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Solving Methane Fluxes at Northern Latitudes using Atmospheric and Soil EO data – MethEO

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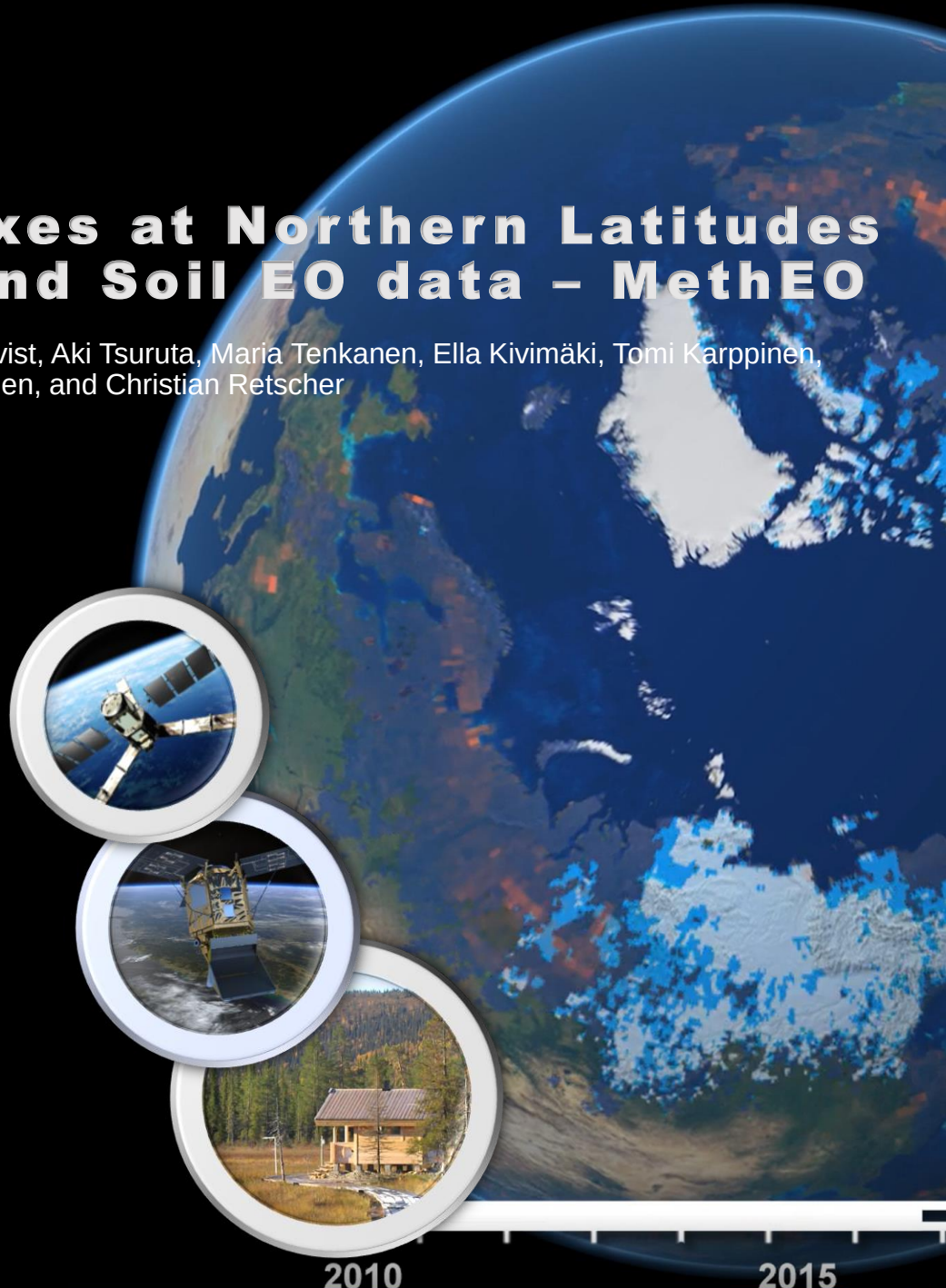
- Methane emissions from the Arctic and boreal wetlands constrained with inverse modelling and using satellite observations of methane (GOSAT, TROPOMI) and soil frost (SMOS).
- **MethEO-I:** Focus on freezing period methane emissions and trends
  - Freezing period is shortening but emissions showed no systematic trends (still preliminary!)
- **MethEO-II ongoing**: Focus on permafrost regions, winter, and spring. Anthropogenic emissions, trends and hotspots at high latitudes also considered.
- Collaboration with the Nasa-ESA AMPAC initiative



