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Eddy covariance measurements of CO_2 fluxes along an urban-to-rural gradient in the Paris area

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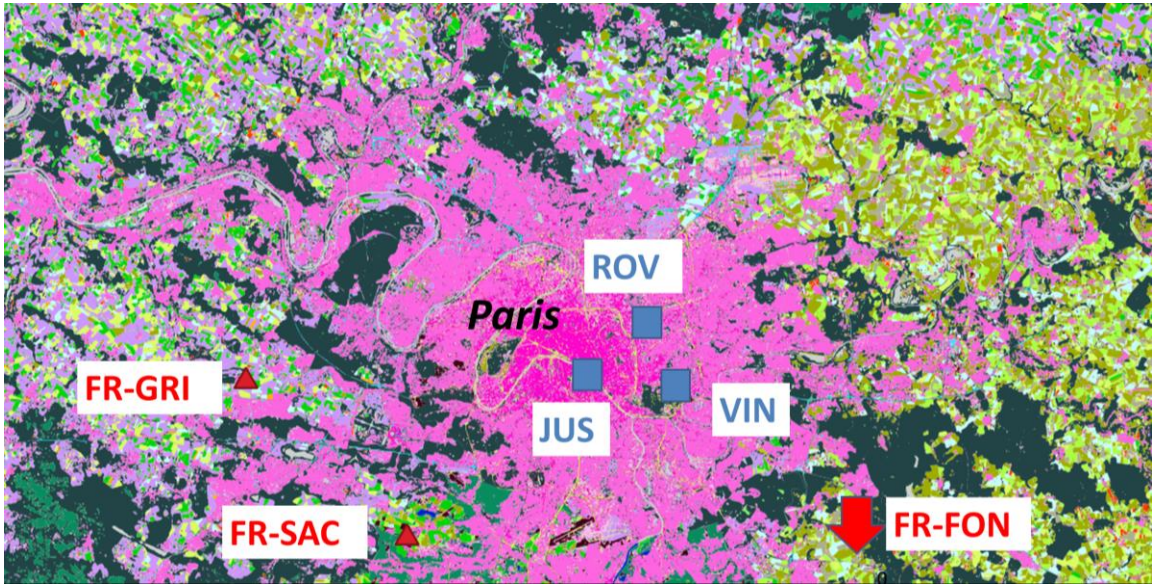
ICOS Cities, aka Pilot Applications in Urban Landscapes - Towards integrated city observatories for greenhouse gases (PAUL), has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101037319

Context

ICOS Cities Project

- 3 pilot cities with different sizes (Paris, Munich, Zurich) + 12 cities in the observatory
- Developing an observation network integrating different measurement techniques to improve the estimation of GHG emissions from cities.

Paris EC network



urban sites:

- **1 in the city centre (urban dense area)**
- **1 on the border of the city (urban diffuse area) [tall tower]**
- **1 urban forest**

Semi-urban/rural sites

- **1 semi-urban site [tall tower]**
- **1 crop site**
- **1 forest site**

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Objectives

- Provide direct measurements of CO_2 and heat fluxes from different areas of a megapole;
- Assess the variability of CO_2 and heat fluxes along an urban-rural gradient;
- Disentangle urban anthropogenic and biogenic fluxes using a simple approach linking anthropogenic and biogenic fluxes to the percentage fraction of urban and vegetated land covers within the flux footprint;
- Compare flux measurements with emission inventory estimates.

