



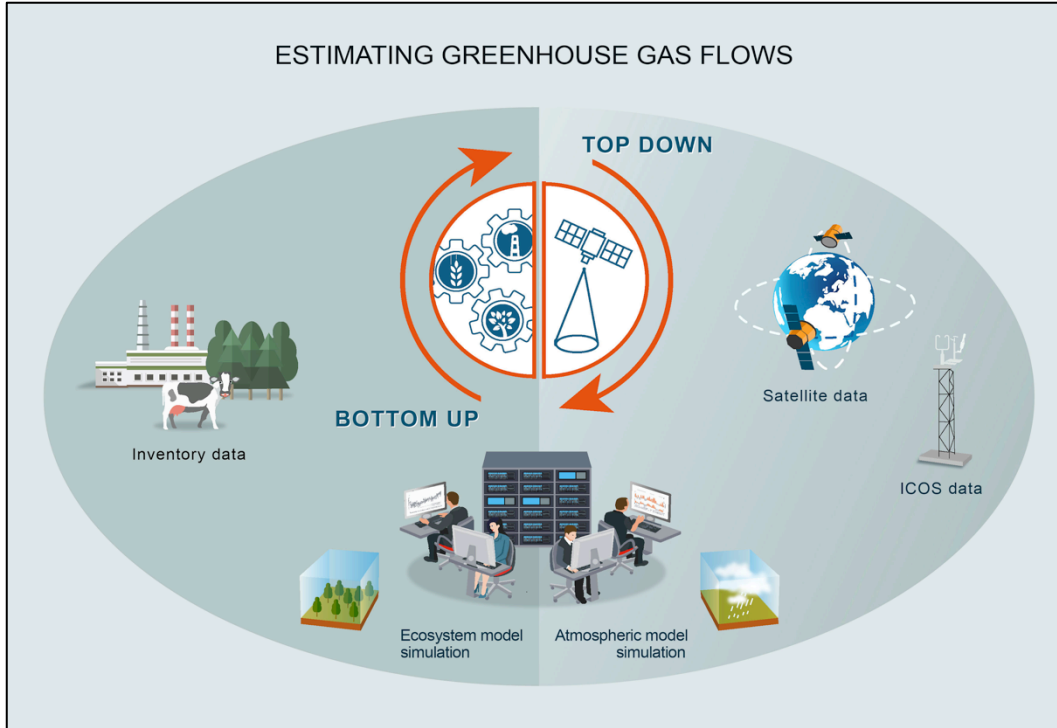
VERIFY:

Observation-based system for monitoring and verification of greenhouse gases

Philippe Peylin (CEA-LSCE) for the VERIFY consortium

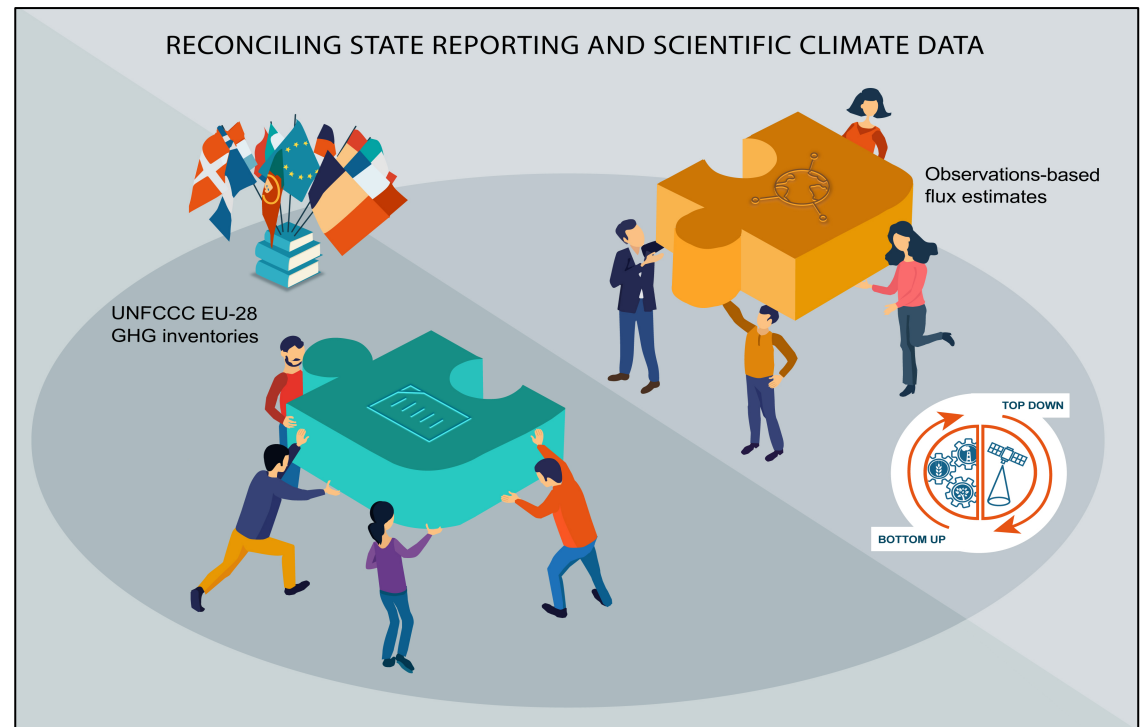
- Consortium of **40 institutes and inventory agencies**
- Period: 4 years (2018 – 2022)

