

ICOS | Cities

LERMA

Obs4Clim  
Système d'Observation Intégré pour l'Atmosphère



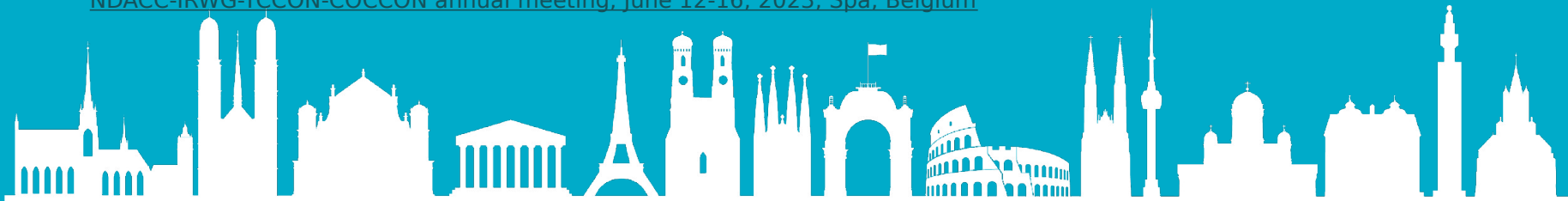
# Total greenhouse gas column measurements in the Paris region

**J. DOC<sup>1</sup>, M. RAMONET<sup>1</sup>, M. LOPEZ<sup>1</sup>, F-M. BREON<sup>1</sup>, B. MACQUART<sup>1</sup>, S. LATCHABADY<sup>1</sup>, P. JESECK<sup>2</sup>, Y. TE<sup>2</sup>**

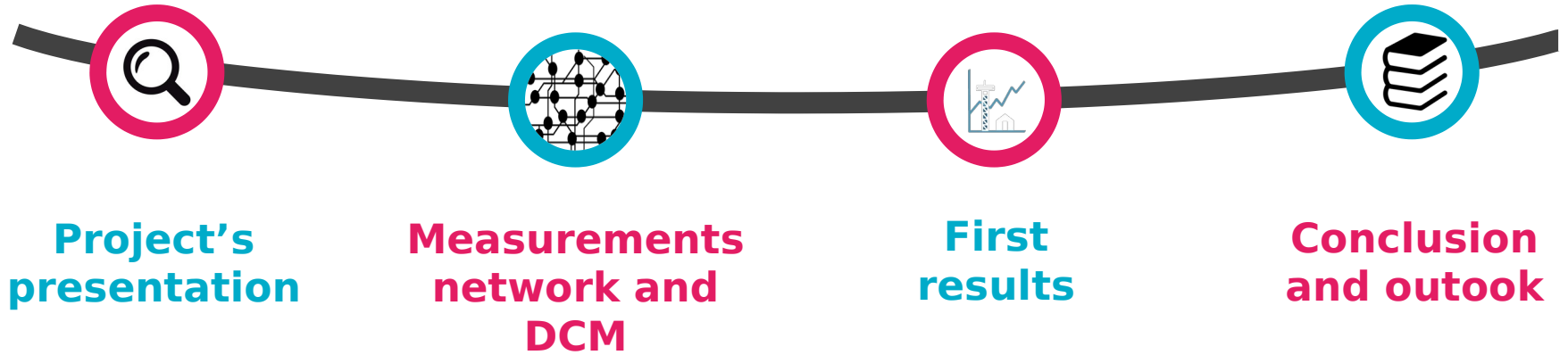
*1 : CEA-LSCE/CNRS/UVSQ, France*

*2 : LERMA, France*

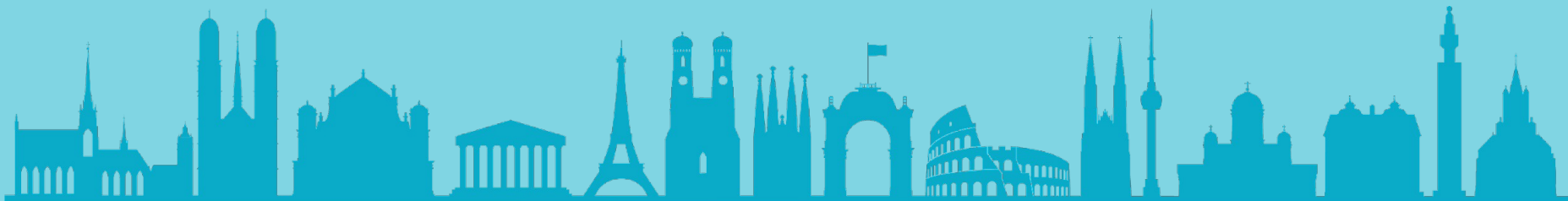
NDACC-IRWG-TCCON-COCCON annual meeting, June 12-16, 2023, Spa, Belgium



