

## Dix ans de mesures de la composition atmosphérique à l'observatoire Saclay/SIRTA en région parisienne : apport des infrastructures ICOS et ACTRIS pour l'analyse des émissions urbaines

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Laura Bouillon

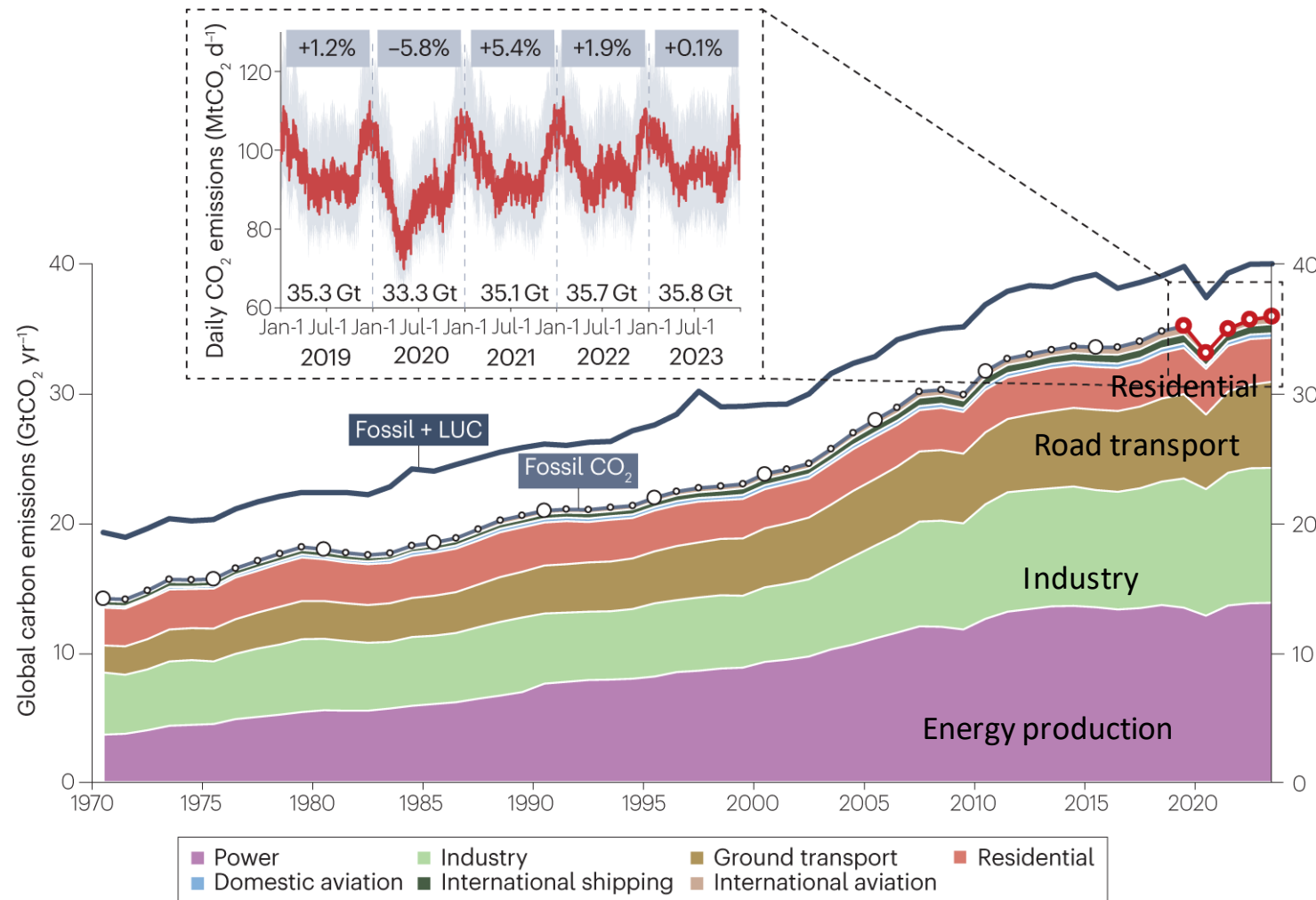
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# 70% of CO<sub>2</sub> anthropogenic emissions linked to cities

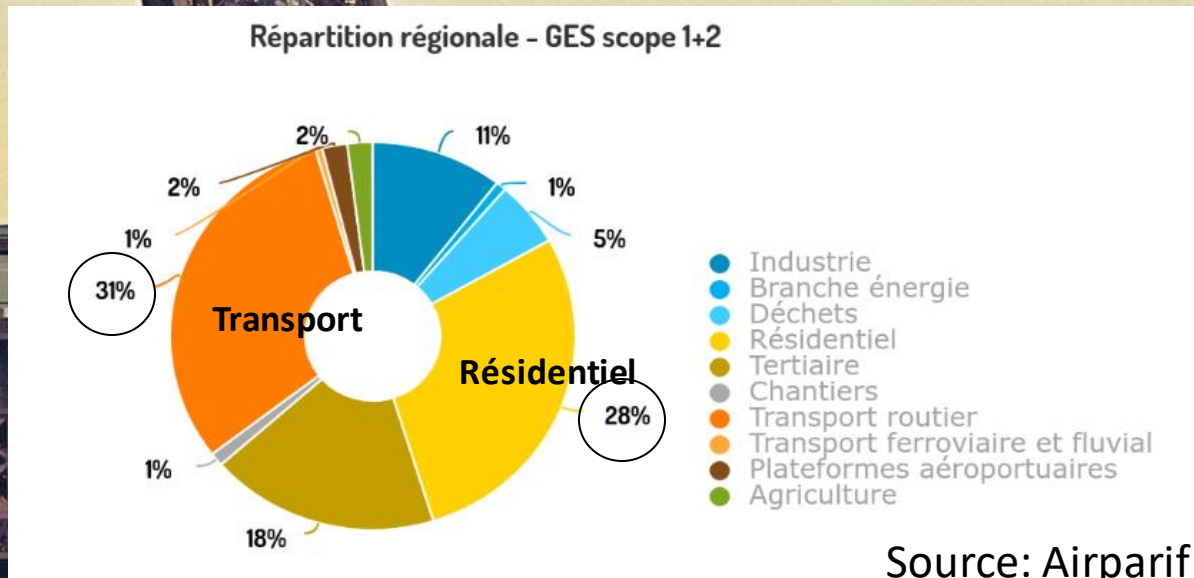
More than half of the world's population currently lives in urban areas -> expected to rise to 70% by 2050.



- Health issues due to air quality
- Increase of CO<sub>2</sub> emissions if no action is taken

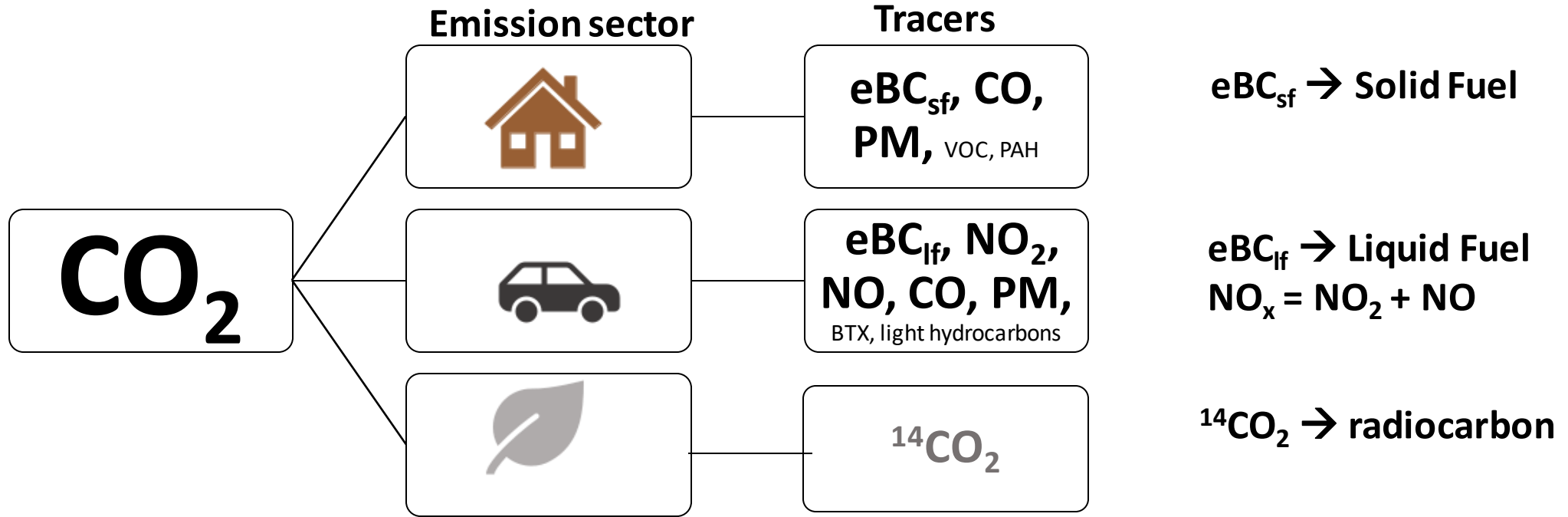
# The city of Paris

- Paris and surrounding cities → 20% of the population living on 2% of the land area, accounting for 9% of national CO2 emissions
- Road transport and residential sector → main emissions sources in Paris city and region

