A reply to https://doi.org/10.5194/amt-2022-208-RC2

Original referee comments in blue, with author response in black.

This manuscript describes a new modular box enclosure called ISE-CUBE that can be used to deploy water vapor isotopic analyzers and water vapor isotopic cold-trap systems in the field under extreme cold-weather conditions. The manuscript provides a short description of the enclosure and subsequently evaluates the isotopic analyzer's housekeeping variables from a two-week winter deployment in Svalbard. The housekeeping data suggest the analyzer is able to maintain satisfactory ranges for its Data Acquisition System temperature, its cavity temperature and pressure, and its warm box temperature. The analyzer's water isotopic measurement precision in the field is also comparable to its measurement precision while sampling calibration gas in a laboratory setting.

The manuscript also describes an optional "profiling module" for ISE-CUBE, consisting of a tripod with an articulating measurement arm, that can be used to position a heated inlet line for the isotopic analyzer anywhere from 4 to 205 cm above the ground surface. A 90-minute window of data is presented that shows water vapor concentrations and isotope ratios from six height levels within the articulating arm's 2-m range. The paper argues that the articulating arm provides a means to resolve and study the water and isotopic gradients closest to the surface, although doing so requires repositioning the inlet height via a manual pulley every few minutes.

Comments

Where this paper really advances our measurement abilities is in the design and presentation of the box enclosure for the isotopic analyzer and cold trap; yet most of these details are in the Supplemental material instead of in the main paper. I would recommend revisiting Figures 1-2 and using these to convey specific details about the box connections and tubing materials, something more akin to the Connectors Template in the SI. As currently presented, Figure 1a is simply too dark to make out details, and Figure 1b requires more detail and explanation. For example, what are the "power out" and "data" ports used for? Where are the fan inlets and exhaust ports? Where do the boxes connect to one another? Is the CRDS inlet unheated after the check valve? Which lines are PTFE and which SS? In addition, the main text mentions components such as an "adapter," an "exterior inlet bulkhead," "incoming ventilation tubing," and "manifold tubing." Can these be labeled on Figs 1-2? The list of components in Appendix A is fantastic. Consider also a corresponding diagram (again, like the Connectors Template) that shows where all these components go and telling readers how many of each part are required to replicate the system. Another way to think about this: what would a purchase list look like?

We agree that the manuscript as a whole would be enhanced by annotated diagrams. In the revised manuscript, we will therefore include remakes of Figs 1 & 2 that take the reviewer's concern into account. However, upon the recommendation of Referee #1, the manuscript focus will shift slightly to be a presentation of a "field **profiling** system" rather than as a "field **deployment** system". Therefore, we will revise the manuscript to elevate the role of the profiling arm. Thereby, the cold trapping module will remain as an expansion to the profiling system, as mentioned in one of the comments below. In this context, we feel as though some of any additional diagrams might still fit best in the supplemental, or perhaps as an appendix, with the majority of the manuscript text being devoted to proving the validity and reliability of the profiling operations. We will expand the Supplemental material to include more building details, including estimates for costs, and potential cost cutting measures.

It would be helpful if the manuscript discussed the relevance of the ISE-CUBE enclosure to the wider measurement community. Much of the manuscript is specific to the deployment of a Picarro CRDS water vapor isotopic analyzer. Would ISE-CUBE work for other types of isotopic analyzers? If the enclosure is specific to the size and shape of the Picarro systems, could ISE-CUBE work for other gas-phase Picarro analyzers? Moreover, based on the short two-week deployment in Svalbard, is there any sense whether ISE-CUBE could last for longer periods for unattended measurements?

Yes, we had the potential of other analyzers in mind while writing the manuscript. As the manuscript stands now, we only briefly mention this in the Introduction and in L.508 in the Outlook. But we believe that this system could be used with other CRDS analysers manufactured by Picarro; we will clarify and expand on this in the manuscript.

Whether or not the system could be deployed for longer periods is a nuanced and detailed point, which we now see would fit very well in the manuscript. In the revised manuscript, we will include a section presenting the limitations and strengths of the system more clearly.

On a related note, the Data Processing section (Sect. 3.2, including Table 1) presents ISE-CUBE as producing three data streams generally, but these three streams are specific to the way the modular system was set up for testing during ISLAS2020. It would be helpful if the paper distinguished more carefully which aspects of the design are generic and applicable broadly vs. specific to the test case configuration.

With our new focus, the data streams generated by the Analyzer and Profiling modules are the basic outputs, while the Cold Trap output would be specific to our deployment. We will rephrase this paragraph to clarify.

The enclosure is presented as novel, in part, for minimizing disturbance to the environmental flow, but I think this claim might be overreaching, since most ground-based installations are designed to minimize flow disturbance (e.g. flux towers). The real draw of the enclosure in my mind is the ability to deploy a water vapor isotopic analyzer in an environment with minimal infrastructure support (e.g. nothing more than a power drop) and/or to reduce the length of inlet lines and thus measurement hysteresis.

