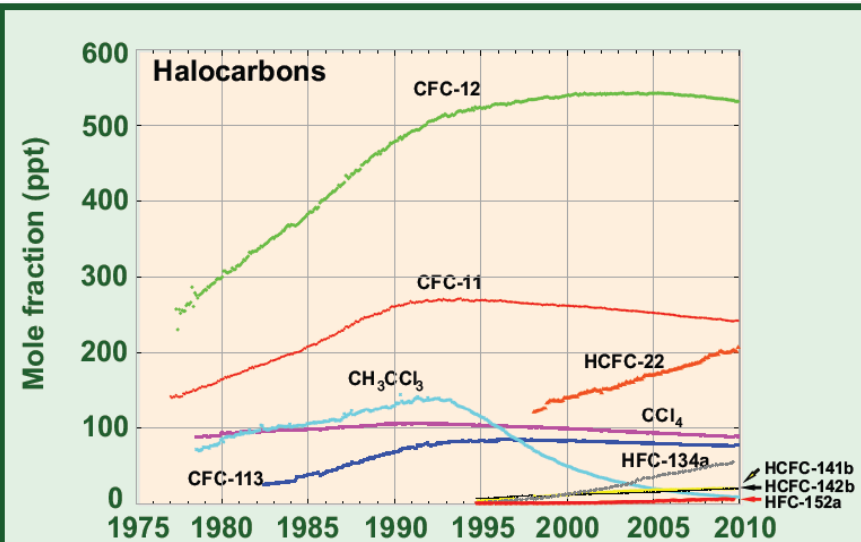


Figure 7. Monthly mean mole fraction of the most important halocarbons from 1977 to 2009 averaged over the network (between 5 and 18 stations).



