ATMO ACCESS
Access to Atmospheric Research Facilities

ATMO-BOX Service provided by ICOS ATC

This work has received funding from the European Union's Horizon 2020 research and innovation programme through the ATMO-ACCESS Integrating Activity under grant agreement No 101008004

Description of the services

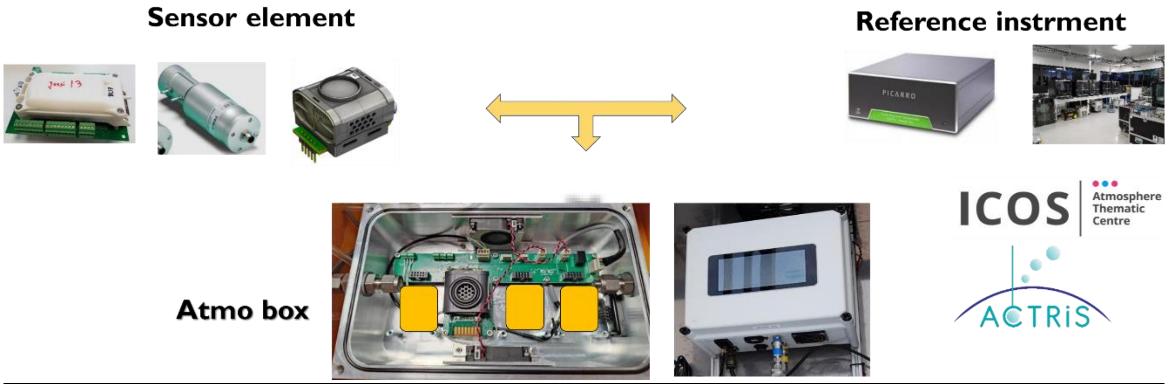
SERVICE 1 - Testing sensor elements against reference instruments	
TYPE OF SERVICE	Research and Technical service
SERVICE DESCRIPTION	The Atmobox provides a modular platform to integrate mid and low-cost sensor elements allowing benchmarking and performance assessment including comparison with reference instruments. The platform can receive up to 8 sensors to be mounted at once in 1 or 2 "exposing cells". The cells are designed for reactive and non-reactive gas and allow to expose sensors to controlled gas with a monitored and controlled (externally currently) environmental parameters: P, T and RH/H2O. It has a versatile datalogger with automatic data transfer (4G, Wifi) to FTP/SFTP server. Sensors require an interface electronic board to integrate the Atmobox system. The board handle mainly the power supply and the interface with the versatile data logger. Standard analog output sensor may use a generic interface board whereas specific digital output sensor may require a specific one. Several interface boards are currently available for different brands/models. The service includes: - Administrative support to comply with internal procedures for accessing facilities (physical). - Administrative and technical support for providing a workspace for visitors: desk space with computer and internet access, meeting rooms, kitchen and lunch room (physical). - Administrative support and advice for transportation, reception and storage of equipment. - Technical support at the facility to fulfill visitor needs and constraints related to installation, deployment and operation of equipment: power connections, remote access, storage, security constraints, internet network (physical). - Testing/intercomparisons of sensor elements - Sensor characterization under controlled conditions according to "standard" procedure. - Scientific support for supervision and analysis of collected data.
ATMOSPHERE TYPE	Ambient, partially controlled (e.g. targeted gas). Monitored and/or controlled environment parameters are P,T,RH/H2O
TYPE OF ACCESS	Physical and Remote
TARGET USERS	Academic and Private sector
SERVICE STATUS	The service is available (operational and ready to be offered in 2024 for GHG, in 2025 for other parameters)

This work has received funding from the European Union's Horizon 2020 research and innovation programme through the ATMO-ACCESS Integrating Activity under grant agreement No 101008004

