In this response, the referee comments are in black and our responses are in blue. The line numbers noted in the response refer to the manuscript with tracked changes turned on.

The authors appreciate the comments made by the three referees. These comments, especially by Referee #1 and #3, motivated us to review the treatment of the entrainment and scavenging efficiency calculations in terms of both the averages and uncertainties. As a result, there are several minor updates to the numbers presented in Tables S2 and S3 (now Tables S3 and S4). However, these changes do not affect the conclusions drawn in the submitted manuscript. Further, the comments posed by all three referees have strengthened the conclusions of the paper. Below are point-by-point responses to the referee comments.

Anonymous Referee #1, 25 Feb 2026

This manuscript derives composition-specific aerosol scavenging efficiencies (SE) through the analysis of ten storms from the Deep Convective Clouds and Chemistry (DC3) and the Studies of Emissions, Atmospheric Composition, Clouds and Climate Coupling by Regional Surveys (SEAC$^4$RS) field experiments combined with process-scale modeling. The manuscript addresses an important problem—quantifying composition-dependent aerosol scavenging in deep convection—and provides a valuable observational dataset. The results presented can be used directly for evaluating cloud-scale chemistry transport model representation of aerosol scavenging.

The article is written clearly and would be a good contribution to ACP. However, the authors need to address the following comments before I can recommend publication in ACP.

**Major comments:**

The largest concern is the limited evaluation of uncertainty in entrainment rates and its propagation into scavenging efficiency (SE). Given that SE is directly dependent on the entrainment, a quantitative uncertainty analysis (e.g., sensitivity tests or error propagation) would substantially strengthen the robustness of the conclusions.

Entrainment rates used in this study are from the methodologies and results from our previous work (Fried et al., 2016; Barth et al., 2016; Cuchiara et al., 2020; Cuchiara et al., 2023). These papers discuss the methodologies and uncertainties in more detail. The impact of their uncertainties is now included in the manuscript and discussed further below, which has been added to the supplementary material (Text S1) and is cited in the manuscript (L229-231) as well as the key point noted in the manuscript (L239-240).

- Entrainment rates vary substantially among cases (Table S2), and different tracers were used to diagnose entrainment in different storms. While this is understandable given observational constraints, a more explicit discussion of the comparability of entrainment rates derived from different tracers would strengthen confidence in the results.

Text S1. Methodology for determining passive trace gases used for the entrainment rate calculation

The entrainment rates were originally determined by previous work (Barth et al., 2016; Fried et al., 2016; Cuchiara et al., 2020; Cuchiara et al., 2023) where more details can be found. Here, we present the logic in choosing trace gases and list the trace gases used in the entrainment rate calculations as well as the entrainment rates determined from each trace gas for each storm case.

In choosing insoluble, passive trace gases for determining the entrainment rate in a storm, a few criteria are imposed. Insoluble trace gases generally have an effective Henry's Law constant of 1 M $atm^{-1}$ or less and include trace gases like CO, $O_3$, NO, $NO_2$, alkanes, and alkenes. Passive trace gases have a chemical lifetime much greater than the transport time from the inflow measurement location near cloud base to the outflow measurement location near cloud top.

Based on model simulations where trajectories are launched near cloud base, the transport time ranges from 10-60 minutes (Skamarock et al., 2000; Bela et al., 2018). It is preferable to use insoluble, passive trace gases that have a substantial difference in mixing ratio between the boundary layer and the free troposphere. Many previous studies have used CO as the insoluble, passive trace gas because it is a fast-response measurement (1 Hz) with small uncertainty (5%), has a low Henry's Law constant ($9.8 \times 10^{-4}$ at 298 K), long chemical lifetime (typically > 1 month), and often higher mixing ratios in the boundary layer than the free troposphere. However, because of its long chemical lifetime, its free troposphere mixing ratios are not necessarily much smaller than its boundary layer mixing ratios. Thus, when possible, i-butane, n-butane, i-pentane, and n-pentane are used for this analysis. These alkanes meet the criteria for being insoluble with a chemical lifetime greater than 1-5 days. However, their collection time via the whole air sampler method ranges from 45 s to a few minutes with longer collection times at high altitude. The sampling of convective outflows during SEAC$^4$RS were less than a minute. Thus, CO and $CO_2$ are used to calculate the entrainment rate for the SEAC$^4$RS storms, except for the marine convection on 18 September 2013 where the entrainment rate is from a WRF calculation that simulated tracers at 1-km altitude layers (for more information see Cuchiara et al., 2023). Table S3 lists the trace gases used for the entrainment rate calculations. For most storm cases, the entrainment rate standard deviation is small compared to its average. More entrainment rate variation is seen for the 22 June 2012 and 18 September 2013 storms. Note that there is no systematic difference in entrainment rates when different trace gases are used (e.g., the entrainment rates using the alkanes as the passive, insoluble trace gas range from 4 to 15% $km^{-1}$, while the entrainment rates using CO and $CO_2$ range from 8 to 11% $km^{-1}$).

