Co-ordinated by ECMWF

CoCO2
Prototype system for a Copernicus CO_2 service

WP6 INTEGRATION, TESTING, APPLICATION AND INITIAL VALIDATION OF PROTOTYPE SYSTEMS

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and the WP6 team

CoCO2 Presentation Day

05/12/2022

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Structure of WP6

16 participants: CEA, ECMWF, EMPA, ICOS ERIC, MPG, TNO, ULUND, VUA, WU, CICERO, CMCC, FMI, iLab, UEDIN, FC.ID, Cyl

Legacy of VERIFY

- T6.1 Prolongation of the VERIFY synthesis for an additional year

Contribute to the 1st Global StockTake (GST)

- T6.2 Identify relevant needs for the periodic GST
- T6.3 Prepare prototype systems and data flow for the 1st GST
- T6.4 Provide emission estimates and corresponding evaluation for the 1st GST

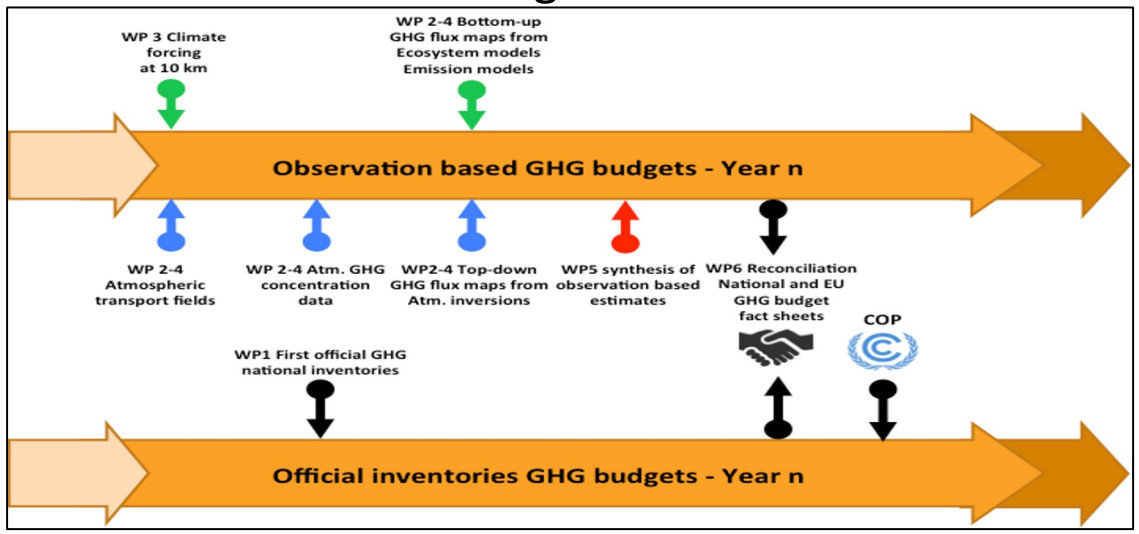
Prepare for the 2nd GST

- T6.5 Build pre-operational IFS global multi-scale system
- T6.6 Design of pre-operational EQC system

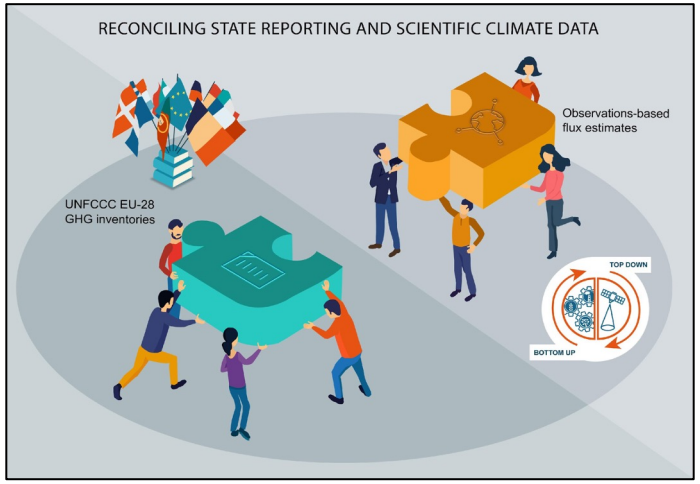
T6.1 Prolongation of the VERIFY synthesis for an additional year

⇒ VERIFY established a pre-operational GHG flux monitoring and verification support system

Yearly estimates of CO_2 and CH_4 GHG budgets (similar to GCP's Global carbon budget but for the EU countries)



Comparison of observation-based vs. National inventory flux estimates



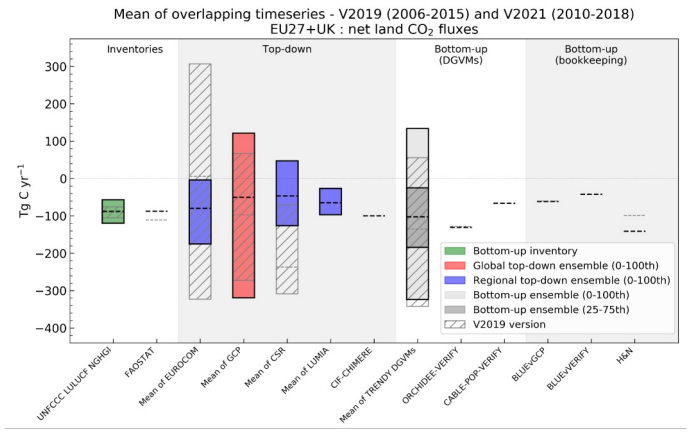
⇒ CoCO2 Prototype system for a Copernicus CO_2 service extends the process: the 2022 synthesis will include data **up to 2021** (base year for the 1st GST) – No specific funding guaranteed after it

