FRM4GHG

Fiducial Reference Measurements for Greenhouse Gases

Retrieval strategy &

Intercomparison strategy and protocol

Deliverable: 2.5

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Our ref.: **Proposal No. 1129/2015 –**
Proposal from February 16, 2016 plus comments from May 27, 2016

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1 Document change record

Issue	Date	Item	Comment
V0.0	2017-01-22	–	Initial version, for completion by H. Chen
V0.1	2017-04-03	–	Initial version, for feedback and completion by all participants to the campaign
V0.2	2017-08-14	–	Final version, included comments from ESA

2 Access list

This document is a deliverable "D2.5: Retrieval strategy & Intercomparison strategy and protocol" created for the project FRM4GHG and will be submitted to ESA. The document will be a publicly accessible document and can be downloaded from the project webpage http://frm4ghg.aeronomie.be.

3 Purpose

The aim of the FRM4GHG campaign is to assess different spectrometric instruments for remote sensing of atmospheric trace gases as to their performances regarding precise measurements of column-averaged dry-air volume mixing ratios of greenhouse gases. These instruments will be deployed at Sodankylä during an observation campaign that will last from mid-March to end of October 2017, and will be complemented by regular AirCore measurements launched from the same site. The performances of the instruments will be compared among each other and to the ones from a standard TCCON instrument. Regular simultaneous AirCore measurements will provide vertical profiles of the greenhouse gas concentrations as auxiliary reference data for the column measurements. The greenhouse gases under consideration are carbon dioxide (CO_2), methane (CH_4) and carbon monoxide (CO). An overview of the suite of instruments and their actual status, as well as of the characteristics of the AirCore has been provided in D2.2. D2.3 describes the measurement strategy that will be adopted for each instrument during the campaign to ensure comparable observations.

This document, Retrieval strategy & Intercomparison strategy and protocol (D2.5), will outline the approach that will be adopted to carry out the campaign and intercomparison.

4 Document structure

Section 5 Referee – Presents the referee and describes the role of the referee in the project.

Section 6 Campaign schedule – Describes the campaign schedule in detail as well as highlighting the timeline for the milestones and deliverables.

Section 7 Characteristics of the retrievals and comparison strategies during the different campaign phases – Describes the retrieval and comparison strategies for all participating instruments for the semi-blind and formal intercomparison studies.

Section 8 Data file conventions – Describes the file format used for the data submission for the intercomparison studies.

Section 9 & 10 Applicable and reference documents – Presents a list of all applicable and reference documents related to this deliverable.

Section 11 References for software/tool mentioned – Presents a list of all software/tool mentioned in this document.

5 Referee

BIRA-IASB will not be in charge directly of performing measurements – and will therefore act as the ‘referee’ and be responsible of comparing the data from all participating instruments.

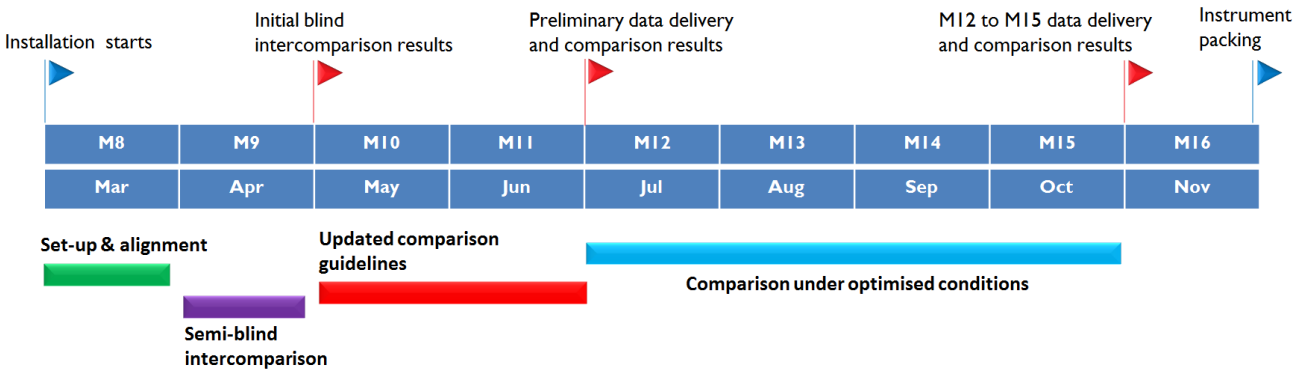
6 Campaign schedule

After an initial period of 2 weeks (the last 2 weeks of March 2017) during which all instruments will be aligned and test measurements will be carried out by each instrument team, the real intercomparison campaign will start end of March. The intercomparison will be done (1) first, according to a semi-blind intercomparison strategy, during the first month of the campaign (April), (2) secondly, with updated measurement strategies and retrieval settings up to month 11 of the project (end of June) when preliminary datasets and intercomparison results will be provided, and (3) in the third phase, (July to

