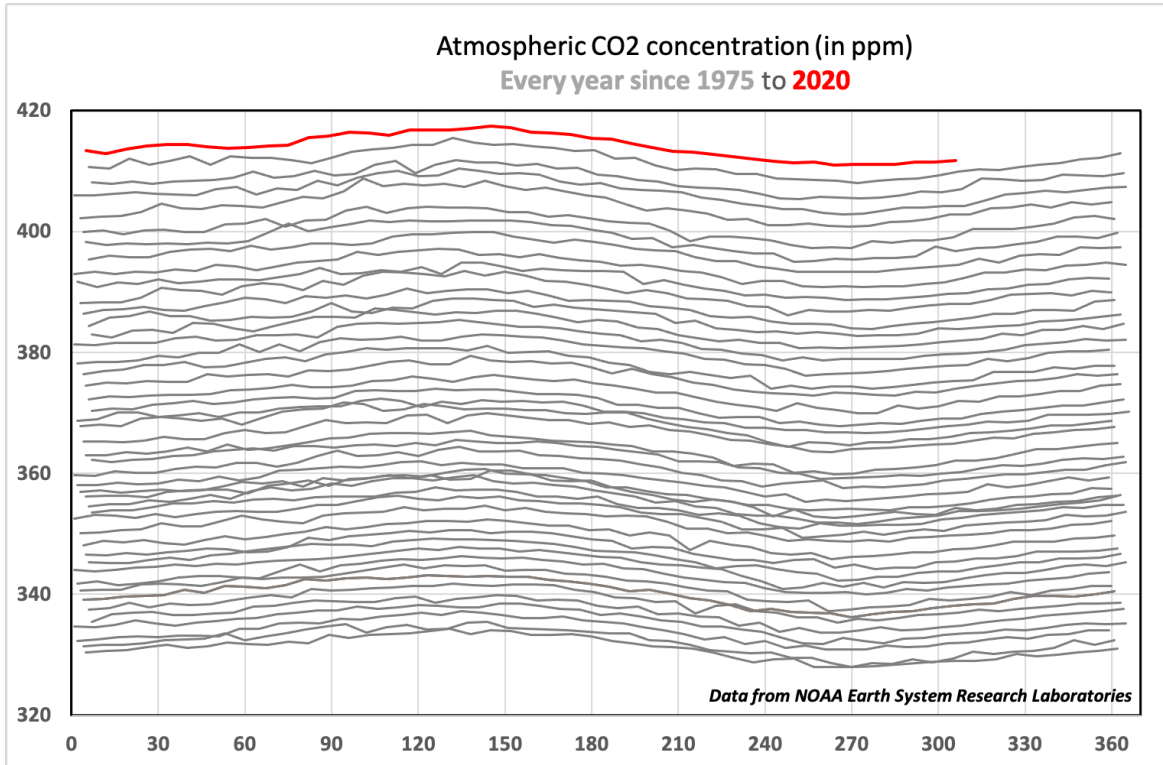


Summary and Recommendations on  
Carbon budgets including climate factors  
in the COVID-19 pandemics

*Philippe Peylin, Kasia Tokarska, Pierre Friedlingstein, Han Dolman, Debbie Rosen,  
Jessica Clarke, Chris Jones, Gianpaolo Balsamo, Jean-Baptiste Sallee, Christophe Heinze,  
& Project Members (VERIFY, CONSTRAIN, CRESCENDO, 4C, CHE, COMFORT, SO-CHIC)*

# Limited impact of Covid-19 on CO<sub>2</sub> emissions

- Drop in CO<sub>2</sub> emissions had no detectable impact on atmospheric CO<sub>2</sub> or climate change
- It is extremely small compared to the emissions accumulated so far, and compared to the emission cut needed to tackle climate change.



- **Covid-19 crisis**

## **Policy – Relevant Messages**

- **Revealed** how drastic **changes in human behaviour impact** on anthropogenic GHG fluxes.
- Highlighted the **current lack of near real time direct quantification** of anthropogenic CO<sub>2</sub> emissions (i.e. not based on proxies of activity) at the country level.

