Partitioning anthropogenic and natural methane emissions in Finland from 2000 to 2021 using CTE-CH_4

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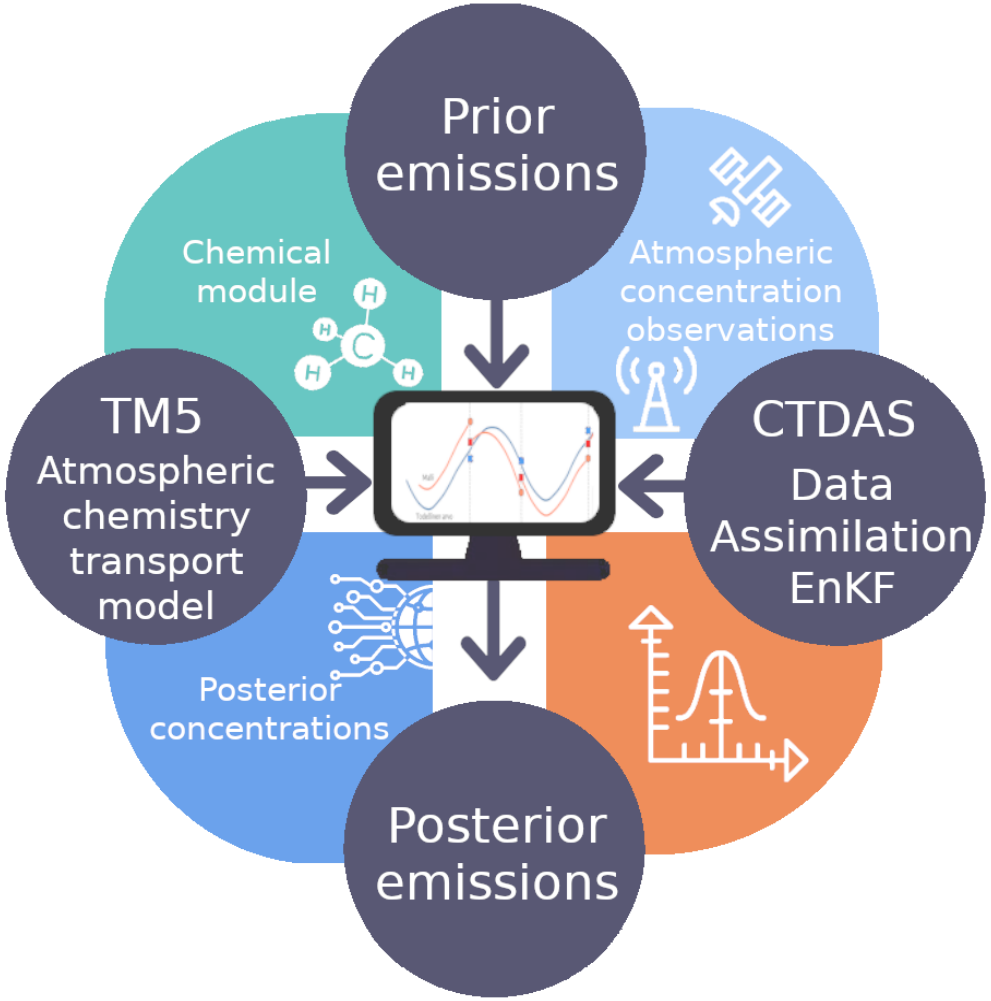


Motivation and aim

- Accurate national CH_4 emission estimates are essential for tracking progress towards climate goals.

- We investigated Finnish CH_4 emissions from 2000–2021 using bottom-up and top-down approaches.

How well CTE-CH_4 is able to estimate CH_4 emissions within a single country, focusing on how the choice of priors and uncertainties affected optimised emissions?

Atmospheric inversion model setup

TM5

- Constrained by ERA5 meteorology (3-hourly)
- Horizontal resolutions: 6° x 4° (glb) + 1° x 1° (eun)
- Vertical levels: 25

Priors

- Anthropogenic: EDGAR v6 or CAMS-REG CH_4 (in Europe)
- Biospheric: LPX-Bern DYPTOP, JSBACH-HIMMELI or GCP wetland prior
- Others: GFED v4.1s (fire), Saunois et al. (2020) (termites), Weber et al. (2019) (ocean), Etiope et al. 2019 (geological, downscaled)

Optimisation (5 setups)

- Biospheric (wetlands + soil sink) and anthropogenic emissions are optimized simultaneously
- Surface measurements
- 1° x 1° resolution in Canada, the USA, Europe and Russia. Elsewhere region-wise.
- 7-day temporal resolution
- Ensemble Kalman Filter, 500 memebers
- Longest runs 2000-2021
- Biospheric prior uncertainty 80% or process-model spread-based

