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Analysis of high northern latitude CH₄ emissions

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Finnish Meteorological Institute

22.11.2019 29th International TM5 Meeting



Content

- ✦ Improving northern natural emission estimates

- ✦ Improving European anthropogenic methane emission estimates

Objectives & motivation

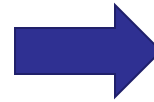
- To improve the seasonal cycle of northern natural methane emissions
- Only some in situ flux measurement during winter
 - ➡ Winter emissions are uncertain
- Even though emissions are small in winter, wintertime can be significant
 - ➡ Wintertime emissions might be significant part of the whole year's emissions
 - Large emissions observed during soil freezing and thawing periods in high latitudes

Objectives & motivation

CarbonTracker Europe – CH₄

+

SMOS Soil Freeze/Thaw



Reducing the
wintertime
uncertainties &
improving the
seasonal cycle



Methods

- Modified previously used natural a priori LPX-Bern DYPTOP by using SMOS F/T data

LPX-Bern DYPTOP ecosystem model

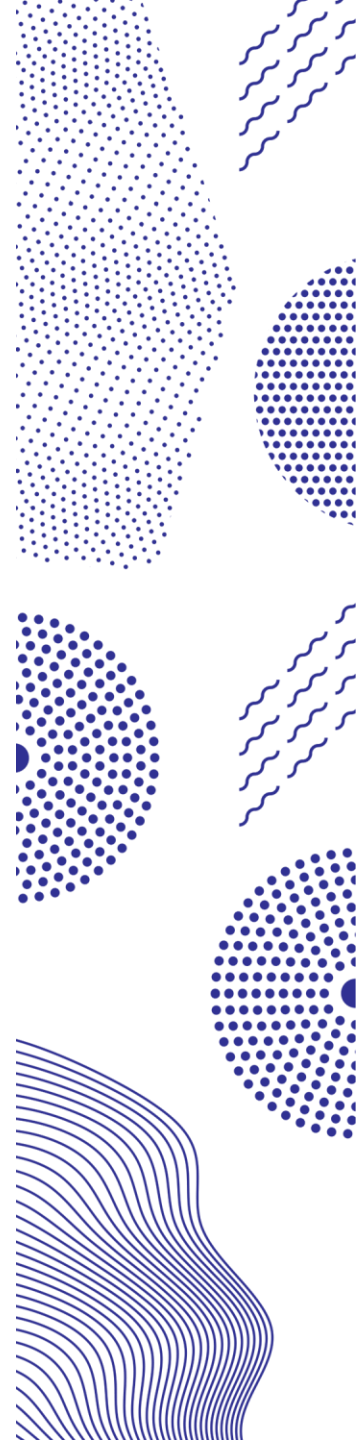
- Monthly values until the end of 2014
➔ the values of the year 2014 was used
- 1° x 1° resolution

Methods

- Modified previously used natural a priori LPX-Bern DYPTOP by using **SMOS F/T** data

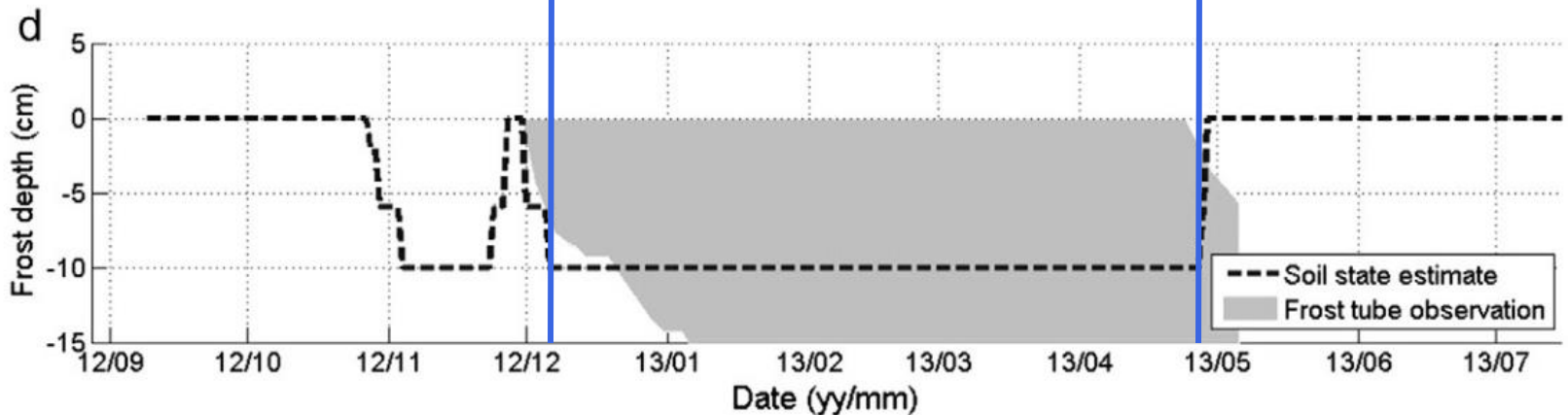
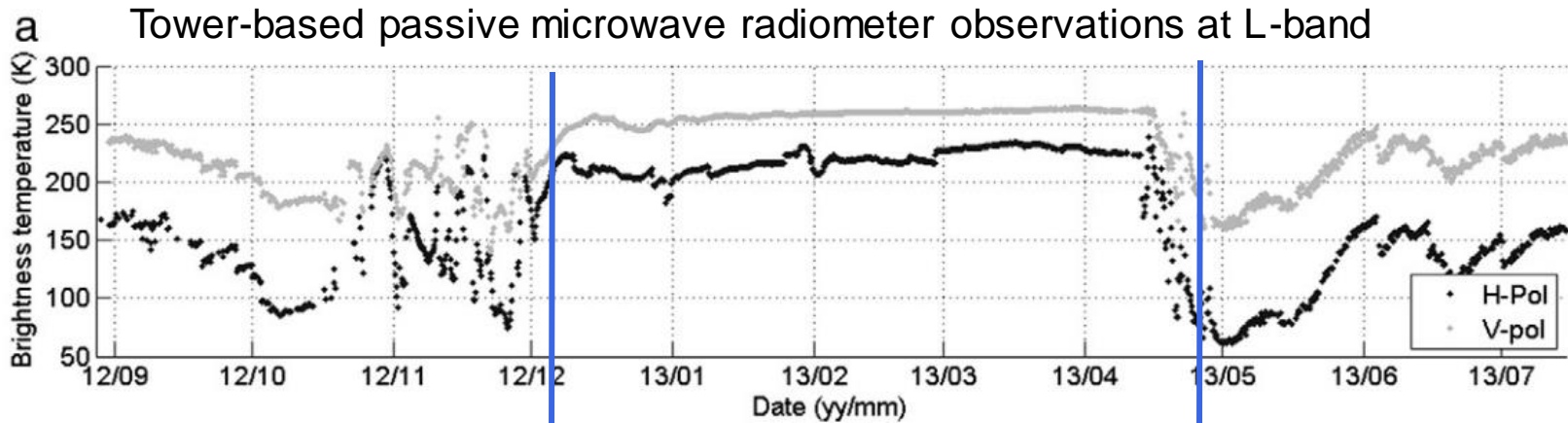
SMOS F/T

- **Daily** information on the Northern hemisphere soil state
 - Operative product, one day latency
- 25 km x 25 km, EASE-2
- 3 levels: "thaw", "partly frozen", "frozen"



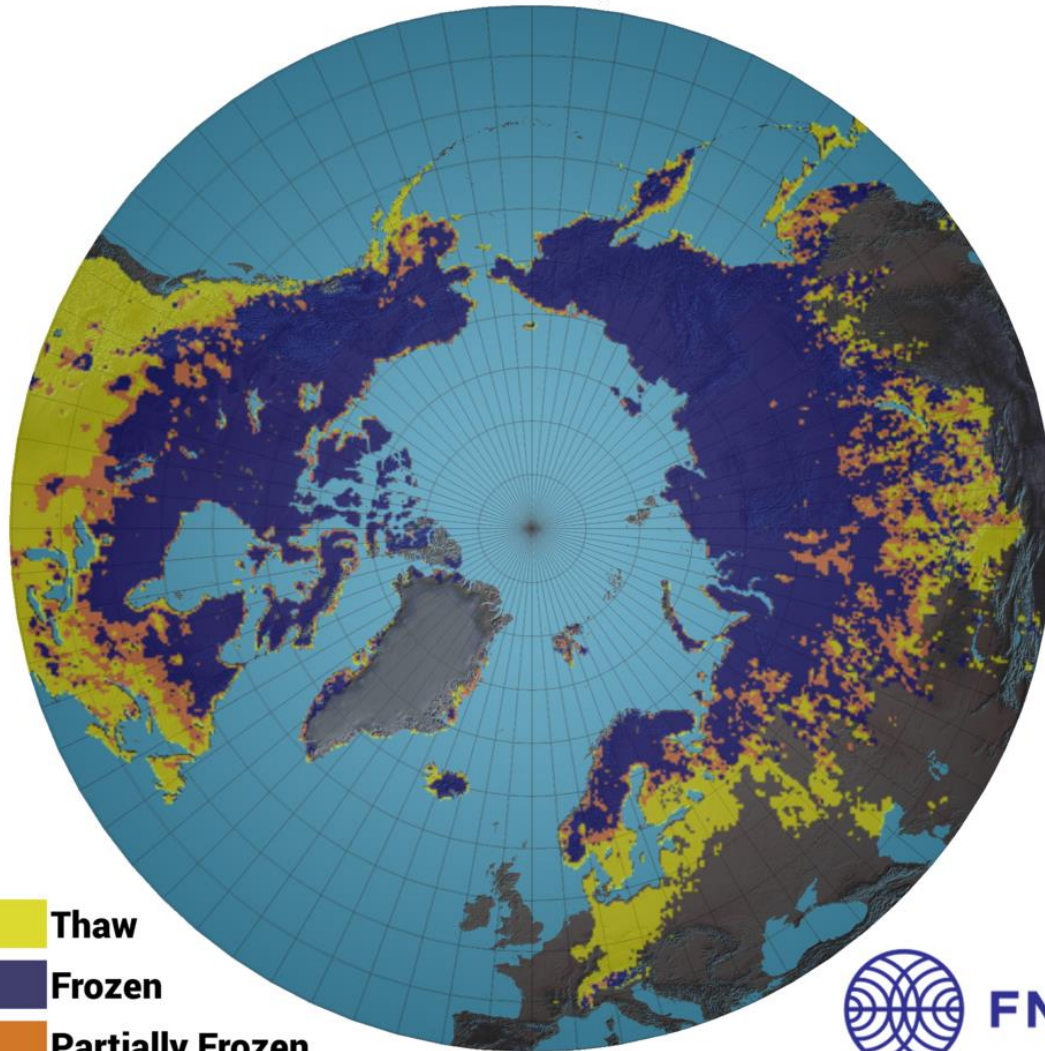
SMOS F/T

Sodankylä, Northern Finland 9/2012-7/2013



SMOS F/T

SMOS soil status over northern hemisphere on 18-Nov-2019



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FMI

<http://nsdc.fmi.fi/services/SMOSService/>

Methods

- SMOS F/T to $1^\circ \times 1^\circ$ coordinates
- $1^\circ \times 1^\circ$ grid cell: how many SMOS F/T grid cells were "frozen"