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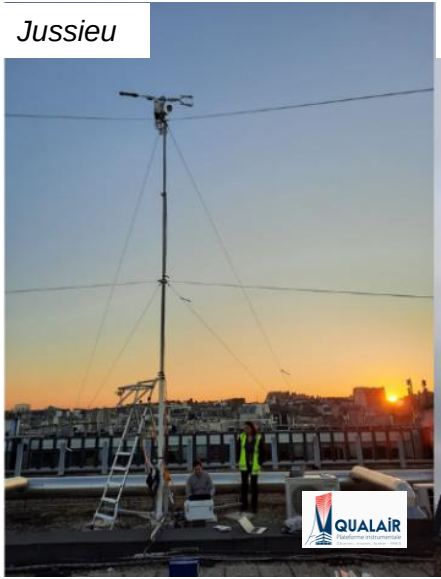
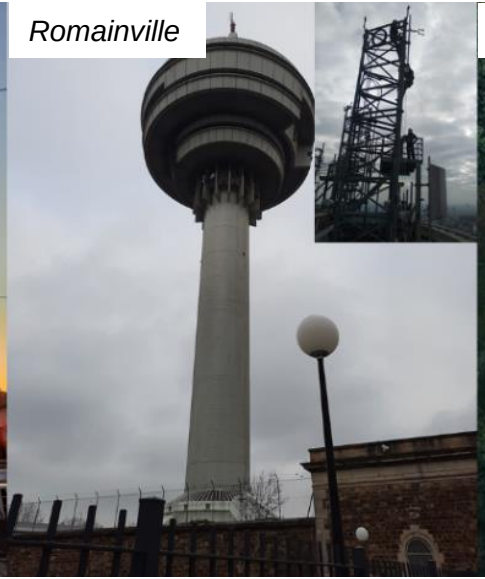
Study sites and measurement period





	2023												2024												2025					
Site	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
Jussieu																														
Romainville																														
Saclay																														
Vincennes																														

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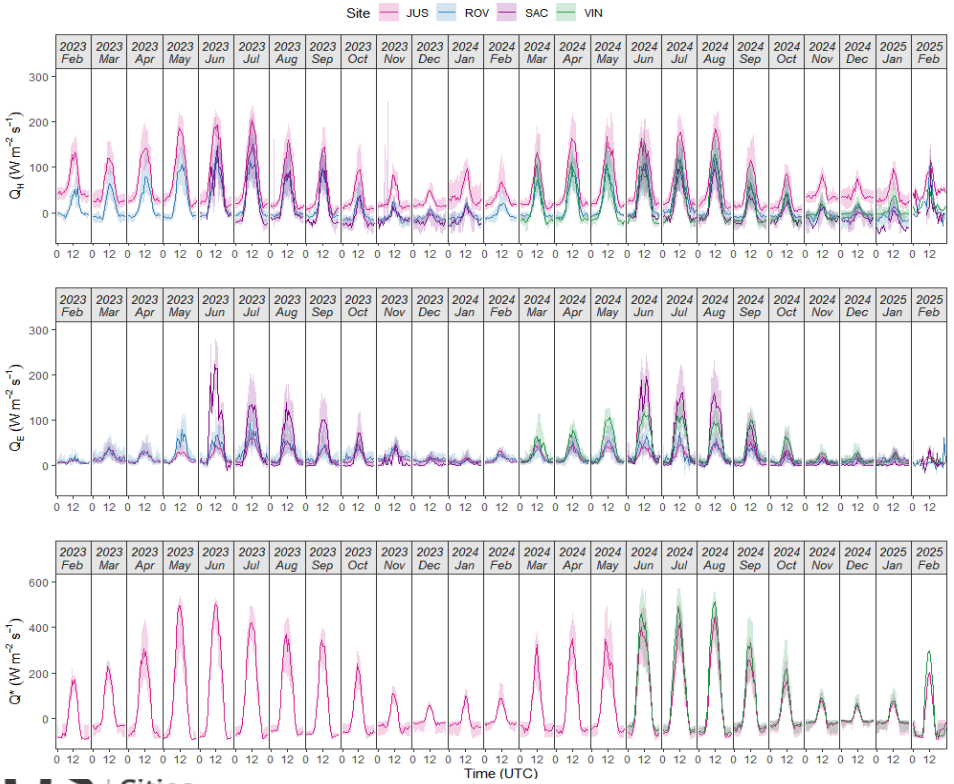
Monthly variation of Heat Fluxes



