

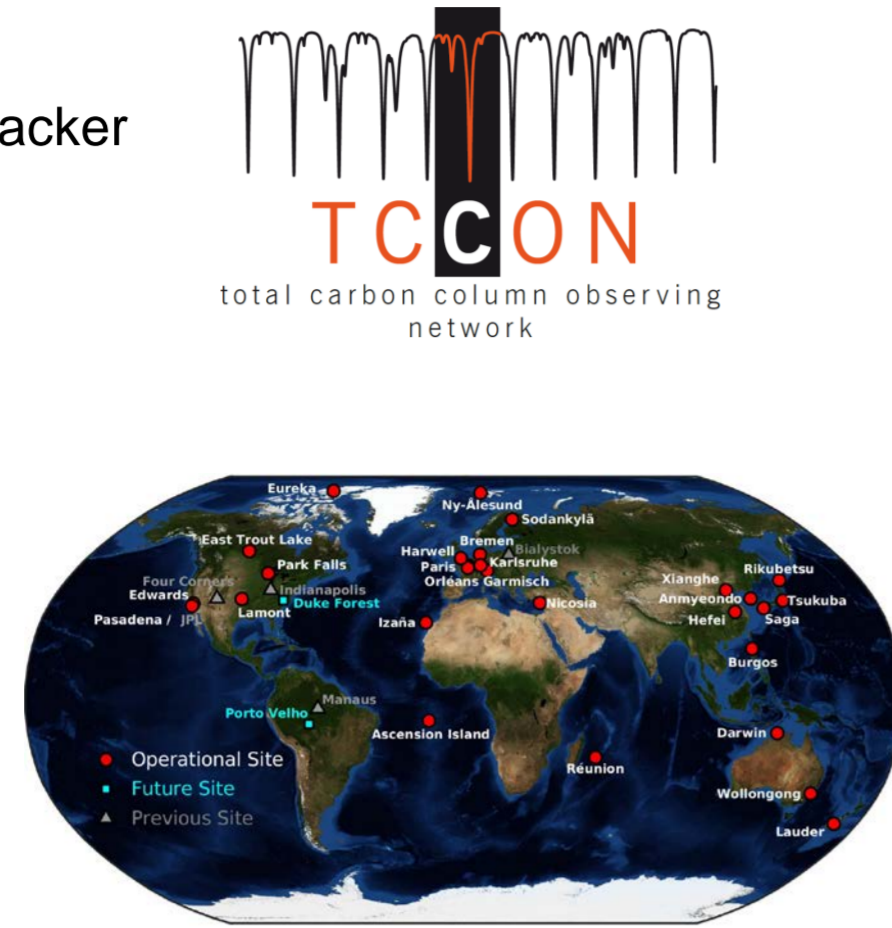


Greenhouse gas measurements at Sodankylä, Finland and comparisons with satellite borne observations

