IWGGMS-21 - Session 5

Can we obtain consistent emissions using three CH_4 TROPOMI products?

A comparison of atmospheric inversions at the regional and global scale

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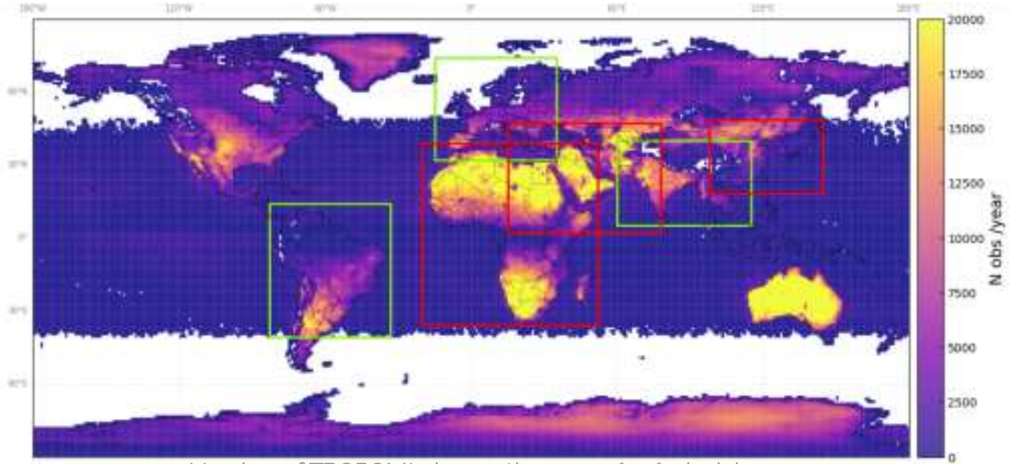
IWGGMS-21

Bridging scales of CH4 inversions with TROPOMI

TROPOMI…

- On-board Sentinel 5-P
- Daily coverage
- Relatively high spatial resolution: $5.5 \times 7 km^2$



Number of TROPOMI observations per 1°×1° pixel, in 2019

→ High potential for **global** and **regional** atmospheric inversions

→ **Purpose**: build robust top-down emission budgets at national level

*Can we obtain **consistent estimates** from the 3 TROPOMI products ?*
*At **global** and **regional** scale ?*

Data: introducing the TROPOMI XCH4 products

Official (SRON), v2.04

Lorente et al., 2022, 2023

- **Operational** Copernicus product
- Reprocessed (**RPRO**) version

BLENDED (Harvard), v1.0

Balasus et al., 2023

- Blended **TROPOMI** and **GOSAT** product
- **ML post-processing** of SRON

WFMD (IUP-UB), v1.8

Schneising et al., 2023

- Research product
- Retrieved with the **WFMD-DOAS** algorithm
- Higher **coverage**

SRON-corr (this study)

- **Linear correction** of the aerosol-dependent bias of SRON

GOSAT v9.0

Parker et al., 2020

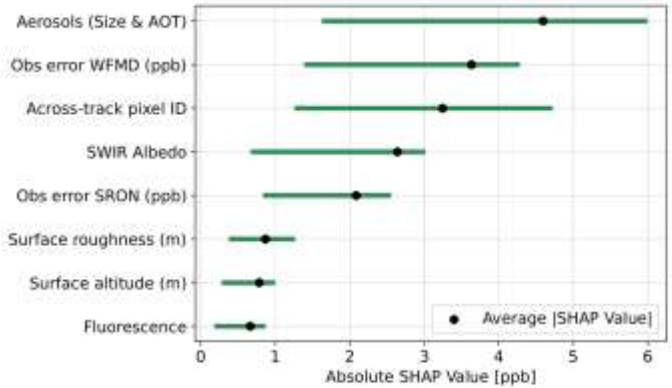
- **Proxy** retrieval product
- **Widely used** at global scale

