TROPOMI CH4 inversions

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Outline

- TROPOMI CH_4 inversions
- IASI (Metop-B) CH_4 inversions
- Community Inversion Framework

3 model runs (6° lon × 4° lat)

- General settings
  - model runs from 1-1-2018 till 1-7-2019; analyse from 1-5-2018 till 1-5-2019
  - 4 sources: biomass burning, rice, wetlands, and other (based on CAMS)
  - same initial concentration (based on CAMS), ERA5 meteo, maximum of 40 iterations
- 1: surface measurements only
  - NOAA CH_4 flask measurements
- 2: TROPOMI measurements only
  - horizontal merging on 6° × 4° (lon × lat)
  - qa_value = 1
  - bias corrected data from the operational product
  - uncertainty: σ_{meas} of gridbox, with a minimum of 2 × mean precision
- 3: TROPOMI measurements only + bias correction wrt 1)
  - as in run 2)
  - bias correction derived by comparing TROPOMI measurements with results from run 1)

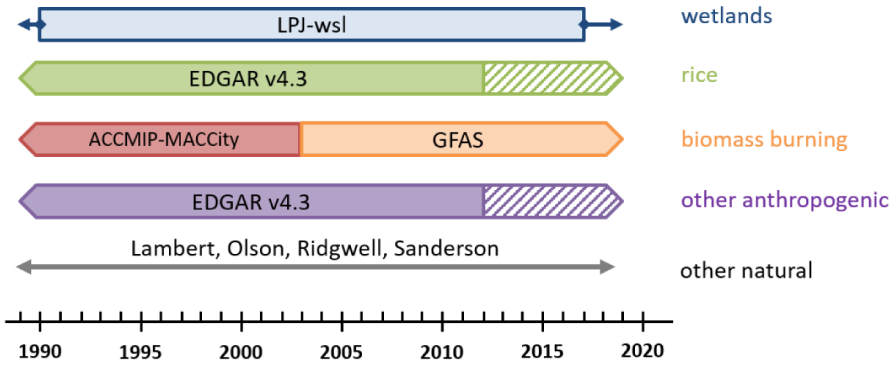
4 sources

- biomass burning, rice, wetlands, and other
- these sources have distinct spatio-temporal properties so that the inversion algorithm can distinguish their effect on the CH_4 concentration

Table 2 - Overview of *a priori* emission inventories used for the CH_4 inversions. The colors represent the different emission super-categories that are optimized by the inversion.

Category	Period	Source
Wetlands	*< 1990*	*(1990)*
	1990-2017	LPJ-wsl
	> 2017	*(2017)*
Rice	≤ 2012	EDGAR v4.3 with Matthews seasonality
	≥ *2013*	*EDGAR v4.3 with Matthews seasonality, extrapolated*
biomass burning	≤ 2002	ACCMIP-MACCity
	≥ 2003	GFAS
other anthropogenic	≤ 2012	EDGAR v4.3 with 2010 seasonality
	≥ 2013	*EDGAR v4.3 with 2010 seasonality, extrapolated*
oceans	*climatology*	Lambert
wild animals	*climatology*	Olson
soil sink	*climatology*	Ridgwell
termites	*climatology*	Sanderson

Figure 2 – Timeline of *a priori* emission inventories used during for the CH_4 inversions.

