#IWGGMS18 Present at the booth: 9:00 – 12:00 EEST

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SPATIAL DISTRIBUTION AND SEASONAL CYCLE OF NORTHERN HIGH LATITUDES CH_4 FLUXES INFERRED FROM AN ATMOSPHERIC INVERSE MODEL USING TROPOMI XCH_4

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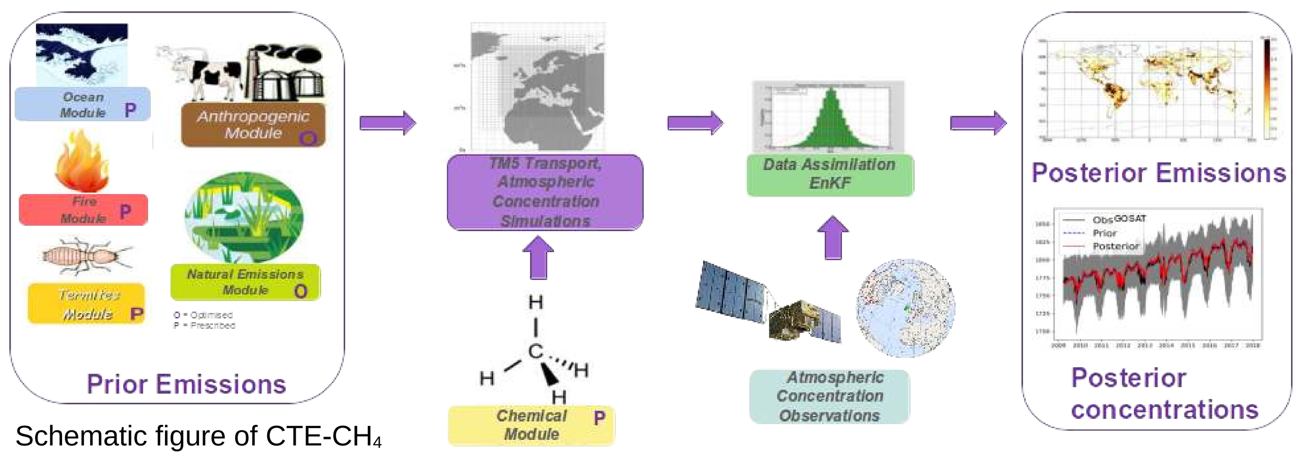
INTRODUCTION

- Methane (CH_4) is a second most powerful anthropogenic greenhouse gas after carbon dioxide.
- Northern high latitude (NHL) is a source of CH_4, and rapid changes in its climate due to global warming may increase CH_4 emissions significantly.
- In NHL, surface CH_4 concentrations are mostly measured in rural areas – limited information on anthropogenic source signals.
- Satellite data has a good spatial coverage, providing a great potential to help understand NHL CH_4 budgets more in detail.
- TROPOMI data is yet new to be used in the atmospheric inversions.
- We will examine the potential of TROPOMI to estimate spatial and temporal distribution of NHL CH_4 fluxes.