Data: comparing the TROPOMI XCH4 products

- **Coverage (quality filtering)**

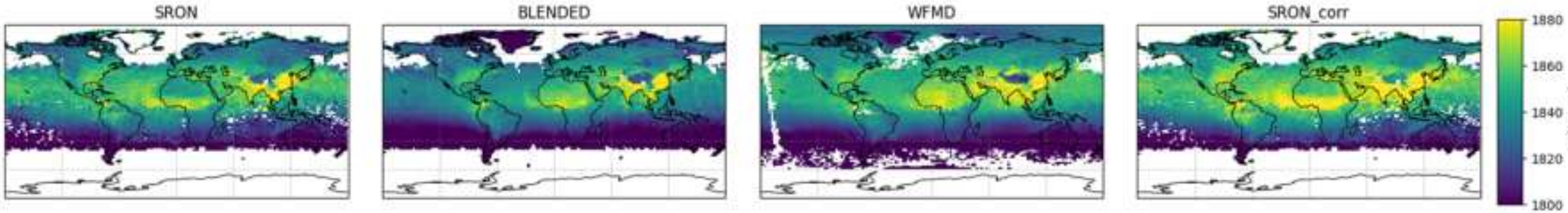
Product	SRON	BLENDED	WFMD	GOSAT
Global	1.4×10^8	1.4×10^8	1.8×10^8	5.5×10^5
Europe	4.7×10^6	4.7×10^6	7.6×10^6	1.2×10^4

Number of observations in 2019



Predictors (SHAP values) of the **SRON - WFMD** XCH4 difference, following the method of Balasus et al. (2023)

- **XCH4 distributions**

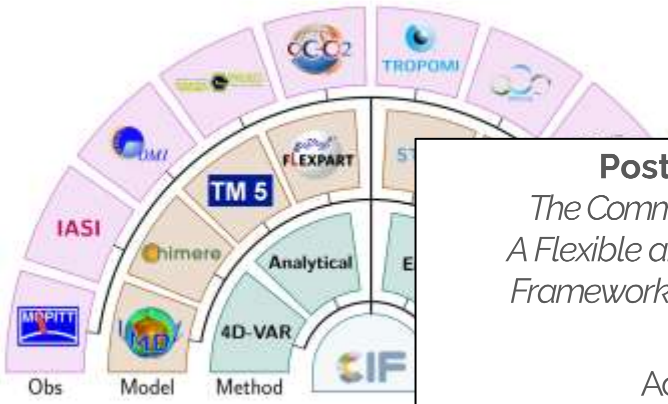


Spatial average of XCH4 in 2019

Method: the CIF, a modular platform for inversions

Community Inversion Framework (CIF)

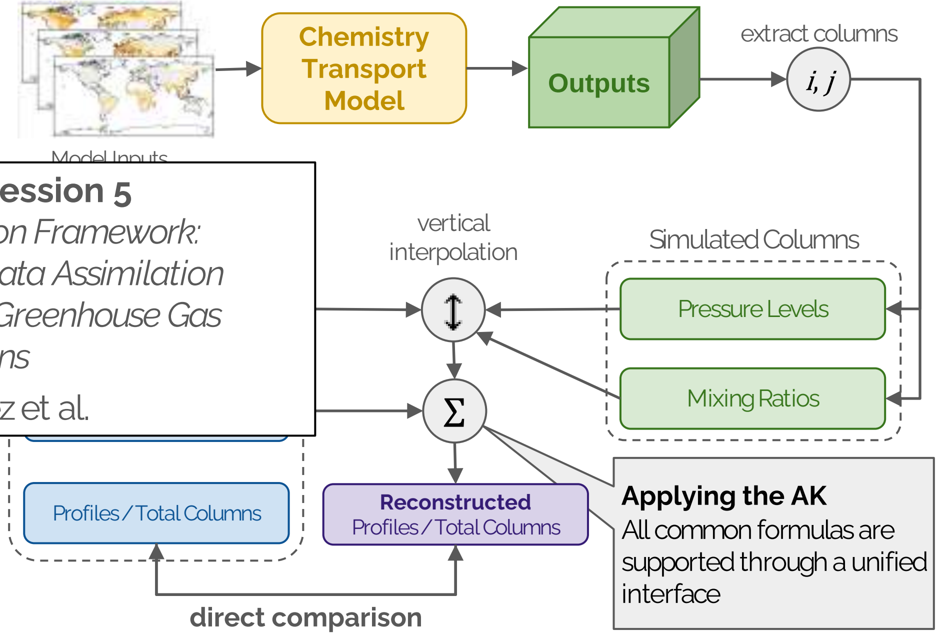
A **modular** and **flexible** open-source tool written in **Python**