Optimisation regions and in situ sites

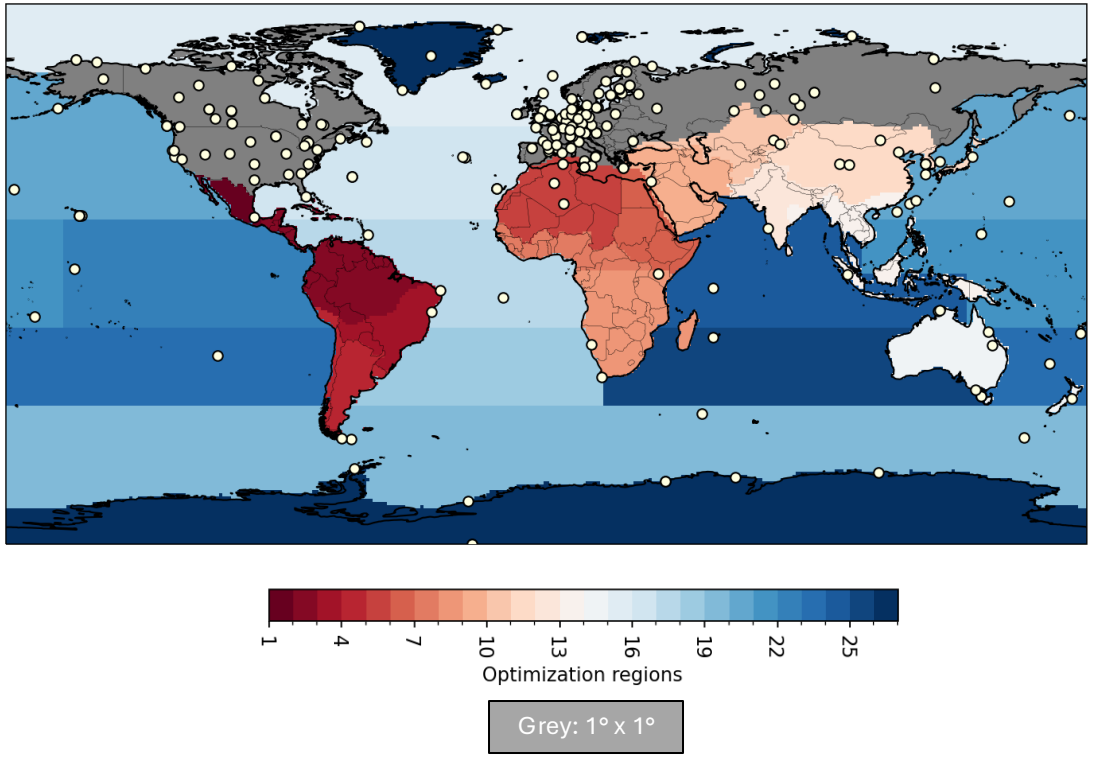
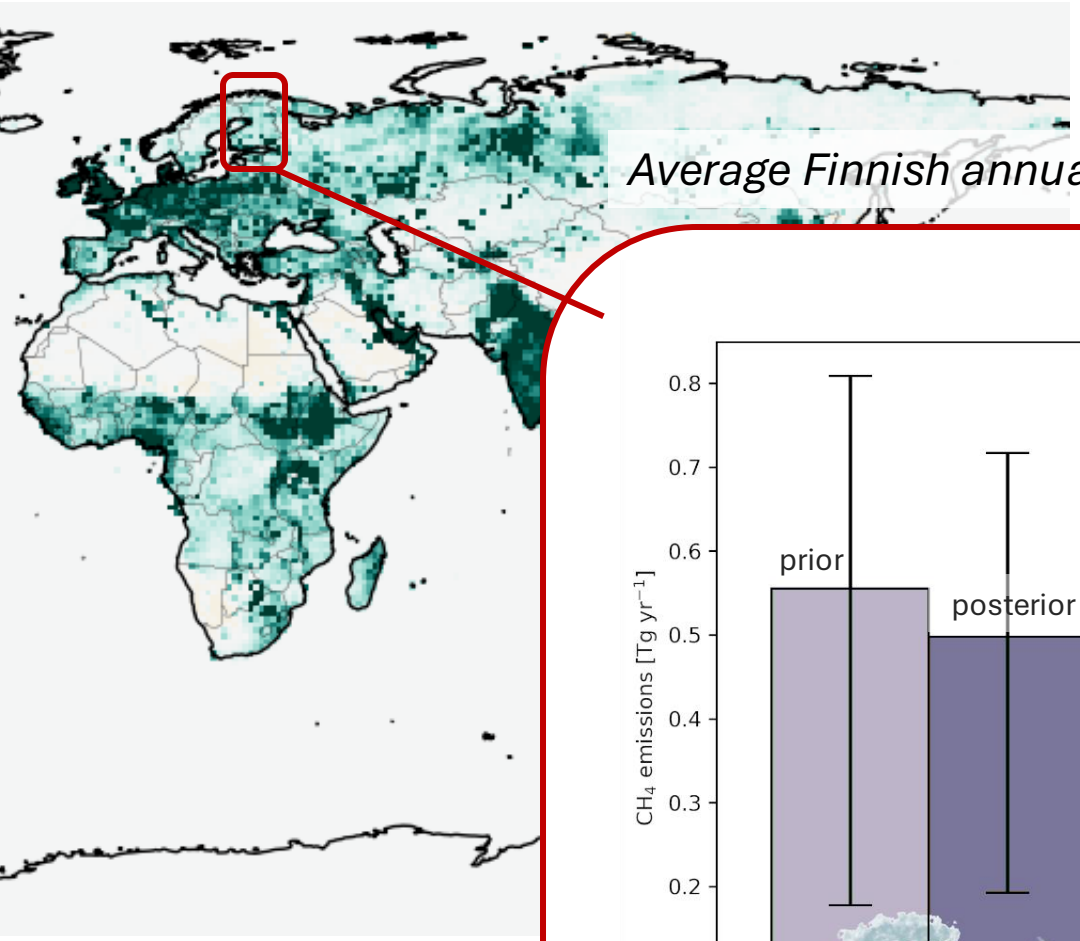


