Anonymous Referee #2

RC1) The manuscript "Measurement Report: Properties of aerosol and gases in the vertical profile during the LAPSE-RATE campaign" by Brus et al. provides a description of UAS platform measurements of particles, trace gases and meteorological parameters in the San Luis Valley of Colorado in July 2018. The measurements were made as part of a multi-institution campaign associated with the ISARRA meeting that was held in Colorado that summer. The authors provide substantial details regarding the instruments, platforms and operation, and as such, the manuscript serves to provide a solid example of the kind of research that can be accomplished, and likely most effectively, using sUAS platforms. The manuscript is well organized and fairly well written, but the readability would benefit from careful copyediting for usage and punctuation. Overall, given the focus of the paper on the description of measurements and measurement systems rather than scientific analysis, I would think the manuscript would be a better fit in AMT than ACP.

AR1) We thank reviewer #2 for constructive comments, we really appreciate their time spent reading our manuscript. We will use Copernicus free copyediting service if our manuscript proceeds to publication. The submission to a new "ACP Measurement Report" was suggested by Editor as appropriate fit.

General comments:

RC2) The authors should be consistent with the description of the team (FNMI-KSU) or teams (FNMI and KSU), both are used in the manuscript, e.g. L42 "A flight team", L44 "by the FMI and KSU teams".

AR2) This will be corrected in revised version of manuscript.

RC3) In terms of lower atmosphere/boundary layer studies, height AGL is more relevant or important to know than absolute altitude (MSL). Similarly, for diurnal processes such as boundary layer development, using local time is clearer than UTC, which requires the reader to calculate the local time to interpret the data.

AR3) The use of MSL altitude and UTC time was based on LAPSE-RATE organizers and participants decision. The standardization of all data sets produced during LAPSE-RATE and their interpretation was a must. The driving force for such decision were the needs of known in advance end users, the modeling and forecasting community.

We are going to use both in the manuscript text, the AGL and local time in parenthesis.

RC4) The discussion of the vertical profile observations is mostly descriptive rather than analytical, with the exception of the final paragraph of 3.2.2 (NPF), which would still benefit from substantially stronger arguments to derive the conclusions from the observations. Figures 4 and 5 are somewhat tangential to the focus of the manuscript. The inclusion of the descent data in Figure 9 clutters the picture when it has been argued in the text that the ascent data are believed to be more reliable. A single panel with both ascent and descent for comparison could be included instead to illustrate the description in the text.

AR4) Yes, we are aware of limited analysis provided in the manuscript, since it was submitted as "Measurement report". We are going to add inter-comparison of particle counters and T, RH, P at surface level just before each flight as suggested by reviewer1.

Figure 4 will be changed to time series, figure 5 will be omitted. Figure 9 will be split to single panels of separate ascent and descent profiles.

Specific comments:

RC5) L14: The opening sentence of the introduction is a bit absolutist. Perhaps "Most air pollution, including both gases and particulates, is released near the surface from various sources." The specific mention of wet deposition seems out of place since it is discussed nowhere in the manuscript, it could be omitted.

AR5) Manuscript text changed accordingly.

RC6) L18: The sentence "The atmospheric boundary layer can be investigated. . ." lists many measurement methods and relevant references, but then just stops without any following statement about why this list was presented. UAS are merely included as one item instead of the paragraph being used to set up the paper by describing why one might use sUAS instead of, or to complement, other methods.

AR6) UAS method will be elaborated in revised version of the manuscript.

RC7) L46: suggest replacing "leveraging" with "utilizing" or "using"

AR7) Changed to "using".

RC8) L72: "employed a parachute system" was the parachute actually used regularly for landing, or was it there in case of emergency (power failure) and not actually needed during the campaign?

AR8) Parachute system was not used regularly for landing, only in case of emergency to safe costly payload. It will be clarified in revised version of the manuscript.

RC9) L79: If 15.5 kg GTW / 5.5 kg PW would have been too much for operation at the altitude of the SLV, what were the actual KSU Matrice operational weights for LAPSE-RATE?

AR9) The actual weight of DJI Matrice 600 Pro was 9.5 or 10 kg depending on battery set used. The payload maximum total weight was about 1.1 kg: DJI Zenmuse X3 (221 g), GoPro Hero 7 (117 g), naked POPS (700 g), and Meteorological sensor (30 g, iMetXQ2, International Met Systems, Grand Rapids, MI, USA) borrowed from Oklahoma State University. Not all payload parts were used together during all flights.

This will be clarified in revised manuscript.

RC10) L85: "These modules were easily detached. . .swapping between sensor modules but since you were using two aircraft, did you actually swap the payloads? It didn't seem so from the description of operations.

AR10) True, the modules were not exchanged during the campaign. Will be changed to following:" These modules could be easily detached from the rotorcraft frame, allowing for swapping between sensor modules to meet the requirements of a given flight. However, this was not necessary during LAPSE-RATE since pair of rotorcraft was available".

RC11) L90: "The CPCs were calibrated" perhaps "were set", "were adjusted"

AR11) Change to "were adjusted".

RC12) L92: The voltage applied to the TEC (or Peltier cooler) sets [or regulates], the temperature difference between the saturation and condensation regions.

AR12) Changed accordingly.

RC13) L94: given the cut-off (50%?) diameters of 7 and 14 nm how did the temperature instability limit the detection of sub-20 nm particles, how much did the cut-points vary? Was this incorporated in uncertainty, or was the delta-T measured and compensated?