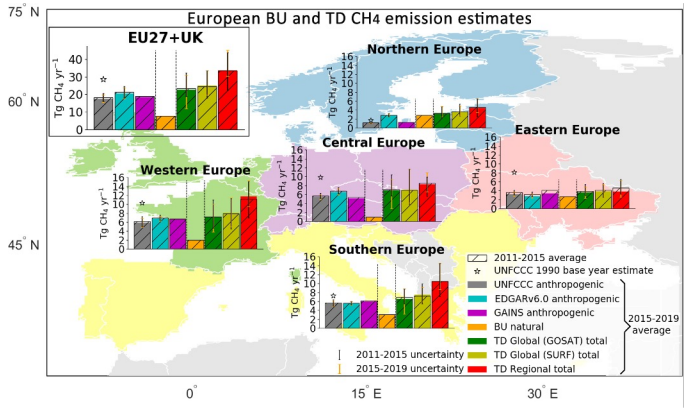
- Simulations done during the summer, synthesis still on-going

T6.1 Prolongation of the VERIFY synthesis for an additional year

- Annual synthesis published in journal ESSD (last version with data -> 2020 just submitted)

CO_2 land fluxes (McGrath et al.). Regional top-down methods better agree with each other now

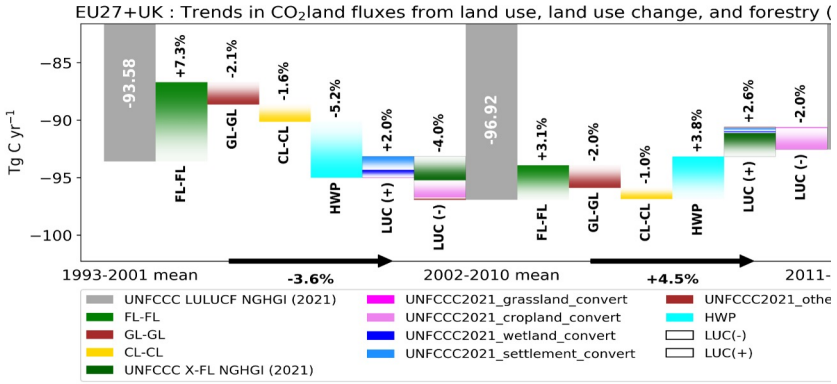


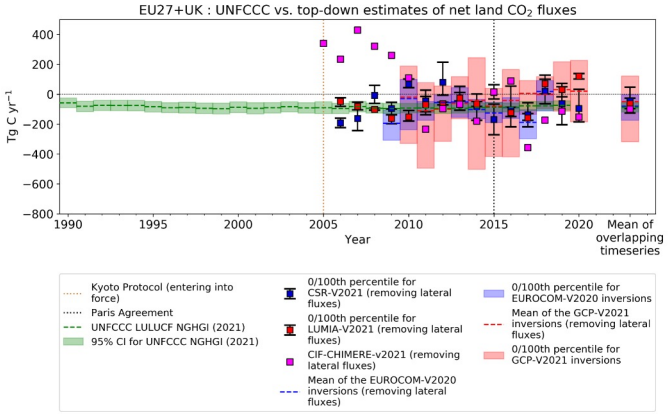


CH_4 (Petrescu et al.). Bottom-up methods show much lower emissions for most regions than top-down

- Country factsheets (http://verify.lsce.ipsl.fr/index.php/products)

Example: EU27+UK, Decadal trend in CO_2 land fluxes: sector contributions





Example: EU27+UK, UNFCC CO_2 land fluxes vs. top-down estimates

T6.2 Identify relevant needs for the periodic GST

Final version publicly available (41 pp., Feb 2022)

https://www.coco2-project.eu/node/331

- *Verification of Parties' GHG inventories*
- *Support to developing-country Parties*
- *Innovation in climate research and systematic observation*

"The challenge that the CoCO2 project is facing is the creation of a system that is compatible with the multilateral process within the UNFCCC. This means being able to develop products that can adequately support countries in improving their reporting over time, in line with the methodologies and requirements under the Convention and the Paris Agreement, including transparency arrangements under the new Enhanced Transparency Framework (ETF) and the GST process, which will continue being the frameworks guiding countries' efforts over the next decades."

T6.4 Provide emission estimates and corresponding evaluation for the 1st GST

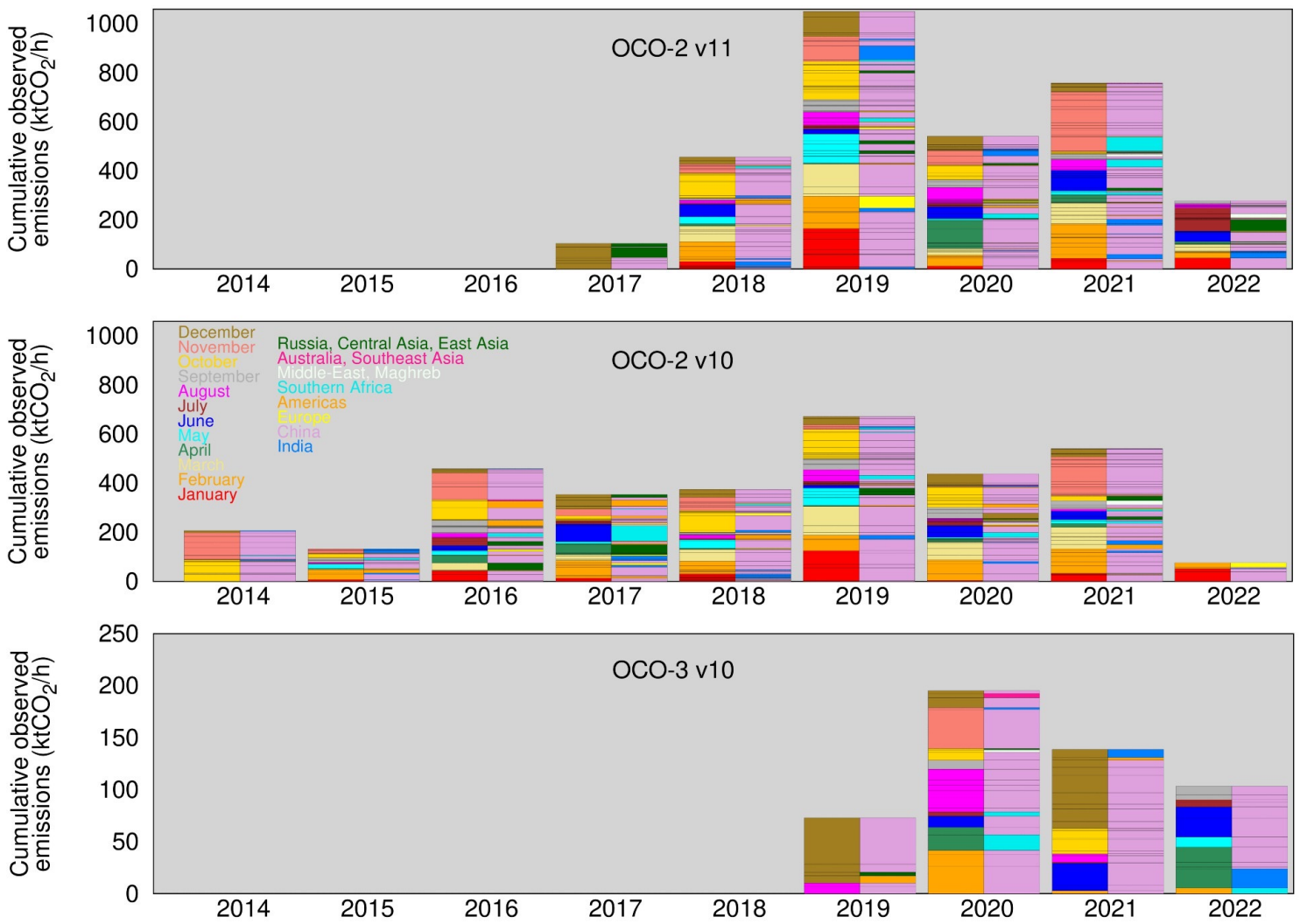
Leaflet prepared for submission to the 1st GST

