S5P/TROPOMI CH$_4$ and CO total column average mixing ratio validation over Thessaloniki, Greece using FTIR spectrophotometry

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SUMMARY

In this work, operational column-averaged dry-air mole fractions of methane (XCH$_4$) and carbon monoxide (XCO) from the TROPOspheric Monitoring Instrument (TROPOMI), Sentinel-5P space borne sensor are validated against those obtained using the Bruker EM27/SUN ground-based low-resolution Fourier Transform spectrometer operated according to the requirements of the Collaborative Carbon Column Observing Network (COCCON) at a mid-latitude urban station, Thessaloniki, Greece, (*Mermigkas et al., 2021*) from January 2019 to May 2022.

- The TROPOMI XCH$_4$ and XCO products show very good agreement to FTIR XCH$_4$ measurements and capture both their seasonal variability and pollution episodes such as high isolated values of XCO in July-August 2021 due to the big forest fires in Athens and Evia, Greece.
- The overall relative mean biases fall well within mission requirements (**-0.19% ± 0.68%**, for standard XCH$_4$, **0.15% ± 0.58%** for bias-corrected XCH$_4$ and **+2.17% ± 5.45%** for XCO).
- Implementation of new spectroscopy and de-stripping algorithms lead to changes in overall XCH$_4$ and XCO relative biases.
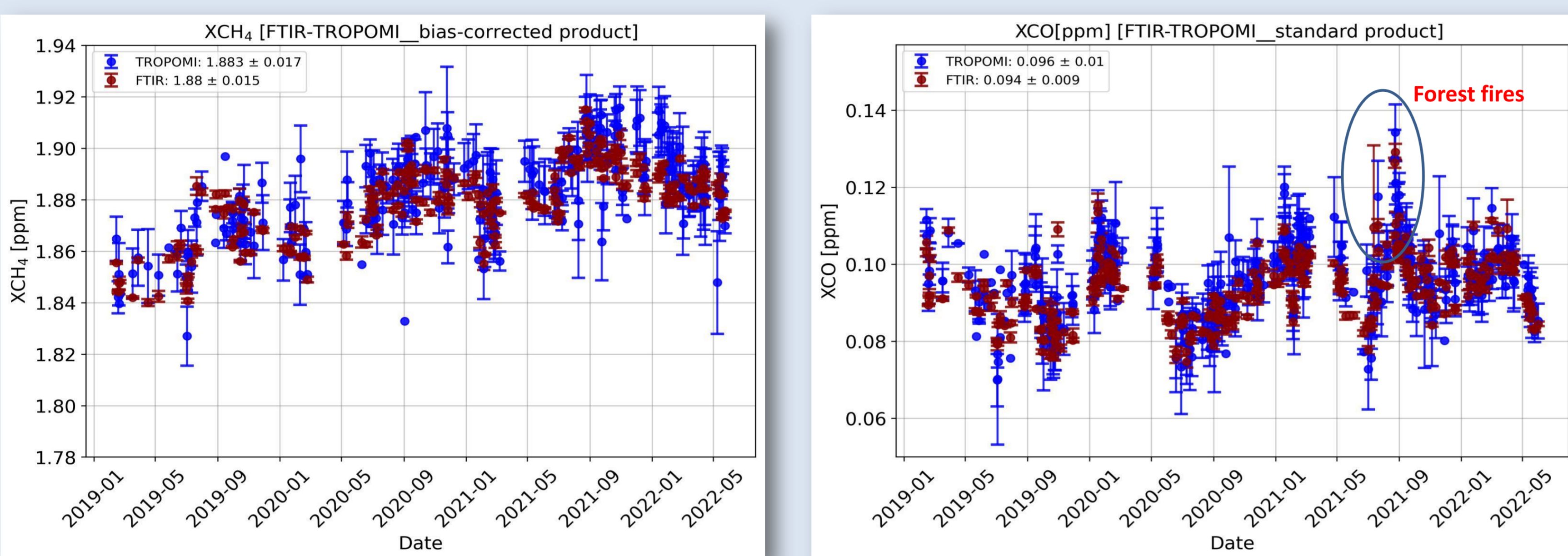
RESULTS

Timeseries

Figure 1: Time series of XCH$_4$ and XCO measurements from FTIR (red symbols) and TROPOMI (blue symbols). TROPOMI has captured both the seasonal variability of the two species and local pollution events such as CO transportation from the south, during the summer 2021 big forest fires in Athens and Evia.