end of October), optimized settings will be adopted to enable final intercomparison and the final assessment of the performances. However, an update of the measurement or retrieval strategy in the third phase is only needed if the instrument PI sees noticeable differences in their results from their instrument compared to the reference TCCON results. Figure I summarize the schedule. The main goal of this exercise is to identify the optimized settings for the instrument operation relatively soon and have the longest possible time series with these settings. This will also enable us to verify possible long term drifts in the instrument. If any instrument PI believes that their initial chosen settings in the semi-blind phase are best fitted for their instrument, they may decide to continue measuring with the same setting for the entire duration of the campaign.

Measurements will be carried out on each clear-sky day. If, because of bad weather conditions or any other logistics problem, not enough days of measurements are available by the end of April, the initial phase will be extended by the necessary time period.

Figure 1 Campaign schedule (year 2017)



After the end of the measurement phase (months 16 to 18), the available data set will be reprocessed to the extent that this is appropriate (e.g., depending on possibly changed instrument settings, it may be or may not be useful to reprocess) such as to obtain the best possible homogeneous data set for a final intercomparison. The final data set and intercomparison results, together with the assessment conclusions drawn from it, will be delivered by month 18.

In the next chapter, we will detail the AirCore strategy and we will detail the conditions for the three phases of the campaign, for the spectrometric remote-sensing instruments. The nominal timings of the various phases of the intercomparison campaign may be adapted if weather conditions are such that more or less time is needed to have sufficient statistics.

Data will be delivered according to the format and naming convention described in Section 6.

7 Characteristics of the retrievals and comparison strategies during the different campaign phases

7.1 AirCore retrievals

Quick-look profiles

The quick-look (preliminary) profiles will be made available within four weeks after each individual AirCore flight is made, which takes into account the temperature density corrections during the flights, but not the corrections due to the pressure drop across the dryers. Note that the radiosonde data and the data logger files logged during flights are needed to process each individual flight.

The AirCore measurement data will be first calibrated using a predetermined calibration curve using 3-5 cylinders in the laboratory, and then one point single bias correction during the analysis of the AirCore samples.

Final profiles

The AirCore profiles will be finalized after taking into account the following procedures three months after the AirCore campaign in April 2017:

1) Apply additional minor corrections due to the pressure drop across the dryer;

2) Apply the concentration corrections based on the cylinder standards from RUG that are traceable to the WMO scales;

3) Compare the AirCore profiles with stratospheric air sample measurements after the AirCore campaign in April 2017;

4) Improve the AirCore profile retrieval algorithm and update the AirCore profiles.

7.2 Semi-blind intercomparison

Retrieval strategy

During this initial phase which will last during 1 month, all teams will make the measurements according to the recommended measurement strategy described in D2.3, and provide retrieval results obtained according to their own retrieval strategy, ie, the strategy that each team considers to be the optimal or usual one for his/her instrument.

All retrieval strategies will use their own line list for blind phase of intercomparison. The linelist will be made available on the project webpage for each instrument. Later on, for the next phase of analysis, it will be decided jointly whether to include the same spectroscopic linelist in the processing by all groups, in order to avoid systematic biases originating in differences in spectroscopic parameters. The spectroscopic linelist will be agreed among the participants and will thereafter be provided by the referee. All retrieval strategies will use the same atmospheric P/T profiles provided by FMI.

The microwindows used for the retrievals are not necessarily the same, nor are the retrieval settings.

