METROLOGICAL TESTS ON MICROSENSORS: TOWARDS A FRENCH CERTIFICATION?

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Microsensors for air quality monitoring:
lessons learned and challenges - Workshop Airparif
21/01/2020

The French National Reference Laboratory

Scientific Group working with actors of the national air quality monitoring network since 1991

~60 people

Annual budget ~4.5 M€

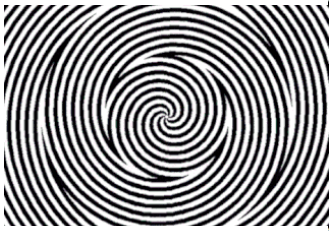
Scientific and technical support for the Ministry of the Environment and for regional networks (AASQA) to improve the national air quality monitoring network

- **Guarantee the quality of the data**, devices or methodologies and their adequacy with the European requirements and the needs of the national network
- Ensure the distribution and the exploitation of the data produced by the national network
- **Improve the scientific and technical knowledge** of the national network to help the implementation of action plans and anticipate the future monitoring strategy
- Coordinate the national network

How to guarantee data quality?

Confidence in quality of the data provided by micro-sensors is often very low

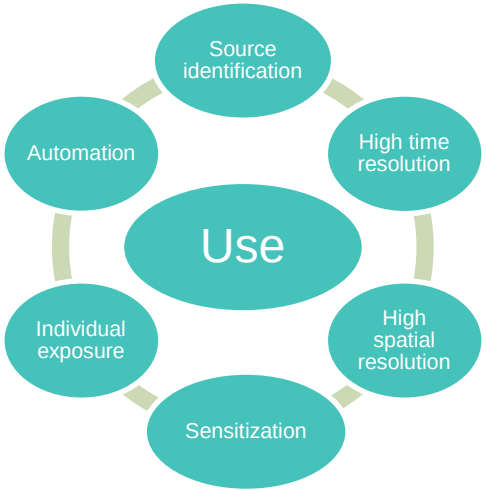
At best, the sensors see blurry, at worst, they lie to us!

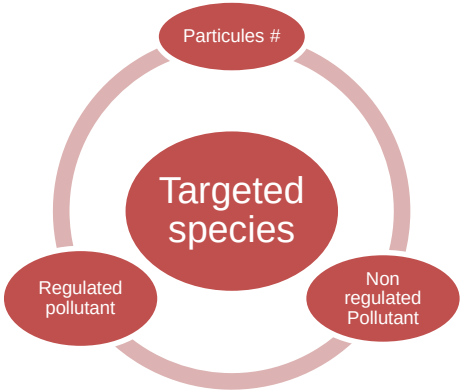


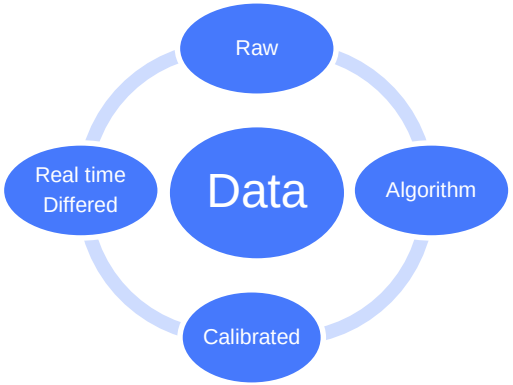
What are the parameters that characterize a “good” measurement?

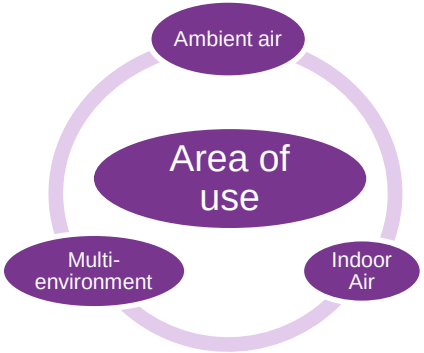
It depends! → Data Quality Objectives (DQO) is a complex issue

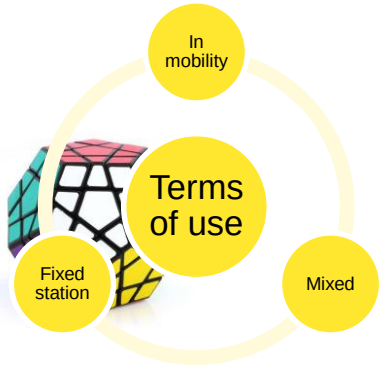
DQO of sensors, a multidimensional problem











