

# Design and performance assessment of “Mid Cost” CO<sub>2</sub> sensor system for urban monitoring network.

\*O. Laurent<sup>1</sup>, L. Lienhardt<sup>1</sup>, M. Chariot<sup>1</sup>, H. Utard<sup>2</sup>, L. Rivier<sup>1</sup>, M. Ramonet<sup>1</sup>, Karina Cucchi<sup>2</sup>, Jinghui Lian<sup>2</sup>, Laurent Millair<sup>2</sup>

<sup>1</sup> Laboratoire des Sciences du Climat et de l'Environnement (LSCE), Unité Mixte de Recherche (CEA-CNRS-UVSQ), Gif-sur-Yvette, France

<sup>2</sup> SUEZ Origins.earth, Le Pecq, France

## Introduction

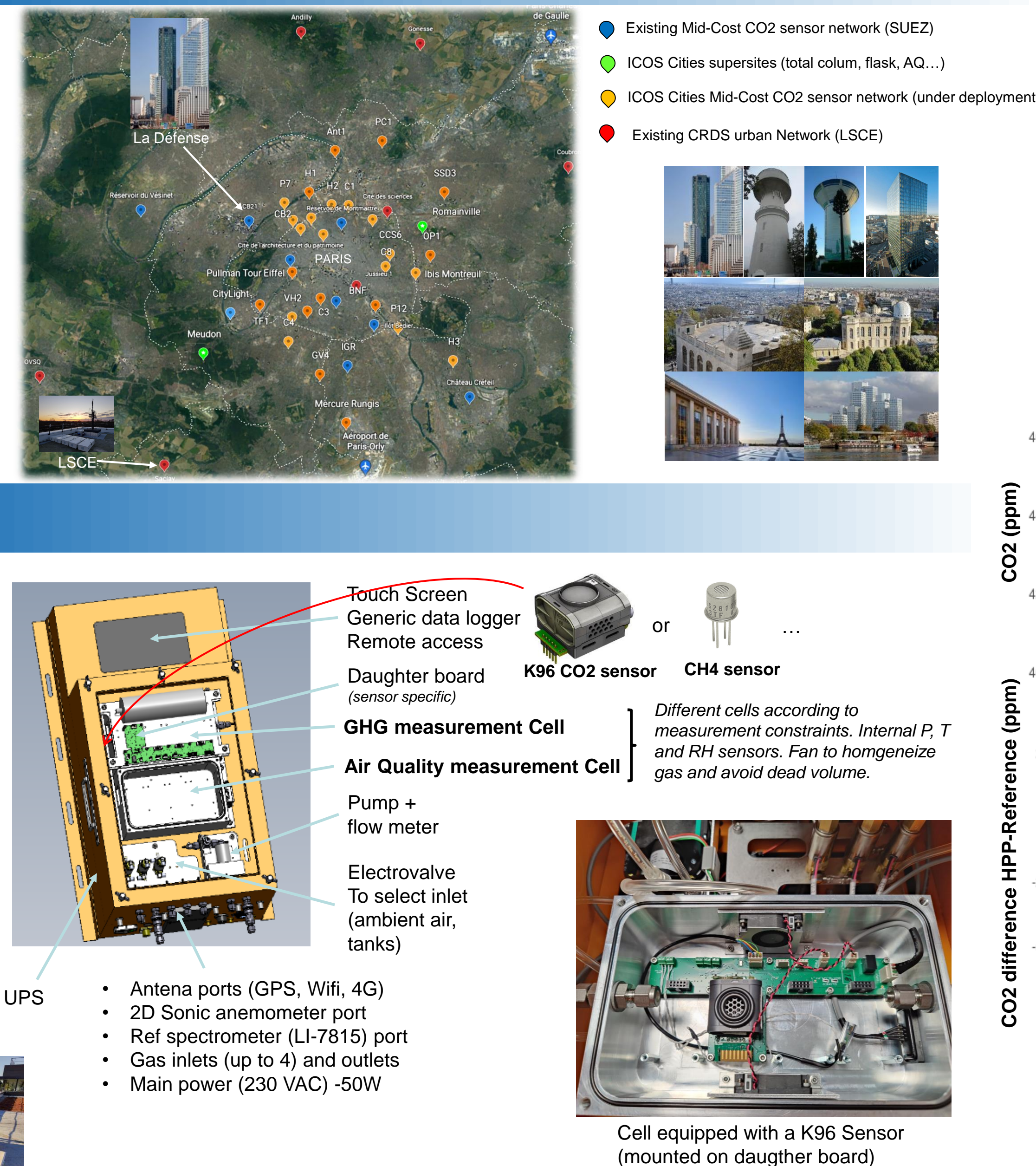
In the framework of the **ICOS Cities** – PAUL, a H2020 European project aiming to assess different techniques and methodologies to better estimate the CO<sub>2</sub> emission in urban area, the LSCE and Origins.earth are developing and deploying a **network of 30 “mid cost” CO<sub>2</sub> NDIR sensors within Paris** and its near suburb. In addition to few stations equipped with high precision spectrometers, such dense “mid cost” CO<sub>2</sub> sensor network allows a better monitoring of the complex spatial distribution of CO<sub>2</sub> gradient at a local scale. In order to represent larger footprint and avoid the direct measurement of very local CO<sub>2</sub> sources (e.g. traffic) difficult to handle by inversion model, these sensors are deployed at the roof level (between 25m and 180m agl). With such network configuration, the typical site to site CO<sub>2</sub> gradient observed in Paris is limited to few ppm and up to 10-20 ppm depending mainly to the meteorological conditions (wind speed, mixing layer height). In order to be able to monitor this atmospheric signal, the **“mid-cost” CO<sub>2</sub> sensors accuracy target has been set at 1 ppm**. On the other hand, we aim to **reduce the cost of the sensors by an order of magnitude compared to high-precision analyzers**.