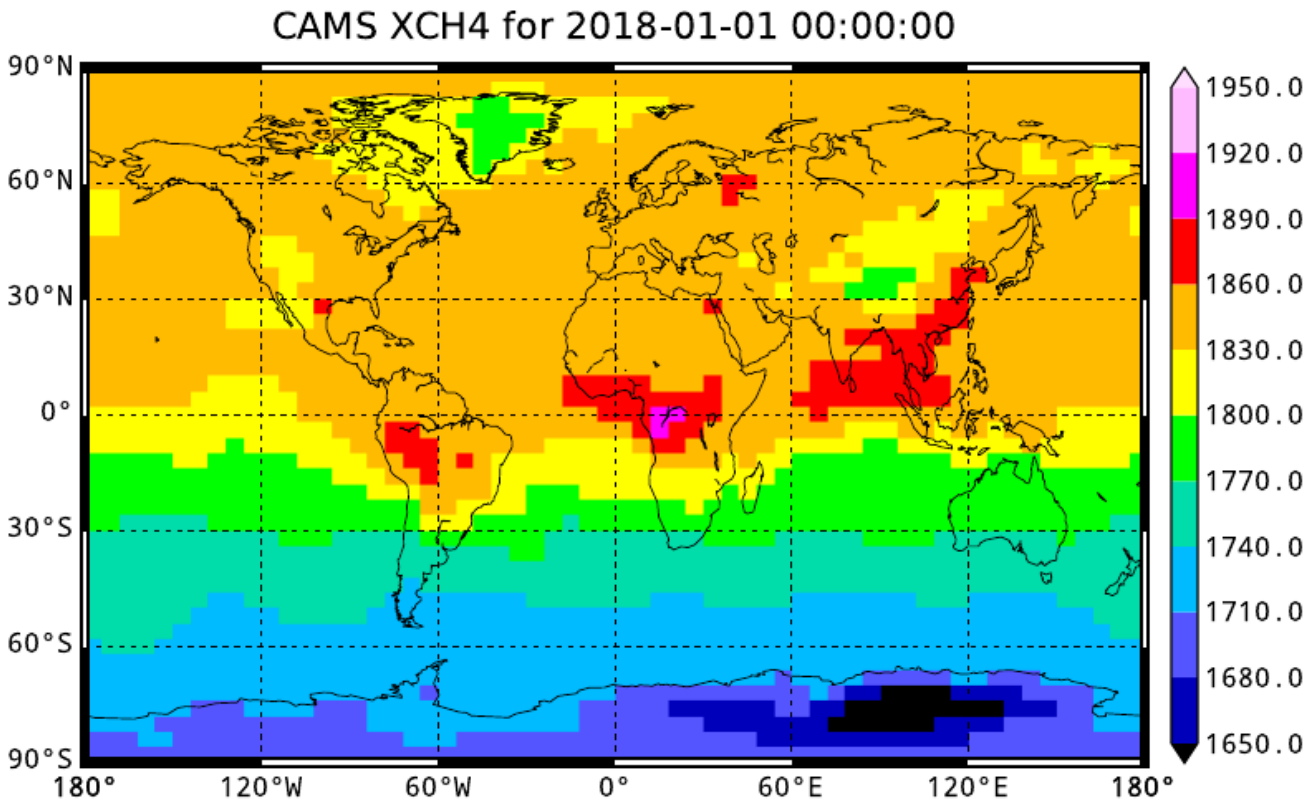


From: Segers (2020), Description of the CH4 Inversion Production Chain, Ref: CAMS73_2018SC1_D73.5.2.2-2019_202001_production_chain_v1, updated version.

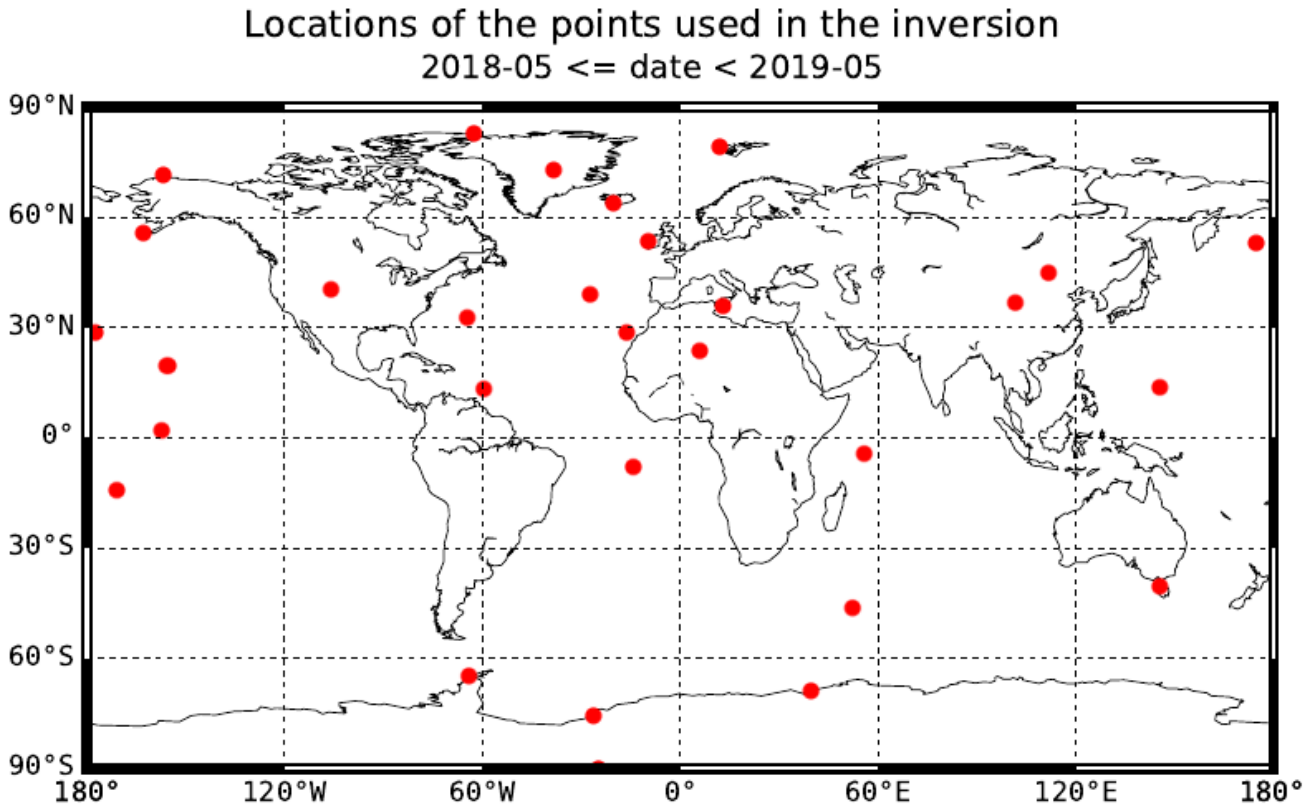
Initial concentration

- Updated by default in 4DVAR. To disable:
  - set the error to 0
  - remove initial concentration from the state vector ✓
- Use a daily mean from the CAMS dataset and convert it to an initial concentration file
  - z_cams_l_cams73_201801_v18r1_ra_ml_dm_ch4_conc.nc
  - provided by Arjo Segers
- The initial concentration is derived from an optimised inversion using surface measurements only