Running modes:
- Forward simulation
- Variational inversions
- Ensemble methods
- ...

Features:
- Satellites, in-situ and isotope observations
- Covariance matrices
- Several pre-processors

Satellite Products in CIF

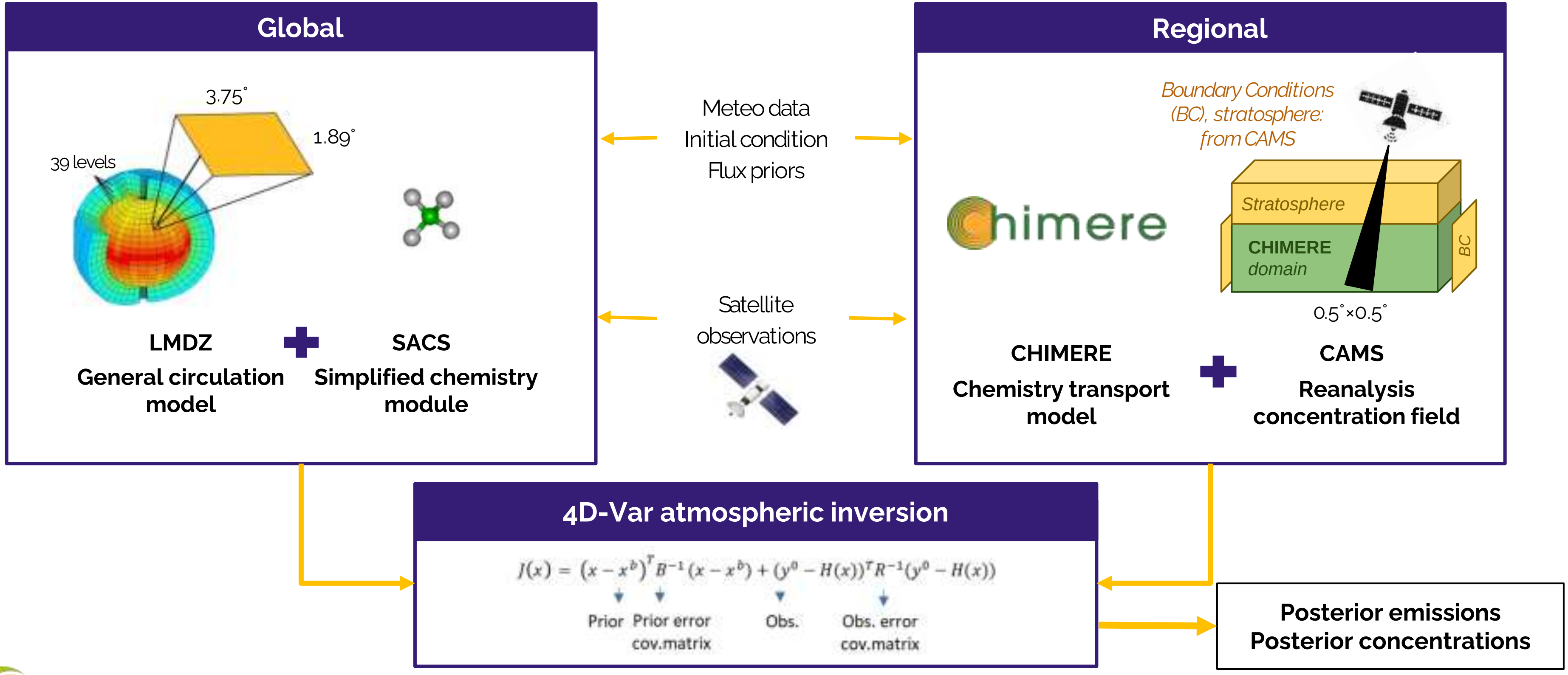


Poster N°5.20, Session 5

The Community Inversion Framework: A Flexible and Scalable Data Assimilation Framework for Satellite Greenhouse Gas Observations

Adrien Martinez et al.

Method: assimilating TROPOMI satellite data in the CIF



- **Comparison** of the CH_4 emissions from **inversions**

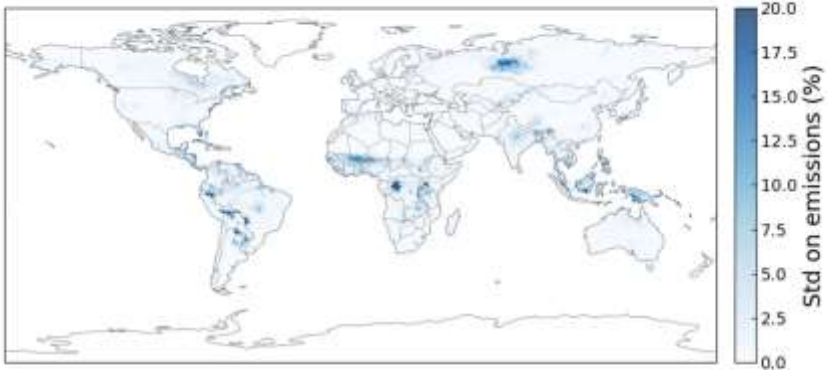
	Global	Europe
SRON	√	√
BLENDED	√	√
WFMD	√	√
SRON_corr	√	
Evaluation	GOSAT	Surface

- **Drivers of the differences** of emission estimates
- **Regional case-studies**: South America, Southeast Asia

Sentinel S5-P (credits: ESA)