## Sensor integration

The **10 first CO<sub>2</sub> monitoring boxes designed with SUEZ** are using HPP CO<sub>2</sub> sensors, a NDIR sensor prototype from Senseair. Sensors have been deployed in Paris from 2020.



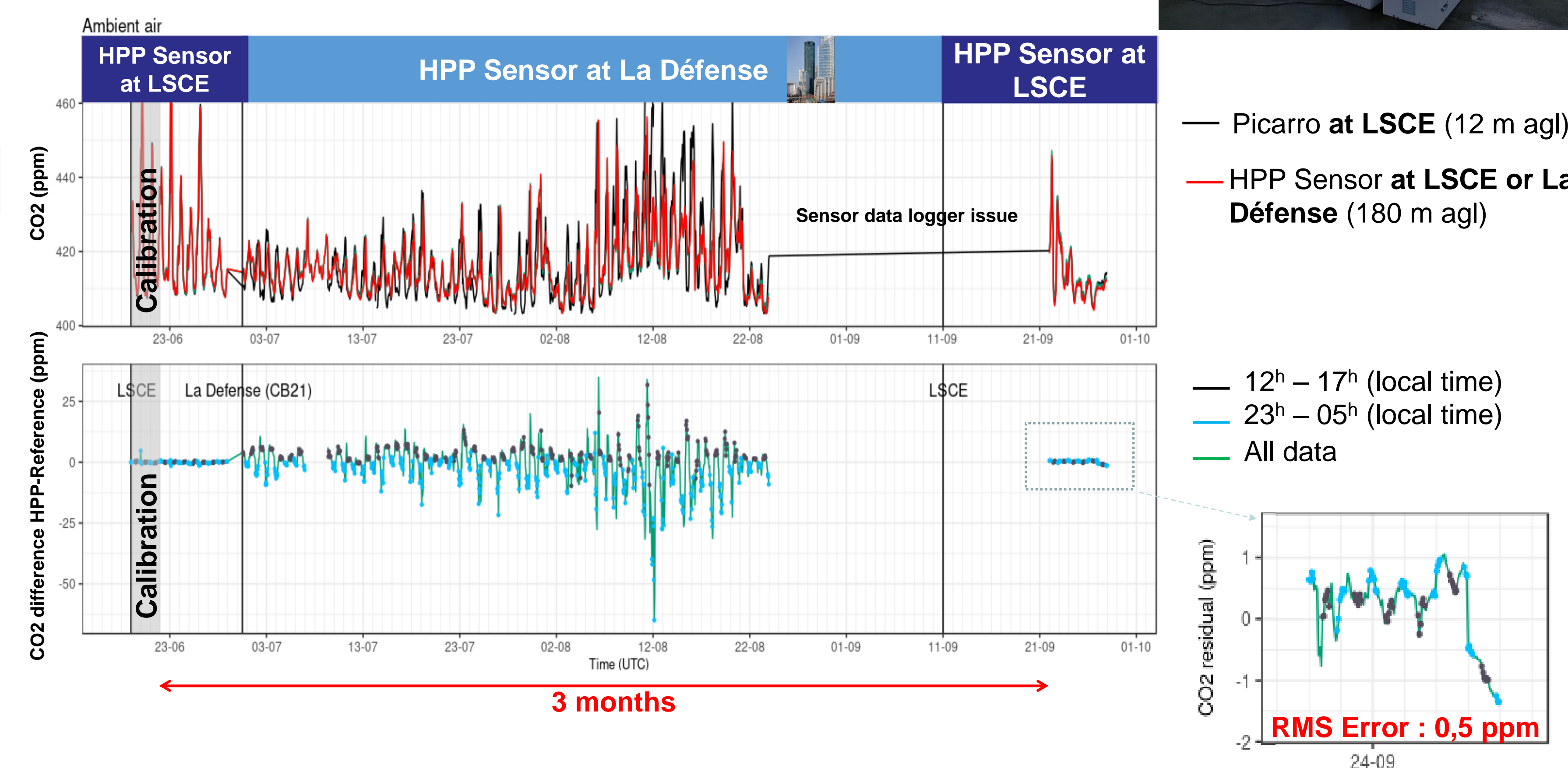
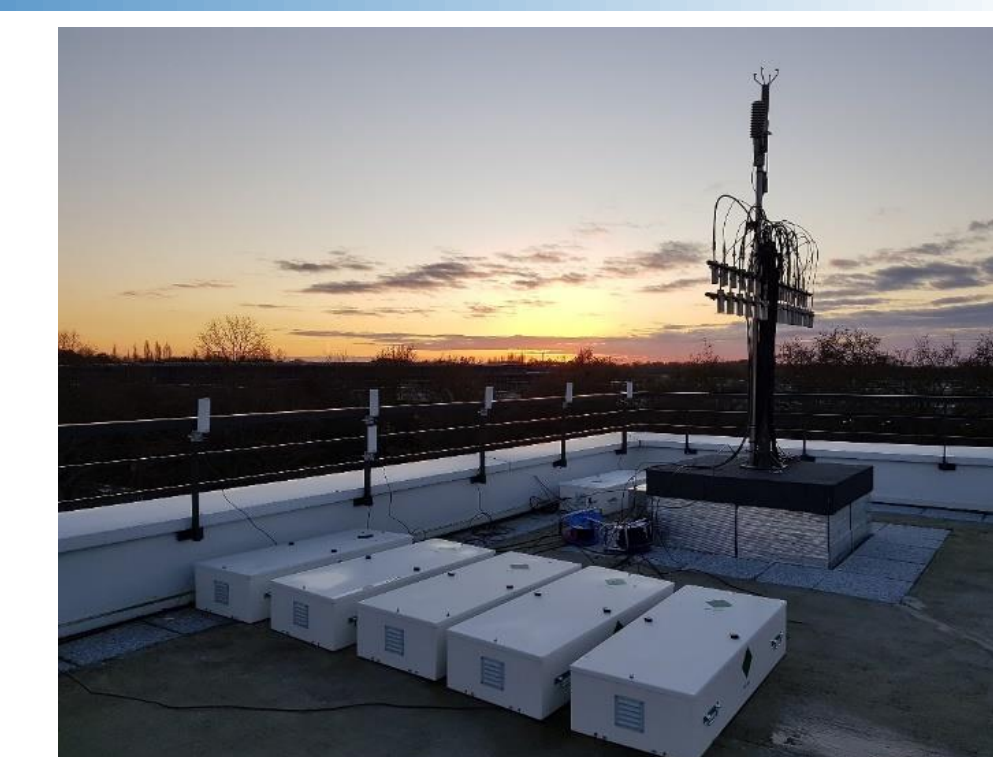
**20 new sensor logger boxes**, so called “AtmoBox” have been designed, built and are currently deployed in Paris. These AtmoBoxes consist in a modular multi sensor monitoring platform for GHG (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, H<sub>2</sub>O...) and Air Quality (NO<sub>2</sub>, O<sub>3</sub>, VOC, NH<sub>3</sub>, H<sub>2</sub>S...) measurement. For Paris Network, AtmoBox is using NDIR sensors for CO<sub>2</sub> measurement : a new Senseair prototype (K96) and a Vaisala GMP 343. Each AtmoBox is equipped with a sonic wind sensor to monitor the wind conditions at the air sampling point.



