Recent changes in global CH_4 emissions constrained by TROPOMI and IASI data

Sander Houweling (VUA/SRON), Jacob van Peet (VUA), Tonatiuh Nunez Ramirez (MPI-BGC), Julia Marshall (DLR), Ilse Aben (SRON), Michael Buchwitz (iUP), Cyril Crevoisier (LMD), Tobias Borsdorff (SRON), Alba Lorente Delgado (SRON), Richard van Hees (SRON), Brian Kerridge (RAL), Diane Knappett (RAL), Nicolas Meilhac (LMD), Christian Retscher (ESA), Oliver Schneising (iUP), Richard Siddans (RAL), Steffen Vanselow (iUP), Lucy Ventress (RAL)

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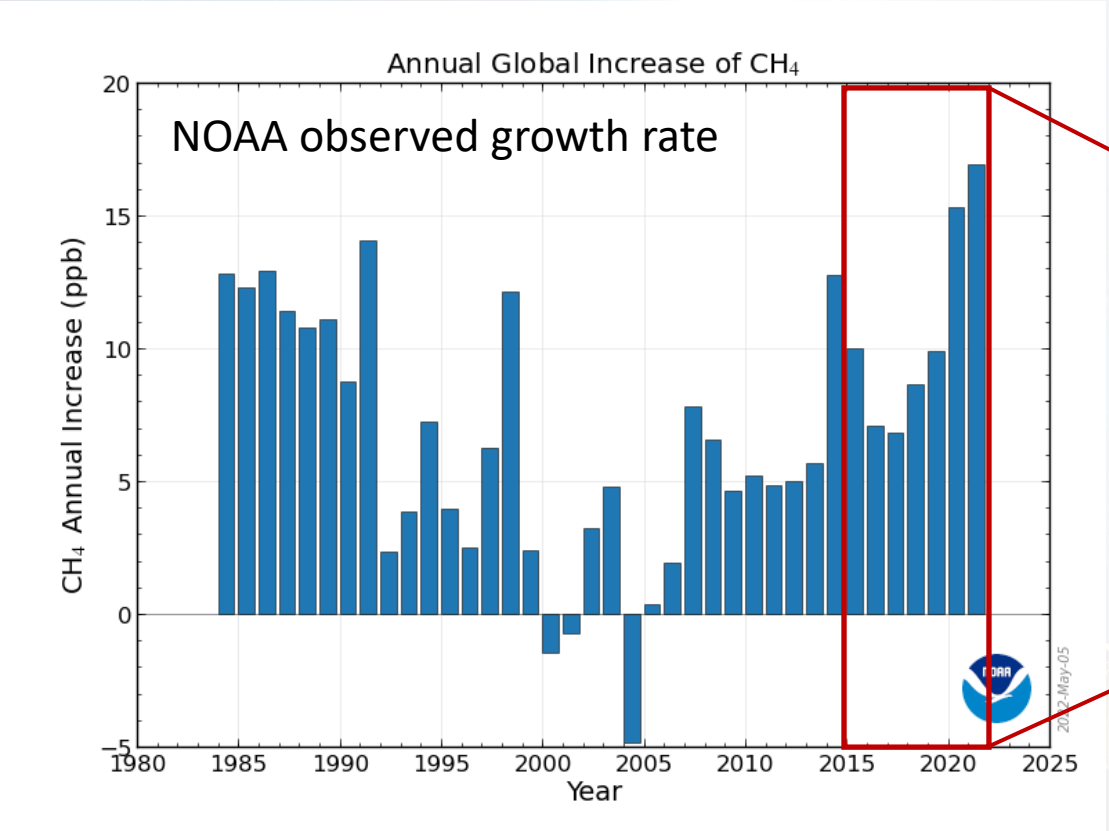
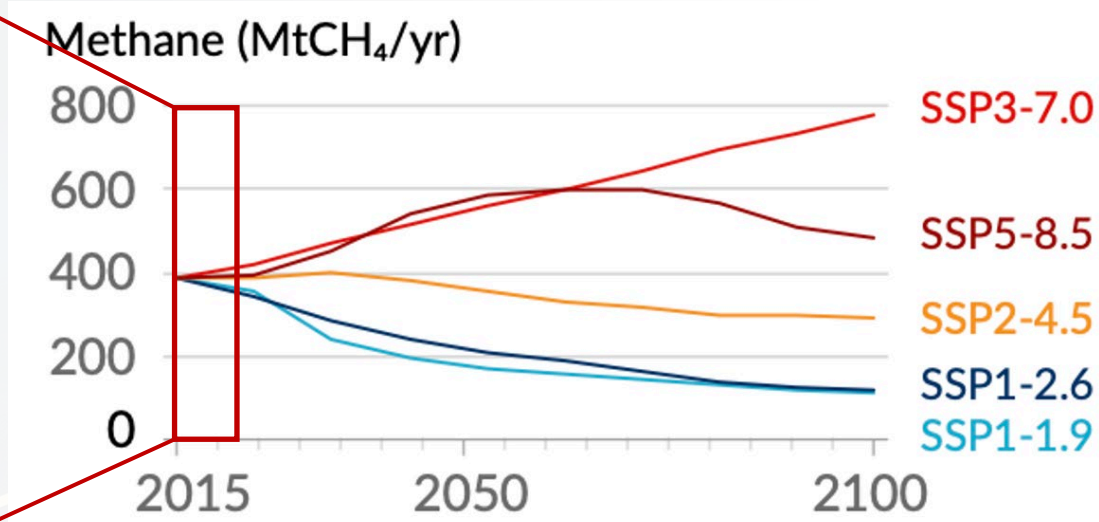
CH_4 growth rate & progress towards Paris goals



