Anonymous Review #2

We thank the reviewer for their insightful comments. Many of which echo comments from reviewer 1, which have been addressed in the updated manuscript. In particular, we have added additional statistical analyses to better qualify the high coefficients of determination, have clarified the text to ensure consistency and not over-simplify the SSA-SST dependence, and improved the discussion of the CFs and their use cases. We believe the manuscript is significantly improved following the reviewer's comments.

This manuscript systematically investigates the impact of sea surface temperature (SST) on sea spray aerosol (SSA) production by a combined wind–wave facility (the Scripps Ocean–Atmosphere Research Simulator, SOARS). SSA is the most prevalent aerosol and is essential to the radiation budget and climate system. The authors characterized the connection between SST, seawater bubble concentrations, SSA number concentrations, and SSA emission fluxes using measurements in the SOARS. This topic is a classic topic in ocean-atmosphere interaction and it is becoming more and more important in the future because of the ongoing global warming. The dataset presented in this study will be of broad interest to the modeling community. Nevertheless, I have several concerns that need to be addressed before the manuscript can be recommended for publication.

Major comments:

1. Section 2.4: Different measurement periods were used for submicron and supermicron PNFDs. Submicron PNFDs were derived from the first 5 minutes of observations, while supermicron PNFDs used the full time series. Would the results change substantially if the full time series were also adopted for submicron PNFDs?

   We thank the reviewer for raising this question, which is in line with some concerns raised by reviewer #1. It's true that we applied different methods to different size ranges, which could introduce uncertainties to the flux estimates. We chose these different methods to use the most information available from each measurement accounting for the limited characterization of aerosol loss mechanisms in the SOARS instrument, see Leibensperger III et al. (2026) for an overview of some of these pertinent, unconstrained processes.

   Additionally, a comparison of applying different methods (the three included here and others) to a common size range and dataset is currently underway for inclusion in a forthcoming manuscript. However, the results indicate that applying the different methods to submicron PNFDs results in variations of about a factor of 8, which is well within the uncertainty of current source functions. Specifically, the chosen method for

each size range yields a higher estimate of flux than the other method, which we now describe in the methods section and supplement (see Text S4):

Sec. 2.4., lines 197-202: "However, when the initial rise and steady state methods are compared to one another, the chosen method in each size range represents an overestimate compared to the other method. That is, the initial rise-derived fluxes are larger than the steady state-derived fluxes for submicron SSA (by up to a factor of about 6) and the steady state-derived fluxes are larger than the initial rise-derived fluxes for supermicron SSA (by up to a factor of about 5) (Fig. S5). This variability is of similar magnitude to daily variability of SSA number concentrations in SOARS (Leibensperger III et al., 2026), reinforcing the validity of these estimates."

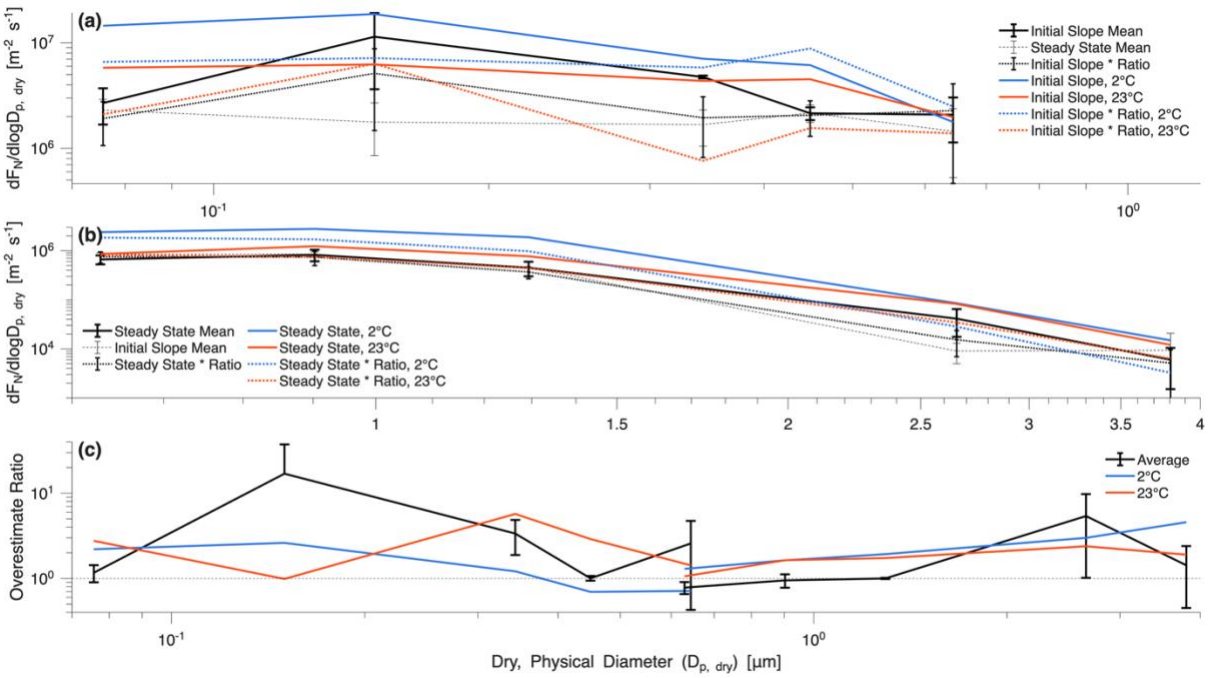


Figure S5.

To address this, we have updated the text in Sec. 2.4. Accordingly:

Sect. 2.4., lines 191-192: "Size- and SST-dependent loss rates exhibit an asymptotic behaviour above 2 µm (approaching a value of 0.55 min-1) and differences within error between experiments (Fig. S12)."