# Contents



## Project's presentation



# What is the ICOS Cities project about?

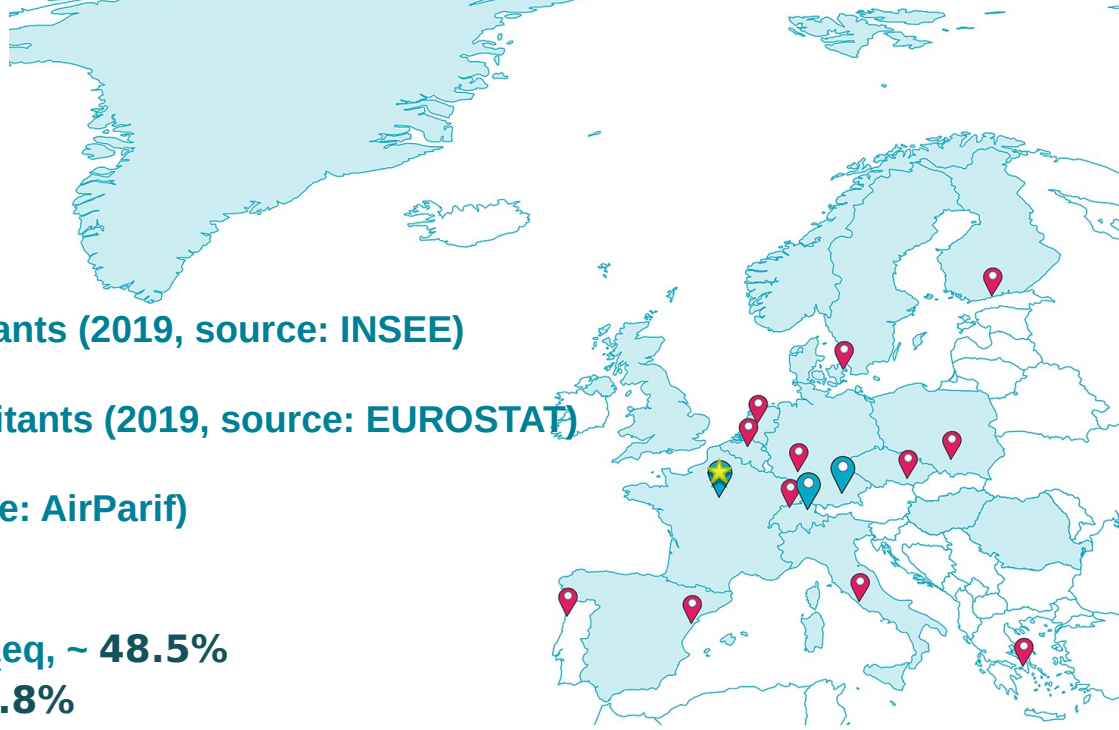
A European Green Deal project with **3** PILOT CITIES:

**Paris, Munich and Zurich**

- develops systematic observations to monitor the level of greenhouse gas emissions in urban areas
- creates useful tools and services for cities in support of their local climate action plans
- provides data services that have societal impact

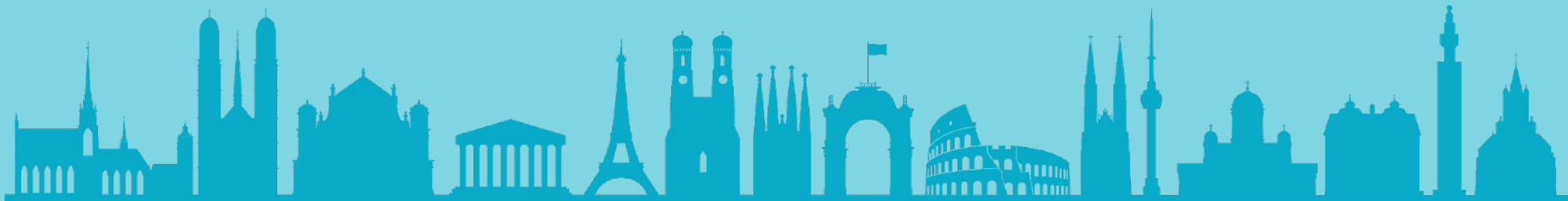


# Focus on Paris

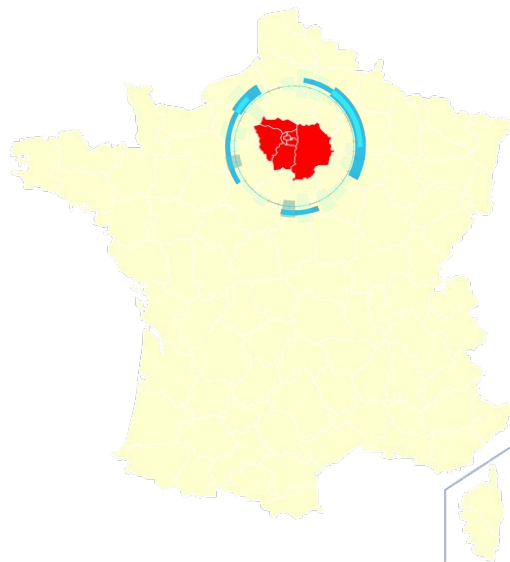


- **City-center: 2.16 million inhabitants (2019, source: INSEE)**
- **Urban area: 12.21 million inhabitants (2019, source: EUROSTAT)**
- **64.630 Mt CO<sub>2</sub>eq in 2019 (source: AirParif)**
- **Main sectors:**
  - **Road traffic: 31.360 Mt CO<sub>2</sub>eq, ~ 48.5%**
  - **Airports: 7 Mt CO<sub>2</sub>eq, ~ 10.8%**
  - **Residential: 5.990 Mt CO<sub>2</sub>eq, ~ 9.3%**
  - **Others (energy, industry, wastes, ...): 20.280 Mt CO<sub>2</sub>eq, ~ 31.4%**

