

Interactive comment on “Calibration of TCCON column-averaged CO₂: the first aircraft campaign over European TCCON sites” by J. Messerschmidt et al.

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This paper describes the comparisons between total column measurements of carbon dioxide at five European sites in the Total Carbon Column Observing Network (TCCON), and co-incident in-situ vertical profiles of CO₂ measured by analysers onboard an aircraft above the sites. The measurements relate the calibration scales of the remote-sensing TCCON measurements and the WMO calibration scales used by the in situ networks. This calibration is very important to establish comparability and lack of bias between the two types of measurement, so that they may be combined in atmospheric models and other analyses with knowledge of potential biases.

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The paper is well structured and well presented, and suited to publication in ACP after the general points concerning uncertainties and technical corrections addressed below are addressed.

General comments My principal concern is with the error analysis of the TCCON measurements, section 3.6 and Tables 3 and 4. Since 2009 TCCON is a part of the Global Atmospheric Watch, which brings an increasing requirement to treat errors in a thorough way consistent with metrological methodology.

The approach outlined at the start of 3.6 is correct – we consider three types of error:

1. Random error, measured for example as repeatability or 1-sigma scatter in consecutive measurements
2. Systematic errors which can be corrected, such as in this case ghosts. The corrections should be applied and their uncertainties combined in quadrature with the random error, as recommended by JCGM.
3. Systematic errors which are not known and cannot be corrected, such as linestrengths used in the GFIT spectrum model. These errors cause a systematic shift in the measured quantity. Their magnitude may be estimated, but they are not random. They should not be combined with the random and corrected systematic errors, but quoted separately. They can be corrected by calibration against a standard, which is the objective of this paper.

However I find that the error analysis discussion for the TCCON measurements is incomplete; random error (repeatability, or spectrum to spectrum variability) is not described (though it might have been quantified, but how?), and of the systematic errors which are corrected in the GFIT analysis, only the ghosts error is addressed (in some detail), while others such as air mass corrections are ignored – are they included in the error budget? Page 14555 line 24 states that Table 3 provides this overview of errors but it does not – it provides a detailed description of the ghost error estimates, but no

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overview of the random errors (1 above) other systematic corrected errors (2 above), or estimates of uncorrected systematic errors (3 above) . Table 4 does this more correctly for the in situ measurements, but should be checked for completeness. I would therefore ask the authors to describe ALL random errors, and systematic errors which have been corrected and whose uncertainties are known, to be described and listed in a revised table 3, or new table if Table 3 is to be kept for ghosts errors only. The table should include the total uncertainty which is represented as the error bars in figures 4 and 5.

Uncorrected systematic errors should be listed, with estimated magnitudes. Does the eventual calibration fall within these estimated systematic error limits?) The total uncertainties should also added to the table – they should be the same as the error bars in Figures 4 and 5.

The equivalent approach should be taken with the in situ measurements, the contributions in Table 4 should be reviewed and checked for completeness.

Wunch et al. provide a good basis for the error catalogue: Wunch, D., G. C. Toon, J.-F. Blavier, R. Washenfelder, J. Notholt, B. Connor, D. W. T. Griffith, and P. O. Wennberg (2011), The Total Carbon Column Observing Network (TCCON), *Phil. Trans. Roy. Soc. A*, 369, 2087-2112 Wunch, D., et al. (2010), Calibration of the Total Carbon Column Observing Network using Aircraft Profile Data, *Atmos. Meas. Techn.*, 3, 1351-1362.

Minor technical comments are contained in the attached supplement.

In table 5, I have trouble relating the total column uncertainties with the error analyses in tables 3 and 4. Most are quoted as +/- 0.1ppm, but for example the total error from Table 4 for aircraft profiles is at least 3 ppm. In reviewing the treatment of errors, the quoted errors in Table 5 should be confirmed or clarified.

Please also note the supplement to this comment:

<http://www.atmos-chem-phys-discuss.net/11/C4057/2011/acpd-11-C4057-2011->

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supplement.pdf

Interactive comment on *Atmos. Chem. Phys. Discuss.*, 11, 14541, 2011.

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