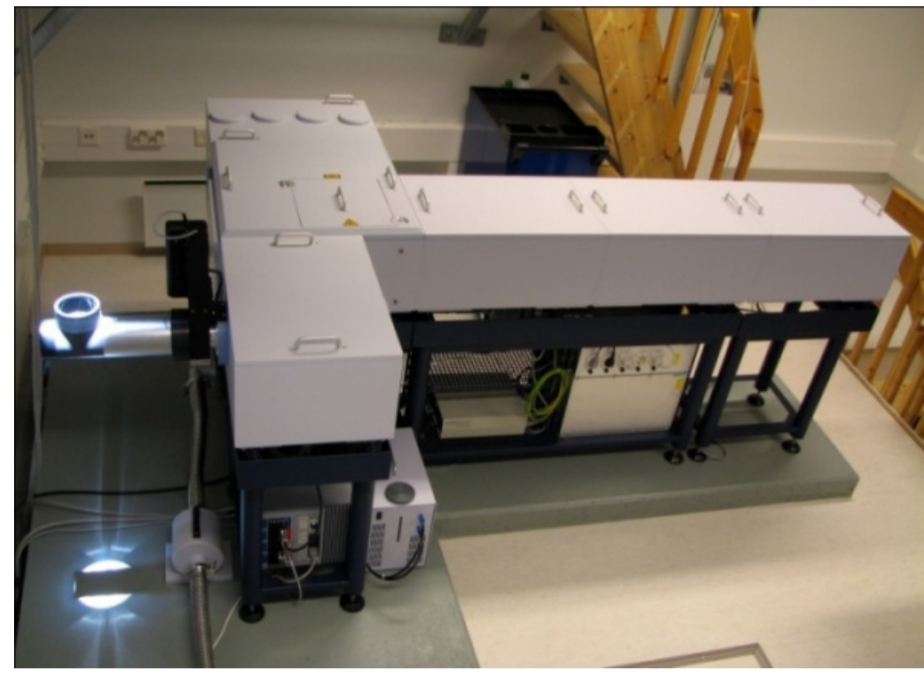
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Bruker IFS 125 HR with A547N Solar Tracker
 • Gold coated mirrors
 • Optical path difference ≤ 258 cm
 • Resolution ≥ 0.0035 cm^{-1}
 • Detectors and wave number ranges

• RT-Si: 25000* – 9000 cm^{-1}
 • RT-InGaAs: 12800 – 4000 cm^{-1}
 • LN-InSb: 9600 – 1850 cm^{-1}



Retrieved gases include:
 • Carbon dioxide, CO_2
 • Methane, CH_4
 • Nitrous oxide, N_2O
 • Hydrogen fluoride, HF
 • Carbon Monoxide, CO
 • H_2O and HDO



Fourier transform infrared spectrometer (FTS) system was installed at Sodankylä (67.4°N, 26.6°E) in early 2009 (Kivi and Heikkinen 2016).

