WP 7: OBSERVATIONS

CoCO2 Presentation Day

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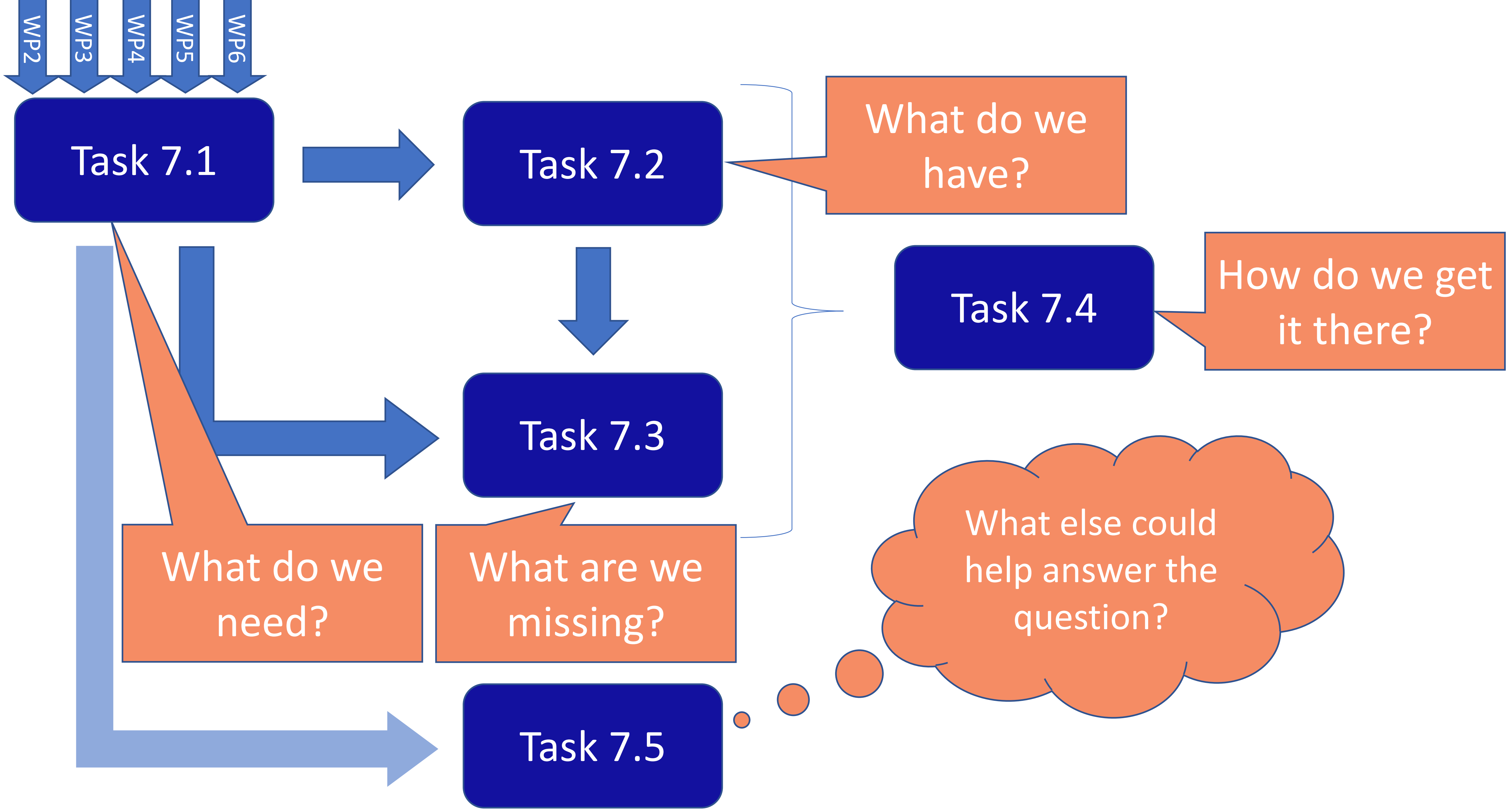
Co-ordinated by ECMWF

CoCO2
Prototype system for a Copernicus CO_2 service

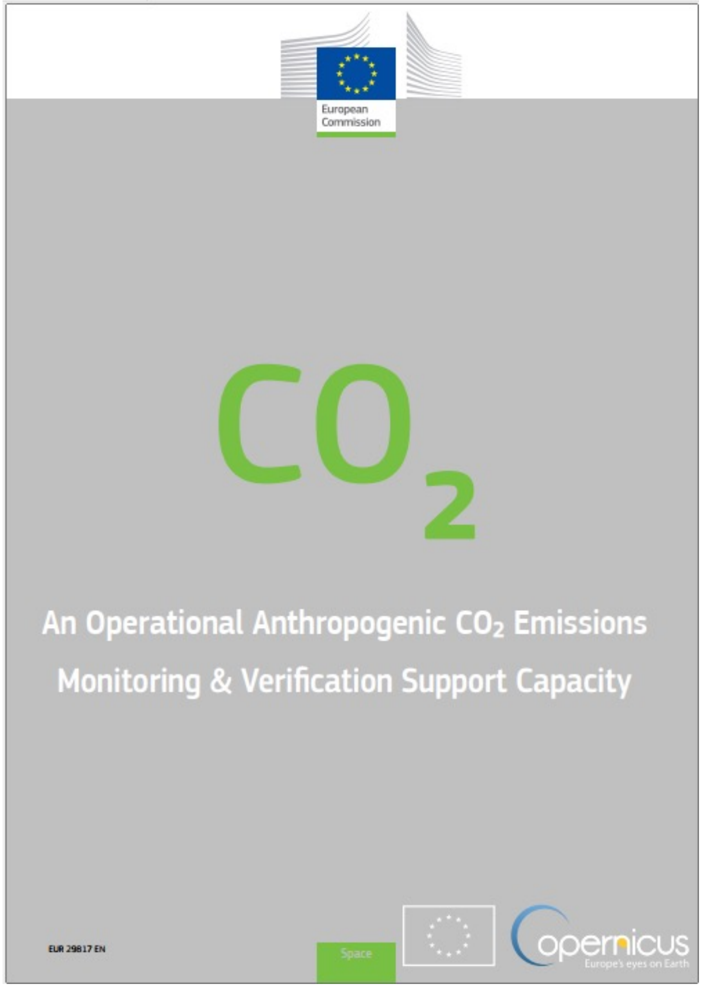

WP2
WP3
WP4
WP5
WP6
Task 7.1
Task 7.2
What do we have?
Task 7.4
How do we get it there?
Task 7.3
What do we need?
What are we missing?
What else could help answer the question?
Task 7.5

What do we need: How are *in situ** data used in an MVS capacity?

From the [“Green Report” (Pinty et al, 2019),](#) *in situ* measurements are required to:

- calibrate and validate the space component of the MVS capacity,
- assimilate data in the models and to integrate information in the core MVS capacity,
- validate and further improve physical models that govern the evolution of CO_2 in computer simulations, and
- evaluate the output generated by the MVS capacity for its end users.

Timeliness



* Note that in the context of the Copernicus Programme, *in situ* data refers to measurements collected by ground-based, seaborne or airborne sensors, including remote sensing sensors, as well as reference and ancillary data.