➡ **Wintertime** when $> 90\%$

- Defined for each grid cell

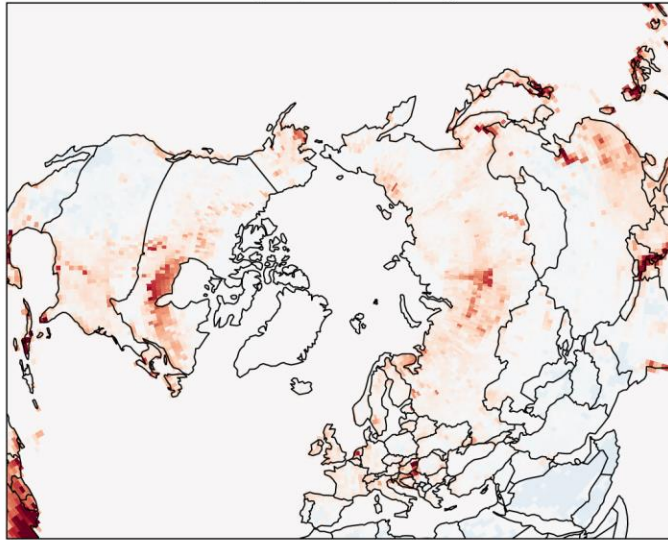
- LPX-Bern DYPTOP: the average monthly flux
 - Smallest monthly flux = "wintertime flux"

➡ when "wintertime", then "wintertime flux"

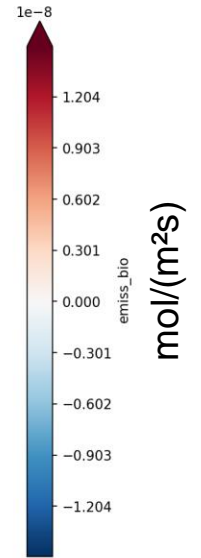
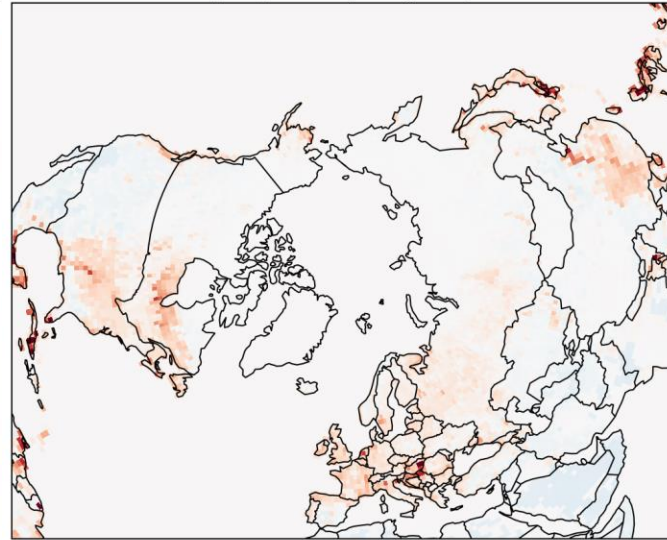
Results Mean

Monthly mean, November

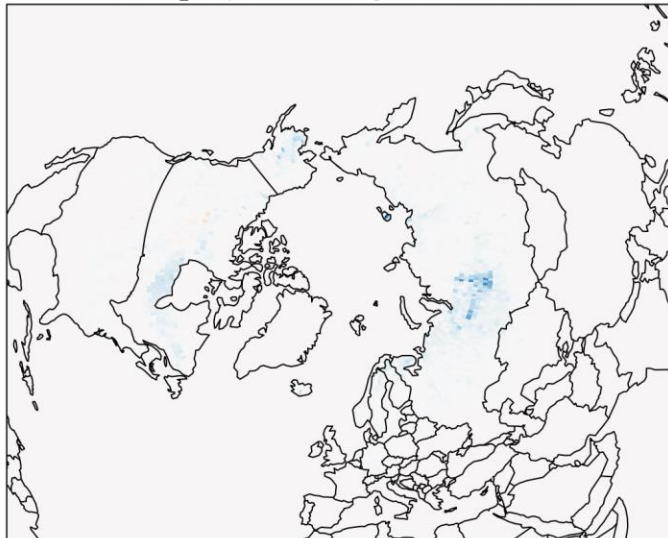
New LPX_FTimplemented, average flux



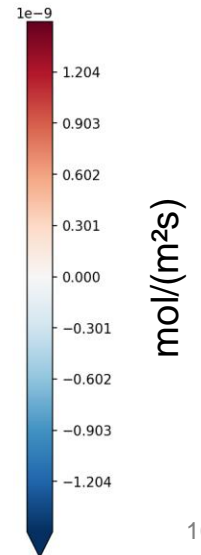
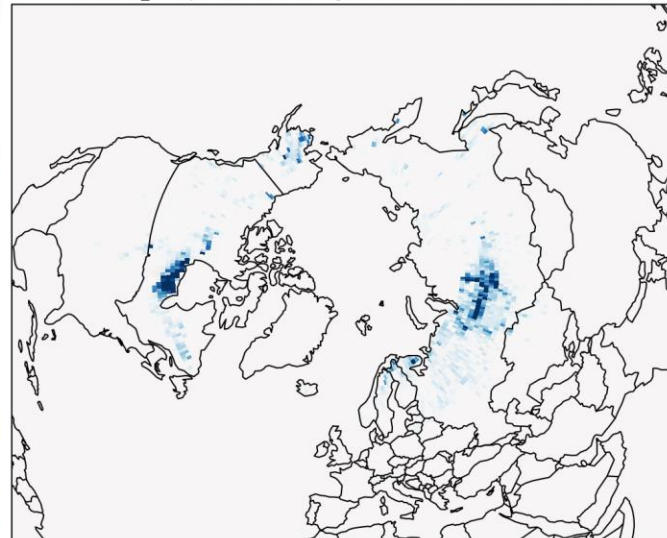
New LPX_FTimplemented, average flux, month 11



New LPX_FTimplemented, average flux difference to LPX



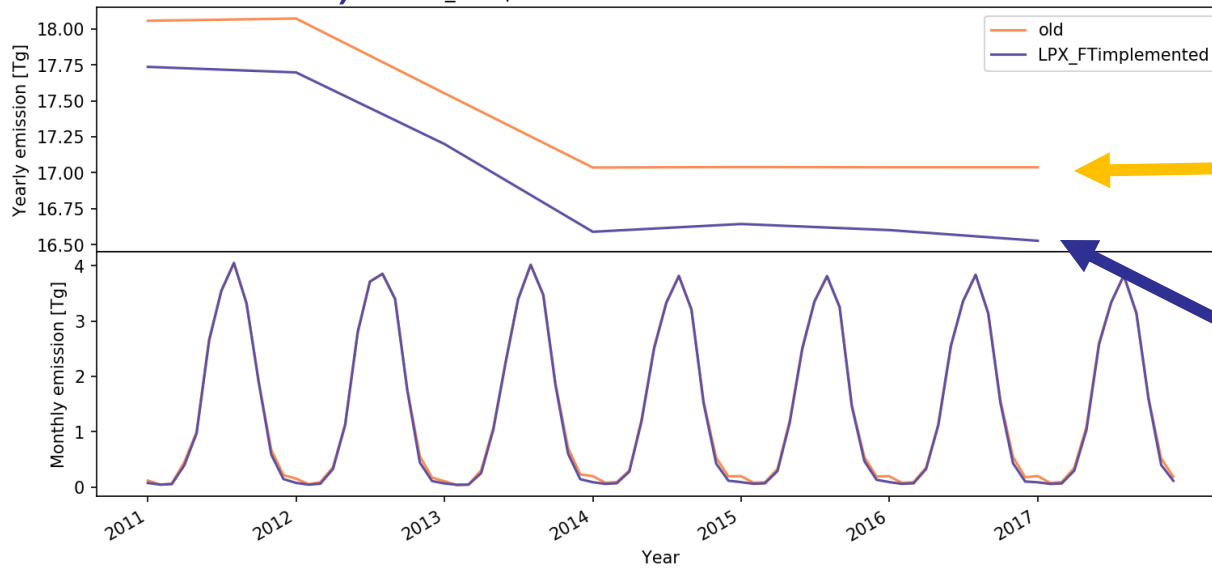
New LPX_FTimplemented, average flux difference to LPX, month 11



