Co-ordinated by ECMWF

CoCO2
Prototype system for a Copernicus CO_2 service

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

CoCO2 1st General Assembly

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Nicolas Bousserez (ECMWF)

16/11/2021

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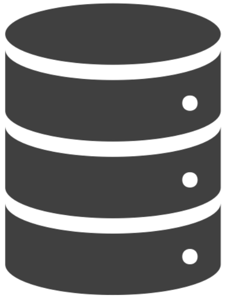
WP6 =  4 

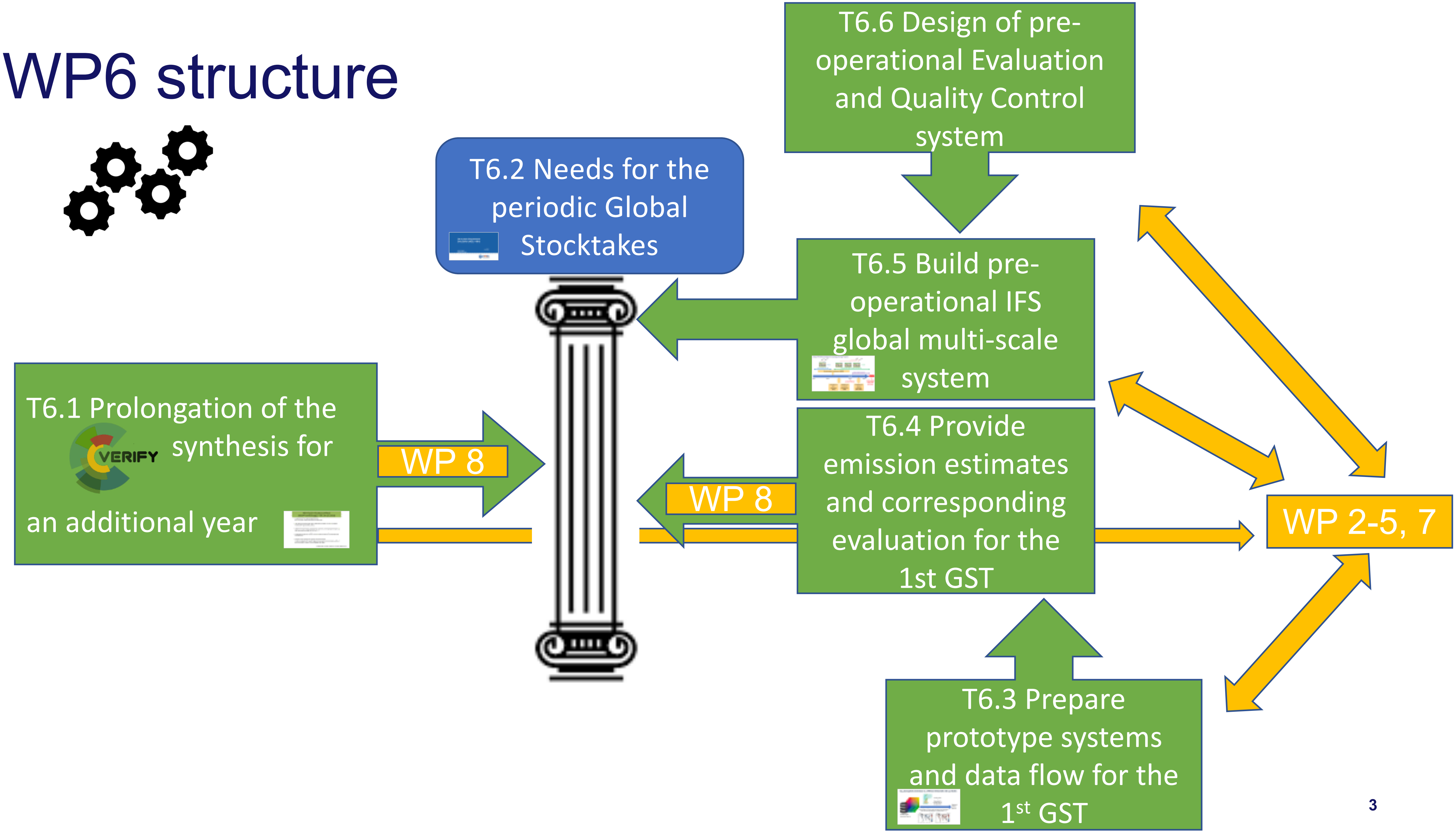
Detailed objectives:

- CO_2 and CH_4 syntheses of the H2020 VERIFY project ➡ year 2021.
- Provide CO_2 products for the 1st Global Stocktake (GST).
- Coordinate WP 2-5 activities ➡ integrated prototype for the future Copernicus CO_2 service.
  ➡ CO_2 emission estimates on time for the 2nd GST.

16 partners:

- CEA, ECMWF, Empa, ICOS ERIC, MPG, TNO, ULUND, VUA, WU, CICERO, CMCC, FMI, iLab, UEDIN, FC.ID, CyI

WP6 structure



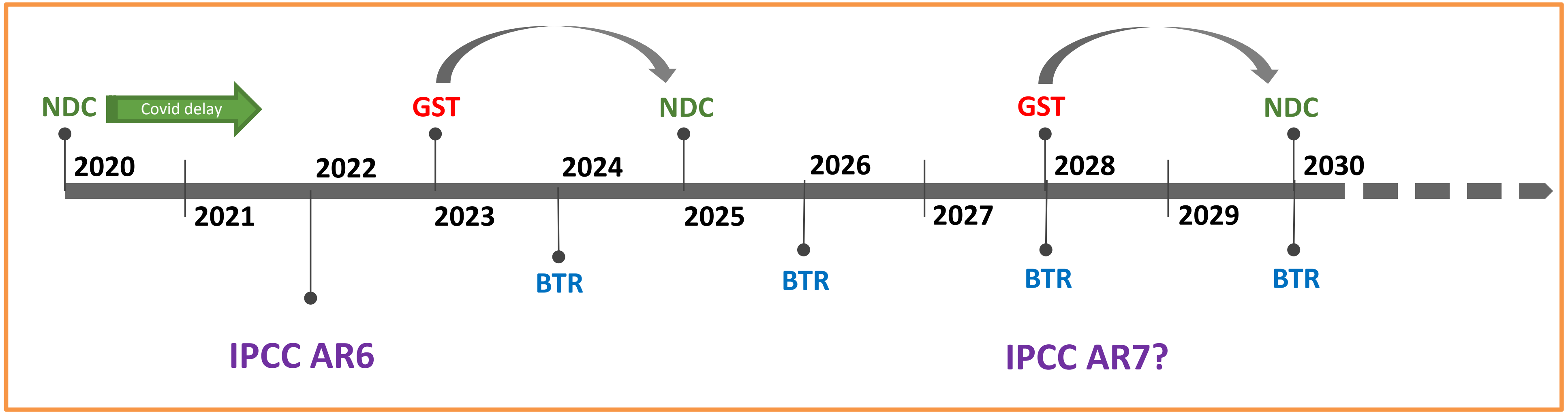
D6.3 User Requirement Document (T6.2) – M12

16/11/2021

Lucia Perugini
Federico Brocchieri

User Requirement Document

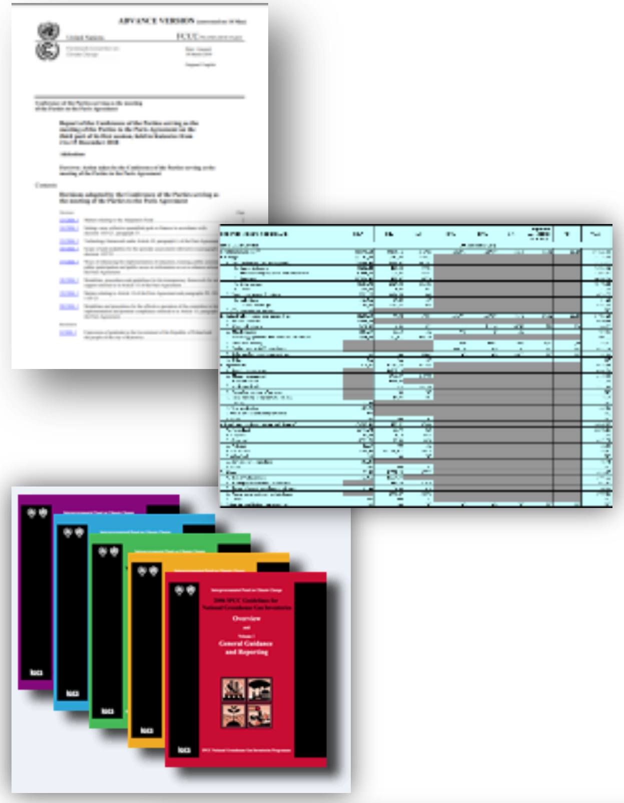
Task's objectives: Define requirements for an observation-based emission monitoring system in the periodic **Global Stocktake process**



The outputs of the global stocktake should:

- focus on taking stock of the implementation of the Paris Agreement **to assess collective progress**, have **no individual Party focus**, and
- include **non-policy prescriptive consideration of collective progress** that Parties can use to inform the updating and enhancing, in a nationally determined manner, of their actions and support.

