Response to Reviewer 1

EGUSPHERE-2025-2659

" Implications of Sea Breeze Circulations on Boundary Layer Aerosols in the Southern Coastal Texas Region."

Thank you for the opportunity to submit a revised version of our manuscript. We sincerely appreciate the reviewers' time and effort in providing thoughtful comments, insightful questions, and constructive suggestions. Their feedback has been invaluable in improving the manuscript's clarity, rigor, and overall quality.

Below, we provide a point-by-point response to the reviewers' comments and concerns. Reviewer comments are shown in blue, our responses are provided in black, and the corresponding revised statements in the manuscript are highlighted in *black italics*.

General Comments:

This paper presents an overview of aerosol and (to a lesser extent) meteorological changes associated with the passage of a sea-breeze front at two ARM sites during the DOE TRACER field campaign in the Houston region of SE TX during Summer 2022. WRF-Chem simulations supplement the point-based observational analysis. In general, the paper is largely descriptive (rather than explanatory) of broad changes in aerosols, providing analysis of before/after SBF passage changes. A key finding of the paper is the number and relative frequency of SBF passage events where aerosols increase, decrease, or stay the same during the SBF passage. As a general description of the field project and presumably regional climatology this paper has value. Where the paper lacks is in rigorous scientific investigation of the reasons why there are differences between sites or days that lead to increases vs. decreases in aerosols. The paper also seeks to tie changes in aerosol to changes in cloud microphysics and aerosol indirect and direct radiative effects. While these are interesting questions, there is not much depth to the analysis and it feels rather tacked on, and these topics may be better suited by separate more detailed analysis in other papers. I think a reframing of the paper that provides a detailed analysis of each of the three case study days (July 10, July 17, August 16) where the three regimes are observed that seeks to analyze air trajectories differences in SBF meteorology and timing on these days, and the factors that lead to different antecedent aerosol conditions would be more of more interest.

Finally, two recent papers in the literature focus on very related meteorological (Sharma et al. 2024 https://doi.org/10.1175/MWR-D-23-0243.1) an aerosol changes (Thompson et al. 2025 https://doi.org/10.1029/2025JD043353) in continental and maritime air masses divided by the SBF during TRACER. This may come across as shameless self-promotion since I was involved in both papers, but the analysis here complements those studies nicely since it focuses on analyzing ARM site observations while those papers emphasized TAMU TRACER (Rapp et al. 2024 https://doi.org/10.1175/BAMS-D-23-0218.1) measurements. Where possible, I think this paper should put its findings in the context of the existing literature and provide comparisons/contrasts where appropriate.

Response: We thank the reviewer for these thoughtful and constructive comments. We appreciate your recognition of the descriptive value of the study and your suggestions on how to strengthen the analysis. While the original framing emphasized broad before/after changes associated with SBF passage, we agree that the paper benefits from a deeper exploration of the factors driving site-to-site and day-to-day variability.

We took your concern seriously and revised the manuscript to strengthen the causal analysis behind increases vs. decreases in aerosols. In the revision, we have therefore reframed the manuscript to elaborate on three highlighted case study days (10 July, 17 July, and 16 August), each representing different aerosol response regimes. In addition, we have now included a table that summarizes the total number of SBC events, along with the number and percentage of days exhibiting enhancement, reduction, or neutral influence. This addition provides a clear quantitative summary to support the discussion of event-to-event variability.

We also recognize that aerosol–cloud interactions, indirect effects, and direct radiative forcing are complex topics that could each warrant stand-alone papers. Nonetheless, we believe it is important to include some of these aspects in the present study for these reasons:

The central goal of this work is to investigate the implications of sea-breeze circulations (SBCs) on boundary-layer aerosols and their broader consequences. We believe that integrating measurements with modeling is essential because it strengthens the interpretation of the observed processes and places the local-scale findings into a broader regional context. However, to streamline the manuscript and focus the narrative, in the modified manuscript, we have retained only the CCN-relevant analysis (Section 3.7.1) and removed the aerosol direct radiative forcing (ARF) analysis (Section 3.7.2). The radiative-forcing results will be developed as a separate manuscript, where we can treat methodology, uncertainties, and sensitivity tests in appropriate depth. In this way, the current paper emphasizes the complementarity of observations and modeling without detracting from its central observational focus. In the revised paper we:

- Clarified the limitations of using N_{100} as a CCN proxy and explicitly stated the assumptions.
- Kept the CCN figures (formerly Fig. 11 and related Supplementary Figs.) and emphasized how sea-breeze processes affect the cloud-relevant particle population.
- Removed text, figures, and references specific to ARF from the Abstract, Results, and Conclusions, and added a forward reference noting that a detailed ARF study is recommended.

We believe this change addresses the reviewer's concern while strengthening the focus of the current manuscript on CCN-relevant impacts of SAI.

Finally, we appreciate the references to the recent papers by Sharma et al. (2024), Rapp et al. (2024), and Thompson et al. (2025). We have revised the discussion to place our findings in the context of this literature, highlighting how the ARM-AMF sites-based analysis complements

TAMU-focused studies. In particular, we draw contrasts and comparisons to show how the ARM site perspective provides additional insight into the spatial variability of aerosol and meteorological responses to SBF passage during TRACER.

We believe these changes improve the rigor and relevance of the paper and strengthen its contribution to the growing body of work on sea-breeze–aerosol interactions in southeastern Texas.

Specific Comments

1. (abstract, line 24) The coastal vs. inland categorization of the AMF1 and ANC sites is somewhat misleading. While AMF1 is closer to Galveston Bay, it is about the same distance from the Gulf of Mexico as the ANC site.

Response: You are right, the AMF1 site is at a similar distance from the Gulf of Mexico as the ANC site. However, its proximity to the Galveston Bay allows the propagation of the SB to propagate over water rather than over land before reaching the site. That said, we agree with the suggestion to avoid categorizing the two sites simply as “coastal” vs. “inland”. We have now revised as shown below:

Lines 24-27: “The main site, influenced by both Galveston Bay and the Gulf of Mexico, reflects a stronger marine influence. In contrast, a supplemental site, at a similar shoreline distance but exposed to the Gulf of Mexico and typically upstream of the urban core, samples SB air that has traversed land and partially regained continental characteristics.”

2. (Page 2, line 50) I suggest adding “in the warm season” behind “along coastal regions.”

Response: Added “in the warm season” as suggested. Please refer to *Line 56* in the revised manuscript.

3. (Page 3, line 65) I caution against using the relatively general terms “stable” and “unstable” here to describe the maritime and continental airmasses. While the low-level lapse rates may be more stable on the maritime side, we observed throughout forecasting for the project (and described in Sharma et al. 2024https://doi.org/10.1175/MWR-D-23-0243.1) that conditional instability (CAPE) was often larger on the maritime side of the SBF given the greater moisture in that airmass (similar to MAHTEs described by others, including Hanft and Houston 2018 https://doi.org/10.1175/MWR-D-17-0389.1). I suggest either simply removing these descriptors and leaving it at as “cooler” and “warmer” or adding a sentence or two here to add this nuance.

Response: We have modified the sentence to avoid generalizing the description as “stable” and “unstable”. In addition, we have added a sentence to describe the above-mentioned distinction:

Lines 73-77: "While low-level lapse rates are often more stable on the maritime side of the SBF, the conditional instability (Convective Available Potential Energy-CAPE) is often observed to be greater on the maritime side due to the higher moisture content in that air mass (Hanft and Houston, 2018; Sharma et al., 2024; Boyer et al., 2025)."

4. (Page 4, Line 124 and throughout) Here the main site is referred to as coastal, and while it is coastal in the sense that it is very close to Galveston Bay, it is not much closer to the Gulf of Mexico coast than the ANC site. This should be clarified here and elsewhere were appropriate. More generally in the introduction, I think some distinction between air masses and SBCs associated with Galveston Bay vs. the Gulf of Mexico should be described. The SBFs associated with each body of water are often distinct at the onset of the SBF, but become more merged later in the afternoon/evening. There is likely considerable meteorological heterogeneity and aerosol variability within the maritime airmass that is heavily modified by Galveston Bay as compared with one only sourced over the Gulf of Mexico.

Response: We agree with the reviewer's observation. While the main site is indeed coastal in the sense that it is located very close to Galveston Bay, it is not closer to the Gulf of Mexico coast than the S3 site. We have clarified this in the revised manuscript by specifying the site's proximity to Galveston Bay rather than broadly referring to it as "coastal."

We have now revised the manuscript to include the above details wherever appropriate; some examples are shown below:

Lines 187-190: "Although both the M1 and S3 sites are a similar distance from the Gulf of Mexico, the M1 site is located near the western shore of Galveston Bay. This urban M1 site may experience different sea-breeze timing because of its location, the added influence of the Galveston Bay breeze, and urban heating that alters local circulations."

Lines 482-491: "The M1 site is influenced by the air masses and SBCs from both sources, whereas the S3 site is affected predominantly by those originating from the Gulf of Mexico. As discussed in detail by previous studies (Sharma et al., 2024; Wang et al., 2024), the SBFs originating from Galveston Bay and the Gulf of Mexico are often distinct at onset but tend to merge later in the afternoon or evening. Due to the M1 site's proximity to Galveston Bay, it is more directly influenced by maritime air masses that are heavily modified by Galveston Bay as the SBF originating from the Gulf of Mexico traverses the Bay. On the other hand, the Gulf-originating SBF must cross land before reaching S3. The difference in SBF pathways can lead to notable meteorological and aerosol contrasts between the two sites."

5. (Section 2.1) A few points that should be included in the description of the M1 and S3 sites: While the text accurately describes M1 as "urban" I would also suggest discussing the concentration of heavy industry surrounding the M1 site, which one might expect to lead to aerosol populations above and beyond the typical "urban" air mass. Conversely, while S3 is relatively removed from the Greater Houston area pollution, with a typical SSE wind direction, it is still downstream of some heavy industry on the SE TX coastline in the vicinity of Freeport and Lake

Jackson (as Figure 2b hints at, there are still some anthropogenic sources upstream of S3). Thus, S3, though rural may not always be expected to be as pristine as a typical rural site.

Response: Section 2.1 is now modified to include the above suggestions:

Lines 190-201: "The M1 site is expected to be strongly influenced by anthropogenic activities due to its proximity to the Houston urban core, large-scale industrial complexes and the HSC. The HSC is lined with dense clusters of industrial facilities, including major petrochemical complexes (Yoon et al., 2021), which can contribute to aerosol populations beyond those typically associated with an urban environment. Similarly, the Texas A&M University (TAMU) TRACER measurements also showed that short-lived ship emissions contributed to high aerosol concentrations (up to 34,000 cm^{-3}) (Rapp et al., 2024; Thompson et al., 2025). The S3 site, while relatively less impacted by the emissions from the Greater Houston area, is not representative of a pristine rural location in terms of aerosol loading. Under typical south-southeasterly wind, this S3 site is located downstream of heavy industry along the southeast Texas coastline (Freeport, TX and Lake Jackson, TX) and can be influenced by upstream anthropogenic sources (Fig. 2b)."

6. (Page 7, Line 197) Please discuss the timing of the "simulations" in more detail. Was one simulation begun at the beginning of the 2 month period and run for 2months, or were daily simulations initialized at some fixed time for each day in that period? If so, what times, and how long was accounted for model spin up for the WRF domain before using the results? How often were the boundary conditions and emission sources updated?

Response: We have expanded the model description section to address the questions above.

Lines 268-291: "The model simulations were performed for the period from 1 July to 30 August 2022, using a 5x5 km horizontal grid spacing with 45 vertical layers. A model spin-up time of 3 days was used, and the restart files were used for the remainder of the simulations. Initial and boundary conditions for meteorology were provided by the North American Mesoscale (NAM) model every 6 hours. The model configuration was successfully set-up and is considered sufficient to resolve the key meteorological processes relevant to the aerosol chemistry examined in this study. To validate this assumption, simulated meteorological fields and aerosol variabilities are compared against observations. Similar model setups have been successfully applied in previous WRF-Chem studies over the continental US (e.g., Berg et al., 2015; Wang et al., 2021; Subba et al., 2023; Shrivastava et al., 2024), which demonstrate their suitability for representing aerosol-cloud interactions. The details of the configurations are shown in Table 2.

The model simulations were performed with (with aerosol-WA condition) and without (no aerosol-NA condition) full aerosol-gas chemistry, and land-atmosphere interactions enabled. Boundary conditions for gas-phase species and aerosols were provided by the Whole Atmosphere Community Climate Model (WACCM) (Gettelman et al., 2019). The WACCM output datasets, available on a horizontal grid resolution of 1°×1° were spatially interpolated to our model domain every 6 hours. Biogenic emissions were generated online by WRF-Chem model based on meteorology and land use data, using the Model of Emissions of Gases and Aerosols from Nature version 2.1 (MEGAN2.1) by Guenther et al. (2012). The U.S. Environmental Protection Agency

National Emission Inventories (NEI, Ma and Tong, 2022) was used to provide anthropogenic emissions of trace gases and aerosols from diverse sources, including point, area, on-road mobile, non-road mobile, and other sectors. These emissions are incorporated to WRF-Chem at hourly intervals."

7. (Page 7, Line 214) The word "feasible" here is vague/unclear. What is meant by feasible? Close enough to trust and use? If so, what criteria were used to judge this? To my eye, it looks like the model significantly under predicts the diurnal temperature cycle (meaning it is likely to also struggle handling the SBC, and it also over predicts the wind speeds during calm periods (presumably night time). I understand that this paper is more focused on the model performance as related to aerosols (which is described in some detail later in this paragraph), but since the hypothesized mechanism for variability in aerosols (the SBF) is after all a meteorological phenomenon, I think a more detailed discussion of the model's meteorological skill is needed.

Response: We appreciate the reviewer's observation. The purpose for these simulations is to provide a physically-reasonable approximation of the meteorological and aerosol environments across the southern Texas region that are not captured by point measurements during TRACER.

By "feasible", we intended to convey that the model's performance is within an acceptable range of our application. We have now replaced "feasible" with "adequate agreement for the purposes of this study".

Specifically, we assessed model performance using the metrics, mean bias (MB), root mean square error (RMSE), correlation coefficient (R) for temperature, wind speed, and wind direction. In addition, we also implemented widely applied MERRA-2: Modern-Era Retrospective analysis for Research and Applications to compare these meteorological variables to assess the performance of the model simulations. The model reproduces the measured temperature diurnal cycle at both the sites with high correlation (r up to 0.87) and low MBE ($<\pm 1$ ℃). Wind speed and wind directions show weaker correlation (r up to 0.65) and MBE of 0.76 m s^{-1} and 12.5°, respectively. Individual SB days are further analysed to compare the measured and modeled variables in later sections. These changes are now added in the modified manuscript:

Lines 303-313: "The simulated meteorological time series show adequate agreement for the purposes of this study at both sites (Fig. S1). We assessed model performance using metrics: mean bias (MBE), root mean square error (RMSE), and correlation coefficient (R) for the quantities of temperature, wind speed, and wind direction. In addition, we also considered Modern-Era Retrospective analysis for Research and Applications (MERRA-2) reanalysis products to further evaluate the model performance (Geralo et al., 2017). Our model reproduces the measured temperature diurnal cycle at both sites with high correlation (r up to 0.87) and low MBE (<±1 ℃). Wind speed and wind directions show weaker correlation (r up to 0.65) and MBE of 0.76 m s-1 and 12.5°, respectively. Individual SBF events are further analysed to compare the measured and modeled variables in later sections."

Lines 530-535: "In Fig. S6, we supplement these discussions with displays for the temporal variation of measured and model-simulated meteorological properties for this event. Both sites *suggest the typical temperature decreases and surface wind speed increase associated with the SBF reaching the site. The wind direction changes from east to south at the M1 site and from southwest to south at the S3 site."*

8. (Page 8, Lines 243-245) The authors state that the two sites have a statistically significant difference, but in what sense? Is every meteorological variable statistically different between the sites, or in the whole? Is the important difference in the magntudes of the variables or in their diurnal cycles? It's not clear what these differences actually are or why it's relevant that they are meteorologically distinct.

Response: We thank the reviewer for this comment and agree that clarification is needed. In our analysis, the statement that the two sites have a statistically significant difference refers to the difference in the mean values and the diurnal patterns of key meteorological variables, including temperature, wind speed, and wind direction.

Lines 330-360: "Comparisons between the background summertime meteorology around the TRACER sites help to identify the underlying factors that may influence the aerosol transport and transformation processes. Fig. 4. shows composite averaged diurnal variations of meteorological properties during the IOP period. When comparing meteorological variables between M1 and S3 sites, paired t-test results calculated a very low p-value (<0.0001) and a large negative or positive t-statistic, indicating a statistically significant difference. M1 exhibits higher temperatures during the cooler parts of the day (early morning) and slightly lower temperatures during the warmest parts of the day (early afternoon). w at M1 is slower during the warmer periods and higher during the cooler periods of the day. At both sites the value stays near 17-18 g kg^{-1} for most of the day, with a common moistening pulse around 13:00-15:00 UTC that coincides with increased wind speed. At similar hours, the wind directions are similar at both the sites. Except in the morning, winds at M1 are typically 1-2 m s^{-1} stronger than at S3. The M1 site shows an increase in w near 20:00 UTC, likely tied to the SBC. S3 exhibits a larger shift in the wind directions compared to that of M1. The two sites have similar directions during the late night (00:00- 05:00 UTC) and early morning (13:00-15:00 UTC) hours. During the dominant afternoon SBC period (around 20:00 UTC), winds are predominantly from the southeast at M1 and from the southwest at S3.

Although these sites are geographically close, their different proximities to water bodies and varying land cover types may account for the observed meteorological variations, such as differences in temperature modulation, humidity, and breeze development. M1 lies adjacent to both Galveston Bay and Gulf of Mexico, thus nearby water moderates temperature and promotes higher humidity, favoring sea- or bay- breeze circulations. In contrast, although S3 is at a similar distance from the Gulf as M1, it is more inland, separated from the shoreline by an intervening expanse of land, so it experiences stronger daytime heating and a weaker, more modified marine influence than M1. It has a land surface covered predominantly with vegetation and soil that cools faster at night than urban landscapes. However, urban landscapes retain heat, remaining warmer into the nighttime and potentially moderating temperatures during the subsequent daytime (Maria et al., 2013). These behaviors are consistent with the prior studies showing the coastal sites experienced moderate temperature and enhanced humidity (Hu, 2021; Subramanian et al., 2023), and that land-use influenced local temperature and boundary layer dynamics via evapotranspiration and surface heating (Fang et al., 2025)."

9. (Page 8, Lines 247-249) The authors say that "the opposite trend is observed for RH" which is true in the strictest sense, but for a constant amount of absolute moisture, the differences in RH are consistent with the differences in temperature between sites (RH for constant vapor pressure or dewpoint is lower when it is warmer and higher when it is cooler). Because RH depends on both temperature and moisture, I suggest that the authors use an absolute measure for moisture like vapor pressure, mixing ratio, or dewpoint temperature instead of RH. This temperature dependence of RH may obscure moisture changes associate with the diurnal SBC cycle.

Response: We thank the reviewer for this observation and agree that RH is influenced by both temperature and moisture, and that the difference in RH between the sites can be partially attributed to the corresponding temperature difference. Our intent in stating "the opposite trend is observed for RH" was to note the qualitative relationship between RH and temperature in the context of site-to-site differences. We acknowledge that variables such as vapor pressure, mixing ratio, or dewpoint temperature would provide a better measure of moisture. Considering this we have used the water vapor mixing ratio from measurements to understand the change in the moisture during the propagation of the SBF. For this section, we have now revised the statement as shown below:

Lines 335-343: "M1 exhibits higher temperatures during the cooler parts of the day (early morning) and slightly lower temperatures during the warmest parts of the day (early afternoon). w at M1 is lower during the warmer periods and higher during the cooler periods of the day. At both sites the value stays near 17-18 g kg^{-1} for most of the day, with a common moistening pulse around 13:00-15:00 UTC that coincides with increased wind speed. At similar hours, the wind directions are similar at both the sites. Except in the morning, winds at M1 are typically 1-2 m s^{-1} stronger than at S3. The M1 site shows an increase in w near 20:00 UTC, likely tied to the SBC. S3 exhibits a larger shift in the wind directions compared to that of M1."

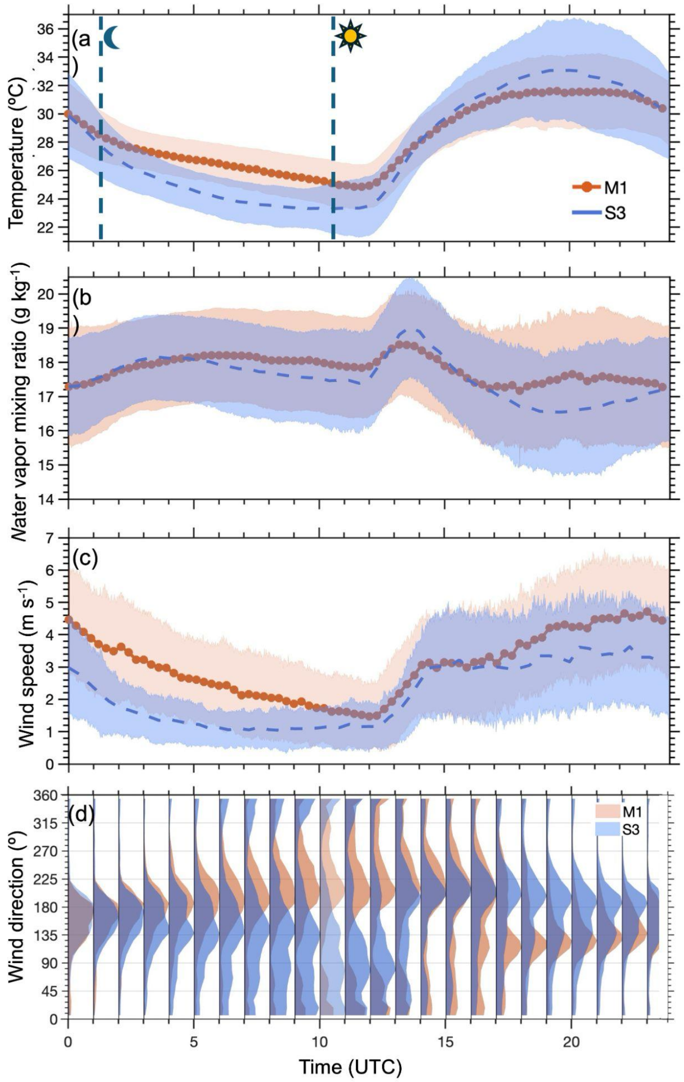


Figure 4. *Diurnal variation of meteorological variables (a) Temperature at 2 m, (b) water vapor mixing ratio (w) (c) wind speed at 10 m sites averaged during IOP, and (d) wind direction waterfall diagram at 10 m measured at M1 (in orange) and S3 (in blue). The shaded color represents the standard deviation from the mean.*

10. (Page 9, Lines 261-269) This paragraph largely describes methodology for identifying SBC from a prior paper that is used later in the analysis of this paper. Some or all of this text is more relevant in the data/methods section. It does bring to mind several relevant questions that this section could/should seek to answer, including: does the SBC have a notable effect on the observed surface meteorological variables at each site? Is this affect more pronounced at one site vs. another? What time does the SBF typically pass each site? There may be some hints of this in Figure 4, and since the paper is motivated by the effects of the SBC on aerosols it seems relevant to me to also analyze/discuss the effects of the SBC on the surface meteorology in this section where possible. Particularly relevant to the later aerosol discussion is addressing the questions of: Is the diurnal meteorological cycle distinctly different on days with a SBC than without (it seems

like Figure 4 includes all days regardless of if they feature a pronounced SBC)? This is important, because some of the observed aerosol changes could be diurnally forced rather than SBC forced. For example, as the surface temperature warms in the afternoon vertical mixing may increase which could lower aerosol concentrations independent of the SBC, which may confound later results that are attributed to the SBC. Alternatively, the diurnal inertial oscillation in the flow could affect aerosol variability without a SBC.

Response: We agree that some of the methodological description of how SBCs are identified is better suited for the Data and Methods section. We have moved portions of this text accordingly (*Lines 238-247*) to improve clarity and organization.