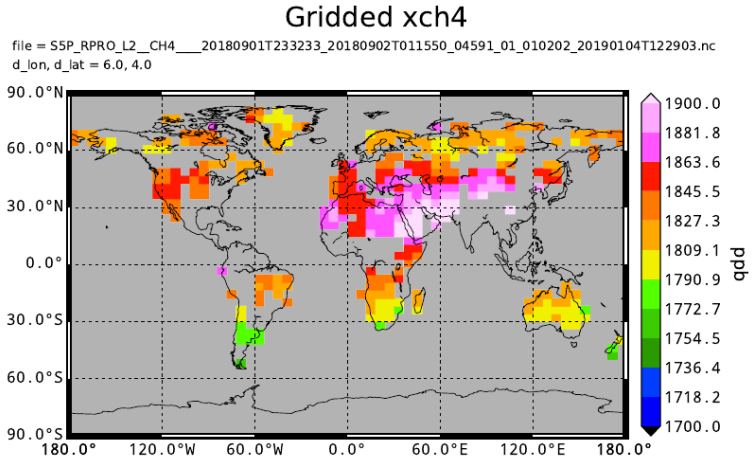
Initial concentration

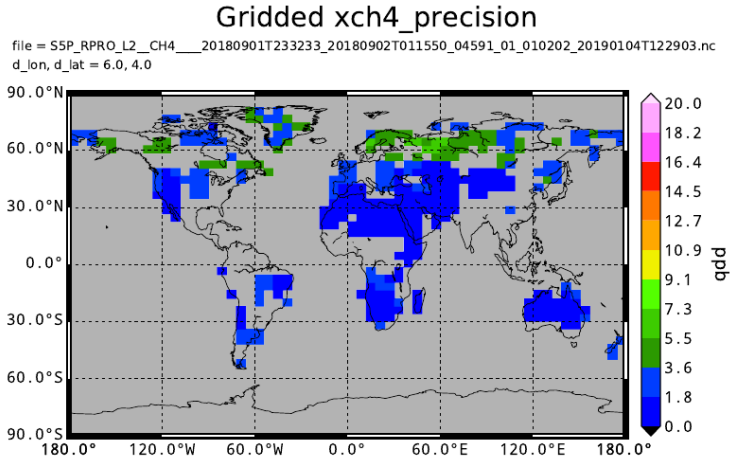


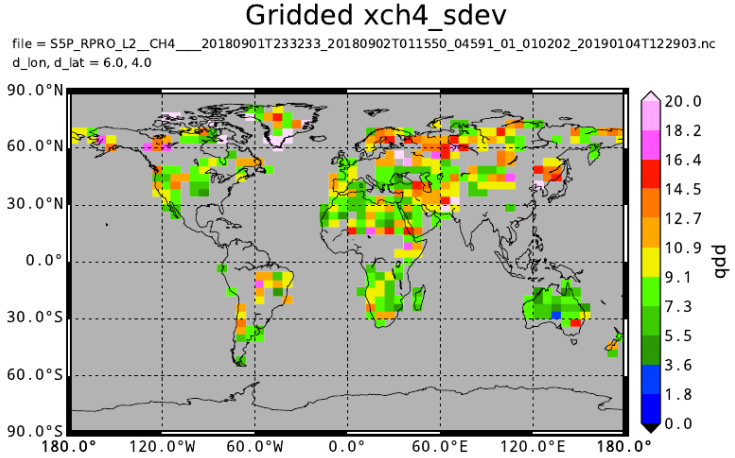
Surface measurements

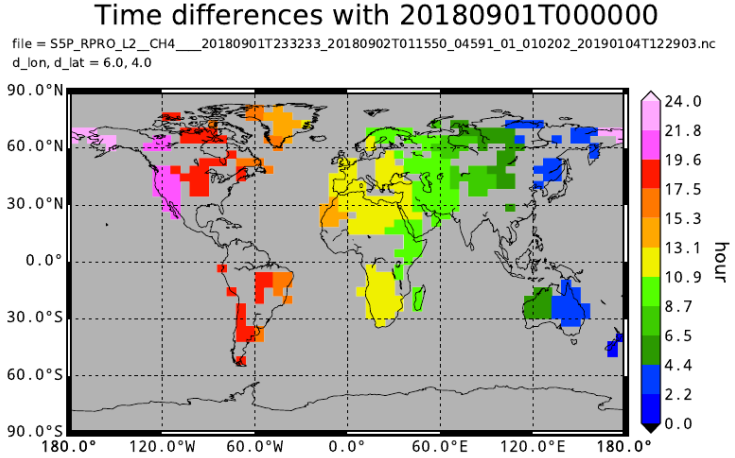


TROPOMI measurements: merging and uncertainty





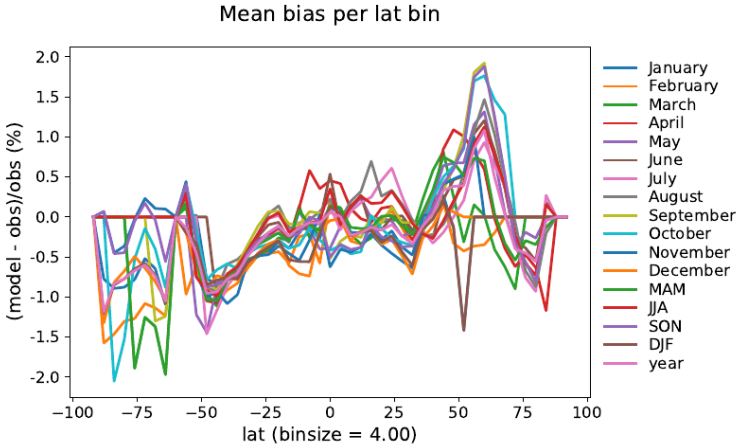


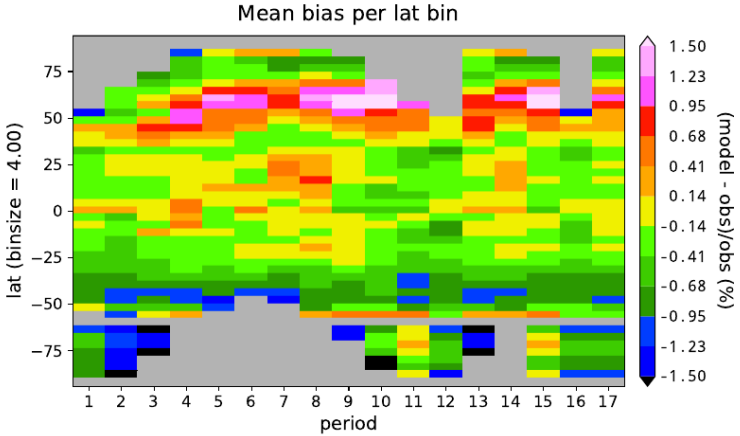


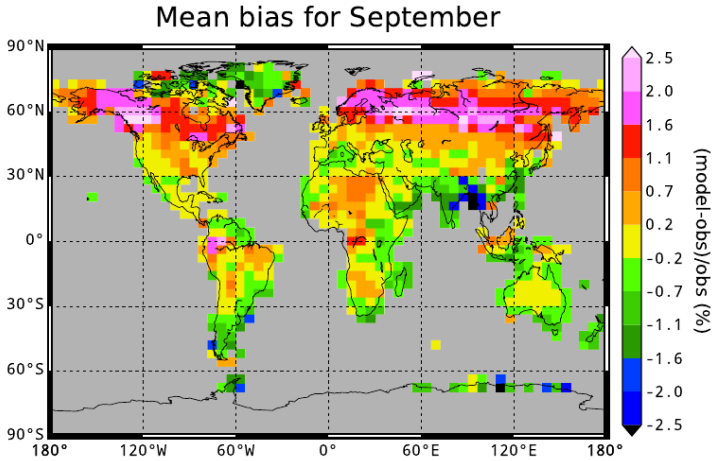
TROPOMI measurements: bias correction

- Compare TROPOMI measurements to points-only inversion
- Apply AK to TM5 profile and calcuate column averaged concentration as it would be observed by TROPOMI