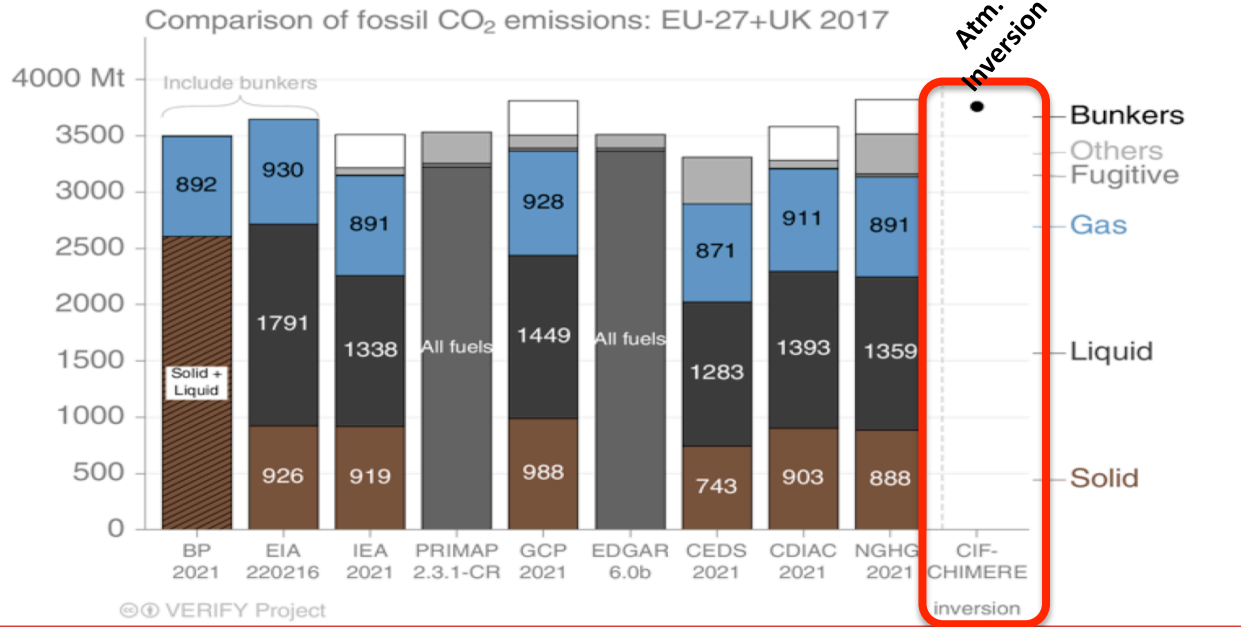
ESTIMATING GREENHOUSE GAS FLOWS



1) Estimate CO_2 - CH_4 - N_2O GHG fluxes at European country scale from bottom up (models) and top down (inversion) observation-based approaches

2) Compare observation-based estimates with the reported fluxes by each country to UNFCCC on annual basis !



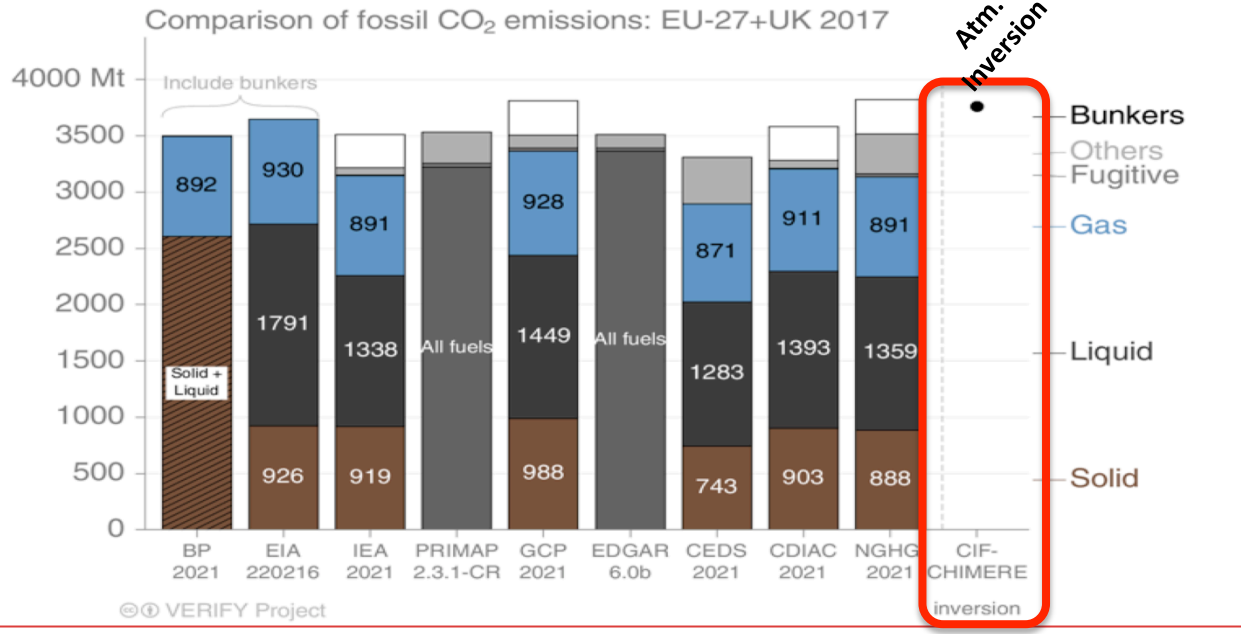


First synthesis of EU27+UK CO₂ fossil emissions

Fossil CO₂

- Fossil CO₂ emissions from 9 sources & a first inversion
- Differences mostly due to different accounting systems
- Inversions are still very uncertain and at their infancy.

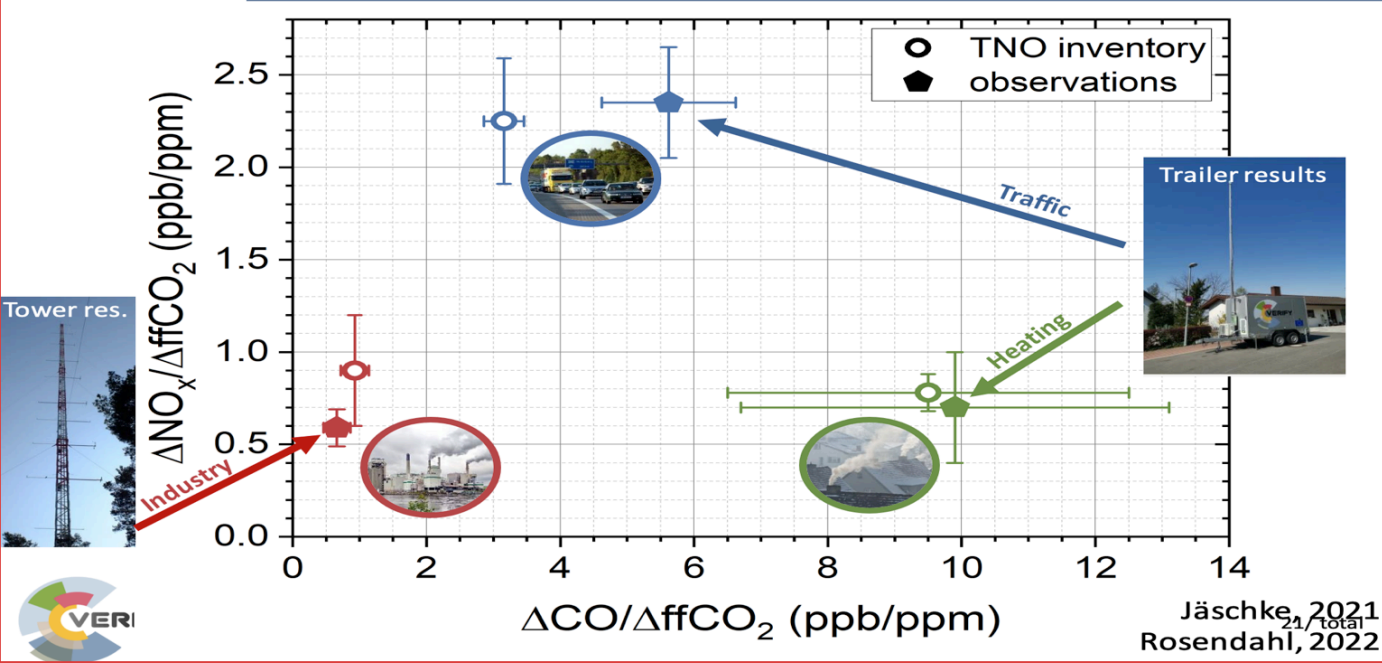
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Fossil CO₂