- Presents CoCO2 Prototype system for a Copernicus CO_2 service

- Presents data from 5 demonstrators that prefigure some capabilities of the future CO2MVS, driven by real observations – even though the current observing systems have not been designed for that purpose
  - ✓ Large point source fossil fuel CO_2 emissions using OCO-2 and OCO-3
  - ✓ Fossil fuel emissions from regional atmospheric inversions using OMI, TROPOMI, and MOPITT
  - ✓ Carbon Cycle Fossil Fuel Data Assimilation System using GOSAT, GOSAT-2, OCO-2, FAPAR satellite products, etc.
  - ✓ AFOLU emissions from CO_2 atmospheric inversions using OCO-2 and CO_2 surface measurements
  - ✓ The global Integrated Forecast System using GOSAT, MetOp, and Sentinel 5P

- Presents current research axes from WP4 targeting local or national scales

Large point source fossil fuel CO_2 emissions based on satellite observations



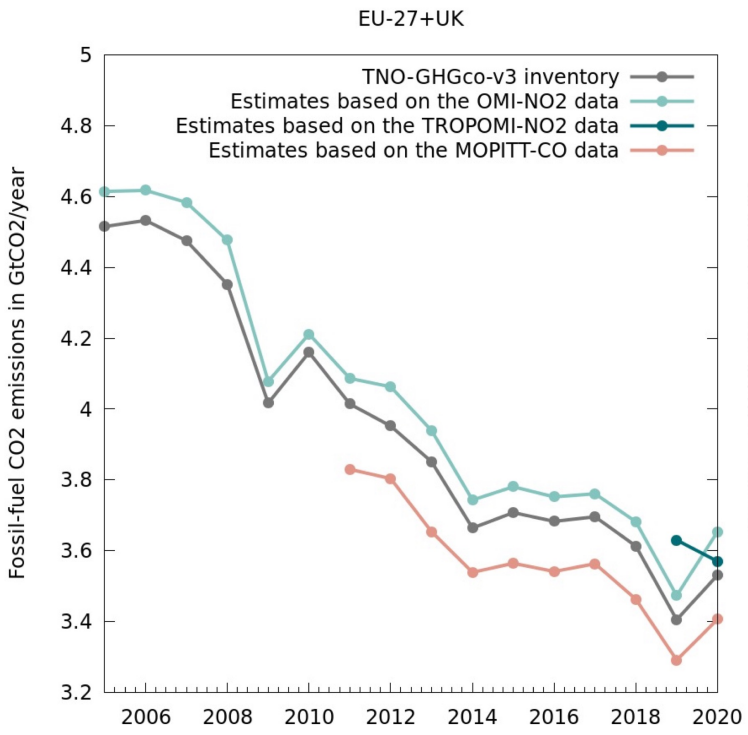
Method

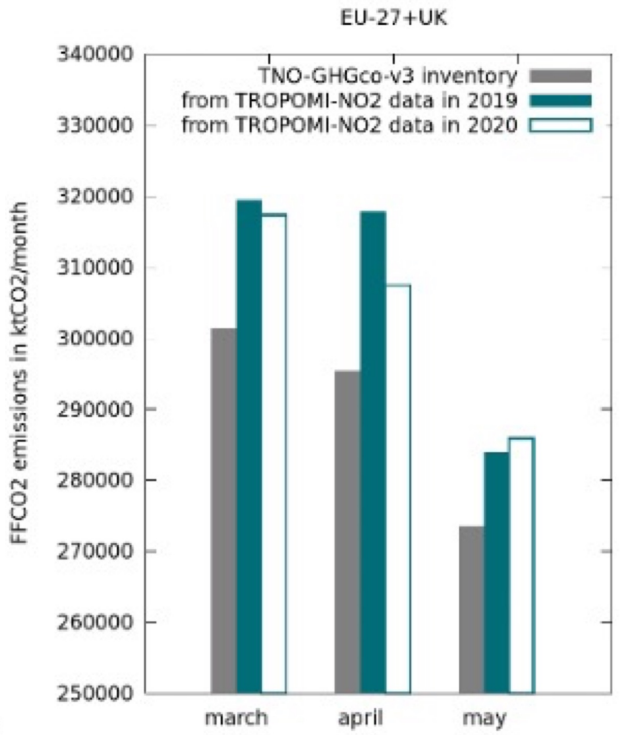
- Selection of isolated CO_2 column enhancements along satellite orbits, potentially corresponding to plume transect.
- Fit with a Gaussian shape, quality-control and combine with wind speed to estimate the fossil fuel CO_2 emissions.

