Review of “Portable system for characterizing greenhouse gas analyzers for sensitivity to water vapor” by Liu et al.

General Comments:

This manuscript details a low-cost, lightweight and portable humidification system for calibrating trace gas analyzers. In short, the system uses a combination of “wet” (produced by humidifying air through a Nafion membrane in a water bath) and “dry” (dry standard gas) air streams to produce stable water vapor levels comparable to ambient levels for trace gas analyzers in an automated fashion using pre-programmed Raspberry-Pi control. Currently, maximum water vapor levels achievable are dependent upon water bath temperature and mass flow of air through the system. The system is lightweight enough and has a low enough footprint that it can be efficiently moved from one observations site to another for deriving dry mole fractions of trace gases using empirically-derived water vapor corrections with this system. The system was tested on both Aeris MIRA and Picarro CRDS systems, and indicates lower errors in corrected dry mole fraction measurements of trace gases relative to instrument-provided water vapor corrections, in addition to general adherence to recommended WMO compatibility goals for specific trace gases. The system is generally well-documented here and presents a worthwhile contribution to AMT over current methodologies; I provide some comments below to mainly clarify the description, potentially additional testing involved, and some additional details for consideration before publication.

1. Figure 1 and the main text description could use some expansion for clarity. First, please state whether there is any temperature control at all within the system at present. My understanding is that the water bath is not temperature-controlled. In L87, the stability of the water vapor levels is controlled by the stability of the water bath, so if this changes due to room temperature, etc., how does this affect the stability of the water calibration steps?

   Please specify tubing composition – is this stainless steel (and which diameter)?

   Please describe the purpose of the overflow in Figure 1 for the reader (presumably for analyzer pressure stability).

2. Figure 2: it is difficult to see in a) how stable the water actually us at the end of the 3-5 minute step – can you zoom in on a few of these steps to show that the H2O mole fraction equilibrates relatively quickly to a stable value? As you describe tests with both the Picarro (up to 1.7% H2O) and the Aeris instrument later in the text (up to 3% H2O) and as it looks as if the precision of the water vapor mole fraction degrades at higher H2O, can you provide results in b) that substantiate your claim for stability and repeatability in the humidity control up to these H2O mole fractions? The example of

only stepping up to 0.7% in Section 2.1 seemed somewhat incomplete given that the rest of the manuscript describes system tests to higher H2O levels.

3. Describe which MFCs would be needed to achieve higher water vapor levels comparable to those observed for the Picarro analyzer.
4. L294-295 states that the Nafion-based system should minimize solubility-related effects from the water bath since there is no direct air-to-gas interaction, and before this, that permeability effects are somewhat negligible. However, have you tested this for CO2 (and potentially also CH4) when the water bath is not acidified? It is still somewhat unclear to me whether deionized or more basic water baths could still create issues with the Nafion system at higher water vapor levels > 1.5%.

Specific Comments:

- Title: you might consider renaming to something more general like "Portable system for characterizing trace gas analyzers for sensitivity to water vapor" as you describe water vapor corrections for CO in the main text.
- L44: Please provide a citation for the stated WMO compatibility goals. These are often found in WMO annual meeting reports.
- L47: "500 ppm H2O potentially resulting in significant measurement errors" – Rella et al. 2013 state that there are CO2 measurement biases from 500 ppm H2O, so you could cite this paper here for reference.
- L90: Specify maximum and/or average power draw to better substantiate the potential for portable operation under battery power.
- L102 "…requires longer steps" – Do you have a sense for how long?
- L139: Please also state value of CO dry mole fraction for completeness.
- L142: It would perhaps be useful to state how long it takes for the H2O mole fraction to equilibrate (also see comment for Figure 2 above) to provide justification for 3-5 minute time steps.
- L215: It is somewhat surprising that there was no water vapor dependence for CO for the CKADS2025 as these analyzers in the past have shown a water vapor dependence (Chen et al., 2013). You may note or comment for the reader that this is somewhat unexpected.
- Figure 8: It may be useful to provide the same y-axis scale for Figures 8(a-c) to compare variability between tests.
- L338: "if a linear dependence is assumed" – but we know that the CO bias is non-linear (Chen et al., 2013); perhaps caveat this statement in some way?

Technical Comments:

- L41 and others: please list citations in ascending order by year

- L82: please define acronym ‘MFC’ here as it is used in Figure 1 below.
- L128 – please punctuate the end of this sentence with a period after Eq. 1.
- Figure and Table appearance: For Figs 3-10 in general, it is difficult to differentiate between the triangles and circles for different dry vs. corrected values. One suggestion may be to use filled vs unfilled shapes for dry vs. corrected values. Shapes in Figures 5-10 are somewhat small, as is the text in Table 2 (maybe this can be rotated 90 degrees).
- L241: “Picaro” → Picarro