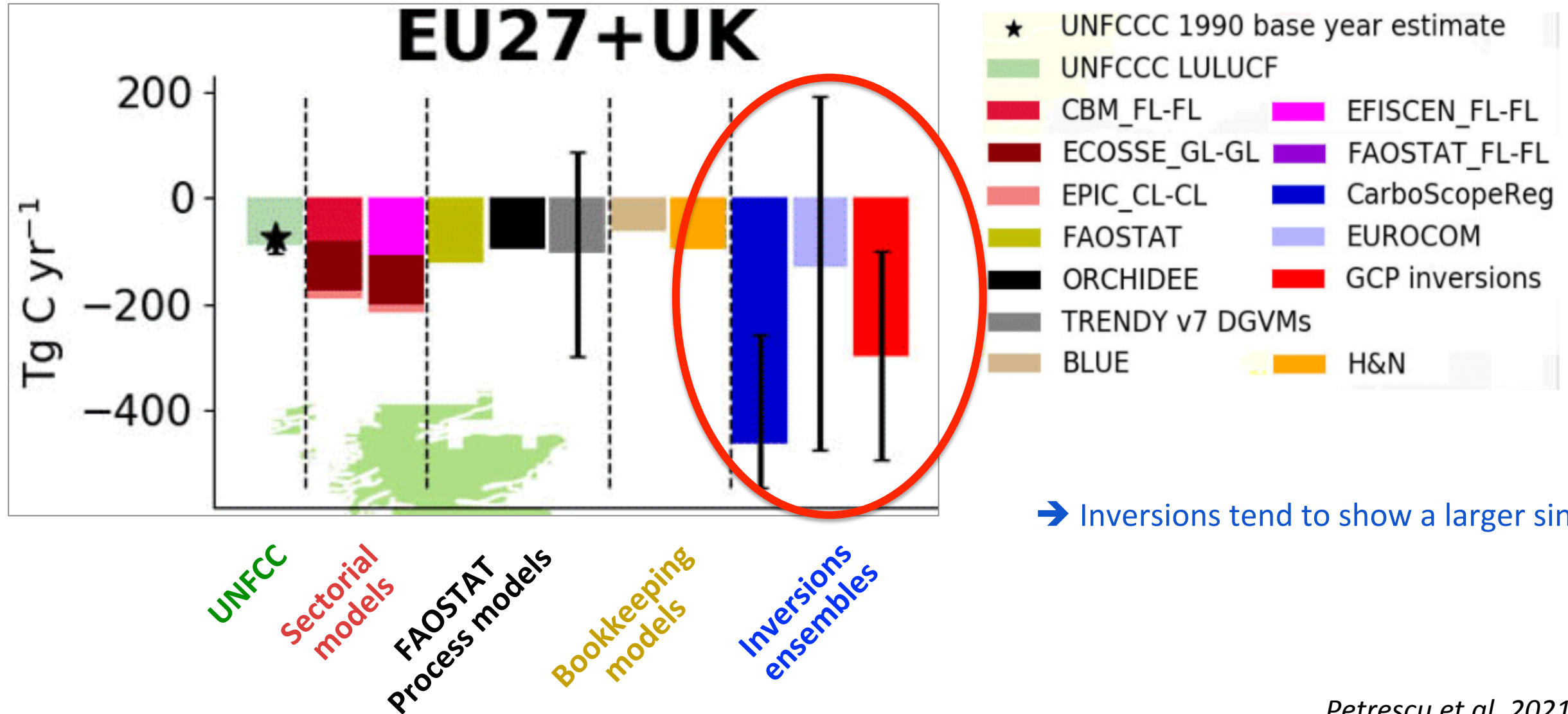
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CO AND NO_x DOUBLE-RATIO PLOT

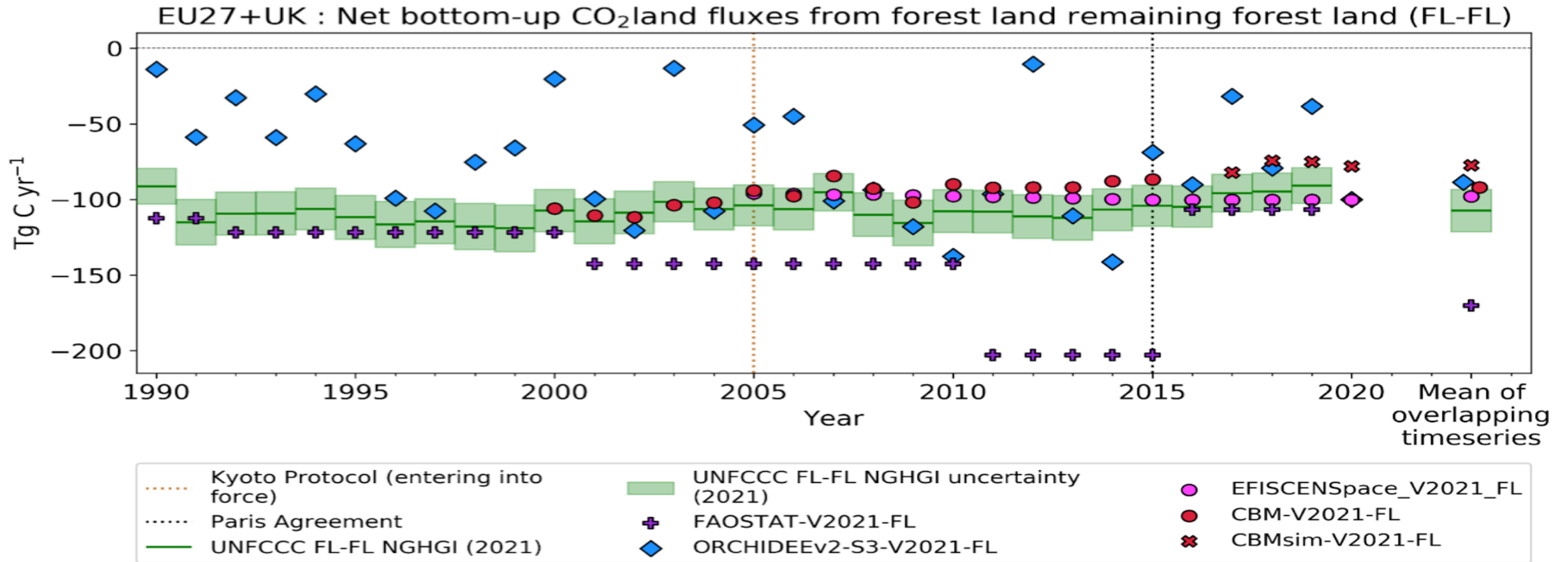


Fossil CO₂ inversion

- Based on CO / NO_x proxies using prescribed CO₂ / Proxy ratios (ex TNO inventory)
- Measured Ratio during 2020 campaign in Rhine valley
- ➔ Good agreement but small differences may be critical !