We agree that clarifying the extent to which SBCs influence surface meteorological variables provides important context. In the revised manuscript, we now include additional details describing how SBCs affect temperature, water vapor mixing ratio, and wind speed/direction, (Section 3.3.). This addition explicitly links the meteorological changes with subsequent aerosol variability. We have expanded the discussion to note that the M1 site, influenced by both bay and Gulf breezes, typically experiences earlier frontal onset and stronger fronts compared to S3, which is only influenced by the Gulf breeze. This site-to-site variability is now explicitly described (Sections 3.1 and 3.3). We have clarified in the revised text that M1 tends to experience earlier frontal onset due to bay-breeze influence, while S3 exhibits later passages. This point is now explicitly stated in the discussion of SBC variability:

Lines 248-252: "Overall, Wang et al., (2024) found that the SBF typically arrived at the M1 site at 20:30 UTC (i.e., 15:30 LT), and at the S3 site at 20:50 UTC (i.e., 15:50 LT). The M1 site, situated along the western shore of the Galveston Bay, was also influenced by bay breeze circulations, frequently resulting in an earlier shift in the local meteorological state compared to that of the S3 site (only influenced by the Gulf SBC). The M1 site was shown to experience an additional bay breeze contribution during 22 out of 43 SBC events."

We appreciate the reviewer noting the potential for misinterpretation. We have clarified in both the figure caption and main text that Figure 4 shows average diurnal cycles across all days, not just SBC days, and therefore does not isolate SBC-specific meteorological responses.

Lines 332-333: "*Fig. 4. shows composite averaged diurnal variations of meteorological properties during the IOP period.*"

We agree this is an important point, as some aerosol changes could arise from diurnal forcing rather than SBC passage. While a full comparison of SBC vs. non-SBC diurnal cycles is beyond the scope of this study, it has been previously studied extensively. We also reference prior work (Wang et al., 2024) that provides detailed analyses of SBC impacts on diurnal meteorological cycles. We also agree with the reviewer that processes such as enhanced vertical mixing from surface heating or inertial oscillations in flow could influence aerosol variability independent of SBCs. We have added text acknowledging these potential confounding factors, emphasizing that while SBCs are a major driver, other diurnal processes may also contribute to aerosol variability.

These changes are implemented here:

Lines 253-262: "Wang et al. (2024) also reported that M1 experienced higher intensity changes in the meteorological conditions associated with these SBFs as compared to S3, particularly when the background wind directions are southwesterly or westerly. At both the sites, these SBF passages were associated with a significant increase in water vapor mixing ratio and wind speed, along with a decrease in surface temperature. The arrival of the fronts also typically increased the vertical wind speed within the boundary layer, with a mean speed of up to 2 m s^{-1} within the lowest 1 km. The enhanced updrafts associated with SBF low level convergence also was shown to promote short lived-isolated convective clouds and likely associated with vertical mixing of aerosols by diluting near-surface concentrations and redistributing aerosols aloft."

11. (Page 10, lines 286-296) The percentages listed in this paragraph do not match those shown in Figure 5c. Since this figure is not cited here, it is not clear if they should match or if the statistics listed here are computed differently than in the figure. If this is an error, please correct. If it is intentional, please explain why the listed percentages should not match the pie charts.

Response: Thank you for pointing out the error, we have corrected it in the revised manuscript:

Lines 374-377: "The ACSM observations suggest a similar percentage contribution from various species, with organics having the highest concentration (59.2% at M1 and 53.0% at S3), followed by sulfate (23.3% at M1 and 30.6% at S3), ammonium (11.4% at M1 and 10.8% at S3), nitrate (5.2% at M1 and 5.0% at S3) and chloride (less than 0.9% at M1, and less than 0.6% at S3)."

12. (Page 11, first paragraph) While this paragraph is a nice summary of the possible changes on a local/regional airmass' aerosol, one key possibility is missing that should be included. Since much of the analysis relies on point measurements at the S3 and M1 sites, it's possible that small wind shifts caused by the SBC could lead to very large aerosol changes if the wind shift causes the upstream trajectories to shift away from or towards a very local emissions source. This is a highly localized effect that would lead the point observation sites to be less representative of the overall airmass. The authors somewhat account for this by including WRF simulations to fill in the gaps with approximate aerosol states, but this possibility should be mentioned here, and throughout when one of the site measurements could be unrepresentative of the larger airmass.

Response: We agree with the reviewer that this is a highly localized event, and M1 and S3 measurements may not always be representative of a broader airmass or regional conditions. Indeed, small-scale wind shifts associated with the SBC could lead to substantial changes in aerosols concentrations if local sources are intermittently upwind of the measurement sites. To address these limitations, as the reviewer correctly pointed out, we have incorporated WRF-Chem simulations, which will help provide a regional context and assess the broader impact of the SBC on aerosol distributions.

We have now revised the paragraph to explicitly acknowledge the possibility of localized source influence and clarify that the WRF-Chem modeling was used in part to bridge this spatial representativeness gap. Similar clarifications were added in other relevant sections where point measurements are interpreted.

Lines 422-426: "Finally, TRACER site measurements may not always be representative of a broader air mass or regional conditions (e.g., intermittent local source interactions with smaller-scale SBC features). WRF-Chem modeling may help to bridge these spatial representativeness gaps and provide reference for the regional context of the potential impact of the SBC on aerosol distributions."

Lines 695-698: "The model simulations supplement the observations by filling observational gaps and enabling the extrapolation of findings across a broader regional scale, an endeavor that would be challenging to achieve with limited in-situ observational sites or standalone models."

13. (Page 12, lines 353-355) Please provide some explanation for why +/- hour was selected as the before and after times. Is this because, as in the stated example that most enhancement or reduction effects last at least one hour? Or was some other criteria used for this selection?

Response: Thank you for the question. The choice of a 1-hour window is based on the observation that most of the enhancement or reduction effects are most pronounced during the first hour following the passing of the SBF. For instance, the normalized changes in aerosol number concentration (Figures S2 and S3) show a sharp shift within the first hour. In addition, please refer to the representative cases shown in Figure 6. Beyond the first hour, the observed variations are likely influenced by additional processes, such as secondary effects of meteorological transitions induced by the SBF, as well as changes in direct aerosols or precursor emissions from both local or regional sources. Moreover, the intensity of the SBF's influence typically dissipates or becomes less distinct after the first hour. There were no additional criteria applied in selecting this time frame. These clarifications have been added to the revised manuscript:

Lines 445-453: "Considering all the SBF passages we collected (Figs. S2 and S3), we suggest $\Delta T = TSBF \pm 1$ hr often best represents the "before" ($\Delta T- = TSBF - 1$ hr) and "after"- SBF ($\Delta T+ = TSBF + 1$ hr) times over a location. The enhancement or reduction effects are most pronounced during the first hour following the passing of the SBF. Beyond this period, the observed changes may be influenced by additional factors, such as the secondary effects resulting from meteorological transitions induced by the SBF. Additionally, the intensity of the SBF's impact may begin to weaken or become less pronounced after the first hour. With that assumption, a percentage change of the aerosol number concentration [(after-before)/before x 100%] can be further calculated."

14. (Page 12, lines 359-366) The percentages in parentheses (60% and 34% of SB days with a change in aerosol concentration) is somewhat unclear in the first sentence here Does this mean that 40% and 56% of SB days would be considered "neutral influence" days? It's also not clear if the total SB days are the same at each site. Some of this information is discussed later in this paragraph but it's a bit hard to decipher. I think that supplementing or replacing some of this text with a table showing the number and percent of SB days at each site showing the total, number with an enhancement, number with a reduction, and the neutral days would be helpful here. Moreover, the average aerosol change is stated for each site during SB days, but it's not clear if

this includes the neutral days with the enhancement/reduction days or only the latter. On line 368 the authors state that neutral days aren't included in the analysis, yet later in this paragraph they state the number of neutral days at each site, which leaves some ambiguity on which statistics include neutral days and which don't. This should be clarified. It also seems to mask the characteristic aerosol concentration for each regime (enhancement or reduction) by averaging them together. It would be more useful to show the average change of the enhancement and reduction days separately for each site. As is currently presented, the enhancement and reduction day concentration changes partially cancel each other out, so the "typical" change in each regime (likely a larger percentage change) is masked.

Response: We appreciate the reviewer for these comments and questions. We have now revised the statements as shown below:

Lines 458-466: "Out of 46 SBC events at the M1 site, 29 events (~63%) showed an enhancement or reduction influence on total aerosol number concentration, while the remaining 17 events (~37%) were classified as having a neutral influence. In contrast to M1, at the S3 site, out of 30 SBC events, only 12 events (~40%) exhibited a detectable change in aerosol number concentration, with the remaining 19 days (~60%) considered neutral. At the M1 site, reduction events (16 events) slightly outnumbered enhancement events (13 events). In contrast, at S3, enhancements (8 events) were twice as common as reductions (4 events). This opposite pattern underscores the site-dependent nature of the sea-breeze influence."

We agree that this information could be better presented in a summary table, so we have now included a supplementary table showing the total number of SBC events, along with the number and percentage of days showing enhancement, reduction, or neutral influence.

*"**Table 1**: Summary of SBC influence on aerosol number concentration at the M1 and S3 sites. Events are classified into enhancement, reduction, and neutral categories.*

Site	Description	Combined	Enhancement	Reduction	Neutral
M1	Days (fraction of the total events %)	46 (total SB events)	13 (28 %)	16 (35 %)	17 (37 %)
	Concentration change (after - before) %	-23 (all enhancement + reduction events) -7 (total number of events)	+55	-42	-11
S3	Days	30 (total SB events)	8 (27 %)	4 (13 %)	18 (60 %)

Concentration change (after - before) %	+9 (all enhancement + reduction events) +3 (total number of events)	+64	-45	-10

Again, we appreciate the reviewer's comments. To avoid confusion, we have removed the statistics that include neutral days, and now only present results based on days showing either enhancement or reduction. Clarifications have been made in the relevant section to specify that neutral days are excluded from all statistical summaries (*Line 457-458*). We have now included a discussion on the average changes on enhancement and reduction days separately for each site, to avoid partial cancellation when estimating the net change, as shown below.

Lines 467-476: "During enhancement days, the M1 site shows an average increase in aerosol number concentration of ~ 55%, rising from 3.8x 10^3 cm^{-3} during ΔT- to 5.9x 10^3 cm^{-3} during ΔT+. In contrast, during the reduction days, the concentration decreases by ~ 42%, dropping from 13.2x 10^3 cm^{-3} during ΔT- to 7.6x 10^3 cm^{-3} during ΔT+. At the S3 site, the average changes are ~64% (from 2.4x 10^3 cm^{-3} during ΔT- to 3.9x 10^3 cm^{-3} during ΔT+) enhancement and ~45% (from 4.9x 103 cm-3 during ΔT- to 2.7x 10^3 cm^{-3} during ΔT+) reduction. When averaged across all events, the aerosol number concentration at M1 shows a net decrease of ~23%, from 8.9x 10^3 cm^{-3} during ΔT- to 6.8x 10^3 cm^{-3} during ΔT+, while S3 exhibits a net increase of ~9%, from 3.2x 10^3 cm^{-3} during ΔT- to 3.5x 10^3 cm^{-3}. These contrasting trends underscore the regional variability in aerosol responses associated with SAI events."

15. (Page 12, lines 368-370) I'm glad that the authors differentiate between the Galveston Bay Breeze and the Gulf of Mexico Sea Breeze front here, which will be familiar to TRACER participants, however, as stated in an earlier comment, it would be good to mention some of these particulars earlier in the manuscript when describing the sites and the local meteorology. Moreover, I also suggest discussing how the maritime air masses behind each front may be different (Sharma et al. 2024 describe some meteorological differences), and also atypical for maritime airmasses. For instance, the recently published paper by Thompson et al. 2025 https://doi.org/10.1029/2025JD043353 shows that the "maritime" airmass near Galveston, TX is often heavily polluted compared to the typical maritime airmass, such that a bay breeze passage transitioning to a maritime airmass heavily modified by industry and shipping along Galveston Bay might not be that surprising if it often enhances the aerosol concentration rather than decreasing them.

Response: We appreciate and agree with the reviewer's comments on the importance of properly characterizing two types of frontal passage over the southern TX region. Please also refer to our responses for comments 1, 3 and 4. In the last paragraph of section 2.2, we have now included a description of the characteristics of Galveston Bay Breeze and the Gulf of Mexico Sea Breeze front, and how they would influence the maritime airmass. We have also incorporated a discussion of how these maritime air masses can vary, drawing on the recent findings of Sharma et al. (2024) and Thompson et al. (2025).

Lines 484-495: "As discussed in detail by previous studies (Sharma et al., 2024; Wang et al., 2024), the SBFs originating from Galveston Bay and the Gulf of Mexico are often distinct at onset but tend to merge later in the afternoon or evening. Due to the M1 site's proximity to Galveston Bay, it is more directly influenced by maritime airmasses that are heavily modified by Galveston Bay as the SBF originating from the Gulf of Mexico traverses the Bay. On the other hand, the Gulf-originating SBF must cross land before reaching S3. The difference in SBF pathways can lead to notable meteorological and aerosol contrasts between the two sites. In addition, as observed by Thompson et al. (2025), the maritime air masses near Galveston can deviate significantly from typical clean maritime conditions. As a result, bay breeze passages may not always lead to cleaner air but can, in fact, be more polluted. The consequences of this increased aerosol concentration in the modified maritime air mass are reflected in the enhancement aerosol response observed at the M1 site."

16. (Page 10, last paragraph, Page 13, first paragraph). A bit more description of how NPFs are identified from the data is needed here. For instance, it's not obvious to me from Figure S4 why this event is clearly a NPF event rather than simply representative of aerosol increases through transport/advection. Also, on Page10, the authors state there are more NPF events during the period than stated on Page 13, where only 11 events are stated to have occurred. Please correct/clarify. There is also some unclear wording in the NPF paragraph on Page 13. The authors state there were 11 NPF events on SB days, only 5 of which showed changes in the NPF characteristics during the SBF passage. However, later in this paragraph the authors state "the cleaner air mass trailing the SBF passage led to a sharp reduction in the aerosol number concentration" as a general statement without clarifying how often this occurred, which implies to me that the SBF always leads to a reduction in aerosol number after passage on a NPF day… but this is at odds with the beginning of the paragraph. Please clarify the text with more specificity.

Response: We thank the reviewer for these thoughtful comments and helpful suggestions. We have revised the manuscript to provide additional clarification on how NPF events are identified in our analysis. Specifically, we now state that NPF events are characterized by the sudden appearance of nucleation mode particles ($D_p < 25$ nm) followed by their continuous growth to larger sizes, forming the characteristic "banana-shaped" pattern in the aerosol number size distribution (Dal Maso et al., 2005).

Regarding the number of NPF events, we have corrected and clarified the text for consistency across the manuscript. We now clearly state that a total of 11 NPF events occurred on SB days, of which 5 showed clear changes in NPF characteristics associated with the passage of the SBF.

Finally, we have revised the wording in the relevant paragraph on Page 13 (original manuscript) to avoid overgeneralization. Instead of implying that all SBF passages lead to post-SBF reductions in aerosol concentrations, we now explicitly state that such reductions were observed only in the subset of cases (5 out of 11) where the cleaner air mass trailing the SBF directly influenced ongoing NPF events. This ensures that our interpretation is both accurate and specific.

These modifications have been incorporated into the updated manuscript for clarity and consistency.

Introduction-

Lines 47-54: "One such process is new particle formation (NPF), which is a common aerosol microphysical process that impacts the overall aerosol number concentration (Kulmala et al., 2004; Kerminen et al., 2005; Kuang et al., 2008; IPCC 2013). NPF events typically include a sudden burst of aerosols, i.e., the nucleation of gas molecules and formation of stable clusters of diameters 'Dp' > 2 nm, followed by subsequent growth, firstly to a size range with Dp > 50 nm and possibly growing to a size where the particles can act as a CCN (Dp > 100 nm) (Yu and Luo, 2009; Kerminen et al., 2012; Gordon et al., 2017)."

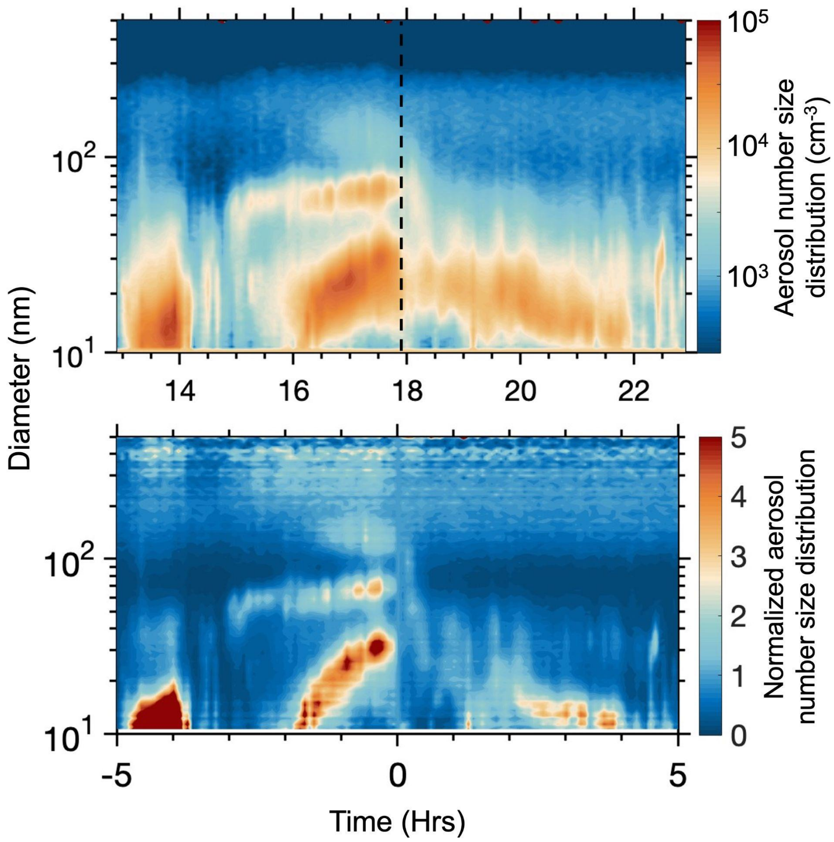
Section 3.2.-

Lines 381-395: "The NPF events are identified by analyzing the aerosol size distribution measured by the SMPS (Kuang et al., 2008; Dal Maso et al., 2002; Mikkonen et al., 2011). This is accomplished by designating characteristic features for NPF found in the size distribution behaviors in time, including the appearance of the nucleation mode at a diameter (Dp) < 25 nm, followed by distinct growth pattern (where the particles increase in size over several hours) forming the characteristic "banana-shaped" pattern in the aerosol number size distribution. NPF events were common at both the M1 and S3 sites. During summertime, NPF events were identified at both the M1 and S3 sites, finding 23 and 17 events, respectively. In approximately 35% of cases, NPF events were observed simultaneously at the sites, implying a regional-scale behavior. These regional NPF nucleation modes appear at Dp < 25 nm and grow consistently across a broader region, covering a minimum radius of tens of kilometers. However, these simultaneously-occurring NPF events displayed different characteristics in terms of their duration and growth, hinting at the possible influence of mesoscale to larger-scale meteorological controls on these processes (such as SBCs), the background aerosol concentration and/or the availability of necessary precursors."

Section 3.3.-

Lines 496-505: "SAIs can also interfere with NPF events. On SB days, a total of 7 NPF events were observed at the M1 site and 4 at the S3 site, with 3 occurring simultaneously at both sites. Among these, 45% (5 out of 11) events showed distinct changes in NPF characteristics during the SBF passage. For example, on 16 July an NPF event was observed at M1 prior to the SBF (Fig. S4). With the arrival of the SBF, particle growth abruptly ceased, and the elevated particle concentration (~14 e3 particles cm-3) rapidly decreased to ~5 e3 particles cm-3 (Fig. S4). The normalized aerosol size distribution further shows that the NPF activity evident in the hours before the SBF period (ΔT-=TSBF - 1 hr) disappeared in the hour following the SBF (ΔT+=TSBF + 1 hr). The low aerosol concentration air mass trailing the SBF passage thus led to a sharp reduction in the aerosol number concentrations in the after-SBF period."

Supplementary material-



***"Figure S4.** Aerosol number size distribution at the M1 site during an NPF event on 16 July 2022. (Top panel) Time series of measured aerosol number size distribution (cm^{-3}). The vertical dashed line marks the passage of the SBF (T_{SBF}). (Bottom panel) Normalized aerosol number size distribution (relative to aerosol number size distribution at T_{SBF}, i.e., T=0)."*

17. (Page 13, lines 388-392) This discussion seems to be at odds with earlier analysis. Here it's stated that "this transition" which the earlier sentence implies is an overall wind shift towards faster winds and a more SE direction after the SBF is "consistently accompanied by a reduction in aerosol concentrations" however, earlier in the paper the authors state that the M1 site had 16 events with a reduction and 13 events with an enhancement in aerosols, which is anything but a consistent reduction! Please clarify or adjust the text to be more consistent with earlier analysis.

Response: In response to Comment 18, we have modified Figure 7 (formerly Fig. 6b in the previous manuscript) and revised the corresponding paragraph accordingly. Please see our response to Comment 18.

18. (Page 13, line 394) The authors state that the S3 site responds "similarly" to the M1 site, but I don't really see the similarity at all. The M1 site more often (though not consistently) has a

decrease in aerosol concentration after the SBF, but the S3 site more often has an increase, and the average change is positive at S3 but negative at M1 (as discussed on Page 12). This analysis (showing the aerosol concentration with wind direction and the shift in winds before/after SBF passage) seems designed to explain why the S3 and M1 are different, not similar, yet there is no detalied discussion/analysis of these differences. I think this analysis/discussion could be improved with a more specific analysis of pre/post SBF wind direction and aerosol concentration at each site on days when there is an enhancement vs. reduction. This would seem to be more valuable/important than the current decomposition by month shown in the supplemental figure.

Response: Thank you for this helpful comment. The similarities exist in the meteorological aspects. We agree that our original wording overstated the similarity between the two sites and that the responses at M1 and S3 are in fact distinct. As you point out, M1 more often shows decreases in aerosol concentration following SBF passage, while S3 more frequently shows increases, with the mean change being negative at M1 and positive at S3. We have revised the text to clarify this distinction and expand the discussion to better highlight the differences in site response. Please refer to the response to comment 14 for this part of the comment.

In addition, following the comment of the reviewer, we have incorporated pre-/post-SBF analysis of wind direction and aerosol concentration at both sites, separated into enhancement and reduction cases, to more explicitly address how wind sector influences these changes. This will replace Figure 6b (in the previous manuscript) with Figure 7 (in the current manuscript), which we agree is less informative than the directional breakdown you suggest. We have modified the lines 384-396 (previous manuscript) accordingly as shown below:

Lines 506-525: "The open-air polar plots summarize the relationship between aerosol number concentration, wind speed and wind direction within ΔT= TSBF±1 during enhancement and reduction events (Fig. 7). At M1, enhancement events reveal elevated aerosol concentrations when the prevailing winds emanate from the east and southeast, where the airmass is influenced by industry and shipping along Galveston Bay. During the reduction influence the pre-SBF aerosol loading is higher compared to that of the reduction events. These high concentrations are associated with the influence from the Houston urban core in the northwest and the other influences from the east as mentioned above. These are also apparent in the monthly plots shown in Fig. S5. After-SBF winds, particularly from the southeast and south, are associated with markedly lower aerosol loads, indicative of cleaner marine air intrusion.

Meanwhile at S3, enhancement scenarios also manifest somewhat higher concentrations when winds shift southeastward, though to a lesser extent, reflecting rural aerosol dynamics. In reduction scenarios at S3, aerosol levels decrease most notably under southerly and southwest flow, reinforcing the interpretation that sea breeze incursions generally replace continental aerosol-laden air with cleaner marine air at both sites, albeit with stronger source influence at M1. This wind-direction-dependent concentration pattern aligns with previous findings: northwesterly to easterly winds bring continental aerosols, while southerly to southwesterly flows usher in marine-influenced clean air that modulates aerosol number concentrations (Levy et al., 2013; Pinto et al., 2014). However, as shown in Figs. S2 and S3, each SB event is unique in terms of the change in the aerosol concentrations."

