



**CoC02**

Prototype system for a  
Copernicus CO<sub>2</sub> service

# WELCOME TO THE COC02 1<sup>ST</sup> GENERAL ASSEMBLY

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From science innovation to  
operational services

Richard Engelen, Project Coordinator  
ECMWF  
16/11/2021

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958927.



**Period: January 2021 – December 2023**

**With support from:**

**CO<sub>2</sub> Monitoring Task Force**

**External Expert Group**

**Inventory Agency Advisory Board**

**CoCO2 reviewers**

**HaDEA**



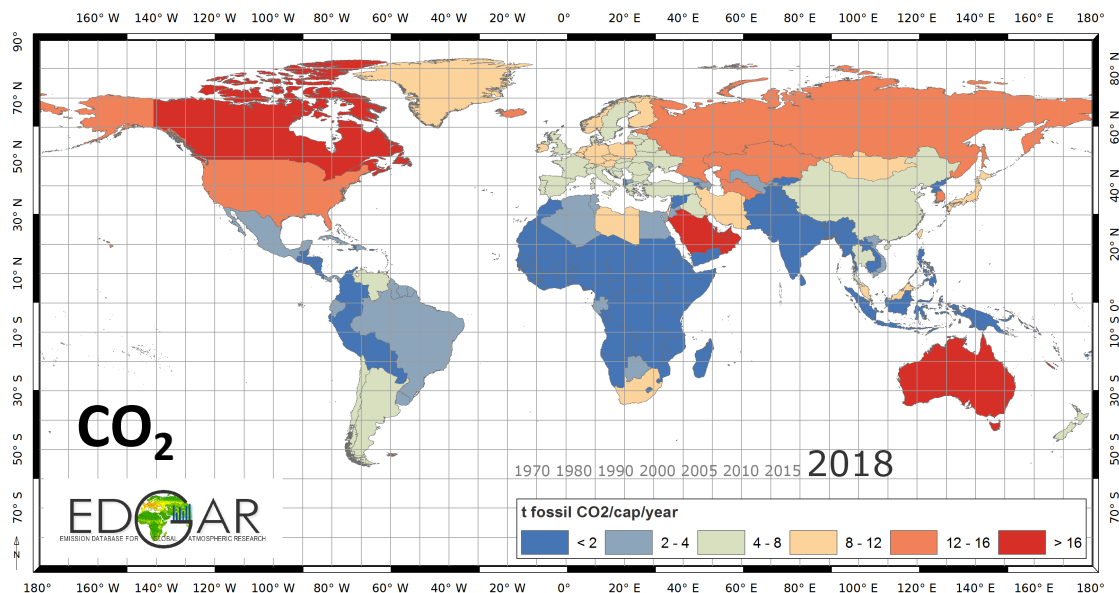
# CoCO2

**Prototype system for a  
Copernicus CO<sub>2</sub> service**





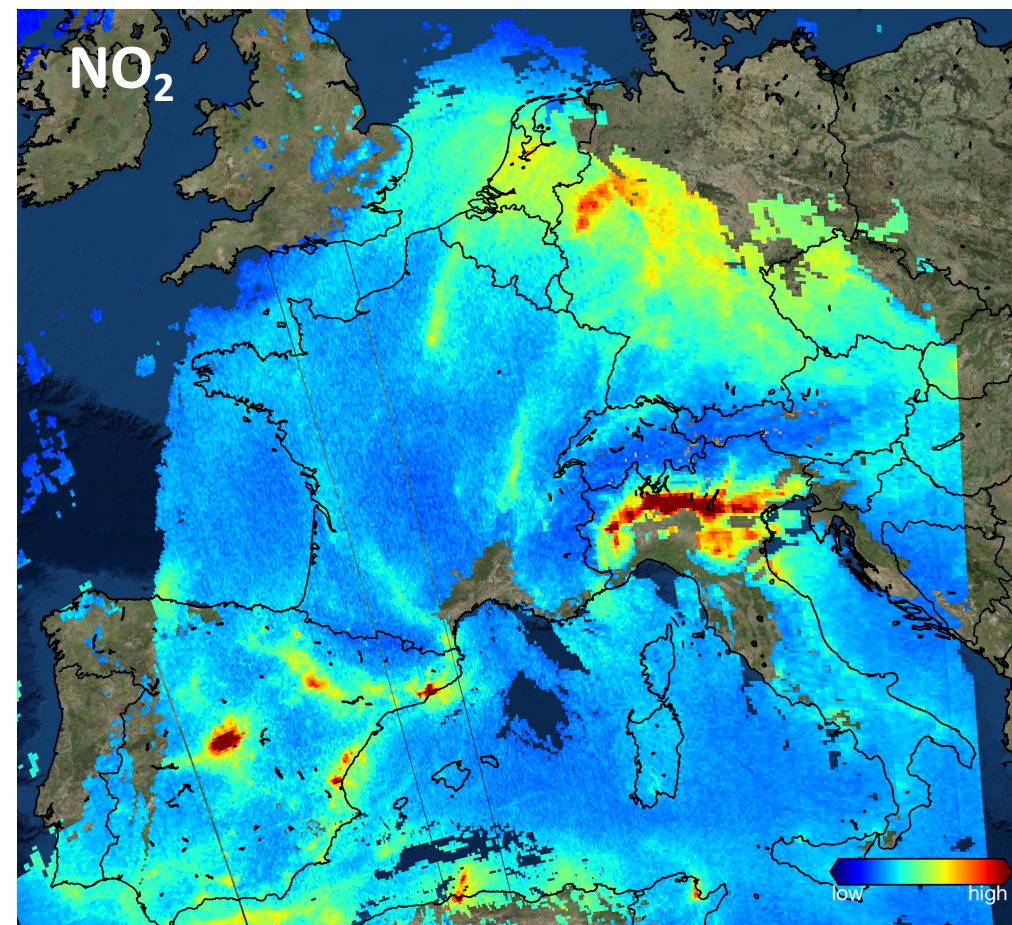
# Understanding our emissions and how they change



