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Author Response (AR) to Referee #2

We thank Referee #2 for the time spent on reviewing the manuscript and providing constructive comments. We will work on the revised manuscript accordingly. Answers to the comments are given below.

General Referee Summary: This paper reports the characterization of a new commercial formaldehyde sensor for monitor grade purpose. The detection limit of the instrument (3σ) was 690 pptv and 420 pptv for 15 and 60 minutes integration time, respectively. The sensor was compared to research grade Laser Induced Fluorescence instruments, which showed agreement within 10% in accuracy with up to ± 0.5 ppbv absolute difference. The sensor is useful for indoor monitor and outdoor network setup and such a paper would help to address the fundamental and technical concerns of this sensor. The authors should consider adding more discussion on how to perform a data processing method. Also, a discussion on the accuracy determination from a theoretical aspect instead of comparing with other state-of-art instruments would be helpful.

Nevertheless, this paper is well written and structured and meets the scope of AMT. Therefore, I recommend publication after minor revision.

Author Response: We appreciate the general and specific comments of Referee #2 and have added more information about HAPP fit since ART fit is proprietary to Aeris Technologies who was not willing to publish the analysis routines. This was one of the primary reasons for developing the open-source HAPP fit. An accuracy determination from LIF intercomparison was possible since all instruments were calibrated with HCHO standard gas cylinders whose concentration had been checked by Fourier transform infrared spectroscopy (FTIR) (see Cazorla et al., 2015). As such, we were able to report an accuracy of ±(10% + 0.3) ppbv and indicate that the primary factor driving this uncertainty is largely due to movements and instabilities of fringes caused by etalons in the optical train that impact how well the HCHO line is fit. Other minor factors include particles that happen to pass through the inline filter and minor molecular absorbers not listed in the HITRAN database.

Manuscript Changes: "The factor that affects the accuracy of the Aeris sensor the most likely stems from any instabilities and movements in fringes caused by the optical train's etalons (perhaps from temperature fluctuations) since any drift can subsequently impact how well the HCHO line is fit. Other matrix effects impacting the sensor's accuracy include particles that happen to pass through the inline filter and scatter the laser light as well as minor gas-phase absorbers not listed in the HITRAN database."

Comment 1: Line 15 Page 1. 'good agreement with LIF instruments from Harvard and NASA Goddard' Please be quantitative on the 'good agreement'.

Author Response: We agree with the opinion of the referee. Having added the accuracy of the sensor to the abstract (as requested by Referee #3), we have actually removed this phrasing from the abstract.

Manuscript Changes: Phrasing removed from the abstract.

Comment 2: Line 2 Page 3. Please define HITRAN. The authors should describe all the abbreviation when presented in the paper for the first time.

Author Response: HITRAN is an acronym for the **hi**gh-resolution **tran**smission molecular absorption database which compiles spectroscopic parameters for a wide range of gas-phase species in the atmosphere. HPLC stands for high-performance liquid chromatography.

Manuscript Changes:

- "A search of the nearby spectral region using HITRAN (an acronym for the *hi*gh-resolution *tran*smission molecular absorption database) shows this region to be free of strong spectral interferences from other molecular absorbers"
- "for analysis of the formaldehyde–DNPH derivative by high-performance liquid chromatography (HPLC) (Winberry et al., 1999)"

Comment 3: Line 5 Page 6. It is like a mismatch in the reference.

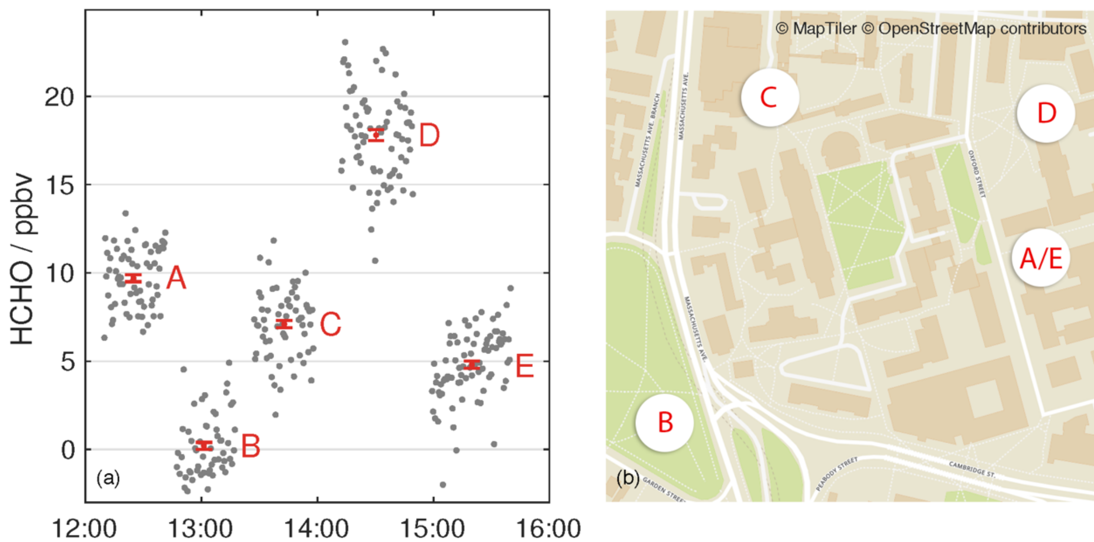
Author Response: We've used the same procedure described in Cazorla et al., 2015, for verifying the HCHO mixing ratio in calibration gas cylinders. The Cazorla paper uses the UV cross-sections of HCHO published by Meller and Moortgat (2000).