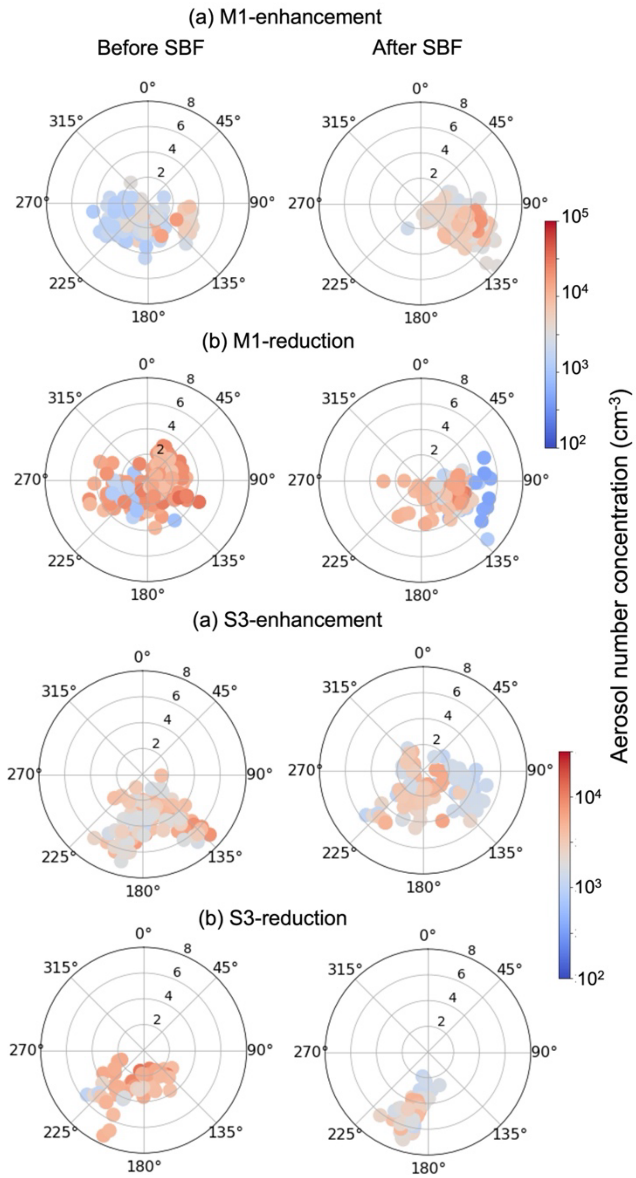


Figure 7. *Open-air polar plots for aerosol number concentration before and after the passing of the SBF ($\Delta T = T_{SBF} \pm 1$) during enhancement and reduction events at M1 and S3 sites. The wind speed (in m s^{-1}) grid lines are presented with black circles; the color scales represent the concentrations observed with each wind speed and direction combinations.*

19. (Lines 400-410) Much of this text seems more relevant to the introduction section since the authors have not conducted any analysis to show that any particular aerosol enhancement days are due specifically to any of these phenomenon.

Response: We agree with the reviewer's comment. These lines are now moved to the Introduction section (Line 116-125).

20. (Page 14, Lines 422-425) I think this statement is generally true, but this and the following analysis neglect some interesting differences in the size distribution changes at the M1 site that contradict this statement. For instance, at smaller sizes, the number concentration stays the same at the SBF passage time and even increases a few hours after the SBF passage. This might suggest a shift towards different aerosol species (for instance, the composition time series shows that the reduction at M1 seems mostly in the sulfate and ammonium categories) or sources rather than simply a transition to a "cleaner" maritime airmass. Indeed, the much greater aerosol concentrations after the SBF at M1 compared to S3 suggest that the maritime air mass near Galveston Bay and Houston is still quite dirty compared to the more pristine maritime airmass that comes straight from the Gulf of Mexico. The manuscript would benefit if such subtleties were pointed out and described rather than glossed over, as is currently the case.

Response: We agree with the reviewer's observation. The revised manuscript includes the discussion to capture the role of frontal passage on the aerosol characteristics in detail.

Lines 562-572: "The aerosol bulk chemical mass concentration at the M1 site shows a steady buildup through the day, peaking just before the passing of the SBF. Organics were the dominant species throughout, with sulfate and nitrate also contributing. After the passage of the SBF, concentrations dropped rapidly by about 1 to 3 μg m⁻³, with the drop being more apparent in sulfate and ammonium. Within a few hours, concentrations returned to the background levels. These concentrations remained higher than those at the rural S3 site. However, the more pronounced changes in aerosol properties were observed at the S3 site. The concentrations of all species, including organic, decreased by 2 to 3 μg m⁻3. This is consistent with the earlier discussion that the maritime air mass near Galveston Bay exhibits higher aerosol concentrations compared to the more pristine maritime airmass originating directly from the Gulf of Mexico."

For details regarding the changes in aerosol properties please refer to the revised Section 3.3. (*Lines 527-605*). Please also refer to the response to comment 16.

21. (Page 15, line 439) Please provide a more physical explanation with references where relevant for how higher wind speeds would "dilute" the existing airmass in terms of the production of turbulent mixing that could do the "diluting". Do you mean that mechanical production of turbulence increases mixing with greater wind speed? If so, does such increased mechanical mixing compensate for reduce boundary layer buoyant production of turbulence with a more stable surface layer?

Response: Higher wind speeds increase wind shear near the surface, leading to enhanced mechanical production of turbulence, which expedites both horizontal and vertical dispersion of aerosols and vapor (Kgabi and Mokgwetisi, 2009; Dueker et al., 2017; Liu et al., 2025). Boundary layer height and vertical transport fluxes are increased with increasing wind speed, which will dilute the aerosol and water vapor concentrations (Glantz et al., 2006). On the other hand, lower wind speed causes atmospheric particles to accumulate in one area, which is aided by the lower boundary layer and decreased turbulent mixing. This is oftentimes associated with causing the air quality to worsen due to lack of dilution of air emissions (Seinfeld and Pandis, 2006). Under stable stratification, when buoyancy-driven turbulence is suppressed, shear turbulence becomes the dominant mechanism for dilution. This is supported by modifications in turbulent kinetic energy formulation that explicitly include shear production alongside buoyant production (Rodier et al., 2017). Thus, while mechanical mixing may not match the vigor of convective turbulence, it can significantly mitigate concentration buildup under stable conditions.

Lines 550-561: "However, we suggest that the higher wind speed associated with the SBF dilutes the existing air mass with marine air with lower aerosol concentration. Higher wind speeds enhance near-surface shear, mechanically generate turbulence, deepen the boundary layer, and strengthen vertical transport, thereby accelerating dispersion and diluting aerosol and water-vapor concentrations (Kgabi and Mokgwetisi, 2009; Dueker et al., 2017; Liu et al., 2025). Conversely, low winds with a shallow boundary layer and weak turbulence promote accumulation and often worsen air quality due to limited dilution (Seinfeld and Pandis, 2006). The modified near-surface air mass at S3 persists overnight until convective mixing begins the following day. Under stable stratification, buoyant turbulence is suppressed, and shear-driven mixing becomes the primary dilution mechanism; although weaker than convective mixing, it can still substantially mitigate concentration build-up (Rodier et al., 2017)."

22. (Page 16, Lines 473-475) I don't see where this statement is evident in Figure 8. In fact, it looks from the panels in Figure 8f that the normalized change in aerosol concentration is actually stronger at 00Z than earlier times. Please correct or clarify with a figure citation where this effect is demonstrated.

Response: We agree with the reviewer that the normalized change in aerosol concentration is stronger inland. We have now corrected the statement as shown below:

Lines 633-636: "Over time, a well-defined dipole pattern emerges, characterized by reduced concentrations over the coastal zone and enhanced concentrations farther inland, consistent with the inland penetration of the maritime air mass and displacement of pre-existing polluted air."

23. (Page 16, middle paragraph and Figure 9). In this section comparing the July 17 and August 16 cases to July 10, the authors demonstrate that the change in aerosols following the SBF passage at each site is highly sensitive to the initial aerosol distribution, which is intuitive. However, they neglect to show/discuss any differences in the meteorological properties of the SBC in this case. Another issue with this figure/discussion is that the times plotted are much earlier than in Figure 8 for the July 10 case. While the supplemental figures show that the SBF passes the ARM sites earlier on July 17 and August 16, the times plotted for the July 17 and August 16 case don't even include when the SBF passed the S3 site. For instance supplemental figure S7 shows this was 22Z on July 17 and figure S8 shows this was about 21Z on August 16—both of which are beyond the times shown in Figure 9. I think this comparison would benefit greatly from expanding Figure 9 into two figures that show exactly what is shown in Figure 8 (including meteorological variables and the times before SBF passes both sites, after it passes M1 only, and after passing both sites). This will allow for an apples-to-apples discussion of both the meteorological differences with the SBF on all three days (which may also contribute to the observed shifts in aerosols) as well as the

current focus on the antecedent aerosol distributions. In general, thema in paper currently focuses on a detailed analysis and discussion of the July 10 case, then casually mentions the other days. I think the paper would benefit from a more direct and comprehensive comparison of July 10 with July 17 to better get at the root of why some SBF passages lead to enhancement vs. reduction of aerosols.

Response: Thank you for these detailed and constructive comments. We agree that in original version of the manuscript, our discussion of the July 17 and August 16 cases was not as comprehensive as for July 10, and that the analysis would be improved by placing the three cases on equal footing. Specifically, we acknowledge that the omission of the associated meteorological properties of the SBC on July 17 and August 16 limits the ability to fully interpret the aerosol responses. Consideration the reviewer's comments, the following modifications are included in the revised manuscript:

Firstly, we include the approximate SBF arrival times at both sites and briefly describe the associated meteorological signatures. The two events are also described in detail in *Lines 573-605,* in the section when these two events are first introduced. For this we have made the Figures S7 and S8 identical as Fig. 8 (current manuscript).

Secondly, following the Reviewer's suggestions, we expanded Figure 9 (original manuscript) into two figures structured in the same way as Figure 9 (Figure 8 in the original manuscript), with consistent time windows that span before SBF arrival, after its passage at M1 only, and after its passage at both M1 and S3. These revised figures (Figs. 10 and 11, in the revised manuscript) include both meteorological variables and aerosol properties, allowing a direct comparison across July 10, July 17, and August 16. This way, these figures help track the inland propagation of the SBF.

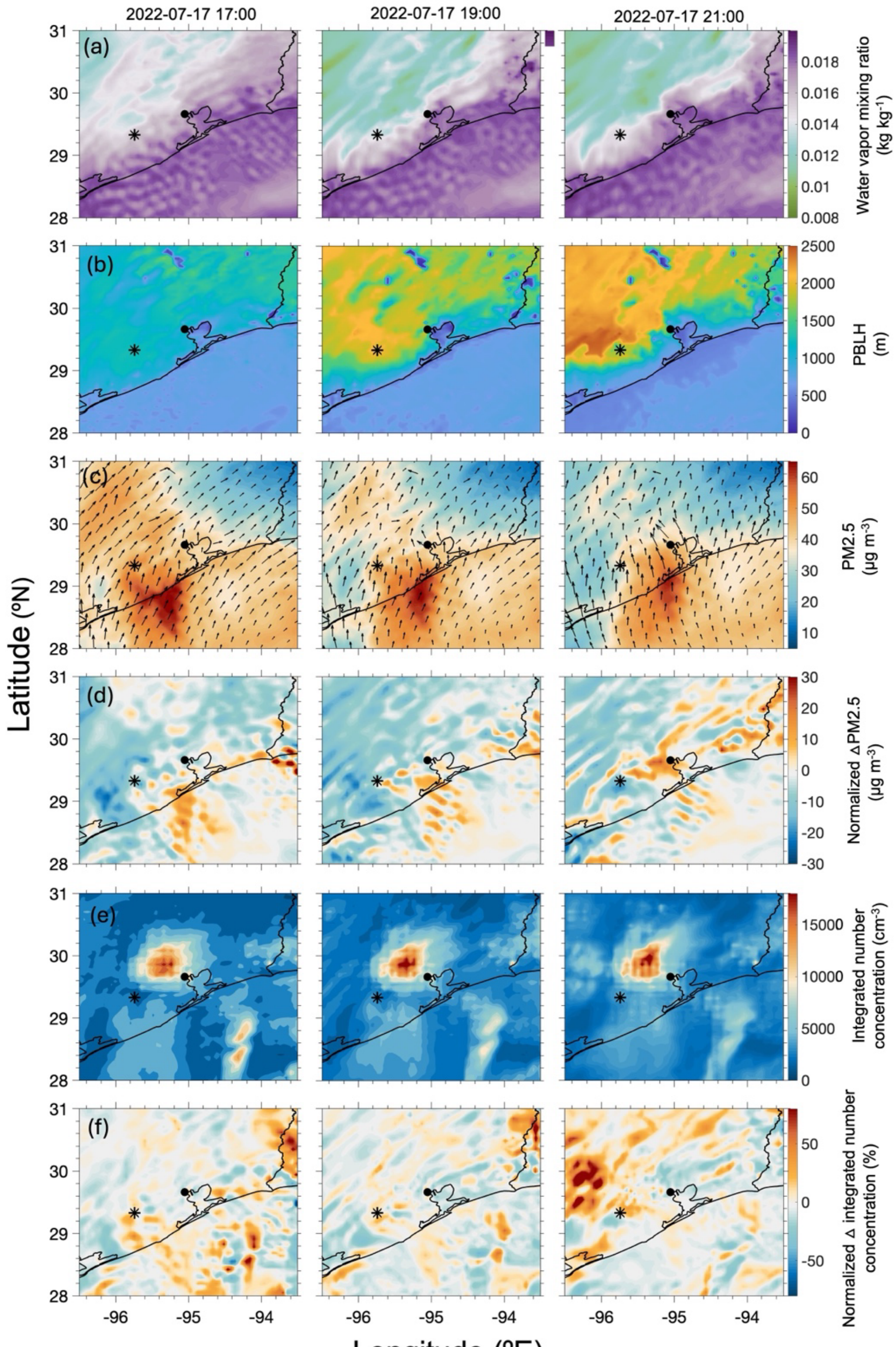


Figure 10. *Modeled surface distribution of (a) water vapor mixing ratio, (b) PBLH, (c) $PM_{2.5}$, and wind vector (black arrows, at the surface), and (e) integrated aerosol number concentration (nucleation + accumulation mode) at three-time steps: 17:00, 19:00, and 21:00 UTC on 17 July. Sub-panels (d) and (f) show the normalized changes, where Δ is the change from the previous time step. The filled-circle marker in the panels represent the M1 site, while the star represents the S3 site.*

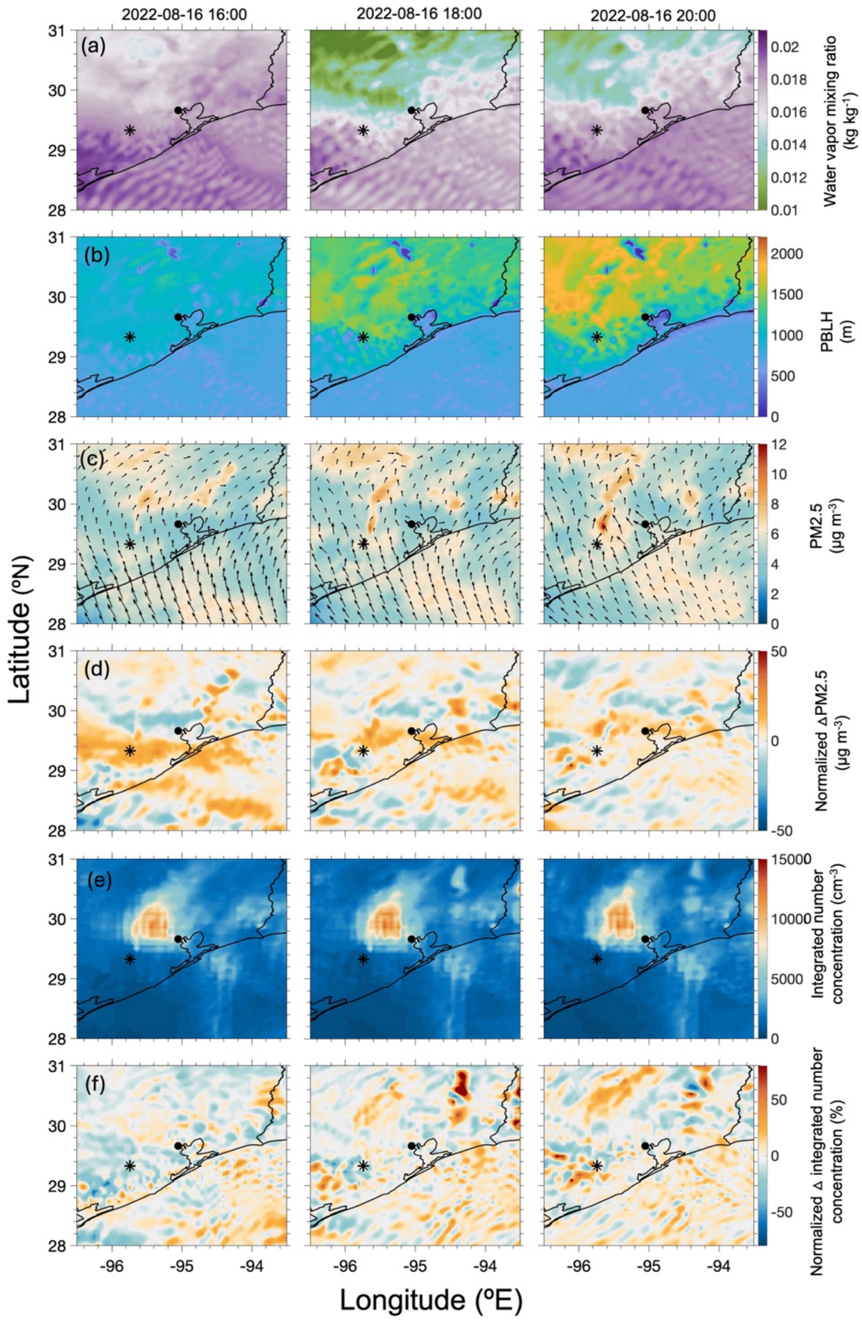


Figure 11. *Modeled surface distribution of (a) water vapor mixing ratio, (b) PBLH, (c) PM$_{2.5}$, and wind vector (black arrows, at the surface), and (e) integrated aerosol number concentration (nucleation + accumulation mode) at three-time steps: 16:00, 18:00, and 20:00 UTC on 16 August. Sub-panels (d) and (f) show the normalized changes, where Δ is the change from the previous time step. The filled-circle marker in the panels represent the M1 site, while the star represents the S3 site.*

We have further expanded the discussion in Section 3.4 to highlight not only the differences in antecedent aerosol distributions but also the variability in meteorological conditions associated with each SBF, and how these jointly influence whether an event leads to an enhancement or reduction in aerosol concentrations. These are the corresponding modifications in the revised manuscript:

Lines 637-656: "*The additional example on 17 July (Fig. 10) is suggestive of an enhancement in aerosol concentration associated with the SBF event, while the 16 August event (Fig. 11) is indicative of a neutral influence from the SBF passage. Similar to 10 July, both days exhibit an increase in water-vapor mixing ratio associated with passage of the SBF, relative to inland areas not influenced by the front (Figs. 10a, 11a). The SBF passage was also accompanied by a decrease in modeled PBLH (Figs. 10b, 11b). On 17 July, the SBF had reached M1 and S3 by ~19:00–21:00 UTC; winds were predominantly from southwest to east, with easterlies likely advecting emissions from the HSC and contributing to the observed enhancements.*

Notably, the 17 July event occurred in a different ambient aerosol environment than the 10 July event. MERRA-2 column dust mass concentrations (Fig. S9) indicate Saharan dust transport on this day, yielding elevated dust loading over the Gulf of Mexico and resulting in marine aerosol mass concentrations that exceeded those over land. The high concentrations are also observed to be more prominent to the southwest of the M1 site (Fig. 10c). Hence, as the SBF moves inland on 17 July, it transports this higher aerosol containing air mass, replacing the lower aerosol containing air over the site and causing an increased aerosol concentration at the M1 site. The onshore winds carry an air mass influenced by both local and long-range transport, originating from both land and sea. In contrast to the other two events, the 16 August event occurred under a transitional regime and likely influenced by the bay breeze. The aerosol environment was notably uniform over the wider regional air masses, thus SBF passage resulted in minimal changes to the aerosol distribution (Fig. 11c, d, f)."

24. (Page 16, lines 478-481). While this is evident from the figure and somewhat intuitive that it must be true for days to have an aerosol enhancement to have more antecedent aerosols in the maritime airmass, a more interesting question that could be addressed here is

Why are the antecedent aerosol conditions so different? Since your WRF chem simulations span the entire IOP, can you comment on differences in the synoptic or regional meteorology in the days leading up to these events that would cause the aerosol distributions to be so different prior to SBF passage?

Response: Thank you for this insightful suggestion. We agree that it is important to address why the antecedent aerosol conditions differ so markedly between cases. The antecedent aerosol distribution on July 17, for example, was strongly influenced by enhanced dust transport from the Saharan Desert in the days leading up to the event. This is evident in MERRA-2 column dust fields (included as a supplemental figure in the revised manuscript), which show elevated dust loading over the Gulf of Mexico and southern U.S. during this period. Our WRF-Chem simulations also capture this elevated dust transport, consistent with the observed higher aerosol concentrations in the maritime air mass prior to SBF passage on July 17. In contrast, July 10 and August 16 lacked comparable dust intrusions, leading to lower background aerosol levels in the pre-SBF maritime air.

In addition, Wang et al. (2024) categorize the July 17 case as a convective cloud type associated with local forcing, which may have further modulated the regional aerosol environment. We will incorporate this discussion into the revised manuscript to make clear how synoptic and regional meteorology, and specifically dust transport events, contributed to the different antecedent aerosol conditions observed across the case studies. Finally, we note that the potential two-way interactions, where cloud processes modify aerosols and feed back onto subsequent cloud formation, are indeed interesting but fall outside the scope of this study.

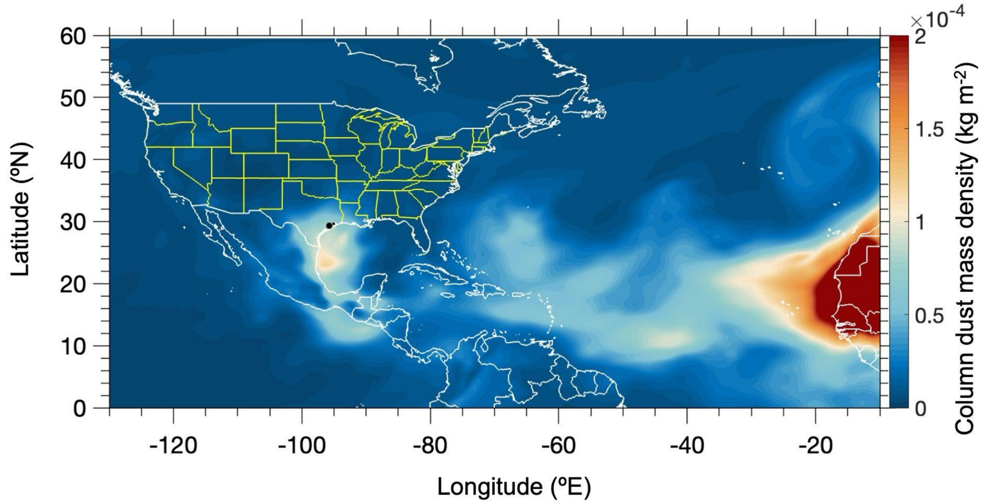


Figure S9. *Spatial distribution of MERRA-2 derived dust column mass density, averaged over 16-17 July 2022.* The filled-circle marker in the panels represent the TRACER site.

Lines 645-656: "Notably, the 17 July event occurred in a different ambient aerosol environment than the 10 July event. MERRA-2 column dust mass concentrations (Fig. S9) indicate Saharan dust transport on this day, yielding elevated dust loading over the Gulf of Mexico and resulting in marine aerosol mass concentrations that exceeded those over land. The high concentrations are also observed to be more prominent to the southwest of the M1 site (Fig. 10c). Hence, as the SBF moves inland on 17 July, it transports this higher aerosol containing air mass, replacing the lower aerosol containing air over the site and causing an increased aerosol concentration at the M1 site. The onshore winds carry an air mass influenced by both local and long-range transport, originating from both land and sea."

25. (Page 16, lines 493-500). The reference to the scanning radar wind data is somewhat out of the blue and not clear how it relates to the prior analysis. Do these results refer to a specific day/event or are they more generally true? To this point your analysis does not clearly differentiate between bay breeze vs. gulf-breeze passage, so it's not clear which results the scanning radar wind data support. Please clarify which findings/figures from the WRF simulations or site analyses are supported by the radar data.

Response: Thank you for pointing this out, we agree the reference to the scanning-radar winds read as abrupt. In the revision we state explicitly that the radar panel corresponds to a separate SB Day during the IOP (one of the events in Fig. S2), and it is not used to validate any of the three primary WRF-simulated case days in the main text. A comprehensive scanning-radar analysis is beyond the scope here and has been treated in prior TRACER studies.