What do we need: Collecting input from across the project

- First iteration (2021): online survey
- Second iteration (2022): virtual interviews (by work package)
- Data needs documented in project deliverable report 7.1, second iteration (D7.2) prepared for review
- Accompanying project deliverable (D7.4) documenting current availability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CoCO2: in-situ and ancillary data needs

Within WP7 we're collecting and documenting the in-situ and ancillary data requirements from across the project, so we can ensure that these data streams are available when they are needed. The goal is to identify and mitigate potential bottlenecks down the road, as we move towards an operationalized service.

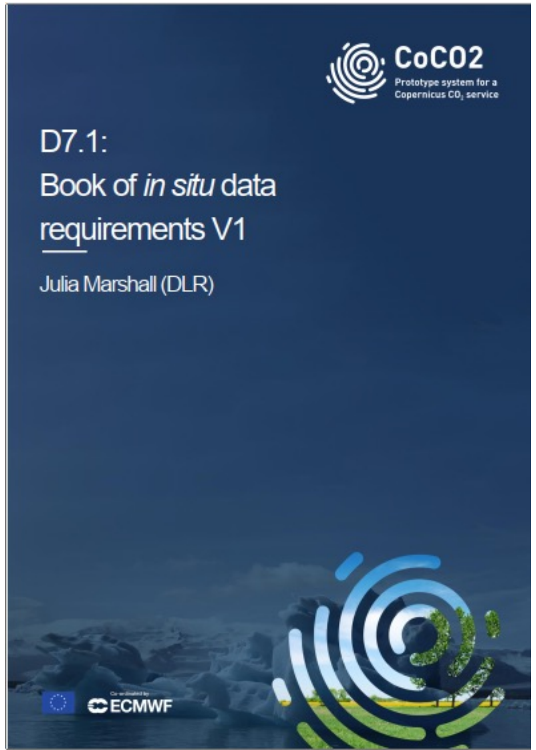
We need to consider these data needs in terms of methodology, accuracy, data quality, spatial-temporal resolution, and timeliness. There might be different requirements on the same type of data at different point in the system, e.g. a fast-track product needed for near-real-time assimilation vs. a fully quality-controlled product used for evaluation and quality control later in the processing chain.

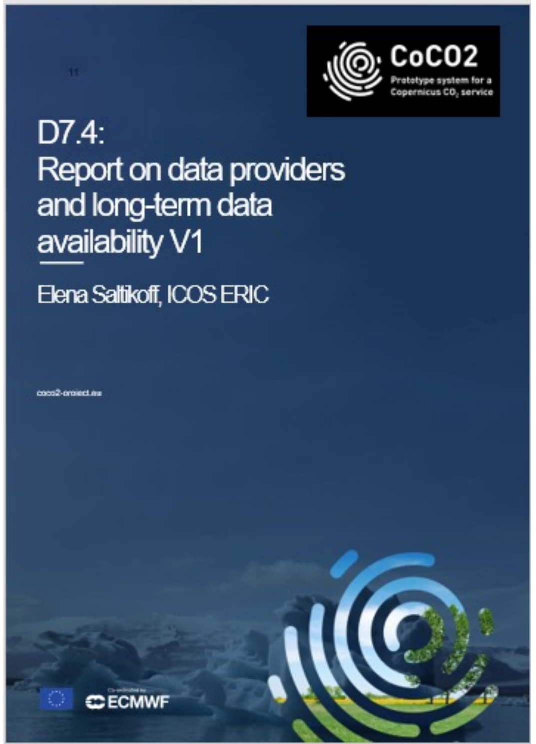
Please respond to this survey based on your activity in a given task. If you are involved in different tasks, please fill out the survey again for each task.

Note: We are not limiting this data collection activity to strictly in-situ data (or even just sub-orbital data, the Copernicus definition of in-situ), but rather including additional ancillary data that may come from satellite, such as night lights measurements, or MODIS reflectances.

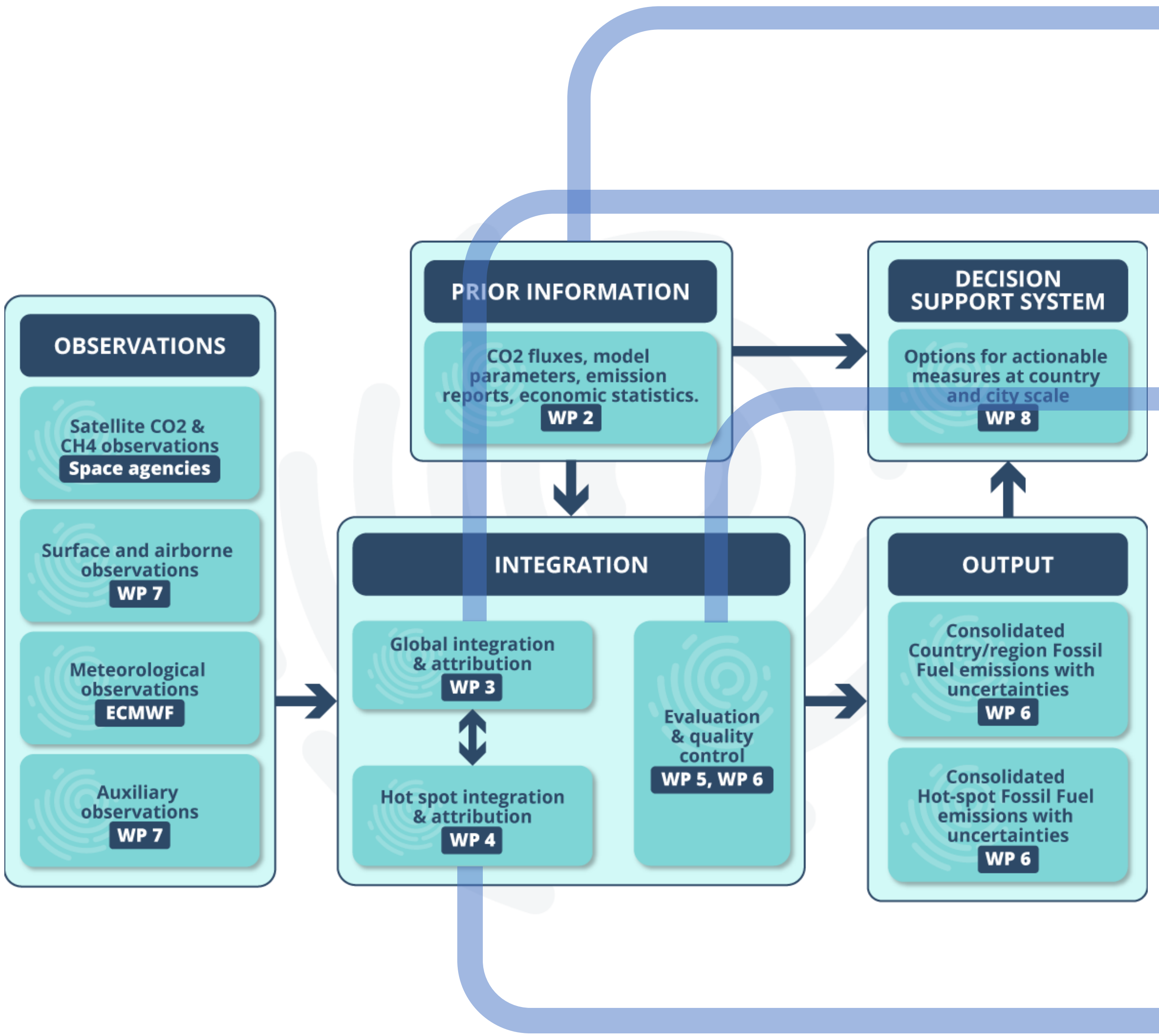
The survey consists of three parts:

