QUANTIFYING THE IMPACT OF OBSERVING SYSTEMS ON ATMOSPHERIC METHANE FLUX ESTIMATES VIA OSSES

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1 INTRODUCTION

Top-down approaches are limited by different uncertainties:
- Systematic and random uncertainties in the observing satellite.
- Systematic and random errors in the transport model
- Errors in prior emissions including spatial resolution [1].

Uncertainties on methane emissions estimated by TD:
- ±7% in the tropics, ±12% in mid-latitudes, and > ±20% in high latitudes [2].

Discrepancies in methane flux estimates derived from different observing systems:
- Tropics: GOSAT>Surface data (15–30 $TgCH_4$ $year^{-1}$)
- Northern mid-latitudes: Surface data>GOSAT (2-36 $TgCH_4 year^{-1}$) [2].
- Southern Hemisphere: GOSAT>Surface data (15–30 $TgCH_4 year^{-1}$) [3].
- TROPOMI-based fluxes less consistent than GOSAT-based fluxes in India and eastern China [4].

OBJECTIVE:

Determine the capability of each observing system to retrieve CH_4 surface fluxes and to reduce uncertainties on fluxes at the regional and sectorial scales.
Observing System Simulation Experiments (OSSEs) are conducted within the Community Inversion Framework (CIF) [5] over the period June 1, 2018 to June 30, 2020 using the LMDZ transport model [6].

OBSERVING SYSTEMS USED:

		PRODUCTS [11]
SATELLITES	GOSAT	1. NIES SWIR V02.96 2. University of Leicester Proxy XCH4 v9.0
	TROPOMI	WFMD v19.446
	IASI	MetOp-A LMD NLIS v9.1
IN-SITU	NOAA	ObsPack-CH4 GLOBALVIEWplus version 4.0 2021-10-14 ObsPack-CH4 NRTv3.0 version 2021-05-18
	ICOS	Near Real-Time (Level 1) Atmospheric Greenhouse Gas Mole Fractions of CH4.
	CSIRO	World Data Centre for Greenhouse Gases (WDCGG)

