

FIDUCIAL REFERENCE MEASUREMENTS FOR GROUND-BASED INFRARED GREENHOUSE GAS OBSERVATIONS

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<https://frm4ghg.aeronomie.be/>

The Project: Rationale And Objectives

Aim

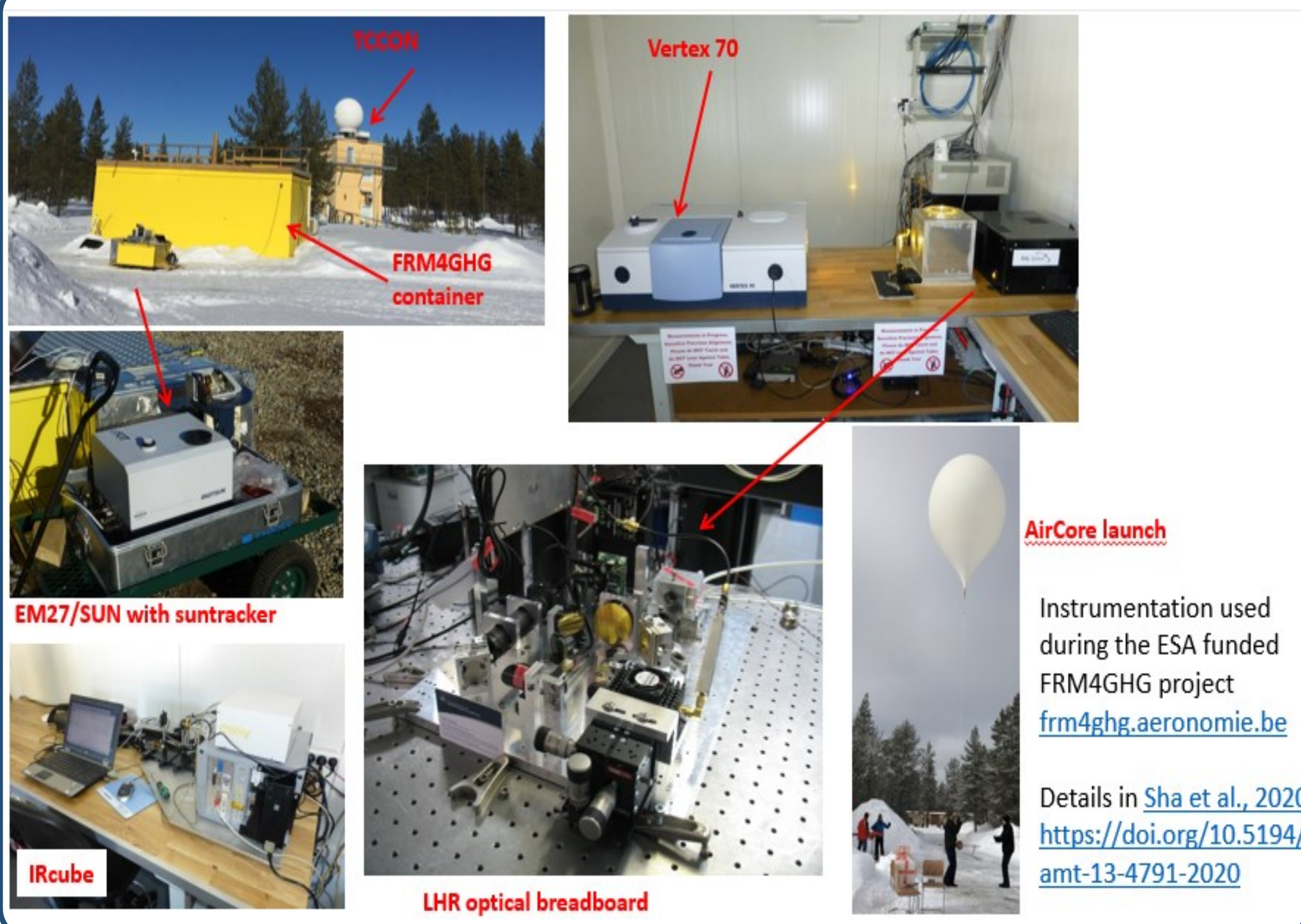
- Provision of Fiducial Reference Measurements (FRM) for satellite Cal/Val — suite of independent, fully characterised, and traceable measurements that follows the guidelines outlined by the GEO/CEOS QA4EO
- FRM data representing a homogeneous and consistent data set as representative for the atmospheric states and observational parameters
- ESA's FRM initiative is aimed at improving the quality of GHG measurements and implementing new methods

