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Lessons learned from five years of Sentine-5P Methane and Carbon Monoxide validation using TCCON, COCCON and NDACC-IRWG data

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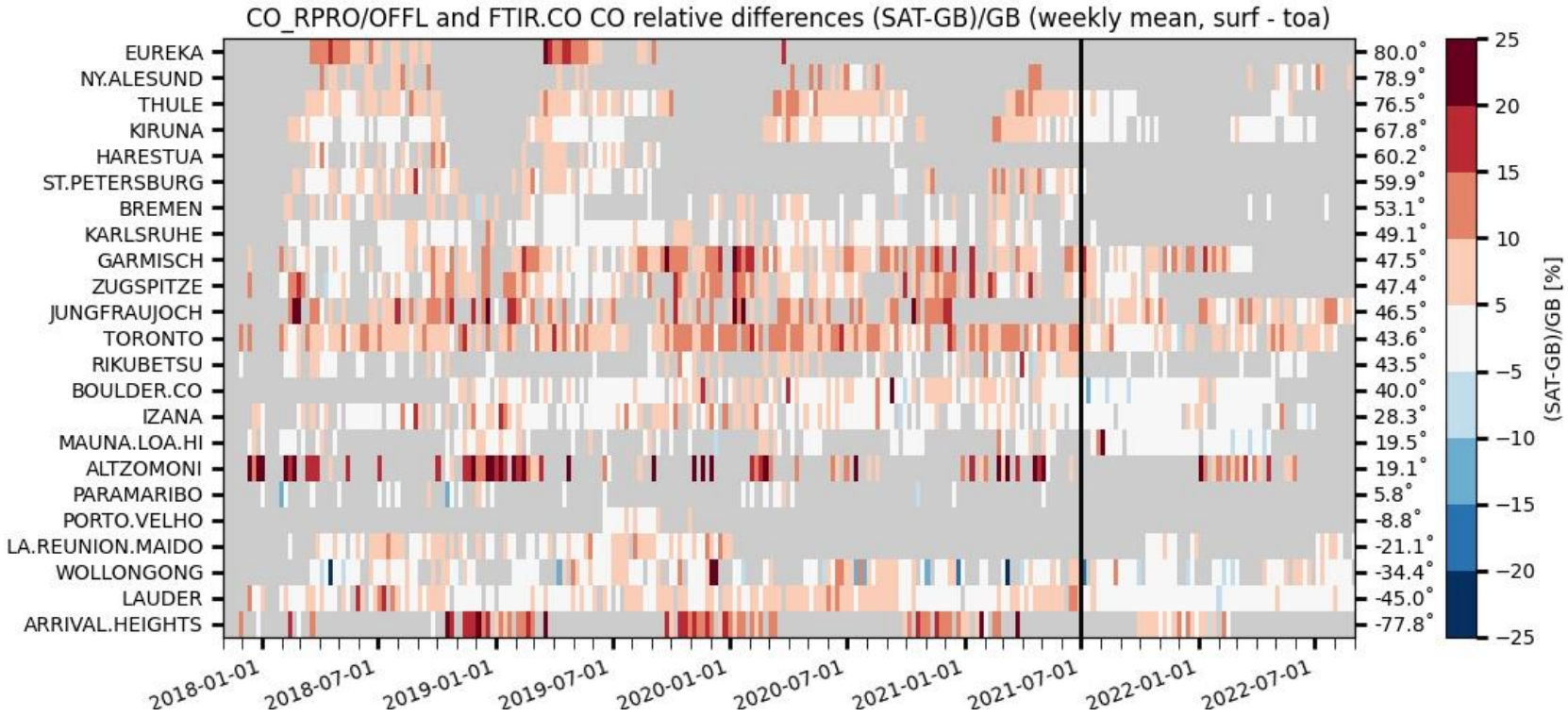
2. SRON Netherlands Institute for Space Research, Netherlands, Netherlands
3. Total Carbon Column Observing Network
4. Collaborative Carbon Column Observing Network
5. Infrared Working Group of the Network for the Detection of Atmospheric Composition Change

L2 – Carbon monoxide

Comparison with **averaging** co-located s5p pixels: **COLLECTION 1,2 results**

Validation using **NDACC** data



15 Nov 2017 – 1 July 2021 (version 01.xx.xx): Bias = **6.5%**; STD = **5%**; correlation coefficient = **0.93**

1 July 2021 – 1 Sept 2022 (version 02.xx.xx): Bias **~ 3.0%**; STD = **5%**; correlation coefficient = **0.93**

Destriped product since July 2021: evaluation using **closest** pixel criterion

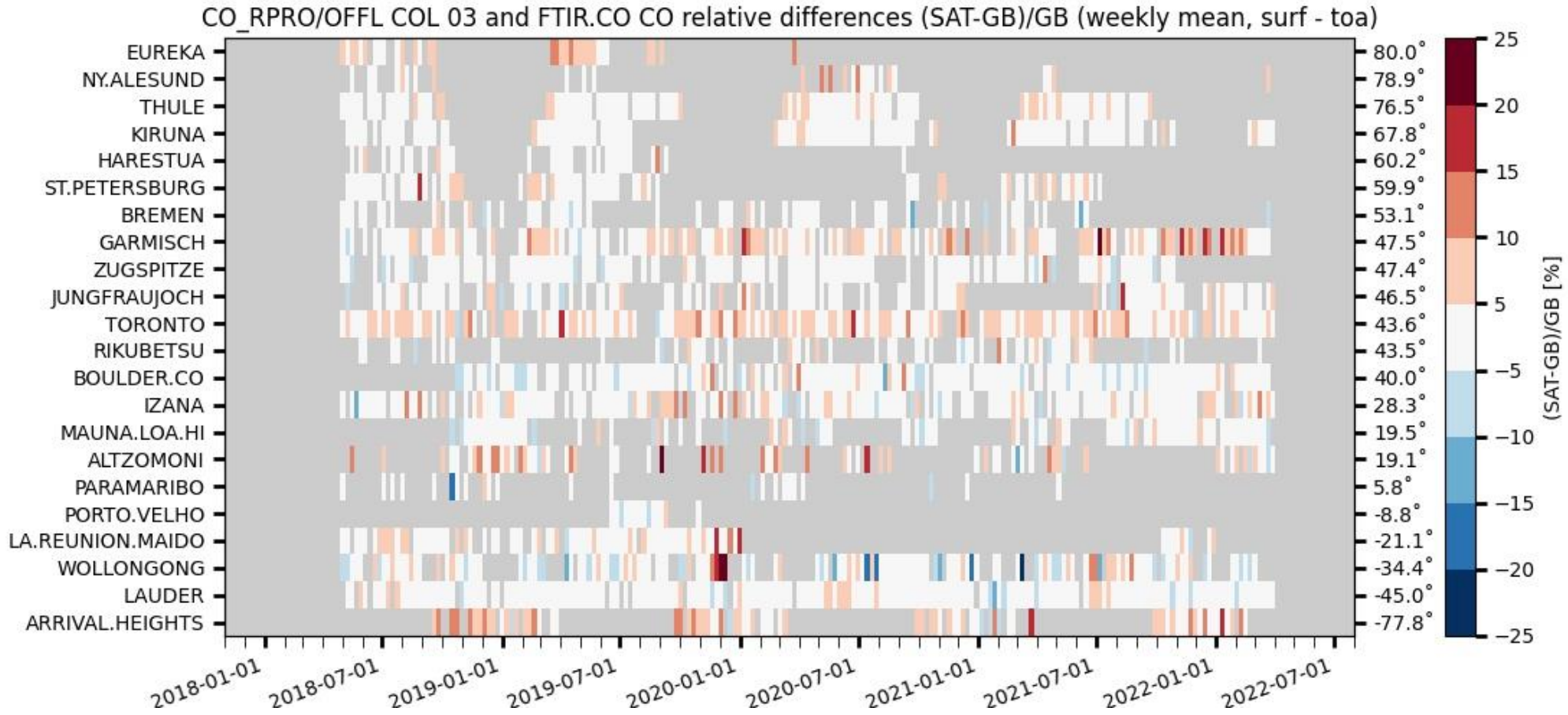
1 July 2021 – 1 Sept 2022 (standard): Bias = **3.1%**; STD = **10.6%**; correlation coefficient = **0.79**

1 July 2021 – 1 Sept 2022 (destriped): Bias **2.9%**; STD = **9%**; correlation coefficient = **0.83**

L2 – Carbon monoxide

Comparison with **averaging** co-located s5p pixels: **RPRO COLLECTION 3**

Validation using **NDACC** data



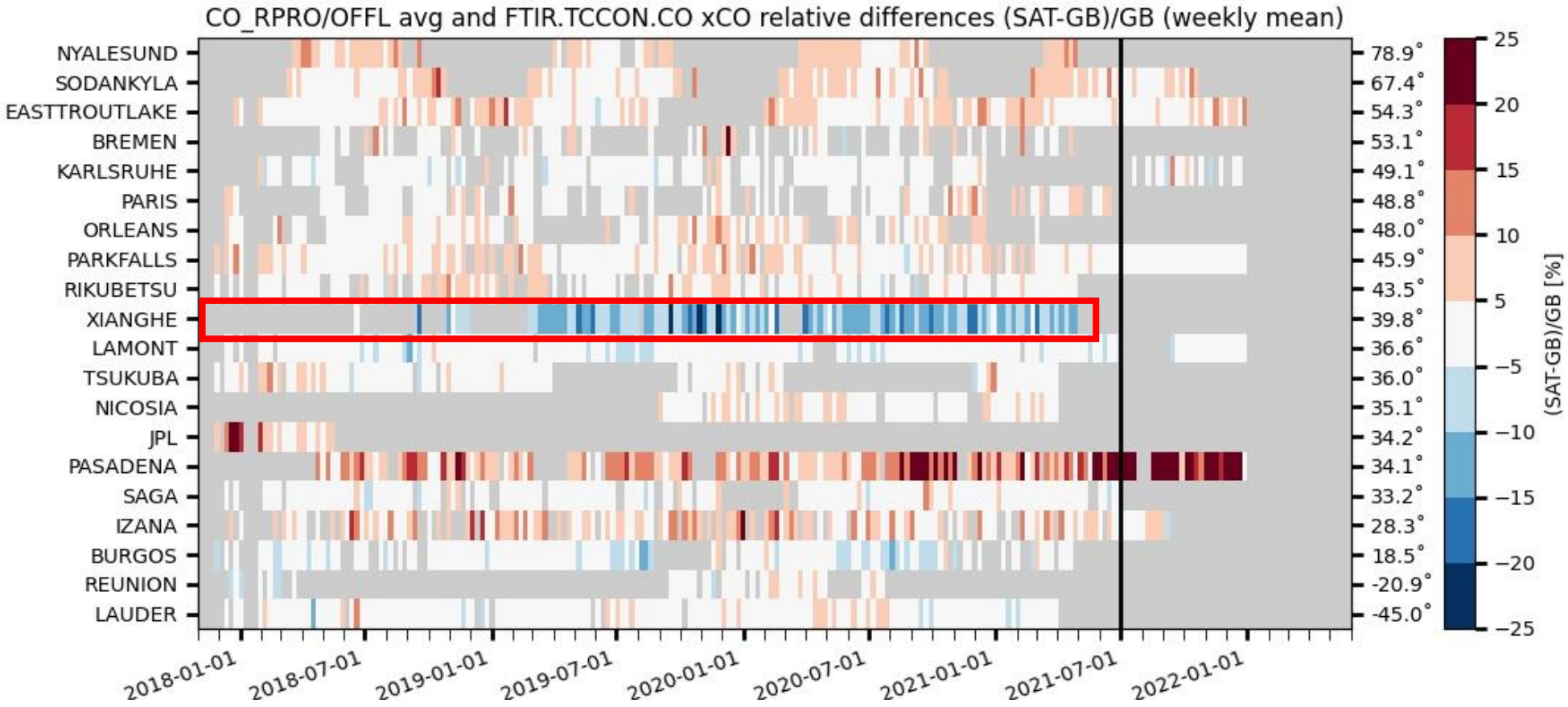
April 2018– March 2022 (collection 03, version 02.04): Bias = **2.14%** ; STD = **7.5%** ; correlation coefficient = **0.9**