FTS measurements since 2009

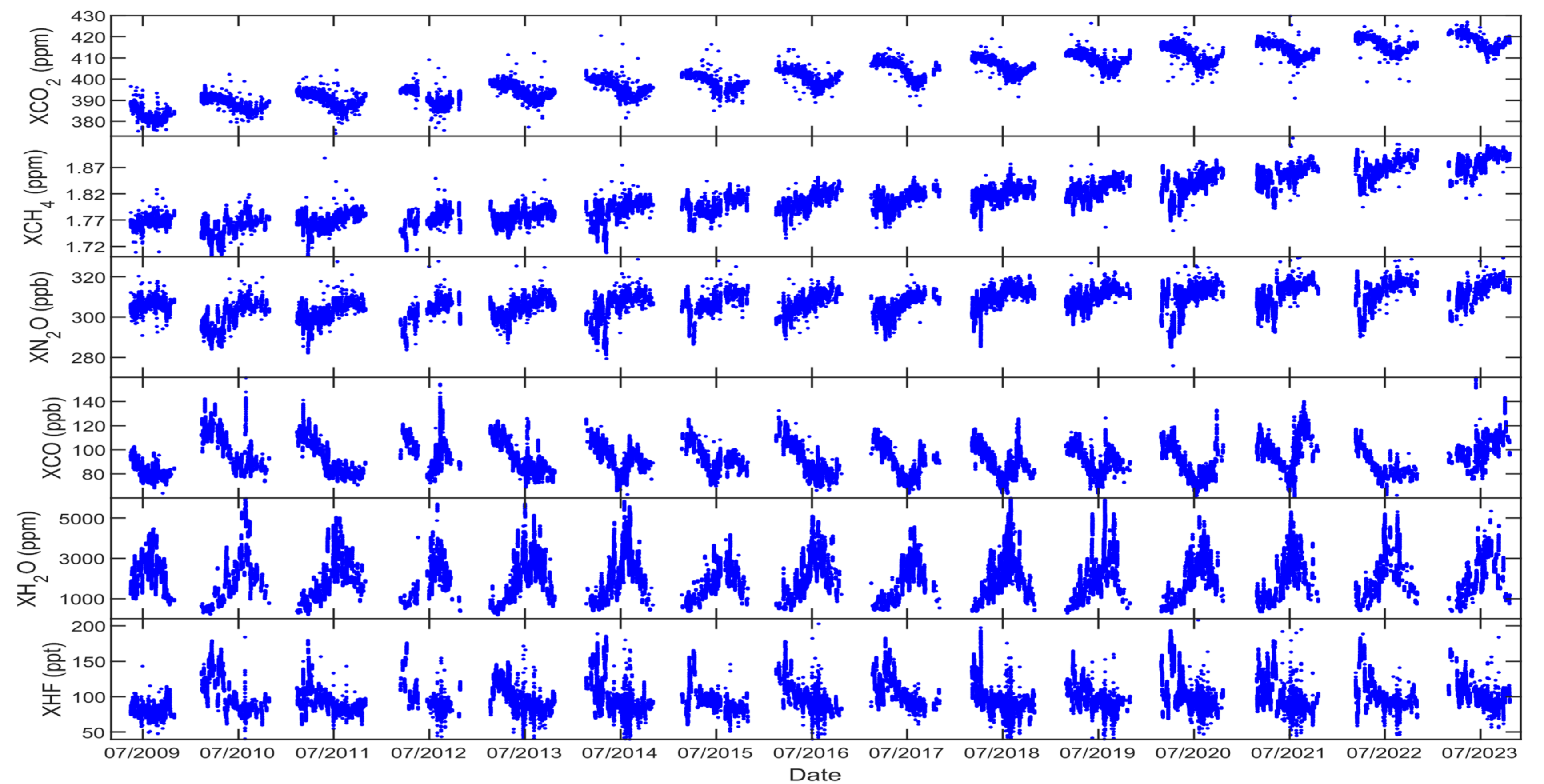
