

FRM4GHG 2.0

Fiducial Reference Measurements for Greenhouse Gases



Report on Vertex and IRcube data uptake in the COCCON schema

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Table of contents

1 Document change record 3

2 Access list.....3

3 Purpose 3

4 Document structure.....3

5 DELIVERABLES.....3

6 Results.....3

7 Conclusion 8

8 OUTLOOK 8

9 Applicable documents 9

10 Reference documents 9

1 DOCUMENT CHANGE RECORD

Issue	Date	Item	Comment
V1.0	2024-09-11		Initial version
V2.0	2024-10-25		Modified version

2 ACCESS LIST

This document is a deliverable “D2.1.2 Report on Vertex70 and IRcube data uptake in the COCCON schema” and will be submitted to ESA. The document can be downloaded from the project webpage <http://frm4ghg.aeronomie.be>.

3 PURPOSE

The document describes the demonstration of uptake of Vertex70 and IRcube data in the COCCON processing scheme of WP2 over the time period January 2024 to September 2024.

4 DOCUMENT STRUCTURE

The document describes in the first part the retrieval of trace gases from the Vertex70 measurements in Sodankyla using two different codes, GGG2014 and PROFFAST. In the second part the work on the IRcube from the University of Wollongong and its comparison with EM27 measurements is described.

5 DELIVERABLES

This report is deliverable D2.1.2

6 RESULTS

In order to expand the COCCON network by the uptake of new low resolution spectrometers requires the development of a strict protocol necessary to expand the size and scope of the instruments that can be used within the COCCON network. The deliverable D.2.1.2 is premature at this stage of the project. The Vertex70 has demonstrated nicely that it can get good results with respect to TCCON, while the work on the IRcube concentrates on testing and improving the FO coupling technology.

The task of our deliverable D2.1.2 is a first step in the integration of the Vertex70 and IRCube into the COCCON schema. For the IRcube spectrometer, a field campaign was executed with four solar Fourier transform spectrometer (FTS) instruments and co-incident AirCore flights. For the Vertex70 instrument a comparison of the results from the retrieval codes used by COCCON (PROFFAST v2.4) and TCCON (GGG2020) has been performed.

Work on the Vertex70

So far, the TCCON retrieval has been used for the Vertex70 and IRcube. While TCCON works with GGG, COCCON uses PROFFAST, also a scaling retrieval, based on the profile retrieval algorithm PROFFIT. The results presented have been retrieved using GGG2014 and the current PROFFAST version (September 2024).

Fig. 1 gives a comparison of Xair for the Vertex70 instrument. Xair is a sensitive indicator for misalignments of the instrument. All values from PROFFAST are higher than the GGG results. The mean difference is 6.94×10^{-3} . This behavior can be understood by looking at a zoomed in view for three days, as shown in Fig. 2. Both curves show opposite behavior, because Xair in Proffast is defined inversely to GGG (defined here as Xluft, Wunch et al., 2015). Considering this, the comparison of both retrieved Xair and Xluft is excellent.

