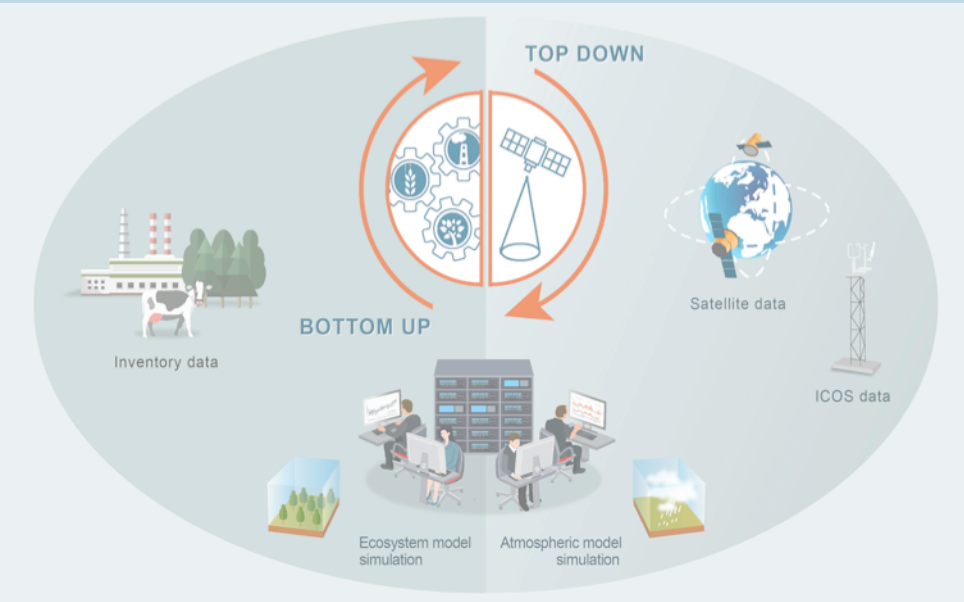
VERIFY General Assembly
What did we learned from VERIFY ?

Philippe Peylin for all VERIFY partners

May 9th -11th , 2022



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 776810

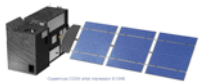
What did we learn in VERIFY ?

VERIFY

CHE

CoCO2

1st GST



2nd GST

2016

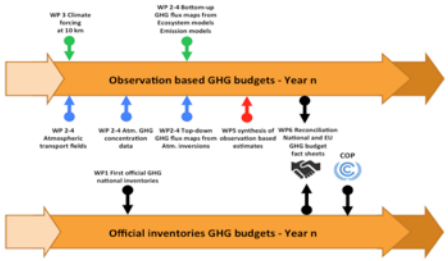
2018

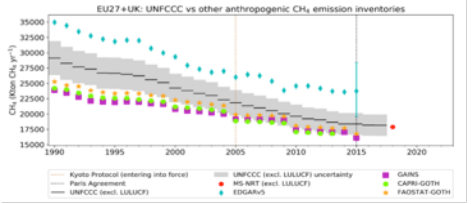
2023

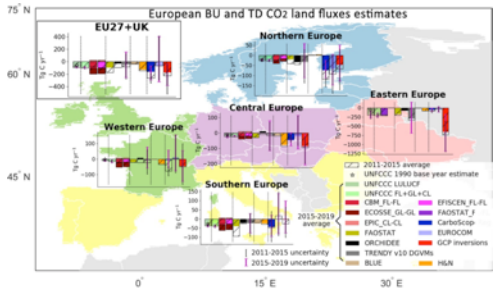
2025

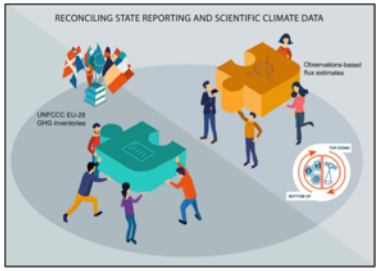
What did we learn in VERIFY ?

Several key contributions
(Monitoring & Verification Support capacity)







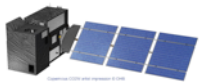


VERIFY

CHE

CoCO2

1st GST

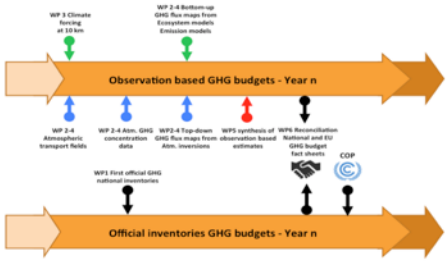


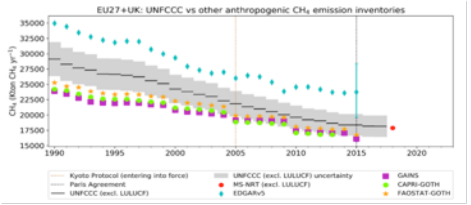
2nd GST

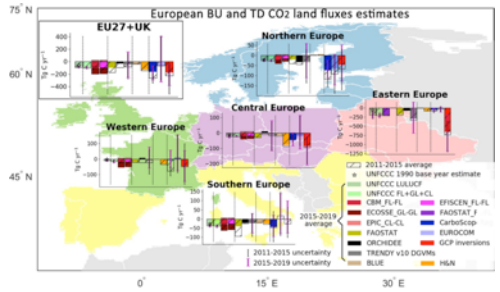
2016 2018 2023 2025

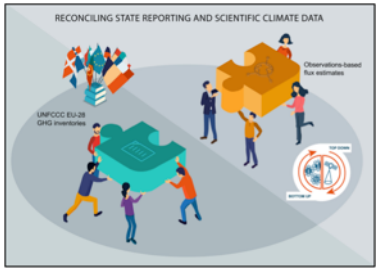
What did we learn in VERIFY ?

Several key contributions
(Monitoring & Verification Support capacity)









But still a lot of work to be done !

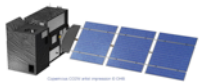
- Fossil CO2 emissions still at their infancy !
- Large differences between Inversions / Bottom-up models to be resolved
- Sectoral flux estimates remains a challenge !

VERIFY

CHE

CoCO2

1st GST



2nd GST

2016 2018 2023 2025

WP1: A new constructive dialogue with Inventory agencies has emerged !

2016: Aeroport CDG

WP1: A new constructive dialogue with Inventory agencies has emerged !

2016: Aeroport CDG

2018: Kick off (Bruxelles)

➢ We do not speak the same language

WP1: A new constructive dialogue with Inventory agencies has emerged !

2016: Aeroport CDG

2018: Kick off (Bruxelles)

➢ We do not speak the same language

2019: First Network meeting

➢ Obs-based method are not usefull !

WP1: A new constructive dialogue with Inventory agencies has emerged !

2016: Aeroport CDG

2018: Kick off (Bruxelles)

➢ We do not speak the same language

2019: First Network meeting

➢ Obs-based method are not usefull !

2020: Second Network meeting

➢ Maybe one can use obs-based data !

WP1: A new constructive dialogue with Inventory agencies has emerged !

2016: Aeroport CDG

2018: Kick off (Bruxelles)

- We do not speak the same language

2019: First Network meeting

- Obs-based method are not usefull !

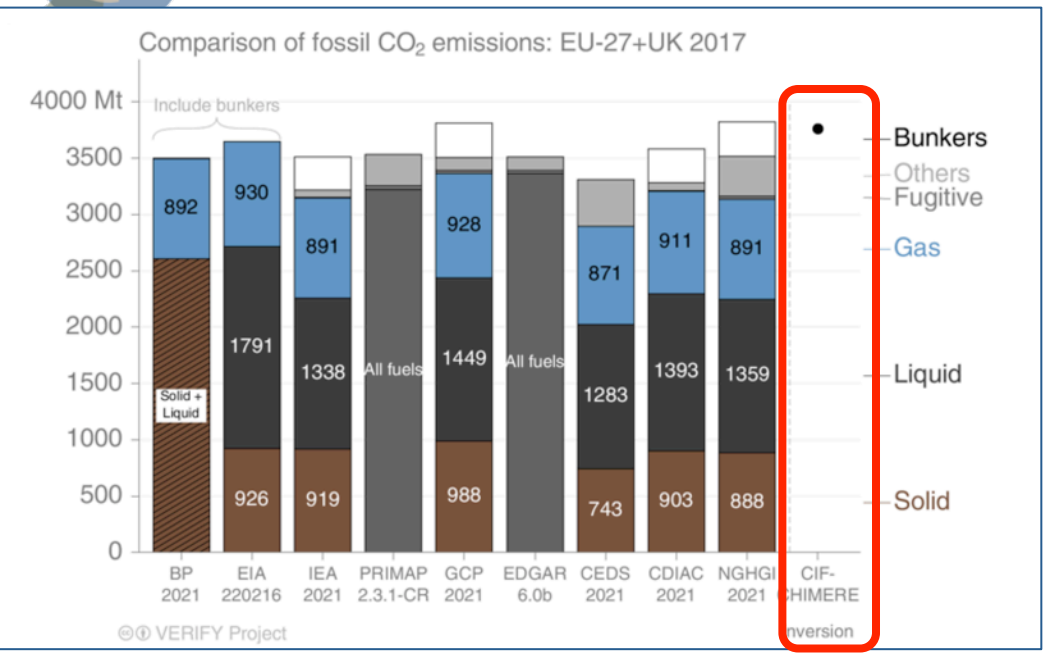
2020: Second Network meeting

- Maybe one can use obs-based data !

2022: Final meeting

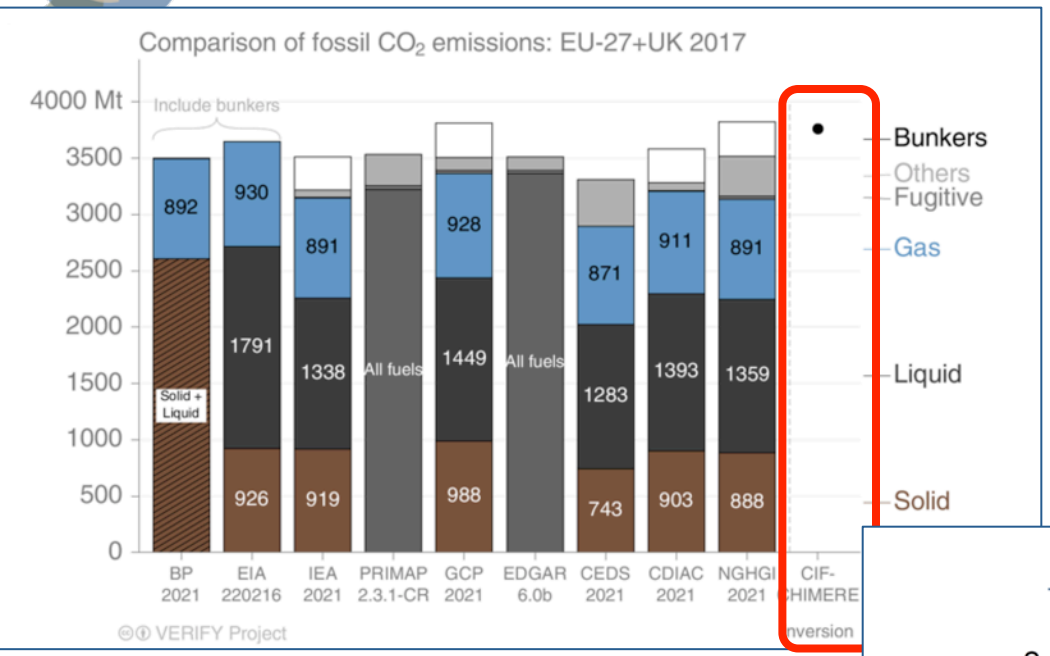
- We now trust that we can work together !

