

Interactive comment on “An aircraft gas chromatograph-mass spectrometer System for Organic Fast Identification Analysis (SOFIA): design, performance and a case study of Asian monsoon pollution outflow” by Efstratios Bourtsoukidis et al.

Anonymous Referee #3

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Summary:

Fast GC-MS measurements for the in situ analysis of VOCs represent an important analytical tool in understanding complex and often rapidly-changing air mass compositions, especially aboard mobile platforms such as aircraft. The authors describe a newly constructed in-situ GC-MS system that is deployable on the High Altitude and Long Range Research Aircraft (HALO). While many of the underlying principles for the

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SOFIA system have been in use in various GC-MS systems in one form or another, the design of the individual components of SOFIA is new and offers an additional resource for instrument engineers. For example, the sample conditioning and pre-concentration components are a new design capable of achieving a range of cold temperatures for three separate traps utilizing a single liquid nitrogen reservoir that does not need to be refilled for up to 17 hours. The manuscript is concise, well written, and will benefit the scientific community. I recommend publication after the reviewer comments are addressed.

General comments:

- I would like to see a brief discussion on the power requirements and pre/post-flight protocols. These are all critical considerations for a flight-based instrument. How much power does the entire system draw? How much time does it take to get the instrument online (heaters up, reservoirs cold, MSD's pumped down, etc.)? Also, the information in the last paragraph of the discussion section (size and weight) should be moved to Section 2 along with the above discussion.

- There needs to be a discussion on ozone artifacts and/or mitigation, particularly since this instrument is designed for high altitude sampling where high levels of stratospheric ozone may be encountered and given the fact that the authors report isoprene, a species that is reactive with ozone.

- Since this manuscript details the instrument performance, I would like to see more discussion on the calibrations. The author state that the response (of just the detector or the whole sampling system?) is linear for mixing ratios ranging from few ppt up to 3 ppb (Section 2.4). That is impressive for an open tubular trap that does not contain a substrate such as glass beads that increase the surface area for absorption thereby minimizing nonlinear surface effects. How were the calibrations conducted (e.g., dynamic or static dilutions)? For dynamic dilutions, did that include air from the catalyst and therefore ambient levels of water or was it a dry sample stream? How does the

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in-flight calibration dynamic range compare to the observations? How is LOD determined? What about breakthrough at higher VOC concentrations? What range of VOCs to the author's realistically expect to be able to measure such highly volatile compounds (e.g., ethane, ethene, ethyne), high molecular weight species (e.g., C9 aromatics), or highly polar species (e.g., butanal)? What are the current sampling limitations of this instrument?

Technical comments:

- The abstract should include a description of the analytical range of the instrument including the types of compounds that can be measured.

- MuPo is not defined until page 4 (P4), but first appears on P3. I suggest getting rid of the "MuPo" nomenclature entirely as it is unnecessary jargon – it's a valve. The vast majority of GC-MS systems have these types of valves and I have never heard it called a "MuPo."

- P4L15: It should be stated clearly that the ambient air is also a possible gaseous input to the sample selector valve.

- P4L28: Is the calibrated volume evacuated prior to sampling? It's not clear if the sample is pushed or pulled through the cold traps. Is the calibrated volume evacuated and therefore acts to pull the sample through the traps since the sample pump is isolated from the sample stream during sampling? Or, does the inlet pump create enough pressure to push the sample through the traps and pressurize the calibrated volume to a set pressure?

- P11L35: The NOAA GC-MS system (Lerner et al., AMT 2017) also utilizes a Stirling cooler. Depending on the cooler's lift capacity, Stirling coolers can easily obtain minimum temperatures below that of liquid nitrogen (i.e., -200 °C). The cooling rates obtained for the NOAA GC-MS trapping system are in the range of – 6 to -10 °C/second for a larger, dual-channel system.

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- Figure 1 (F1) is hard to read and decipher, partly because the resolution is too low. Additional corrections/suggestions for Figure 1 are below:

F1a.) I am confused about the purpose of the 6-port inlet valve. No matter what position the valve is in, the Zero/Calibration unit will always be in the sample stream, never bypassed. The only thing that changes is whether the sample pump is upstream or downstream of the Zero/Calibration unit. I'm assuming this has something to do with managing the hot catalyst exhaust, but it's not clear in the diagram or text.

F1b.) Is there a four-way union directly downstream of the inlet valve and upstream of the catalyst? If so, wouldn't the catalyst represent a large dead volume as it is always exposed to the sample stream?

F1c.) Why is there an arrow to the right of the N₂? Shouldn't the flow be going the other way to flush the catalyst when not exposed to ambient air? If so, this is not described in Section 2.1.1.

F1d.) The authors missed a few of the sample line crossover junctions (e.g., just below the sample selector valve and just below HALO exterior).

F1e.) I would suggest overlaying the arrows indicating flow direction over the various connections on the valve itself as well as clearly stating which position the valve is in (i.e., inject or transfer).

F1f.) There should also be a key to clearly identify 2-way, 3-way, needle valves, etc.

- Figure 2. It is difficult to know what each part is without added annotations.

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