Table S3. Trace gases used for the entrainment rate calculation for each storm and the entrainment rate average ± standard deviation among the 2-4 trace gases used for its calculation.

| Date | Insoluble, Passive Trace Gases | Entrainment Rate (% $km^{-1}$) |
|---|---|---|
| | *DC3* | |
| 18 May 2012 | i-,n-butane, i-,n-pentane | 14.7 ± 0.2 |
| 29 May 2012 | i-,n-butane, i-,n-pentane | 7.8 ± 0.9 |
| 02 June 2012 | CO | 11.5 |
| 06 June 2012 | i-,n-butane, i-,n-pentane | 4.1± 0.7 |
| 16 June 2012 | i-,n-butane, i-,n-pentane | 15.4 ± 1.2 |
| 22 June 2012 | i-,n-butane, n-pentane | 5.5 ± 2.0 |
| | *SEAC$^4$RS* | |
| 02 Sept 2013 | CO, $CO_2$ | 11.4 ± 1.6 |
| 02 Sept 2013 | CO, $CO_2$ | 8.3 ± 1.6 |
| 18 Sept 2013 Marine | WRF tracer calculation | 9.6 ± 3.2 |
| 18 Sept 2013 Land, core 2 | CO, $CO_2$ | 7.8 ± 5.2 |
| 18 Sept 2013 Land, core 3 | CO, $CO_2$ | 10.4 ± 5.4 |

- It would be helpful to show the vertical profiles of the tracers used to derive entrainment alongside the corresponding aerosol vertical profiles, to assess how similar their vertical structures are and how sensitive the entrainment correction may be to profile heterogeneity.

The vertical profiles of the passive, insoluble tracer gases used to derive entrainment rates have been added to Fig. 2 (shown below), which shows the clear sky vertical profiles.

