TROPOMI CH4 inversions

Jacob van Peet

29th International TM5 meeting

Wageningen, 21-22 November 2019

VU VRIJE UNIVERSITEIT AMSTERDAM
Faculty of Science
Department of Earth Sciences
Earth and Climate Cluster

Outline

- CH4 inversions using TROPOMI data
- Vertical interpolation
- Horizontal merging
- Initial concentration
- Model runs
- Results
- Conclusions and Outlook

CH4 inversions using TROPOMI data

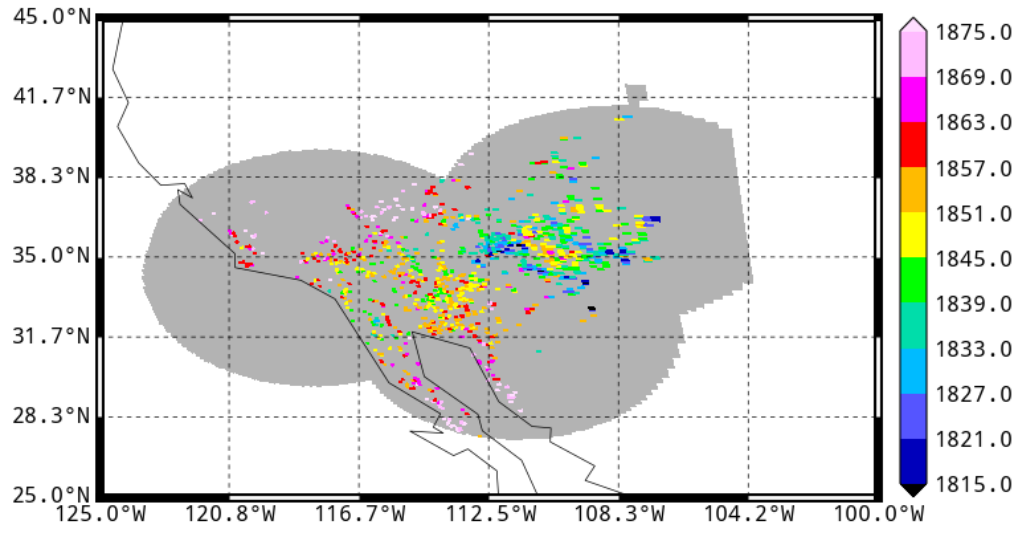
- CH4 measurements from TANSO on board GOSAT can be assimilated into TM5 using 4DVAR
- Using the existing code as a template, try to assimilate TROPOMI CH4 data into TM5
- 1st step: try to read and plot the data
- Two formats: “SRON R&D” and the official product, available from https://scihub.copernicus.eu/
  - The R&D format is "1D" (i.e. pixels are included sequentially), while the official format is "2D" (i.e. pixels are ordered in orbits on a lat/lon grid).

R&D

official

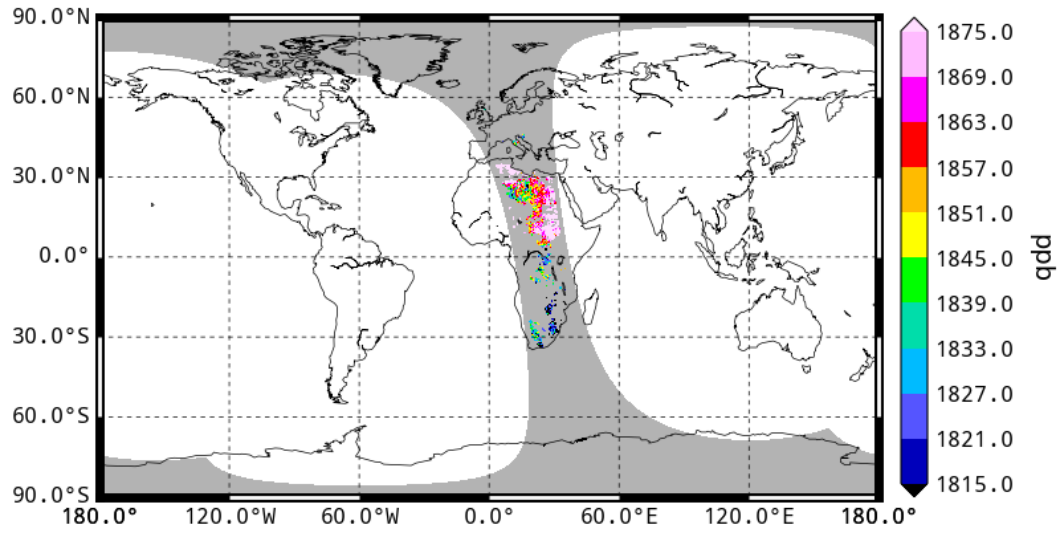
XCH4

file = s5p_l2_ch4_0301_04745.nc



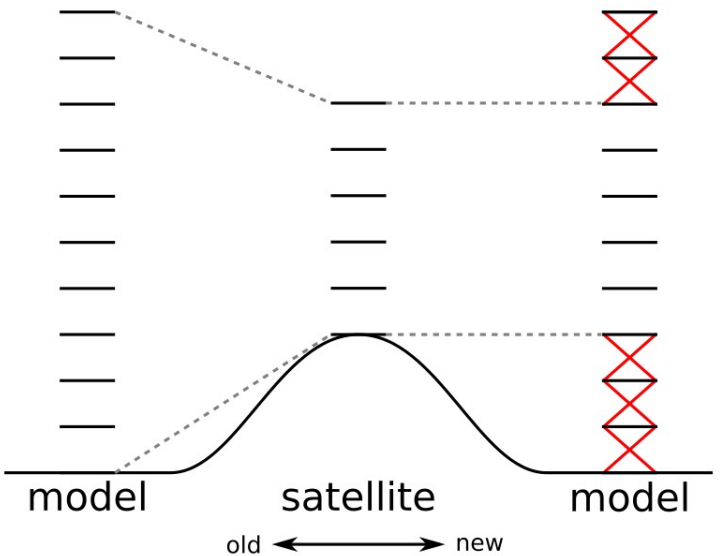
XCH4

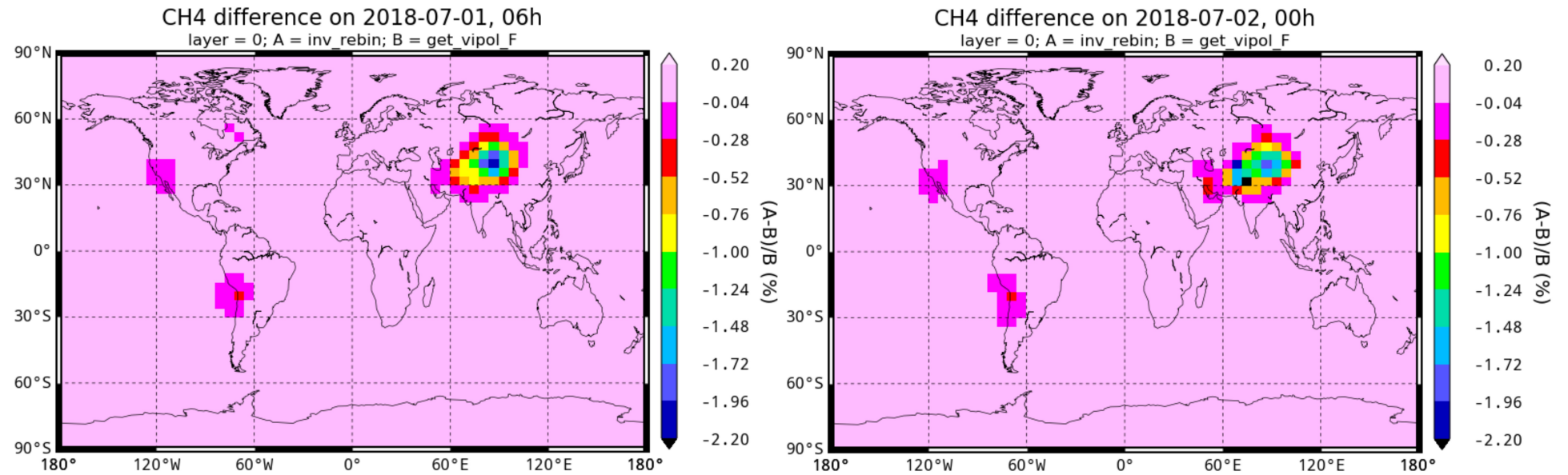
file = S5P_OFFL_L2__CH4____20190314T110140_20190314T124310_07336_01_010202_20190320T125906.nc



