**Title: Towards Fiducial Reference Measurements of Greenhouse Gas Abundances in the Atmosphere**

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**Abstract:**

The provision of fiducial column-averaged greenhouse gas (GHG) abundances from remote sensing (RS) techniques is of utmost importance for improving our knowledge of the atmospheric carbon budget, for the stocktaking of anthropogenic emissions and for the validation of models and space-borne GHG missions. For this reason, ESA has launched the [FRM4GHG (Fiducial reference Measurements for Greenhouse Gases)](https://frm4ghg.aeronomie.be/) project, which recently has entered its four-year extension phase.

FRM4GHG brings together an expert consortium with the aim (1) to develop, improve, test and properly characterize remote sensing instrumentation, (2) to improve the quality of the retrieved GHG products by enhancing the algorithms used for data analysis (3) to perform comparisons with independent AirCore in-situ observations for the verification of improvements.

Here, we present key results of the first project phase and current activities. As a practical realization of a GHG RS network resulting from the FRM4GHG strategy implemented by ESA, we present the [COllaborative Carbon Column Observing Network (COCCON)](https://www.imk-asf.kit.edu/english/COCCON.php), which uses standardized and centrally calibrated portable FTIR spectrometers and a common source-open data processing chain for closely approximating the ideal of a RS network delivering fiducial GHG reference data.

We finally investigate the role of metrology for supporting RS networks and argue that an effective use of funds calls for a proper division of work packages, those which can be tackled by remote sensing experts and those requiring metrology assistance. The verification of many important network performance indicators can be achieved solely by relative comparisons without the need of an explicit metrological reference.

In contrary, the traceability of a spectroscopic remote sensing measurement to proper WMO units cannot be achieved by network-internal measures. It requires either (1) comparison to a set of available collocated well-calibrated in-situ measurements, or (2) the use of well-calibrated spectroscopic line lists for the spectral analysis. A successful closure experiment comparing both pathways on the required level of accuracy would guarantee the desired fiducial character of the network beyond any reasonable doubt. Still, the metrological calibration of available line lists is insufficient and GHG remote sensing networks need to apply approach (1). We conclude that from the viewpoint of fiducial GHG RS measurements, the improvement and proper characterization of the relevant spectroscopic datasets appears to be the prominent metrological key task.