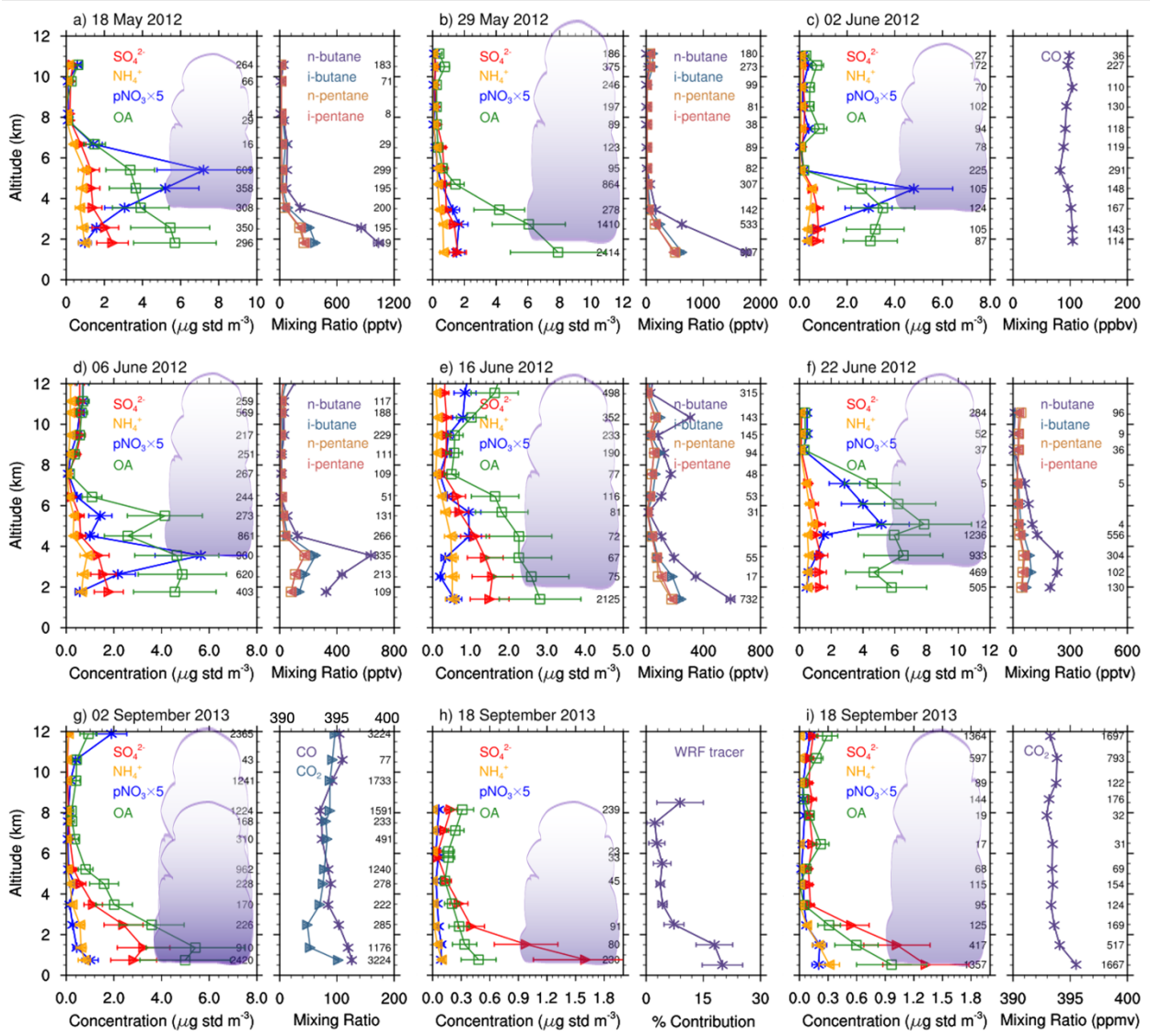


Figure 2. Clear air vertical profiles of sulfate (red with right arrows), particulate nitrate (blue with asterisks), ammonium (gold with left arrows), organic aerosol (green with squares) and the passive, insoluble trace gases used in the entrainment model for a) 18 May 2012, b) 29 May 2012, c) 2 June 2012, d) 6 June 2012, e) 16 June 2012, f) 22 June 2012, g) 2 September 2013, h) 18 September 2013 over the Gulf of Mexico, and i) 18 September 2013 over South Texas. Average and standard deviations are plotted for each altitude bin, which is plotted at the average altitude of each 1-km bin. Nitrate concentrations shown are multiplied by a factor of 5 for visibility. In g), the $CO_2$ mixing ratio (ppmv) axis is at the top of the panel. The cloud schematic in each panel is used to locate the approximate cloud base and cloud top heights for each case. Cloud tops extending above the panel indicate that the actual cloud top was much greater than 12 km and is noted in Table 1. In g) two cloud tops are shown, ~8 km for the airmass storm and ~13 km for the multicell storm.

- More importantly, the manuscript does not quantify how uncertainty in entrainment rates and in the clear-air and outflow aerosol profiles propagates into SE uncertainty. In Table S2, only cases with multiple outflow legs include standard deviations, while other cases appear to lack uncertainty bounds.

The reviewer's point about discussing uncertainty in the results is well taken, resulting in this information being added to the paper (L404-410; Tables S3, S4; Fig. 3). An analysis of the entrainment rate among passive tracers for each storm shows that there is often a small variation, although a couple of storm cases have a larger variation (see Table RR1 below). The 1-sigma uncertainty (accuracy, not precision) in the AMS measurements is 17% of the measurement value for the inorganics and 19% for organic aerosol (Bahreini et al., 2009) and is discussed in more detail in the response to Referee #3. The AMS measurement uncertainty propagates to an uncertainty in the derived scavenging efficiencies that is larger than the uncertainty from the entrainment rate variation in all cases except for the land convection on 18 September 2013.

The 18 May 2012 DC3 case is used to give an example. For that case, the entrainment rate is $14.7 \pm 0.2$ % $km^{-1}$ where the variability is equal to the largest deviation of the individual entrainment rate from the average entrainment rate. Calculating the $SO_4^{2-}$ SE using entrainment rates of 14.9 % $km^{-1}$ and 14.5 % $km^{-1}$ results in a $62.9 \pm 0.6$% scavenging efficiency. In contrast, propagating the 17% measurement uncertainty to the calculation of $SO_4^{2-}$ SE results in $62.9 \pm 7.4$% scavenging efficiency. Therefore, we now report in Table S4 and Fig. 3 the scavenging efficiency uncertainties as the maximum of the propagation of the uncertainty of the AMS measurements or standard deviation from the entrainment rate variability.