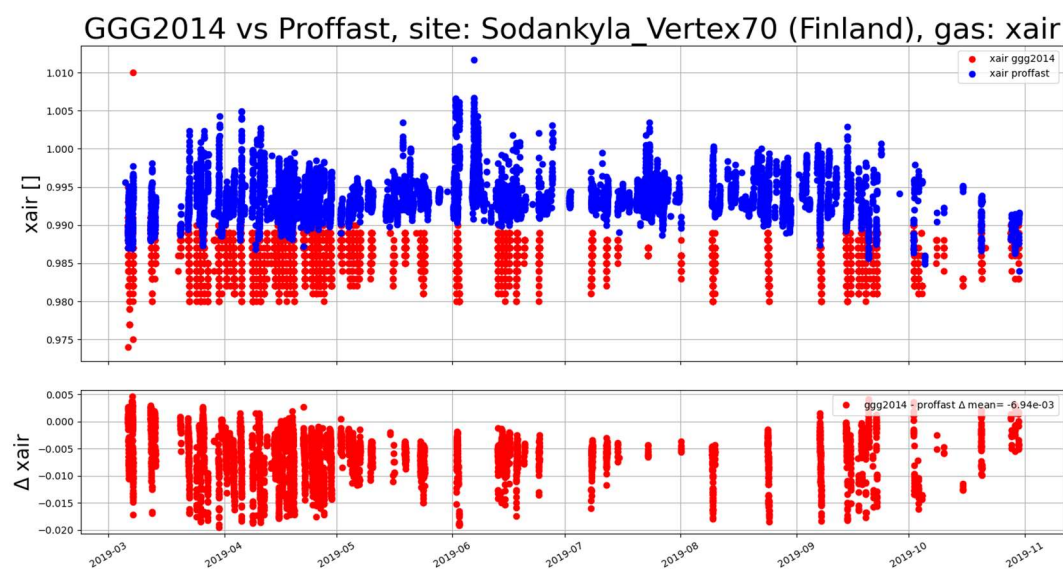


Figure 1: Xair for spectra measured in Sodankyla in 2019, analysed using GGG2014 and PROFFAST.

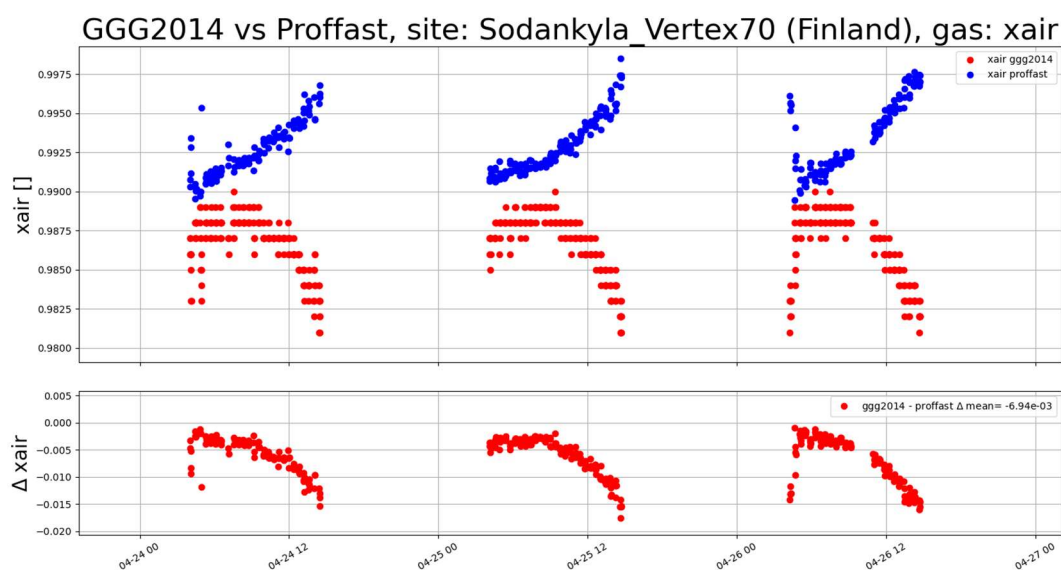


Figure 2: Xair for spectra measured in Sodankylä for three days in April 2019, analysed using GGG2014 and PROFFAST.