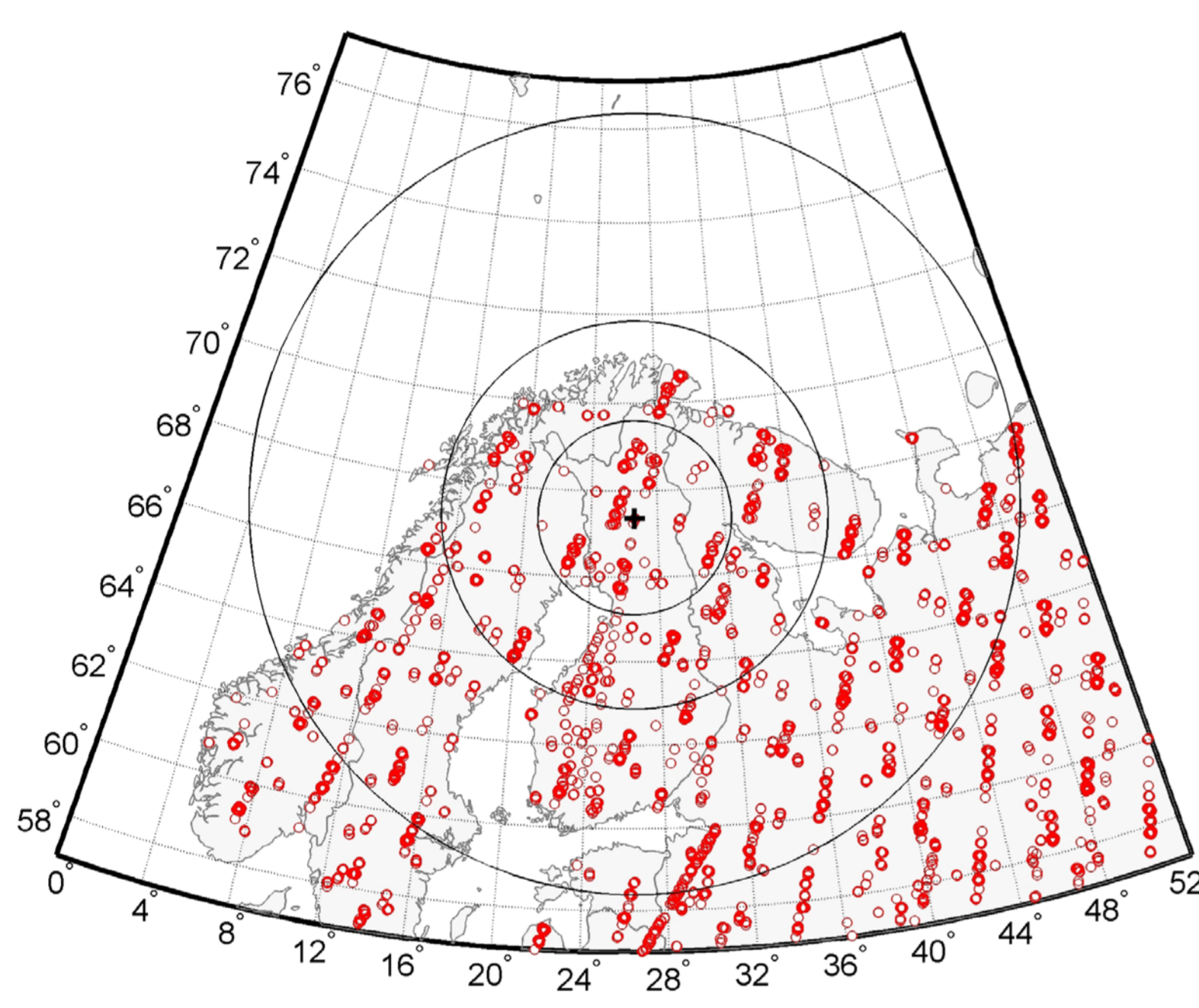