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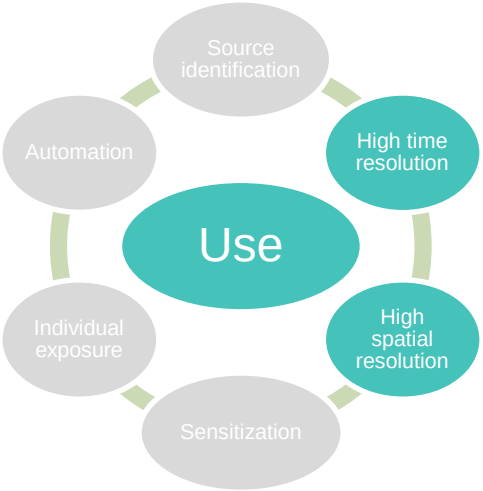

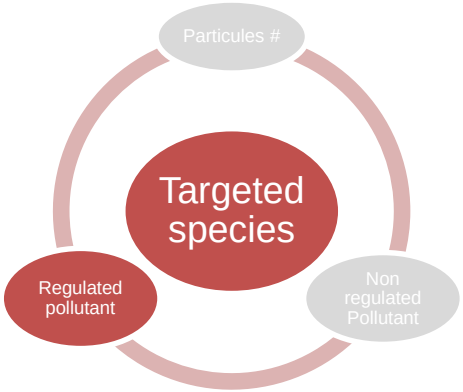

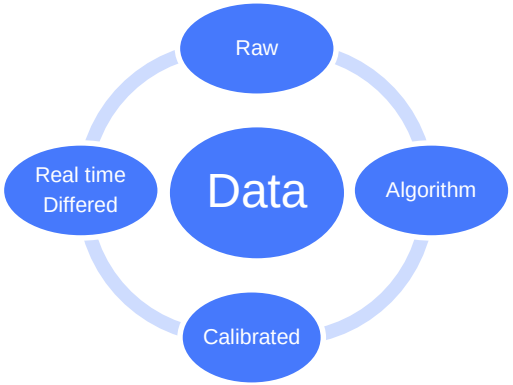

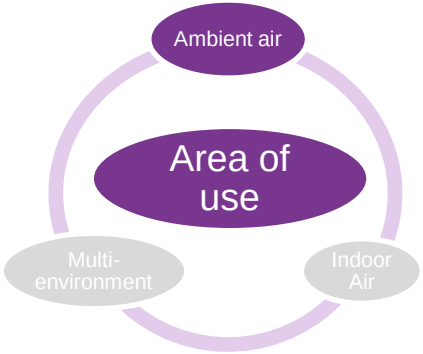

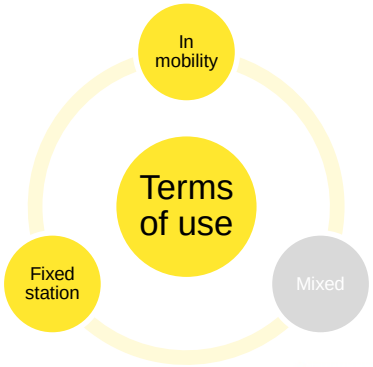

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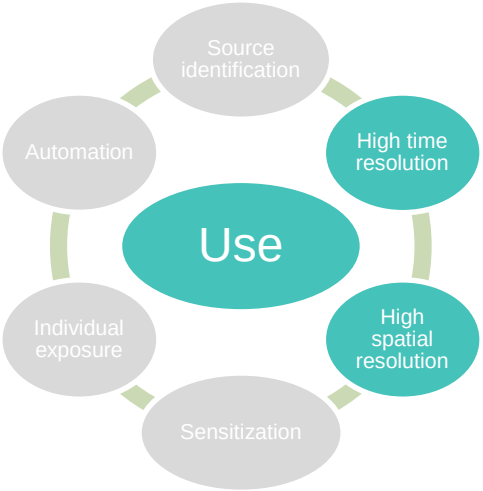
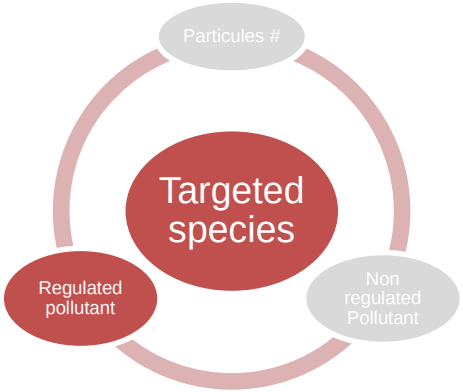
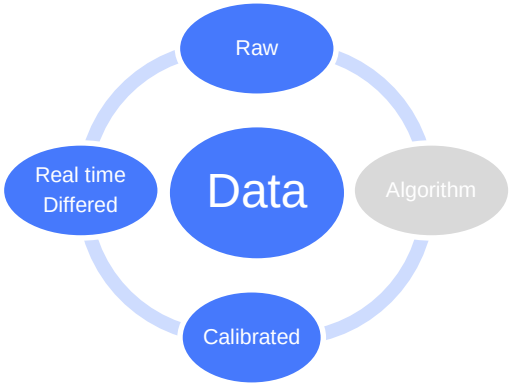
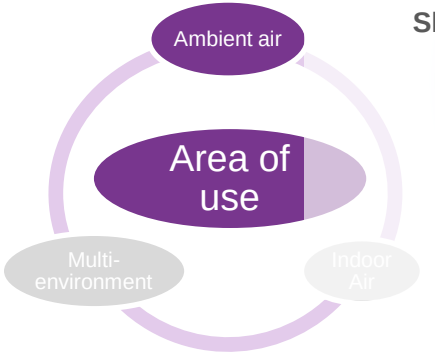
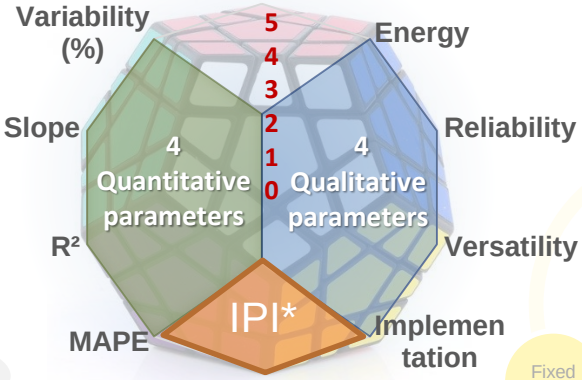
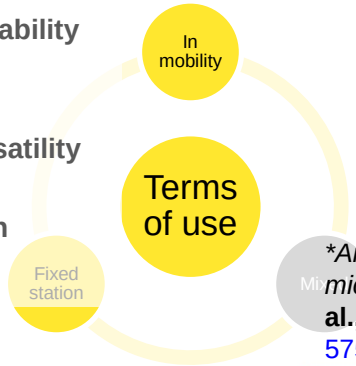












LCSQA evaluation criteria

*An evaluation tool kit of air quality micro-sensing units, **B. Fishbain & al.,** Science of the Total Environment 575 (2017) 639–648

How to determine the score of a sensor?

Define different **metrological qualification protocols** responding to different strategies of interest for stakeholders

➢ **In laboratory :**
In order to address specific response of sensor to gas and/or particles in controlled conditions (T°C, RH%, interfering species)



➢ **On field, in fixed station**
In order to compare as many multi-sensor systems as possible in similar conditions like air monitoring station