IPCC AR6 Methane scenarios



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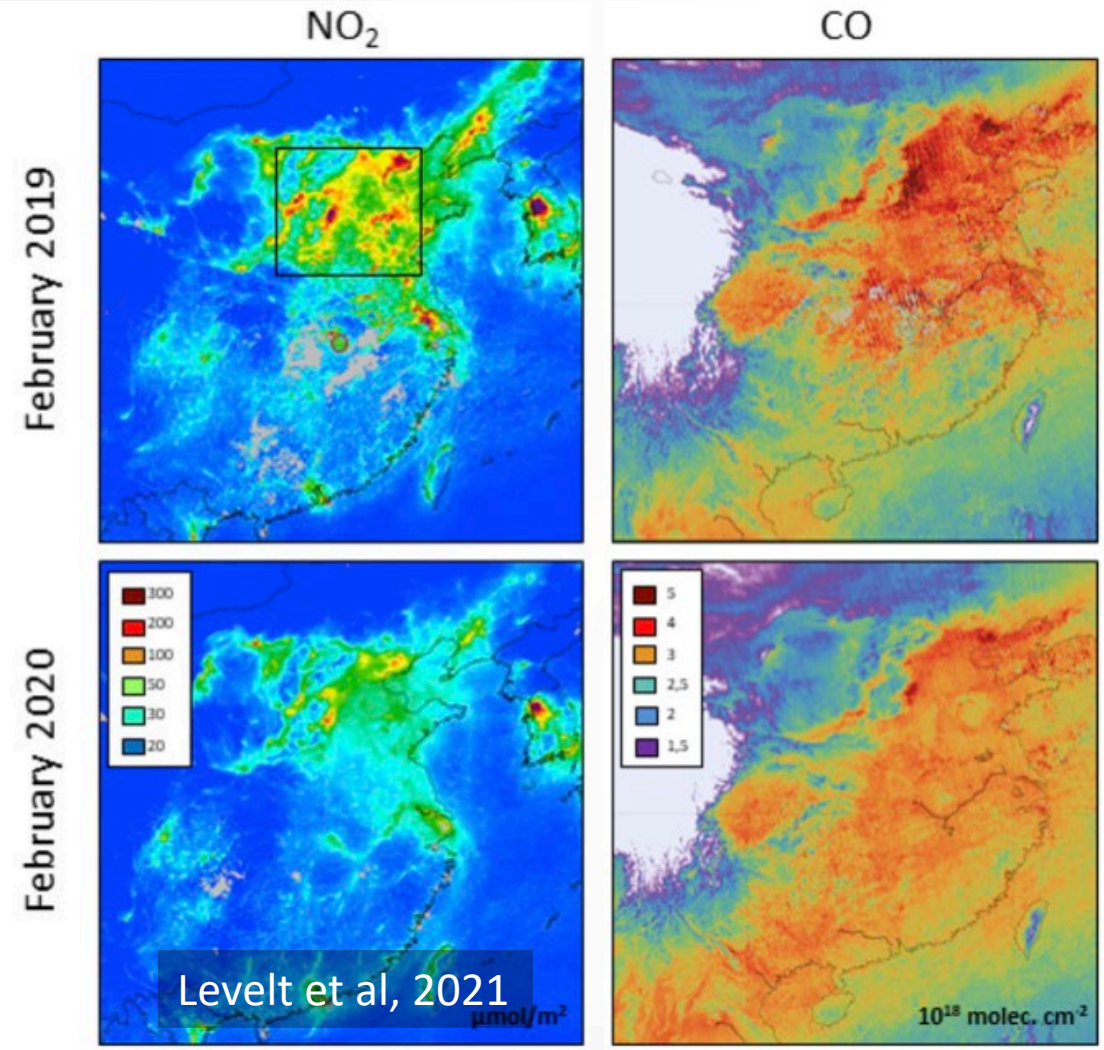
COVID-19 & atmospheric composition

- Shift in the NO_2/CO emission balance
- Possible impact on global OH

Stevenson et al (2021):

sufficient to explain the recent CH_4 growth

⇒ Atmospheric monitoring is essential, as emission inventories alone are insufficient to keep track of methane!



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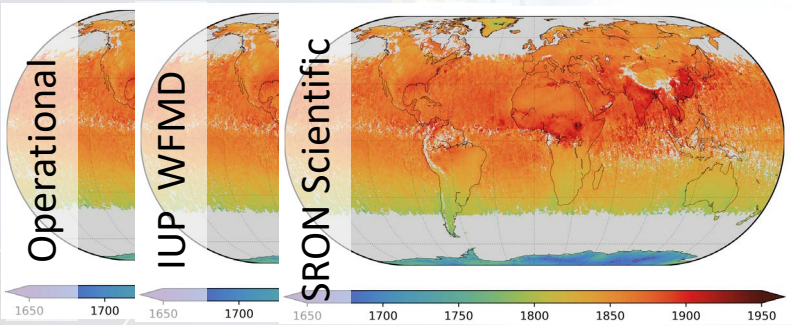
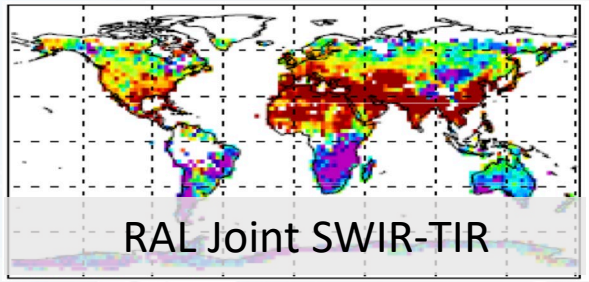
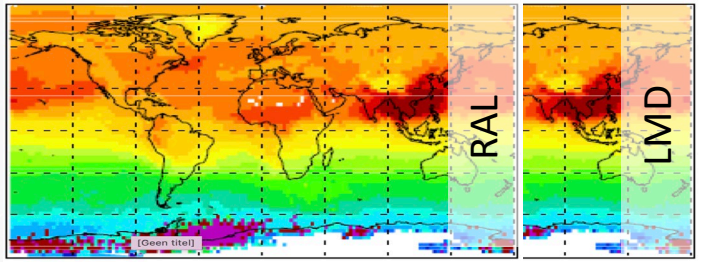
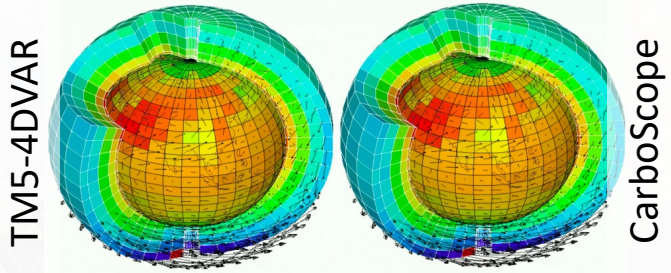
L2



