

Response to comments of anonymous referees # 1

This manuscript focuses on the description and characterization of the MAC chamber. It contains a detailed description of the chamber itself and results from different tests that were performed such as loss rate of trace gases and degassing from the chamber walls, loss rate of particles, etc.

I think the paper is relatively well written and it covers a good amount of testing. One thing is not clear to me though is if the chamber is a new chamber or the improvement of an older chamber or neither. I think it is not a new chamber as there are references of studies done with it since 2012. Therefore, I think it would be useful as this paper summarize the chamber itself to also summarize all the studies done within this chamber and in particular it would be interested, if possible, to show together in this paper the results of previous characterizations. One of the message of this study is that the chamber needs to be properly checked routinely during experiments as it is shown that indeed the behavior of the chamber in respect of degassing and losses of gases and particles changes significantly. Therefore I assume there are more tests available that could help track the behavior of the chamber over a longer time. This could be the paper where such information could be included.

If the chamber is new and/or if it consists of a drastic change from the previously used chamber it should be more precisely mentioned as it is not clear as it is described at the moment.

I also think it could be interesting to include within this paper the standardized set of tests that should be performed to properly characterized the chamber before new experiments are carried out.

We thank the reviewer for their time and effort in providing comments for our manuscript. Indeed, our chamber is not newly built and has been widely developed since 2005, in order to understand the chemical and physical properties of aerosols from different sources (e.g. engine, real-plant emission, biogenic or anthropogenic VOC). In all cases, a particular focus has been on the evolution of the changing composition and properties of the gaseous and particle constituents as they undergo simulated atmospheric processing. There has hitherto been less regard for quantification of the yield of components that has necessitated full quantification of the “confounding” processes associated with walls and mixing effects, for example. Nonetheless, aspects of these have previously been reported where necessary. We have taken advantage of our recent exploration of SOA formation from mixed precursors to perform a more systematic characterisation than previously attempted. These quantifications supersede our previous, more ad hoc, investigations of such processes.

A clearer statement of the chamber status has been added at the start of the last paragraph:

“This manuscript provides a description and characterisation of an indoor simulation chamber, Manchester Aerosol Chamber (MAC), located at The University of Manchester. Although the MAC has been developed and predominantly used since 2005, the majority of the preceding studies were aimed to understand the chemical and physical properties of aerosols from different sources. There has therefore been less regard for quantification of the yield of components that has necessitated full quantification of the “confounding” processes associated with walls and mixing effects, for example. Here, we present a more systematic characterisation than previously attempted, along with a detailed description of the unique features of the MAC compared to other atmospheric simulation chambers”

Specific comments:

Introduction. I feel the first sentence belongs more to the end of the introduction rather than to the beginning.

We agree with the reviewer. This sentence has been moved to the last paragraph of introduction.

Page 2, line 34. What does their stands for? I assume organic compounds but it could be specified.

Indeed this was referring to organic compounds. This has been now specified as suggested:

“..an estimated 10000~100000 atmospheric organic compounds (Goldstein and Galbally, 2007), only around 10% have been identified, such as alkanes, carbonyls, alcohols, esters, acids and etc (Hallquist et al., 2009, Goldstein and Galbally, 2007)”

Page 2, line 37. It would be good to have a reference at the end of sentence.

The reference has been added:

“Such an inadequate understanding of aerosol particles, and particularly the organic fraction, leads to large uncertainties in understanding their role in air quality and global climate (McFiggans et al., 2006).”

Page 2, line 48. I am sure there are more recent studies out there where chamber studies helped elucidating gas-phase reactions and chemical pathways (see everything that was done on isoprene and Criegee intermediates as two examples...).

Indeed, there are quite recent studies elucidating the gas phase chemistry and to reflect that we have added some additional references as:

“...gas-phase reactions and chemical pathways (Carter and Lurmann, 1991, Seakins, 2010, Atkinson et al., 1992, Surratt et al., 2010, Paulot et al., 2009, Ehn et al., 2012, Bianchi et., 2019, Thornton et al., 2020),”

Page 3, line 72. I would rephrase “A universal challenge is the presence of walls that can be a sink of the ...”