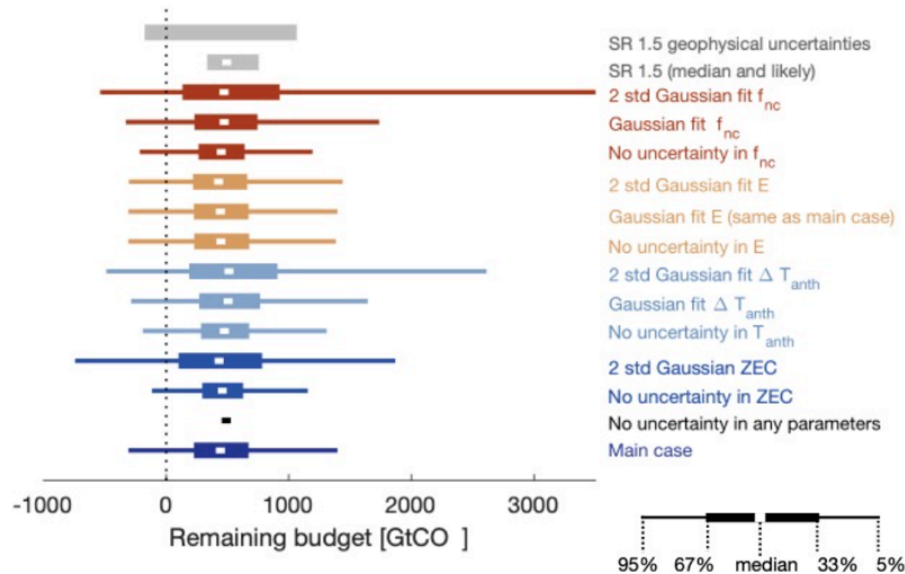
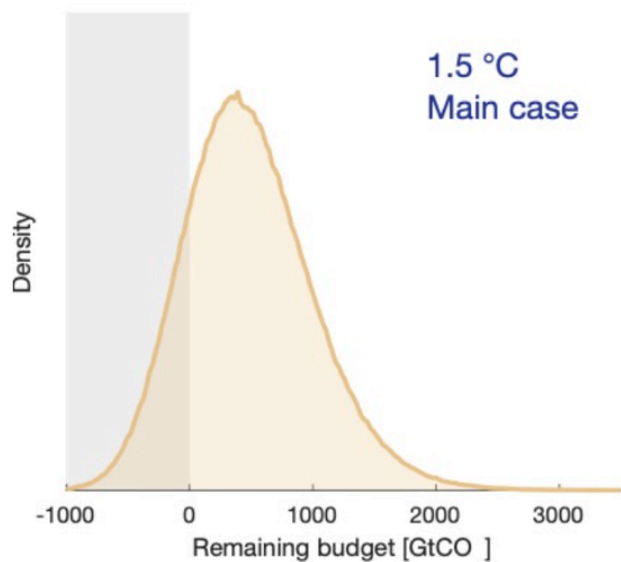
## **Research & Innovation gaps**

- Better **quantify “near real time”** anthropogenic CO<sub>2</sub> emissions (especially for EU, US, China, India).

- **Future carbon budgets and climate change**

# Reducing uncertainty in the remaining carbon budgets

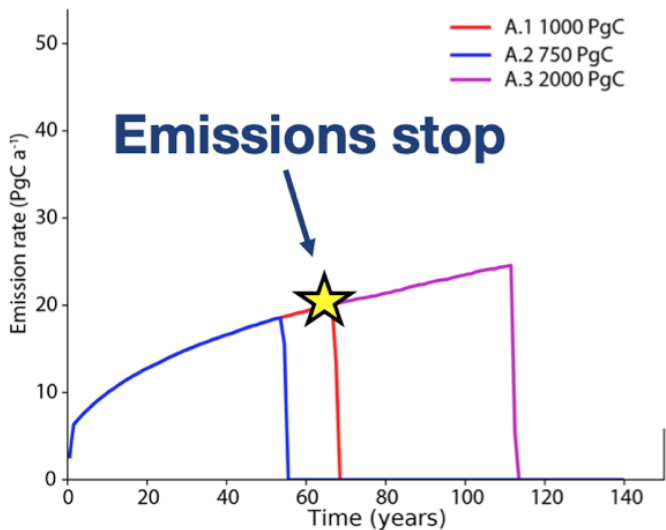
Considering only geophysical uncertainties, a median estimate of the 1.5 °C remaining carbon budget (globally) is around 440 GtCO<sub>2</sub> from 2020 onwards, equivalent to approximately **10 years at the current CO<sub>2</sub> emission rate**