Vertical interpolation

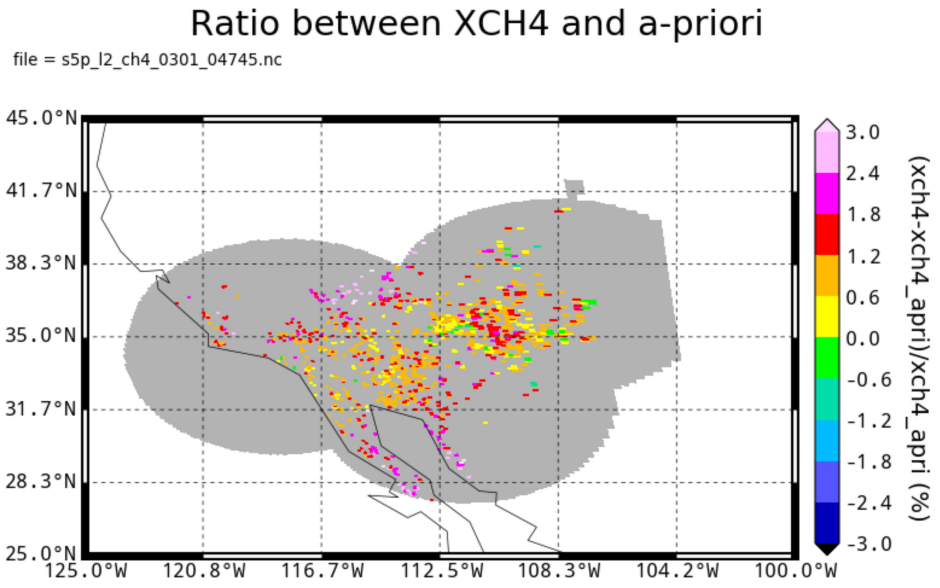
- old: "squeeze" model profile onto measurement grid, pressure levels are changed
- new: ignore model profile outside measurement grid, pressure levels are not changed

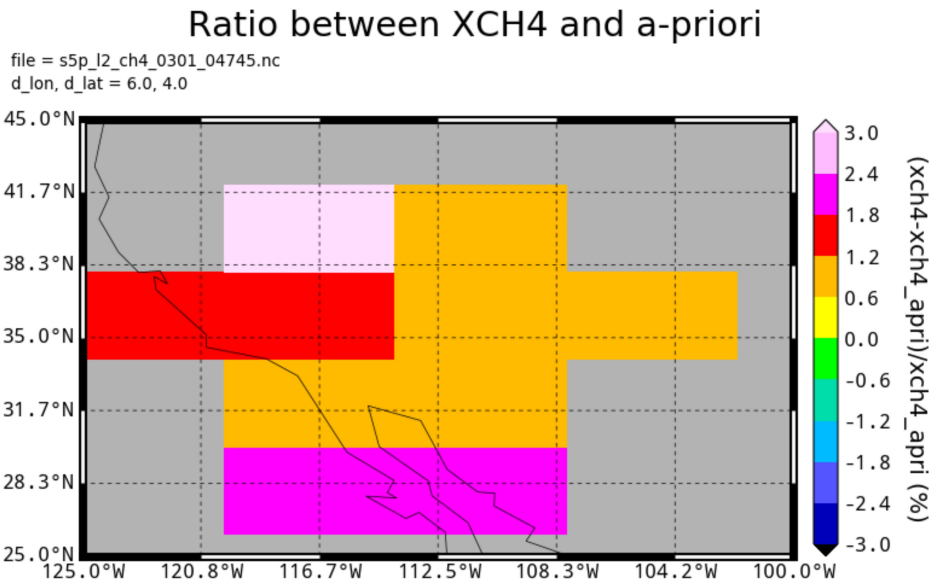


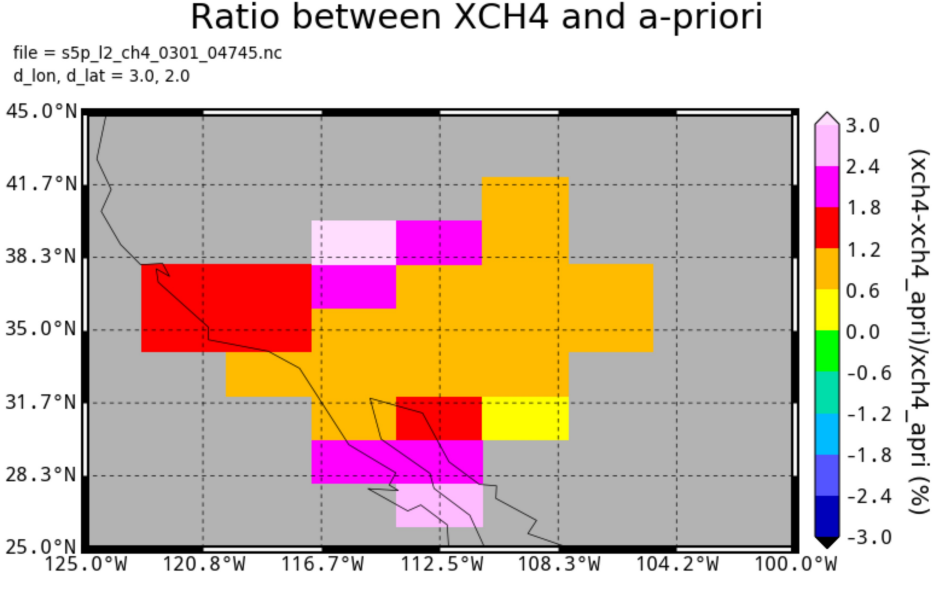

CH4 difference on 2018-07-01, 06h
layer = 0; A = inv_rebin; B = get_vipol_F
CH4 difference on 2018-07-02, 00h
layer = 0; A = inv_rebin; B = get_vipol_F
CH4 difference on 2018-07-01, 06h
layer = 24; A = inv_rebin; B = get_vipol_F
CH4 difference on 2018-07-02, 00h
layer = 24; A = inv_rebin; B = get_vipol_F
90°N
60°N
30°N
0°
30°S
60°S
90°S
180°
120°W
60°W
0°
60°E
120°E
180°
0.20
-0.04
-0.28
-0.52
-0.76
-1.00
-1.24
-1.48
-1.72
-1.96
-2.20
(A-B)/B (%)

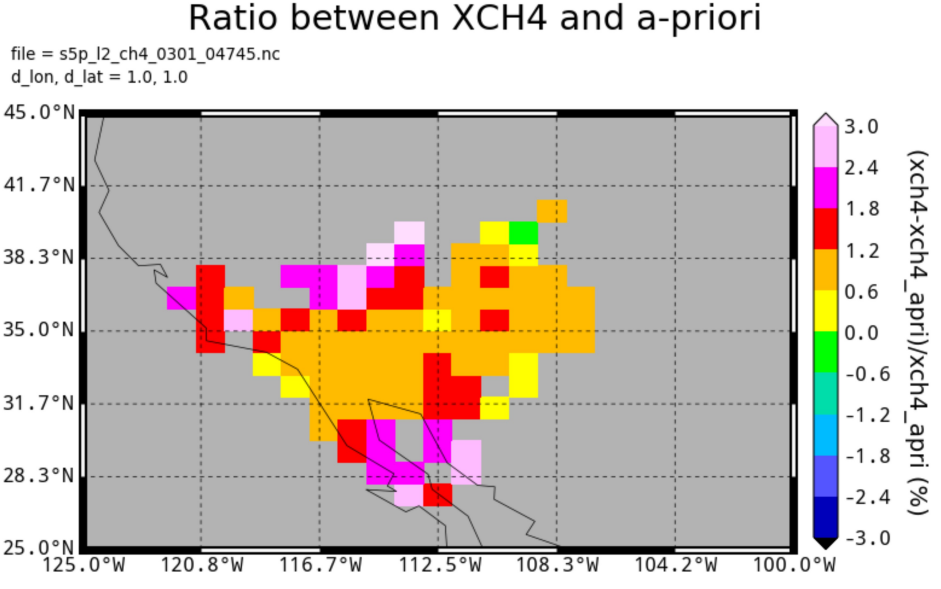
Horizontal merging

- Merge TROPOMI data on a regular grid
  - -180 <= lon < 180 and -90 <= lat < 90
- Take the weighted average of the relevant variables.✓
  - how to interpret the “mean AK”
- Select the median observation in the gridcell
  - Aki Tsuruta & Ella Kivimäki; FMI


Ratio between XCH4 and a-priori
file = s5p_l2_ch4_0301_04745.nc
45.0°N
41.7°N
38.3°N
35.0°N
31.7°N
28.3°N
25.0°N
125.0°W
120.8°W
116.7°W
112.5°W
108.3°W
104.2°W
100.0°W
3.0
2.4
1.8
1.2
0.6
0.0
-0.6
-1.2
-1.8
-2.4
-3.0
(xch4-xch4_apri)/xch4_apri (%)