CO<sub>2</sub> emission estimates based on nationally reported data

Observing atmospheric composition from space is a rapidly developing field. Many exciting new instruments, large and small, are being developed and launched.

Can we use Earth observations to improve our knowledge of anthropogenic emissions?

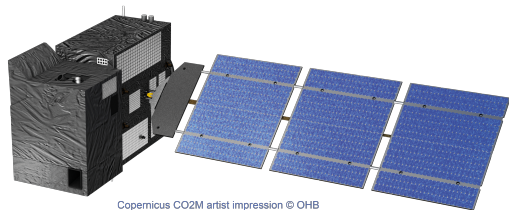


contains modified Copernicus Sentinel data (2017), processed by KNMI/ESA  
NO<sub>2</sub> tropospheric columns observed by Sentinel-5p





# Challenges of observation-based emission monitoring

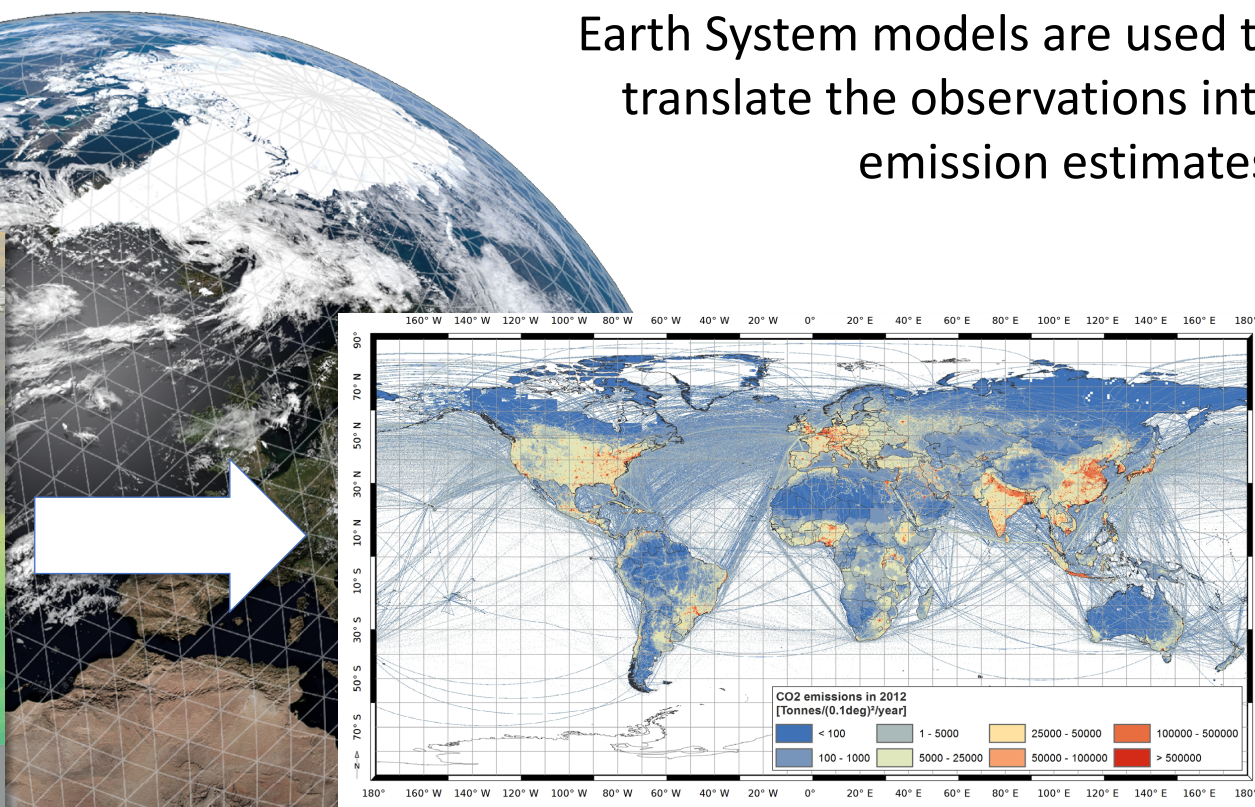
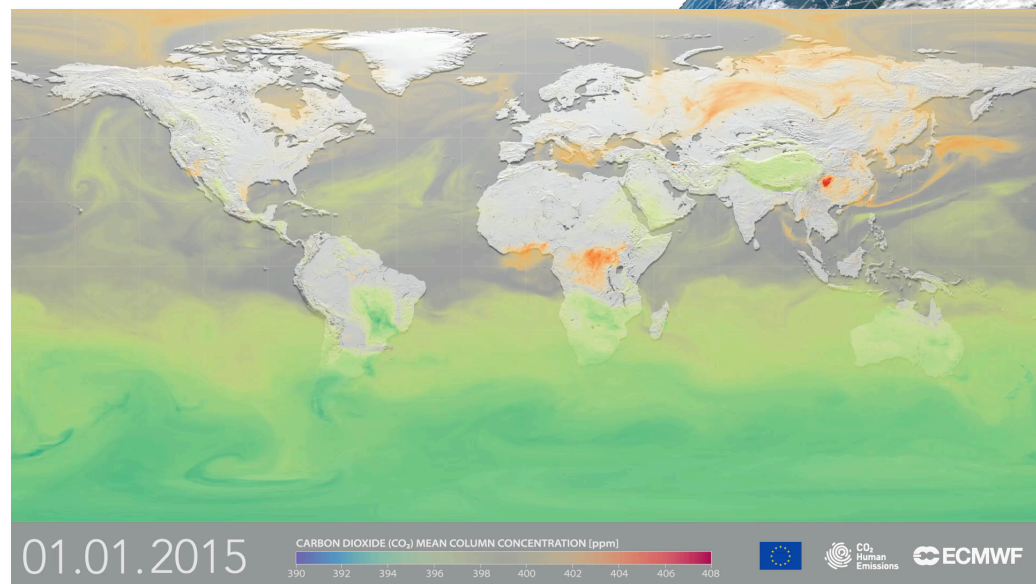