Lines 662-666: "A study by Deng et al., (2025) using scanning radar data collected during TRACER reported similar findings during one of the SB events on 10 September 2022. They reported a reduced influence on the aerosol concentration immediately after the passing of the bay breeze front for the next few hours, due to the dominance of onshore flow consistent with the findings from this study (Fig. S2)."

26. (Page 17, Lines 511-518, Figure b,c) It's interesting to me that the magnitude of the changes in nu0 and ac0 tend to increase with altitude but the changes in PM2.5 do not. Do the authors have any explanation as to why this is the case? It's important to address this inconsistency because if the largest changes in nu0 and ac0 are occurring above the layer where the SBC is most prominent, it suggests there is another process causing changes in the aerosol at this time rather than just the SBC, and that not all the changes occurring here are due to the SBC.

Response: Thank you for pointing out this important observation. We agree that the apparent inconsistency between the vertical structure of changes in nu0 and ac0 versus surface PM2.5 warrants clarification. One explanation is that the largest changes in nu0 and ac0 occur aloft where the sea-breeze circulation interacts with residual or transported aerosol layers, while surface $PM_{2.5}$ reflects only the near-surface response and therefore shows weaker sensitivity.

Lofted layers of dust or aged pollution can undergo substantial modification in number and composition without producing a proportional change in surface $PM_{2.5}$. Another contributing factor is that nu and ac0 are microphysical parameters that are more sensitive to shifts in aerosol size distribution, whereas $PM_{2.5}$ is a bulk mass measure that may not change as much if mass is redistributed across size bins rather than added or removed.

Not all the observed vertical changes can be attributed solely to the SBC; other processes such as long-range transport, vertical mixing above the boundary layer, or localized convective activity likely also contribute. This interpretation highlights that the SBC signal is most prominent near the surface but that the column-integrated response reflects the combined influence of multiple processes. This raises the important consideration of the role of the SBC in particle formation and growth. A thorough analysis of this process, however, would require additional work and substantially lengthen the current manuscript. We have addressed some of the aspects of the aerosol size distribution in sections 3.3, 3.5, 3.6, and the response to comment 16.

27. (Section 3.7.1 and Figure 11) I find this section and figure 11 to be somewhat redundant and to be less than persuasive as a discussion of changes in aerosol indirect effects (as implied by its inclusion in Section 3.7). First, using N100 as a proxy for CCN is a rough approximation. Secondly, this information is available already in Figure 7. Finally, there are a lot of assumptions

required for the change in N100 to translate to a change in the aerosol indirect effect, namely that these aerosol actually form clouds on either side of the SBF and that the change in CCN meaningfully affects the cloud drop size distribution, which are not analyzed here. Thus, I suggest simply removing this section and then when discussing Figure 7 in Section 3.4, you could add a sentence or two that specifically describes the changes in N100 and the implications for CCN.

Response: We thank the reviewer for this valuable comment. We agree that using N_{100} as a proxy for CCN is a simplification and have now clarified these limitations more explicitly in the revised text. However, we believe that including this section and Figure 13 (previously Figure 11) is important for two reasons.

First, while Figure 8 (previously Figure 7) presents the overall aerosol number budget, Figure 13 isolates the N_{100} fraction, which is directly relevant as a CCN proxy. This allows us to highlight how sea-breeze-related processes affect particles that are most relevant for cloud formation, providing a more targeted perspective than the total number concentration alone.

Second, the Figures S10 and S11 demonstrate event-to-event variability, showing that while N_{100} is less frequently impacted than the total aerosol number concentration, reductions of up to 25–60% are still observed during certain events, which would not be evident from section 3.4.

We have also added text acknowledging the assumptions required to connect changes in N_{100} directly to aerosol–cloud interactions and clarified that our analysis is limited to observational evidence of N_{100} variability (Lines 702-704). We therefore feel that retaining this section provides valuable context, complements Figure 8, and strengthens the discussion of how sea-breeze interactions may influence the CCN-relevant aerosol population.

In addition, we now reference prior TRACER findings (ROAM-V measurements) which demonstrated that aerosol cloud-forming properties vary substantially between polluted marine and continental air masses due to differences in aerosol size, hygroscopicity, and CCN efficiency.

Lines 769-775: "This aligns with Thompson et al. (2025), which showed that aerosol cloud-forming properties differ between polluted marine and continental air masses, with variability in size, hygroscopicity, and CCN efficiency across sites. Given the complex mix of marine, terrestrial, and urban sources, and the strong spatial heterogeneity revealed by both our analysis and prior TRACER studies, future studies should include direct CCN and INP measurements and size-resolved aerosol properties to better capture the role of SAI in aerosol–cloud interactions."

28. (Page 18, lines 551-554) The details of these simulations need to be included either here or in the methods section when they differ from those of the other WRF-Chem simulations. How exactly is aerosol chemistry excluded vs. included? Are aerosols simply set to zero everywhere in the simulation NA simulation and the WA simulation is the realistic WRF-chem simulation as described earlier? What physical processes may be affected by this choice? How are CCN prescribed in the microphysics parameterization of the simulation without aerosol chemistry? Were these simulations conducted for the full IOP or only on particular case study days?

Response: Thank you for this comment. This section 3.7.2 no longer exists in the revised manuscript.

However, we have added additional details on the configuration of the simulations. The model simulations were performed for the period from 1 July to 30 August 2022 using a 5 × 5 km horizontal grid spacing with 45 vertical layers. A 3-day spin-up was applied, and restart files were used thereafter. Meteorological initial and boundary conditions were provided by the NAM every 6 h. This grid spacing and configuration is sufficient to capture the salient meteorology relevant to aerosol–chemistry interactions, and similar setups have been successfully applied in prior WRF-Chem studies (Berg et al., 2015; Wang et al., 2021; Subba et al., 2023; Shrivastava et al., 2024).

The NA (no aerosol) simulations were configured by turning off aerosol chemistry, effectively setting aerosol fields to zero such that cloud droplet activation relied only on prescribed background CCN and meteorology. In contrast, the WA (with aerosol) simulations were performed with full aerosol–gas chemistry, and land–atmosphere interactions enabled. Boundary conditions for gas-phase species and aerosols were taken from WACCM (Gettelman et al., 2019), interpolated to our domain every 6 h. Biogenic emissions were generated online using MEGAN2.1 (Guenther et al., 2012), while anthropogenic emissions were prescribed from the U.S. EPA NEI inventory (Ma and Tong, 2022). These simulations were conducted for the full IOP period (1 July–30 August) to ensure that synoptic variability and antecedent conditions were properly represented. The complete list of model configurations is provided in Table 1.

29. (Figure 12 and related discussion) In the second column of Figure 12b, it shows the “after” SBF time for the M1 site as 18Z, however supplemental figure S7shows the SBF time at M1 on this date is after 18Z. How can this time represent the post SBF time for that day? Please correct or explain the discrepancy in the analysis.

Response: Figure 12 from the previous manuscript is no longer included, as Section 3.7.2 has been removed in the revised paper. Please refer to the response to Comment 30.

30. (Section 3.7.2) While this is an interesting discussion of the ARF as it relates to SBC associated aerosol changes, A few additional pieces of analysis could improve this section and add more depth to the analysis. Have you compared the simulations to observations of surface radiative forcing from the M1 site? While the total ARF cannot be directly compared, a comparison of the simulated surface radiative flux to the observations would be enlightening and add confidence to the model simulations if they agree. Second, an implication of increased ARF is that it can lead to warming of the atmosphere, which would have effects on clouds/convection and other meteorological aspects. Do the simulated changes in ARF correspond to significant changes in the simulated vertical temperature profiles?

Response: Thank you for the comments. No, we have not compared the simulations to observations of surface radiative forcing from the M1 site in this paper. However, considering both the reviewers’ comments and to streamline the manuscript and focus the narrative, in the modified manuscript, we have retained only the CCN-relevant analysis (Section 3.7.1) and removed the

ARF analysis (Section 3.7.2). The radiative-forcing results will be developed as a separate manuscript, where we can treat methodology, uncertainties, and sensitivity tests in appropriate depth. In this way, the current paper emphasizes the complementarity of observations and modeling without detracting from its central observational focus. In the revised paper we:

- Clarify the limitations of using N_{100} as a CCN proxy and explicitly state the assumptions.
- Keep the CCN figures (formerly Fig. 11 and related Supplementary Figs.) and emphasize how sea-breeze processes affect the cloud-relevant particle population and its event-to-event variability.
- Remove text, figures, and references specific to ARF from the Abstract, Results, and Conclusions, and add a forward reference noting that ARF will be presented in a companion paper.

31. (Summary and Conclusions in general) As discussed in earlier comments, some of the summary statistics here for each site that average over both reduction and enhancement days mask some of the nuance/detail. I suggest adjusting this text to reflect any corresponding changes made earlier in the manuscript in response to earlier comments.

Response: Please refer to the response to comment 14.

32. (Page 21, line 638) Along the lines of an earlier comment, this paper has only shown the ARF, but it has not demonstrated corresponding heating/cooling in response, which might be implied by this statement in the conclusions. This sentence should be removed if such heating/cooling is not demonstrated in the simulations.

Response: Thank you for this helpful comment. We agree with the reviewer that our simulations did not explicitly quantify atmospheric heating or cooling rates associated with the aerosol radiative forcing (ARF). However, Section 3.7.2 has been removed in the revised paper. Please refer to the response to Comment 30.

33. (Page 21, lines 639-641) If, following an earlier comment, the CCN section is removed, this text should be changed accordingly. At the very least, it needs to be stated here that “N100, a proxy for CCN” is used rather than actual CCN measurements.

Response: Thank you for this comment. We agree that clarification is needed. In the revised manuscript, we explicitly state that N_{100} is used as a proxy for CCN concentrations, rather than direct CCN measurements.

Lines 702-703: “Due to the unavailability of measured CCN data at both M1 and S3, N_{100} serves as our proxy for the CCN (CCN_{proxy}) concentration (Ahlm et al., 2013).”

34. (Conclusions, general) If my earlier suggestion to discuss existing complementary literature from the TRACER field project is adopted, please include some high-level comparison/contrasts to that literature in the conclusions section.

Response: Thank you for the comment. We've added the discussion in the conclusion section.

Alignment with Rapp et al. (2024): Our fixed-site results complement the targeted mobile sampling, supporting the conclusion that characterizing the distinct maritime vs. continental airmasses across boundaries, and their timing is critical to disentangling aerosol vs. meteorological controls. Consistency with Sharma et al. (2024): The meteorological contrasts across SBF that Sharma documented are consistent with our concurrent aerosol and w/wind shifts, linking environmental changes to the observed aerosol responses. Consistency with Thompson et al. (2025): Our finding that CCN-proxy (N_{100}) decreases after SBF are infrequent (~25%) aligns with Thompson's airmass-dependent CCN variability and strong spatial heterogeneity, implying a weaker SAI imprint on the marine-influenced background accumulation mode without size/composition constraints.

Lines 721-785: "Sea breezes influence multi-scale processes across the land-ocean-atmosphere interface within the region of influence of the SBC. The TRACER field campaign provided a unique opportunity to understand how aerosol and meteorological processes impact weather and climate in the urban and rural coastal environment of Houston, Texas. A total of 46 (M1) and 30 (S3) instances of SB passages were identified during the summertime TRACER IOP period. Summertime measurements from the ARM sites coupled with WRF-Chem model simulations (July and August 2022) help to quantify aerosol changes resulting from onshore transport of marine boundary layer air masses due to SBF passage and the associated atmospheric SBC impacts.

Understanding the spatial extent and duration of SAIs is crucial for assessing their environmental and meteorological impacts. For inland-penetrating SBFs, aerosol responses fall into one of the three types: reduction (clean marine air replacing more polluted continental air); enhancement (import of more polluted air), or neutral (similar air masses). The sign and magnitude of changes depend on coastal proximity to the coast and the upwind air mass history prior to SBF arrival.

TRACER measurements indicate that the urban M1 site, closer to both Galveston Bay and the Gulf of Mexico, experiences more frequent aerosol concentration changes (increase or decrease during 63% of SB events) than the rural S3 site (increase or decrease during 40% of SB days), which is primarily Gulf-breeze influenced and farther from urban/industrial sources. During IOP events, surface aerosol number changed by up to a factor of two. On average, SBF passages were associated with a decrease of ~23% at M1 and increase of ~4% at S3. SBF passages produce distinct aerosol responses depending on the type of SAI event. At M1, enhancement days (28% of SB events) are associated with an average increase of aerosol concentration by ~55%, while reduction days (35% of SB events) show an average decrease of ~42%. At S3, enhancement days

(27% of SB events) exhibit an average increase of ~64%, whereas reduction days (13% of SB events) show a decrease of ~45%.

This study also provides support for how SAIs may interfere with aerosol microphysical processes, including NPF events, a key driver of the overall aerosol number budget. These changes occur with sharp meteorological shifts, including RH (+30%) and wind speed (+4 m s-1) increases, and backing to southeasterly flow (Figs. 7. and 8.). The relationship between wind and aerosol number concentrations showed that aerosol concentrations at the M1 site are higher when prevailing winds originate from the direction of the Houston urban core (northwest) to north, compared to the winds coming from the sea (south and intermediate directions) (Fig. S5). Recently, Rapp et al. (2024) emphasized using targeted mobile sampling that collecting measurements on both sides of SB boundaries are critical for disentangling aerosol from meteorological controls. These findings are complementary to the results in this study that boundary timing and air mass origin drive the different responses at M1 and S3.

WRF Chem simulations extend the site perspective regionally, indicating heterogeneous SAI footprints (Figs. 9, 10, 11, and 12). Across 18 simulated events, near surface PM2.5 tends to decrease by ~15% around the M1 site and increase by ~3% near the S3 site (Fig. S13). However, these responses vary with altitude (Fig. 12). The SBF may alter the vertical aerosol distribution in the boundary layer up to 2 km. Beyond thermodynamics, SB fronts also reshape convective environments (Wang et al., 2024). The storm characteristics across maritime vs. continental sides of these fronts drive the air mass contrasts produced by SBCs (Sharma et al., 2024), which can further influence the aerosol environment.

With respect to cloud-relevant particles, both observations and simulations indicate that the surface CCNproxy concentrations decrease by up to 60% following SBF passage (Fig. 13), although such changes are infrequent (~25% of the SB events at both M1 and S3 site), implying a weaker impact of SAI on marine influenced regional background accumulation mode. This aligns with Thompson et al. (2025), which showed that aerosol cloud-forming properties differ between polluted marine and continental air masses, with variability in size, hygroscopicity, and CCN efficiency across sites. Given the complex mix of marine, terrestrial, and urban sources, and the strong spatial heterogeneity revealed by both our analysis and prior TRACER studies, future studies should include direct CCN and INP measurements and size-resolved aerosol properties to better capture the role of SAI in aerosol–cloud interactions. It is important to remember that these effects are localized, occurring only during shorter timescales (~5 h) associated with daily SBC cycles over these locations. But these SAI timings align with periods of peak solar radiation and elevated aerosol concentrations, potentially leading to significant impacts on the radiation budget over the coastal regions. During times in close proximity to SBF passage, changes in solar radiation and cloud formation may influence the aerosol formation and distribution, modify atmospheric chemical reactions, and affect cloud formation and properties, thereby impacting various atmospheric processes and interactions. Because many coastal cities have high aerosol loading with frequent SBCs, accounting for SAI when estimating direct aerosol radiative forcing *is crucial. However, quantifying these changes is challenging, underscoring the need for detailed future studies across diverse coastal regions.*"

Technical Comments

1. (abstract, lines 27-28) I suggest moving the sentence starting with "SAIs modify cloud condensation nuclei…" to before the previous sentence since it is currently sandwiched in between two sentences that discuss the radiative impacts.

Response: The sentence is moved as suggested. Please refer to *Lines 29-30*.

2. (Page 11, line 318) "resulting to" should be "resulting from"

Response: Changed as suggested. Please refer to *Line 402*.

3. (Figure S2 and S3) Please make it clear in the captions to these figures why some cases are included in the left column and others are in the right column. Presumably these are dates when the aerosol concentration increased (left) or decreased (right) after SBF passage?

Response: You are right. The captions are now modified to reflect the columns with enhancement influence (left) and reduction influence (right).

4. (Page 12, line 343) "continental sites" is unclear here since I don't think this phrase has been used/defined previously. Does this refer to both S3 and M1?

Response: Yes, it refers to both S3 and M1 sites. To avoid the confusion, "continental sites" is now replaced with "both the M1 and S3 sites" (*Line 435*).

5. (Page 13, line 377) remove "that" before "occurred"

Response: The word no longer exists in the modified manuscript.

6. (Page 14, lines 425-427) This sentence is repeated from text at the beginning of this paragraph and can be removed.

Response: Repeated sentence is removed.

7. (Page 16, line 485) Insert "an" before "air mass"

Response: Inserted "an" as suggested.

8. (Figure 6a label) The x-axis label here states the time is UTC, but it appears to be the SBF-relative time. Please correct.

Response: Thank you for noticing. The x-axis label is corrected.

9. (Page 18, line 556) "ARM" should be "ARF"

Response: Replaced as suggested.

10. (Page 19, line 574) I think "preceding" here should be "following" since the air mass behind the SBF (or after it passed) had less aerosol on this date.

Response: The word no longer exists in the modified manuscript.

11. (Page 20, line 598) add "is" before "therefore warranted."

Response: The word no longer exists in the modified manuscript.

12. (Page 20, lines 616-617; 618) I suggest replacing with "land-ocean interface" with "Galveston Bay" since M1 isn't actually closer to the Gulf of Mexico than S3. Likewise replace "downstream" in reference to S3 with a more accurate modifier like "rural" or "farther removed from urban and industrial influences"

Response: The sentence is modified to include both the suggestions:

Lines 736-739: "TRACER measurements indicate that the urban M1 site, closer to both Galveston Bay and the Gulf of Mexico, experiences more frequent aerosol concentration changes (increase or decrease during 63% of SB events) than the rural S3 site (increase or decrease during 40% of SB days), which is primarily Gulf-breeze influenced and farther from urban/industrial sources."

END OF RESPONSE TO REVIEWER 1

Response to Reviewer 2

EGUSPHERE-2025-2659

" Implications of Sea Breeze Circulations on Boundary Layer Aerosols in the Southern Coastal Texas Region."

Thank you for the opportunity to submit a revised version of our manuscript. We sincerely appreciate the reviewers' time and effort in providing thoughtful comments, insightful questions, and constructive suggestions. Their feedback has been invaluable in improving the manuscript's clarity, rigor, and overall quality.

Below, we provide a point-by-point response to the reviewers' comments and concerns. Reviewer comments are shown in blue, our responses are provided in black, and the corresponding revised statements in the manuscript are highlighted in *black italics*.

General comments:

This manuscript provides an observational overview of aerosol changes due to sea breeze events, focused at two DOE TRACER sites in Southeastern Texas during the TRACER IOP that took place June 1 - September 30 2022, as well as a modeling component for individual cases to investigate spatial trends. The paper provides a nice overview of observed aerosol evolution during previously identified sea breeze events, with three identified sea breeze changes to the aerosol characteristics. While the authors provide good descriptions of different case study examples, the depth of analyses used throughout are shallow in many areas, leaving the reader with many unanswered questions and/or unclear connections being made between the observations and the explanations for what's causing observed changes. Houston has a history of air quality/aerosol focused studies that could be beneficial for the authors to tie their results to past works, which could also help clear up areas where things are currently unclear.

While I believe the scientific goals and aims of this paper are sound, I think a major reorganization is necessary and I could see this as being two separate papers. This would allow the authors to expand the observational analyses and go into more depth while a second paper focused on the modeling outcomes could stand as its own paper. Additionally, there are several places where supplemental figures are being referenced and used more like core analyses. In general, supplemental materials should include things that are not integral to the results, but add confidence that the results shared are robust. By breaking into multiple papers, more room to include the currently supplemental figures could be made.

There are many places throughout where the same statements are being made (e.g. SBC influence extends 50km inland) that could be reduced or slightly modified so they're not so repetitive. Some of these occur in transition areas between paragraphs or sections, suggest revising these transitions.

Response: Thank you for the thoughtful and constructive feedback. We appreciate your recognition that the paper provides a nice overview of aerosol evolution during sea-breeze events. We thank the reviewer for recognizing that the paper's scientific goals and aims are sound. We took seriously your concern that the depth of analysis was uneven, that some links between observations and their causes were insufficiently developed, and that reorganization was needed.

In revision, we have reorganized the paper to center the observational analysis and deepen the explanation of why aerosol responses differ between sites and days. Specifically, we reframe the narrative around three representative case-study days (10 July, 17 July, 16 August), each illustrating a distinct aerosol-response regime, and expand the diagnostics to include SBF timing and propagation, boundary-layer structure, wind/thermodynamic context, and antecedent air-mass conditions. To provide concise quantitative context beyond the case studies, we add a summary table reporting the total number of SBC events during the TRACER IOP and the counts/percentages of enhancement, reduction, and neutral cases.

We also clarify the role of the modeling component. WRF-Chem is now used selectively to supply regional context and fill spatial/temporal gaps, with interpretation anchored in the ARM site observations. In line with your suggestion that aspects of the modeling could stand alone, we have streamlined the main text to retain only the CCN-relevant analysis (using N_{100} as a proxy with limitations stated explicitly) and removed the direct radiative forcing (ARF) subsection; the ARF analysis will be developed in a separate manuscript with fuller treatment of methods, uncertainties, and sensitivities. Figures that are central to the results have been moved from the Supplement into the main text; the Supplement now contains supporting/robustness material rather than core analyses.

To address clarity and context, we strengthen links to prior Houston/TRACER literature, adding targeted comparisons and contrasts with recent studies to situate our findings within the broader body of work. We also reduce repetitive statements, improve section transitions, and update figure color maps/captions accordingly. Collectively, these changes sharpen the explanatory focus, clarify the observational-modeling relationship, and present the core analyses where they belong, addressing your concerns while preserving the manuscript's contribution as an ARM-based assessment of sea-breeze–aerosol interactions during TRACER.

We believe the revisions make the study more rigorous and impactful, advancing the regional understanding of sea-breeze-aerosol interactions in southeastern Texas.

Specific Comments

1. Abstract, line 23: Technically the two site's proximity to the sea are very similar, but their proximity to the bay differ.

Response: We agree with the reviewer, both M1 and S3 are equidistant from the Gulf, but M1 lies in close proximity to the bay. So, we have now modified the statement as:

Line 22-23: 'SAI impact on aerosols varies with site proximity to water and the preceding sea breeze (SB) history,'

2. Page 2, line 40: 'These impacts…'. What impacts are you referring to here? The global scale changes to energy balance?

Response: Thank you for pointing this out. In the sentence at line 40 in the original manuscript, "these impacts" referred to the influence of aerosols on Earth's energy balance'. We have revised the text to clarify this:

Lines 37-44: "Aerosol particles can negatively impact human health (Partanen et al 2018; Mack et al., 2020), and influence Earth's energy balance. They exert direct effects by scattering and absorbing the incoming solar radiation, altering net radiative fluxes (Charlson et al., 1992; Bond et al., 2013; IPCC, 2021), and indirect effects by acting as cloud condensation nuclei (CCN) and ice nucleating particles (INP), thereby modulating cloud microphysical properties and precipitation processes (Twomey, 1974; Albrecht et al., 1989; Ramanathan et al., 2001; Rosenfeld et al., 2008; Ariya et al., 2009; Burkart et al., 2021)."

3. Page 2, lines 47-49: As written this sounds like the only complicating factor is the sea breeze, suggest a rephrase so it isn't so definitive. Things like urban characteristics can also affect the aerosol processes.

Response: Agreed. The sentence is now modified:

Lines 53-56: "In addition, mesoscale meteorological phenomenon around Houston, such as sea breeze circulations (SBCs), further modulate these aerosol dynamics"

4. Page 3, line 65: I would change 'stable' and 'unstable' to 'more moist' and 'drier' respectively. The stability, as written, is overly generalized here and there's recent works (Boyer et al., 2025 https://doi.org/10.1175/JAS-D-23-0180.1) showing how the cooler side of an airmass can actually be more 'unstable'.

Response: Thank you for the suggestion, 'unstable' is changed to 'drier', and to clarify the context of stable airmass, we have added an additional sentence to describe the distinct behaviors of the airmasses.

Lines 73-77: "While low-level lapse rates are often more stable on the maritime side of the SBF, the conditional instability (Convective Available Potential Energy-CAPE) is often observed to be greater on the maritime side due to the higher moisture content in that airmass (Sharma et al., 2024; Boyer et al., 2025)."