We agree with the reviewer. The sentence has been rephrased according to their suggestion.

Page 3, Lines 77 and 78. Although it is true that humidity and temperature cannot be controlled in large outdoor chamber in the same way they can be in smaller indoor chamber, I find the sentence relatively misleading. First, at least for gas-phase mechanisms development, a difference of 20% in water content in a chamber will not affect the reproducibility of a study and the water content can be

reproduce better than that. Same goes for temperature which although of course having a larger effect, it is unlikely that two consecutive day of measurement in an outdoor chamber will see striking differences in the temperature in the chamber and experiments can be repeated when the conditions are similar. So, I would recommend taming down the sentence a little bit as to avoid giving the impression outdoor chambers might not give reproducible results.

We fully agree with the reviewer and we appreciate that our original sentence might have been misleading. The sentence has now been rephrased.

“Outdoor chambers, particularly the larger ones, are challenged by control of relative humidity and temperature due to the ambient diurnal variation, which may introduce some challenges in the interpretation of the results (Barnes and Rudzinski, 2006)”

Figure 1. I found it a bit hard to follow from figure one what was described in the text. I think adding more information (labels) in the figure would help the reader and, if available, I think a real picture of the chamber would help the reader following the discussion of the different parts of the chamber.

Thanks for both reviewers. Figure 1 has been revised.

Page 6, line 153-154. After the semicolon I think the main verb is missing.

We thank the reviewer for pointing out this error. The sentence has been rephrased to:

“Purified dry air is supplied by passing dried laboratory air at up to $3 \text{ m}^3 \text{ min}^{-1}$ using a 3-phase blower (Nash Elmo; model G200), a drier (ML180, Munters) and three filter canisters; the first containing Purafil/charcoal, the second containing activated charcoal, and the third with a HEPA filter, to remove the NO_x, volatile organic compounds and particles, respectively”

Page 7, line 195. I cannot quite identify which one is the third specific experimental procedure.

Thanks to the reviewer for pointing this out. The third specific experimental procedure is the harsh cleaning described in line 214-217. This sentence has been rephrased to:

“The third, a more aggressive “harsh cleaning” procedure is carried out weekly during experimental campaigns. In this procedure a high concentration of O₃ (~1ppm) is filled into the chamber with illumination, undergoing several hours of photooxidation at high relative humidity (~80%).”

Page 8, line 210. Sample instead of sampling.

Addressed.

Page 9, Lines 250-251. I find this sentence not very clear. I would recommend rephrasing it.

We agree that this sentence might have been confusing. This sentence has been rephrased to

“The temperature in MAC is controlled by the AC system, which compensate the releasing heat from illumination system”

Page 10, lines 266-266. Any possible explanation why the RH differed between center of the chamber and at the walls?

Indeed, as the reviewer points out, there is differences of RH between the centre of the chamber and at the walls. The possible cause for this variance might attributed by the radiative heating. The RH and T difference between the centre and the edge of the bag is larger in light experiments, compared to the dark experiment where the RH and T differences between the centre and edge of our chamber are falling within the measured variance, i.e., $40 \pm 1\%$ vs. $39 \pm 1\%$ RH and $24 \pm 1^\circ\text{C}$ vs $23 \pm 1^\circ\text{C}$ T.

To reflect this, in the revised manuscript we had altered the text in section 3.1 that reads as:

“Figure 4 shows the temperature and relative humidity, measured at the edge (Edgetech sensor) and at the middle of the MAC (Sensirion sensor) for three characteristic experiments; one conducted in the dark and two in the presence of light. In the light experiments, it appears that both the temperature and humidity were higher in the centre of the MAC than that of the wall, while in the dark experiments these differences were negligible as they were within the uncertainty of our measurement. A likely explanation for this unexpected behaviour in the light experiments can be possibly to the radiative heating of the sensors in these experiments that could result in an over-estimation of the RH.”

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