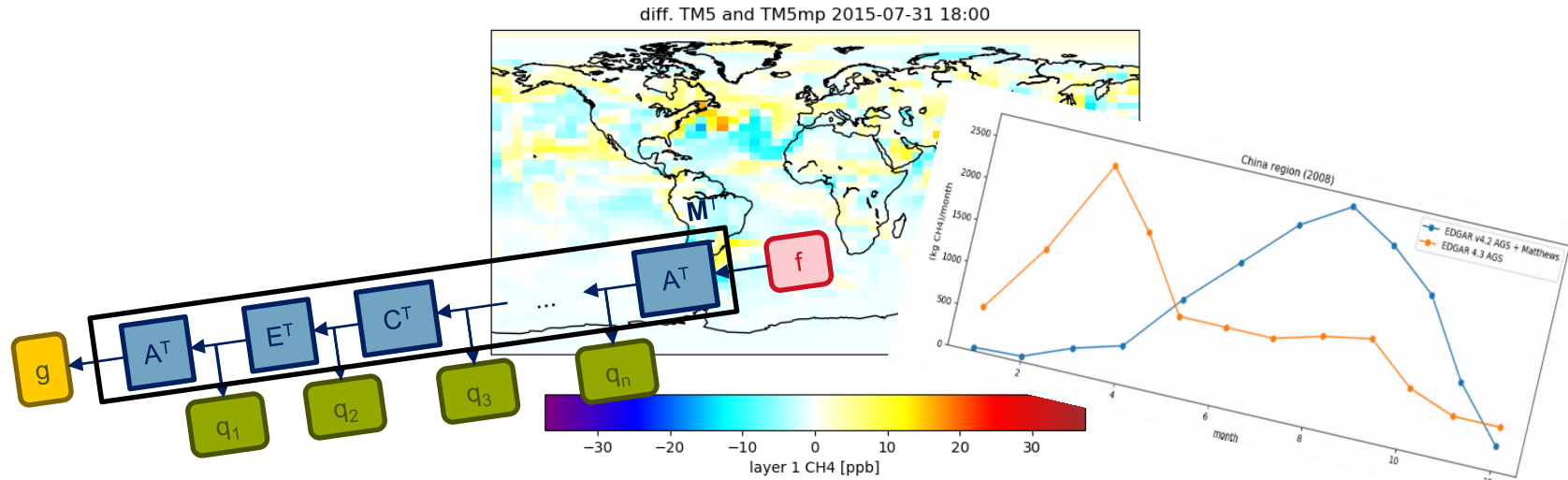


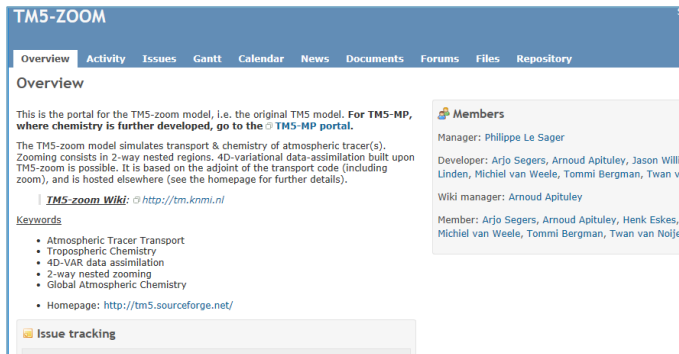
STATUS 4DVAR-TM5-MP & CAMS & OTHER ACRONYMS

Arjo Segers, Richard Kranenburg (TNO)

Sander Houweling, Jacob van Peet (VU)



VERSIONS, VERSIONS, AND MORE VERSIONS ...



TM5-ZOOM

Overview Activity Issues Gantt Calendar News Documents Forums Files Repository

Overview

This is the portal for the TM5-zoom model, i.e. the original TM5 model. For **TM5-MP**, where chemistry is further developed, go to the **TM5-MP portal**.

The TM5-zoom model simulates transport & chemistry of atmospheric tracer(s). Zooming consists in 2-way nested regions, 4D-variational data-assimilation built upon TM5-zoom is possible. It is based on the adjoint of the transport code (including zoom), and is hosted elsewhere (see the homepage for further details).

Members

Manager: Philippe Le Sager

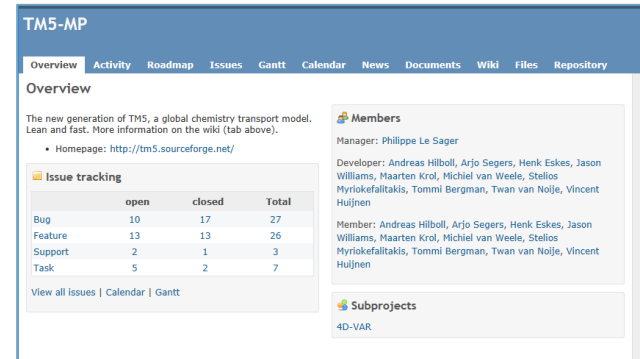
Developer: Arjo Segers, Arnoud Aplituley, Jason Willia Linden, Michiel van Weele, Tommi Bergman, Twan van Nijl

Wiki manager: Arnoud Aplituley

Member: Arjo Segers, Arnoud Aplituley, Henk Eskes, Michiel van Weele, Tommi Bergman, Twan van Nijl

Issue tracking

TM5-ZOOM
dev.knmi.nl/projects/tm5



TM5-MP

Overview Activity Roadmap Issues Gantt Calendar News Documents Wiki Files Repository

Overview

The new generation of TM5, a global chemistry transport model. Lean and fast. More information on the wiki (tab above).

• Homepage: <http://tm5.sourceforge.net/>

Issue tracking

	open	closed	Total
Bug	10	17	27
Feature	13	13	26
Support	2	1	3
Task	5	2	7

Members

Manager: Philippe Le Sager

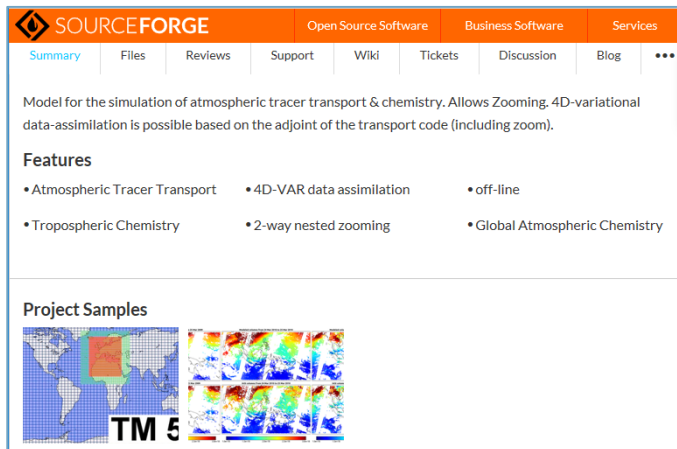
Developer: Andreas Hilboll, Arjo Segers, Henk Eskes, Jason Williams, Maarten Krol, Michiel van Weele, Stelios Myriokefalitakis, Tommi Bergman, Twan van Nijl, Vincent Huijnen

Member: Andreas Hilboll, Arjo Segers, Henk Eskes, Jason Williams, Maarten Krol, Michiel van Weele, Stelios Myriokefalitakis, Tommi Bergman, Twan van Nijl, Vincent Huijnen

Subprojects

4D-VAR

TM5-MP
dev.knmi.nl/projects/tm5mp



SOURCEFORGE Open Source Software Business Software Services

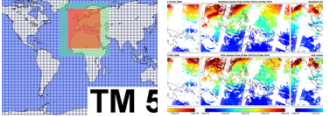
Summary Files Reviews Support Wiki Tickets Discussion Blog

Model for the simulation of atmospheric tracer transport & chemistry. Allows Zooming. 4D-variational data-assimilation is possible based on the adjoint of the transport code (including zoom).

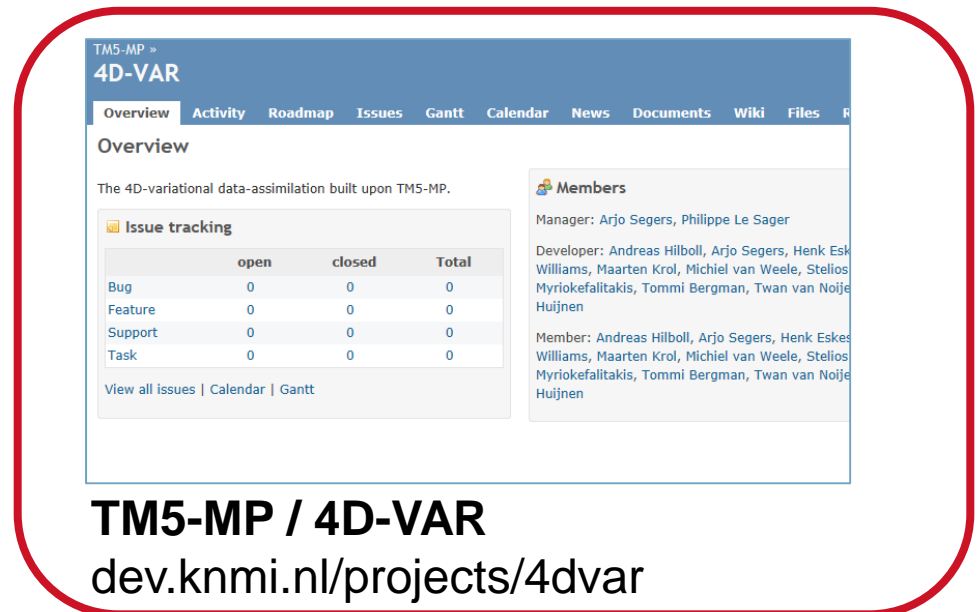
Features

- Atmospheric Tracer Transport
- Tropospheric Chemistry
- 4D-VAR data assimilation
- 2-way nested zooming
- off-line
- Global Atmospheric Chemistry

Project Samples



TM5-4DVAR
sourceforge.net/projects/tm5



TM5-MP / 4D-VAR

Overview Activity Roadmap Issues Gantt Calendar News Documents Wiki Files R

Overview

The 4D-variational data-assimilation built upon TM5-MP.