Table RR1. Entrainment rates ± standard deviation and scavenging efficiencies (SE) ± uncertainty based on uncertainty of measurement for each storm case. The entrainment rate standard deviation is equal to the maximum difference between the highest or lowest entrainment rate minus the average entrainment rate. For cases where the outflow leg is below the detection limit, the scavenging efficiency is shown as 100% and an uncertainty is not assigned since the measured outflow concentration is not statistically different than zero. The not a number (NaN) entry is due to both the outflow and inflow concentrations being below the detection limit.

| Storm | Entrainment Rate | $SO_4^{2-}$ SE | $NH_4^+$ SE | $NO_3^-$ SE | OA SE |
|---|---|---|---|---|---|
| 18 May 2012 | 14.7 ± 0.2 | 62.9 ± 7.4 | 39.2 ± 12.0 | – | 28.9 ± 15.8 |
| 29 May 2012 | 7.8 ± 0.9 | 86.8 ± 3.2 | 81.3 ± 4.6 | 40.5 ± 13.7 | 84.5 ± 4.4 |
| 02 June 2012 | 11.5 | 56.5 ± 8.4 | 37.0 ± 12.3 | – | 48.0 ± 11.7 |
| 06 June 2012 | 4.1± 0.7 | 89.6 ± 2.5 | 86.0 ± 3.4 | 41.9 ± 10.6 | 86.7 ± 3.6 |
| 16 June 2012 | 15.4 ± 1.2 | 90.7 ± 1.9 | 87.6 ± 2.5 | 82.8 ± 3.1 | 89.5 ± 2.3 |
| 22 June 2012 | 5.5 ± 2.0 | 75.2 ± 7.9 | 65.3 ± 9.7 | – | 66.2 ± 11.1 |
| 02 Sept 2013, airmass | 11.4 ± 1.6 | 95.0 ± 1.2 | 100 | 42.9 ± 13.5 | 84.4 ± 4.0 |
| 02 Sept 2013, multicell | 8.3 ± 1.6 | 92.7 ± 1.9 | 80.9 ± 4.9 | – | 57.6 ± 11.7 |
| 18 Sept 2013 | 9.6 ± 3.2 | 100 | 100 | NaN | 100 |
| 18 Sept 2013, land core 2 | 7.8 ± 5.2 | 90.7 ± 4.9 | 100 | 100 | 100 |
| 18 Sept 2013, land, core 3 | 10.4 ± 5.4 | 87.9 ± 7.0 | 100 | 100 | 100 |

The discussion focuses primarily on chemical processes and entrainment of mid-free-tropospheric aerosol layers in interpreting SE variability. However, the dynamical controls on scavenging are less clearly developed. Although SE is shown as a function of the SWEAT index, the analysis does not fully explore how dynamical factors (e.g., convective intensity and updraft strength) may influence the observed chemical and scavenging signatures. The connection between storm dynamics and composition-dependent SE could be developed further, particularly in the Conclusions section.

The SWEAT index combines thermodynamic and dynamic factors and provides an indication of convective intensity. It is used primarily to separate severe storms from weaker storms. The SWEAT index is useful with aircraft measurements as near-surface data are not needed for its calculation. Comparison of scavenging efficiencies to individual parameters shows a strong correlation of scavenging efficiency with CAPE but a weak correlation with the 0-6 km shear for the DC3 storms, suggesting that the thermodynamics plays a stronger role. We also found a moderately strong correlation with the depth of the cloud base to the freezing level for the DC3 storms, which is an indication that nucleation scavenging controls the transport efficiency to the upper troposphere. There is no strong correlation of these other meteorological parameters with the SEAC$^4$RS storms because of other factors, which include using the same NWS sounding for each date and several outflow concentrations being less than the detection limit. Scavenging efficiency also did not have a strong correlation with the volume of the 35 dBZ region of the storm (not shown). These comments are now included in the manuscript (L323-325; L393-402) and Fig. RR1 below has been added to the supplement as Fig. S9.