# Reducing uncertainty in the remaining carbon budgets



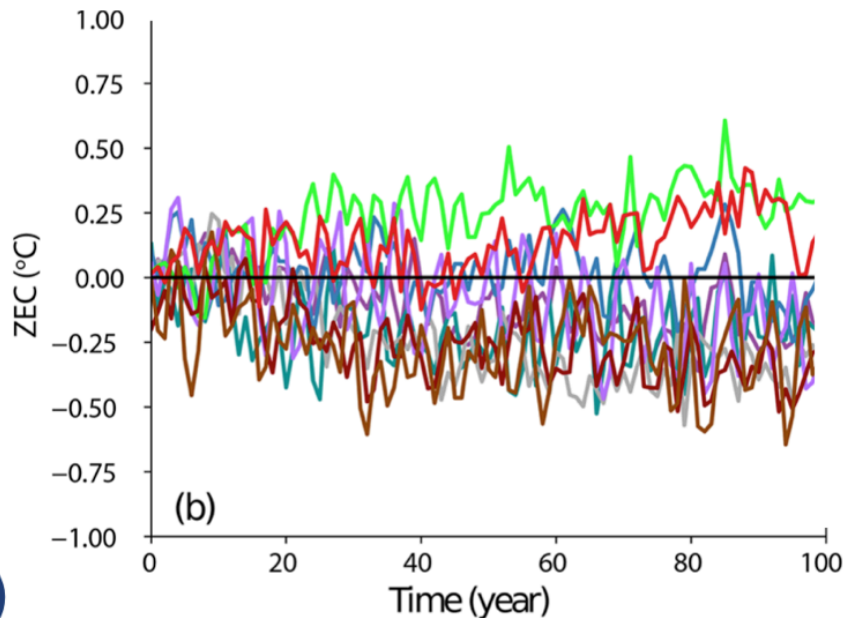
MacDougall et al. 2020 Biogeosciences



is approximately zero

(i.e., no additional warming)

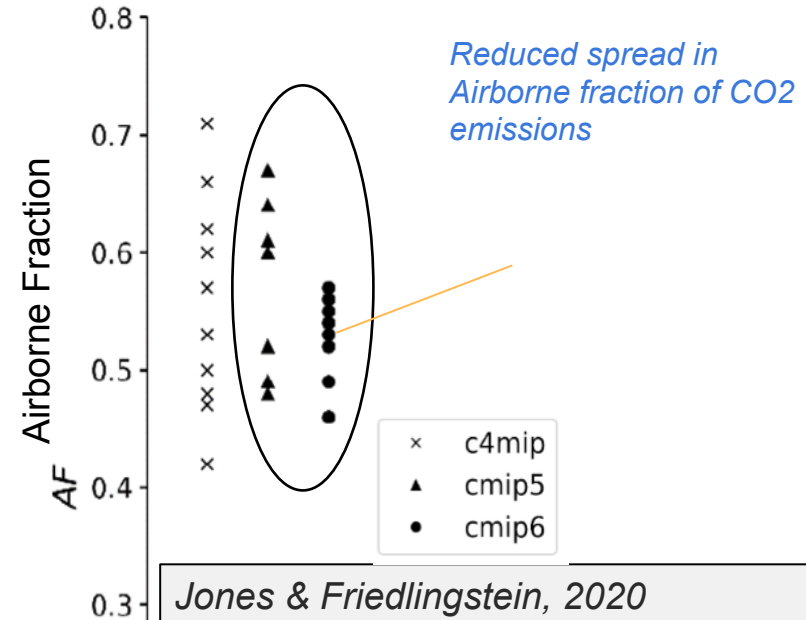
**Additional temperature change after emissions are stopped**