TROPOMI XCH$_4$-XCO relative bias vs FTIR

Methane	Carbon monoxide
OFFL standard product (green)	OFFL standard product (green)
OFFL bias corrected (orange)	OFFL corrected (de-striped after July, 1, 2021 (orange))
100km & 1h co-location criteria, qa=100	50km & 1h co-location criteria, qa=100

Figure 2: Relative mean bias of collocated TROPOMI column-averaged dry-air mole fractions of methane (XCH$_4$) (left) and carbon monoxide (XCO) (right) compared to EM27 FTIR ground measurements in Thessaloniki from 2019 to mid 2022.

- Implementation of processor update (**v. 02.02.00, July 1, 2021**) introduces a different spectroscopy and changes in the overall biases (S5P-MPC-IASB-ROCVR-15.01.00-20220713) and can explain the decrease of XCH$_4$ and XCO bias seen in the second half of 2021.

- A de-striping algorithm is also available for XCO data since July,1, 2021. Biases were calculated for non de-striped and de-striped data after July, 1, 2021. The de-striping algorithm seems to cause a decrease to both bias and standard deviation.

- All biases fall well within mission requirements of **1.5% ± 1% for XCH$_4$** and **15% ± 10% for XCO** and are consistent with validation from stations of different frameworks such as TCCON and COCCON (Tobias Borsdorff et al.,2019 & Alba Lorente et al.,2021 & S5P-MPC-IASB-ROCVR-15.01.00-20220713).

Table 1: Relative mean biases of TROPOMI XCH$_4$ and XCO vs FTIR measurements (overall and per processor period).

XCH$_4$	[%] bias up to 1/7/2021	[%] bias after 1/7/2021	Overall mean relative bias [%]	XCO	[%] bias up to 1/7/2021	[%] bias after 1/7/2021	Overall mean relative bias [%]
Standard	-0.12±0.65	-0.31±0.71	-0.19±0.68	Standard	3.04±5.64	0.62±4.74	2.17±5.45
Bias Corrected	0.15±0.56	0.14±0.62	0.15±0.58	De-striped data (after 1/7/2021)	"	0.28±4.34	2.05±5.37