- Highest Q_H in Jussieu
- Highest Q_E on vegetated and semi-urban areas (Vincennes and Saclay) in spring and summer
- Comparable Q_E for all sites in winter
- Slightly higher Q* in Vincennes compared to Jussieu

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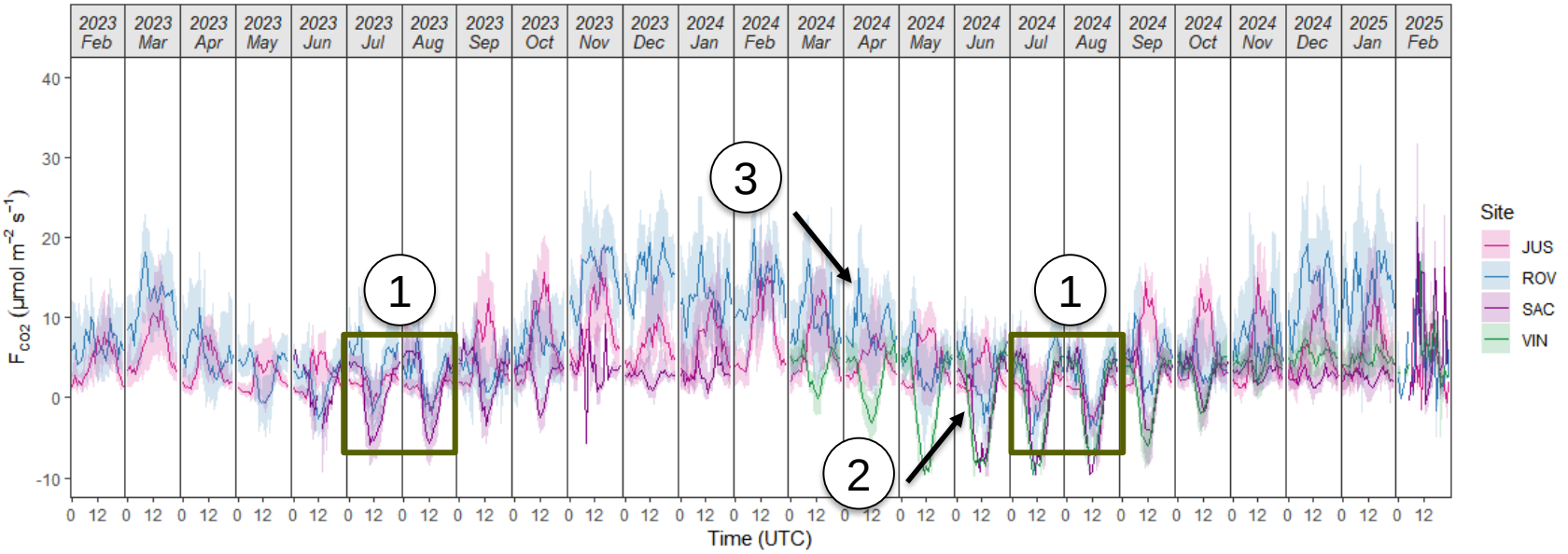
Monthly variation of CO_2 fluxes



(1) Holiday period: JUS fluxes aligned with ROV fluxes

(2) CO_2 uptake by vegetation? Or Switching-off of domestic heating?

(3) Emission at night from the city « périphérique »?