- Calculate the relative difference between TROPOMI and AK-convolved TM5 XCH4
- Bin those differences as a function of latitude
- Use the mean differences per month as a correction factor on the TROPOMI data before merging and assimilation

TROPOMI measurements: bias correction







Top left plot: lines from top to bottom are periods in top right plot:

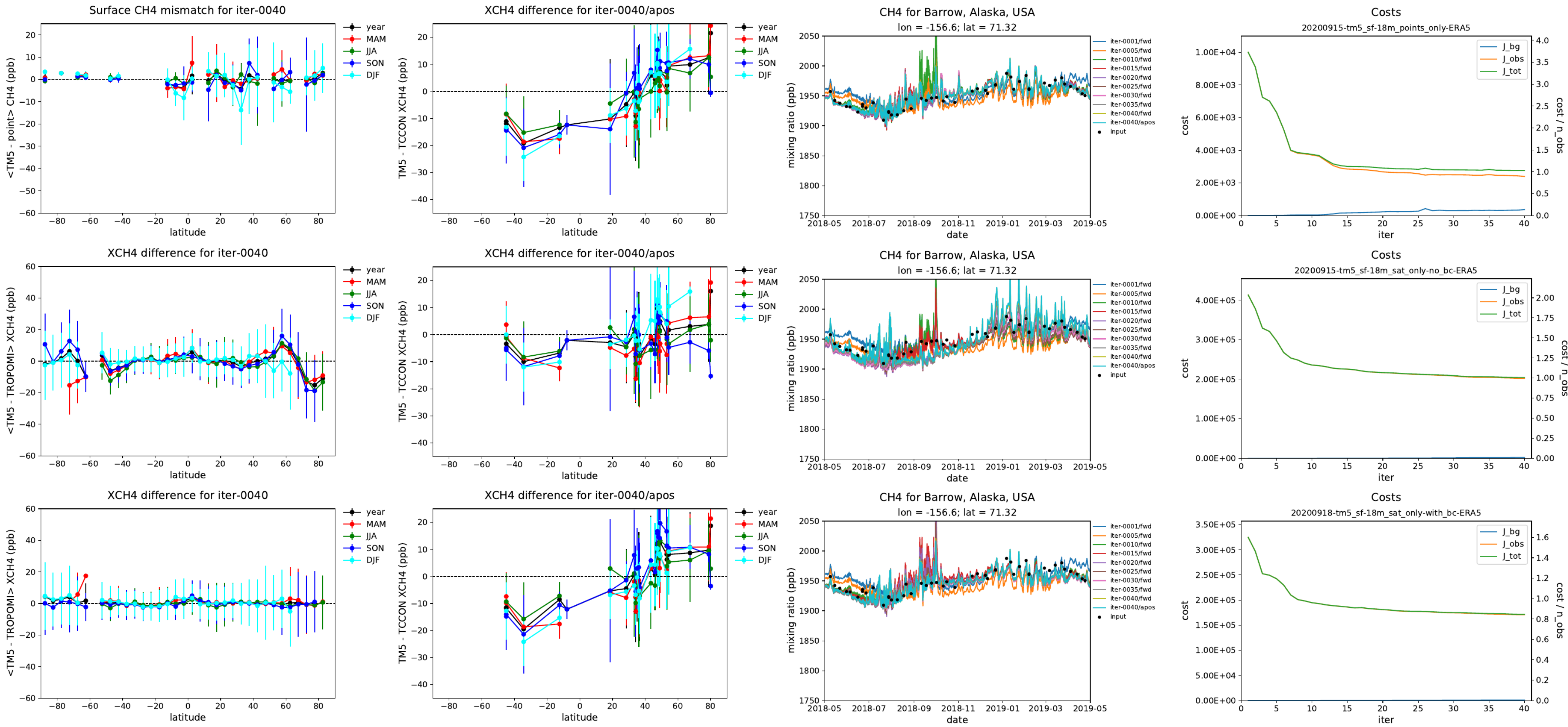
1-12 = January – December

13-16 = seasons

17 = yearly mean

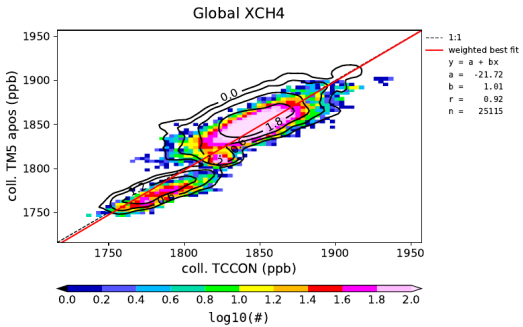
top: surface only (1), middle: sat only (2), bottom: sat only + bc (3)