Outline of the URD



UN CLIMATE CHANGE CONFERENCE UK 2021

IN PARTNERSHIP WITH ITALY

Verification arrangements under the Paris Agreement

- The Enhanced Transparency Framework (ETF): updates after COP26,
- A focus on GHG inventories,
- The Global Stocktake: process, requirements, scope and objectives.

CoCO2 inputs relevant to the Global Stocktake

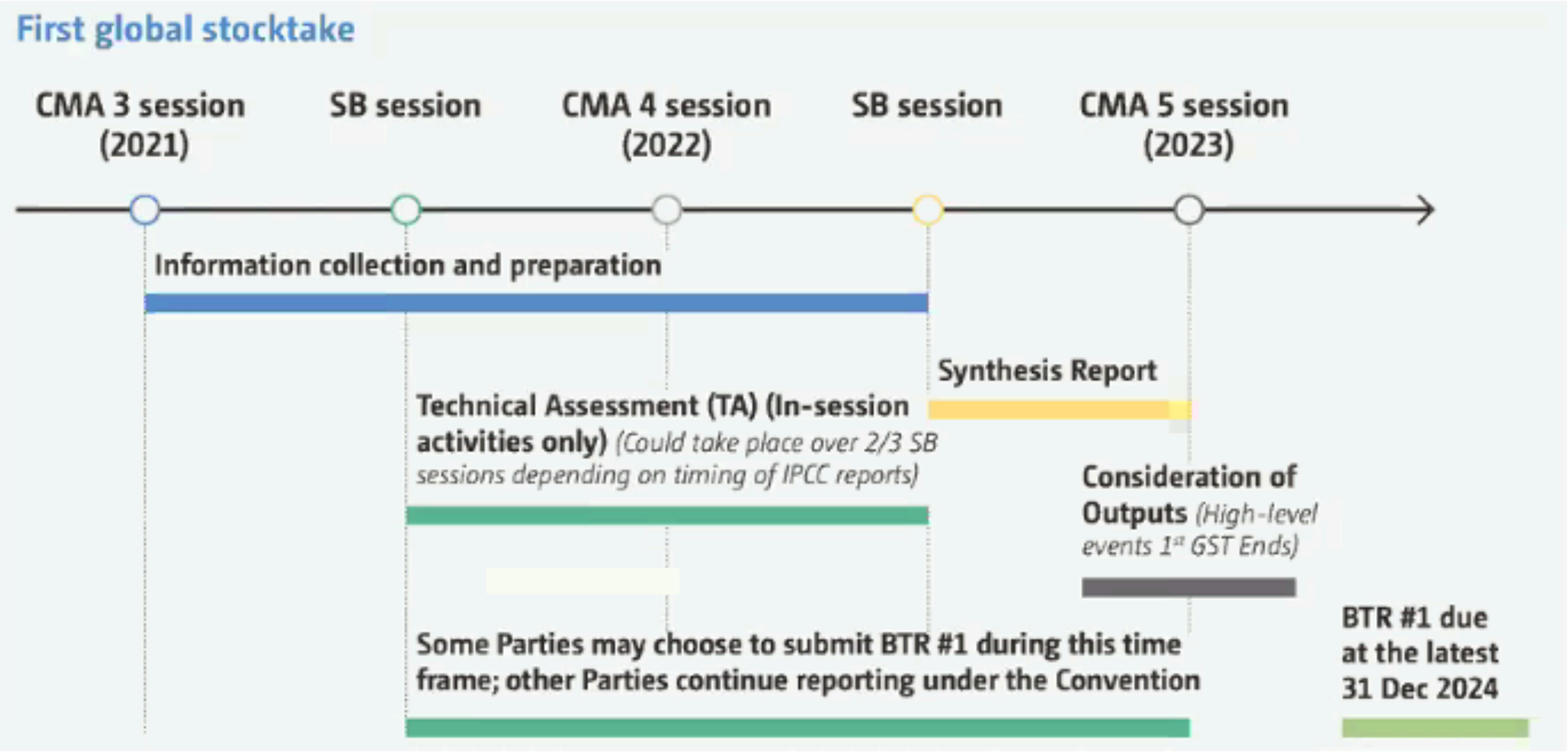
- Verification of Parties' GHG inventories,
- Support to developing country Parties,
- Innovation in climate research and systematic observation.

Modalities to input the Global Stocktake

- Sources of input identified under the GST,
- Identifying channels and additional relevant information,
- Requirements for data provision.

With relevant updates from COP26

PROCESS AND TIMELINE



Source: UNFCCC Secretariat

Planning for the 2022 synthesis (VERIFY methodology) – D6.1 & 6.2 (M24)

- Preparation of the meteorological forcing :
  Bias correction of ERA5-land with CRU data (UEA)

- List of process-based model will be expanded including some of the TRENDY model (Cable-pop already in 2021)

- Update of the processing scripts (at LSCE) to process more rapidly all bottom up / top down data (including UNFCCC, FAO, …)

- Preparing the web-site of VERIFY to host various releases of the synthesis plots and factsheets

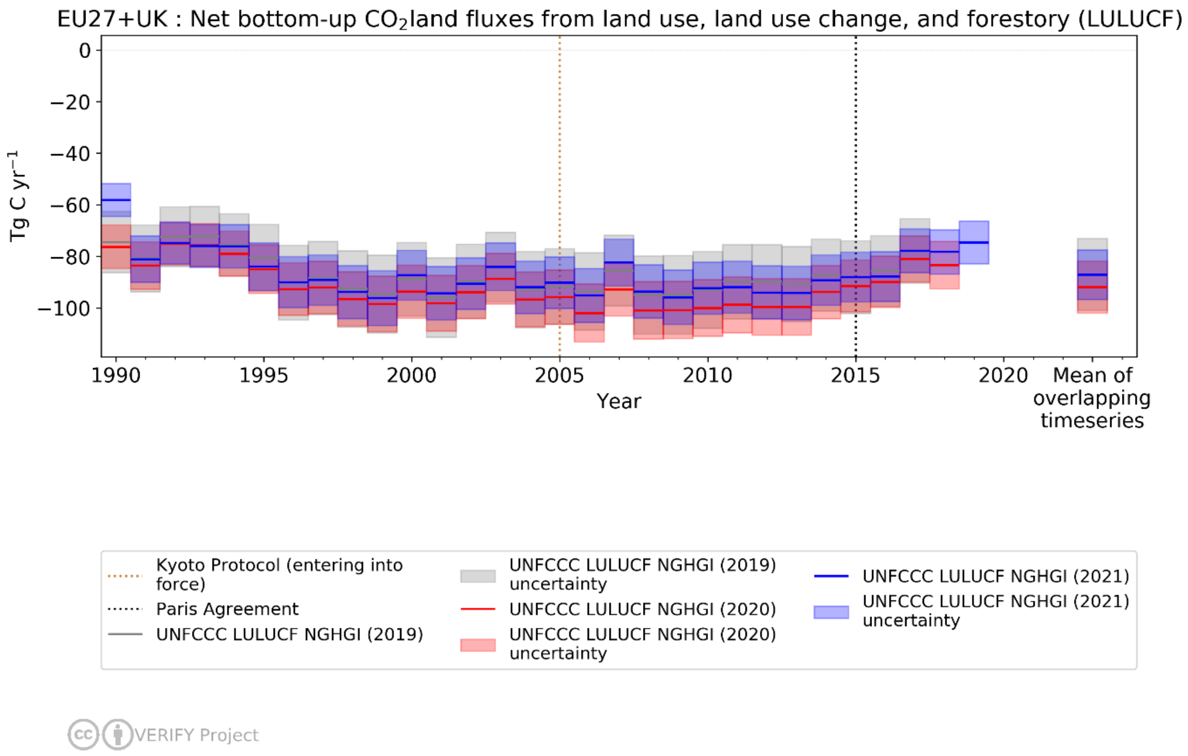
- Progress on the Community Inversion Framework (CIF):
  Protocol established for specific regional inversions for CO_2land and CH_4 with at least 3 transport models: to be completed early 2022 !

