

FRM4GHG 2.0

Fiducial Reference Measurements for Greenhouse Gases



Technical Note on Vertex70 instrumental improvement

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1 DOCUMENT CHANGE RECORD

Issue	Date	Item	Comment
V0.0	2024-12-05	-	Initial version

2 ACCESS LIST

This document is a deliverable “D1.1.1: TN on Vertex70 instrumental improvement – created for the project FRM4GHG 2.0 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 instrumental improvements made during the current phase of the FRM4GHG 2.0 project to make the Vertex70 type of instruments more mobile and making its deployment in the field more practical from a logistic point of view.

4 DOCUMENT STRUCTURE

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5 STANDARD DEPLOYMENT OF THE VERTEX70 DURING THE SODANKYLÄ CAMPAIGN IN PHASE 1.0 OF THE PROJECT

The Vertex70 spectrometer has been purchased from the company Bruker to be tested as part of the FRM4GHG project and has since then undergone several modifications during the campaign to be used for solar absorption measurements. These changes have been performed by the members of the teams from the Royal Belgian Institute for Space Aeronomy and University of Bremen. The campaign took place at the Sodankylä facility of the Finnish Meteorological Institute (FMI), north Finland (67.4 degrees N, 26.6 degrees E; 180 m a.s.l.). The Vertex70 spectrometer is primarily meant to be used as a laboratory instrument and therefore Bruker does not offer a solar tracker for this spectrometer. During the deployment of the instrument in Sodankylä, it has been coupled with a large solar tracker system typically used for our high spectral resolution instruments (see Figure 1). The instrument worked well for three years of the campaign period from 2017 – 2019 in this configuration. However, this system is not as mobile as the deployment of the solar tracker would always need a roof of an infrastructure such as a container or a building. Relocation of the setup to

a new place requires quite a lot of effort and furthermore the airmass independent calibration factor needs to be re-determined to scale the measured trace gas values to WMO standards via TCCON. Therefore, as part of the second phase of the FRM4GHG project, it was proposed to develop an enclosure system with compact solar trackers for automated operation of the instrument to perform solar absorption measurements. This is described in detail in the next section.