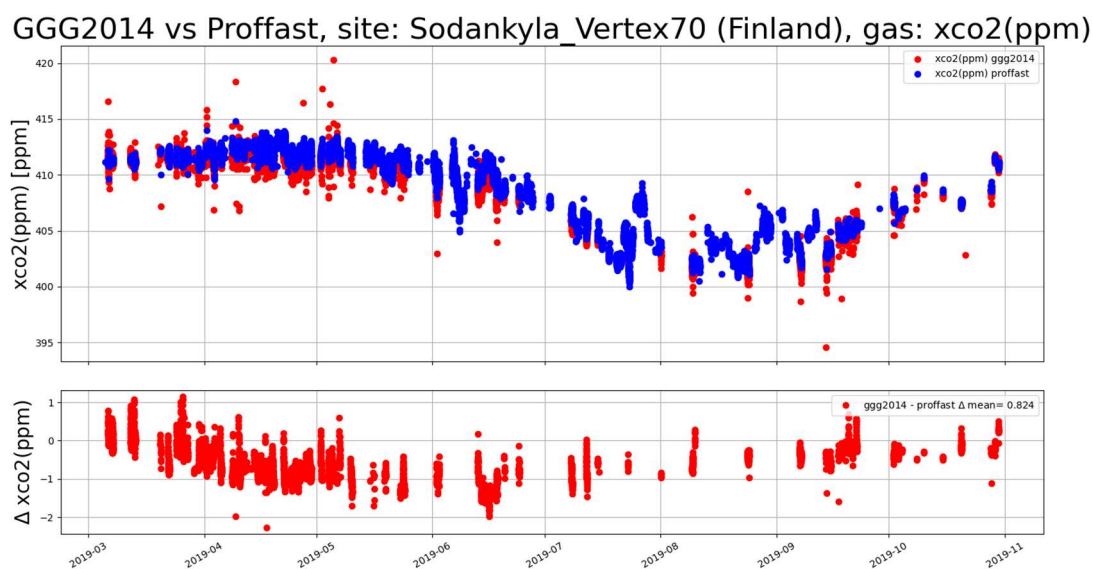


Figure 3: XCO₂ for spectra measured in Sodankyla in 2019, analysed using GGG2014 and PROFFAST.

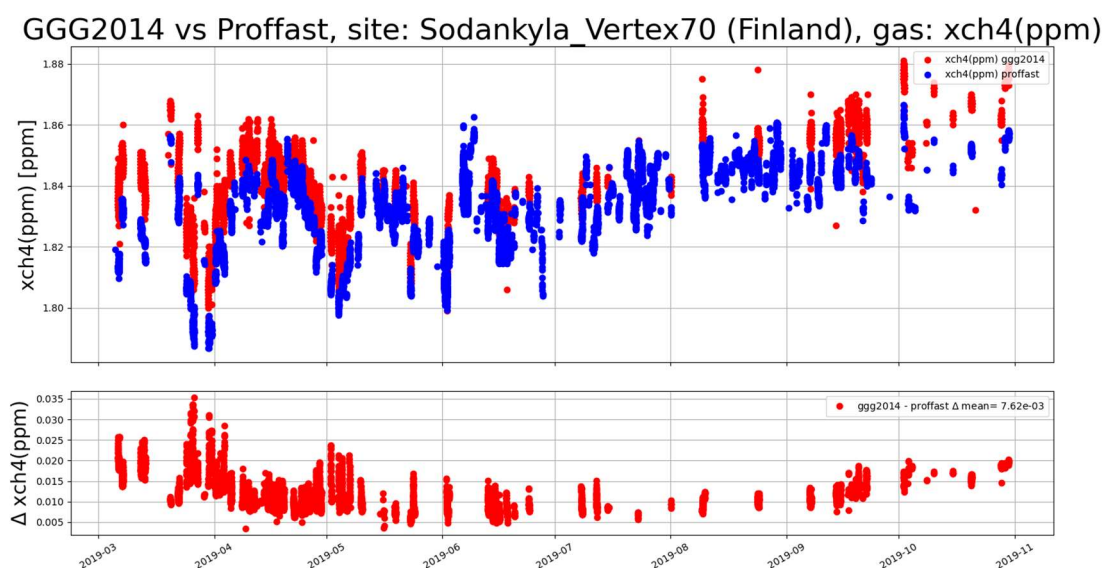


Figure 4: XCH₄ for spectra measured in Sodankylä in 2019, analysed using GGG2014 and PROFFAST.