Issue tracking

	open	closed	Total
Bug	0	0	0
Feature	0	0	0
Support	0	0	0
Task	0	0	0

Members

Manager: Arjo Segers, Philippe Le Sager

Developer: Andreas Hilboll, Arjo Segers, Henk Esk Williams, Maarten Krol, Michiel van Weele, Stelios Myriokefalitakis, Tommi Bergman, Twan van Nijl Huijnen

Member: Andreas Hilboll, Arjo Segers, Henk Eskes Williams, Maarten Krol, Michiel van Weele, Stelios Myriokefalitakis, Tommi Bergman, Twan van Nijl Huijnen

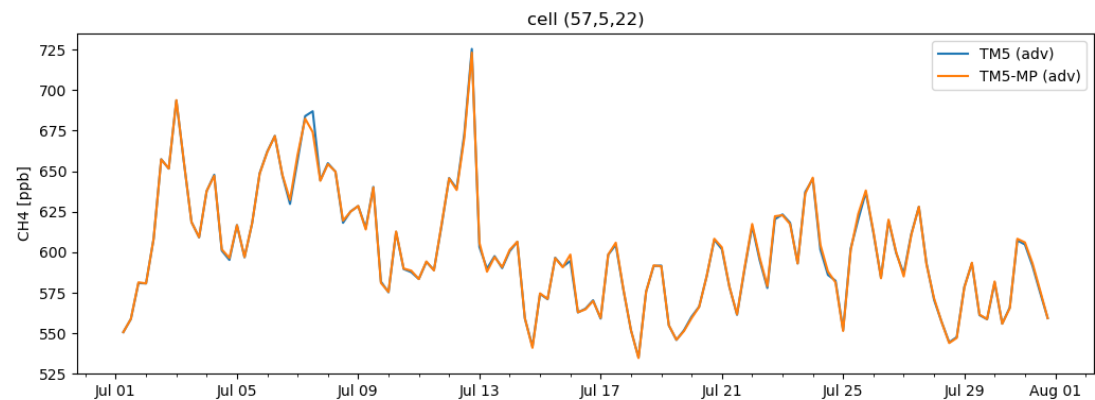
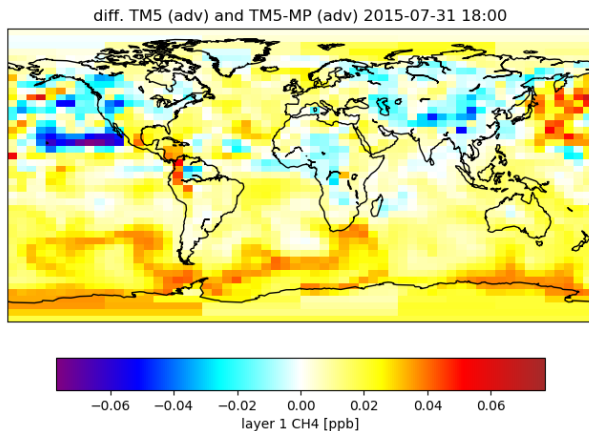
TM5-MP / 4D-VAR
dev.knmi.nl/projects/4dvar

TM5-MP/4D-VAR: MODEL VERSIONS

- › "CAMS CH₄ demo" configuration with TM5-MP
 - › 1 month, CH₄ tracer, emission, sinks, observation operator

- › Compared CH₄ simulations using "original" TM5 and TM5-MP, fixing differences in processes one-by-one

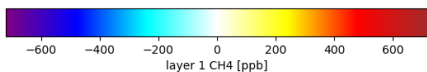
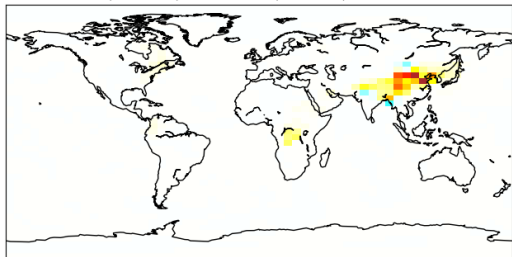
enabled processes: advection



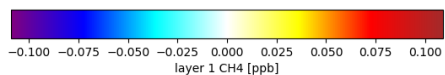
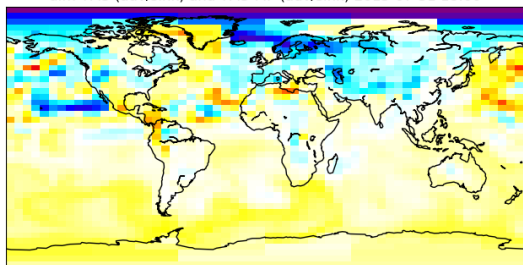
*Difference in surface CH₄
after 1 month simulation*

Timeseries in cell with max difference

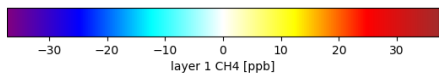
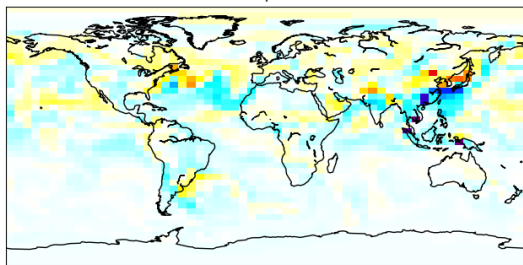
diff. TM5 (adv/emis) and TM5-MP (adv/emis) 2015-07-31 18:00



diff. TM5 (adv/sink) and TM5-MP (adv/sink) 2015-07-31 18:00

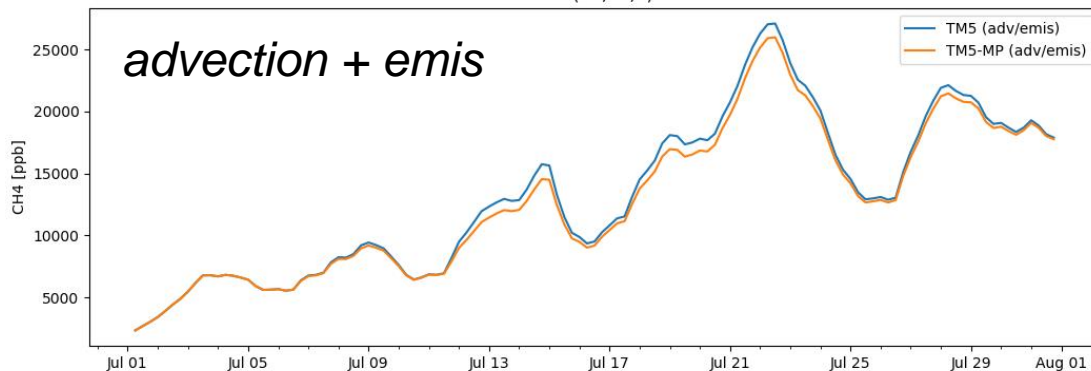


diff. TM5 and TM5mp 2015-07-31 18:00

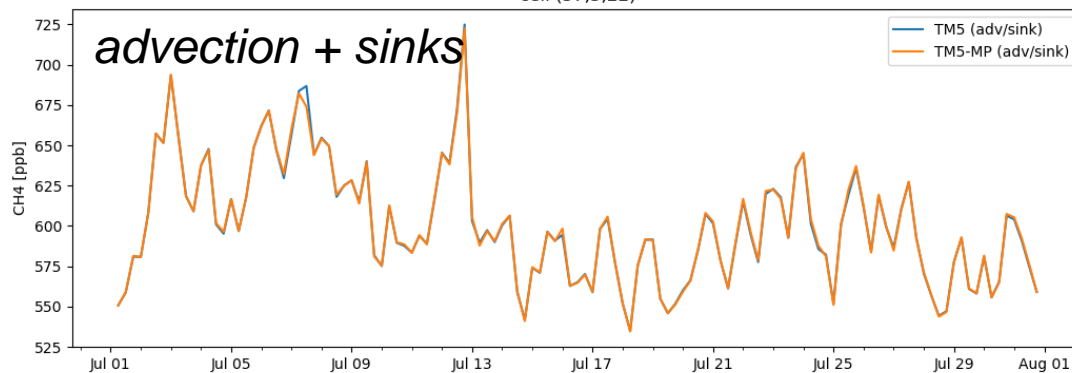


*Difference in surface CH4
after 1 month simulation*

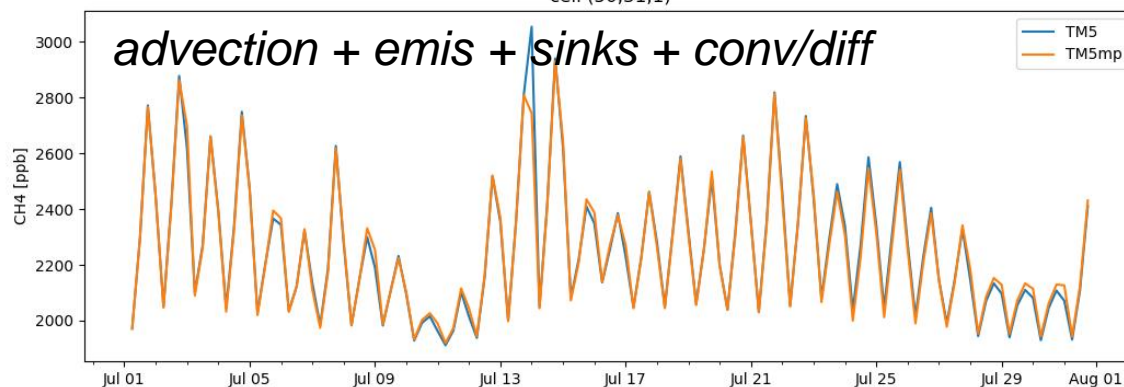
cell (48,30,1)