A Prior is available: now SAT prior is substituted in GB profiles (**2.5% -> 2.14%**)

L2 – Carbon monoxide

Comparison with **averaging** co-located s5p pixels: **COLLECTION 1,2 results**

Validation using **TCCON** GGG2020 data



Mean –> Bias = **2.61%** ; STD = **5.84%** ; correlation coefficient = **0.90** (15 Nov 2017 – 1 Jan 2022)

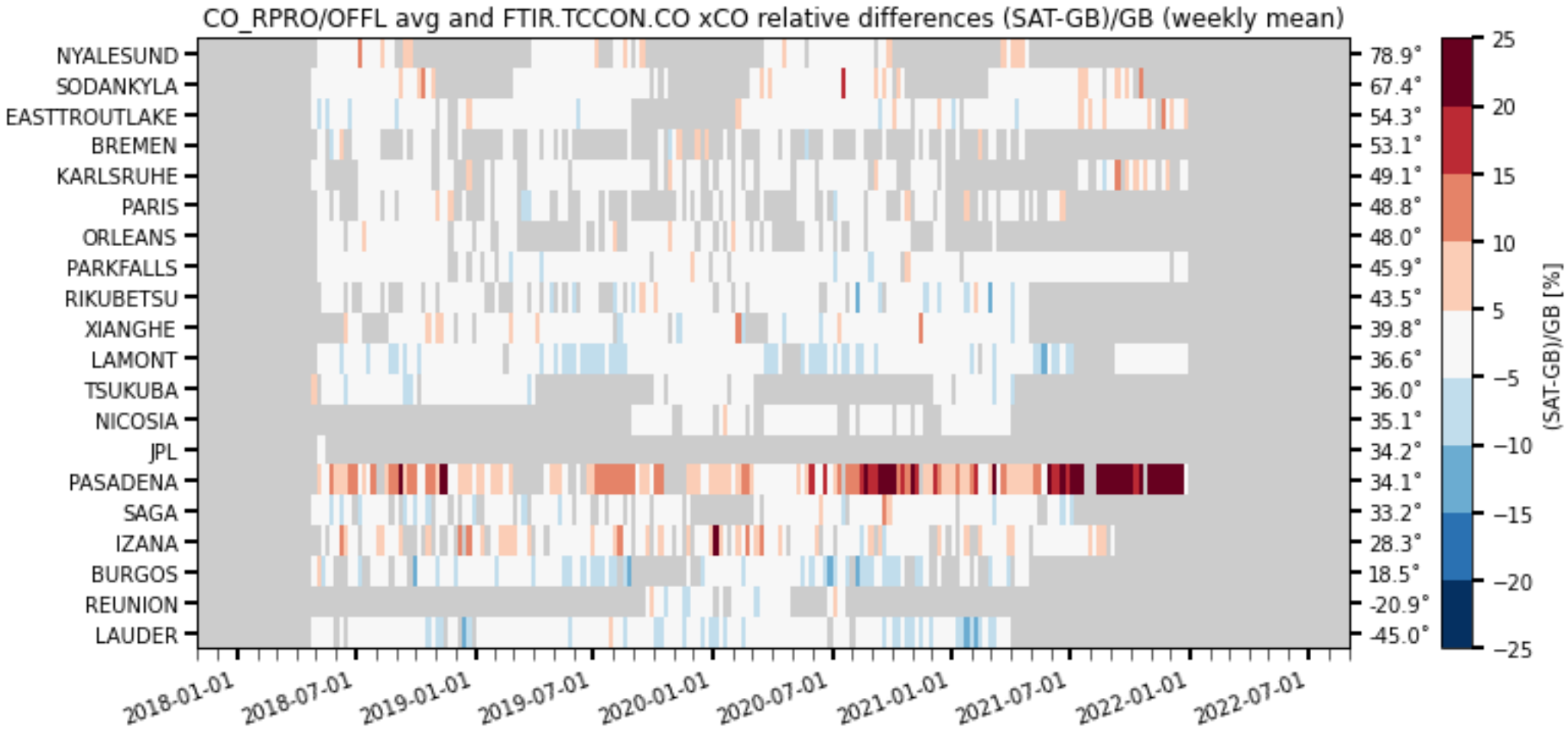
Important change in CO: GGG2020 xCO has no calibration factor to scale to WMO

L2 – Carbon monoxide

Comparison with **averaging** co-located s5p pixels: **COLLECTION 3 results**

Validation using **TCCON** GGG2020 data

GB with SAT prior vs SAT comparison (SAT prior as common prior)



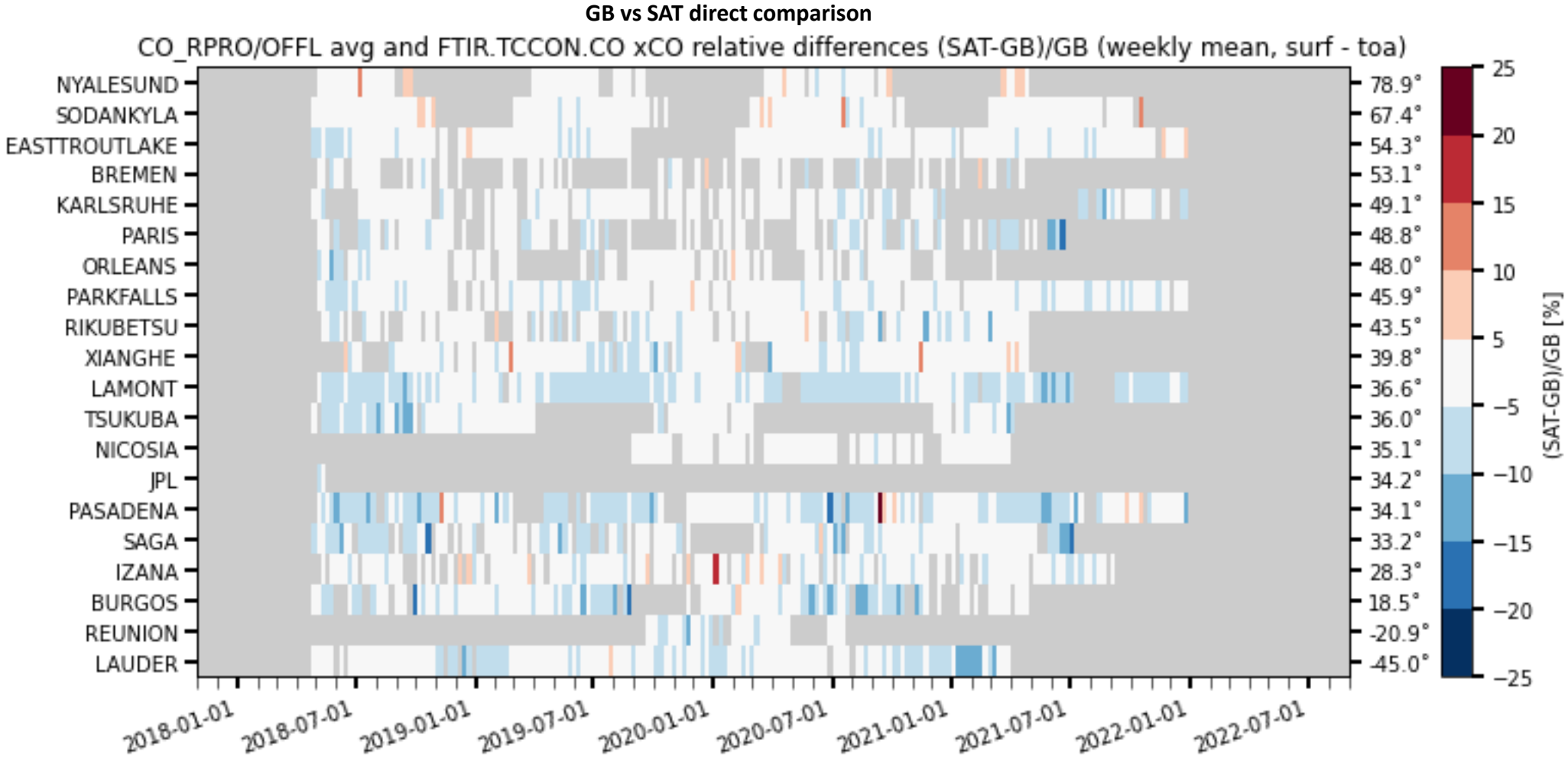
Mean –> Bias = **0.74%** ; STD = **5.29%** ; correlation coefficient = **0.90** (April 2018 – Dec 2021)

Mean –> Bias = **0.11%** ; STD = **4.45%** ; correlation coefficient = **0.93** (April 2018 – Dec 2021) – exc. Pasadena