Report on the WMO-BIPM workshop on

# Measurement Challenges for Global Observation Systems for Climate Change Monitoring

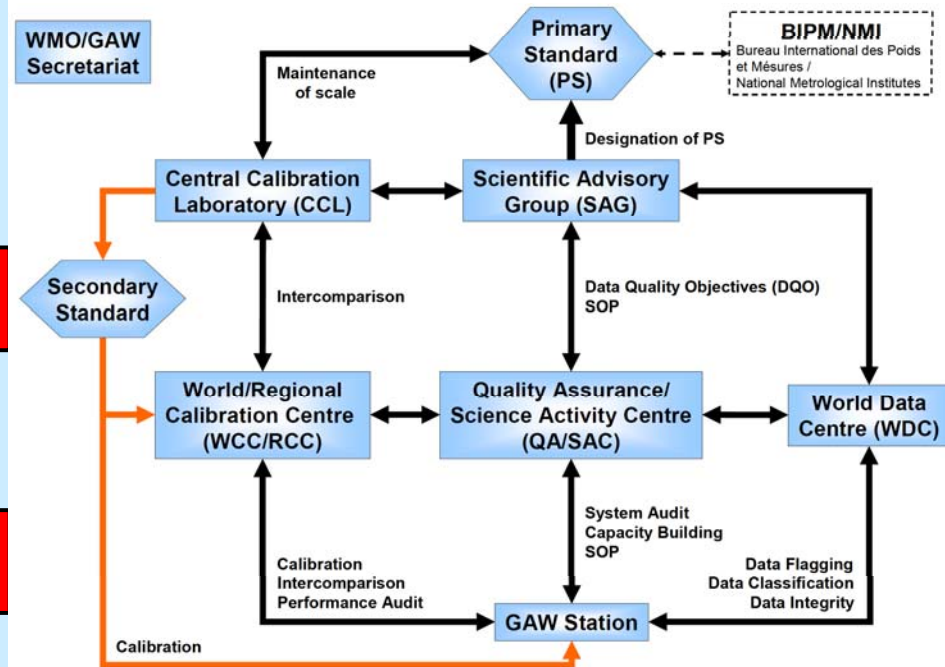
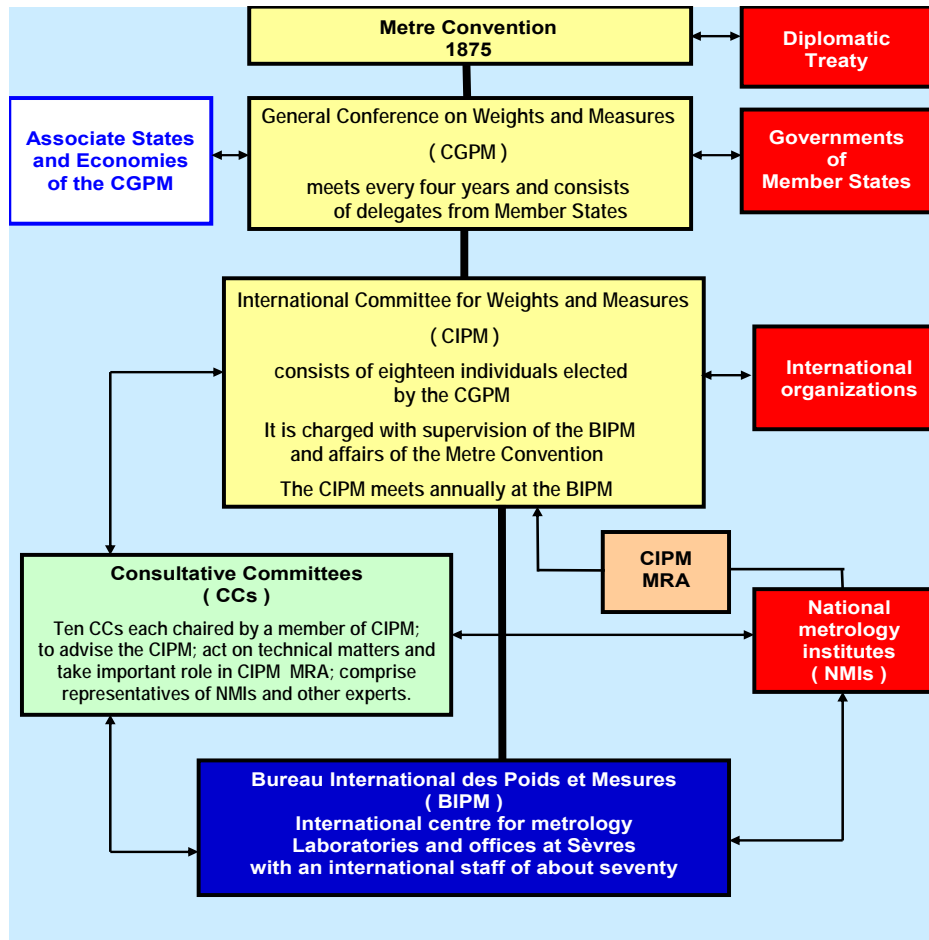
*Traceability, Stability and Uncertainty*

30 March – 1 April 2010  
WMO Headquarters  
Geneva, Switzerland

IOM-Report No. 105  
WMO/TD-No. 1557

Rapport BIPM-2010/08

# BIPM (Metrology)-WMO (Meteorology)



Two problems are associated with global analyses of greenhouse gases using observational data from multiple measurements programs.

First, the measurements have to be on the same **measurement scale** derived from a common reference standard (otherwise, they cannot be compared).

Second, measurement data from all stations have to be synchronized for the observation period. However, the observation period for each station, particularly beginning of observation, is usually different. Furthermore, many stations have gaps in their observation time series due to instrument malfunctions or other reasons.

If global analyses are performed without considering these problems, the results may be biased by the particular stations used and the availability of data.

In the contrast, if only stations that have long observation periods are selected, data from many stations in recent years would not be included in global analyses.

For global analyses, it is practical to prepare a dataset of uniform quality without gaps and that is not biased by variation in station and data number.