Copernicus CO2M artist impression © OHB

Satellites do not measure emissions directly; they measure the impact of emissions on the atmosphere.

Satellites see only the total impact of anthropogenic and natural effects.

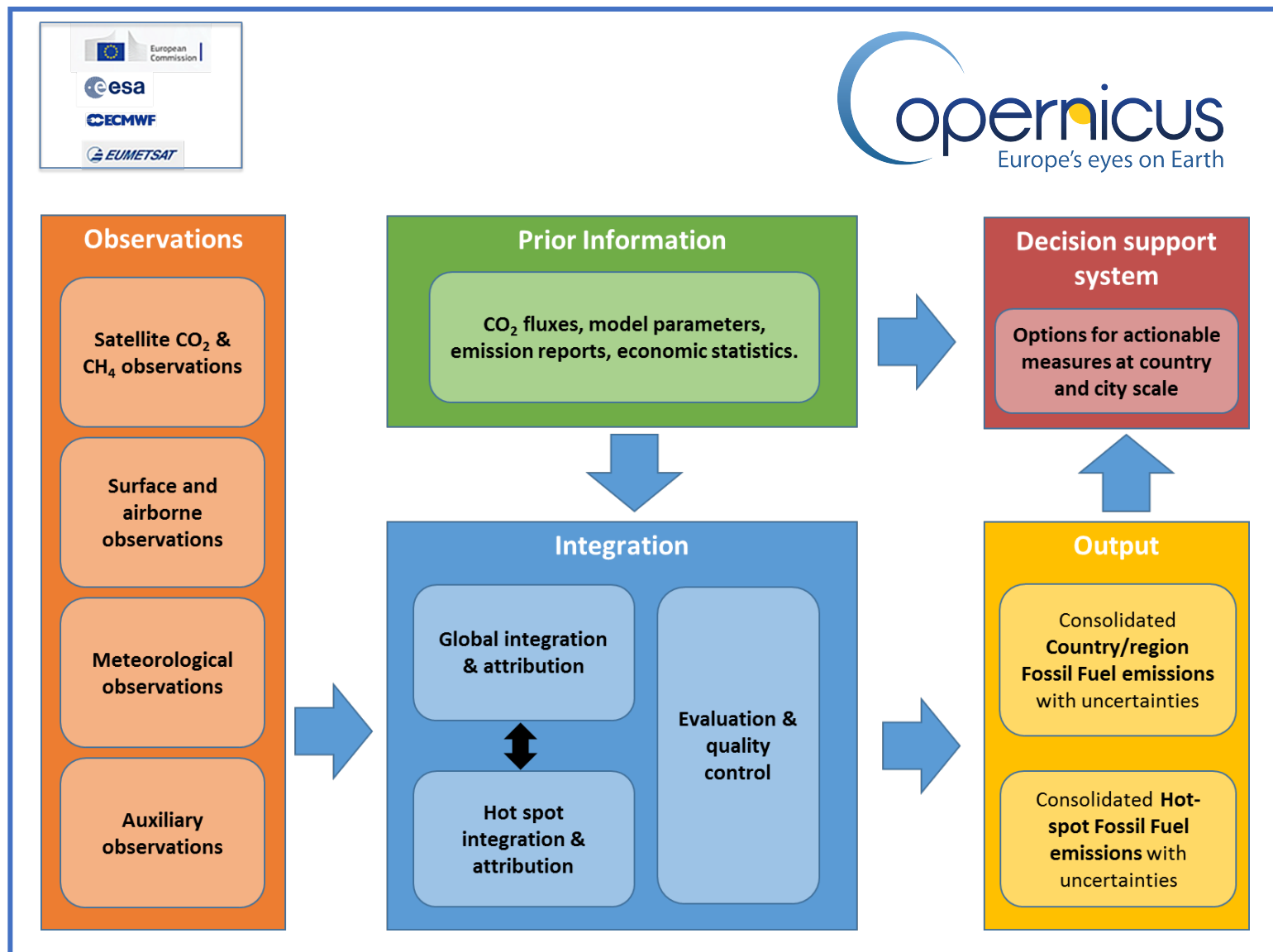
Earth System models are used to translate the observations into emission estimates.