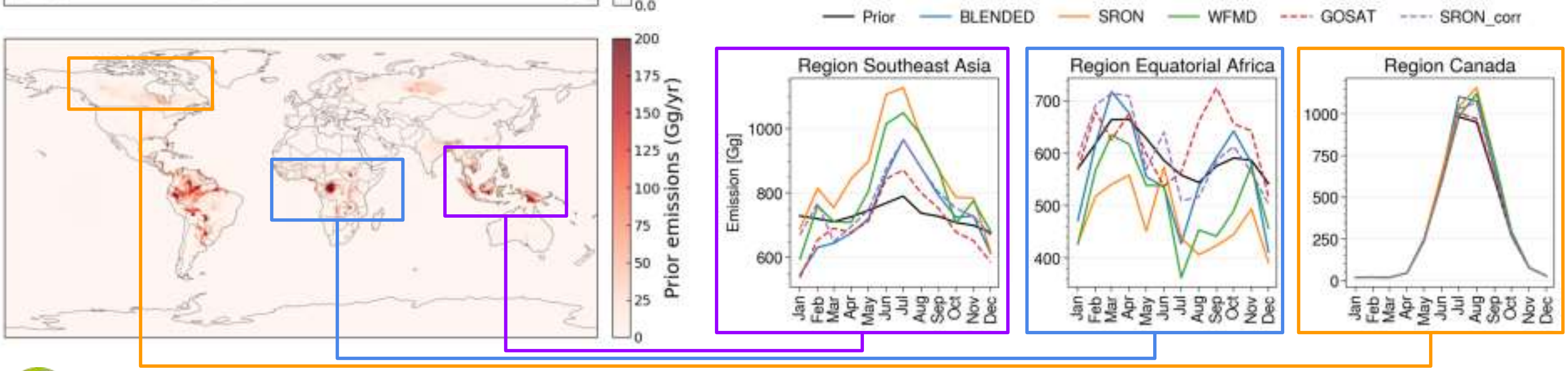
LSCE

Comparing global CH4 emissions from inversions



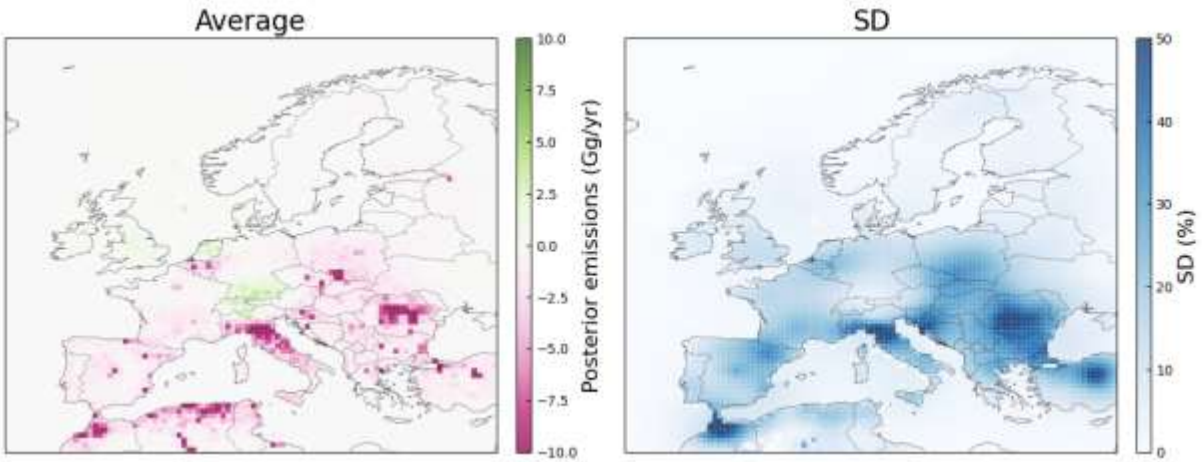
Standard deviation of the posterior emissions (% of the avg) for the SRON, BLENDED, WFMD inversions

Seasonal variations of the posterior emissions (Gg/yr) for the 5 inversions (same + SRON_corr, GOSAT)



Comparing CH_4 emissions from inversions