2.13 (3.5) **measurement accuracy**, accuracy of measurement, accuracy

closeness of agreement between a measured **quantity value** and a **true quantity value** of a measurand

NOTE 2 The term “measurement accuracy” should not be used for **measurement trueness** and the term **measurement precision** should not be used for ‘**measurement accuracy**’, which, however, is related to both these concepts

2.20 **repeatability condition** of measurement, repeatability condition

condition of measurement, out of a set of conditions that includes **the same measurement procedure**, **same** operators, **same** measuring system, **same operating conditions** and **same** location, and replicate measurements on the **same** or similar objects over a **short period of time**

2.24 **reproducibility condition of measurement**, reproducibility condition

condition of **measurement**, out of a set of conditions that includes **different** locations, operators, **measuring systems**, and replicate measurements on the same or similar objects

## Traceability to the SI

### **Rationale**

Values disseminated that are traceable to the SI as realised by a primary method.

### **Benefits**

Highly coherent and **accurate**

➤ Good “absolute” data

Possibility for more than one source.

### **Disadvantages**

Values may change (in absolute terms) within stated uncertainties but will always “improve”.

## The scale approach

### **Rationale**

Values disseminated that are traceable to a collection (“family”) of artefacts carefully, monitored and maintained

### **Benefits**

Highly **consistent** (“precise”)

➤ Good trend data

### **Disadvantages**

- Responsibility / cost of maintenance concentrated at one institution
- Impossible to regenerate or develop independently
- (May be) insensitive to drift in the reference artefacts

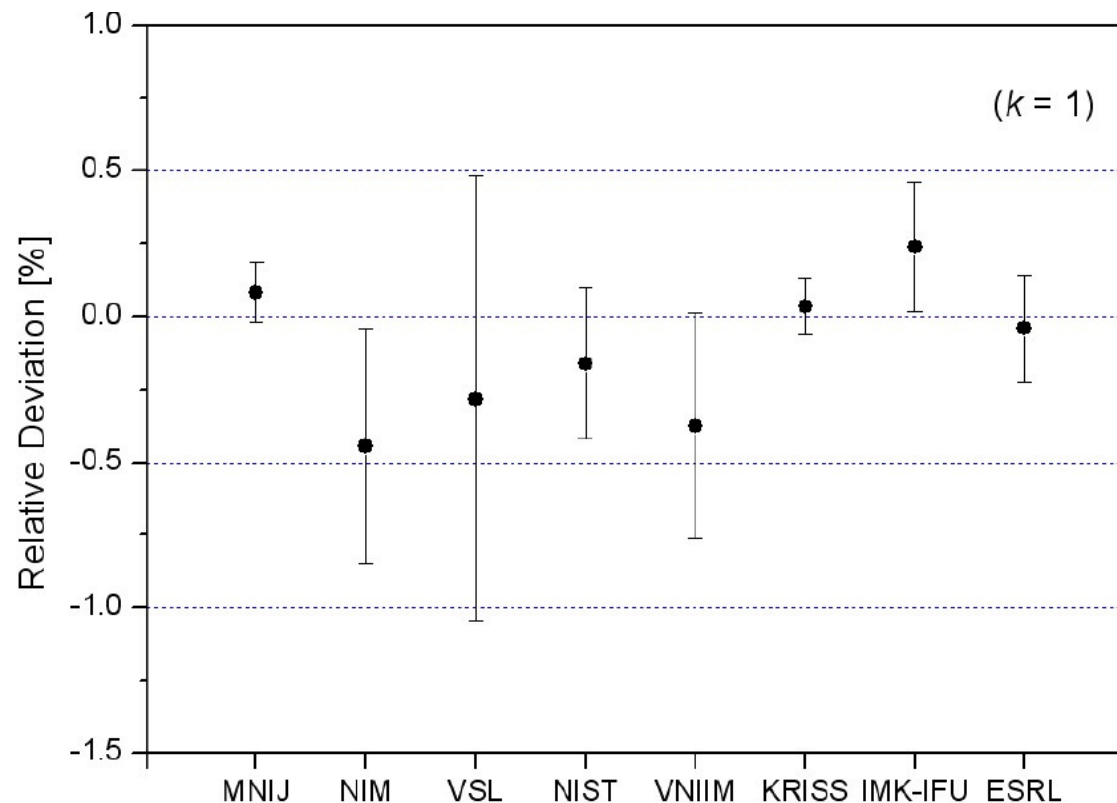
$$u(x) = Q[u(x_{prep}), u(x_{verif}), u(x_{stability})]$$