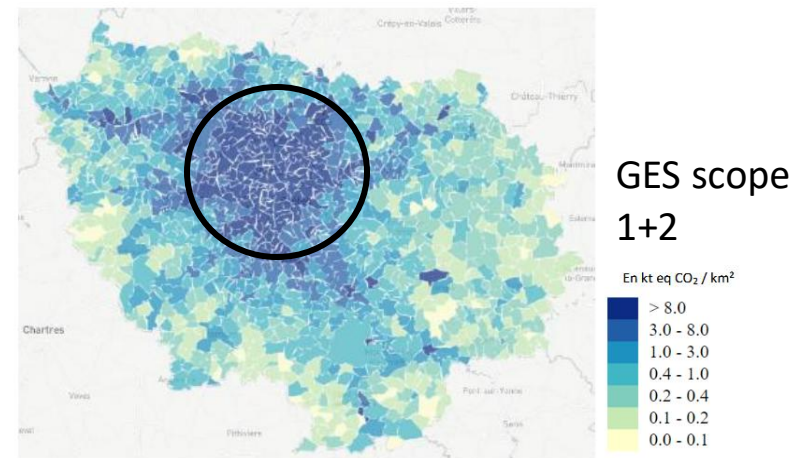
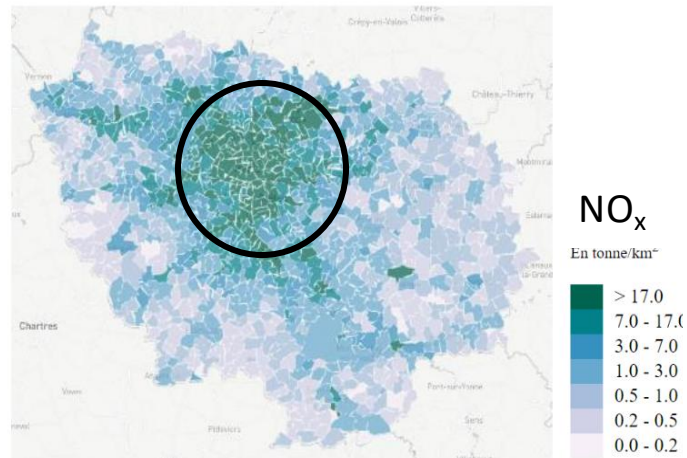


- Paris Climat Plan : objective of carbon neutrality by 2050
- Importance to evaluate the emissions and their evolution → inventory
- Necessity to have independent approaches