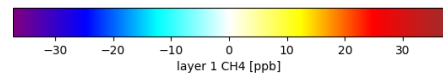
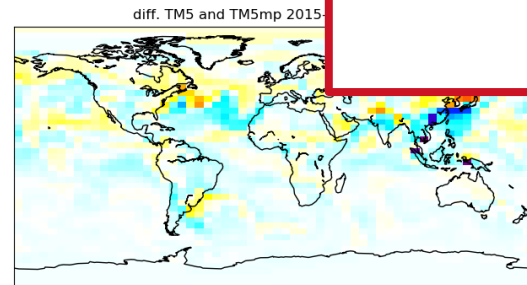
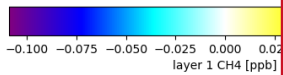
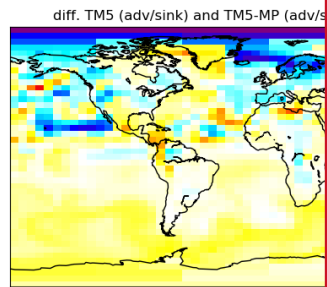
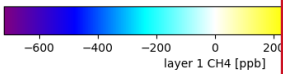
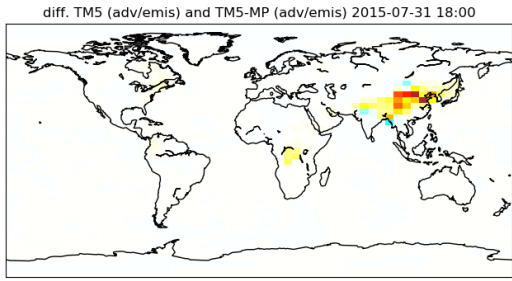
cell (57,5,22)



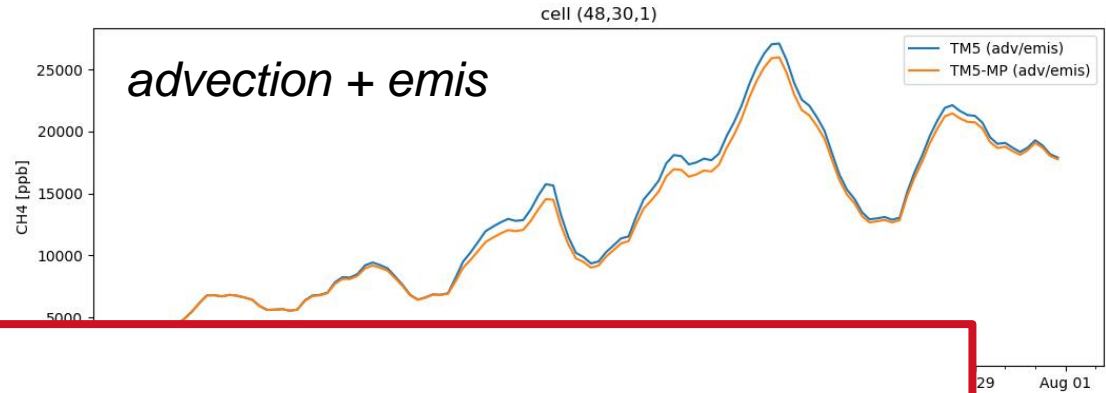
cell (50,31,1)



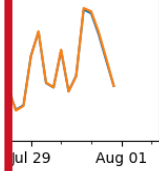
Timeseries in cell with max difference



Difference in surface CH4 after 1 month simulation



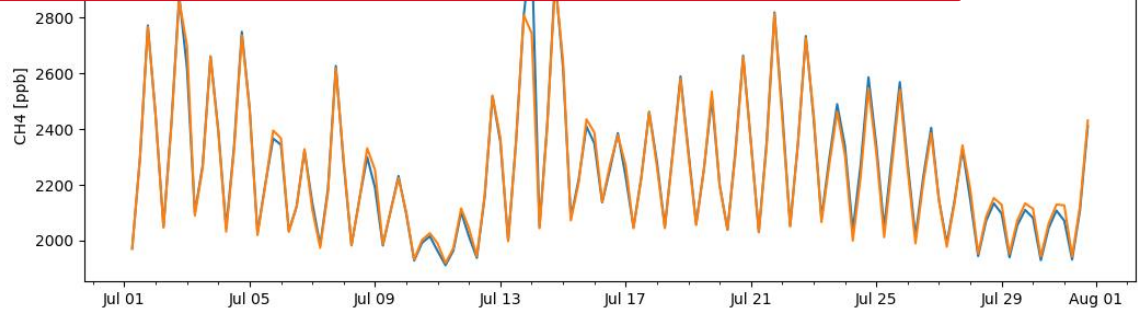
TM5 (adv/sink)
TM5-MP (adv/sink)



Conclusions:

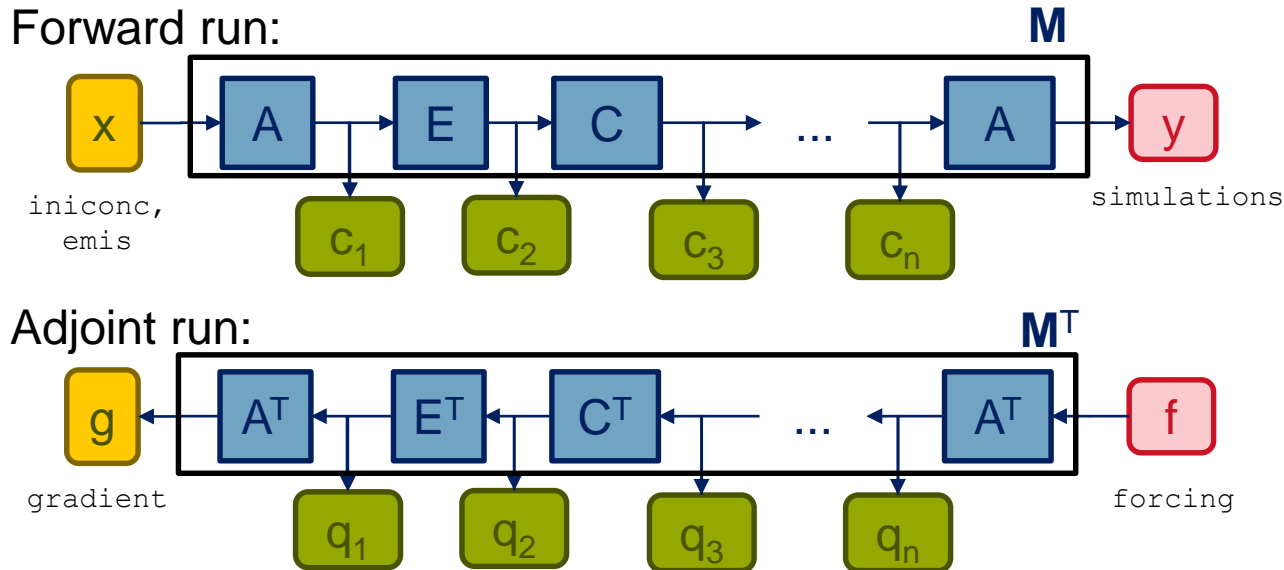
- Implementations of **TM5** and **TM5-MP** can be synchronized and configured similar
- *TM5-MP only allows conv/diff as 1 processes, TM5 allows separate processes*

— TM5
— TM5mp




Timeseries in cell with max difference

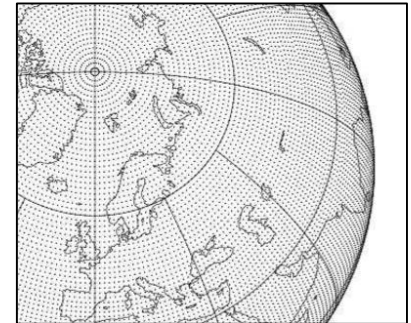
TM5-MP/4D-VAR: ADJOINT



- › One code, two directions
- › Minimum amount of differences between directions:
 - › allow negative time steps
 - › use flags to enable forward or adjoint code

TM5-MP/4D-VAR: NEW ADVECTION CODE

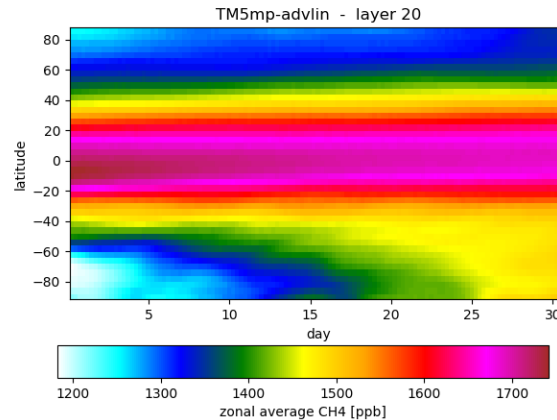
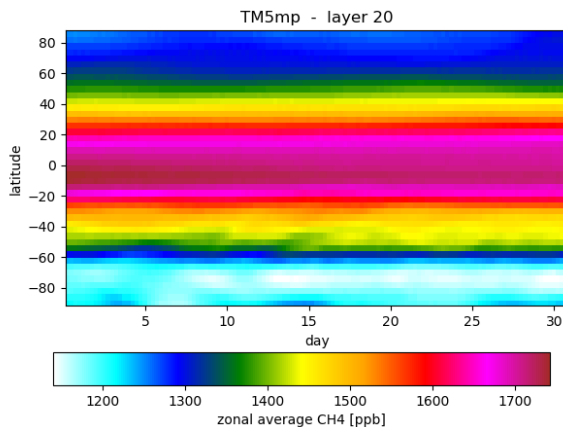
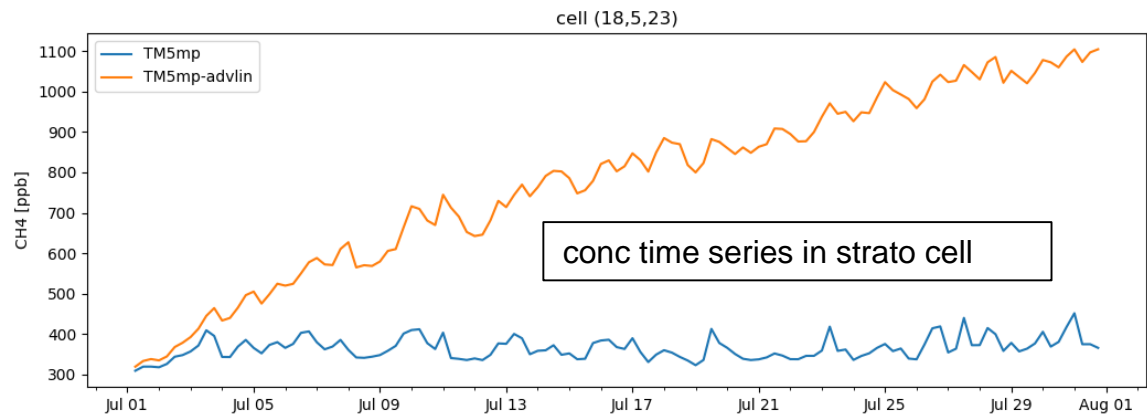
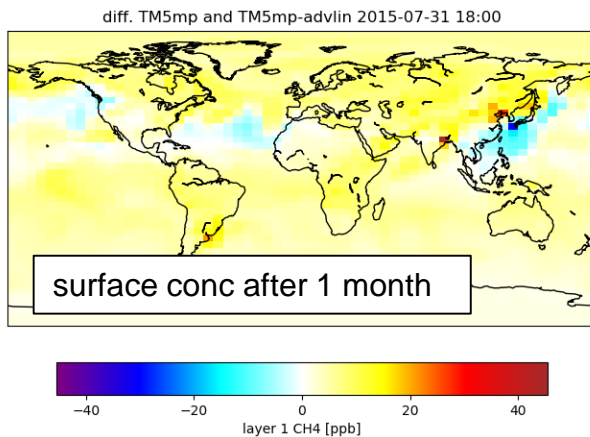
- › Following (Hooghiemstra, 2006)
- › implemented as (sparse) matrix operator,
adjoint is just transpose
- › prepared for "ECMWF" grid 



