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Evaluation of partial column CH_4: comparison of model results with GOSAT and IASI data

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19/12/2022 **33rd International TM5 meeting, hybrid**

Background

- Posterior XCH_4, derived from surface inversion, does not match satellite retrievals
  - Often positively biased (model estimates are higher than retrievals) at high northern latitudes and negative in the Tropics
  - Regardless of transport model and satellites, retrieval methods etc.
- BUT agreement with surface stations are good for background sites
- Questions
  - Where the problem in XCH_4 comparison come from?
  - Do we do better if we only look at troposphere?
- Compare model estimates to partial column products
  - JAXA GOSAT $pXCH_4$ (lower tropospheric (LT) and upper tropospheric (UT) data)
  - IASI CH_4

Model setup

- Flux estimates from CTE-CH_4 using the “GCP” setup.
  - Prior fluxes: EDGAR v6.0 (agriculture, waste, coal, oil&gas), Saunois et al. (2020) (wetlands), MeMo model (soil sink), GFED v4.1s (biomass burning), Saunois et al. (2020) (termites), Weber et al. (2019)(ocean), Etiope et al. scaled to 23 Tg (geological)
  - Biospheric (wetlands + soil sink) and anthropogenic emissions are optimized simultaneously
  - Assimilated observations: surface measurements
  - Optimization: 1° x 1° resolution (with some spatial correlation) in Canada, USA, Europe and Russia. Elsewhere by region-wise.
  - 7 day temporal resolution
- Concentration fields are obtained from TM5 with optimized fluxes.
  - Constrained by ERA5 meteorology (3-hourly)
  - Horizontal resolutions: 6° x 4° (glb) + 1° x 1° (eun)
  - Vertical levels: 25
  - Chemistry: scaled Spivakovsky et al. (2000) and Brühl and Crutzen (1993).

Comparison to JAXA GOSAT pXCH$_4$

- Total column are calculated as

  $XCH_4 = \Sigma_i (CH_4[i] * dp[i]) / psurf,$

  where $CH_4[i]$ is dry-air mixing ratio at level i, dp is layer thickness at level i, psurf is surface pressure.

- **Partial column (LT, UT)**

  $XCH_4\_LT/UT = \Sigma_{jj} (CH_4[jj] * dp[jj]) / \Sigma_{jj} (dp[jj]), jj = 1,..,w$

  where w = level where model pressure is between [Psrf_ret, Psrf_ret*0.6] (LT) and [Psrf_ret*0.6, Psrf_ret*0.2] (UT) from the GOSAT data.

- No averaging kernel
- Interpolation = nearest neighbour
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Results: JAXA GOSAT pXCH$_4$

- Spatial distribution of total column show clear hemispheric biases – model overestimates in the NH, and underestimates in the SH.
  - Such dependences are not seen in LT.
  - But maybe more prominent over ocean than in UT.
- UT has some bias over high latitudes?
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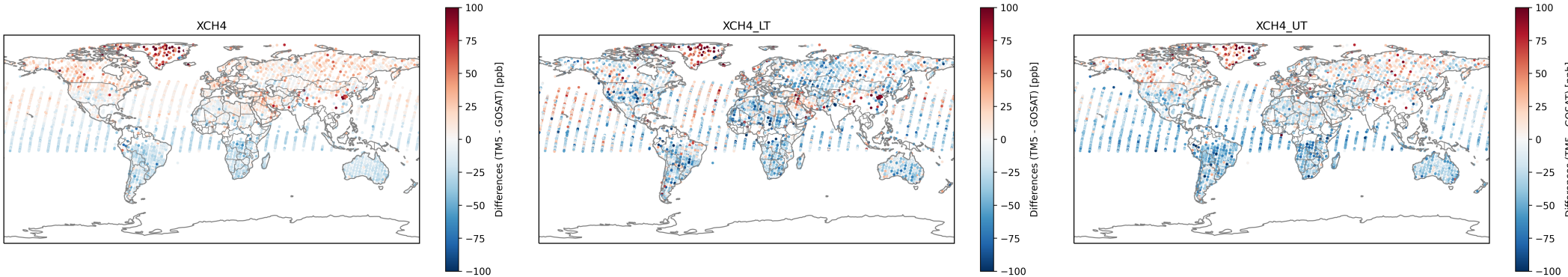