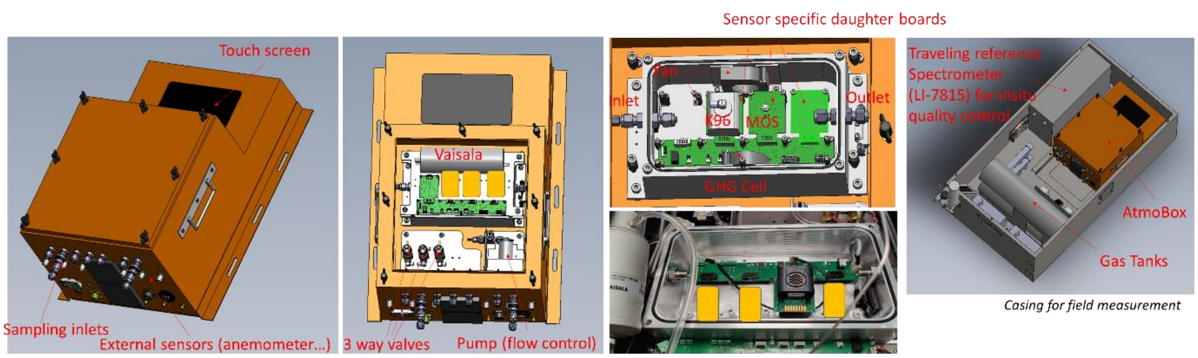
AVAILABILITY PERIOD	All year round
TIME CONSTRAINTS	None
CONTACT	Leonard Rivier, Olivier Laurent, Stéphane Sauvage
SERVICE 2 –Access to Atmobox as a transportable resource	
TYPE OF SERVICE	Research service
SERVICE DESCRIPTION	The Atmobox (see description above under Service 1) can be requested to be deployed in the field on a campaign basis mode. The Atmo Box allows for up to 8 sensors to be mounted at once. Potential atmospheric concentration to be measured are CO2, CH4, CO, NO_2, O3, VOC, NH_3, PM . It has a versatile datalogger at 1 Hz for atmospheric compound (see above), GPS position and meteorological parameters recording, with an automatic data transfer (4G, Wifi) and remote control. It allows concomitant measurement of both GHG gases and Air quality related gases. It allows automatic quality control and calibration in field (depending to the atmospheric compound). Atmo Box includes target gases to automatically perform regular quality controls. The service includes: - Shipment out of the Atmobox - Remote sci/tech support for installation. - Remote sci/tech support for operation - Training
CONTACT	Leonard Rivier, Olivier Laurent, Stéphane Sauvage
ATMOSPHERE TYPE	Ambient
TYPE OF ACCESS	Physical to a mobile platform
TARGET USERS	Researchers
SERVICE STATUS	The service is available (operational and ready to be offered from 2024 for CO_2, 2025 onwards for other compounds)
AVAILABILITY PERIOD	All year round
TIME CONSTRAINTS	Max duration of a campaign is three months

Testing sensors against reference instruments:

This work has received funding from the European Union's Horizon 2020 research and innovation programme through the ATMO-ACCESS Integrating Activity under grant agreement No 101008004

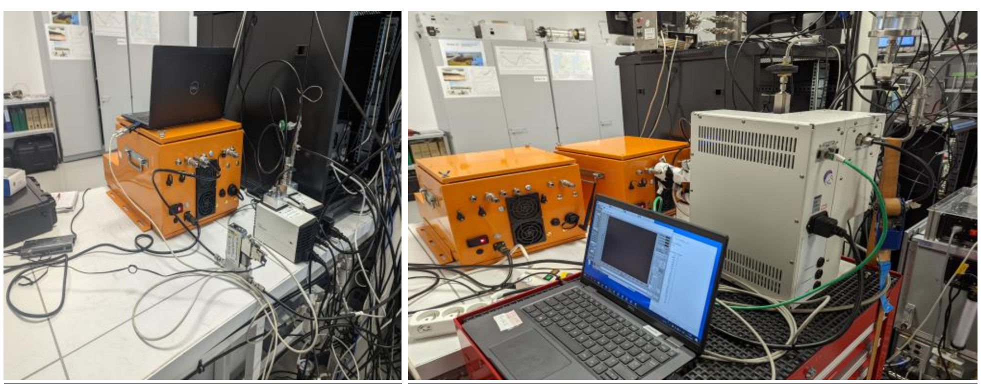


Atmo Box design and example of deployment



Casing for field measurement

Atmo Box and reference instrument side by side



Demonstration test bed: example of deployed ATMO-BOXES

Deployment on top of the LSCE lab building in Saclay near Paris , for comparison with reference instruments. Figure on the right shows double casing which includes target gases for automatic quality control.

This work has received funding from the European Union's Horizon 2020 research and innovation programme through the ATMO-ACCESS Integrating Activity under grant agreement No 101008004

Description of the central laboratory involved

The ATC Metrology Lab: Mlab of ICOS

The main tasks of the ATC Metrology Laboratory are:

- Testing all the greenhouse gases (GHG) instruments before deployment within the ICOS Atmospheric network, producing a test report and a certificate of compliance. Development of meaningful tests (e.g water vapor correction).
- Carrying out a technology watch.
- Elaborating the measurement/calibration protocols.
- Studying the possible artifacts (sampling system, analyzer...).
- Providing network support and spare instruments when necessary.
- Development of new sensors through R&D programs at national and international level.
- Participating at the European training centre for ICOS atmospheric measurements with the Data Unit.