# CoCO2: Developing a new Copernicus CO<sub>2</sub> monitoring service



## CoCO2

Prototype system for a Copernicus CO<sub>2</sub> service



Atmosphere  
Monitoring Service

[atmosphere.copernicus.eu](https://atmosphere.copernicus.eu)





## 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.

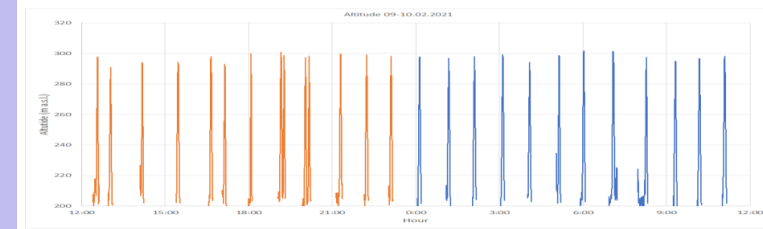
The survey consists of three parts:

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



Max altitude:  
100 m a.g.l.  
Temporal resolution ca. 1 hour  
Total 26 profiles  
from 9.02 1pm to 10.02 12pm

Measurements:  
• Meteorology  
• CO2  
• CH4  
• PM10



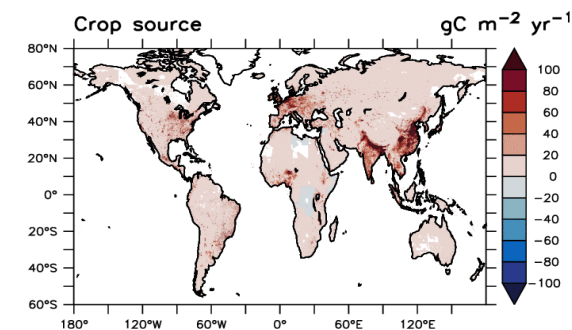
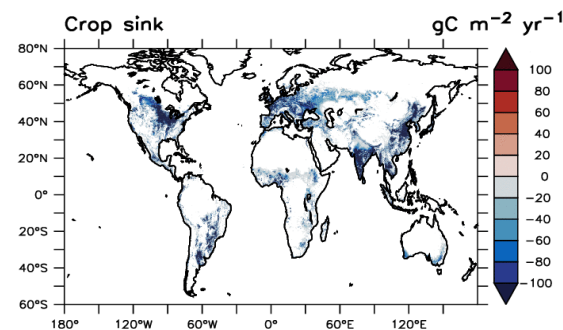
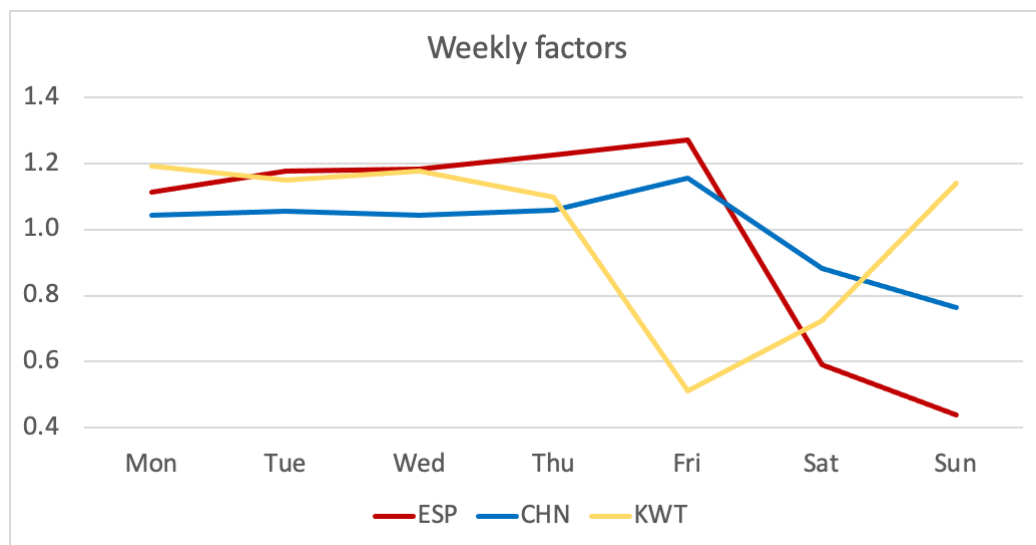




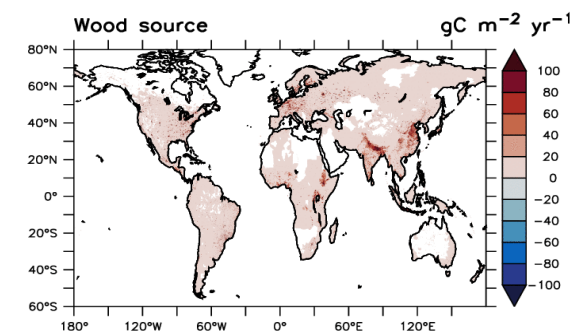
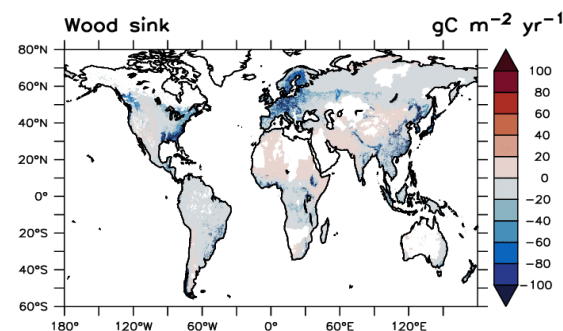
# Priors

Development of weekly country-dependent temporal profiles using TomTom congestion statistics.