Jul. 2018

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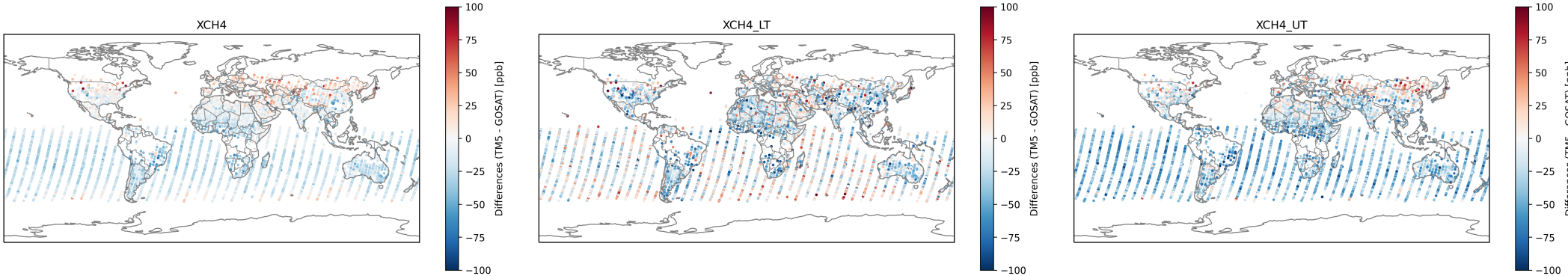
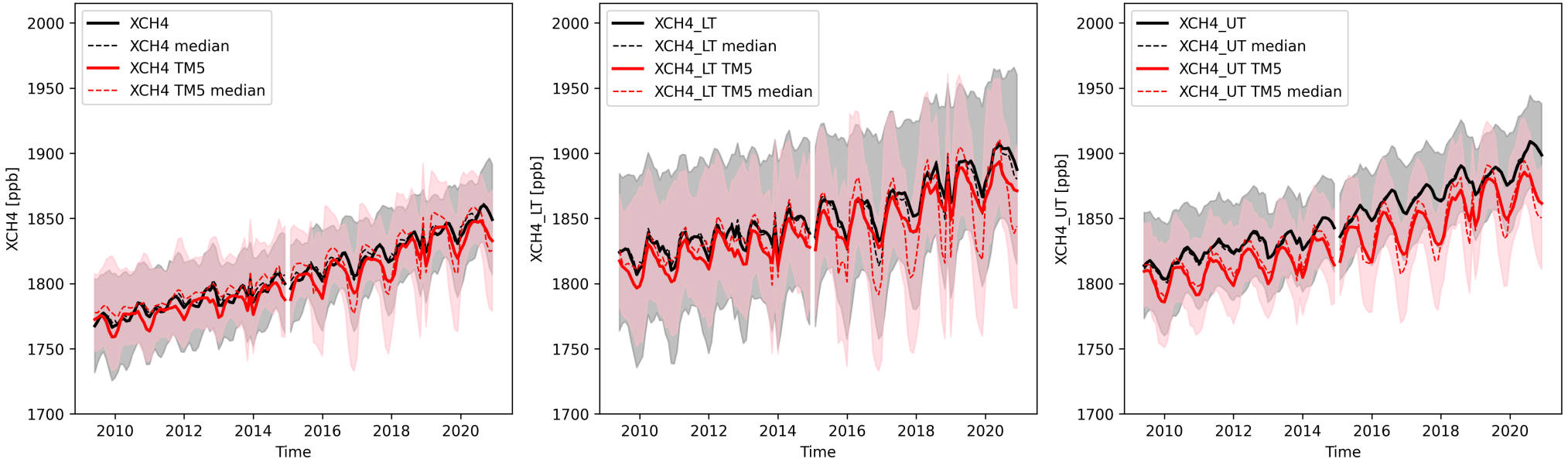
  - But maybe more prominent over ocean than in UT.
- UT has some bias over high latitudes?
  - Not clear as no data over Antarctica over winter as well
  - Latitudinal bias over **land** in total column maybe associated with UT (and stratosphere?)