We take your point that such a claim can be overreaching, especially with the current structure of the manuscript. However when considered and presented together as a near-surface profiling system, we believe the value and novelty of the system's compactness is emphasised.

To evaluate ISE-CUBE, the water vapor isotopic analyzer's performance in the field is compared to its performance in the laboratory. The intention is to compare two distinct environmental settings. However, there is another relevant difference that needs to be communicated more transparently: in the laboratory, the analyzer samples reference gas continuously, whereas in the field, the analyzer is measuring real variability related to the environment. I would not be surprised if this difference in sampled air causes the differences in humidity-binned standard deviations presented in Fig. 10 or results in the differences in spectral-fit residuals (RS) presented in Fig. 8. The paper concludes that the field data are "marginally less precise," but, again, I wonder if this is not just a reflection of the environmental air. Would one reach the same conclusion if the analyzer were measuring reference gas while deployed as part of ISE-CUBE in the Arctic?

This is a very interesting point, though since we didn't have a way to make a direct analog to the lab (i.e. a constant vapor stream of standard), it is ultimately difficult to determine. We will consider to reformulate our conclusions as "marginally less precise **than optimal measurement conditions**". We will mention this possibility when discussing Fig 8 & 10.

While I'm not sure it is necessary for the point the paper is trying to make, it would be awfully interesting to see how the isotopic analyzer and cold trap compare during the ISLAS2020 deployment. Such a comparison could provide some indication of the accuracy of the isotopic analyzer when deployed with ISE-CUBE.

We will include a brief evaluation from two cold trap samples in the manuscript. However, we don't believe that the system is mature enough such that it can currently indicate the accuracy of the CRDS. The design is proven in Peters and Yakir (2010), but we were deploying it for the first time under very different conditions. Regardless, this module will stay categorised as an "expansion".

Lastly, for Fig. 12, it appears there are environmental data missing during the period highlighted in the text (9:07, onwards). In addition, it would be helpful to know, are these data from the AWS? And can the figure be made larger?

These periods are, unfortunately, actual gaps in the data. However, in response to Referee #1, Figure 12 will be significantly modified in our revisions. Since the system is being put forward as a profiling system, it naturally follows to show the vertical profiles. Therefore, we will change the day we show (to 9 Mar 2020) in order to best present an example of an actual profile. Right now, the particular day shown in the manuscript was chosen as an illustration of its iterative height capability (after around 9:20), which is well visualised in a time series.

Overall, the paper is very clearly written; however, a few minor comments on presentation are provided below:

L 15 - perhaps "components" instead of "compartments"

Changed to "reservoirs in the Earth System."

L 29-32 is a bit awkward and could be presented more clearly

Under our proposed reframing, we will expand upon the limitations of fixed height inlet systems, and the benefits of a continuous inlet line.

L 39 and elsewhere - "pneumatically" might be the wrong word as this implies compressed air

We will find a different term to avoid any confusion.

L 165 - is there a reference for ISLAS2020?

The data paper for this campaign is in preparation for Earth System Science Data.

L 177 - Does the ISLAS2020 data span 21 Feb to 14 Mar?

It does, though part of that time (29 Feb to 3 Mar) had our instrument installed up at Zeppelin Observatory (472 m ASL). The remaining days were dedicated to calibration and maintenance inside the Marine Laboratory.

L 187 - “reliable” seems like the wrong word for what is intended

Changed to “comprehensive”

L 219 requires clarification

Each of the 17 individual calibrations had standard deviations equal to or slightly larger than the standard deviation found across the mean of all calibrations. We will make sure to clarify this in the text.

L 239 and elsewhere - “minutely” means “meticulously.” I think the paper intends to say “1 minute”

Yes, we will change this accordingly.

L 375 - since “field” and “laboratory” have specific meanings, I would use “remote observatory” or some other phrase here

It was an intentional blending of the two terms, but we see how it can be confusing, especially as we’ve already established it as an “observatory”. This line will read “same quality as a remote observatory”

Fig. C1 - caption says observatory margins are for the same “time” but not the same dates, right? Perhaps clarify.

Yes, the sentence is confusing. The light grey shading indicates the “same” 2nd and 98th percentiles, ***from*** the time period when we were measuring in Zeppelin Observatory. We will change the sentence to clarify this distinction.

L 521 - says “could be” but should it say “is” or does it really mean “might be comparable” (as in it’s unknown)?

More so the former, since we do know it. The T_WB recovery times were longer during the longer profiling periods, as compared to briefer routine site checks. But the magnitude of the initial T_WB dip/spike *could be* just as large during a site check, as during a profiling period. We will rephrase the sentence to clarify this.

Fig. D1 seems to be missing the gray shading mentioned in the caption

The grey shading is similar to the width of the dotted line, and is almost invisible underneath the dotted line; we will mention this in the figure caption.

References

Peters, L. I. and Yakir, D.: A rapid method for the sampling of atmospheric water vapour for isotopic analysis, Rapid Communications in Mass Spectrometry, 24, 103–108, https://doi.org/10.1002/rcm.4359, 2010.