# Reducing uncertainty in carbon budgets

“Allowable” carbon budget to meet climate goals requires **knowledge of climate sensitivity (esp. TCR)**, natural carbon sinks, and committed climate response

→ Carbon cycle response has been constrained in CMIP6, relative to CMIP5, possibly due to inclusion of terrestrial Nitrogen cycle



## • Future carbon budgets and climate change

### Policy – relevant messages:

- Longer term reductions in CO<sub>2</sub> emissions **strongly depend on government actions.**
- We **need to reach a net-zero global emissions level** to stabilize global warming.
- Current **NDC pledges are insufficient** to meet the PA long-term temp stabilization goal.
- **Only around 10 years of today CO<sub>2</sub> emission left**, to reach the 1.5 °C target
- Limiting other environmental changes (e.g., **ocean acidification**) can be more demanding.

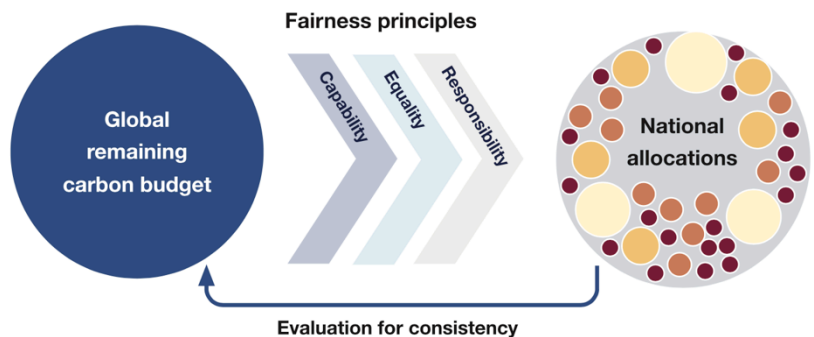
### Research and innovation gaps

- Better quantify transient **climate sensitivity and the climate-carbon cycle feedbacks.**
- Better **understand the robustness of TCRE** (Transient climate response to cumulated emissions) range in scenarios where CO<sub>2</sub> emissions decline to zero
- Monitor the progress towards warming target while keeping the global C budget target.