$$u(x) = Q[u(x_{prep}), u(x_{rif}), u(x_{stability})]$$

Primary gas standards- uncertainty of assigned values

$$u(x) = Q[u(x_{prep}), u(x_{verif}), u(x_{stability})]$$

$$u(x_{prep}) = Q[u(x_{purity}), u(x_{gravimetry})]$$

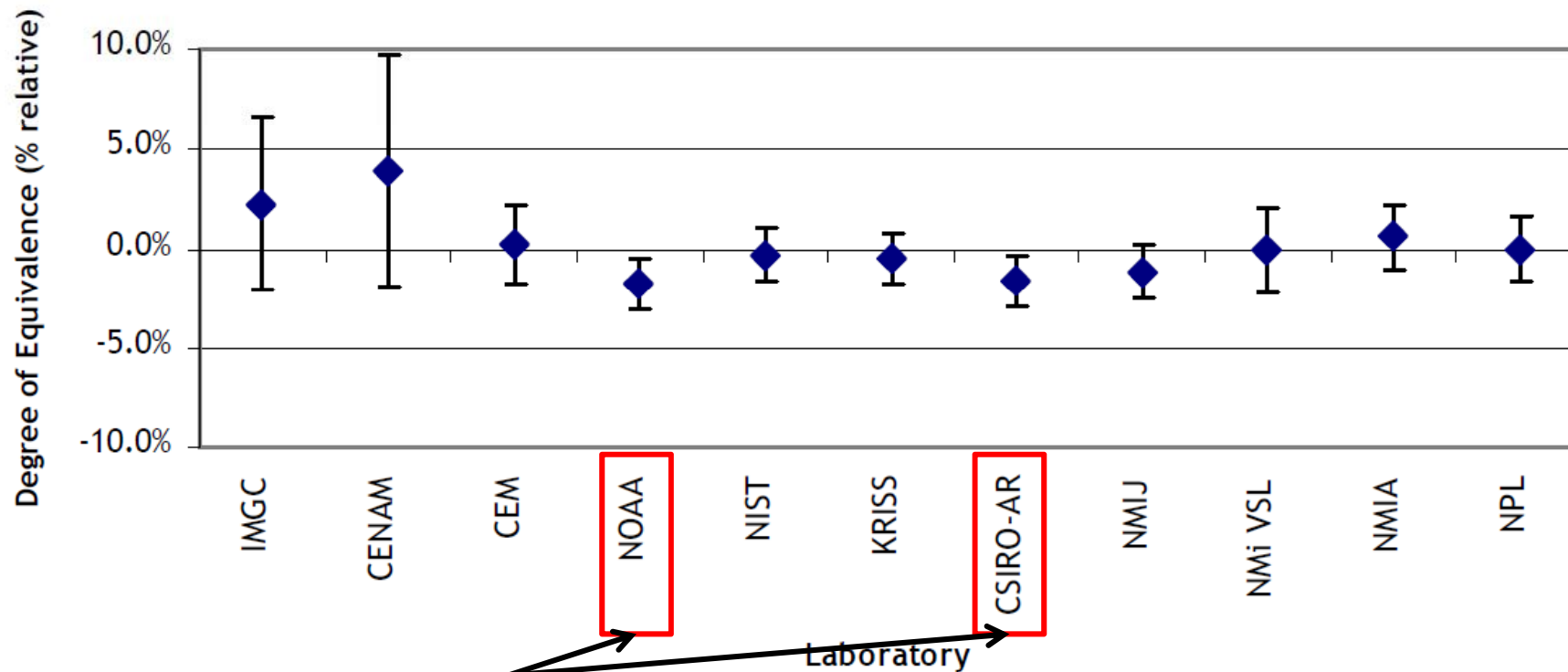


CCQM K68 Nitrous oxide  
(in synthetic air)  
320 nmol/mol

# DQO and measurement capabilities

Component	DQO	Range in the unpolluted troposphere	Range of Certified value, <b>KRISS</b>	Exp. Uncertainty ( $k=2$ ), <b>KRISS</b>	Ref.
CO <sub>2</sub>	±0.1 ppm	360-420 ppm	> 10 µmol/mol	0.06 at 380 µmol/mol	CCQM-K3, K52
δ <sup>13</sup> C (CO <sub>2</sub> )	± 0.01 ‰	-7.5 - -9 ‰ vs. VPDB*			
δ <sup>18</sup> O (CO <sub>2</sub> )	± 0.05 ‰	-2 - +2 ‰ vs. VPDB*			
Δ <sup>14</sup> C (CO <sub>2</sub> )	± 1 ‰	0-70 ‰			
O <sub>2</sub> /N <sub>2</sub>	± 1 per meg	-250 - -550 per meg			
CH <sub>4</sub>	± 2 ppb	1700-2000 ppb	> 100 nmol/mol	0.002 at 1.9 µmol/mol	CCQM-P41
CO	± 2 ppb	30-300 ppb	> 5 µmol/mol	0.002 µmol/mol	CCQM-K1.a, K51
N <sub>2</sub> O	± 0.1 ppb	320-335 ppb	> 50 nmol/mol	0.24 at 320 nmol/mol	CCQM-K68
H <sub>2</sub>	± 2ppb	450-600 ppb			
SF <sub>6</sub>	± 0.02 ppt	5-9 ppt	> 6 pmol/mol	0.06 at 6 pmol/mol	CCQM-K15