Intercomparison procedure

a) When measurements have been taken on day dd, then in the morning of day dd+4, before 10:00 LT, all measurement teams will hand in to the referee their retrieval results of day dd. The retrieval results will include the total column values of the target GHG that their instrument is capable of measuring, as well as the corresponding column-averaged dry-air volume mixing ratios, the O2 column values if their instrument can measure them and the column values of CO2, CH4, and CO.

b) The referee will make anonymous comparison plots that will be sent out to all participants on day dd+4 after sunset and discussed through Email or WebEx if that sounds useful.

c) If an AirCore has been launched on day dd, the retrieved CO2, CH4 and CO vertical profiles and integrated columns will be delivered on day dd+1 to the referee, who will compare the integrated columns (after extrapolation to top of atmosphere) to the columns measured by the spectrometric instruments.

d) The referee will inform the PI if the data look aberrant in order to give a chance to the PI to correct for obvious errors.

e) At the end of this first phase of the campaign, plots for the whole period of the first phase will be made with institute/instrument names attached, and plots of mean differences from the TCCON instrument (that will be considered as the reference throughout all campaign phases) will be drawn.

f) These results will be discussed during a WebEx meeting with all participants.

7.3 Formal intercomparison

The results of the semi-blind intercomparison will possibly lead to some changes in the measurement and retrieval strategies: these will be implemented and the intercomparison campaign will then continue according to similar procedures as during the semi-blind intercomparison, but on a weekly instead of daily basis.

At the end of month 11 (nominally), preliminary datasets and results will be distributed among partners via the project Web portal (D3.1) and updates of deliverables for the measurement and retrieval strategies (D2.3 and D2.5) will be made if required (D3.2). These results and changes will be discussed during a plenary WebEx.

7.4 Continuation of the intercomparison campaign

The above discussions will lead to optimized measurement and retrieval settings.

Two retrievals will be performed: one with the standard TCCON a priori profiles, and one using AirCore profiles or a climatology profile, as a priori profiles. The campaign will be continued with these settings until the end of the campaign (October 2017). Intercomparison results will then be discussed on a monthly basis, by WebEx.

The datasets from the above two phases will be reprocessed with the latest optimised retrieval settings.

Final datasets and intercomparison results for the whole duration of the campaign will be delivered by month 18 (D4.1).

8 Data file conventions

The data can be submitted either in the ASCII or NetCDF format with proper documentation of the content. The referee will then convert the files to NetCDF format for the intercomparison exercise. A recommendation for the main and the auxiliary parameters which has to be submitted by the individual PI's is given in table I. The individual PI's are recommended to communicate their data format to the referee (Mahesh Kumar Sha – BIRA-IASB) as soon as possible and definitely before the end of February. This will help in the development of the necessary software for the intercomparison campaign.

It is also mandatory for the individual PI's to send on a regular basis (e.g. once a month) few example of their level 0 (e.g. interferogram), level 1 (e.g. spectrum) products and the spectral residual/noise plot or data from the trace gas retrievals to the referee.

Table I. File format and content. The header lines are text format. The column values are numbers with 2 digits; the units are provided in the column headers and are fixed. Day of year 2017 (Jan. 1 at 0:00 UTC = 0); solar azimuth angle is counted positive from North (0°) to the East)

NofHeaderlines	21												
NofColumns													
Institute	UBremen												
Instrument	Vertex70												
file version number	1												
Retrieval code	GFIT												
data provider	T. Warneke												
CO2 microwindow(s)													
CH4 microwindow(s)													
CO microwindow(s)													
H2O microwindow(s)													
source of a priori profile of CO2													
source of a priori profile of CH4													
source of a priori profile of CO													
SNR													
aperture diameter (mm)													
spectral resolution (MOPD in cm))													
number of scans/spectrum													
source of a priori profile of H2O													
Day of Year	UTC decimal time	SZA	solar azimuth angle	P_surface	T_surface	CO2 column	CH4 column	CO column	H2O column	O2 column	XCO2	XCH4	XCO
	(decimal hours)	(°)	(°)	(hPa)	(K)	10^^x mol cn	10^^x mol cn	10^^x mol c	10^^x mol cn	10^^x mol c	ppmv	ppbv	ppbv

9 Applicable Documents

Statement of Work: Fiducial Reference Measurements for Ground-Based FTIR Greenhouse Gas Observations (FRM4GHG)
Prepared by: T. Fehr/B. Bojkov (EOP-GMQ), Reference: ESA-EOPG-MOM-SOW-0007

10 Reference documents

FRM4GHG deliverable D2.2: Instrument overview, made available via the project website http://frm4ghg.aeronomie.be/index.php/outreach/deliverables

FRM4GHG deliverable D2.3: Description of measurement strategy to ensure comparable observations, made available via the project website http://frm4ghg.aeronomie.be/index.php/outreach/deliverables

TCCON Sodankylä site: https://tccon-wiki.caltech.edu/Sites/Sodankyla

11 Reference for software/tool mentioned

N/A