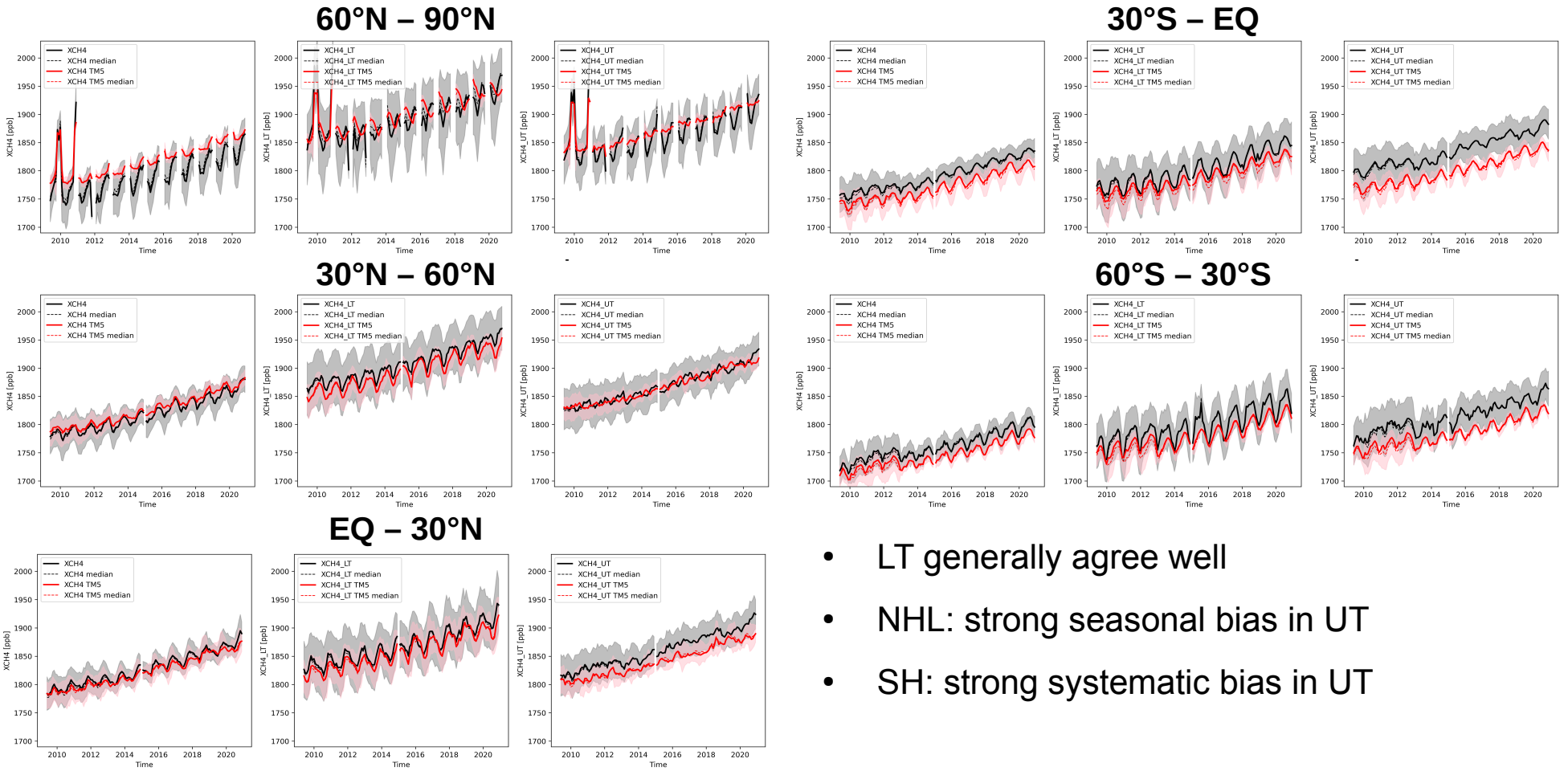
Jan. 2018

Results: JAXA GOSAT pXCH$_4$

- Global mean level & trend agree well for total column (XCH$_4$) and lower troposphere (XCH$_4$_LT)
- LT seasonal cycle: TM5 not capturing second peak / decreases too soon after annual max.
- UT has noticeable bias. Seasonal cycle also look different
  - Larger amplitude from TM5, and it reaches annual max. earlier than GOSAT



Results: JAXA GOSAT pXCH$_4$



- LT generally agree well
- NHL: strong seasonal bias in UT
- SH: strong systematic bias in UT

Results: JAXA GOSAT pXCH$_4$

April profiles

- Sodankylä stratospheric CH_4 is slightly higher with ECHAM chemistry
- 34-levels has lower tropospheric CH_4

→ Proper spin-up may be needed?