**BSC**



Biofuel CO<sub>2</sub>



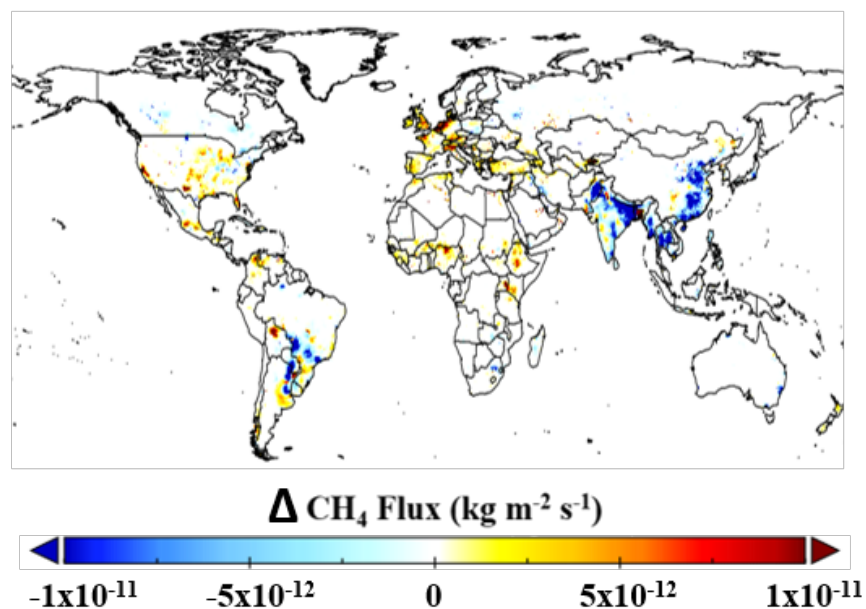
Annual for 1961-2019,  $0.08^\circ \times 0.08^\circ$

Extended from Deng, Ciais et al., ESSDD, 2021  
**LSCE**

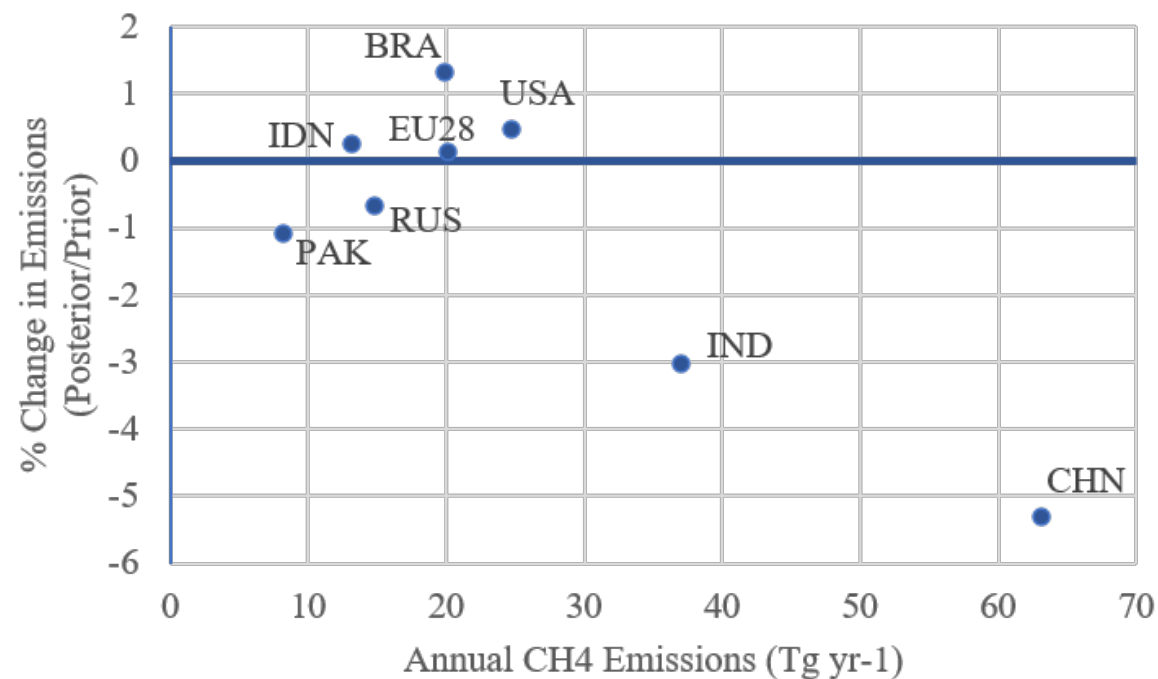


# Global system

Global emission estimation capabilities in **ECMWF's** IFS are being tested on CH<sub>4</sub> observations from Sentinel-5p TROPOMI.