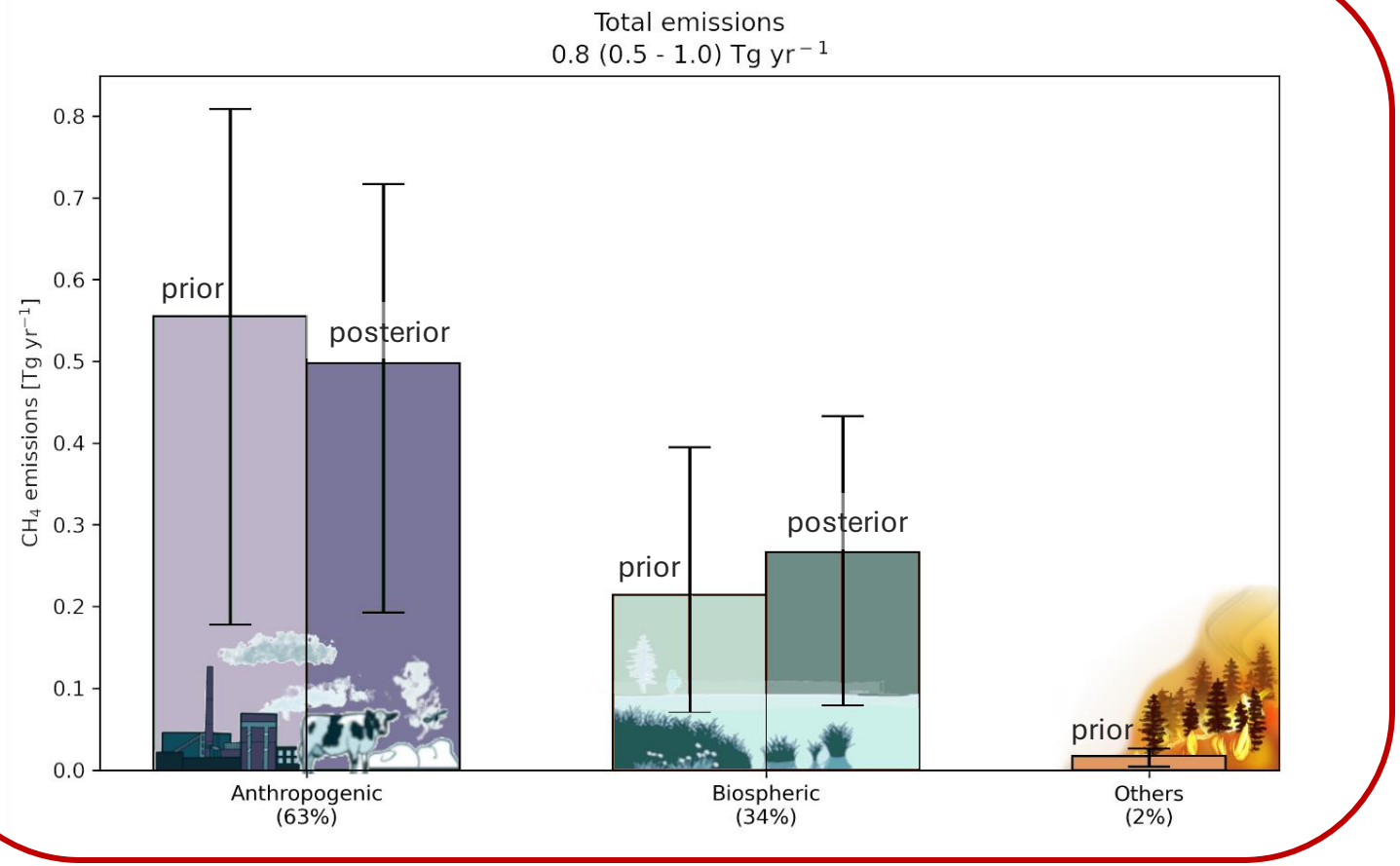
Table 1. List of inversion set-ups.