- › Initial tests:
 - › small differences after a few days
 - › parallel runs same as serial
 - › adjoint test succeeded

TM5-MP/4D-VAR: NEW ADVECTION CODE

- › Longer tests over 1 month:
 - › unexpected drift in concentrations ...



*Drift of tracer mass
towards south pole
when using new linear
advection code*

TM5-MP/4D-VAR: STATUS

- › TM5-MP adjoint version:
 - › new advection code requires re-implementation:
 - › drift towards south pole ... (*wrong plus/minus sign?*)
 - › single large matrix operator is too slow ... (*factor 4-8*)
 - › adjoint tests passed per process
 - › equal results serial/parallel

TM5-MP »
4D-VAR

Overview Activity Roadmap Issues Gantt Calendar News Documents Wiki Files

Overview

The 4D-variational data-assimilation built upon TM5-MP.

Issue tracking

	open	closed	Total
Bug	0	0	0
Feature	0	0	0
Support	0	0	0
Task	0	0	0

View all issues | Calendar | Gantt

Members

Manager: Arjo Segers, Philippe Le Sager

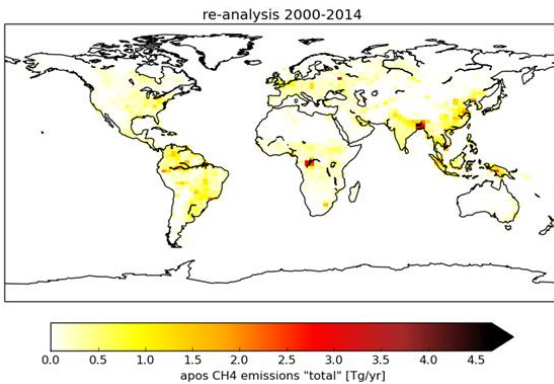
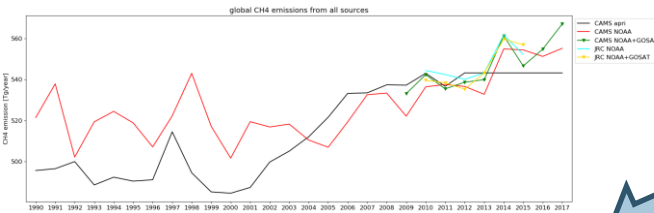
Developer: Andreas Hilboll, Arjo Segers, Henk Eskes, Williams, Maarten Krol, Michiel van Weele, Stelios Myriokefaltakis, Tommi Bergman, Twan van Noije, Huijnen

Member: Andreas Hilboll, Arjo Segers, Henk Eskes, Williams, Maarten Krol, Michiel van Weele, Stelios Myriokefaltakis, Tommi Bergman, Twan van Noije, Huijnen

TM5-MP / 4D-VAR
dev.knmi.nl/projects/4dvar

CAMS CH4 FLUX INVERSIONS

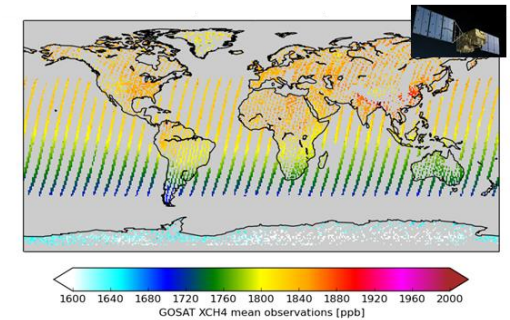
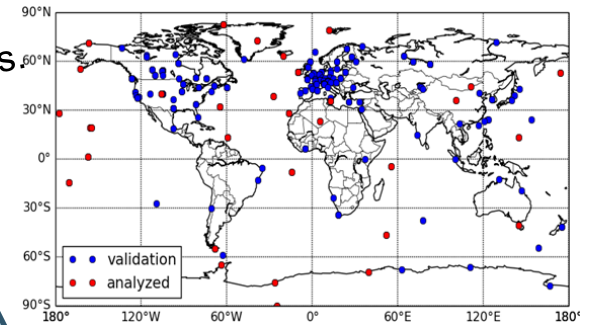
› Monthly maps of CH4 emissions from inversion (1990 - YYYY-1)



TM5 4D-Var

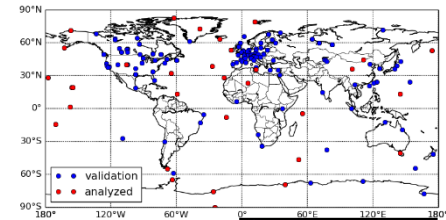
Stream 1
NOAA sfc. obs.

Stream 2
NOAA sfc. obs.
+ GOSAT sat.
col.

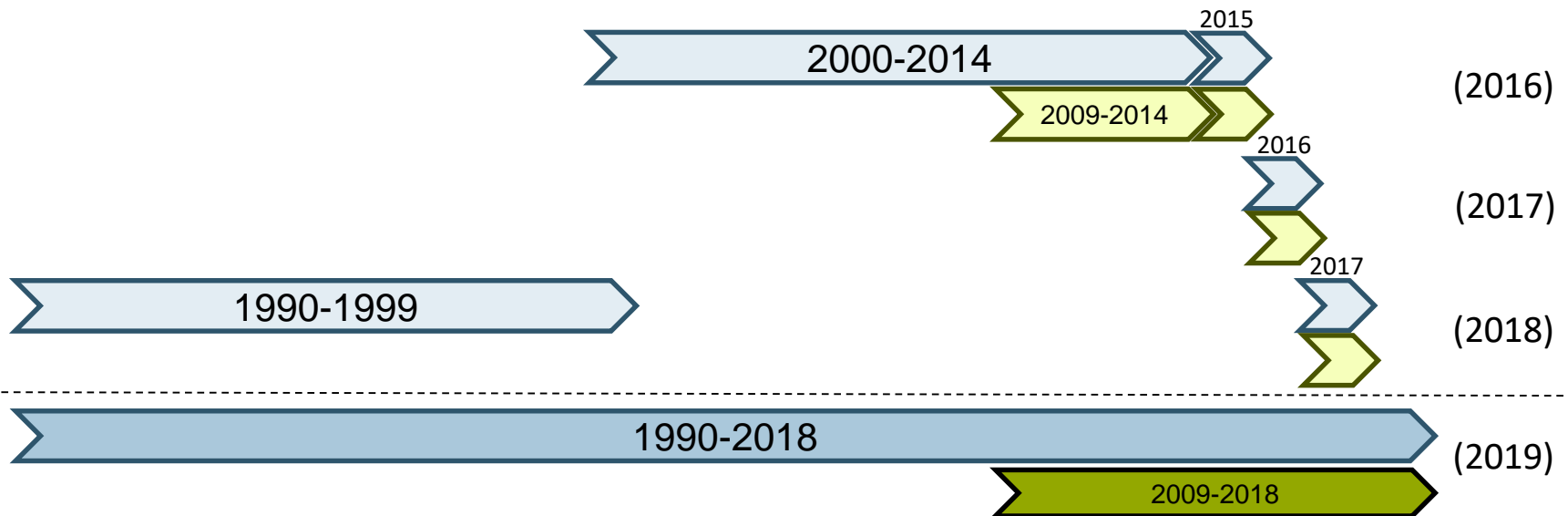


wetlands
rice
biomass burning
other (anthro)

CAMS CH₄ FLUX INVERSIONS

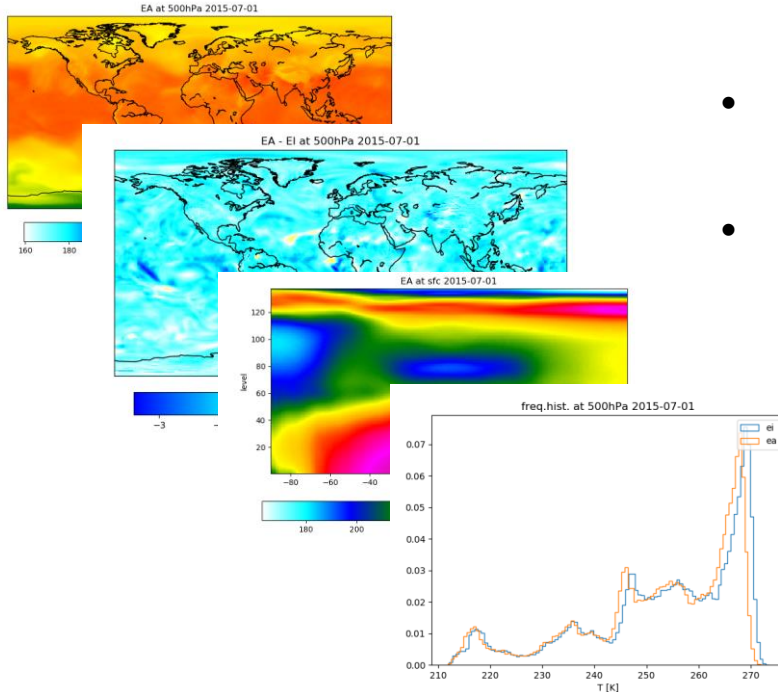


- "Stream 1" using NOAA surface observations only (1990-...)
- "Stream 2" using NOAA surface observations and GOSAT XCH₄ columns (2009-...)



