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Greenhouse gas measurements over northern Finland and comparisons with the satellite borne observations

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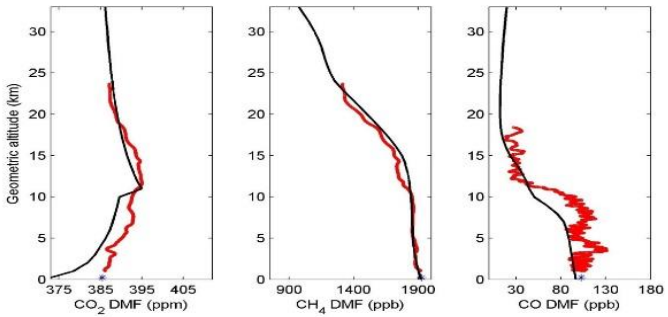
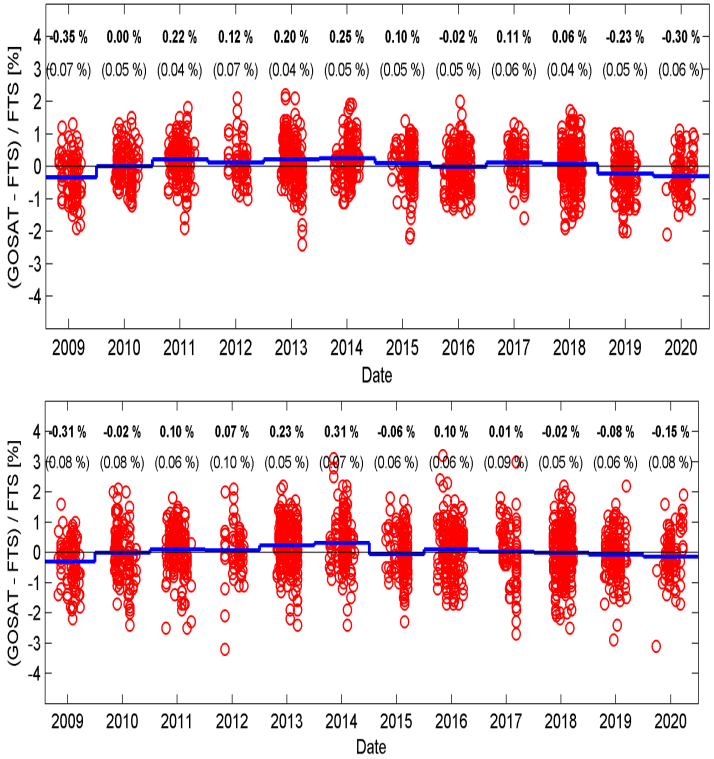
- At Sodankylä we have performed FTS measurements since early 2009. We find a statistically significant increase of column amounts of carbon dioxide by 2.3 +/- 0.2 ppm per year and methane increase by 7.0 +/- 0.5 ppb per year.
- Comparisons with the Greenhouse Gases Observing Satellite (GOSAT) were made concerning years 2009-2020. In case of CO_2 mean relative difference between the two data sets ((GOSAT-FTS)/FTS) has been 0.04 +/- 0.01 % and in case of CH_4 the relative difference has been 0.04 +/- 0.02 %.
- AirCore balloon borne observations were performed at the Sodankylä FTS site during all seasons. The profile observations were used to study accuracy of the remote sensing retrievals.

AirCore profiles





Time series of Sodankylä FTS comparisons with GOSAT observations for CO_2 (upper panel) and CH_4 (lower panel). Mean relative difference for CO_2 and CH_4 is 0.04 %.

