

Authors' answer to the interactive comments of anonymous referee #2 on paper Frey et al., Atmos. Meas. Tech. Discuss., 8, 2735-2766, 2015

First of all, we would like to thank the anonymous referee #2 for the helpful comments and questions. Below we give answers and clarifications to all comments and questions made by the referee.

Referee: *“This is part 1 of 2 papers in which five portable solar FT spectrometers were deployed around Berlin to measure total column CO₂ and CH₄ in the atmosphere over a 3 week campaign in summer 2014. In part 1 the intercalibration of the spectrometers before and after the campaign is described in detail. Part 2 describes the campaign measurements and their interpretation through a relatively simple Lagrangian dispersion model to estimate city-wide emissions of the target gases. This is an valuable piece of research and the papers are suited to publication in AMT. The work is thoroughly presented and I recommend publication, however I suggest a re-structuring of the work into a single, more concise paper. The splitting into two papers makes the publication longer than necessary and awkward to read either paper without referring to the other. Some material must be repeated in each paper, and some material in one paper better belongs in the other. While the need for tight intercalibration is essential for the purposes of the field campaign and is well justified, it does not justify a standalone paper as it does not have clear relevance without the context of the measurement campaign.*

Part 1 contains introductory material that better belongs to part 2 (e.g. 1. Introduction, and 3.2 describing the Berlin campaign). Part 2 relies heavily on part 1 to follow the measurements. I therefore recommend combining the two papers into one, merging the duplicated material in introductions campaign descriptions and conclusions, with a single introduction to the importance of the work, followed by (existing) sections on the instrumentation, (calibration, ILS determination, spectrum analysis and processing to total columns), Berlin campaign description, results and modelling. This is mostly a matter of reorganising existing sections rather than rewriting new material. The authors might consider placing some of the calibration material from part 1 into an appendix to the combined paper. It is important that this material be included, but for the less interested reader it can be summarised in the main text with details in the appendix to enhance readability.”

Authors: Concerning the suggested aggregation of both papers, we decidedly disagree. Especially, we reject the claim that “intercalibration ... does not justify a standalone paper as it does not have clear relevance without the context of the measurement campaign.”. The level of consistency between the spectrometers demonstrated in this work is well beyond what has been demonstrated hitherto with ground-based low-resolution solar absorption measurements. Concerning the instrumental line shape (ILS) calibration procedure described in our work, we have already been contacted by several other working groups operating EM27/SUN spectrometers for further guidance. Therefore, it seems evident that the calibration procedures and consistency checks described in part 1 are a vital prerequisite for any successful detection of XCO₂ enhancements on the ppm level and will serve as a reference for defining a good practice for this kind of application in a much wider context than the subsequent demonstration concerning the observation of Berlin as a source of CO₂, as treated in the Hase et al. submission. However, we are inclined to

agree that the current titles might abet the erroneous assumption that the two publications are the result of an artificial separation. We therefore perform an adjustment of titles, for this work, we choose “Calibration and instrumental line shape characterisation of a set of portable FTIR spectrometers for detecting greenhouse gas emissions”, and the Hase et al. work becomes “Application of portable FTIR spectrometers for detecting greenhouse gas emissions of the megacity Berlin”. In addition, we will expand the section concerning the ILS calibration procedure, considering some additional practical aspects of the procedure as raised in the discussions with other EM27/SUN users mentioned above. Sections overlapping with the Berlin campaign (3.2 and 6) have been moved to the Hase et al. publication. In addition a chapter (5.2) comparing barometric records and ground pressure derived from solar observations in Karlsruhe has been added.

Referee: *“P2737 L13: ...from the total column measurements of O₂ and barometric records.”*

Authors: Ok

Referee: *“L18: “In the last years” => “recently””*

Authors: We will adopt this change.

Referee: *“L24: Caltech => spell out in full.”*

Authors: Ok

Referee: *“P2738 L10: lightweight”*

Authors: We will correct the typo

Referee: *“L17: The review of relevant previous work is quite minimal - there are many more relevant studies of boundary layer emissions measurements around GHG and urban sources than the two selected – they should be briefly reviewed or referenced, for example: - the entire INFLUX experiment around Indianapolis (Shepson and co workers, many publications), - Utembe et al Estimating CO₂ emissions from point sources: a case study of an isolated power station, Atmos. Chem. Phys. Discuss., 14, 31551- 31601, 2014, - Wunch, D., et al.: Emissions of greenhouse gases from a North American megacity - Geophysical Research Letters, 36, 15810-15810, 2009, - Wong, K. W., et al.: Mapping CH₄ : CO₂ ratios in Los Angeles with CLARS-FTS from Mount Wilson, California, Atmos. Chem. Phys., 15, 241-252, 2015.”*

Authors: We will include the mentioned references.