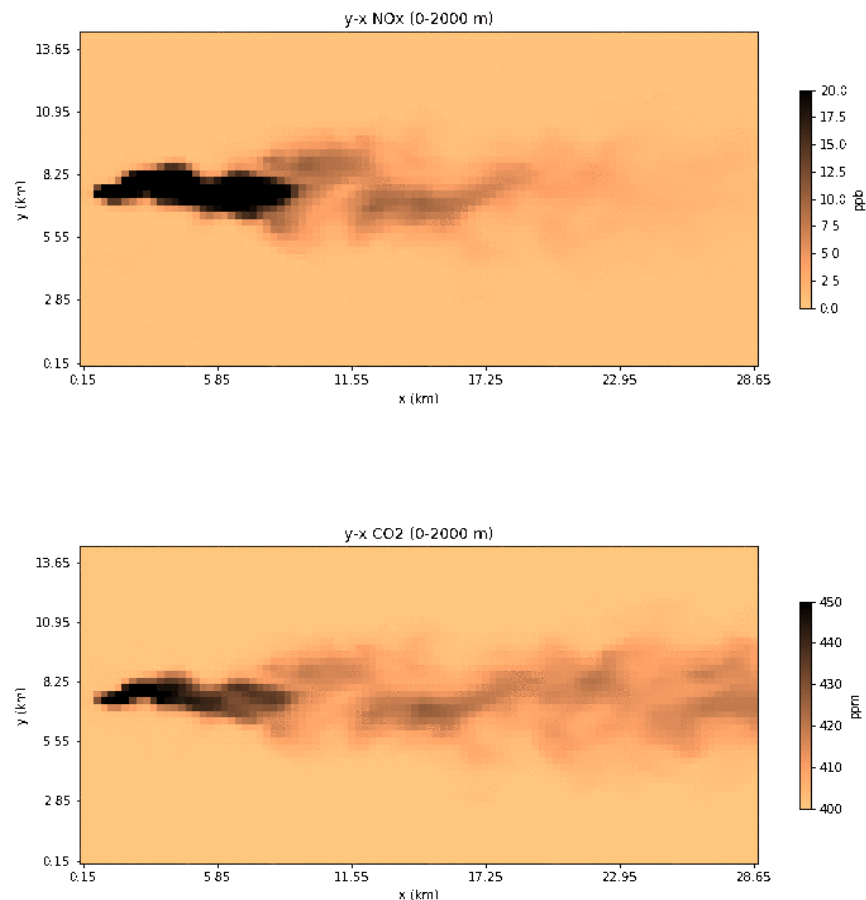
Change in CH<sub>4</sub> emissions posterior/prior







# Local systems

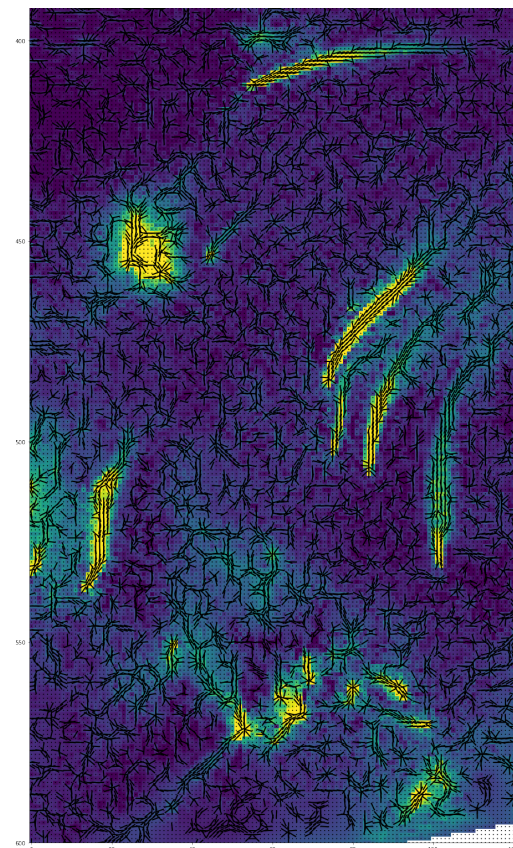


New techniques to detect & separate (overlapping) plumes & characterize the background; tests on the SMARTCARB NO<sub>x</sub> / CO<sub>2</sub> simulations.