- Differences at Wollongong is small, but surface CH_4 is higher with glb100x100
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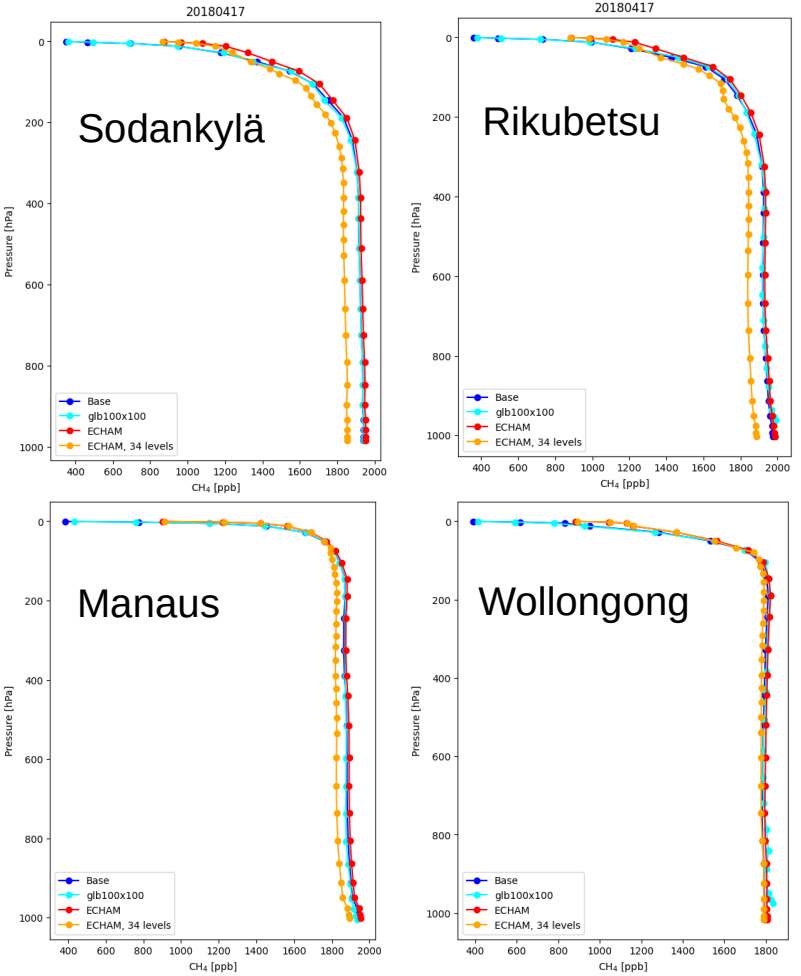
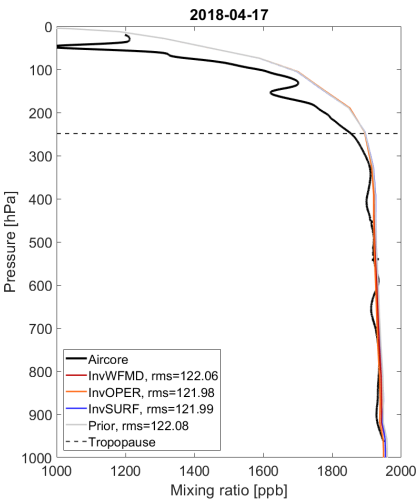
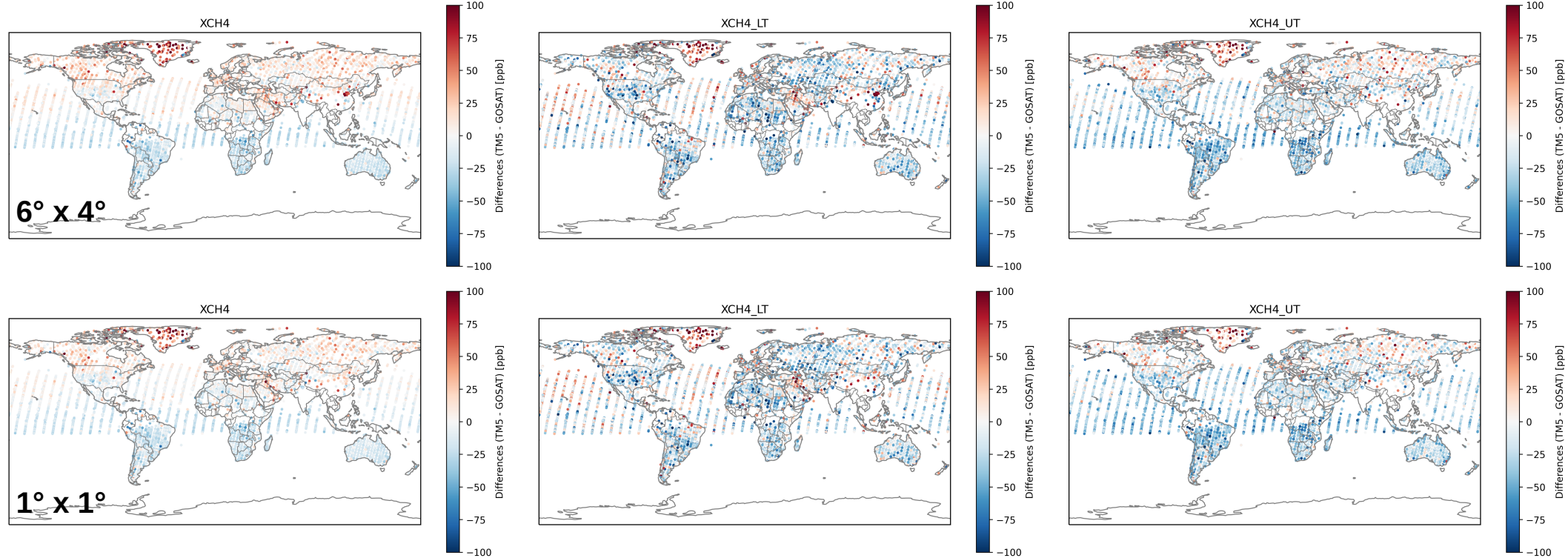




