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Atmospheric Measurement Techniques Discussions

Interactive comment on "The AquaVIT-1 intercomparison of atmospheric water vapor measurement techniques" *by* D. W. Fahey et al.

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Received and published: 29 April 2014 This manuscript describes a comparison of the instruments which claim to make accurate measurements of water vapour amounts at the very low levels present in the upper troposphere and lower stratosphere (UTLS). This has been an area of some contention for many years as comparisons in the field have indicated real and variable differences. The AquaVIT activity thus represents an important step forward as it provided a comparison of the measurement quality of many instruments under the highly controlled conditions achievable in the AIDA chamber facility. This manuscript describes the results of the first part of AquaVIT in which the conditions in the chamber covered the pressure and temperature space encountered

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in the UTLS and were held approximately constant for significant lengths of time. As such they test the instruments operating under stable laboratory conditions, not under the dynamic conditions encountered in the real atmosphere during aircraft or balloon flights.

The manuscript contains important information which is clearly presented. It deals well with the complexities of operating the participating instruments in ways which are not necessarily optimal. This is a multi-layered, almost fractal problem and the authors do a good job of presenting the important points clearly. I think the manuscript should be published once the following comments have been addressed by the authors.

The authors would like to thank Dr. Harris for his careful and thorough reading and his supportive comments about the manuscript.

1. The main finding is that the measurements of the core instruments agree to within 10-20% over the range of conditions used. This level of agreement is better than seen in comparison flights in the real atmosphere. There is a section entitled “Atmospheric Implications....” which could usefully discuss what limitations this level of uncertainty puts on our quantitative understanding of UTLS water vapour (e.g., prevalence of supersaturation, understanding of ice-related dehydration).

This is an important concern. Unfortunately addressing it is beyond the scope of this manuscript. The limitations are noted now in the first paragraph in Section 7.

2. In addition, it would be helpful to have some more discussion about other instrumental factors such as whether individual instruments are linear in the atmospherically important range from 2-150 ppm. Presumably something can be gleaned about this from Fig 7, even if it is relative to the reference values. For example the HWV & JLH seem to exhibit more of a positive deviation as the water vapour mixing ratio decreases, while the FISH deviations become more scattered.

Statements added in Section 6.3.1.

AMTD

7, C2223–C2228, 2014

3. It would be helpful to state what type of air was used in the chamber (synthetic?), and how clean it was of particles.

To add this information we modified section 6.1. to:

"Overnight between experiments the chamber was evacuated to less than 0.01 hPa. Each morning, an amount of pure water vapor (not disclosed to the instrument investigator teams) was added to the chamber and then subsequently mixed with dry synthetic air (22.5% oxygen in nitrogen; low hydrocarbon grade, < 3ppm H2O) as the pressure was increased stepwise to 500 hPa. The resulting water vapor mixing ratios in the static measurement segments varied from 0.2 to 150 ppm as shown in Table 3. Values were kept below ice saturation except on the last two experiment days. Particle number concentrations in the AIDA chamber after humidification and filling with synthetic air are typically below 1 cm-3. These particles are typically smaller than 100 nm in diameter."

4. It is not completely clear whether the individual parts of the appendix are 'owned' by the PI or the whole author team as they often have a less balanced tone than the main paper. For example, the description of how stray light inside the chamber might be affecting the FLASH instrument is clearly written, but it is not obvious if this is the PI's rationalisation of why FLASH did not perform as well as expected or if these arguments are accepted by all authors (or by the referees). Similar comments could be made about other parts of the Appendix.

This issue has been clarified at the end of Section 4:

"Brief descriptions of the intercompared instruments, their configuration in the AIDA chamber, their performance during the static experiments and lessons learned from AquaVIT-1 are included in Appendix A as provided by the respective instrument teams."

In such an intercomparison activity, it is implicit and reasonable that all the authors are not experts for all the other instruments and, hence, that authors have accepted the

AMTD
7, C2223–C2228, 2014

descriptions provided.

5. Further, the descriptions of the instruments in the Appendix are somewhat uneven. For example, the opening paragraphs of the APicT spectrometer reads somewhat like a sales pitch with all papers listed, while that of the FISH instrument is rather terse with few publications listed. My personal preference is the style of the JLH instrument, but the main thing is to aim for a greater degree of consistency. In addition it would help the reader if phrases such as 'expected precision' (as picoSDLA do) could be used to indicate estimates of performance prior to AquaVIT.

Polishing the appendix for consistency across participant teams is beyond the scope of this manuscript. The authors were given freedom to describe their instrument in their terms. The content reflects the diversity of this intercomparison exercise; that is, many approaches to the same objective. The instrument performance specifications prior to analysis of the AquaVIT data but for the conditions at the AIDA chamber are listed in Table 2.

6. The section on the additional CFH experiments (A2.4) is somewhat out of place and is not clearly written. I do not object in principle to the inclusion of these paragraphs here, but the aim and the result of each experiment needs to be made much clearer if it is to remain. For example the section on Controller Settings makes little sense to a new reader as it stands and the others are not much better.

The AquaVIT configuration for the CFH instrument differed substantially from that used in atmospheric balloon payloads, more so that for most other instruments. The appendix content is warranted since it was important to the instrument team to evaluate different aspects of the AquaVIT configuration and performance for the possibility that its performance was inadvertently altered as a result. The details are necessarily of primary interest to other frost point instrument experts which is acceptable for an appendix of supporting material. In response, we have added a clarifying introductory sentence as follows:

AMTD
7, C2223–C2228, 2014

"A2.4. CFH Experiments in addition to the AquaVIT-1 program Since the CFH was significantly modified from its balloon configuration in being adapted to the AIDA chamber tests, several aspects of the CFH operation were examined in more detail to ensure that the CFH measurements were of expected high quality during the intercomparison campaign."

Minor Comments

3192, 8-10 - please clarify whether this problem with FISH-1 was a one-off or whether it is always the case.

The text has been changed to read: "Both instruments are almost identical concerning the core components. However, a problem arose during AquaVIT-1 that the Lyman-α lamp in FISH-1 could not be tuned to its optimum mode resulting in a lower signal-to-noise ratio compared to FISH-2. This problem had not been observed previously in FISH-1, which has been replaced now by new, updated Lyman-α instrument."

3195, 5 - delete 'very'

Done

3207, 14 – '... likely the there...' – that?

Done

3207, 21 – '... again too high...'

Done

3207, 25 – ' ... the FISH-1 instrument...'

Done

3212, 7-8 – not sure what the 2nd half of the sentence means.

Modified.

AMTD

7, C2223–C2228, 2014

Figure A3 – I do not get much out of this figure. It looks as though it is prepared for a talk rather than a publication

The figure is useful for those not familiar with the CFH system.

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