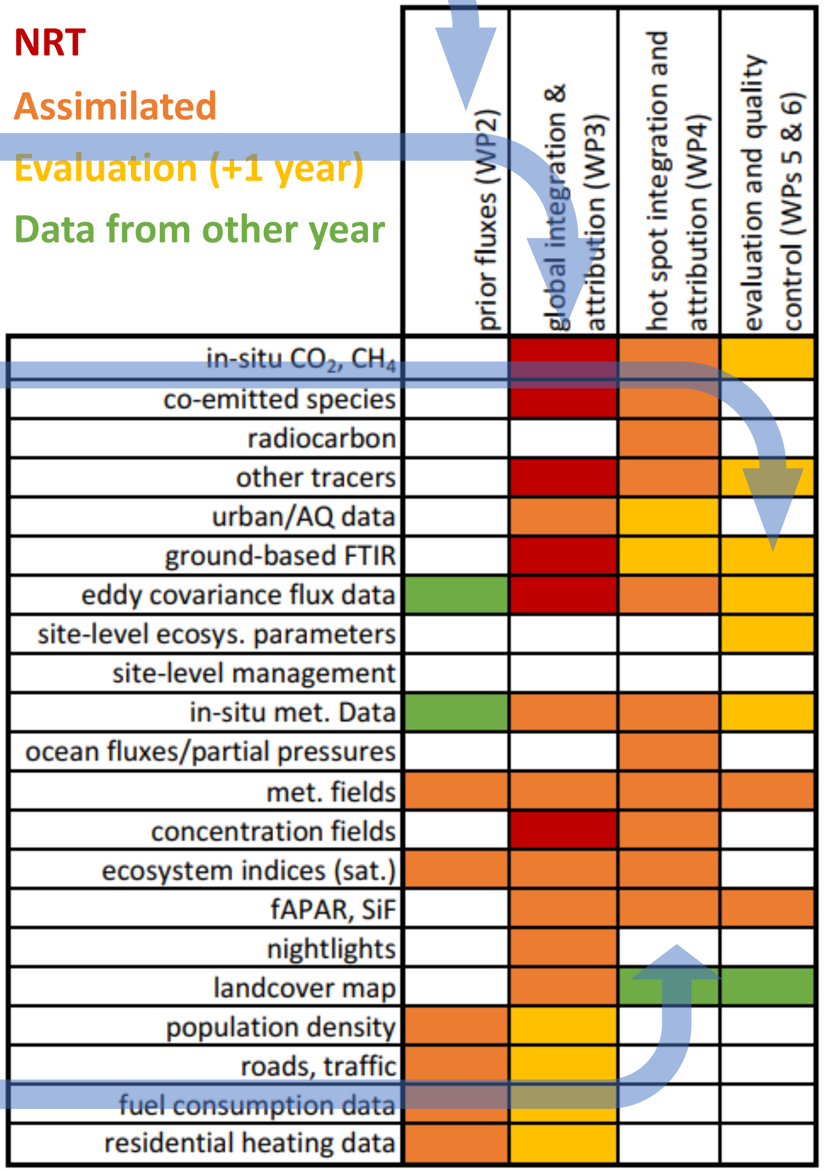
1. the first collects some minimal information about the task and who's doing it





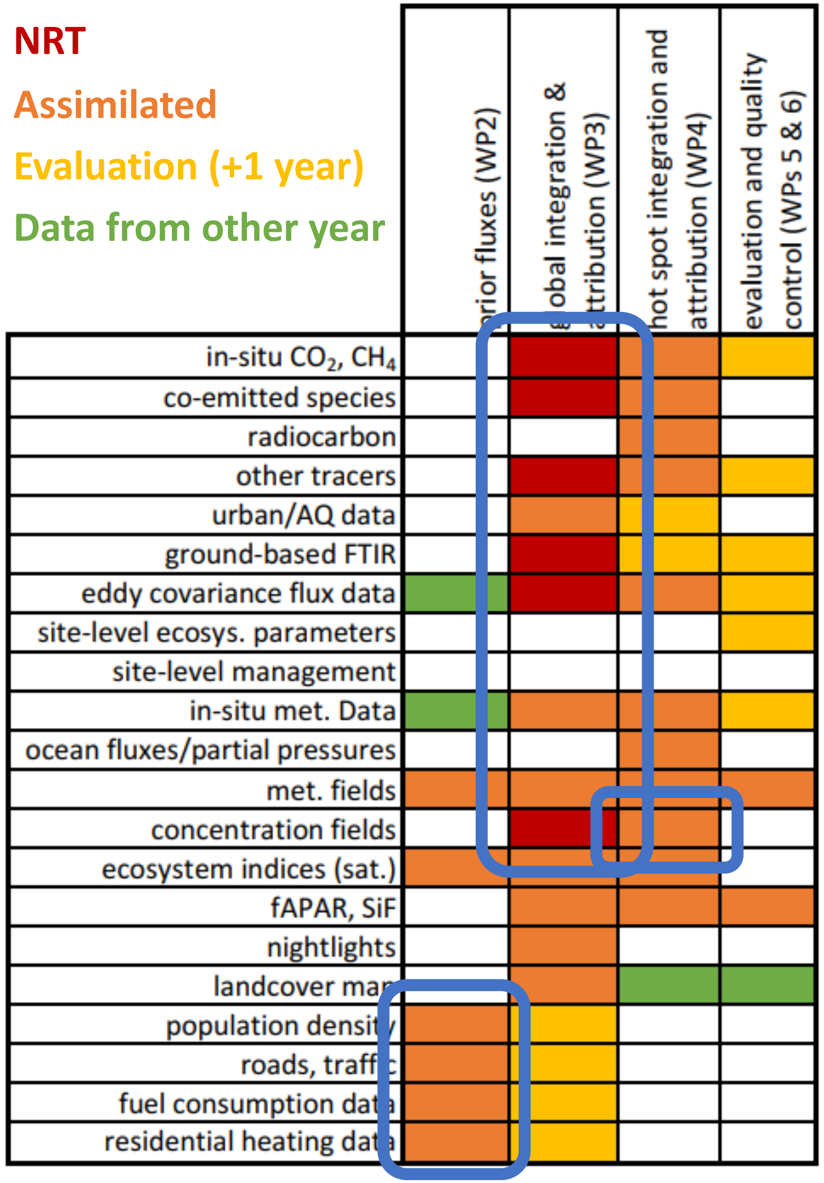
What do we need: Timeliness requirements