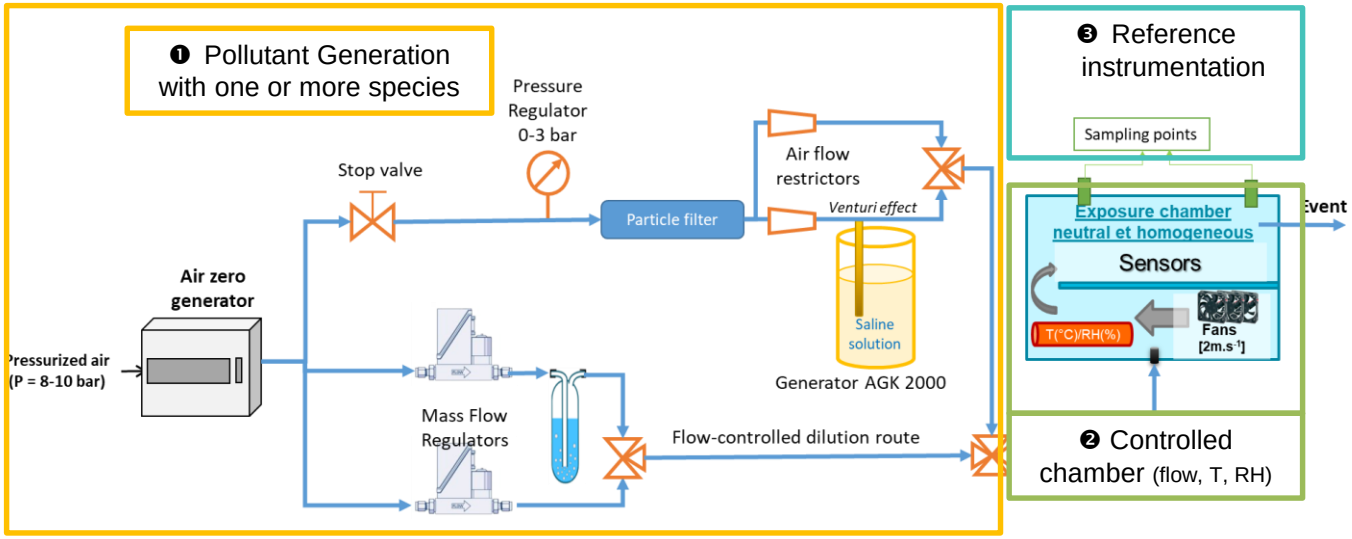
➢ **On field, in mobile situation**
In order to evaluate for example the impact of speed on measurements, thus to define the right use for cartography or modeling applications


How to determine the score of a sensor?

➢ **Qualification in laboratory :**
Keyword → Simplicity

French protocol
for gas sensors [NO_2, O_3]

French protocole
for particle sensors $PM_{2.5}$, PM_{10}



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French protocol
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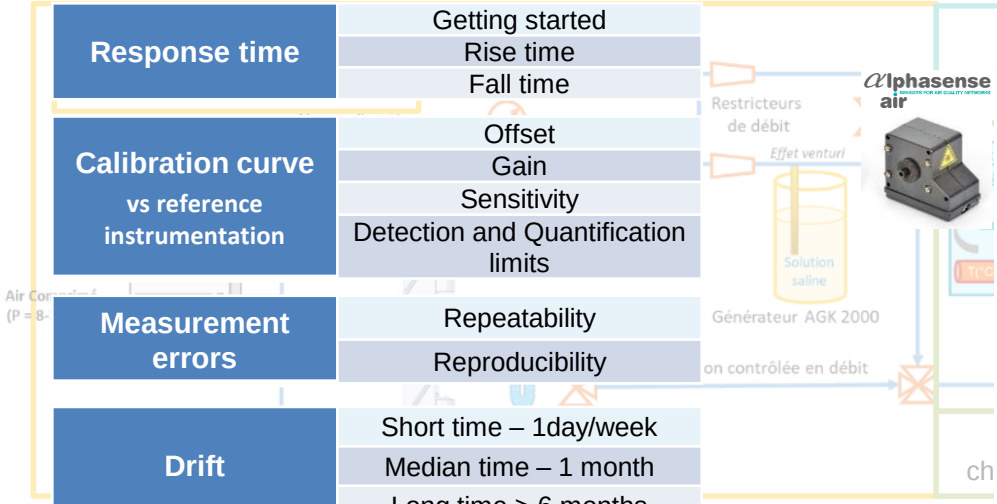
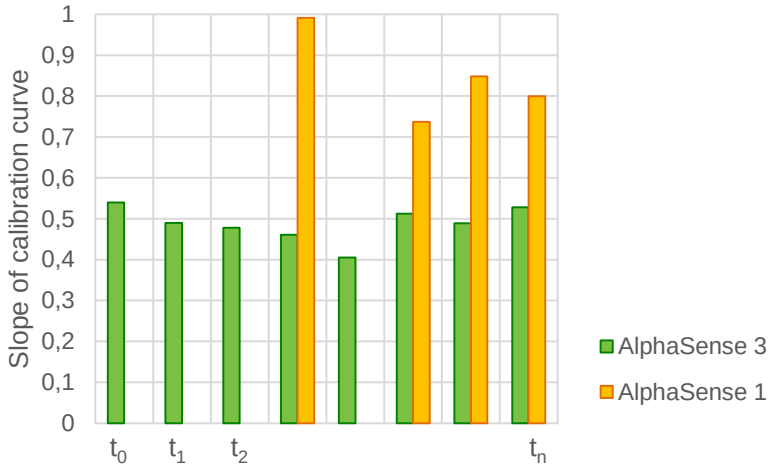
Response time	Getting started
	Rise time
	Fall time
Calibration curve vs reference instrumentation	Offset
	Gain
	Sensitivity
	Detection and Quantification limits
Measurement errors	Repeatability
	Reproducibility
Drift	Short time – 1day/week
	Median time – 1 month
	Long time > 6 months
Influence parameters	Temperature
	Relative humidity
	Wind speed
	Interfering species (H_20, etc.)