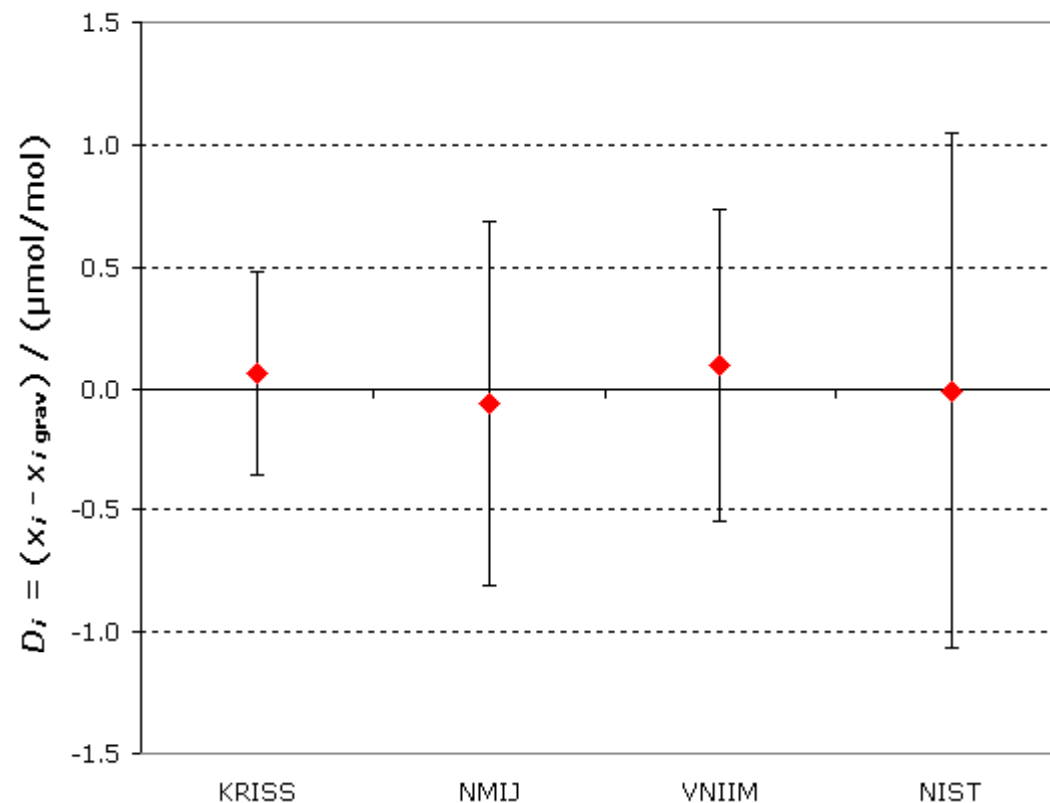
\* Vienna Peedee Belemnite



**WMO-GAW Laboratories** 1.7 % difference from gravimetric value

Corrected for 5 nmol/mol of CH<sub>4</sub> in diluent zero air in 2005.  
Correction factor 1.0124

Component	x (mmol/mol)
<b>Methane</b>	<b>0.0018</b>
Carbon dioxide	0.365
Argon	9.3
Oxygen	209
Nitrogen	balance