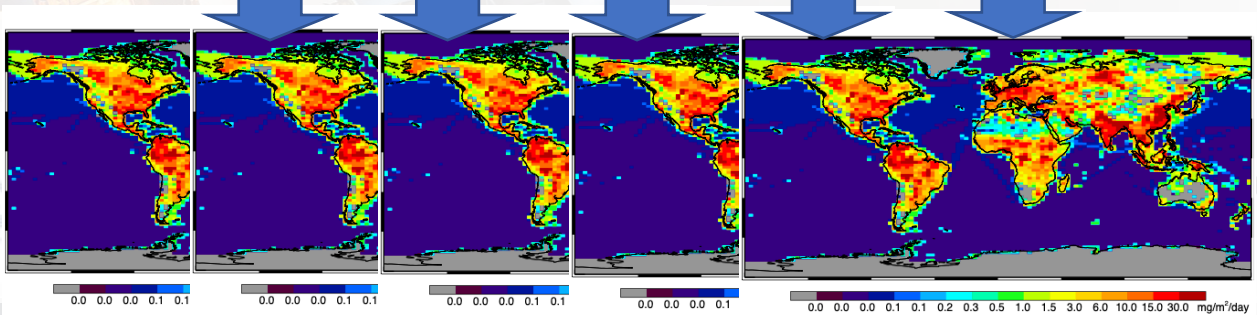




L2



L4



L4

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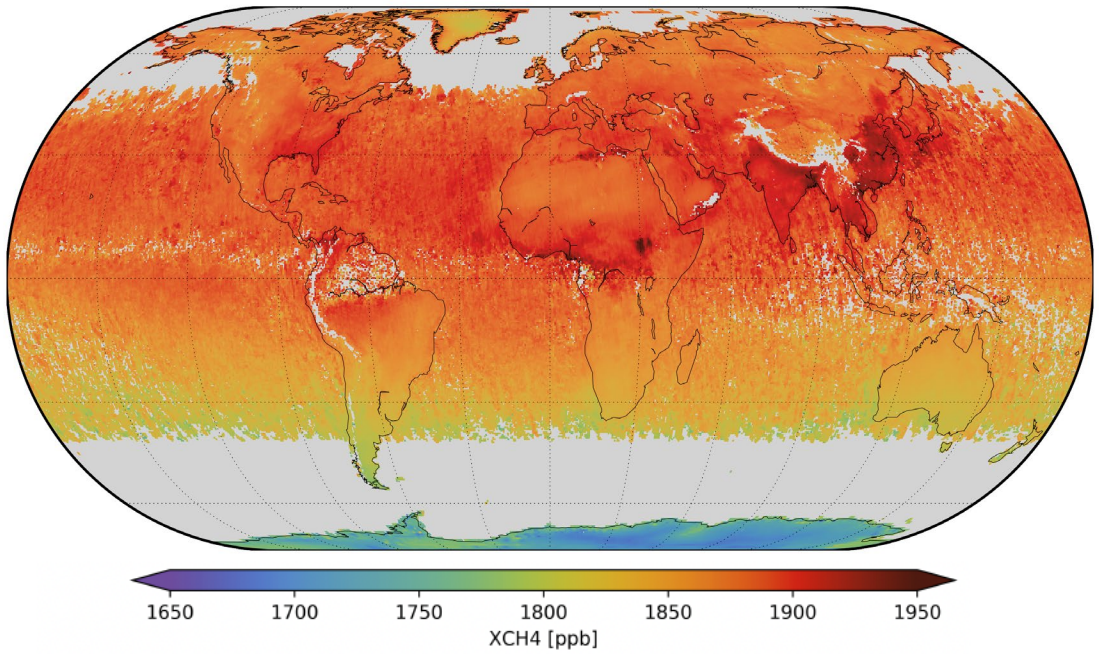
Methane+ retrieval: TROPOMI

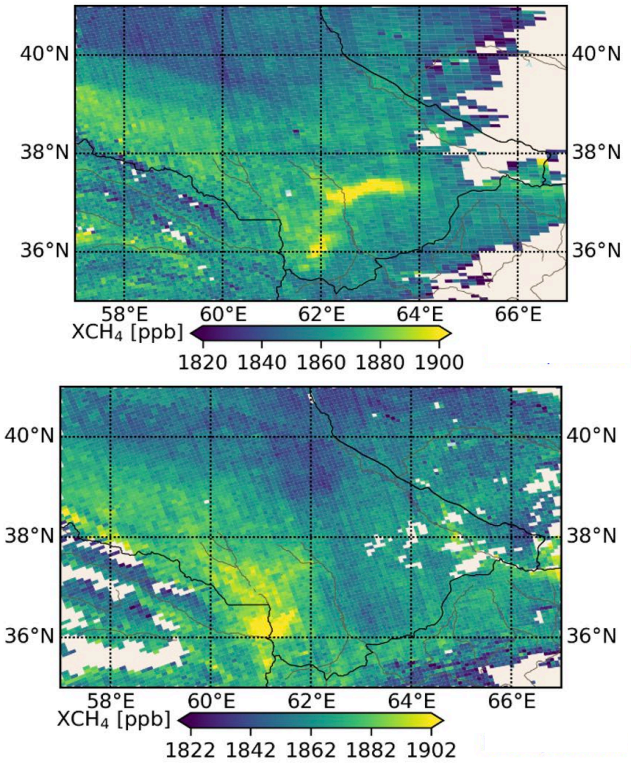
Retrieval developments => improved coverage

SRON Scientific sun glint retrieval

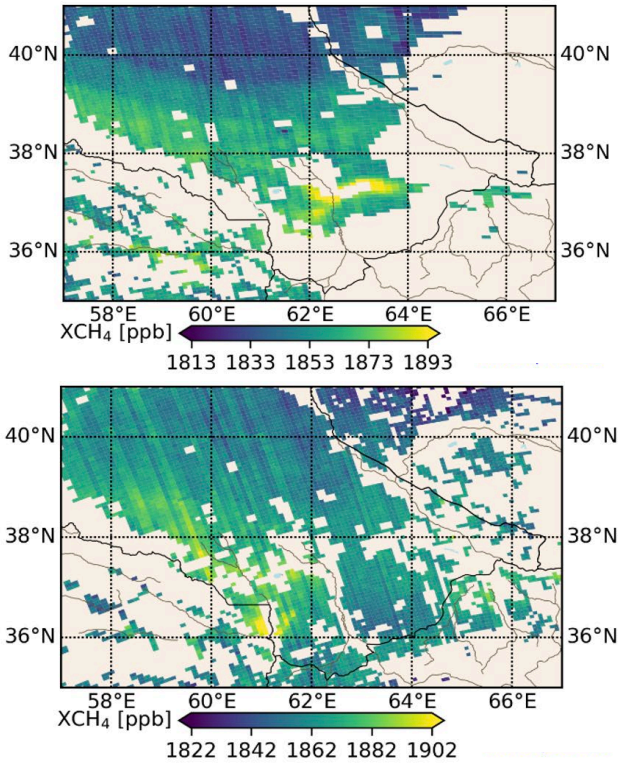
2021 mean XCH_4



WFMD v1.2



Operational (v14_14; qa>0.5)