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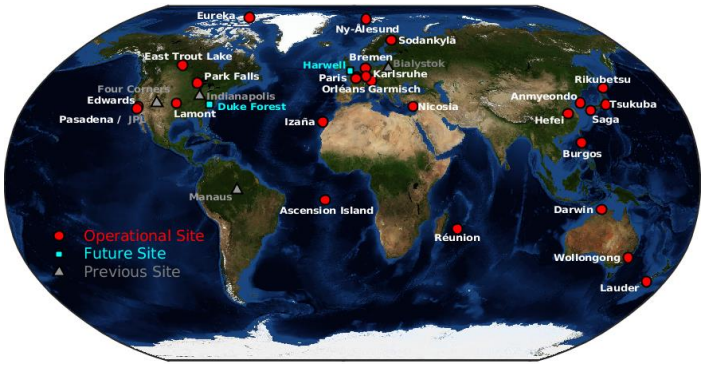
Sodankylä FTS

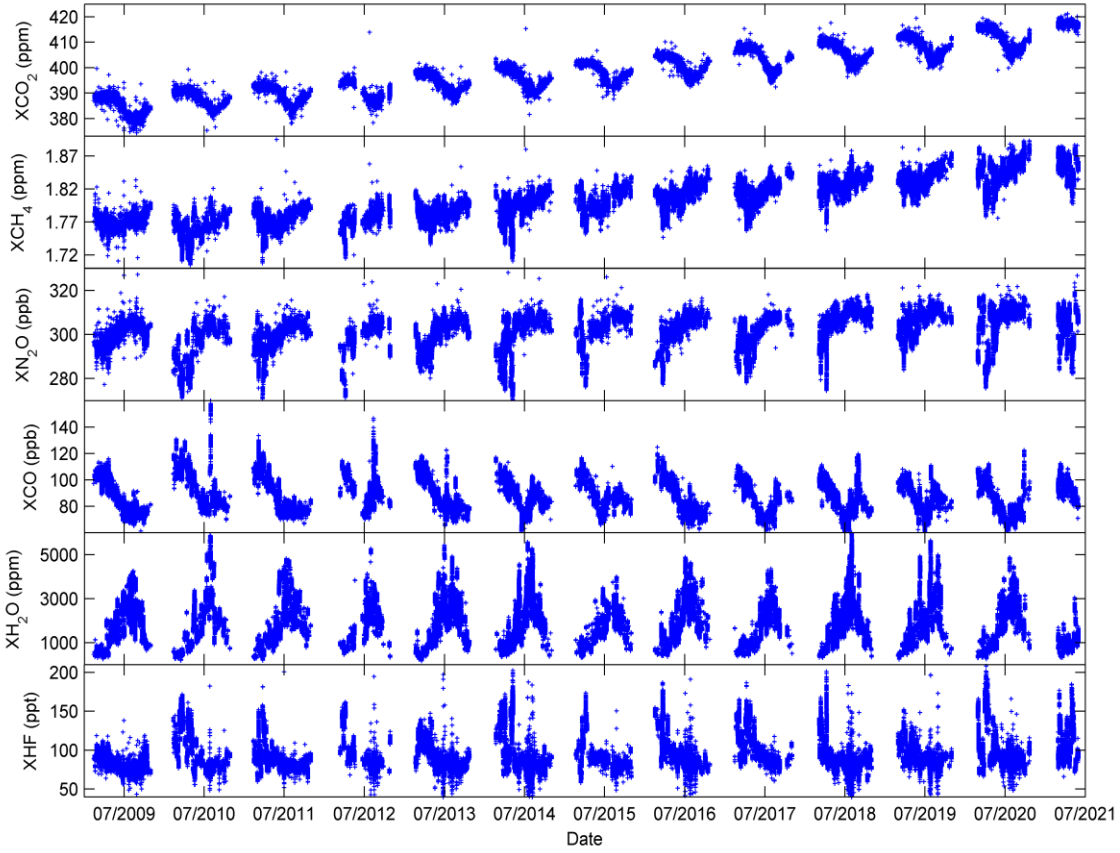
TCCON
total carbon column observing network

Bruker *IFS 125HR* with *A547N* solar tracker.
Detectors:
RT-InGaAs: *12800 - 4000 cm^{-1}*
RT-Si: *25000 - 9000 cm^{-1}*
LN-InSb: *10000 - 1850 cm^{-1}*