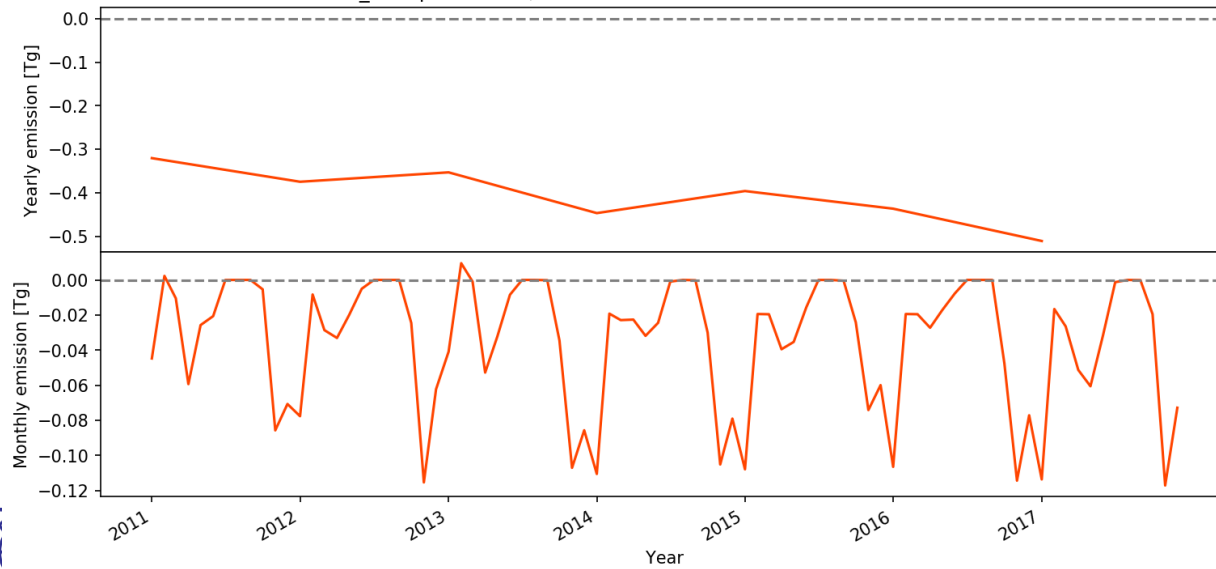
Northern latitudes

(~above 50 °N)

New LPX_FTimplemented, emissions of northern mTC areas



New LPX_FTimplemented, difference to LPX emissions of northern mTC areas



LPX

LPX FT

Difference



Model runs

- **TM5**: forward runs with the original LPX-Bern DYPTOP ("LPX") and modified LPX ("LPX FT")
- **CTE-CH₄**: with these two different LPX a priori ("CTE old posterior" and "CTE FT posterior")
- Years 2010-2017

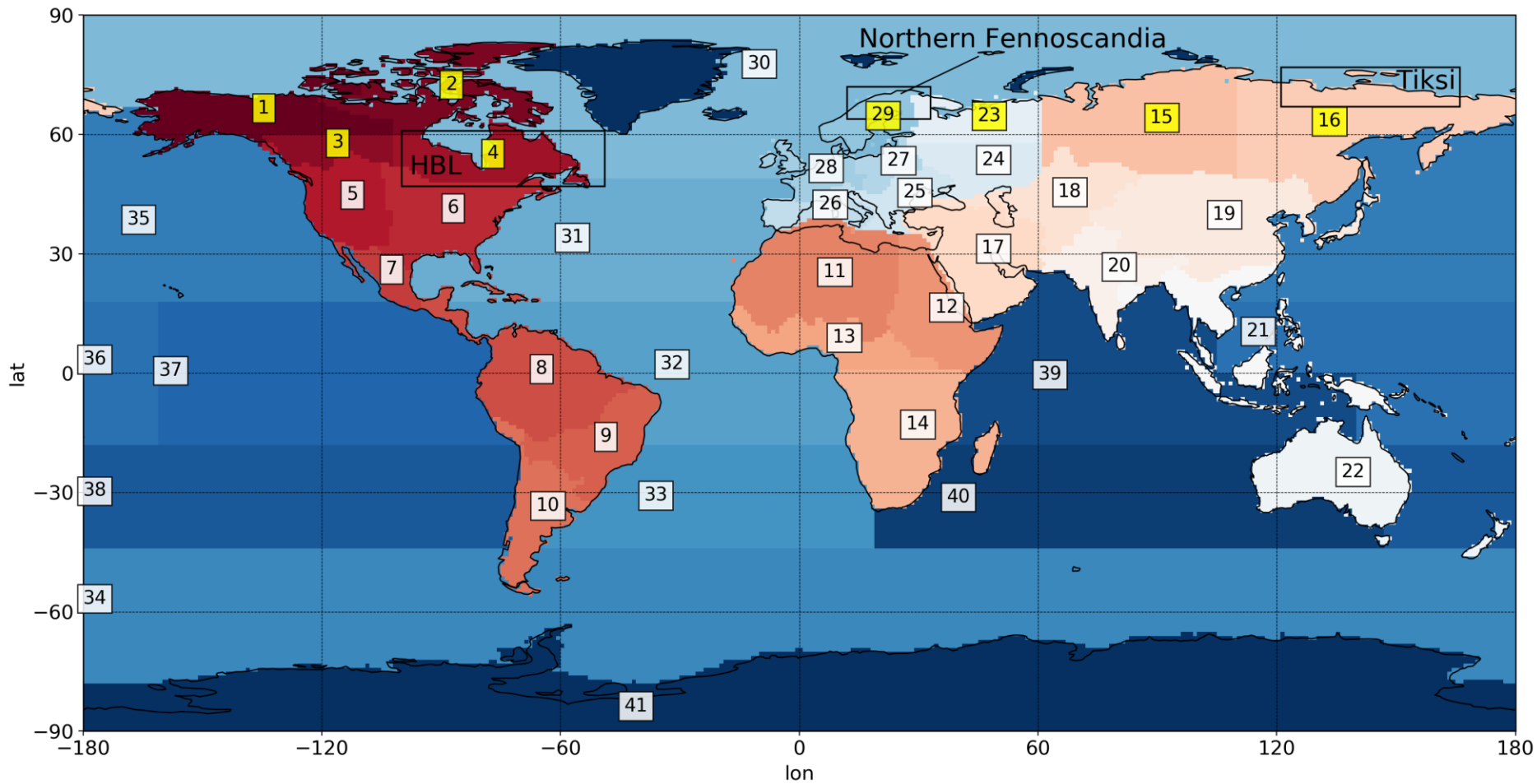
CTE-CH₄

- Global inversion model, optimizes methane fluxes
- In situ measurement

A priori

- Anthropogenic: EDGAR v4.2 FT2010
- Fire: GFEDv4.1
- Ocean: Tsuruta, A. et al., doi:10.1080/16000889.2018.1565030, 2019
- Termites: Ito and Itanomi, doi:10.5194/bg-9-759-2012, 2012

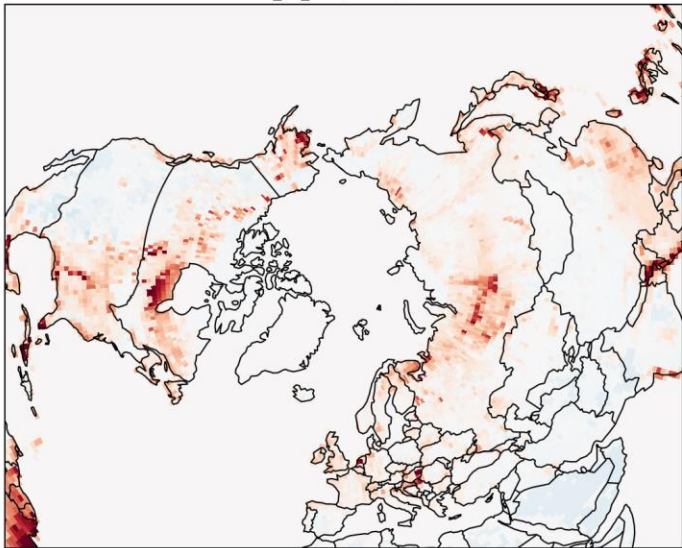
CTE-CH₄



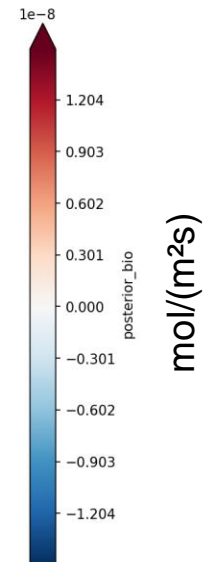
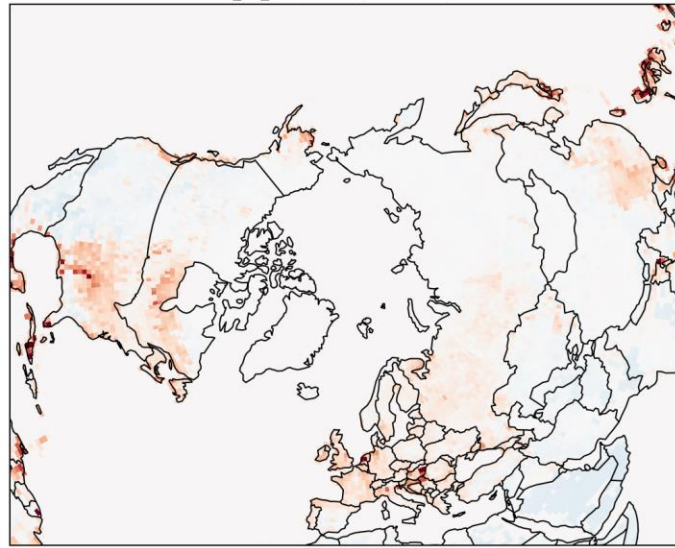
CTE-CH₄ Mean