Hereafter, we present the main tests conducted on all the GHG instruments for ICOS, extracted of Yver Kwok, C., Laurent, O., Guemri, A., Philippon, C., Wastine, B., Rella, C. W., Vuillemin, C., Truong, F., Delmotte, M., Kazan, V., Darding, M., Lebègue, B., Kaiser, C., Xueref-Rémy, I., and Ramonet, M.: Comprehensive laboratory and field testing

This work has received funding from the European Union's Horizon 2020 research and innovation programme through the ATMO-ACCESS Integrating Activity under grant agreement No 101008004

of cavity ring-down spectroscopy analyzers measuring H2O, CO2, CH4 and CO, Atmos. Meas. Tech., 8, 3867–3892, https://doi.org/10.5194/amt-8-3867-2015, 2015.

Testing descriptions:

- Continuous Measurement Repeatability and Short-term drift: The continuous measurement repeatability (CMR) is evaluated with the SD of the continuous measurements of a cylinder over 24 h. The short-term drift is defined as the peak-to-peak amplitude of the same measurements. These two metrics are evaluated for different integration times (typically, raw data, 1 min and 1 h). Usually, in the synthesis report, we provide values for 1 min and 1 h averages.
- Allan deviation: The Allan deviation, which shows the stability as a function of the integration time and informs about the optimal integration time, is also calculated and provided in the synthesis report.

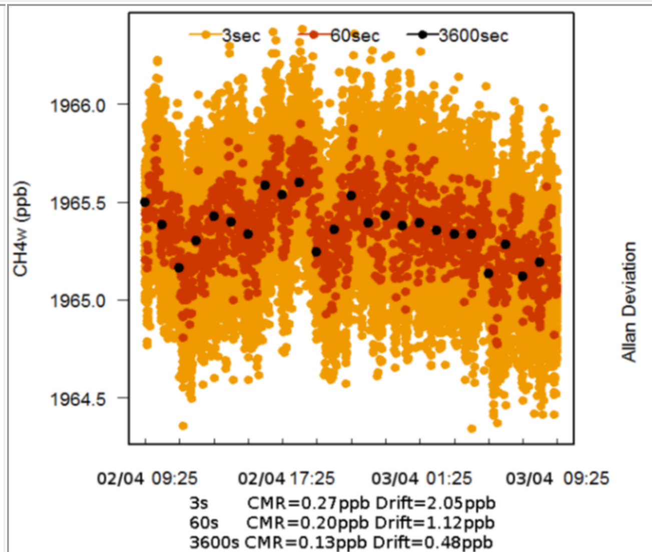


Figure 1. CH4 continuous measurement repeatability. First panel: measurements averaged over different time intervals. Second panel: Allan deviation.

- Short-term repeatability: The short-term repeatability (STR) is defined as the repeated measure of a sample over a short period of time (about 3 h). In the laboratory, a target gas is measured 10 times in 15 min sequences bracketed by 5 min of wet ambient air measurements. For each measure, only the last 9 min are averaged. The repeatability is then expressed through the mean and SD of these averaged measures.

- Long-term repeatability: The long-term repeatability (LTR) is comparable to the short-term repeatability but on a longer timescale (3 days). In the laboratory, a target gas is measured for 30 min bracketed by around 5 h of wet ambient air over 72 h of total measurements. For each measure, only the last 10 min are averaged. The long-term repeatability is then expressed through the SD

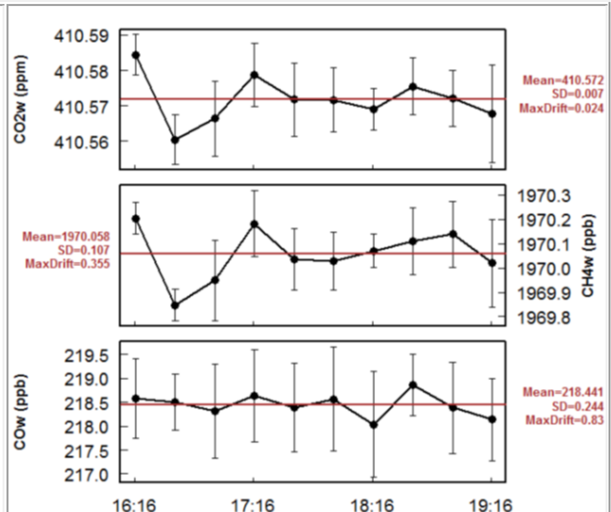


Figure 2. Short-term and long-term repeatability for the three species. First panel: short-term repeatability. Second panel: long-term repeatability.