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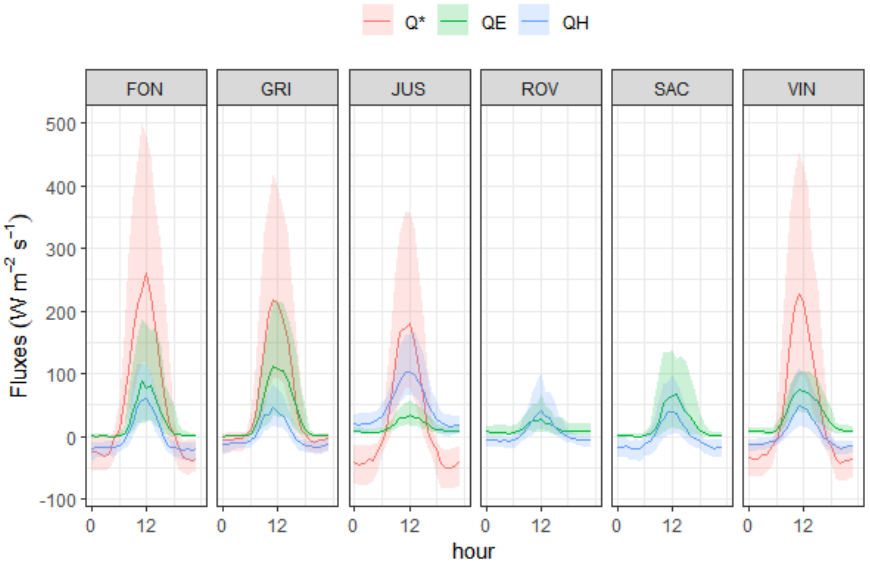
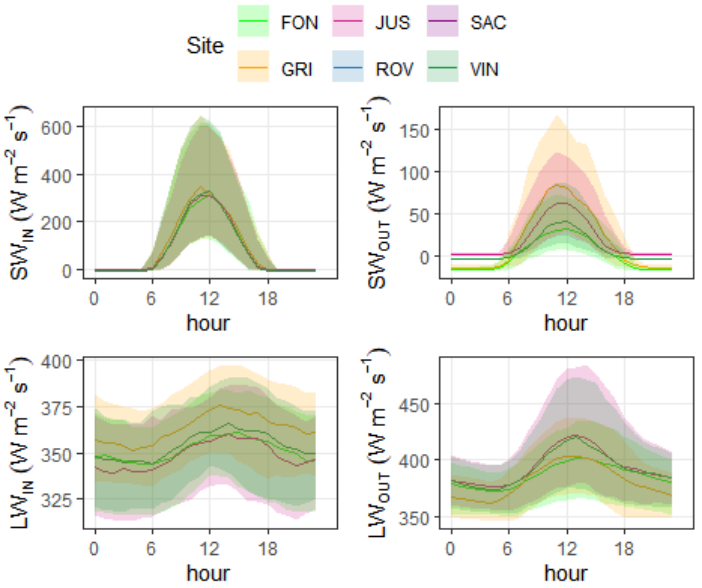
Diurnal variation of heat fluxes



Period: 2024/07/01 -2024/12/31

- LW_{OUT}(JUS,VIN)>LW_{OUT}(GRI,FON)
- Lowest LW_{IN} in in Jussieu
- Different albedo: SW_{OUT}(JUS)>SW_{OUT}(VIN)



- Natural and semi-natural sites: Q_E>Q_H
- Urban sites Q_H≥Q_E
- Highly negative nocturnal Q* in Jussieu

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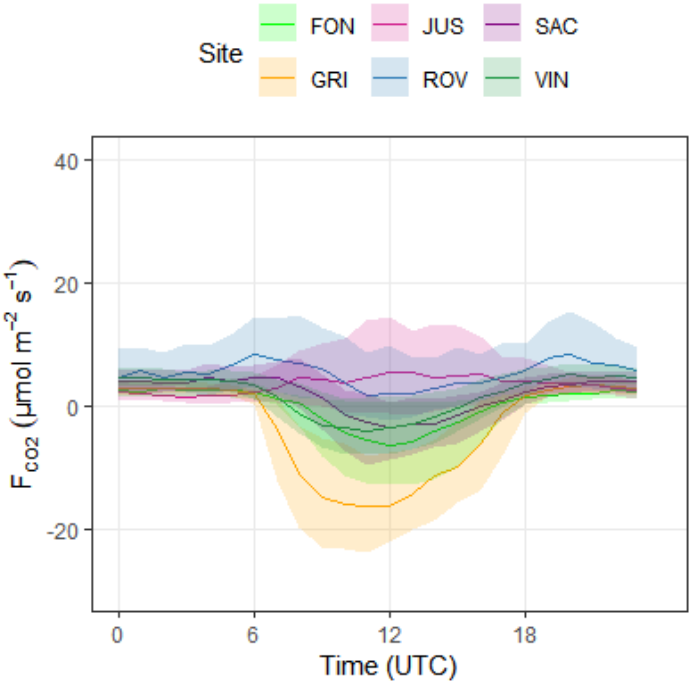
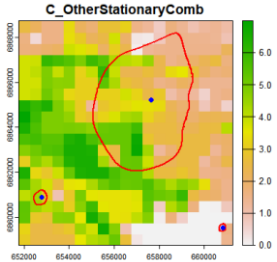
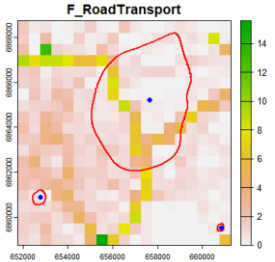
Diurnal variation of CO2 fluxes