Release:	v17r1	v18r1
years	1990-2017	1990-2018
released	2018 Dec	(2019 Dec)
meteo data	ERA-Interim	ERA5
a priori emissions	EDGAR v4.2 MACCity / GFED wetland climatology	EDGAR v4.3 + extrapol. MACCity / GFAS LPJ-wsl
atmospheric sinks	TM5 scaled (tropo), ECHAM/Messy (strato)	
output collection	multiple productions	single production

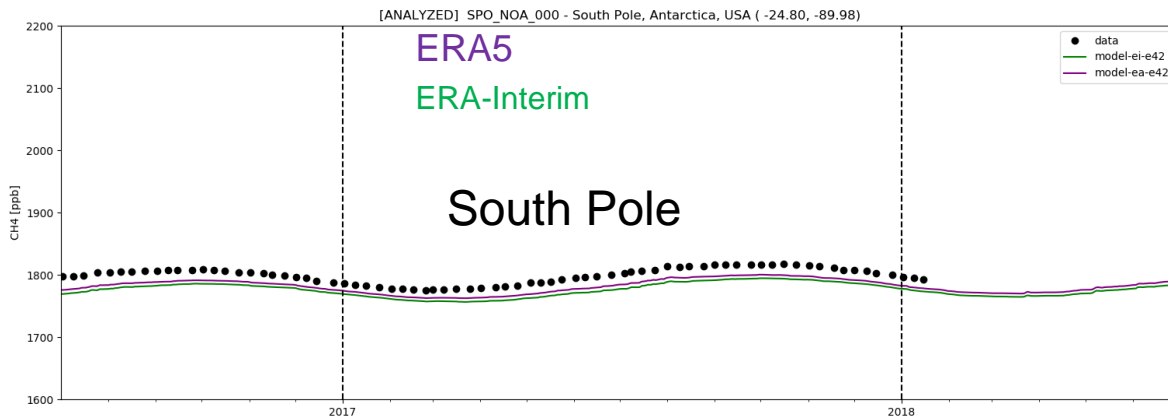
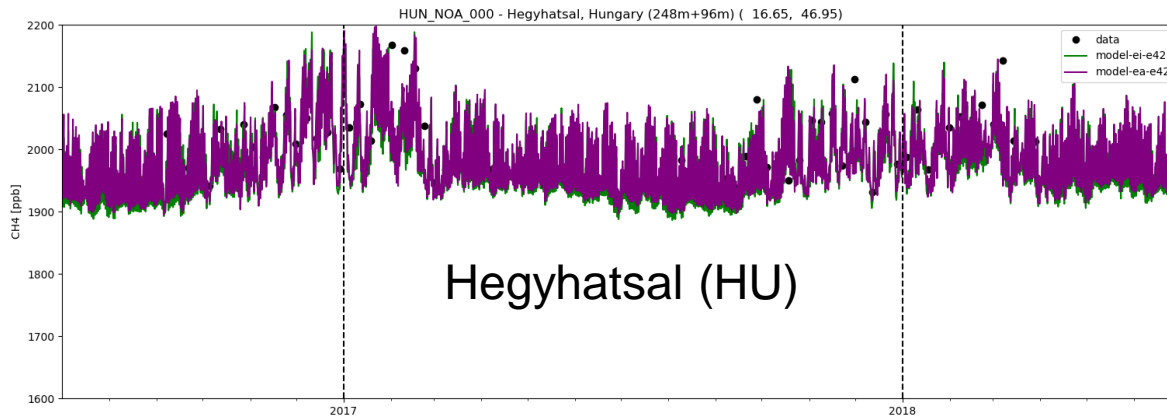
› Change from ERA-Interim (EI) to ERA-5 (EA)



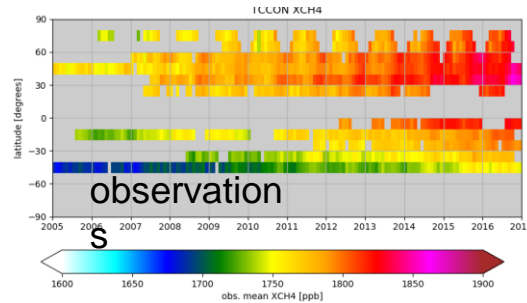
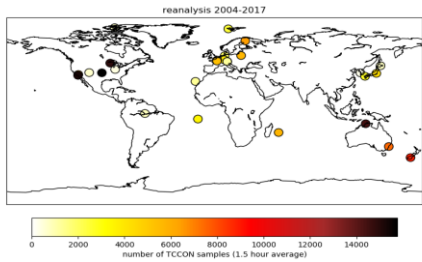
- Increased resolution (30 km, L137)
(inversions still on 3°x2°, 34 layers)
- Available hourly
(used hourly for sfc, 3 hourly for levels)
- tricky: 'accumulated' fields now archived as 'average over last hour' ...

← Compared EI and EA processed meteo for TM5: minor differences ...

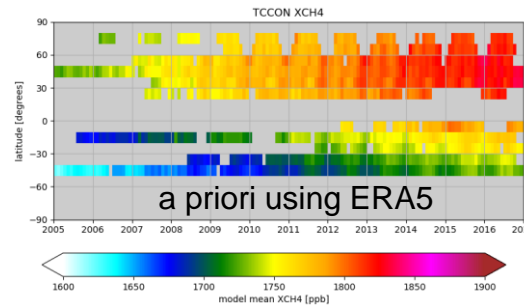
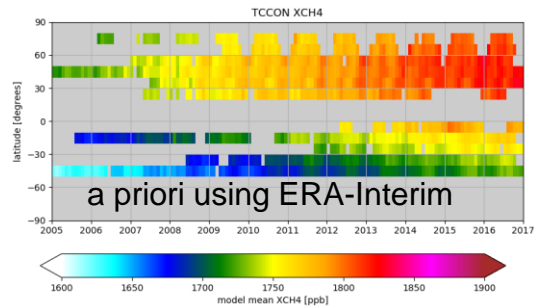
- › Example of surface concentrations in 2017 using free running model from 1990 onwards:



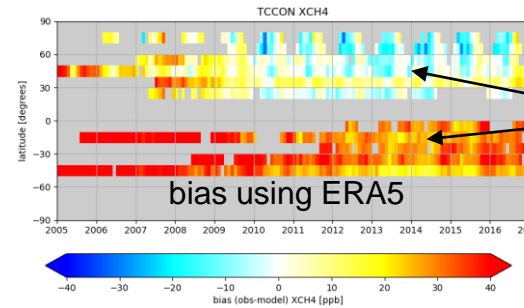
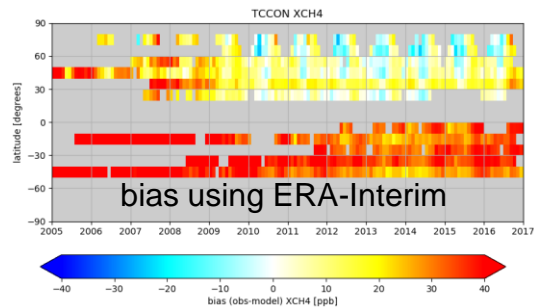
At South Pole station about 10 ppb higher concentrations after 27 years of simulation