Referee: *“L24: clarify meaning of “signal” here”*

Authors: We will rephrase: “The emission of Berlin introduces an increase of downwind column averaged mole fractions in the sub percentage range.”

Referee: *“P2739 L21: It would be helpful to mention the FOV of the sun’s disk here”*

Authors: Ok

Referee: *"L23: use "interferogram" not IFG (also in several places later)"*

Authors: Ok

Referee: *"P2741 L4: Justify this selection of H2O spectrum used for ILS"*

Authors: The selected microwindow encompasses a large number of water vapour lines spanning a wide range of line intensities. Residuals of spectral fits to fully resolved open path spectra collected with the TCCON spectrometer were used to verify that the selected microwindow does not contain lines with significantly inconsistent line parameters.

Referee: *"L10 "Neded" => "required""*

Authors: Ok

Referee: *"L14: SD - spell out standard deviation, remove "very low" – let the reader decide if it is low, just give the value."*

Authors: We will adopt this change.

Referee: *"L26: "in a Transporter" => "by road""*

Authors: Ok

Referee: *"P2742 L4:...is of utmost importance to avoid bias between stations."*

Authors: Ok

Referee: *"Section 3.2 would belong in the second paper if separated, it is out of place here"*

Authors: This section will be included in the second paper.

Referee: *"L24: relatively isolated from what? – please clarify."*

Authors: see above

Referee: *"P2743 L2: is favourable for modelling/transport/dispersion studies"*

Authors: see above

Referee: *"P2744 L10: use 24 hour clock times 00:00 and 18:00 to avoid ambiguity"*

Authors: see above

Referee: *"P2744 L27: subsume => combine"*

Authors: We will adopt this change.

Referee: *"P2745 L3: residuum => residual – also in several places later in the paper."*

Authors: Ok

Referee: *"L5: "larger linelist errors" what is meant here? Do you mean larger errors due to the variable actual vertical profile?"*

Authors: This sentence is imprecise and we will omit it.

Referee: *"L6: "very good" - in general, please avoid such subjective judgements and leave them to the reader, or put the value in context so the reader can decide for him/herself. Eg 0.2% in comparison to the random noise component of the residual of ??%"*

Authors: Ok

Referee: *"L11: DMF – use dry air mole fraction or define DMF at first use. Please check ALL abbreviations and acronyms for definition at first use."*

Authors: DMF was defined on page 2741 in line 24. All other abbreviation will be checked again.

Referee: *"L17: "Calibration factors" Please clarify, are these the factors taken straight from TCCON, or of the EM27 relative to TCCON?"*

Authors: These are the factors taken straight from TCCON.

Referee: *"L20 It is clear that the lineshape of all the spectrometers..."*

Authors: We will adopt this change.

Referee: *"L22: briefly describe the hardware problem."*

Authors: The tracker did not follow the sun anymore but moved to a random position during initialization.

Referee: *"P2746 L18: rationing => ratioing"*

Authors: Ok

Referee: *"P2747 L1: agreement is never perfect! Quantify – eg obtain agreement within measured noise or precision"*

Authors: Ok

Referee: *"L17:...similar to the implemented by Wunch et al in TCCON (implemented, not simply proposed)"*

Authors: We will change this

Referee: *“P2748 L13: Please comment on the relative scatter between TCCON and EM27 – the EM27 scatter is lower, presumably due to lower resolution, but this will not be obvious to many readers who might expect the higher quality TCCON instrument to be better.”*

Authors: Due to the much lower spectral resolution of the EM27/SUN, the noise level of the resulting XCO₂ data is even superior to the data generated by the TCCON spectrometer.

Referee: *“P2749 L26: as above, “excellent” please avoid such value judgements and leave them to the reader.”*

Authors: Ok

Referee: *Table 1: Please specify that the modulation efficiencies quoted are at max OPD ie 1.8 cm*

Authors: We will do this