➔ Inversions tend to show a larger sink !

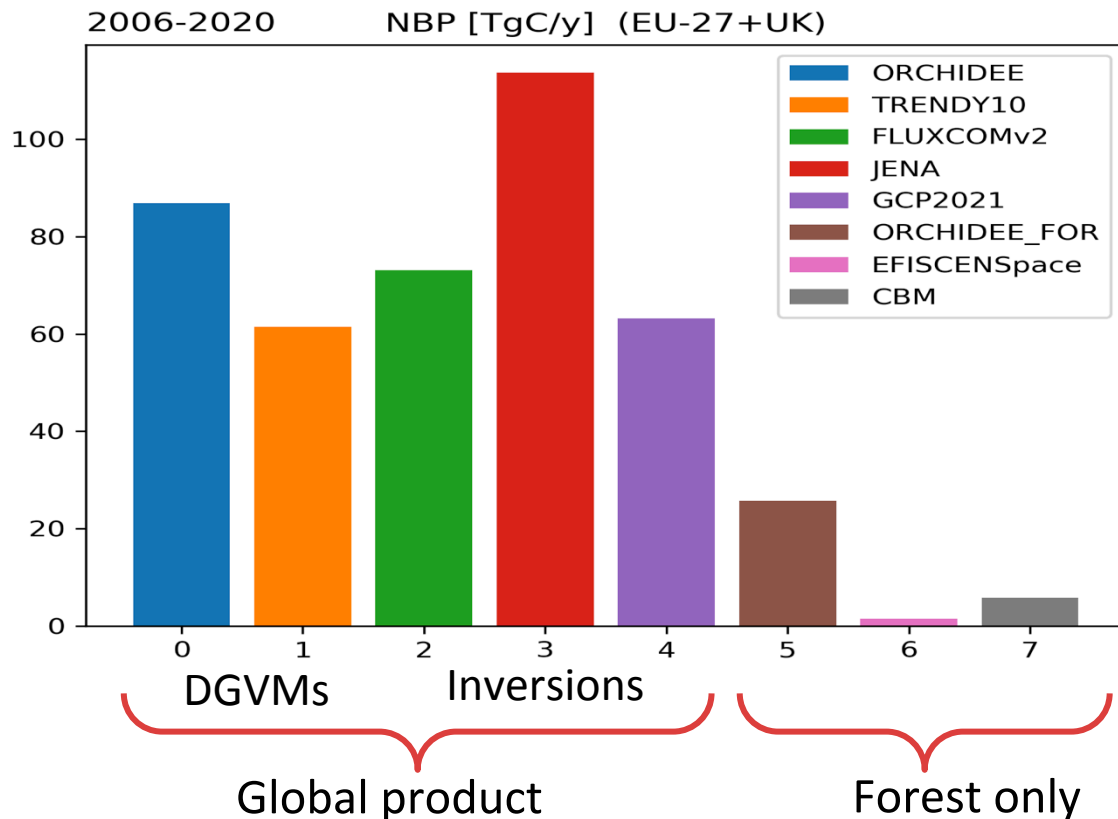


- Potential effect of forest area differences (CBM vs EFISCEN)
- ORCHIDEE high resolution (10 km) has a much larger yearly variability !

➤ Is the large yearly variability of DGVM models robust ?

IAV (standard deviation of yearly mean fluxes)

EU 28

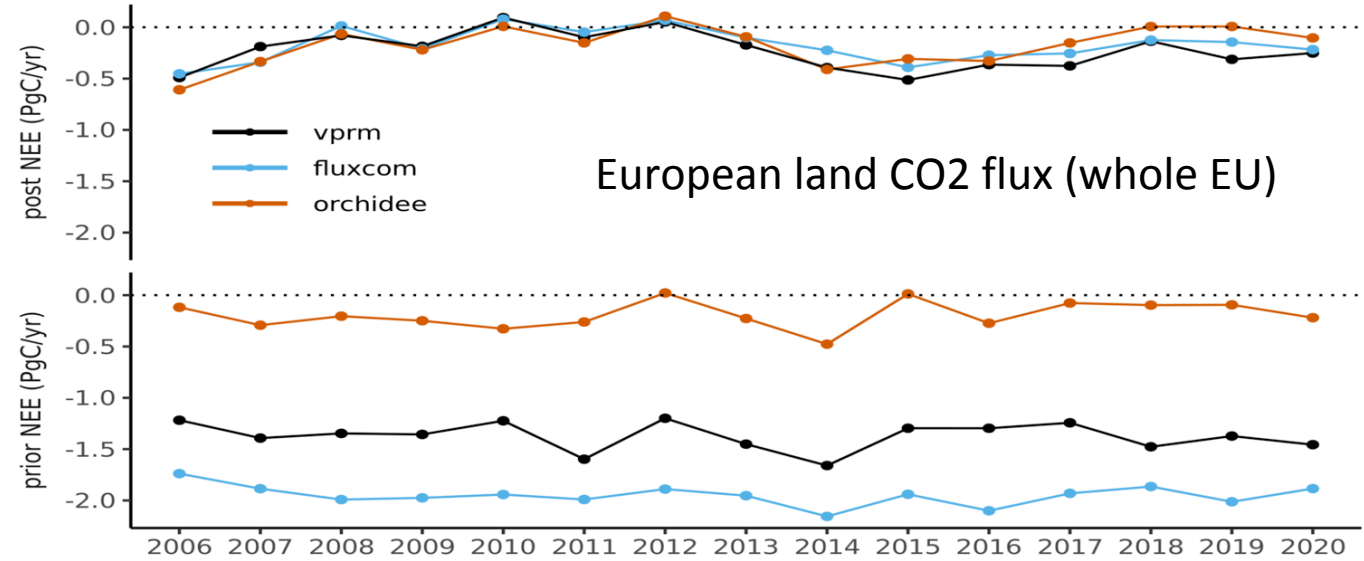


➔ DGVMs and inversions show much larger variability than

« forest – data driven models »

➔ Should be taken into account when comparing with UNFCCC reported fluxes ? (important for the Global stocktake)

- Very promising results with CarboScopeRegional inverse system
- Robust NEE against different prior fluxes