Figure 1: Column-averaged mixing ratios measured by the FTS instrument at Sodankylä, the GGG2020 retrieval (Laughner et al., 2024).

Comparisons with GOSAT satellite observations



Spatial coverage	1000 km radius	500 km radius	250 km radius
Time window	± 3 h	± 2 h	± 1 h
Number of coincident measurements	7385	2016	661
Absolute difference, GOSAT – Sodankylä FTS [ppm]:			
Mean	-0.38	-0.42	-0.18
StdDev	2.71	2.48	2.22
StdErr	0.04	0.06	0.09
Relative difference, (GOSAT – Sodankylä FTS) / Sodankylä FTS [%]:			
Mean	-0.10	-0.10	-0.04
StdDev	0.68	0.62	0.56
StdErr	0.01	0.01	0.02

Spatial coverage	1000 km radius	500 km radius	250 km radius
Time window	± 3 h	± 2 h	± 1 h
Number of coincident measurements	7409	2026	668
Absolute difference, GOSAT – Sodankylä FTS [ppm]:			
Mean	0.0065	0.0038	0.0054
StdDev	0.0165	0.0147	0.0129
StdErr	0.0002	0.0003	0.0005
Relative difference, (GOSAT – Sodankylä FTS) / Sodankylä FTS [%]:			
Mean	0.36	0.21	0.30
StdDev	0.91	0.81	0.71
StdErr	0.01	0.02	0.03