L2 – Carbon monoxide

Comparison with **averaging** co-located s5p pixels: **COLLECTION 3 results**

Validation using **TCCON** GGG2020 data

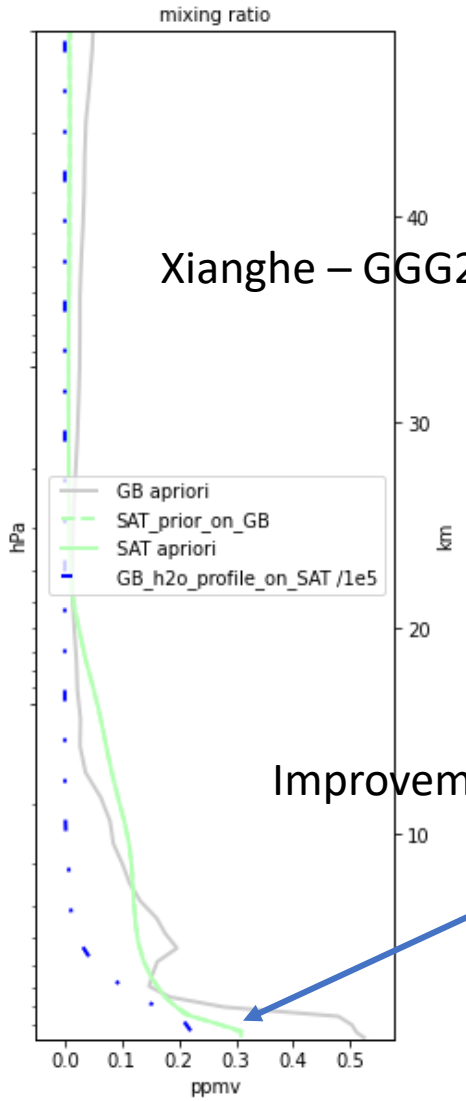


Mean –> Bias = **-2.28%** ; STD = **4.84%** ; correlation coefficient = **0.92** (April 2018 – Dec 2021)

Mean –> Bias = **-2.16%** ; STD = **4.55%** ; correlation coefficient = **0.93** (April 2018 – Dec 2021) – exc. Pasadena