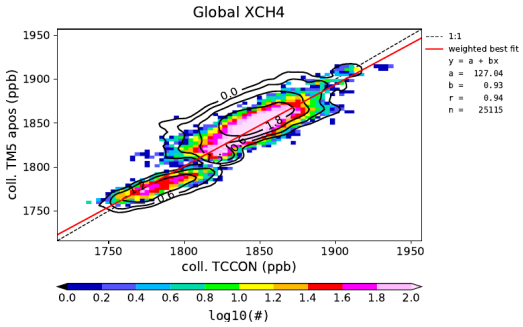
TM5 – obs vs. latitude | comparison with TCCON | output at Barrow | cost

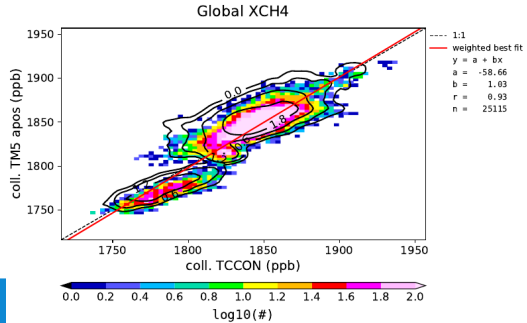


top: surface only (1), middle: sat only (2), bottom: sat only + bc (3)

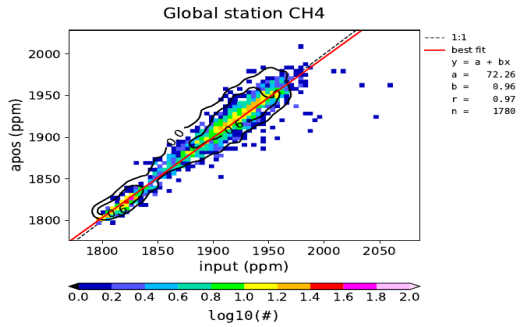
comparison with TCCON

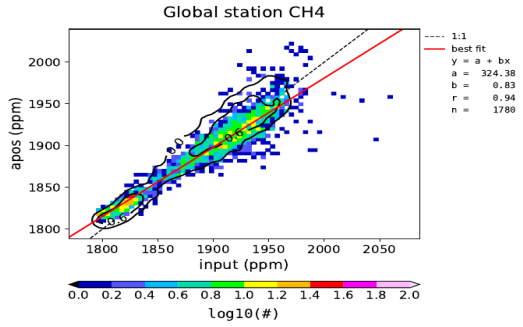


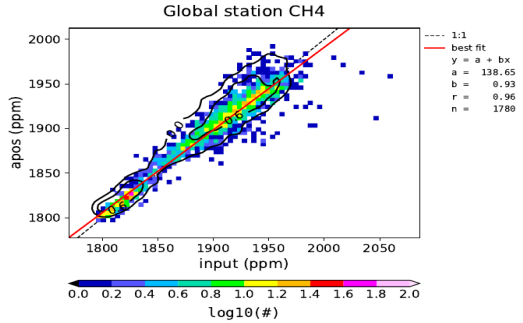




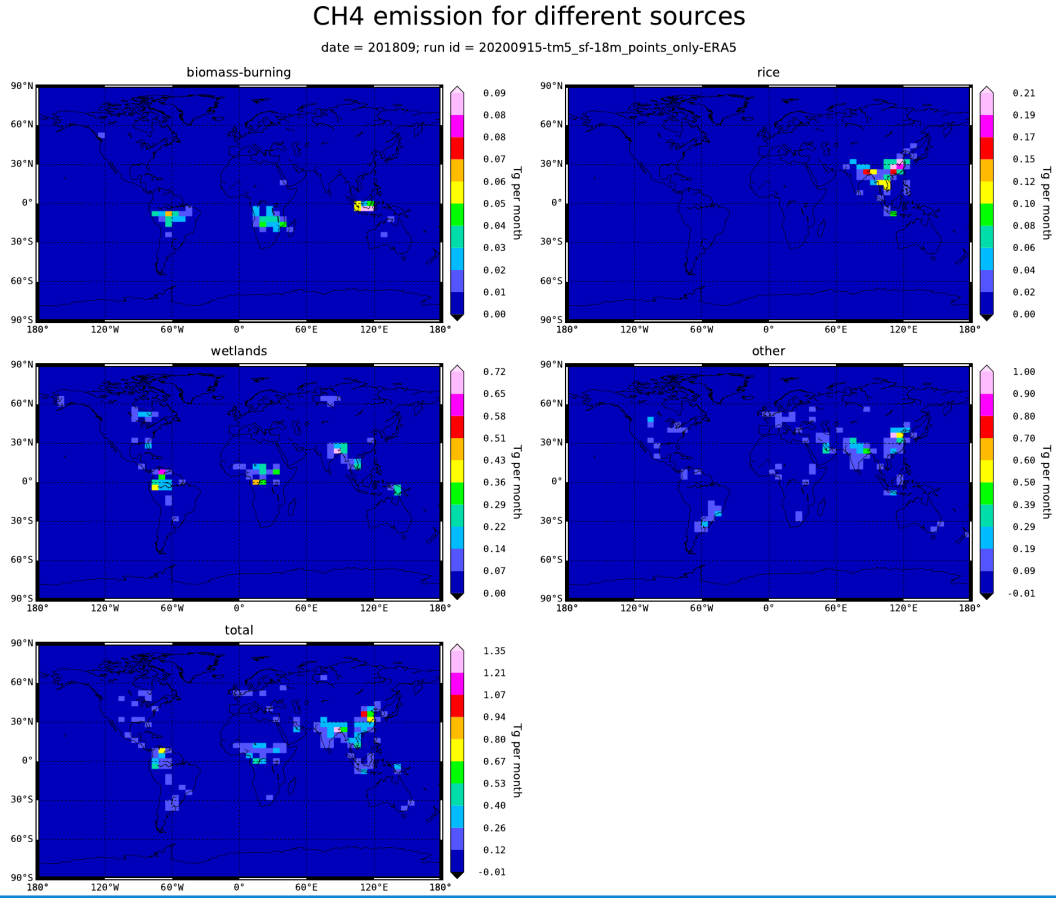
comparison with surf. meas.