This work has received funding from the European Union's Horizon 2020 research and innovation programme through the ATMO-ACCESS Integrating Activity under grant agreement No 101008004

of these averaged measures. Typically, several 3-day exercises are performed and the results compared and aggregated at the end of the 1-month duration of the instrument test period. In Fig. 2 shows an example of short-term and long-term repeatability. For each species the mean, the SD and the drift are calculated.

- Ambient temperature and pressure dependence: For the pressure, we plot the target gas measurements realized during the long-term repeatability test against the atmospheric pressure over several days and evaluate the correlation between the two. For the temperature dependence, the room temperature was until now varied using the room air conditioning system and we plot the target gas measurements against this varying temperature. Plans have been made to acquire a temperature-controlled chamber. As for the pressure, the correlation between the two is calculated. Two examples are shown in Fig. 3 with for each case, the linear regression and the correlation coefficients calculated.

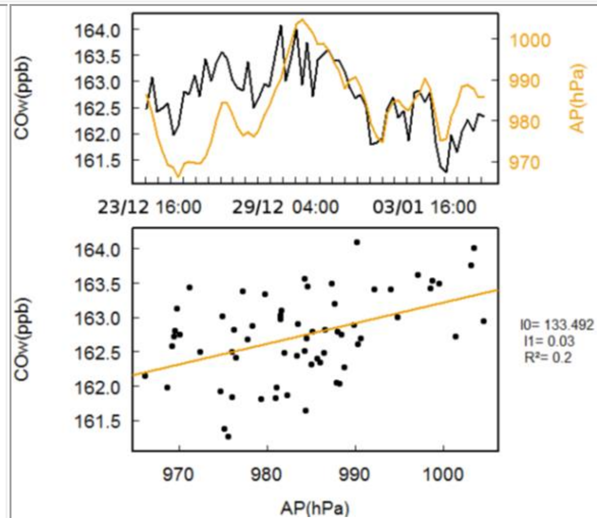


Figure 3. CO pressure and temperature dependency. First panel: pressure dependency. Second panel: temperature dependency. On the right of the lower plot, the slope (I1), intercept (I0) and the coefficient of correlation (R2) are indicated.

This work has received funding from the European Union's Horizon 2020 research and innovation programme through the ATMO-ACCESS Integrating Activity under grant agreement No 101008004

- Linearity: The linearity of the instrument is also evaluated. For the first instruments, the same cylinders as for calibration (four cylinders) were used. Then, two cylinders (low and high concentrated cylinders; see Fig. 5) were added to the set. The residuals from the fit are calculated, and their concentrations along with the correlation coefficient allow us to judge of the linearity of the instrument against the calibration scale. It is important to note that the validity of this test depends strongly on the proper assignation of the concentrations from each calibration cylinders, hence the importance of the linto internationals scales and the regular recalibrations of the MLab calibration cylinders against a “master” set of cylinders provided by the central calibration laboratories.

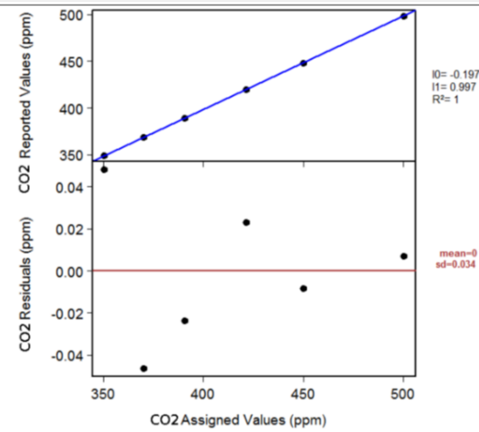
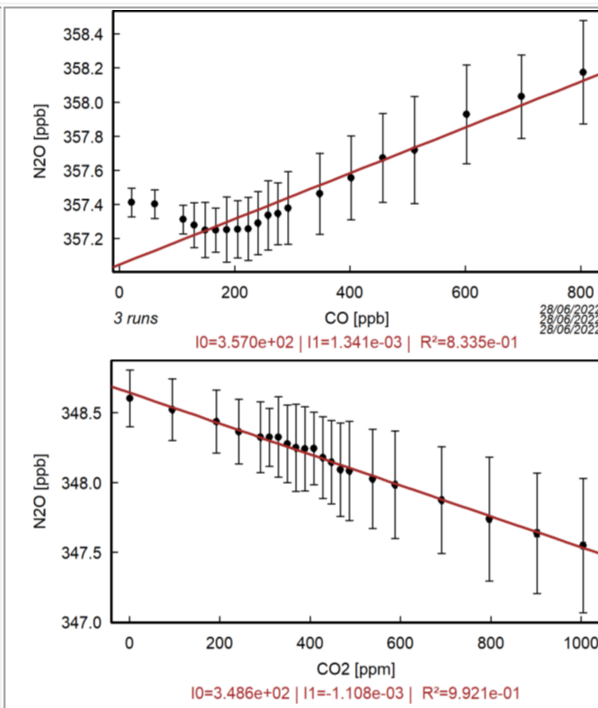