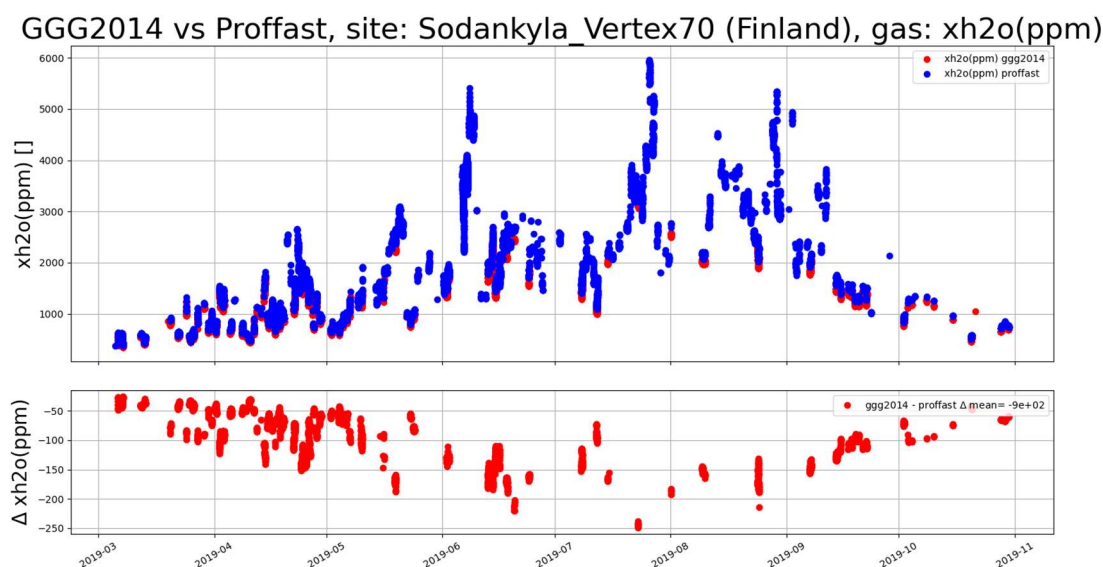


Figure 5: XH₂O for spectra measured in Sodankylä in 2019, analysed using GGG2014 and PROFFAST.

Figure 3, 4 and 5 give the comparison for XCO₂, XCH₄ and XH₂O from both retrieval codes for spectra recorded with the Vertex70 spectrometer in Sodankylä for the year 2019. The comparison is excellent with mean differences (for the years 2017 to 2019) of 0.824 ppm for XCO₂, 7.62 10⁻³ ppm for XCH₄ and -0.9x10² ppm for XH₂O. This corresponds to 0.2% for XCO₂, 0.4% for XCH₄ and 4.5% for XH₂O.

Work on the IRcube

In September/October 2022, the University of Wollongong team executed a field campaign with four solar FTS instruments and co-incident AirCore flights at Broken Hill in western NSW, Australia. The four instruments were

- The IRcube with Ekotracker with fibre optic (FO) coupling of the solar beam to the FTS, in the configuration deployed in the Sodankyla campaigns in 2017 and 2018
- An EM27 FTS with similar FO-coupled solar beam – the EM27 was an EM27/SUN with the camtracker replaced by the fibre optics.
- Two COCCON-standard EM27/SUN instruments on loan from NIWA and the University of Auckland (UoA), NZ.

Figure 6 shows the instrumentation as deployed at an AirBnB house in Broken Hill. Data were collected over 7 days with five AirCore flights. Detailed results are not presented here.

Figure 7 gives an overview of all data over the campaign (8 days). General comments:

- The two EM27/SUNs (blue, green) and the FO-coupled EM27 (red) show generally good agreement on all days. The FO coupling does not appear to cause a significant bias in retrieved column average mole fractions relative to the COCCON EM27/SUN instruments. We have confirmed this lack of bias in further studies currently in progress, using both GGG and PROFFAST analysis.
- The IRcube results do show significant biases, as already noted in the Sodankylä and other campaigns. Previous experience suggests these biases are constant for a given set up of the instrumentation, but can change when reconfigured or relocated.

We believe the biases in the IRcube results are due to the optical configuration of the standard IRcube, not the FO coupling. In 2023, we rebuilt the optical configuration of the IRcube to closely resemble the EM27 and this configuration is currently undergoing testing at UoW. This work is described in D1.1.2.





Figure 6. a. Two EM27/SUNs (left) and two Ekotrackers as deployed at Broken Hill. The fibre optic cables lead from the Ekotrackers to the two FTSs housed in the garage behind the green roller door (Figure 1b).