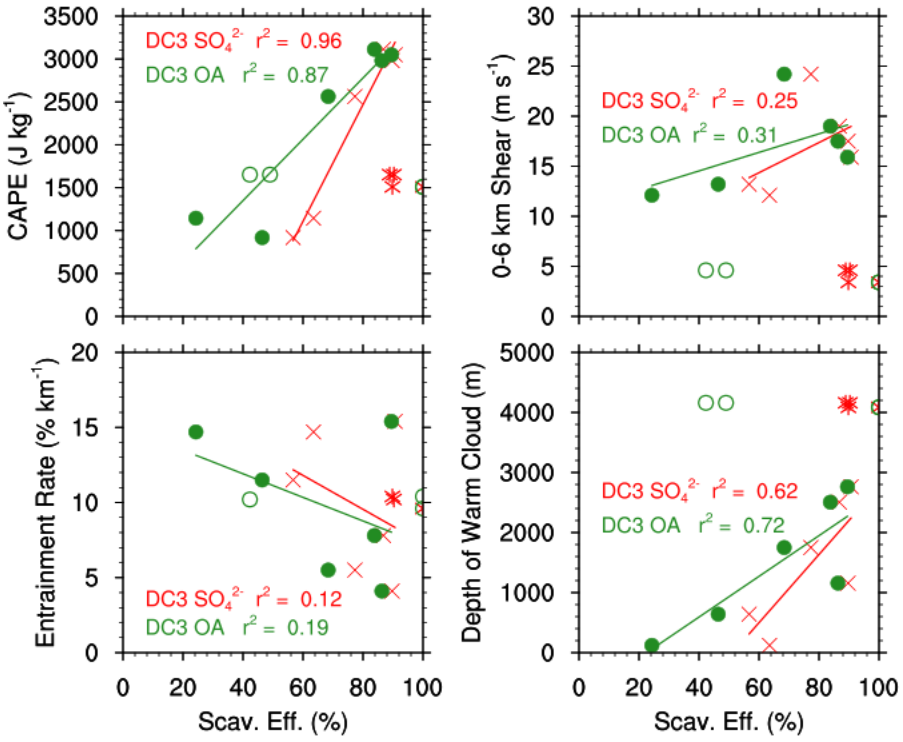

Figure RR1. Scatter plots of $SO_4^{2-}$ (red) and OA (green) scavenging efficiencies with various storm parameters (upper left: CAPE; upper right: 0-6 km wind shear; lower left: entrainment rate; lower right: depth from cloud base to 0°C). The DC3 storms are red x markers and solid green circles for $SO_4^{2-}$ and OA, respectively, and the SEAC$^4$RS storms are red asterisks and open green circles for $SO_4^{2-}$ and OA, respectively. The CAPE, wind shear, and warm cloud depth are from DC3 radiosondes or NWS radiosondes. The correlation coefficients are based on only the DC3 storms.

**Minor comments:**

Tick directions are inconsistent across figures. For example, Fig. 4 and Fig. 6 have inward ticks, while other figures use outward ticks. Please standardize formatting.

The figure formatting is more standardized.

Figure 2: It would be helpful to include the sample size (e.g., number of seconds of sampling) within each 1-km bin for the clear-air vertical profiles. Additionally, the method used to define the inflow aerosol concentration below cloud base should be clarified. Was the bin closest to cloud base used, or was an average taken across all sub-cloud layers?

The number of measurements contributing to each sample has been added to the figure (see above).

The inflow aerosol concentrations are taken from the pre-defined time period used in previous studies (Table S2, which also lists the altitude of the inflow). This is already stated in Section 3 in lines 239-242 of the original submitted paper, but is now noted earlier in that section as well (L222-224). In contrast, the clear air vertical profiles include all measurements within the 0-1 km or 1-2 km altitude bins.

Line 381: It would strengthen the discussion to provide references and typical magnitudes for below-cloud scavenging efficiency for comparison.

We now cite Flossmann (1991) who found 90% of the aerosol mass scavenged is incorporated into cloud water via nucleation scavenging, and ~30% of the aerosol in rain at the ground is due to below cloud impaction scavenging (L426-427).

The Conclusions section would benefit from a brief, explicit statement of the main limitations of the study (e.g., entrainment uncertainty, tracer dependence, simplified chemical interpretation).

We have added the following paragraph to the Conclusions section (L670-680).

The conclusions from this analysis are limited by a number of factors. The uncertainties associated with the scavenging efficiency calculations due to the uncertainties in the aerosol concentration measurements, the derived entrainment rates, and the estimated inflow and outflow time periods. This paper attempts to quantify these uncertainties, which are mostly < 10% of the average for sulfate and ammonium scavenging efficiencies and < 16% for particulate nitrate and organic aerosol scavenging efficiencies. Explanations for why particulate nitrate scavenging

efficiencies are lower for some cases are based on simple calculations of entrainment effects and potential impacts of lightning-produced nitrogen oxides. Detailed cloud-resolving chemistry transport modeling can extend our knowledge for both these processes (e.g., Cummings et al., 2024; Pickering et al., 2024). Likewise, the explanations for why organic aerosol scavenging efficiencies are lower in some cases are based on simple parcel model calculations of the aqueous-phase production of organic acids. A more complete representation of gas and aqueous phase chemistry coupled with aerosol thermodynamics and SOA formation in a cloud-resolving chemistry transport model would provide better quantification of the contribution of aqueous-phase chemistry.

