The paper titled "Synthesis of the tethered balloon system and other TRACER campaign measurements elucidates aerosol property profiles" reports a topic of a great interest concernig the aerosol vertical profiles.

Here below my major and minor comments listed from the abstract till the conclusions of the paper:

Abstract:

- **Lines 17: explain DOE (Department of Energy?)**

Response: Revised.

Section 2.1:

- **Line 101: "June to September 2022". Please specify why the campaign was planned in summer and if other campaigns are planned in other seasons**

Response: Thank you. We revised the text to, "Conducted from June through September 2022 in the Houston, Texas, region, the TRACER Intensive Observation Period (IOP) was timed to capture frequent warm-season convection generated by strong surface heating, abundant Gulf moisture, and sea-breeze circulations. Combined with Houston's urban and industrial emissions and the contrasting marine and rural air masses, these conditions provided an ideal setting for investigating aerosol–convective-cloud interactions across a wide range of aerosol loadings and meteorological conditions."

- **Figure 1 does not report the transects cited at line 113**

Response: The specific transect routes are not shown because they varied among sampling days. We revised the sentence to avoid confusion.

Section 2.2:

- **Inlcude a picture of payload (described in table 1) of the TBS**

Response: Thank you. We include a picture of the payload in the supplementary document.

- **Lines 138-139: report briefly even in the present paper the frequency distribution of TBS profiles per hour of day. It is needed for the environmental and meteorological context of TBS soundings**

Response: Thank you. We have included a supplement table of taking off and landing time for each TBS flight and revised the text, "Detailed TBS daily operation reports can be found

in Appendix A of the campaign report (Jensen et al., 2023). The taking-off and landing times for each flight were listed in Table S1."

- **Lines 145-151: you used stage D of STAC. What about the other stages?**

Response: For the TRACER campaign, we focused on Stage D samples because their limited sample material was analyzed using both CCSEM/EDX and STXM/NEXAFS. This complementary approach maximized the information obtained from each sample and was most relevant to CCN number concentration.

- **Lines 166-170: provide here the methodology, equations and parameters used for Lidar f(RH) corrections. Please note that as reported by Martin (2000, DOI: 10.1021/cr990034t), the aerosol can be humid even below the activation relative humidity depending on RH history and efflorescence RH. As you used RH vertical profiles, discuss the limitation of your approach in the context of the scientific literature as above and the lack of temporal trend of RH with height.**

Response: Thank you for pointing this out. The CCN estimation from the MPL retrieval has been carried out and detailed in another study by Chen et al. 2025. We revised the text to, "Chen's retrieval method assumes that surface measurements of aerosol size distribution, composition, and cloud-activating ability are representative of their vertical profiles, except in cases of elevated layers like smoke or dust. The approach involves determining the vertical profile of the cloud-free aerosol backscatter coefficient using lidar and radiosonde data. The aerosol backscatter coefficient is then corrected for hygroscopic growth using the lidar hygroscopic growth correction factor $f(RH)$, which is calculated from hygroscopicity parameters derived from ground-based Scanning Mobility Particle Sizer (SMPS), POPS, and CCN counter measurements, along with relative humidity profiles from radiosondes. The resulting dry aerosol backscatter profiles were subsequently used to retrieve vertical CCN concentration profiles. We used these retrieved profiles to complement our CCN profile estimated from the ANC location and to provide broader spatial and vertical context."

- **Line 168: "CCN count measurements": as in section 2.3 you estimated it. As the Lines 166-170 are also based on CCN data, discuss the error of f(RH) even considering the fact that CCN are estimated**

Response: The CCN estimation from the MPL retrieval has been carried out and detailed in another study by Chen et al. 2025. The estimated CCN data discussed in section 2.3 is based on the aerosol measurements after a dryer (RH < 40%). We have revised the text to avoid confusion. "Both the POPS and CPC were equipped with dryers in their sampling lines to reduce the relative humidity of the sampled aerosol flow to below 40%."

Section 2.3:

- **The size distribution interpolation and log-normal reconstruction is feasible only if the POPS data are corrected with respect to aerosol refractive index, laser properties of POPS and POPS inner geometry. Improve this section with such calculations (Heyder et al., 1979: Optimization of response functions of light scattering instruments for size evaluation of aerosol particles. Appl Opt 1979;18(5):705–11), compare them with the original ones and redo the CCN estimation based on new POPS size distribution interpolation. Consider that POPS can bring undersizing (Guyon et al., 2003: Refractive index of aerosol particles over the Amazon tropical forest during LBA-EUSTACH 1999. J Aerosol Sci 2003;34:883–907). As one of the goal of the present manuscript is related to CCN, its methodology has to be perfect.**

Response: We thank the reviewer for raising this point, which has led to a more rigorous treatment. We would like to first clarify an important detail that was not sufficiently explicit in the submitted manuscript: **the size bins of our POPS are referenced to an ammonium sulfate calibration performed with DMA-classified monodisperse particles, not to a polystyrene latex calibration.** The reference refractive index of our sizing scale is that of ammonium sulfate ($n \approx 1.54$–1.56 at $\lambda = 405$ nm), which lies within the range reported for ambient submicron aerosol, rather than the $n = 1.615$ of PSL. The undersizing bias highlighted by the reviewer and by Guyon et al. (2003), which for PSL-calibrated counters can reach tens of percent, is therefore much smaller here.

