

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.

Annette Filges et al.

annette.filges@bgc-jena.mpg.de

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Author’s response to Interactive comment by Anonymous Referee #2 on “Evaluation of the IAGOS-Core GHG Package H₂O measurements during the DENCHAR airborne inter-comparison campaign in 2011” by Annette Filges et al.

A version of the manuscript with all changes is added as supplement to the author’s response to referee #1.

All changed Figures are added in the author’s response to referee #1.

General Comments

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

Some proof reading was carried out.

2) 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.

Mole fractions in unit “%” were changed to “ppm” in the whole manuscript (text, tables, and figures). Ratios in “% (relative)” were changed to “%”.

3) 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.

Text and figure captions were changed accordingly. See also answer to General Comment 5) of referee #1.

4) 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.

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“Repeatability” was replaced by “precision”. See answer to Specific comment 30) of referee #1.

5) 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.

Changed in Section 3.2.2, page 11 line 1-2: “ ... 2013 dew point mirror comparison, ...”

Changed in Section 3.2.3, page 11 line 25: “ ... 2013 dew point mirror comparison, ...”

Changed in Section 4.1.1, page 14 line 16-17: “ ... (according to the 2013 dew point mirror comparison; in the following simply referred to as CRDS measured water vapor) ...”

Removed in Section 4.1.2, page 15 line 7-8: “In addition to the offset corrected and calibrated (according to the 2013 dew point mirror comparison, calibration factor = 0.802 ± 0.010) water vapor measurements of the CRDS analyzer, in the following simply referred to as ...”

Specific Comments:

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

Changed in the whole manuscript. See answer to Specific Comment 1) of referee #1.

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

Lines 23-28 in the Abstract (“The inlet system, ... within IAGOS”) were deleted.

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Added in Section 2, page 6 line 11: “operation of the instrument with a controlled pressure in the sample cell of 186.65 hPa (140 Torr) throughout the aircraft altitude operating range...”

3) P1, L30: “instruments” should be capitalized.

Changed in Abstract, page 1 line 30: “. . .Michell Instruments Ltd. . . .”

4) 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.”

Changed in Abstract, page 1 line 31-33: “. . .compared on the ground over the range from 2 to 600 ppm against the dew point hygrometer used for calibration of the reference instrument FISH. A new, independent calibration method based on the dilution effect of water vapor on CO₂ was evaluated.”

5) 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”

Changed in Abstract, page 2 line 3: “. . . down to 7000 ppm, increasing to . . .”

6) P3, L6: sufficient quality for what?

Changed in Introduction, page 3 line 5-8: "... Solomon et al., 2010). However, due to only few existing measurement data in the UTLs, and . . .”

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

Changed in Introduction, page 3 line 5-8: “However, due to only few existing measurement data in the UTLs, and limitations in prognostic model simulations of this region (Solomon et al., 2010), uncertainties in chemistry, transport processes, and trace gas composition are relatively large. This influences . . .”

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

See answer to Specific Comment 5) of referee #1.

9) P3, L32: What is meant by “beneath”?

Changed in Introduction, page 3 line 32: “Besides frost point hygrometers . . .”

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

Changed in Section 2, page 5 line 28: “. . . ambient and cabin pressure . . .”

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

The physical exchange time of the sample cell is only 3.6 s (volume = 35 ml, sample flow = 100 ml/min, pressure = 186.65 hPa, sample temperature = 45°C). Surface effects on the walls of the inlet line and sample cell, as well as the filters can contribute to a longer time constant, especially when the change in water vapor is large. However, comparison of all instruments in Section 4.1.2 shows that the response time of the CRDS is similar to that of the other instruments.

12) 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.

Changed in Section 3.1.2, page 7 line 19: “. . . ranging from around 5000 to 30000 ppm.” After correcting the offsets of all analyzers we expect the relative differences for water vapor <5000 ppm to also be around some percent.

13) 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.

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Added in section 3.1.3, page 8 line 15: "... the contribution of the permeation to the water vapor mole fraction in the flow is negligible ..."