Soil frost controls natural methane emissions from wetlands in large scales

SMOS F/T web page:
http://nsdc.fmi.fi/services/SMOS Service/

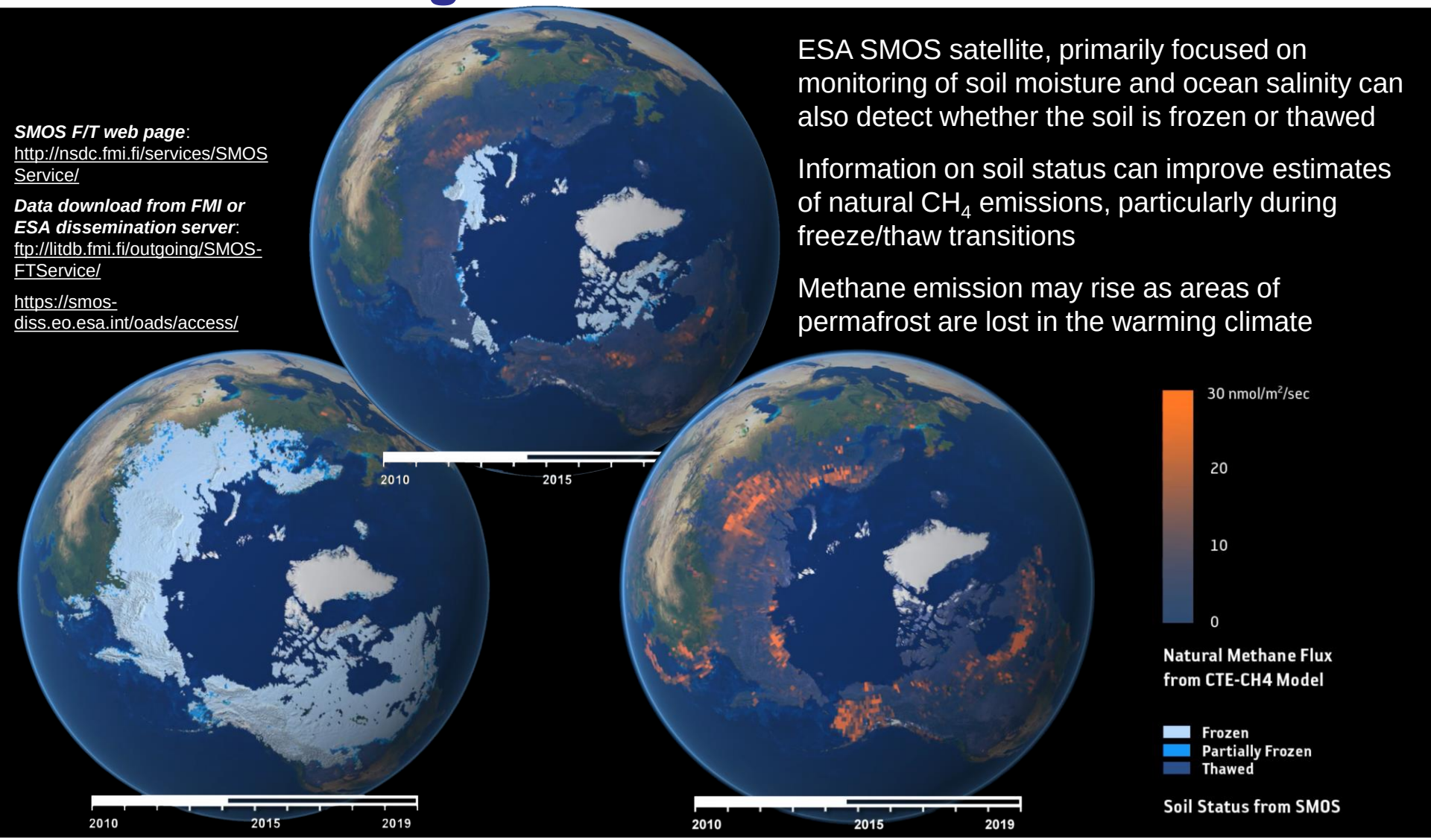
Data download from FMI or ESA dissemination server:
ftp://litdb.fmi.fi/outgoing/SMOS-FTService/

https://smos-diss.eo.esa.int/oads/access/

ESA SMOS satellite, primarily focused on monitoring of soil moisture and ocean salinity can also detect whether the soil is frozen or thawed