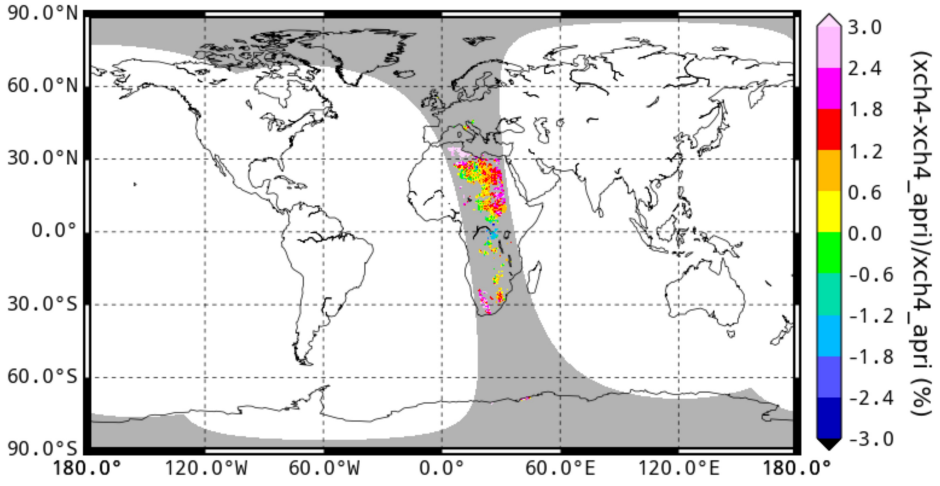

Ratio between XCH4 and a-priori
file = s5p_l2_ch4_0301_04745.nc
d_lon, d_lat = 6.0, 4.0
45.0°N
41.7°N
38.3°N
35.0°N
31.7°N
28.3°N
25.0°N
125.0°W
120.8°W
116.7°W
112.5°W
108.3°W
104.2°W
100.0°W
3.0
2.4
1.8
1.2
0.6
0.0
-0.6
-1.2
-1.8
-2.4
-3.0
(xch4-xch4_apri)/xch4_apri (%)


Ratio between XCH4 and a-priori
file = s5p_l2_ch4_0301_04745.nc
d_lon, d_lat = 3.0, 2.0
45.0°N
41.7°N
38.3°N
35.0°N
31.7°N
28.3°N
25.0°N
125.0°W
120.8°W
116.7°W
112.5°W
108.3°W
104.2°W
100.0°W
3.0
2.4
1.8
1.2
0.6
0.0
-0.6
-1.2
-1.8
-2.4
-3.0
(xch4-xch4_apri)/xch4_apri (%)


Ratio between XCH4 and a-priori
file = s5p_l2_ch4_0301_04745.nc
d_lon, d_lat = 1.0, 1.0
45.0°N
41.7°N
38.3°N
35.0°N
31.7°N
28.3°N
25.0°N
125.0°W
120.8°W
116.7°W
112.5°W
108.3°W
104.2°W
100.0°W
3.0
2.4
1.8
1.2
0.6
0.0
-0.6
-1.2
-1.8
-2.4
-3.0
(xch4-xch4_apri)/xch4_apri (%)

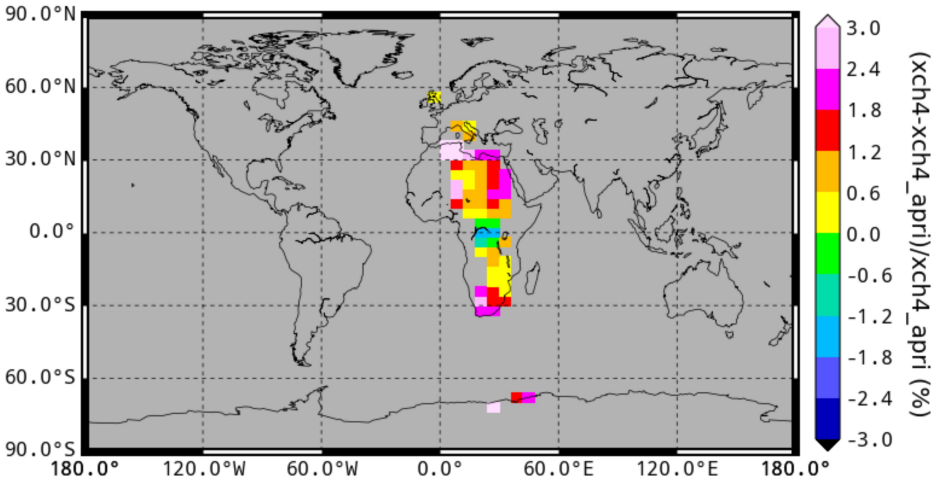
Ratio between XCH4 and a-priori

file = S5P_OFFL_L2__CH4____20190314T110140_20190314T124310_07336_01_010202_20190320T125906.nc



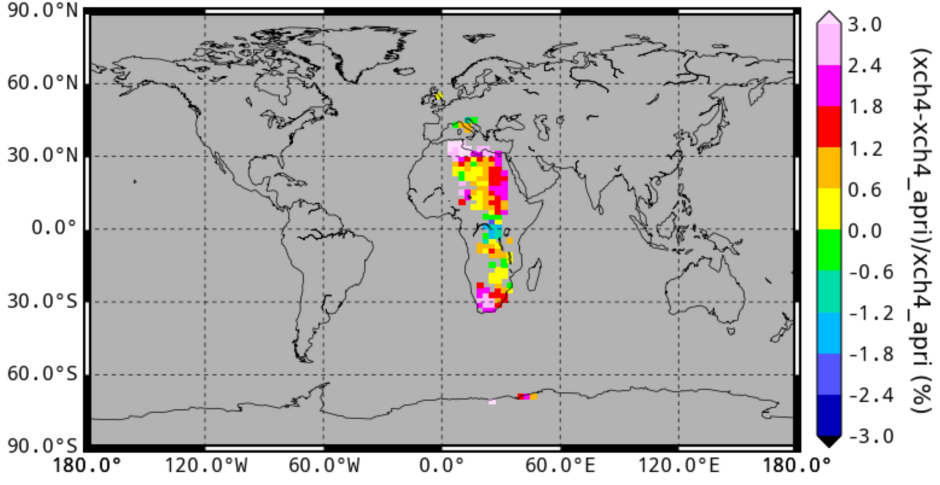
Ratio between XCH4 and a-priori

file = S5P_OFFL_L2__CH4____20190314T110140_20190314T124310_07336_01_010202_20190320T125906.nc
d_lon, d_lat = 6.0, 4.0



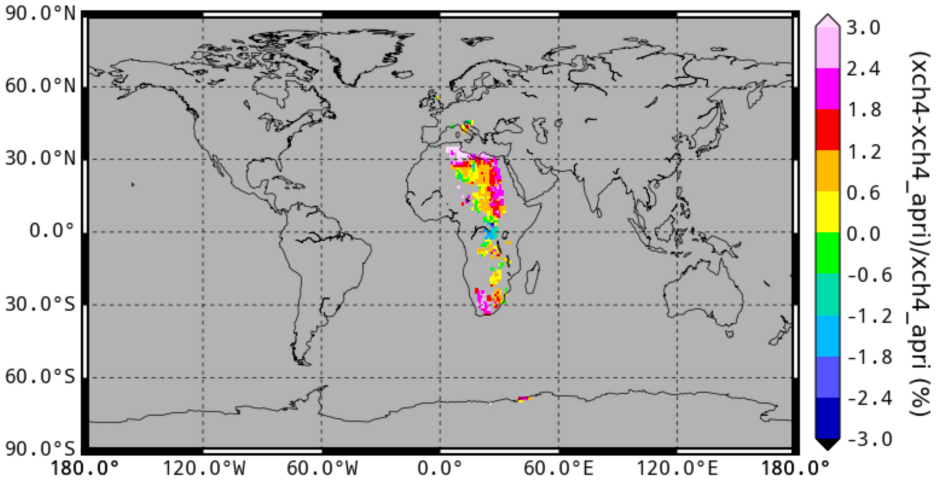
Ratio between XCH4 and a-priori

file = S5P_OFFL_L2__CH4____20190314T110140_20190314T124310_07336_01_010202_20190320T125906.nc
d_lon, d_lat = 3.0, 2.0



