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Atmospheric Measurement Techniques Discussions

Interactive comment on "The Zugspitze radiative closure experiment for quantifying water vapor absorption over the terrestrial and solar infrared. Part II: Accurate calibration of high spectral resolution infrared measurements of surface solar radiation" *by* Andreas Reichert et al.

Anonymous Referee #3

Received and published: 9 June 2016

This paper introduces a new method to perform absolute radiometric calibration of direct solar viewing atmospheric NIR Fourier transform spectrometer (FTS) spectra. The authors approach is to use the combination of two standard techniques: the Langley extrapolation technique and independent radiometrically calibrated blackbody (BB) radiance measurements. The BB radiance measurements are used to provide the calibration curve shape in spectral regions where the application of the Langley extrapolation method is not possible. The BB calibration curve is scaled to overlap with specifically

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Discussion paper

defined Langley calibration points. The authors then discuss caveats involved in applying the new method, provide experimental data to demonstrate the technique along with error analysis to derive an uncertainty budget. The combined calibration curve is then used to radiometrically calibrate a set of FTS spectra. This calibrated spectra set are then compared to model simulations of the NIR water continuum. Results indicate this technique has an uncertainty comparable or better than other absolute radiance calibration methods. A full discussion on the measurement-model comparison results are presented in another paper.

The novelty is that this is the first time such a combined calibration method has been applied to atmospheric FTS measurements. There is a high likelihood the technique will be used by other research groups to advance water continuum and aerosol research in the NIR spectral region. The technique will possibly allow a greater number of research groups to participate in such investigations since the calibration equipment used in this study is more readily available than that used in the standard method of using a high temperature back body emission source. This new combined method is a welcome addition to the literature and meets the scope and requirements of the AMT journal. The paper is structured in a logical format and written in a clear and concise manner. The figures are clearly presented and the single table is legible. The reviewer has no expertise in MT-CKD water continuum theory and analysis therefore cannot offer expert commentary on the comparison of the measurements with this model simulation. Overall, I advise the paper be published after the following comments have been addressed. Most of the comments below pertain to providing more explicit technical details to allow for experiment replicability.

General comments:

Given that this paper will potentially be used as a methodology template for similar investigations by other research groups I think there needs to be additional information added. Areas where more information is required:

1/ additional background explanatory details: There is no mention why a 2000K BB external source cannot be used as in the method described in Gardiner 2012. A concise summary is required as some readers may not have an implicit understanding of the plank function as applied in the mid/near infrared region. For background/introduction completeness a description (and possibly an equation) of how the derived combined calibration curve is applied to FTS spectra to get calibrated spectra is required. The use of a transfer standard white lamp is only mentioned in the summary/conclusion section, so again for background completeness this technique should be mentioned in the introduction as it is another valid calibration method. The authors could also comment if the combined calibration technique could be (or not) also used with a transfer standard white lamp instead of a BB external source.

2/ additional technical information on FTS spectra acquisition and set up: this would assist in experiment replicability and comparison by other research groups. An extra table could added containing FTS spectra acquisition settings (Field of view, scan rate, resolution, average SNR etc...) along with details already given (resolution, detectors, beam splitter and scan averaging). Is the FTS spectra acquisition and set up common between the Langley extrapolation technique and black body measurements? If not, then what is the effect of this.

3/ further discussion on the advantages and limitations of the combined technique would be helpful.

4/ instrument stability, instrument line shape: there is little mention of instrument stability and effects of instrument line shape changes. The method and examples given assume the instrument over the time period is completely stable. There is nearly a 9 week difference between the spectra taken for the Langley extrapolation technique and the back body measurements. Any instrumental difference over this time could bias the combined calibration curve, thus the importance of instrument stability needs reinforcing and is a requirement of any absolute radiometric technique. It should be mentioned that any change in the instrument stability or instrument line shape would require the construction of another combined calibration curve and is only valid to calibrate atmospheric spectra taken in the same configuration. Validation via self-consistency (section 5.1) assumes complete instrument stability, this is shown but only over two days. Did self-consistency hold over a longer time period?

5/ InSb detector performance: There is no discussion on the effects of detector intensity non-linearity. Is the InSb detector completely linear (a simple literature citation would suffice)? In the case of trace analysis InSb detector non-linearity is negligible. Is this also the case for absolute radiometric studies? InSb detectors are commonly cooled with Liquid nitrogen. Did the authors encounter ice forming on the detector windows? If so what was the effect in the combined calibration method and how did they correct for it.

Specific comments:

Page 1, line 23 - The authors should define the NIR range, i.e. XXXX to XXXX cm-1.

Page 2, line 5 - Possibly remove the word ‘unfortunately’, it is superfluous in this context.

Page 4, line 3 – Define ‘short time scales’.

Page 4, line 7 – Mention what ray-tracing code package or algorithm was used in this study to allow experiment replicability by other groups if they choose.

Page 4, line 11 – 4 scans are stipulated. 4 to 8 scans are mentioned on page 3 line 8. Can the authors clarify throughout this study the number of scans that are averaged?

Page 4, line 30 – Could the authors elaborate why an air mass of 9 was chosen.

Page 4, line 34 - Could the authors elaborate why the lower limit of 10 scans was chosen.

Page 5, line 9 – It is unclear how the two ESS’s are combined. Could more detail please be given?

Page 7, line 7 - Why is ESS not part of the total error budget? Assuming that in the water continuum measurement and model comparison exercise ESS uncertainty cancels implies that the ESS uncertainty is purely systematic, the random component will not cancel.

Page 8, line26 – For completeness and replicability, could the version of LBLRTM be stated.

Page 9, line 31 - The term 'MIR' is introduced. Possibly not needed, or if required, then the wavenumber range should be stated.

Page 10, line 4 - For completeness, the paragraph starting at this line should also stipulate the ESS uncertainty independently or as part of the overall uncertainty budget.

Page 10, line 12 - Possibly replace the statement "NIR spectral range under atmospheric conditions", replaced with "NIR spectral range under a defined limited range of atmospheric conditions". This is to clarify to the reader that this calibration technique has been tested and is valid in a narrow range of optimal atmospheric conditions (no clouds, low water vapour content).

Figure 2 – The legend does not stipulate at what wavenumber this Langley plot is for. I.e. 7000cm-1? Also to avoid ambiguity, could the abscissa title 'air mass' the replaced with 'moist air mass'. Is this correct?

Figure 3 – The ordinate axis symbol c_lan(v) is first encountered by the readers in this figure. A definition of c_lan(v) should be given before figure 3 is referenced.

Figure 7, plot b – Little information is conveyed in this plot. The authors could think about how to better display the information they want to portray to the reader.

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