



## **Findings from the 2-years ESA - Fiducial Reference Measurements for Ground-Based Infrared Greenhouse Gas Observations (FRM4GHG) project and relevance for S-5P validation.**

Martine De Mazière (1), Justus Notholt (2), Thomas Blumenstock (3), Huilin Chen (4), David Griffith (5), Frank Hase (3), Pauli Heikkinen (6), Christian Hermans (1), Alex Hoffman (7), Marco Huebner (7), Nicholas Jones (5), Rigel Kivi (6), Bavo Langerock (1), Christof Petri (2), Mahesh Kumar Sha (1), Qiansi Tu (3), and Damien Weidmann (7)

(1) Royal Belgian Institute for Space Aeronomy, Brussels, Belgium (martine.demaziere@aeronomie.be), (2) University of Bremen, Bremen, Germany, (3) Karlsruhe Institute of Technology, Karlsruhe, Germany, (4) Center for Isotope Research (CIO), University of Groningen, Groningen, Netherlands, (5) University of Wollongong, Wollongong, Australia, (6) Finnish Meteorological Institute, Sodankylä, Finland, (7) Rutherford Appleton Laboratory, Didcot, United Kingdom

The European Space Agency (ESA) funded project “Fiducial Reference Measurements for Ground-Based Infrared Greenhouse Gas Observations (FRM4GHG)” at the Sodankylä (Finland) TCCON site was aimed at characterizing the performance of several low-cost portable ground-based spectrometers in comparison to the standard TCCON Fourier-transform Infrared spectrometer for precise solar absorption measurements of CO<sub>2</sub>, CH<sub>4</sub> and CO dry-air column-averaged mixing ratios. The collocated measurements were performed continuously between March and Oktober in 2017 and 2018, when the sun was above the horizon. The TCCON instrument was also operated in a special low-resolution mode, with a spectral resolution comparable to that of the other participating portable spectrometers. In addition, regular balloon-borne AirCore launches were performed from the same site: these provided vertical profiles of CO<sub>2</sub>, CH<sub>4</sub> and CO up to about 25 km altitude. The AirCore vertical profiles were calibrated to WMO reference standards and were used as reference profiles for the ground-based remote sensing measurements. The campaign CO and CH<sub>4</sub> data have been compared to coincident Sentinel-5 Precursor (S-5P) products.

In this presentation we will present the intercomparison results from these two years of CO<sub>2</sub>, CH<sub>4</sub> and CO measurements from the six participating instruments. We will discuss instrument related problems, like non-linearity effects that have been identified during the campaign, and the methodologies that have been developed to correct for these issues. We will also show the validation results for the S5-P CH<sub>4</sub> and CO data using the campaign data. Furthermore we will discuss guidelines for the deployment of these low-cost portable instruments at new observation sites to complement the TCCON network and improve the validation capabilities for the existing and future satellite missions and models for greenhouse gases.