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Anonymous Referee #2, 27 Mar 2026

This paper describes aerosol scavenging in deep convective storms based on DC3 and SEAC4RC field measurements and the entrainment model simulations. The deep convective cloud scavenging efficiencies of sulfate, nitrate, ammonium, and organic aerosols are calculated, and physical and chemical processes affecting the scavenging efficiency analyzed. The results provide valuable information and dataset for further investigating the spatiotemporal distributions of aerosols in the upper troposphere. The paper is well written in general and can be accepted for publication in ACP subject to minor revisions.

Comments in detail

In this study, the scavenging efficiencies (SEs) of sulfate, ammonium, and nitrate aerosols are calculated based on aircraft observations combined with parcel model simulations. The results show that organic nitrate SEs (~40%) are lower than sulfate and ammonium SEs (75%), and the causes of difference are attributed to the entrainment of mid-tropospheric nitrate layers formed from lightning-produced nitrogen oxides. These results appear to be sensible/reasonable from the field observation of view. On the other hand, scavenging here should be referred to wet deposition of aerosols via nucleation, impaction and Brownian diffusion, as mentioned in this paper. This wet scavenging process is clearly defined and treated separately from the lightning production of nitrogen oxides in regional or global chemistry model. The questions are:

Thank you for providing the short summary of our findings. To clarify, the causes of differences between particulate nitrate SEs (~40%) and sulfate and ammonium SEs (75%) are likely due to lightning-produced nitrogen oxides. The entrainment of mid-tropospheric nitrate layers can explain some of the difference but not all of it.

The observational analysis focuses primarily on the nucleation scavenging since it utilizes information of air composition entering the storm near cloud base and exiting the storm near cloud top. Thus, the study is confined to processes occurring between cloud base and cloud top. Any impaction scavenging of aerosols by falling precipitation below cloud is not part of the current analysis. Wet deposition, or the removal of aerosols within precipitation to the Earth's surface, would include scavenging occurring between the surface and cloud top. Thus, it is not quite correct to refer to scavenging, as presented in this paper, as wet deposition. A sentence has been added to the introduction (L64-67) mentioning that wet deposition is a result of many processes within the storm.

It is quite true that wet scavenging is treated separately from lightning-$NO_x$ production in our chemistry transport models. In some models, convective transport and wet scavenging are treated separately as well. The findings from our study suggest that models should not overly isolate processes that occur within convection. We now comment about this point in the Conclusions (L683-686) of the paper.

Could the term ‘scavenging efficiency’ and calculation method still be used appropriately in the case that there are much more aerosols entrained from mid-troposphere than from the inflow region?

This is a good question, which depends on the context of the topic or application. If one is focused on how much of the aerosol is removed from the gas phase into the cloud particles, then scavenging would be focused on that one process. However, if the topic is how good is the representation of aerosol scavenging in convection in a regional or global models, then one should consider the collection of processes (vertical transport, entrainment, scavenging, gas and aqueous chemistry, and lightning-$NO_x$ production) together as scavenging. Isolating one or more of these processes can be achieved (e.g., the model’s capability of representing convective transport can be evaluated with insoluble, passive trace gases). Yet, the evaluation of a model is often performed by comparing the simulated aerosol concentrations to measurements, which are a result from the combination of processes occurring within the convection. We now comment about this point in the Conclusions (L683-686) of the paper.

Should nitrate have a same SE level as sulfate and ammonium if there were no nitrate mid-troposphere layer or lightning nitrogen oxide source in the model simulation?

This question can be answered by estimating the nitrate aerosol SEs from storms that do not have a mid-troposphere layer or lightning-$NO_x$ source. We report $pNO_3$ SEs for five storms: 29 May 2012, 6 June 2012, 16 June 2012, 2 September 2013 airmass, and the land convection on 18 September 2013. In the table below we list only the averages of the $pNO_3$, $SO_4^{2-}$, and $NH_4^+$ SEs for those five storms and note whether there was a mid-troposphere $pNO_3$ layer and the $NO_x$ mixing ratio in the outflow region. To answer the reviewer’s question, a storm with low $NO_x$ mixing ratios in the outflow region and no mid-tropospheric $pNO_3$ layer would be needed. Two SEAC$^4$RS storms (2 September 2013 airmass and 18 September 2013 land convection) fulfill these two criteria. For the 18 September 2013 storm, the measured outflow $pNO_3$ concentration was below the detection limit indicating 100% scavenging. However, the 2 September 2013 storm has a moderate $pNO_3$ scavenging efficiency of 43%, suggesting other factors may play a role and noting that the outflow $pNO_3$ concentrations and $NO_x$ mixing ratios have a high variability compared to their average outflow values. A high $pNO_3$ scavenging efficiency is also seen in the 16 June 2012 case even though the outflow $NO_x$ mixing ratios are > 1 ppbv. We now note this finding in section 7.3 (L518-525) that discusses the scavenging of nitrate aerosols.

