FINNISH METEOROLOGICAL INSTITUTE

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Greenhouse gas measurements at the Sodankylä TCCON site and comparisons with the satellite borne observations

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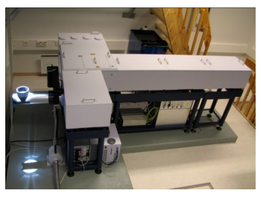
Bruker IFS 125 HR with A547N Solar Tracker
- Gold coated mirrors
- Optical path difference ≤ 258 cm
- Resolution ≥ 0.0035 cm^{-1}
- Detectors and wave number ranges
  - RT-Si: 25000* – 9000 cm^{-1}
  - RT-InGaAs: 12800 – 4000 cm^{-1}
  - LN-InSb: 9600 – 1850 cm^{-1}

TCCON total carbon column observing network



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 February 2009. The instrument, by recording direct solar spectra, is capable of greenhouse gas column retrievals, such as carbon dioxide and methane. Our instrument is participating in TCCON (www.tccon.caltech.edu).

FTS measurements during 2009-2019

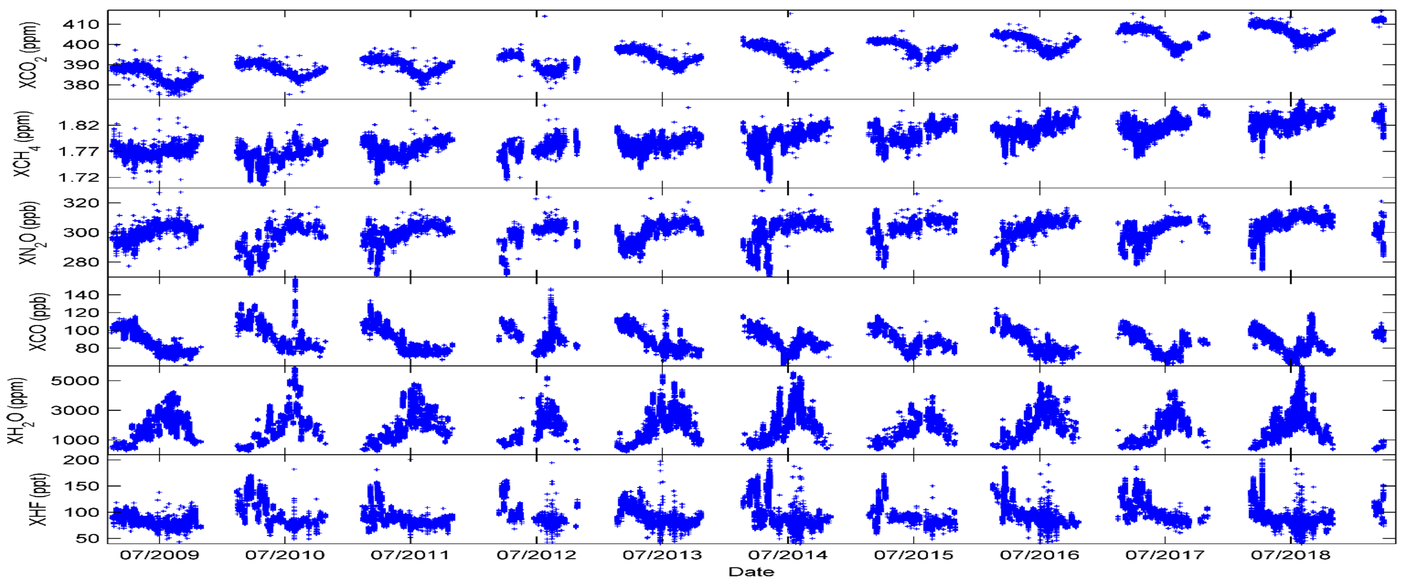


Figure 1: Column-averaged mixing ratios measured by the TCCON FTS instrument at Sodankylä.

FTS and satellite comparisons

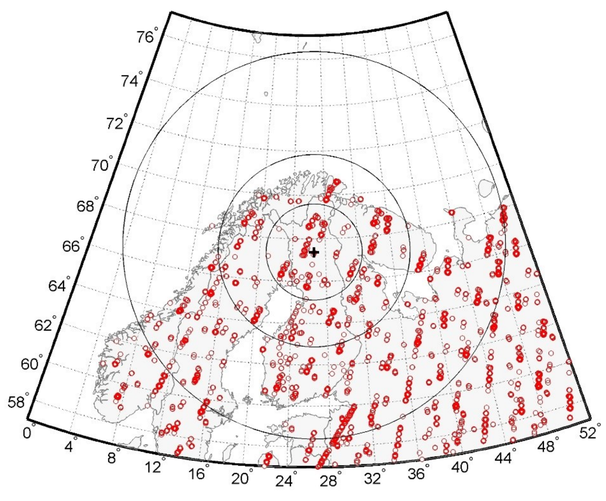


Figure 2: GOSAT data points near Sodankylä. Three different co-location radii have been indicated; 250 km, 500 km and 1000 km.

