Towards integrated city observatories for greenhouse gases

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ICOS Cities project

• brings together and evaluates measurement and modelling approaches for monitoring greenhouse gas emission in densely populated urban areas.
• supports the European Green Deal and aims at developing tools and services for cities in support of assessing emission reduction efforts.
Observation strategies

- Comparing techniques
- Identify synergies between approaches and scales
- In three cities (metropolitan, large, mid-size)

1. High-precision tall tower concentrations
2. Roof- and street-level networks
3. Ground-based total column network
4. Tall eddy covariance towers
5. Biogenic process observations
6. Ground-based wind and meteorology
7. Satellite total column observations*
Zurich Observatory
Jul 2022 – Jun 2024

- High-precision background station (2)
- Mid-precision rooftop station (20)
- Low-precision street level station (60)
- Tall-tower eddy covariance (1)
- Doppler wind LIDARs (2)

Legend:
- Built-up area
- Forests
- Agriculture
- Water bodies
Munich Observatory Jan 2023 – Dec 2025

- Total column FTIR station (5)
- Mid-precision rooftop station (20)
- Low-precision street level station (100)
- Tall-tower eddy covariance (1)
- Doppler wind LIDARs (3)

Map showing various stations and their locations.

- Built-up area
- Forests
- Agriculture
- Water bodies
Mid- and low-cost sensors
Biogenic activity – from satellite to local observations

e.g. Sentinel enh. veg. Index (EVI)
Zurich Emission inventory

- 60 source categories
- vector-based (area, line, point sources)
- > 20,000 point sources
- GHG: CO₂, CH₄, N₂O
- AQ: SO₂, NOx, CO, VOC, C₆H₆, PM, NH₃
Simulation of air flow and transport
Tall building as observation point

Collaboration: city police and buildings administration
CO$_2$ emissions observed at the Hardau tower

Footprint (source sensitivity)
average July 2022 – March 2023

Eddy-covariance CO$_2$ emissions
Total column network

Figure by Chen/F. Dietrich
Atmospheric inversion over Paris

Inventory based emissions and CO₂ measurement stations (cyan circles). Inversions were performed for the Greater Paris region (blue line) and IdF region (black line).

Annual fossil fuel CO₂, IdF 2005 to 2021. Blue boxplots are distribution of posterior CO₂ emissions from an ensemble inversion configurations.

Jinghui Lian et al., EGUsphere preprint (2023), doi.org/10.5194/egusphere-2023-401
ICOS Cities

• Concurrent observations with different systems in metropolitan (Paris), large (Munich) and mid-size city (Zurich).
• Exploration of novel and complementing technologies (e.g. low-cost sensor networks, co-species eddy fluxes, $^{14}$C fluxes)
• Create a blueprint for independent urban monitoring and attribution of GHG emission reduction efforts.
• The best and most cost efficient strategy will likely depend on local parameters and on local support.
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http://www.icos-cities.eu

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