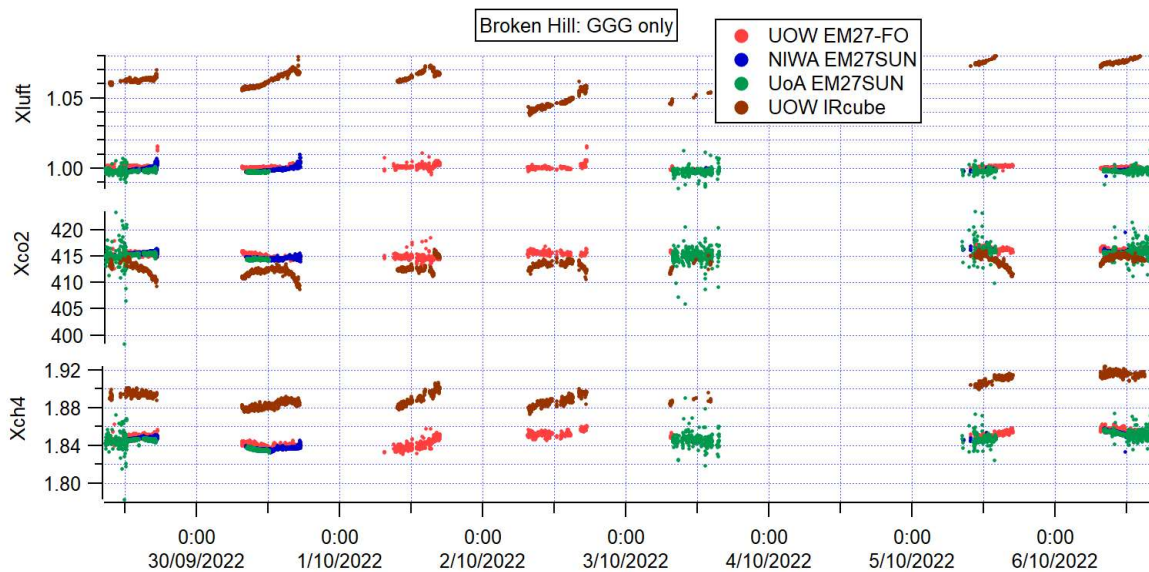


Figure 7. Overview of Xgas retrievals from four co-located instruments at Broken Hill, 2022.

7 CONCLUSION

The comparison of the Vertex70 analysis using GGG2014 with PROFFAST show the opposite behaviour for X_{Luft} as a function of the solar zenith angle. Considering that X_{Luft} is inversely defined in PROFFAST vs. GFIT, the agreement is very good.

The comparison of four different low resolution spectrometer at Broken Hill in western Australia. We believe the biases in the IRcube results are due to the optical configuration of the standard IRcube, not the FO coupling. In 2023, we rebuilt the optical configuration of the

IRcube to closely resemble the EM27 and this configuration is currently undergoing testing at UoW. This work is described in D1.1.2.

8 OUTLOOK

During the next 12 months the partners will work on

- The IRcube data recorded using the new EM27/SUN like optical arrangement will be fully analysed using PROFFAST.
- The IRcube will be deployed to the clean air site in Tasmania.

9 APPLICABLE DOCUMENTS

Statement of Work: Fiducial Reference Measurements for Ground-Based IR Greenhouse Gas Observations (FRM4GHG 2.0)

Prepared by: EOP-GMQ, Reference: ESA-EOPG-EOPGMQ-SOW-21

10 REFERENCE DOCUMENTS

- Griffith et al., AirCore Broken Hill 2022 - Total column remote sensing with solar FTS, presented at TCCON annual meeting, Spa, Belgium, June 2023.
- Wunch, D., Toon, G., Sherlock, V., Deutscher, N., Liu, C., Feist, D., and Wennberg, P. (2015). The Total Carbon Column Observing Network's GGG2014 Data Version. doi: 10.14291/TCCON.GGG2014.DOCUMENTATION.R0/1221662