Estimating fossil CO2 fluxes : Still a great challenge !



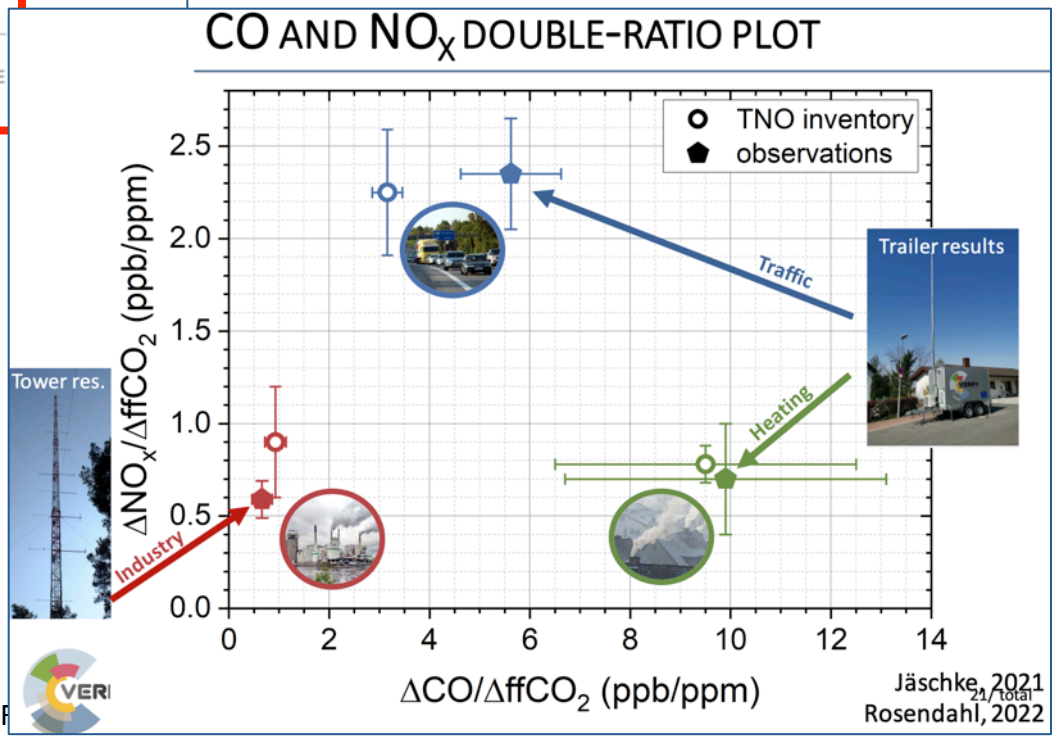
- **Relatively good agreement hide the fact that the inversion stayed relatively closed to the prior !**
- **Satellite observations (CO2M) will provide better constraints but varying NO2/CO2 and CO/CO2 ratio is critical**

Estimating fossil CO2 fluxes : Still a great challenge !

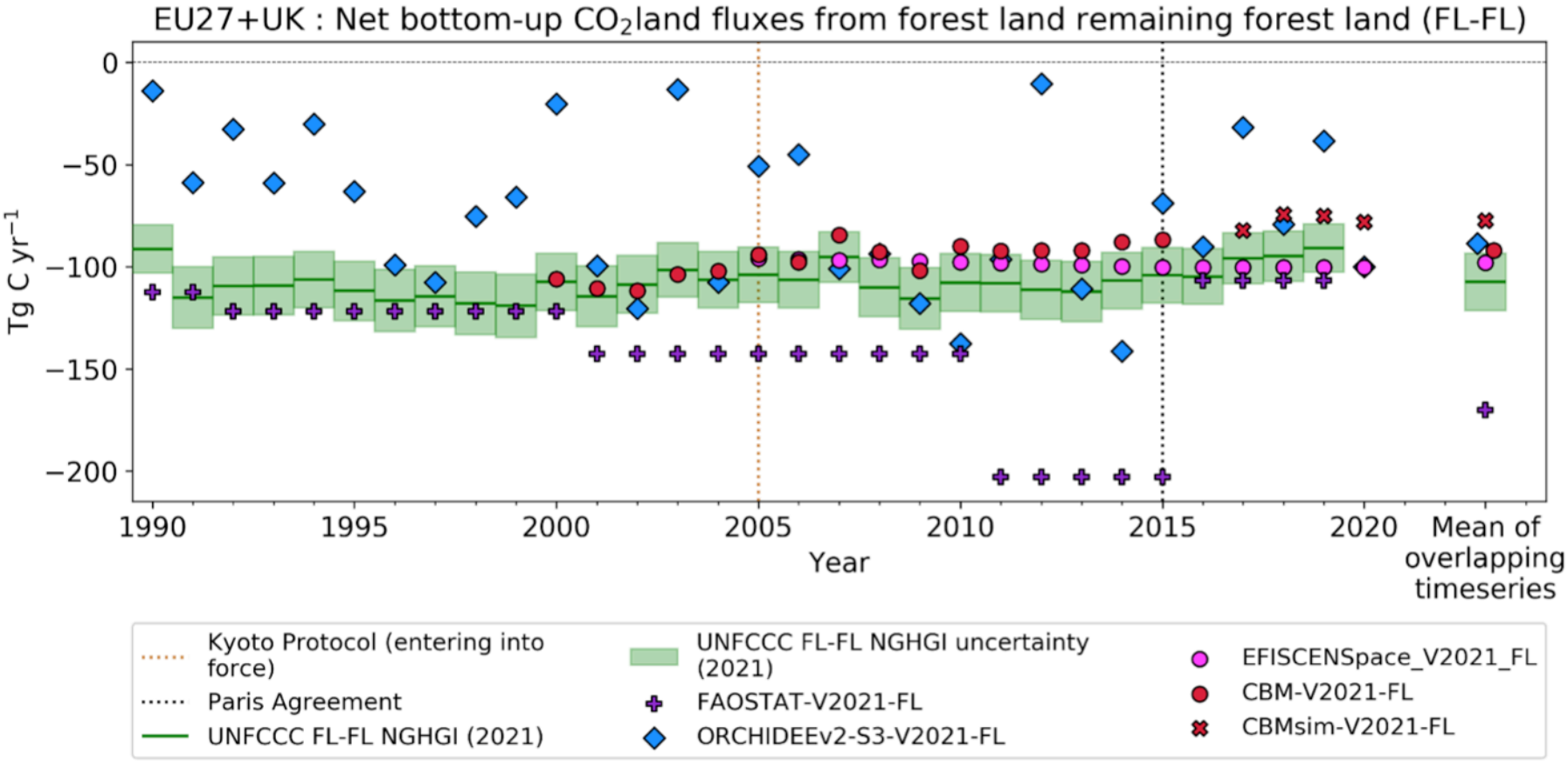


- **Relatively good agreement hide the fact that the inversion stayed relatively closed to the prior !**
- **Satellite observations (CO2M) will provide better constraints but varying NO2/CO2 and CO/CO2 ratio is critical**

- **Measured Ratio during 2020 campaign in Rhine valley ⇒ provide critical information**
- **Relatively good agreement with TNO ratio !**
- **But small difference are critical !**

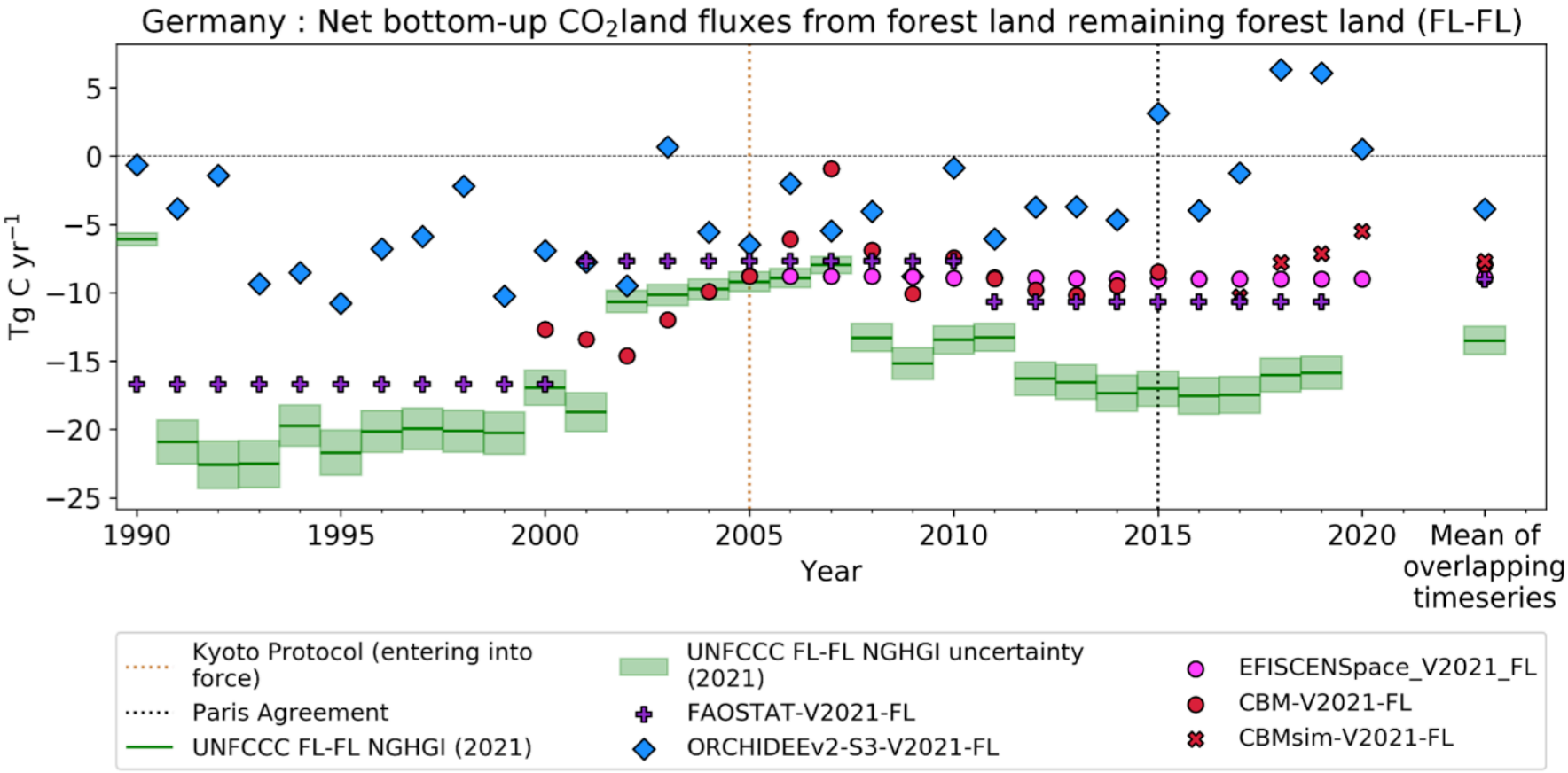


CO2 land : Ecosystem models (ex. Forest)



- **Potential effect of forest area differences (CBM vs EFISCEN)**
- **Comparison over Romania CBM vs EFISCEN:10% diff (Blujdea et al. 2021)**
- **ORCHIDEE has a much larger yearly variability !**

CO2 land : Ecosystem models (ex. Forest)