We have revised the manuscript and stated in the revised Methods (Sect. 2.2):

“The POPS size bins were assigned from a calibration with DMA-classified ammonium sulfate particles rather than polystyrene latex spheres, so the reference refractive index of the sizing scale ($n \approx 1.54$ at $\lambda = 405$ nm) lies within the range reported for ambient submicron aerosol, reducing the sizing bias associated with the assumed refractive index. A further consideration is the influence of long-range-transported mineral dust, whose refractive index differs from that of the ammonium sulfate used to assign the POPS size bins. We therefore assessed the sensitivity of the retrieved size distribution to the assumed refractive index. Adopting a dust-representative value ($m = 1.52 + 0.002i$) in place of the PSL calibration value and recomputing the Mie response curve shifts the bin boundaries by less than 4% in diameter below 1.38 μm (Kezoudi et al., 2026). These shifts are smaller than the corresponding POPS bin widths across the size range; i.e., within the instrument's size resolution, the shape of the binned distribution is preserved to within counting uncertainty. This indicates that the change in CCN concentration is small.”

- **Line 180: please also add as a control the comparison between the fitted size distribution number concentration between 10 and 135 nm obtained as difference between CPC and POPS**

Response: Thank you for your suggestion. We revised the sentence to clarify our approach, "The parameters of the fitted size distribution were determined through iterative optimization, minimizing the sum of squared errors between the fitted and measured size distributions over the 135–1000 nm range. The fit was further constrained such that the integral of the distribution from 10 to 135 nm reproduced the difference between the total number concentrations measured by the CPC and the POPS to within 10 %, consistent with the combined counting uncertainty of the two instruments. Consequently, the integral of the fitted distribution over the full 10–1000 nm range agrees, within the same tolerance, with the total number concentration measured independently by the CPC."

- **Line 182-184: please discuss the assumption of an homogeneous chemical composition. What about vertical formation of secondary aerosol components. Please discuss this part with respect to scientific literature referred to the context of TBS. Finally, also discuss the limitation of a chemical change with altitude with respect to aerosol refractive index and therefore POPS size correction.**

Response: We thank the reviewer for raising this important point. We agree that the assumption of vertically uniform chemical composition is a simplification, and that secondary aerosol formation and gas–particle repartitioning above the surface layer can invalidate it. We revised this section and added, "Aerosol composition is not necessarily vertically uniform, even within a nominally well-mixed boundary layer. New particle formation has been observed to occur preferentially in the upper mixed layer, the entrainment zone, and the residual layer rather than at the surface, where condensation sinks are larger, and precursor photochemistry differs. Semi-volatile species repartition in response to the vertical temperature and relative humidity gradients: ammonium nitrate and semi-volatile organics shift toward the particle phase at the lower temperatures encountered aloft, so the organic-to-inorganic ratio measured at the surface may not apply at the top of the profile. (Zhang et al., 2026; Lata et al., 2025; Lata et al., 2023; Creamean et al., 2021; Huffman et al., 2009) Our assumption is therefore most appropriate for the daytime and convectively well-mixed boundary layer, and may not apply for decoupled profiles, such as cases on September 6 (discussed more in section 3.5)."

- **Line 191: add the densities used for the volumetric average**

Response: Thank you. Revised to, "The densities of $(NH_4)_2SO_4$ and NH_4NO_3 were assumed to be 1770 kgm^{-3} and 1730 kgm^{-3}, respectively. Organics were assumed to have a density of 1350 kg m^{-3}, which is within the typical range of previous measurements.(Engelhart et al., 2011)"

Section 3.2:

- **Figure 4: As Ran et al. (2016, doi:10.5194/acp-16-10441-2016) did, when averaging vertical profiles of aerosol it is necessary to use a normalized height with respect to the PBL calculated from h/PBL_height−1; Please compute again vertical profiles average in Figure 4 to check them and compare with the absolute altitude averaged profiles to ensure consistency within the environental interpretations of the results, for example the assertion that "This suggests that the local-scale thermal structure and boundary-layer depth were not strongly dependent on air-mass origin during the sampled period...". This is what you did in section 3.4 for CCN profiles**

Response: Thank you for your suggestions. We have added additional supplementary plots as suggested to confirm our discussion. "This suggests that the local-scale thermal structure and boundary-layer depth were not strongly dependent on air-mass origin during the sampled period, as confirmed with the normalized vertical profiles in Figure S2(a)."