**EMPA**

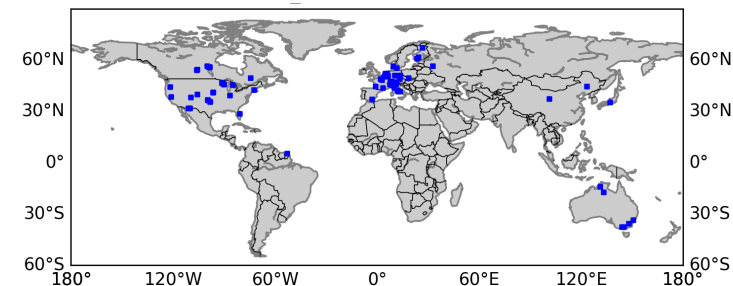
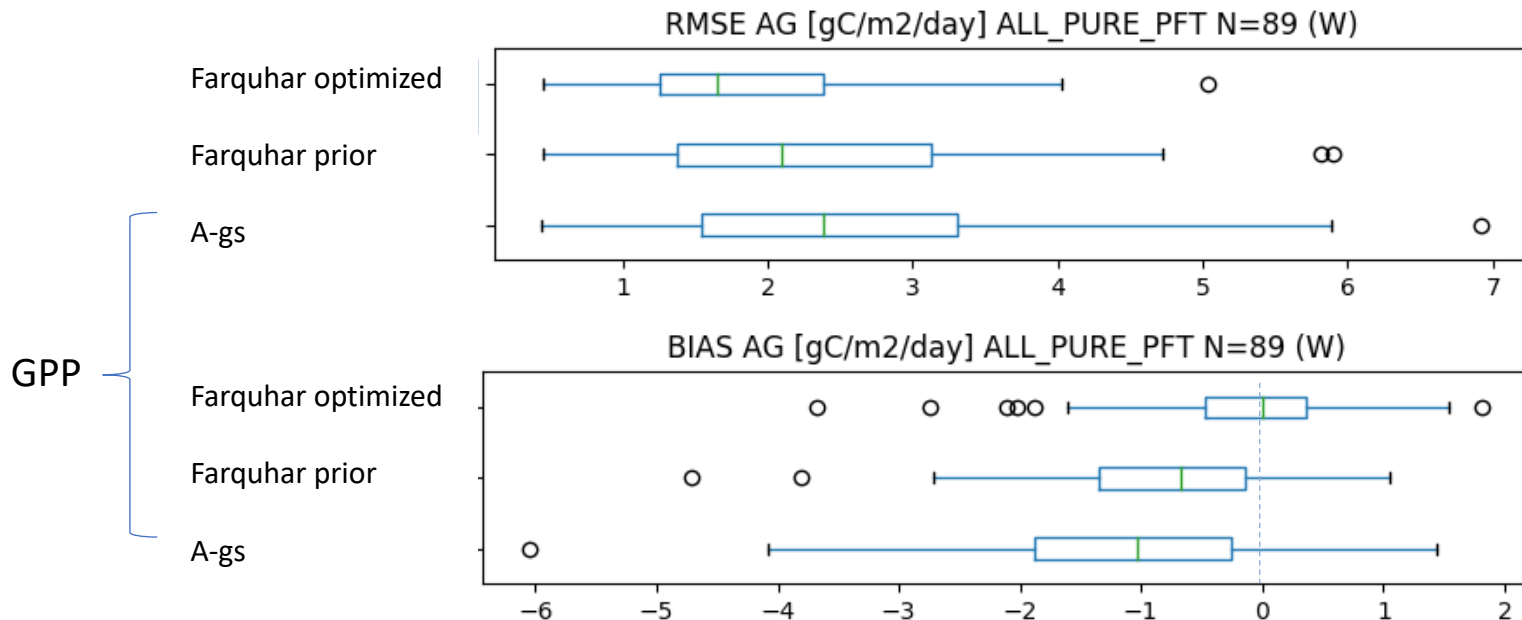
Simulations of NO<sub>x</sub> and CO<sub>2</sub> plumes.