2 METHODOLOGY: Application of Observing System Simulation Experiments in the CIF

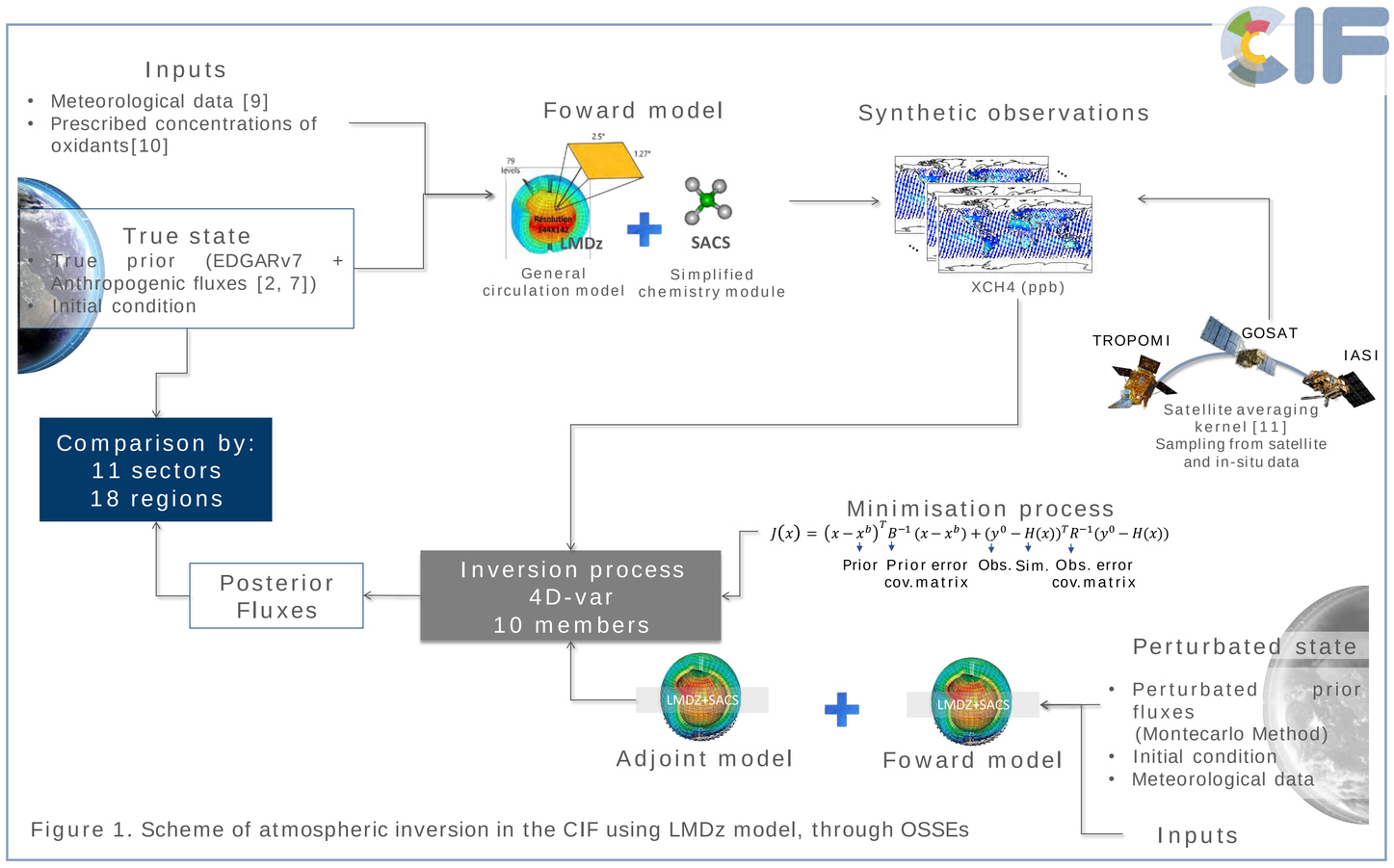


Figure 1. Scheme of atmospheric inversion in the CIF using LMDz model, through OSSEs

1. Comparing the true state vs posterior fluxes

$$sum\_log = \sum_{n=day} \log\left(abs\left(\frac{Post - True}{*\,\boldsymbol{Prior} - True}\right)\right)$$

$$metric = (\exp(sum\_log) - 1) * 100)$$

Case 1: $Post - True =* Prior - True$; $metric$ 0 no change
Case 2: $Post - True >* \boldsymbol{Prior} - True$; $metric$ + closer to target
Case 3: $Post - True <* \boldsymbol{Prior} - True$; $metric$ - further to target

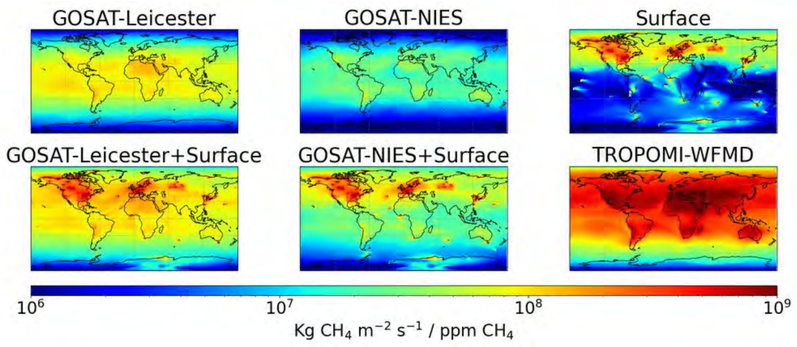
$* \boldsymbol{Prior}$ perturbated

2. Estimating the uncertainty reduction

Uncertainty Reduction = $\frac{\sigma_{Posterior\ 10\ members}}{\sigma_{prior\ 10\ members}}$ *100 (%)