Corrected XCH$_4$-XCO FTIR-TROPOMI comparison

Bias corrected XCH$_4$ data and **de-striped (after July 1, 2021) XCO data** were chosen for a direct comparison vs ground bases FTIR data.
Only days with more than 15 available scans per satellite orbit were used.
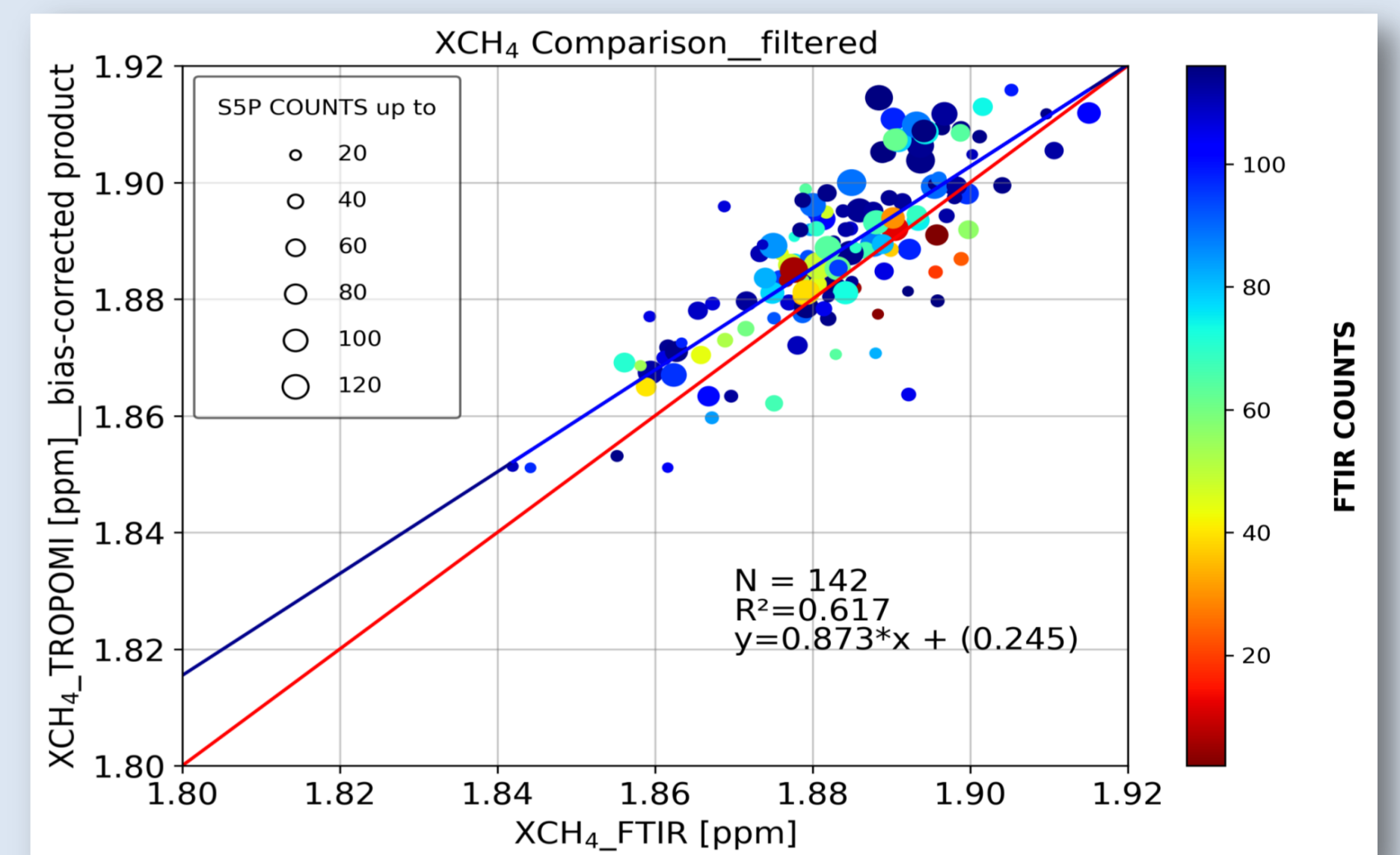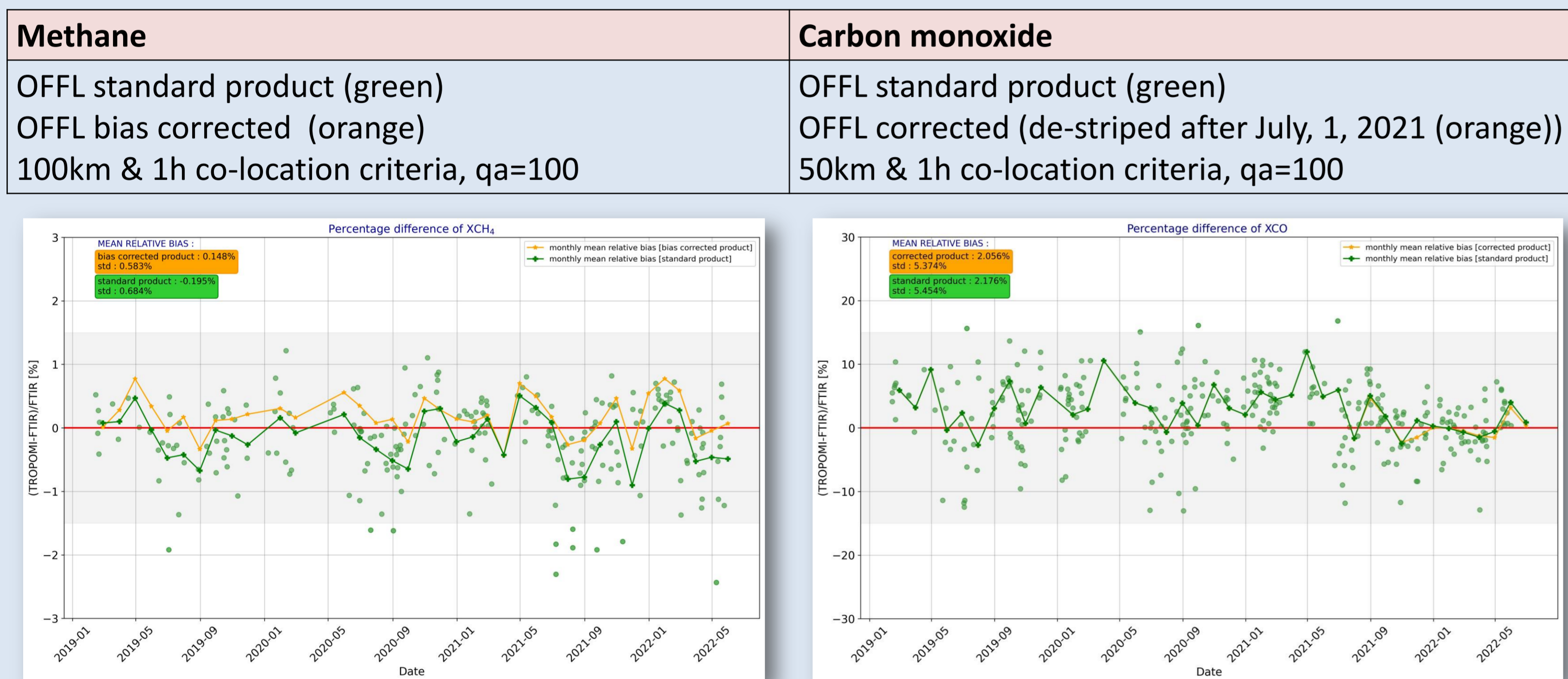