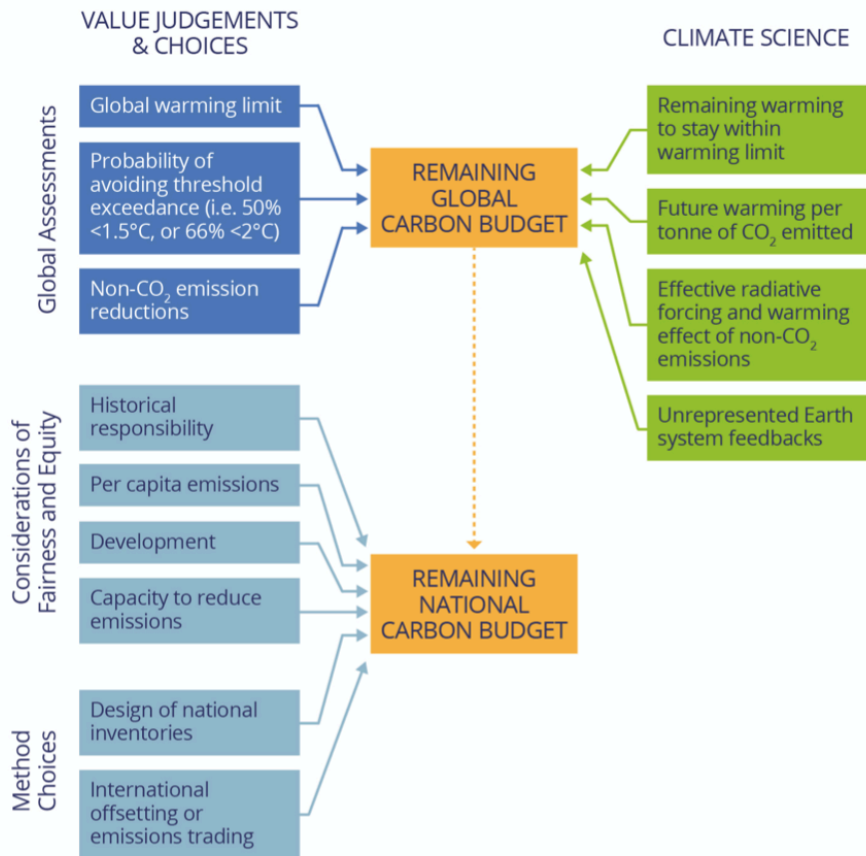
- **Carbon budget accounting**

# Fair distribution of the remaining carbon budgets

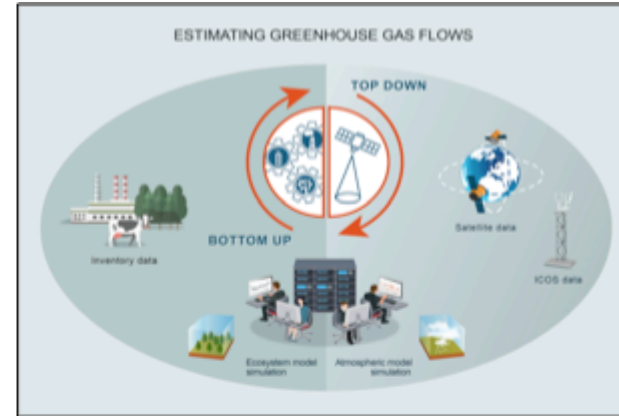
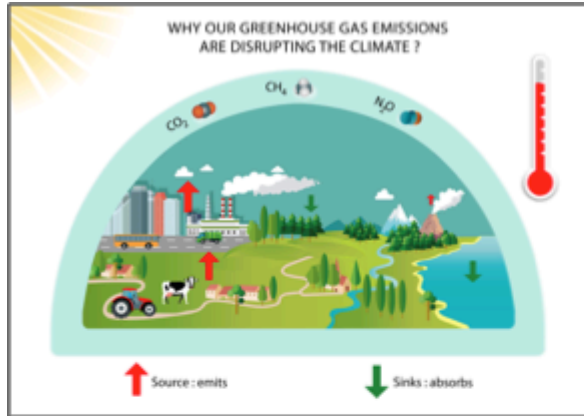
There is a need for scientists to work together with both social scientists and policy makers to **communicate the implications** of the remaining carbon budgets in a way that can help improve and **strengthen national climate policies**.



Matthews et al. 2020 Nat. Geosci. (2020/accepted)



# VERIFY: Observation-based system for monitoring - verification of GHG



- Estimate CO<sub>2</sub> - CH<sub>4</sub> - N<sub>2</sub>O GHG fluxes at European country scales from bottom up / top down observation-based approaches
- Compare observation-based estimates with the reported fluxes by each country to UNFCCC

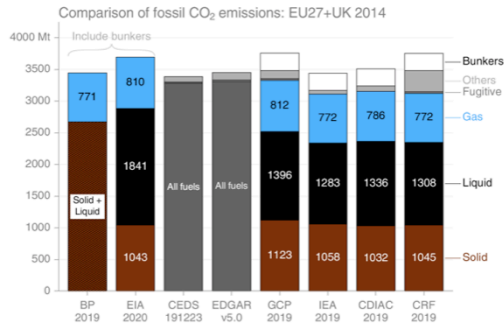
# Obs - based vs UNFCCC carbon flux estimates (EU27+UK)

⇒ All country scale GHG flux synthesis (for EU) at:

<http://webportals.ipsl.jussieu.fr/VERIFY/FactSheets/>

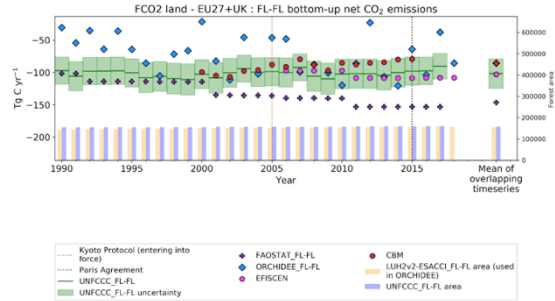
## CO2 fossil emissions

- Differences in inventory estimates due to accounting differences



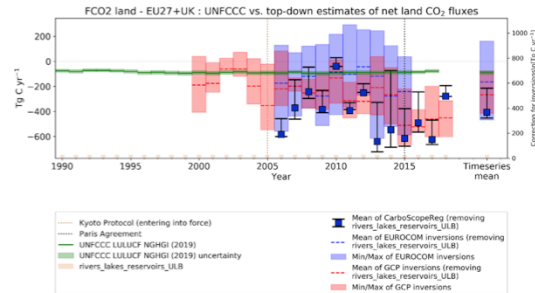
©/VERIFY Project

## CO2 land biosphere fluxes



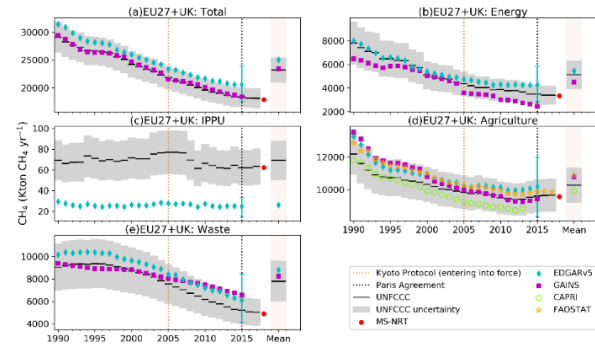
©/VERIFY Project

- Process-models and inversions show larger yr-2-yr variability
- Inversions show stronger sink

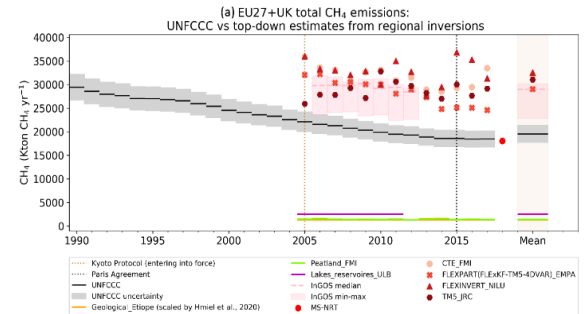


©/VERIFY Project

## CH4 anthropogenic emissions



- Inversions show larger total emissions
- Differences due to natural sources or underestimated anthropogenic sources