MODELLING



Schematic figure of CTE-CH_4

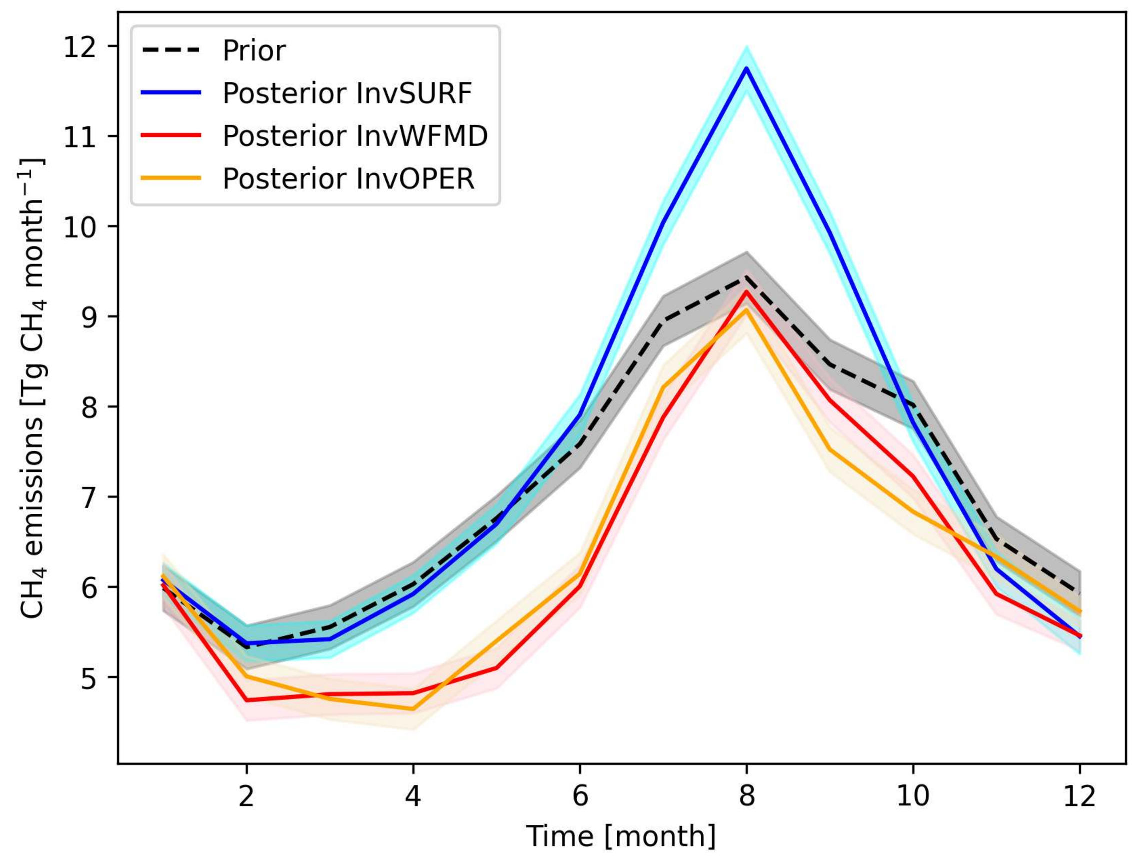
- Main tool
  - CTE-CH_4[7] atmospheric inverse model
  - Fluxes are optimized at 1° × 1° × 3-day resolution over NHL
- Assimilated observations
  - **SURF:** High precision surface (tropospheric) CH_4 observations from ground-based stations
  - **WFMD*:** Total column-averaged dry air mole fraction of CH_4 (XCH_4) retrieval from Sentinel-5P TROPOMI, WFM-DOAS v1.2 retrieval[5,6]
  - **OPER*:** XCH_4 retrieval from TROPOMI, operational v1.0 data[2]

  *Data are preprocessed by taking 1° × 1° × daily averages

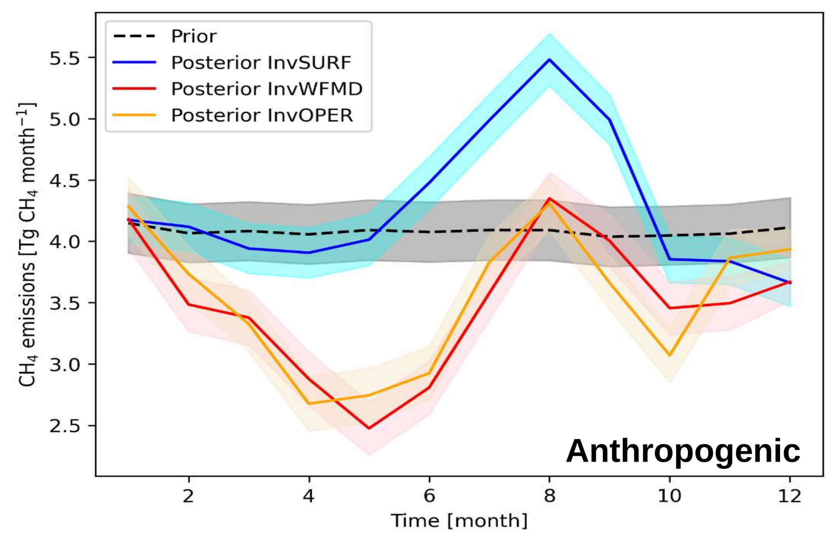
  **See also IWGGMS presentation by Lindqvist et al.*
- Prior fluxes
  - Anthropogenic: EDGAR v6.0 inventory[10]
  - Biospheric (wetlands + soil sinks): LPX-Bern v1.4 ecosystem model[3]
  - Biomass burning: GFED v4.2 inventory[8]
  - Termites & other microbial sources: Saunois et al. (2020)[4]
  - Geological sources: Etiope et al. (2019)[1]
  - Ocean: Weber et al. (2019)[9]