Repeatability/ Reproducibility/Drift



How to determine the score of a sensor?

➢ **Qualification in laboratory :**
Keyword → Simplicity

→ Numerous tests to be conducted to represent **real field complex conditions**

➢ **Qualification in field conditions :**
Keywords → Representativeness

Organization of **2 French Joint Intercomparison Exercises for Air Quality sensors**

Campain 1: **EAµC#1**

- ❑ 6 weeks from January to middle February 2018
- ❑ Winter conditions (low O_3 levels)
- ❑ 16 participants, 17 different systems (44 inclunding replicas) (FR, ND, UK, ES, IT, P, US)

Campain 2: **EAµC#2**

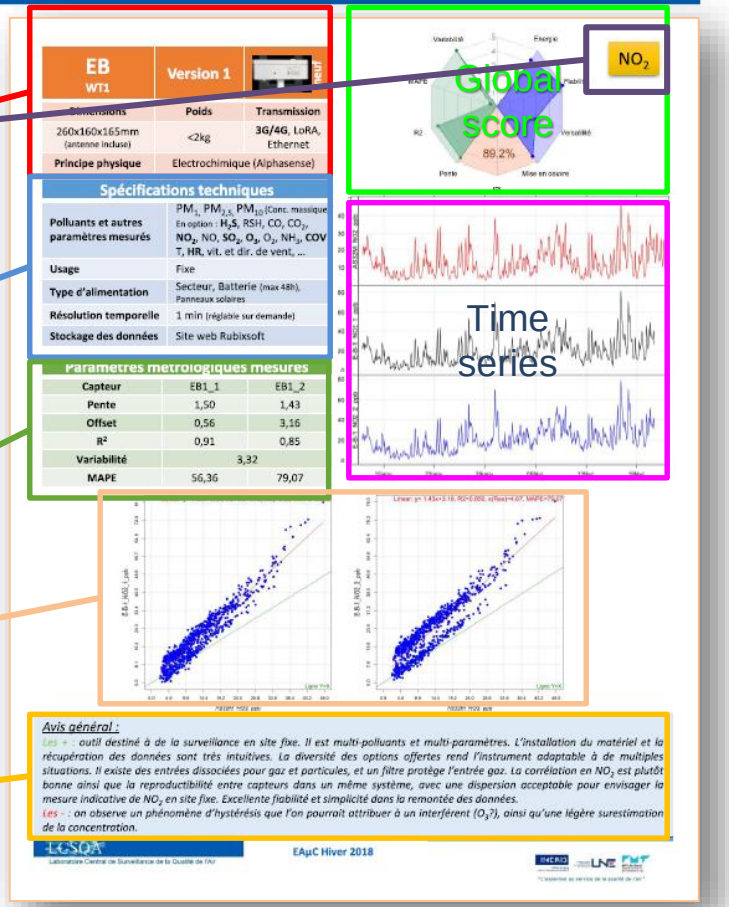
- ❑ 6 weeks from July to middle August 2018
- ❑ Summer conditions (more O_3, other particles compositions)
- ❑ 20 participants, 20 different systems (45 including replicas)

How to determine the score of a sensor?