| Storm | $pNO_3^-$ SE (%) | $SO_4^{2-}$ SE (%) | $NH_4^-$ SE (%) | Outflow $NO_x$ (pptv) | Mid-troposphere $pNO_3$ layer |
|---|---|---|---|---|---|
| 29 May 2012 | 40.5 | 86.8 | 81.3 | 1366 +/- 2159 | No |
| 6 June 2012 | 41.9 | 89.6 | 86.0 | 660 +/- 541 | Yes |
| 16 June 2012 | 82.8 | 90.7 | 87.6 | 2124 +/- 916 | No |
| 2 September 2013 | 42.9 | 95.0 | 100 | 146 +/- 230 | No |
| 18 September 2013 | 100 | 90.7 | 100 | 321 +/- 60 | No |

It might not realistic to address these issues by performing additional modeling work. But adding some discussions in the conclusions might be helpful for guiding future modeling research.

We have added some discussions to the conclusions section of the paper.

Anonymous Referee #3, 27 Mar 2026

The article “Aerosol Scavenging in DC3 and SEAC4 RS Deep Convective Storms” by Barth et al., interpret scavenging efficiencies of speciated mass concentrations of aerosols for investigations performed during DC3 and SEAC4RS field experiments on different storms. The studies are in line with the investigations performed by the research group. The results highlight the importance of multi and intercorrelation of dynamics, physics, and chemistry used to interpret processes occurring during thunderstorms. This study add important information on more robust quantification of aerosol scavenging by studying more convective storm than existing research which was limited to a maximum of 3 storms.

Major comments:

Please add information about the dependency on pressure of instrument calibrations. Aircraft measurements handle with vertical distributions and an accurate measurement needs knowledge on the influence of pressure and temperature on measurements. If the instruments were ground base calibrated and measurements were performed at high altitude it could affect the measurements, please comment.

We appreciate the question, it is a legitimate concern. However, while obviously varying ambient pressure is a major challenge in the design of airborne in-situ instrumentation, calibration considerations is just one aspect to take into account. For aerosol measurements in particular, altitude-dependent inlet losses (e.g. McNaughton et al., 2007) and inlet artifacts due to impaction/resuspension (Murphy et al., 2004) are certainly more important to overall quantification.

For the instrument used in this study (customized Aerodyne HR-AMS), a combination of a NCAR HIMIL inlet (Stith et al., 2009) outside the plane and a pressure controlled inlet/interface inside the plane (Bahreini et al., 2008, Guo et al., 2021, Kim et al., 2025) is used to sample the aerosol and analyze it under constant instrument conditions. Hence the calibrations are performed on the ground post-flight. For DC3, these calibrations were very stable (<7% for both absolute and relative sensitivities), showing consistent performance downstream of the inlet. Both Guo et al., (2021) and Kim et al., (2025) discuss the in-depth characterization of the losses in the pressure interface and the inlet plumbing.

The comparisons of the AMS measurements as installed on the NASA DC-8 with other sensors using very different measurement principles and inlets show a consistent performance regardless of altitude (deCarlo et al., 2008); Cubison et al., 2011; Nault et al., 2018; Brock et al., 2019). Since such comparisons have not been published previously for the DC3 campaign, we now include them in the revised paper (L166-175; Figs. S1-S4). The new figures document not only the campaign-wide comparisons of AMS reported species with other sensors, but also comparisons of aerosol extinction and aerosol volume. They all show a consistent aerosol dataset

with high correlations and slopes, with the exception of the absolute magnitude of the reported physical volume from the UHSAS instrument, which likely has a 40% low bias. Figures S2 and S3 specifically look at the Referee's concern about the altitude dependence for the aircraft campaign wide (Fig. S2) and the specific inflow and outflow periods (Fig. S3).

We think that the agreement shown addresses Referee #3's concerns. They should also serve as an additional confirmation of the 17 and 19% stated accuracy figures used in the uncertainty propagation calculation requested by Referee #1.

Even if the study consider zero initial concentration of organic acids it is evident that these concentrations can not be zero. Please comment based on the existing field measurements studies which stated various concentrations of organic acids in the atmosphere, how the model could be affected.