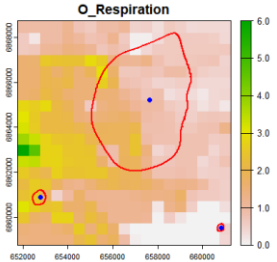
Period: 2024/07/01 -2024/12/31



- JUS and ROV: CO_2 sources, different diurnal cycles
- Different distribution of CO_2 emissions by sector in different areas of the city







Inventory AIRPARIF 2019

- Lower CO_2 uptake in VIN than FON and GRI
- CO_2 anthropogenic sources within the tower footprint?

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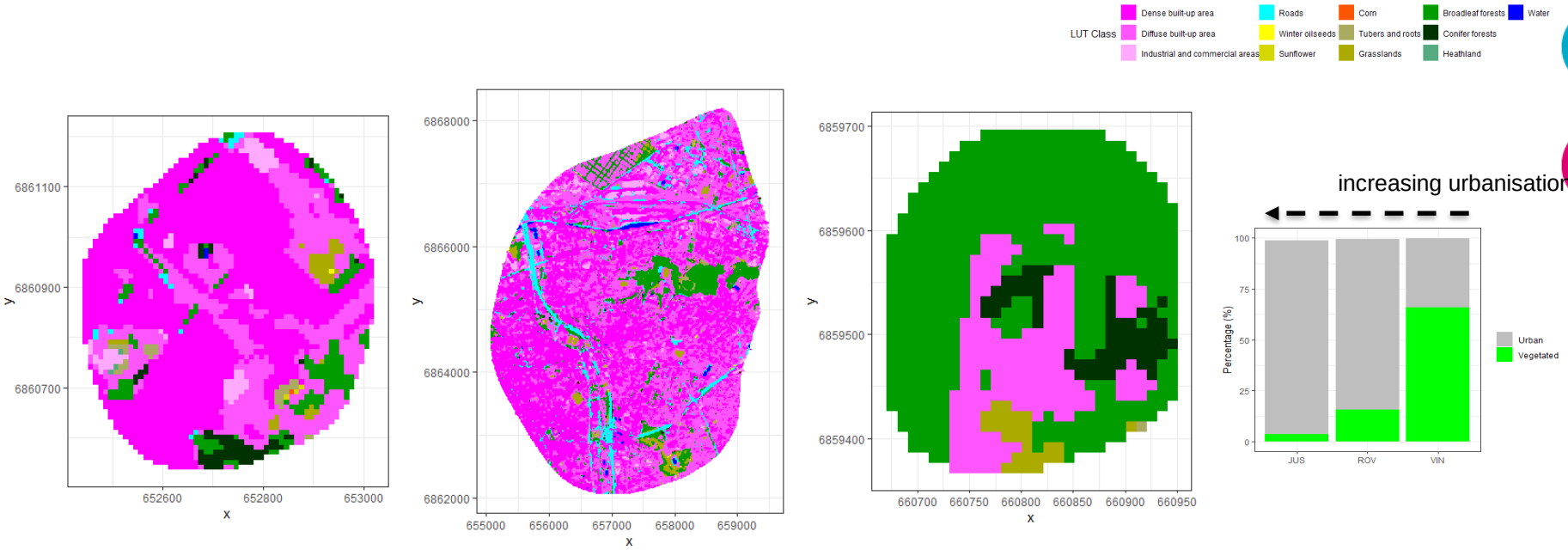
Land cover distribution