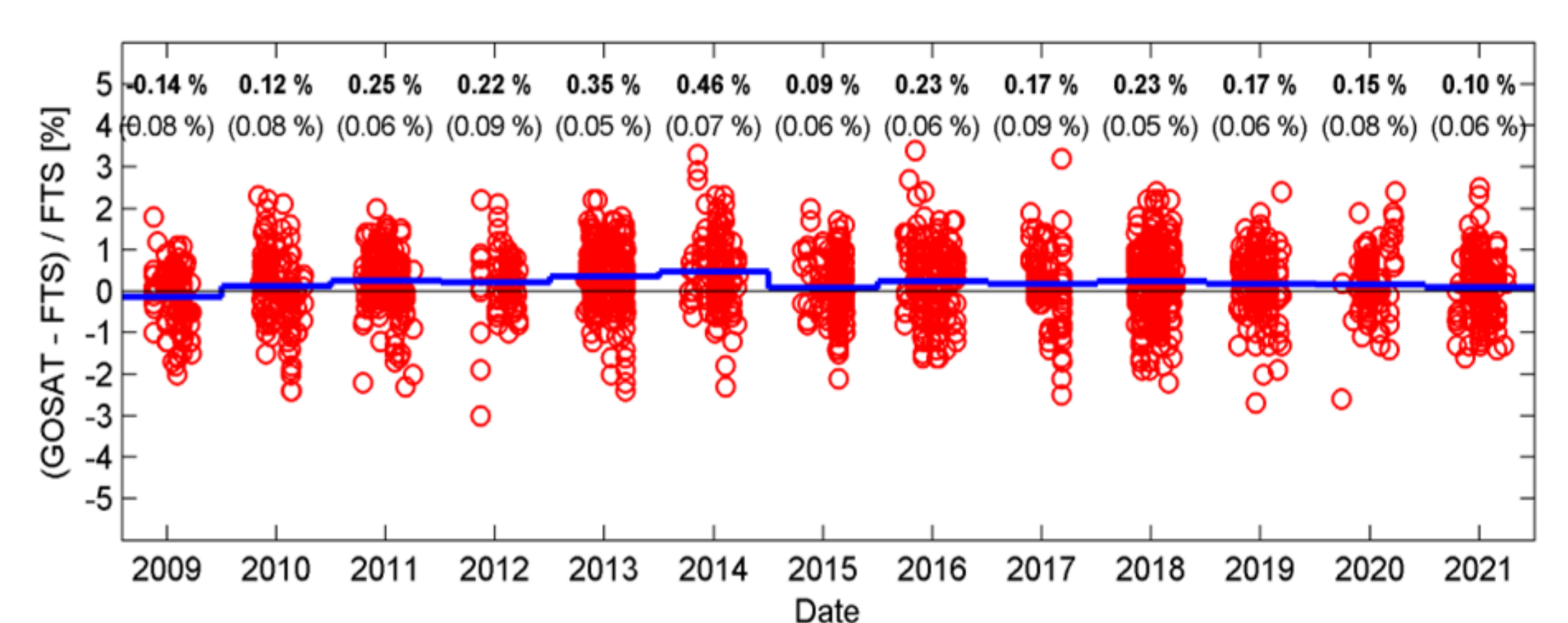
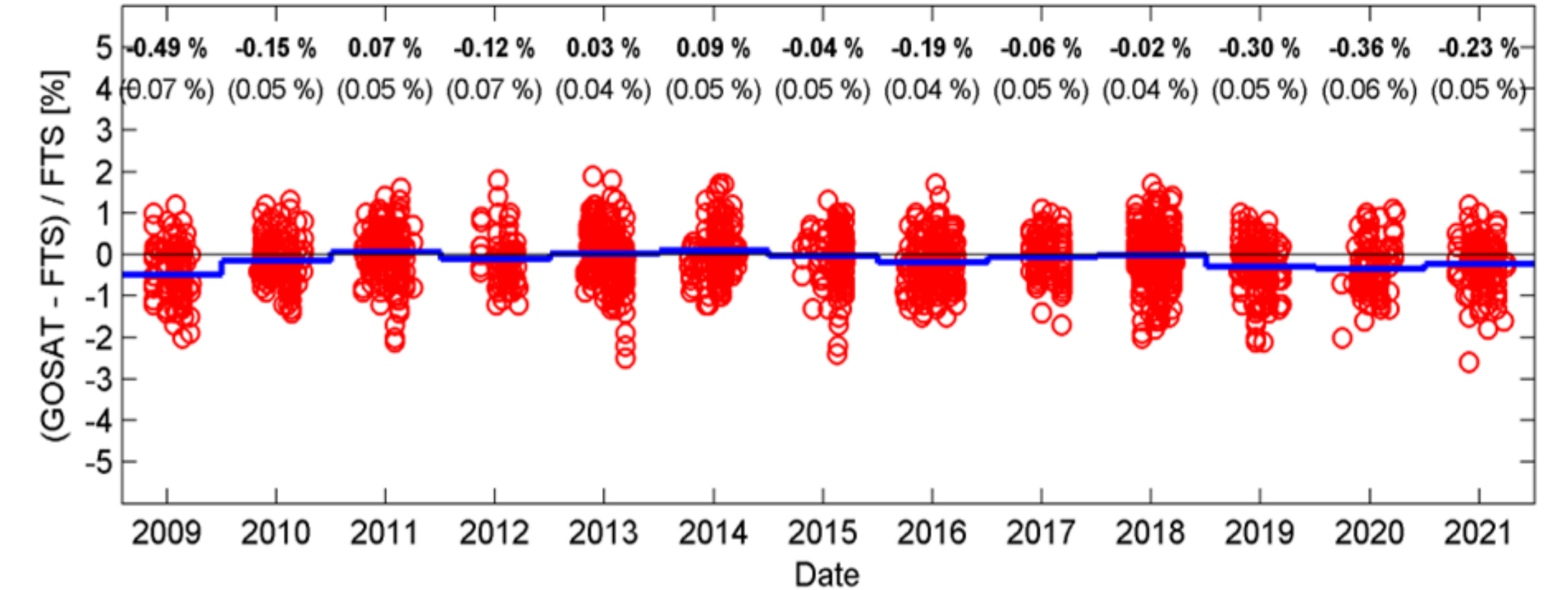