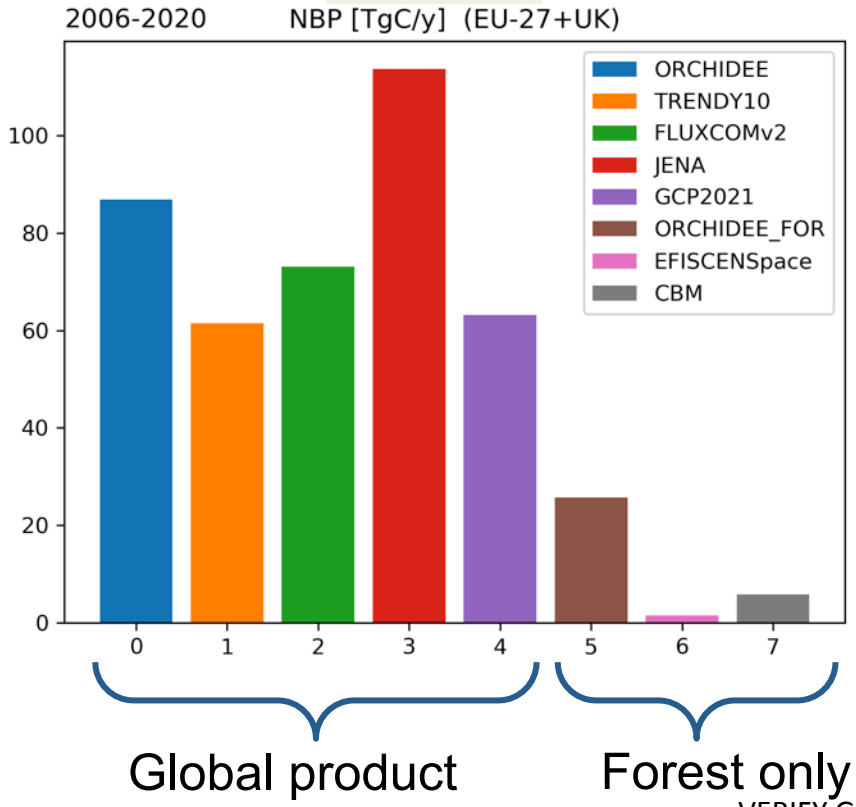
- **Potential effect of forest area differences (CBM vs EFISCEN)**
- **Comparison over Romania CBM vs EFISCEN:10% diff (Blujdea et al. 2021)**
- **ORCHIDEE has a much larger yearly variability !**

CO2 land : Example of forest ecosystem models

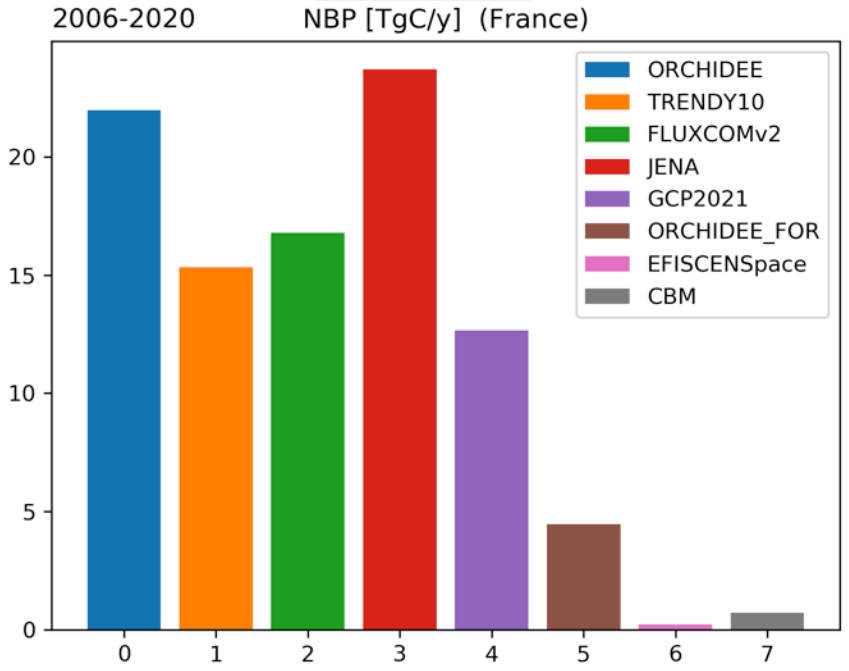
➢ **Is the large yearly variability of ORCHIDEE robust ?**

IAV (standard deviation of yearly mean fluxes) for different products !

EU 28



France

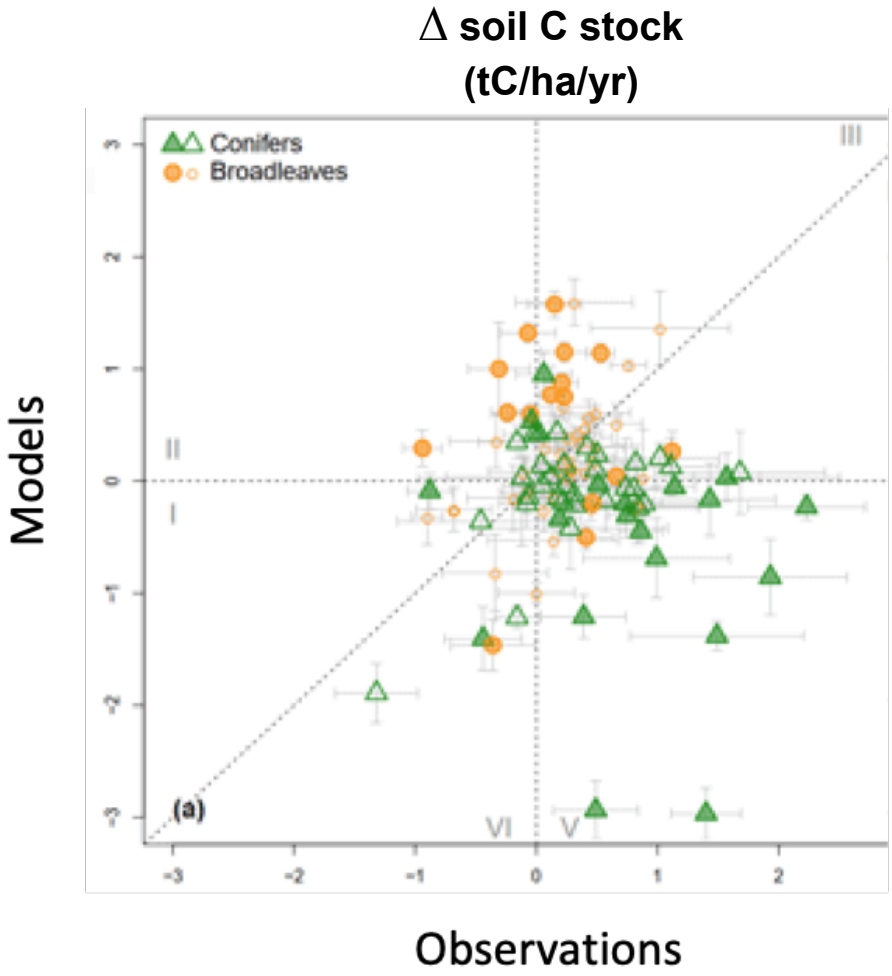


CO2 land : For all ecosystems….

➢ **Soil C dynamic is still poorly modeled !**

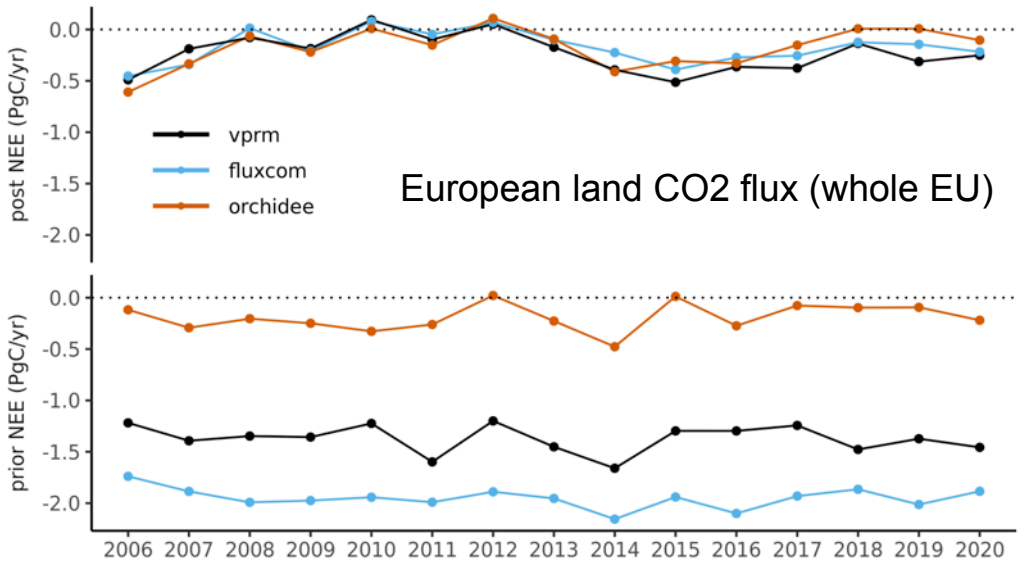
⇒ Current models do not represent well the observed Δ **soil C stock** (Mao et al., 2019; YASSO model)

⇒ Need to use these data to calibrate current models !