Aircore vs model at Sodankylä.
ECHAM chemistry, 1° x 1° x 25l

Results: JAXA GOSAT pXCH$_4$ Jul. 2018

- Not much differences in spatial distribution
- Beijing hot spot in XCH$_4$ and LT removed (same for chemistry experiment).



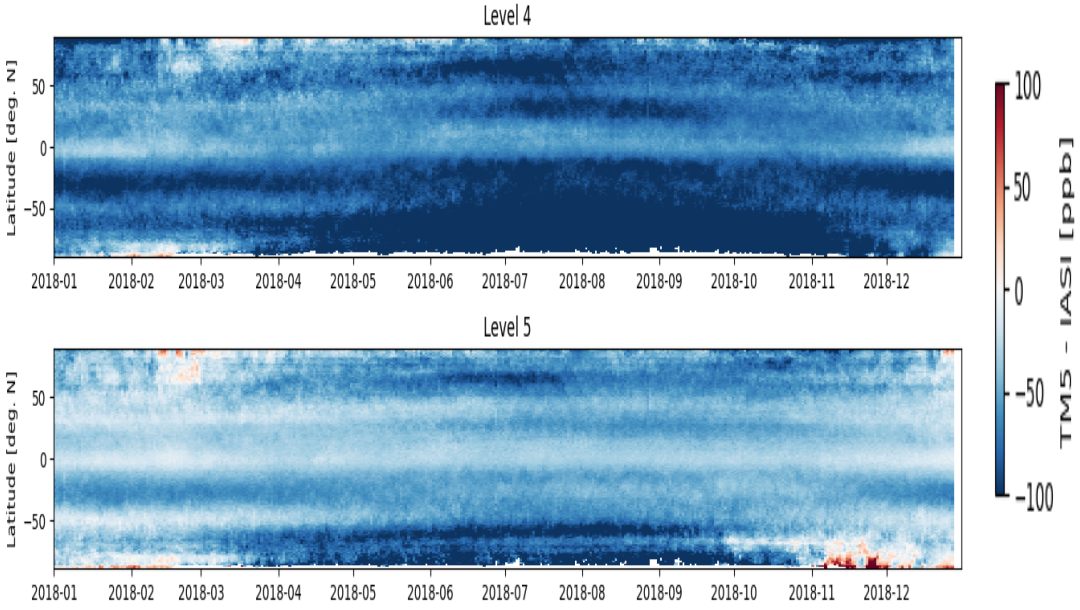
Comparison to IASI CH_4

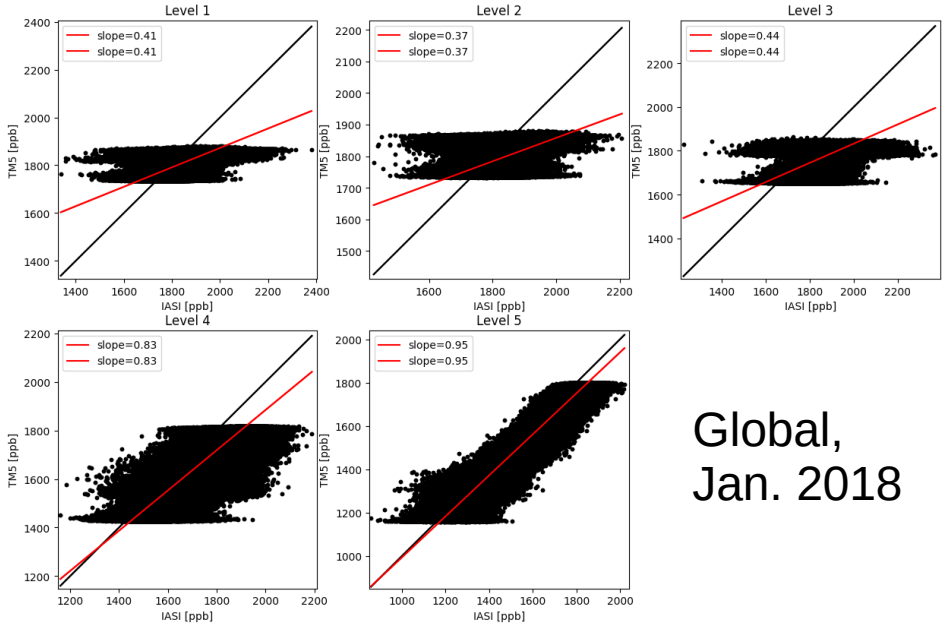
- Spatial interpolation – linear
- Vertical interpolation – linear
- Comparison for 1-5 IASI vertical levels separately
  - IASI data provides AK for first 5-layers from the surface

- Focus on Northern high latitude, especially in winter

Results: IASI CH_4

- Model is underestimated in general
  - Some seasonality at high latitudes
- At level 4 or 5, agreement is good on global level
- The agreement at 50°N> is not good