Lessons learned

- Capability to track high-emission hot-spots over the globe with low latency. Most of them are found over China, India and South Africa.
- Consistent temporal variations of median emissions – trends can be robustly calculated when more data become available.

Fossil fuel emissions from regional inversions using co-emitted species





Method

- NOx/CO inversions over Europe during 2005-2020 correcting the TNO inventory at high temporal/spatial resolution (1-day / 0.5°) to fit satellite NO_2 and CO data.
- Conversion of the resulting NOx and CO emission budgets per country per month partitioned into 5 sectors into CO_2 emissions.

Lessons learned

- National and annual fossil fuel CO_2 budgets derived from the NOx (CO) inversions are larger (smaller) than that of the inventory.
- Emission reduction in 2020 due to the Covid-19 crisis: missed by inversions based on OMI and MOPITT, shown by inversions based on TROPOMI albeit with a smaller amplitude than generally reported.

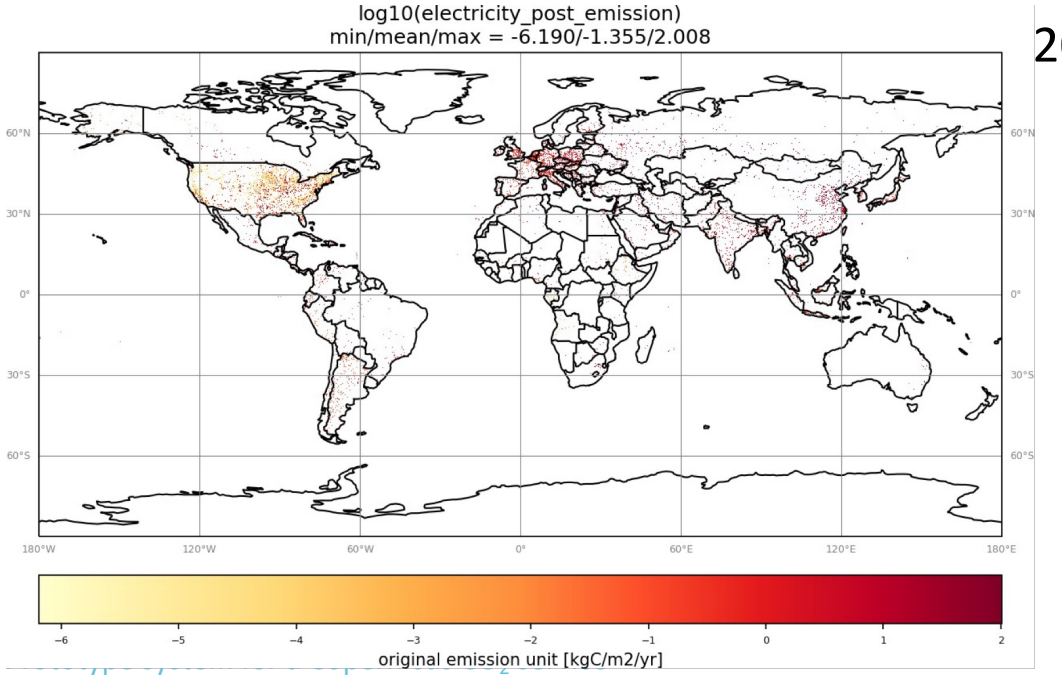
Carbon Cycle Fossil Fuel Data Assimilation System

Method

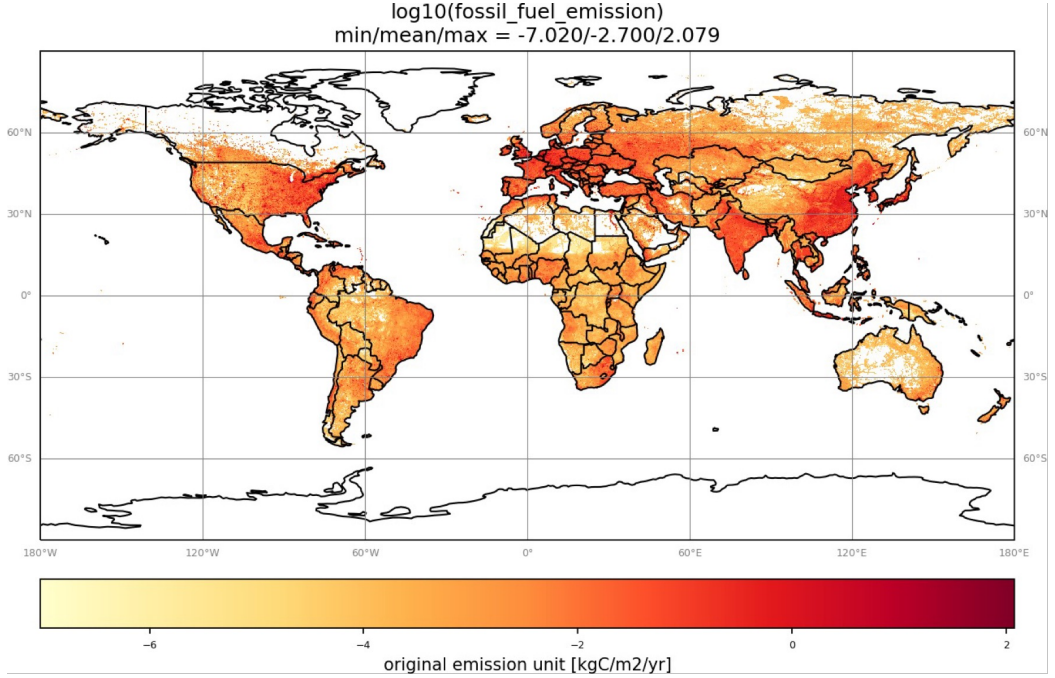
- Numerical simulations of global CO_2 atmospheric transport, sectoral fossil fuel emissions and biospheric fluxes.
- Optimizes parameters of process-based models against a wide range of observations/data.