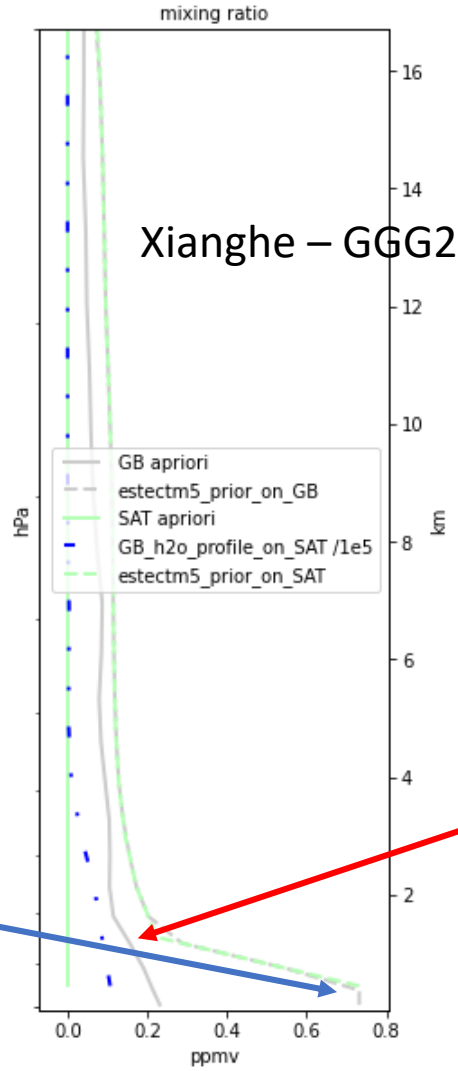
L2 – Carbon monoxide

collection 3

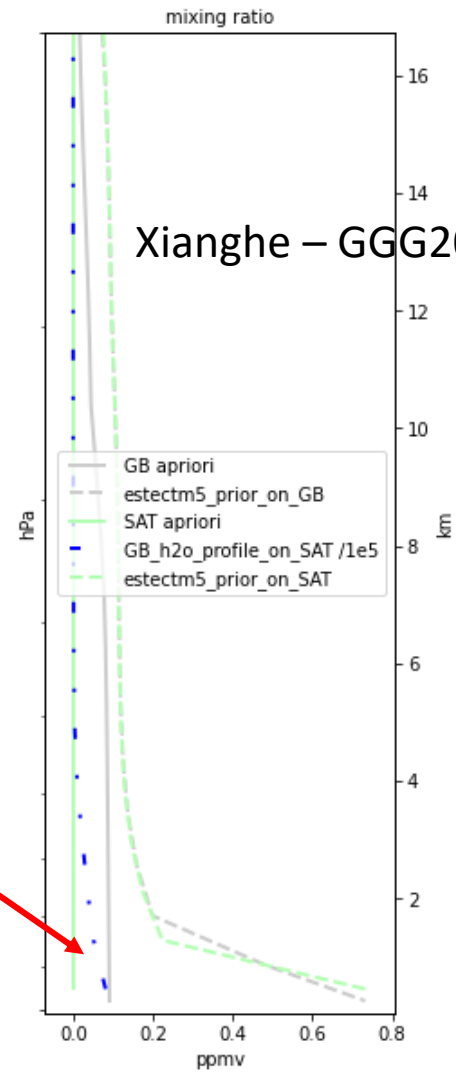


Xianghe – GGG2020

Validation using **standard** TCCON data – collection 1,2



Xianghe – GGG2020

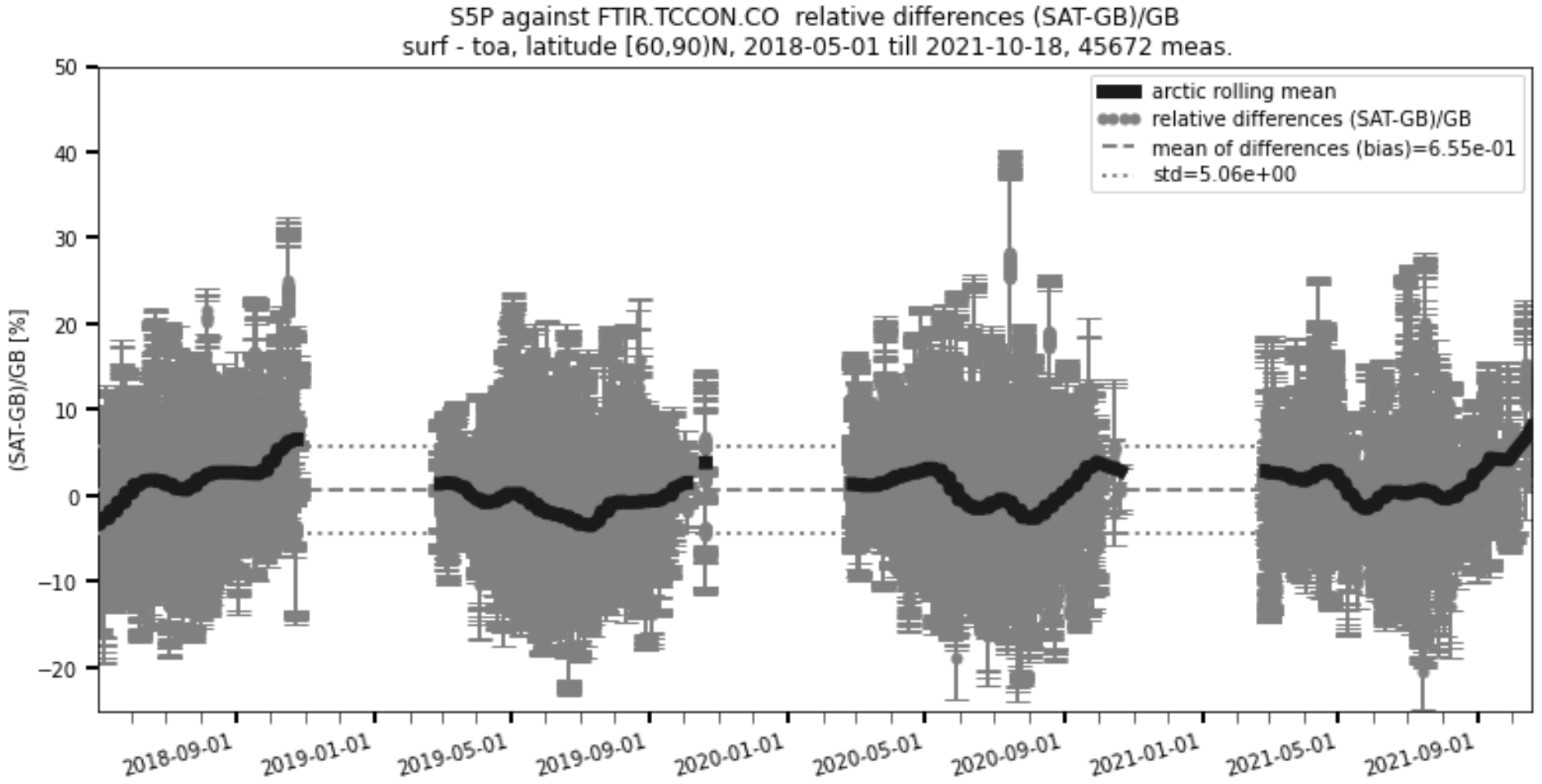


Xianghe – GGG2014

Improvement in collection 3

L2 – Carbon monoxide

Validation using **TCCON** GGG2020 data



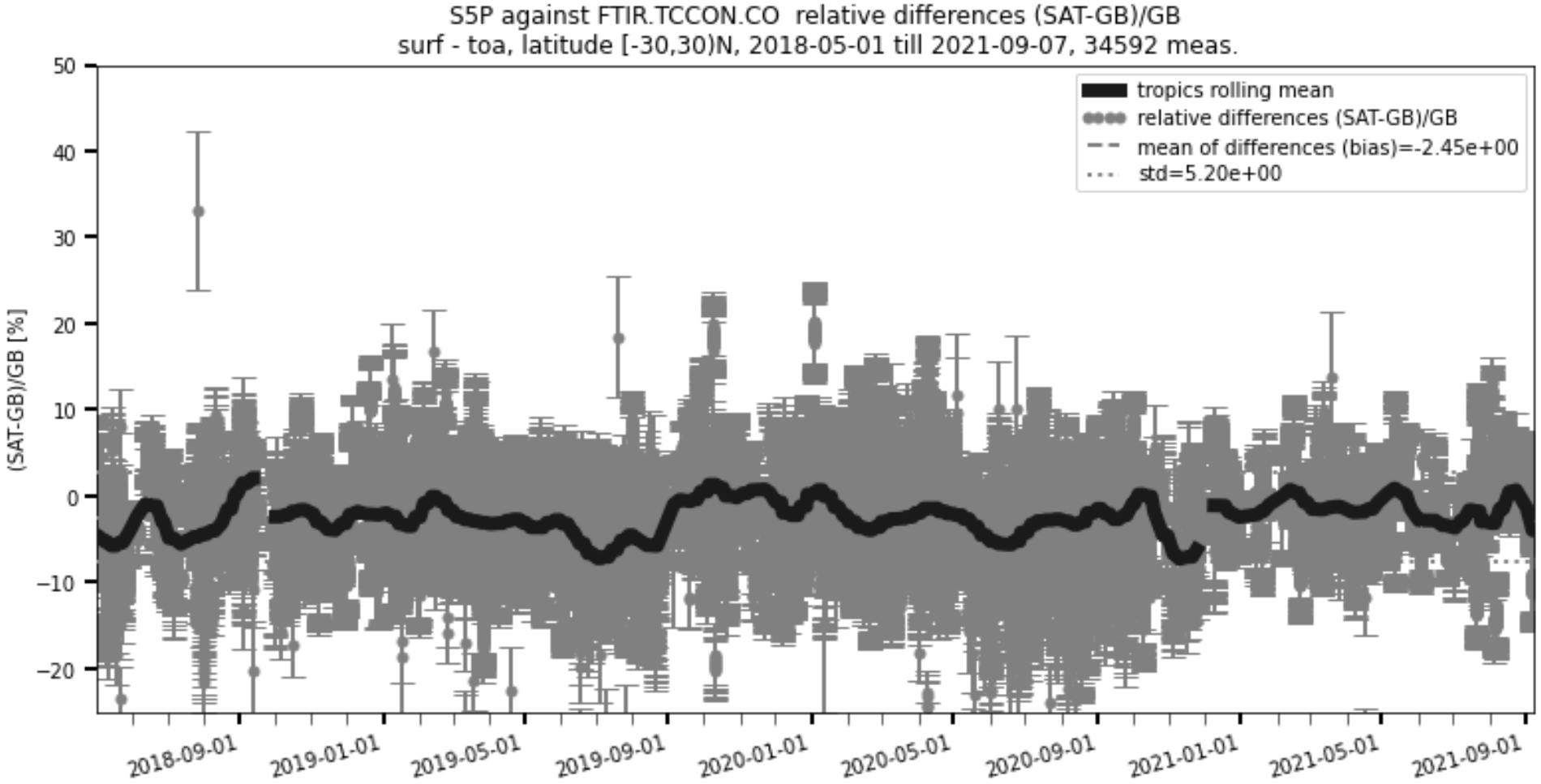
Seasonal dependence in differences? No clear signal

regrouped data in latitude bins

applied a rolling mean on 7-day average and 5th order binomial weighing

L2 – Carbon monoxide

Validation using **TCCON** GGG2020 data



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L2 – Carbon monoxide

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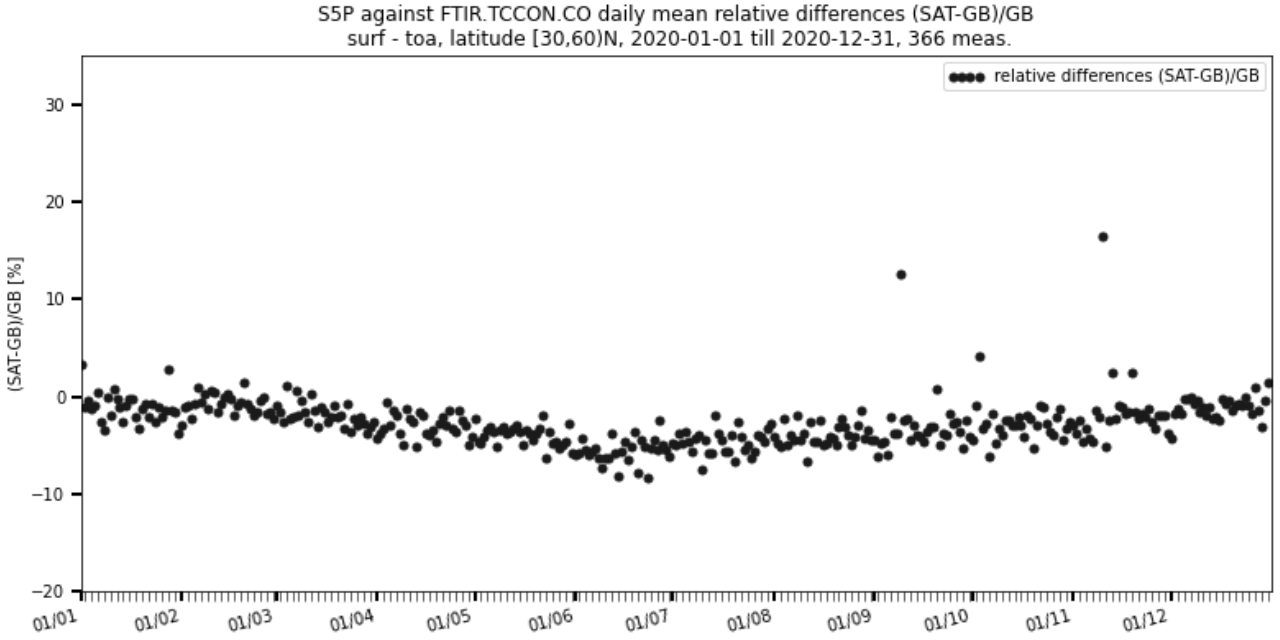
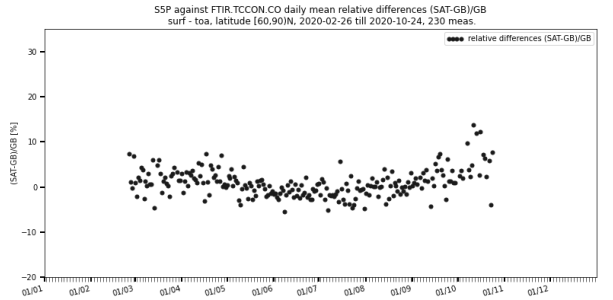
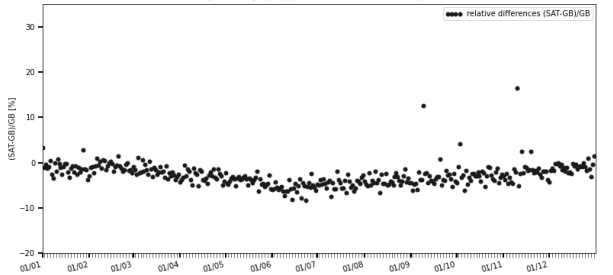
Validation using **TCCON** GGG2020 data



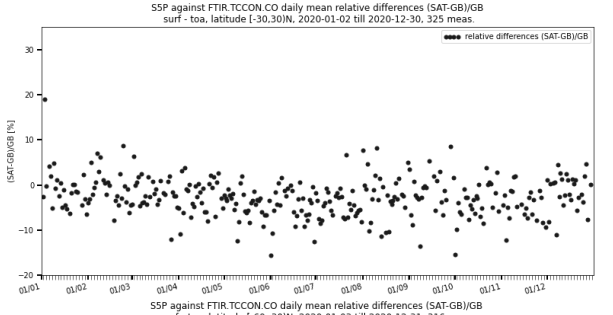
Latitude [60,90]N



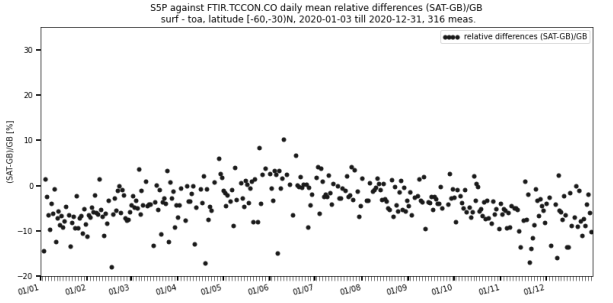
Latitude [30,60]N



Latitude [-30,30]N



Latitude [-60,-30]N



Seasonal difference in bias of about 5% seen
Maximum during local winter

L2 – Carbon monoxide

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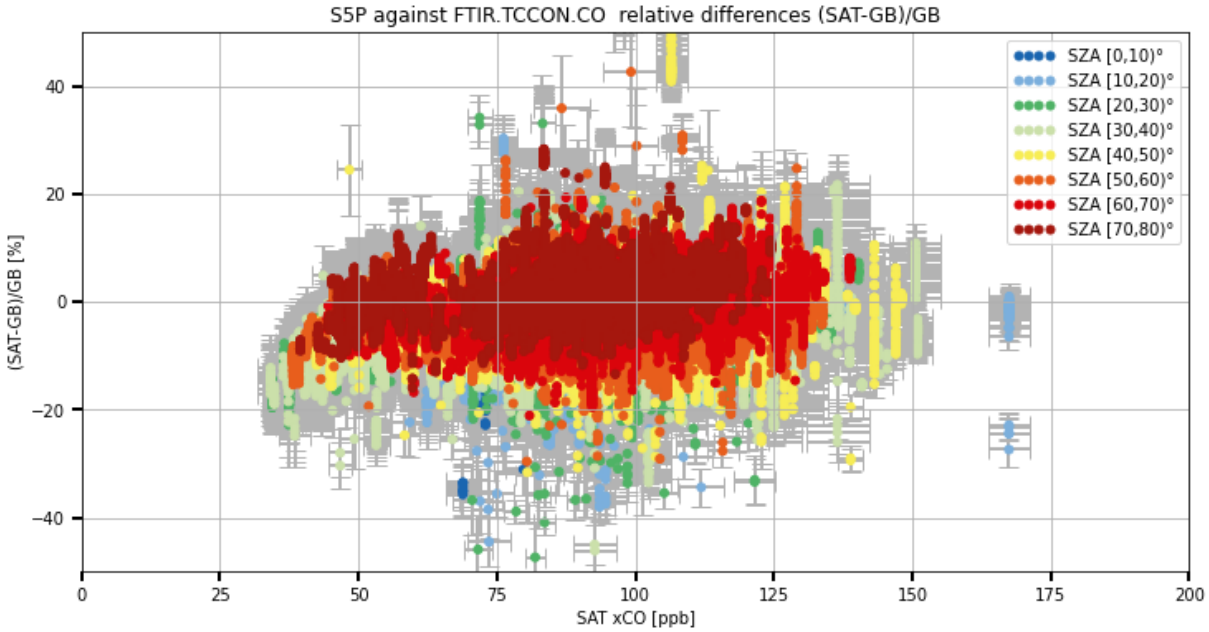
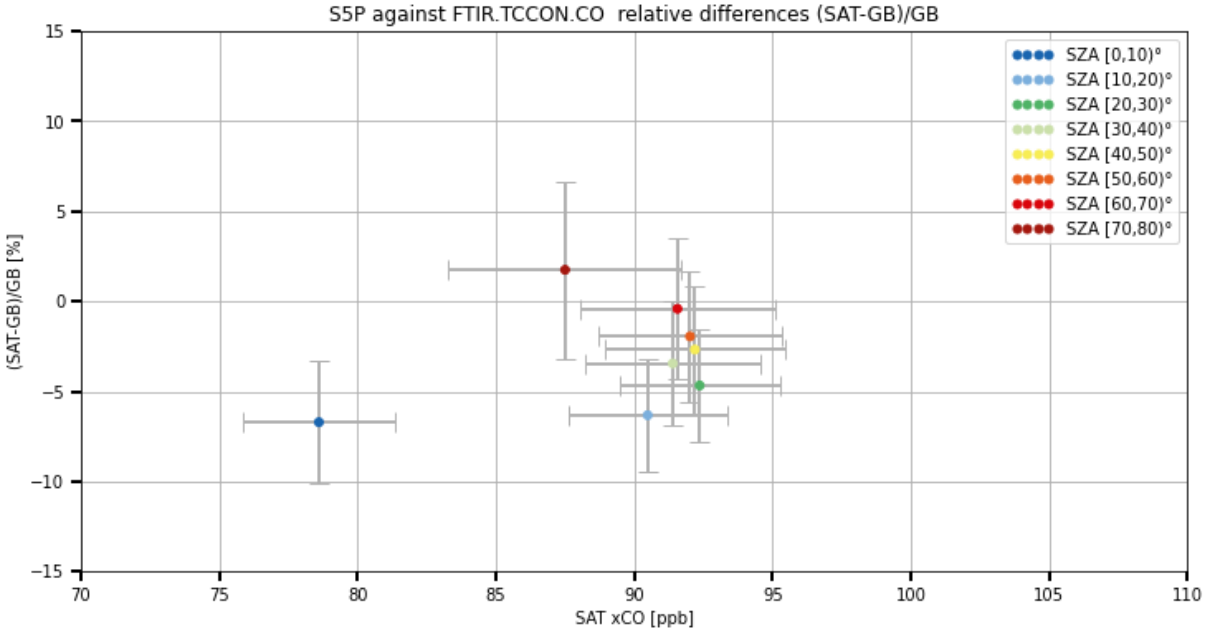
Validation using **TCCON** GGG2020 data