Inversion	Anthropogenic prior	Biospheric prior	Bio unc	Years
$Inv_{JSBACH\_CAMSREG}$	CAMS-REG	JSBACH-HIMMELI	80%	2005–2020
$Inv_{LPX\_CAMSREG}$	CAMS-REG	LPX-Bern DYPTOP	80%	2005–2020
Inv_{LPX_EDGAR}	EDGAR v.6	LPX-Bern DYPTOP	80%	2000–2021
$Inv_{LPX\_EDGAR\_UNC}$	EDGAR v.6	LPX-Bern DYPTOP	varying	2010–2021
Inv_{GCP_EDGAR}	EDGAR v.6	GCP climatological	80%	2000–2020

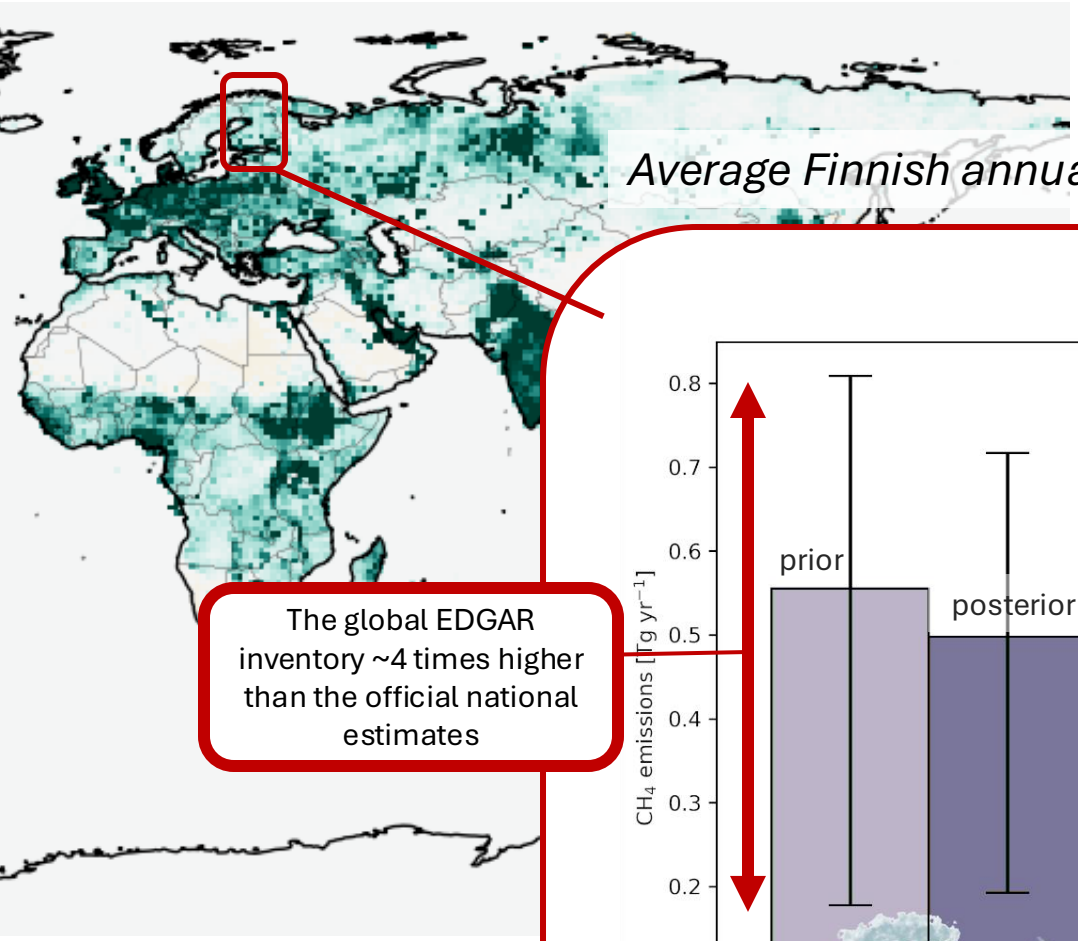