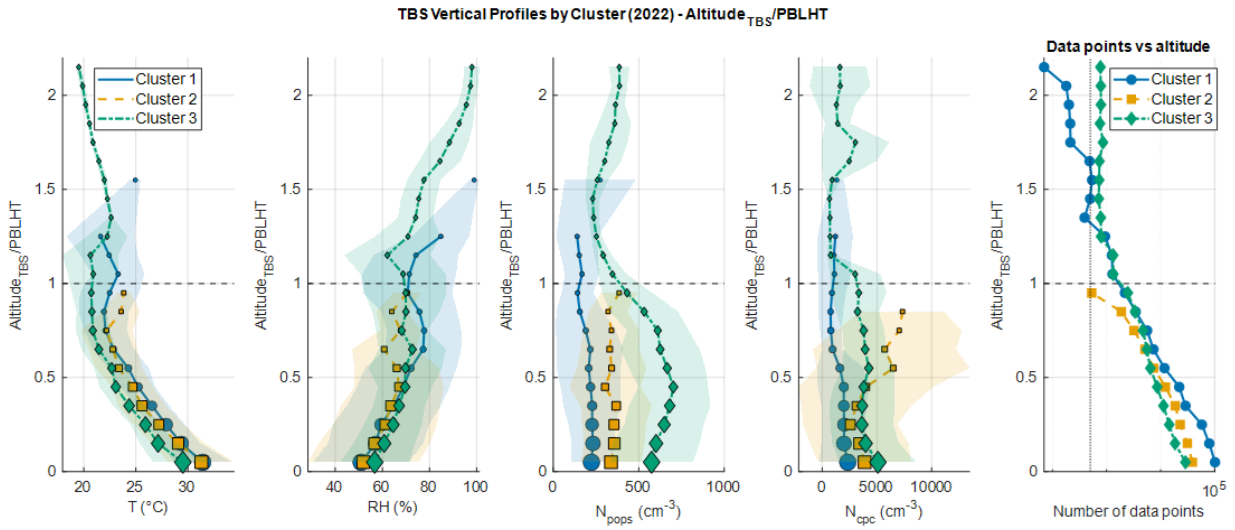

Figure S2. Normalized vertical profiles of atmospheric conditions (a) ambient temperature; (b) ambient relative humidity; (c) total particle concentration measured by the portable optical particle spectrometer (POPS, particles ranging from 135 to 3,000 nm); and (d) total particle concentration measured by the condensation particle counter (CPC, particles

greater than 10 nm) (e) data points collected at the corresponding altitude for each cluster with a dash line marks the 500 data points. The square symbols represent the averaged mean values of the sampling periods, while the error bars denote the standard deviation of the measurements. The altitude was normalized by the boundary layer height derived from radiosonde profiles.

- **Figure 4: panels c) and d) are inverted, moreover the panel letter is missing within the figure**

Response: Thank you. Corrected.

- **Line 288: "subtle"? Suitable?**

Response: changed it to “slight”

- **Line 314: "new particle formation". With the present apparatus it is impossibile to speculate about it. Please remove the statement.**

Response: Thank you, removed.

Section 3.4:

- **Results seems interesting, however refer to my comment related to section 2.3 and POPS size distribution correction before interpolation and CCN determination. After the number size distribution correction and new CCN determination results have to be updated. The same happens for section 3.5**

Response: Thank you for your suggestions. We have clarified this issue with the previous response.

- **Lines 434-437: you assumed homogeneous chemical composition…. these lines are mostly a matter of speculation, please remove them**

Response: Thank you. Removed.

- **Figure 7 lacks of panel letters**

Response: Thank you. Revised.

- **What about number size distribution change with altitute in respect to CCN? Please add the vertical profiles of mean diameter and geometric standard deviations of the modes interpolated for each cluster and compare them with CCN**

Response: Thank you for this great suggestion. We have reordered section 3 and revised section 3.3 to include a discussion of the vertical profiles of the mean diameters and

geometric standard deviations of the modes in merged CPC-POPS size distributions (Figure S3).