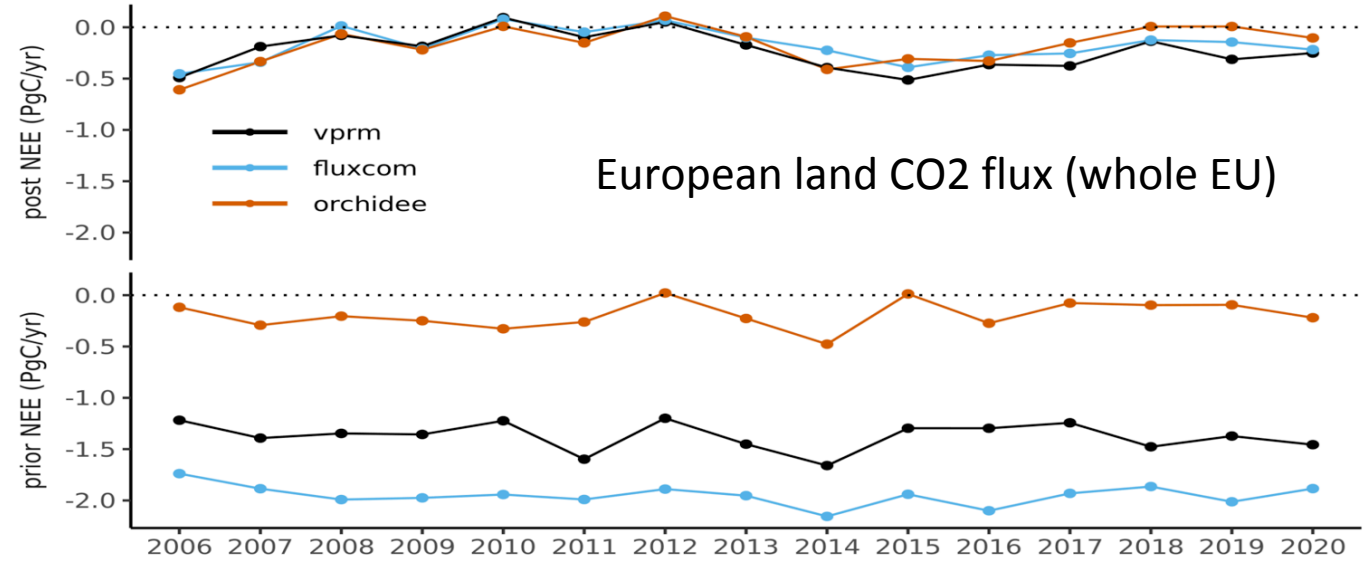




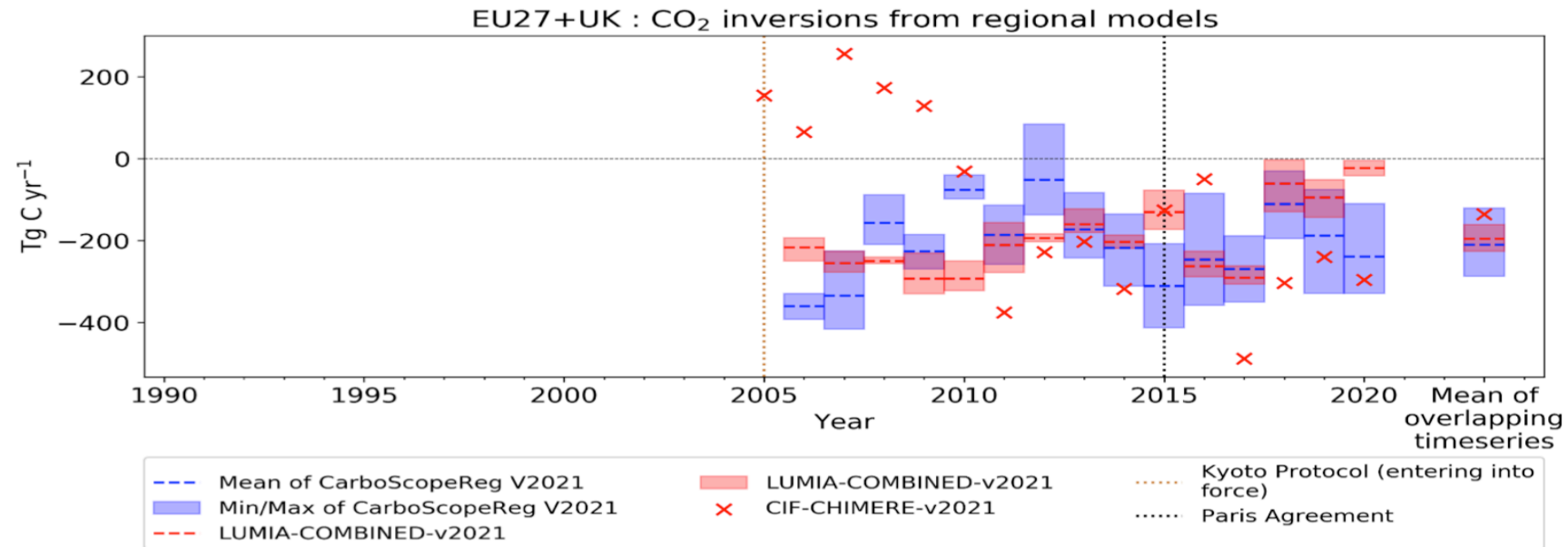
Regional CO2 land flux inversion



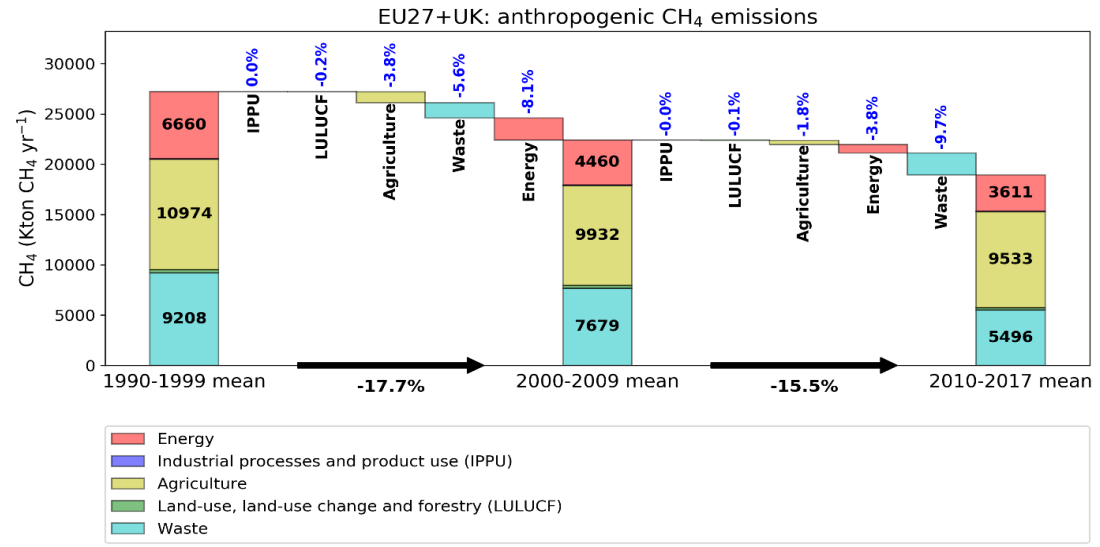
- Very promising results with CarboScopeRegional inverse system
- Robust NEE against different prior fluxes



- Comparison with others inversion models (CHIMERE, FLEXPART) show large year to year differences !

