Metrological Traceability in Eddy Covariance Measurements of CO_2 Flux

Alberto Bottacin[1,2]*, Michela Sega[1], Francesca Durbiano[1], Francesca Rolle[1], Nicola Arriga[3]   *Corresponding author: a.bottacin@inrim.it

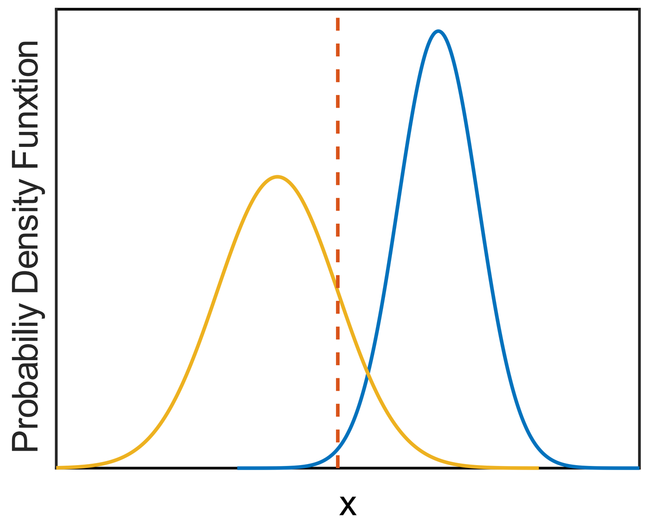
[1]Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy [2]Politecnico di Torino, Torino, Italy [3]European Commission, Joint Research Centre (JRC), Ispra, Italy

EGU General Assembly

AS2.3 - X5.109

A Why worry about measurement uncertainty?

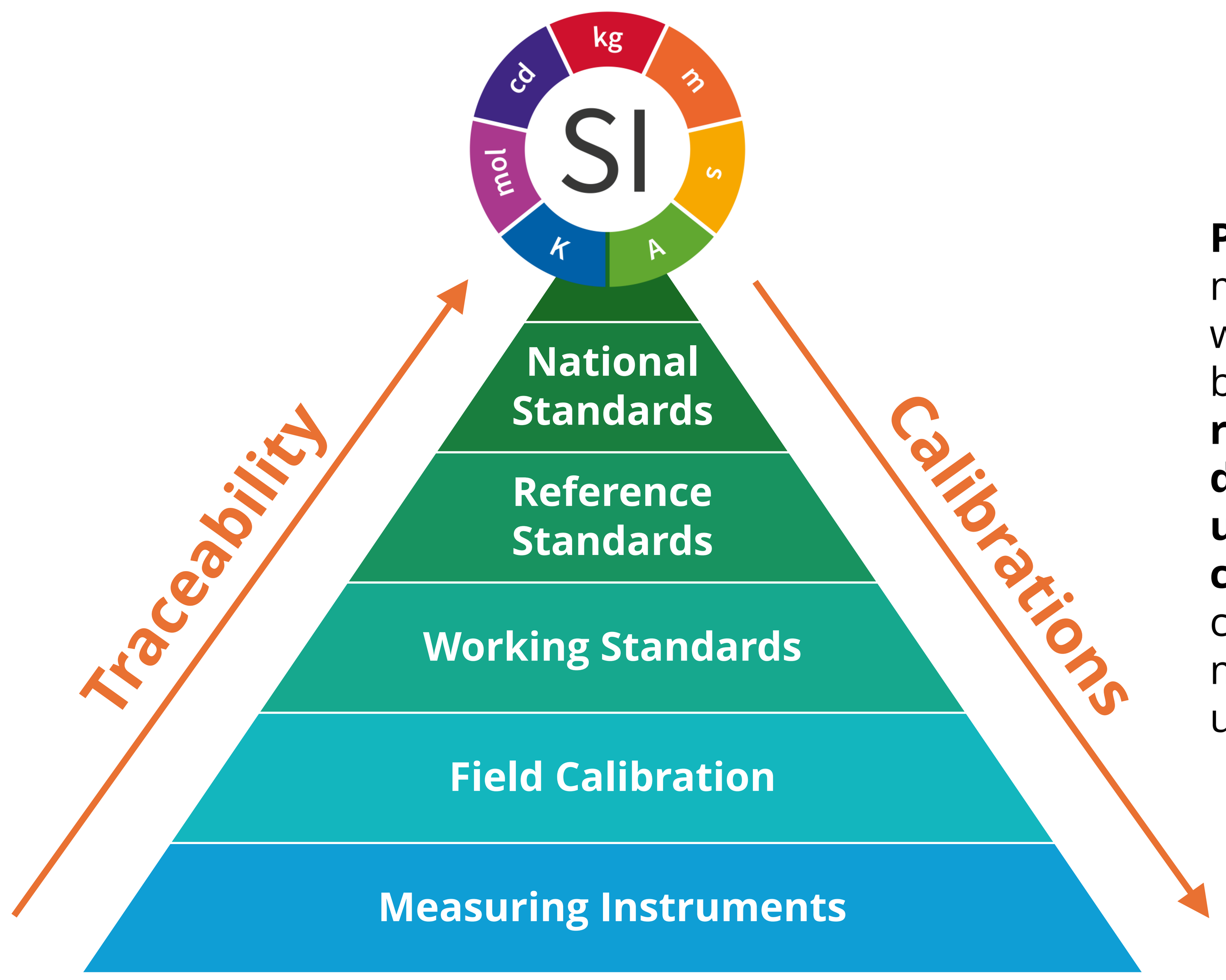
- **Measurement uncertainty** is related to the *doubt about the true value of the measurand* (the quantity intended to be measured) *that remains after making a measurement.* It is a non-negative parameter characterizing the dispersion of the quantity values being attributed to a measurand, based on the information used.
- A **measurement result** is therefore **incomplete without** a statement of the **uncertainty.**