Estimating methane emissions in Finland



Average Finnish annual CH_4 emissions, 2010-2020

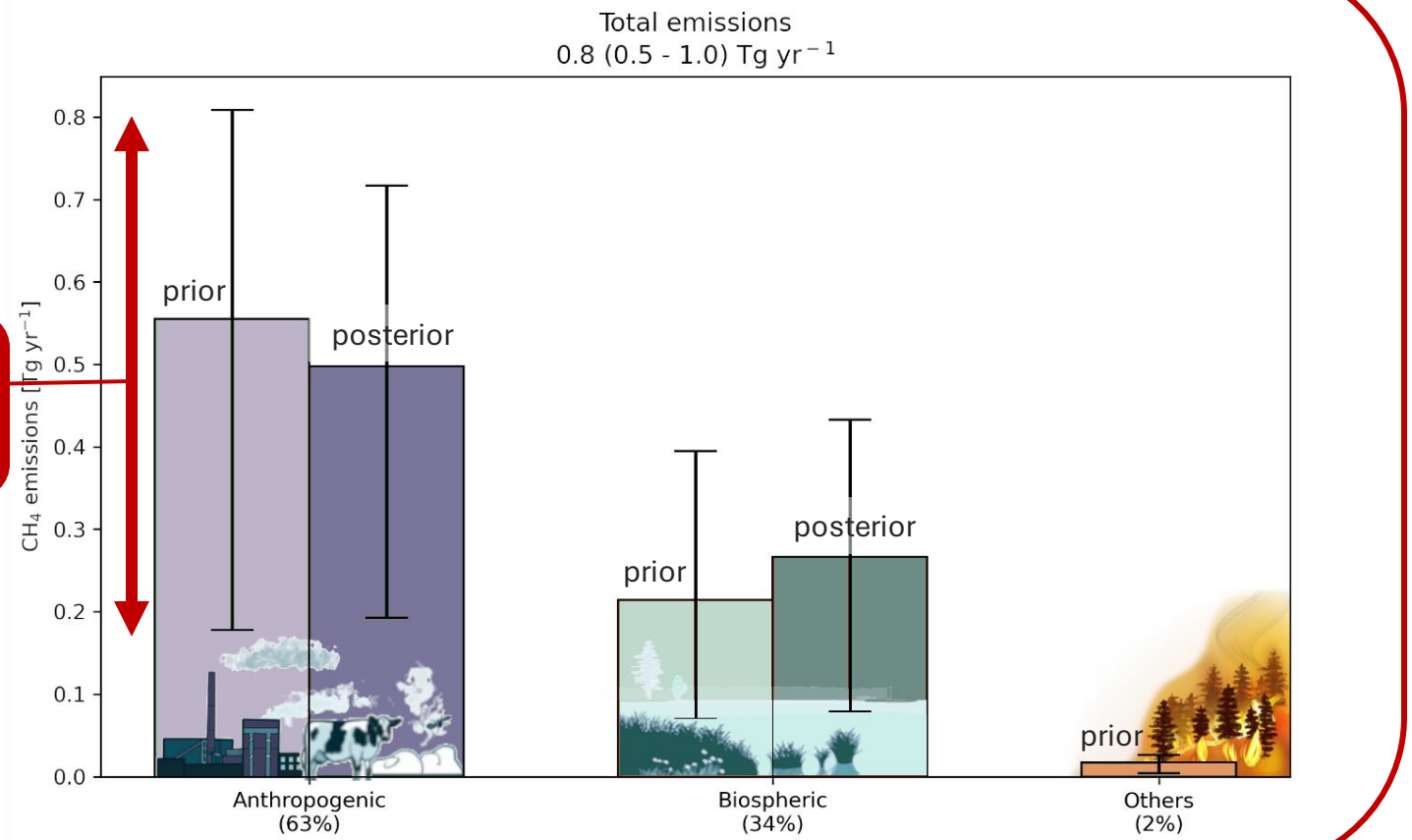


Estimating methane emissions in Finland



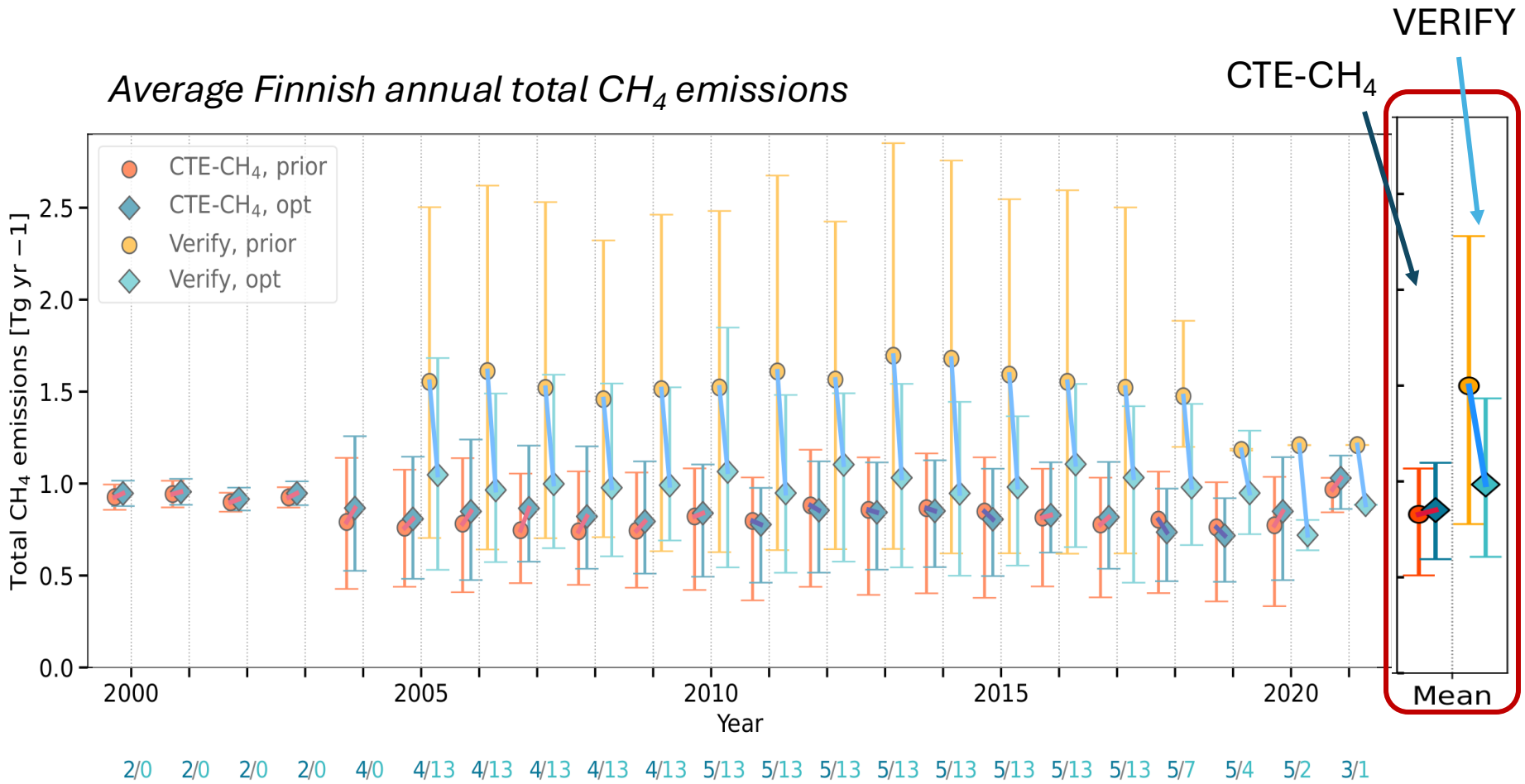
Average Finnish annual CH_4 emissions, 2010-2020

The global EDGAR inventory ~4 times higher than the official national estimates



Estimating methane emissions in Finland: Comparison with VERIFY inversion model ensemble

The average total posterior emission of the CTE-CH_4 ensemble was similar to the average of the VERIFY ensemble including different inversion models but similar priors.



Estimating methane emissions in Finland: Natural (wetlands & soil sink)

The seasonal cycle of peatland CH_4 emissions match with the flux observations after the optimisation