Monthly mean, November

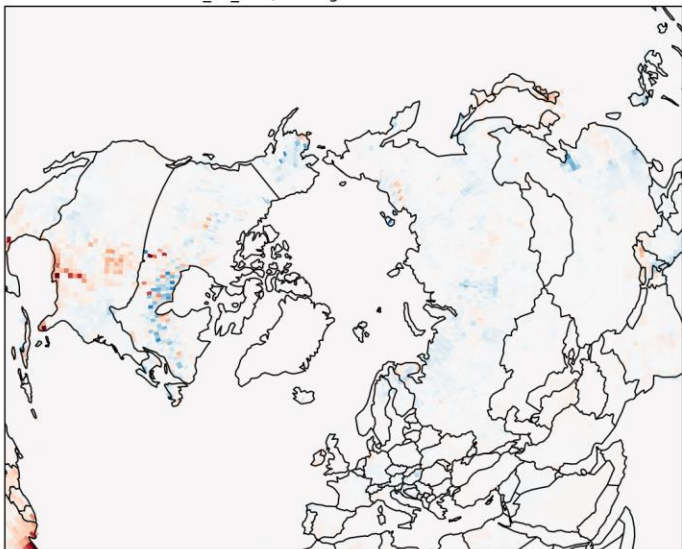
New LPX_FT_CTE, average bio flux



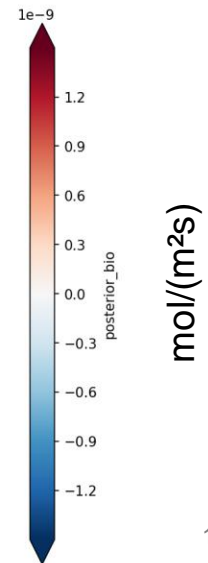
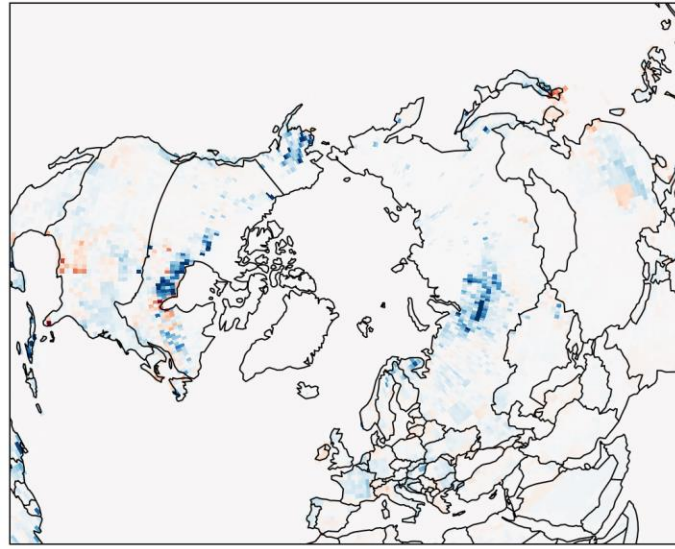
New LPX_FT_CTE, average bio flux, month 11



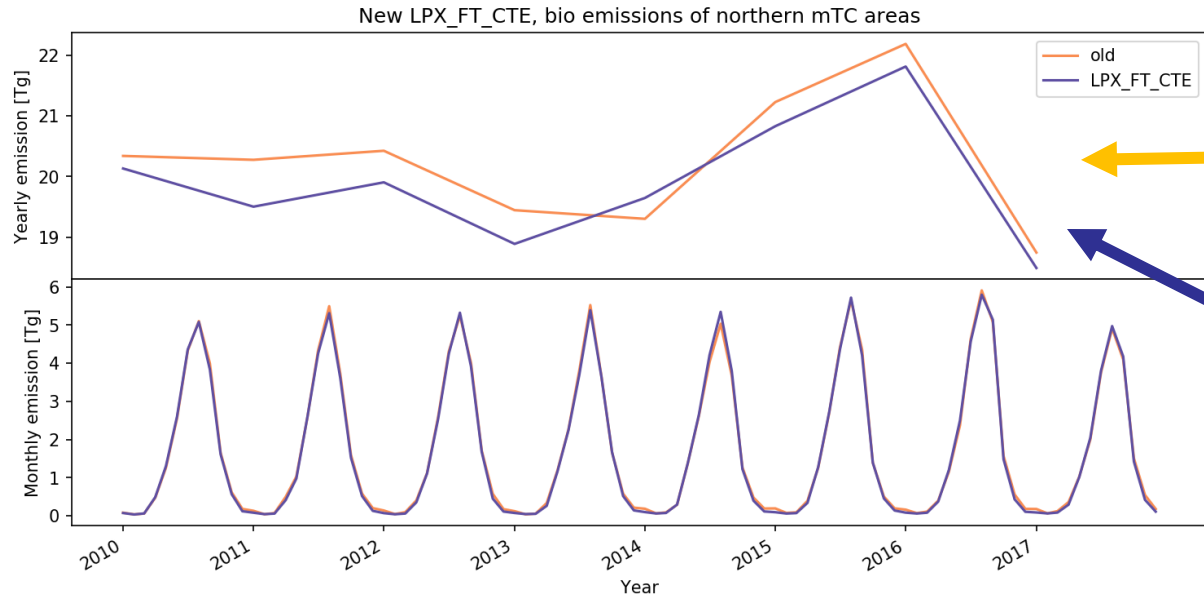
New LPX_FT_CTE, average bio flux difference to old



New LPX_FT_CTE, average bio flux difference to old, month 11

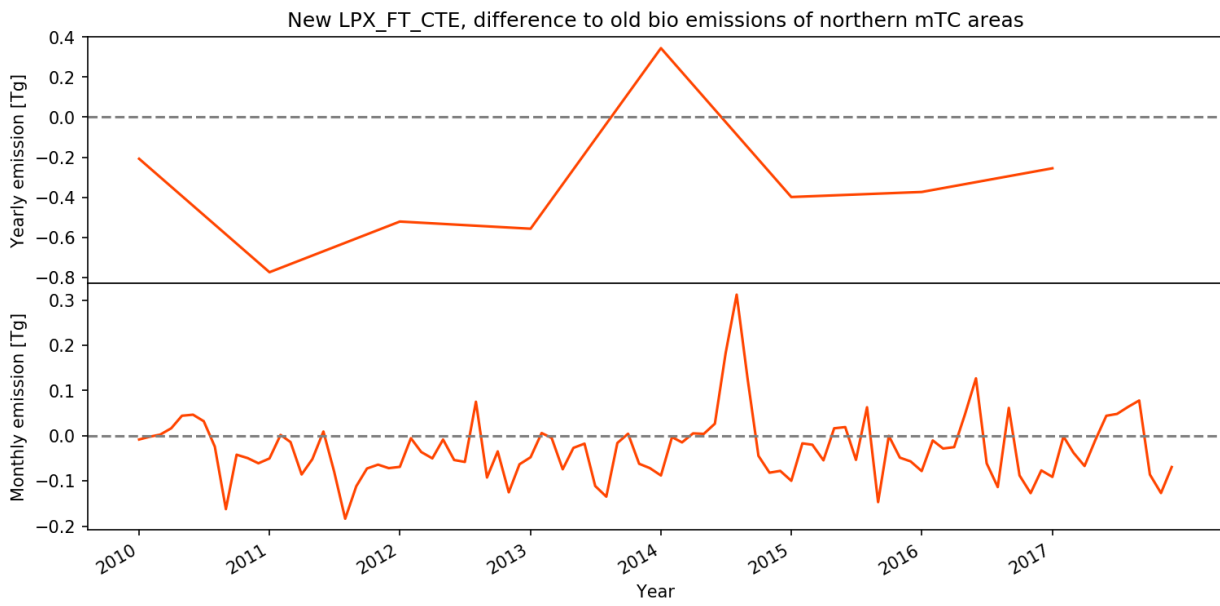


Northern latitudes (~above 50 °N)



CTE old posterior

CTE FT posterior



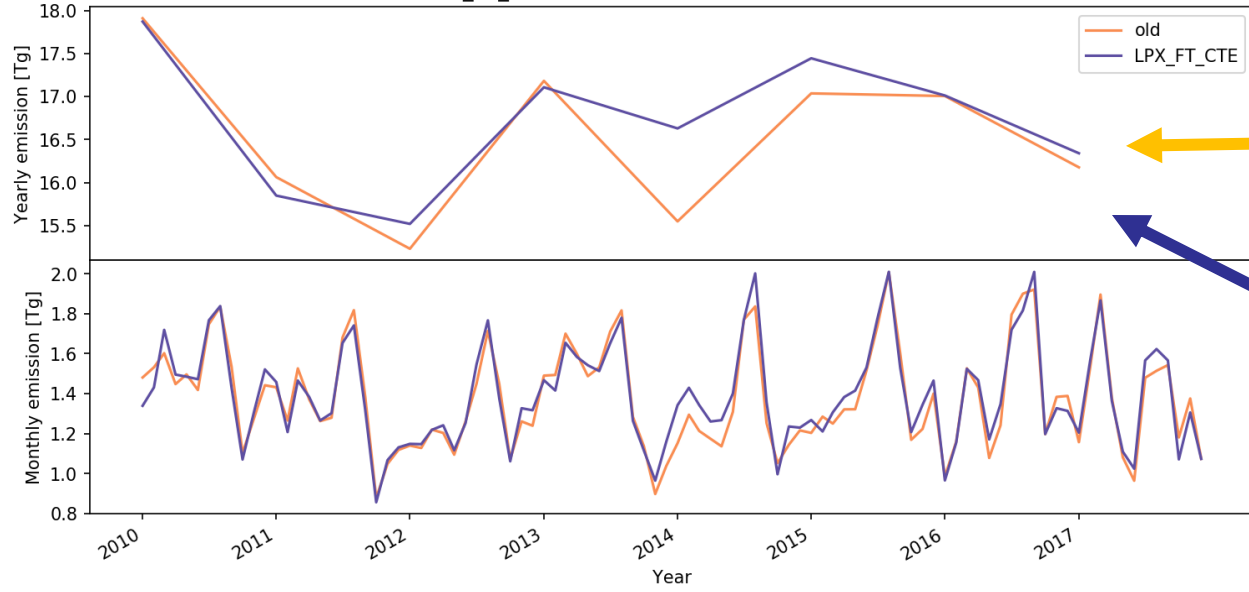
Difference



Northern latitudes (~above 50 °N)