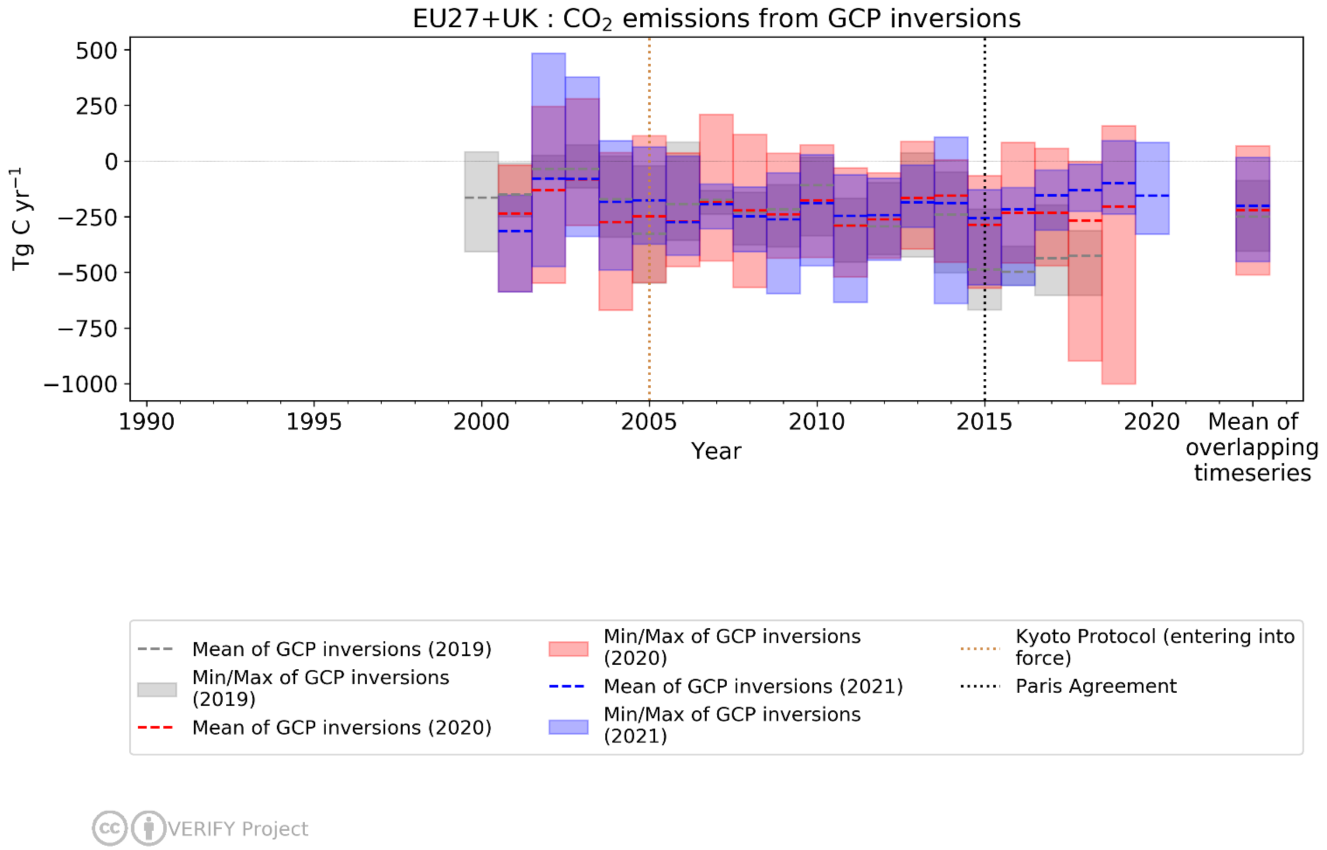
M McGrath, P Peylin, R Petrescu, and the VERIFY team

Illustration of recent changes of the estimates over time (EU+UK)

2019 → 2021 update of the UNFCCC data for LULUCF: Slightly lower sink in the new submission

2019 → 2021 updates of the GCP CO_2 inversions: not the same set of global inverse systems each time, but the spread changes





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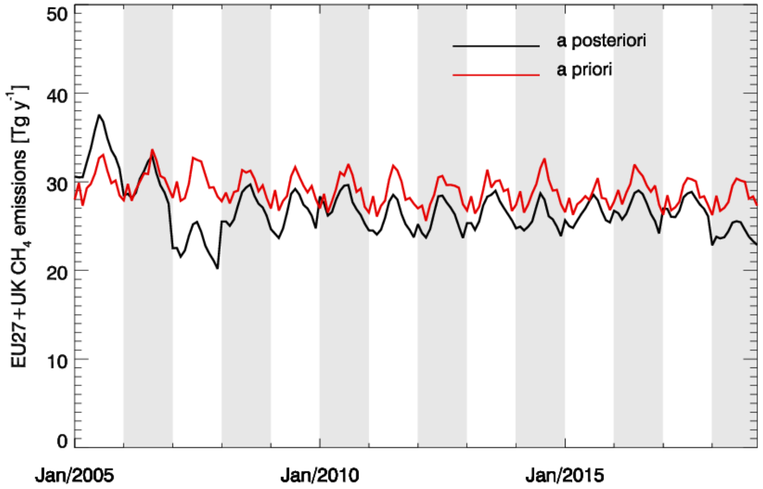
Empa: estimation of European CH_4 emissions 2005 - today

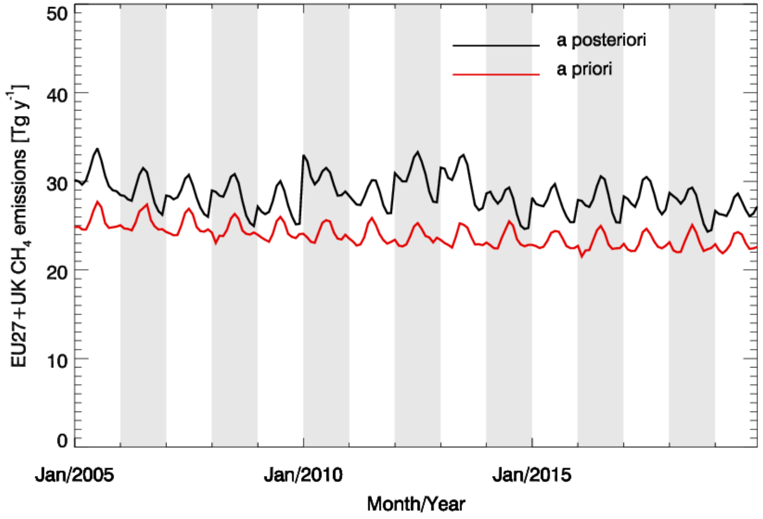
EU27+UK emissions (monthly mean)

Inversion with FLEXPART-ExKF extended Kalman Filter (Brunner et al. 2012)