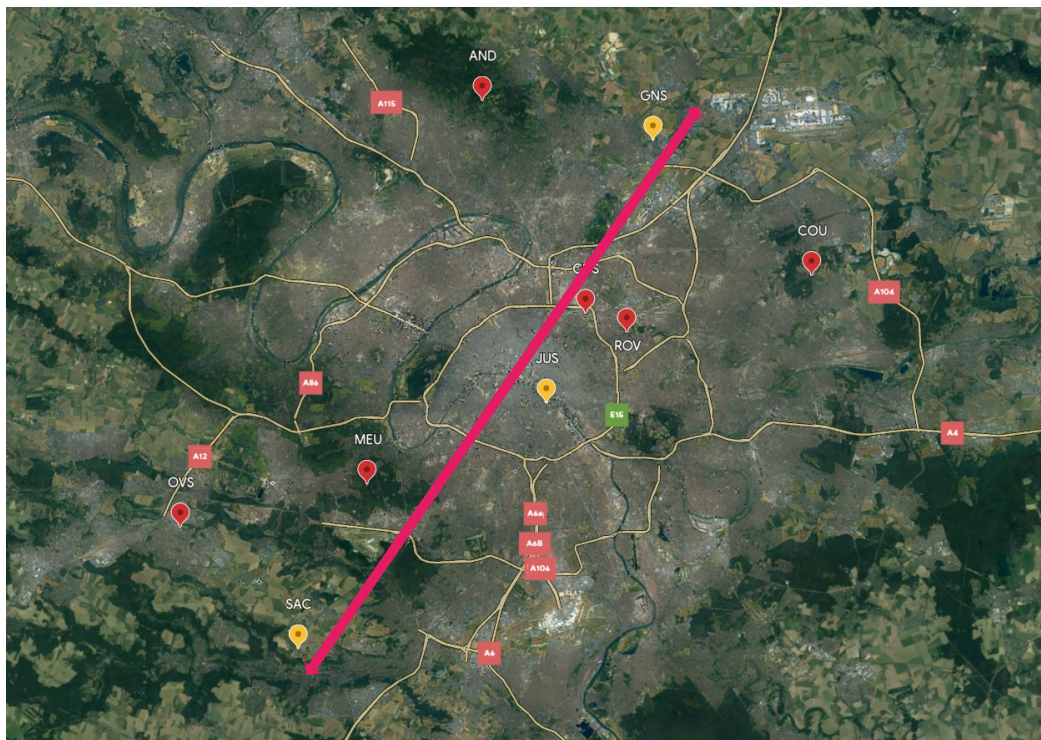
## Network and method



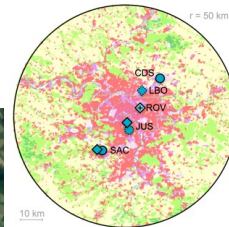
# Network



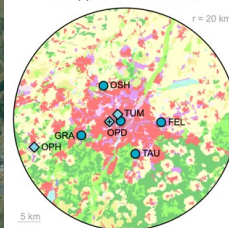
Prevailing wind 



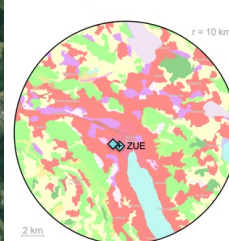
**Paris**  
3 total column CO<sub>2</sub>  
4 Doppler wind LIDARS



**Munich**  
5 total column CO<sub>2</sub>  
3 Doppler wind LIDARS



**Zurich**  
2 Doppler wind LIDARS



# Network

## Jussieu

## Sorbonne-University

- Paris' city-center
- TCCON (+ EM27) site operated by LERMA
- Co-located with an in-situ ICOS station

Prevailing  
wind





# Network

## Saclay

### LSCE

- 21 km, SW of Paris
- Operated by LSCE
- Co-located with an in-situ ICOS station
- Works since 2021

Prevailing  
wind



# Network

## Gonesse

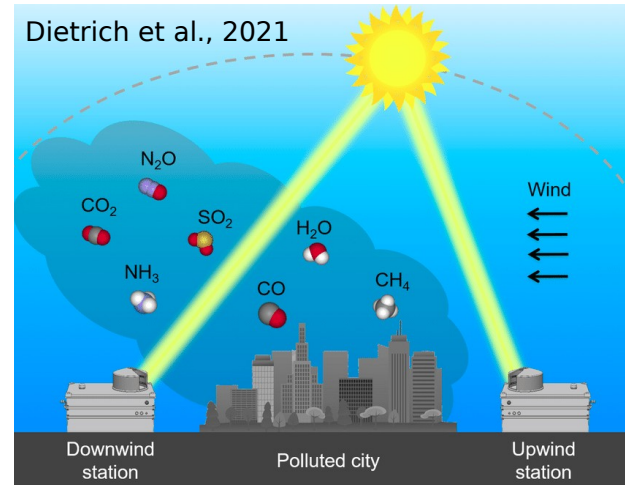
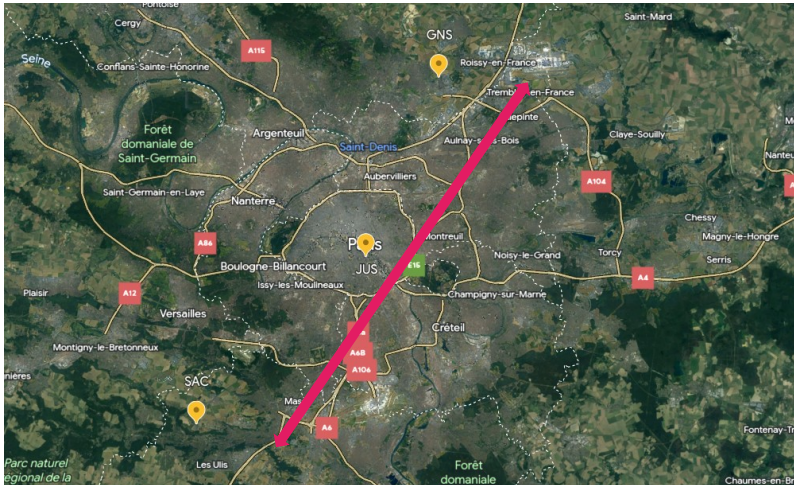
### Firefighters station

- 17 km, NE of Paris
- Operated by LSCE
- Near *CDG* (5 km, East) and *Le Bourget* airports (3 km, South)
- Co-located with an in-situ ICOS station
- Works for one year



# The Differential Column Measurements method (DCM)

Prevailing wind 



# Automatic EM27/SUN enclosure system and NRT data processing chain

See also:

***“Urban and tropical EM27/SUN network for satellite validation, observation and verification of greenhouse gas emissions”***

M. Lopez, S. Latchabady, B. Macquart, M. Ramonet, J. Doc and C. Bes, Poster #19


## Urban and tropical EM27/SUN network for satellite validation, observation and verification of greenhouse gas emissions

M. Lopez<sup>1</sup>, S. Latchabady<sup>1</sup>, B. Macquart<sup>1</sup>, M. Ramonet<sup>1</sup>, J. Doc<sup>1</sup> and C. Bes<sup>2</sup>

1 - Laboratoire des Sciences du Climat et de l'Environnement, UMR8122 CEA-CNRS-UVSQ, 91191 Gif-sur-Yvette, France  
2 - Centre National d'Etudes Spatiales, 31401 Toulouse, France

The EM27/SUN instrument is a transportable FTIR spectrometer allowing to retrieve total atmospheric abundance of XCO<sub>2</sub>, XCH<sub>4</sub> and XCO from solar measurements. Regarding the strong potential of such instruments for greenhouse gas monitoring and satellite measurement validation, LCE is developing tools to ensure data quality and availability in order to build a robust network and strongly contribute to the Collaborative Carbon Column Observing Network (COCCON) initiated by Karlsruhe Institute of Technology.