- Spatial distributions, country budgets **differ**. SRON and BLENDED are rather consistent.
- Comparison with independent surface-based inversion: **no product better than the others** !



Average and standard deviation of the emissions for the SRON, BLENDED and WFMD inversions.

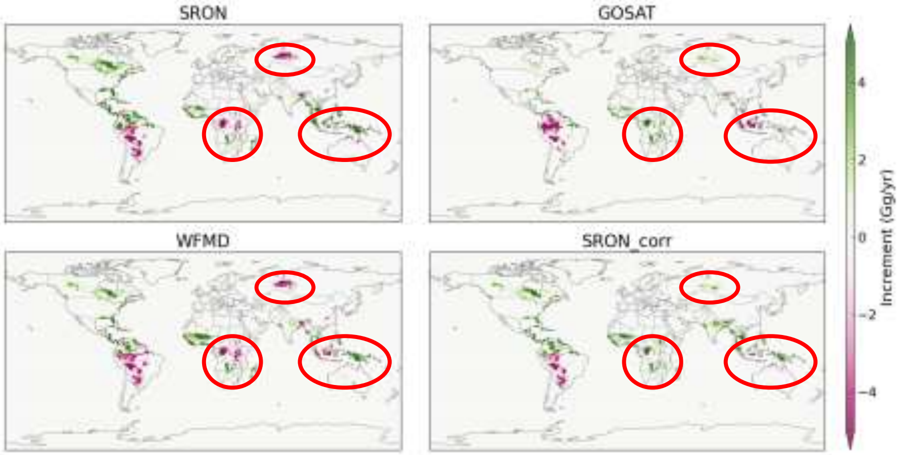
Product	*EU27+3 (Tg/yr)*
Prior	25.2
SRON	25.7
BLENDED	25.0
WFMD	16.9
Surface	23.0