Anthropogenic emissions

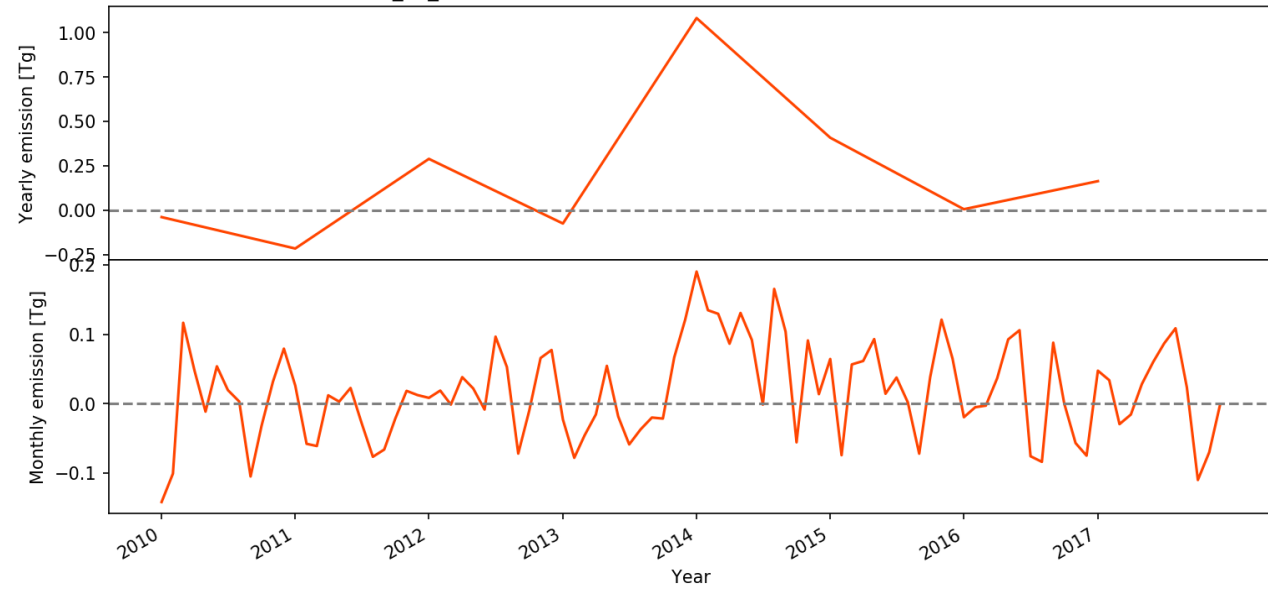
New LPX_FT_CTE, antro emissions of northern mTC areas



← CTE old posteriori

← CTE FT posterior

New LPX_FT_CTE, difference to old antro emissions of northern mTC areas



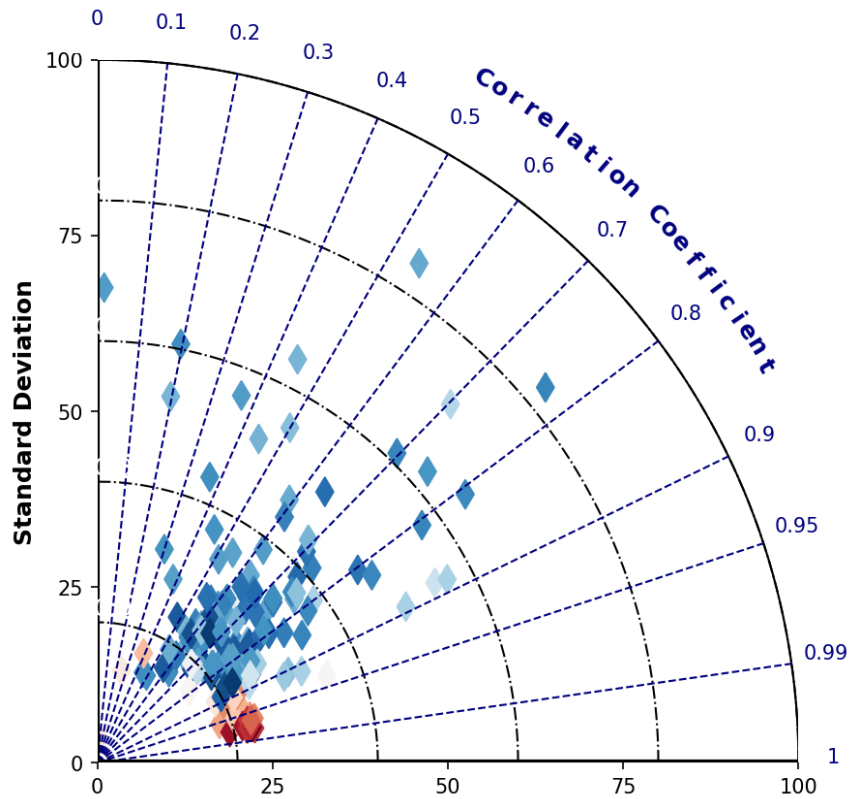
Difference

TM5

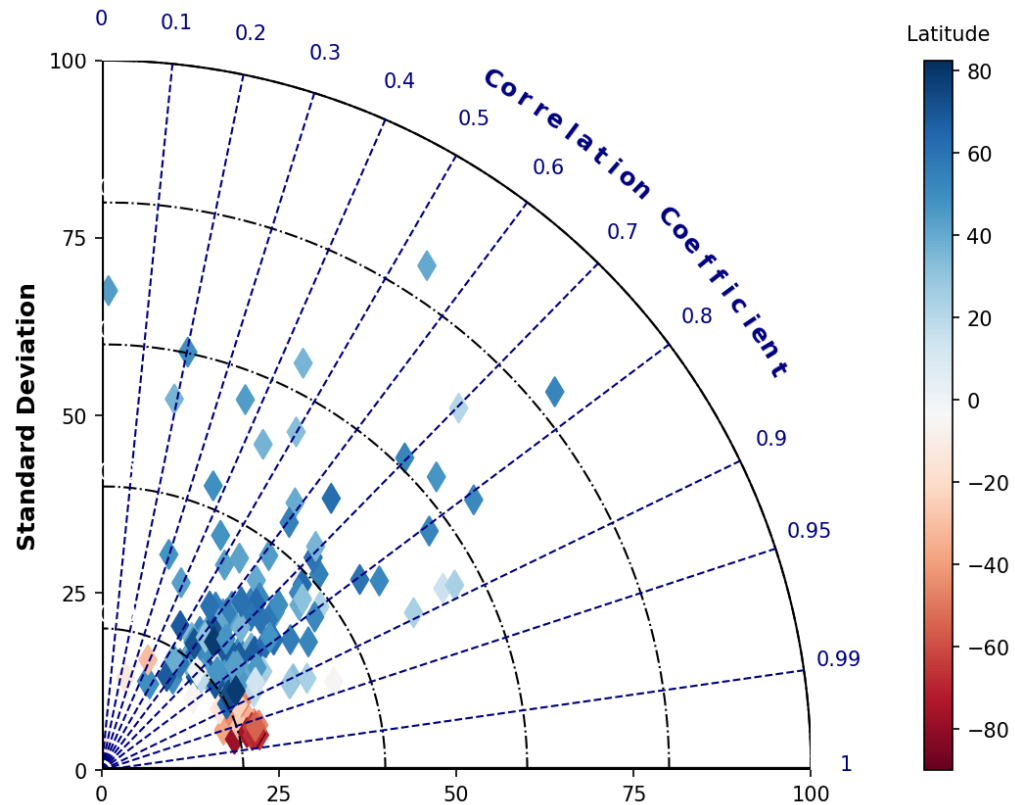
How did the **bias and RMSE change** when SMOS F/T data was implemented?

- In **winter** (November—February)
- In **summer** (June—September)