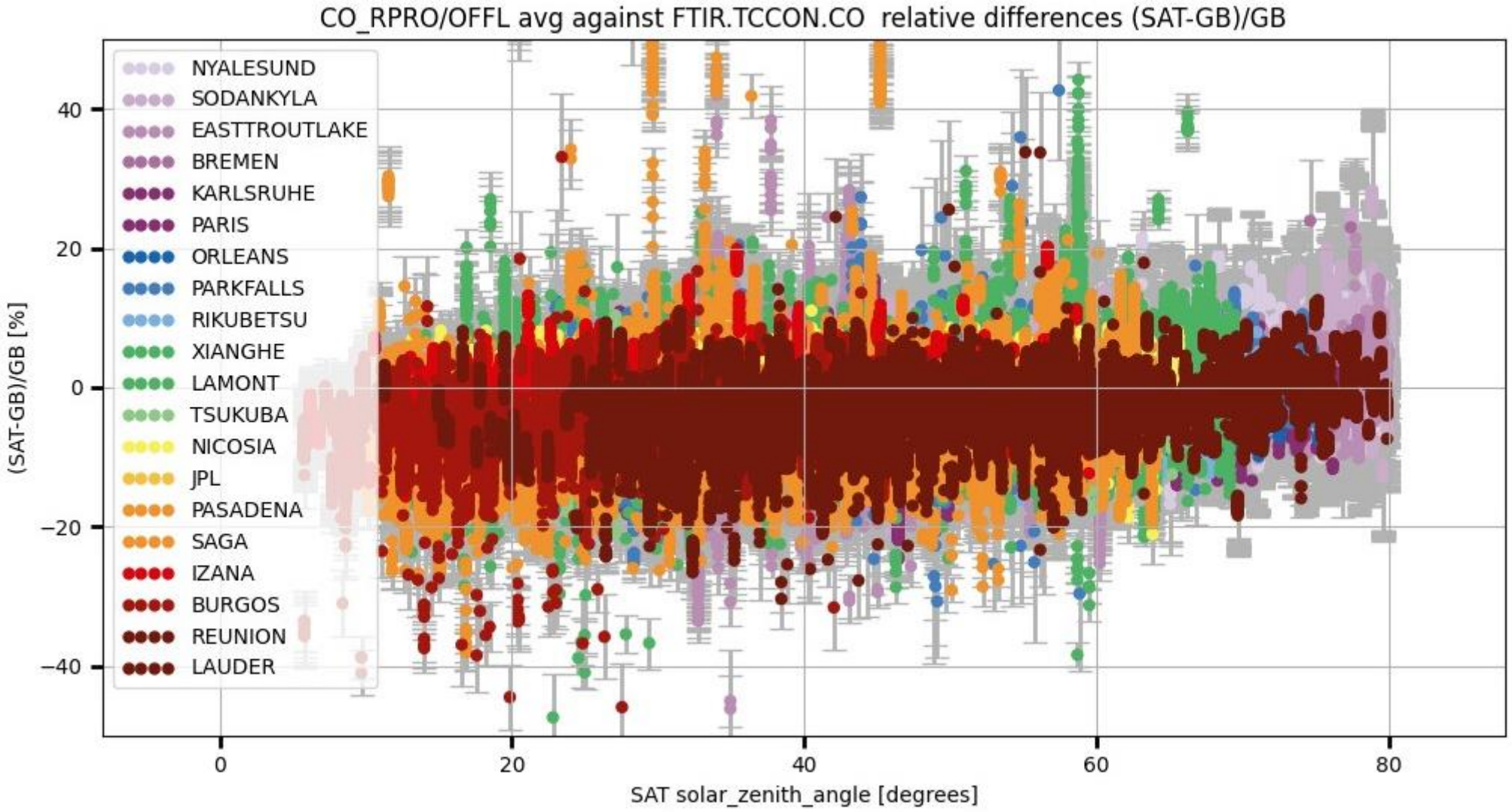


Data for SZA [0,10)°(1229), SZA [10,20)°(20811), SZA [20,30)°(48422), SZA [30,40)°(59194), SZA [40,50)°(52240), SZA [50,60)°(57656), SZA [60,70)°(52344), SZA [70,80)°(29410)