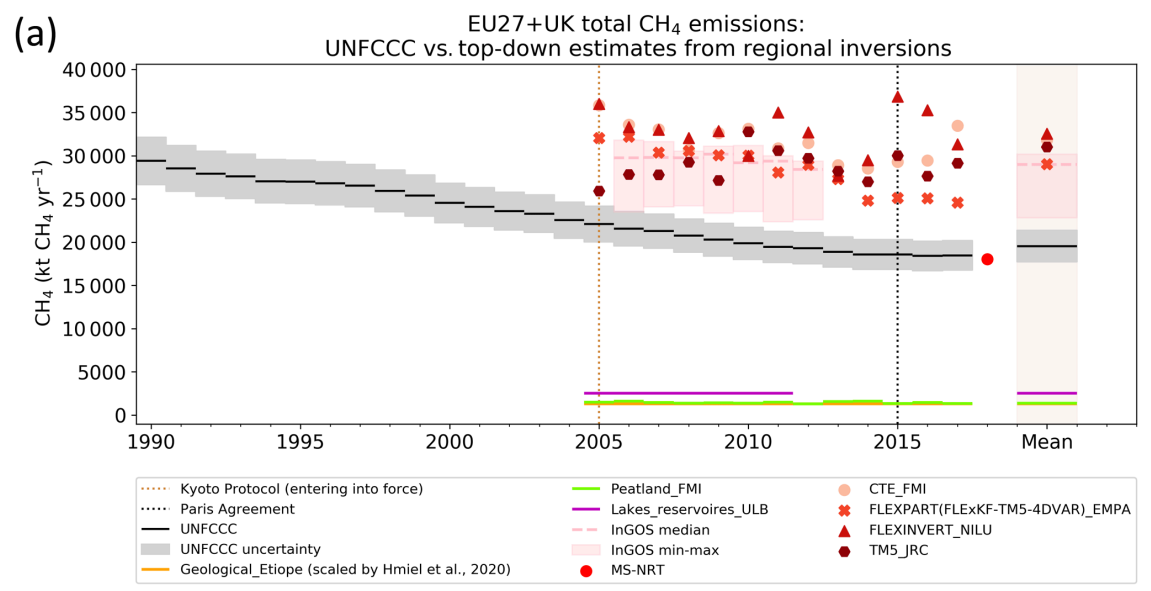
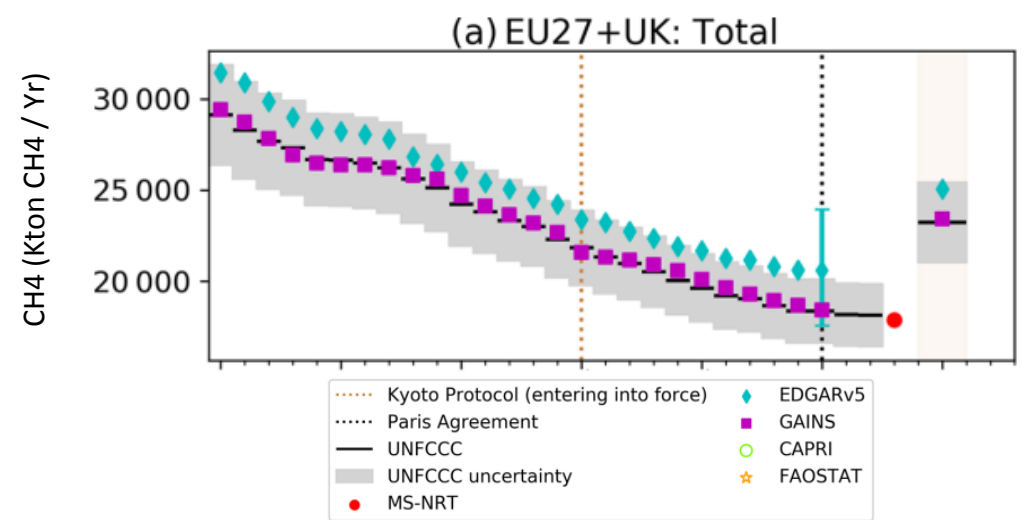