Global background from TM5-4DVAR



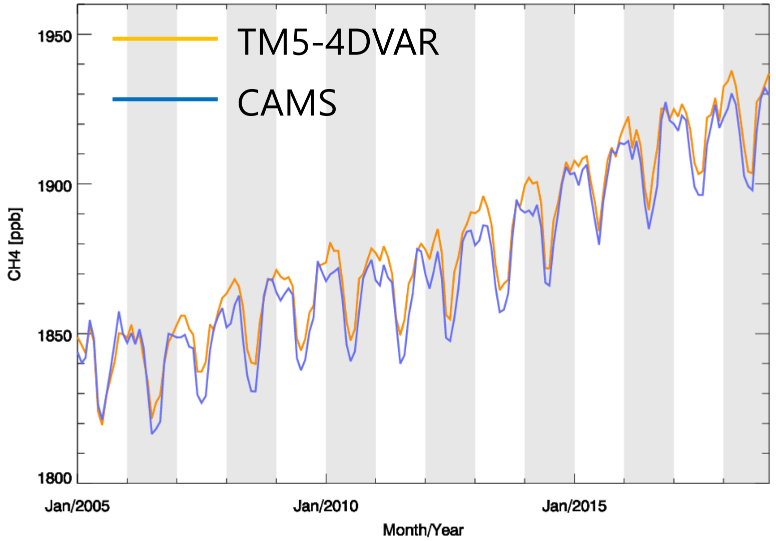
Global background from CAMS



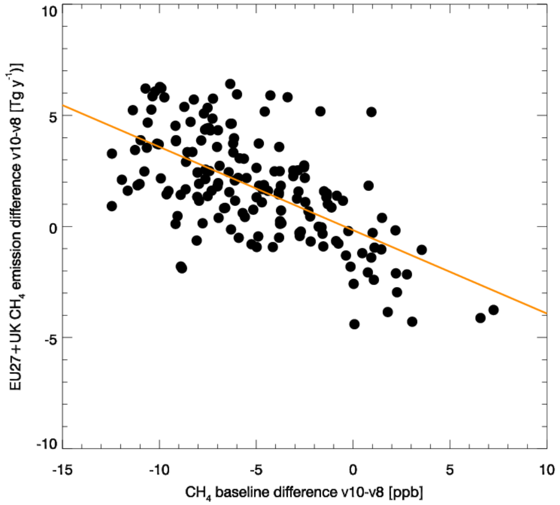
Influence of background

About 1.3% increase in EU27+UK emissions per 1 ppb difference in background CH_4

CH_4 background at Mace Head



Difference in monthly emissions versus difference in monthly mean background CH_4 between upper right and upper left



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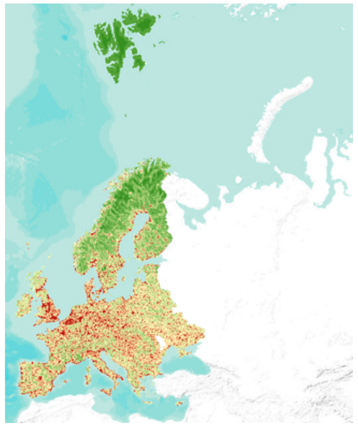
CO_2 atmospheric inversions vs. UNFCCC AFOLU (D6.4 & 6.5, M18+)

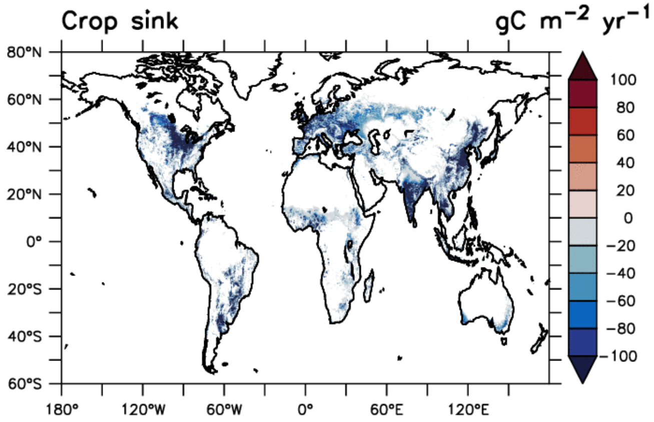
Gridded total inversion flux ±σ

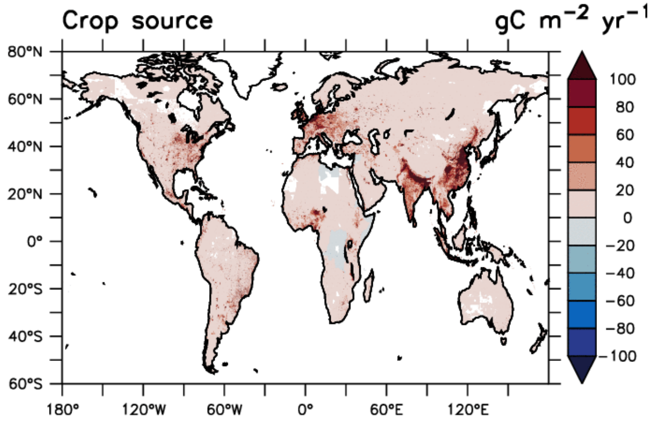


Country mask
+
Proxy mask for managed forests and grasslands

National AFOLU Flux ±σ

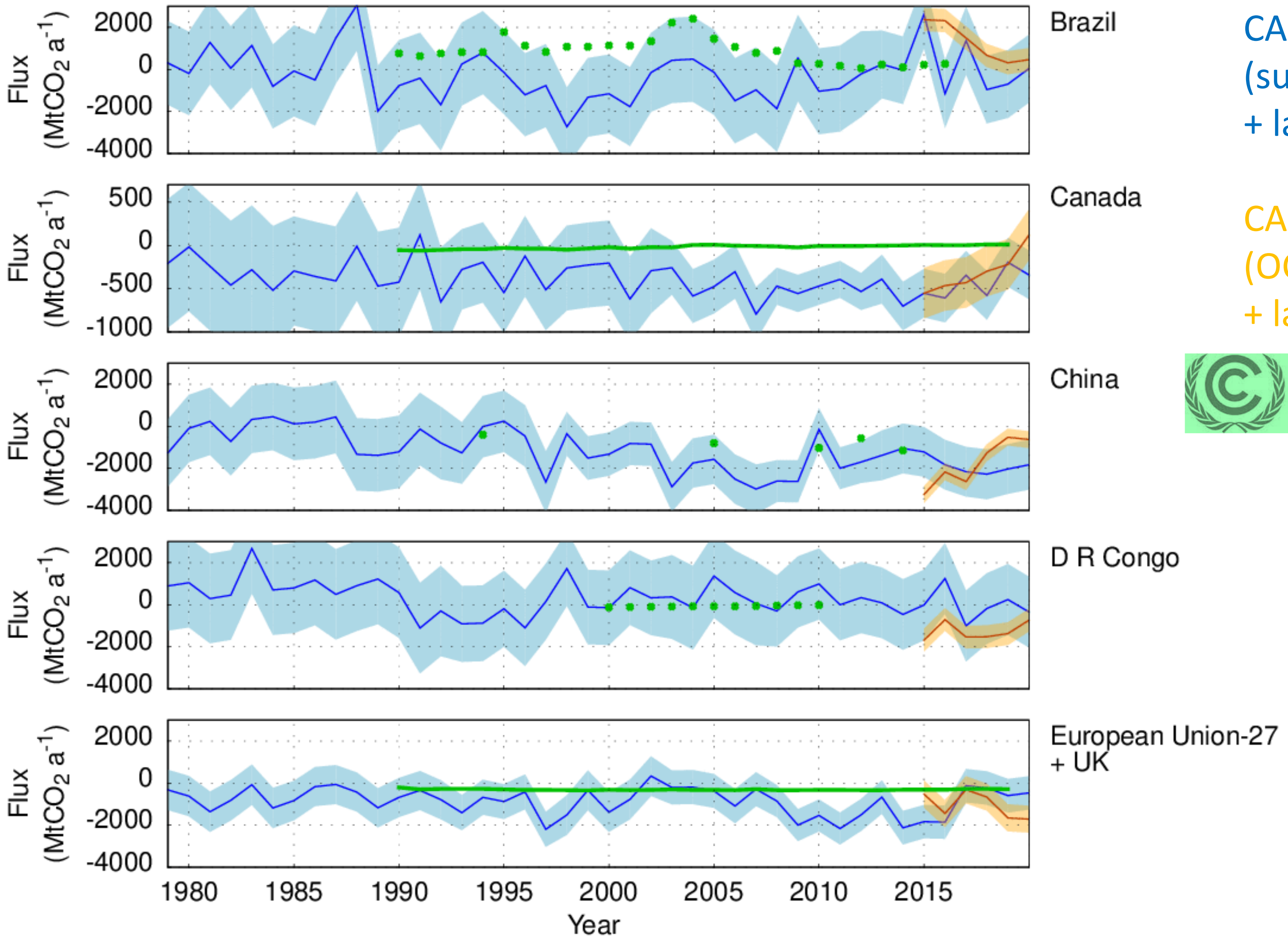
Lateral fluxes of C from crop trade and rivers (estimated from FAO and climatologies + spatial proxies + …)





CO_2 atmospheric inversions vs. UNFCCC AFOLU: Bayesian σ

Bayesian error bars (1 σ)