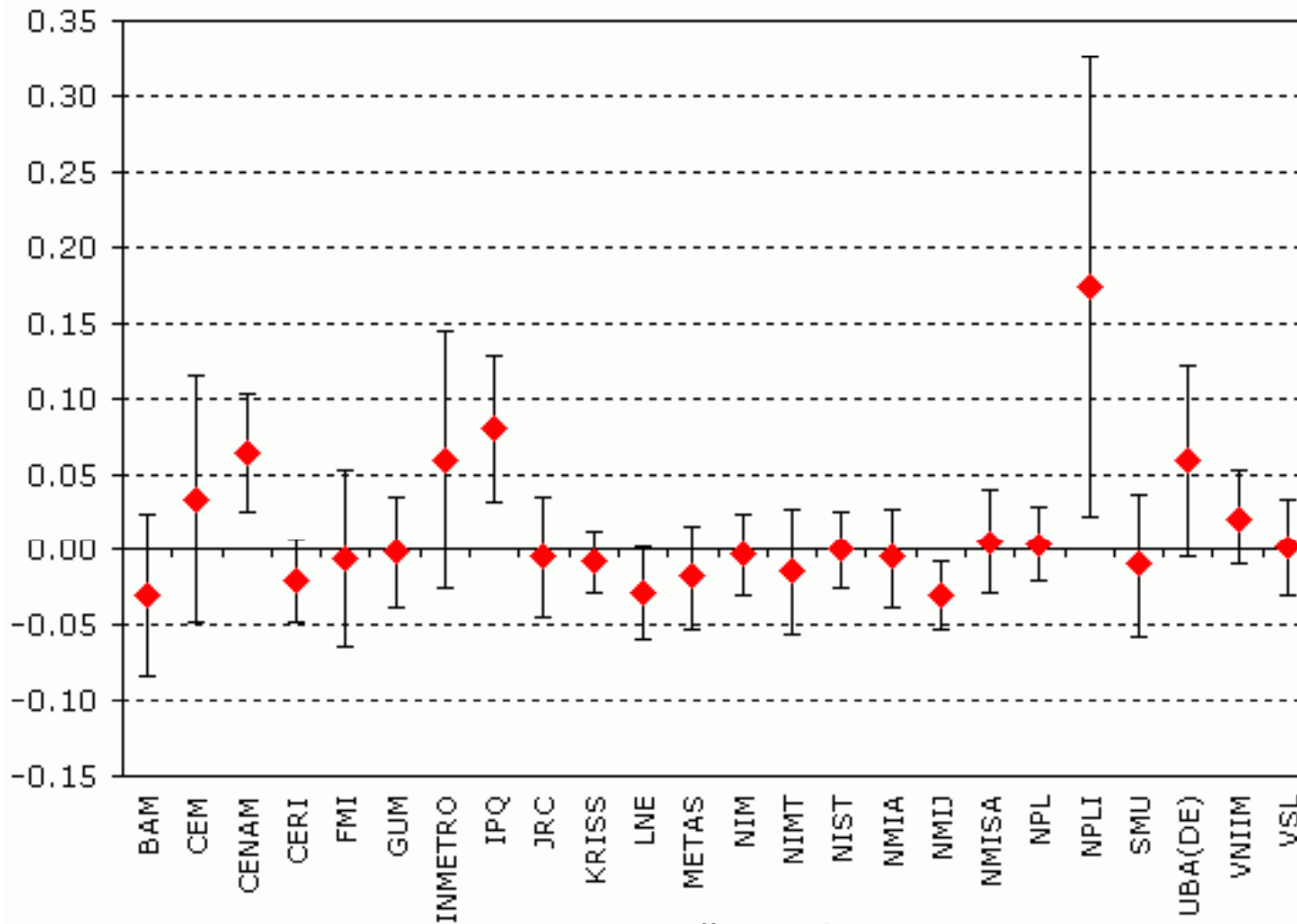


**MEASURAND** : Amount-of-substance fraction of SF<sub>6</sub> in Nitrogen

**NOMINAL VALUE** : 100  $\mu\text{mol/mol}$

**Degrees of equivalence**:  $D_i = (x_i - x_{i_{\text{grav}}})$  and expanded uncertainty  $U_i$  ( $k = 2$ ), both expressed in  $\mu\text{mol/mol}$

Carbon monoxide in Nitrogen  
 $D_i$  and  $U_i$  ( $k = 2$ ) in  $\mu\text{mol/mol}$