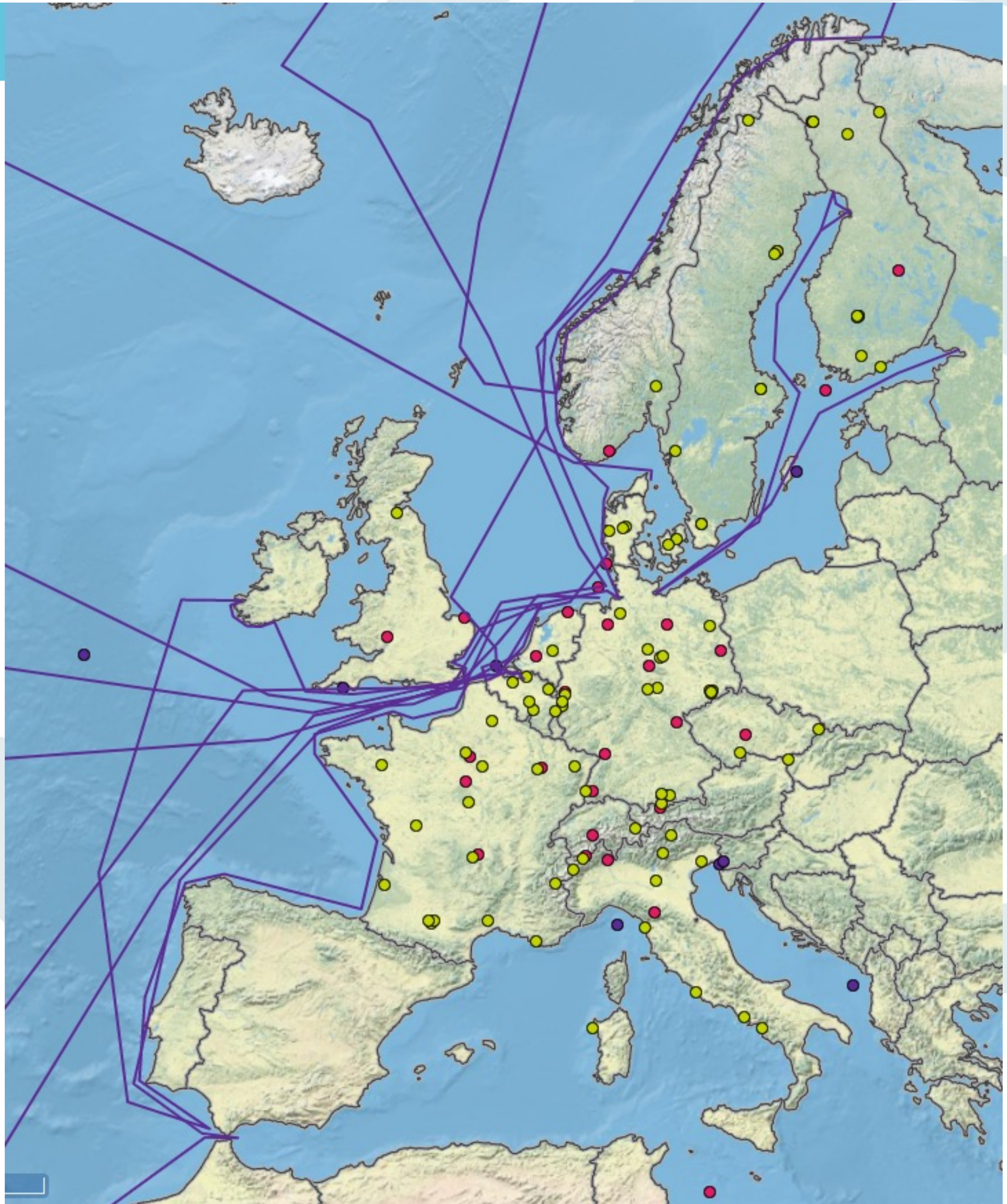
What do we need: Timeliness requirements

- NRT needs driven by global assimilation system (WP3/ECMWF)
- Regional/hotspot assimilation (WP4) requires input from global system (WP3) → *NRT dependency*
- (Anthropogenic) priors (WP2) remain out of step of NRT assimilation, extrapolation required



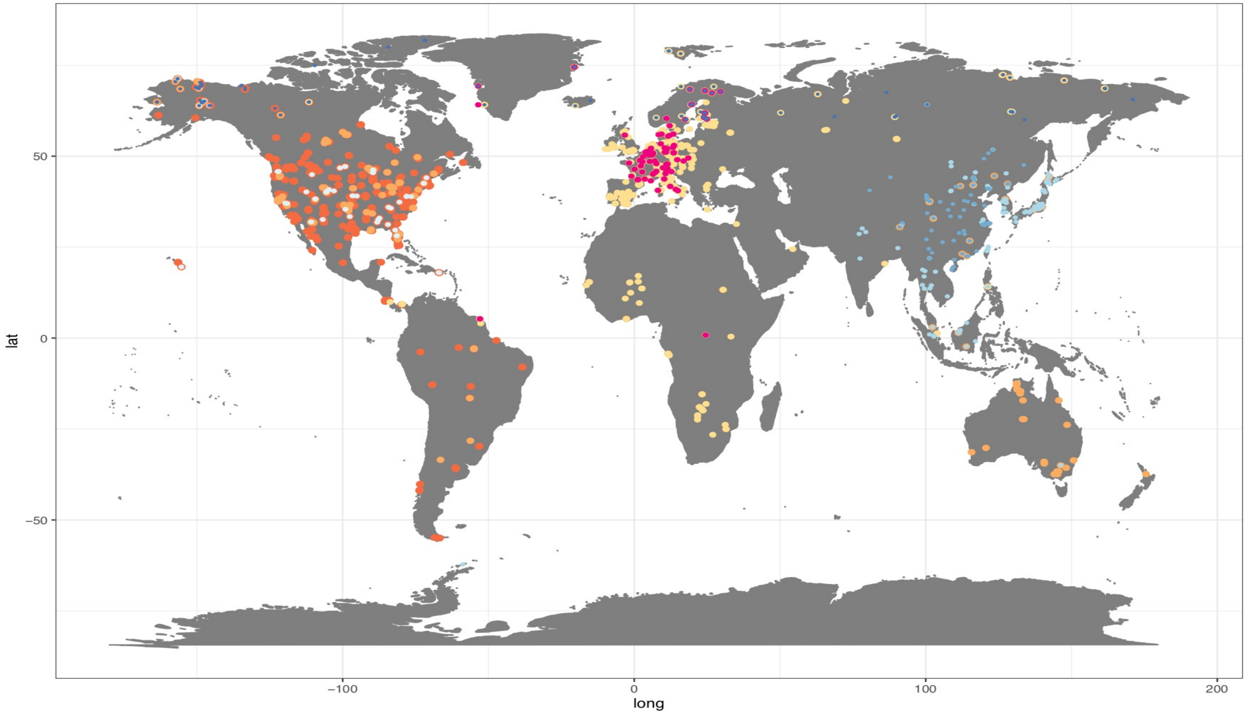
What we have now

- ICOS produces 25-30 TB of sensor data per year, mostly time-series of observed variables, for example atmospheric carbon dioxide concentrations, given for every 30-minute interval.
- There 150 stations measuring the atmosphere (tall towers), ecosystems (flux measurements) and oceans (pCO2 and more), with 50-100 variables each.



What we have now

- Information about existing stations and measurements networks has been gathered, e.g. at the ICOS Science conference
- Second iteration of the deliverable documenting data providers and long-term data availability (D7.5) being prepared for September 2023
- Exploiting synergy with the developing WMO GHG infrastructure
- ICOS ERIC has a prominent role in the study group and upcoming symposium



From D7.4: Map of the global distribution of 1699 eddy covariance measurement sites reporting CO_2 and energy fluxes.