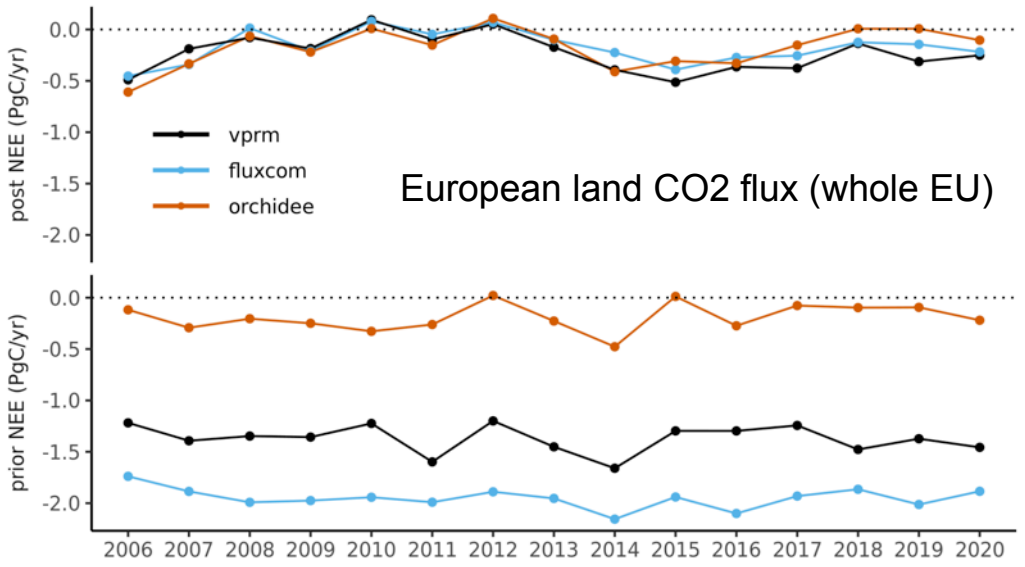
Atmospheric inversions : CO2 land

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

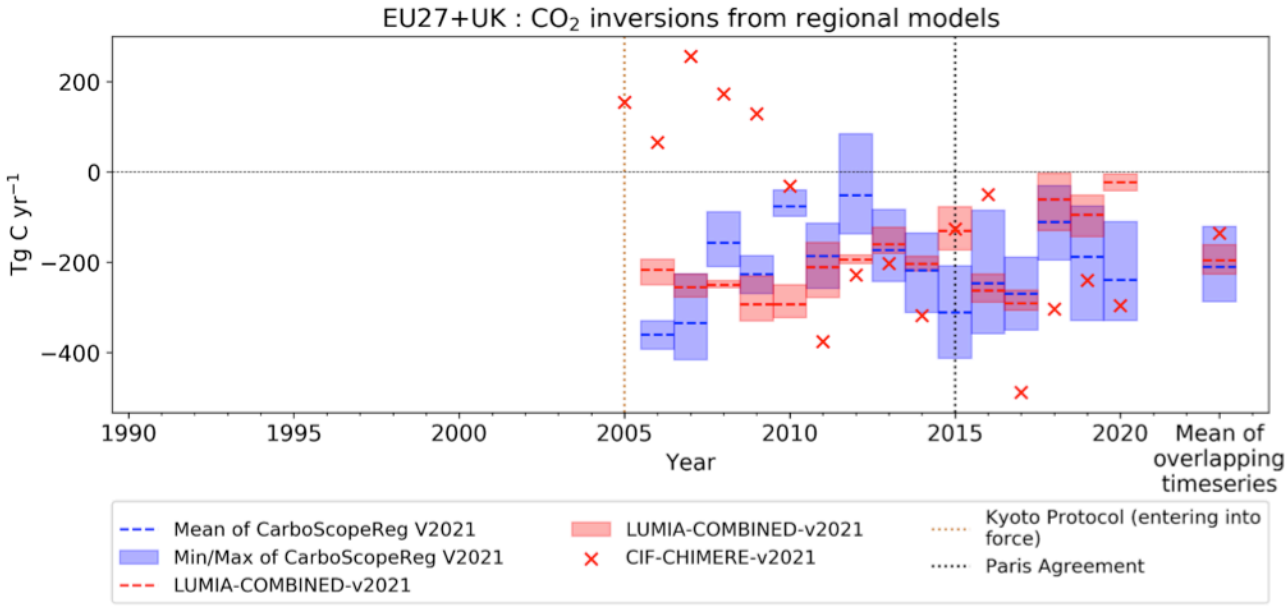


Atmospheric inversions : CO2 land

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

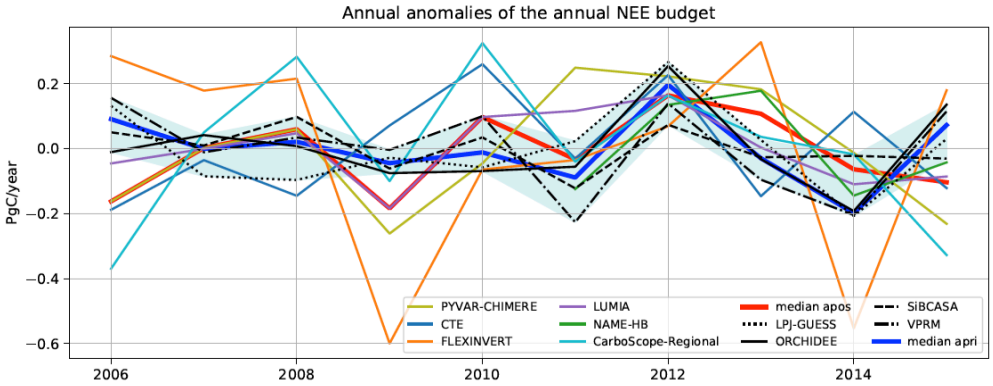


- Comparison with others models (CIF-CHIMERE, LUMIA) show large year to year differences !



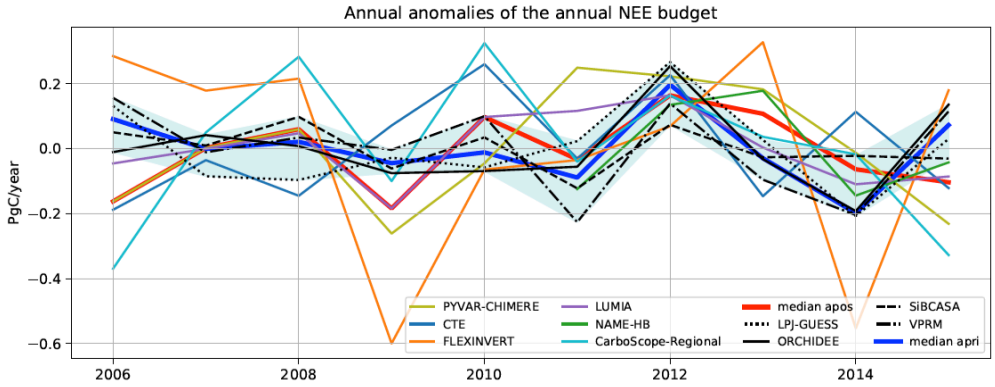
Regional atmospheric inversions

EUROCOM : 1st Regional inversion inter-comparison (Monteil et al., 2020)

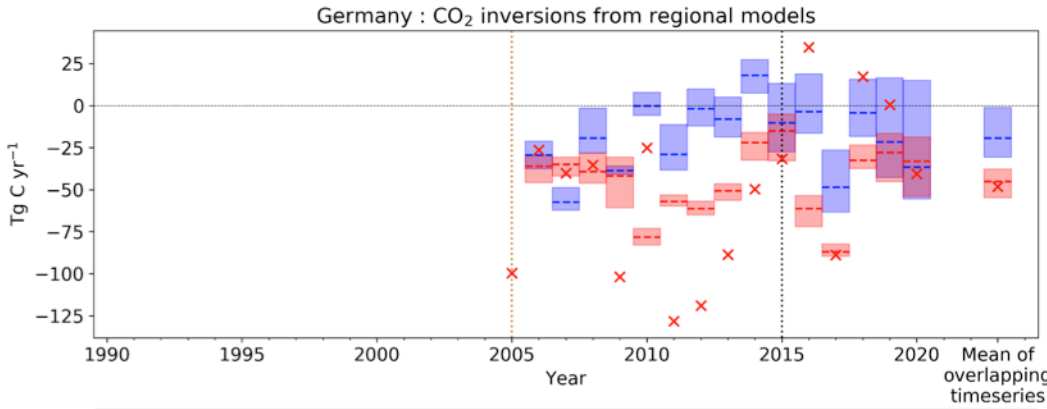


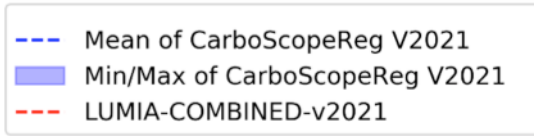
Regional atmospheric inversions

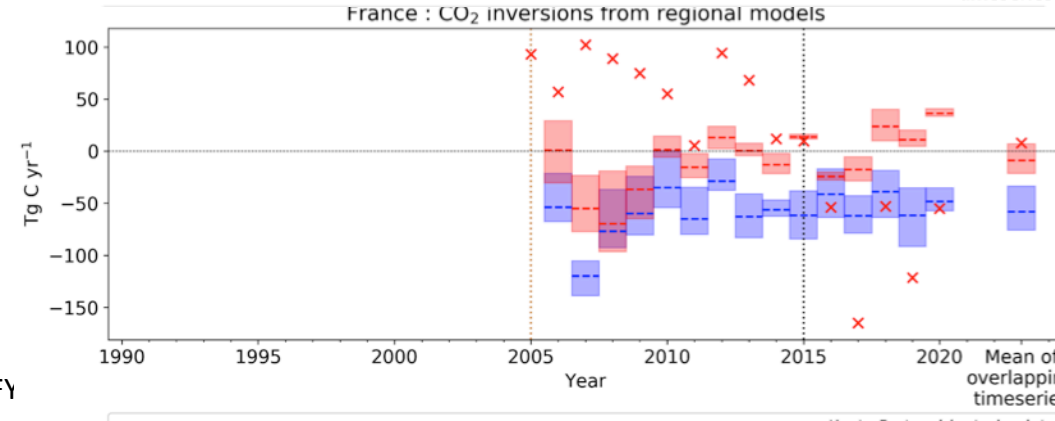
EUROCOM : 1st Regional inversion inter-comparison (Monteil et al., 2020)

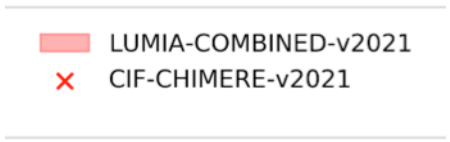


VERIFY : 2nd Regional inversion inter-comparison
⇒ But still preliminary !









Atmospheric inversions : Community framework

Available models and features:

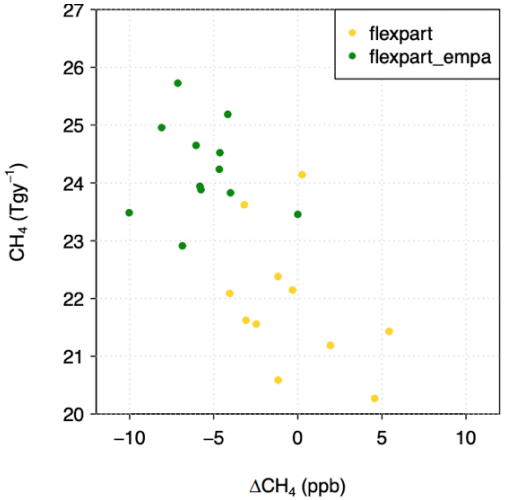
- CHIMERE, LDMZ, TM5, FLEXPART (NILU and Empa), WRF-Chem, ICON-ART
  soon: STILT, DYNAMICO
- Elaborated observations: satellites (OMI, TROPOMI, GOSAT, MOPITT, OCO2), isotopes, AirCore
- Interface to classical datastreams: EDGAR, TNO, CAMS, ObsPack, etc.
- High flexibility in defining control vectors
- Several inversion approaches: 4d-var, EnKF, analytical
- Integrated pre-processors: regridding, interpolations, etc.
- Extensive documentation and tutorials: **community-inversion.eu**
- Continuous development and testing on GitLab (see tutorials)

Legacy and future projects:

- Leverage work for future inter-comparisons
- Propagation to operational applications
- Implementation of multi-species inversions, FFDAS, CCDAS, etc.
- Nested model coupling (e.g., FLEXPART-LMDZ) for multi-scale inversions

Do we need one inverse system per country ?

Large dependence of regional inversions to BACKGROUND !

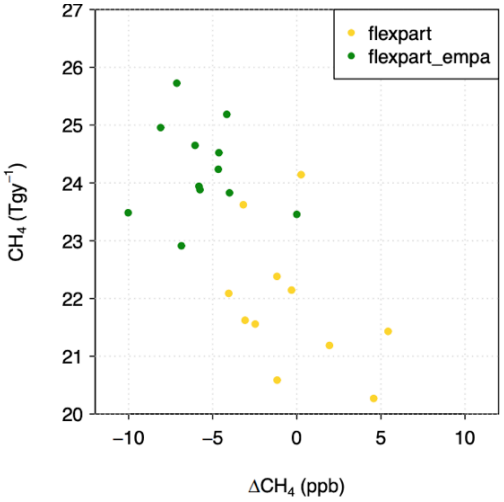


Regional CH4 inversion

The 2 FLEXPART inversions provided background mixing ratios – found negative correlation between bias in background and total emissions

Do we need one inverse system per country ?

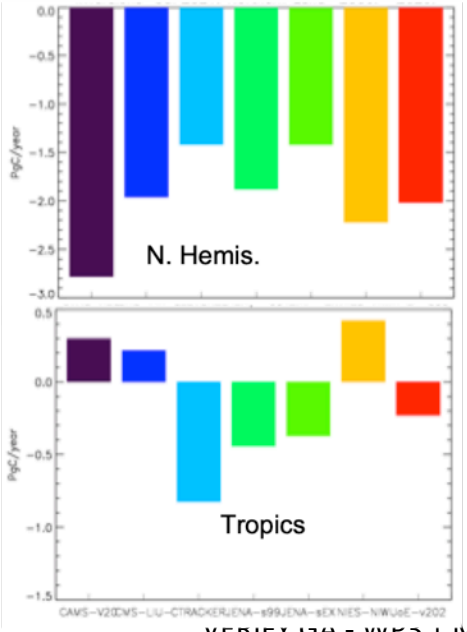
Large dependence of regional inversions to BACKGROUND !