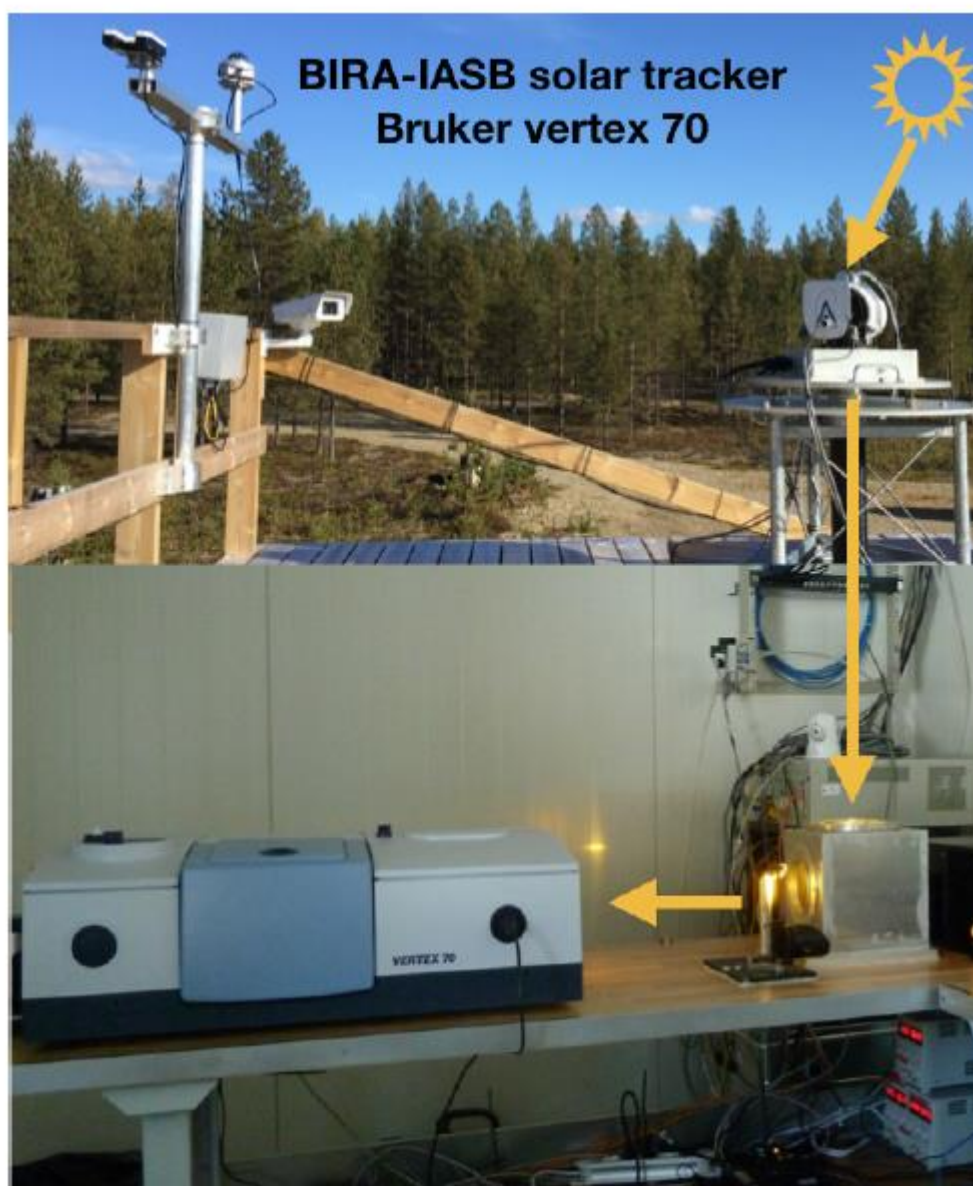


Figure 1: Bruker Vertex70 spectrometer deployed inside the FMI container at Sodankylä facility. A large solar tracker system is installed on the roof of the container to bring the solar radiation (orange arrows) to the laboratory. A meteorological station is installed on the roof to assist in the automated operation of the solar tracker depending on the weather condition. Figure from Zhou et al., 2023.

6 DEVELOPMENT OF AN ENCLOSURE SYSTEM WITH ASSOCIATED SOLAR TRACKER FOR DEPLOYMENT OF VERTEX70 SPECTROMETER AS A STANDALONE SYSTEM

This work package's main aim was to make the instrument mobile to facilitate easy deployment at other locations. The existing enclosure system solutions were all directed towards the EM27/SUN type of spectrometers which already has its own solar tracker system sold by Bruker. Therefore, a completely new design of the enclosure system had to be done for hosting the Vertex70 or Invenio (replaced the Vertex70 spectrometer that was discontinued by its manufacturer). This design was also considered to be modular such that other spectrometers like the EM27/SUN or IRCube can be integrated using the newly developed small solar tracker system. The development therefore also included a compact solar tracker and its integration with the spectrometer and enclosure system.

The portable instruments are meant to fill the gaps in the high spectral resolution Fourier transform spectrometer networks like the TCCON and NDACC-IRWG. Therefore, its deployment can be in any kind of situation even with harsh conditions like high or low temperatures, rainy or dry conditions, polluted dusty conditions, etc. The enclosure system should be able to perform under such conditions. Therefore, the spectrometer is housed inside an insulated temperature controlled and waterproof box, installed on a base plate with mounting positions that can be dedicated to any of the above spectrometer for the purpose of achieving the same orientation each time it is taken out and placed back inside the enclosure. The Vertex70 and the Invenio are the largest in size amongst the tested portable spectrometers in the project. Therefore, fitting in the EM27/SUN or IRCube will require little modifications in the base plate and the mounting positions. The enclosure has an opening on the top for easy access to all components installed inside.