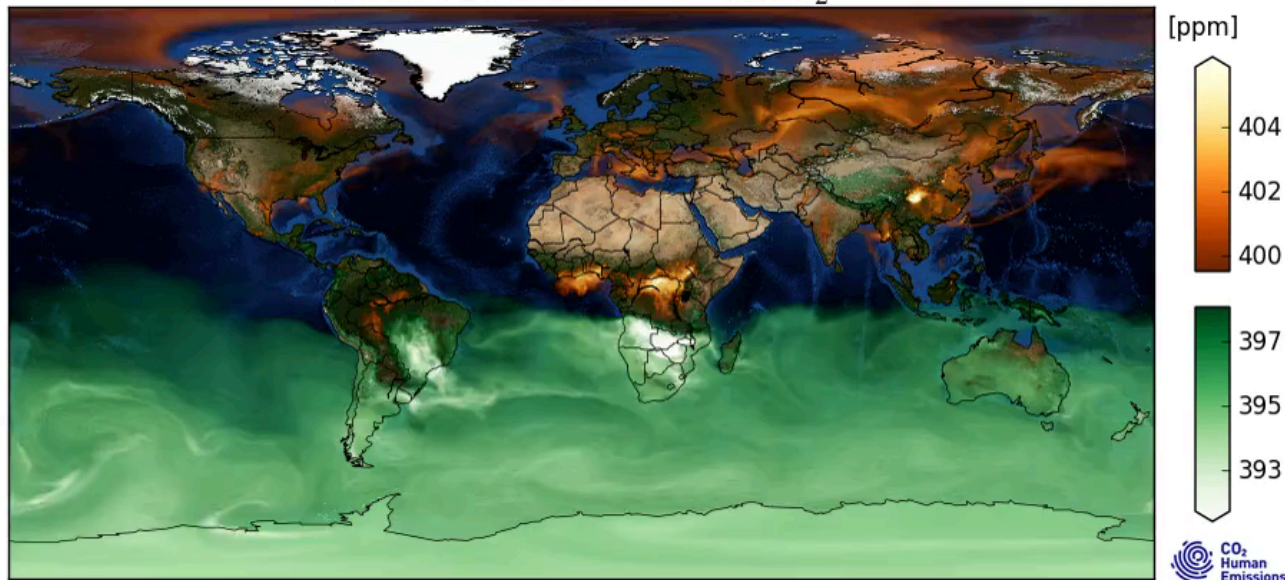


# Study CO<sub>2</sub> in 2015 Paris Agreement's year prepares for CO2M

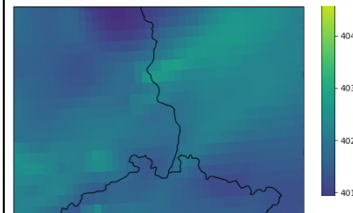
The CO<sub>2</sub> Monitoring & Verification Support capacity developed in CHE focus on 3 scales: Global / Regional / Local

## Global scale

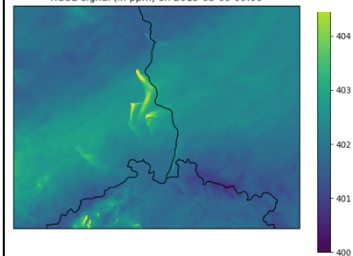
20150101 03 UTC XCO<sub>2</sub>



## Regional scale 9km



XCO<sub>2</sub> signal (in ppm) on 2015-03-09 09:00

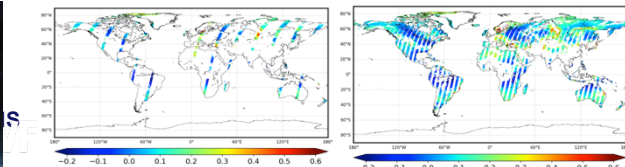
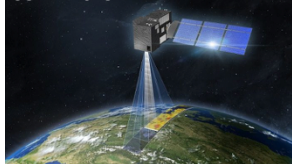


## 1km

## Local scale



CO2M 2025



Testing data assimilation with 1 & 4 satellites

CHE investigated the CO<sub>2</sub> human emission **detection capability** (of Observations & Modelling) to be **prepared** for the future dedicated CO<sub>2</sub>M European Satellite Mission

- **Carbon budget accounting**

## Policy – relevant messages

- Fair allocation of the remaining C budget to individual countries - sectors is a key priority
- Providing a **transparent & robust country level Monitoring and Verification System** (complement to the existing UNFCCC CO<sub>2</sub> and non-CO<sub>2</sub> emissions reporting) is crucial to assess country progresses.
- **Observations-based methods** for CO<sub>2</sub> emissions are **not yet robust enough at country scales**.
- Strong needs for **more integrated & freely available carbon cycle measurements** (in situ & satellites).

## RESEARCH & INNOVATION GAPS

- **Increase Monitoring of both C fluxes and C stocks & stock changes** in all reservoirs (land, ocean)
  - ✓ To evaluate current trends
  - ✓ To improve model skills (i.e., through model data fusion) and reduce modelling errors.
- Understanding and **quantifying the role of non-CO<sub>2</sub> emissions** in the carbon budget framework.
- Understand and **quantify the role/impact of land management and extreme events** on the terrestrial C budget
- **Earth system model biogeochemical developments** are still highly needed (C-N cycles coupling, permafrost, ...).

## Ocean carbon budgets (COMFORT & SO-CHIC projects)

### Key policy-relevant messages:

Oceanic uptake of carbon leads to acidification with hazards for a suite of marine organisms, *for many warm water corals the tipping point for bleaching has already been crossed*

Crossing tipping points and associated abrupt changes in different marine hotspots can induce abrupt changes in marine carbon uptake/storage, *hot spots: North Atlantic circulation, Arctic ocean sub-sea permafrost destabilisation, changes in **Southern Ocean carbon sink***

Once the ocean is acidified (by C uptake), this cannot be reversed on human time scales

### Research & innovation gaps

Assessing planetary boundaries and safe operating space: *What are the multiple Earth system targets for emission reductions that work?*

Feasible mitigation pathways: *Find a climate-crisis-exit strategy that achieves optimal global fare?*