Dependence on solar zenith angle? ~ 5%

L2 – Carbon monoxide

Validation using **TCCON** GGG2020 data

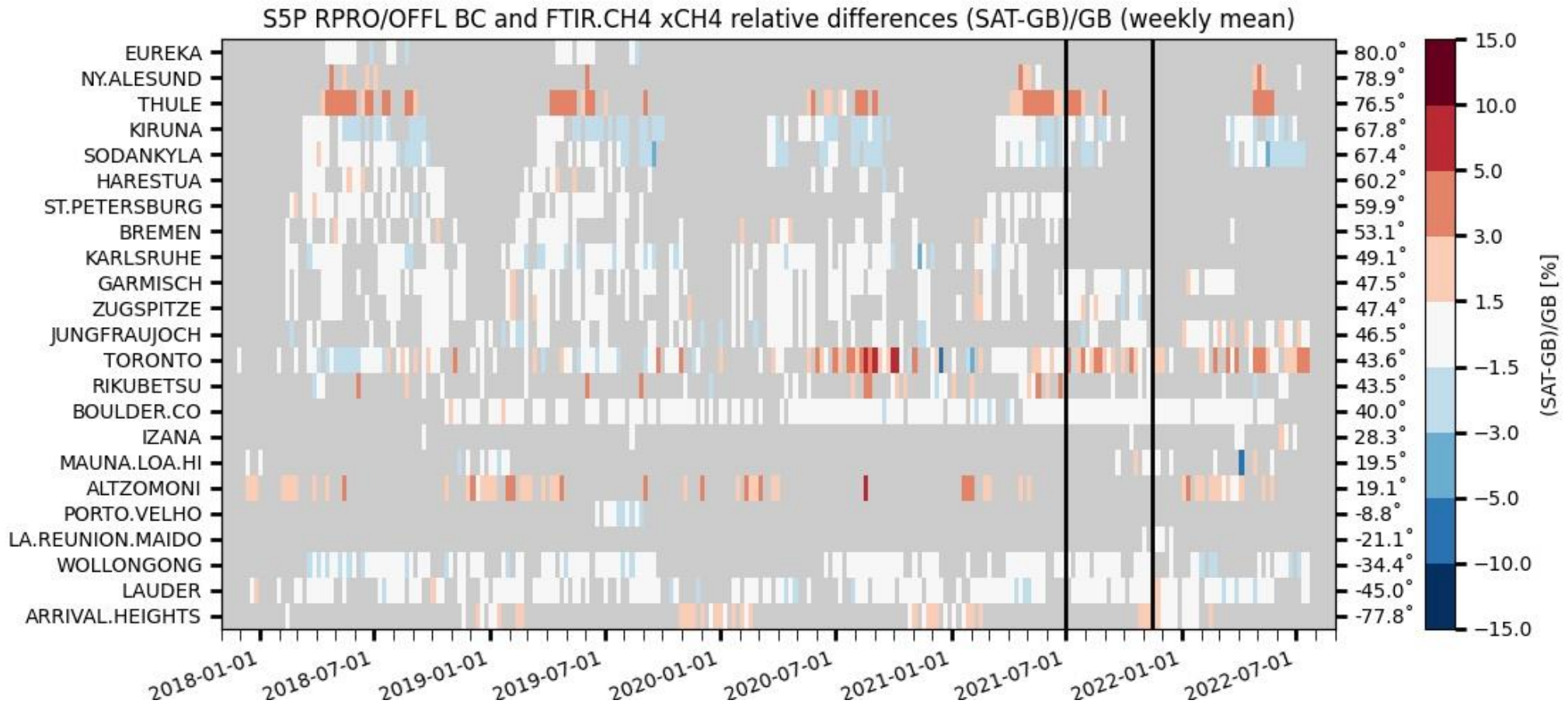


Dependence on solar zenith angle at individual sites: ~ 5%

L2 – Methane

Fewer colocations due to less frequent measurements

Validation using **NDACC** data



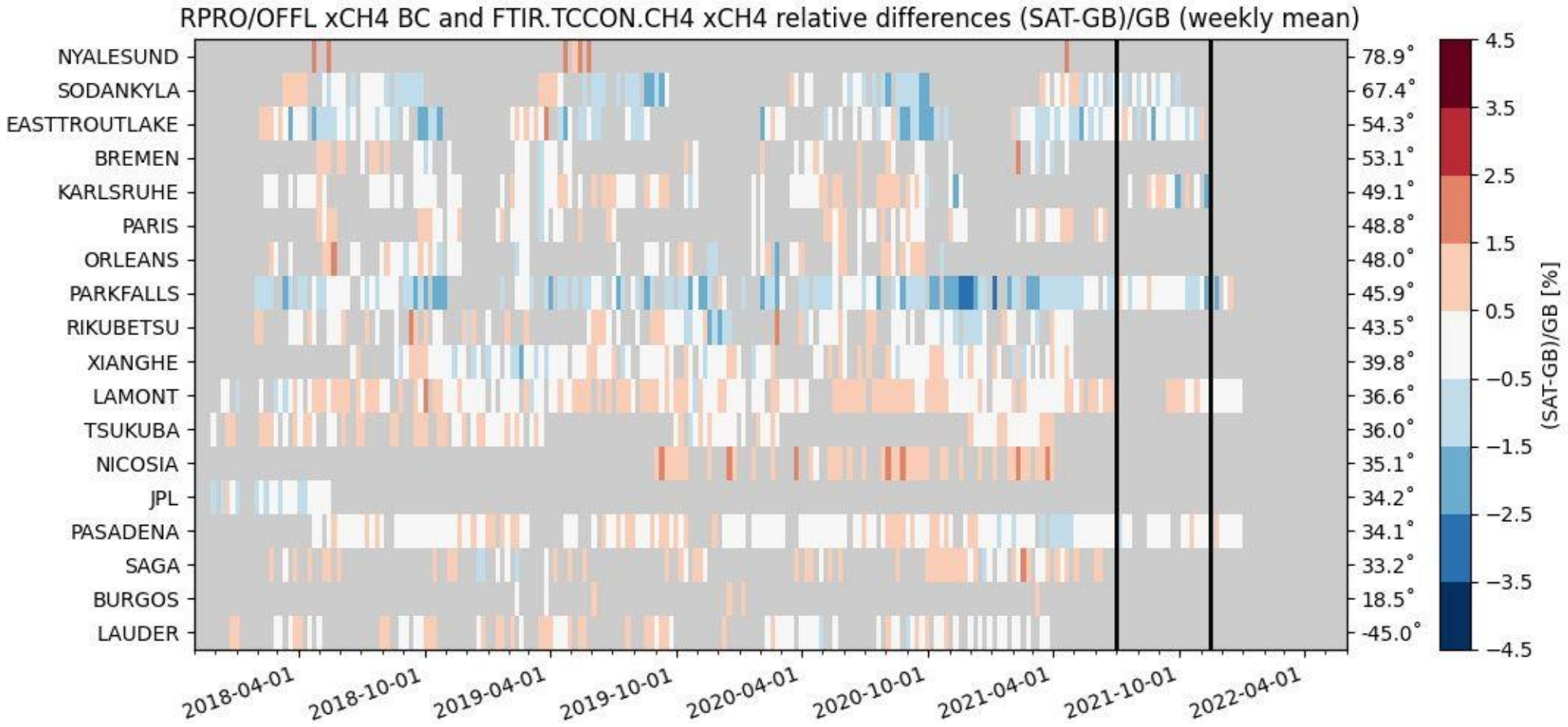
Lower correlation **0.5**, bias **0.4%** and below reported measurement uncertainty

Estimate after 1 July: bias **0.35%** (to be confirmed with TCCON)

Sunglint pixels appear in timeseries for Maido, Wollongong,.. evaluated before with SRON product

L2 – Methane

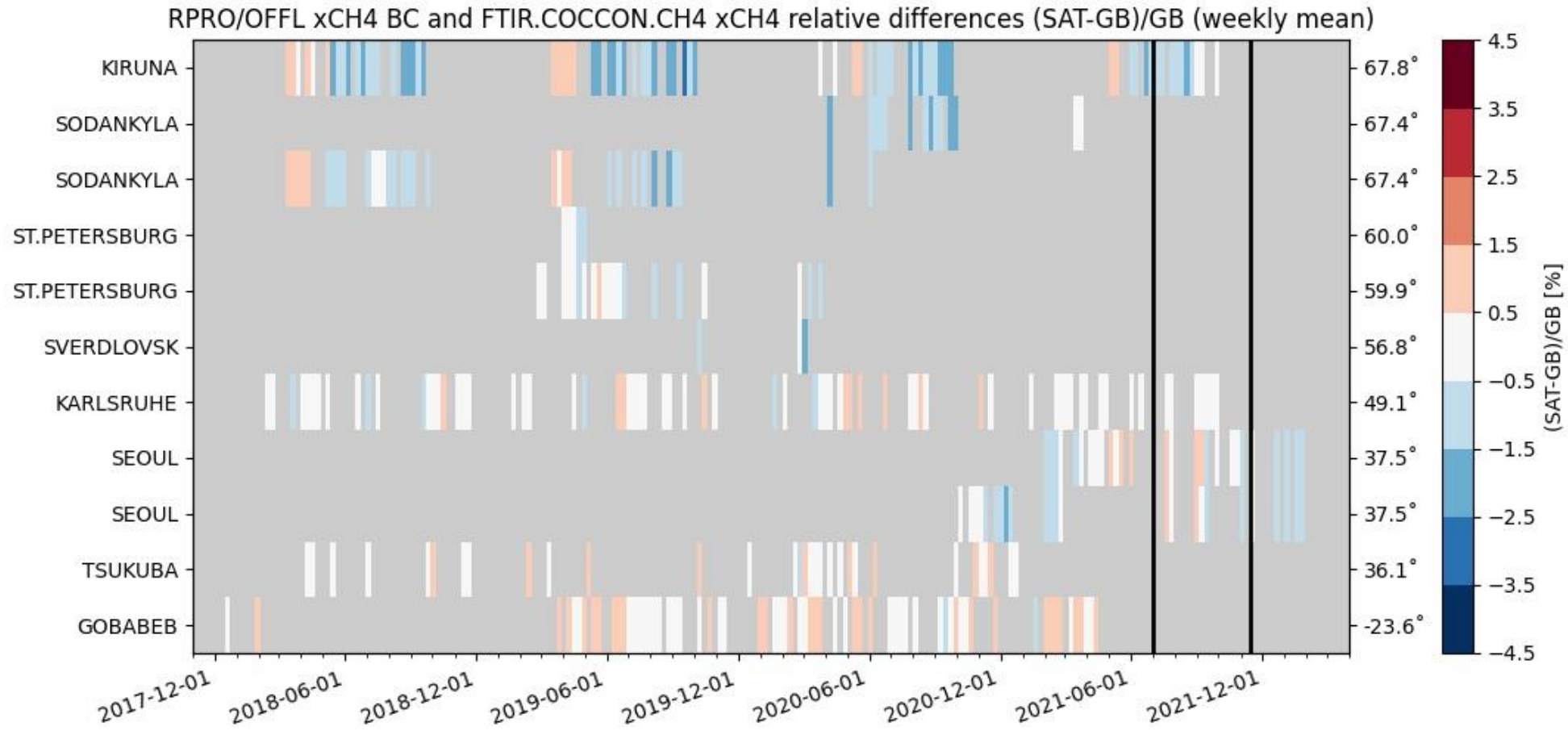
Validation using **TCCON** GGG2020 data



Mean –> Bias = **0.29%** ; STD = **0.62%** ; correlation coefficient = **0.78** (15 Nov 2017 – 1 Jan 2022)

L2 – Methane

Validation using **COCCON** data



Bias corrected XCH4 Mean –> Bias = **-0.34%** ; STD = **0.75%** ; correlation coefficient = **0.59**

L2 – Methane

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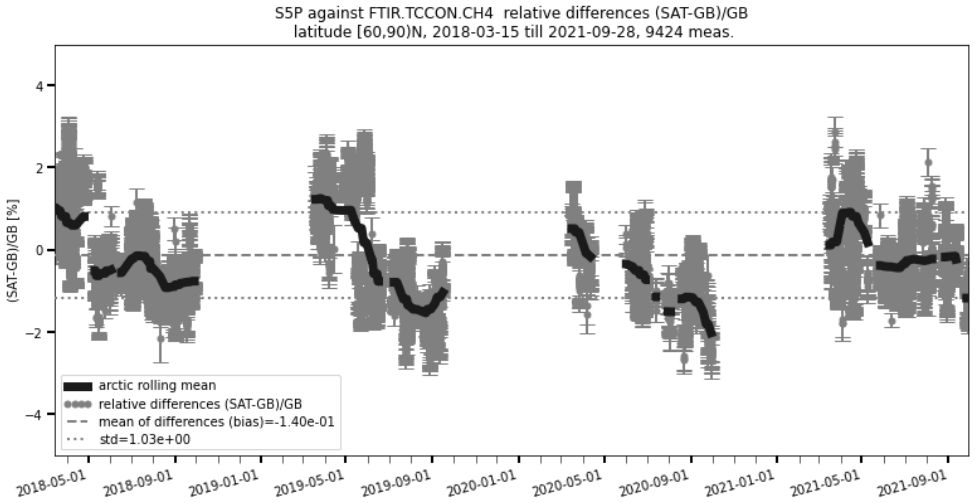
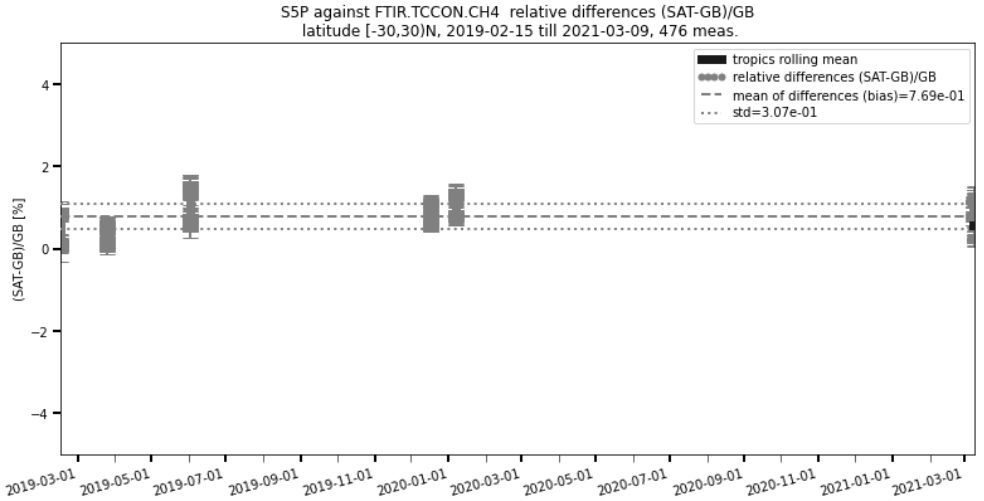
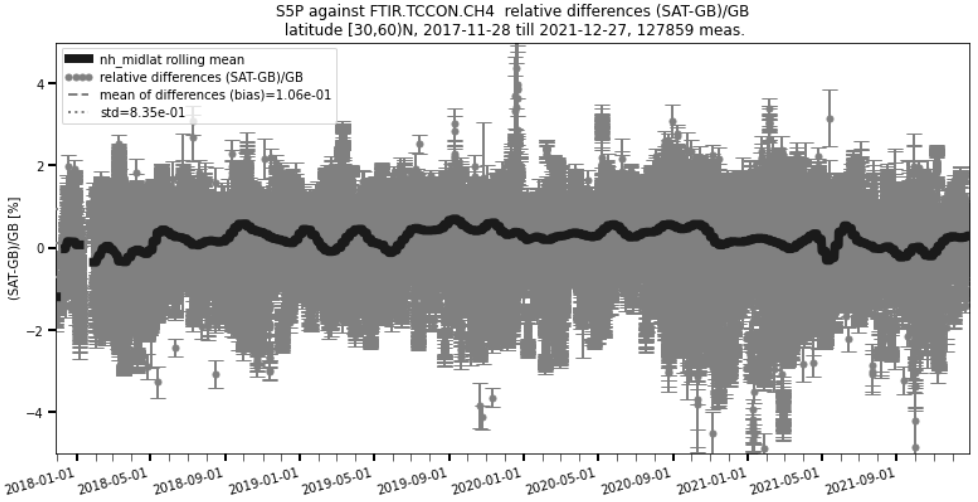
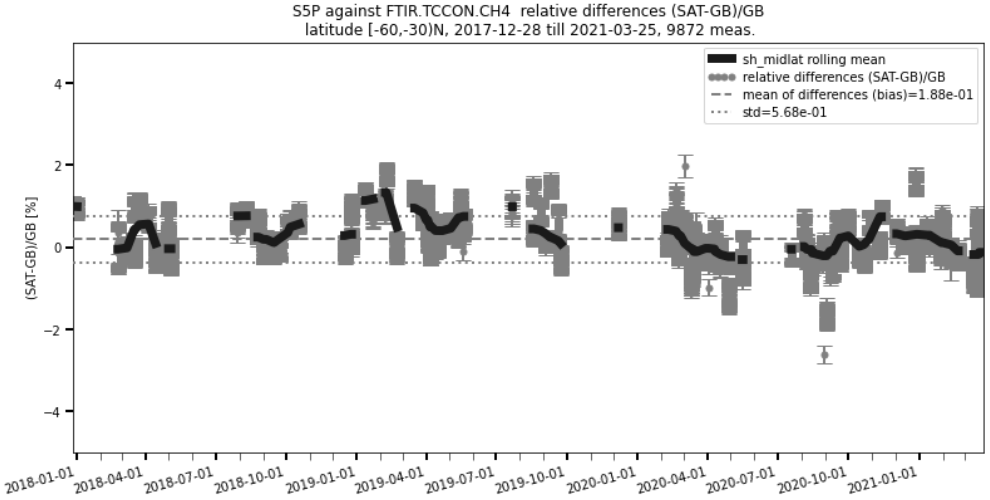
Validation using **TCCON** GGG2020 data