European emission budget in 2019

Drivers of the differences of increments

Aerosols:

- **Simple approach** (linear correction) that highlights the impact of aerosols
- **SRON_corr** increments are **more consistent** with GOSAT, slightly with WFMD

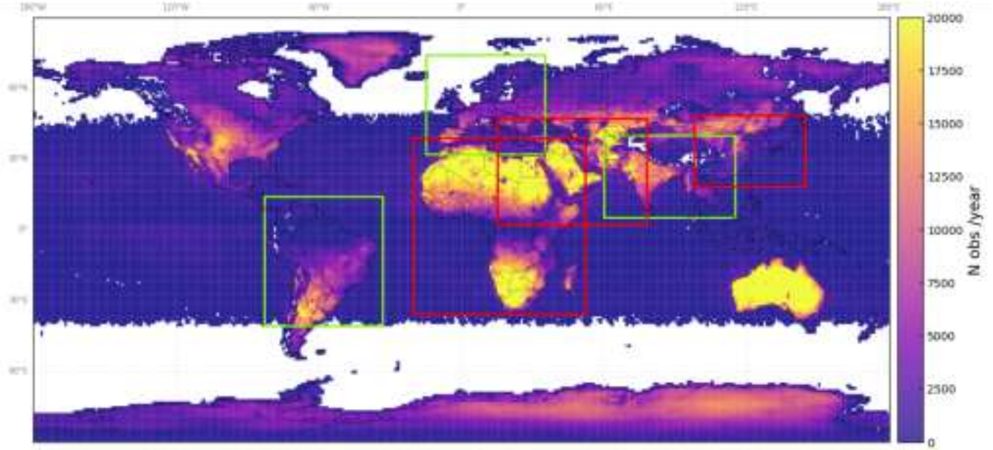


Spatial average of the increments, in 2019.

OSSE:

- Observing System Simulation Experiments performed at the **global** (*Montenegro, Opler et al., in prep.*) and the **regional** (*Sicsik-Paré et al., submitted*) scale
- Highlighted the role of **observation density, error definition, albedo, boundary conditions optimization** (regional)...

What is the motivation of our regional inversions?