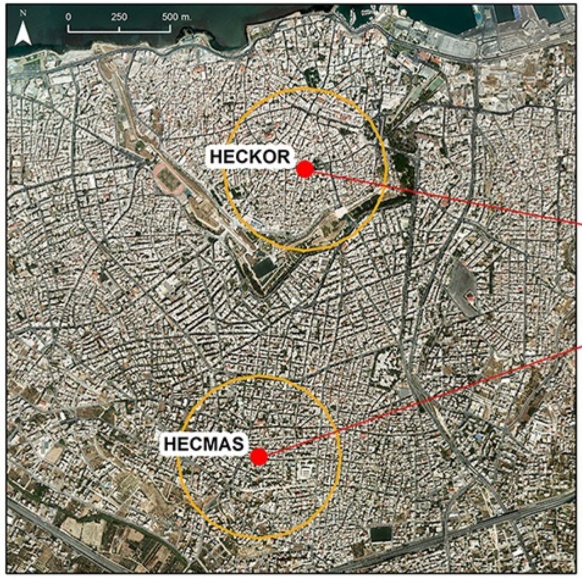
What else could help answer the question?

- Urban flux measurements from Heraklion
- Urban measurement campaign and flux data from Krakow
- Regular GHG profiles using AirCore

Heraklion urban flux measurements

Heckor

FFP model (Kljun et al., 2015)



Hecmas

Both flux towers are equipped with IRGASON Integrated CO2/H2O Open-Path Gas Analysers, 3D Sonic Anemometers and Net Radiometers.

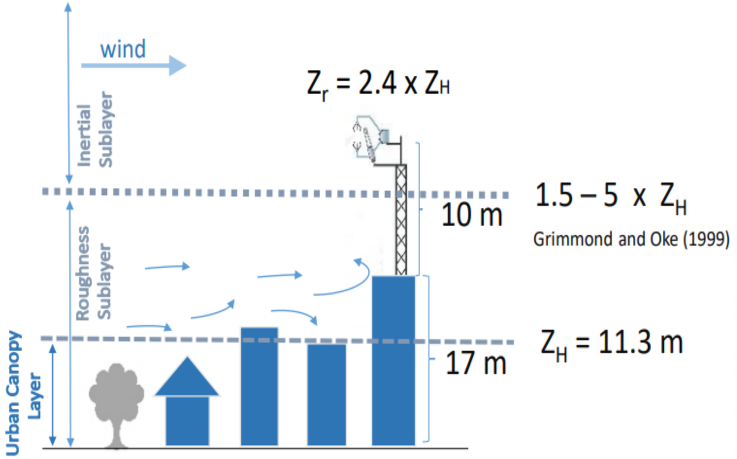
- HECKOR operates since autumn 2016 at the city center.
- HECMAS operates since spring 2021 at a residential area in Heraklion.

Site description: HECKOR

Land cover map of the Heraklion city center. The average turbulent flux source area (1 year-2017) isopleths are displayed as white contours, surrounding the location of HECKOR.

The center of Heraklion is an interesting study area in the global network of urban EC stations due to the urban morphology, the Mediterranean climate and the mixture between residential neighborhoods and busy commercial zone.

The EC tower (HECKOR)



Site description: HECKOR

Land cover map of the Heraklion city center. The average turbulent flux source area (1 year-2017) isopleths are displayed as white contours, surrounding the location of HECKOR.

The current nearly 5-year study is focused on determining the extent to which dynamic shifts in urban structure and traffic regulations in the city center effect urban eddy covariance CO_2 emissions in Heraklion’s city center.

Major modifications:

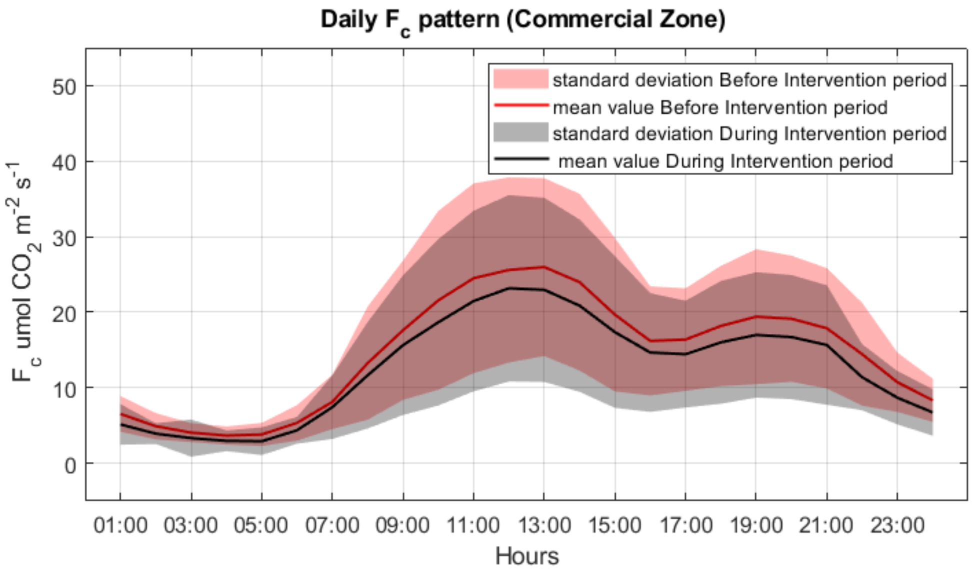
1. Heraklion's municipality has been implementing extensive traffic regulation and rebuilding initiatives since January 2018, occurred inside the flux footprint area.

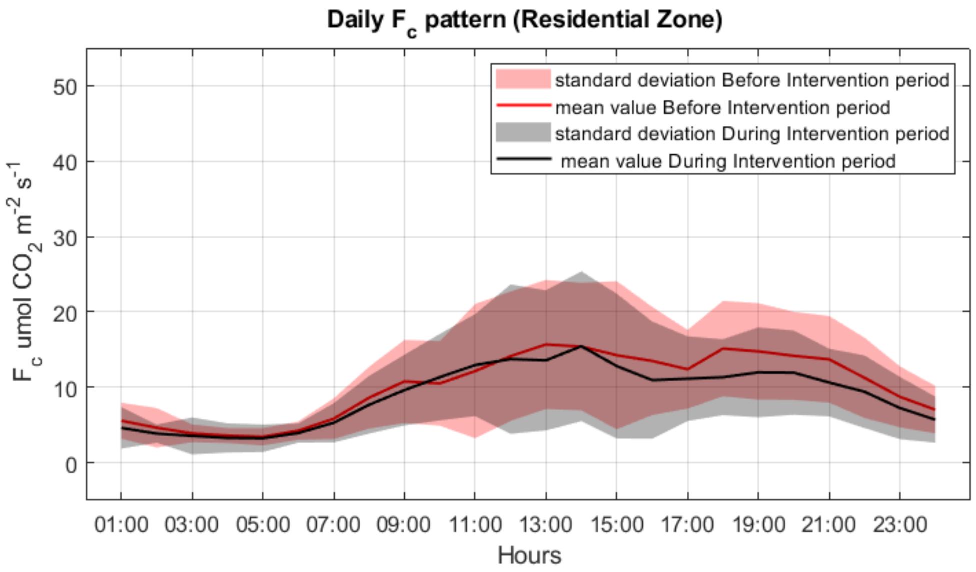
Intervention Starting Date: **05 January 2018**

I. Road Closing
II. Pedestrinazations
III. Minor Planting
IV. Traffic Regulations

2. Reduction of vehicular traffic during lockdown periods resulted in a temporary reduce of CO_2emissions. Recent study have shown that CO_2 emission reductions showed a **reduction of 63%** during the **lockdown period** compared to previous years. (Nicolini et al, 2022)