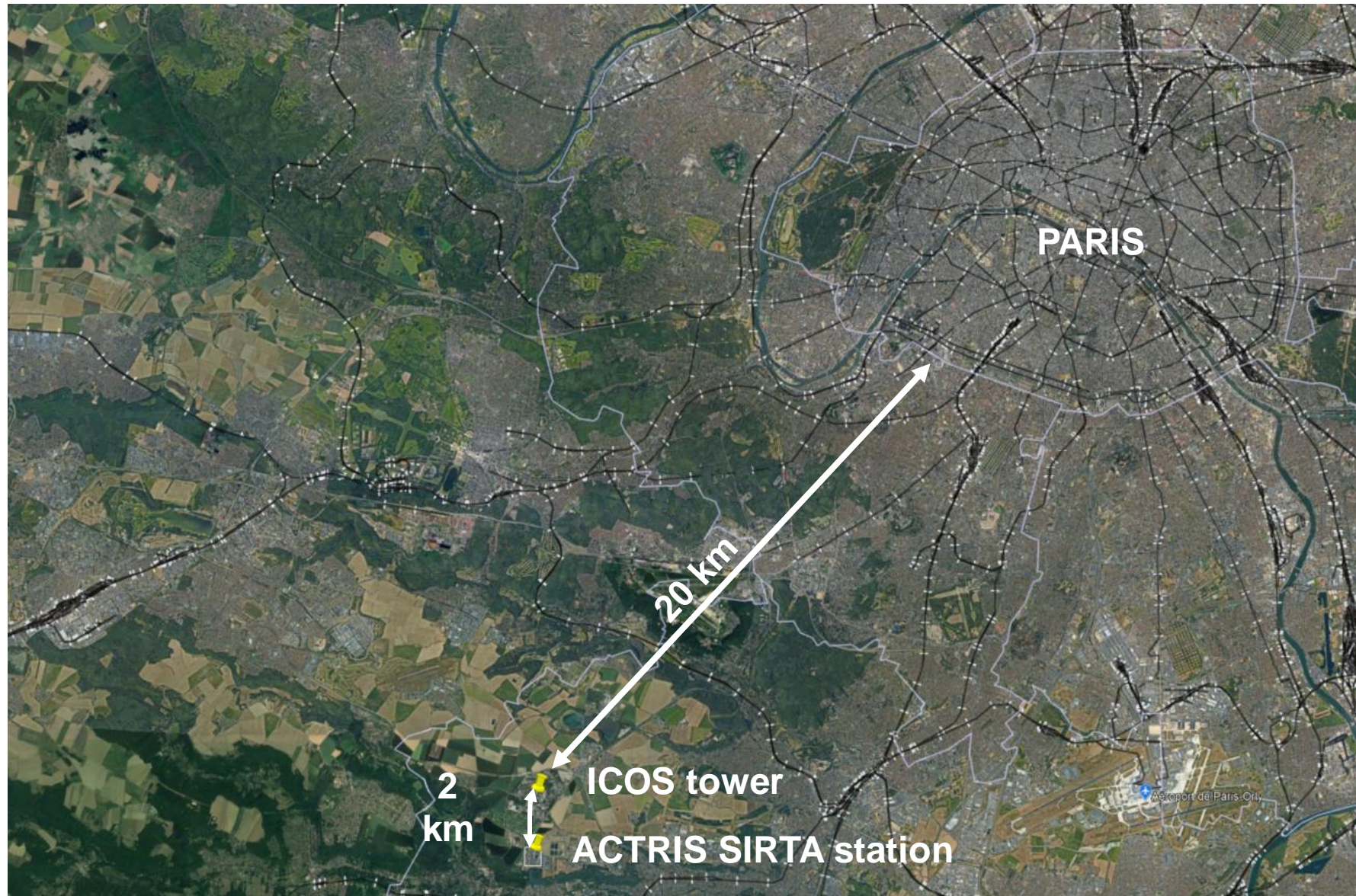
# Tracers approach



Co-Emissions between pollutants and greenhouse gases



# SIRTA-Saclay site: a peri-urban station



**ICOS**

Integrated  
Carbon  
Observation  
System



Saclay ICOS  
station

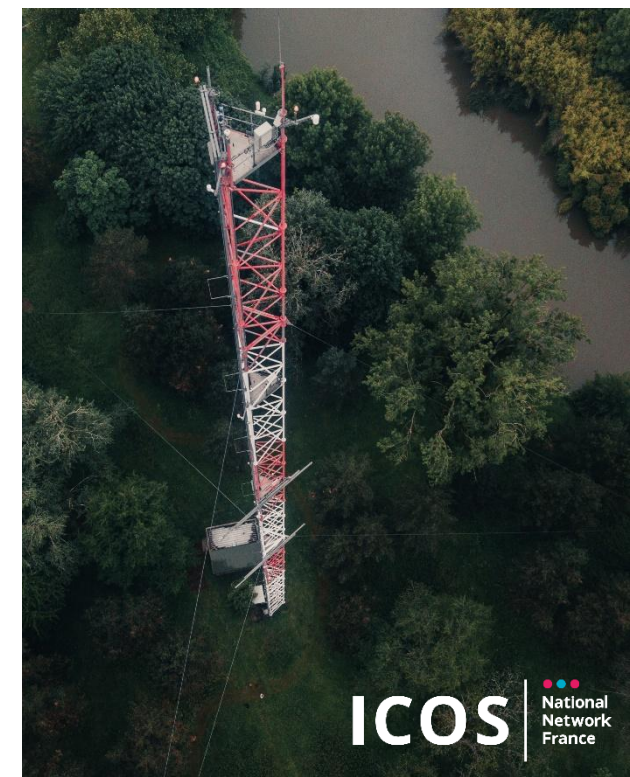
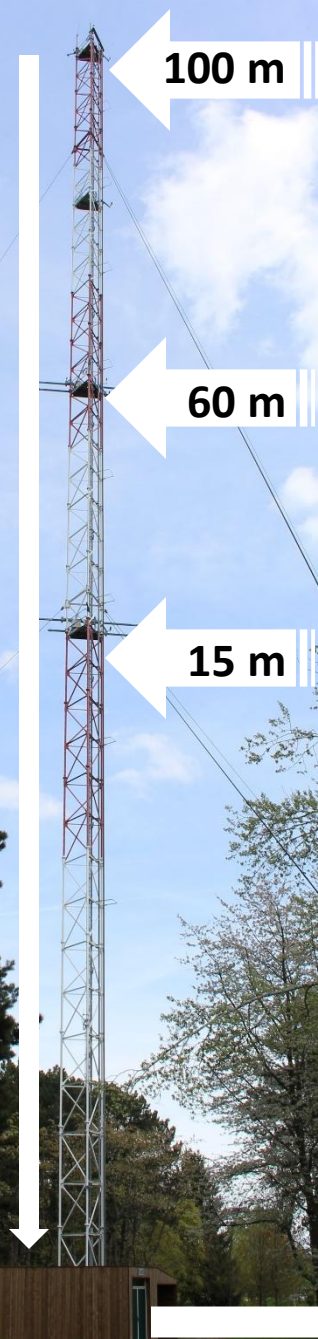
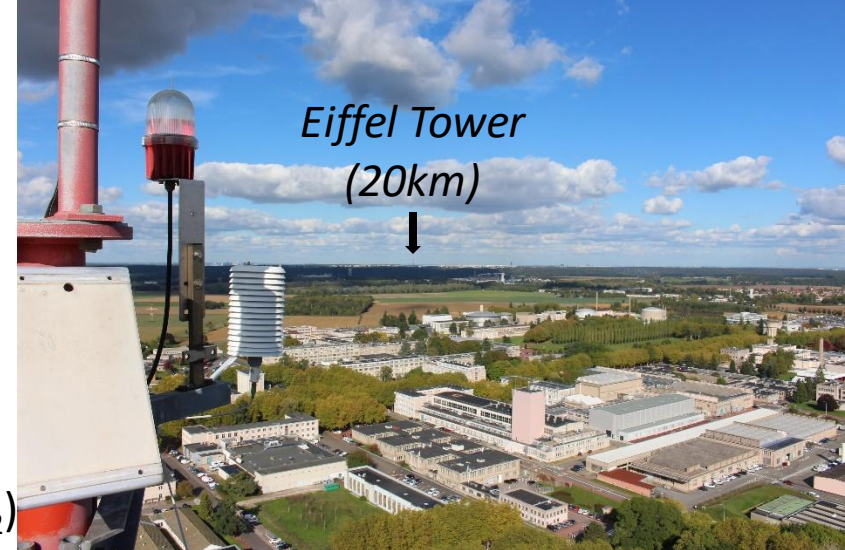
**ACTRIS**

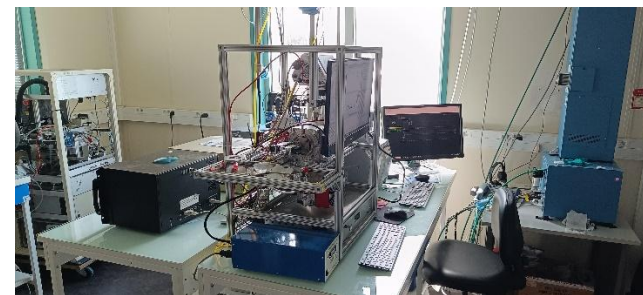


SIRTA-ACTRIS  
station

# Saclay ICOS station (*since 2015*)

- ❑ In-situ measurements (3 levels) :  $\text{CO}_2$ ,  $\text{CH}_4$ ,  $\text{N}_2\text{O}$ ,  $\text{CO}$
- ❑ Eddy-flux  $\text{CO}_2$  measurements (100m)
- ❑ Meteorological data since 2004
- ❑ Radon at two levels (5m – 100m)
- ❑ Regular flask sampling ( $\text{CO}_2$ ,  $\text{CH}_4$ ,  $\text{N}_2\text{O}$ ,  $\text{CO}$ ,  $\text{H}_2$ ,  $\text{SF}_6$ ,  $^{14}\text{CO}_2$ ,  $^{13}\text{CO}_2$ )
- ❑ Integrated (week)  $^{14}\text{CO}_2$  samples

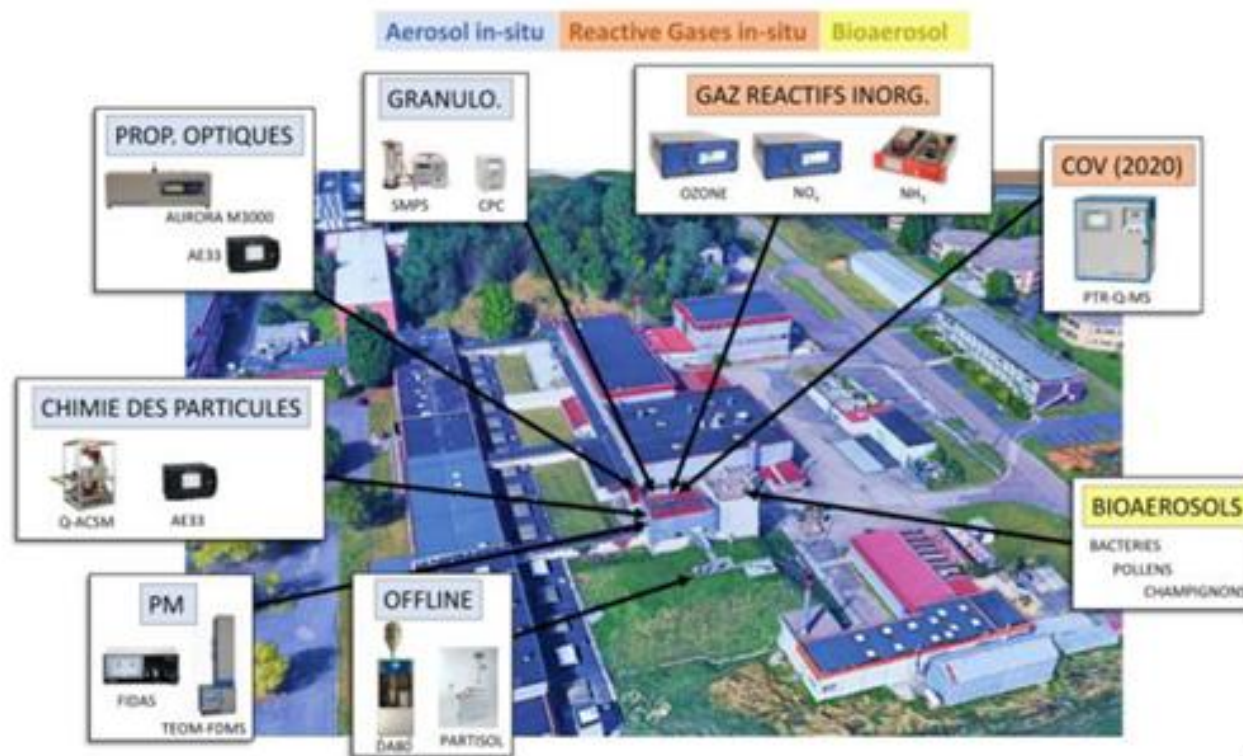




2012    2013    2014    2015    2016    2017    2018    2019    2020    2021    2022    2023    2024



Absorption	O3
PM	COV offline
Granulo.	
Filtres	
Diffusion	



## NO<sub>x</sub>, eBC (eBC<sub>sf</sub>, eBC<sub>lf</sub>)

T200UP Teledyne API



AE33 Magee Scientific



- eBC
- Liquid fuel (lf) solid fuel (sf)