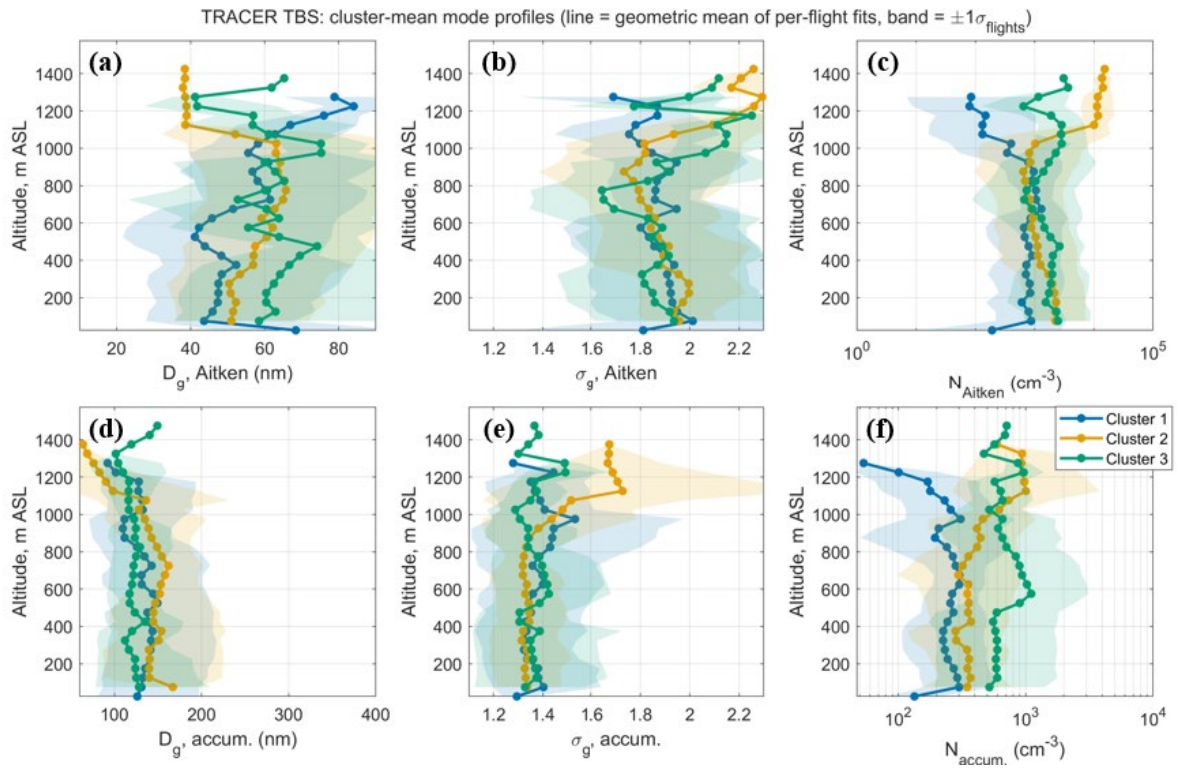

Figure S3 Clustered vertical profiles of aerosol mode parameters from 49 TRACER tethered-balloon flights: geometric mean diameter D_g(a, d), geometric standard deviation σ_g(b, e) and number concentration N(c, f) for the Aitken (top) and accumulation (bottom) modes. Two log-normal modes were fitted to 50-m altitude-binned merged CPC–POPS size distributions for each flight, interpolated onto a common grid and averaged logarithmically within each cluster. Lines denote the geometric mean of per-flight fits; shaded bands denote ±1 geometric standard deviation across flights. Aitken-mode D_g and σ_g depend on the assumed sub-135 nm reconstruction.

Section 3.5:

- **Panel labels of Figures 8, 9 and 10 are missing**

Response: Thank you. Revised.

PLEASE PROVIDE AN ACRONYMS TABLE OR APPENDIX

TBS	Tethered Balloon System

TRACER	Tracking Aerosol Convection interactions ExpeRiment
CCN	Cloud Condensation Nuclei
CPC	Condensation Particle Counter
ARM	Atmosphere Radiation Measurement
AMF	ARM Mobile Facility
Tof-ACSM or ACSM	Time-of-Flight Aerosol Chemical Speciation Monitor
ACTIVATE	Aerosol Cloud meTeorology Interactions oVer the western ATlantic Experiment
IOP	Intensive Observation Period
ANC	Ancillary site
PWV	Precipitable Water Vapor
LWP	Liquid Water Path
NEXRAD	Next Generation Weather Radar
PPI	Plan Position Indicator
POPS	Portable Optical Particle Spectrometer
STAC	Size- and Time-Resolved Aerosol Collector
nano-DESI-HRMS	nanospray Desorption ElectroSpray Ionization High-Resolution Mass Spectrometry
PBLHT	Planetary Boundary Layer Height
MPL	MicroPulse Lidar
TAMU	Texas A&M University
HYSPLIT	Hybrid Single-Particle Lagrangian Integrated Trajectory
ECMWF	European Center for Medium-Range Weather Forecasts
PCA	Principal Component Analysis
CAPE	Convective Available Potential Energy
CIN	Convective Inhibition