➤ Comparison with TCCON XCH₄ columns

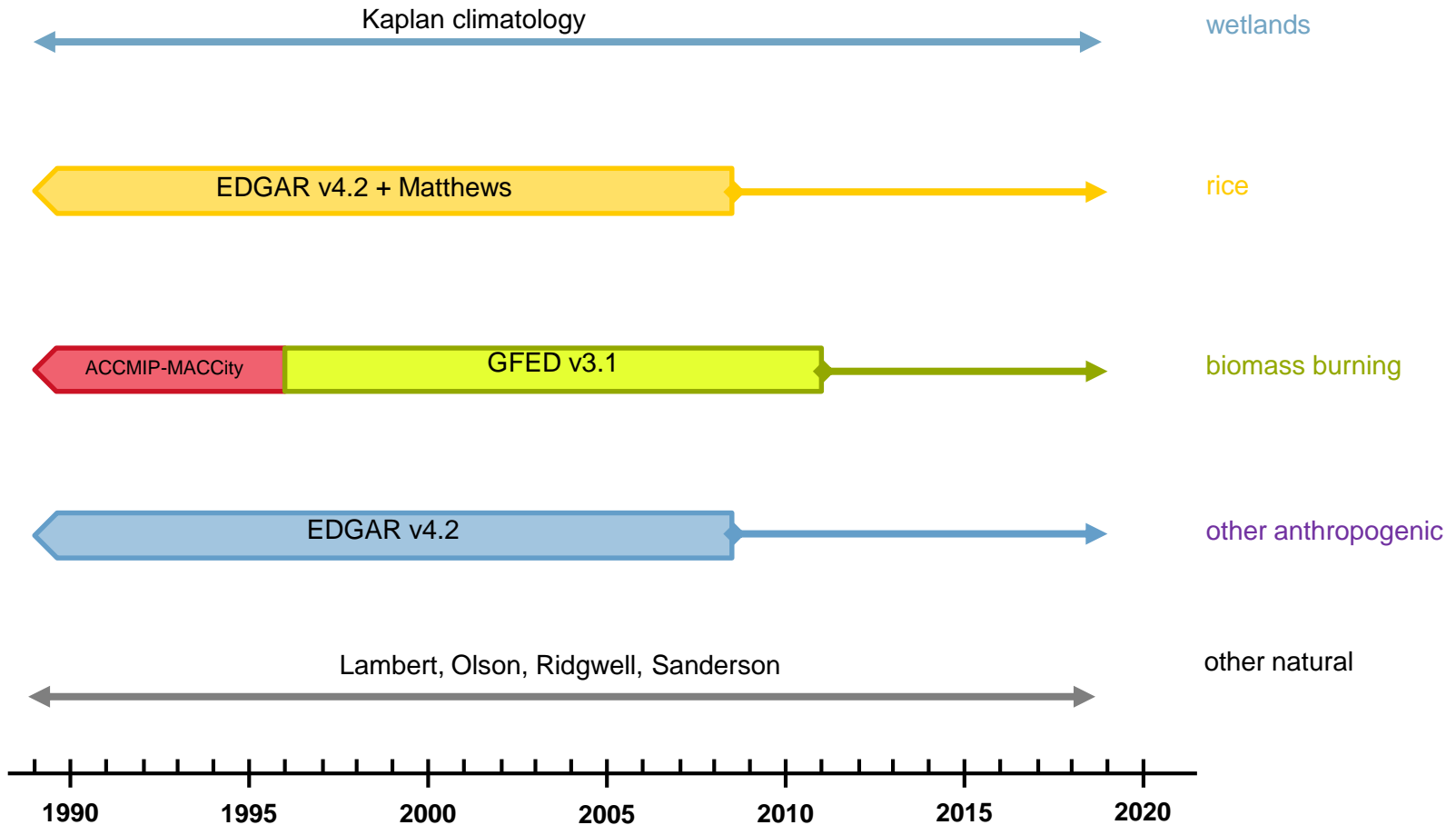


TM5 simulated North-South gradient is too strong

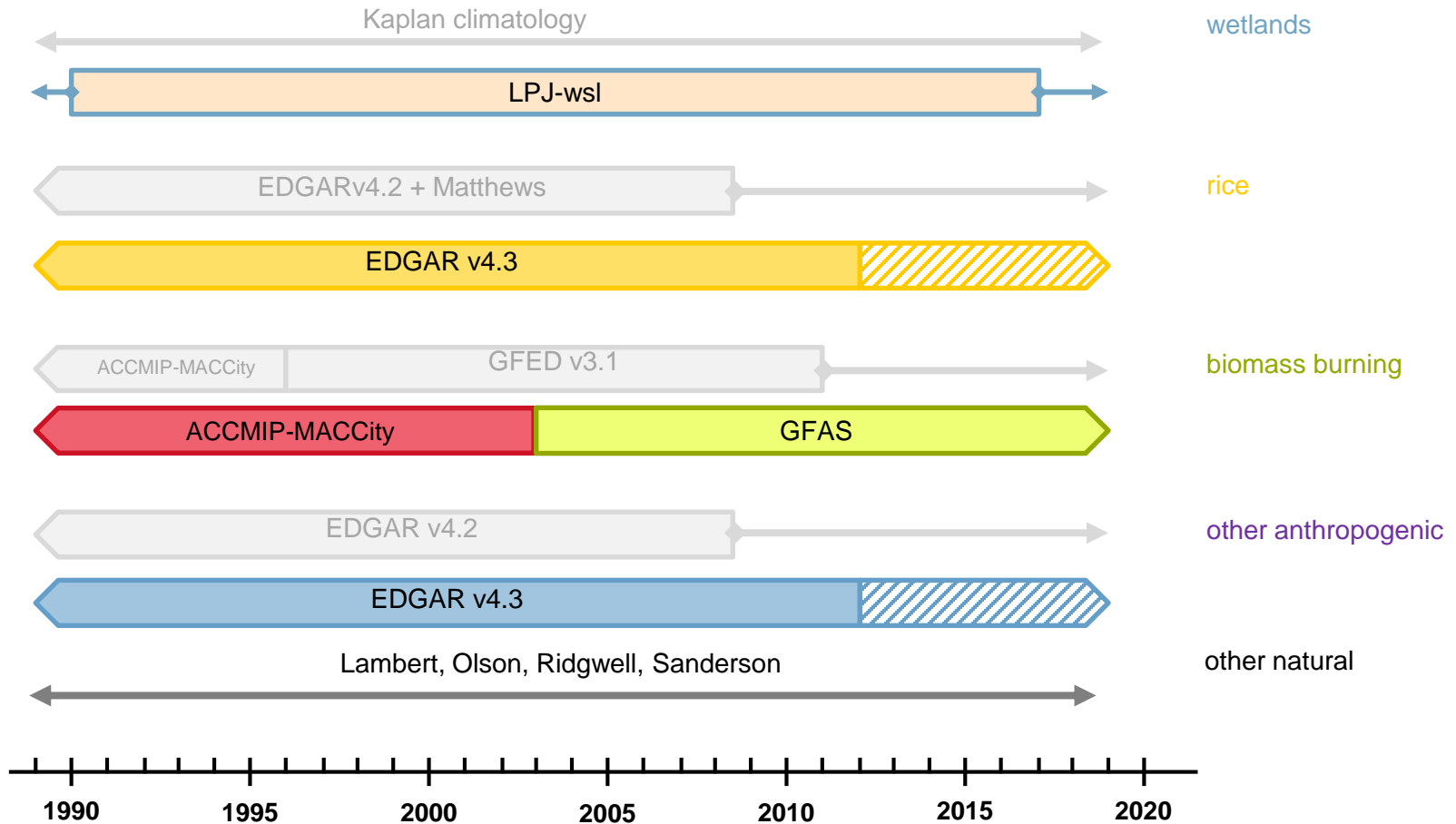


lower biases when using ERA5

UPDATE OF EMISSIONS

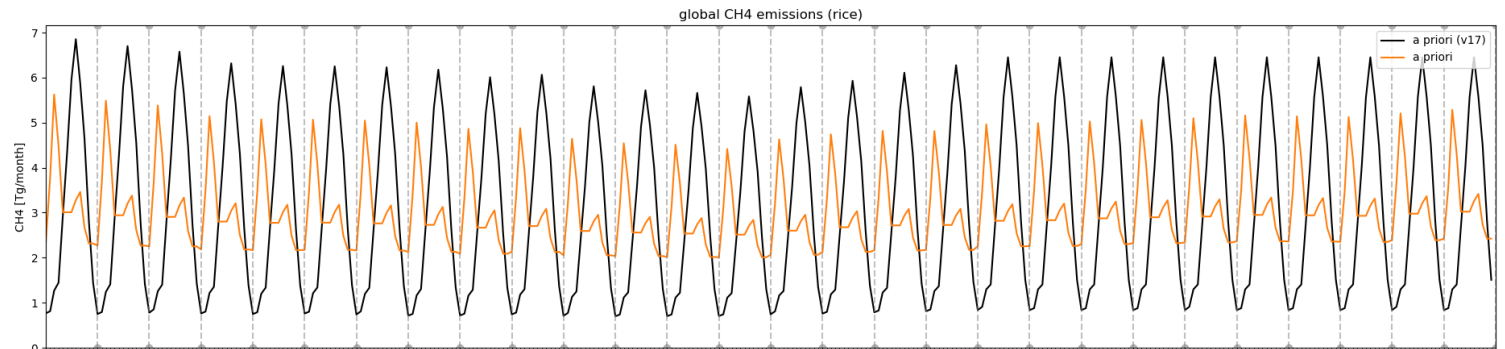


UPDATE OF EMISSIONS



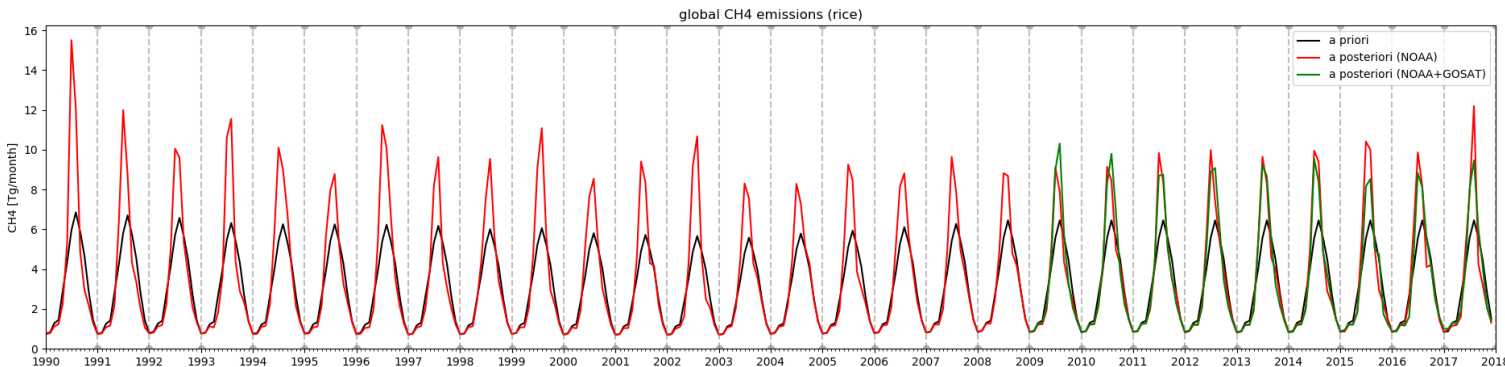
EXAMPLE: EDGAR 4.3 RICE EMISSIONS

- › EDGAR 4.3 supplies monthly profiles per grid cell
(data for 2010, use same profile for all years)



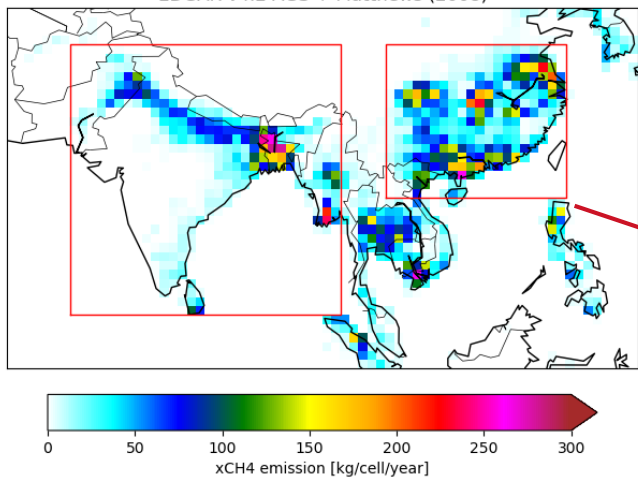
Rice

EDGAR v4.3 has **smaller seasonal cycle and winter peak** compared to Matthews used with EDGAR v4.2