We believe the reviewer is referring to the cloud chemistry parcel model calculations used to determine if aqueous-phase chemistry in the cloud water is contributing to OA concentrations in the outflow region of the storm. We reviewed the literature to find typical values of organic acids that were initialized to zero in the cloud chemistry parcel model. Nah et al. (2018) measured gas-phase organic acids at a rural site in Georgia during September-October 2016. Since these measurements are from the southeastern US and during the same time of year as the SEAC$^4$RS measurements, it seems reasonable to use their findings as guidance here. Their average diurnal profile for the Georgia campaign revealed mid-day formic, acetic, and oxalic acid mixing ratios of 1.3 ppbv, 0.6 ppbv, and 10 pptv, respectively. Glycolic, glyoxalic, and pyruvic acids were not explicitly reported. Adjusting only the organic acid initial mixing ratios to those that were measured and 10 pptv for glycolic, glyoxalic, and pyruvic acids, the cloud chemistry parcel model was integrated again. The results show higher oxalic acid and SOA mass at cloud top compared to the original simulation (which used initial mixing ratios of 565 pptv formic acid, 224 pptv acetic acid, 0 pptv for other organic acids). That is, cloud top oxalic acid as SOA increased from 0.46 µg C std m$^{-3}$ in the original simulation to 0.78 µg C std m$^{-3}$ with the new initial concentrations and total SOA mass at cloud top increased from 2.39 µg C std m$^{-3}$ to 2.58 µg C std m$^{-3}$. This information is added to the manuscript (L610-614), noting that the numbers reported in the submitted paper have been adjusted to report results from the no lightning-$NO_x$ simulation.

Figure 5S represents the scatter plot of pNO3 and the NO3 - fraction of NO3 - + HNO3 for 6 different cases. Excluding the extreme purple dot the outflow linearity change drastically and data became more representative in terms of linearity. Please discuss how this potential exclusion would affect the results.

We believe the reviewer is referring to the purple point where $pNO_3$ = 0.42 µg m$^{-3}$ and $NO_3^-$ fraction is 0.82. The reviewer is correct in that the linearity of the outflow points increases ( $r^2$

value of 0.95 without the outlier). Excluding this point suggests that $pNO_3$ would contain 100% $NO_3^-$ at $pNO_3$ concentrations of 0.26 or greater. However, this does not affect the conclusions that a) the outflow $NO_3^-$ fraction is higher than the inflow $NO_3^-$ fraction or b) the points where $pNO_3$ concentrations are greater in the outflow region than the inflow region have $NO_3^-$ fractions > 0.8. Since the conclusions of the paragraph in the manuscript (L477-488) are the same, no changes have been made to the text.

May you better explain why the aerosols scavenging efficiency differ for all of them (sulfate, ammonium, etc.) during the 18 May 2012 and 2 June 2012 events? It could be an effect of experiment failure?

As discussed above, we do not think the 18 May and 2 June 2012 scavenging efficiencies are a result of experimental failure. Reasons are already discussed in the manuscript. For example, comments about the effect of the mid-troposphere aerosol layer on scavenging efficiency is mentioned for each aerosol component. Further, we mention that $SO_4^{2-}$ scavenging efficiencies may be affected by aqueous-phase chemistry. Likewise, aqueous-phase chemistry can affect OA scavenging efficiencies. We have added comments that the two identified storms have lower CAPE and more shallow warm cloud depths than the other storms and that these factors might affect scavenging efficiencies (L442-445, L448-449, L488-490, L637-639, L660).

Minor comments:

Line 129: better add „using i- to n- ratios of butane and pentane isomers”

Following the reviewer’s suggestion, this has been changed.

Line 148: Faloona et al., 2004 is missing from reference list. Please check all the references in this sub-section. Most probably references from Supplementary information should be added in the list of main article

The Faloona et al. (2004) paper has been added to the reference list and we have proofread the paper again to ensure all citations are in the reference list.

The ACP guidance in the author instructions for the journal is not clear where to place references from the supplementary information. We will follow the guidance of the editor.

Line 379-381: please revise the sentence

It is not clear what the issue is with this particular sentence. It has not been changed.

Line 389: Isn’t there „West”?

Changed

Line 542: „hydroxyacetone”

Line 542 (now L608) writes hydroxyacetone, which, in the literature, is an accepted way to write this compound.

Line 562-563: please add „;" for reference literature separation

Changed

Figure 2 (06 June 2012) pNO3 x 5 is missing

The new figure includes this information.

Please add a short note to table 2S to explain the reason of outflow time representation in the form of e.g. 25:50:00.

A footnote has been added to Table S2.

Please be consistent with the cases representation form „12 June" or „12 June 2012"

We added the year to instances of "day month" not including the year.

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