Number of TROPOMI observations per 1°×1° pixel, in 2019

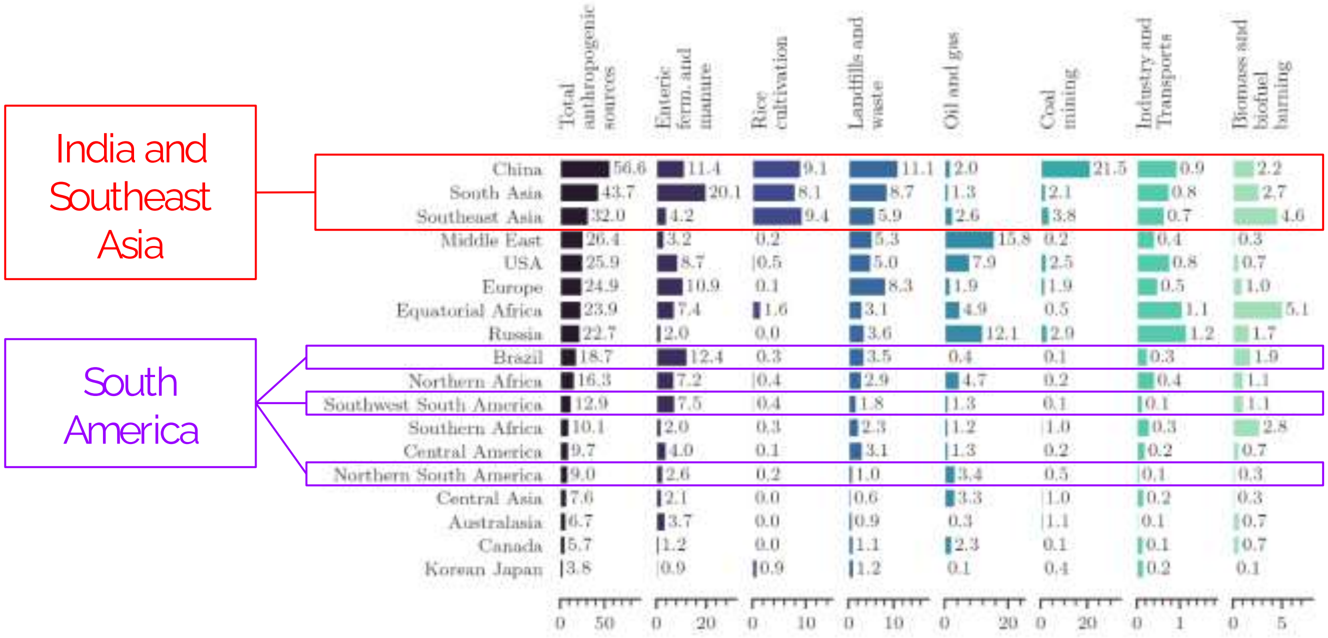
- **Differences between the TROPOMI products** (quality filtering, XCH4, albedo, aerosols…).
  → New versions try to **correct** the known biases.
- They drive **differences** in the estimated CH4 emissions.
- **No** product is **clearly superior** than the others: we recommend to use the **complementarity of the 3 products**.

- **Global** emissions have already been studied with GOSAT
- **European** emissions with surface stations.

Poster N°5.19, Session 5
Capability of observing systems to estimate CH4 fluxes at regional and sectoral scales through OSSEs
Nicole Montenegro

What is the motivation for these regional domains?

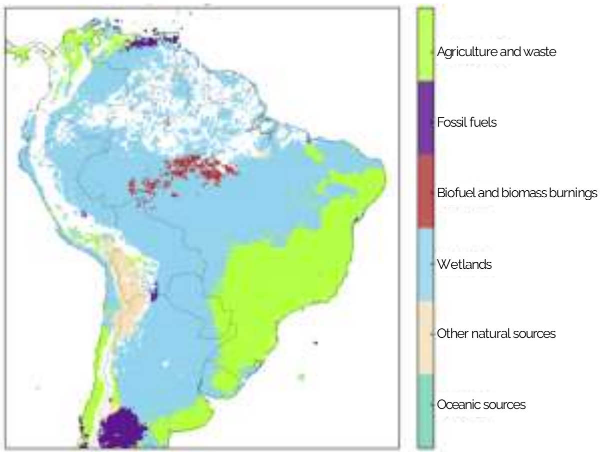
- Focus on regional domains with **high emissions** and **low number of surface stations**, where **TROPOMI is a game-changer**: South America, India and Southeast Asia.



Regional anthropogenic emissions for the 2010–2019 decade from bottom-up estimates (in Tg CH_4 yr^{-1}). Source: Global Methane Budget (Saunois et al., 2025).