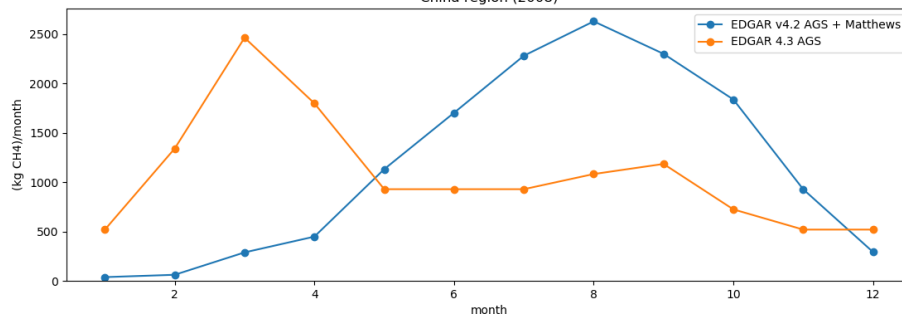
Inversion v17r1 increased amplitude of summer peak

EDGAR v4.2 AGS + Matthews (2008)

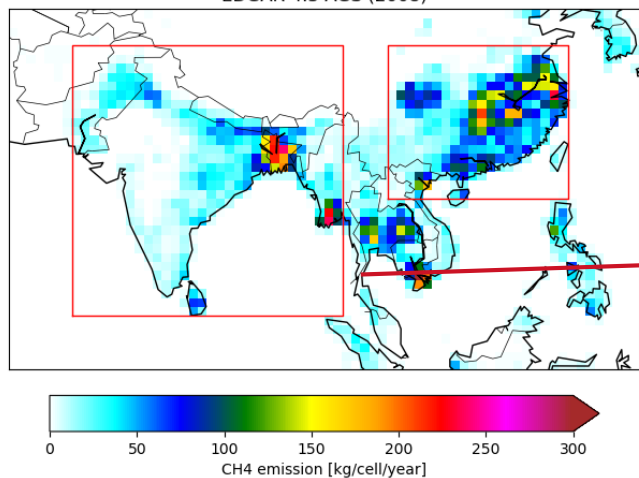


EDGAR v4.3: seasonal differences between China and India

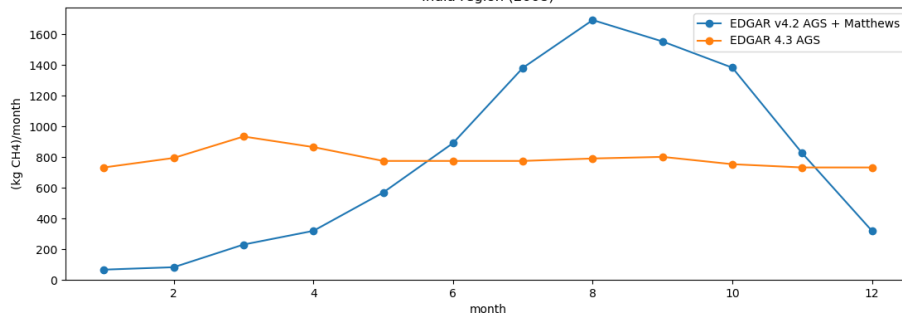
China region (2008)



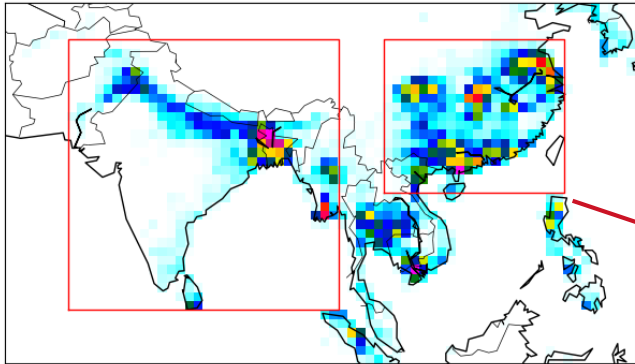
EDGAR 4.3 AGS (2008)



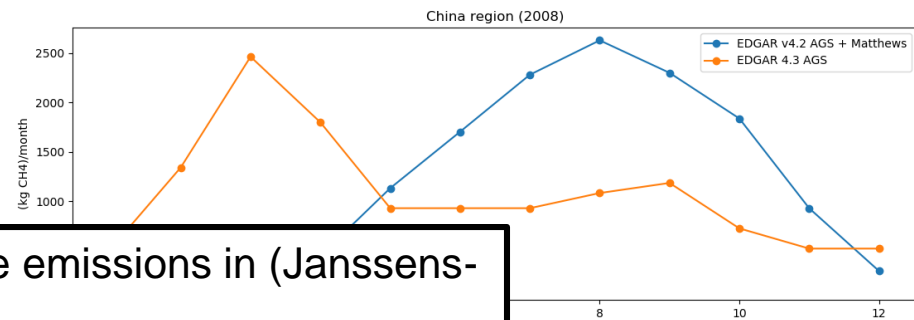
India region (2008)



EDGAR v4.2 AGS + Matthews (2008)



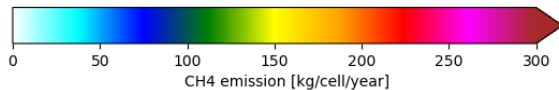
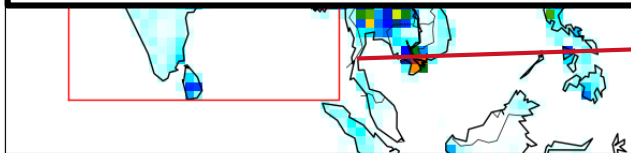
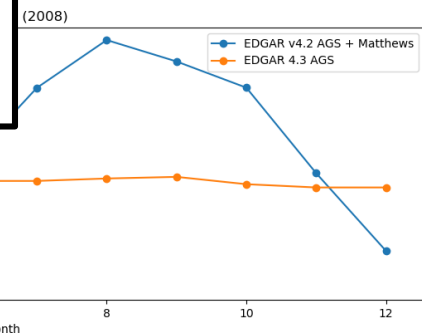
EDGAR v4.3: seasonal differences between China and India



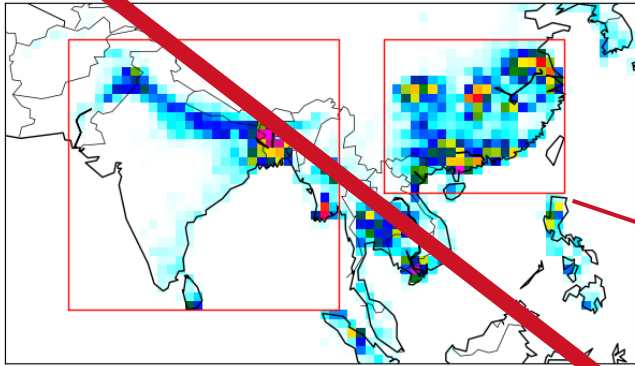
Remark on different seasonality in rice emissions in (Janssens-Maenhout, ESSD, 2019) :

together give much higher emissions than solid waste disposal. Rice cultivation contributes significantly to the total CH₄ inventory of China (21.5% or 14.2 Tg in 2012), which is almost 11 times the CH₄ emissions of rice cultivation in India (3.8 Tg), despite the larger area for rice fields in India than in China (425 compared to 303 thousand km²). This is explained by the fact that India typically has one harvest per year from 1/3 rain-fed fields and 2/3 irrigated fields, whereas China has multiple harvests per year from irrigated rice fields. Rain-fed rice fields in India are modelled with a five times lower emission factor than the irrigated fields in China. Figure 13a

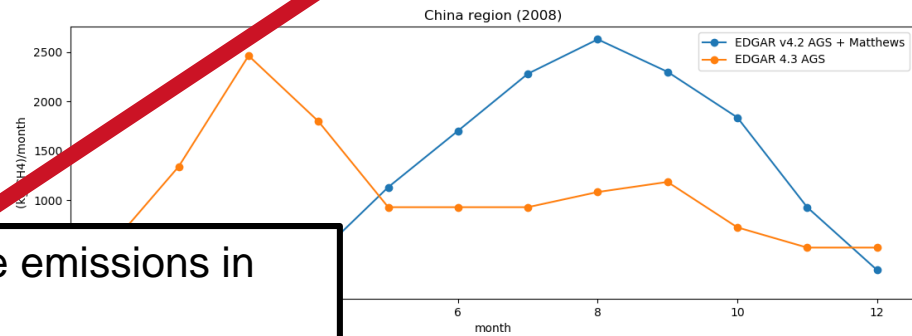
15



EDGAR v4.2 AGS + Matthews (2008)



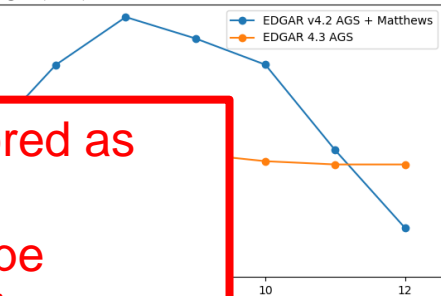
EDGAR v4.3: seasonal differences between China and India



Remark on different seasonality in rice emissions in (Janssens-Maenhout, ESSD, 2019):

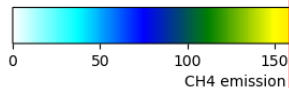
together give much higher emissions than solid waste disposal. Rice cultivation contributes significantly to the total CH₄ inventory of China (21.5% or 4.2 Tg in 2012), which is almost 11 times the CH₄ emissions of rice cultivation in India (3.8 Tg), despite the larger area for rice fields in India (225 compared to 303 thousand km²). This is explained by the fact that India typically has one harvest per year from rain-fed fields and 2/3 irrigated fields, whereas China has multiple harvests per year from irrigated rice fields. Rain-fed rice fields in India are modelled with a five times lower emission factor than the irrigated fields in China. Figure 13a