TM5, LPX-Bern DYPTOP



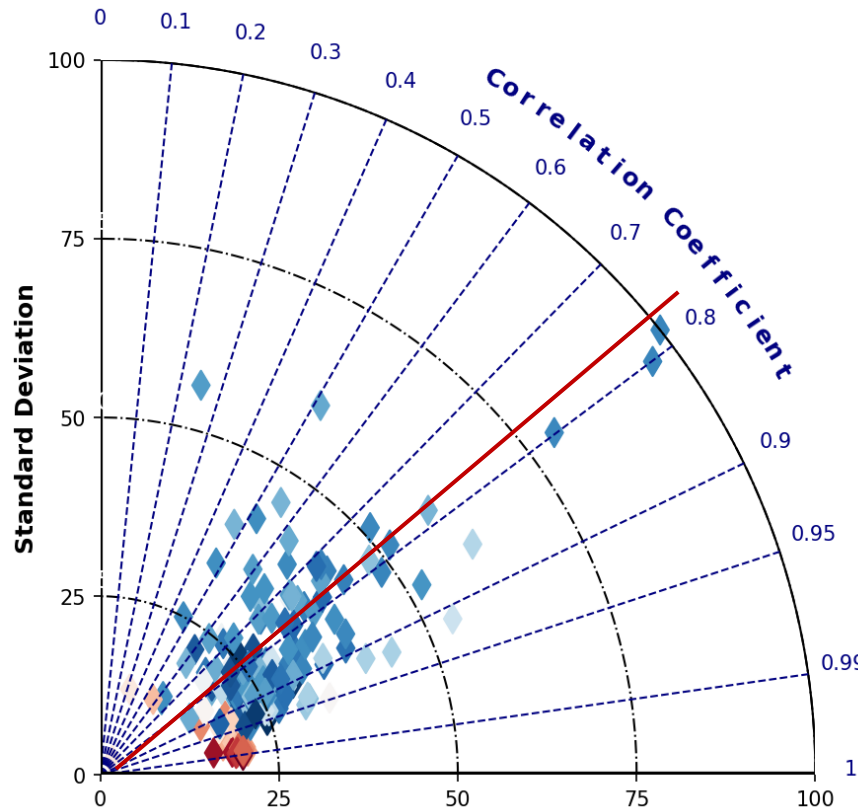
Original



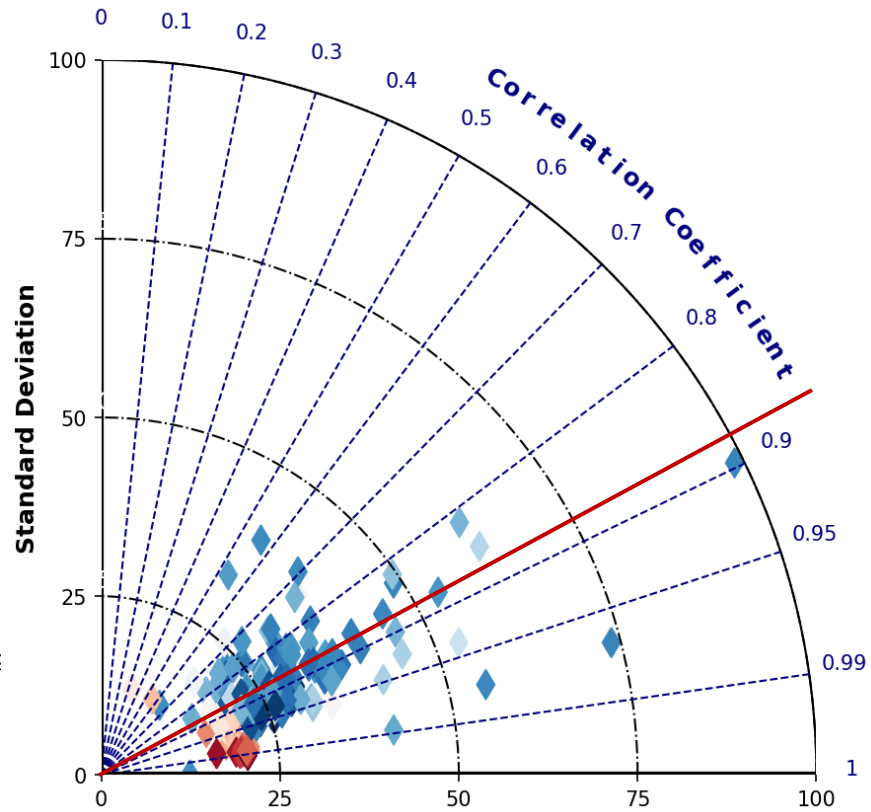
SMOS F/T
implemented



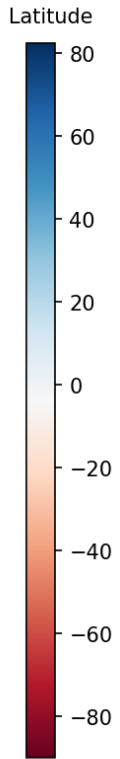
TM5, CTE-CH₄ posterior



Original



SMOS F/T
implemented

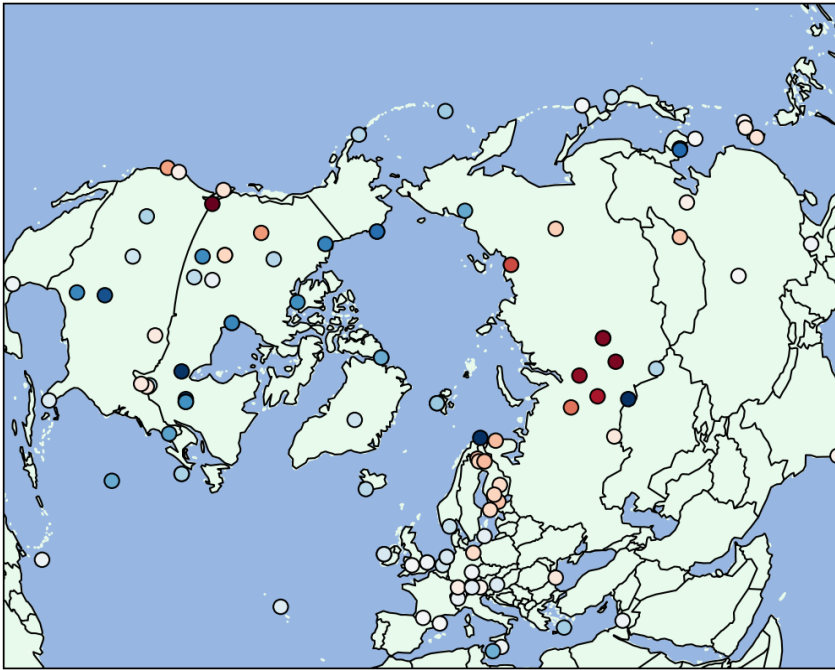


TM5, LPX-Bern DYPTOP

Difference between LPX FT and LPX

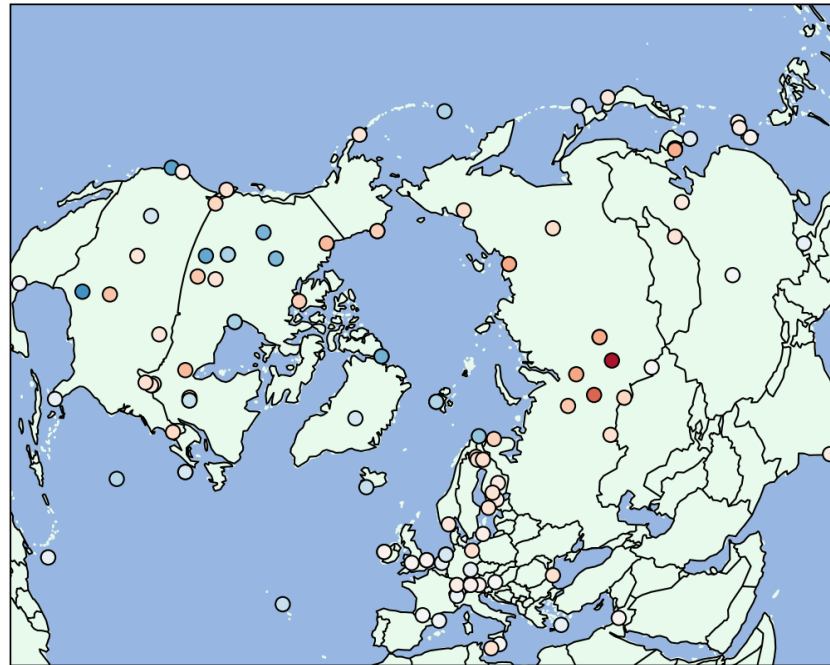
Positive values mean improvement

Difference between LPX FT and LPX, winter bias



Winter bias

Difference between LPX FT and LPX, summer bias

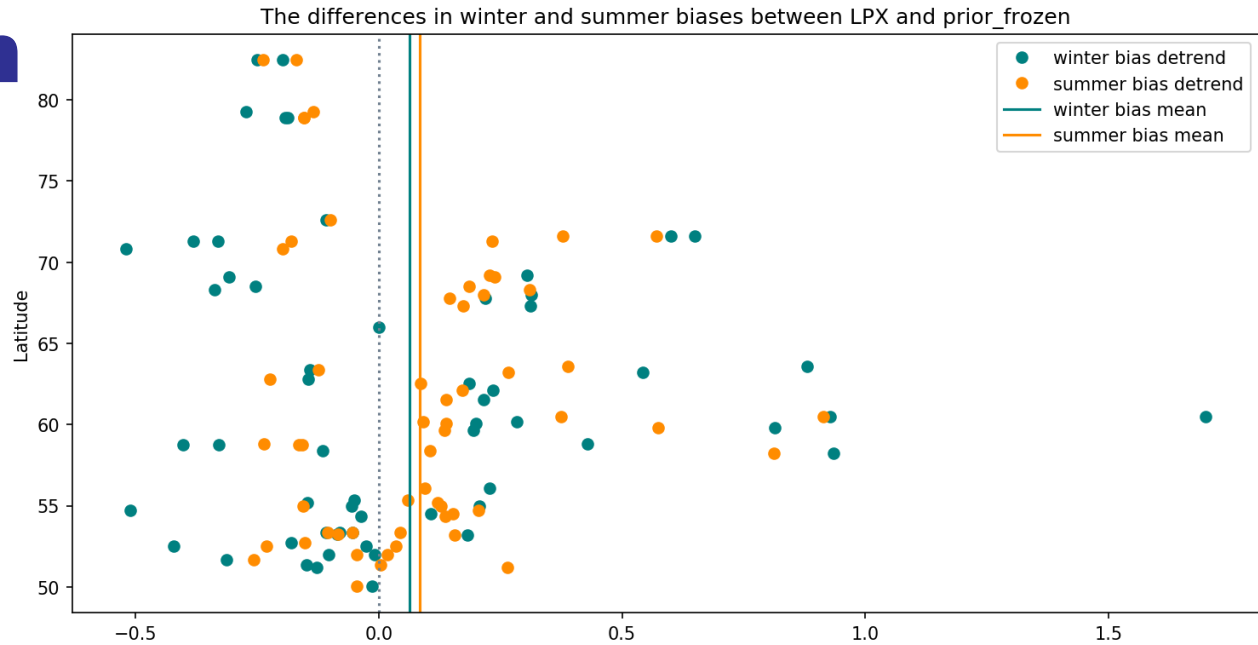


Summer bias

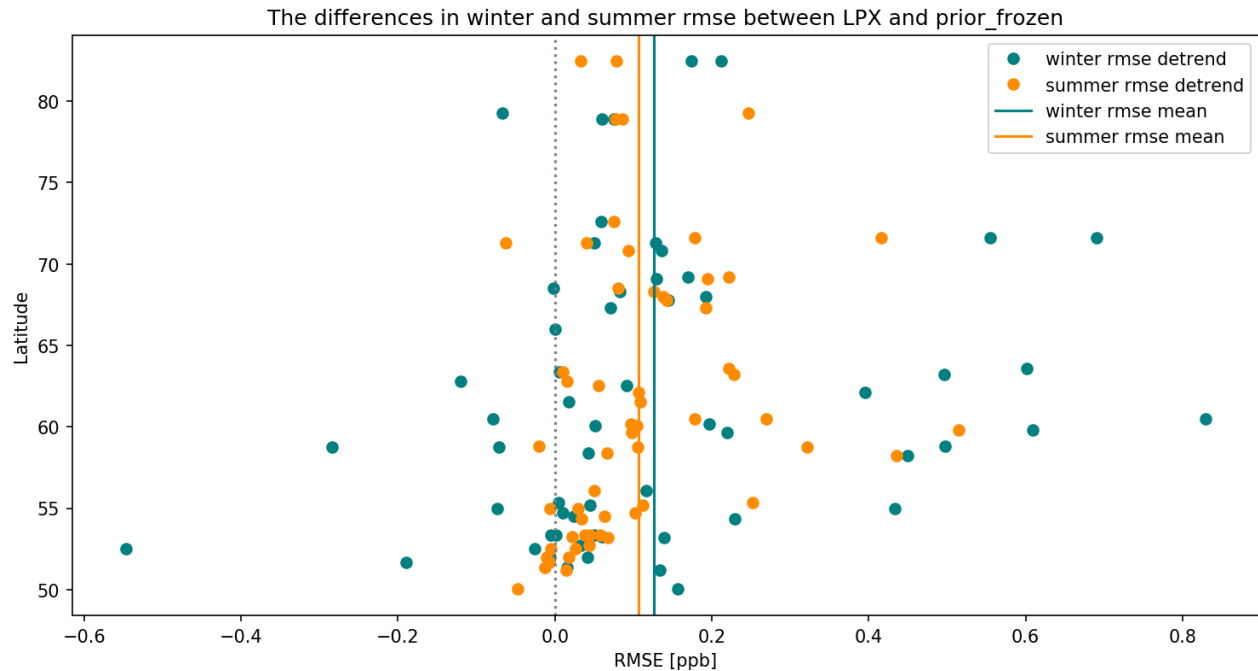


LPX-Bern DYPTOP

Bias



RMSE

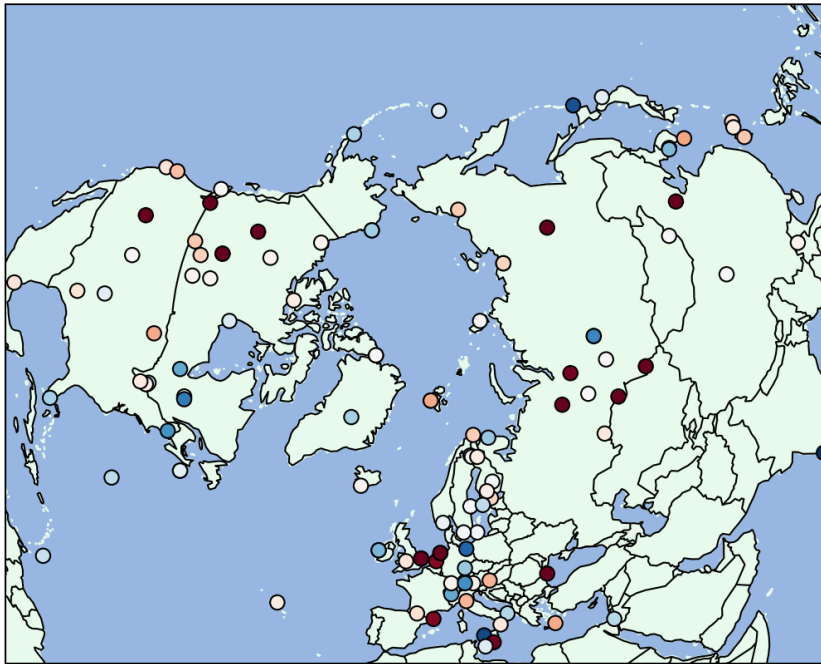


TM5, CTE-CH₄ posterior