Regional CH4 inversion

The 2 FLEXPART inversions provided background mixing ratios – found negative correlation between bias in background and total emissions

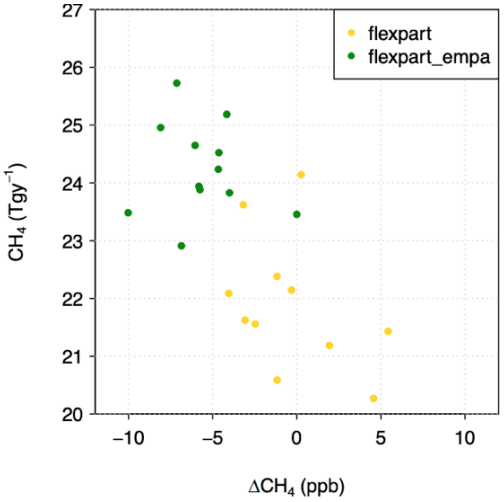
Global inversion used for CO2 still differ at very broad scale !



Net C fluxes: Mean over 2010-2020

Do we need one inverse system per country ?

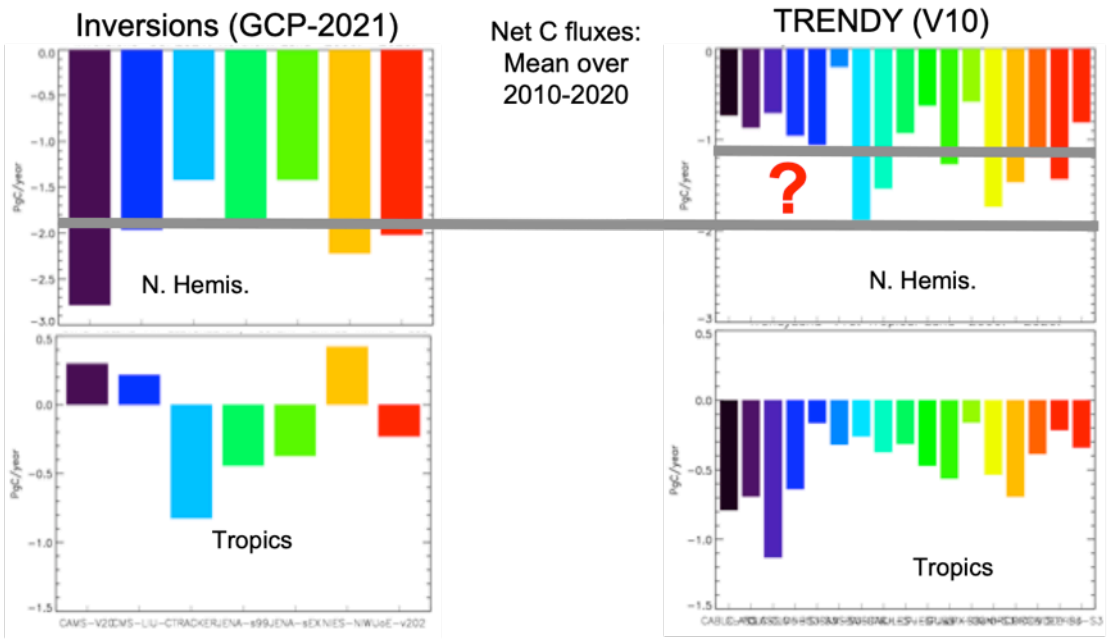
Large dependence of regional inversions to BACKGROUND !



Regional CH4 inversion

The 2 FLEXPART inversions provided background mixing ratios – found negative correlation between bias in background and total emissions

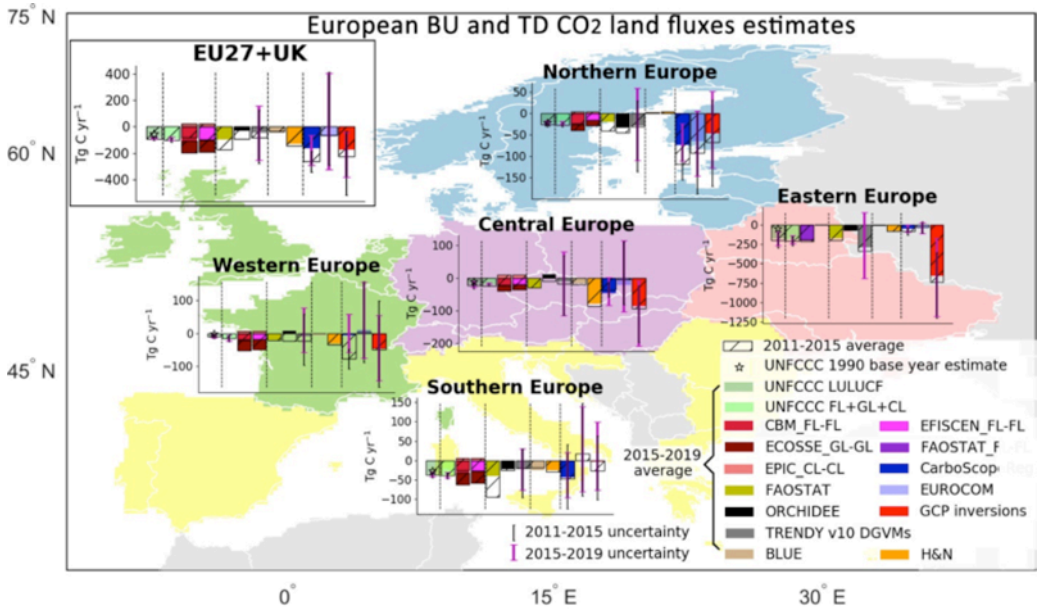
Global inversion used for CO2 still differ at very broad scale !

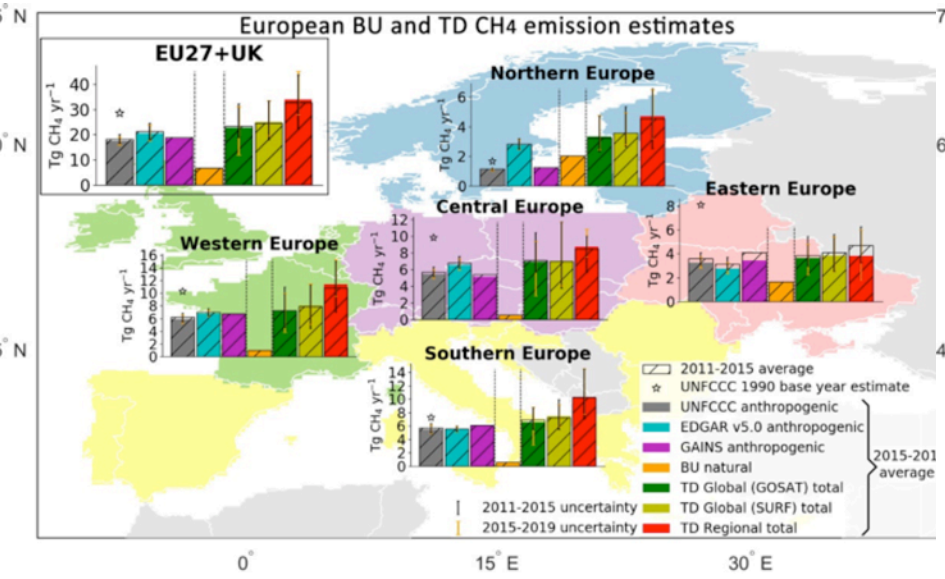


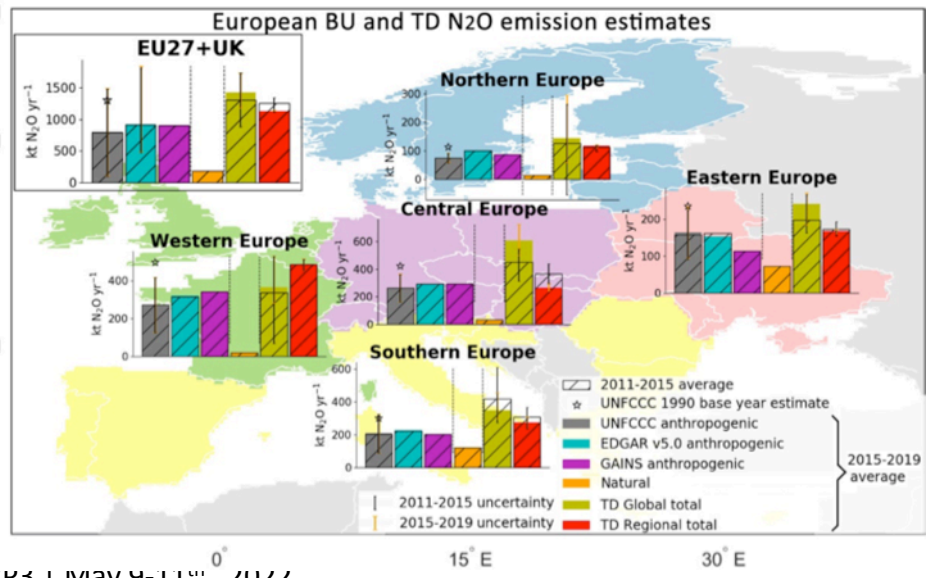
New EU / Country-based GHG flux synthesis !

- CO2land, CH4 and N2O flux synthesis for each country !
- Updated each year !

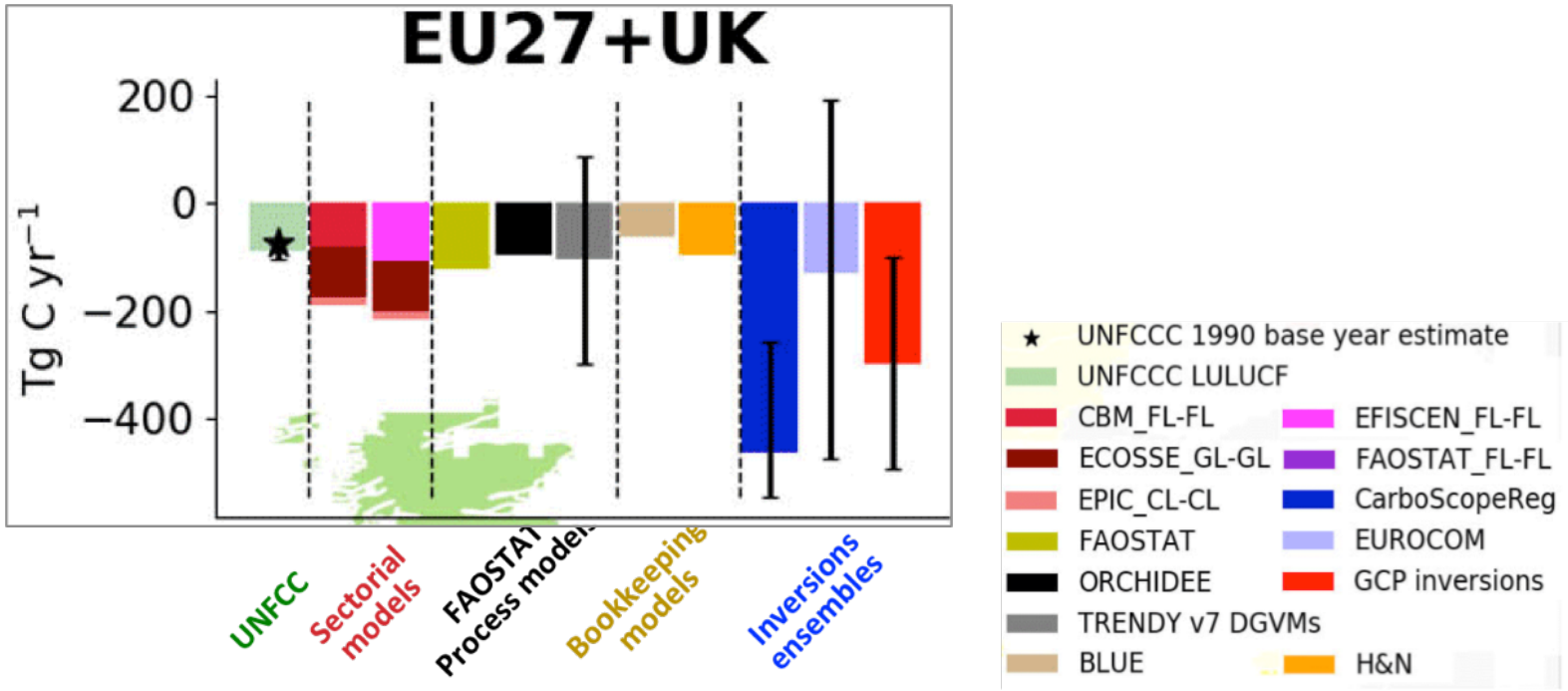
⇒ Enlarged to 230 countries (using global products)