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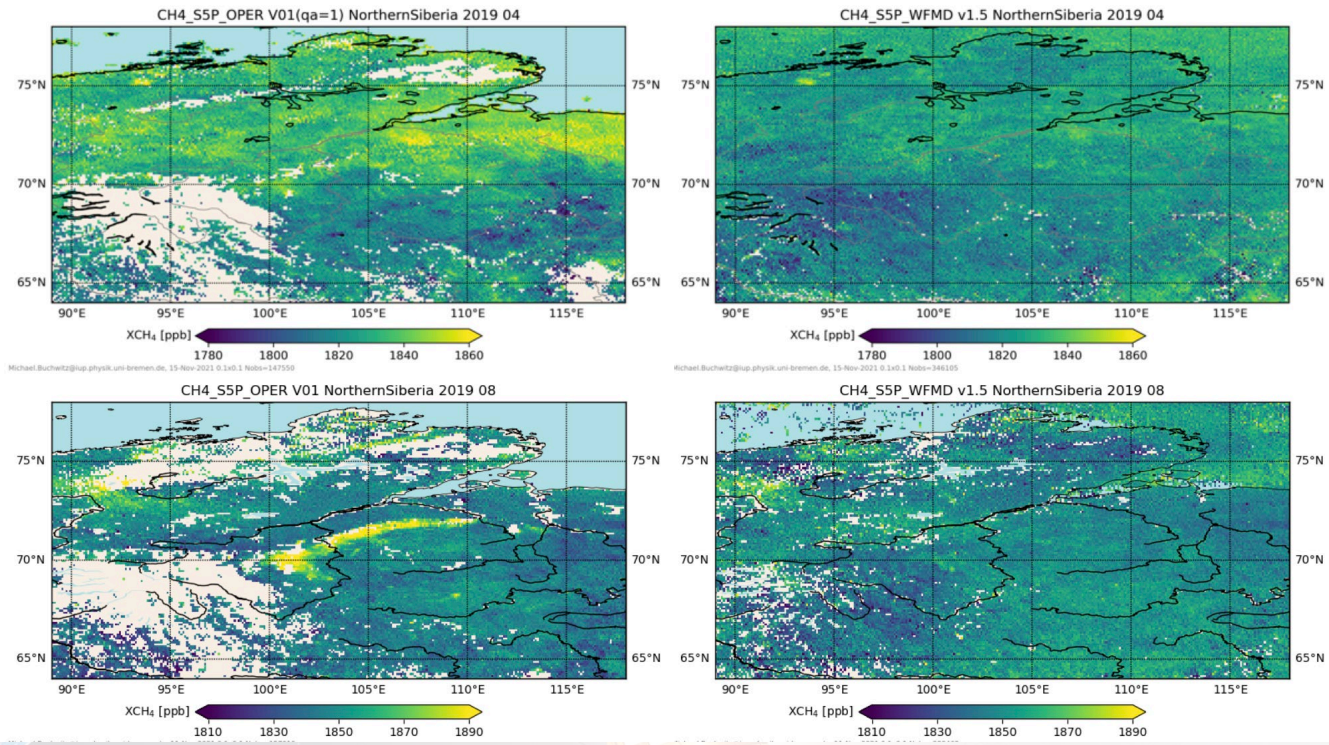
Methane+ retrieval: TROPOMI

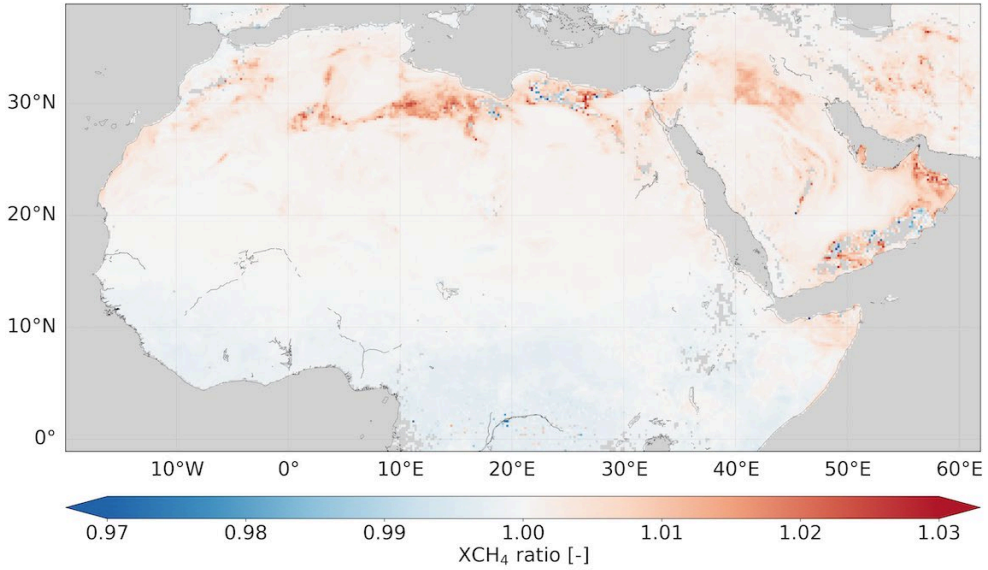
Retrieval accuracy => Reduced surface albedo dependence

Operational v01 (qa=1)



WFMD v1.5

SRON v18_17 Order 3 / Order 2



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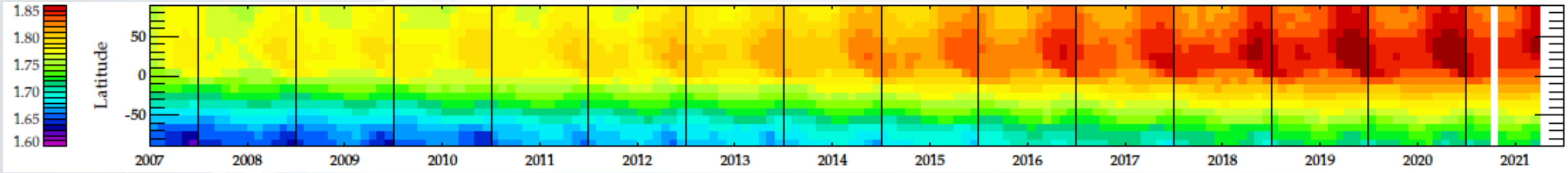
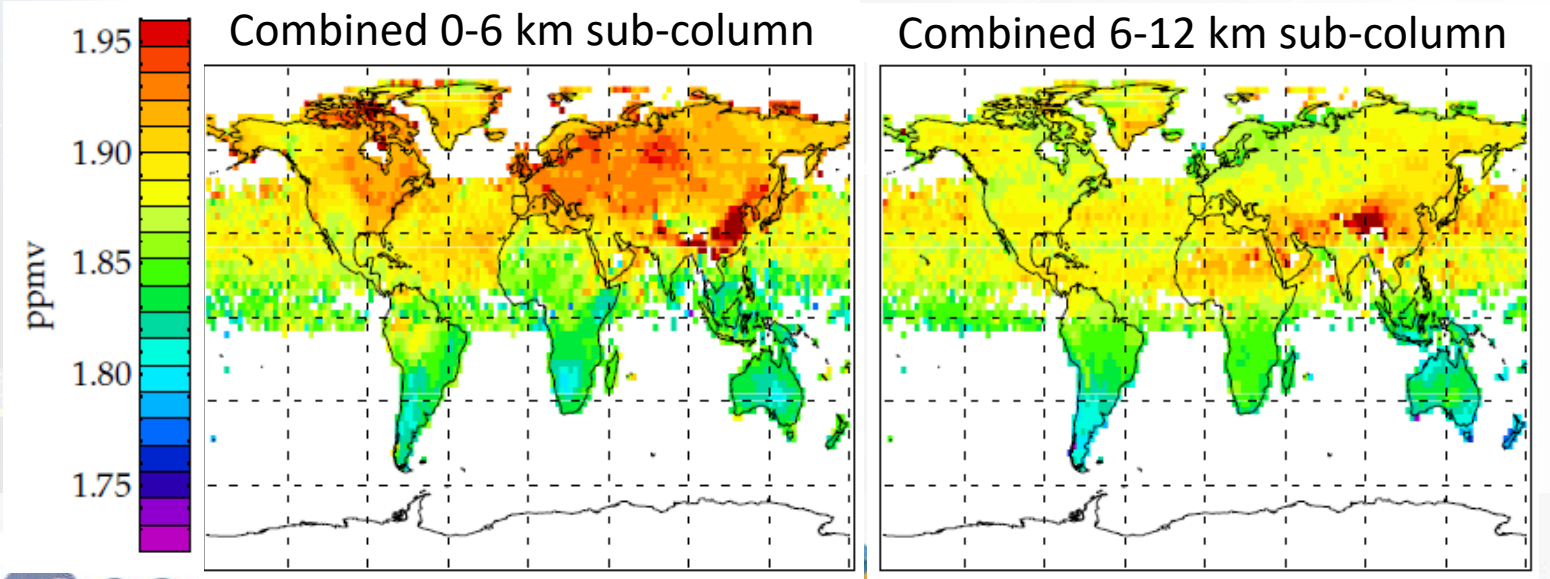
Methane+ retrieval: IASI