Spatial coverage	1000 km radius	500 km radius	250 km radius
Time window	± 3 h	± 2 h	± 1 h
Number of coincident measurements	3697	1584	513
Absolute difference, GOSAT – Sodankylä FTS [ppm]:			
Mean	0.3	0.4	0.6
StdDev	2.66	2.5	2.2
StdErr	0.04	0.1	0.1
Relative difference, (GOSAT – Sodankylä FTS) / Sodankylä FTS [%]:			
Mean	0.08	0.09	0.16
StdDev	0.67	0.63	0.56
StdErr	0.01	0.02	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	3706	1593	519
Absolute difference, GOSAT – Sodankylä FTS [ppm]:			
Mean	0.0033	0.0011	0.0033
StdDev	0.0165	0.0149	0.0128
StdErr	0.0003	0.0004	0.0006
Relative difference, (GOSAT – Sodankylä FTS) / Sodankylä FTS [%]:			
Mean	0.19	0.06	0.18
StdDev	0.92	0.83	0.71
StdErr	0.02	0.02	0.03

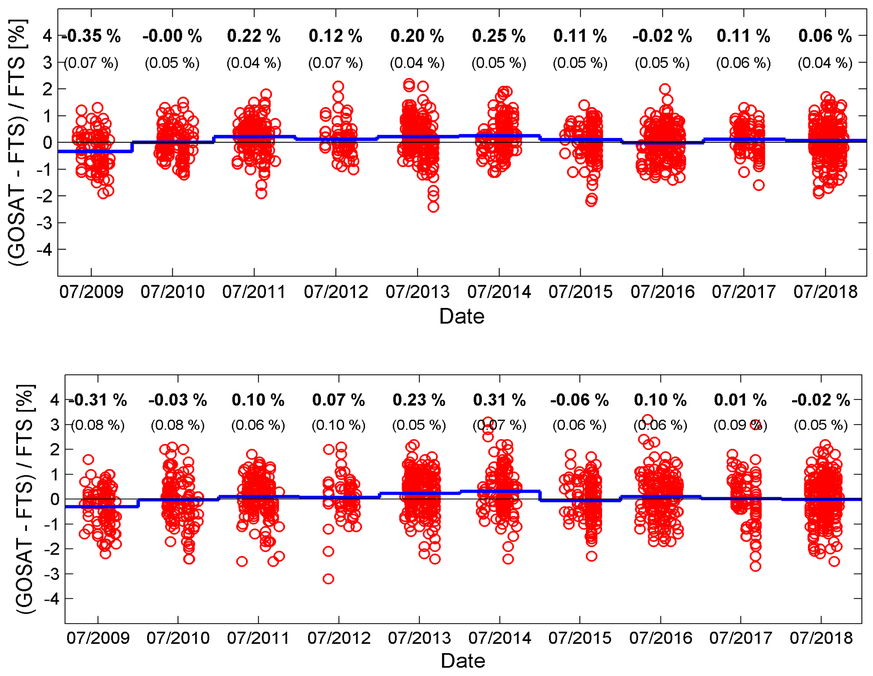


Figure 3: Sodankylä FTS comparisons with GOSAT observations for CO_2 (upper panel) and CH_4 (lower panel).