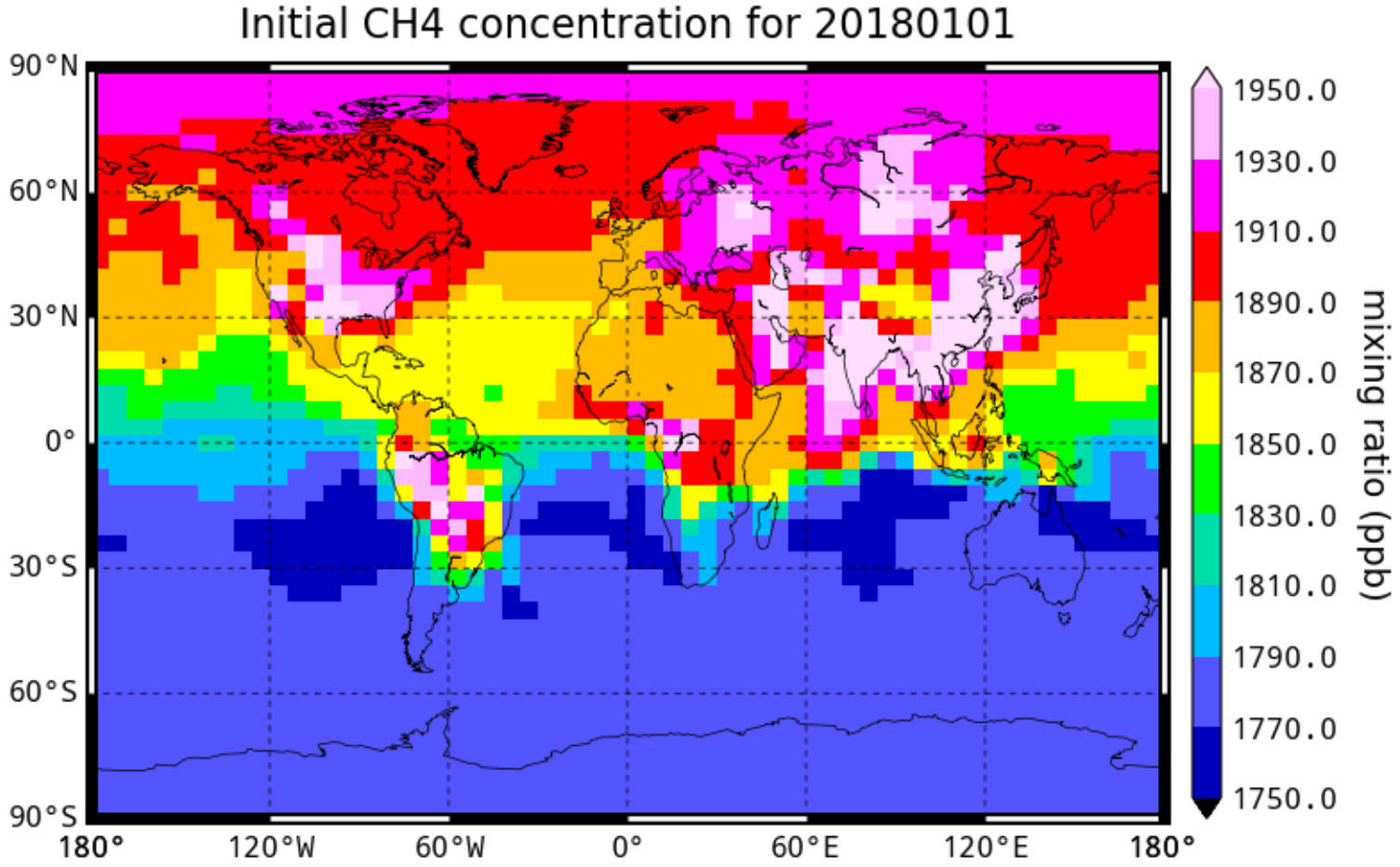
Ratio between XCH4 and a-priori

file = S5P_OFFL_L2__CH4____20190314T110140_20190314T124310_07336_01_010202_20190320T125906.nc
d_lon, d_lat = 1.0, 1.0



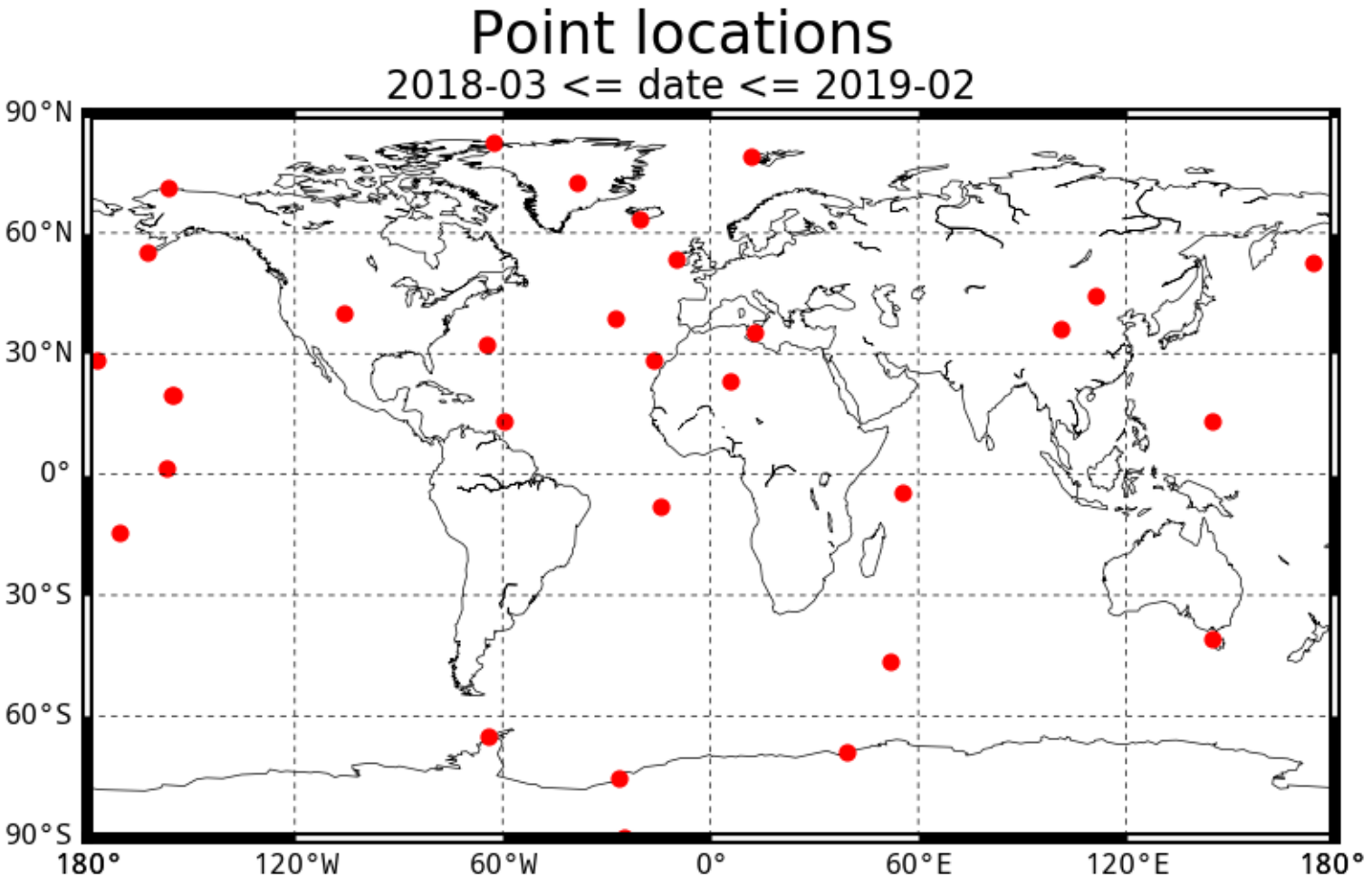
Initial concentration

- Updated by default in 4DVAR. To disable:
  - set the error to 0
  - remove initial concentration from the state vector ✓
- Use a mean mix file from the CAMS dataset and convert it to an initial concentration file
  - v18r1-c73-S1-A-model-mmix_glb600x400_20180101.hdf
  - provided by Arjo Segers


Initial CH4 concentration for 20180101
90°N
60°N
30°N
0°
30°S
60°S
90°S
180°
120°W
60°W
0°
60°E
120°E
180°
1950.0
1930.0
1910.0
1890.0
1870.0
1850.0
1830.0
1810.0
1790.0
1770.0
1750.0
mixing ratio (ppb)