- Updated time series LMD & RAL retrieval

RAL: Metop-A + B timeseries (ppmv)



- RAL Joint SWIR-TIR retrieval (TROPOMI-IASI):



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Inverse modelling in ESA Methane+

- Inversion systems: TM5-4DVAR, Jena Carboscope
- Setup: following the CAMS reanalysis
- Datasets: TROPOMI (Operational, SRON scientific, iUP)
  IASI (LMD, RAL)
  Combined SWIR-TIR 0-6 km (RAL)
- TM5-4DVAR: extended with OH optimization (global annual scaling factor)

- Time window: 2018/05/01 – 2021/01/01 (excluding spin-up/spin-down)

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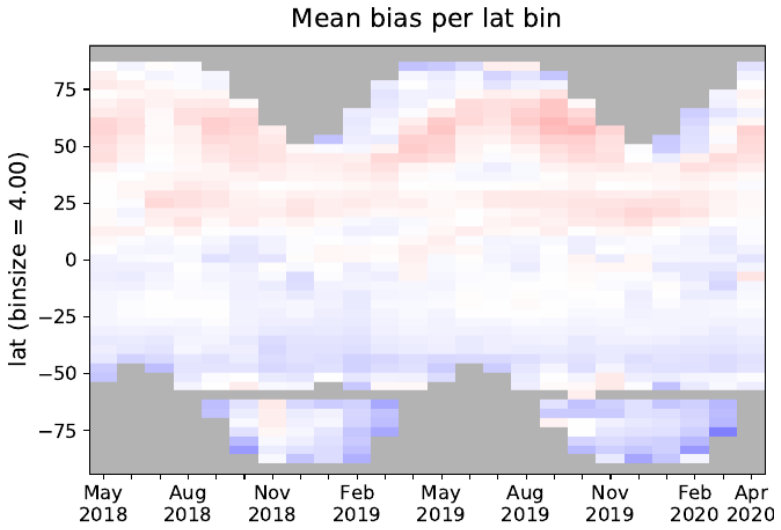
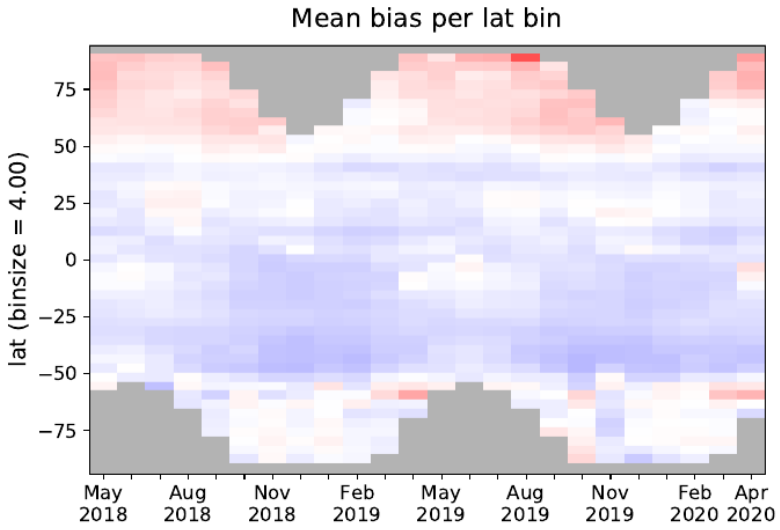
Latitudinal bias correction