L2 – Methane

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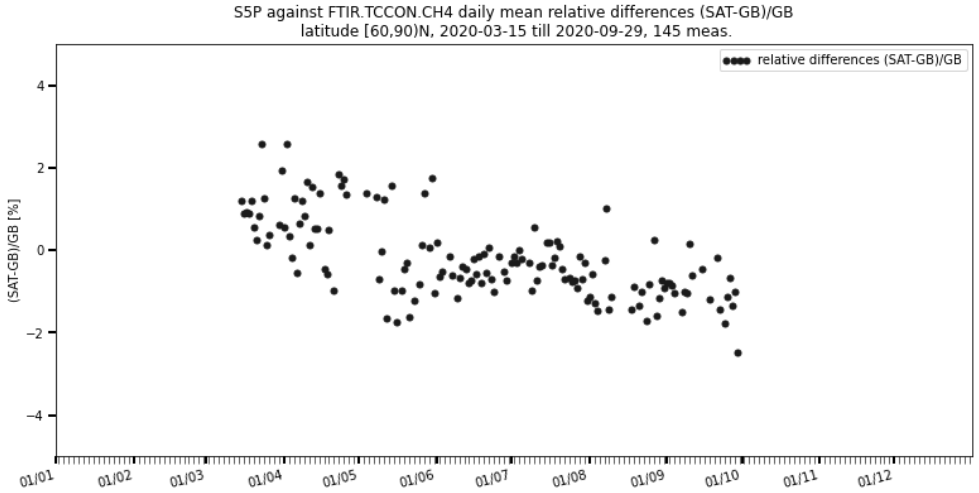
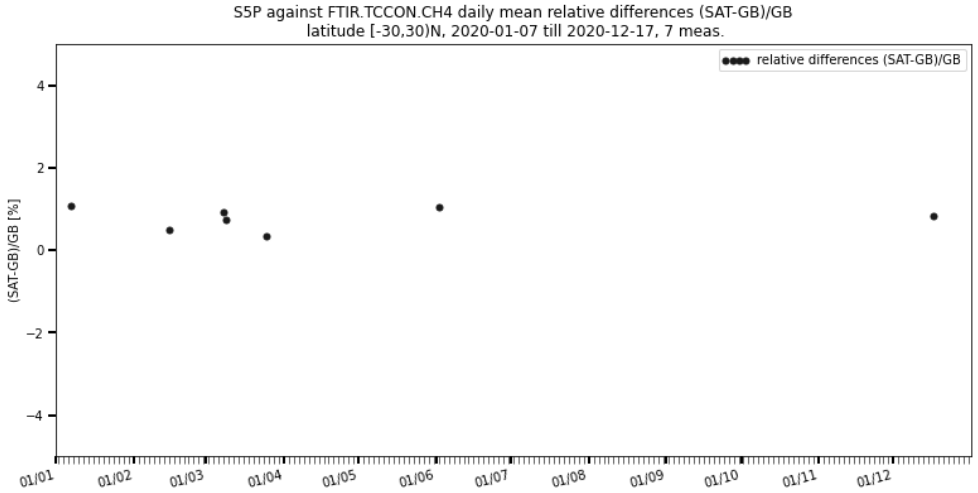
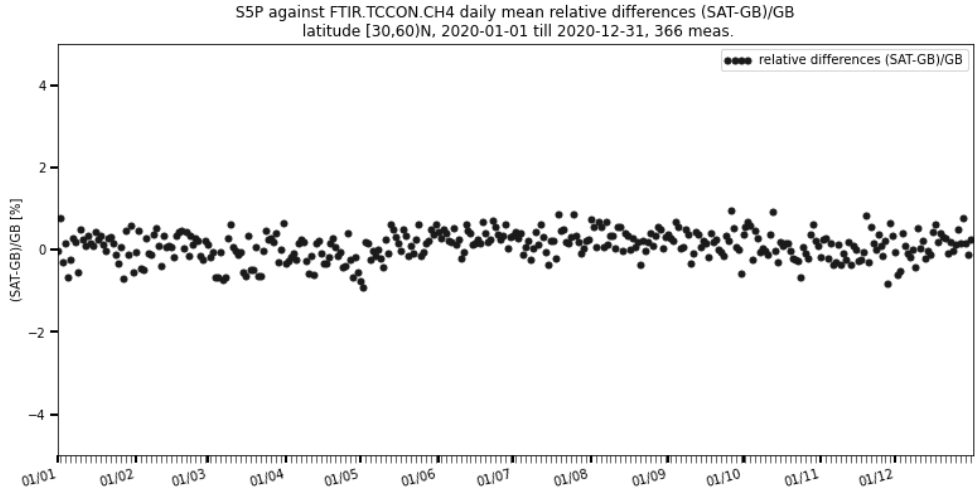
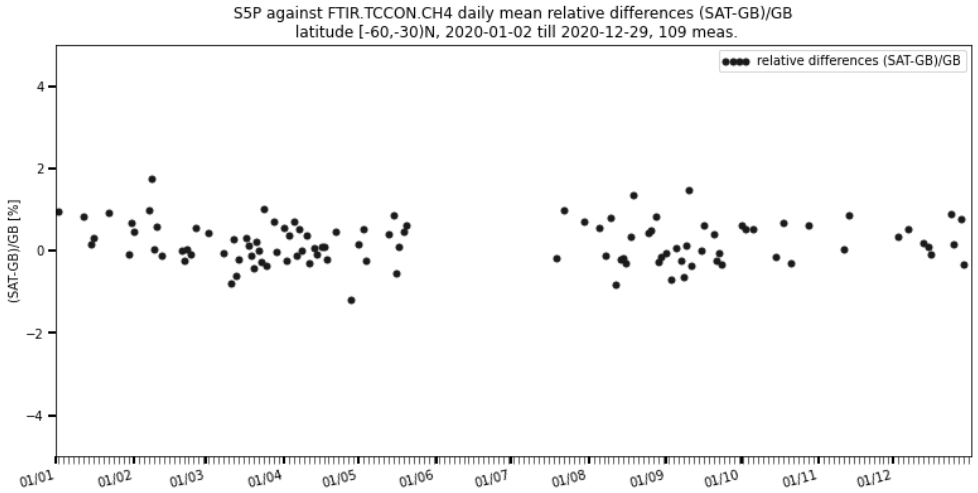
Validation using **TCCON** GGG2020 data