Difference between CTE FT and CTE old

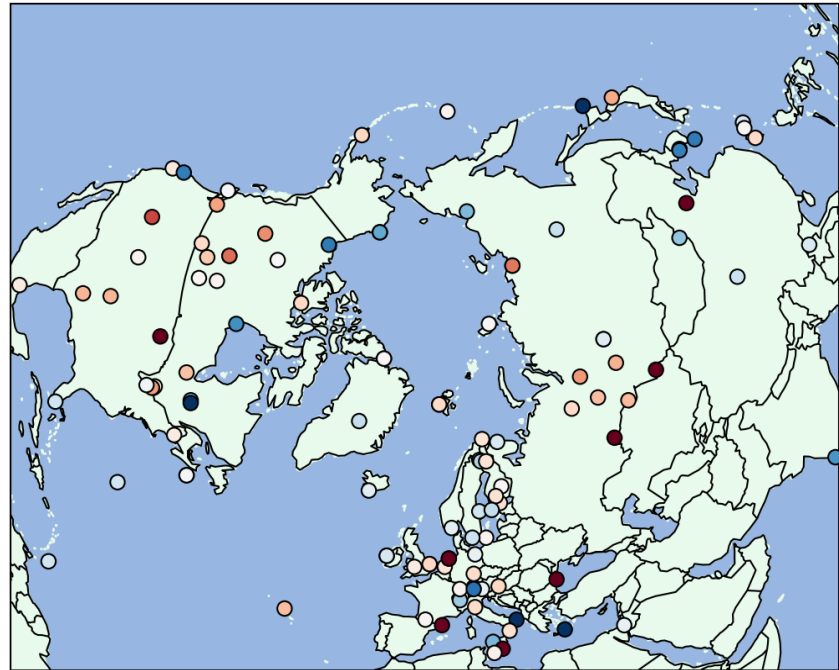
Positive values mean improvement

Difference between CTE FT posterior and CTE old posterior, winter bias



Winter bias

Difference between CTE FT posterior and CTE old posterior, summer bias

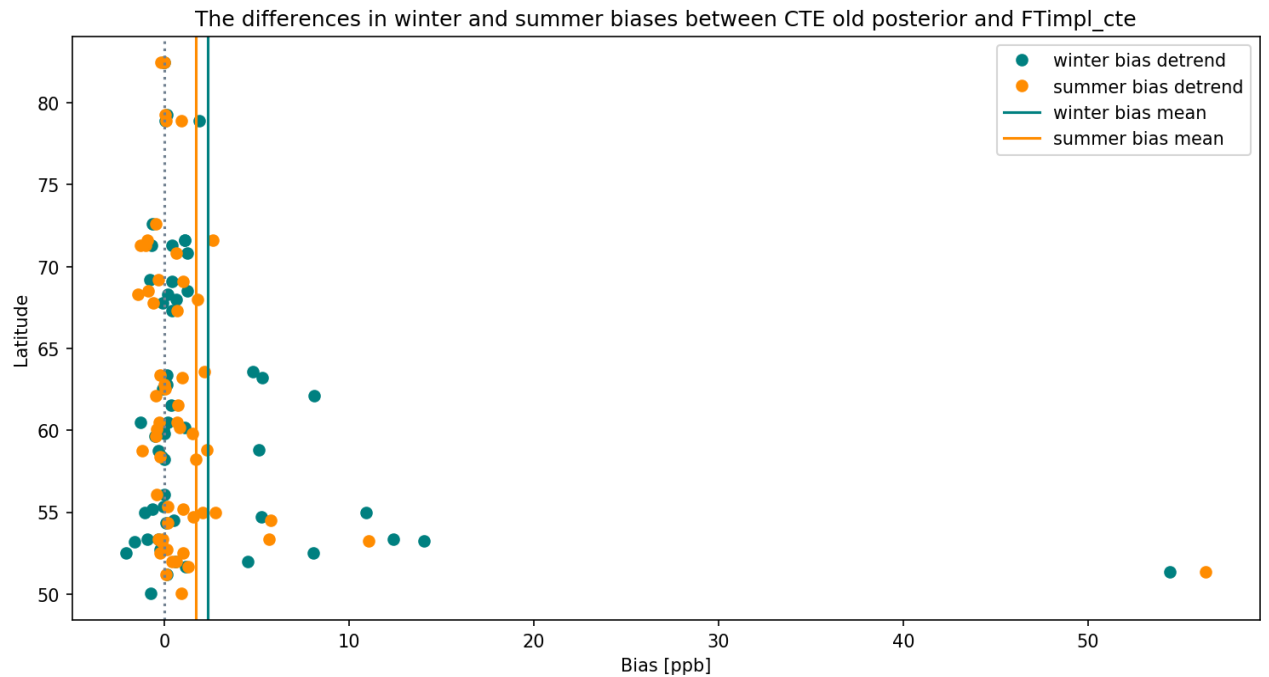


Summer bias

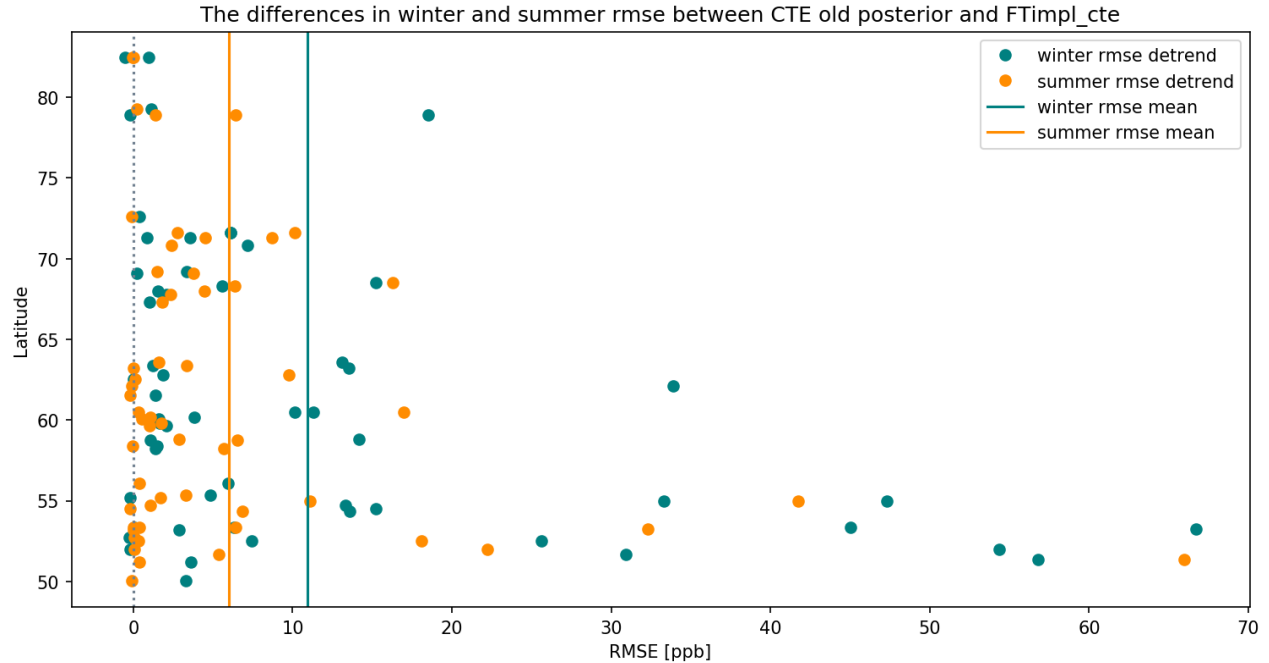


CTE-CH₄ posterior

Bias



RMSE



Conclusions

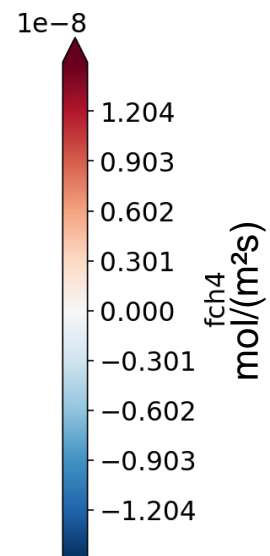
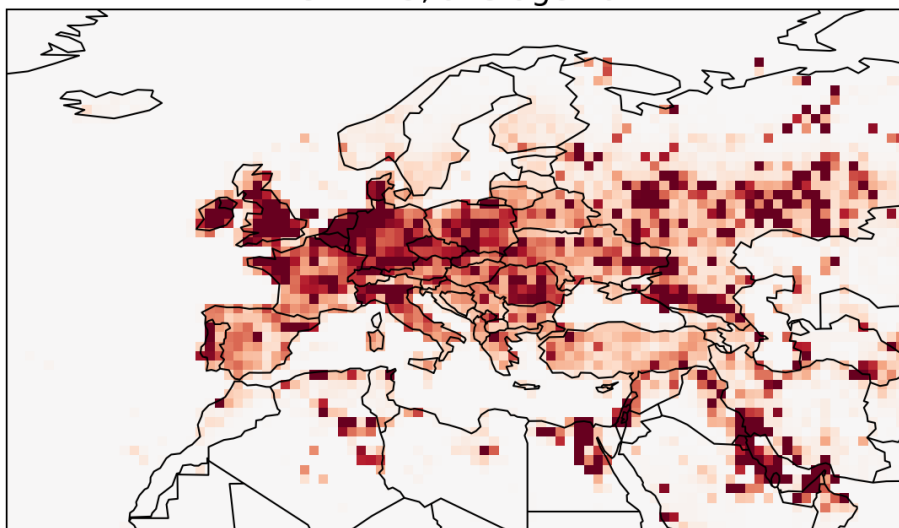
- SMOS F/T decreased northern yearly emissions on average 0.41 Tg and 0.34 Tg for LPX and CTE respectively
 - LPX: highest monthly decrease was 0.12 Tg
 - CTE: highest monthly decrease was 0.18 Tg