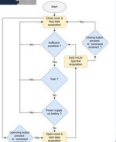
**Automatic enclosure system**



First version of the LCE enclosure system (picture above) is deployed at Saclay and Gonesse in the framework of ICOS cities. A second version, keeping the same features with a more robust design (schematic below), is under development to be deployed in background and tropical environment in the framework of the national Obs4Clim project.

**Key features:**

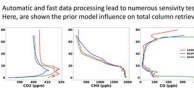
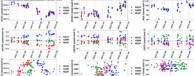
- Rain and solar radiation sensors:
  - automatic launch of spectra acquisition
  - open / close hood
- PTIR sensor
- Thermocoupled via TEC (T130W4)
- 4G and wifi communication



**Automatic data treatment**



- Based on proflair V2 – developed and maintained at KIT
- data processing duration > 20min / day / instrument
- Systematic use of several prior models: CAMS, GGG2020 and GGG2024 with automatic data download
- NRT data retrieval using CAMS model

Automatic and fast data processing lead to numerous sensitivity tests. Here, are shown the prior model influence on total column retrieval

**ICOS Cities**

The PAUL (Pilot Applications in Urban Landscapes) project aims at evaluating different observational approaches to determine CO<sub>2</sub> emissions from large cities, such as Paris. A chosen strategy consists in evaluating the Paris carbon budget by coupling total column measurements to inverse modeling. In the PAUL framework, two EM27s are deployed in a north to south transect of Paris, in addition to the Paris TCCON site located at Boulogne.

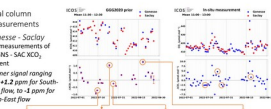
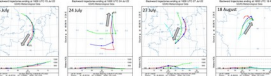



Saclay - SAC      Gonesse - GDS

**Total column measurements**


Gonesse - Saclay  
First measurements of the GDS - SAC XCO<sub>2</sub> gradient

Summer signal ranging from +2.2 ppm for South West flow, to -2 ppm for North-East flow






**Obs4Clim**

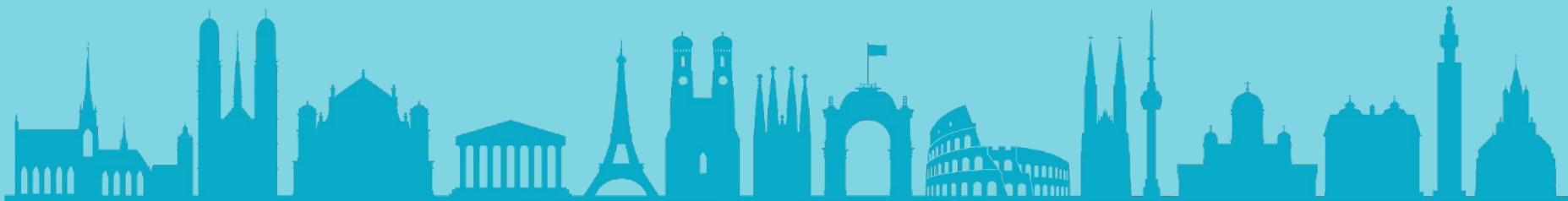
Système d'Observation Intégrée pour l'Observation



In the framework of Obs4Clim project, LCE aims at deploying four EM27 by 2023 at observatories located in tropical and background regions for long-term observations and satellite validation purposes: Morocco (AMN), Ivory Coast (IYO), French Guiana (GOS) and Bolivia (BOL). A fifth EM27 will rotate between stations for quality control purpose. Since 2021, the first XCO<sub>2</sub>, XCH<sub>4</sub> and XCO measurements at Amsterdam Island (Indian Ocean) are in going figure below.