Lessons learned

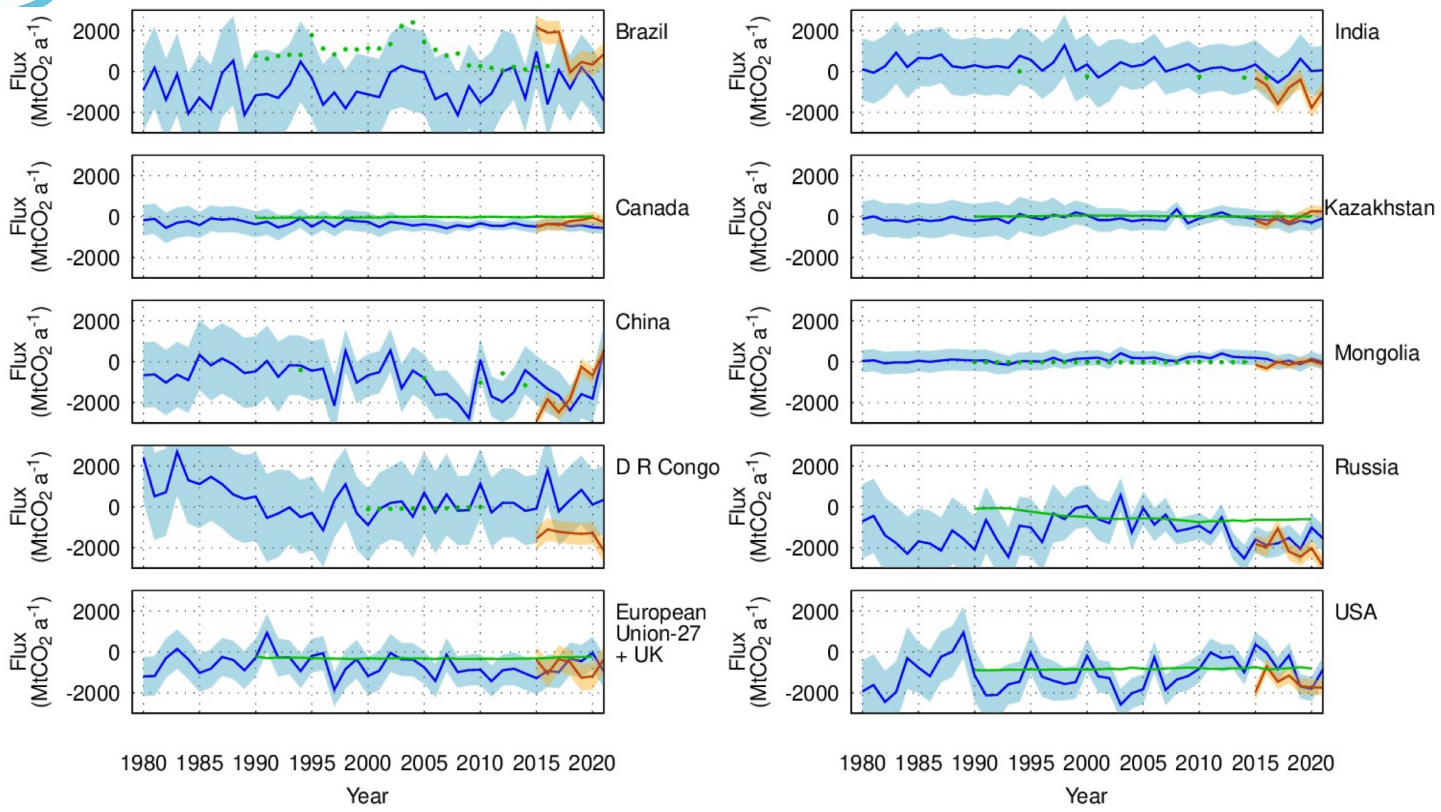
- Capability to attribute sources to emission sectors.
- Capability to use more observation types (e.g. activity data) to constrain sectoral emissions.
- Provides integrated view on the global carbon cycle that is consistent with a large range of observations/data



2021



AFOLU emissions from CO_2 atmospheric inversions



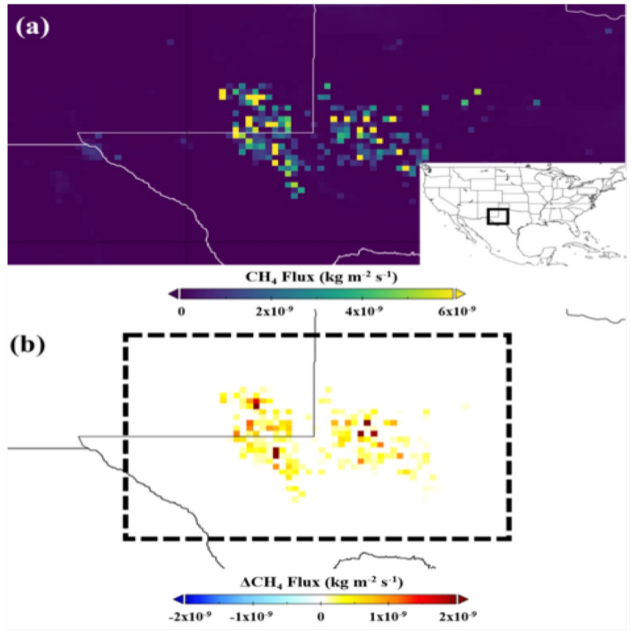
Method

- Post-processing of two CAMS global inversion products assimilating: 1) **air-sample measurements** (1979 onwards); 2) **satellite CO_2 retrievals** (2015 onwards).
- Aggregation of CO_2 fluxes at the annual national scale and **correction to fit the UNFCCC definitions**.
- Comparison between aggregated fluxes and National Inventory Reports.