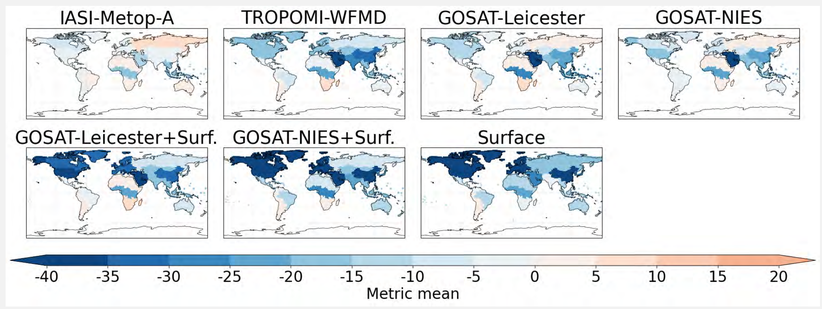
3 RESULTS

3.1 SENSITIVITY OF OBSERVING SYSTEMS TO CH4 FLUXES



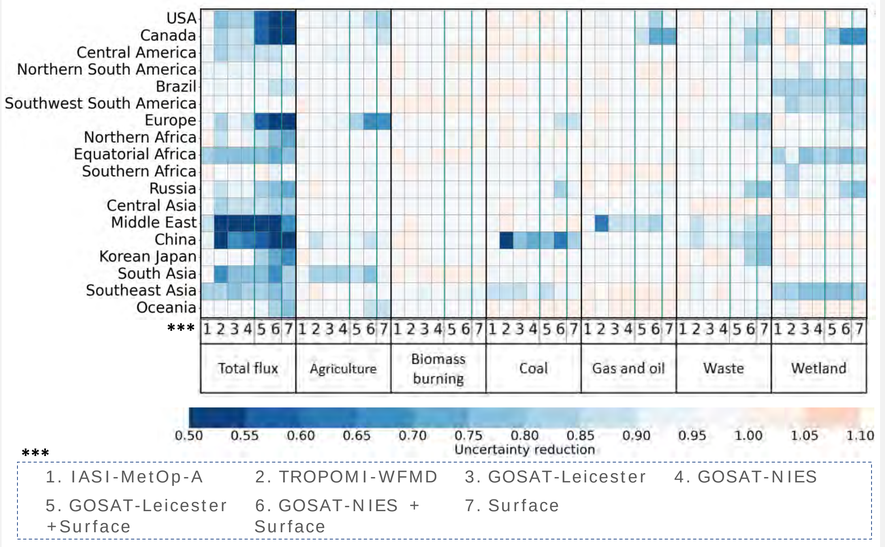
- GOSAT-Leicester's sensitivities larger over continental regions between 30°S -30°N compared to higher latitudes.
- GOSAT-NIES shows the lowest overall sensitivity among the observing systems, lower than 1 or 2 order of magnitude compared to other systems.
- TROPOMI-WFMD has the highest sensitivity among the systems and the largest in the tropics.
- In-situ data exhibits high sensitivity throughout the NH, comparable to TROPOMI in N. America and Europe, but 3 to 4 orders of magnitude lower elsewhere.

3.2 CAPABILITY TO RETRIEVE TARGETED FLUXES



- Except for IASI, most obs. systems are capable of retrieving the targeted fluxes in most regions.
- Better results in: the Middle East, the USA, Canada, China and Equatorial Africa.
- Surface obs. network shows better performance compared to satellites in NH.
- The combination of Surface + GOSAT shows better retrievals (Surface+TROPOMI-WFMD is ongoing)
- Some regions are not sufficiently constrained by any obs. system: Southern Africa, and SW. South America.

3.3 UNCERTAINTY REDUCTION (UR)



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1. IASI-MetOp-A 2. TROPOMI-WFMD 3. GOSAT-Leicester 4. GOSAT-NIES
5. GOSAT-Leicester +Surface 6. GOSAT-NIES + Surface 7. Surface

1. UR ON TOTAL FLUXES:
- Largest UR ~ 50%: North America, Europe, the Middle East, and China
- Lowest UR in South America, Oceania, and Southern Africa (10< %).
- Higher UR using Surface and Surface + GOSAT data

2. UR AT THE SECTORIAL SCALE:
- Highest UR in the main sector contributing to the total flux: agriculture in South Asia and Europe, coal in China, oil and gas in the Middle East, wetlands in Brazil, Canada, and Equatorial Africa.

4 CONCLUSIONS

- The results suggest that most observing systems provide valuable information that enables the atmospheric inversions to reduce uncertainty in the flux estimates
- The combination of surface with GOSAT data proved to be an excellent complement to improve estimates and reduce uncertainty for Northern Hemisphere.
- However satellite observations do not show significant improvements for the Southern Hemisphere.
- Although TROPOMI-WFMD retrieval has the highest sensitivity over most the globe (due to its high temporal and spatial resolution), do not perform much better than the others, which may be related to large errors in the matrix B.

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