Fiducial Reference Measurements for Ground-Based Infrared Greenhouse Gas Observations (FRM4GHG) at the Sodankylä TCCON site

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Motivation for the project — FRM4GHG

- Greenhouse gas (GHG) measuring satellites require ground-based measurements for validation. These measurements must be made with instruments sampling the atmosphere in a comparable way.
- Total Carbon Column Observing Network (TCCON) provides accurate and precise measurements of GHGs and is the current standard for GHG measuring satellites (e.g. SCIAMACHY, GOSAT, OCO-2).
- Bruker IFS 125HR spectrometer as TCCON instrument allows simultaneous measurements of several gases XCO_2, XCH_4, XCO, XH_2O, XN_2O, XHF.
- TCCON network has shown deficiencies in terms of the gaps in the coverage, especially in remote locations, locations with high/low albedo.
- Limitations for TCCON — very expensive 400 - 500 k€, requires good infrastructure (container, Bruker IFS 125HR, solar tracker) - not easy to move, requires special operating conditions, trained personnel for both operation and maintenance
  — very expensive if further expansion of the network is desired.

➢ Development of portable, easy to maintain and low cost systems for remote sensing GHG observations by several research institutes.

➢ These spectrometers have the potential to eliminate the deficiencies of the TCCON network, however their performances have not yet been fully characterized.

Aim of project

- Perform an intercomparison of measured total column concentrations of a few GHGs (CO_2, CH_4, CO) using several different portable low cost spectrometric instruments simultaneously under different atmospheric conditions in comparison to the TCCON instrument.
- A campaign planned at the Sodankylä TCCON site for approximately one year in 2017.
- We plan to measure with four different spectrometers: Vertex 70, EM27/SUN, IR Cube, QCLHR along with the Bruker IFS 125HR. In addition, regular Aircore launches will be performed from that site and will provide in-situ reference profiles of the target gases — useful for verifying instrument calibration.

Instrumentation for the FRM4GHG campaign

Institute	Instrument	Spectral range	Resolution	Main GHGs
FMI	Bruker IFS 125HR Fig. 1 (right)	1800 — 15000 cm^{-1}	0.004 cm^{-1}	XCH_4, XCO, XCO_2 @ 0.02 cm^{-1}
Uni Bremen BIRA	Bruker Vertex 70 Fig. 4 a	2500 — 15000 cm^{-1}	0.16 cm^{-1}	XCH_4, XCO, XCO_2
KIT	Bruker EM27/SUN Fig. 4 d	4000 — 9000 cm^{-1}	0.5 cm^{-1}	XCH_4, XCO, XCO_2
Uni Wollongong	IR Cube Fig. 4 b	4500—15000 cm^{-1}	0.5 cm^{-1}	XCH_4, XCO_2
RAL	QCLHR Fig. 4 c	950 / 1280 cm^{-1}	0.002 and 0.02 cm^{-1}	CH_4, CO_2
Uni Groningen FMI	AirCore Fig. 4 e	-	13.4 mbar (Amb.P. > 232 mbar) 3.9 mbar (Amb.P. < 232 mbar)	CH_4, CO, CO_2 vertical profiles, calibrated to WMO standards

Expected outcomes from the campaign

➢ Campaign will provide a significant dataset of GHG measurements which can be used for satellite validation purposes specially during the S5P commissioning phase.

➢ It will provide a comparative characterization of the participating instruments with respect to the standard TCCON instrument in terms of the precision, accuracy, stability, portability and ease of deployment, cost factor, etc.

— A guideline for the further development of new observation sites to complement the TCCON network and provide better support for the validation of the existing and future satellite missions.

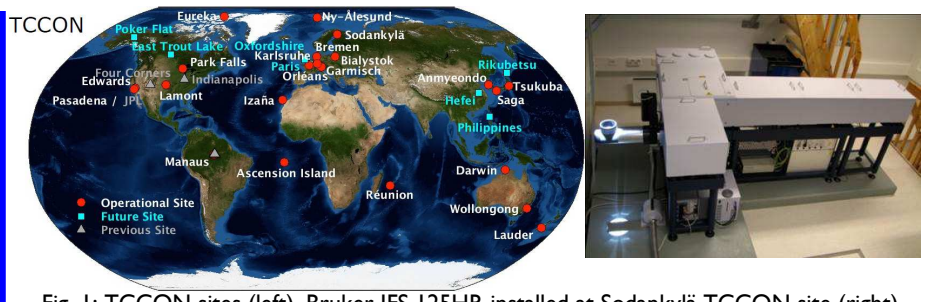


Fig. 1: TCCON sites (left), Bruker IFS 125HR installed at Sodankylä TCCON site (right)