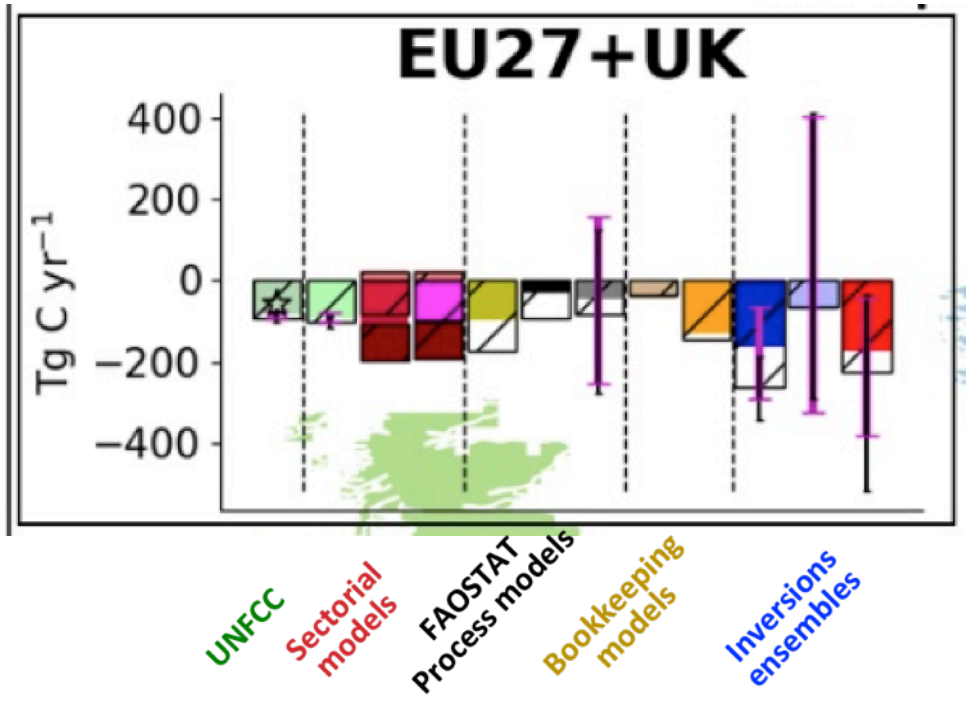


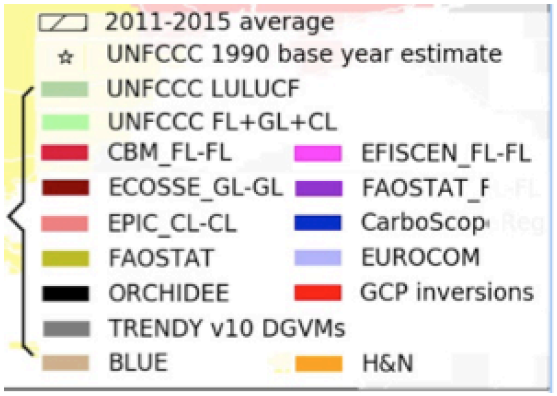
CO2 land flux synthesis - next steps



- Inversions tend to show a larger sink !

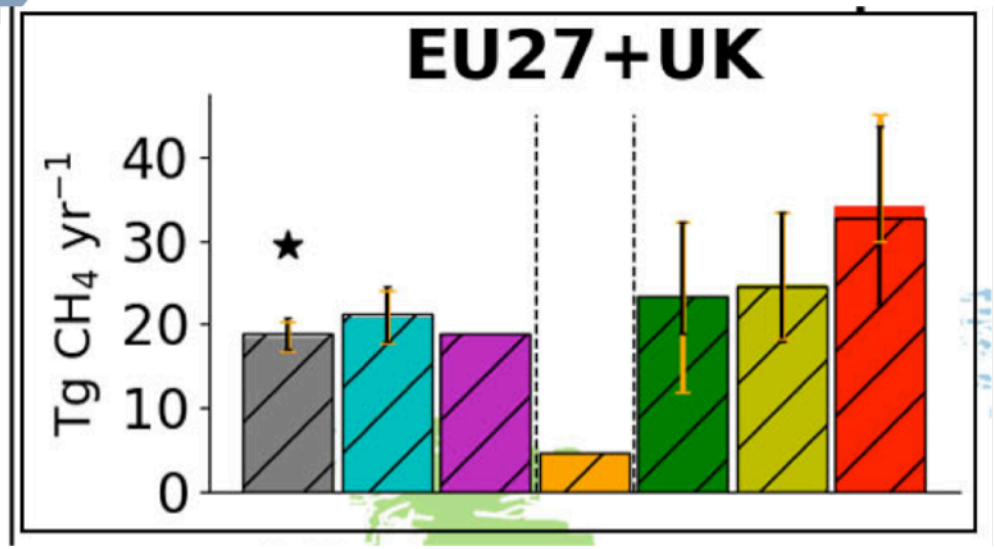
CO2 land flux synthesis - next steps





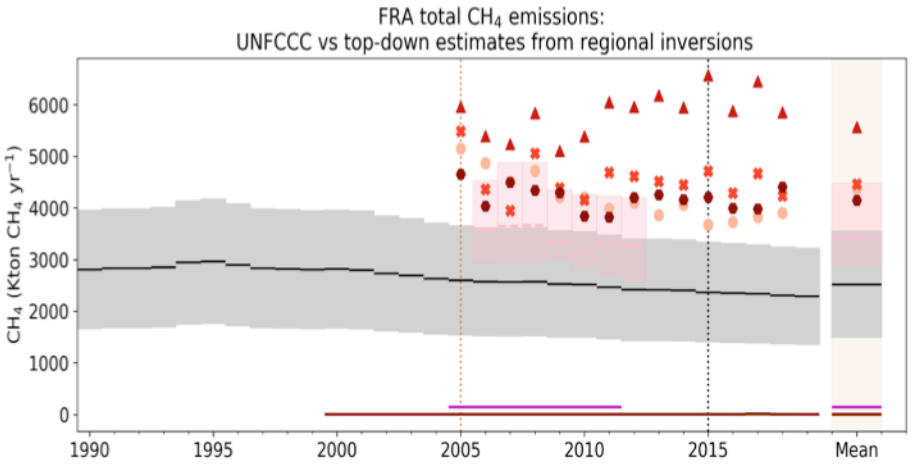
- Reduction of the Inversion sink !
- **Need to account for lateral transfers of C (and to account for rivers / lakes CO2 outgasing)**
- **Comparison with UNFCCC still suffer from what is considered Natural vs Anthropogenic (mainly for non EU countries)**

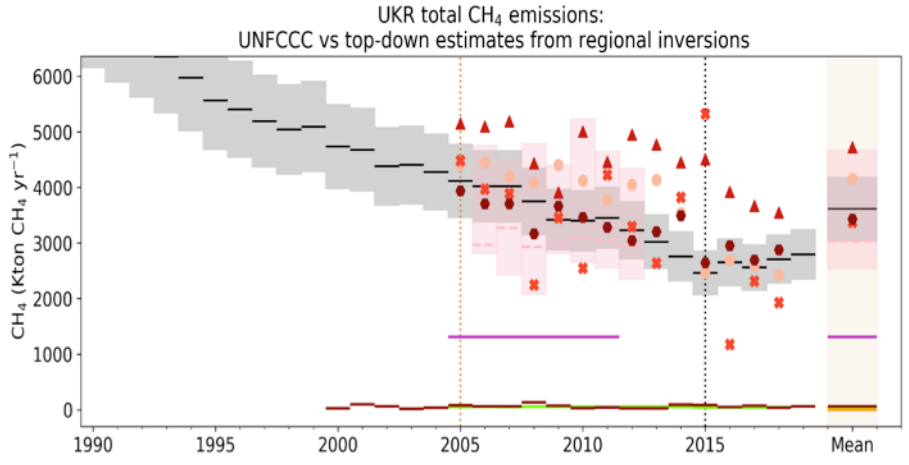
CH4 flux synthesis - total fluxes



2011-2015 average
UNFCCC 1990 base year estimate
UNFCCC anthropogenic
EDGAR v5.0 anthropogenic
GAINS anthropogenic
BU natural
TD Global (GOSAT) total
TD Global (SURF) total
TD Regional total
2013-2017 average

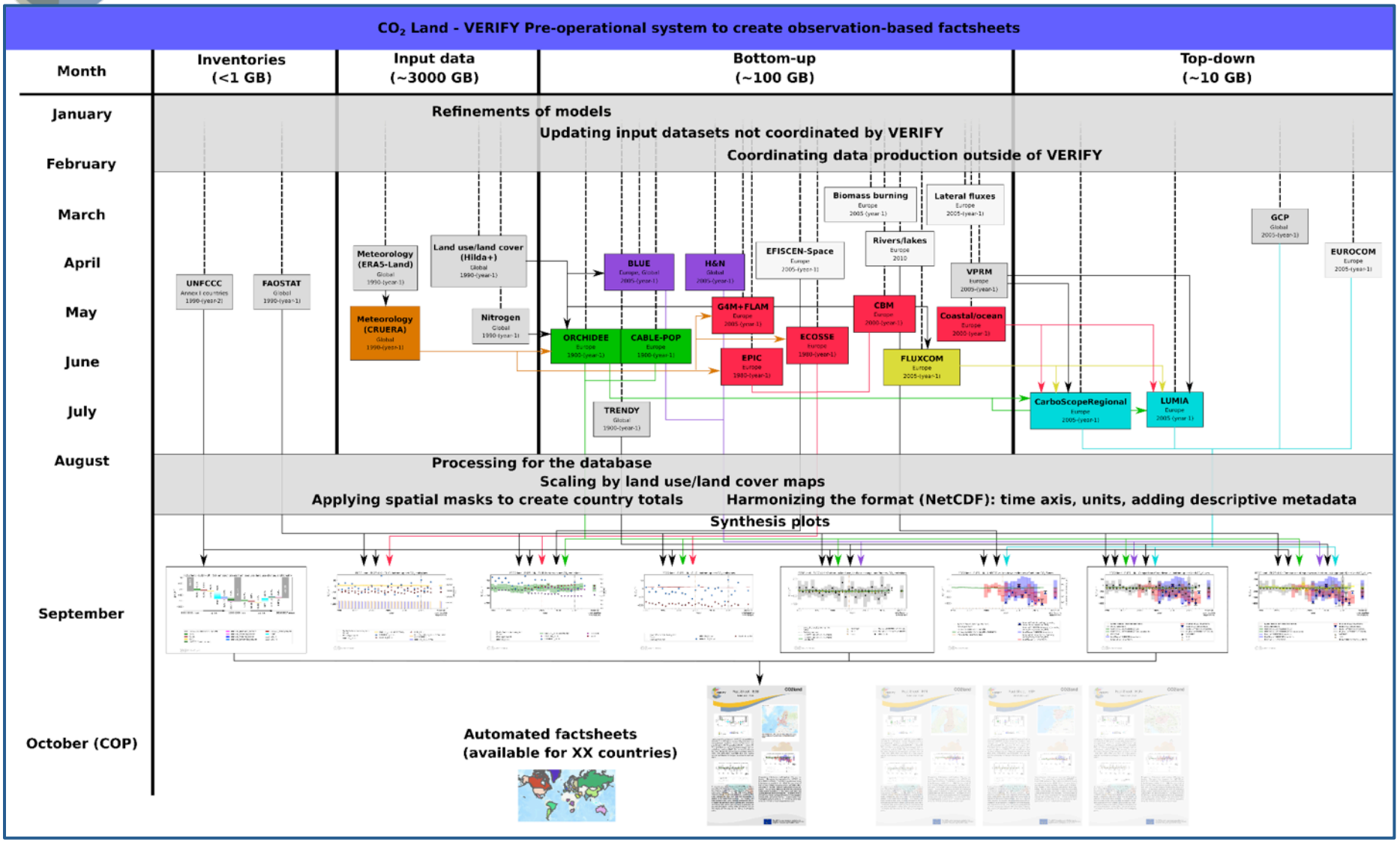
- **Larger Reg. Inver. flux**
- **But country specific**