L2 – Methane

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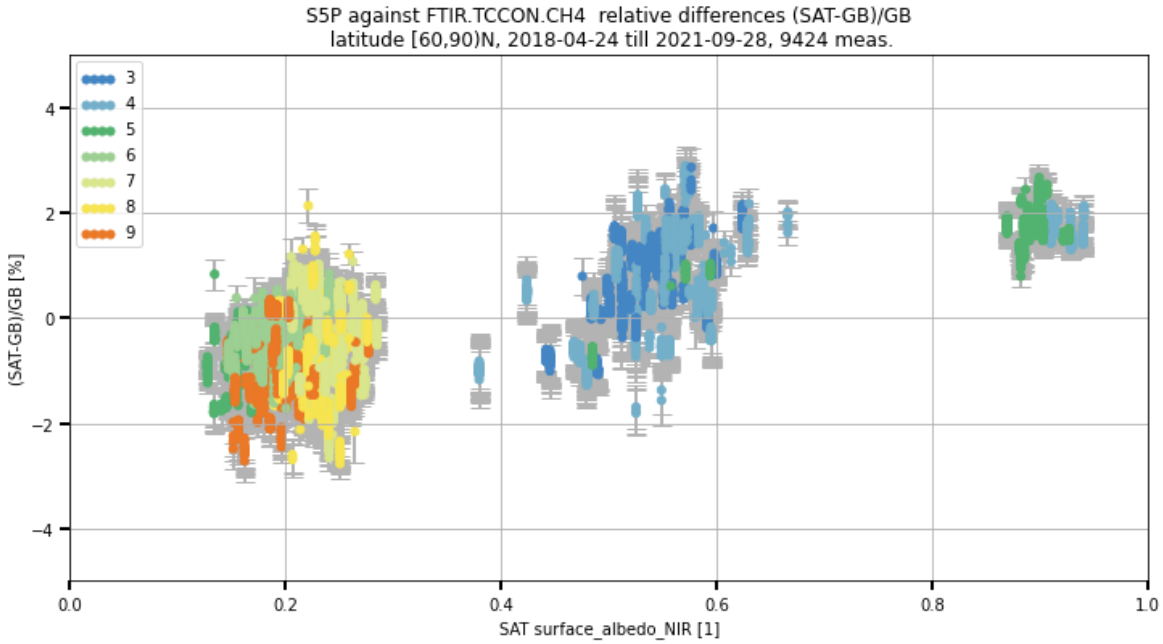
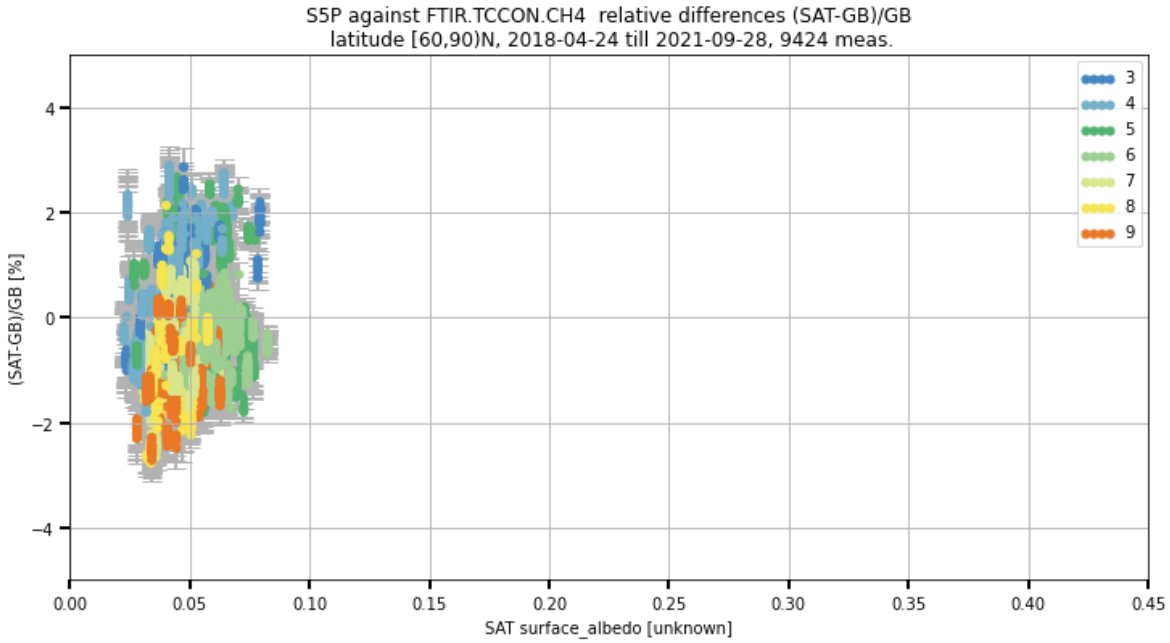
Validation using **TCCON** GGG2020 data





L2 – Methane

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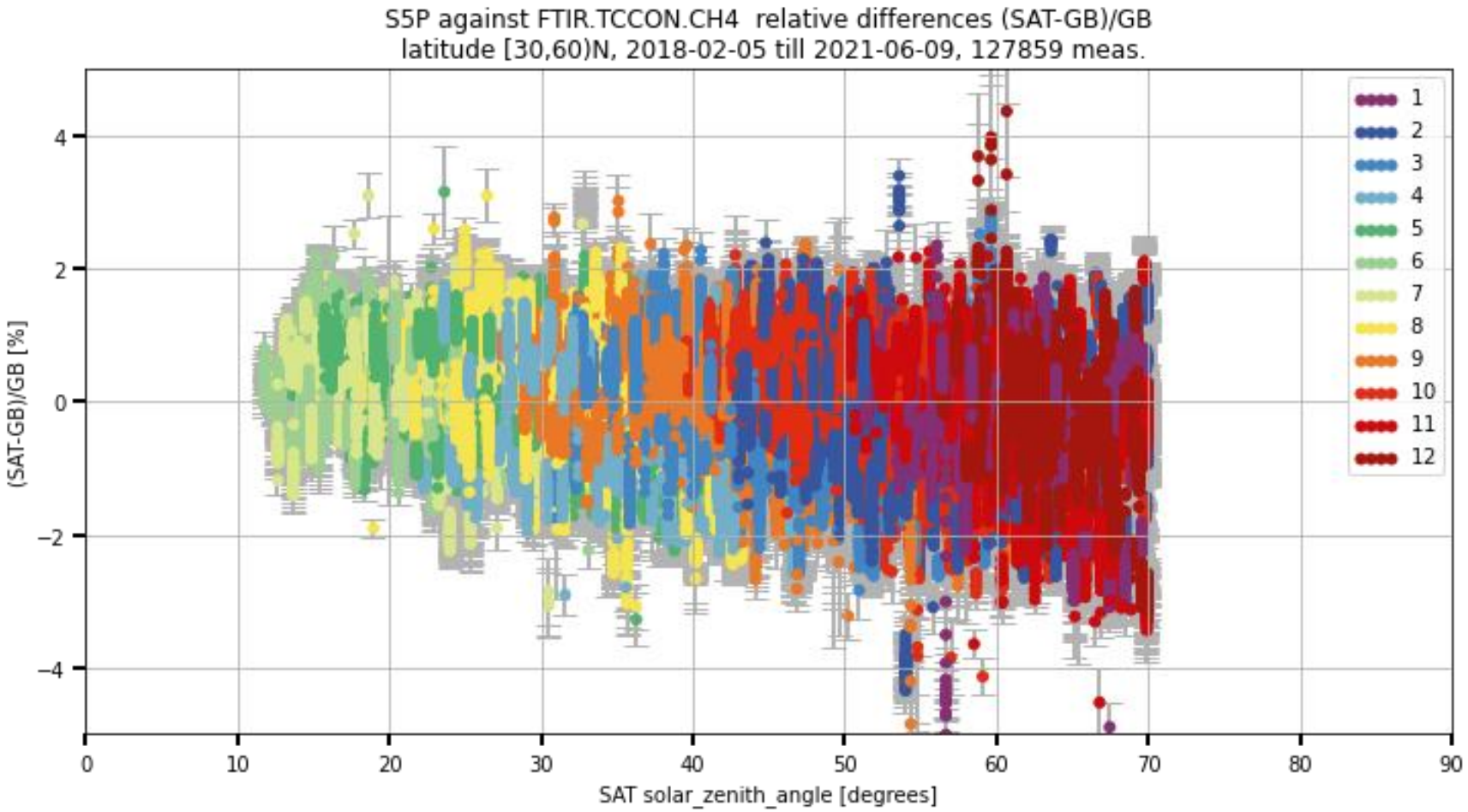
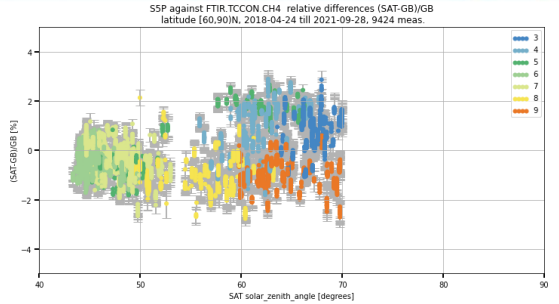
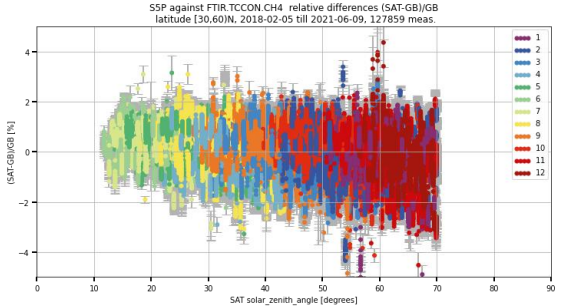
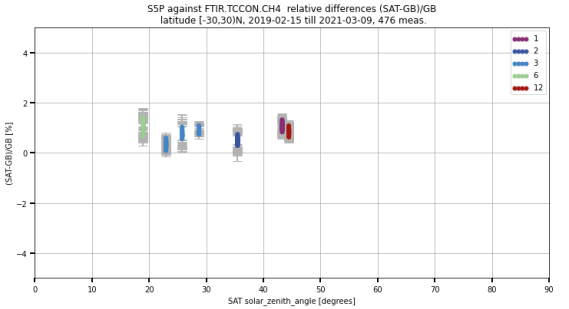
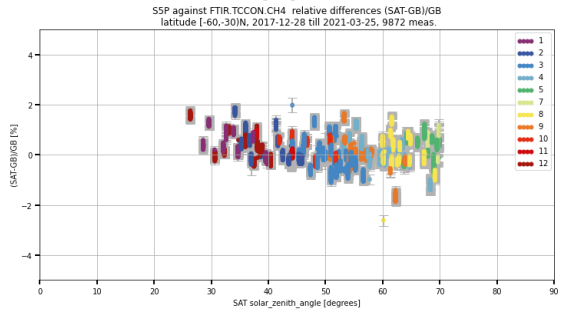
Validation using **TCCON** GGG2020 data











Conclusions

Ground based FTIR networks – NDACC-IRWG, TCCON & COCCON play a significant role in validating the S-5P CO and CH4 products.
- Many thanks to the data providers

Carbon Monoxide

Overall **bias** w.r.t. ground based FTIR stations improved for each new version of the product ➔ from 6.5% for collection 1 to 3% for collection 2 and currently ± 2% for collection 3. The **dispersion** improved slightly over the different versions (5% ➔ 4.5%). Pearson correlation coefficient of > 0.9.
No clear signal of trend in bias seen, a seasonal dependence of < 5% is observed with maximum during local winter. The annual cycle in TCCON is within the combined uncertainty and not seen in NDACC

Methane

Overall bias w.r.t. ground based FTIR stations improved from collection 1 to 2 ➔ 0.3%. The dispersion over the different versions stayed around 0.6%. Pearson correlation coefficient of about 0.8.
Influence of surface albedo observed in the bias (**1-3%**).
Seasonal and solar zenith angle dependence observed.

Systematic and random uncertainty of S-5P CO and CH4 products validated against the combined FTIR stations is well within the mission requirements. Please refer to the quarterly validation report for detailed validation results (https://mpc-vdaf.tropomi.eu/index.php/search?view=search).

The latest updated product “collection 3” show lower bias and dispersion and seems to be a very good product.

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Thank you for your attention!

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Ministry of Infrastructure and Water Management

DLR Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

s[&]t

University of Bremen

Science & Technology Facilities Council

SRON
Netherlands Institute for Space Research

NILU

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