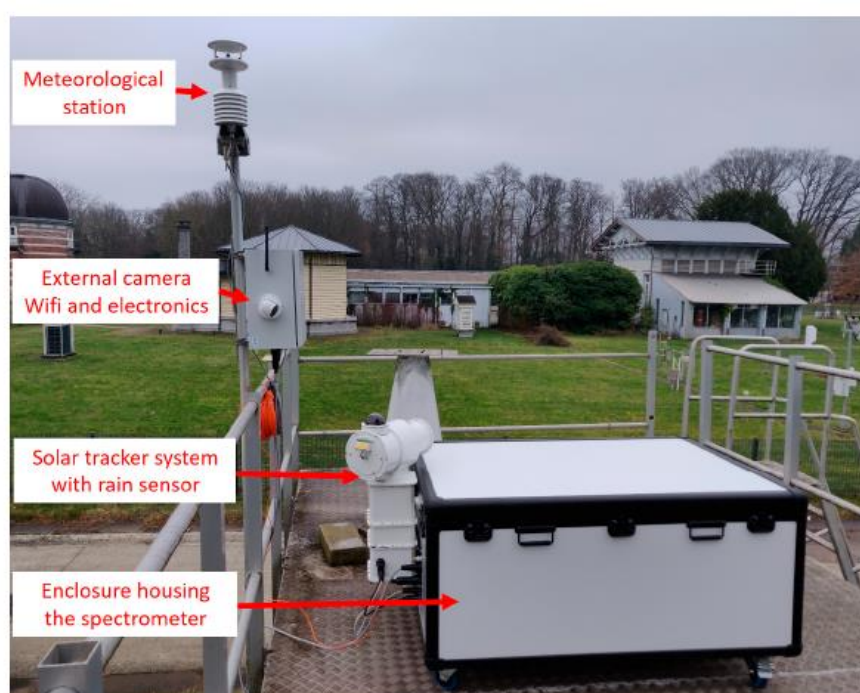


Figure 2: Picture of the enclosure, compact solar tracker, and meteorological station on the mast during deployment at a field test performed in the campus of BIRA-IASB in Uccle, Belgium. Figure from Sha et al., 2024

Figure 2 shows the enclosure system with integrated compact solar tracker and meteorological

station during its deployment at the campus of BIRA-IASB in Uccle, Belgium. The enclosure box also contains an electronics bay that houses an industrial PC, UPS, power supplies, barometer, heating and cooling elements, and cabling. Four wheels are attached to the base on the four sides for transportation or adjustments of orientation during measurement setup. The homemade solar tracker system was built based on the same principle of operation of the large solar tracker designed by BIRA-IASB engineers (Neefs et al., 2007). A full sky camera is included to find the sun quickly after the passing of clouds from the scene. A rain sensor is included on the solar tracker and allows for the detection of rain or no rain conditions and therefore helps the automation system to point the tracker mirrors in the direction of the sun or to be in the park position, respectively. In addition, a meteorological station with ICOS-compliant (Laurent et al., 2020) weather station providing high-quality measurements of temperature, surface pressure, relative humidity, wind speed and wind direction is included in the system to assist in the automation and data analysis. This is mounted as a separate unit on the mast of the meteorological station. It also contains an external camera looking at the spectrometer and the antennas for internal connection. The monitoring and data transfer is foreseen either using WiFi or mobile (4G/5G) network depending on the availability of the infrastructure at the measurement station. The automation software allows for fully autonomous operation of the measurements with the possibility of manual or remote intervention at any time. The dimensions of the enclosure with the solar tracker are 154 cm x 96 cm x 100 cm (l x w x h) and the dimensions of the enclosure without the solar tracker are 147 cm x 96 cm x 74 cm (l x w x h) and weighs 70 kg. The dimensions of the compact solar tracker are 19 cm x 41 cm x 65 cm (l x w x h) and it weighs 15 kg. The inside temperature of the enclosure system can be controlled to a set value using Peltier elements. Lightening protection is included to avoid damage, especially during deployments in the tropics. The setup is capable of working with the AC supply voltage ranging from 100 to 240 V (50 – 60 Hz). The maximum total electrical power consumption is 640 W, where most of the power is used for temperature controller. Therefore, for locations where the ambient temperature is closer to the set operating temperature, which is determined by the specification of the installed spectrometer, the power consumption will be lower. In addition, with the provision of battery and solar panels, the spectrometer can be operated in the field, making it independent of an external power supply.

The enclosure system with the compact solar tracker will make the Vertex70/Invenio type of instrument portable and will therefore extend the observational capacity of the TCCON and NDACC-IRWG networks for the observation of CO₂, CH₄, CO and H₂O in the near-infrared as well as additional species like N₂O, CH₄, HCHO, OCS and perhaps others in the mid-infrared spectral regions. The data from these instruments will be useful for satellite validation of the measured trace gases.

7 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

8 REFERENCE DOCUMENTS

Zhou, M., Langerock, B., Sha, M. K., Hermans, C., Kumps, N., Kivi, R., Heikkinen, P., Petri, C., Notholt, J., Chen, H., and De Mazière, M.: Atmospheric N₂O and CH₄ total columns retrieved

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