Global,
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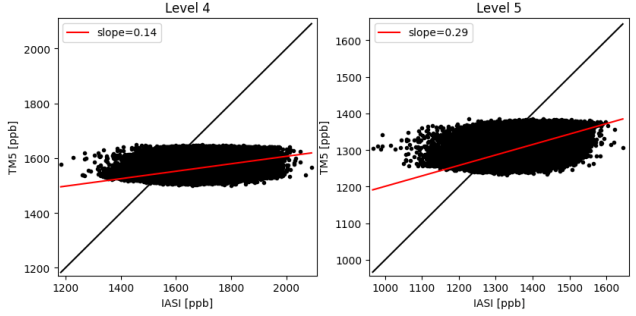
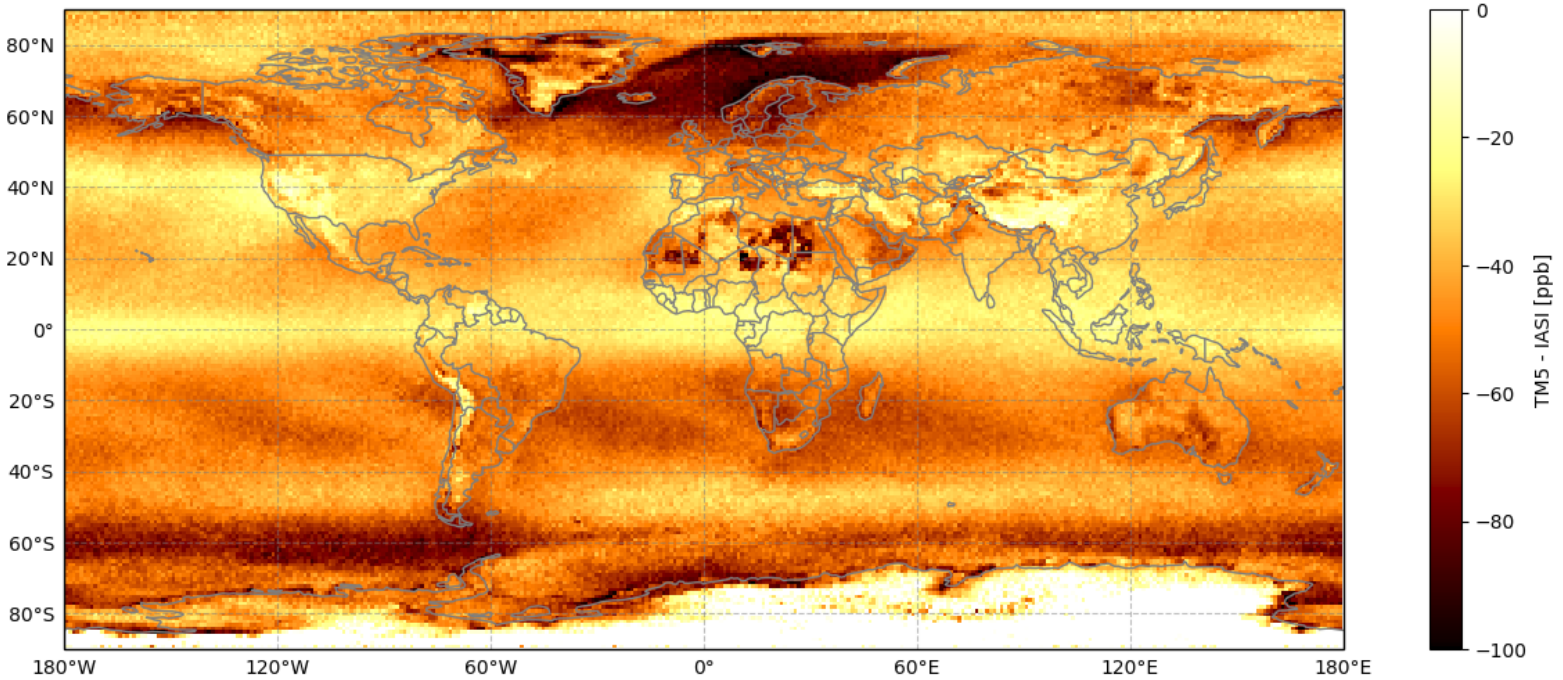


50N,
Jan. 2018

Results: IASI CH_4

- Strong underestimation in the ocean area and ice over Northern high latitudes. → Could we use data only over land?
- Bias is somewhat stronger over Fennoscandia,east Russia and west Canada

Annual mean differences, Level 5



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Other news from FMI

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- Two papers published
  - Kangasaho, V., et al.: The Role of Emission Sources and Atmospheric Sink in the Seasonal Cycle of CH4 and δ13-CH4: Analysis Based on the Atmospheric Chemistry Transport Model TM5, Atmosphere, 13, 888, https://doi.org/10.3390/atmos13060888, 2022.
  - Tenkanen, M., et al..: Utilizing Earth Observations of Soil Freeze/Thaw Data and Atmospheric Concentrations to Estimate Cold Season Methane Emissions in the Northern High Latitudes, Remote Sensing, 13, 5059, https://doi.org/10.3390/rs13245059, 2021.
- Contribution to multimodel intercomparison with CTE-CH_4
  - WMO IG^{3}IS (also H2020 CoCO2) (S. Houweling)
  - GCP (M. Saunois)
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