FTS and AirCore measurements

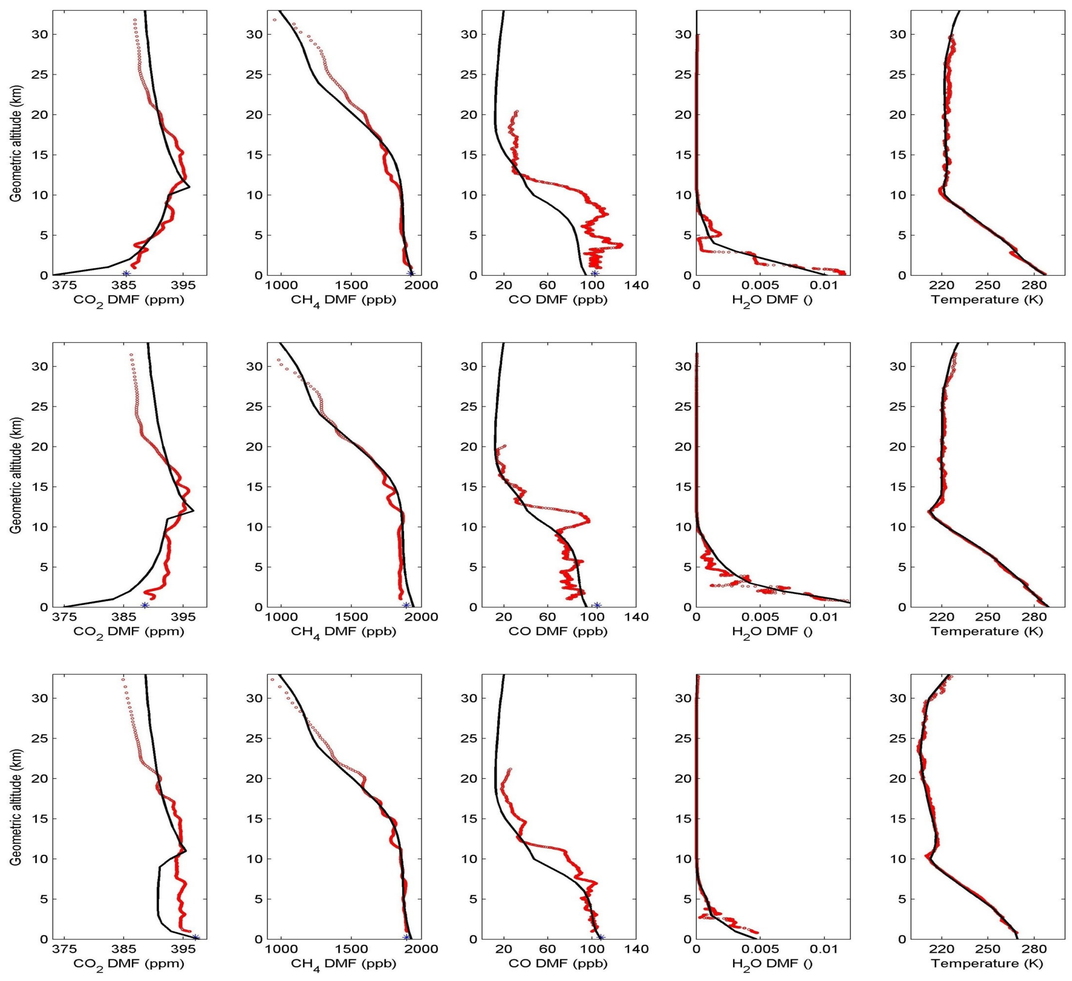
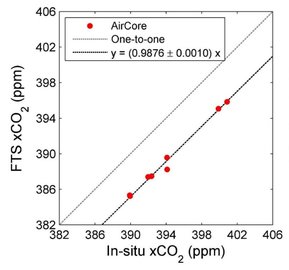


Figure 4: AirCore profiles (red) versus TCCON a priori profiles (black curve). Blue star corresponds to mast measurements in the vicinity of the AirCore landing site.

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 made during each season in Sodankylä. AirCore measurements can be used for comparisons with the FTS data, to study the validity of the a priori profile shapes and to improve the retrievals.

Regular AirCore soundings provide a tool to monitor the data quality of a TCCON instrument. The TCCON calibration line derived from 7 AirCore flights covering all seasons is presented in Figure 5. Here AirCore profiles were used as a priori in GFIT retrievals.

Figure 5: Comparison of the FTS retrievals of CO_2 with the AirCore measurements.



AirCore drone flights at Sodankylä

A new drone based AirCore system was recently developed at the FMI and the first flights were performed in July-August 2018 over wetlands, river and forest sites. The drone-AirCore profiles will be also used to get overlap with the balloon borne and mast measurements in the lowermost troposphere.

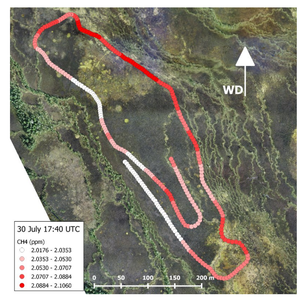


Figure 6. Methane concentrations mapped above the measurement site at Sodankylä. The background map is based on aerial images.

Conclusions

FTS measurements have been performed at Sodankylä since early 2009. GOSAT xCO2 and xCH4 values were compared to our FTS measurements. With the 500 km / ± 2 h coincidence criteria the mean difference was found to be 0.09 % ± 0.02 % for xCO2 and 0.06 % ± 0.02 % for xCH4. We have made year around AirCore measurements at Sodankylä. AirCore observations are relevant to the TCCON, satellite and model validation purposes. In addition we have recently started drone based AirCore measurements to study methane and carbon dioxide emissions. The drone based AirCore will be also used together with balloon borne instrument to reduce measurement uncertainties near the surface. The first flight with drone based SIF instrument was in May 2019.

Acknowledgement

The GOSAT and TCCON data were analysed within the GOSAT RA; support by the FMI and the Finnish Academy (grant no. 140408) is also acknowledged.

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, doi:10.5194/gi-5-271-2016, 2016.