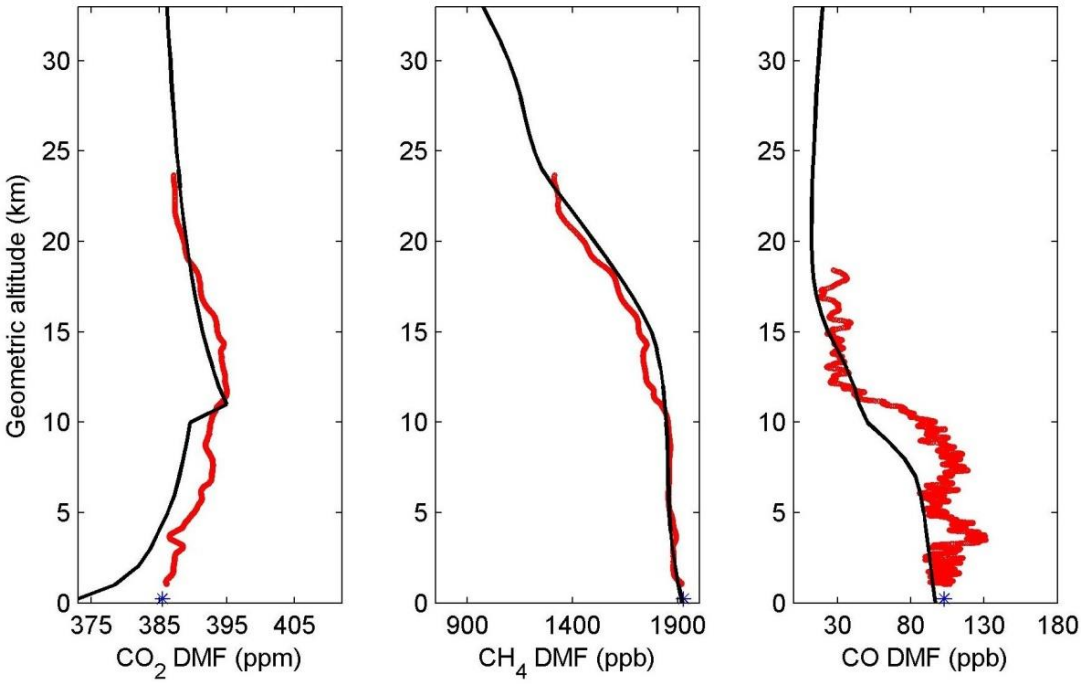
In operation since FEB-2009, relevant networks are TCCON and NDACC



Map of the TCCON sites



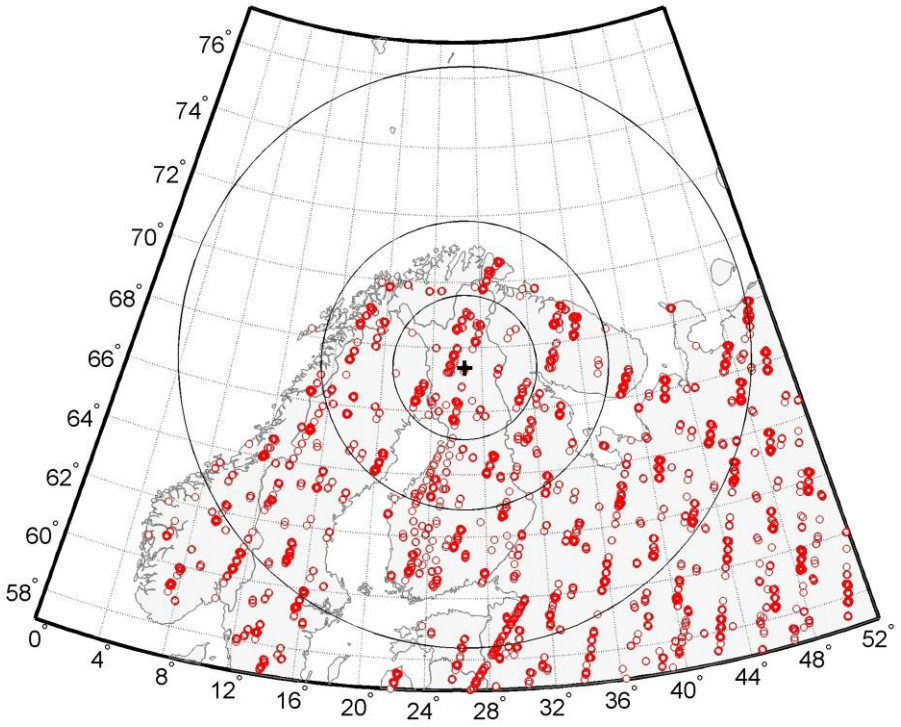
Column-averaged dry air mole fractions since 2009. Carbon dioxide has increased by 2.3 +/- 0.2 ppm per year and methane by 7.0 +/- 0.5 ppb per year.