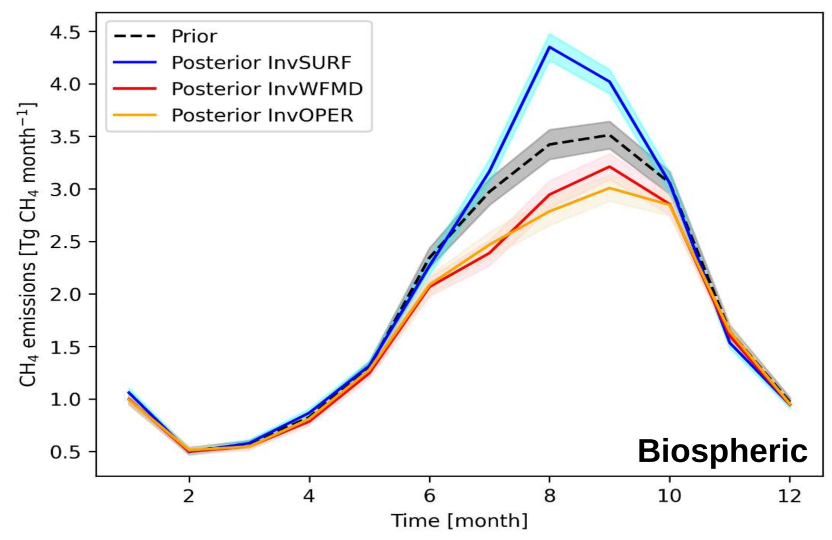
NORTHERN HIGH LATITUDE CH_4 EMISSIONS

Monthly total CH_4 emissions over 45°N>, 2018



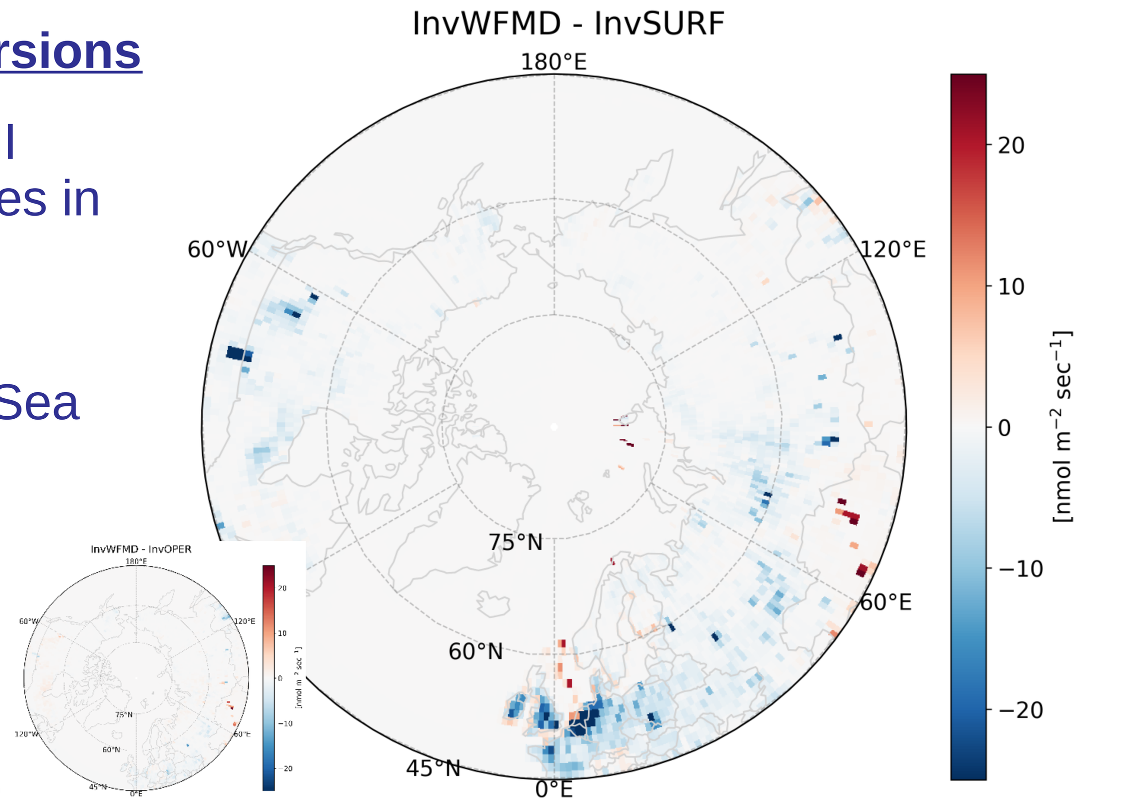
- NHL CH_4 emissions have clear seasonal cycle with maximum in summer and minimum in winter, driven by biospheric fluxes.
- Inversion using surface data shows the largest emissions, increased from the prior.
- Inversions using TROPOMI data show reduction of emissions from prior, except for anthropogenic source in August.





Spatial differences between the inversions

- The low emissions found in TROPOMI inversions are mostly due to differences in central Europe, southern Canada and Russia.
- Over Fennoscandia, islands in North Sea and Kara Sea, and in Kazakhstan, TROPOMI inversions show higher emissions.
- Note: we did not find significant spatial differences between WFMD and OPER inversion for annual totals.