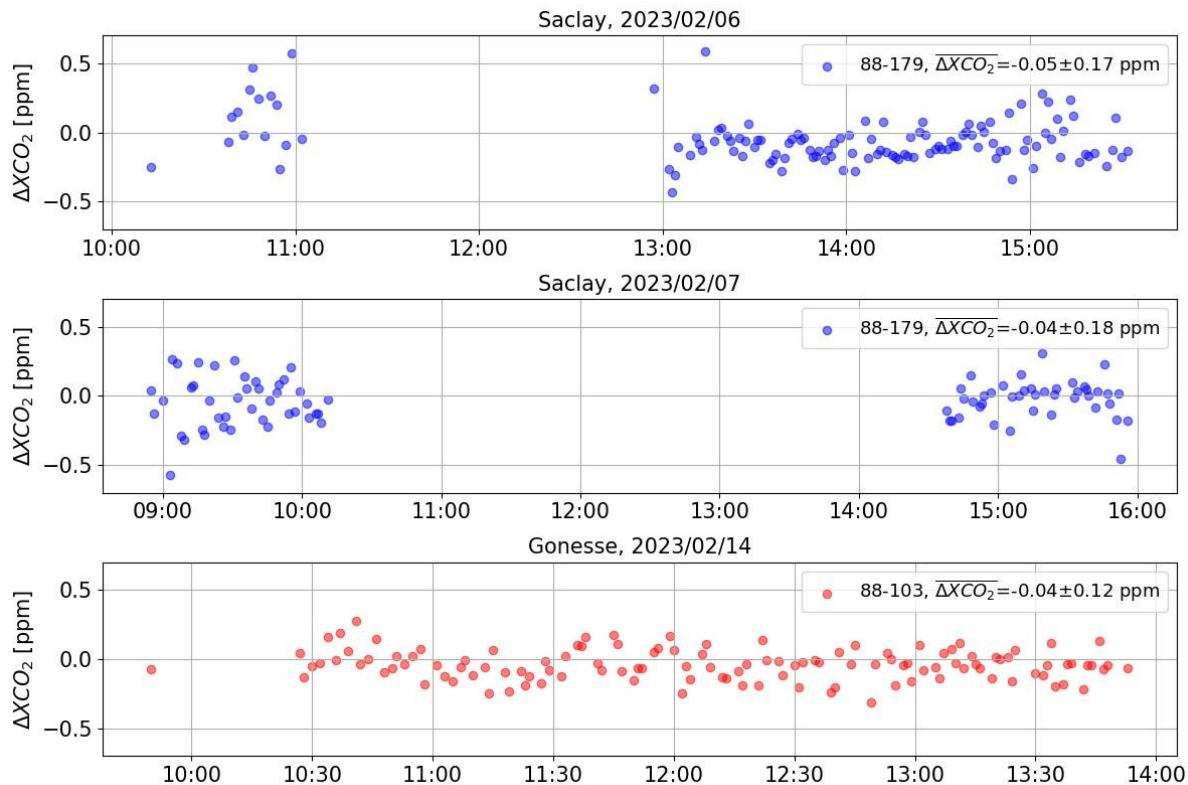



## Results

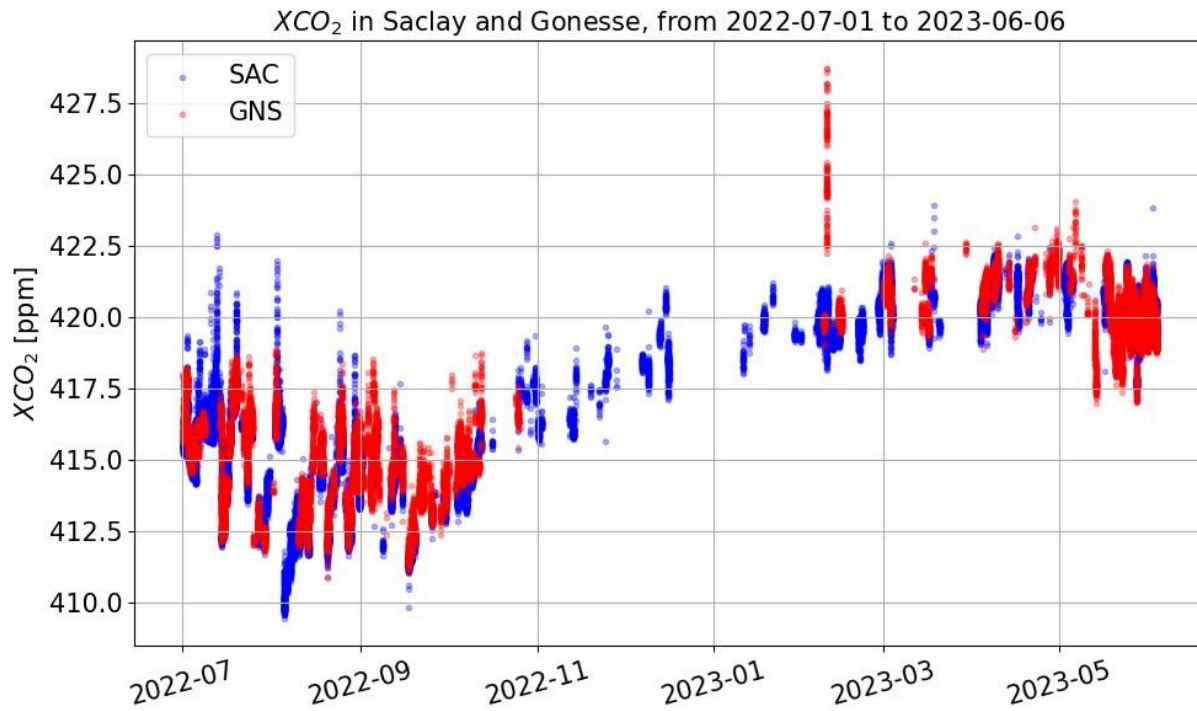


# How to keep a good agreement between the instruments in the network?

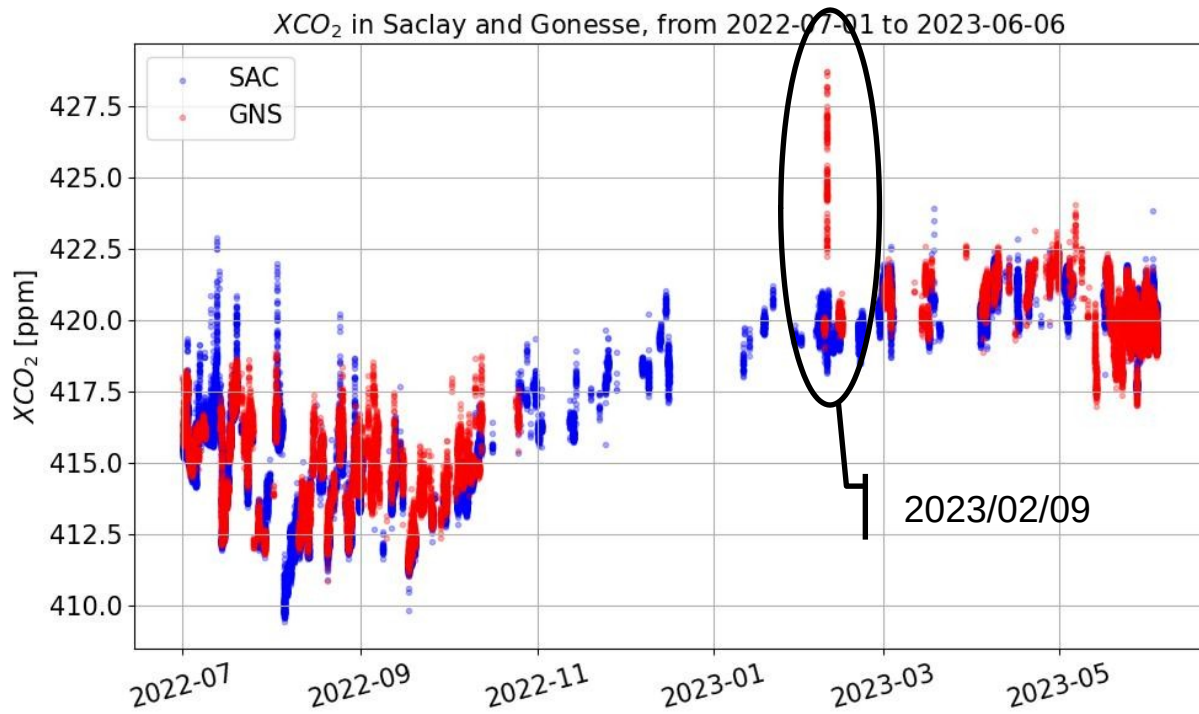
- A mobile instrument travels from site to site