14) P9, L5: "gets only changed by" → "is only affected by" Changed in Section 3.1.4, page 9 line 5: "... the peak area gets only changes due to the dilution effect. ..."

15) P9, L13: "whereby it required about" → "requiring"

Changed in Section 3.1.4, page 9 line 13: "...line, requiring about 1.3 s ..."

16) 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.

Added in Section 3.2.1, page 9 line 30: "... dew point (2-sigma), which corresponds to a relative uncertainty of 1.3 %."

17) 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).

Added in Section 3.2.2, page 11 line 11: "... up to 600 ppm after correcting for an offset of 12 ppm. ..."

Added in Section 3.2.2, page 11 line 21: "...than 1 ppm. Another possibility would be that the offset was caused by either an outgassing or a very small leak."

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

Changed in Section 3.2.3, page 12 line 3: "...is likely a significant underestimate."

19) P12, L20: The section is unclear—are you saying that the pressure sensor response

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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?

See answer to Specific Comment 24) of referee #1.

20) 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?

The conservative estimate for the presented experiment is 1 % (see page 13, line 5). For future experiments uncertainties at sub-percent level are achievable. Added in Section 3.2.3, page 13 line 4: “... is achievable for the dilution method in future experiments.”

21) P14, L2: “Hohn, Germany, the flights”

Changed in Section 4, page 14 line 2: “... Hohn, Germany, the flights ...”

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

Changed in Section 4, page 14 line 5: “... up to 12.5 km, so that also the lower ...”

23) P14, L10: “total water instead of only water vapor since the forward-oriented inlet resulted in sampling of cloud droplets and ice crystals when present.” The sentence “Both instruments were...” seems unnecessary.

Changed in Section 4, page 14 line 10: “...instead of only water vapor ..., since it’s forward-oriented inlet resulted in sampling of cloud droplets and ice crystals when present.

Removed in Section 4, page 14 line 10: “Both instruments were operated by the research centre Jülich.”

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

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Changed in Section 4.1.1, page 14 line 14: "... CRDS analyzer, water vapor ..."

25) 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.

See answer to General Comment 1) of referee #1.

26) 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."

Changed in Section 4.1.2, page 15 line 8-11: "CRDS measured water vapor is shown along with the flight data from the reference instruments CR-2 and FISH. Water vapor measurements from two additional analyzers that participated in the inter-comparison campaign are also presented: ..."

27) P15, L17: "not slower than any other instrument." → "is similar to that of the other instruments."

Changed in Section 4.1.2, page 15 line 17: "...is similar to that of the other instruments."

28) P15, L30: "CRDS data from the first flight" and "influenced" → "compromised"

Changed in Section 4.1.3, page 15 line 30: "... CRDS data from the first flight ... were compromised by ..."

29) P16, L1: "can be seen" → "are shown" or "are presented" or "are plotted"

Changed in Section 4.1.3, page 16 line 1: "... water vapor intervals are plotted in ..."

30) P16, L7: "are neglected." → "are omitted."

Changed in Section 4.1.3, page 16 line 7: "...are omitted. ..."

31) P16, L11: "sampled data only for two flights" → "operated successfully for only two

of the four flights”

Changed in Section 4.1.3, page 16 line 11: “... FISH operated successfully for only two of the four flights, ...”

32) 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.

Changed in Section 4.1.3, page 16 line 20-21: “This indicates that the CRDS sampling was likely also affected by cloud particles, ...”

Added in Section 4.1.3, page 16 line 26: “Such small enough particles could be produced e.g. by the shattering of water droplets or ice crystals in the Rosemount housing.”

33) 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 determine H₂O using methane instead of CO₂, or are you trying to say that methane could be measured by the method by comparing to CO₂?

Both options are meant. H₂O can be calibrated using another species instead of CO₂, and other species instead of H₂O can be also calibrated by CO₂ or any another species, provided both used species are measurable by a CRDS analyzer and the dilution effect is large enough.

Changed in Conclusions, page 18 line 1: “... used for the calibration of other species, too, provided they and the corresponding diluted species are measurable by a CRDS analyzer and the dilution effect ...”

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