## CO<sub>2</sub>, CO

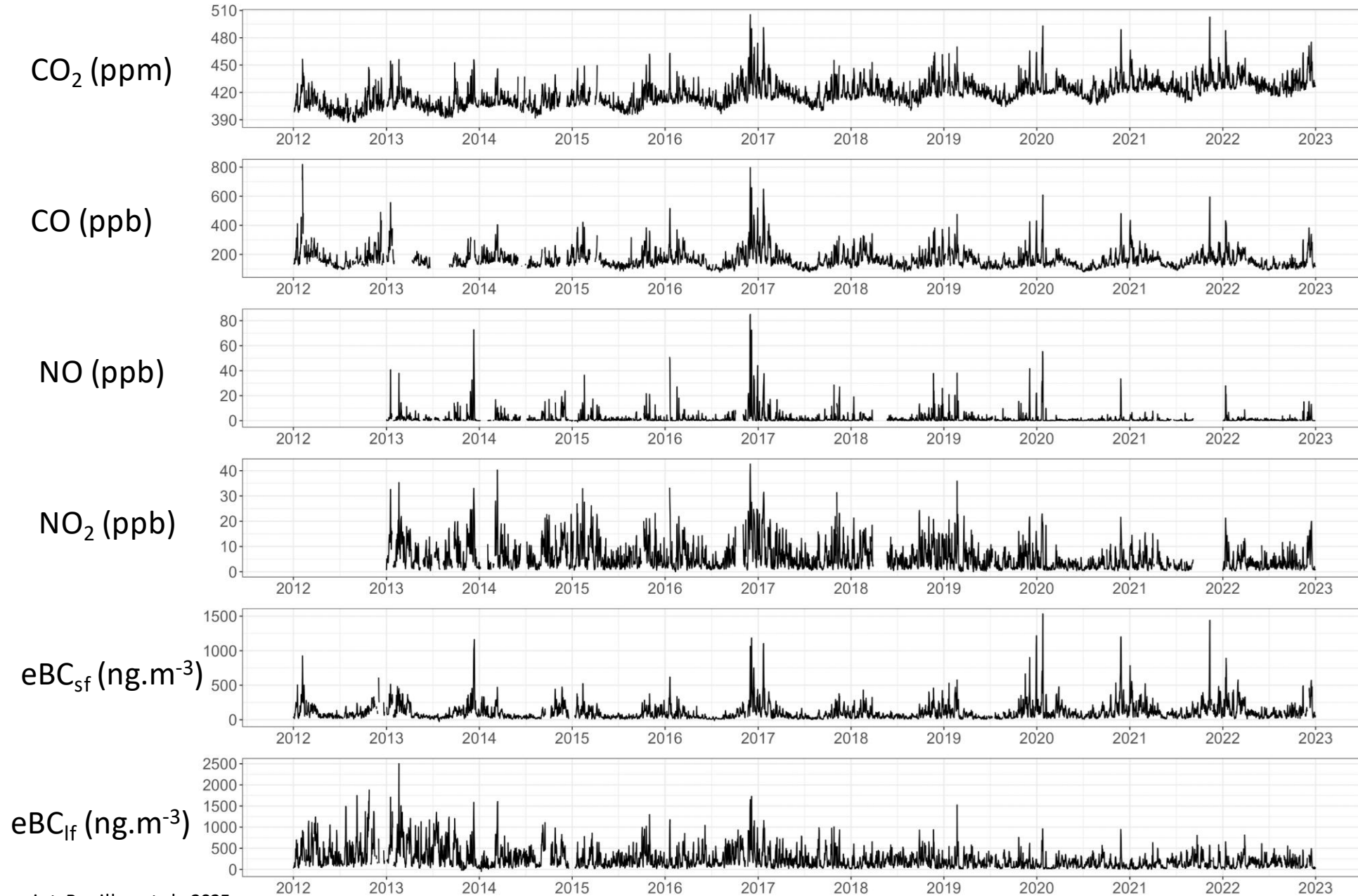
Before 2015  
Gas  
Chromatography



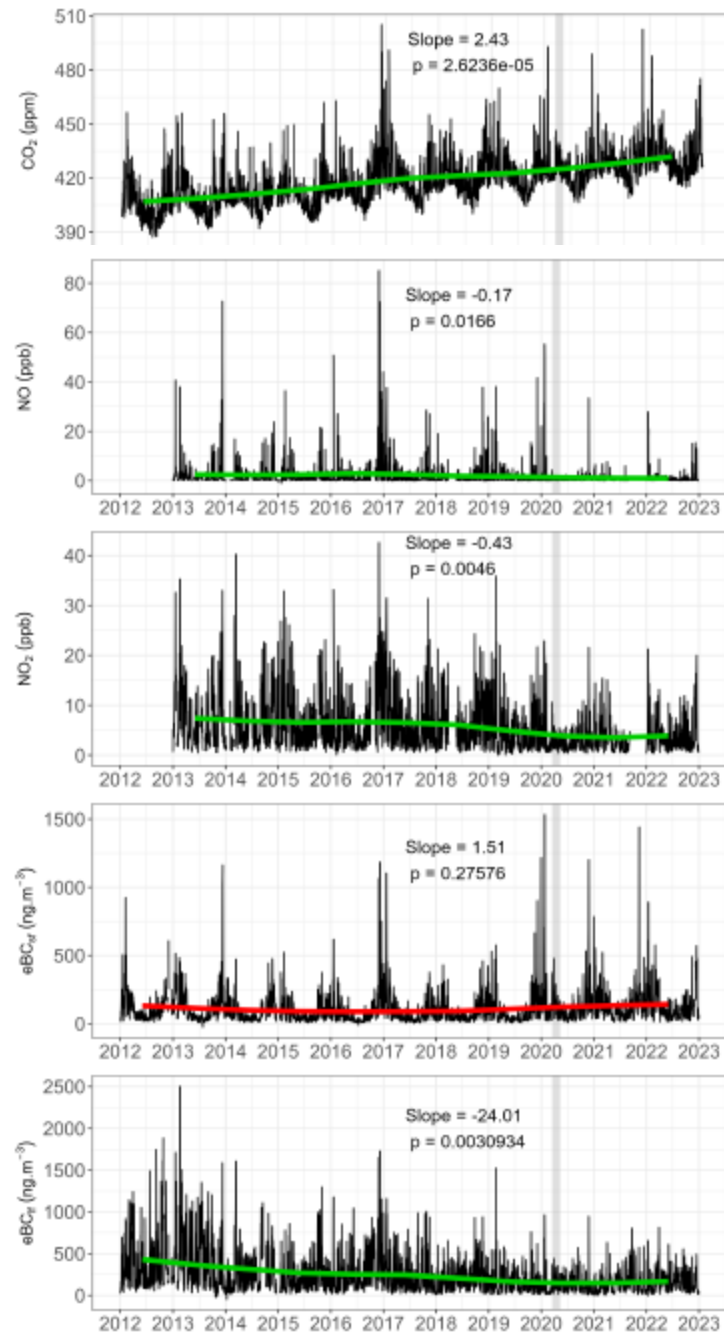
Since 2015  
Cavity Ring  
Down  
Spectrometer



# Time series 2012 - 2022



# Trends (2012 – 2022)



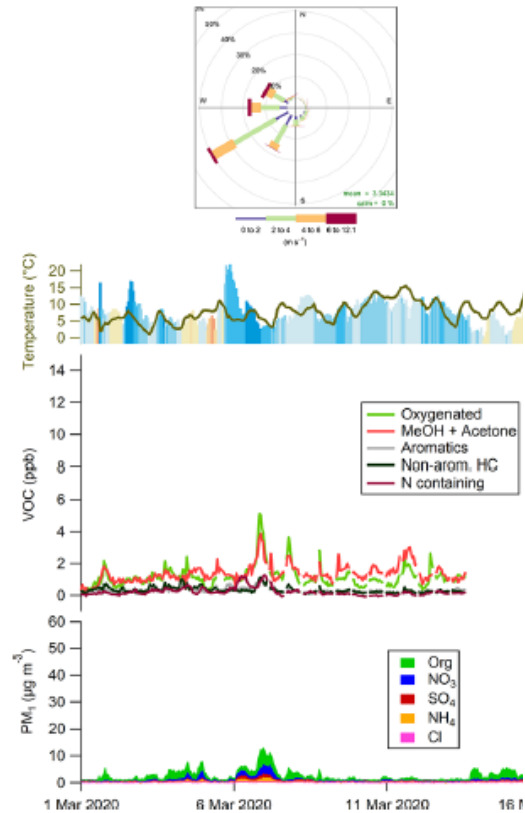
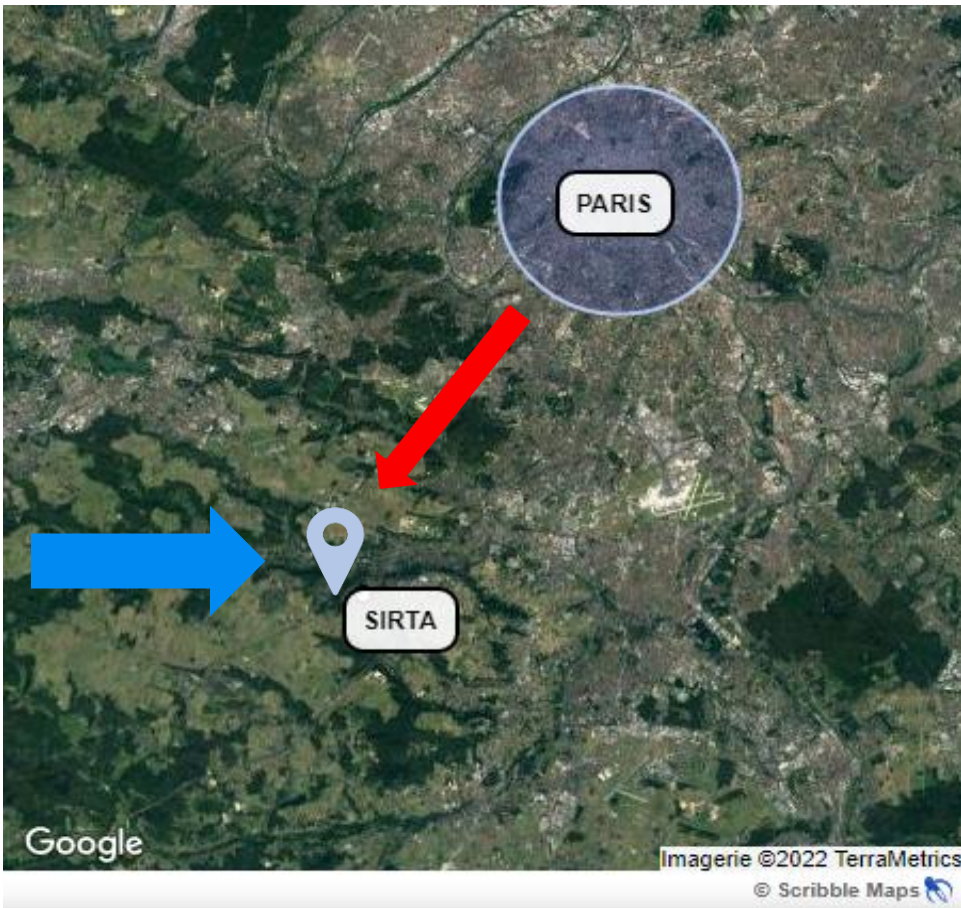
Significant trends for CO<sub>2</sub>  
(increasing)

and NO<sub>x</sub>, eBC<sub>1r</sub> (decreasing)

But how to analyse these trends in regards to  
Paris emissions?