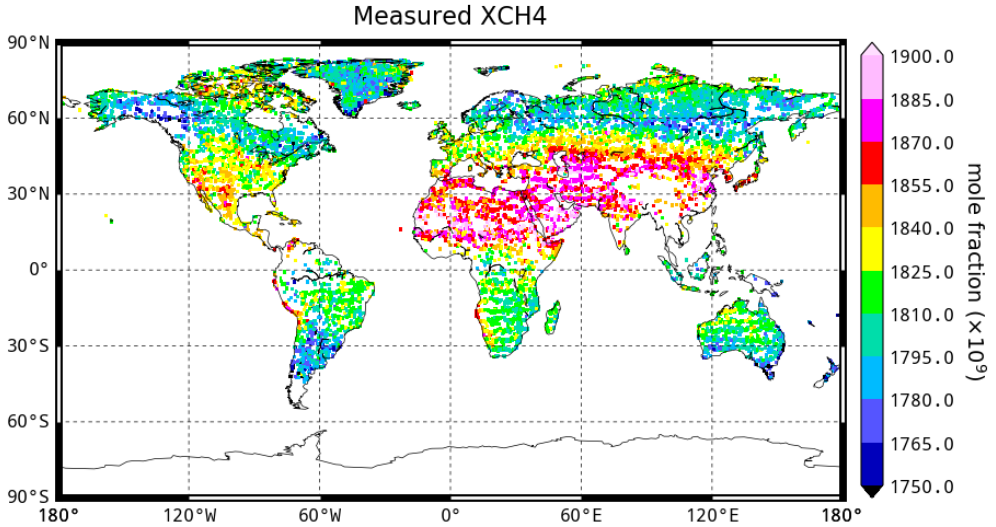
Model runs

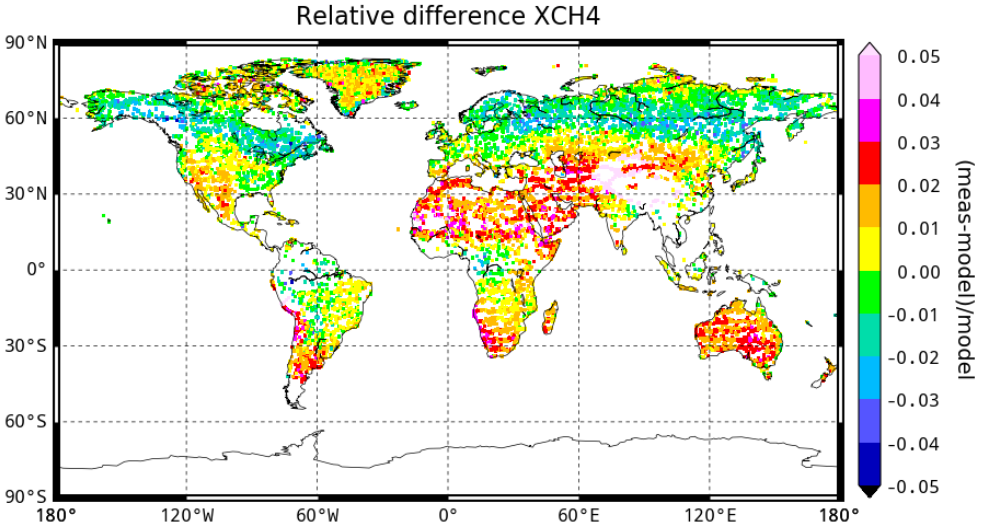
- With surface measurements only
  - data provided by Arjo Segers
  - c73-S1-A-years-2018-INPUT-point_input.nc4
- With TROPOMI CH4 measurements only
  - new vertical interpolation
  - horizontal merging on 6 x 4 degrees
- 4 sources: biomass burning, rice, wetlands, and other
- Maximum of 10 iterations due to time constraints for this meeting
- Model runs from 1-1-2018 till 1-5-2019
- Analyse from 1-3-2019 till 1-3-2019

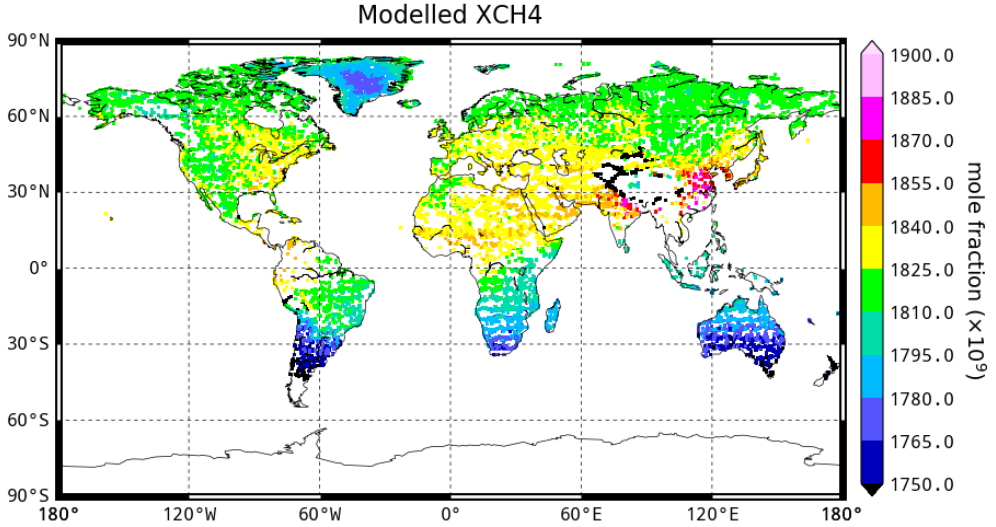

Point locations
2018-03 <= date <= 2019-02
90°N
60°N
30°N
0°
30°S
60°S
90°S
180°
120°W
60°W
0°
60°E
120°E
180°

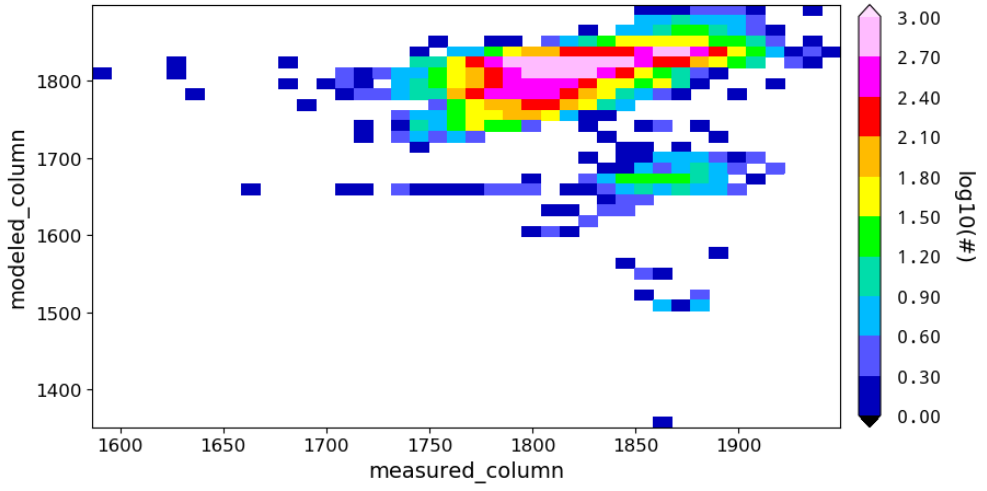
run id = 20191115-tm5_sf-1y_sat_only-merge_6x4