India region (2008)

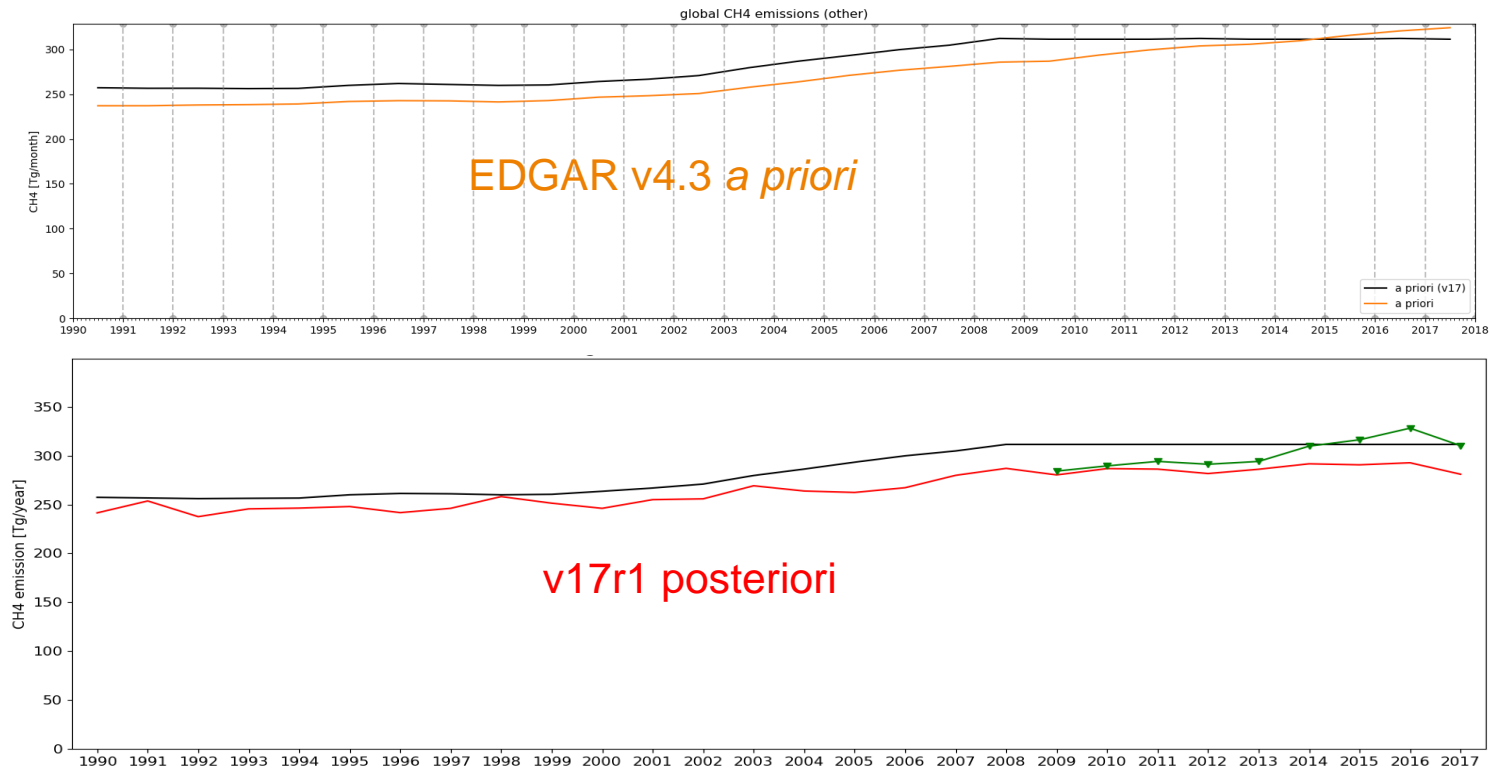


EDGAR 4.3 CH₄ "rice" emissions are stored as CH₄ "agricultural soils"; uses time profile for "Agriculture" in Europe (NH₃ emissions from manure application)

Use Matthews seasonal profile instead!

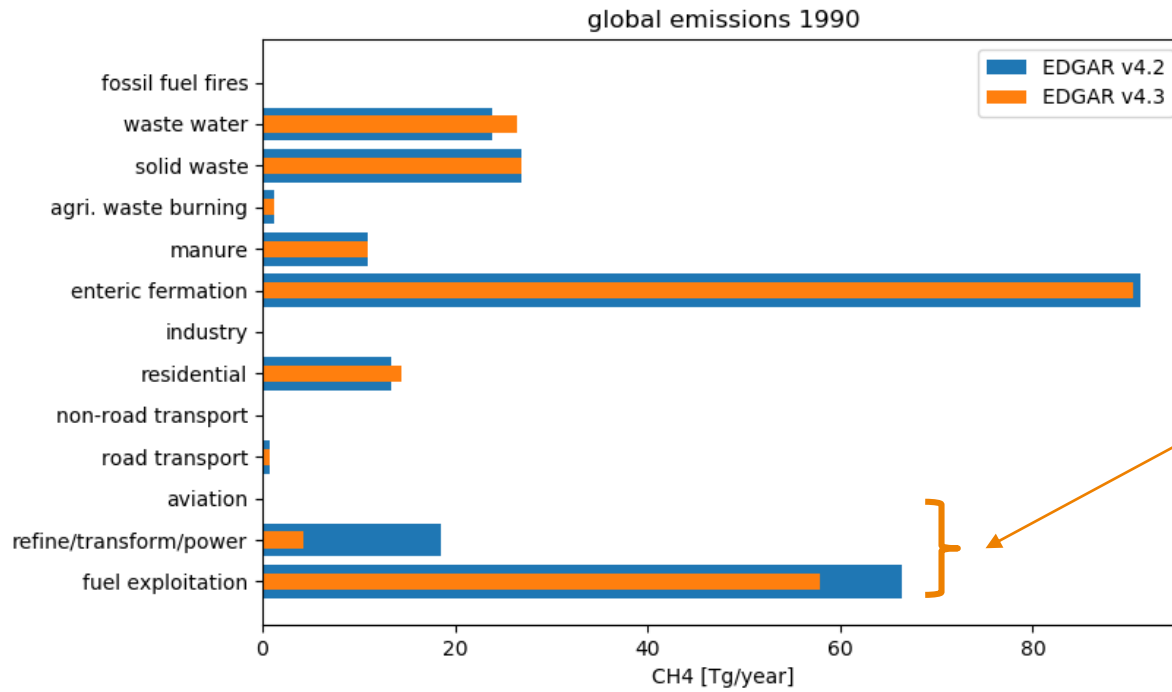


› Trend in "other" emissions (anthropogenic), global total:



Non-rice:
EDGAR v4.3 has
lower emissions
than EDGAR v4.2
(up to 2008)

Inversion v17r1
decreased emissions
too (over entire
period)

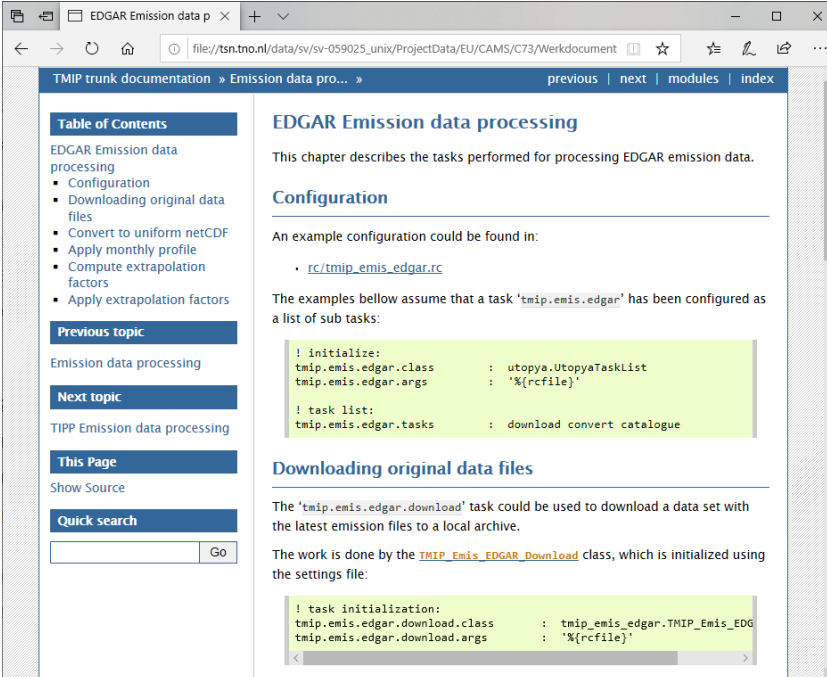


Lower emissions from energy sectors:

- power production
- less leakage from pipelines

CAMS CH4 INVERSION STATUS

- › Current production: v18r1 (1990-2018)
- › Updated *a priori* emissions:
 - › EDGAR 4.3
 - › *be careful with seasonal profiles!*
 - › ACCMIP and GFAS for fires
 - › LPJ/wsl for wetlands (Univ. Maryland)
- › *New emission processing tool*
 - › *format conversion*
 - › *add seasonal profiles*
 - › *extrapolation for recent years*
 - › ...



EDGAR Emission data processing

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EDGAR Emission data processing

This chapter describes the tasks performed for processing EDGAR emission data.

Configuration

An example configuration could be found in:

- [rc/tmp_emis_edgar.rc](#)

The examples below assume that a task 'tmp.emis.edgar' has been configured as a list of sub tasks:

```
! initialize:
tmp.emis.edgar.class      : utopya.UtopyaTaskList
tmp.emis.edgar.args      : '%{rcfile}'

! task list:
tmp.emis.edgar.tasks     : download convert catalogue
```

Downloading original data files

The 'tmp.emis.edgar.download' task could be used to download a data set with the latest emission files to a local archive.

The work is done by the `TMIP_Emis_EDGAR_Download` class, which is initialized using the settings file:

```
! task initialization:
tmp.emis.edgar.download.class      : tmp_emis_edgar.TMIP_Emis_EDG
tmp.emis.edgar.download.args      : '%{rcfile}'
```