## Performance assessment

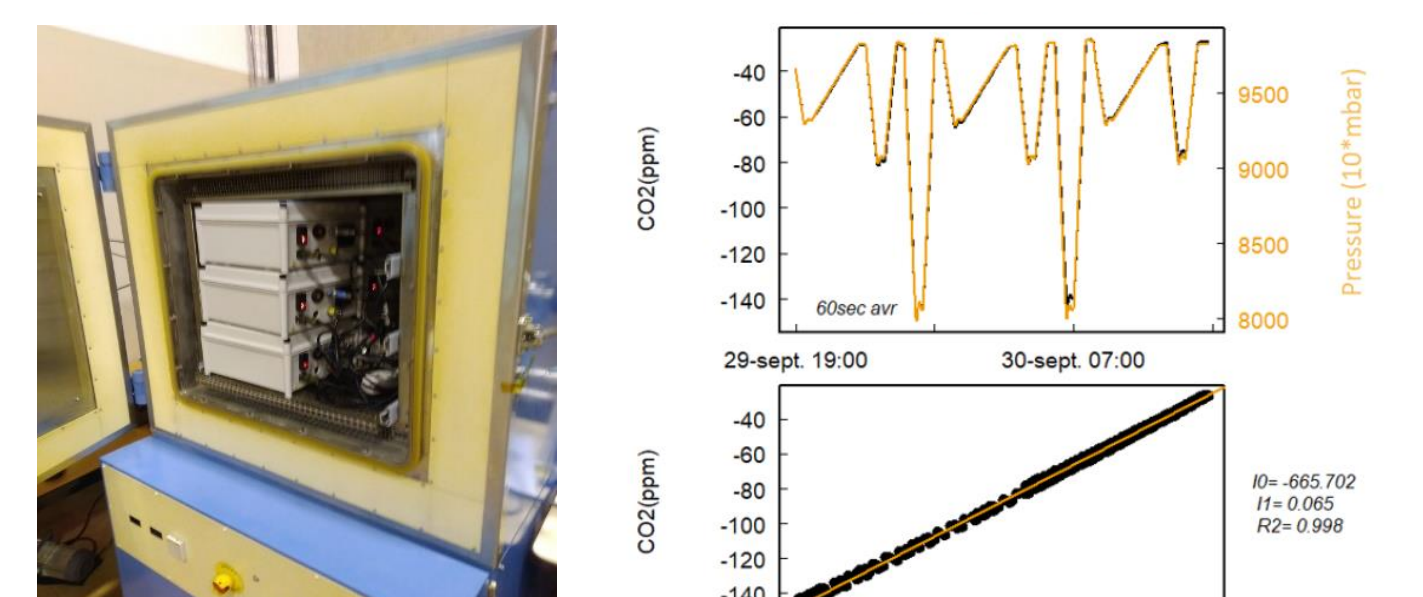
Performance assessment conducted at LSCE by measuring the CO<sub>2</sub> difference between Mid-Cost Sensor corrected/calibrated data (see Data Processing section) and Calibrated ICOS ATC MLab reference High precision CRDS analyzer while collocated. Mid-Cost sensors are installed outside on the LSCE rooftop (field conditions).