CAMS v20r2 (surface) + lateral fluxes

CAMS FT20r3 (OCO-2 satellite) + lateral fluxes

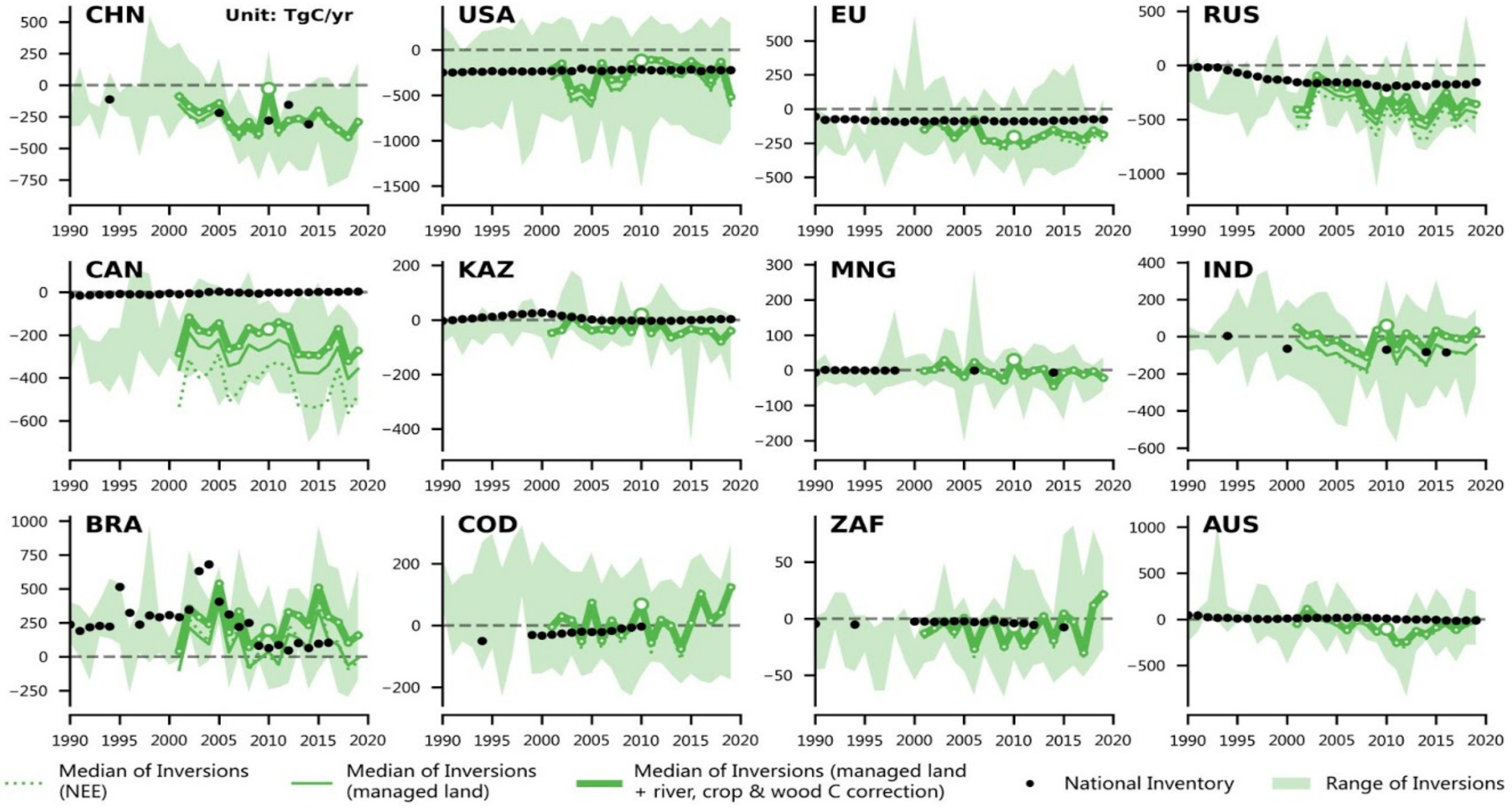
United Nations Framework Convention on Climate Change

Extended from Chevallier (2021)

CO_2 atmospheric inversions vs. UNFCCC AFOLU: Ensemble

CO_2 – terrestrial flux LULUCF (sink = negative values)