5. Page 3, lines 80-85: First sentence discusses trapped aerosols, but then the next sentence discusses mixing out aerosols. Suggest a rephrase to make things clearer here. Also, 'The competition between converging winds' is an awkward phrasing, 'The often opposing winds associated..' reads cleaner and avoids personification.

Response: Agreed, we have implemented the suggestions.

Lines 90-94: "In SBC environments, competing processes can yield opposite aerosol responses, as the formation of a shallow thermal boundary layer can confine particles near the surface and raise aerosol concentrations, whereas inland buoyant (convective) lifting within the convective boundary layer, can lift aerosols aloft (Simpson, 1994; Boyouk et al., 2011; di Bernardino et al., 2021)."

6. Page 4: lines 99-100: I'm not sure what you mean by 'aerosol property implications'. I believe this is an example where some rephrasing could help connect this sentence to the following two where you give direct examples.

Response: To clarify and link the introductory statement with the examples, we have rephrased the sentences as shown below:

Lines 107-112: "In a similar case of these farther-reaching influences, Parajuli et al. (2020) found that the SBC influences the aerosol vertical distribution over the eastern coast of the Red Sea while lifting dust aerosols along the western slope of the Sarawat mountains, with the elevated dust at a height of ~1.5 km over the mountains. Similarly, Talbot et al. (2007) observed that enhanced turbulent activity along the SBF facilitated vertical aerosol transport above the boundary layer top (~1.1 km a.s.l) over a flat coastal area of the North Sea."

7. Page 4, lines 114-118: It's stated that this work expands on Li et al. 2020 work, however it isn't very clear how this expands on it, since the Li work is focused on Ozone. A better connection here is needed.

Response: Thank you for the comment. We agree that our original wording did not clearly describe the direct connection to Li et al. (2020). While Li et al. focused on ozone variability, their study highlighted the critical role of SBCs in modulating regional air quality. Our study expands on this by examining the same meteorological driver (SBCs) but focusing on aerosol number concentrations and composition. Because many of the emission sources that influence ozone (e.g., traffic, industrial activity, shipping) also contribute to aerosol loading, understanding how SBCs redistribute ozone provides a complementary framework for investigating their role in aerosol variability. We have revised the text to clarify this connection. We have revised the text to clarify this connection.

Lines 138-144: "These efforts expand on previous air quality studies over Houston, including Li et al. (2020) who employed a K-Means clustering algorithm to study the relationship between Houston-region SBCs and the daily ozone variability during the DISCOVER-AQ (Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality) field campaign. While Li et al. (2020) focused on gas-phase chemistry, the same emissions and meteorological processes that drive ozone variability can also influence aerosol loading over the southern Texas region."

8. Page 4, lines 123-: The main site is labeled here as 'urban coastal' and the second site as 'rural'. While the M1 site is close to the Bay, I would either add an explanation of this classification or use a different word for it, as both sites are almost equidistant from the Gulf coast (which many people would consider coastal). The evolution of the bay breeze and sea breeze are also different, with the M1 site experiencing a mix of both breezes throughout TRACER. This is a place where further clarification of the general meteorology over the region could be useful for the reader. Also, be consistent with your naming convention throughout. Sometimes the M1 site is 'coastal' other times it's 'urban coastal', which can be confusing.

Response: Thank you for this helpful suggestion. We agree with the reviewer that our original site classification could be confusing, since both sites are almost equidistant to the Gulf coast. M1 experiences a mixture of both gulf and bay breezes unlike S3 which experiences the gulf breeze alone. And our intent in using the term "urban coastal" for M1 was to emphasize its location within the Houston metropolitan region, whereas the S3 site is more representative of a rural background environment. To avoid confusion, we have revised the text to clarify the rationale behind these classifications and ensure consistency in naming throughout the manuscript. We have now consistently referred to M1 and S3 as urban coastal and rural coastal locations respectively.

Lines 187-201: "Although both the M1 and S3 sites are a similar distance from the Gulf of Mexico, the M1 site is located near the western shore of Galveston Bay. This urban M1 site may experience different sea-breeze timing because of its location, the added influence of the Galveston Bay breeze, and urban heating that alters local circulations. The M1 site is expected to be strongly influenced by anthropogenic activities due to its proximity to the Houston urban core, large-scale industrial complexes and the Houston Ship Channel (HSC). The HSC is lined with dense clusters of industrial facilities, including major petrochemical complexes (Yoon et al., 2021), which can *contribute to aerosol populations beyond those typically associated with an urban environment. Similarly, the Texas A&M University (TAMU) TRACER measurements also showed that short-lived ship emissions contributed to high aerosol concentrations (up to 34,000 cm^{-3}) (Rapp et al., 2024; Thompson et al., 2025). The S3 site, while relatively less impacted by the emissions from the Greater Houston area, is not representative of a pristine rural location in terms of aerosol loading. Under typical south-southeasterly wind, this S3 site is located downstream of heavy industry along the southeast Texas coastline (Freeport, TX and Lake Jackson, TX) and can be influenced by upstream anthropogenic sources (Fig. 2b)."*

Lines 482-489: "The M1 site is influenced by the air masses and SBCs from both sources, whereas the S3 site is affected predominantly by those originating from the Gulf of Mexico. As discussed in detail by previous studies (Sharma et al., 2024; Wang et al., 2024), the SBFs originating from Galveston Bay and the Gulf of Mexico are often distinct at onset but tend to merge later in the afternoon or evening. Due to the M1 site's proximity to Galveston Bay, it is more directly influenced by maritime air masses that are heavily modified by Galveston Bay as the SBF originating from the Gulf of Mexico traverses the Bay."

9. Page 5, line 145: The M1 site is southeast of Houston, not south. This is an important distinction since other TRACER data was collected in Pearland, which is south and later discussions include aerosol sources in proximity to the city.

Response: Thank you for pointing this out, we have changed 'south' to 'southeast' (Line 176).

10. Page 5, line 151: You're classifying the S3 site as 'rural', but then say it is 'periphery' to highly populated and commercial sectors, which is contradictory to a true rural definition.

Response: Thank you for pointing this out. We agree that our initial wording may be contradictory. While S3 has been referred to as the rural site, we acknowledge that it does not represent a truly rural or pristine rural location. Therefore, we have added a discussion to clarify this point:

Lines 197-201: "The S3 site, while relatively less impacted by the emissions from the Greater Houston area, is not representative of a pristine rural location in terms of aerosol loading. Under typical south-easterly wind, this S3 site is located downstream of heavy industry along the southeast Texas coastline (Freeport, TX and Lake Jackson, TX) and can be influenced by upstream anthropogenic sources (Fig. 2b)."

11. Page 5-6, lines 155-159: While this sentence is important, it feels out of place here. Would fit better within the introduction when discussing TRACER.

Response: The sentence is moved to the introduction section (*Lines 149-154*).

12. Section 2.2: This section needs some further expansion/added detail. As it stands it is very surface level. How is missing data handled? What is the resolution of the different datasets and/or why is a 5 minute interval used? For composites, how are these being made? Is there data quality control or processing being applied? TCEQ has many sites, why is only one chosen, why only PM2.5, and how close is the actual site to the M1 site? I'd suggest adding the TCEQ site to the figures that you label the TRACER sites on.

Response: Thank you for the questions. We agree with the reviewer that our original description was too brief. In the revised manuscript, we expanded the methods section to provide additional details on data handling and processing.

Lines 221-226: "Missing data were excluded from this analysis. If more than 20% of the data were missing during the 5 hours before and after the passing of the SBF, the dataset was not used to study SAI processes. SMPS and ACSM sample data at 5-minute and ~30-minute intervals, respectively. State meteorological variables were observed at one second intervals. All datasets, except for the ACSM, were averaged over a 5-minute interval, centered on the time of the SMPS sample."

To address the reviewer's comment related to the TCEQ site, we have revised the text to include the explanation and added the TCEQ C45 site to the figures showing the TRACER sites.

Lines 227-235: "To supplement the ARM observations, we use particulate matter of 2.5 micrometers or less in diameter (PM2.5) mass concentrations from the Texas Commission on Environmental Quality (TCEQ) database (Shrestha et al., 2023; sfcmetradaq-tceq ARM PI product). Although TCEQ operates a broad network of air quality monitoring stations throughout Texas, the Seabrook Friendship Park site (C45, -95.02°E, 29.58°N) was selected because it is the nearest monitor to the M1 site (~6 km away) and provided continuous hourly PM2.5 data during the study period. $PM_{2.5}$ *was chosen as a representative aerosol to directly compare with the model simulations. For reference, this TCEQ C45 site location was added to the map displaying the TRACER sites (Fig. 1)."*

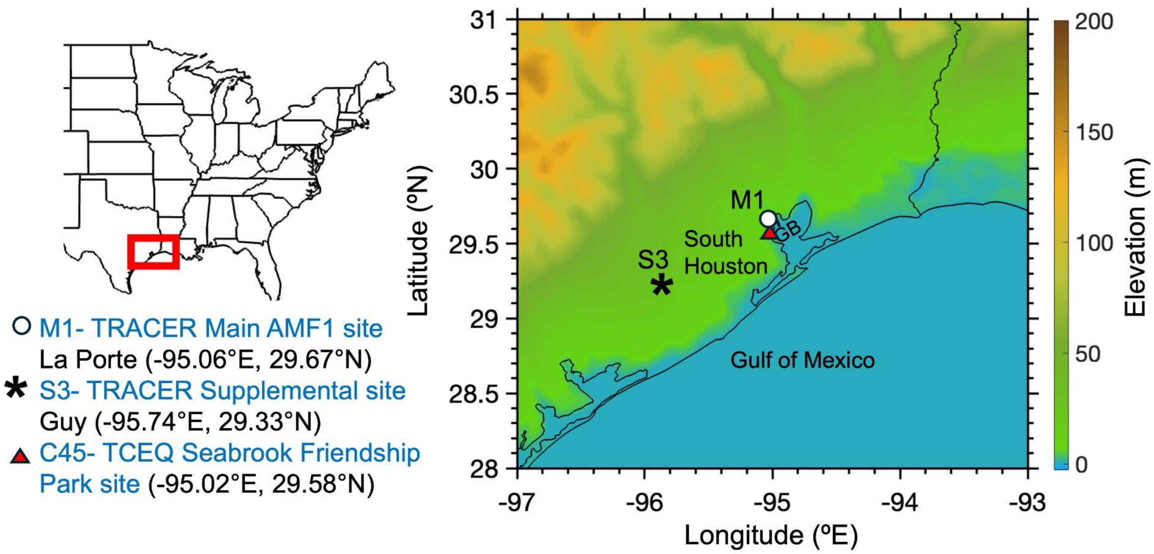


Figure 1. *Map showing the TRACER field campaign main site (M1) and supplemental site (S3), and the TCEQ Seabrook Friendship Park site (C45). Terrain elevation is shown in color. Here, "GB" corresponds to the Galveston Bay.*

13. Section 2.3, lines 188-201: Additional explanation for choices made are needed here. Why are simulations only conducted for part of TRACER? How are you determining that the grid spacing and configuration is 'assumed sufficient'? Is there literature you can point to? Is the simulation period one long simulation that began on 1 July? Or is it daily, individual simulations? This isn't clear and could have significant impacts to the results.

Response: Simulations were only conducted for part of TRACER due to limitations in computational resources. WRF-Chem simulations are highly resource-intensive and running them for the full TRACER period would require substantially more computing time and storage than was feasible. Therefore, we focused on a subset of the campaign to balance resolution, accuracy, and available resources.

We have now included the answers for the above questions in the revised manuscript:

Lines 268-279: "The model simulations were performed for the period from 1 July to 30 August 2022, using a 5x5 km horizontal grid spacing with 45 vertical layers. A model spin-up time of 3 days was used, and the restart files were used for the remainder of the simulations. Initial and boundary conditions for meteorology were provided by the North American Mesoscale (NAM) model every 6 hours. The model configuration was successfully set-up and is considered sufficient to resolve the key meteorological processes relevant to the aerosol chemistry examined in this study. To validate this assumption, simulated meteorological fields and aerosol variabilities are compared against observations. Similar model setups have been successfully applied in previous WRF-Chem studies over the continental US (e.g., Berg et al., 2015; Wang et al., 2021; Subba et *al., 2023; Shrivastava et al., 2024), which demonstrate their suitability for representing aerosol-cloud interactions. The details of the configurations are shown in Table 2."*

14. Page 7, lines 202-210: This information feels better suited to the site description section. While it's using land use/cover information by the model it's actually describing the site itself, not the model set up. Suggest either rephrasing or moving. Also, lines 204-206 don't make sense as written, suggest a rephrase to better describe the differences of the land cover at each site.

Response: While we agree that the land use land cover details would fit better in the site description section, these descriptions are only apparent from the model results. Therefore, it is also appropriate to include them in the model setup section where the domain is described. However, we acknowledge that the original lines 204-206 were unclear, so we are replacing the sentence with:

Lines 293-295: "Both sites have cropland and grassland to the west and north, as well as evergreen, deciduous, and mixed forests from the north to east directions."

15. Section 2.3, lines 211-229: This paragraph is not describing the model setup and feels out of place. There are also a lot of initial results here. Suggest moving to a different section that would focus on model verification/results.

Response: Thank you for the suggestion, we agree that parts of that paragraph read like results. However, we intentionally retain a brief comparison of the key meteorological fields and bulk aerosol properties in Section 2.3 (Model simulation setup) because this section also documents how the configured model represents the regional meteorology and aerosol environment. Keeping this concise performance context alongside the setup clarifies the link between configuration choices and model behavior and better frames the subsequent analyses. We keep this discussion succinct and defer detailed verification to the Results.

16. Page 7, line 214: What is 'feasible'? It isn't clear what guidelines are being used and feasible is subjective. Looking at S1, the model doesn't appear to capture the amplitude of the diurnal cycle well and over-estimates wind speed, which are both important when considering the meteorology and sea breeze characteristics. Discussing where the model is and isn't doing well would add context and benefit the paper.

Response: We appreciate the reviewer's observation. The purpose for these simulations is to provide a physically-reasonable approximation of the meteorological and aerosol environments across the southern Texas region that are not captured by point measurements during TRACER.

By "feasible", we intended to convey that the model's performance is within an acceptable range for our application. We have now replaced "feasible" with "adequate agreement for the purposes of this study". Specifically, we assessed model performance using the metrics, mean bias (MB), root mean square error (RMSE), correlation coefficient (R) for temperature, wind speed, and wind direction. In addition, we also implemented widely applied MERRA-2: Modern-Era Retrospective analysis for Research and Applications to compare these meteorological variables to assess the performance of the model simulations.

Lines 304-313: "We assessed model performance using metrics: mean bias (MBE), root mean square error (RMSE), and correlation coefficient (R) for the quantities of temperature, wind speed, and wind direction. In addition, we also considered Modern-Era Retrospective analysis for Research and Applications (MERRA-2) reanalysis products to further evaluate the model performance (Geralo et al., 2017). Our model reproduces the measured temperature diurnal cycle at both sites with high correlation (r up to 0.87) and low MBE (<±1 ℃). Wind speed and wind directions show weaker correlation (r up to 0.65) and MBE of 0.76 m s^{-1} and 12.5°, respectively. Individual SBF events are further analysed to compare the measured and modeled variables in later sections."

17. Fig. S1: figure caption needs expanded to include the stats that are within the figures (assuming obs vs simulation/MERRA). No mention of MERRA data set takes place anywhere, it's just shown in the figure without an explanation of what it is or why it's used.

Response: Please refer to the response to Comment 16.

Figure S1's caption is expanded as shown below:

*"**Figure S1.** Time series of hourly meteorological variables from 04 July to 30 August 2022 at the M1 and S3 sites: (a) 2 m Temperature, (b) 10 m wind speed, and (c) 10 m wind direction. Observations (yellow) are compared with WRF-Chem simulations (pink) and MERRA-2 reanalysis (blue). For each variable and site, the correlation coefficient (r), mean bias error (MBE), and mean fractional bias (MFB) are reported in the panels, quantifying model performance relative to observations."*

18. Page 8, lines 221-228: Suggest a rewrite/reconnection between what is shared in the previous sentences and how you connect them with literature. What discrepancies are you referring to, how does the cited literature (i.e. dust storm) compare with what you're trying to simulate here? The connection feels disjointed.

Response: We agree that the original phrasing was disjointed and did not clearly connect our findings with the literature. The discrepancies we refer to as the biases in the simulated aerosol concentrations compared to observations, specifically the tendency of WRF-Chem to underestimate or overestimate aerosol levels depending on different background conditions. We have revised the sentences to highlight that such discrepancies are a consistent feature of WRF Chem across regions and applications, underscoring that our results fall within the range of previously reported model performance.

Lines 320-326: "These model-measurement discrepancies are consistent with previously reported WRF-Chem biases. For example, Soni et al. (2022) reported that during dust storm events over the Indian sub-continent, WRF-Chem captured spatial aerosol patterns but underestimated concentrations in regions of high aerosol loading. Similarly, Tuccella et al. (2012) reported that WRF-Chem underestimated peak aerosol concentrations by 7.3%. More recently, Georgiou et al. (2022) reported underestimation of background PM2.5 by 16% and of industrial by ~20%."

19. Page 8, lines 238-240: Cite your figure. Are your wind speed measurements able to be precise to the tenth of a m/s? How are you calculating average wind direction? I'm suspicious of if this is accurate, especially in the overnight periods when offshore flow was common. Ensure you're breaking the wind direction into u and v components to find the average, because a simple degree average can lead to southeasterly winds a lot of the time, particularly for northerly winds (e.g. (358 + 2)/2 = 180). Personally, I think the first paragraph of 3.1 could be removed in its entirety.

Response: Thank you for pointing this out. We have removed this paragraph as suggested by the reviewer, since it does not add anything new and has already been discussed in other sections of the manuscript.

We also agree that averaging wind directions using a simple arithmetic mean is inappropriate because it obscures magnitude of direction. We have now replaced the averaged wind direction figure (Fig. 4b) with the waterfall wind direction plot, where hourly wind directions hour extends to the right from its hour line, the width at a given direction is proportional to how frequently that direction occurred at that hour.

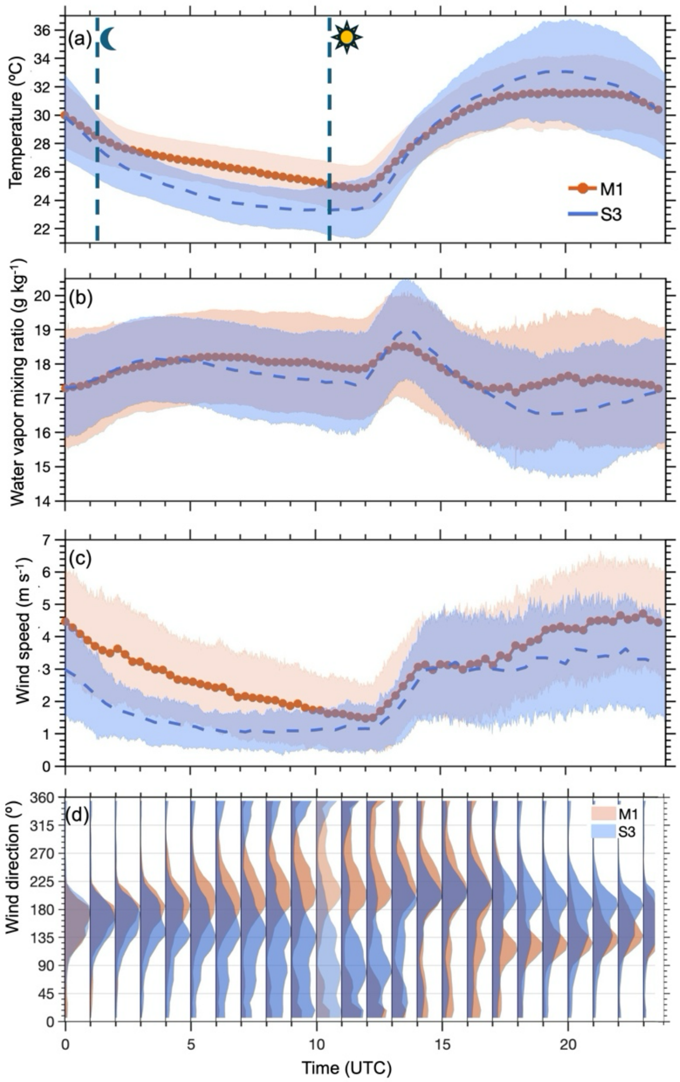


Figure 4. *Diurnal variation of meteorological variables (a) Temperature at 2 m, (b) water vapor mixing ratio (w) (c) wind speed at 10 m, and (d) wind direction waterfall diagram at 10 m measured at M1 (in orange) and S3 (in blue) sites averaged during IOP. The shaded color represents the standard deviation from the mean.*

Lines 335-346: "M1 exhibits higher temperatures during the cooler parts of the day (early morning) and slightly lower temperatures during the warmest parts of the day (early afternoon). w at M1 is lower during the warmer periods and higher during the cooler periods of the day. At both sites the value stays near 17-18 g kg^{-1} *for most of the day, with a common moistening pulse around 13:00-15:00 UTC that coincides with increased wind speed. At similar hours, the wind directions are similar at both the sites. Except in the morning, winds at M1 are typically 1-2 m s*$^{-1}$ *stronger than at S3. The M1 site shows an increase in w near 20:00 UTC, likely tied to the SBC. S3 exhibits a larger shift in the wind directions compared to that of M1. The two sites have similar directions during the late night (00:00- 05:00 UTC) and early morning (13:00-15:00 UTC) hours.*

During the dominant afternoon SBC period (around 20:00 UTC), winds are predominantly from the southeast at M1 and from the southwest at S3."

20. Page 8, line 248: Suggest using water vapor mixing ratio (or another absolute moisture measurement) rather than RH, since RH depends on temperature.

Response: Thank you for the suggestion, we have now replaced the RH analysis with that of water vapor mixing ratio's. Please refer to the response to comment 19.

21. Page 8, line 249: 'These values are comparable'. What values? RH? Temperature? Try to be clearer when making these statements. Also, what do you mean comparable? Within a certain range? This is vague wording.

Response: Thank you for pointing this out. We no longer have this statement in the modified manuscript. Please refer to the response to comments 19 and 20.

22. Page 9, lines 253-255: How would the differences in proximity to water and land cover account for the meteorological variations? Which met. Variations? Can you tie this to past findings?

Response: Thank you for the helpful suggestion. We have clarified the specific meteorological differences such as moderate temperature range, elevated humidity and coastal breeze development at M1 that arise from its proximity to water vs. S3's more inland land cover can influence the land-atmosphere interaction. We've also cited the relevant literature to support these mechanisms.

Lines 347-360: "Although these sites are geographically close, their different proximities to water bodies and varying land cover types may account for the observed meteorological variations, such as differences in temperature modulation, humidity, and breeze development. M1 lies adjacent to both Galveston Bay and Gulf of Mexico, thus nearby water moderates temperature and promotes higher humidity, favoring sea- or bay- breeze circulations. In contrast, although S3 is at a similar distance from the Gulf as M1, it is more inland, separated from the shoreline by an intervening expanse of land, so it experiences stronger daytime heating and a weaker, more modified marine influence than M1. It has a land surface covered predominantly with vegetation and soil that cools faster at night than urban landscapes. However, urban landscapes retain heat, remaining warmer into the nighttime and potentially moderating temperatures during the subsequent daytime (Maria et al., 2013). These behaviors are consistent with the prior studies showing the coastal sites experienced moderate temperature and enhanced humidity (Hu, 2021; Subramanian et al., 2023), *and that land-use influenced local temperature and boundary layer dynamics via evapotranspiration and surface heating (Fang et al., 2025).”*

23. Page 9, lines 261-269: This is a big change in focus from the previous paragraphs in this section, I would consider moving this to the data/methods section and providing significantly more information. While the focus of this paper is on aerosols, this paragraph does not give enough information on the sea breeze circulations themselves, which is the other key component to your work. Things like ‘Most of these cases are under the control of anticyclonic systems’ does not provide the necessary background information of how this applies to the two sites. The sea breeze timing needs more information, as diurnal trends in aerosol lifecycles could play a part in your analyses, coupled with the sea breeze timing, which varied throughout the campaign. It also isn’t clear if your sea breeze events for M1 are only sea breeze or bay breeze events. There is no discussion on how many sea breeze events there are (although this is included in the conclusions and elsewhere later). Discussion on how Wang determines the timing would be beneficial, as wind direction and moisture changes don’t always happen simultaneously with the passage of a sea breeze.