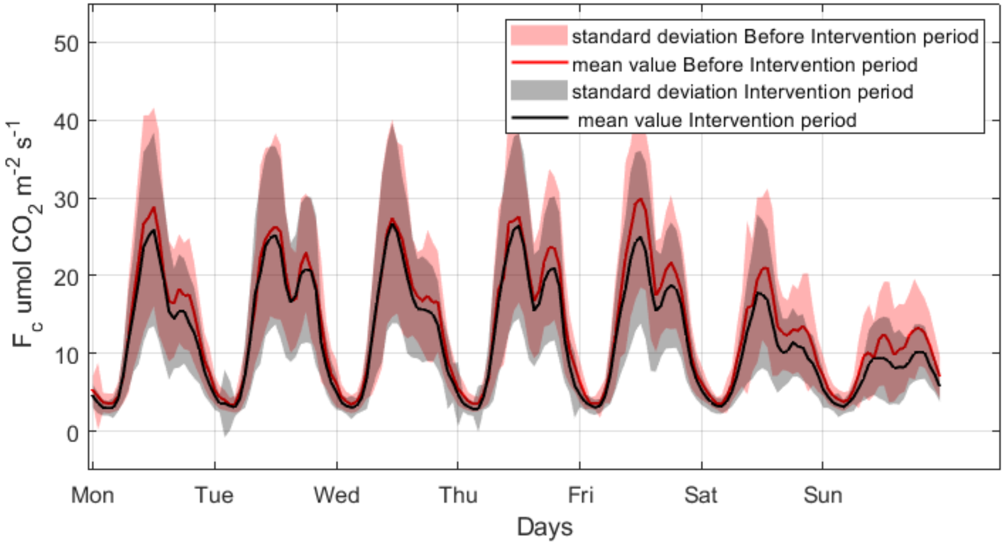
Daily F_C Patterns





Daily F_c Patterns:

- **Before Intervention Period**: 01 January 2017 – 04 January 2018
- **After Intervention Period:** 05 January 2018 – 30 April 2022
- Lockdown Periods were removed.
- Daily F_c Patterns in Commercial Zone show two characteristic peaks, which follow citizens' commercial and business behavior. In contrast, in Residential Zone the two peaks are not easily observed and F_c are significantly lower.
- On a weekly basis F_c, weekdays follow the traffic pattern, contrary to weekends. With an exception for Saturday's midday, when commercial sector is still open.

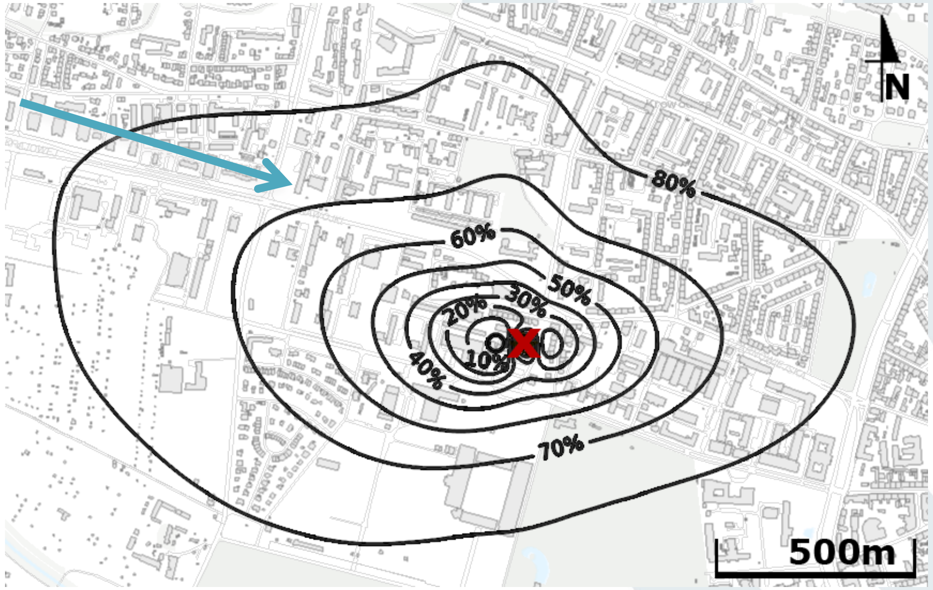


Krakow eddy covariance site

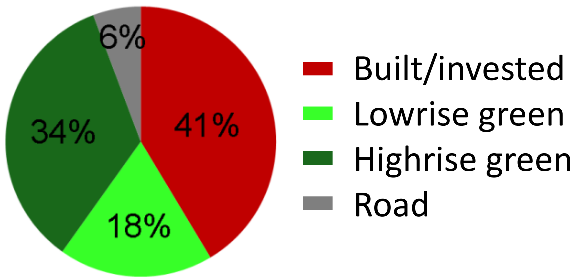
The AGH eddy covariance site PL-Krk was established in February 2021. Since then, continuous measurements of sensible and latent heat, as well as CO_2 fluxes are performed at a height of 40 m with Licor-7500DS and Gill Windmaster anemometer. Additional sensors provide meteorological and incoming/outgoing radiation information.

In the neigborhood several urban landscapes are present: both loosely and narrowly set buildings, including the university campus as well as private housing; busy streets; and significant amount of green areas including municipal park and a football stadium.

The site surroundings. The mast is mounted on a rooftop of the building in the bottom left corner.



Flux source area with the site location marked with **X** and prevailing wind direction marked with an arrow.

