

Interactive comment on “Evaluation of the IAGOS-Core GHG Package H₂O measurements during the DENCHAR airborne inter-comparison campaign in 2011” by Annette Filges et al.

Anonymous Referee #2

Received and published: 9 May 2018

This manuscript describes the calibration and intercomparison of a Picarro CRDS instrument for measurement of ambient water vapor. Multiple laboratory calibrations of the instrument by comparison with a NIST-traceable dewpoint hygrometer, the FZ Jülich calibration setup, and a new method using co-measured CO₂ dilution by the added H₂O are described to assess the instrument accuracy and stability over time (up to years). Comparison of in-flight measurements with several research hygrometers are presented to assess the instrument performance. The CRDS instrument described is the model that has been selected for the IAGOS-Core payload for regular in-service measurements, and therefore the assessment provided will have bearing on a significant atmospheric data set. The manuscript topic and material presented are

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appropriate for publication in AMT. The manuscript would benefit from some changes to the analysis, structure and presentation.

General Comments:

The manuscript would benefit substantially from copyediting to correct usage and punctuation. Examples include: the use of commas after introductory prepositional phrases,

The inclusion of water vapor mixing ratios in both ppm (ppmv) and % units is somewhat awkward, although I understand that those units are regularly used for water in different environments. Suggest consistently using ppmv for the manuscript with an initial parenthetical equivalence for the reader, e.g. on line 30 “7000 ppmv (0.7%) to 25,000 ppmv (2.5%)”. This would have the additional benefit of simplifying the discussion of the uncertainty in % of measurement without needing to specify “(rel.)”. The DENCHAR website uses ppmv even for high values mentioned.

The details of representations (e.g. blue line, dark blue triangle) of data in the plots should not be included in the text, only in the figure captions (where they should be fully described for clarity). The text should discuss the interpretation and implications of the data presented in the figures. The figure captions could be more descriptive.

The term “repeatability” is used in a number of places in the manuscript (e.g. section 4.1.1) that would appear to be better described as measurement precision. Repeatability is typically the measure of how consistently an instrument will produce the same response when challenged at different times with the same input—related to drift. Precision is more typically used for the short time variation of measurement (as is the case here for the variation about the 60 s or 30 s mean value) or repeated consecutive measurements of a constant input.

Some pieces of information are repeated numerous times within the manuscript out of a desire to be clear, but it seems to go too far. For example, it should be stated at the first reasonable opportunity in the manuscript that 0.802 calibration factor from 2013

will be used going forward and then it need not be repeated every time.

Specific Comments:

P1, L16: “North-Germany” should be “northern Germany”; similarly elsewhere, “South-Norway” and “North-Poland” should be “southern Norway” and “northern Poland”

P1, L23: This paragraph seems inappropriate for the abstract—suggest removing and including the details in the instrument description section.

P1, L30: “instruments” should be capitalized.

P1, L31+: “on the ground over the range from 2 to 600 ppmv against the dew point hygrometer used for calibration of the FISH instrument. A new, independent calibration method based on the dilution effect of water vapor on CO₂ was evaluated.”

P2, L3: “than” should be “then”, but even better could just be deleted—“1% for the water vapor range from 25,000 ppmv down to 7000 ppmv, increasing to 5% at 50 ppm”

P3, L6: sufficient quality for what?

P3, L7: “difficulty representing”; overall this sentence is awkward and difficult to parse.

P3, L18: for what purpose do the satellite measurements have insufficient spatial resolution? Horizontally? Vertically?

P3, L32: What is meant by “beneath”?

P5, L28: “independent on ambient, respectively cabin pressure” is confusing. “independent of both ambient and cabin pressure”?

P5, L29: the filters in the sample line are likely contributing significantly to the long tail in the time constant.

P7, L19: the use of ± 125 ppm as a metric for stability over a range that includes 3 ppm does not induce confidence—would be better to use a relative measure.

P8, L15: “the permeation is negligible” for 3500 sccm is technically incorrect since the permeation rate through the tubing is largely flow independent. The contribution of the permeation to the water vapor mixing ratio in the flow might be argued to be negligible.

P9, L5: “gets only changed by” → “is only affected by”

P9, L13: “whereby it required about” → “requiring”

P9, L29: it would be helpful to the reader to convert the °C uncertainty of the Dewmet to mixing ratio (using the relevant operating pressure) for comparison with other uncertainties.

P11, L11: the CRDS and FISH cal system can’t agree within 3% at mixing ratios below 400 ppm without first correcting for the 12.2 ppm offset. It seems reasonable that there was either an outgassing or small leak (it doesn’t take much) that led to the offset, but that should be argued and removed before stating the agreement in the response (slope).

P12, L3: “likely unrealistic”—should be more descriptive; “the calculated error of 1.6 ppmv for the offset is likely a significant underestimate.”

P12, L20: The section is unclear—are you saying that the pressure sensor response to H₂O is different from that to other molecules, leading to an incorrect measurement of the wet flow cell pressure that depends on the H₂O content?

P13, L4: It would be better to state a best estimate of the CO₂ dilution method uncertainty rather than saying that a value “is achievable”. What do you estimate that you actually achieved, and is that consistent with the comparisons?

P14, L2: “Hohn, Germany, the flights”

P14, L5: “Hence, also the lower stratosphere was reached.” is an awkward construction, this could be better included within the previous sentence.

P14, L10: “total water instead of only water vapor since the forward-oriented inlet re-

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sulted in sampling of cloud droplets and ice crystals when present.”

The sentence “Both instruments were...” seems unnecessary.

P14, L14: “CRDS analyzer, water vapor measurements during periods with stable”

P14, L26: the value of 4 ppm/5% stated for the <100 ppmv precision seems to be at odds with the plotted standard deviations in the 10-100 ppmv range, which are typically higher than both.

P15, L9: “and the flight data...” → “along with the flight data from the reference instruments CR-2 and FISH. Water vapor measurements from two additional analyzers that participated in the intercomparison campaign are also shown.”

P15, L17: “not slower than any other instrument.” → “is similar to that of the other instruments.”

P15, L30: “CRDS data from the first flight” and “influenced” → “compromised”

P16, L1: “can be seen” → “are shown” or “are presented” or “are plotted”

P16, L7: “are neglected.” → “are omitted.”

P16, L11: “sampled data only for two flights” → “operated successfully for only two of the four flights”

P16, L20: “This might indicate that also the CRDS samples cloud” → “This indicates that the CRDS sampling was likely also affected by cloud particles”

Looking at the Rosemount inlet, there is a good likelihood that impaction of droplets or ice crystals (shattering) will produce particles small enough to be entrained in the sample flow and ingested into the instrument. The ice crystal fragments would then be small enough to sublime in the inlet and affect the measurement.

P18, L1: It is unclear exactly what is meant by the statement “The dilution method can be used for other species...”.

The dilution method could be used to determined H₂O using methane instead of CO₂, or are you trying to say that methane could be measured by the method by comparing to CO₂?

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