MtCO$_2$ a^{-1}

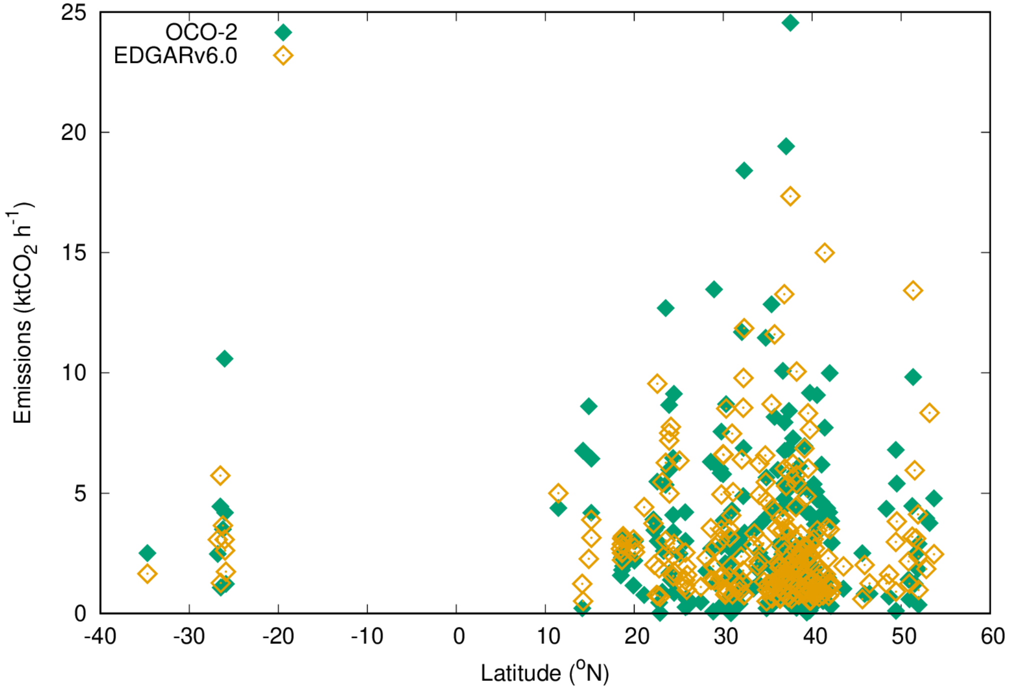


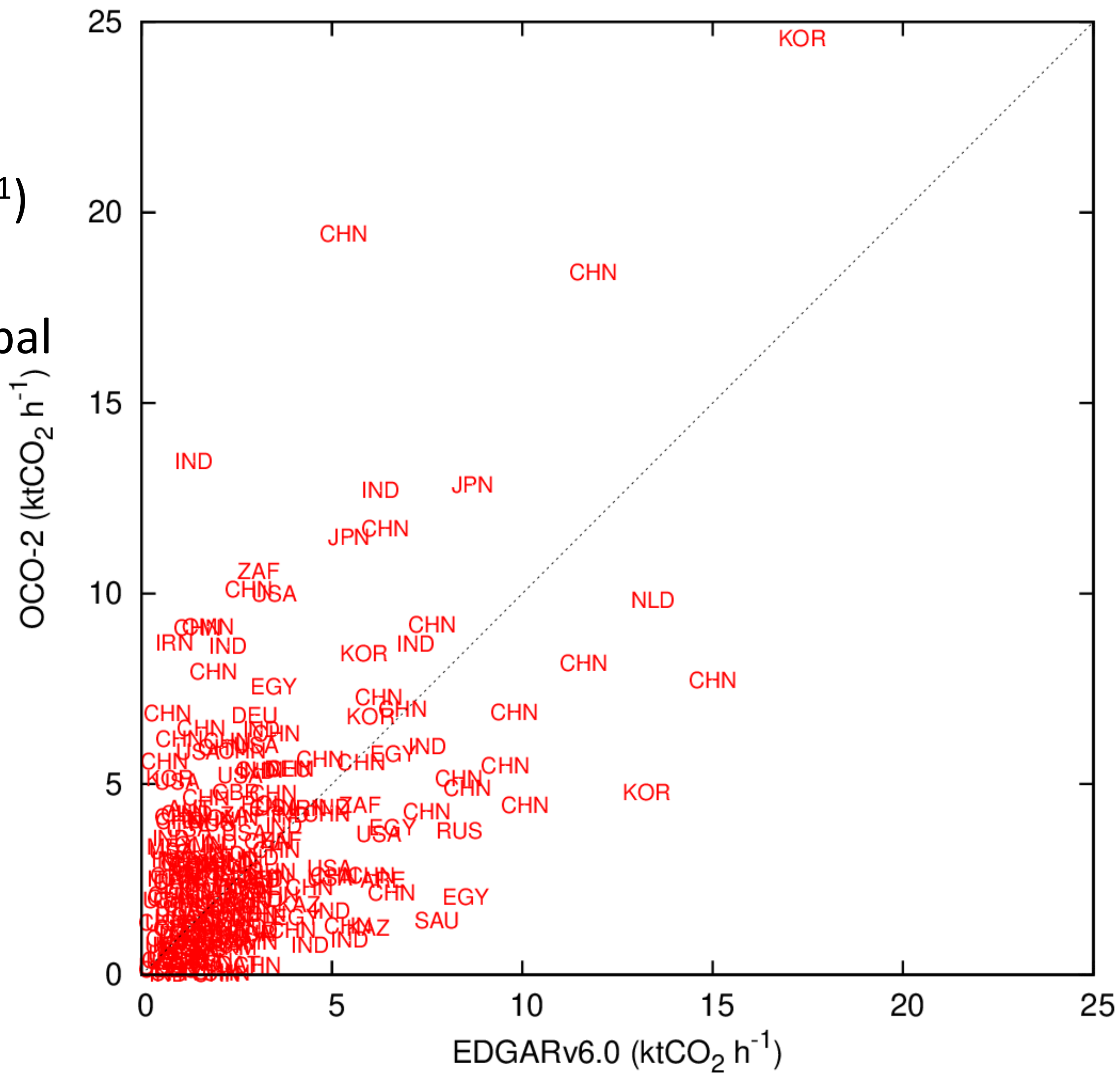
● UNFCCC　　Range of CO_2 inversions

Deng, Ciais et al (2021)

Fossil fuel emission retrieval from OCO-2 (D6.4 & 6.5, M18+)

- Together with WP4
- Full latest ACOS archive (2014 – 2021)
- Comparison to EDGARv6.0 mixed with the sub-annual temporal profiles of Crippa et al. (2020)
- Focus on small plumes (2σ < 30 km) and small wind (< 5 ms^{-1})
    - N = 235; r = 0.54
    - Agreement on latitudinal, monthly global or annual global patterns



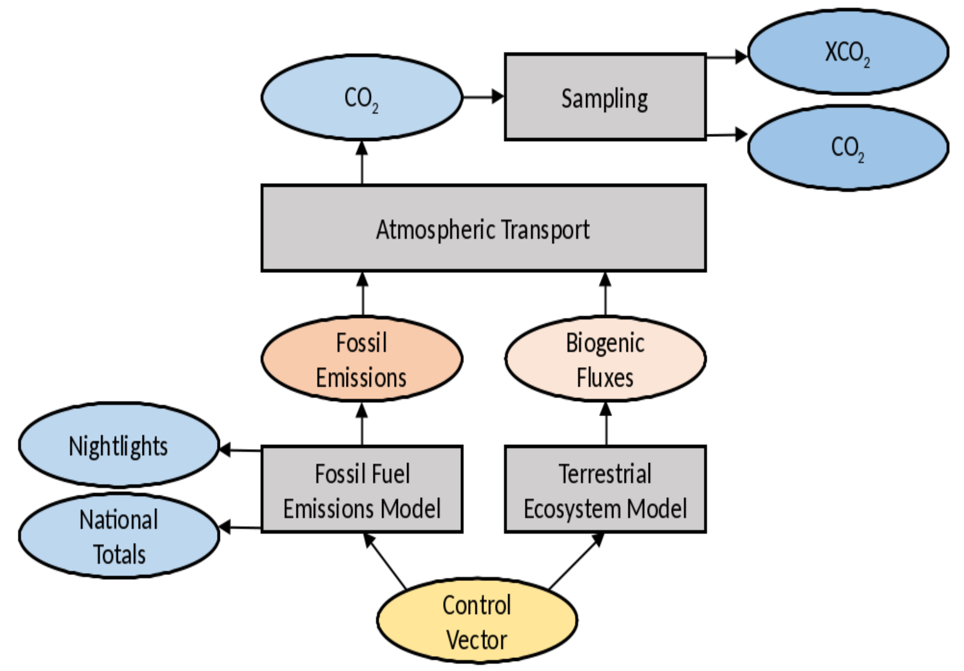


Extended from Chevallier et al. (2020)