- Bias and RMSE are **better** for **modified** LPX-Bern DYPTOP than for the original
- CTE-CH₄ with **modified** LPX-Bern DYPTOP gives **better** results than with the original

EDGAR + TNO

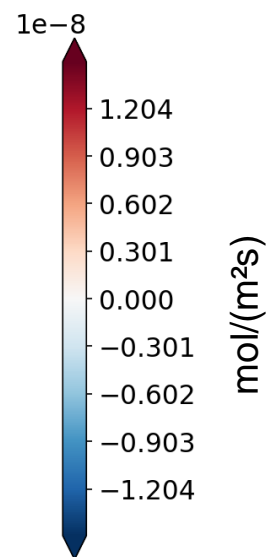
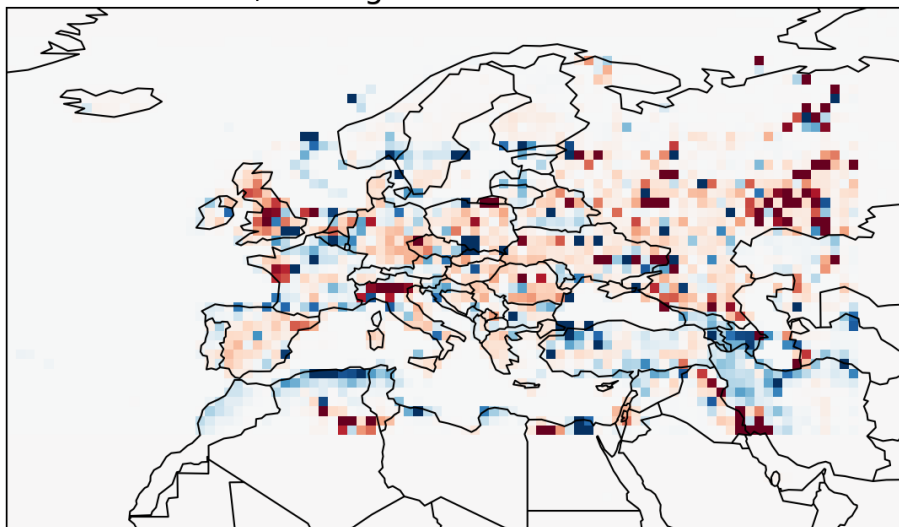
- Test with TNO anthropogenic CH₄ flux data
- TNO (Netherlands Organisation for Applied Scientific Research)
 - Europe
 - Yearly values 2005-2015
- TM5 runs with similar setup than previously presented
 - Anthropogenic:
 - EDGAR v4.2 FT2010
 - EDGAR v4.2 FT2010 + TNO over Europe



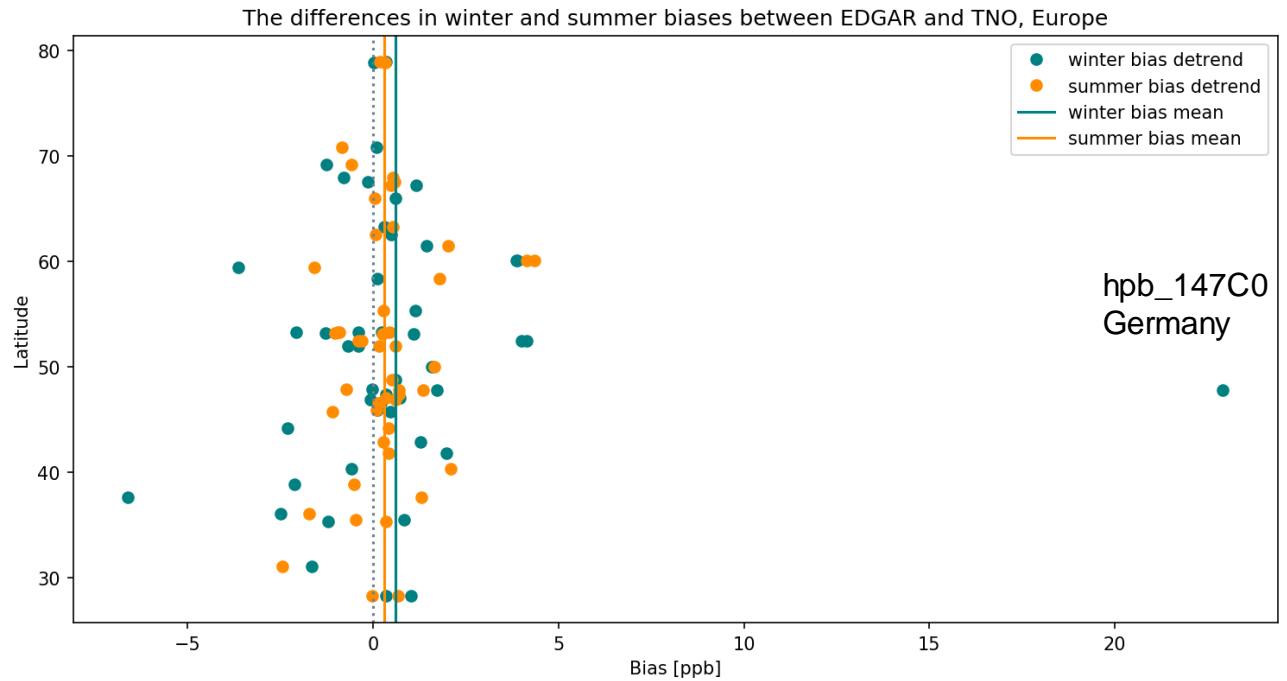
New TNO, average flux



New TNO, average flux difference to EDGAR



Difference between EDGAR and EDGAT&TNO Bias



RMSE