# Specificity of the SIRTA peri-urban station

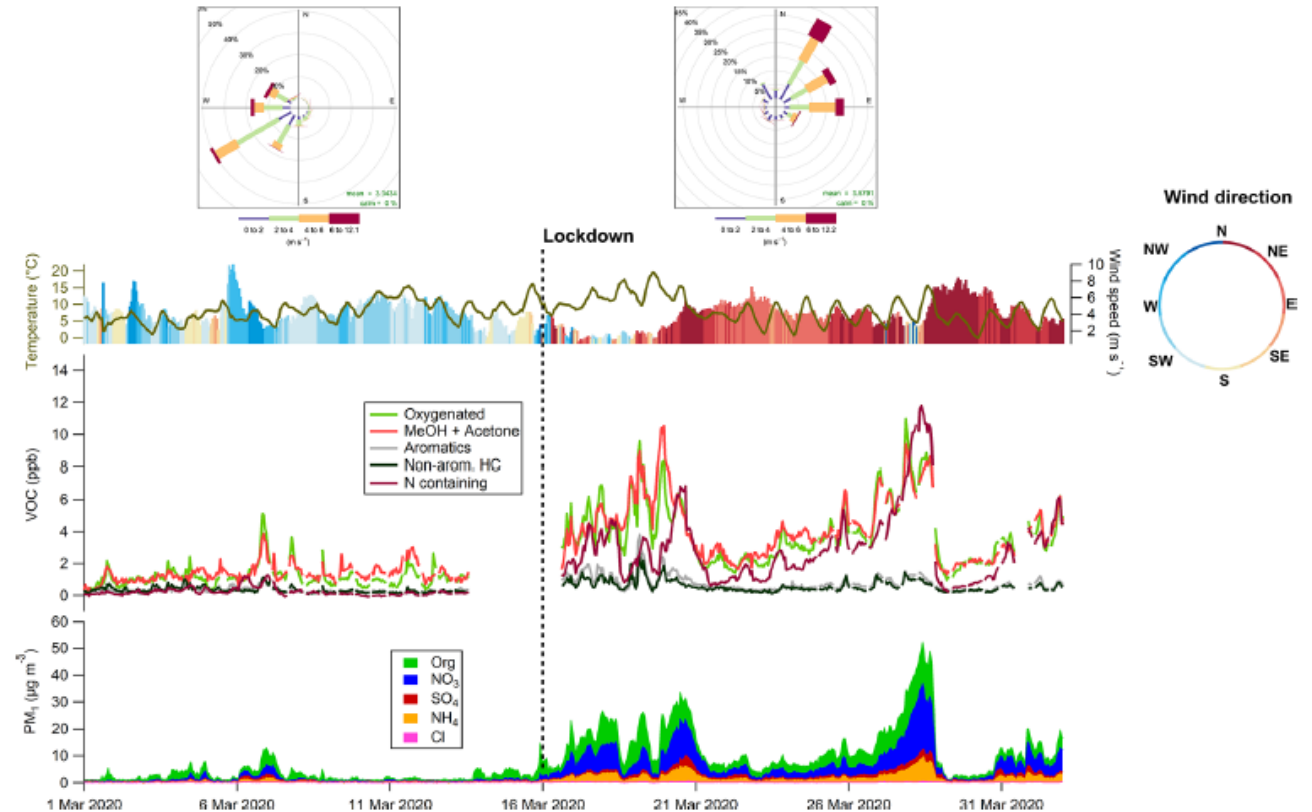
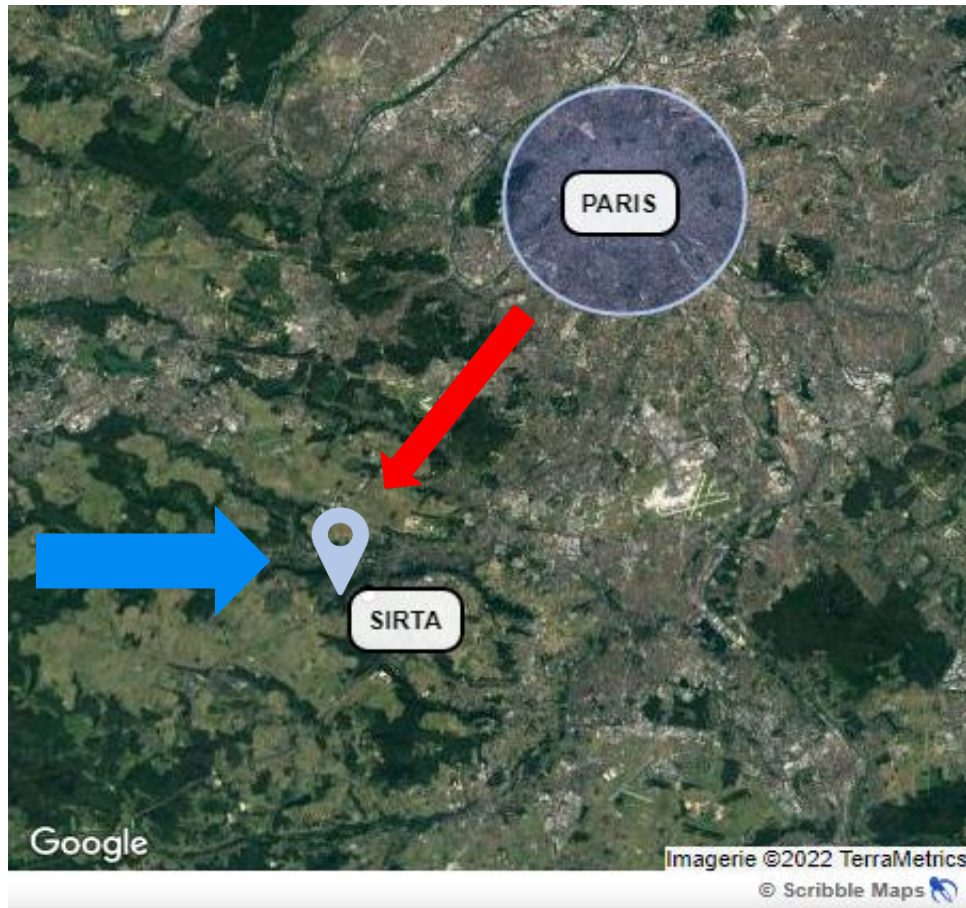
Wind direction is an important parameter to consider → Illustration during the lockdown