- Inter-comparison at least twice a year
- Goal: 0.1~0.2 ppm
- These instruments are validated to work together in the network



# XCO<sub>2</sub> time series in SAC and GNS

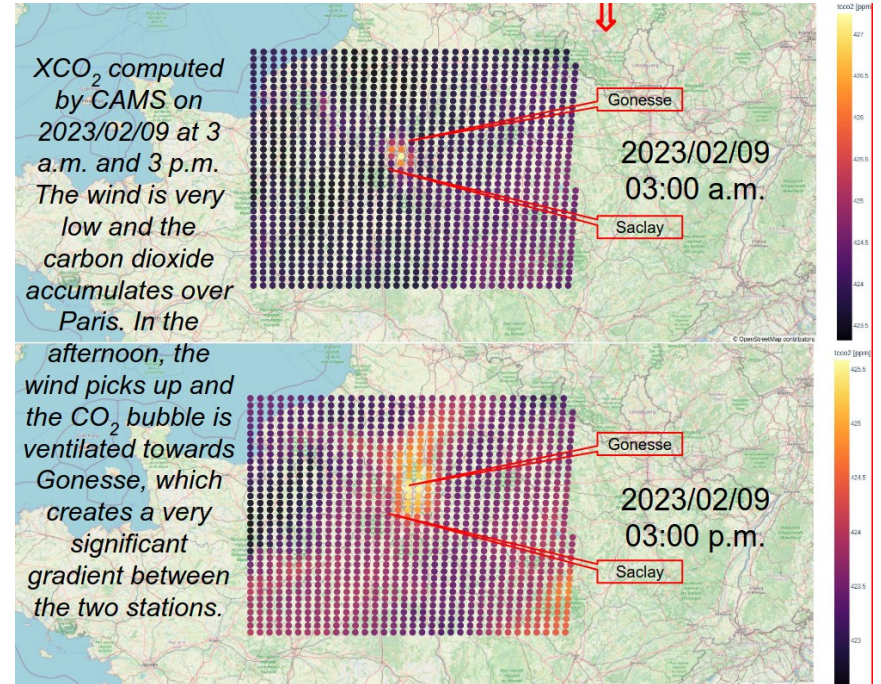
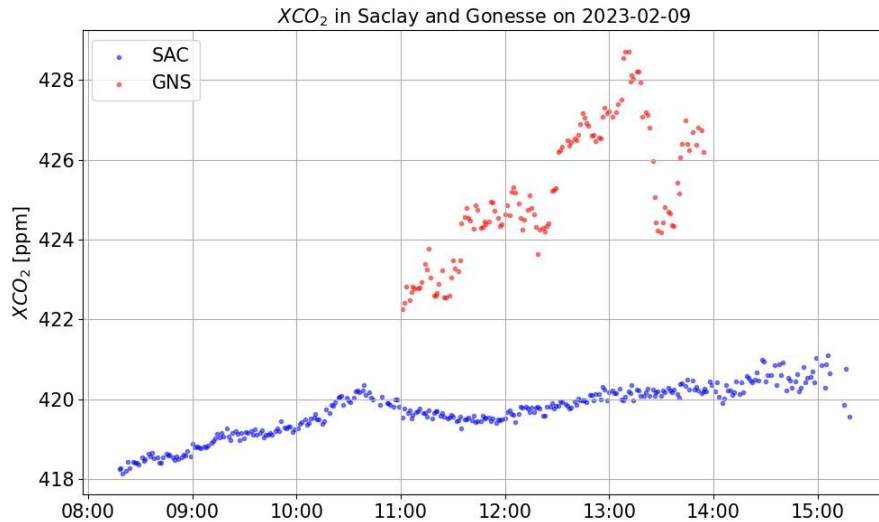