Response: We thank the reviewer for this thoughtful comment. We agree that some of the methodological description of how SBCs are identified is better suited for the Data and Methods section, and we have moved portions of this text accordingly (Lines 236-243). Our intent in this section was to provide the framework for how SBC events were identified, with a focus on their connection to aerosol variability in subsequent analysis. We agree that clarifying the extent to which SBCs influence surface meteorological variables is an important context.

The role of the SBC in shaping the underlying meteorology has been extensively studied in the previous work (Wang et al., 2024 and Deng et al., 2025) and is therefore not repeated in detail here. However, we have now included important details on the role of the SBC in the revised manuscript, as shown below:

Lines 236-259: “This study draws heavily from SBC synoptic-scale regime identification performed by Wang et al. (2024) to further inform on controls affecting SBC evolution and cloud formation at the two sites. Every SBC day identified by Wang et al. (2024) during the IOP period is considered to explore SAI during TRACER. A total of 46 SBC events at the M1 site, and 30 SB events at the S3 site were identified by Wang et al. (2024) during TRACER’s IOP (Table 1). They explored Gulf breeze and bay breeze circulation characteristics using a suite of datasets, including ground-based measurements, satellite observations, and reanalysis datasets, using machine learning techniques, and Lagrangian cell tracking methods. Most IOP SBC events were classified as occurring during large-scale anticyclonic conditions, with the predominant occurrence of SBCs observed during southeasterly background surface wind directions. The SBF timing at both ARM sites was determined using surface wind and water vapor mixing ratio time series.

Overall, Wang et al., (2024) found that the SBF typically arrived at the M1 site at 20:30 UTC (i.e., 15:30 LT), and at the S3 site at 20:50 UTC (i.e., 15:50 LT). The M1 site, situated along the western shore of the Galveston Bay, was also influenced by bay breeze circulations, frequently resulting in an earlier shift in the local meteorological state compared to that of the S3 site (only influenced by the Gulf SBC). The M1 was shown to experience an additional bay breeze contribution during 22 out of 43 SBC events. Wang et al. (2024) also reported that M1 experienced higher intensity changes in the meteorological conditions associated with these SBFs as compared to S3, particularly when the background wind directions are southwesterly or westerly. At both the sites, these SBF passages were associated with a significant increase in w and wind speed, along with a decrease in surface temperature. The arrival of the fronts also typically increased the vertical wind speed within the boundary layer, with a mean speed of up to 2 m s-1 within the lowest 1 km."

We have added a summary table showing the total number of SBC events, along with the number and percentage of days showing enhancement, reduction, or neutral influence.

"Table 1: Summary of SBC influence on aerosol number concentration at the M1 and S3 sites. Events are classified into enhancement, reduction, and neutral categories.

Site	Description	Combined	Enhancement	Reduction	Neutral
M1	Days (fraction of the total events %)	46 (total SB events)	13 (28 %)	16 (35 %)	17 (37 %)
	Concentration change (after - before) %	-23 (all enhancement + reduction events) -7 (total number of events)	+55	-42	-11
S3	Days	30 (total SB events)	8 (27 %)	4 (13 %)	18 (60 %)
	Concentration change (after - before) %	+9 (all enhancement + reduction events) +3 (total number of events)	+64	-45	-10

Small apparent changes in the neutral category reflect natural variability and are not considered a systematic response.

24. Page 9, line 277: Is this supposed to be shown in a figure?

Response: We have removed this sentence since it is not included in the figure.

25. Page 10, lines 286-288: Is the aerosol bulk mass concentration supposed to be shown somewhere? S3 is now being described as within a 'marine coastal environment' which is what you've previously described the M1 site as. This is confusing to the reader, as S3 has always been called rural prior to this instance.

Response: We have removed the statement describing the day-to-day variabilities at each site and have retained only the result describing the overall summertime variability between M1 and S3.

We agree with the reviewer that referring to the S3 site as 'marine coastal environment' can be misleading. To improve the clarity we have revised the terminology and now describe it as a 'rural coastal environment'. However, the rural coastal site does not imply pristine aerosol conditions. Please refer to the response to comment 10.

26. Page 10, lines 290-294: Percentages don't match what is shown in Fig. 5 (assuming this is what you're referring to). Please reference the figure where this would be shown and address the discrepancy.

Response: Thank you for pointing out the error, we have corrected it in the revised manuscript (Lines 374-380).

27. Page 10, line 295: This statement does not match the math stated above or Fig. 5. Please address this discrepancy. Also suggest moving this sentence before the previous one so that you're presenting your findings, giving the average change, then connecting to literature rather than back and forth between findings.

Response: We have corrected the number of the previous statement and now the numbers match as shown below and have moved it above the previous statement. Refer to response 26.

28. Page 10, lines 297-310: Prior to now NPF is not mentioned, which is jarring. Suggest adding some information about NPF (what they are, how they're determined, etc) in the introduction.

Response: We thank the reviewer for this helpful suggestion. We have now revised the introduction to include a brief description of new particle formation (NPF), including what NPF events are and how they are determined in this study. This addition provides context earlier in the manuscript and improves the flow leading into the later discussion of NPF.

Lines 46-53: "One such process is new particle formation (NPF), which is a common aerosol microphysical process that impacts the overall aerosol number concentration (Kulmala et al., 2004; Kerminen et al., 2005; Kuang et al., 2008; IPCC 2013). NPF events typically include a sudden burst of aerosols, i.e., the nucleation of gas molecules and formation of stable clusters of diameters 'Dp' > 2 nm, followed by subsequent growth, firstly to a size range with Dp > 50 nm and possibly growing to a size where the particles can act as a CCN (Dp > 100 nm) (Yu and Luo, 2009; Kerminen et al., 2012; Gordon et al., 2017)."

Lines 381-395: "The NPF events are identified by analyzing the aerosol size distribution measured by the SMPS (Kuang et al., 2008; Dal Maso et al., 2002; Mikkonen et al., 2011). This is accomplished by designating characteristic features for NPF found in the size distribution behaviors in time, including the appearance of the nucleation mode at a diameter (Dp) < 25 nm, followed by distinct growth pattern (where the particles increase in size over several hours) forming the characteristic "banana-shaped" pattern in the aerosol number size distribution."

29. Page 11, lines 334-337: This sentence is valuable, but feels a bit confusing where it's at, suggest moving up or expanding the point further for clarity.

Response: Thank you for your suggestion. We have expanded the point further for clarification.

Lines 420-426: "Nevertheless, aerosol exchanges are complex, and TRACER also provided several examples of marine aerosols carried by the SBF that were associated with negligible influences on the ambient marine aerosol mode. Finally, TRACER site measurements may not always be representative of a broader air mass or regional conditions (e.g., intermittent local source interactions with smaller-scale SBC features). WRF-Chem modeling may help to bridge these spatial representativeness gaps and provide reference for the regional context of the potential impact of the SBC on aerosol distributions."

30. Page 11, line 340: Why this time (i.e. 5 mins before)? Is this an average over the 5 minutes before SBF passage or an instantaneous value? You refer back to Sect. 3.1, but this information isn't there either.

Response: We consider a five-minute average necessary to capture the instantaneous timing of SBF passages. All datasets were averaged over this five-minute interval, so this average normalizing value is an instantaneous value aligned with SBF passage. We have clarified this methodology in Section 3.1.

31. Page 12, line 349: What do you mean by 'clean conceptual model'? I think you just mean a clear trend, but the wording is awkward.

Response: That is correct, we have revised the wording as 'clear trend' in Line 441.

32. Page 12, line 351: Word choice for 'disappears' is not very scientific. Please change. Also, is there any QC taking place to ensure the spikes are legitimate and not erroneous? This goes back to comment 12 above.

Response: We have replaced 'disappears' with 'dissipates'. Thank you for the question. This spike is not erroneous and represents a measured signal. Please refer to comment 12 for the data quality control statements. In addition, ARM provides data quality reports, which have been considered while downloading the datasets.

33. Page 12, lines 354-358: Why is 1 hour chosen? Is this purely subjective based off the observed data or is there any objective reasoning for this time frame choice?

Response: Thank you for the question. The choice of a 1 hour window is based on the observation that most of the enhancement or reduction effects are most pronounced during the first hour following the passing of the SBF. For instance, the normalized changes in aerosol number concentration (Figures S2 and S3) show a sharp shift within the first hour. In addition, please refer to the representative cases shown in Figure 6. Beyond the first hour, the observed variations are likely influenced by additional processes, such as secondary effects of meteorological transitions induced by the SBF, as well as changes in direct aerosols or precursor emissions from both local and regional sources. Moreover, the intensity of the SBF's influence typically dissipates or becomes less distinct after the first hour. There were no additional criteria applied in selecting this time frame. These clarifications have been added to the revised manuscript:

Lines 445-454: "Considering all the SBF passages we collected (Figs. S2 and S3), we suggest $\Delta T = T_{SBF} \pm 1$ *hr often best represents the "before"* ($\Delta T_{-} = T_{SBF}$ - 1 hr) *and "after"- SBF* ($\Delta T_{+} = T_{SBF}$ + 1 hr) *times over a location. The enhancement or reduction effects are most pronounced during the first hour following the passing of the SBF. Beyond this period, the observed changes may be influenced by additional factors, such as the secondary effects resulting from meteorological transitions induced by the SBF. Additionally, the intensity of the SBF's impact may begin to weaken or become less pronounced after the first hour. With that assumption, a* *percentage change of the aerosol number concentration [(after-before)/before x 100%] can be further calculated. 'Neutral influence' days with the change in aerosol concentration <10% are not considered in this analysis."*

34. Same area: Some discussion regarding diurnal cycle trends in aerosols would be beneficial. T +/- an hour centered on the sea breeze, without any consideration in the sea breeze timing, is an important piece of the puzzle that should be addressed somewhere within the results.

Response: We agree that the diurnal cycle is an important context. In our analysis, we have explicitly accounted for the timing of the SBF for each event. The SBF passage time at each site is taken directly from Table A1 in Wang et al. (2024), and we define this as TSBF=0. All measurements are then aligned relative to this reference point, allowing use to examine aerosol changes in the hours before and after the SBF passage in a manner that preserves the diurnal structure. We have clarified these points in the manuscript.

Lines 429-432: "The timing of the SBF for each event is explicitly considered, using the passage times provided in Table A1 on Wang et al. (2024). The SBF passage at a site is defined as T_{SBF}=0. This approach allowed evaluation of aerosol number concentrations before and after the SBF passage while retaining the diurnal cycle context."

35. Page 12, line 357: How many days were considered neutral that are not being accounted for in the analyses?

Response: Please refer to response 23.

36. Page 12, lines 359-360: This sentence is kind of hard to follow as written. What do you mean by 'more frequent' changes? Is this increasing or decreasing aerosol concentration? What about the other 40 or 66% of cases at each site? I would suggest being more specific here by including case numbers (e.g. 20 sea breeze cases at the M1 site show increasing aerosols while only 10 cases at S3 show…). By the time I've gotten to this point in the paper I don't remember how many sea breeze cases there are at each site.

Response: Please refer to the response to comment 23.

37. Page 12, lines 360-362: Are these averages considering all sea breeze cases, regardless of their classification (enhancement, reduction, neutral)? Just the cases where a change occurs? It isn't clear. Maybe think of a clearer way to show these results between sites.

Response: These averages do not include the neutral days, and these results are based on days showing either enhancement or reduction. Clarifications have been made in the relevant section to specify that neutral days are excluded from all statistical summaries (Lines 457-458). We have now included a discussion on the average changes on enhancement and reduction days separately for each site, to avoid partial cancellation when estimating the net change, as shown below. Table S1 summarizes the percentage of events showing enhancement, reduction, or neutral influence on the aerosol number concentration at the M1 and S3 sites. Please also refer to the response to comment 23.

Lines 467-476: "During enhancement days, the M1 site shows an average increase in aerosol number concentration of ~ 55%, rising from 3.8x 10^3 cm^{-3} during ΔT- to 5.9x 10^3 cm^{-3} during ΔT+. In contrast, during the reduction days, the concentration decreases by ~ 42%, dropping from 13.2x 10^3 cm^{-3} during ΔT- to 7.6x 10^3 cm^{-3} during ΔT+. At the S3 site, the average changes are ~64% (from 2.4x 10^3 cm^{-3} during ΔT- to 3.9x 10^3 cm^{-3} during ΔT+) enhancement and ~45% (from 4.9x 10^3 cm^{-3} during ΔT- to 2.7x 10^3 cm^{-3} during ΔT+) reduction. When averaged across all events, the aerosol number concentration at M1 shows a net decrease of ~23%, from 8.9x 10^3 cm^{-3} during ΔT- to 6.8x 10^3 cm^{-3} during ΔT+, while S3 exhibits a net increase of ~9%, from 3.2x 10^3 cm^{-3} during ΔT- to 3.5x 10^3 cm^{-3}. These contrasting trends underscore the regional variability in aerosol responses associated with SAI events."

38. Page 12, lines 363-366: Suggest moving this information up, after the first (revised) sentence.

Response: The sentence is now moved to the paragraph after the summary of the total number of SBC events (467-476).

39. Page 12, line 366: Which discrepancies? The difference in classification or the changes in aerosol number concentration? Be clear here.

Response: After revision, we no longer use the term 'discrepancies' in that sentence. Instead, we have reworded the sentences in Section 3.3 to clearly distinguish between classification differences and changes in aerosol concentration magnitude during SAI.

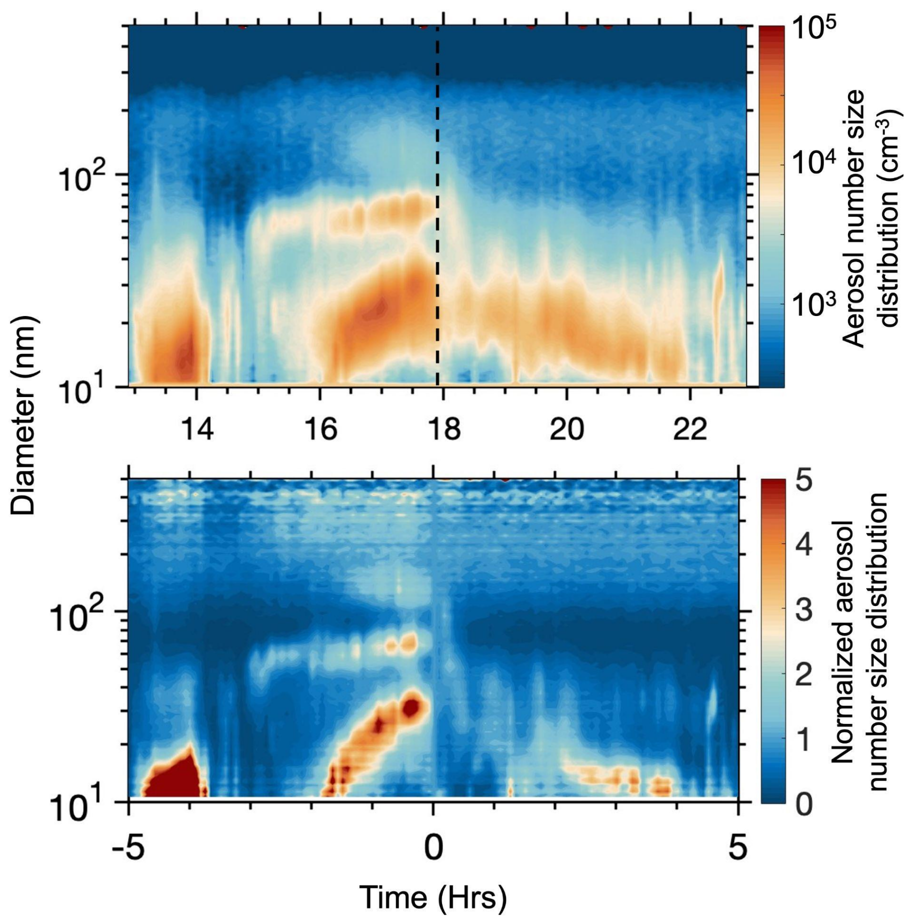
40. Page 12, line 369-374: This is a good start to connecting the results/descriptions of measurements to the 'why' things may be happening. I would suggest expanding on this, while trying to tie in some literature to support your reasoning. Discussing the airmass differences (sea vs bay) and possibly pulling in some trajectory analyses could really strengthen this important piece of the science and story.

Response: We have not included the trajectory plots here, but we have the synoptic scale influence included in the model simulation so, it included the influence of the long-range transportation, which we see in the July 17 case. The difference in the airmass between these events are discussed later in Section 3.5, where the regional influence of SAI is discussed. Please refer to the response to comment 48.

41. Page 13, first paragraph: Switched back to NPFs, feels disjointed. Suggest a reworking of this section for flow purposes. Also, are the 11 NPF SB events observed at both sites?

Response: We appreciate the comments. We have now revised this paragraph as shown below:

Lines 496-505: "SAIs can also interfere with NPF events. On SB days, a total of 7 NPF events were observed at the M1 site and 4 at the S3 site, with 3 occurring simultaneously at both sites. Among these, 45% (5 out of 11) events showed distinct changes in NPF characteristics during the SBF passage. For example, on 16 July an NPF event was observed at M1 prior to the SBF (Fig. S4). With the arrival of the SBF, particle growth abruptly ceased, and the elevated particle concentration (~14 e^3 particles cm^{-3}) rapidly decreased to ~5 e^3 particles cm^{-3} (Fig. S4). The normalized aerosol size distribution further shows that the NPF activity evident in the hours before the SBF period ($\Delta T_{-}=T_{SBF}$ - 1 hour) disappeared in the hour following the SBF ($\Delta T_{+}=T_{SBF}$ + 1 hour). The low aerosol concentration air mass trailing the SBF passage thus led to a sharp reduction in the aerosol number concentrations in the after-SBF period."



***"Figure S4.** Aerosol number size distribution at the M1 site during an NPF event on 16 July 2022. (Top panel) Time series of measured aerosol number size distribution (cm^{-3}). The vertical dashed line marks the passage of the SBF (T_{SBF}). (Bottom panel) Normalized aerosol number size distribution (relative to aerosol number size distribution at T_{SBF}, i.e., T=0)."*

42. Page 13, line 375: Did the NPF events occur during SB events or on SB days? Later in the paragraph it's described as occurring before the SBF passes, so it's a little unclear what is meant here.

Response: We thank the reviewer for pointing this out. The NPF events occurred on SB days, not specifically during the SBF passage. We have revised the text accordingly for clarity.

43. Page 13, line 383: Is the reduction purely 'cleaner' air masses being advected in or could other factors be at play? How are you sure you can definitively state that it is the SB frontal passage causing the change in this case?

Response: Thank you for asking these questions. Changes in aerosol properties over a location are primarily driven by variations in emission sources, precursors, and meteorological conditions. During SBC events, there are distinctive changes in wind properties, including both speed and direction. As we have observed, an SBF can transport air masses with either high or low aerosol concentrations. However, the impact of the SBF at a given location depends on the relative concentration of aerosols in the incoming air mass compared to the local background. In this case, the air mass over the M1 site contained higher aerosol concentrations than the air mass associated with the SBF. For clarity, we have revised the statement as shown below:

Lines 504-505: "The low aerosol concentration air mass trailing the SBF passage thus led to a sharp reduction in the aerosol number concentrations in the after-SBF period."

44. Page 13, lines 387-388: The Houston urban core is northwest of M1, not north and east. There are heavy industry areas directly north and the shipping emissions from the bay to the east, but the Houston urban center isn't in the directions listed and doesn't make sense with the observations.

Response: Thank you for pointing this out. That is correct that the Houston urban core lies northwest of the M1 site, not to the north and east. We have revised the description accordingly.

Lines 750-754: "The relationship between wind and aerosol number concentrations showed that aerosol concentrations at the M1 site are higher when prevailing winds originate from the direction of the Houston urban core (northwest) to north, compared to the winds coming from the sea (south and intermediate directions) (Fig. S5)."

45. Page 13, line 391: Terminology used is making following the findings hard. Here you say 'This transition is consistently…' but earlier you share that things are very inconsistent.

Response: We apologize for the inconsistency and agree that the current wording was misleading. However, in the revised manuscript these lines no longer exist. In the revised section 3.3, we have avoided the above-mentioned inconsistency.

46. Page 13, lines 393-394: What do you mean when you say 'However, concentrations are observed to be higher on days associated with a higher aerosol loaded marine air mass.'? It isn't clear. Next sentence also isn't very clear. Does S3 respond similarly when higher aerosol loads are present or respond similarly in any scenario?

Response: In the revised manuscript these lines no longer exist. In the revised section 3.3, we have avoided the above-mentioned inconsistency *(Lines 506-525)*.

47. Page 13, lines 399-401: Can you make the tie in with this literature a little clearer? How does O3 and NOx compare to the total number concentration that you're looking at?

Response: Thank you for the question. Here's a clearer and more direct response that explicitly ties this work to Pinto et al. (2014). Since these are better suited in the general description, they are placed in the introduction section:

Lines 119-125: "Pinto et al., (2014) observed that wind direction reversals bring aged, aerosol laden plumes with high O_3 and NO_x levels back to the Houston area. They found that easterly winds, originating from the Houston Ship Channel (HSC), are most strongly associated with elevated levels of photochemically produced species. Similar conditions that promote O_3 and NO_x build-up also drive secondary particle formation, leading to increases in aerosol number concentrations. These particle-phase enhancements in total number concentration result in higher aerosol concentration in the air mass transported from the east."

48. Page 13, line 403 and beyond: What does it mean for an 'episodic transboundary aerosol transport' to take place? Are these scenarios important to your results (i.e. were there dust events taking place during TRACER). This and biomass burning should be something you can verify for the time period and would be important context with your results, rather than just an input of what could be a factor.

Response: Thank you for this helpful comment. We agree with your point. In the revised manuscript, we have moved the general description of episodic transboundary transport and biomass burning to the introduction (*Lines 128-132)*.

In this study, detailed analysis of dust and biomass burning events are not analyzed. However, they are generally recognized as factors that can influence the broader aerosol environment, and related effects are the focus of parallel studies currently being carried out by coauthors. However, the enhancement case on 17 July was strongly influenced by dust transport from the Saharan desert in the days leading up to the event. This is evident in MERRA-2 column dust fields (included as a supplemental figure in the revised manuscript), which show elevated dust loading over the Gulf of Mexico and southern U.S. during this period.

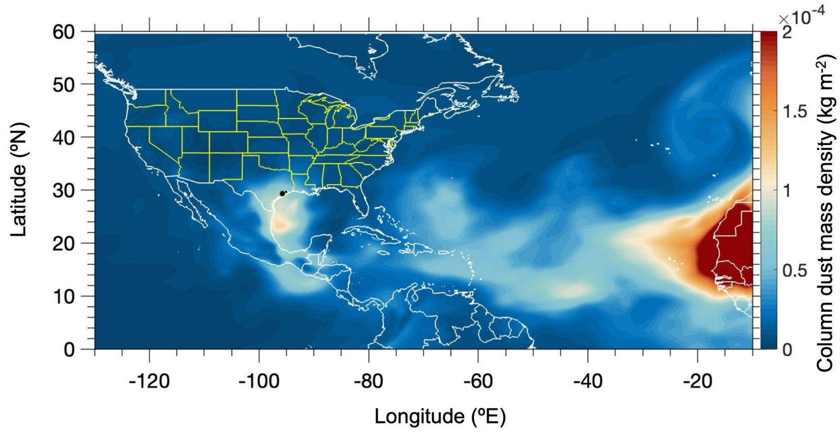


Figure S9. *Spatial distribution of MERRA-2 derived dust column mass density, averaged over 16-17 July 2022.*

Lines 645-656: "Notably, the 17 July event occurred in a different ambient aerosol environment than the 10 July event. MERRA-2 column dust mass concentrations (Fig. S9) indicate Saharan dust transport on this day, yielding elevated dust loading over the Gulf of Mexico and resulting in marine aerosol mass concentrations that exceeded those over land. The high concentrations are also observed to be more prominent to the southwest of the M1 site (Fig. 10c). Hence, as the SBF moves inland on 17 July, it transports this higher aerosol containing air mass, replacing the lower aerosol containing air over the site and causing an increased aerosol concentration at the M1 site. The onshore winds carry an air mass influenced by both local and long-range transport, originating from both land and sea."

49. Page 14, lines 410-411: This is the first real mention of the Bermuda-Azores High. It feels tacked on and shallow, but a better meteorological discussion earlier on could help to tie this in better.

Response: We agree that the mention of the Bermuda-Azores High appeared abrupt in the original draft. To address this, we have added a more detailed meteorological context earlier in the introduction describing the role of large-scale circulation patterns in modulating regional meteorology over the Gulf Coast.