- Bias = Satellite XCH_4 – Inversion optimized XCH_4 using surface data

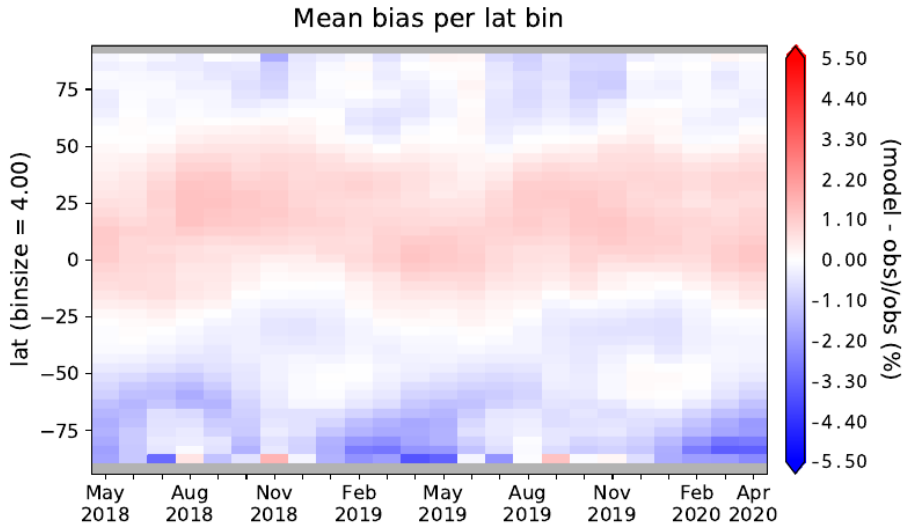
TROPOMI SRON Scientific



TROPOMI iUP WFMD



IASI RAL



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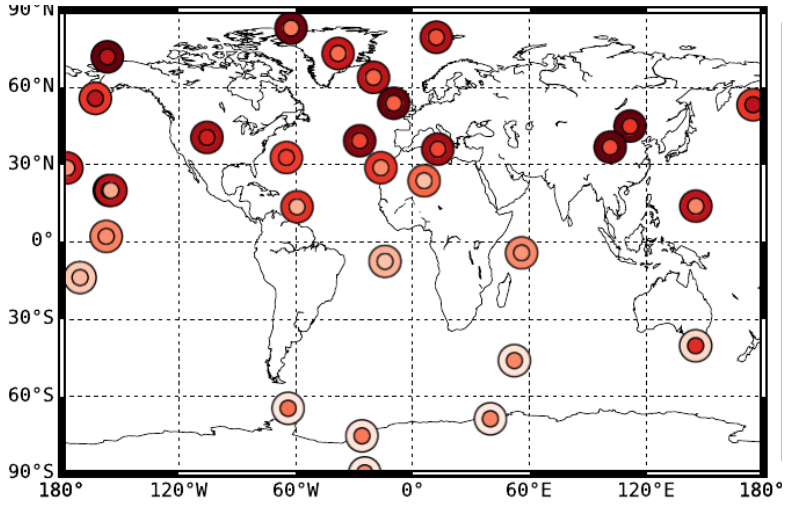
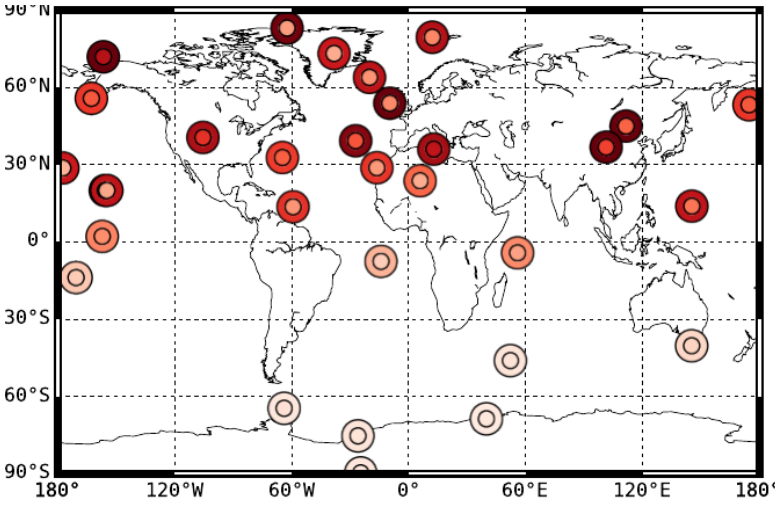
Inversion validation using surface measurements

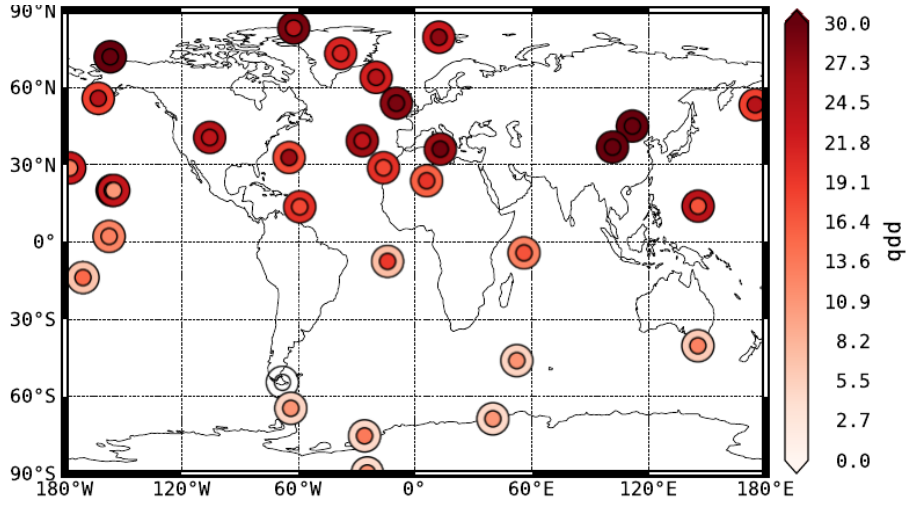
TROPOMI SRON **without** bias corr.



TROPOMI SRON **with** bias corr.



Joint SWIR-TIR 0-6 km with bias corr.



RMSE prior fluxes — RMSE Posterior fluxes

- Bias correction works well, but important residuals remain for the joint SWIR-TIR retrieval

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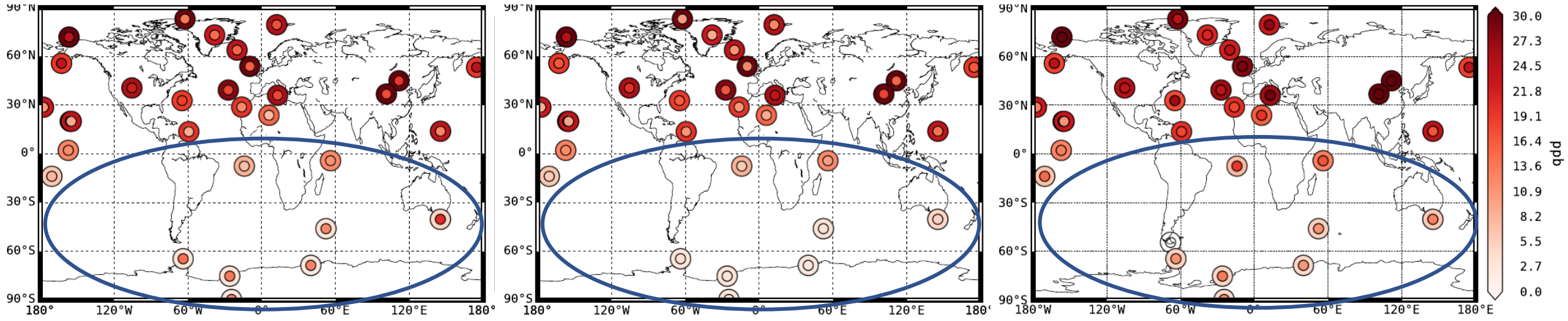
Inversion validation using surface measurements

TROPOMI SRON **without** bias corr.

TROPOMI SRON **with** bias corr.

Joint SWIR-TIR 0-6 km with bias corr.