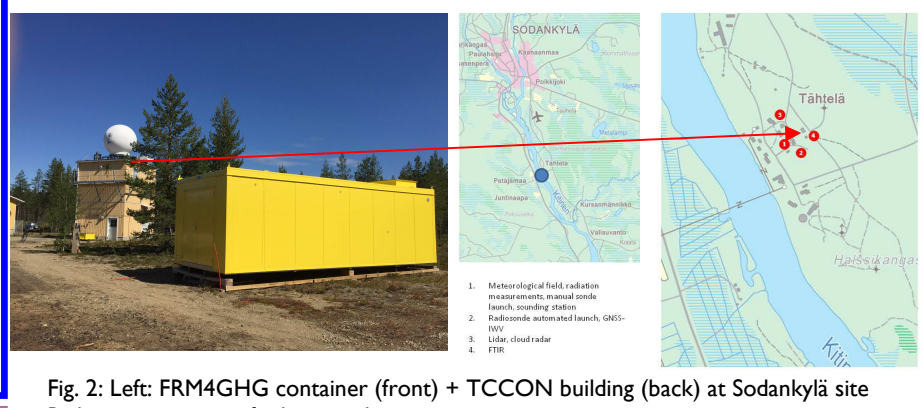
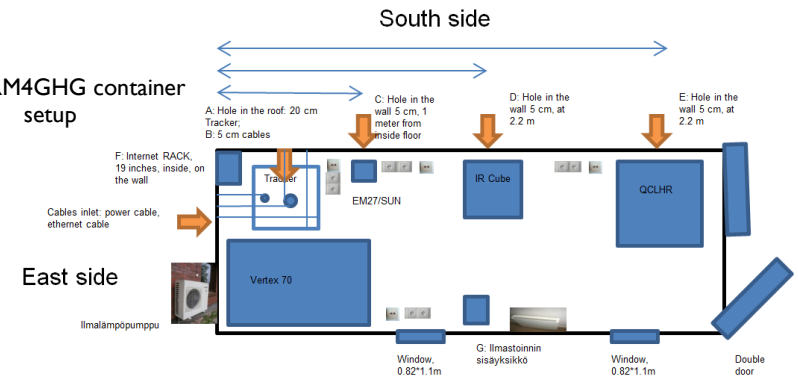


Fig. 2: Left: FRM4GHG container (front) + TCCON building (back) at Sodankylä site
Right: measurement facilities at the site

Fig. 3: FRM4GHG container setup



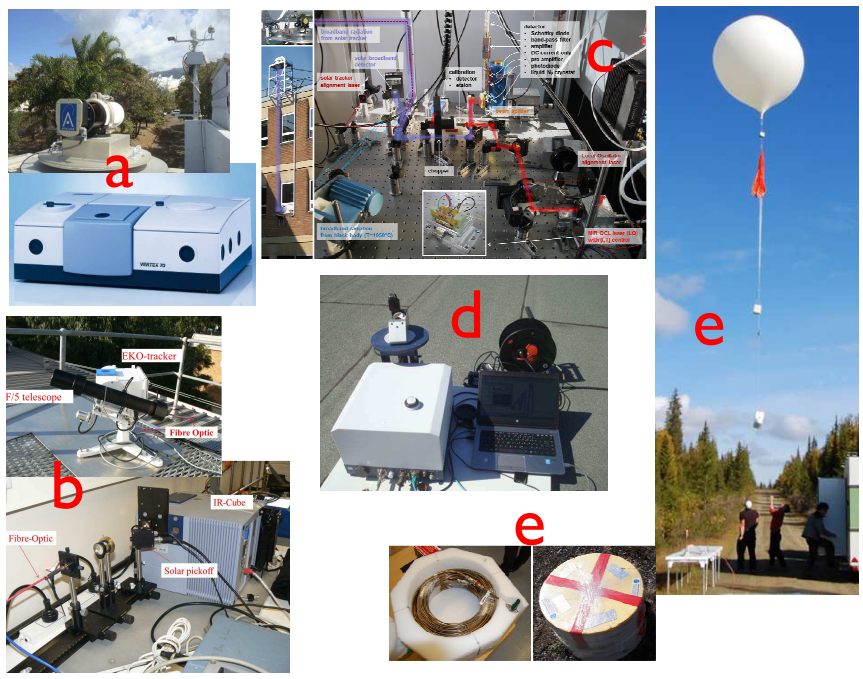
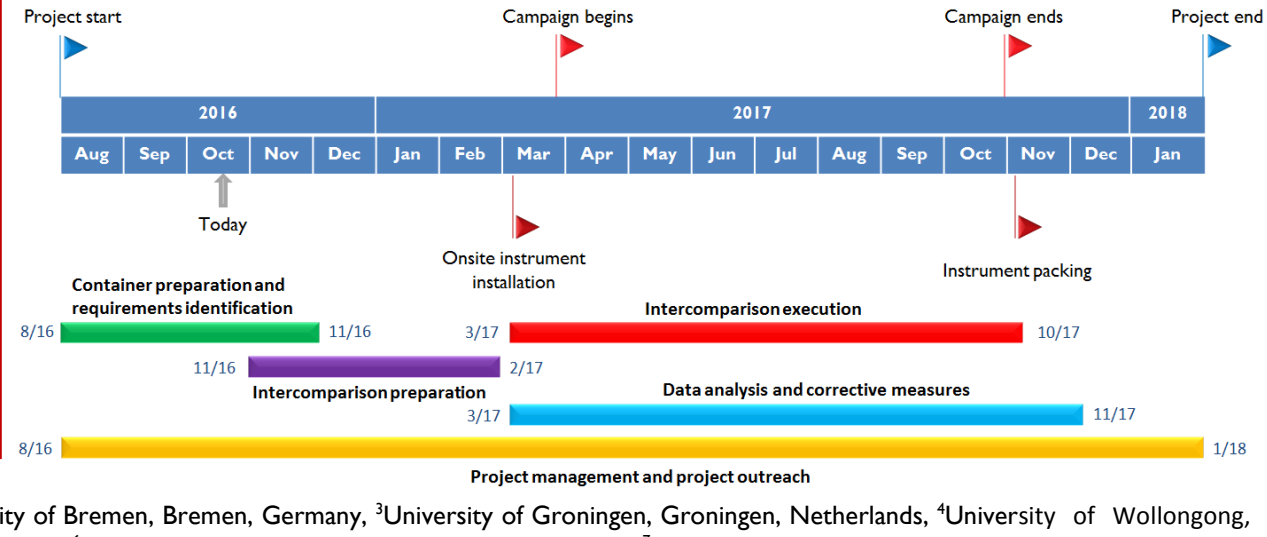


Fig. 4: a) Vertex 70, b) IR Cube, c) QCLHR, d) EM27/SUN, e) AirCore package + launch

FRM4GHG project timeline



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