First synthesis of EU27+UK CH₄ anthropogenic fluxes

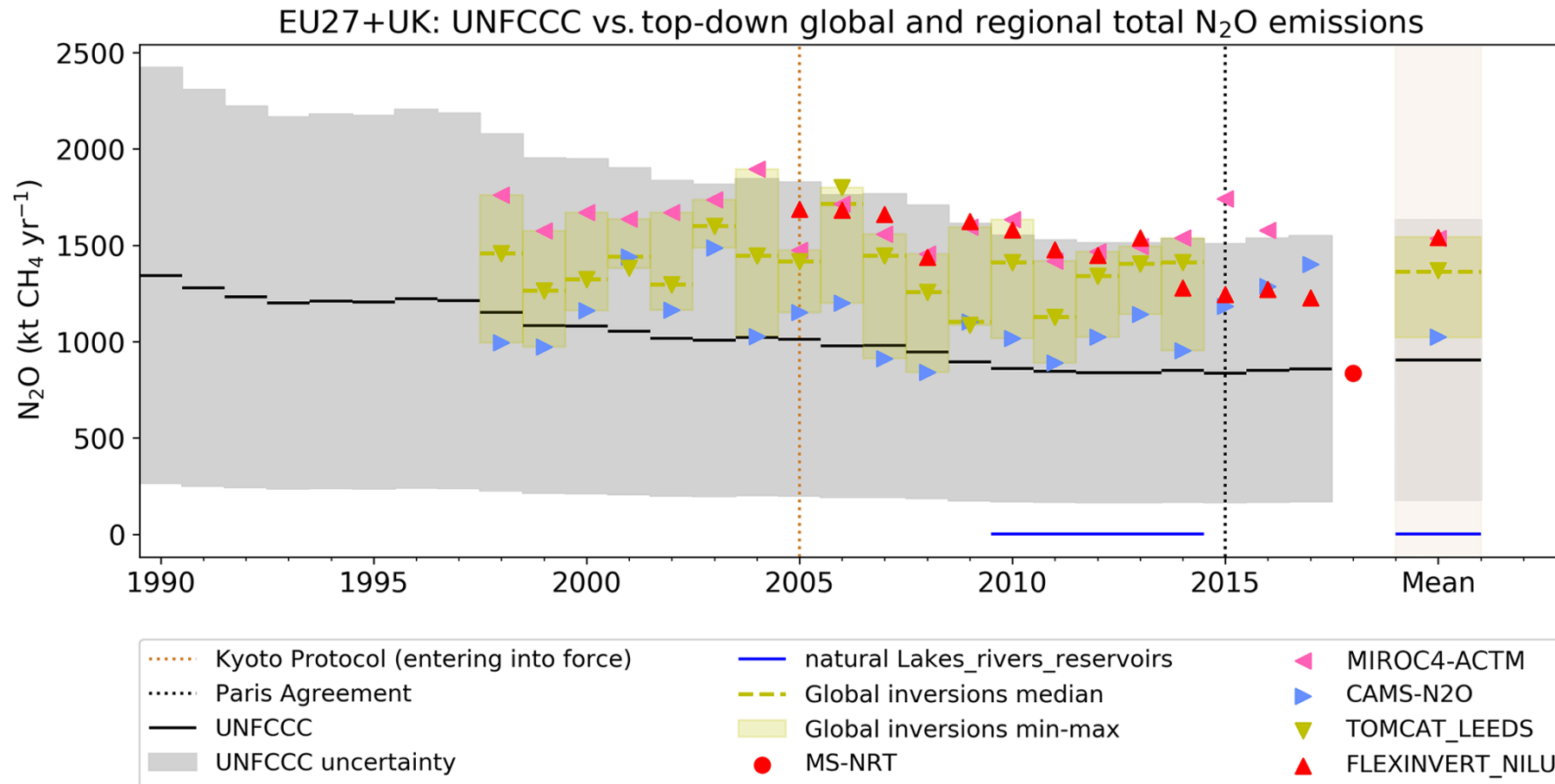


Contribution of 5 sectors to changes in decadal mean (as reported to UNFCCC)

UNFCCC flux changes compared to bottom up estimates for agriculture and all sectors (excluding LULUCF)




UNFCCC flux changes compared to regional atmospheric CH₄ inversions (regional inversions of VERIFY)



UNFCCC flux changes compared to regional / global atmospheric N₂O inversions: Higher emissions from the inversion but within the large UNFCCC uncertainty

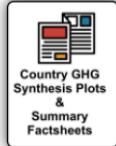
VERIFY PRODUCTS



Key Reports

Key scientific synthesis and reports produced by VERIFY


OPEN



Country GHG Synthesis Plots & Summary Factsheets

Synthetic plots comparing observation-based fluxes with national inventories for CO₂ / CH₄ and N₂O at country level (user-friendly interface)


OPEN



Searchable Data Repository

A list of every raw data source available through the VERIFY project as a country total. The sources are downloadable through the Services link in NetCDF file format, grouped by species (CO₂, CH₄, N₂O) and identified by a few key fields (e.g., institute, author, a simulation key which includes the model used, and an indication of the variables included).

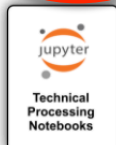
OPEN



Interactive Data Visualizations

Reduced entries from the "Searchable data repository" with a "Time series viewer" link that will connect the user to a webtool that allows instantaneous plotting of the data, with the capacity to plot multiple variables and countries/regions on the same graph, apply a rolling mean to smooth the curves, and zoom in and out for more detailed exploration than is found in the project synthesis plots.


OPEN



Technical Processing Notebooks

A link to the Github page where technical scripts used to explore the project datasets and create synthesis plots are available for downloading. These scripts include Jupyter notebooks and Python scripts.

OPEN



Community Inversion Framework

The CIF is a programming protocol combining various inversion bricks to make a flexible, transparent and open-source python-based tool to estimate the fluxes of various GHGs both at global and regional scales. It allows running different atmospheric transport models, observation streams and data assimilation approaches.

OPEN

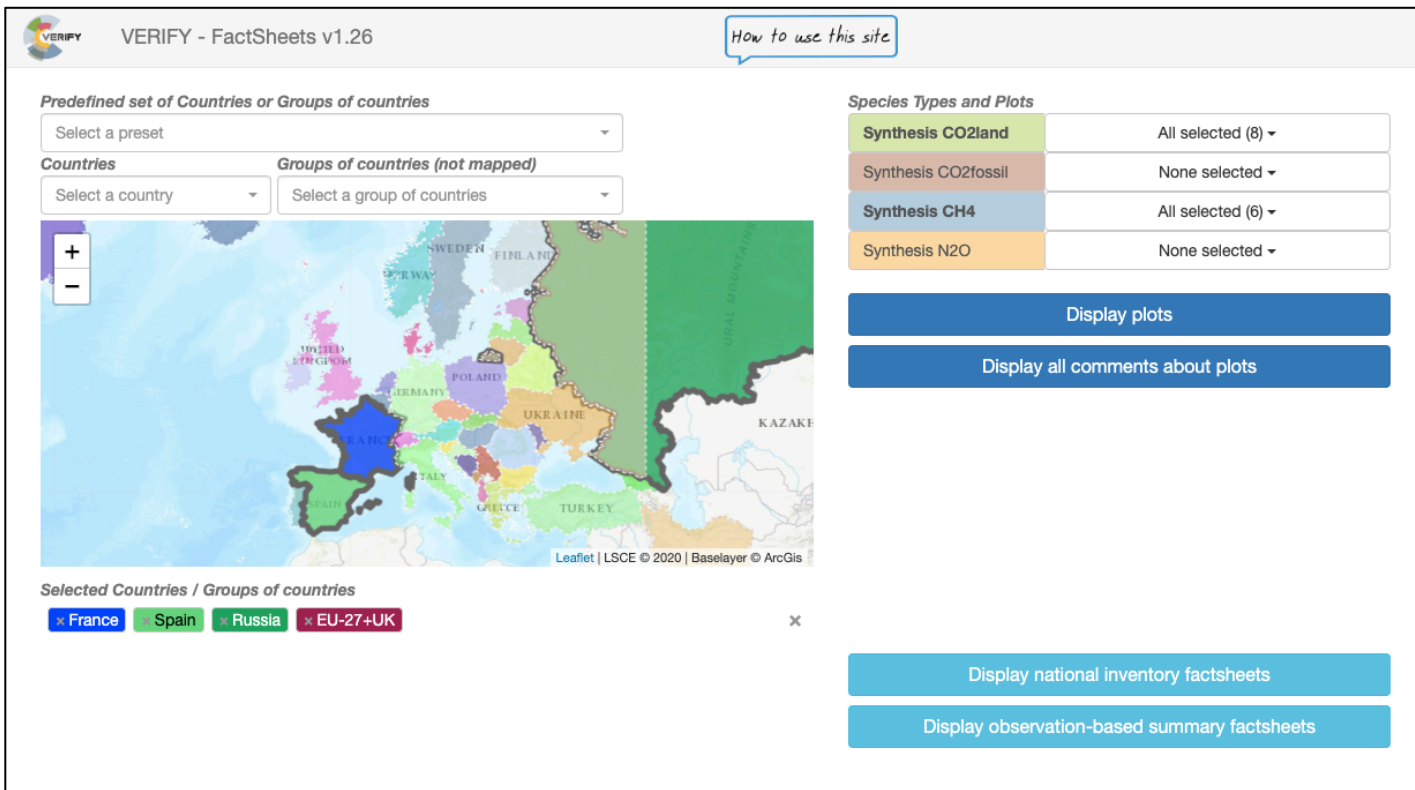
From the VERIFY web page:

<http://verify.lsce.ipsl.fr/index.php/products>
(Free registration)

- Access to all gridded products
- Synthetic plots: GHG time evolution per country, with all estimates
- Key reports and factsheets
- Interactive visualisation tool

From the VERIFY web page:

<http://verify.lsce.ipsl.fr/index.php/products>



The screenshot shows the VERIFY web interface for selecting countries and plots. The interface includes a map of Europe with various countries highlighted in different colors. On the right side, there are several dropdown menus and buttons for selecting species types and plots.