FRM4GHG-1.0 (2017— 2020)

- Characterisation of various portable low-resolution spectrometers for GHG measurements, inter-comparison with TCCON as reference and collocated AirCore observations, demonstration of suitability for campaign deployment or long-term measurements from any location, thereby complementing TCCON

FRM4GHG-2.0 (2021— 2025)

- Improve the investigated low-resolution instruments w.r.t. hardware and software
- Improve the data retrieval algorithms, optimise retrievals for new species and develop additional AirCore observations of new species
- COCCON travel standard for tying COCCON and TCCON calibration closer, and links to complementary COCCON



Summary

- Extensive testing of spectrometers, corresponding necessary improvements to achieve better performance and characterisation in comparison to reference measurements performed with TCCON and AirCore guarantees the excellent performance and demonstrated their ability to provide high quality data.
- Low resolution spectrometers are useful to achieve a denser distribution of ground-based stations, cover geographical gaps for various atmospheric conditions, source regions of special interest, and to create a large latitudinal distribution of stations.

Instrumental Improvements

- Develop a more mobile, stand-alone version of the **Bruker Vertex70** for deployment in the field, test an alternative detector to replace the Liq. Nitrogen cooled InSb detector (e.g., TE-cooled MCT detector)
- Improve stability of **Bruker IRcube** alignment using the Haidinger fringes, investigate further advantages / disadvantages of the fibre optics feed
- Track and solve identified **LHR** instrumental problems, deploy dedicated LHR cam-tracker, integrate passband filters
- Improve alignment tools for low-resolution spectrometers, revise H₂O spectroscopy for open path lamp measurements, new LINEFIT version, redo ILS analysis for all COCCON **Bruker EM27/SUN** instruments
- Develop **AirCore** for retrieving N₂O and OCS in addition to CO₂/CH₄/CO
- Perform side-by-side measurements at TCCON sites Harwell, Wollongong and/or Sodankylä to verify instrumental improvements

Retrieval Algorithm Improvements And Retrieval Of Additional Species

- Improvements and extensions to PROFFAST and updates of associated spectroscopic linelists, line-mixing and speed dependent Voigt schemes
- Optimisation of AICF and ADCF based on measurements in Sodankylä and Karlsruhe for low-resolution spectrometers
- Implementation of modifications/extensions to PREPROCESS and PROFFAST for Vertex70, IRcube, and other low-resolution spectra
- Improvements to retrieval algorithm for LHR based on Optimal Estimation Method
- Further development of GHG profiling using NIR and MIR spectra for CO₂, CH₄, CO and N₂O, perform (quasi-)simultaneous InGaAs + InSb measurements at (NDACC) TCCON resolution, development of strategies for profile retrievals of GHGs and determination of resolution that enables retrieving partial column for the target gases, validate using AirCore, Aircraft, ...
- Investigate feasibility of retrieving OCS from low-resolution MIR spectra, optimise retrieval of HCHO from low-resolution instruments
- AirCore launches of CO₂/CH₄/CO during the project, improve CO and CH₄ profiles in the stratosphere based on dual AirCore and LISA launches
- Update FRM4GHG data set based on latest version of PROFFAST and GGG

Improvements To TCCON And COCCON Network Consistency And Data Delivery

- Develop rapid delivery of GHG data for satellite validation from low-resolution NIR spectra, procure NRT ECMWF P/T profiles and their use as dual option in PROFFAST, use CAMS as prior, co-ordinate with TCCON for using NRT ECMWF P/T profiles
- Plan and implement, for Vertex70 and IRcube, all proper actions and procedures aimed at pursuing harmonisation with COCCON
- Demonstration of an EM27/SUN travelling standard, travel to at least one TCCON site in the Americas, and two in the Western Pacific region—realising a direct calibration bridge between TCCON Americas—Europe—Western Pacific