<http://kcdb.bipm.org>

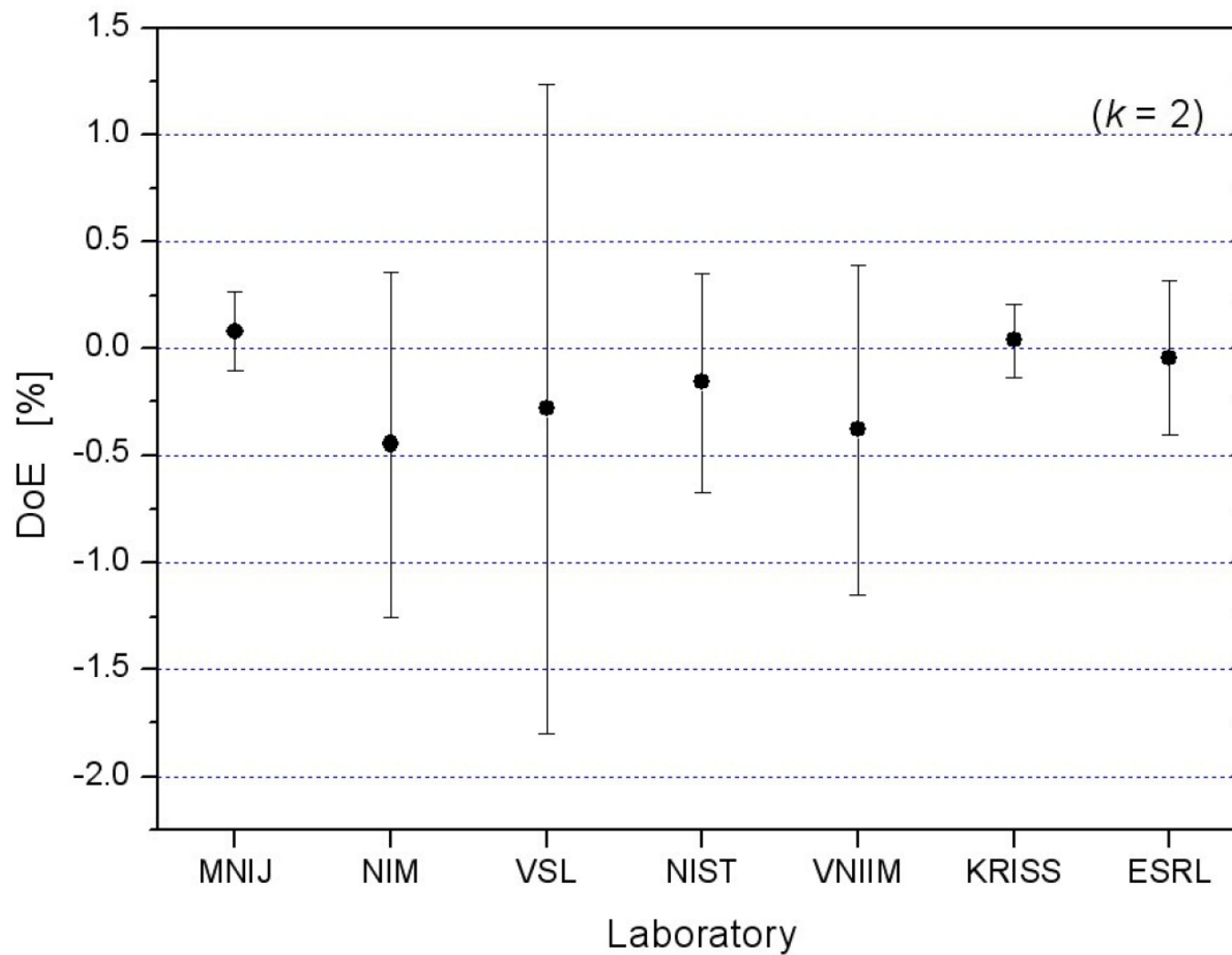


Figure 2. Degree of Equivalence for the CCQM-K68.

# GHG standards established at KRISS

substance	Range of Certified Values	Uncertainty (k=2) [ $U=2xu=2\sqrt{u_{grav}^2 + u_{val}^2 + u_{sta}^2}$ ]	ref
CO <sub>2</sub>	above 10 µmol/mol	0.06 at 380 µmol/mol	CCQM-K3, 52
CH <sub>4</sub>	above 100 nmol/mol	0.002 at 1.9 µmol/mol	CCQM-P41
N <sub>2</sub> O	above 50 nmol/mol	0.24 at 320 nmol/mol	CCQM-K68
SF <sub>6</sub> NF <sub>3</sub>	above 6 pmol/mol for SF <sub>6</sub> above 1 nmol/mol for NF <sub>3</sub> (0.5 pmol/mol after 2011)	0.06 at 6 pmol/mol for SF <sub>6</sub> 0.01 at 1 nmol/mol for NF <sub>3</sub>	CCQM-K15, Paper preparation
PFCs	above 10 pmol/mol for CF <sub>4</sub> above 100 µmol/mol for C <sub>2</sub> F <sub>6</sub> (50 pmol/mol after 2011)	0.1 at 10 pmol/mol for CF <sub>4</sub>	CCQM-K15, Paper preparation
HFCs	above 30 pmol/mol for HFC23	0.15 at 50 omol/mol	
CFCs	µmol/mol~50 pmol/mol for CFC 11,12,113	0.5 at 50 pmol/mol	



- Stronger engagement with Global Monitoring Community
  - NOAA/ESRL to join as a DI
  
- Major science challenges ahead
  - Data Quality Objectives of WMO set a new level for performance
  - Resolve differences between results of static and dynamic methods

## SUMMARY

- Significant contributions have been made by several NMIs and the CCQM to the standards used to underpin the evidences for radiative forcing and global climate change.
- Capabilities built by NMIs are used as high-accuracy standards globally.
- International collaboration is central to the future WMO “Global Atmospheric Watch.”
- Future challenges will be on;
  - Providing standards in real matrices
  - Reconciliation of data (including uncertainties and terminology) in a way that is compatible with scales with long-term stability and accuracy

*Better Standards, Better Life !*



Thanks for your attention.