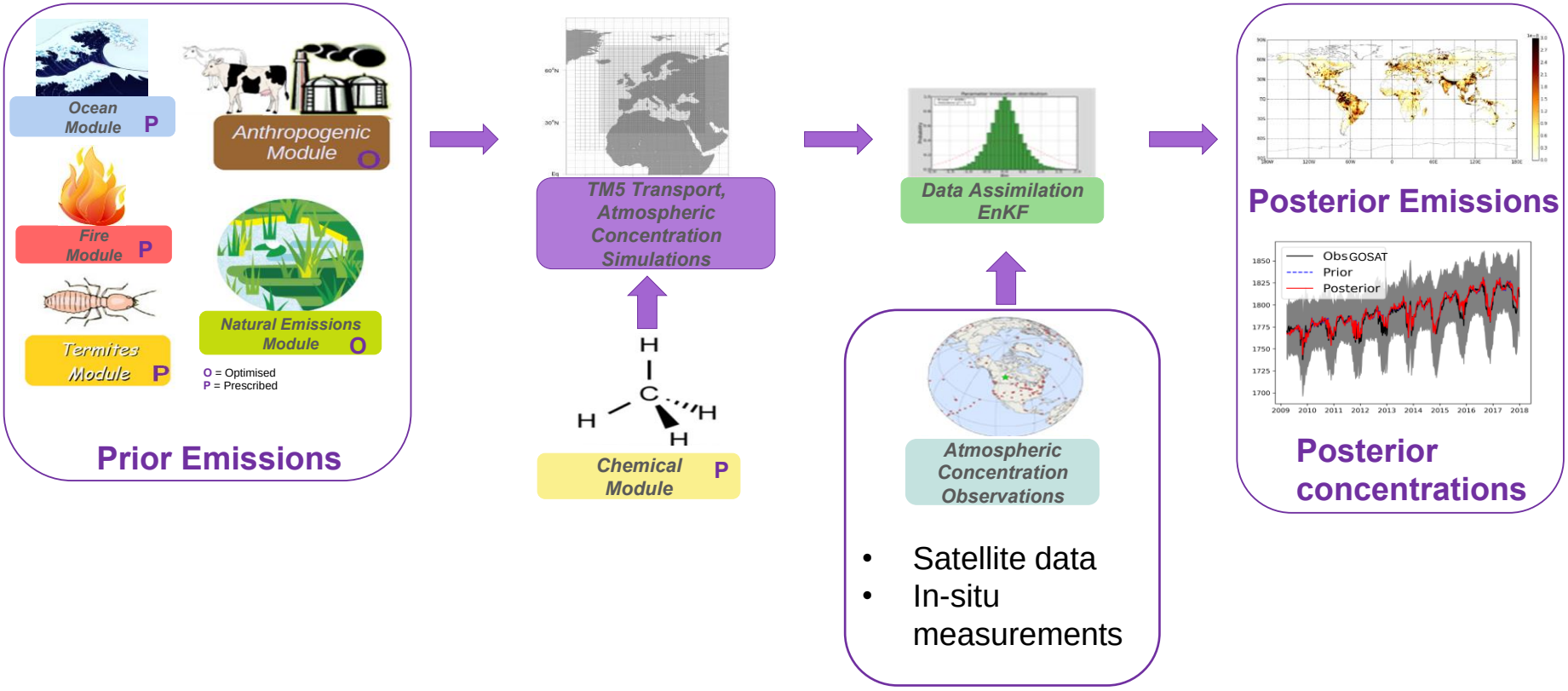
Information on soil status can improve estimates of natural CH_4 emissions, particularly during freeze/thaw transitions

Methane emission may rise as areas of permafrost are lost in the warming climate



Methane fluxes: CarbonTracker Europe – CH_4 (CTE–CH_4)

- Inversion model system which uses global atmospheric observations (in-situ and/or satellite-based) to optimise the prior estimates of anthropogenic and natural emissions.
- TM5 atmospheric transport model and Ensemble Kalman Filter data assimilation methodology.