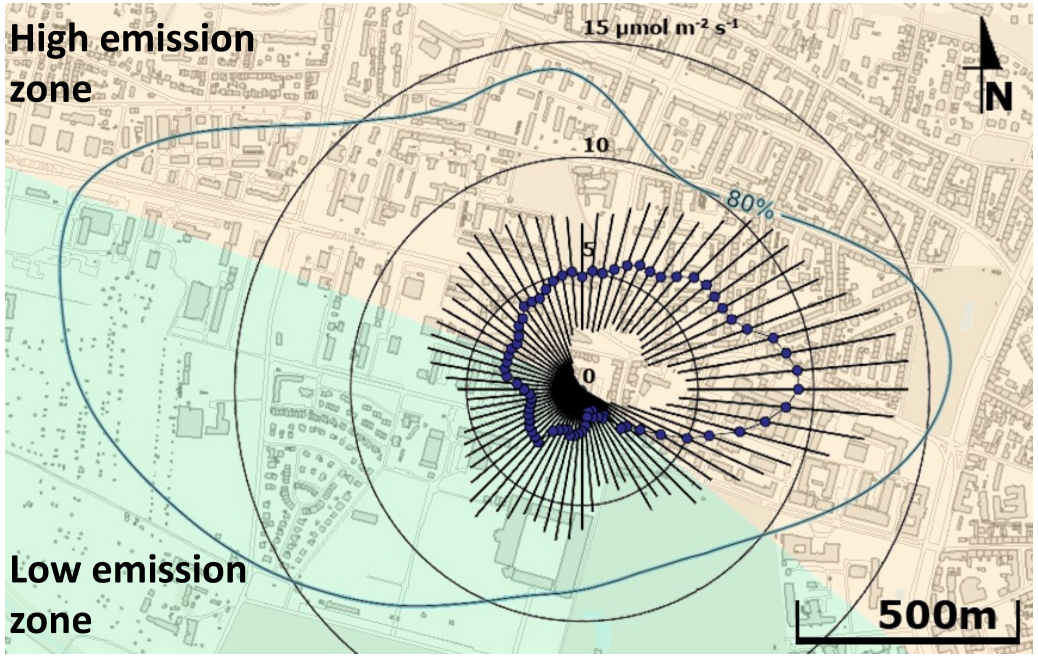


Landuse distribution within 500 m radius

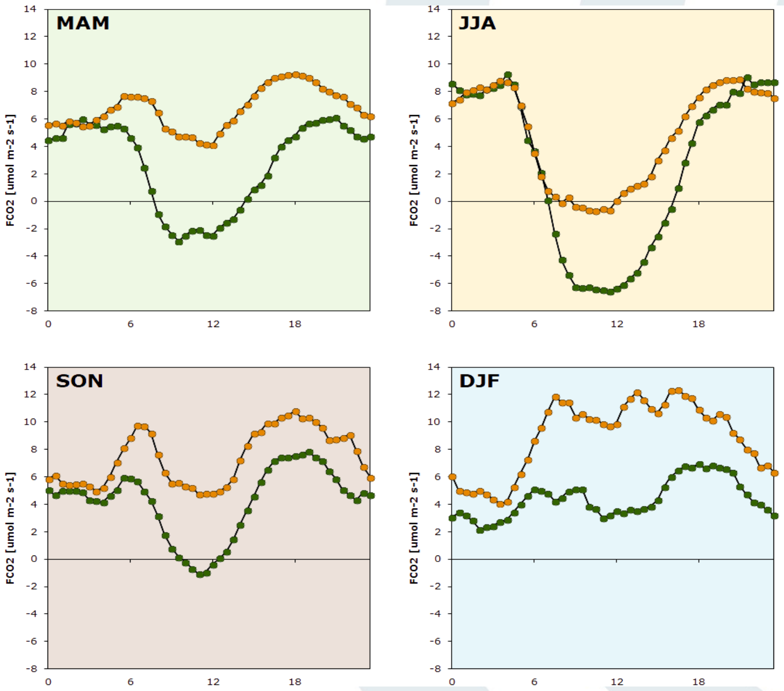
Krakow eddy covariance site

Two zones with distinct CO_2 emission patterns:

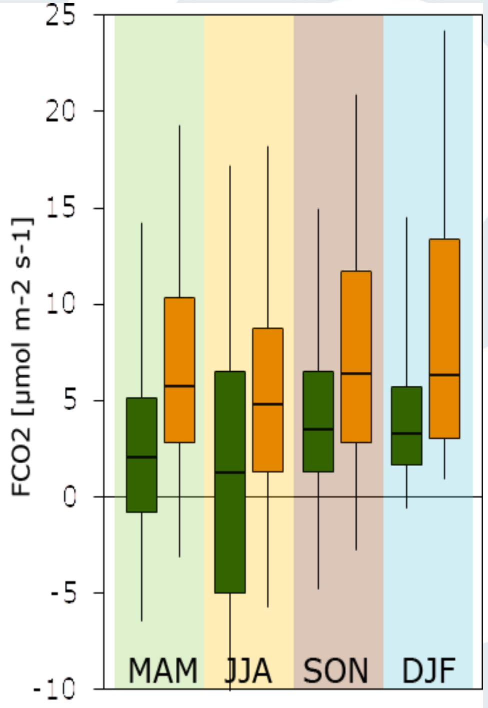
1) low emission zone south of the site, with green areas generally prevailing, and
2) high emission zone north of the site, with closely build-up residential areas as well as busy traffic lanes and intersections.



CO_2 flux (25-50-75%) directional distribution. Flux source area 80%-isoline is highlighted in blue; green and orange shading are the CO_2 emission zones (with respective color coding in the data plots).



Mean diurnal variability of CO_2 flux within the zones with respect to a season.



Seasonal mean CO_2 flux within the zones.

Vertical profiles of CO_2 in Krakow

From March 2021 to February 2022, several measurement campaigns were performed, each consisted of a number of flights. Air pressure, temperature, and humidity were measured as well as CO_2 and CH_4 concentration during each flight. Each measurement campaign lasted at least from the afternoon until the next morning.

Instruments travelled up and down inside the air balloon basket.

Date	Method	Number of flights
2021/03	Balloon	12
2021/04	Balloon	15
2021/06	Balloon	48
2021/07	Balloon	29
2021/09	Balloon	32
2021/10	Drone	13
2021/10	Balloon	29
2021/11	Balloon	34
2021/12	Balloon	21
2022/01	Drone	16
2022/02	Drone	20

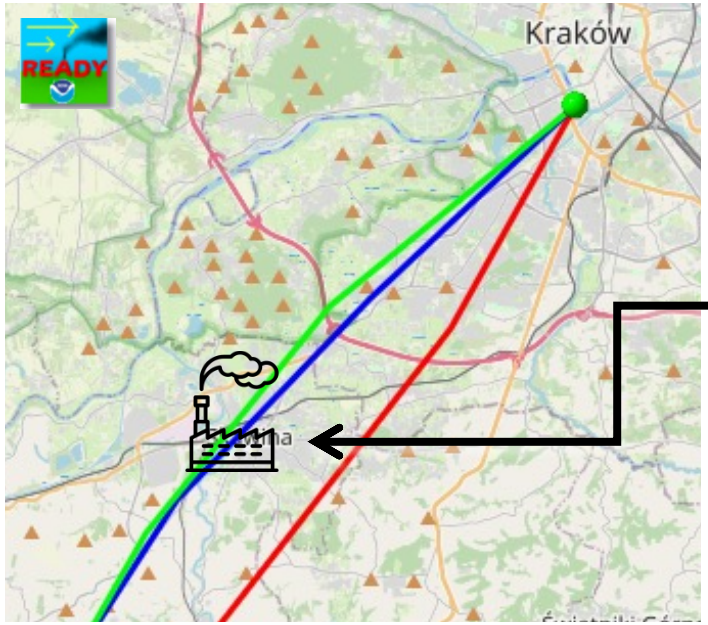
In total: 269 vertical profiles.

A 200m long tube connected the drone with the analyzer.

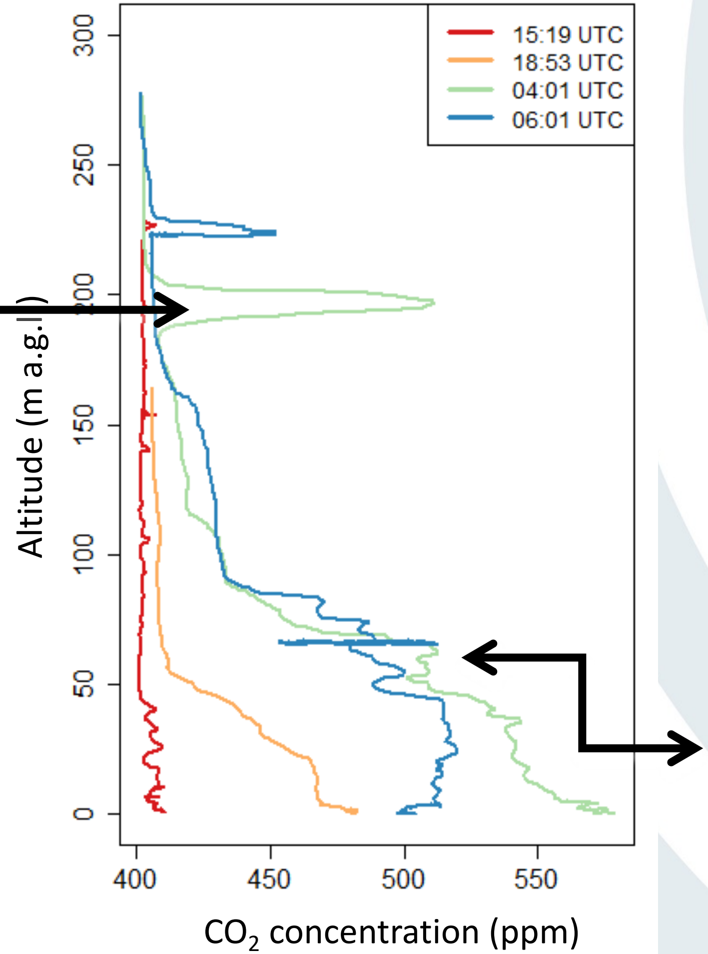
Vertical profiles of CO_2 in Krakow

Example profiles from September 2021.