date = 201806, iter = iter-0001



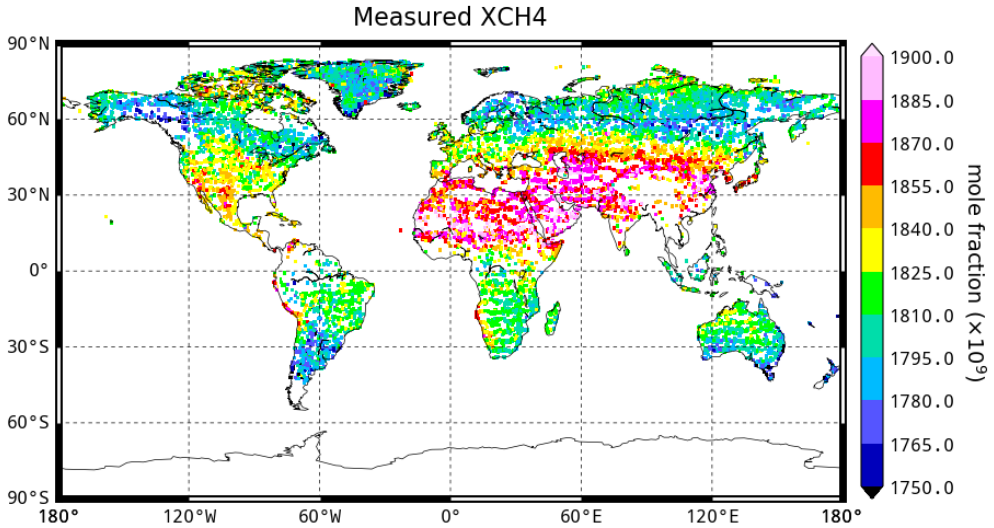


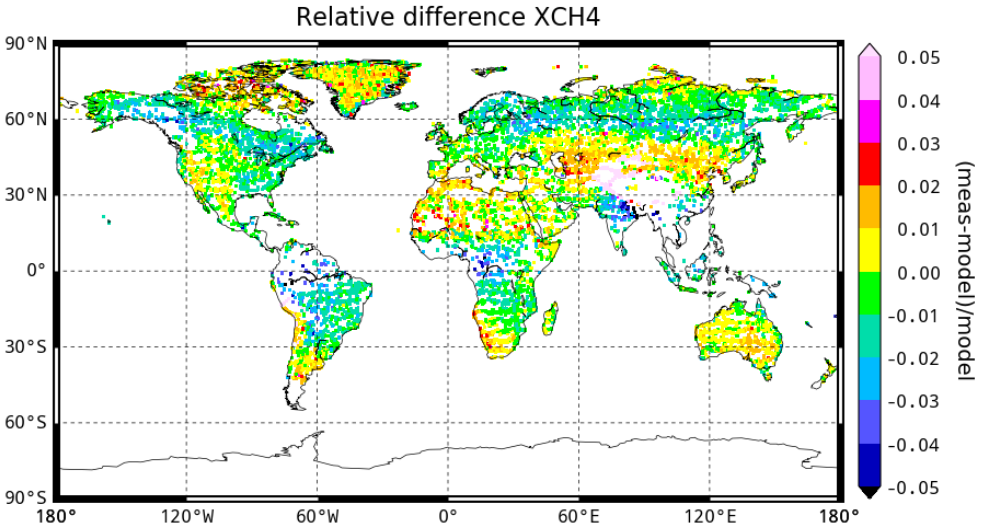


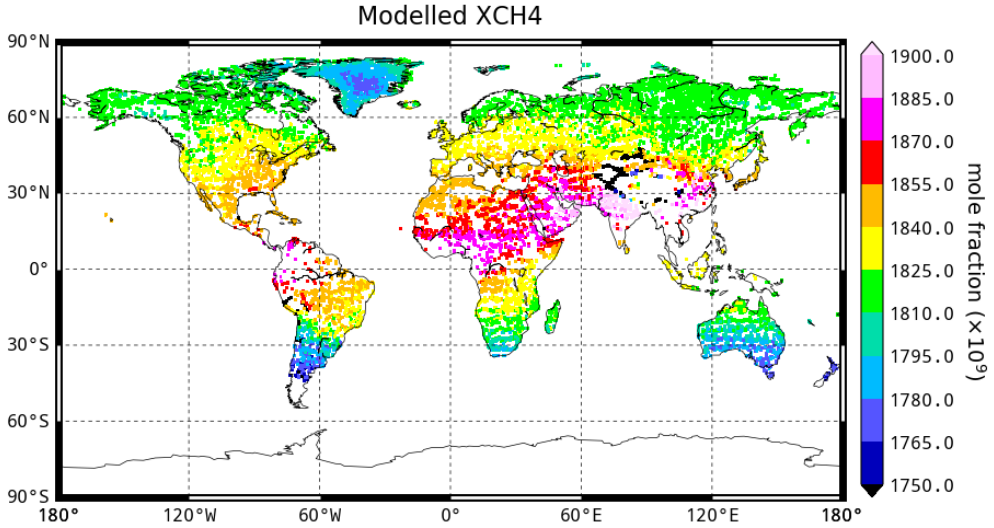


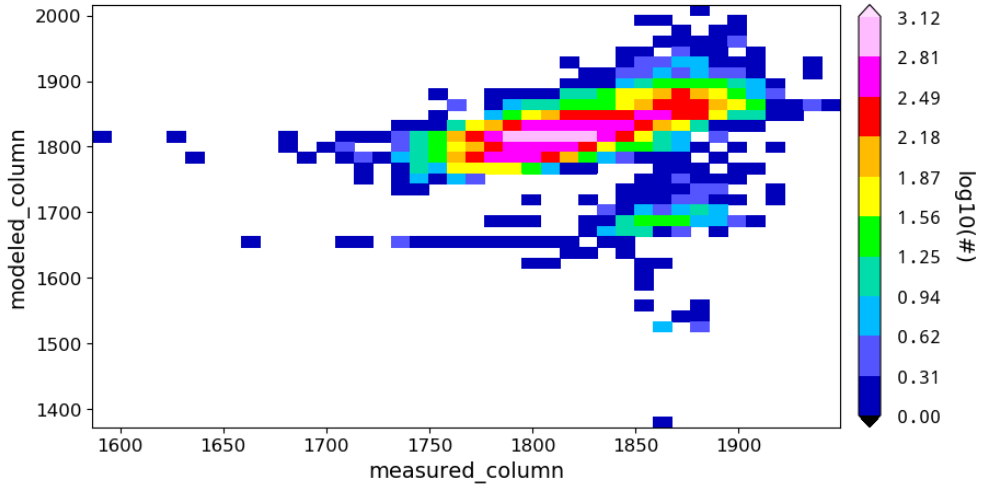
run id = 20191115-tm5_sf-1y_sat_only-merge_6x4