- At Sodankylä we have performed AirCore observations during all seasons. An example of AirCore profiles of CO_2, CH_4 and CO is shown above. AirCore profiles are in red and the TCCON a priori profiles in black. Blue star corresponds to 50 m tower measurements at Sodankylä.
- The AirCore system at Sodankylä is built as a stainless steel tubing of about 100 m long. It is possible to measure profiles with vertical resolution of 5 mb in the stratosphere and 15 mb in the troposphere.
- The system also involves a data acquisition unit to store pressure and temperature during an AirCore flight, a Vaisala RS92 radiosonde, a transponder and a GNSS positioning device.
- AirCore is flown using a meteorological balloon. Shortly after landing we have analysed the sample using a Picarro G2401 gas analyser.

AirCore and FTS instruments.

GOSAT/FTS



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

Spatial coverage	1000 km radius	500 km radius	250 km radius
Time window	± 3 h	± 2 h	± 1 h
Number of coincident measurements	4378	1829	594
Absolute difference, GOSAT – Sodankylä FTS [ppm]:			
Mean	0.1	0.17	0.43
StdDev	2.72	2.5	2.2
StdErr	0.04	0.1	0.1
Relative difference, (GOSAT – Sodankylä FTS) / Sodankylä FTS [%]:			
Mean	0.04	0.04	0.11
StdDev	0.69	0.64	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	4389	1839	501
Absolute difference, GOSAT – Sodankylä FTS [ppm]:			
Mean	0.0030	0.0007	0.0025
StdDev	0.0167	0.0148	0.0132
StdErr	0.0003	0.0003	0.0005
Relative difference, (GOSAT – Sodankylä FTS) / Sodankylä FTS [%]:			
Mean	0.17	0.04	0.14
StdDev	0.92	0.82	0.73
StdErr	0.01	0.02	0.03

Sodankylä FTS comparisons with GOSAT observations for CO_2 (upper panel) and CH_4 (lower panel).