A peak in CO_2 concentration was detected during the night at ca. 200 m agl. Backward trajectory confirmed its source as a power plant. Later on **the plume dispersed**, resulting in lower peak concentration and higher level of occurrence. In **the evening** and during **the night**, a buildup of CO_2 under the inversion took place, in contrast to **daytime** well-mixed boundary layer.



Backward trajectories of the air at 190 m agl calculated with GFS.25 via NOAA HYSPLIT dispersion model. Location of a power plant is marked.

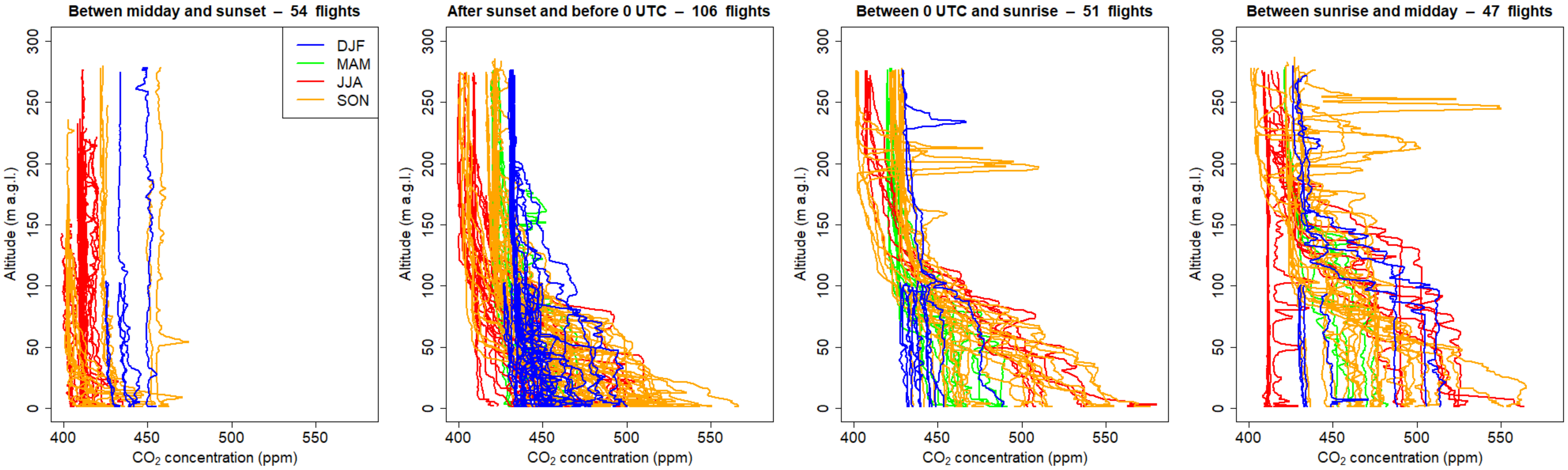


Sun rises over Krakow, breaking the nocturnal inversion.

In the top right corner of the landscape, one of the main CO_2 emitters in the area – a power plant is visible (not the one being the source of CO_2 peak this time though).

Vertical profiles of CO_2 in Krakow

Seasonal (different colours) and diurnal (different panels) variability of CO_2 vertical profiles.



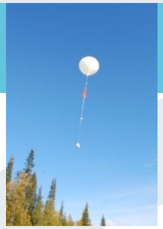
Afternoon: well-mixed boundary layer.

Evening: concentration buildup near the surface.

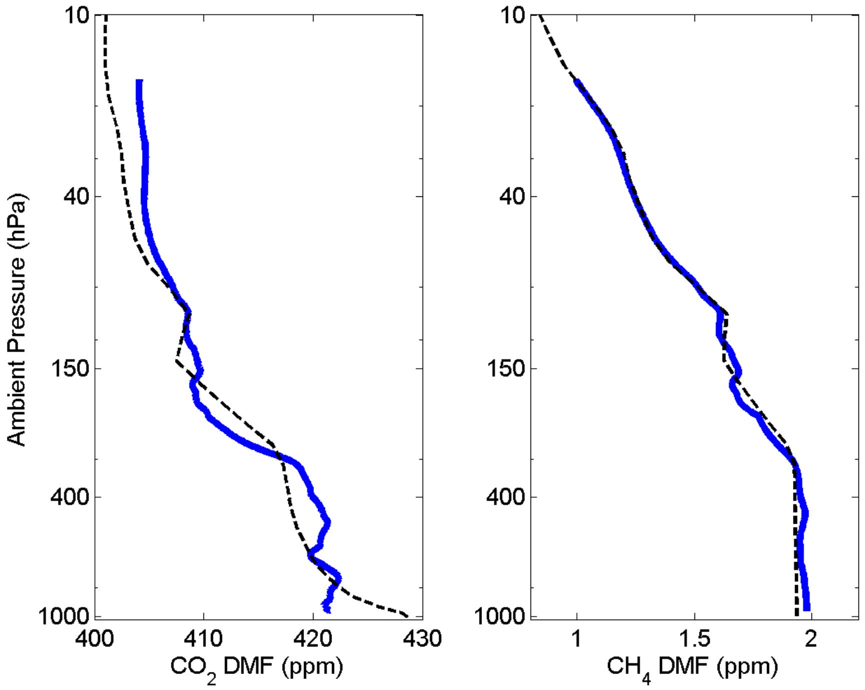
Late night: concentration buildup reaching the top of nocturnal boundary layer.

Morning: vertical mixing sets on, breaking the nocturnal boundary layer.

FMI profiling activities



- Balloon borne AirCore observations at the Sodankylä TCCON site in Northern Finland.
- Development work of the AirCore analysis system, regarding improvements to the pre-flight and post-flight gas analysis.
- FMI has also started a new activity to measure N_2O profiles, using an AirCore.
- Drone-borne measurements of CH_4 and CO_2 were performed in the vicinity of the Sodankylä ICOS site.



An example of AirCore profiles of CO_2 and CH_4 (red) versus TCCON GGG2020 a priori profiles on 26 April 2021 (dashed line).

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Coming up for WP7

- Documenting the metadata, data quality, and timeliness needs associated with new data streams (also drawing upon ICOS Cities project)
- Developing a data transfer pipeline to supply the in situ data needed by the operational MVS
- Documenting gaps in the currently available measurements, to prioritize the deployment of new measurements

THANK YOU

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