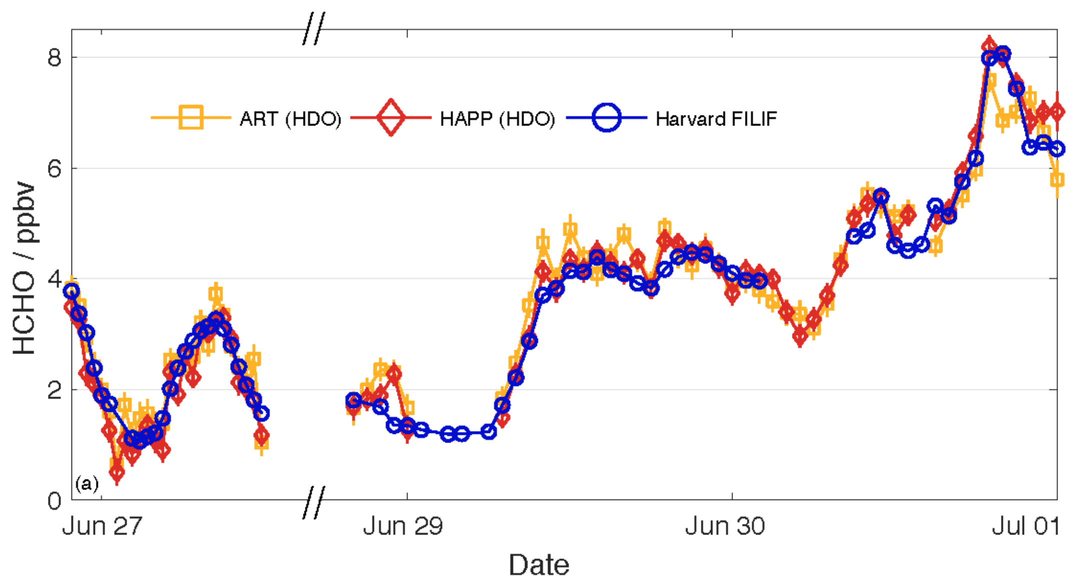
Manuscript Changes: No changes were made to the manuscript.

Comment 4: Figure 7a. The author could consider adding error bars on each data point to show the variability.

Author Response: We agree with the referee and have added error bars to the mean HCHO mixing ratio at each location (error bars representing $\pm 1\sigma$ standard deviation from the mean). The raw 30 s data is also shown (in grey) to allow the reader to visually see the variability at this integration time. Additionally, we have added error bars to Figure 6a (also representing $\pm 1\sigma$ standard deviation from the mean).

Manuscript Changes:





Comment 5: A schematic plot of the instrument is helpful to explain the measurement principle.

Author Response: We agree with the referee and have added a schematic of the sensor

Manuscript Changes: The following figure was added to supplemental information:

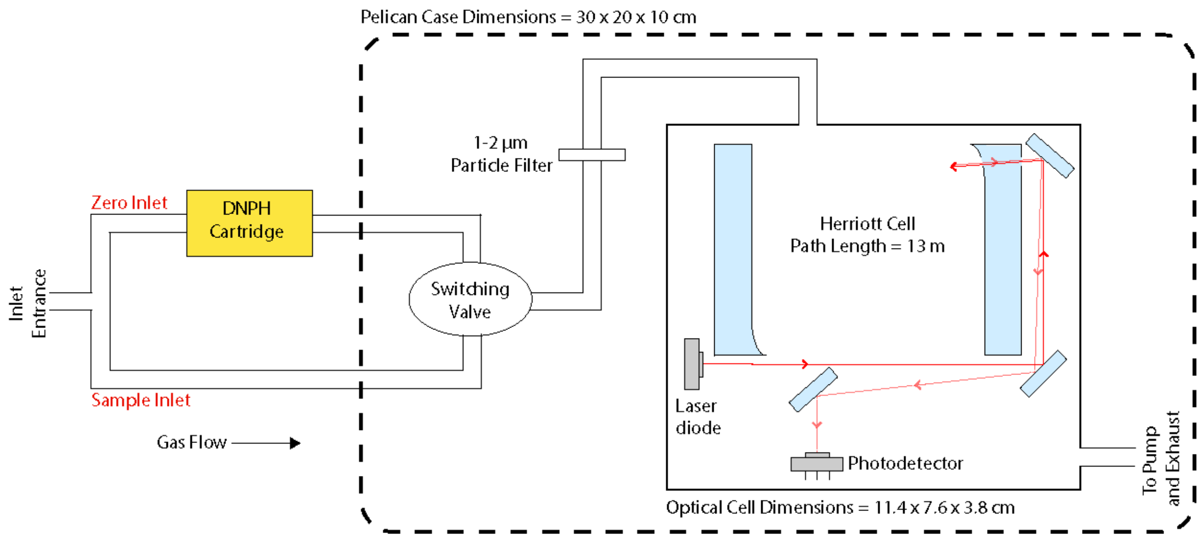


Figure S1. Schematic diagram of the absorption-based Aeris HCHO sensor. Air flows through the inlet entrance, and the switching valve either allows air to pass directly into the instrument via the sample inlet or is first scrubbed of HCHO via the zero inlet. Before entering the Herriott cell, all dust is removed from the air flow with a 1-2 µm particle filter. The patented folded Herriott cell (US Patent #10,222,595) has a path length of 13 m and dimensions of 11.4 x 7.6 x 3.8 cm (Paul, 2019). The laser diode, photodetector, filters, and mirror coatings are proprietary information.