Figure 2: GOSAT data points near Sodankylä. Three different co-location radii have been indicated; 250 km, 500 km and 1000 km.

Figure 3: Sodankylä FTS comparisons with GOSAT CO_2 (upper panel) and CH_4 (lower panel) observations.

AirCore measurements

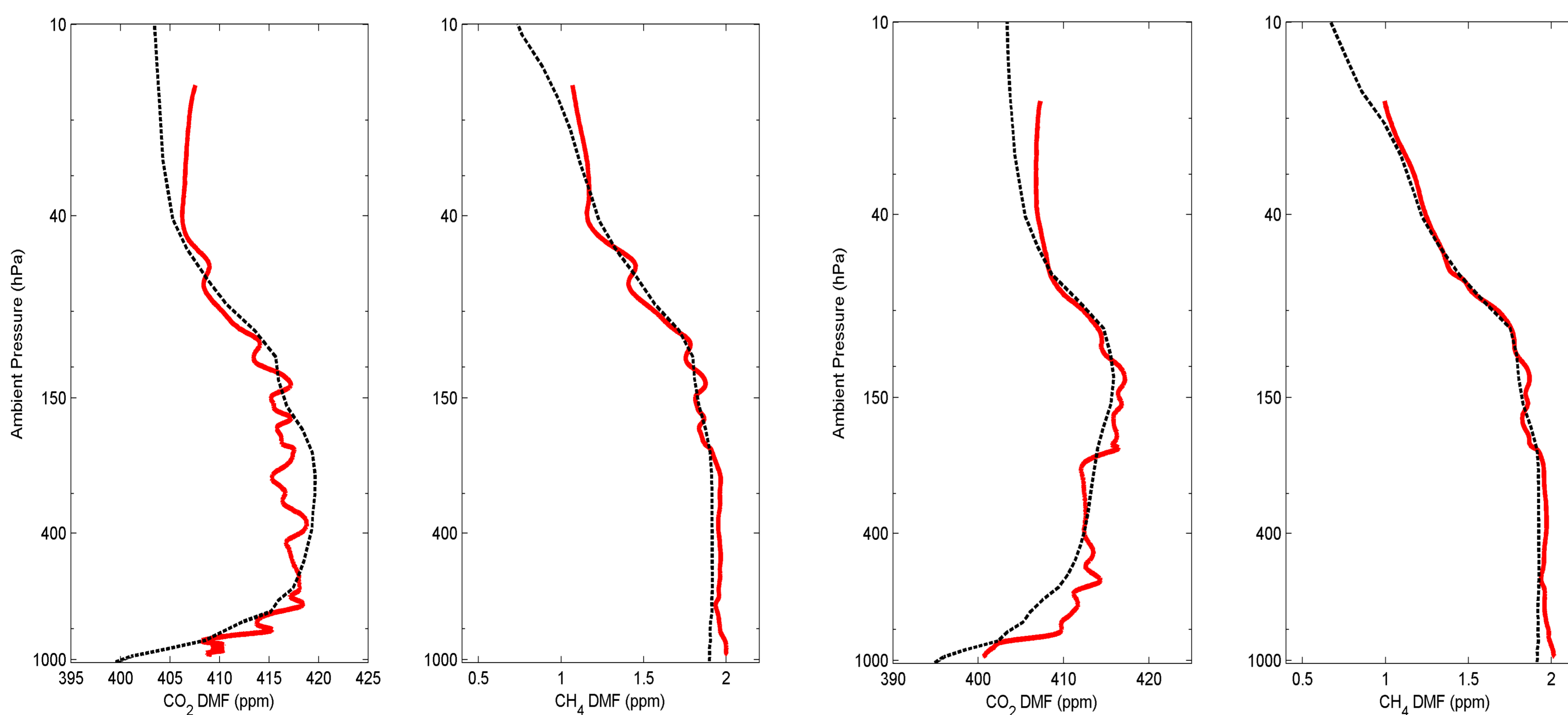


Figure 4: AirCore profiles of CO_2 and CH_4 (red) versus TCCON GGG2020 (dashed line) a priori profiles. Left: measurements taken at Sodankylä on 29 June 2022. Right: AirCore measurements and a priori profiles on 25 August 2022.

Photo: AirCore balloon launch in Northern Finland.

AirCore is an atmospheric sampling system to measure vertical profiles of greenhouse gases in the troposphere and stratosphere (Karion et al., 2010). AirCore profile measurements of CO_2 , CH_4 and CO have been performed at Sodankylä during all seasons.

Summary

- Several ongoing and future satellite missions use ground based remote sensing and in situ observations for calibration and validation. For example, the NASA OCO-2 mission, the GOSAT and the GOSAT-2 mission, ESA Sentinel 5-P, CNES MicroCarb, the Copernicus Carbon Dioxide Monitoring mission CO2M.
- Ground-based FTS measurements have been performed at Sodankylä, Finland since early 2009. GOSAT satellite measurements of $x\text{CO}_2$ and $x\text{CH}_4$ were compared to our ground-based FTS measurements. Within the 500 km / ± 2 h coincidence criteria the mean difference was $-0.10\% \pm 0.01\%$ in case of $x\text{CO}_2$ and $0.21\% \pm 0.02\%$ in case of the $x\text{CH}_4$. We have also performed year around AirCore measurements. We find that TCCON GGG2020 a priori profiles are generally in good agreement with our AirCore measurements.

References

- Karion, A., et al., AirCore: An Innovative Atmospheric Sampling System, *J. Atmos. Ocean. Technol.*, 27, 1839–1853, <https://doi.org/10.1175/2010JTECHA1448.1>, 2010.
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