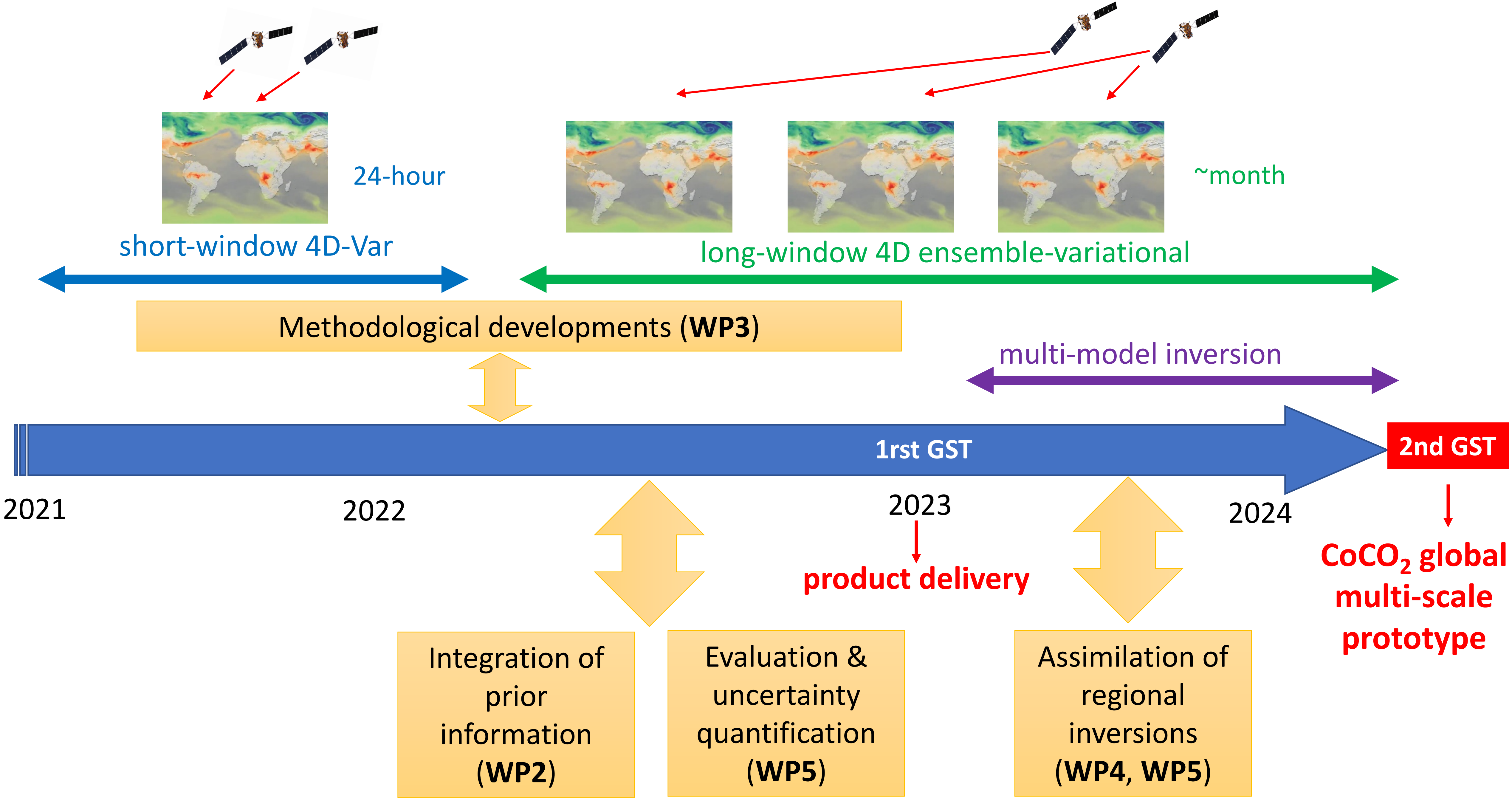
iLab

Towards an integrated vision

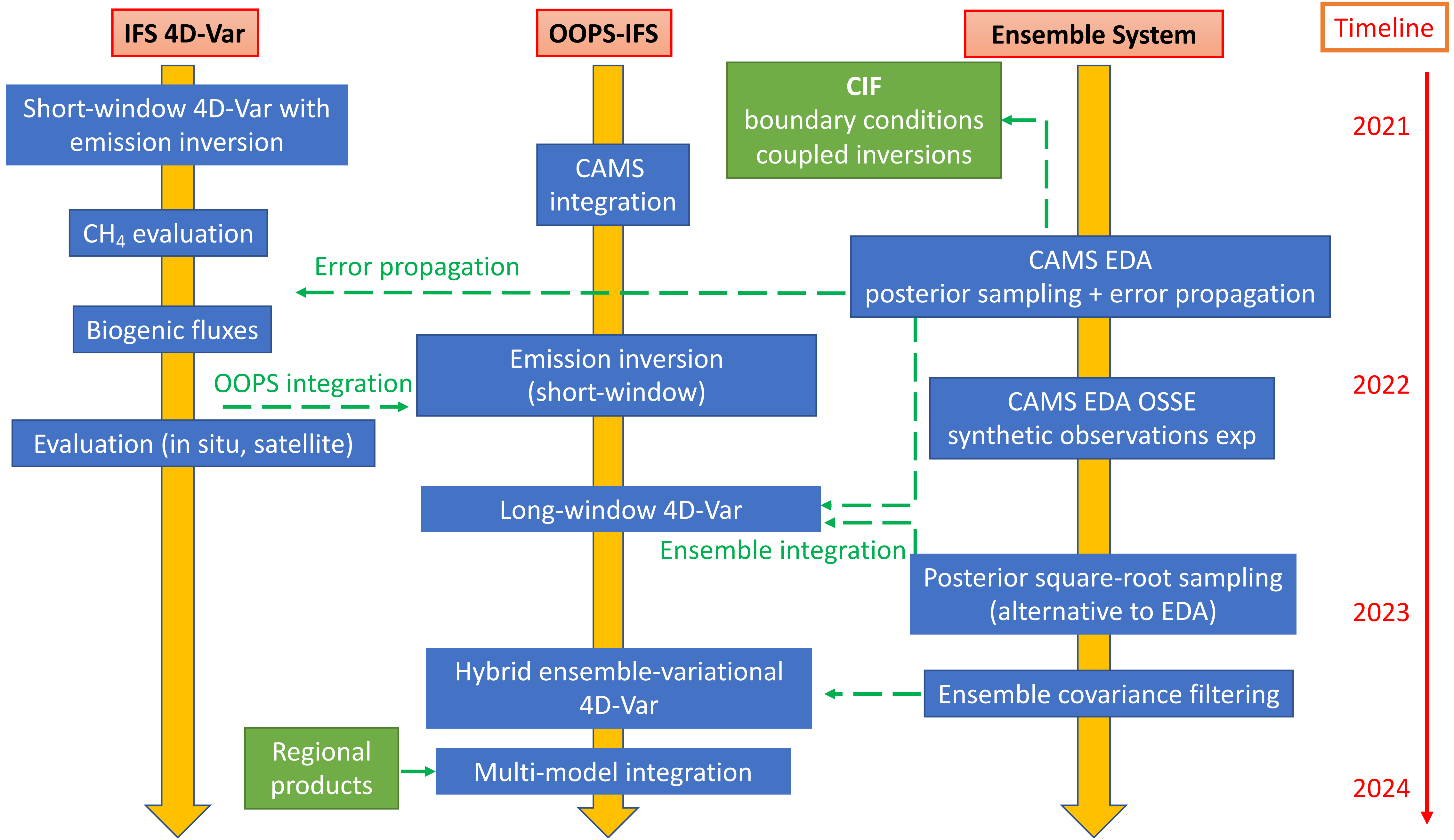
- Setting up global CCFFDAS
  - sectoral fossil emission model
  - diagnostic natural flux model
  - driving data (both components)
  - observations



Global IFS MVS development strategy (the Big Picture)