**Wageningen University  
& Research**





# Benchmarking for uncertainty estimation



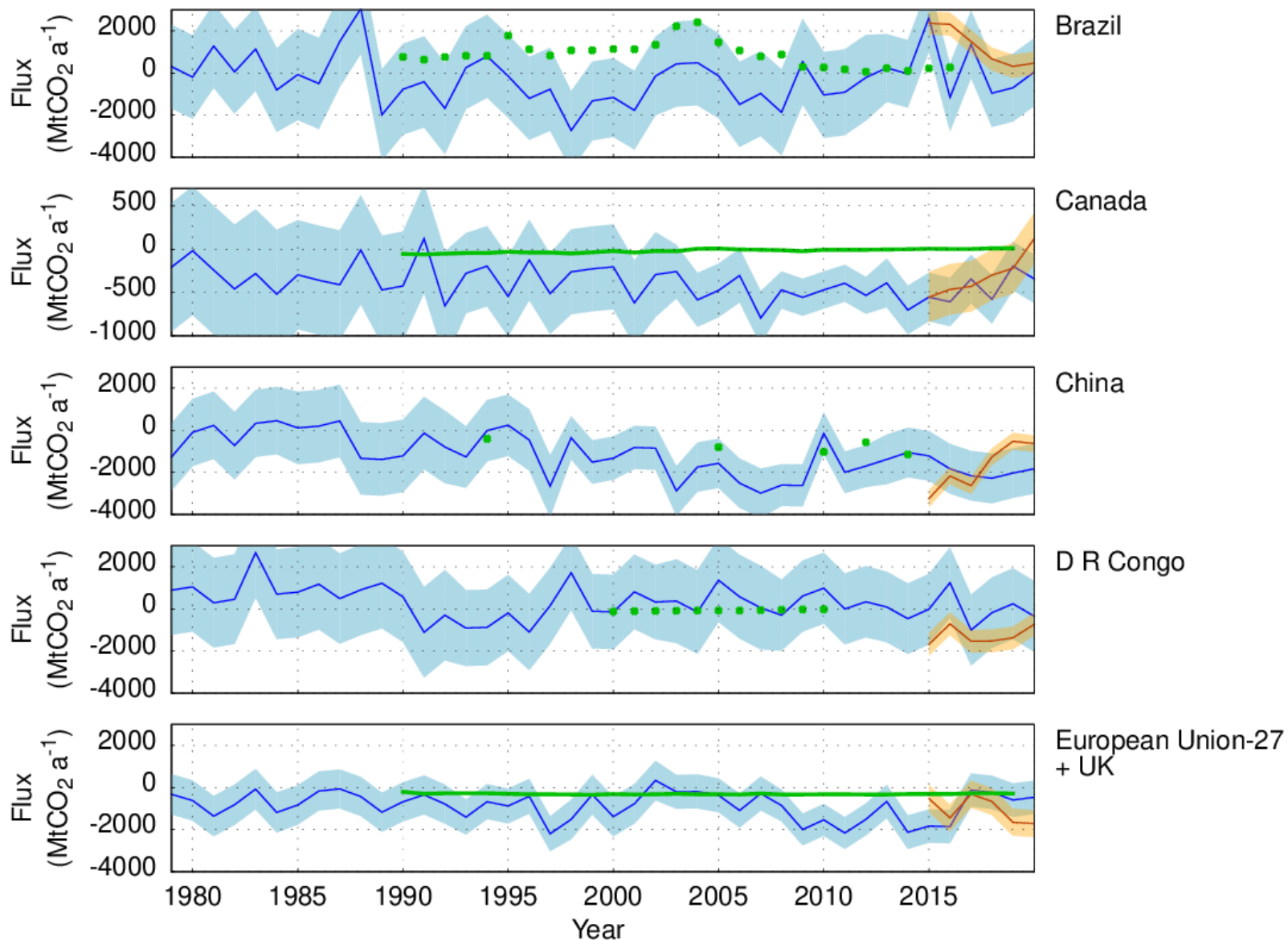
89 FLUXNET2015 sites

ECMWF, LSCE, IPMA

- The Farquhar scheme is a biogeochemical photosynthesis model with a more mechanistic representation of processes than current empirical A-gs model. It also allows the use of **Solar Induced Fluorescence (SIF)** observations to constrain GPP (Global Primary Production).
- Large reduction in RSME and bias of GPP against FLUXNET observations.
- GPP is more realistic, but increased with respect to A-gs
- This means that the Respiration ( $R_{eco}$ ) needs to be revised as well to optimize the net flux.



## Policy-relevant products



Annual CO<sub>2</sub> flux from the AFOLU sector in ten large countries or groups of countries estimated by the 1-σ uncertainty envelope of the two CAMS atmospheric inversions.

**In situ-based estimate**  
**Satellite-based estimate**  
**UNFCCC estimate**

**LSCE**



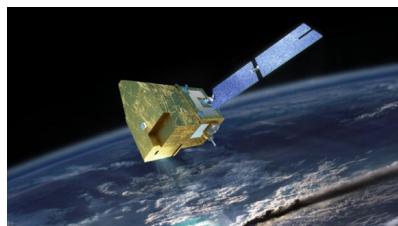


# Moving forward: from science to services



ESA/ATG medialab

Sentinel-5p, OCO-2, GOSAT

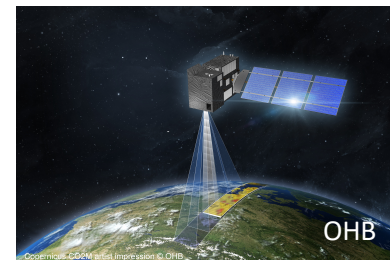


Microcarb, Merlin, ...



ESA/P. Carril

Sentinel-4&5



OHB

CO2M



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2021



Horizon 2020

Horizon Europe



Atmosphere  
Monitoring Service

[atmosphere.copernicus.eu](https://atmosphere.copernicus.eu)

2026



# Today

## Session 1: 10:00 - 12:00 UTC

| Time          | Topic                        | Presenter                                |
|---------------|------------------------------|------------------------------------------|
| 10:00 - 10:15 | CoCO2 welcome & introduction | Richard Engelen                          |
| 10:15 - 10:30 | Welcome from the Commission  | Hugo Zunker (DG-DEFIS)                   |
| 10:30 - 10:55 | WP2 highlights               | Hugo Denier van der Gon & Greet Maenhout |
| 10:55 - 11:20 | WP3 highlights               | Wouter Peters & Anna Agustí-Panareda     |
| 11:20 - 11:45 | WP4 highlights               | Dominik Brunner & Gregoire Broquet       |
| 11:45 - 12:00 | Discussion                   | Gianpaolo Balsamo (moderator)            |

## Session 2: 13:00 - 15:00 UTC

| Time          | Topic          | Presenter                               |
|---------------|----------------|-----------------------------------------|
| 13:00 - 13:25 | WP5 highlights | Marko Scholze & Sander Houweling        |
| 13:25 - 13:50 | WP6 highlights | Frédéric Chevallier & Nicolas Bousserez |
| 13:50 - 14:15 | WP7 highlights | Werner Kutsch & Julia Marshall          |
| 14:15 - 14:40 | WP8 highlights | Glen Peters & Han Dolman                |
| 14:40 - 14:50 | WP9 highlights | Daniel Thiemert & Richard Engelen       |
| 14:50 - 15:00 | Discussion     | Gianpaolo Balsamo (moderator)           |





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