date = 201806, iter = iter-0010



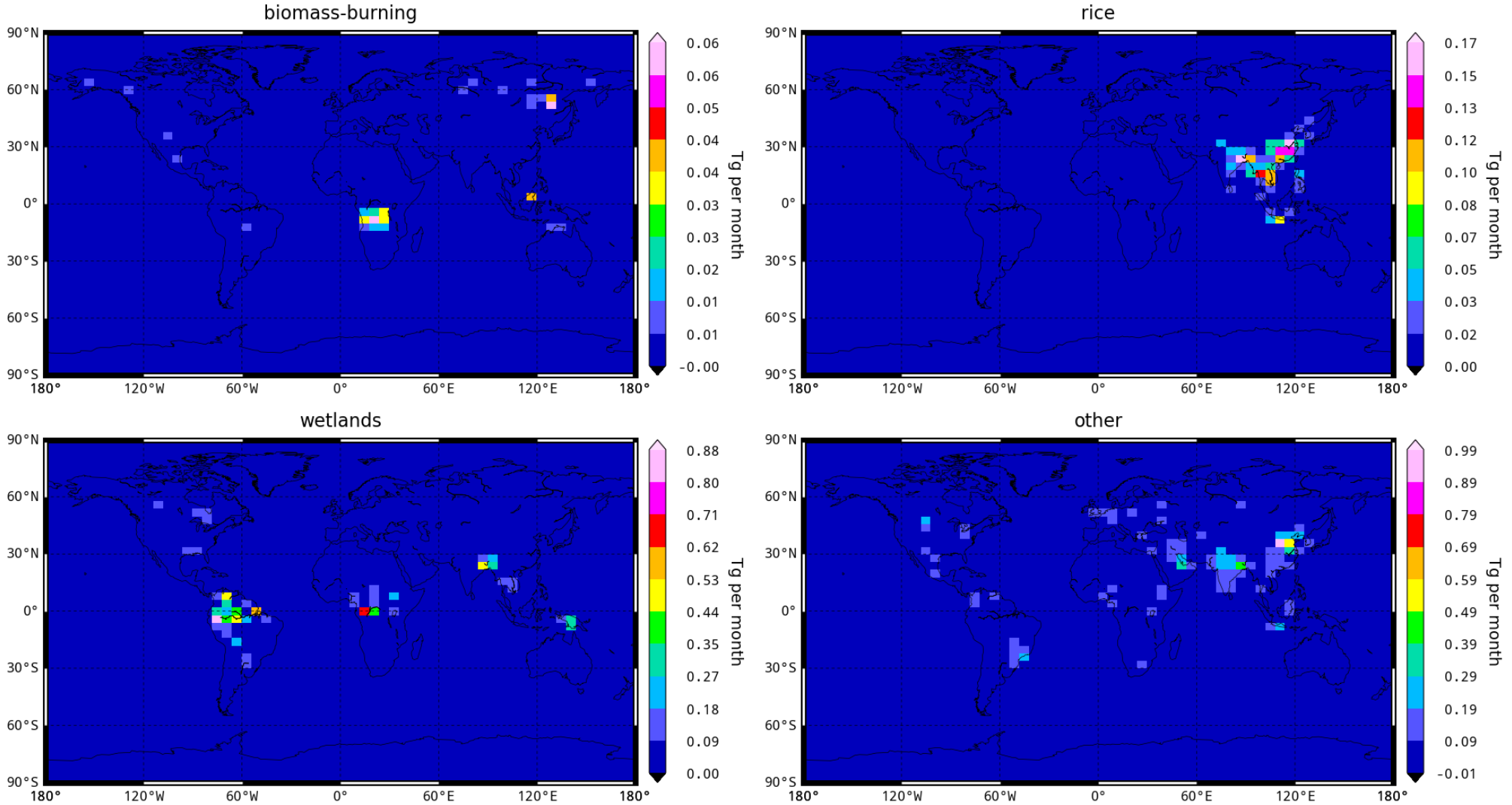






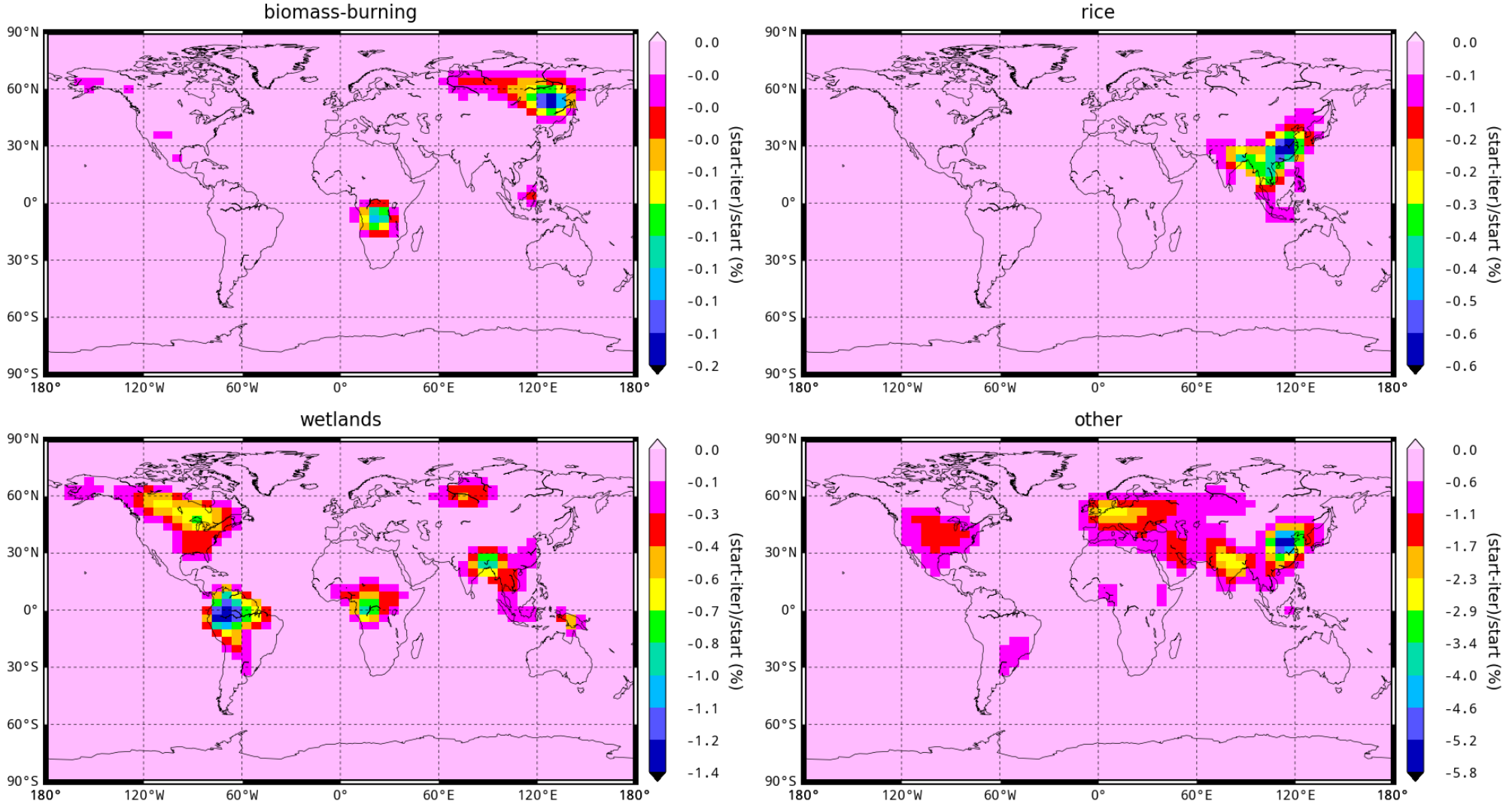
CH4 emission for different sources

date = 201806; run id = 20191114-tm5_sf-1y_points_only



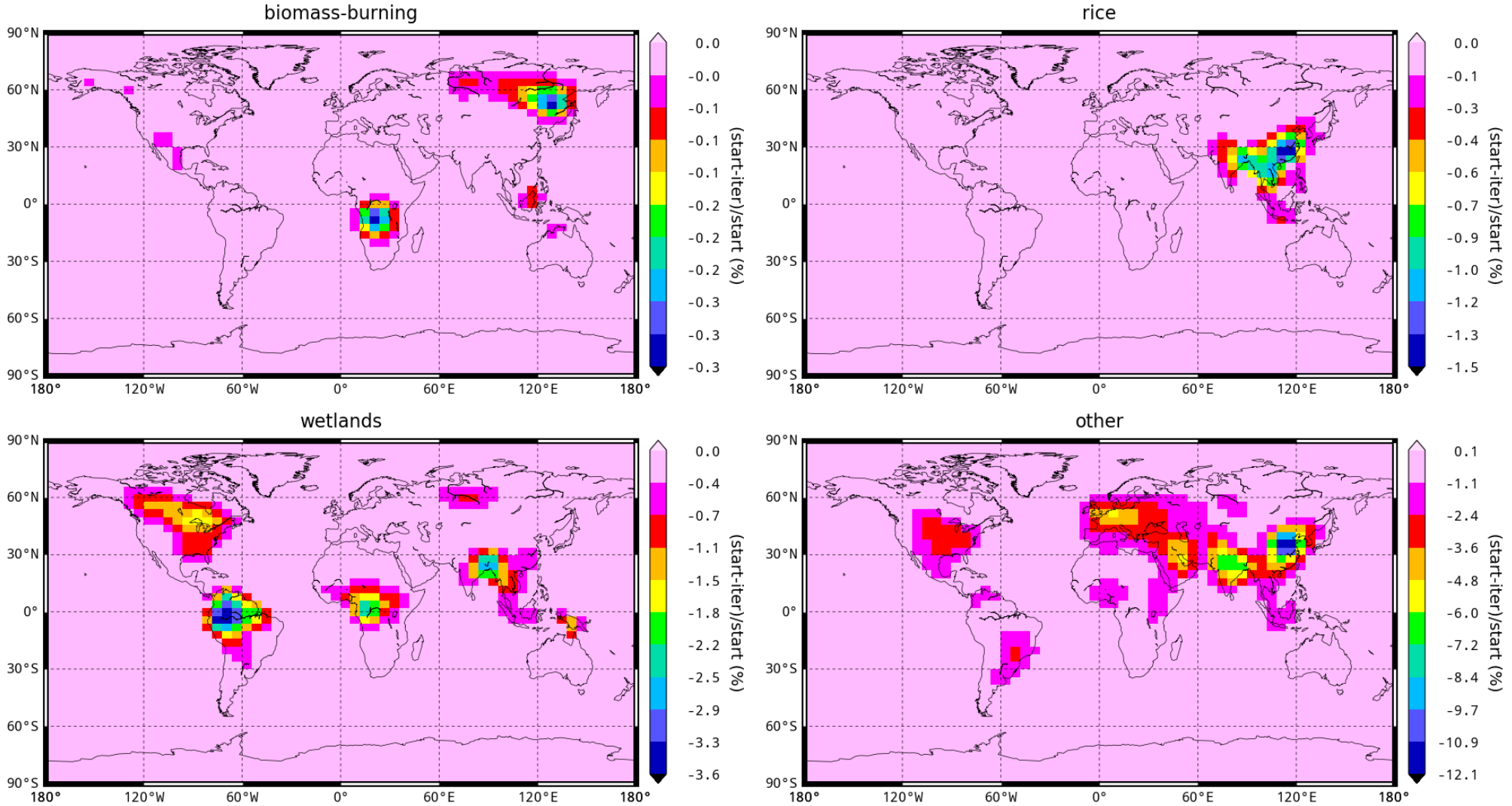
Relative difference in CH4 emission for different sources