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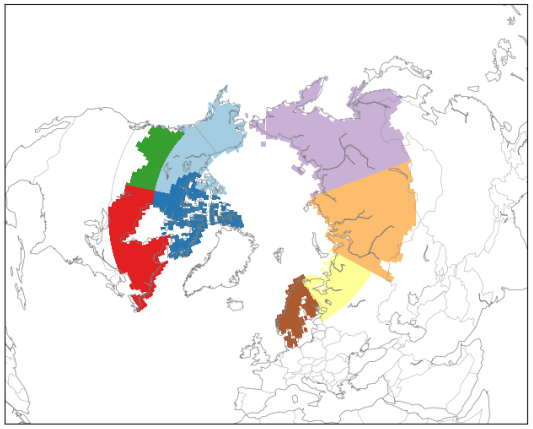
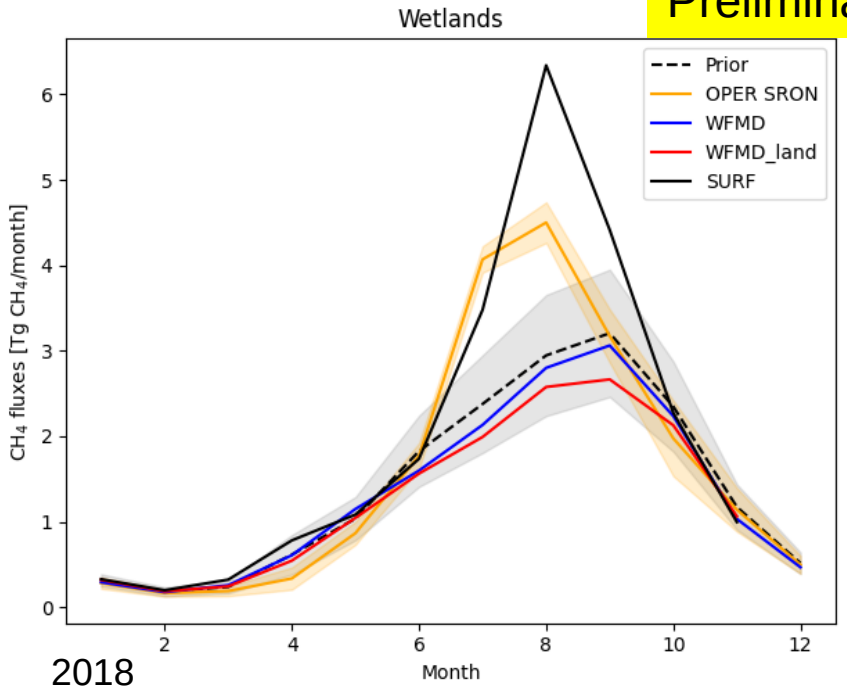
Tsuruta et al.: Global methane emission estimates for 2000–2012 from CarbonTracker Europe-CH4 v1.0, *Geosci. Model Dev.* 10, 2785-2800, 2017.

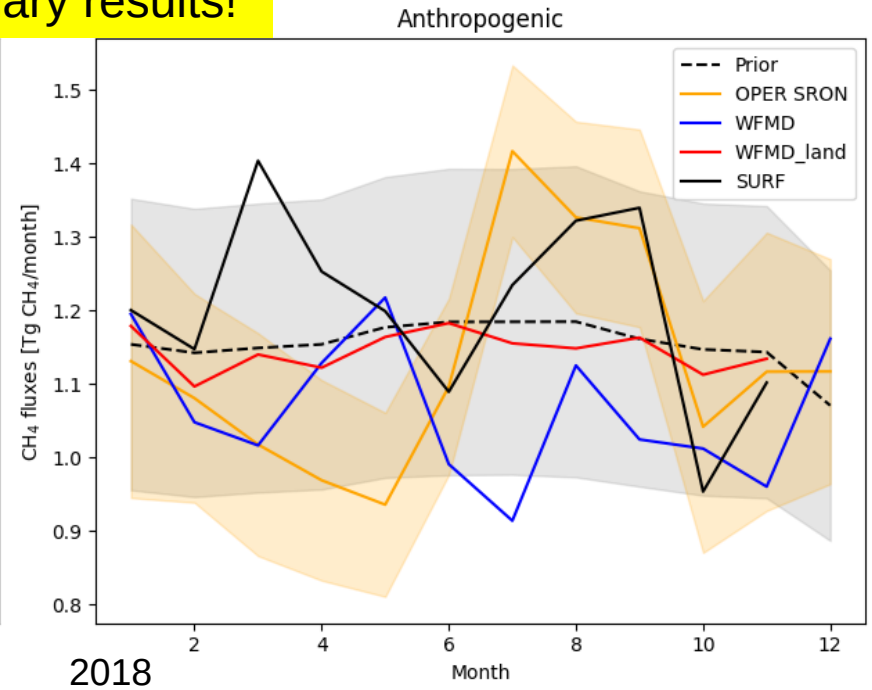
Methane fluxes from inverse modelling



- Flux inversions from CTE-CH4 system (see setup: Tsuruta et al., 2017)
- Large differences in the wetland methane emissions during summer
- TROPOMI results may be affected by the seasonal bias in satellite observations:
  → reduction of biases is important for correctly connecting the fluxes to seasonal changes in the environment.