Simon et al., 2023

# Specificity of the SIRTA peri-urban station

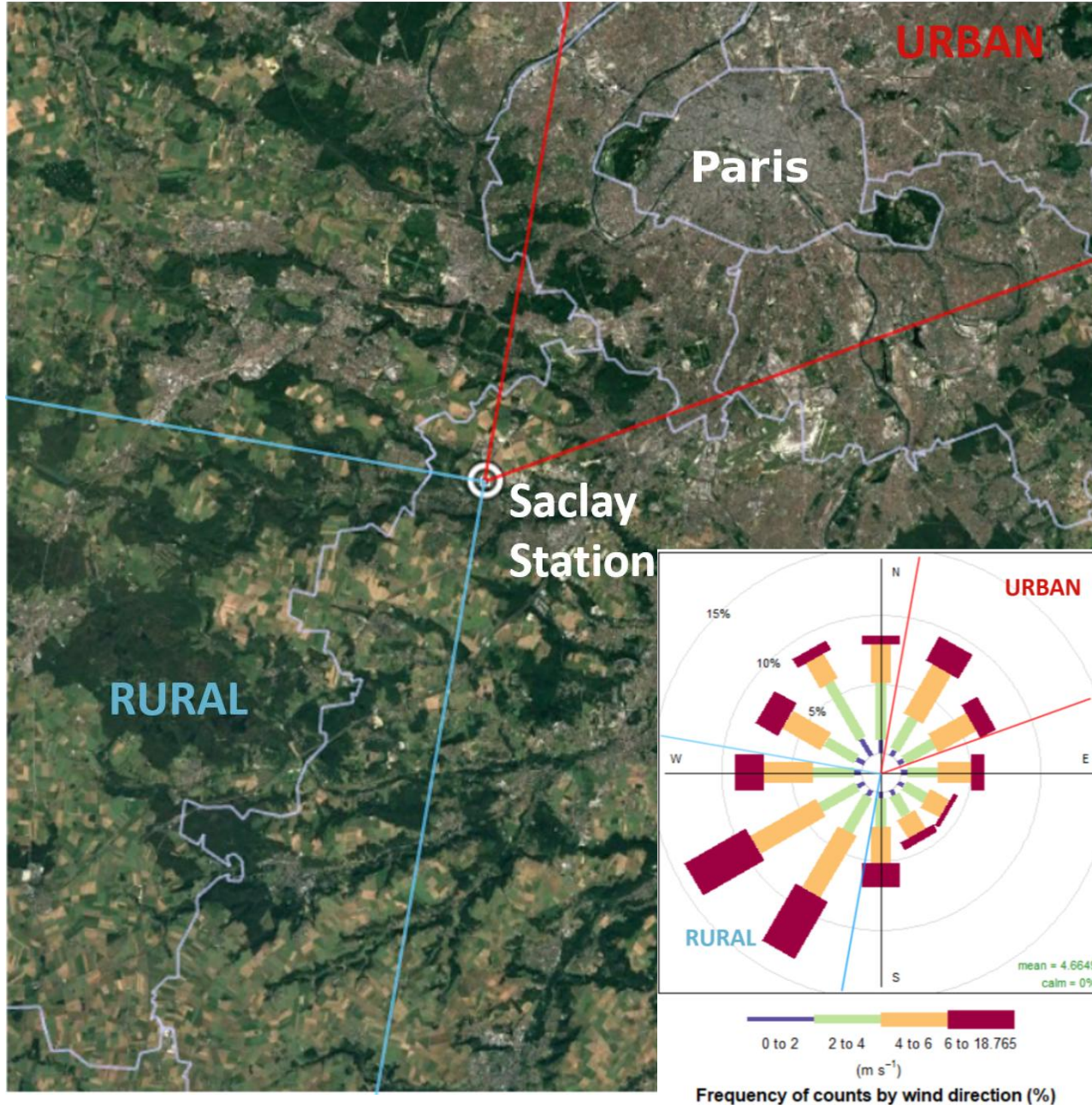
Wind direction is an important parameter to consider → Illustration during the lockdown



Lockdown study  
Petit et al., 2021

Simon et al., 2023

# Urban Offset determination

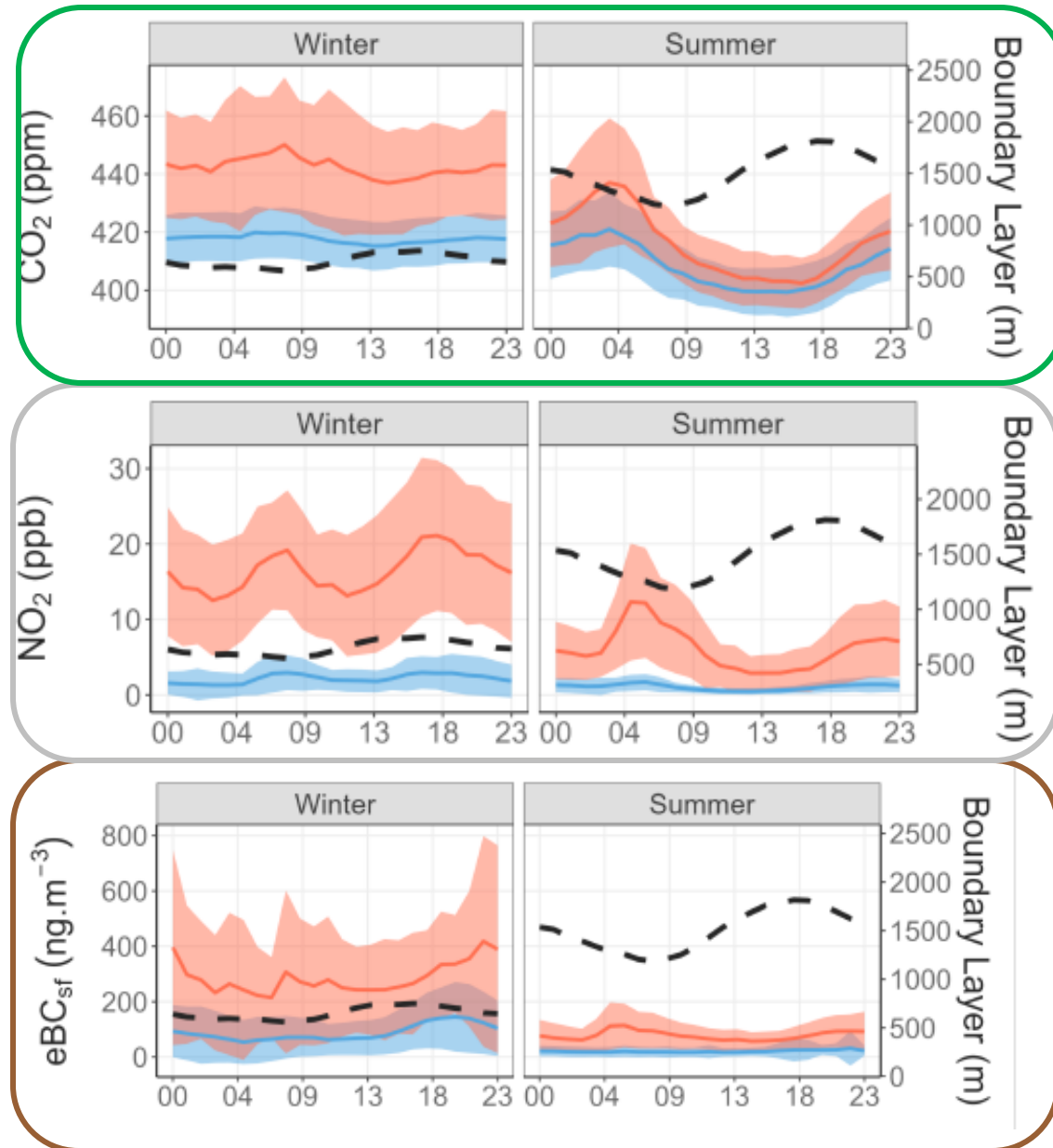


- Data filtered according to 2 wind sectors:
  - ▣ Urban sector (URB) (12.5%)
  - ▣ Rural sector (RUR) (31.1%)