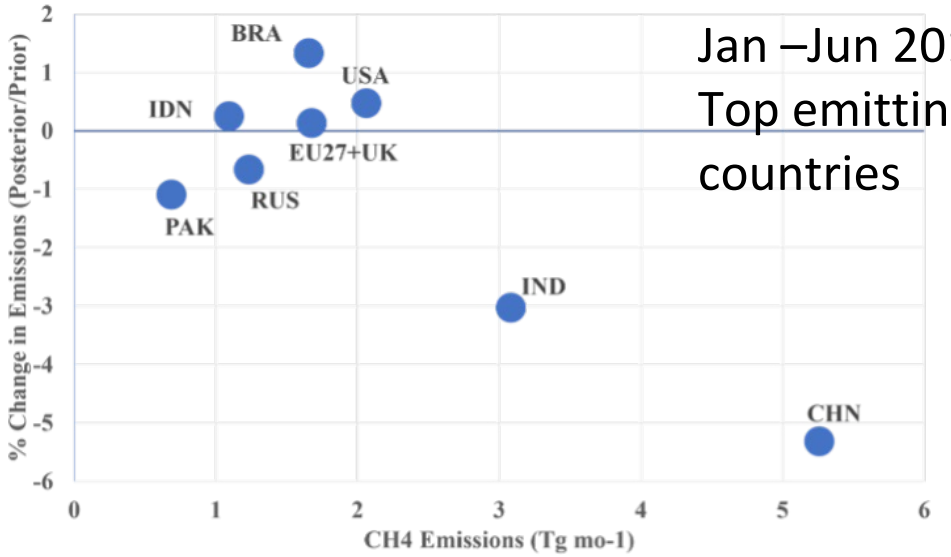
Lessons learned

- Differences between the two CAMS inversions are well explained by their error bars – the comparison is being extended to inversions from CarbonTracker Europe.
- Comparison to UNFCCC numbers reveals similarities for the mean value but a larger variability in the CAMS inversions.
- Lack of metadata in the NIRs explains some of the observed discrepancy between inversions and NIRs.

The global Integrated Forecasting System



Jan –Jun 2019
Permian
basin, USA



Jan –Jun 2019
Top emitting
countries

Method

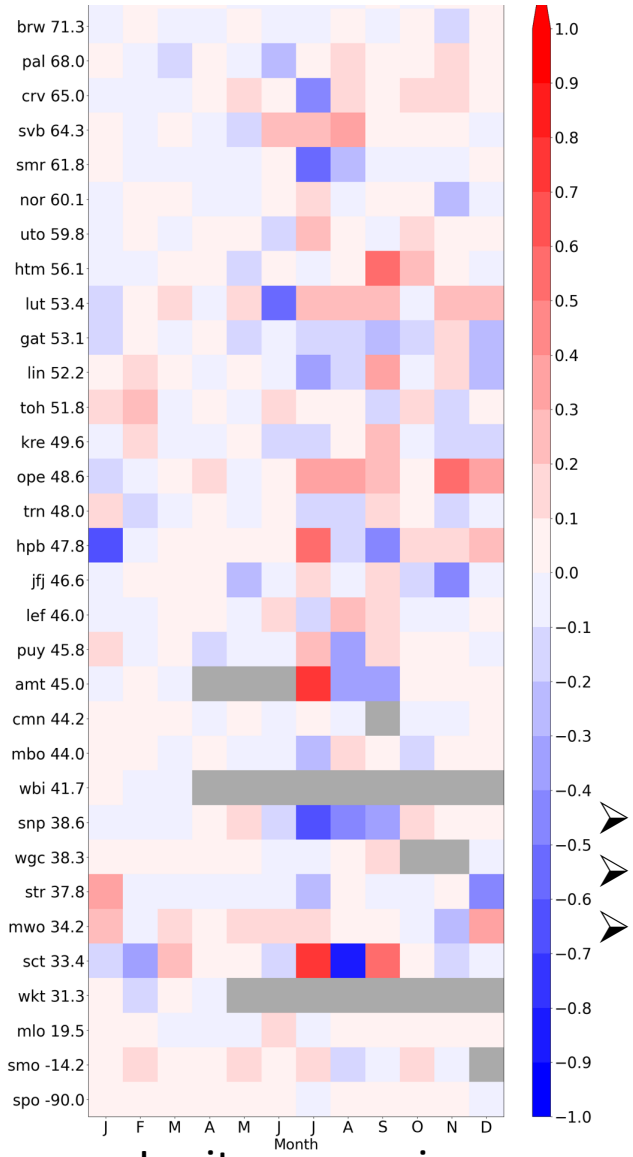
- Variational global CH_4 and CO_2 flux inversion based on satellite observations.
- 80-km resolution, 12-hour window.
- At country and regional scale.

Lessons learned

- While the corrections to the prior emission inventories are small (<1%) for most countries at this temporal scale, they are more significant for India and China, with a decrease by 3 and 5%, respectively.
- Overestimation in China's CH_4 emission inventories is in agreement with previous findings.
- Posterior CH_4 emissions (2.5 $Tg.a^{-1}$) over Permian Basin 30% larger than in prior inventory.