Kyoto Protocol (entering into force)
Paris Agreement
UNFCCC
UNFCCC uncertainty
Peatland_FMI
Lakes_reservoirs_ULB
InGOS median
InGOS min-max
Biomass burning, GFEDv4.1
CTE_FMI
FLEXPART(FLExKF-TM5-4DVAR)_EMPA
FLEXINVERT_NILU
TM5_JRC

A pre-operational GHG MVS has been built !



Much More work needed before operational !

- **Differences exist for each GHG**
  - CH4 and N2O not yet “Yr - 1” as atmospheric data are lagging behind
  - GCP effort to bridge the gap…

Much More work needed before operational !

- **Differences exist for each GHG**
  - CH4 and N2O not yet “Yr - 1” as atmospheric data are lagging behind
  - GCP effort to bridge the gap…

- **Possible next steps to improve the overall system**
  - **How to valorise** different ecosystem model (CO2 and CH4_wetland)

Much More work needed before operational !

- **Differences exist for each GHG**
  - CH4 and N2O not yet “Yr - 1” as atmospheric data are lagging behind
  - GCP effort to bridge the gap…

- **Possible next steps to improve the overall system**
  - **How to valorise** different ecosystem model (CO2 and CH4_wetland)
  - **Use more country-specific prior fluxes**
    (from Inventory Agencies as prior information in the inversions)

Much More work needed before operational !

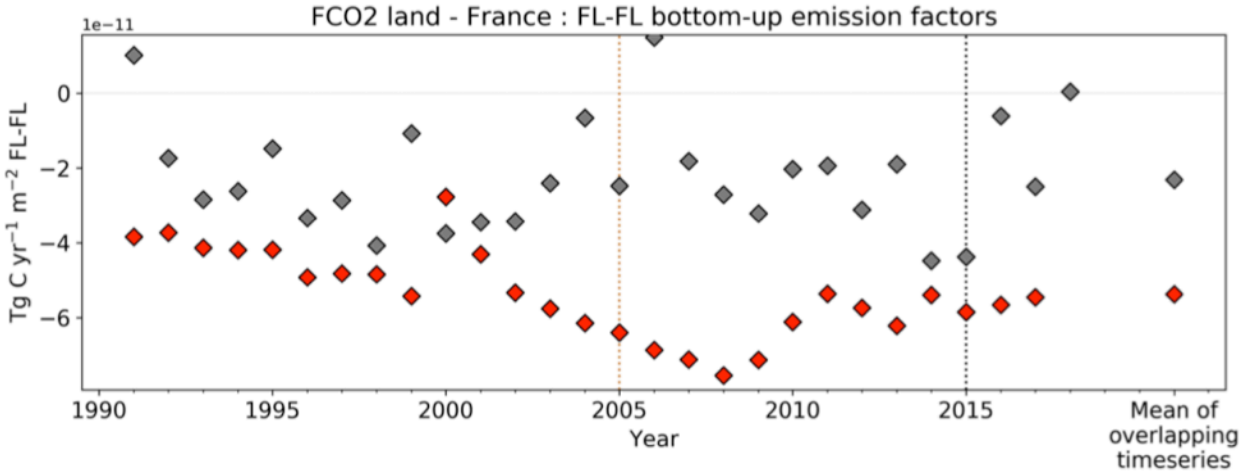
- **Differences exist for each GHG**
  - CH4 and N2O not yet “Yr - 1” as atmospheric data are lagging behind
  - GCP effort to bridge the gap…

- **Possible next steps to improve the overall system**
  - **How to valorise** different ecosystem model (CO2 and CH4_wetland)
  - **Use more country-specific prior fluxes** (from Inventory Agencies as prior information in the inversions)
  - **Derive emission factors (EF) from flux estimates** and or at least EF spatial and temporal variability

LULUCF emission factors from:

UNFCC emission / Forest - Forest

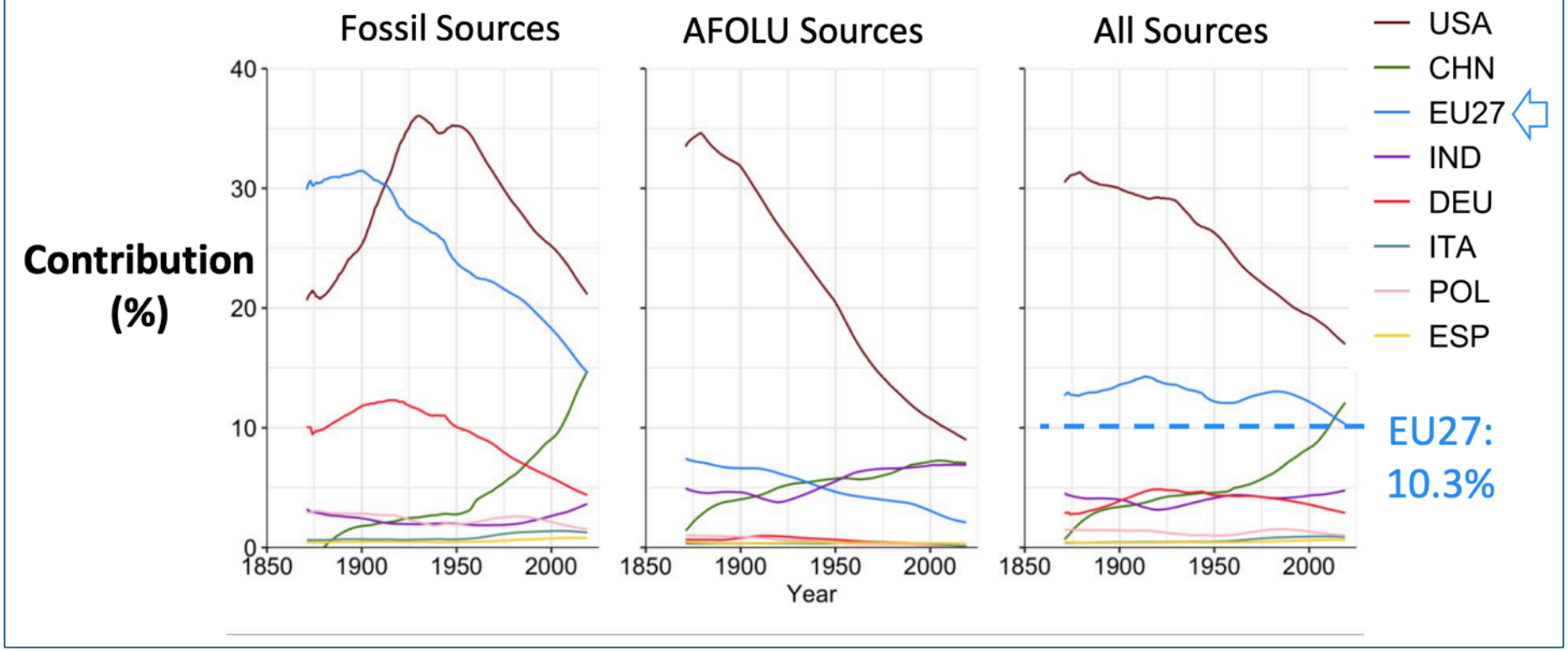
ORCHIDEE derived



WP7: Links to other international programs

⇒ Several contribution to GCB / COP / SBSTA / WMO / ….

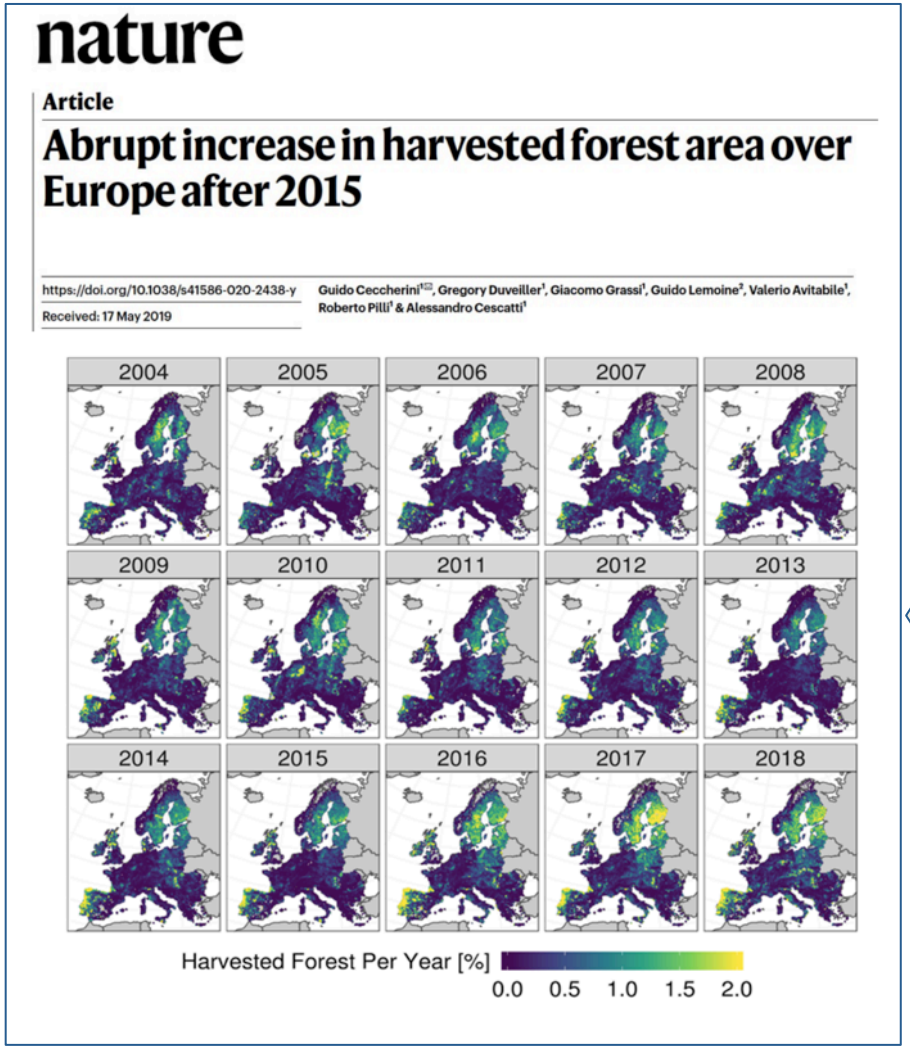
⇒ EU CONTRIBUTION TO GLOBAL CUMULATIVE EMISSIONS AND TO WARMING



Jones et al. in prep

Debates and Controversies were present…

⇒ Nice and fruitful debate about "Trends" in EU harvested forest !



nature

Article

Abrupt increase in harvested forest area over Europe after 2015

https://doi.org/10.1038/s41586-020-2438-y
Received: 17 May 2019

Guido Ceccherini[1✉], Gregory Duveiller[1], Giacomo Grassi[1], Guido Lemoine[2], Valerio Avitabile[1], Roberto Pilli[1] & Alessandro Cescatti[1]

Three main counter -arguments:

- The Global Forest Change (GFC) product used in the study is not consistent over time, including after 2015. The paper did not follow GFC documentation.
- Natural disturbances have not been properly factored out.
- The harvested trend is not in line with country statistics

After VERIFY….