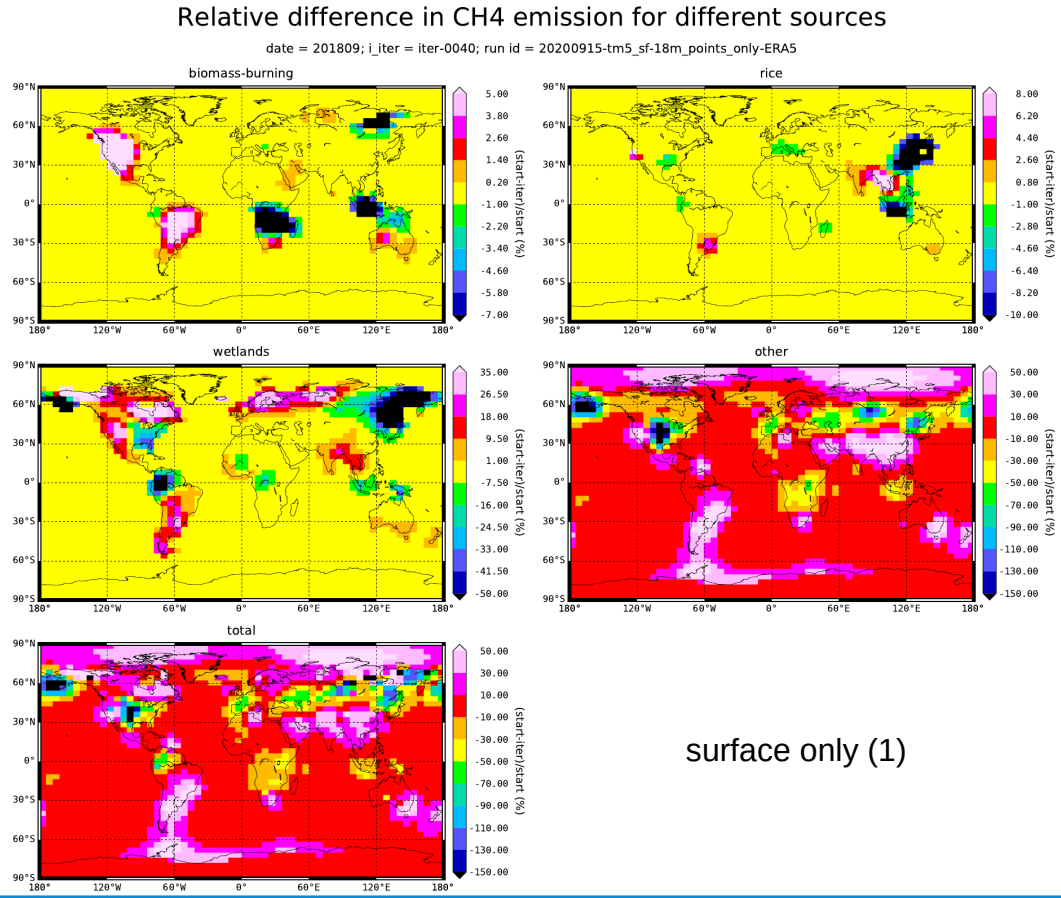






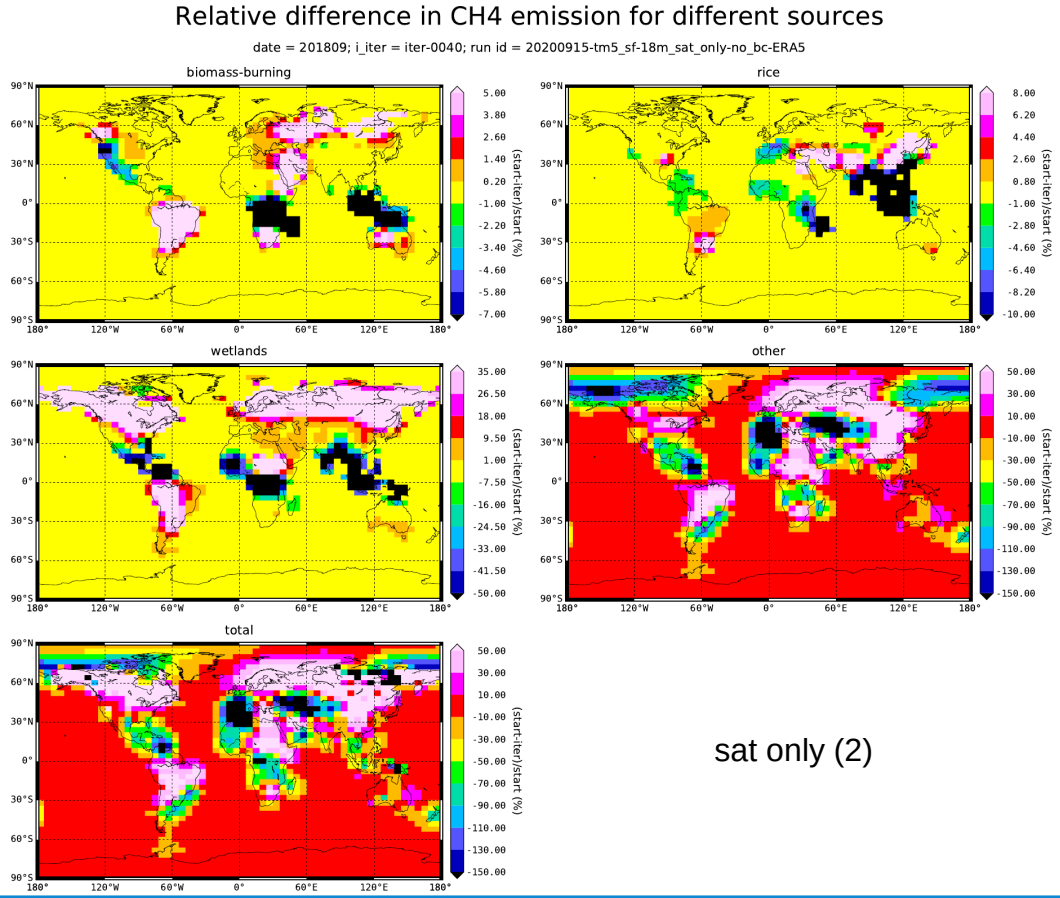
Emission changes



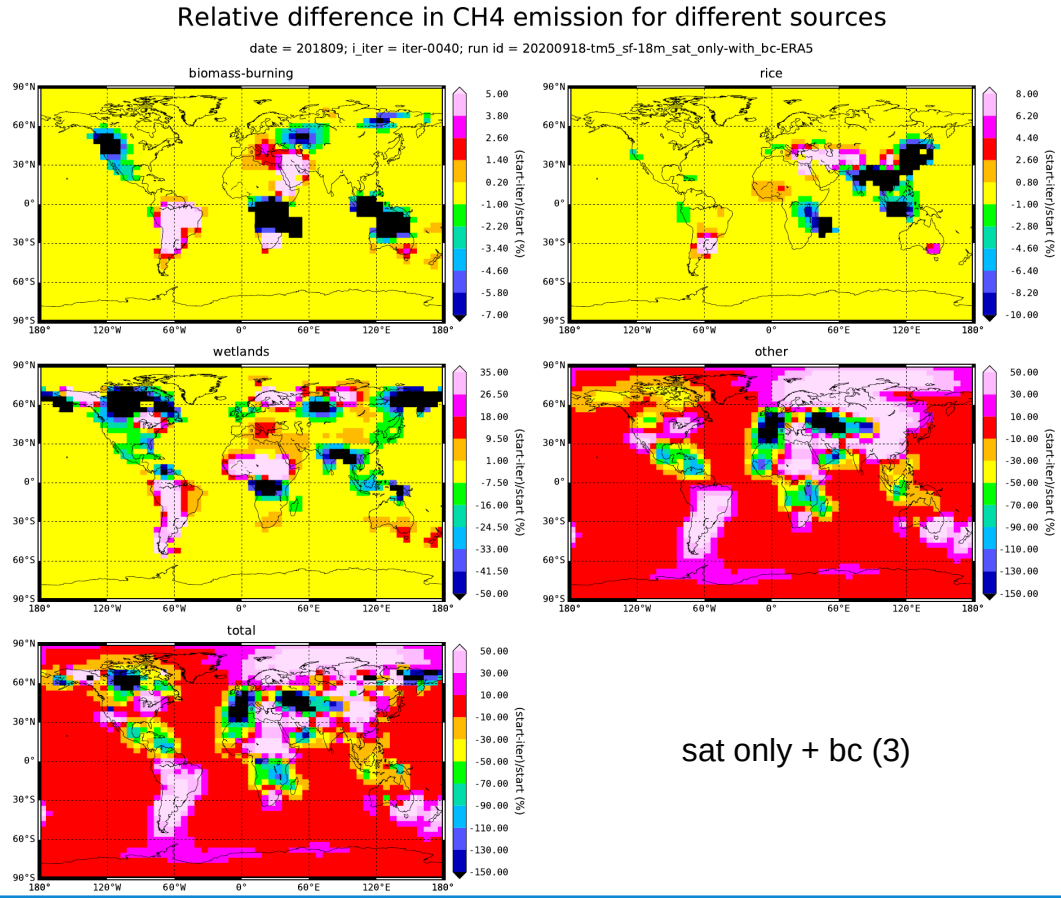


surface only (1)

Emission changes



sat only (2)

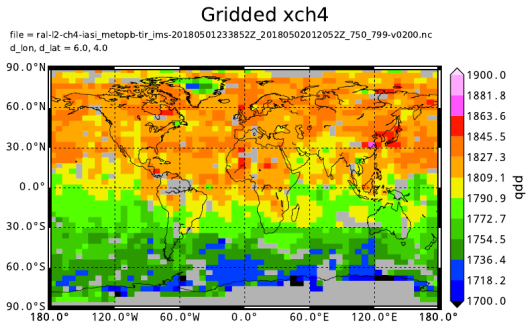


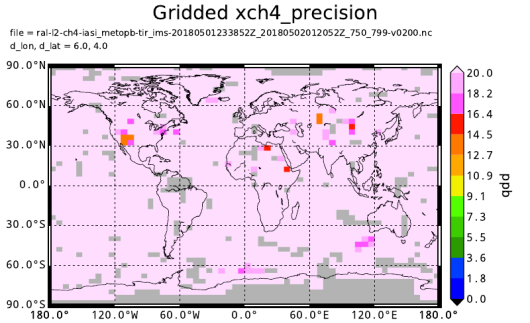
sat only + bc (3)

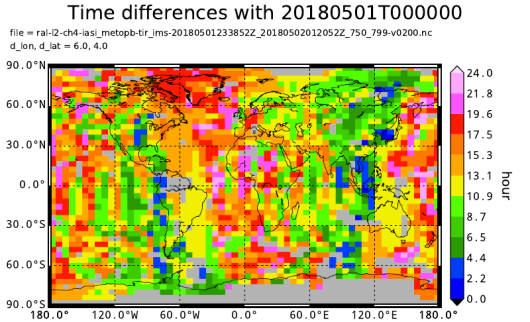
Methane+: RAL IASI (Metop-B)

- ESA project Methane+
  - combining SWIR and TIR CH_4 satellite observations to assess sources and sinks on regional and global scale
  - https://methaneplus.eu/
- day / night time observations
  - time of gridded data
  - variable which indicates the ascending (~night) or descending (~day) phase of the orbit
- data format issues
  - no pressure for layer boundaries, only at layer centers
  - different shapes for AK and a-priori profile (50 vs 12 layers)
  - requires significant code update to implement