Preliminary results!



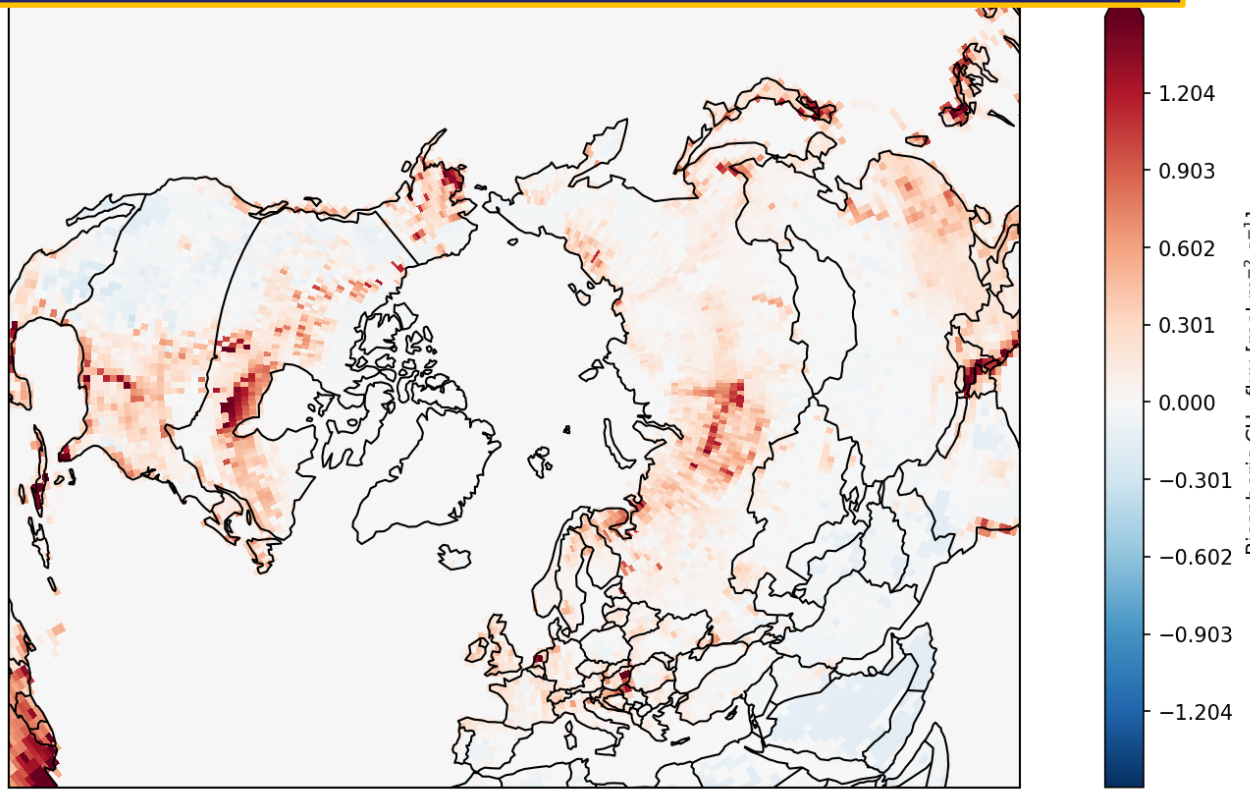


Global and Northern high latitude emissions

The global total wetland methane emissions ranged between 110–126 ± 35 Tg CH4 per year. The NHL share of the global wetland emissions is estimated to be 13%–18%. (preliminary results)

Soil freezing period methane emissions were correlated with the length of the soil freezing period. Constraining the winter methane emissions with SMOS soil F/T data improved the inversion model performance.

Two major Northern high latitude wetland emission regions were Western Siberian Lowlands in Russia, and Hudson Bay Lowlands in Canada.