IFS data assimilation developments

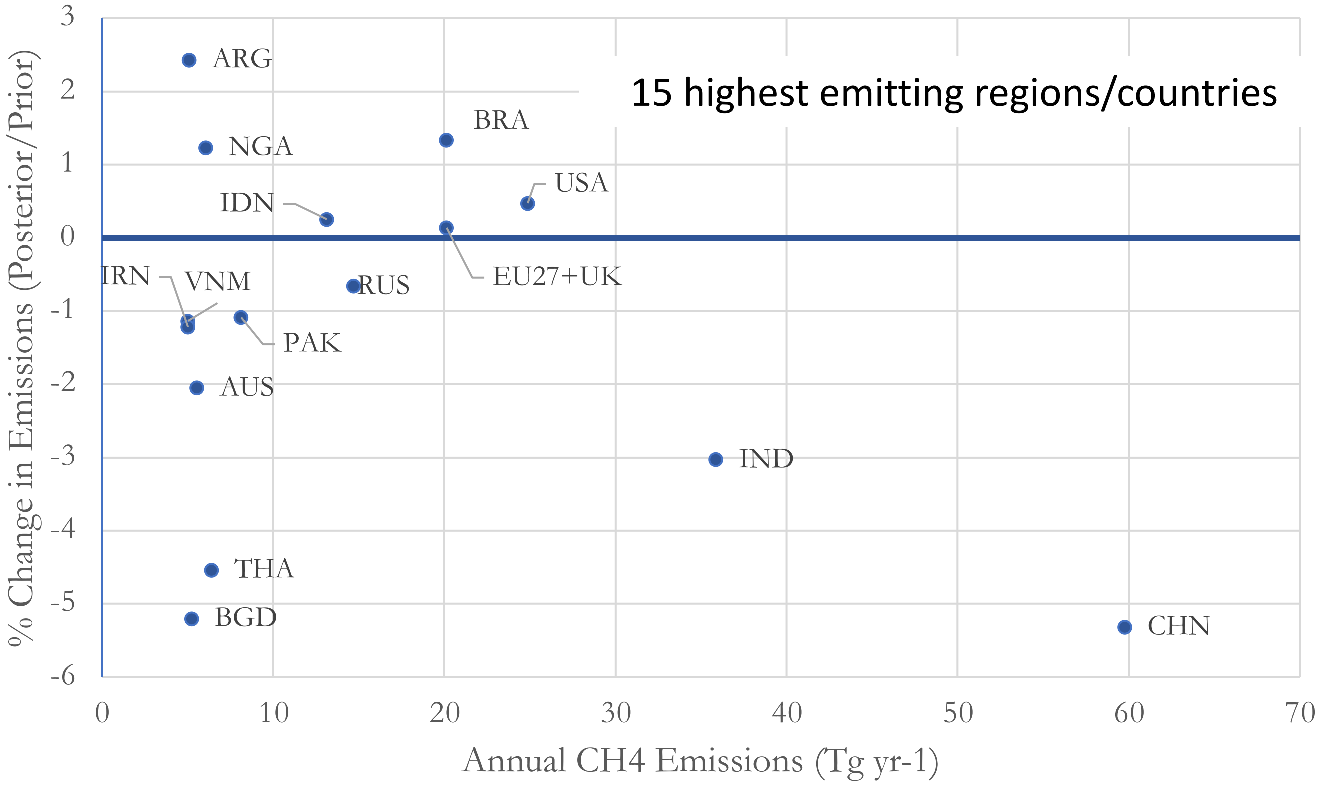


Example of National Reporting – CH_4 based on the first half of 2019/2020

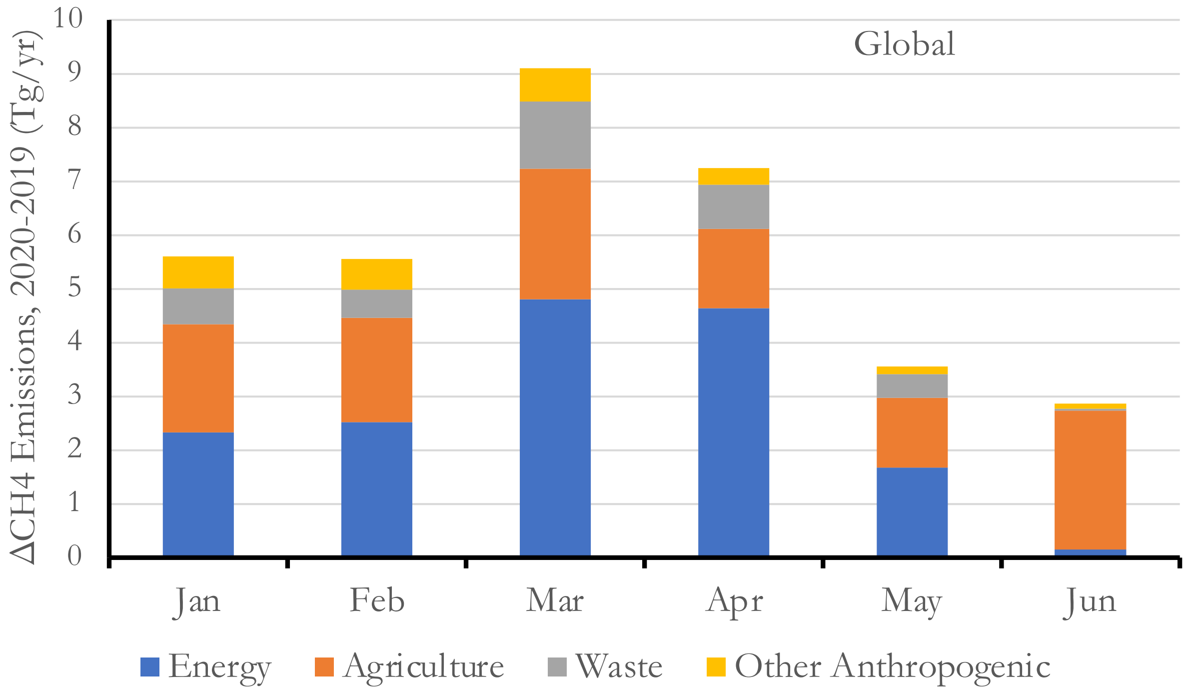
Using 24-hour window IFS 4D-Var system to infer sector specific national/regional CH_4 emissions for 2019/2020

McNorton et al. (in prep.)

CH_4 emission corrections (%) for 2019



Sector specific difference (2020-2019) in global emissions



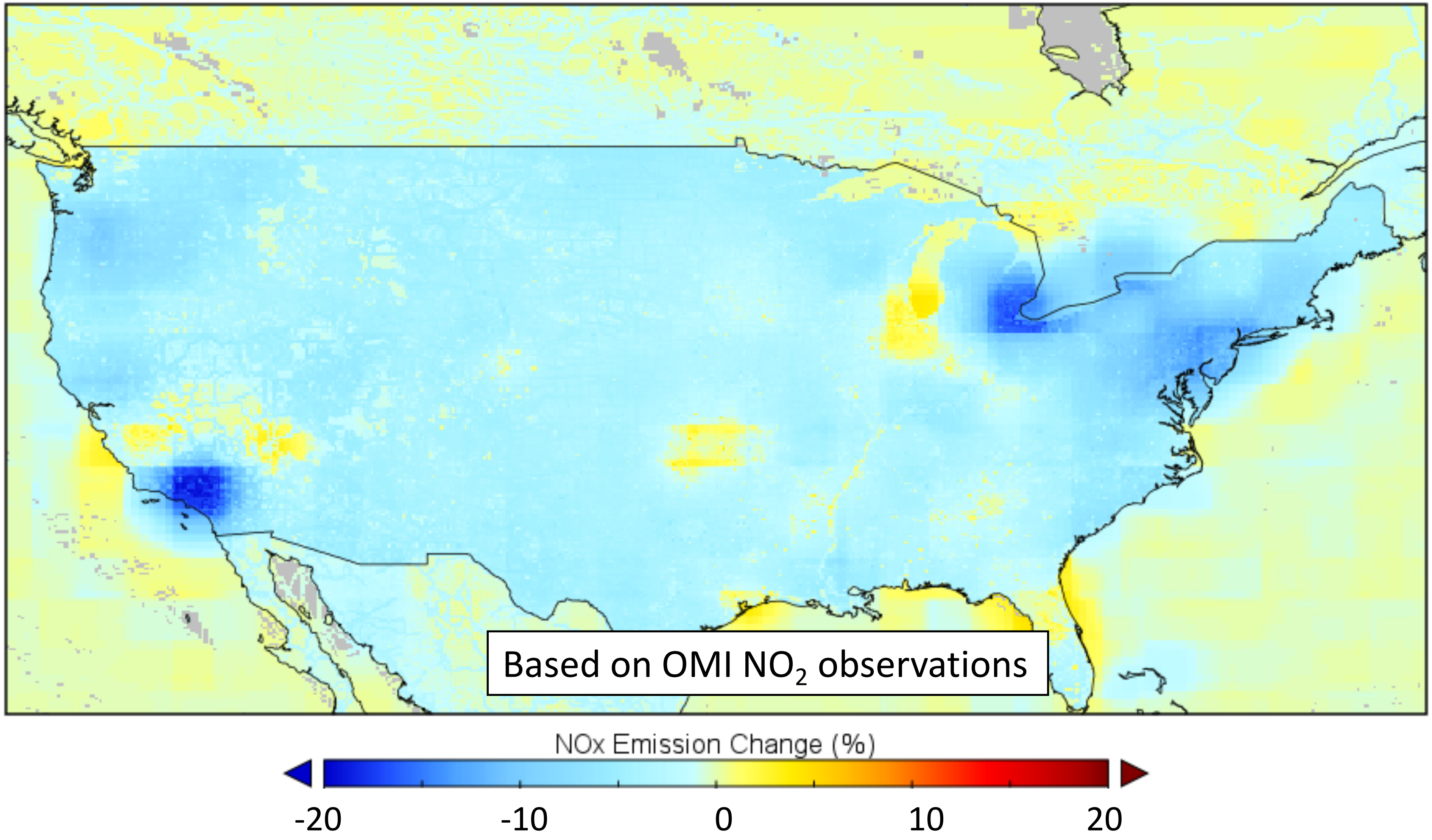
- Prior high over China, in agreement with other studies (see Cheewaphongphan *et al.*, 2019).
- National changes typical agree well with previous studies (e.g. Deng *et al.*, 2021)
- Atmospheric growth for 2020 highest since 1984 (NOAA, 2021)
- Emission growth mainly from the Energy and Agriculture sectors in SE Asia (as seen by Jackson *et al.*, 2020)
- Growth seems to be a general trend (small impact of 2020 slowdown)

Impact of COVID lockdown on US anthropogenic emissions

- **10-20%** reduction consistent with previous studies (e.g., *Keller et al. (2020); Liu et al. (2020)*)

- Provided uncertainties in NO/CO_2 emission ratios are accounted for, top-down NO_2 estimates could help quantify CO_2 emissions variability

NO_x emission changes (%) between May 2019 and May 2020



Towards the 1st GST

- **COP26** revealed the emergence of many new players in the CO_2 monitoring arena → opportunity for collaborations and partnerships but also competitive environment.
- **1st GST** will be key to:
  - Ensure worldwide **visibility** of EU CO_2 monitoring activities
  - Prepare the launch of the future **operational Copernicus CO_2 system**
  - Receive useful **feedbacks** from the community and the stakeholders before the **2nd GST**
- Need for a clear timeline for products **selection**, **preparation** and **delivery**
- Which **global IFS inversion product** can we target?
  - Current CO_2 observational constraints for global monitoring of anthropogenic emissions are limited
  - Focus on constraints from co-emitted species observations (e.g., NO_2, CO)
  - Global NOx and CO emission estimates combined with spatially-resolved emission factors and associated uncertainties →prototype daily CO_2 anthropogenic emission product
  - <u>Inputs & development requirements for 2022:</u>
  - ✓ Prior error covariance (emission errors, spatial and temporal correlations) (**WP2, T2.1 , D2.1**)
  - ✓ Emission factors & uncertainties→ NOx/CO_2, CO/CO_2 error correlations (**WP2, T2.2, D2.1**)
  - ✓ Evaluation framework (**WP5**)

Roadmap to the 1st GST