**URB – RUR = « URBAN offset »**

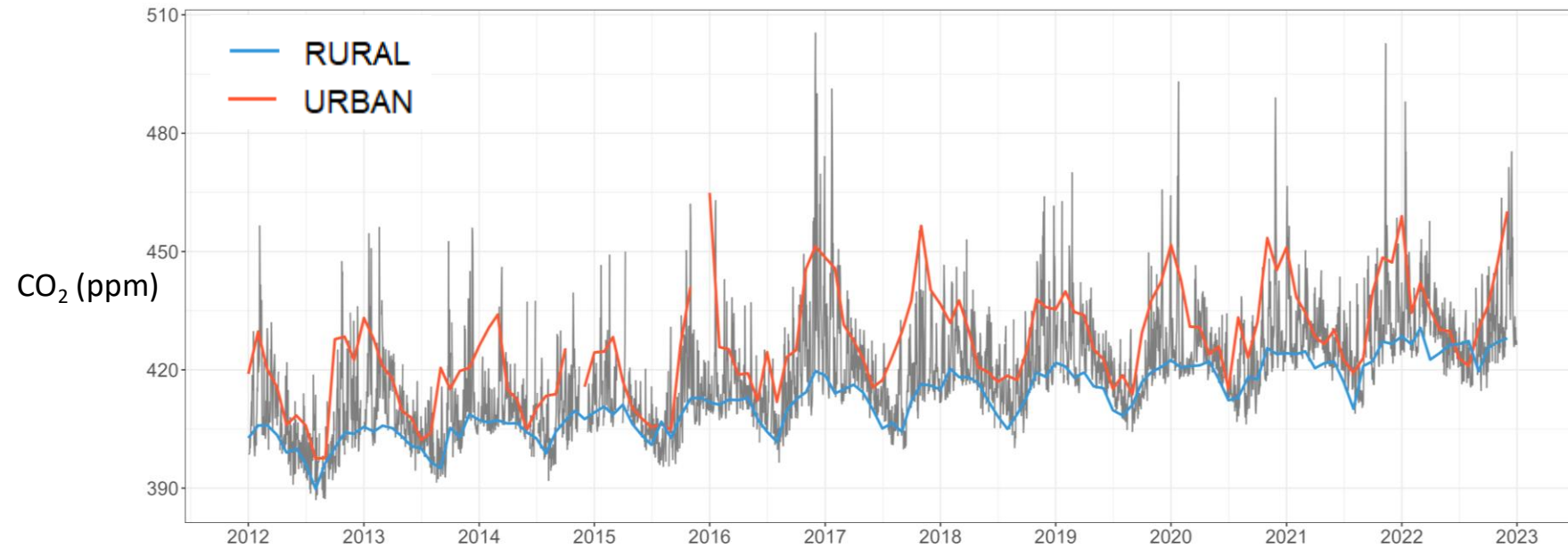
# Diurnal cycle by season

— Boundary layer — Rural — Urban



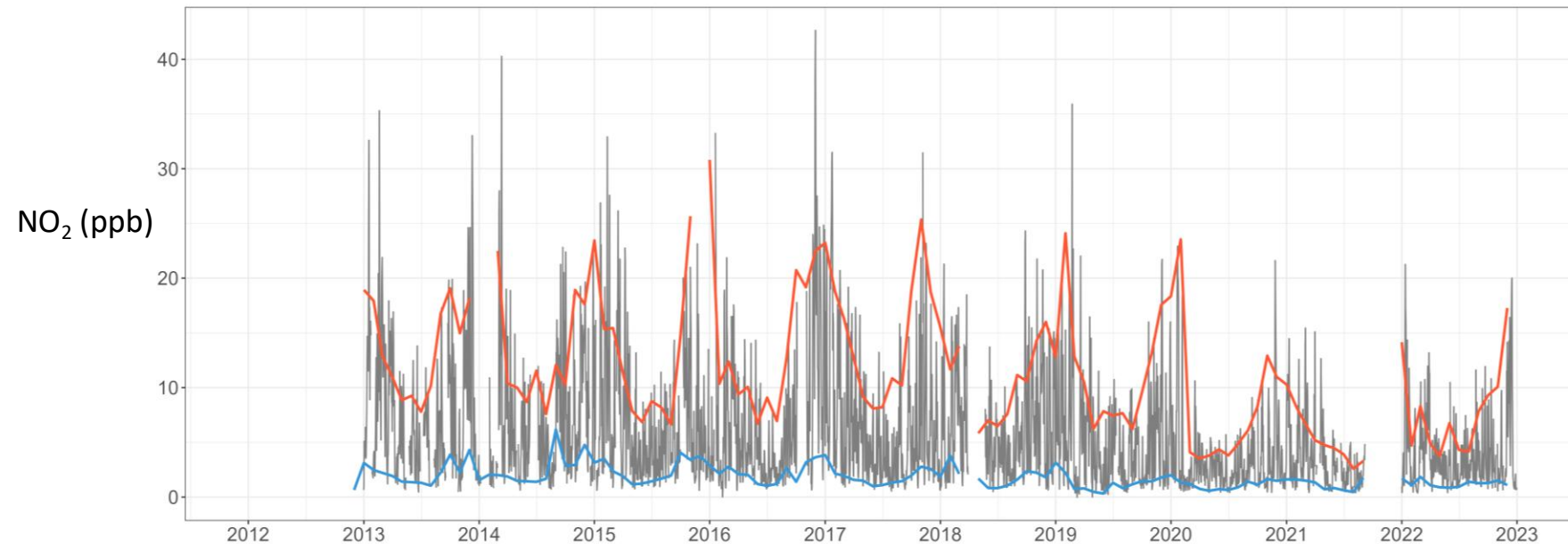
- Concentration higher in winter due to a lower boundary layer height
- CO<sub>2</sub> influenced by **biogenic emissions** in summer → anthropogenic emissions more visible in winter
- Higher concentrations for traffic tracers during rush hours
- Concentrations increase in winter and in the evening for **residential** tracers → heating

# Time series according to wind sectors



CO <sub>2</sub>		
	Summer	Winter
<b>URB</b>	416 ppm	442 ppm
<b>RUR</b>	407 ppm	418 ppm
<b>Offset</b>	9.1 ppm	24 ppm

The rural sector seems satisfactory to use as a proxy for background



NO <sub>2</sub>		
	Summer	Winter
<b>URB</b>	6.3 ppb	16 ppb
<b>RUR</b>	0.99 ppb	2.3 ppb
<b>Offset</b>	5.3 ppb	13.7 ppb

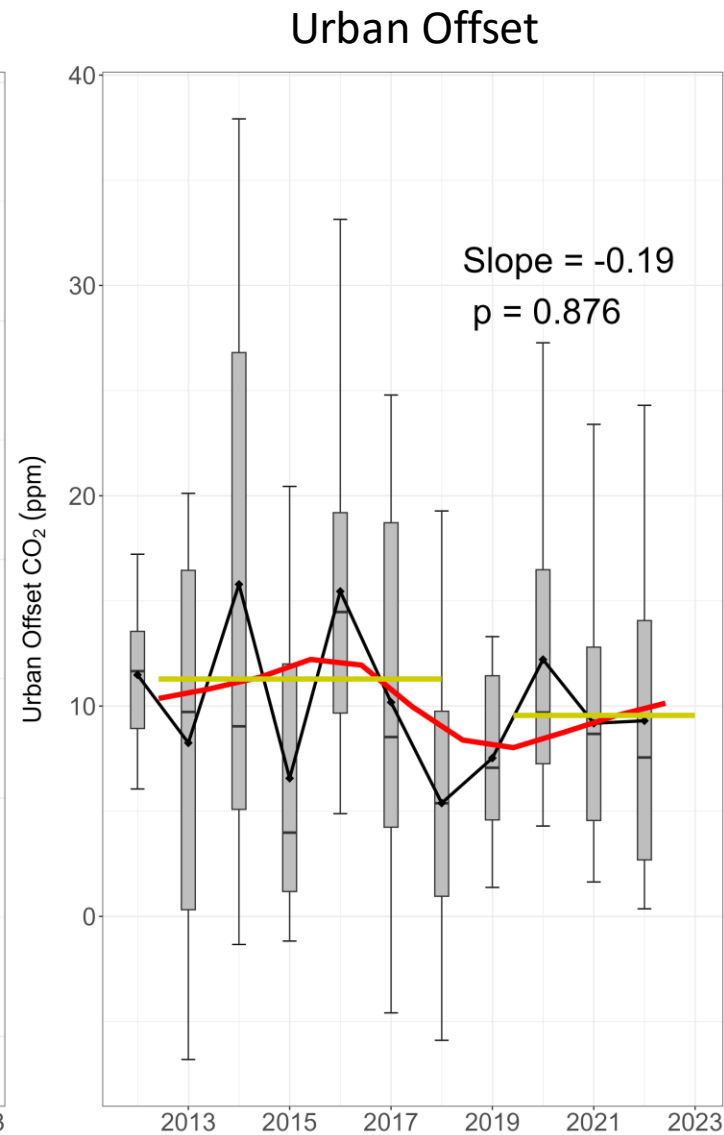
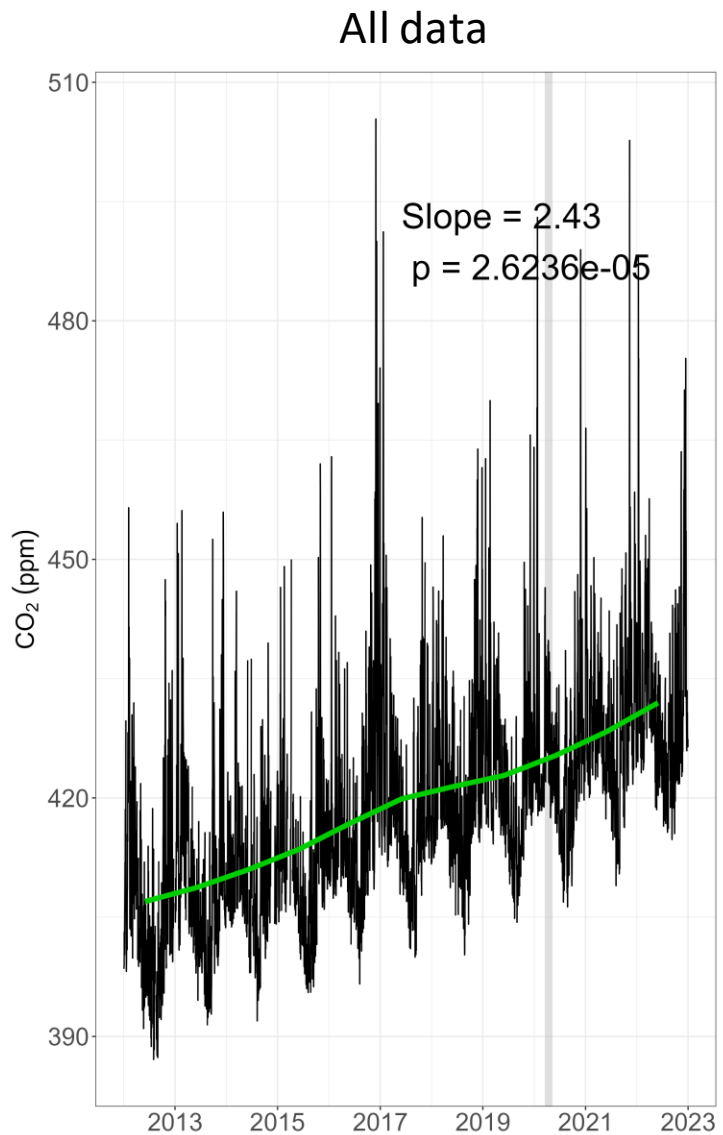
# CO<sub>2</sub> Trends (2012-2022)