VERIFY + CHE + CoCO2

EYE - CLIMA PARIS

AVENGERS

New “Science phase” with different approaches/tools to be developed !

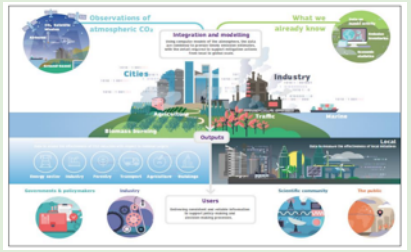
After VERIFY….

VERIFY + CHE + CoCO2

EYE - CLIMA **AVENGERS**

PARIS

New “Science phase” with different approaches/tools to be developed !



We need a common vision / Shared tools / Agreed estimates

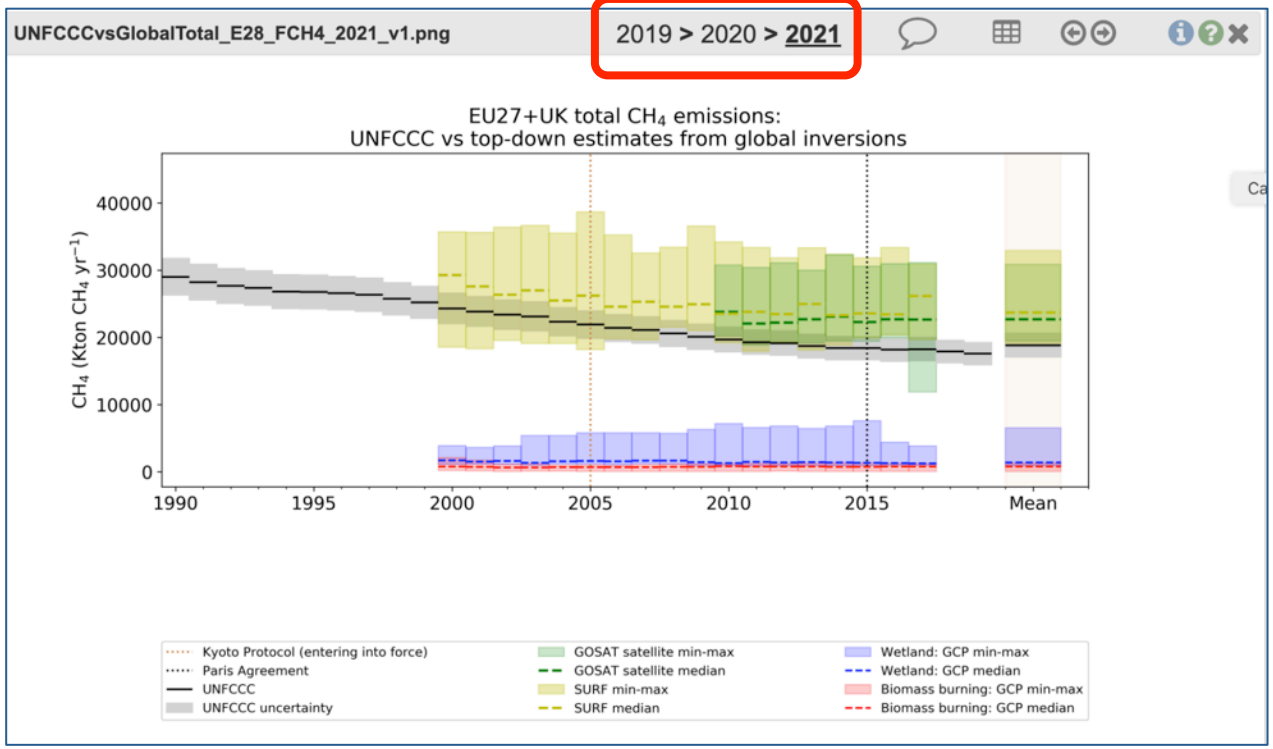
FINAL STEPS FOR 2022 - V2022 SYNTHESIS

⇒ LAST STEPS for the V2022 synthesis with CoCO2

1. Preparation of Input data
   - ERA5-land meteo data with bias correction (On-going)
   - HILDA+ land Cover: Would need an update up to 2021 ?
2. VERIFY will launch the protocol for LSM simulations
   - Suite of VERIFY model (ORC, ECOSSE, EPIC,...)
   - TRENDY models (several groups agreed)
3. VERIFY will finalize the CIF intercomparison (CO2, CH4, N2O)
4. VERIFY will provide the facilities for data processing
   - Data formatting and country-scale aggregation
   - Data access and visualisation
     (**synthesis plots for > 200 countries**)

SYNERGIES WITH CoCO2…

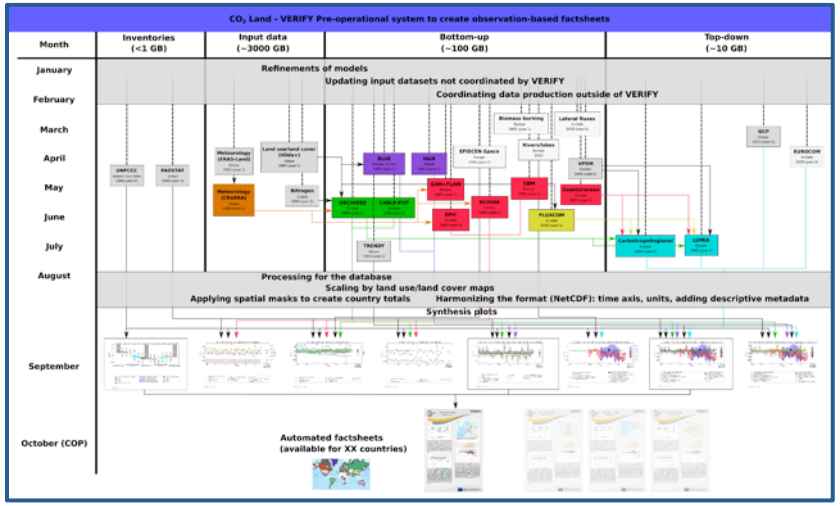
- Update the system to hold new V2022 version



TRANSITION OF THE VERIFY SYSTEM TO FUTURE OPERATIONAL SYSTEMS

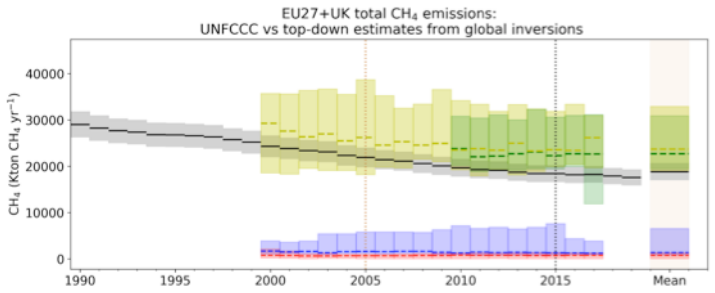
- Dual strategy :
  - ICOS - CP will take up some elements
  - CoCO2 / Copernicus will make use of the method

LSCE - system
(data infrastructure)



ICOS :
➔ Key products of the database

Copernicus :
➔ Methodologie



LEGACY OF VERIFY DATA INFRASTRUCTURE

⇒ **Data Infrastructure will be maintained at least during CoCO2**

- **Progressive transfer to ICOS - CP of:**
  - key data-sets produced within VERIFY (with DOI)
  - "Synthesis plots" / factsheets & tools to access them !
  - Possibly time series / mapping facilities
- **Copernicus (C3S) will use**
  - Part of the methodology defined for synthesis plots
  - But extend to the globe with specific focus on Satellite data
- **Remaining question**
  - How to keep the GHG yearly synthesis after CoCO2 (in the context of new NRT flux estimates) ?

FINAL STEPS….

- **DONT FORGET the last deliverables !**
  - End of May should be the target !

- **ARTICLES / SYNTHESIS linked to the whole project**
  - Revision of ESSD synthesis paper !
  - Potential policy maker oriented article
  - Summary paper on what we learned / improved in VERIFY

- **Many ongoing Task - related papers**

THANKS TO EVERYONE !!

And many more !!!

AND A SPECIAL THANK TO A FEW KEY CONTRIBUTORS

Project / Consortium initiation :

AND A SPECIAL THANK TO A FEW KEY CONTRIBUTORS

Project / Consortium initiation :

Submission of the proposal

AND A SPECIAL THANK TO A FEW KEY CONTRIBUTORS

Project / Consortium initiation :

Submission of the proposal

Dedicated work on synthesis




AND A SPECIAL THANK TO A FEW KEY CONTRIBUTORS

Project / Consortium initiation :

Submission of the proposal

Dedicated work on synthesis

All WP leaders..

AND A SPECIAL THANK TO A FEW KEY CONTRIBUTORS

Project / Consortium initiation :

Submission of the proposal

Dedicated work on synthesis

All WP leaders..

All coordination team hard workers

AND A SPECIAL THANK TO A FEW KEY CONTRIBUTORS

Project / Consortium initiation :

Submission of the proposal

Dedicated work on synthesis

All WP leaders..

All coordination team
hard workers

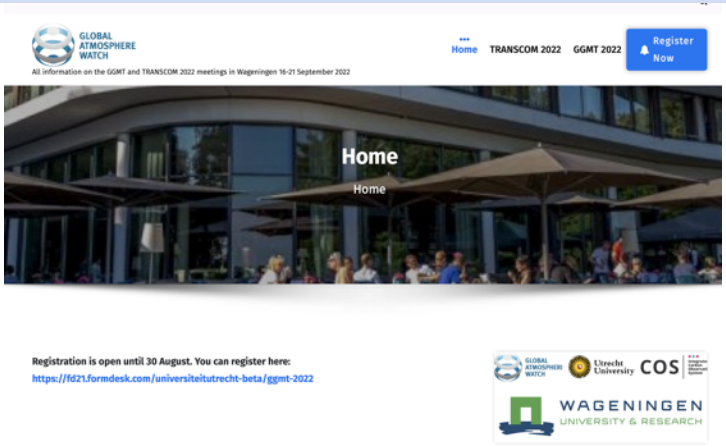
And the EC project officers

Three meetings in September:

(13-15 Sep, Utrecht, NLD) ICOS Science Conference 2022

(16+17 Sep, Wageningen, NLD) TransCom 2022 workshop

(19-21 Sep, Wageningen, NLD) WMO/IAEA Meeting on Carbon Dioxide, Other Greenhouse Gases, and Related Measurement Techniques (GGMT-2022)



Registration links:
https://fd21.formdesk.com/universiteitutrecht-beta/ggmt-2022
More information:
https://www.ggmt2022.online