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Atmospheric Measurement Techniques Discussions

Interactive comment on "A sampler for atmospheric volatile organic compounds by copter unmanned aerial vehicles" *by* Karena A. McKinney et al.

Anonymous Referee #2

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General Comments This is a very well-written manuscript describing the development of a VOC sampler for autonomous, drone-based sampling. The motivation and relevant background is thoroughly but succinctly presented in the introduction, and the platform and results are clearly and generally well-described. I recommend publication of the manuscript, pending the authors: 1) add some context for what results should be expected for vertical distribution of VOCs in Table 1, so that the reader can better interpret the results presented here, and 2) more satisfactorily explore the vertical sampling bias introduced by rotors drawing air down from above (or gather comments from an additional reviewer with substantial experience with the fluid dynamics of drones). The CFD analysis is laudable, but does not conform to experience in working with large drones

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Discussion paper

with payloads, where vertical disruption of plumes extends greater than 5 m in many cases, and the paper cited to suggest < 1 m disruption is based on drone platforms that are substantially smaller.

Specific comments 111 – Noteworthy that the sampler was placed on the platform underneath the drone. Downwash and eddies present a significant challenge in sampling underneath drones (as you explore later), leading many to mount sensors on top of the drone, where flow is laminar, or to extend a sampling inlet outside the rotor influence. CFD simulations are a helpful place to start, but ultimately you can learn a lot by just flying your specific platform through a smoke plume. You'll notice straight, laminar flow lines on top that extend from several meters above (depending on system mass) and a mess of eddies underneath. Dave Barrett and Scott Hersey at Olin College of Engineering presented on this in collaboration with Aerodyne at AAAR and AGU in 2016 – check their materials for more clues. This eddy issue matters less for your application than for their 1-Hz instrument, since you are not after time-dependent (i.e. highly spatially resolved) data, but rather bulk VOC mass over an entire flight segment. But is nonetheless an important consideration. Explore options to mount on top, or to extend a sampling inlet to a point horizontally outside rotor influence.

240 – CFD simulation parameters are described, though it's not explicit at this point why you did CFD simulation (I can assume where you're headed). I suggest giving some sense of the need/purpose for this simulation before introducing it.

258 – The drone was launched and recovered from a platform above the canopy, but one of the key motivations for the drone-based sampling platform is to avoid the need for platforms and to be able to access more remote sampling locations. Can you speak to the usability of this platform in the types of contexts that motivate the study (i.e. those with dense canopies and no platforms)?

262 – Given the note above, and the high velocity of air flow down through the rotors of the drone, I am not convinced that 60 m actually represented 60 m. I should be clear

that I see your exploration of this with CFD modeling, but your model results conflict with my experience seeing drones sample smoke plumes in the field. With a slightly larger drone (S900) and slightly heavier payload (2.5 kg), I consistently see rotors draw down air from several (>/= 5) meters above mounted instruments in buoyant plumes. Experience suggests to me that your vertical sampling bias is greater than the 1 m suggested in line 294. Further, the result suggesting 1 m vertical bias in air sampling based on rotor air flow in Diaz and Yoon (2018) is based on a significantly smaller drone with no payload. Your large drone with payload will, necessarily, exert a greater vertical impact on air flows than theirs. This comment comes with the caveat that I am basing them solely on experience and observations with quad copters, and no modeling or detailed analysis of my own. I recommend either a brief review of this section – especially as it relates to altitude-of-sample bias – by a reviewer with greater expertise in the fluid mechanics of multi-rotor aircraft, or an addition of language that outlines the potential for vertical sampling bias on the order of several meters.

278 – "Reasonable consistency" is subjective. Quantify, and compare with either sampling+measurement uncertainties or previously published variability in VOC concentrations with height above canopy (or both).

282 – CFD modeling appears. I applaud the authors for attempting to address rotor influence in sampling. Ultimately, as I stated above, I expect the below-drone air flow perturbations to be less important for your application of 10 min resolution samples. But the bias introduced in the vertical resolution is of concern and my experience tells me that for a drone your size, the vertical extent of air disruption is substantially greater than the 1 m suggested here, based on results from a much smaller drone platform with no payload. I am, unfortunately, not the right reviewer to critique your CFD model run, and suggest that an additional reviewer explore this.

Table 1 – Can you put these results in context that help the reader understand the consistency of measurements and how they conform to expectation? For example, I notice that isoprene concentrations vary substantially with altitude, though not in a way

that decays with altitude (as I might expect). Same with Pinene(s). As presented, I'm unable to discern why the 100 m sample at the sampling site has higher concentrations of monoterpenes than both the 60 m and 75 m sample. Can anything be determined from ratios of VOCs to tell what's going on here? What should I expect to see in vertical variability? This doesn't conform to my expectations of reducing concentration with altitude, so please explore this so that the reader isn't left with questions about whether sampling bias or the drone platform is responsible.

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