RMSE prior fluxes — RMSE Posterior fluxes

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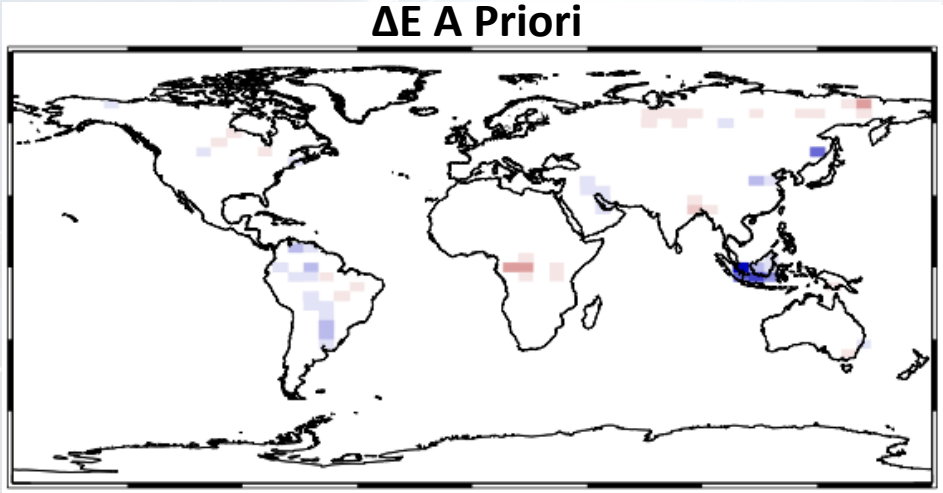
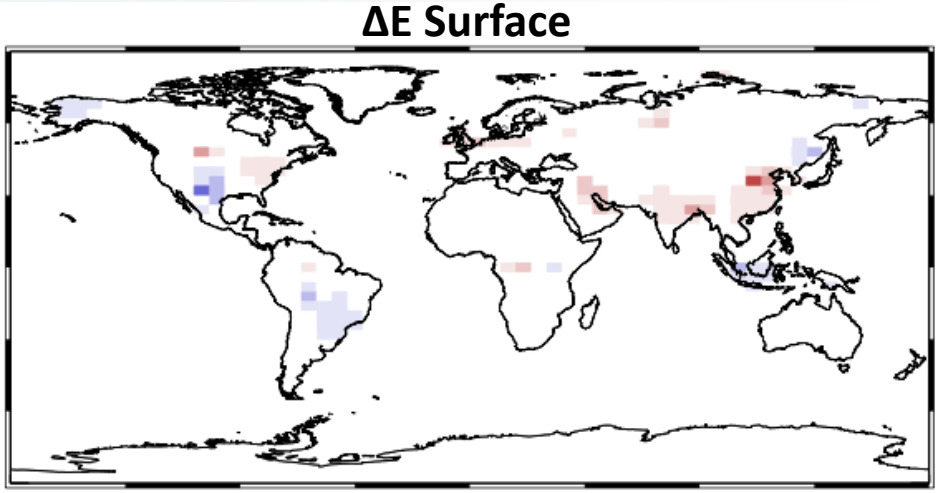
TM5-4DVAR: 2020 – 2019 flux difference