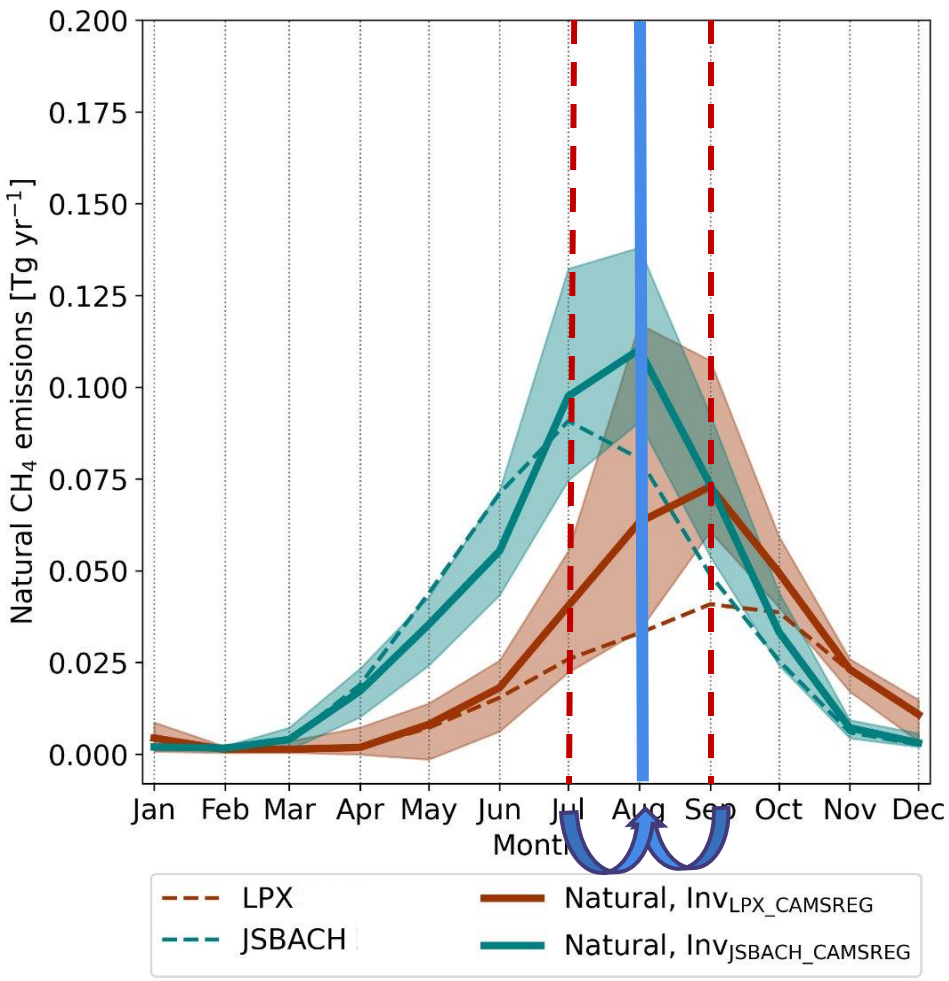
Optimisation emissions were shifted towards co-dependence by temperature and precipitation.

Aalto et al. 2024 (preprint)

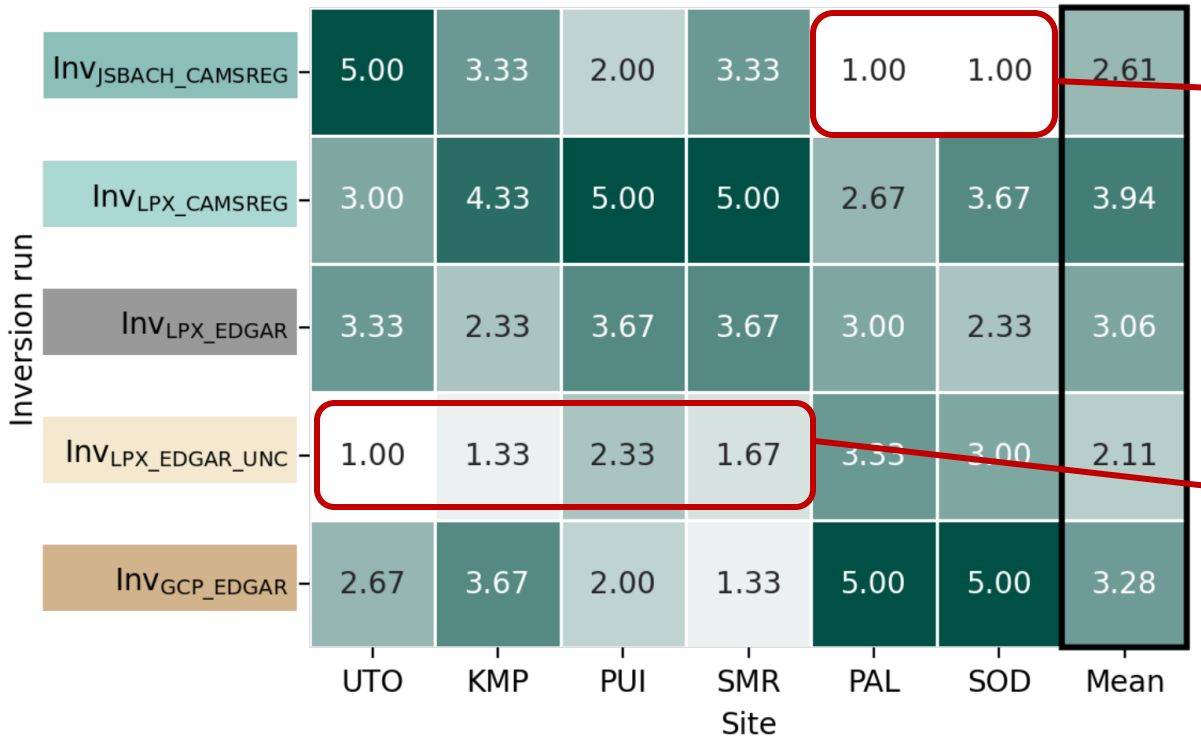
Optimised CH_4 emissions higher than estimated with process-based models

- Process-based models underestimate CH_4 soil emissions in Finland?
- Unaccounted sources like freshwater?