Lines 128-134: "At the synoptic scales, the circulation patterns modulate regional meteorology over the Gulf coast. The Bermuda-Azores High helps trans-Atlantic transport of North African dust to the southeast coast (Perry et al., 1997; Bozlaker et al., 2013). Summertime conditions are notably influenced by episodic transboundary aerosol transport (Mao et al., 2020; Das et al., 2023), including dust events from the Sahara Desert (Aldhaif et al., 2020) and biomass burning events in Central America and its neighboring states. The biomass burning includes prescribed agricultural fires in Central America (Wang et al., 2018) and forest fires in surrounding states (Westenbarger and Morris, 2018)."

50. Page 14, line 433: Be more specific here, east of M1 is the bay, which is at least partially a marine environment, though not the same as what you'd have from the Gulf's environment.

Response: Thank you for this helpful suggestion. We have updated the discussion accordingly to provide this context.

Lines 544-545: "During the after-SBF period, the winds shift predominantly from the southeast and south, bringing in a more marine-influenced air mass."

51. Page 15, line 338: How would higher wind speed lead to dilution? Further explanation of this theory for the observed results is needed.

Response: Higher wind speeds increase wind shear near the surface, leading to enhanced mechanical production of turbulence, which expedites both horizontal and vertical dispersion of aerosols and vapor (Kgabi and Mokgwetisi, 2009; Dueker et al., 2017; Liu et al., 2025). Boundary layer height and vertical transport fluxes are increased with increasing wind speed, which will dilute the aerosol and water vapor concentrations (Glantz et al., 2006).

On the other hand, lower wind speed causes atmospheric particles to accumulate in one area, which is aided by the lower boundary layer and decreased turbulent mixing. This lack of dispersion often degrades air quality by limiting dilution of air emissions (Seinfeld and Pandis, 2006).

Under stable stratification, buoyancy-driven turbulence is suppressed, and shear turbulence becomes the dominant mechanism for dilution. This is supported by modifications in turbulent kinetic energy formulation that explicitly account for shear production alongside buoyant production (Rodier et al., 2017). Thus, while mechanical mixing may not match the vigor of convective turbulence, it can significantly mitigate concentration buildup under stable conditions.

Lines 551-561: "Higher wind speeds enhance near-surface shear, mechanically generate turbulence, deepen the boundary layer, and strengthen vertical transport, thereby accelerating dispersion and diluting aerosol and water-vapor concentrations (Kgabi and Mokgwetisi, 2009; Dueker et al., 2017; Liu et al., 2025). Conversely, low winds with a shallow boundary layer and weak turbulence promote accumulation and often worsen air quality due to limited dilution (Seinfeld and Pandis, 2006). The modified near-surface air mass at S3 persists overnight until convective mixing begins the following day. Under stable stratification, buoyant turbulence is suppressed, and shear-driven mixing becomes the primary dilution mechanism; although weaker than convective mixing, it can still substantially mitigate concentration build-up (Rodier et al., 2017)."

52. Fig. 7: You show the bulk chemical compositions, but don't really tie this into your discussion of pre/post sea breeze changes. I would suggest either removing these subplots from the figure or adding discussion about the changes. As it stands, it isn't really adding anything to the findings.

Response: We agree with the reviewer's observation. The revised manuscript includes the discussion to capture the role of frontal passage on the aerosol mass concentrations in detail.

Lines 562-569: "The aerosol bulk chemical mass concentration at the M1 site shows a steady buildup through the day, peaking just before the passing of the SBF. Organics were the dominant species throughout, with sulfate and nitrate also contributing. After the passage of the SBF, concentrations dropped rapidly by about 1 to 3 μg m^{-3}, with the drop being more apparent in sulfate and ammonium. Within a few hours, concentrations returned to the background levels. These concentrations remained higher than those at the rural S3 site. However, the more pronounced changes in aerosol properties were observed at the S3 site. The concentrations of all species, including organic, decreased by 2 to 3 μg m^{-3}."

53. Page 16, lines 469-471: It isn't clear that there is an increase in particle concentrations ahead of the SBF. Suggest adjusting the colormap and range to make this point clearer to see.

Response: The colormap in Figure 9 (in revised manuscript) is adjusted. Please refer to subplot f, which shows that the positive change in concentration intensifies and moves inland as the SBF moves in the northwest direction.

54. Page 16, line 474: Is the SBF influence diminishing as it moves inland? The normalized change shows more changes as time goes on. Please clarify this.

Response: We agree with the reviewer that the normalized change in aerosol concentration is stronger inland. We have now corrected the statement as shown below:

Lines 633-636: "Over time, the well-defined dipole pattern emerges, characterized by reduced concentrations over the coastal zone and enhanced concentrations farther inland, consistent with the inland penetration of the maritime air mass and displacement of pre-existing polluted air".

55. Page 16, lines 576-489: When did the SBF occur for these cases? Why are no sea breeze characteristics discussed, like they were in the previous paragraph? This is important context for understanding the results. Also, for the July case, how representative is this case (e.g. higher aerosol load over the sea) with other TRACER cases? Is this an outlier or common? How would that influence your overall findings? If these cases are to be discussed and kept in the paper, they need to be expanded and include a similar discussion as to what is shown in Fig. 8. The sea breeze

in this region can be quite variable, so simply stating there was one, is not enough to justify what you're trying to find.

Response: We thank the reviewer for this comment. In the revision, we now include the approximate SBF arrival times at both sites and briefly describe the associated meteorological signatures for all the three cases. We also clarify that the 17 July case represents one of the more polluted examples but is not an outlier, as several other SBC days showed similar enhancements with varying magnitudes. This context has been added to better frame the aerosol responses in relation to SBF variability. The details of these two events are now added in the section when these two events are first introduced.

Section 3.4
Lines 575-605: "In Fig. S7, we present an example of an aerosol enhancement case associated with an SAI event on 17 July. The SBF reached the M1 site in the early afternoon (~18:12 UTC), and at around 21:42 UTC at the S3 site. The aerosol size distribution displayed an enhancement of particles in the diameter range of 15-100 nm. Total organics, sulfate, and simulated $PM_{2.5}$ also increased, suggesting that the post-SBF air mass contained higher aerosol concentrations, likely due to transport from more polluted source regions. Similar to the 10 July case, the SBF acted as the leading edge, but here it marked a more polluted marine-influenced air mass.

At M1, the aerosol number concentration also doubled (~2.2×103 cm^{-3}), accompanied by a significant shift in mean particle diameter (within 15-100 nm) during the first hour after SBF passage, with weaker changes thereafter. These responses were synchronous with shifts in wind direction from southwest to east. The easterly winds, influenced by emissions from the HSC, contributed to the observed increase. In contrast, at S3 the SAI did not produce distinct changes in aerosol size distribution or mass concentrations, and except for the increase in the wind speed, no substantial wind direction change occurred after SBF passage. The modified near-surface air mass at both sites persisted for only ~2 hours, after which background conditions returned. Notably, background aerosol modes at ~60 nm and ~150 nm persisted throughout (Fig. 7d).

Fig. S8 shows an example of a neutral SAI influence on 16 August. The SBF reached M1 at ~17:05 UTC and S3 at ~20:10 UTC. At M1, winds shifted from east to south, while no distinct directional change was observed at S3. Unlike the 10 and 17 July cases, M1 was already under high aerosol conditions, with particle concentrations consistently elevated at diameters <80 nm. In contrast, S3 remained under low aerosol conditions for most of the day, except for a brief increase just prior to the SBF passage. The SAI did not produce notable changes in aerosol size distribution, bulk chemical composition, or simulated $PM_{2.5}$, indicating that pre- and post-SBF aerosol concentrations were comparable at both sites. Although wind direction changed at M1, the marine-influenced air mass was also burdened by high aerosol loading, limiting its impact on conditions at the site. Similarly, S3 showed no discernible change, with concentrations remaining low before and after the SBF passage. Detailed discussions on these example events will be *continued in the next section that expands this discussion to include regional removal and transport influences on these SAI events."*

We have further expanded Figure 9 (original manuscript) into two figures structured in the same way as Figure 9 (Figure 8 in the original manuscript), with consistent time windows that span before SBF arrival, after its passage at M1 only, and after its passage at both M1 and S3. These revised figures (Figs. 10 and 11, in the revised manuscript) include both meteorological variables and aerosol properties, allowing a direct comparison across July 10, July 17, and August 16. This way, these figures help track the inland propagation of the SBF.

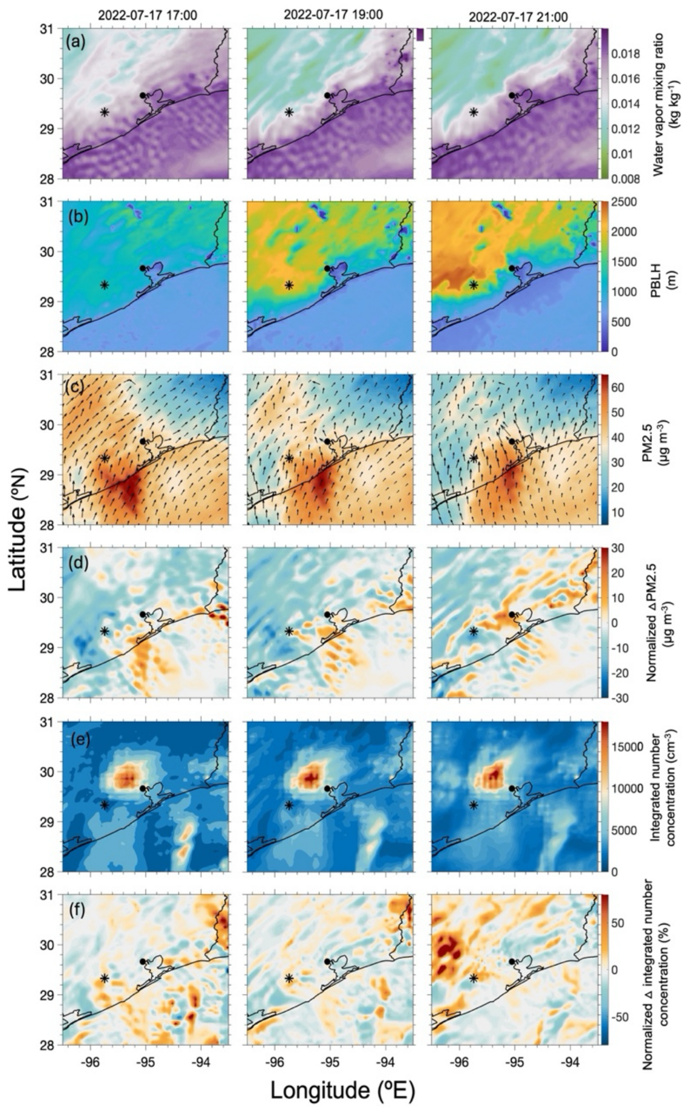


Figure 10. *Modeled surface distribution of (a) water vapor mixing ratio, (b) PBLH, (c)* $PM_{2.5}$*, and wind vector (black arrows, at the surface), and (e) integrated aerosol number concentration (nucleation + accumulation mode) at three-time steps: 17:00, 19:00, and 21:00 UTC on 17 July. Sub-panels (d) and (f) show the normalized changes, where Δ is the change from the previous time step. The filled-circle marker in the panels represent the M1 site, while the star represents the S3 site.*

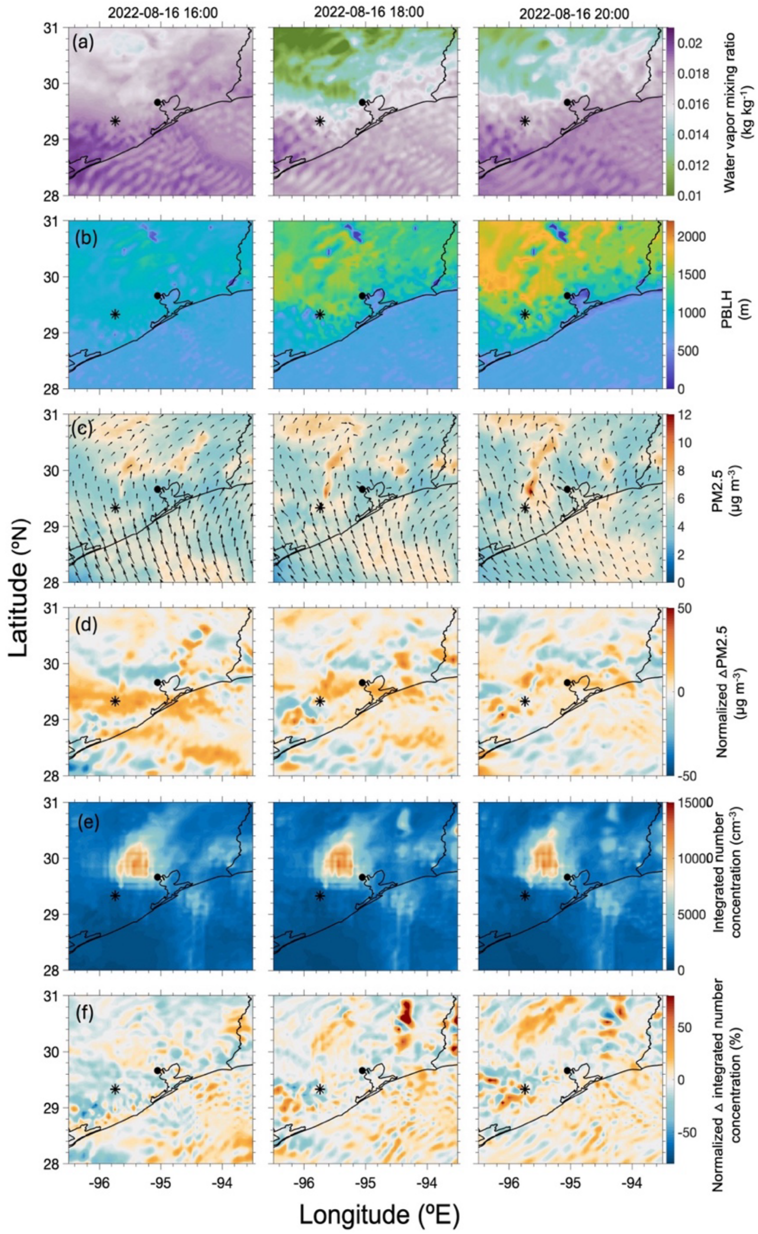


Figure 11. *Modeled surface distribution of (a) water vapor mixing ratio, (b) PBLH, (c) $PM_{2.5}$, and wind vector (black arrows, at the surface), and (e) integrated aerosol number concentration (nucleation + accumulation mode) at three-time steps: 16:00, 18:00, and 20:00 UTC on 16 August. Sub-panels (d) and (f) show the normalized changes, where Δ is the change from the previous time step. The filled-circle marker in the panels represent the M1 site, while the star represents the S3 site.*

Section 3.5

Lines 637-656: "*The additional example on 17 July (Fig. 10) is suggestive of an enhancement in aerosol concentration associated with the SBF event, while the 16 August event (Fig. 11) is indicative of a neutral influence from the SBF passage. Similar to 10 July, both days exhibit an* *increase in water-vapor mixing ratio associated with passage of the SBF, relative to inland areas not influenced by the front (Figs. 10a, 11a). The SBF passage was also accompanied by a decrease in modeled PBLH (Figs. 10b, 11b). On 17 July, the SBF had reached M1 and S3 by ~19:00–21:00 UTC; winds were predominantly from southwest to east, with easterlies likely advecting emissions from the HSC and contributing to the observed enhancements.*

Notably, the 17 July event occurred in a different ambient aerosol environment than the 10 July event. MERRA-2 column dust mass concentrations (Fig. S9) indicate Saharan dust transport on this day, yielding elevated dust loading over the Gulf of Mexico and resulting in marine aerosol mass concentrations that exceeded those over land. The high concentrations are also observed to be more prominent to the southwest of the M1 site (Fig. 10c). Hence, as the SBF moves inland on 17 July, it transports this higher aerosol containing air mass, replacing the lower aerosol containing air over the site and causing an increased aerosol concentration at the M1 site. The onshore winds carry an air mass influenced by both local and long-range transport, originating from both land and sea. In contrast to the other two events, the 16 August event occurred under a transitional regime and likely influenced by the bay breeze. The aerosol environment was notably uniform over the wider regional air masses, thus SBF passage resulted in minimal changes to the aerosol distribution (Fig. 11c, d, f)."

56. Page 17, line 500: Make the connections to why the concentration would increase in the subsequent 5hr period over M1.

Response: The sentence is now revised as:

Lines 659-662: "The wind anomaly associated with the Gulf breeze front can transport more (less) polluted, particle-laden air mass, leading to increased (decreased) aerosol concentration as it passes the site during the subsequent ~5 hours after the front passes."

57. Page 17, first paragraph in 3.6: Prior to this analysis, you've focused on either PM2.5 or integrated aerosol number concentration, but now you're breaking that into Nu0 and ac0. Please clarify why you're choosing to do so and how these two evolutions (horizontally and vertically) matter in the bigger picture. It isn't clear to me what the point in this change is for. You're also missing the 'why' here, it's purely descriptive without connecting why it matters to the science.

Response: Thank you for this helpful comment. Up to this point, our discussion has focused on $PM_{2.5}$ mass and total aerosol number concentrations, as measured by the SMPS, to describe the role of SAI. We introduced the model-derived size-resolved number concentrations (nu_0 and ac_0) at this stage to provide additional context, since changes in aerosol size distributions may not be apparent when only considering mass or integrated number. This distinction is important because $PM_{2.5}$ mass is largely driven by larger accumulation-mode particles, whereas number concentrations are more sensitive to smaller particles. By examining nu_0 and ac_0, we can assess how the SBF redistributes aerosols both horizontally and vertically in ways that influence particle microphysics, radiative effects, and subsequent cloud interactions. We have revised the text to better emphasize why this distinction matters and how it connects to the broader implications of SBF-driven aerosol transport.

Lines 608-613: "In Fig. 9, we provide the spatial distribution of modeled w, planetary boundary layer height (PBLH), surface-level wind vectors, PM2.5, and integrated aerosol number concentration (nucleation-nu0 + accumulation-ac0 mode) using WRF-Chem. Together, nu0 and ac0 concentrations reveal size-dependent aerosol changes that bulk $PM_{2.5}$ mass or total number obscure, allowing SBF-driven redistribution to be attributed to specific aerosol modes and clarifying implications for microphysics, CCN/INP, and radiative effects."

58. Page 17, lines 520-521: I'm not seeing the connection between the literature and the patterns here. What exactly are you trying to tie together by using an example with dust and mountains to compare with SB changes? Please clarify or find a more fitting example to point to.

Response: Thank you for this thoughtful comment. Our intent in citing Parajuli et al. (2022) was not to equate the specific case of dust transport along mountain slopes with the Houston coastal environment, but rather to highlight a broader point, that sea-breeze circulations can redistribute aerosols both vertically and inland over significant distances. We agree that this connection was not clearly conveyed in the original text. To avoid confusion, we have revised this section (Section 3.6) to clarify that while the mechanisms and terrain differ, both studies demonstrate the capacity of sea-breeze circulations to lift and transport aerosols vertically and horizontally.

59. Page 18, line 535: Include a citation for why N100 is being used (if applicable).

Response: We have now included the citation: Ahlm et al. (2013) (Line 703). Direct CCN measurements at the M1 and S3 sites were not available during the study period; therefore, we used N_{100} as the CCN proxy to represent the total number of particles relevant to cloud formation. In the revised manuscript, we explicitly state that N_{100} is used as a proxy for CCN concentrations, rather than direct CCN measurements.

60. Section 3.7: I feel like this section doesn't fit with the rest of the paper. A different modeling approach is being used, without being well described. While I think that this work is important, it feels like it's a big shift from 90% of the rest of the paper. I would think critically on how/if this piece should be within the paper. As I suggested earlier, I think you could break this manuscript into multiple paper, in which this would fit into a second more modeling focused one.

Response: We thank the reviewer for this valuable comment. We believe that integrating measurements with modeling is essential because it strengthens the interpretation of the observed processes and places the local-scale findings into a broader regional context. However, to streamline the manuscript and focus the narrative, in the modified manuscript, we have retained only the CCN-relevant analysis (Section 3.7.1) and removed the ARF analysis (Section 3.7.2). The radiative-forcing results will be developed as a separate manuscript, where we can treat methodology, uncertainties, and sensitivity tests in appropriate depth. In this way, the current paper emphasizes the complementarity of observations and modeling without detracting from its central observational focus. In the revised paper we:

- Clarified the limitations of using N_{100} as a CCN proxy and explicitly stated the assumptions.
- Kept the CCN figures (formerly Fig. 11 and related Supplementary Figs.) and emphasized how sea-breeze processes affect the cloud-relevant particle population and its event-to-event variability.
- Removed text, figures, and references specific to ARF from the Abstract, Results, and Conclusions, and added a forward reference noting that ARF will be presented in a companion paper.

We believe this change addresses the reviewer's concern while strengthening the focus of the current manuscript on CCN-relevant impacts of SAI.

61. Page 20, line 604: This is the first time the actual sea breeze numbers for each site are given. This information, while still important here, should be given way earlier as well.

Response: Please refer to the response to comment 23.

62. Page 21, line 621: Using the average changes defeats the purpose of having three different types of responses to the sea breeze and undersells your work. I would suggest using statistics here that highlight the changes for each of the types of SAI.

Response: Thank you for this thoughtful comment. We agree that presenting only the average change masks the variability in SAI responses and undersells the classification into enhancement, reduction, and neutral cases. To address this, we have revised the text to highlight the statistics for each type of SAI separately.

Lines 740-746: "During IOP events, surface aerosol number changed by up to a factor of two. On average, SBF passages were associated with a decrease of ~23% at M1 and increase of ~4% at S3. SBF passages produce distinct aerosol responses depending on the type of SAI event. At M1, enhancement days (26% of SB events) are associated with an average increase of aerosol concentration by ~55%, while reduction days (31% of SB events) show an average decrease of

~42%. At S3, enhancement days (27% of SB events) exhibit an average increase of ~64%, whereas reduction days (13% of SB events) show a decrease of ~45%."

63. Conclusions: I've left many comments regarding some changes or things to possibly remove. Obviously, if you are to make those changes than a lot of the conclusions would be reworked. Overall, I think the conclusions are hitting the main points well, but I would try to further highlight the importance of the work here too, not just a recap of the findings.

Response: Thank you so much for the thorough read and the specific suggestions on what to trim or revise. We incorporated your line-by-line comments and then reworked the Conclusions to align with those changes.

Lines 721-785: "Sea breezes influence multi-scale processes across the land-ocean-atmosphere interface within the region of influence of the SBC. The TRACER field campaign provided a unique opportunity to understand how aerosol and meteorological processes impact weather and climate in the urban and rural coastal environment of Houston, Texas. A total of 46 (M1) and 30 (S3) instances of SB passages were identified during the summertime TRACER IOP period. Summertime measurements from the ARM sites coupled with WRF-Chem model simulations (July and August 2022) help to quantify aerosol changes resulting from onshore transport of marine boundary layer air masses due to SBF passage and the associated atmospheric SBC impacts.

Understanding the spatial extent and duration of SAIs is crucial for assessing their environmental and meteorological impacts. For inland-penetrating SBFs, aerosol responses fall into one of the three types: reduction (clean marine air replacing more polluted continental air); enhancement (import of more polluted air), or neutral (similar air masses). The sign and magnitude of changes depend on coastal proximity to the coast and the upwind air mass history prior to SBF arrival.

TRACER measurements indicate that the urban M1 site, closer to both Galveston Bay and the Gulf of Mexico, experiences more frequent aerosol concentration changes (increase or decrease during 63% of SB events) than the rural S3 site (increase or decrease during 40% of SB days), which is primarily Gulf-breeze influenced and farther from urban/industrial sources. During IOP events, surface aerosol number changed by up to a factor of two. On average, SBF passages were associated with a decrease of ~23% at M1 and increase of ~4% at S3. SBF passages produce distinct aerosol responses depending on the type of SAI event. At M1, enhancement days (28% of SB events) are associated with an average increase of aerosol concentration by ~55%, while reduction days (35% of SB events) show an average decrease of ~42%. At S3, enhancement days (27% of SB events) exhibit an average increase of ~64%, whereas reduction days (13% of SB events) show a decrease of ~45%.