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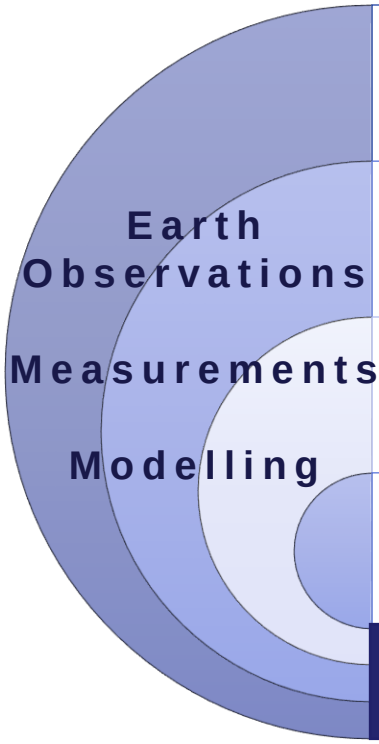
Open research questions



What is the role of environmental drivers, such as snow cover and soil temperature, in driving biospheric emissions, the seasonal cycle and trends?

Can rapid emission changes (due to e.g. abrupt thaw) be *reliably* identified?

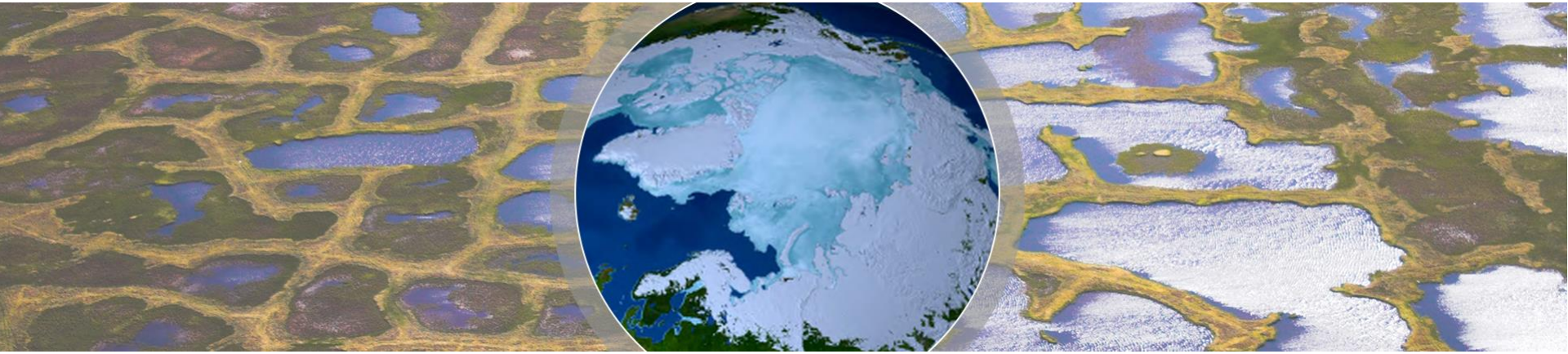
How are the anthropogenic emissions developing at the high Northern latitudes and how to best distinguish these emission signatures from space?

What tracers and proxies are the most valuable for methane source attribution?

Knowledge on methane emissions in the changing Arctic

Impactful link: AMPAC – Arctic Methane and Permafrost Challenge
An ESA-NASA collaborative community initiative
https://eo4society.esa.int/communities/scientists/arctic-methane-and-permafrost/

Arctic Methane and Permafrost Challenge - AMPAC



- ESA – NASA joint community initiative to help solving the Arctic Methane and Permafrost Challenge, launched in Dec 2019.
- Polar Science Conference in 2020 came up with 5 recommendations for actions to strengthen the transatlantic multidisciplinary research:
  - **Strengthen scientific background:** Promoting community paper on *status of the Arctic permafrost and CH4 emissions, knowledge gaps and needs.*
  - **Improve data availability:** Develop community catalogues and data sharing platform
  - **Improve data quality:** Need to improve satellite CH4 retrievals in the Arctic
  - **Improve resolution:** Need to develop high resolution data products
  - **Understand and mininmize discrepancies in different flux estimation methodologies :** Intercomparison of bottom-up and top-down methane emisison estimation.
  - **New, focused observations:** Promote community effors of coordinated observation campaigns

ESA ITT open

MethEO supporting AMPAC

MethEO outcomes so far:

- Evaluation of the satellite CH_4 data in high latitudes using Sodankylä TCCON and AirCore observations. Identification of some systematic issues in satellite CH_4 retrievals which affect CH_4 flux estimates.
- Advances in inverse modelling of Arctic CH4 fluxes to benefit from recent satellite observations of cryosphere and atmosphere.
- Methodology development to allow further analysis on trends, wetland contribution, spatial variability of CH_4 fluxes and concentrations.