# Focus on 2023/02/09 XCO<sub>2</sub> peak



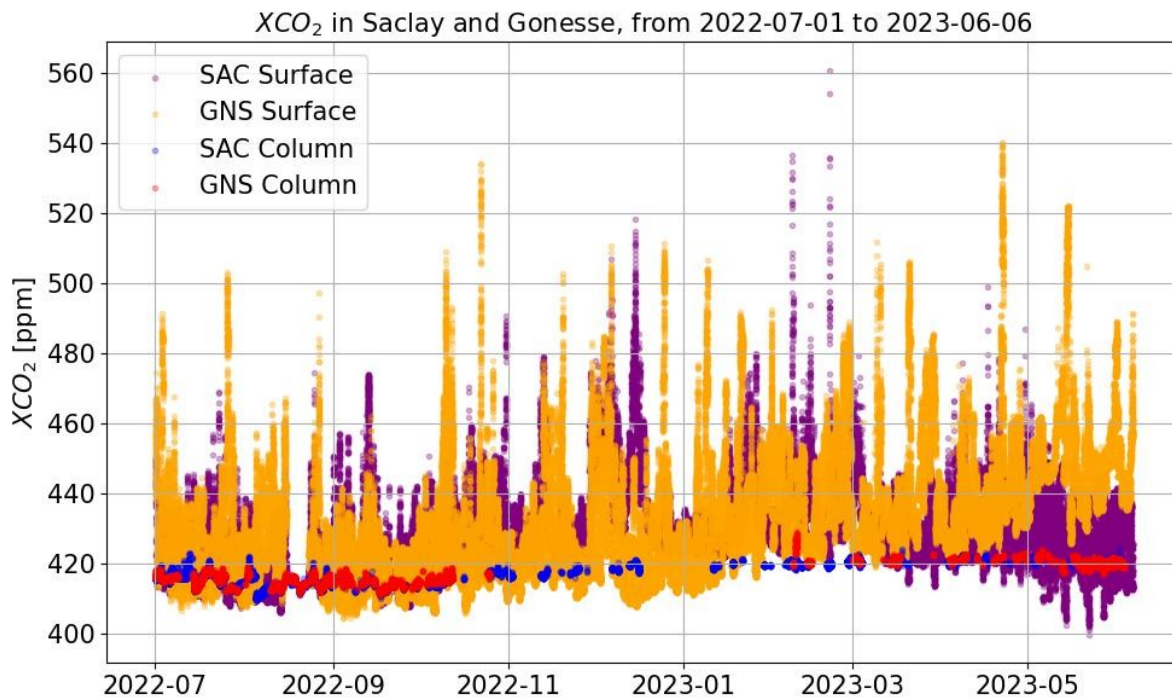


# Focus on 2023/02/09 XCO<sub>2</sub> peak

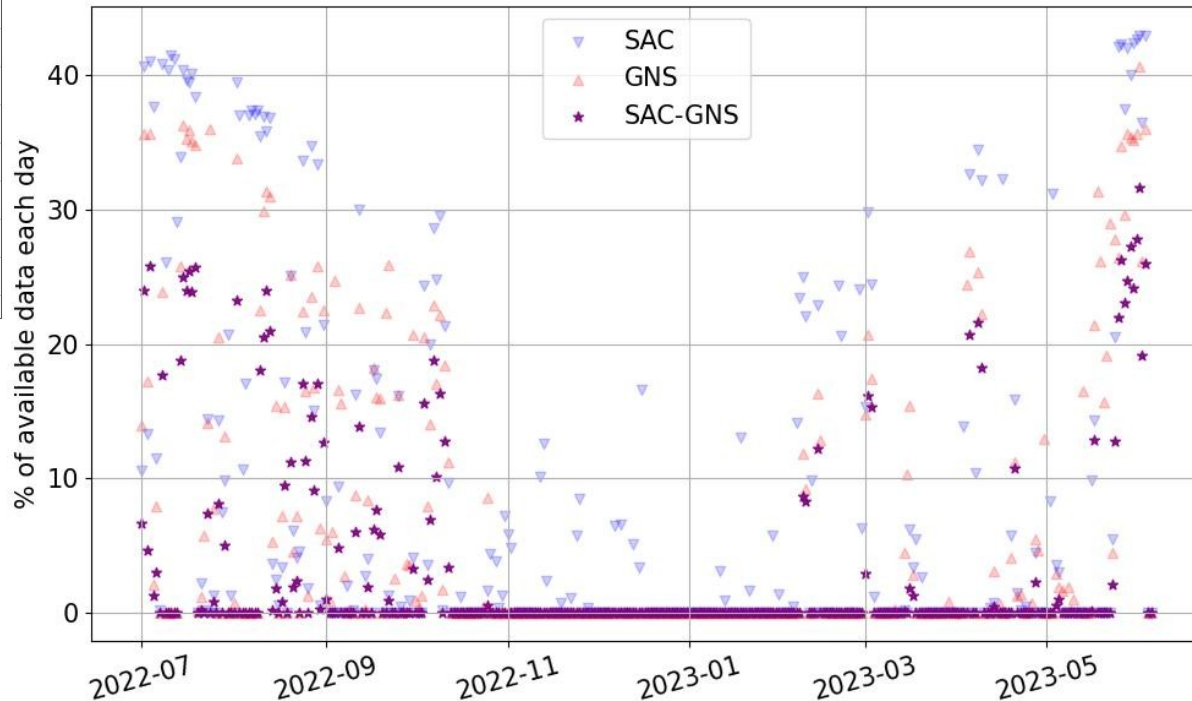
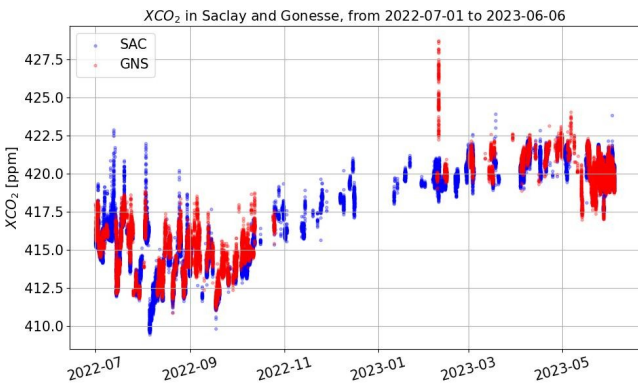


# XCO<sub>2</sub> vs in-situ CO<sub>2</sub> time series

- Less columns measurements than in-situ measurements
- Daytime only
- 10 times smaller variations
- Less sensitive to local sources