UNCERTAINTY ≠ ERROR (!)

Why we need to evaluate measurement uncertainty?

- The evaluation of measurement uncertainty allows us to **assess methods and results** against **data quality requirements.** Indeed, without a complete quantification of uncertainty components, it is impossible to assess if a measurement procedure is fit for purpose and meets target uncertainties.
- **Measurements are comparable** only if measurement uncertainty is stated and measurement results are **traceable** to the same reference.
- Provides an **understanding of the measurement** and which parameters should be given most consideration for method optimization and improvement.



Metrological Traceability

Property of a measurement result whereby the result can be related to a **reference** through a **documented unbroken chain of calibrations**, each contributing to the measurement uncertainty.

B Eddy Covariance Traceability

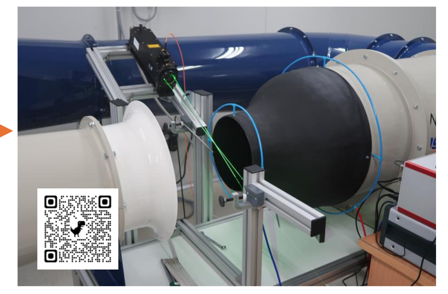
$$F_c = \bar{\rho}(p, T) \cdot \overline{w'c'}$$

Primary mixtures

$c \in [100, 1000]$ ppm

$U_{CMC} = 0.33$ %

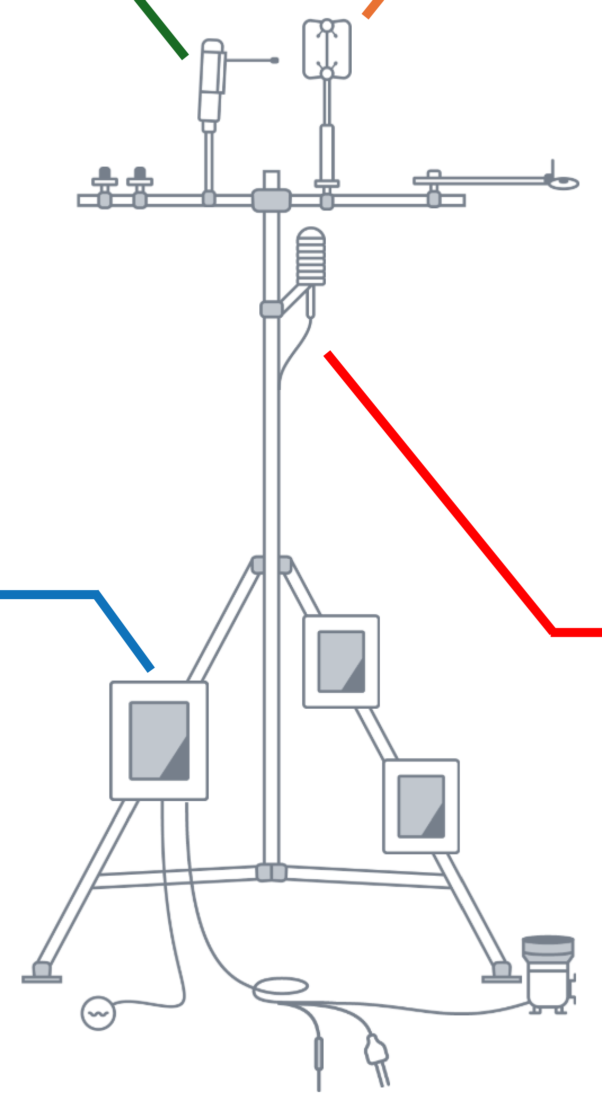
Laser doppler anemometer



Westenberg Engineering wind tunnel & LDA

$w \in [0.1, 40]$ m/s

$U_{CMC} \in [0.01, 0.2]$ m/s



Scheme generated by the LI-COR configuration tool

Pressure balance

Picture from Fluke PG7000 series datasheet

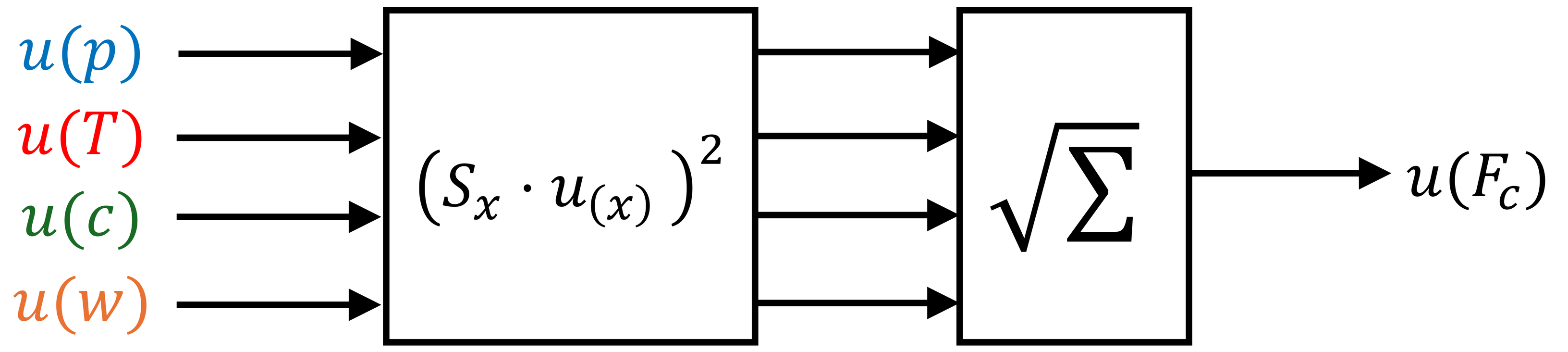
$p \in [6.4 \text{ kPa}, 7 \text{ MPa}]$

$U_{CMC} \in [0.7 \text{ Pa}, 190 \text{ Pa}]$

ITS-90

$T \in [-90, 100]$ °C

$U_{CMC} = 0.1$ °C



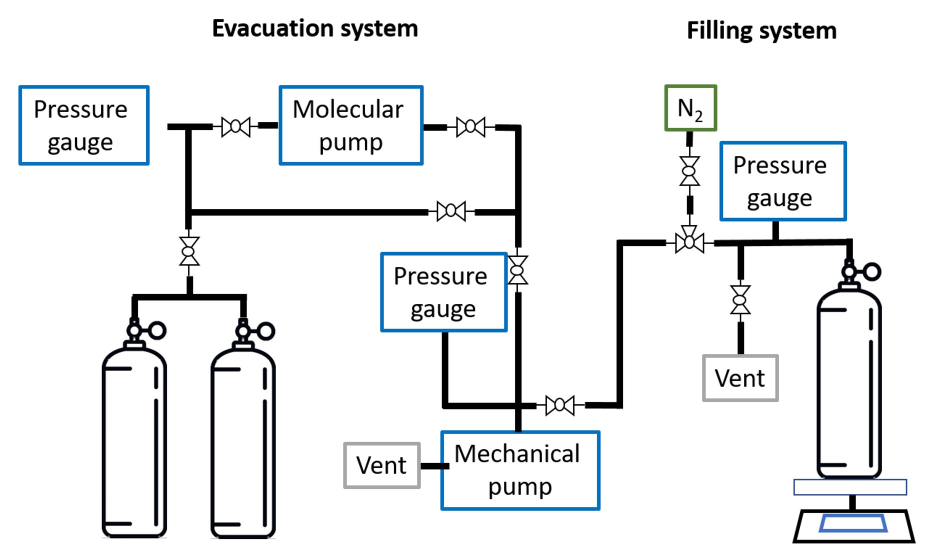
For measurements with more than one input quantity in the measurement model, **each of the input quantity values should itself be metrologically traceable**.