date = 201806; i_iter = iter-0001; run id = 20191114-tm5_sf-1y_points_only



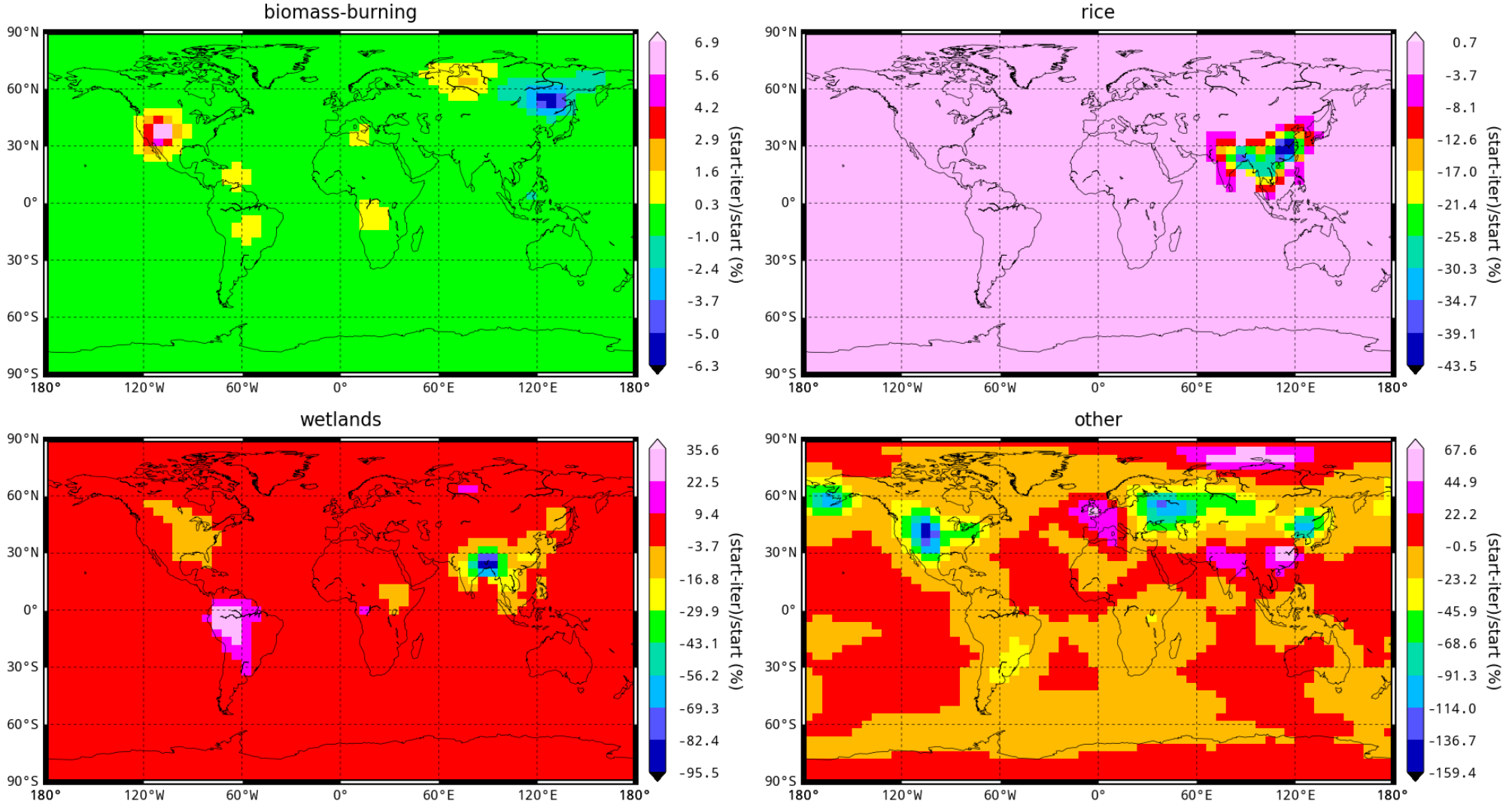
Relative difference in CH4 emission for different sources

date = 201806; i_iter = iter-0001; run id = 20191115-tm5_sf-1y_sat_only-merge_6x4



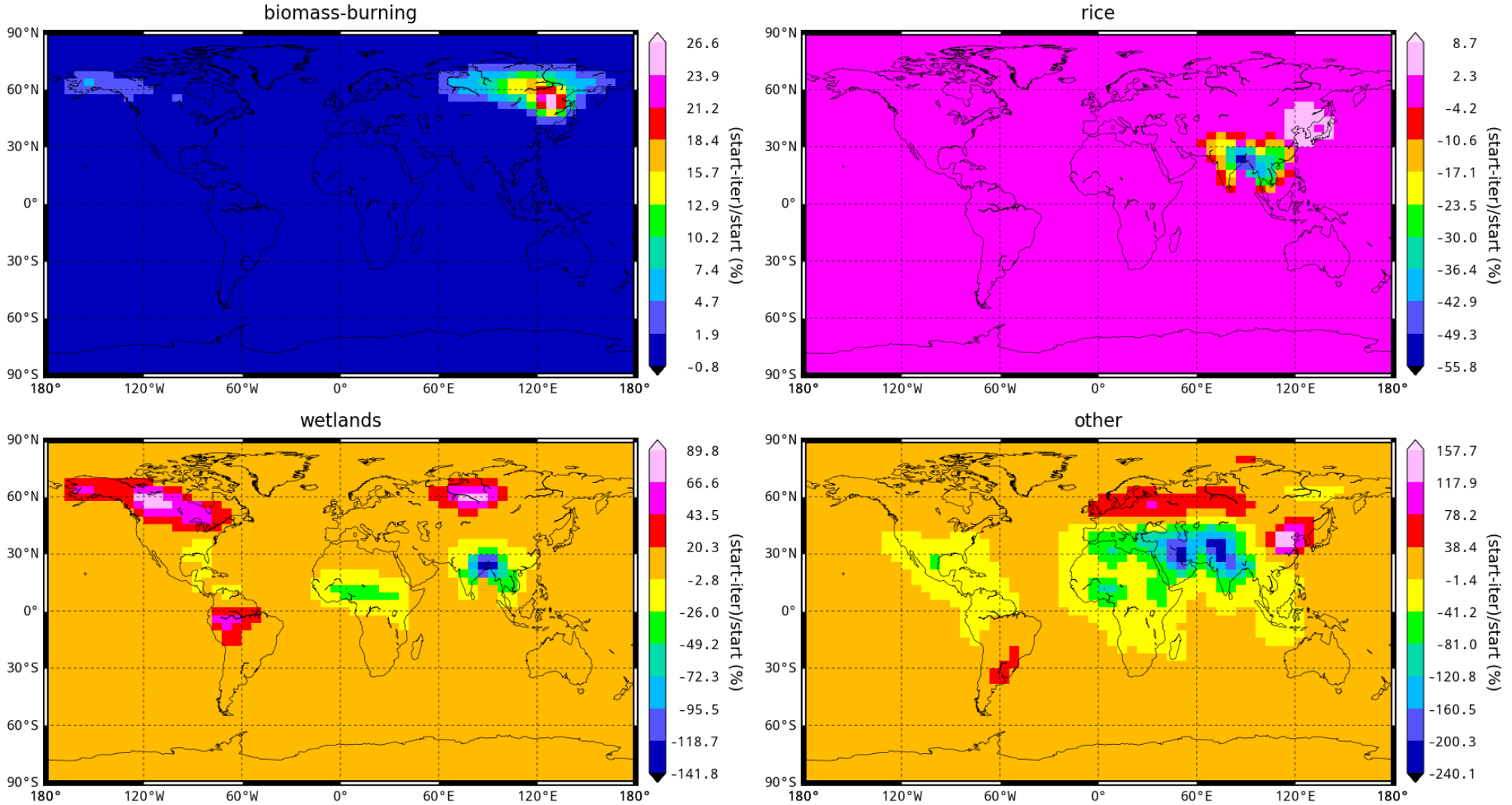
Relative difference in CH4 emission for different sources

date = 201806; i_iter = iter-0010; run id = 20191114-tm5_sf-1y_points_only



Relative difference in CH4 emission for different sources

date = 201806; i_iter = iter-0010; run id = 20191115-tm5_sf-1y_sat_only-merge_6x4



Conclusions and outlook

- The TM5 4DVAR model has been run succesfully on a global scale for a year:
  - with point observations
  - with TROPOMI observations
- After 10 iterations, emission updates show different patterns
- To do:
  - validate with independent measurements (TCCON, stations)
  - check model and measurement uncertainties
  - combined point and satellite assimilation
  - increase maximum number of iterations
  - increase resolution to 3x2 and 1x1 (lon x lat)