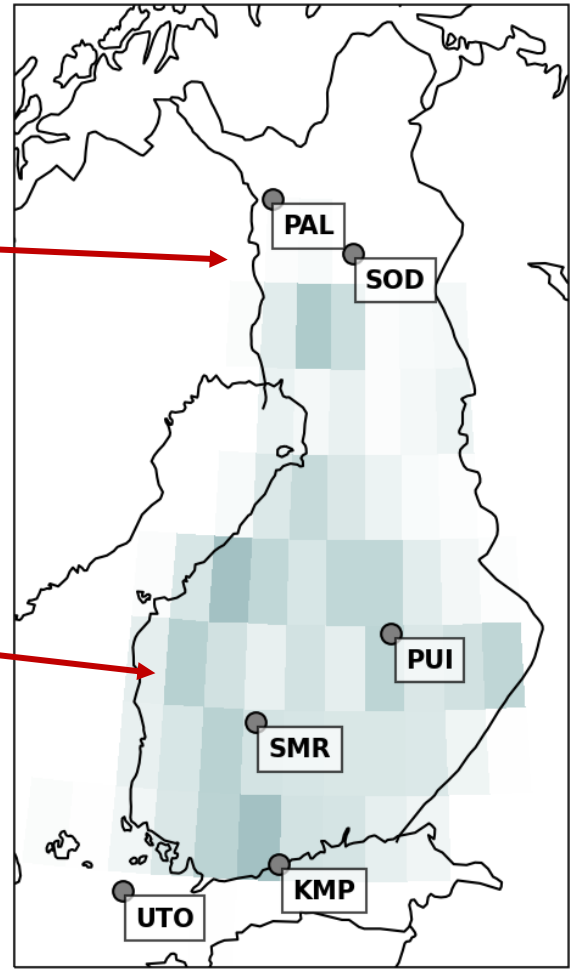
Prior (dashed) and optimised (solid) natural CH_4 emissions estimated with an inversion model

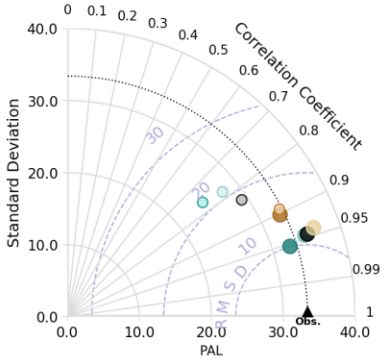


Comparison with CH_4 mole fraction measurements



Bias, detrended RMSE and detrended R: Average ranking



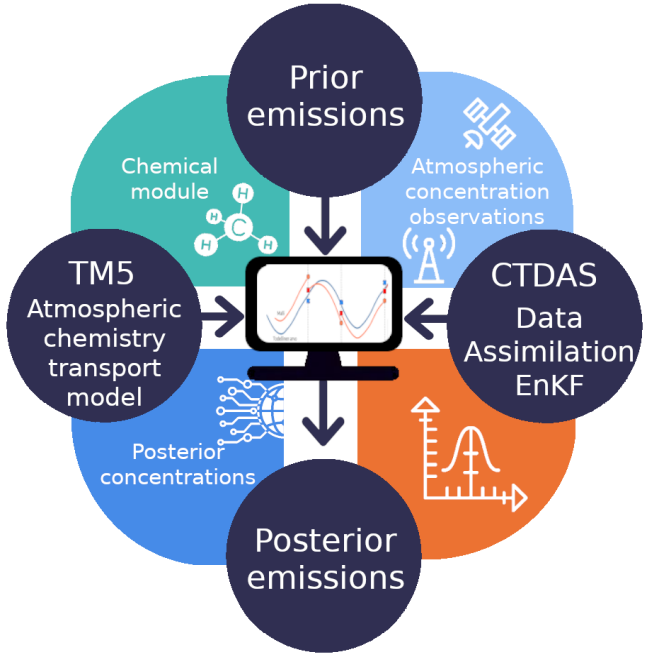


TAKE-HOME MESSAGE

The choice of priors strongly influenced the posterior CH_4 emission estimates on a country-scale.

The ensemble of CTE-CH_4 inversion runs resulted in similar average total posterior emissions as when using different inversion models but similar priors

Finland has large natural CH_4 emissions and they might be underestimated by process-based models.



Tenkanen et al. 2024 (preprint): https://doi.org/10.5194/egusphere-2024-1953

WMO Global Greenhouse Gas Watch

- Tuula Aalto a member of the advisory group
- Antoine Berchet (LSCE) aiming to have CIF as a EU's "official" G^3Watch inversion model system
  - Aki Tsuruta has been implementing TM5-MP to the CIF system
  - Our plan is now to participate to G^3Watch with CIF-TM5-MP (1° x 1° resolution)