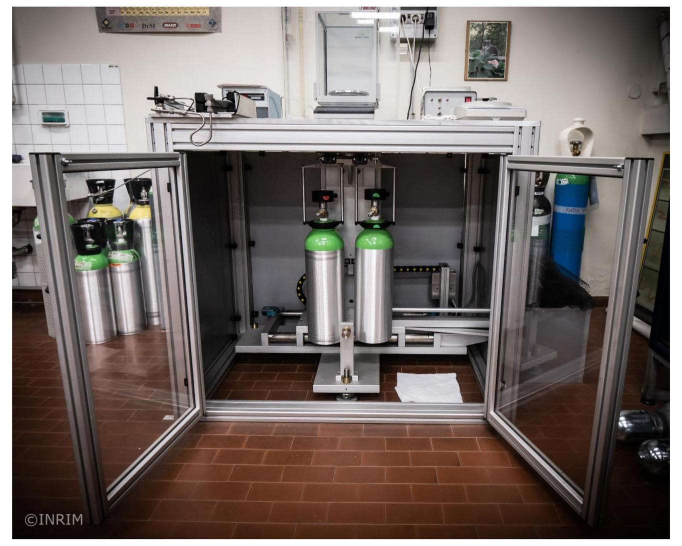
The effort involved in establishing metrological traceability for each input quantity value should be **commensurated with its relative contribution to the measurement result.**

C Calibration of NDIR

The calibration is the operation that, under specified conditions, establishes a relation between the **quantity values** with **measurement uncertainties** provided by **measurement standards** and corresponding **indications** with associated measurement uncertainties.

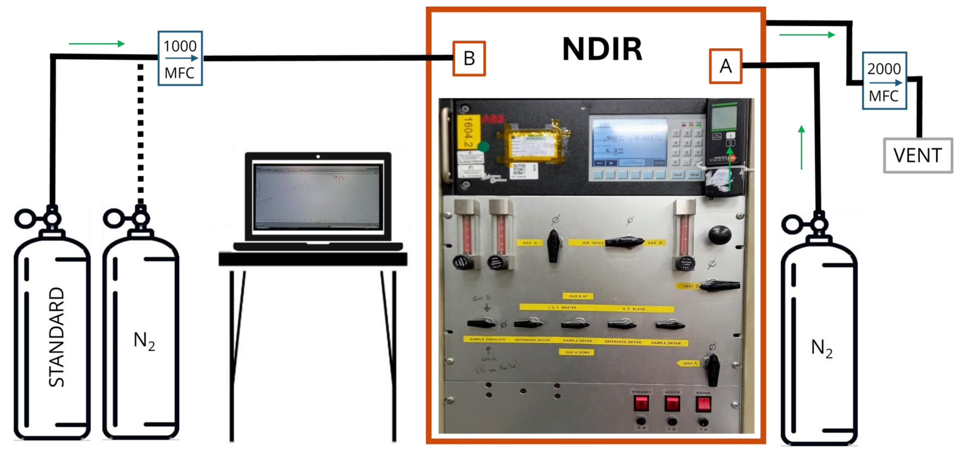
1) Production of primary mixtures with specified amount of substance by gravimetric method





2) Use of primary mixtures to calibrate NDIR

- Once a year
- 7 calibration points from 100 to 1000 ppm
- 3 times: increasing, decreasing, increasing
- Zero at the beginning of the procedure and at the end for stability check



$$u_{cal}(c) = \sqrt{u_{CRM}^2 + u_{stab}^2 + u_{rep}^2}$$

Example: calibration of the analyzer LI-COR 830 resulted in an uncertainty $U_{cal} = 3$ ppm $(k = 2)$

3) On-site verification

- Common to use industrial mixtures: not critical for the zero, but crucial for the span
- Span parameter should be changed if $\frac{|c_{NDIR} - c_V|}{3 \cdot \sqrt{u_{cal}^2 + u_V^2}} > 1$
- After the span test, *instrumental uncertainty* equal to:

$$u_{inst} = \sqrt{u_{cal}^2 + u_V^2}$$

Sharing is encouraged