Joint influence of urban and vegetated zones on CO_2 fluxes for all sites

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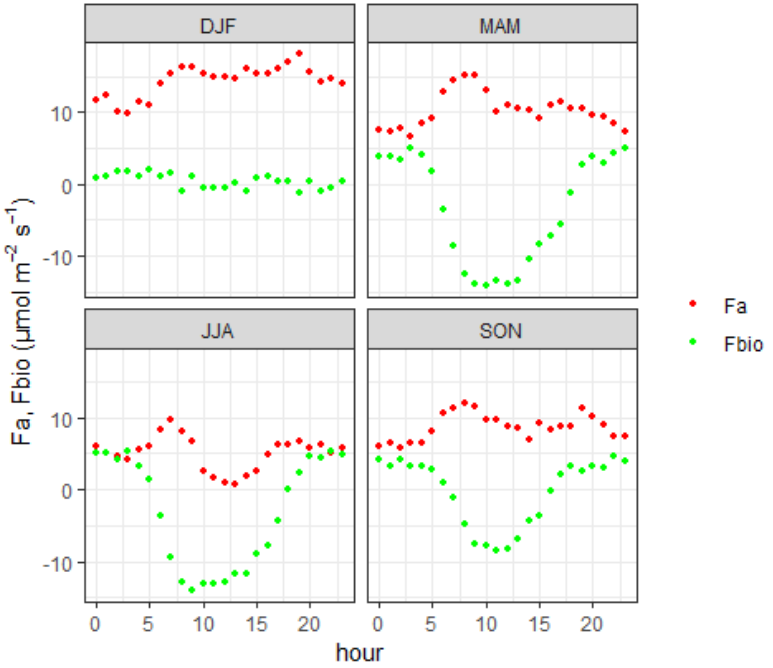
Determination of anthropogenic and biogenic fluxes from EC measurements

EC measurements
(Romainville, Vincennes)

$$\begin{cases} F_{VIN} = Surf\_urb_{VIN} \cdot F_{anthrop} + Surf\_veg_{VIN} \cdot F_{bio} \\ F_{ROV} = Surf\_urb_{ROV} \cdot F_{anthrop} + Surf\_veg_{ROV} \cdot F_{bio} \end{cases}$$

$$F_{anthrop}, F_{bio}$$



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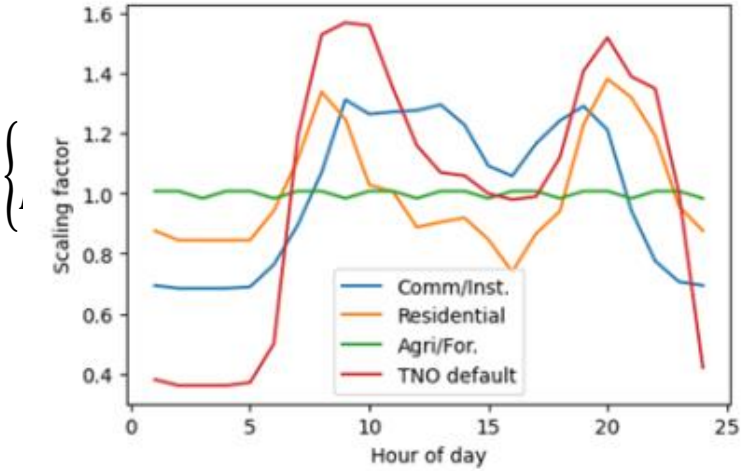
Determination of anthropogenic and biogenic fluxes from EC measurements