- **Qualification in field conditions :**

  Keyword → Representativeness

  - Pollutant
  - Sensor identification
  - Technical specifications
  - Results on metrological parameters
  - Graphical correlation
  - Global advice for users



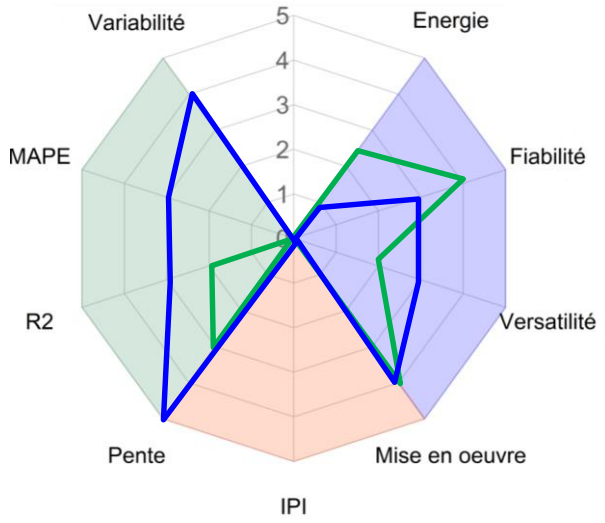
How to determine the score of a sensor?

➢ **Qualification in field conditions :**
Keyword → Representativeness

For similar IPI, different score obtained
IPI (AQT420) = 77,2% / IPI (Cairclip) = 74,9%

Reference instrument	Sensor model/ participant	Number of system tested	IPI (%)
AS32M_ NO2_ppb	**Cairclip**/IMT Lille Douai	3	74,9
	Ecomsmart/Ecomesure	3	77,4
	AQT420/Vaisala	3	77,2
	Libelium/Atmo GE	1	80,8
	Watchtower1/Atmo GE	1	89,2
	AQT420/Atmo GE	2	77,2
	Watchtower1/Rubix	1	68,6
	HA	2	69,3
	AQMesh/ADDAIR	3	67,4
	AirSensEUR/ Atmo Normandie	1	30,8
	MB	2	80,1

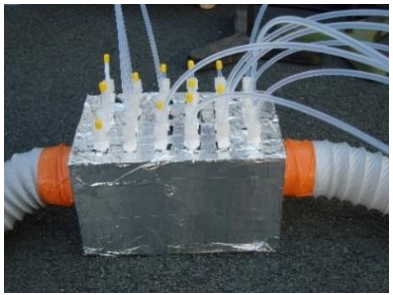
Comparison Cairclip vs AQT420



How to determine the score of a sensor?

➢ **Qualification in field conditions :**
Keyword → Representativeness

Long campaigns are needed to have **a good span of targeted concentrations**



artificial enrichment of ambient air matrix

Implementation of a certification process for sensors dedicated to ambient air monitoring

Only available in fixed applications

What is the impact of **mobility** on the response of sensors for rebuilding a pollution map ?

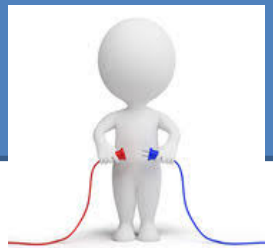
How to determine the score of a sensor ?

➢ **Qualification in field conditions, in mobility :**

Keyword → speed effect

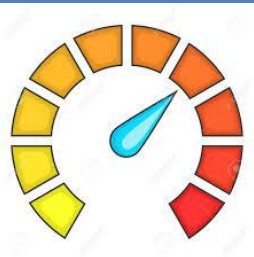
A protocol in 5 steps

Optimal routes

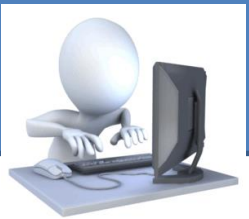


Installations

Calibration in static conditions



Calibration in mobility



Data treatment GPS and time synchronization

Publication in progress …

Conclusions & Perspectives

- Depending on the purpose of using the sensors, the expected performances are different

→ Importance of knowing the evaluation conditions of the sensors and their adequacy with the need for use before considering the results obtained.

- Fields of application related to LCSQA missions are already assessed (measurements in laboratory and on fixed site, use of sensors in mapping) with results available online on the LCSQA website or in scientific publications.

- A French certification scheme for sensors is intended in 2020 for ambient air monitoring

- Other fields of application are evaluated such as the use in mobility, the contribution of the use of networked sensors to reduce uncertainties, ...

Thank for your attention,
Listening for any question