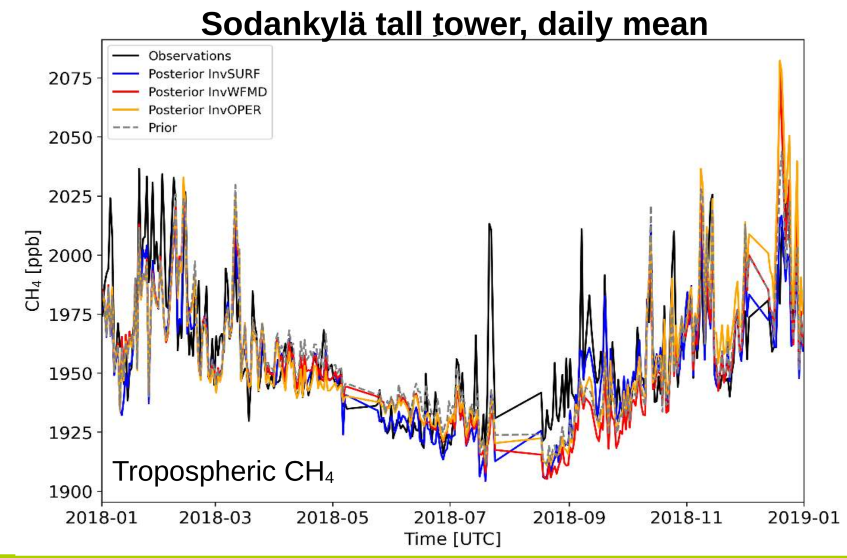


Differences in total CH_4 fluxes between inversions using WFMD retrievals (InvWFMD) and surface data (InvSURF) (left) and WFMD vs OPER (right), averaged over 2018.

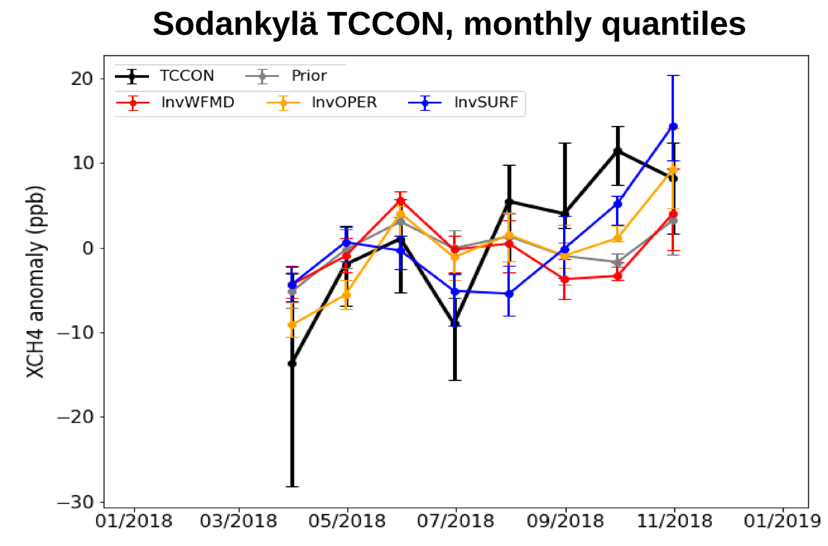
MODEL EVALUATION

- Tropospheric CH_4 is overestimated during early summer and winter, and underestimated during late summer to autumn when TROPOMI data is assimilated.
- XCH_4 anomalies compared to TCCON/GGG2020 data also show overestimation in the TROPOMI inversions during spring and early summer, and underestimation during autumn.
- In both cases, TROPOMI inversions show later summer minima than the observations and surface inversion.

Sodankylä tall tower, daily mean



Sodankylä TCCON, monthly quantiles



References

[1] Etiope, G., Ciotoli, G., Schwietzke, S. & Schoell, M. Gridded maps of geological methane emissions and their isotopic signature. *Earth System Science Data* **11**, 1–22 (2019).
[2] Hu, H. *et al.* The operational methane retrieval algorithm for TROPOMI. *Atmospheric Measurement Techniques* **9**, 5423–5440 (2016).
[3] Lienert, S. & Joos, F. A Bayesian ensemble data assimilation to constrain model parameters and land-use carbon emissions. *Biogeosciences* **15**, 2909–2930 (2018).
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[5] Schneising, O. *et al.* A scientific algorithm to simultaneously retrieve carbon monoxide and methane from TROPOMI onboard Sentinel-5 Precursor. *Atmospheric Measurement Techniques* **12**, 6771–6802 (2019).
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[8] van der Werf, G. R. *et al.* Global fire emissions estimates during 1997–2016. *Earth System Science Data* **9**, 697–720 (2017).
[9] Weber, T., Wiseman, N. A. & Kock, A. Global ocean methane emissions dominated by shallow coastal waters. *Nat Commun* **10**, 4584 (2019).
[10] EDGAR: https://edgar.jrc.ec.europa. eu/overview.php?v=verify_h2020, EDGAR-v6

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CoCO2
Prototype system for a Copernicus CO_2 service

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