— Significant trend

— non significant trend

— Mean 2012-2017 and 2019-2022

2.48 ppm.an<sup>-1</sup> NOAA  
between 2012-2022



15% decrease between  
2012-2017 and 2019-  
2022

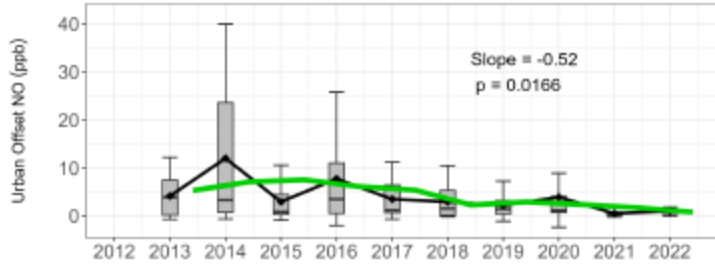
# NOx and eBC Urban offset Trends



— Significant trend      — non significant trend

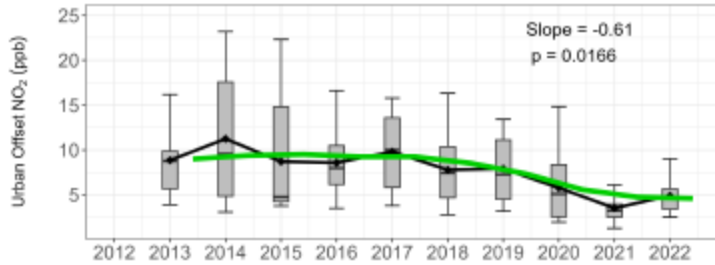
## Urban Offset

NOx



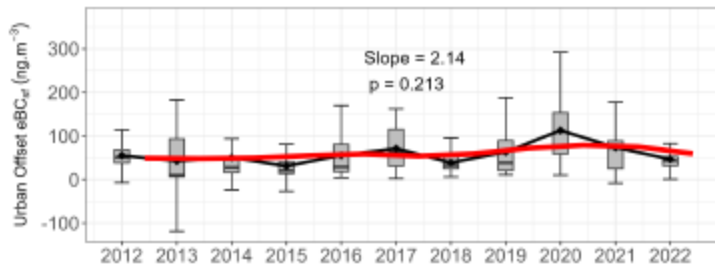
52% decrease between 2012-2017 and 2019-2022

eBCsf

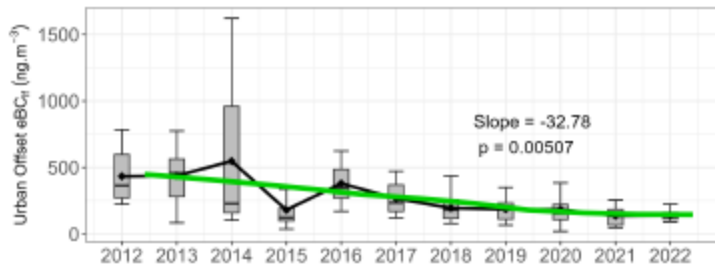


46 % increase between 2012-2017 and 2019-2022

eBClf



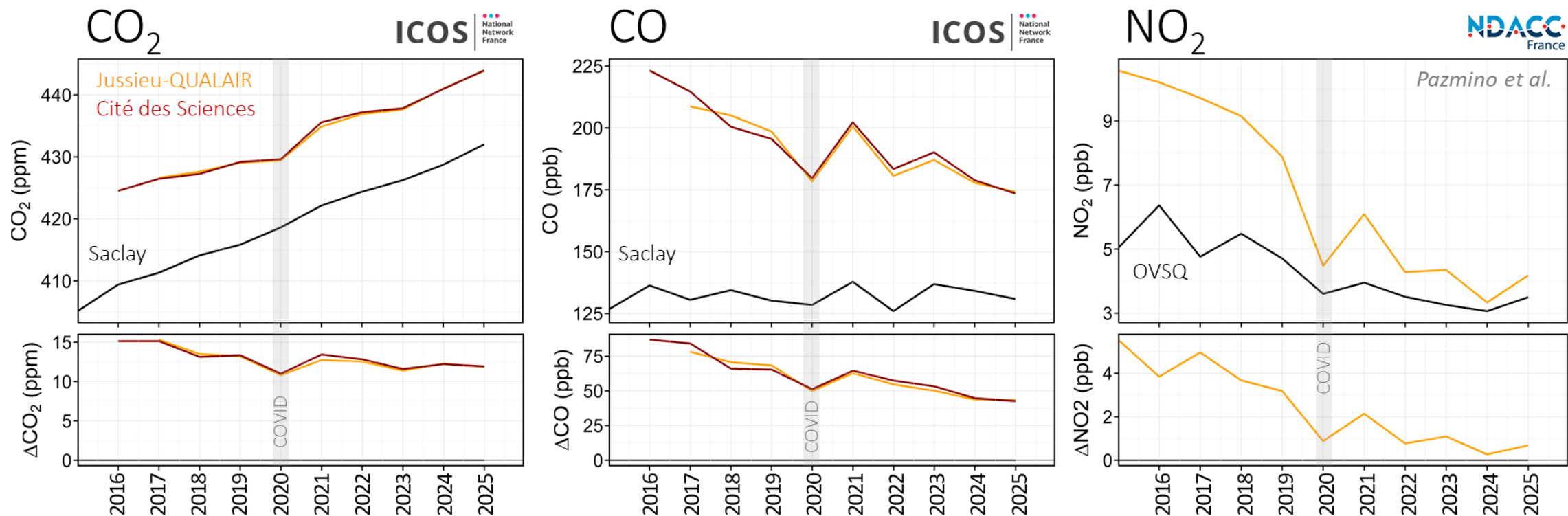
57% decrease between 2012-2017 and 2019-2022



## Comparison with inventory

	Mean 2012-2017 compared to mean 2019-2022	Airparif Inventory All sectors Paris (2012-2021)	Airparif Inventory traffic sector Paris (2012-2021)
CO	-36%	-26%	-50%
NO <sub>2</sub>	-52% (NO <sub>x</sub> )	-40% (NO <sub>x</sub> )	-50% (NO <sub>x</sub> )
NO			
eBC <sub>lf</sub>	-57%		
CO <sub>2</sub>	-15%	-21%	-24%

# Diminution du dôme urbain de CO<sub>2</sub>, CO, NO<sub>2</sub> à Paris



Les émissions de CO<sub>2</sub>, de CO et NO<sub>2</sub> (traceurs des combustions et du trafic routier) génèrent des concentrations atmosphériques plus élevées au cœur de Paris, comparativement à Saclay ou Guyancourt (OVSQ). Les observations indiquent :

- ❑ Une diminution nette en 2020 année des confinements COVID, suivi d'un rebond important en 2021
- ❑ Des tendances à la baisse (-50% de ΔCO, -85% de ΔNO<sub>2</sub>, et -21% de ΔCO<sub>2</sub> depuis 2016), attribuables à la diminution des consommations d'énergies fossiles, et particulièrement au secteur trafic routier (baisse du trafic, amélioration des motorisations)

# Some concluding remarks

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- Added value of combining the analysis of greenhouse gases and pollutants (which are typically studied by different scientific communities)
- Original approach calculating an urban offset based on measurements from a single peri-urban station
- Decreasing trends of the urban offset of CO<sub>2</sub>, NO<sub>x</sub>, CO and eBC<sub>lf</sub> between 2012-2017 and 2019-2022
  - CO<sub>2</sub> -15%
  - CO -36%
  - NO<sub>x</sub> -52%
  - eBC<sub>lf</sub> -57%
- The inventory suggests that traffic is the main factor explaining the decreasing trend, this is confirmed by the tracers
- see Bouillon et al., ESSD, 2025
- On-going: Analyse ratios  $\Delta\text{CO}/\Delta\text{CO}_2$ ,  $\Delta\text{NO}_x/\Delta\text{CO}_2$  at Saclay and at two other sites (towers located upstream and downstream from Paris instrumented during the ICOS-cities project), and compare with ratios determined close to the source (traffic) and with ratios from the inventory
- Next: Consider additional compounds, like VOCs

A photograph of the Eiffel Tower in Paris, France, taken from a low angle looking up. The tower's intricate iron lattice structure is the central focus, with its legs spreading out towards the bottom. The sky is a soft, hazy orange and yellow, suggesting sunset or sunrise. In the background, the Parisian skyline is visible, including several modern high-rise buildings and older European-style buildings. The foreground shows some greenery and a small, spherical, cage-like structure. The text "Thank you for your attention" is overlaid in the center-right of the image in a blue, outlined font.

**Thank you for your attention**