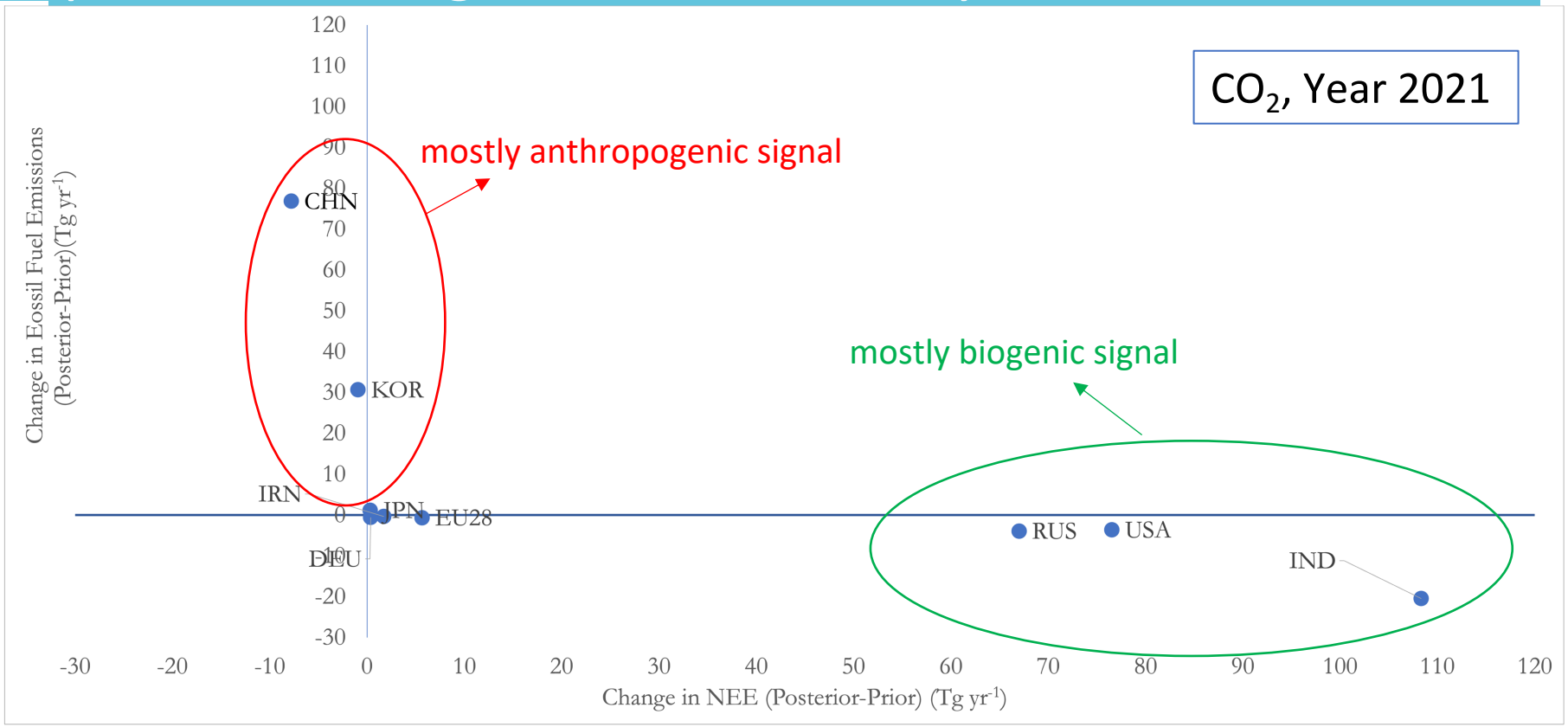
T6.5 Build pre-operational IFS global multi-scale system

RMSE diff (inversion-ctrl) (ppm)



In situ comparison

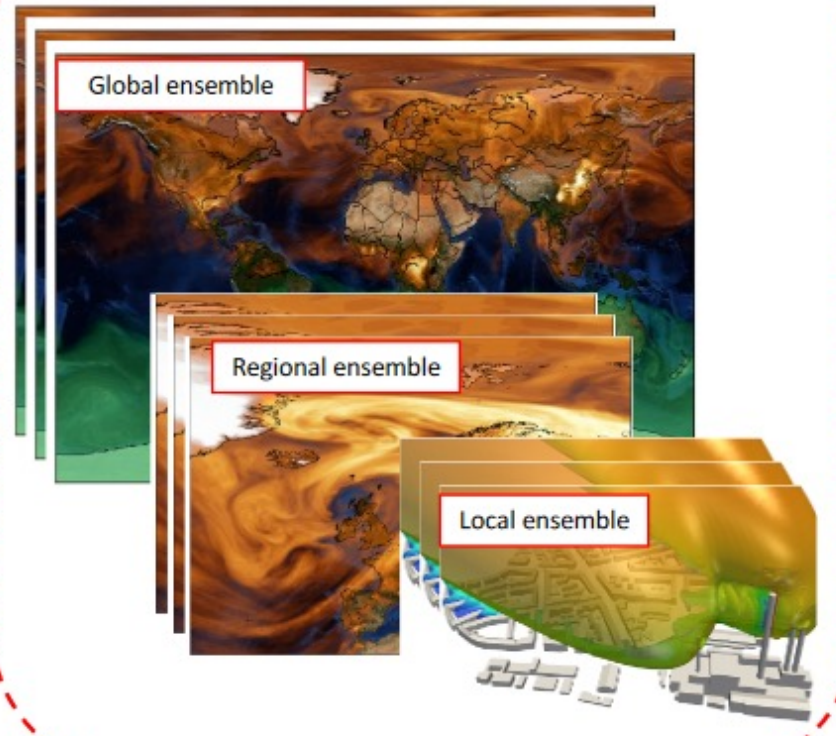
Obspack co2_1_NRT_v6.1.1_2021-05-17



- In situ evaluation: average impact neutral but significant spatial variations
- Results show geographically contrasted observational constraints on fossil fuel and biogenic fluxes
- Need to:
  - Include additional observational constraints from co-emitters such as NO_2 to better disentangle the biogenic from the anthropogenic signal
  - Implement long-window inversion to increase observational constraints from CO_2 observations.