Data set: ambient air (not dry); hourly mean data; whole day



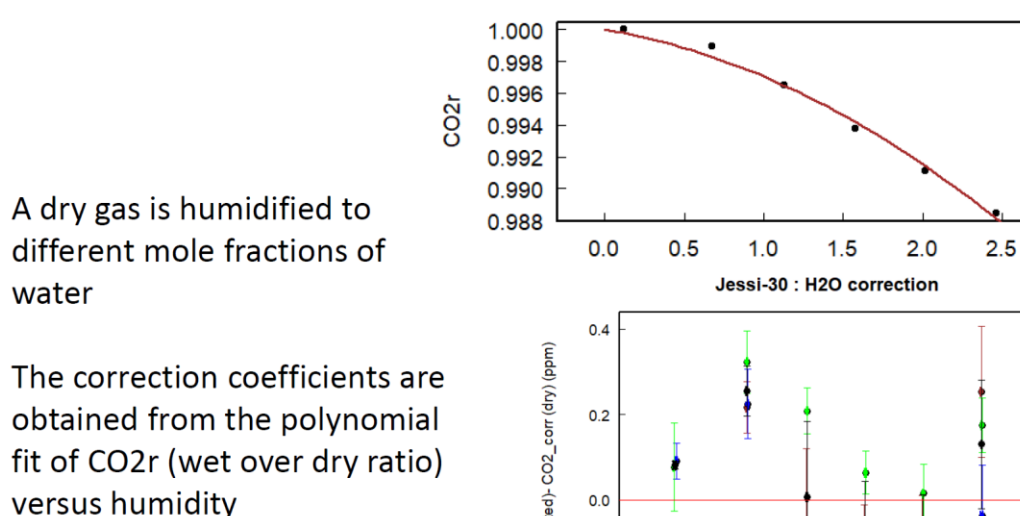
## Sensor characterization

**1. Pressure and temperature sensitivity** determined in climatic chamber. **Instrument specific**



**2. Water vapor correction**

**Instrument specific**



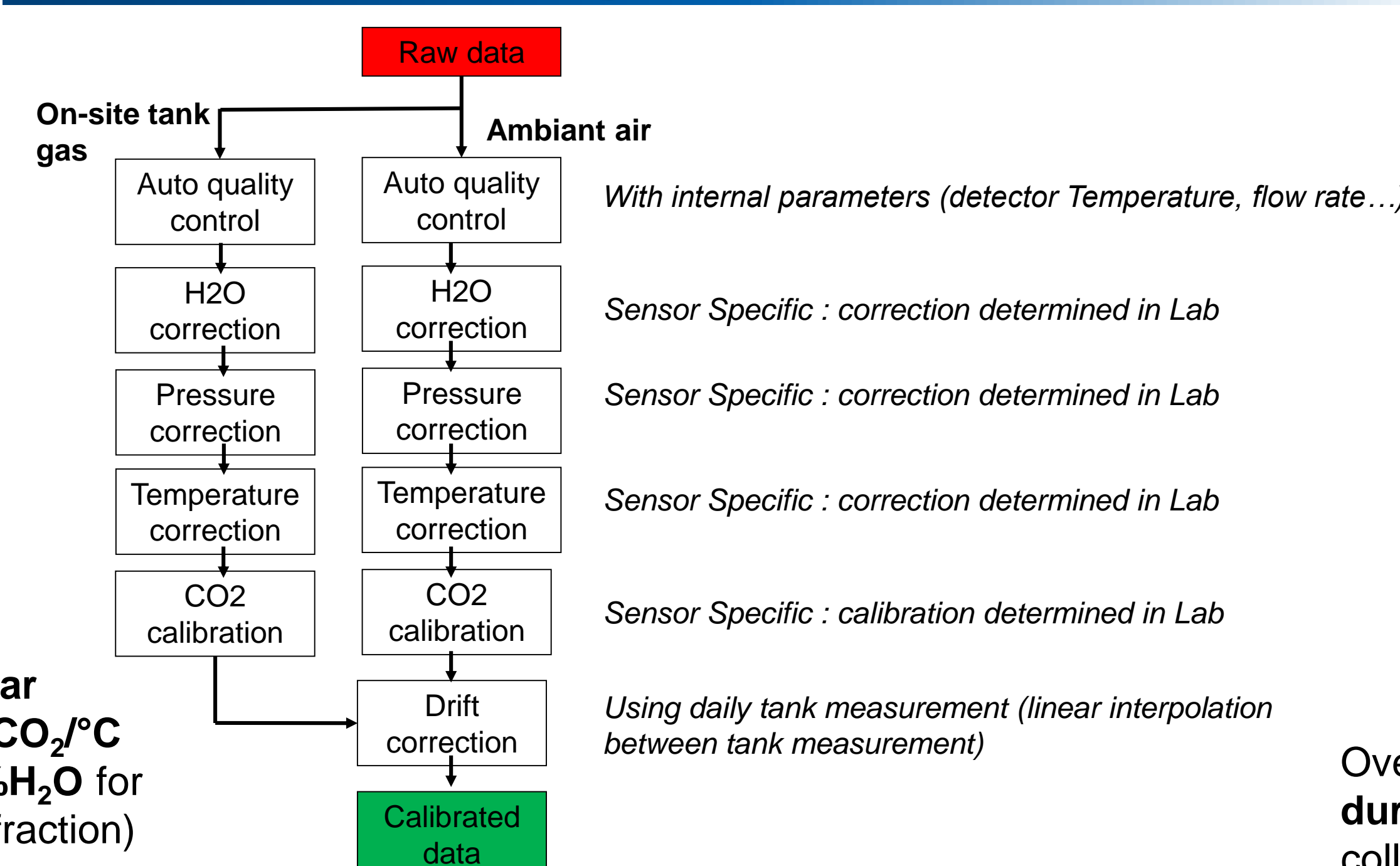
**3. Initial Multi point CO<sub>2</sub> calibration** (using WMO calibration tank set) **Instrument specific**



**Typical sensitivity (magnitude):**

- Pressure (1<sup>st</sup> order): **0.65 ppm CO<sub>2</sub>/mbar**
- Temperature (2<sup>nd</sup> order): **-5 to +1 ppm CO<sub>2</sub>/°C**
- H<sub>2</sub>O (2<sup>nd</sup> order) : **-0,5 to -2 ppm CO<sub>2</sub>/%H<sub>2</sub>O** for 400 ppm CO<sub>2</sub> (depending to CO<sub>2</sub> mole fraction)

## Data Processing



Each site/ sensor is sending automatically its raw data to data server which is processing the data according to the sequence presented above.