AR13) The calibration was done the same way as described in Hameri et al. (2002), the uncertainty of D50 values was determined to be +/- 0.8 nm. The minimum and maximum set points for TEC, 1000 and 2000 mV, are the limiting factor to observe full nucleation mode range up to 20 nm. Using lower or higher setpoints would lead to instrument instability, this claim is based on personal communication with TSI technician. Using lower setpoint than 1000 mV could lead in range extension up to 20 nm, but compromising the device stability. We used values in safe range thus assuming the device is operating in steady state stable mode.

This will be clarified in revised version.

RC14) L96: "The platform was enclosed on all sides except the bottom with polylactic acid (PLA) foam to shield"; "Bosh" → "Bosch"; "pressure (P), temperature (T) and relative humidity (RH).

AR14) Corrected accordingly.

RC15) L100: "6 ms and ±1 hPa for P, 1 s and ±0.5 ◦C for T, and 1 s and ±3% for RH."

AR15) Corrected accordingly.

RC16) L120: "oxygen"? Assumed to be ∼20% of P?

AR16) Cannot comment on this, it is Vaisala proprietary compensation algorithm, confidential.

RC17) L128: suggest stating here that the AQT400 was not useful in the SLV environment.

AR17) This part just describes all sensors, usefulness of AQT400 is clearly discussed in part 4 Concluding remarks line 350.

RC18) L146: How long was the horizontal inlet?

AR18) Corrected accordingly to "…naked inlet about 9 cm (3.5 inch) long…".

RC19) L147: What was the nature/purpose of the POPS "custom electronics"?

AR19) The term simply refers to POPS being a research instrument and the electronics being custom-made by the manufacturer rather than an off-the-shelf solution.

RC20) L149: What is the expected effect of the POPS not being shielded from the sun over the duration of a profile? Did you evaluate the effect by running the instrument on the ground for the same period to see if a measurable effect occurred?

AR20) We expect the effect on the flight POPS to be small due to it being exposed only for short durations and being constantly cooled by an airflow. POPS electronics are rated for up to +85C. The effects on the

ground POPS are harder to quantify. However, given that the ground POPS measurements stayed relatively flat despite the increase in temperature over the duration of the measurement we expect that the effects due to lack of shielding were small.

RC21) L163: Typically, MSL would be denoted "altitude" and AGL "height".

AR21) Corrected accordingly: "…achieved altitude was 3201 m MSL (i.e. height 893 m AGL).".

RC22) L178: "A detailed description of the daily meteorological conditions in the SLV during the LAPSE-RATE campaign"

AR22) Corrected accordingly.

RC23) L181: The data presented in figures 4-7 seem to indicate that the surface measurements were not continuous, but only occurred during portions of each day.

AR23) Correct, "continuous" surface measurements were done with the battery power surface module only during UAV operation. No other surface measurements of aerosols and meteorological parameters were present in place of operation.

RC24) L219: "according to the US Environmental Protection Agency"; EPA or USEPA are not needed since there is no further reference in the paper.

AR24) There is a lack of any reference to PM measurements in the SLV, our goal was to provide at least some data. However, the sentence will be omitted in revised version.

RC25) L230: "based on which the goal" perhaps "the goal of which was to reach the highest altitude possible in a very short time."

RC26) L256: From figure 10 it appears that the bias between the two CPCs was fairly systematic, raising a question about either the determination of cut-off diameter or relative sampling efficiency. This potentially affects quantitative analysis of the results, but does not necessarily impact the qualitative conclusions drawn.

AA26) In Fig. 10c in the boundary layer the difference between the CPCs with 7nm and 14nm cut-offs is less than 10%, which is within the expected accuracy of TSI 3007. Considering that TSI 3007 has higher uncertainty and lower accuracy than a full-size desktop CPC when used in lab, less than 10% of concentration (in left hand side plot), could be considered as an excellent agreement. Compared to delta_CPC > 3km this constant bias is less than 5%.

RC27) L273: The discussion of the Flexpart back trajectories and interpretation of the resulting footprint (shown in Figure 11) is rather superficial and speculative.

AR27) Here, our focus is on the air mass origin of the elevated layer of nucleation-mode particles discussed in the previous paragraph. Please see also reply to reviewer1.

Flexpart footprint shows that power plant emissions cannot be ruled out as a source of the elevated layer of nucleation mode particles, which is relevant information with respect to earlier observations discussed in the previous section.

We have modified line 273 as: "We used the Flexpart dispersion model to investigate the air mass history of the elevated layer of nucleation-mode particles observed on July 18th."

RC28) L293: The description of the effect of aircraft motion on the POPS sampling is somewhat vague. How did the motion cause the effect? Was it the same for the horizontal and vertical inlet configurations (L145-147)?

AR28) Impact on POPS data had only fast movement during horizontal transects with inlet placed horizontally and facing the direction of the movement. There were very few such flights, but we have noticed the bias. This will be clarified in revised manuscript.

RC29) L298: "was 5 cm-3, similarly averaged PM1" should either use a ";" or ", while"

AR29) Corrected accordingly.

RC30) L304: "evaporation" "transpiration" if just from plants or "evapotranspiration" if from the environment (surface + plants).

AR30) Corrected accordingly.

RC31) L310: "from a BME280 sensor that showed a bias of about. . ."

AR31) Corrected accordingly.

RC32) Figure 10: Suggest labeling the panels in order (A, B, C) and change the references in the text to match
AR32) Corrected accordingly.

References:

Hämeri, K., Koponen, I.K., Aalto, P.P. and Kulmala, M: The particle detection efficiency of the TSI-3007 condensation particle counter, J. Aer. Sci., 33, 10, 2002,https://doi.org/10.1016/S0021-8502(02)00090-3