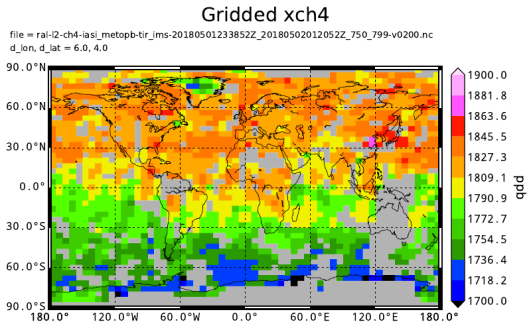
desc + asc

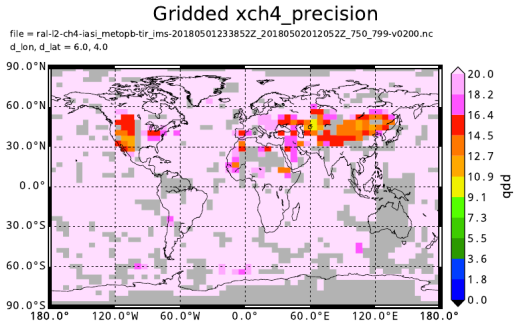


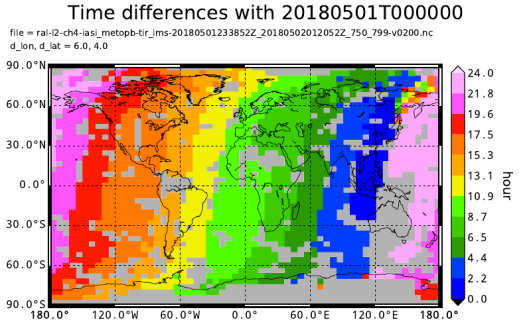




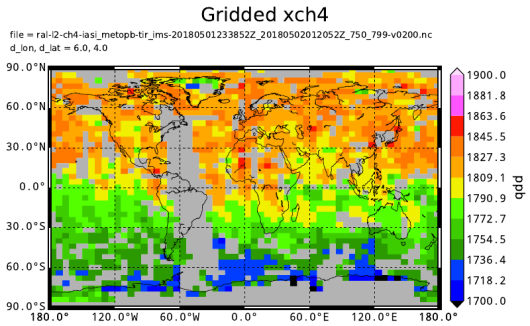
desc only

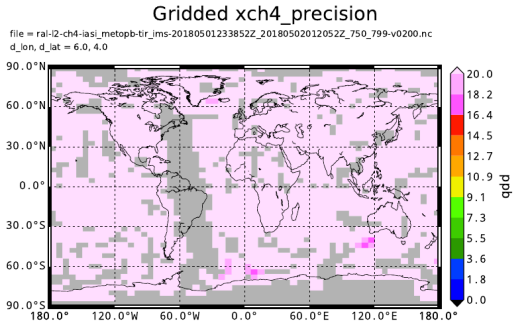


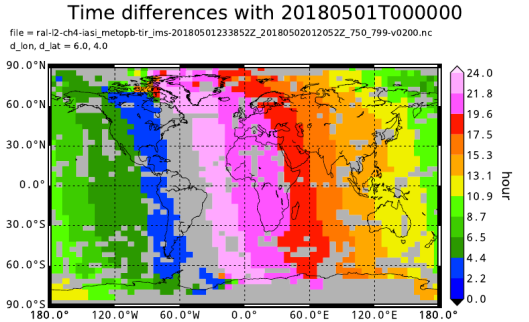




asc only





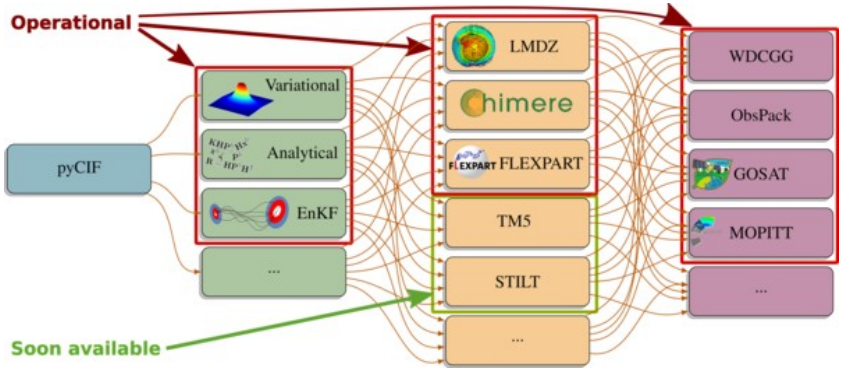


VERIFY: Community Inversion Framework

- H2020 project VERIFY
  - VERIFY develops a system to estimate greenhouse gas emissions to support countries' emission reporting to the UN Climate Change Convention Secretariat
  - The project focuses on the three major greenhouse gases responsible for global warming: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O)
  - quantify GHG fluxes: top down (e.g. satellite data + inversion models) and bottom up
  - http://verify.lsce.ipsl.fr/
- CIF: single inversion framework that can run different models
  - regional or global, Eulerian and Lagrangian
  - inversions can be variational, analytical or EnKF
  - http://community-inversion.eu/

VERIFY: Community Inversion Framework

- objectives
  - rationalize development efforts
  - foster cross-compatibility and inter-comparability of inversion systems
  - ensure quality control with better traceability and transparency
  - open the way towards operational systems
- status
  - framework written in python
  - open source (gitlab server hosted by NILU)
  - Chimere, LMDZ and FLEXPART are implemented
  - STILT is being implemented
  - I’m working on implementing TM5



Conclusion

- TM5 inversions using TROPOMI measurements
  - Model runs for more than a year
  - Four sources: biomass burning, rice, wetlands, and other
  - Bias correction for TROPOMI data based on comparison with inversion using only surface data
- Other work
  - TM5 inversions using RAL Metop-B IASI data
  - Incorporate TM5 into the community inversion framework