Predefined set of Countries or Groups of countries

Select a preset

Countries Groups of countries (not mapped)

Select a country Select a group of countries

Species Types and Plots

Synthesis CO2land	All selected (8)
Synthesis CO2fossil	None selected
Synthesis CH4	All selected (6)
Synthesis N2O	None selected

Display plots

Display all comments about plots

Selected Countries / Groups of countries

France Spain Russia EU-27+UK

Display national inventory factsheets

Display observation-based summary factsheets

- Selection of countries (groups of) (soon over 160 countries)
- Select GHG type
- Select types of plots
- Display synthesis plots or summary Factsheets



Synthesis plots / Summary factsheets for policy makers



Fact Sheet - E28

November 2020

CO₂land

E28 = EU27 + UK

E28: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom.

Summary of decennial trends from data reported to the UNFCCC

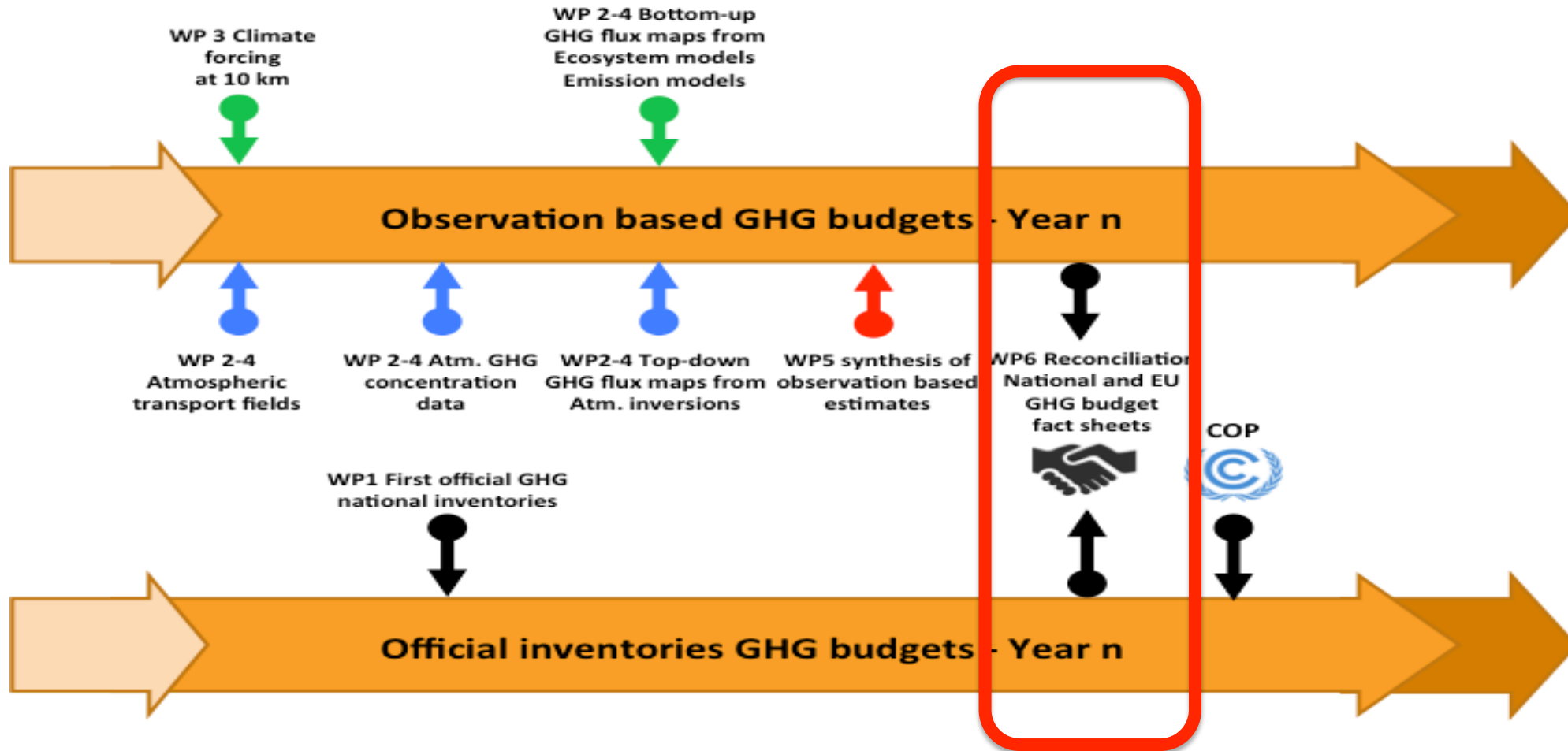
Carbon dioxide emissions reported to the UNFCCC from the land use, land use change, and forestry sector are a **strong sink** over the past three decades, with variation resulting primarily from harvested wood products.

Comparison between bottom-up approaches

Comparison between top-down and bottom-up approaches

Top-down and bottom-up scientific research models **agree** that the sector is a strong sink of atmospheric CO₂, showing much greater year-to-year variability than NGHGs due to **heighted response to climatic variation**.

Horizon 2020 Societal challenge 5: Climate action, environment, resource efficiency and raw materials



- **Annual updates** of observation-based GHG national budgets and inventories (like GCB)
- Regional changes in GHG budgets and drivers and Uncertainties analysis
- Tracking progress towards EU mitigation targets (Paris Agreement NDCs, stocktake)



Summary – Key messages



- Atmospheric inversions provide substantial information to support Inventory estimates;
But highly depend on the GHG, region size ; current observation network,...
- CO₂fossil: still a huge challenge ahead ! But it will improve with new obs (CO₂M, ...)
- CO₂land: already some important results can be obtained (especially on IAV)
- CH₄ & N₂O: the most promising given current uncertainties in National Inventories
- Collaboration with National Inventory Agencies is needed / crucial !
The better the prior flux we get the better the inversion results !