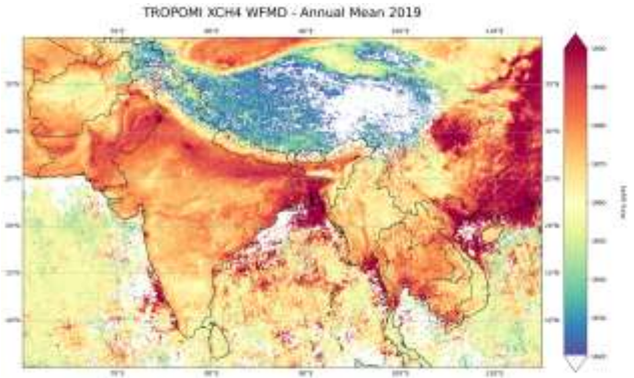
Emissions from tropical regions

- ***South America*** (0.2°×0.2°)
  - Large contributions of wetlands and livestock
  - Comparison of the **TROPOMI simulated XCH4** distribution and the **observations**: impact of the **inversion configuration** (inputs, parameters) and **sectoral contributions**



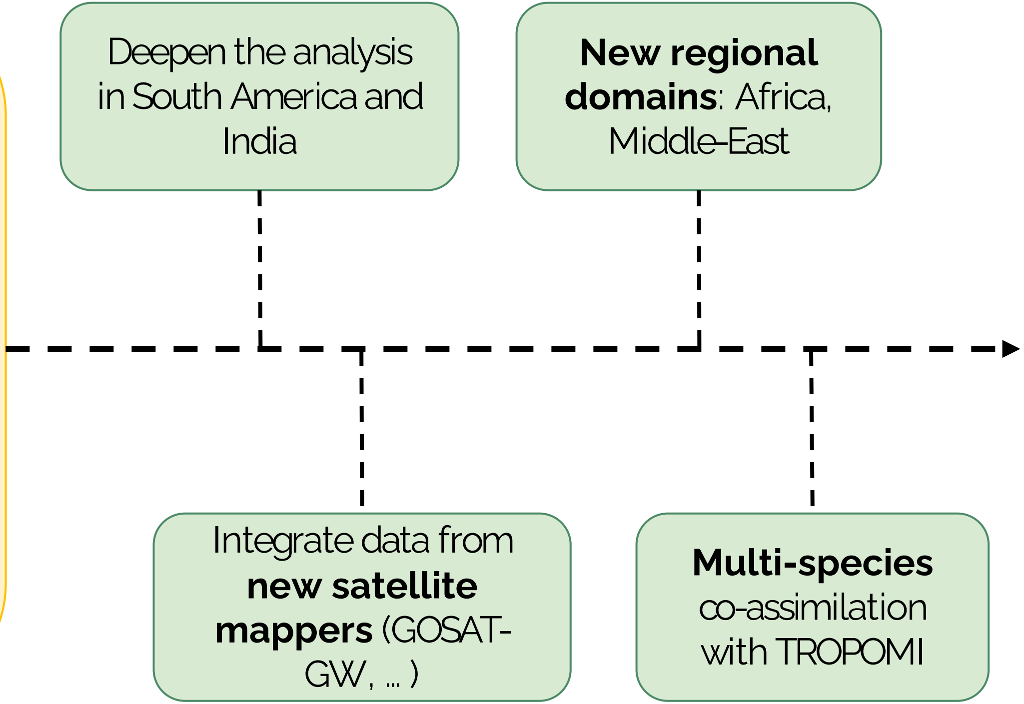
Map of maximum sectoral sensitivity for TROPOMI XCH4

- ***India and Southeast Asia*** (0.35°×0.35°)
  - Large emissions from agriculture (eg: enteric fermentation, rice cultivation), fossil fuels, wetlands
  - Estimation of CH4 budgets using **regional inversions**



Conclusion

- TROPOMI provides **high coverage** XCH4 data, valuable for global/regional inversions.
- The assimilation of the different TROPOMI products leads to **different** CH4 emission estimates: **no product is clearly better than the others**.
- We recommend to use the **complementarity of the TROPOMI products** for future inversions.



THANK YOU FOR YOUR ATTENTION

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reccap-2 cci

SMART-CH4

EYE-CLIMA Verifying emissions of climate forcers

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