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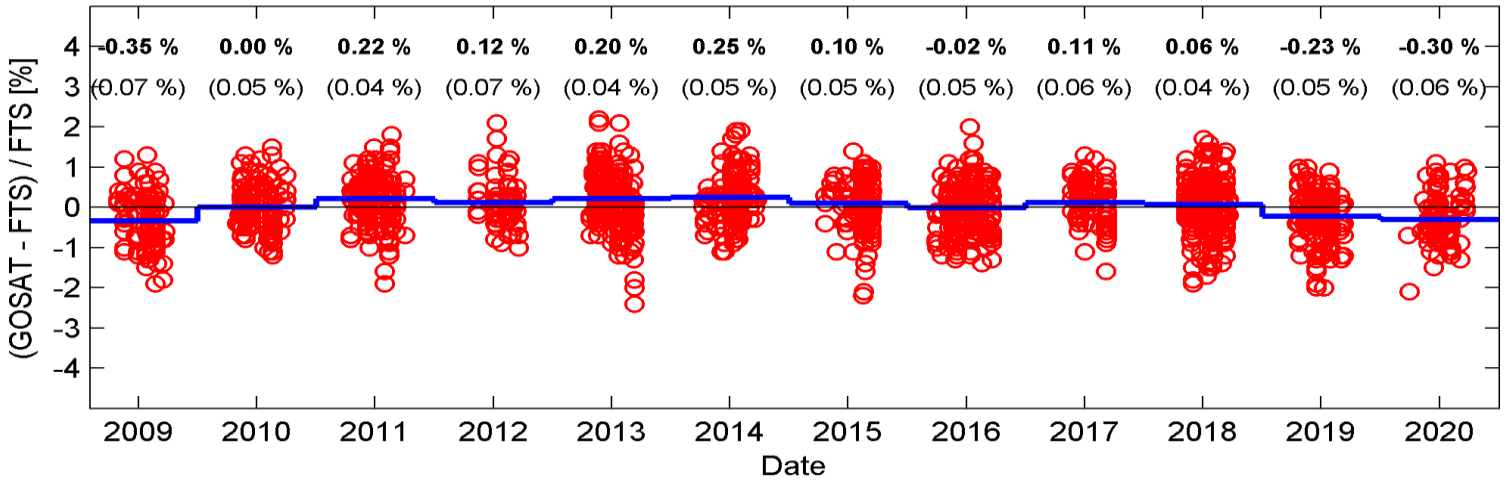
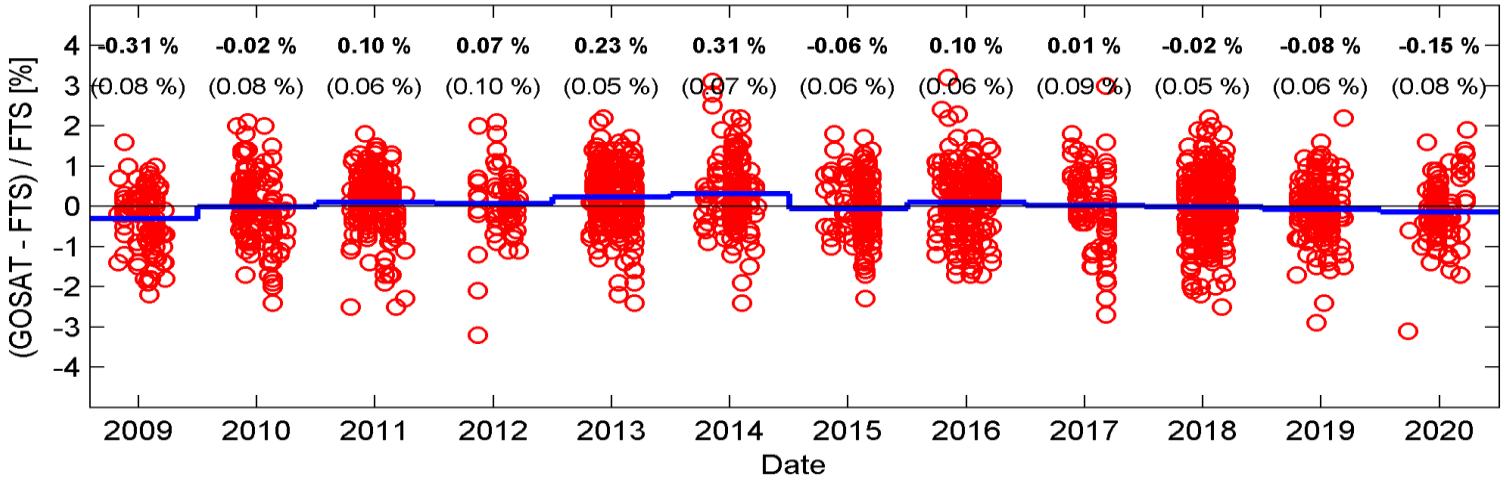
GOSAT/FTS

CO_2



CH_4



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Summary:

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Reference:

Kivi, R. and Heikkinen, P.: Fourier transform spectrometer measurements of column CO_2 at Sodankylä, Finland, Geosci. Instrum. Method. Data Syst., 5, 271–279, https://doi.org/10.5194/gi-5-271-2016, 2016.