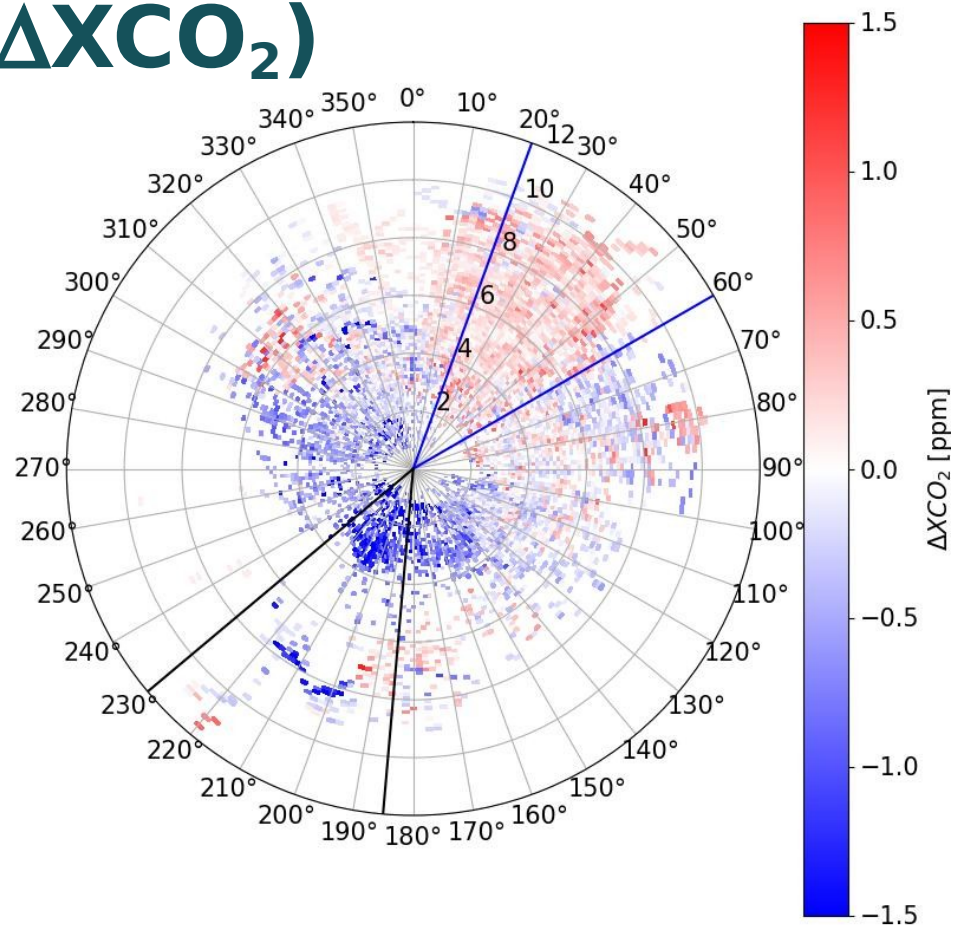
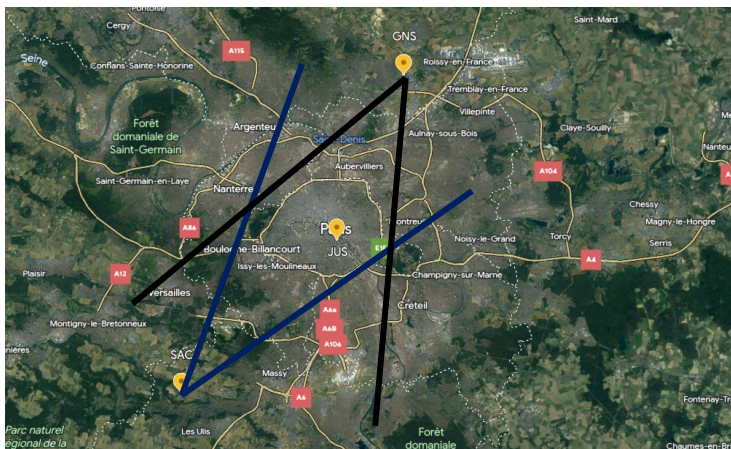


# Data availability

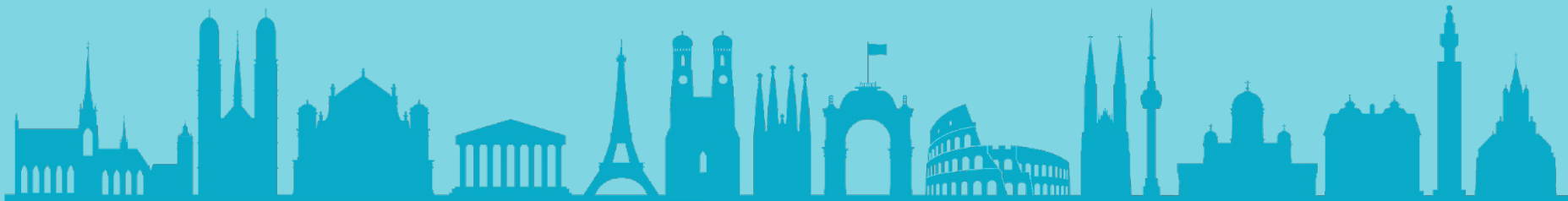


# XCO<sub>2</sub> gradients ( $\Delta XCO_2$ )

- $\Delta XCO_2 = XCO_{2;SAC} - XCO_{2;GNS}$
- 10 minutes averaged gradients between Saclay and Gonesse
- Period: 2022/07/01 - 2023/06/06



## Conclusion



# Conclusion and future work

- ICOS-Cities network has been up and running for almost a year now
- Automatic enclosure system and NRT data processing give us as much data as possible
- Regular inter-comparison of instruments enables us to guarantee the quality of the data
- Averaged  $\Delta XCO_2$ :  $\sim 1$  ppm, strong dependence to the wind direction but not to the wind speed

## Perspectives:

- Inverse modeling: comparison of the inversion using surface measurements
- Goal: get a fast emission inventory and correct statistical ones



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# XCO<sub>2</sub> gradients (ΔXCO<sub>2</sub>)

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