Figure 5. Linearity test for CO2. On the top panel, the measured values vs. the assigned values. On the right of this panel, the slope (I1), intercept (I0) and the coefficient of correlation (R2) are indicated. On the lower panel, the residuals, i.e., the difference between the assigned values and the values calculated using the linear equation, are shown.

- Cross sensitivity: For N2O/CO analyzers, we evaluate the correlation between N2O and CO measurements by measuring a tank filled with a high CO concentration and diluted by step with the same gas passing through a sofnocat trap. Same test is carried out with a tank filled with a high CO2 concentration and diluted thanks to an ascarite/magnesium perchlorate trap to evaluate the correlation with CO2 for N2O and CO measurements.



This work has received funding from the European Union’s Horizon 2020 research and innovation programme through the ATMO-ACCESS Integrating Activity under grant agreement No 101008004

- Comparison with reference instruments: Finally, ambient air measurements from each instrument are compared with other reference instruments maintained by the MLab. The MLab is located in Gif-sur-Yvette, about 50 km southwest of Paris. We are thus sampling suburban air with large variability as we are looking at 1 min averages. Initially, the CRDS analyzers were compared to the gas chromatograph system and if available to another CRDS analyzer in test. Since the end of 2011, most of the instruments have been tested against the same CRDS reference instrument for CO_2 and CH_4 (CFCDS03). For CO, since the end of 2013, a CRDS reference instrument (G2401) has also been chosen. And since mid 2017, a CRDS reference instrument for N_2O/CO (G5310) is also available. The tested instrument measures wet and dry air and is compared to the MLab reference instrument which measures ambient air dried through a cryogenic water trap. This allows the checking of the factory and MLab water vapor correction and the estimation of the biases. In Fig. 6, the comparison for CH_4 is shown. The H_2O and target gas measurements allow a quality check of the tests. The histogram can point out outliers if the distribution is strongly not Gaussian. The difference between the wet corrected air and the dry air in the left panel (about 1.2 ppb on average compared to -0.03 ppb for both instruments measuring dryair) is due to the automatic H_2O correction, which is here not sufficient to correct all the bias introduced by H_2O.

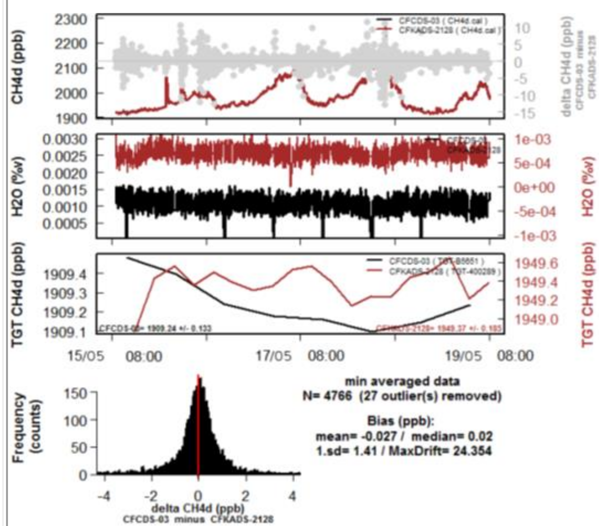


Figure 6. Comparison with the reference instrument for CH_4. First panel: dry air vs. dry air. Second panel: wet air corrected for H_2O vs. dry air. From top to bottom, the concentrations for both instruments and the difference of the two are plotted, then the water vapor concentrations for both instruments, then the evolution of the target for both instruments and finally a histogram of the distribution of the differences along with statistics.

This work has received funding from the European Union's Horizon 2020 research and innovation programme through the ATMO-ACCESS Integrating Activity under grant agreement No 101008004