Figure 3: Scatter plot of bias corrected TROPOMI XCH$_4$ vs FTIR XCH$_4$ measurements. Size of circle symbols increases with available data in each satellite orbit.
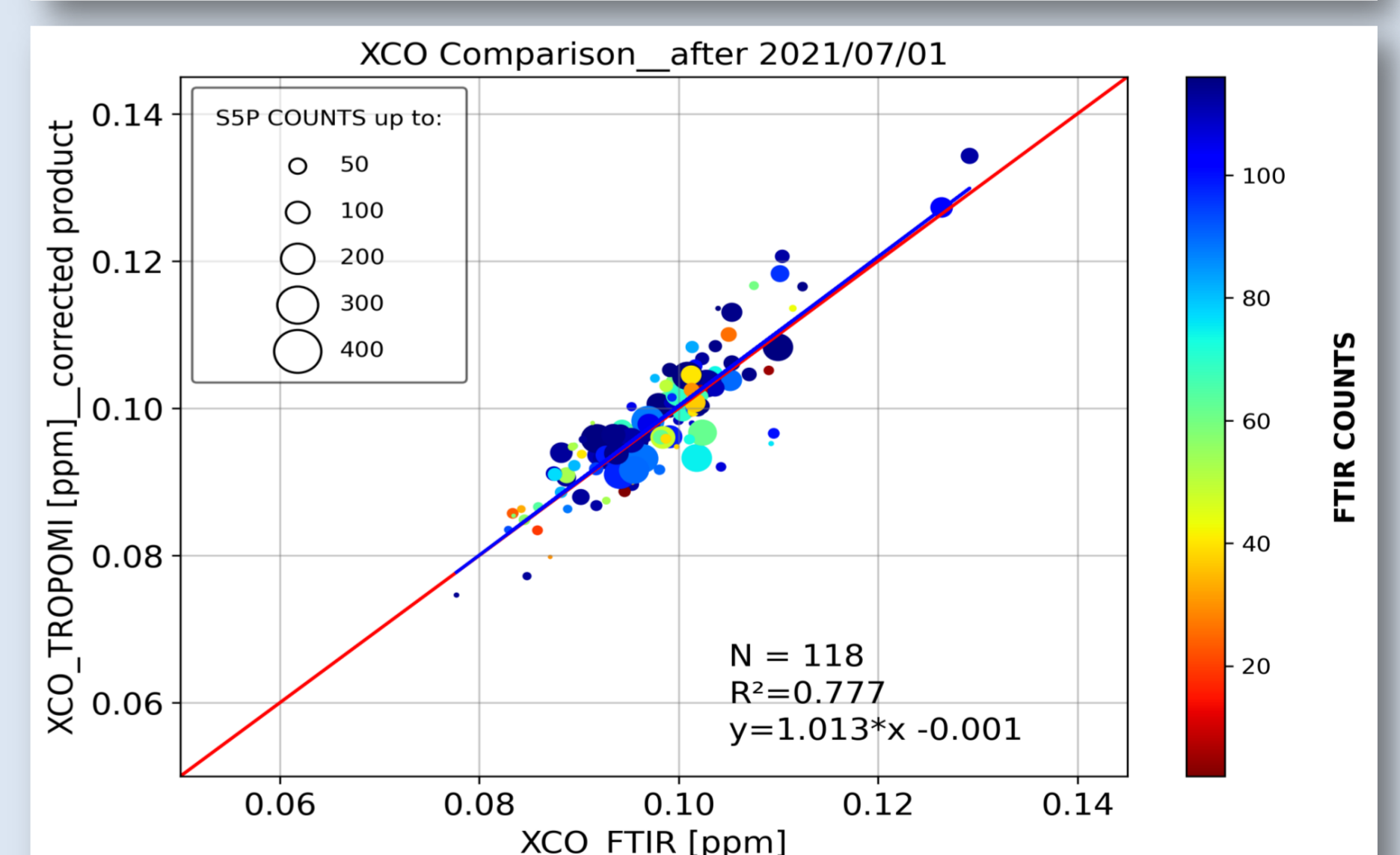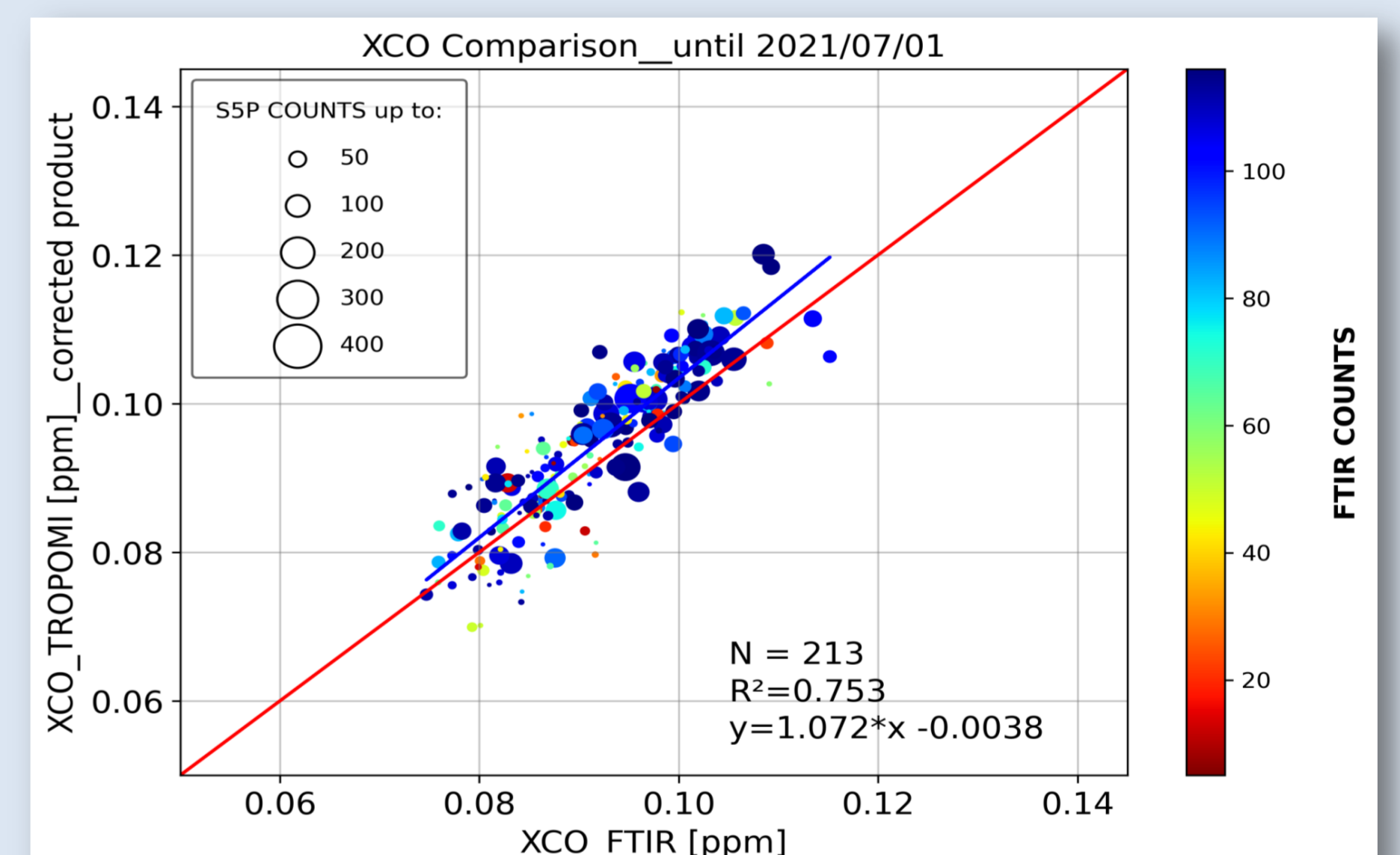

Figure 4: Scatter plots of de-striped (after July, 1, 2021) TROPOMI XCO vs FTIR XCO measurements for the two processor versions periods. Size of circle symbols increases with available data in each satellite orbit.
Before July, 1, 2021 (upper plot), after July 1, 2021 (lower plot).