EC measurements

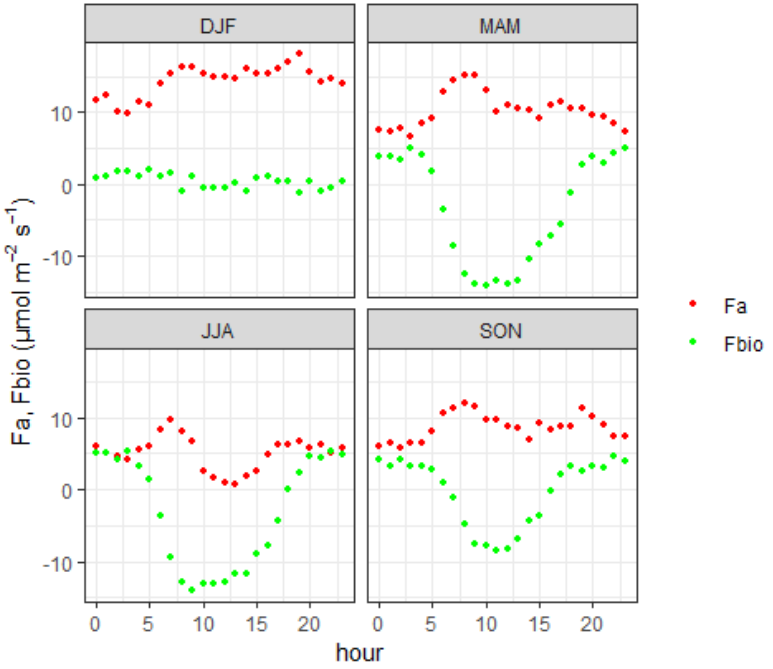


Activity curves for Stationary Combustion

$F_{anthrop}$, F_{bio}

F_{bio}

F_{bio}



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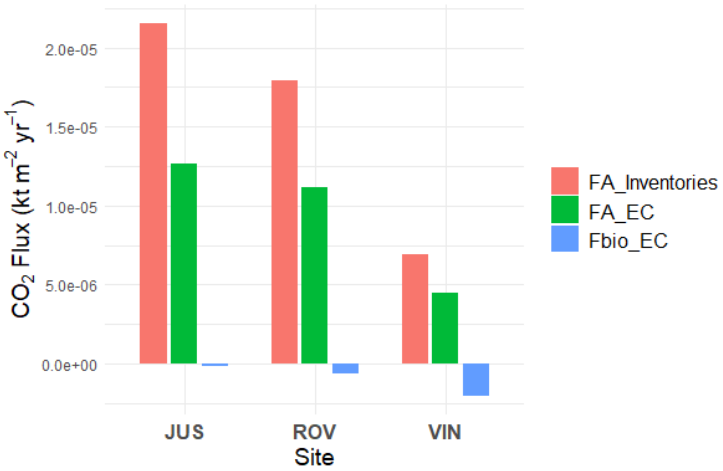
Comparison with emission inventories (Airparif 2018, 500 m x500 m)



- Is vegetation accurately represented in the land cover maps?
- Should a distinction be made between traffic and domestic heating when partitioning CO_2 fluxes?
- Is it necessary to improve the temporal and spatial resolution of emissions inventories?

Emission inventories provide higher emissions than EC measurements

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Conclusions

- Seasonal and diurnal variability of CO_2 and heat fluxes reflects the urbanization level of sites.
- Different repartition of energy between the sites
- Highest emissions are observed in Jussieu and Romainville, with distinct diurnal patterns for the two sites.
- The simple approach used to disentangle biogenic and anthropogenic fluxes provides reasonable seasonal cycles for both anthropogenic and biogenic fluxes.
- However, diurnal summer patterns suggest a possible underestimation of the anthropogenic component of the flux.
- Emission inventories indicate higher anthropogenic emissions than those resulting from eddy covariance measurements.

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Thank you for your attention!

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