This study also provides support for how SAIs may interfere with aerosol microphysical processes, including NPF events, a key driver of the overall aerosol number budget. These changes occur *with sharp meteorological shifts, including RH (+30%) and wind speed (+4 m s-1) increases, and backing to southeasterly flow (Figs. 7. and 8.). The relationship between wind and aerosol number concentrations showed that aerosol concentrations at the M1 site are higher when prevailing winds originate from the direction of the Houston urban core (northwest) to north, compared to the winds coming from the sea (south and intermediate directions) (Fig. S5). Recently, Rapp et al. (2024) emphasized using targeted mobile sampling that collecting measurements on both sides of SB boundaries are critical for disentangling aerosol from meteorological controls. These findings are complementary to the results in this study that boundary timing and air mass origin drive the different responses at M1 and S3.*

WRF Chem simulations extend the site perspective regionally, indicating heterogeneous SAI footprints (Figs. 9, 10, 11, and 12). Across 18 simulated events, near surface PM2.5 tends to decrease by ~15% around the M1 site and increase by ~3% near the S3 site (Fig. S13). However, these responses vary with altitude (Fig. 12). The SBF may alter the vertical aerosol distribution in the boundary layer up to 2 km. Beyond thermodynamics, SB fronts also reshape convective environments (Wang et al., 2024). The storm characteristics across maritime vs. continental sides of these fronts drive the air mass contrasts produced by SBCs (Sharma et al., 2024), which can further influence the aerosol environment.

With respect to cloud-relevant particles, both observations and simulations indicate that the surface CCNproxy concentrations decrease by up to 60% following SBF passage (Fig. 13), although such changes are infrequent (~25% of the SB events at both M1 and S3 site), implying a weaker impact of SAI on marine influenced regional background accumulation mode. This aligns with Thompson et al. (2025), which showed that aerosol cloud-forming properties differ between polluted marine and continental air masses, with variability in size, hygroscopicity, and CCN efficiency across sites. Given the complex mix of marine, terrestrial, and urban sources, and the strong spatial heterogeneity revealed by both our analysis and prior TRACER studies, future studies should include direct CCN and INP measurements and size-resolved aerosol properties to better capture the role of SAI in aerosol–cloud interactions. It is important to remember that these effects are localized, occurring only during shorter timescales (~5 h) associated with daily SBC cycles over these locations. But these SAI timings align with periods of peak solar radiation and elevated aerosol concentrations, potentially leading to significant impacts on the radiation budget over the coastal regions. During times in close proximity to SBF passage, changes in solar radiation and cloud formation may influence the aerosol formation and distribution, modify atmospheric chemical reactions, and affect cloud formation and properties, thereby impacting various atmospheric processes and interactions. Because many coastal cities have high aerosol loading with frequent SBCs, accounting for SAI when estimating direct aerosol radiative forcing is crucial. However, quantifying these changes is challenging, underscoring the need for detailed future studies across diverse coastal regions."

Technical Comments

1. Page 2, lines 38-40: Suggest a rephrasing. The sentence starts with Houston and regional health effects, but shifts to global scale energy balance, which reads awkwardly.

Response: Removed the regional to global context and modified as: "These aerosol particles can have adverse effects on human health (Partanen et al 2018; Mack et al., 2020) and influence Earth's energy balance."

2. Page 2, line 40: Personification is used here with the word choice of 'felt'. Suggest a change to 'exhibited' or something of that nature.

Response: Changed to 'exhibited'.

3. Page 2, line 53: Add commas around 'such as SBCs'.

Response: commas are added.

4. Page 2-3, lines 55-73: This paragraph could benefit from a reorganization for readability.

Response: Reorganized it in the revised manuscript.

5. Page 3, line 79: Add citations to studies here.

Response: Citations are added.

6. Page 3, lines 92-93: Change 'with increase in the concentration of the smaller particles durig passage' to 'with increases in the concentration of smaller particles during the passage'

Response: Changed as suggested.

7. Page 4, line 119: remove 'recent'

Response: 'recent' is removed

8. Page 5, lines 126-127: replace 'we will use targeted… modeling' with 'the… model' and add 'is used' after (WRF-Chem).

Response: Modified.

9. Page 5, line 131: replace 'our' with 'the' – there are several other instances of 'our' throughout that could be changed to 'the' or another word/phrase to be more formal.

Response: Thank you for the suggestion. We've replaced instances of "our" with more formal alternatives throughout the manuscript.

10. Page 5, line 144: Replace 'and its' with 'at the'

Response: Replaced

11. Page 5, line 150: Replace ‘this TRACER’ with ‘the TRACER’, remove ‘also’, and change ‘This S3…’ with ‘The S3…’.

Response: Changes applied.

12. Page 6, line 179: Replace ‘those observations…’ with ‘the TRACER observations…’ and remove ‘we used the’.

Response: Changes applied.

13. Page 6, line 181: Add ‘are used’ after ‘(TCEQ) database’.

Response: Added

14. Page 7, line 188: Remove ‘We use’ and add ‘model is used’ after citations.

Response: Changes applied.

15. Page 7, lines 198-199: Geogrid sentence isn’t necessary, can remove this.

Response: The sentence is removed as suggested.

16. Page 7, line 211: Add ‘spatial’ after ‘physically-reasonable’. The observations still give physically reasonable depictions of the environment, the model adds that’s spatial component.

Response: ‘spatial’ is added after ‘physically-reasonable’

17. Pages 7, lines 216-219: Suggest rewriting this sentence, it’s difficult to read and comprehend as is with so many numbers in the parentheses.

Response: Agreed. The revised sentences are shown below:

Lines 318-320: “The model (mean ~ 10.8 μg m^{-3}, median ~8.5 μg m^{-3}) overestimates the observations (mean ~8.2 μg m^{-3}, median ~7.0 μg m^{-3}), with a correlation of r ~0.6, corresponding to differences of ~30% in the mean and ~ 23% in the median.”

18. Page 9, line 250: Change 1 to 1-2

Response: Changed

19. Page 9, lines 277-279: Suggest a rewrite of this sentence. You don’t need to reference Fig. 5a at the end, if you do in the beginning and it could be shorter.

Response: Agreed. The sentence is now modified as shown below:

Lines 367-368: "In Fig. 5a, aerosol number concentration peaks around 17:00 UTC at M1 and around 20:00 UTC at S3."

20. Page 10, lines 287: Change 'These values did not differ from' to 'The values are very similar to', since they are technically different.

Response: Changes applied.

21. Page 10, line 289: Add 'observations suggest' after ACSM

Response: 'observations suggest' added after ACSM

22. Page 10, lines 300-301: Sentence phrasing is awkward. Suggest a reword to something like 'During summertime, NPF events were identified at both the M1 andS3 sites, consisting of 22 and 18 events respectively.'.

Response: The sentence is modified as suggested.

23. Page 10, line 309: I think you mean SBC, not SAI, since SAI are not purely meteorological.

Response: That is correct. 'SAI' is replaced with 'SBC'.

24. Page 11, line 319: Remove 'formation of'

Response: Removed.

25. Page 11, lines 321-322: Suggest removing 'For any inland-penetrating SBF, the authors find it instructive to define' and just start the sentence with 'Three scenarios for the influence of an inland…' and ending it with adding 'are possible'.

Response: The sentence is now modified as:

Lines 405-406: "Three scenarios for the influence of an inland-penetrating SBF on aerosols within the region of influence are considered."

26. Page 11, line 325: Replace 'there may be' with 'is'

Response: Replaced

27. Page 11, line 339: Remove 'we' and 'the' so it reads 'normalized aerosol concentration…'

Response: Removed

28. Page 13, line 375: Add 'events' after NPF.

Response: Added

29. Page 13, line 376: Combine sentences. 'During the passing of the SBF, like the NPF event that occurred…'.

Response: Sentences as combined as shown below:

Lines 497-499: "Among these, 45% (5 out of 11) events showed distinct changes in NPF characteristics during the SBF passage."

30. Polar plot figures: The chosen colorbar for these plots can be very misleading, especially in S5. With a white centered colorbar, increasing concentrations close to the white values are hard to discern and we could be missing datapoints. Suggest reproducing with a sequential colormap. Also, please increase text sizes for readability.

Response: Thank you for the comment. The figure is now revised.

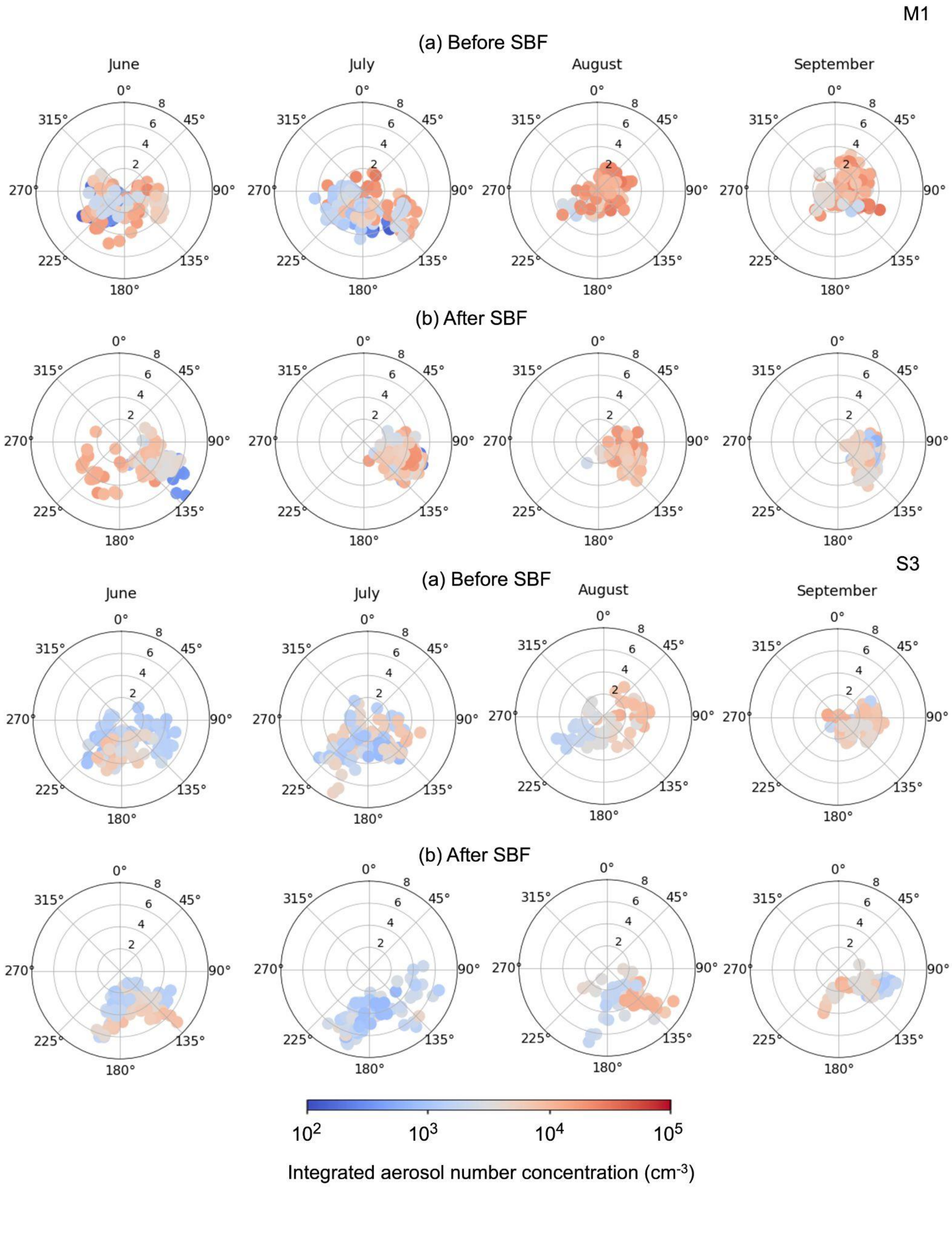


Figure S5. *Open-air polar plots for integrated aerosol number concentration (a) before and (b) after the passing of the sea breeze front at M1 and S3 sites during June to September 2022. The wind speed (in m s^{-1}) grid lines are presented with black circles. The color scales represent the concentrations observed with each wind speed and direction combinations.*

31. Page 13, line 390: Suggest removing ‘and intermediate directions’.

Response: Removed

by increased wind speed and a shift toward more pronounced south-dominated flow.”

32. Page 13, line 397: Change ‘These TRACER’ to ‘The TRACER’.

Response: Changed

33. Page 14, line 412: Suggest changing the section name, since this is now looking at examples with modeling results as well.

Response: changed to:

Section 3.4: “Examples of sea breeze aerosol interaction at the TRACER sites”

34. Page 14, line 425: Remove repetition of first sentence.

Response: Removed

35. Page 14, line 434: Change ‘suggests’ to ‘indicates’

Response: Changed

36. Page 14, line 435: ‘influence’ is a weird word choice for this statement.

Response: The statement is modified as:

Lines 546-547: “the SAI also indicates a reduction of the aerosol number concentration by ~62% (3.3 e^3 cm^{-3})”

37. Fig. 8: Suggest reversing the water vapor mixing ratio colorbar so that more moist values are blue/green and drier values are brown

Response: We have now modified the color map (Figs. 9,10,11).

38. Figures in general: Rainbow colorbars can be hard for colorblind folks to interpret. Where possible, I would suggest using different colorbars/maps so that folks who may be colorblind can see the results in the way you’re intending and they can be more accessible. Many of the captions need to be expanded on and revised. The captions should basically include all the information you need to know and point out each thing in a plot.

Response: Thank you for this helpful suggestion. We agree that rainbow colorbars can present accessibility challenges for individuals with color vision deficiencies. In response, we have revised the figures to adopt more accessible colormaps, following the guidance provided by the NCEAS Science Communication Resource Corner. These colormaps are designed to be interpretable by a broader audience while still conveying the intended gradients. In addition, we have expanded and revised the figure captions to provide more comprehensive descriptions, ensuring that each caption contains sufficient detail to interpret the plot without referring to the main text.

39. Page 16, line 467: Remove ‘also’

Response: Removed

40. Fig. S9: Add a small subplot to indicate the location of the cross section.

Response: Subplot added to Figure S10 (revised manuscript).

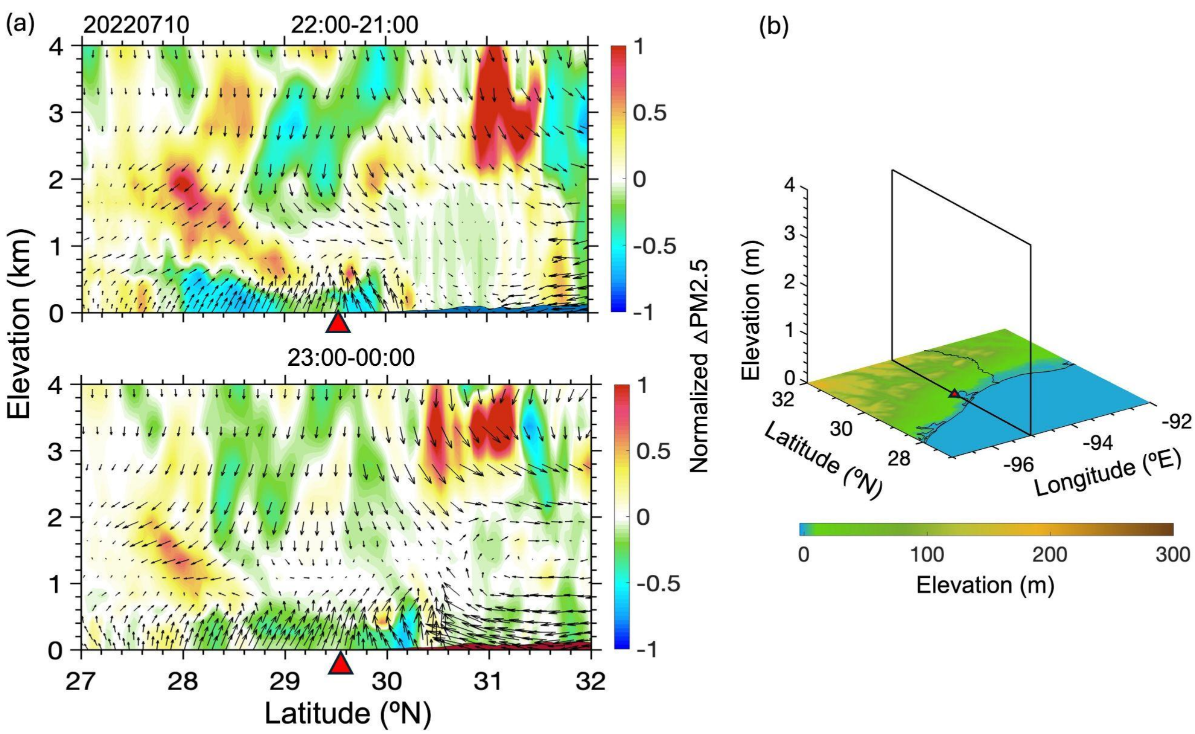


Figure S10. (a) Vertical distribution of the normalized ΔPM2.5 between two time steps along the latitudes across the M1 site (marked by the red triangle). (b) The location of the cross-section.

41. Page 17, line 520: ‘resembles that observed in SB simulations’ is a confusing statement here, when you’re using both observations and simulations within this paper. Suggest rephrasing to something like ‘resembles that shown in SB simulations…’.

Response: Agreed, ‘observed’ is replaced with ‘shown’.

42. Page 18, line 552: Add parentheses around ARF.

Response: Added

43. Page 18, line 556: Change ARM to ARF.

Response: Changed

44. Page 21, line 623: Replace ‘enhancements’ with ‘increases’.

Response: Replaced

END OF RESPONSE TO REVIEWER 2

References added:

Ahlm, L., Julin, J., Fountoukis, C., Pandis, S. N., & Riipinen, I. (2013). Particle number concentrations over Europe in 2030: The role of emissions and new particle formation. Atmospheric Chemistry and Physics, 13(20), 10271–10283. https://doi.org/10.5194/acp-13-10271-2013

Boyer, C. H., Keeler, J. M., & Rakoczy, B. C. (2025). An Idealized Parameter Study of Destabilization and Convection Initiation in Coastal Regions. Part I: Calm or Offshore Synoptic-Scale Flow. Journal of the Atmospheric Sciences, 82(3), 519–539. https://doi.org/10.1175/JAS-D-23-0180.1

Dueker, M. E., O'Mullan, G. D., Martínez, J. M., Juhl, A. R., & Weathers, K. C.: Onshore wind speed modulates microbial aerosols along an urban waterfront. Atmosphere, 8(11). https://doi.org/10.3390/atmos8110215, 2017.

Fang, C., Li, X., Li, J., Tian, J., & Wang, J. (2025). Research on the impact of land use and land cover changes on local meteorological conditions and surface ozone in the north China plain from 2001 to 2020. Scientific Reports, 15(1). https://doi.org/10.1038/s41598-025-85940-0

Gelaro, R., and Coauthors: The Modern-Era Retrospective Analysis for Research and Applications, version 2 (MERRA-2). J. Climate, 30, 5419–5454, https://doi.org/10.1175/JCLI-D-16-0758.1, 2017.

Gettelman, A., Mills, M. J., Kinnison,D. E., Garcia, R. R., Smith, A. K., Marsh, D. R., et al.: The wholeatmosphere community climate modelversion 6 (WACCM6). Journal of Geophysical Research: Atmospheres, 124, https://doi.org/10.1029/2019JD030943, 2019.

Glantz, P., Nilsson, D. E., & von Hoyningen-Huene, W. (2006). Estimating a relationship between aerosol optical thickness and surface wind speed over the ocean. In Atmos. Chem. Phys. Discuss (Vol. 6). www.atmos-chem-phys-discuss.net/6/11621/2006/

Hanft, W., & Houston, A. L.: An Observational and Modeling Study of Mesoscale Air Masses with High Theta-E. https://doi.org/10.1175/MWR-D-17, 2018.

Hu, L. (2021). A Global Assessment of Coastal Marine Heatwaves and Their Relation With Coastal Urban Thermal Changes. Geophysical Research Letters, 48(9). https://doi.org/10.1029/2021GL093260

Jensen, M. P., Flynn, J. H., Gonzalez-Cruz, J. E., Judd, L. M., Kollias, P., Kuang, C., McFarquhar, G. M., Powers, H., Ramamurthy, P., Sullivan, J., Aiken, A. C., Alvarez, S. L., Argay, P., Argrow, B., Bell, T. M., Boyer, D., Brooks, S. D., Bruning, E. C., Brunner, K., … Zhu, Z. (2025). Studying Aerosol, Clouds, and Air Quality in the Coastal Urban Environment of Southeastern Texas. Bulletin of the American Meteorological Society. https://doi.org/10.1175/bams-d-23-0331.1

Kgabi, N. A., & Mokgwetsi, T. (2009). Dilution and dispersion of inhalable particulate matter. WIT Transactions on Ecology and the Environment, 127, 229–238. https://doi.org/10.2495/RAV090201

Liu, H., Zhang, B., Moore, R. H., Ziemba, L. D., Ferrare, R. A., Choi, H., Sorooshian, A., Painemal, D., Wang, H., Shook, M. A., Scarino, A. J., Hair, J. W., Crosbie, E. C., Fenn, M. A., Shingler, T. J., Hostetler, C. A., Chen, G., Kleb, M. M., Luo, G., … Johnson, M. S.: Tropospheric aerosols over the western North Atlantic Ocean during the winter and summer deployments of ACTIVATE 2020: Life cycle, transport, and distribution. Atmospheric Chemistry and Physics, 25(4), 2087–2121. https://doi.org/10.5194/acp-25-2087-2025, 2025.

Maria, V. D., Rahman, M., Collins, P., Dondi, G., & Sangiorgi, C. (2013). Urban Heat Island Effect: Thermal Response from Different Types of Exposed Paved Surfaces. International Journal of Pavement Research and Technology, 6(4), 414-422. https://doi.org/10.6135/ijprt.org.tw/2013.6(4).414

Rapp, A. D., Brooks, S. D., Nowotarski, C. J., Sharma, M., Thompson, S. A., Chen, B., et al. (2024). TAMU TRACER: Targeted mobile measurements to isolate the impacts of aerosols and meteorology on deep convection. Bulletin of the American Meteorological Society, 105(9), E1685–E1702. https://doi.org/10.1175/BAMS-D-23-0218.1

Rodier, Q., Masson, V., Couvreux, F., & Paci, A. (2017). Evaluation of a buoyancy and shear based mixing length for a turbulence scheme. Frontiers in Earth Science, 5. https://doi.org/10.3389/feart.2017.00065

Seinfeld, J.H.; Pandis, S.N. Atmospheric Chemistry and Physics: From Air Pollution to Climate Change, 2nd ed.; Wiley: Hoboken, NJ, USA, 2006.

Sharma, M., Rapp, A. D., Nowotarski, C. J., & Brooks, S. D. (2024). Observed Variability in Convective Cell Characteristics and Near-Storm Environments across the Sea- and Bay-Breeze Fronts in Southeast Texas. Monthly Weather Review, 152(11), 2419–2441. https://doi.org/10.1175/MWR-D-23-0243.1

Shrivastava, M., Zhang, J., Zaveri, R. A., Zhao, B., Pierce, J. R., O'Donnell, S. E.,et al.: Anthropogenic extremely low volatility organics (ELVOCs) govern the growth of molecular clusters over the Southern Great Plains during the springtime. Journal of Geophysical Research: Atmospheres, 129, e2024JD041212, https://doi.org/10.1029/2024JD041212, 2024.

Subba, T., Zhang, Y., & Steiner, A. L.: Simulating the transport and rupture of pollen in the atmosphere. Journal of Advances in Modeling Earth Systems, 15, e2022MS003329. https://doi.org/10.1029/2022MS003329, 2023.

Subramanian, A., Nagarajan, A. M., Vinod, S., Chakraborty, S., Sivagami, K., Theodore, T., Sathyanarayanan, S. S., Tamizhdurai, P., & Mangesh, V. L. (2023). Long-term impacts of climate change on coastal and transitional eco-systems in India: an overview of its current status, future projections, solutions, and policies. In RSC Advances (Vol. 13, Issue 18, pp. 12204–12228). Royal Society of Chemistry. https://doi.org/10.1039/d2ra07448f

Thompson, S. A., Chen, B., Matthews, B.H., Li, R., Nowotarski, C. J., Rapp, A. D.,& Brooks, S. D. (2025). CharacterizingGreater Houston's aerosol by air massduring TRACER. Journal of GeophysicalResearch: Atmospheres, 130, e2025JD043353. https://doi.org/10.1029/2025JD043353.

Wang, K., Zhang, Y., Yahya, K.: Decadal application of WRF/Chem over the continental U.S.: Simulation design, sensitivity simulations, and climatological model evaluation. Atmospheric Environment, 253, 118331, https://doi.org/10.1016/j.atmosenv.2021.118331, 2021.