Multi-model multi-scale approach

Posterior emission products



boundary conditions

satellites

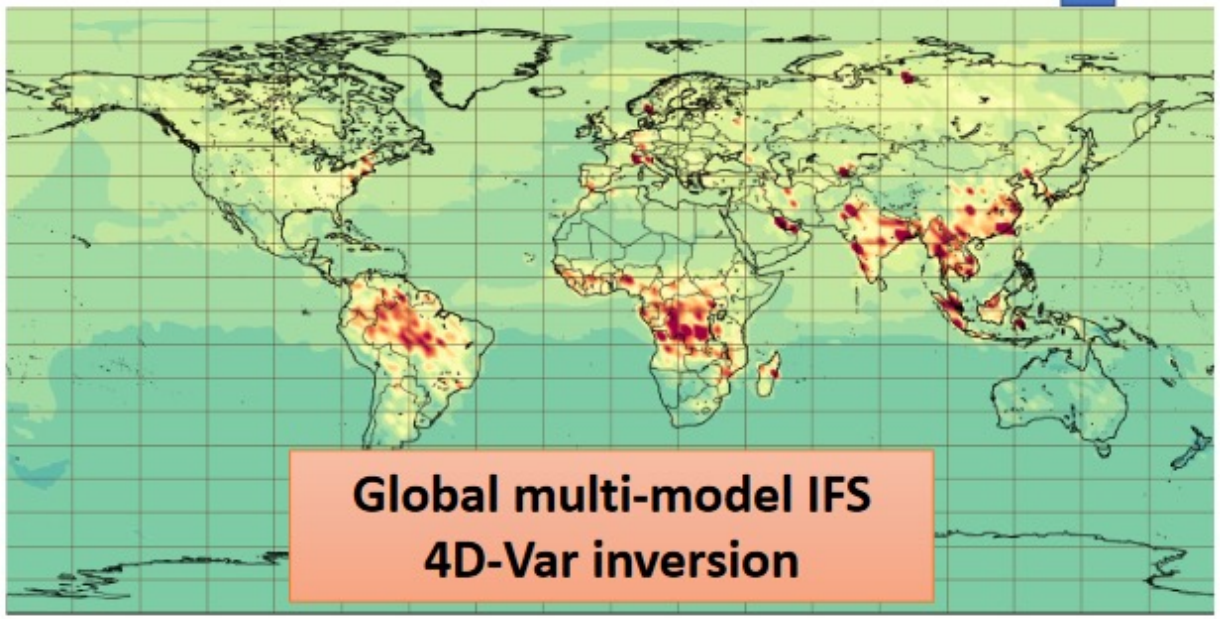
in situ

$$y = h(x) + \varepsilon$$

measurement | forward model | observational error

observation

observation



$$x_a = R(x) + \varepsilon_a$$

posterior emission | inversion operator | inversion error

Computed from statistics of ensemble of pseudo-inversions

Roadmap for the last year

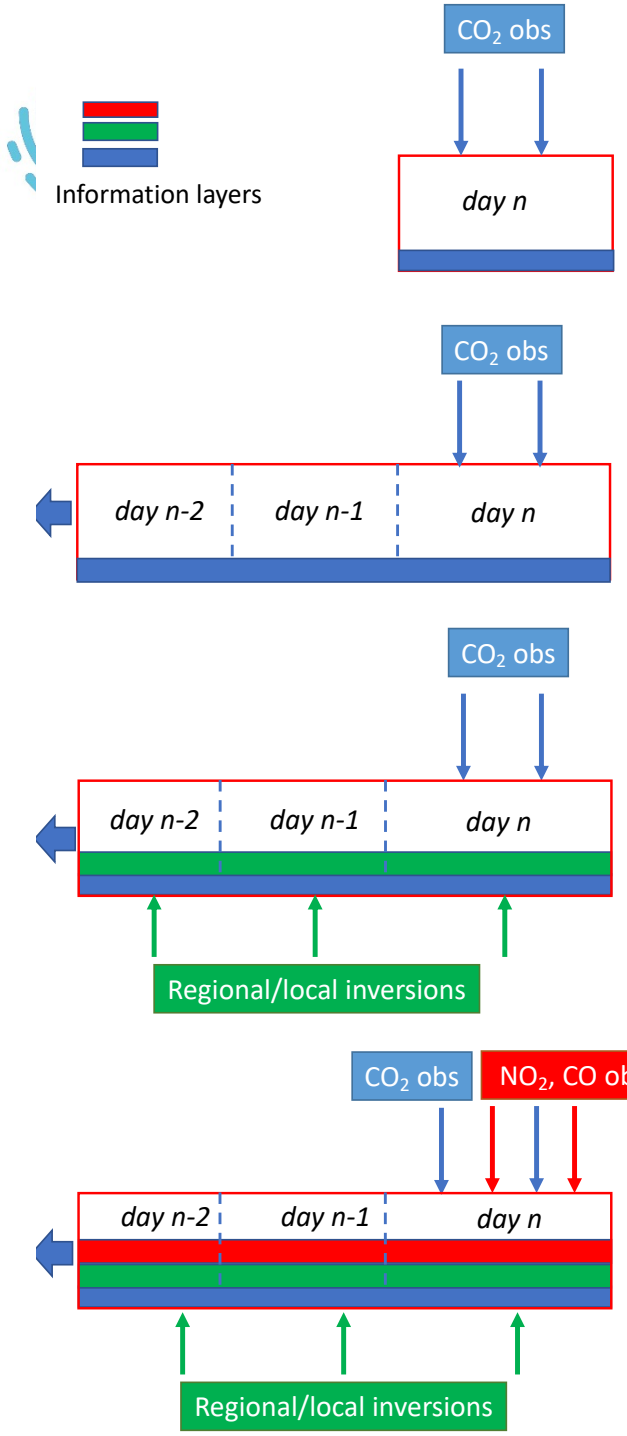
Documentation of the data shown the GST Leaflet

- Describe codes in D6.4 Functional Requirements Specification Documents
- Describe data usefulness in D6.6 Fitness for Purpose Documents

Further prepare the CO2MVS

- Take stock of the Leaflet experience among contributors
- Suggest next steps (from 5 to 1?)
- Integrate more developments from WPs 1-5 in the demonstrators
- Continue the data production with (some of) the demonstrators
- Design a collective evaluation strategy in D6.7 Report on the proposed EQC tool

Incremental building of capabilities



Short-window (24-hr) (current configuration) → **Global CH_4, NO_x, CO inversion**

current

Long-window (in progress) → **Global CO_2 inversion using CO_2 satellite observations**

2023 Q1-2-3

Regional inversions assimilation (end of 2023) → **Global multi-scale integration of regional/local CO_2 inversion products**

2023 Q3-4

Joint inversion of co-emitters (CORSO) → **Global CO_2 inversion using anthropogenic proxy observations (NO_2, CO)**

2023 Q4

THANK YOU

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This presentation reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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