- Note: inversions optimize global & annual OH

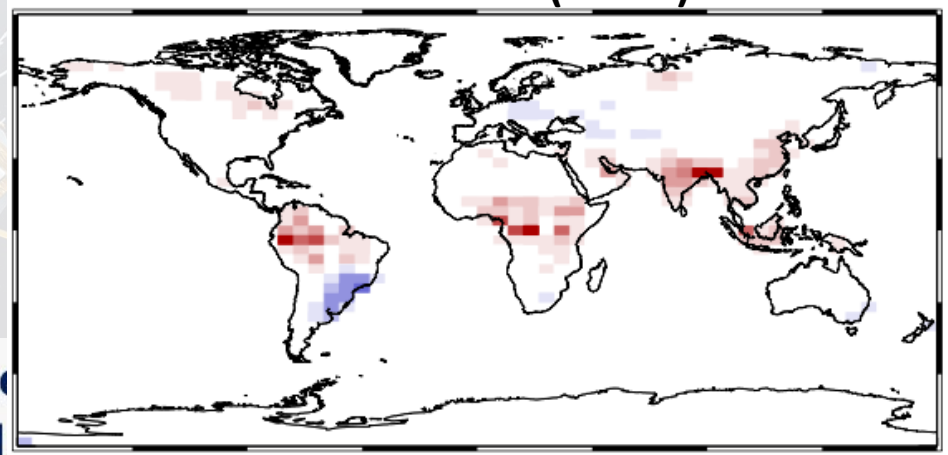
ΔE = -11 Tg/yr

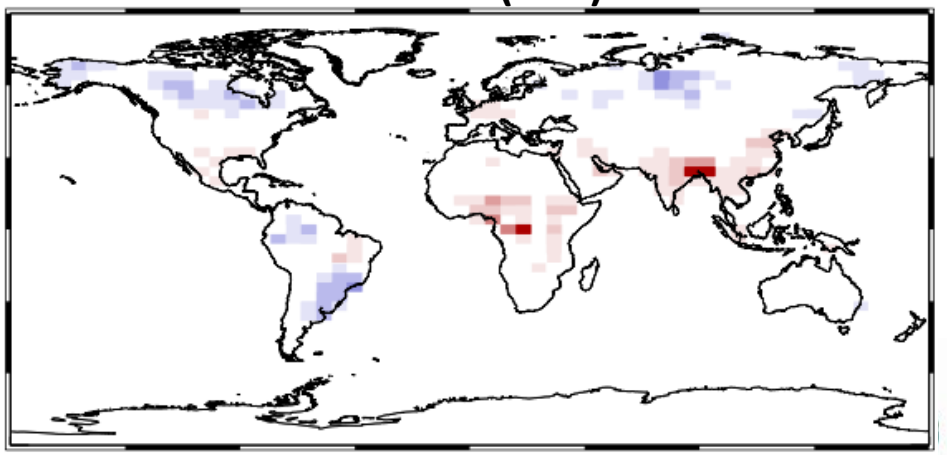




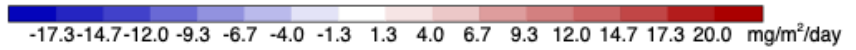
ΔE = -4 Tg/yr
ΔOH = -8%

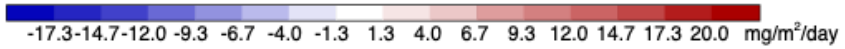
ΔE = +55 Tg/yr
ΔOH = +8%





ΔE = +6 Tg/yr
ΔOH = -2%





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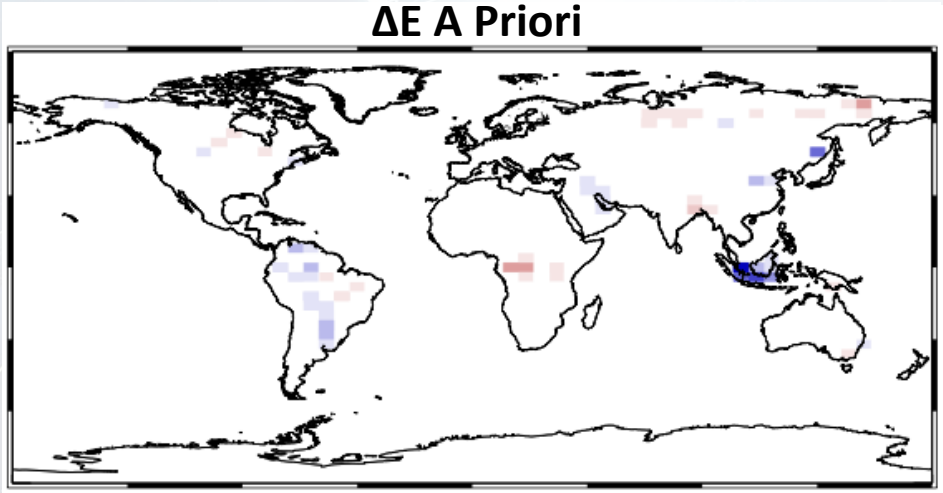
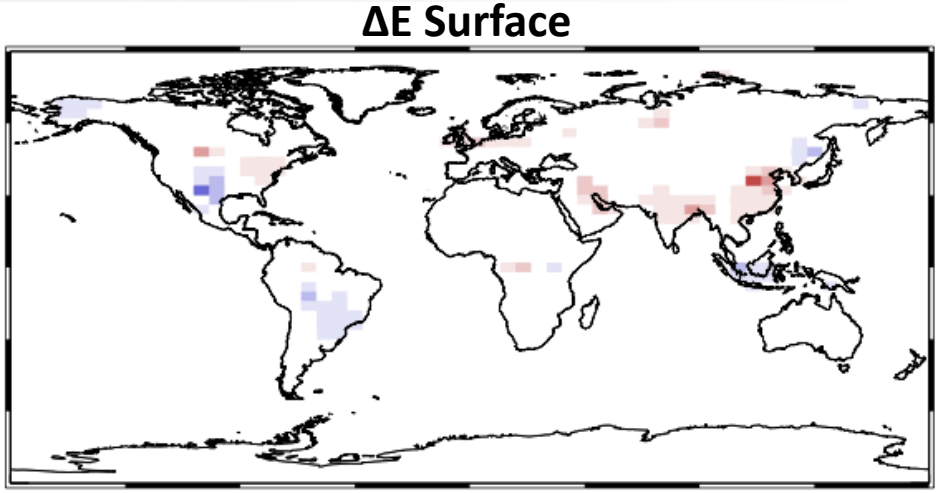
TM5-4DVAR: 2020 – 2019 flux difference

- Note: inversions optimize global & annual OH

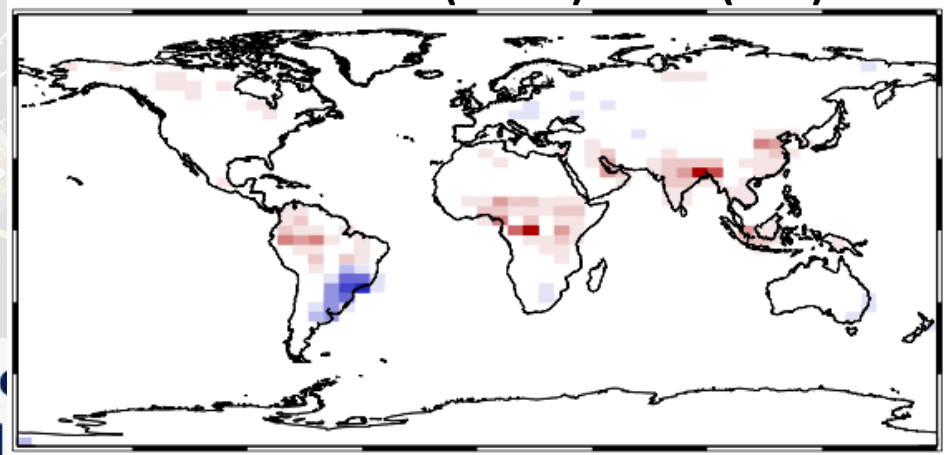
ΔE = -11 Tg/yr

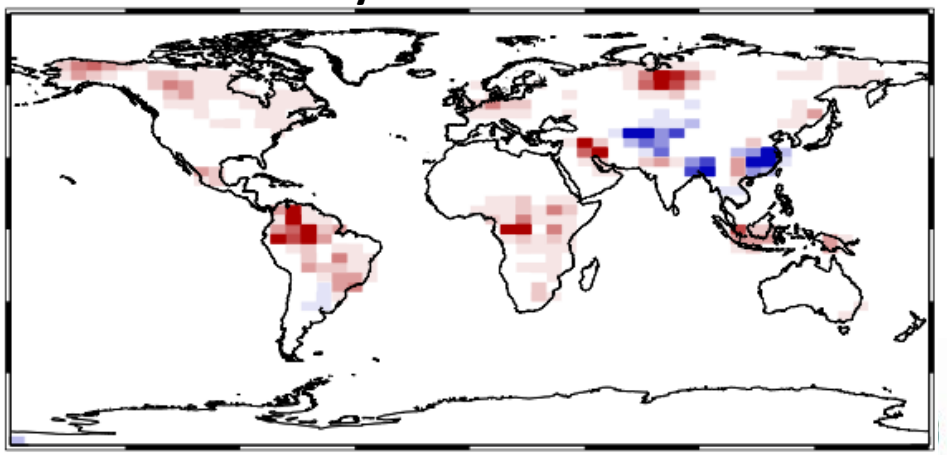




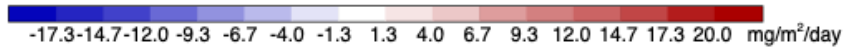
ΔE = -4 Tg/yr
ΔOH = -8%

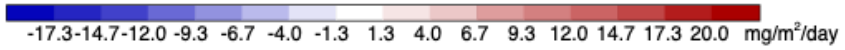
ΔE = +33 Tg/yr
ΔOH = +5%





ΔE = +73 Tg/yr
ΔOH = +3%





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Summary

- Methane+: New updated XCH_4 data available from TROPOMI and IASI
- Inversion codes have been developed that make use of these data
- Inversions focused on the 2019 – 2020 CH_4 increase
- CH_4 sources or sinks are ‘blamed’ for the 2020 increase depending on the dataset that is used
- Joint SWIR-TIR retrieval is a promising development, but the implementation in inversions needs further analysis