Sec. 2.4., lines 194-197: "The steady state-derived supermicron fluxes are not inherently equal to the initial rise-derived submicron fluxes, but each method is the best approach for the specified size range given the complexities of the SOARS instrument. The loss rate assumptions are likely underestimates, generally leading to overestimates by the initial rise method and underestimates by the steady state method compared to the true interfacial emission flux."

2. In many figures (e.g., figures 3, 5, 6, figures S4, S6, etc.), the coefficients of determination are high (close to 1.0). However, several data points clearly deviate from the fitted lines. Please explain this discrepancy.

   Thank you for pointing out this concern. In part, this stems from our use of the uncertainty weighting (see Text S4 and Figure S4). Accounting for the measurement uncertainty in this way results in stronger regressions despite the limited number of points, but can lead to certain points (especially those between 5-15 °C) seemingly deviating from the fitted lines, due to their higher uncertainty. We have added additional statistical information to every coefficient of determination to indicate whether the regression is statistically significant or not. Some examples to the text additions include:

   Sec. 3.3., lines 304-305: "...the strong linear decrease observed in total number (N, R^2 = 0.99, $p < 0.05$)".

   Sec. 3.3., lines 337-341: "All three moments exhibit strong, negative correlations with SST, which are well represented by linear regressions ($R^2 \geq 0.98$). However, only regressions for N and S are statistically significant above the 90% confidence level ($p < 0.1$), which reduces our confidence that SST directly controls V. Again, this is likely a consequence of low supermicron SSA counts in SOARS, resulting in a minimal change in total volume over the SST range explored."

   Updated Table 1

Mode	**a_1 ($\times 10^5$)**	**a_2 ($\times 10^6$)**	**R^2**	**p-value**
Aitken	-2.39	6.73	0.99	**0.09**
Accumulation	-2.89	8.72	1.00	**0.07**
Coarse	-0.0355	0.349	0.06	**0.02**
Total	-5.08	15.7	1.00	0.13

	b_1 ($\times 10^3$)	**b_2 ($\times 10^5$)**	**b_3 ($\times 10^6$)**	**R^2**	**p-value**
Aitken	11.6	-5.00	7.32	1.00	0.25
Accumulation	1.81	-3.29	8.81	1.00	0.71
Coarse	-3.95	1.03	-0.109	0.96	**0.02**
Total	-3.26	-4.33	15.6	1.00	0.71

3. I'm confused about the influence of SST on SSA production. Lines 250-251 state that 'increasing SST reduces the amount of SSA produced without substantially altering the size distribution', but lines 259-260 state that 'This suggests a mechanistically driven (i.e., film vs. jet drop) size-dependent shift in production and indicates that increasing SSTs have a complex influence on the resulting SSA.' Could the authors clarify whether the impact of SST on SSA production is straightforward or complex?

The impact of SST on SSA is complex, but bulk metrics (i.e., total or modal N and F_N) can be well parameterized by simple first- or second-order regressions. Paragraph 2 of Section 3.3 discusses the results when evaluating the impact on the entire size distribution or from a total concentration approach. From that perspective, submicron SSA dominates number concentrations and the overall number size distribution. So the influence of SST on submicron SSA dominates the results. Shifts in supermicron SSA will not be clearly captured by parameters such as mode diameter (D_{mode}), geometric mean diameter (D_g), or geometric standard deviation (σ_g).

The following paragraph of Section 3.3 approaches the problem from a size-resolved perspective. With that approach, a non-linear SST-SSA dependence is observed for supermicron SSA concentrations (Figure 3d).

To clarify this distinction, we have added text to Sec. 3.3 and Sec. 4 to clarify our conclusions and the complexity of the SSA-SST relationship and its potential drivers.

Sec. 3.3, lines 314-322: "These trends were consistent across cooling and warming experiments (Fig. S10) and suggest a mechanistically driven (i.e., film vs. jet drop) size-dependent shift in production. This indicates that increasing SSTs have a complex influence on the resulting SSA and emphasizes the importance of size-resolved measurements. For example, film and jet drop production may have different SST dependencies, causing size-binned N to vary with SST while the shape of the distribution (a consequence of the ratio of film to jet drop production) remains fairly constant. More work is needed to isolate the SST dependencies of film versus jet drop production. Subtle shifts in supermicron SSA production are not captured when assessments are made on bulk changes to SSA number concentrations. Although supermicron concentrations are limited in SOARS (Leibensperger III et al., 2026), supermicron N estimates are dominated by SSA between 1-2 μm, where counting statistics and counting efficiency remain high, providing robust results."

Sec. 4, lines 565-567: "As mentioned in Sec. 3.3., single-bubble experiments can also isolate the SST dependencies of film drop production and jet drop production, which are needed to better understand the mechanistic drivers of the SST dependence of bulk SSA measurements."

4. Two SST-dependent emission correction factors are derived in this study: CFN for number flux and CFM for mass flux. These factors represent valuable outcomes. My question is: when applying them separately to the number and mass flux calculations within an SSA emission scheme, do the two corrected fluxes remain mutually consistent?

For instance, if CFN is first applied to the number flux dF/dr, the corrected number flux is written as dF/dr×CFN. The corresponding mass flux is then calculated as dF/dr×CFN×3/4 πr^3×SSA_density.

Alternatively, if the number flux is first converted to mass flux as dF/dr×3/4πr^3×SSA_density, and CFM is applied subsequently, the final mass flux becomes dF/dr×3/4 πr^3×SSA_density×CFM.

Could you clarify whether I am using these correction factors correctly? I tested the two approaches using the Gong (2003) scheme, and the results differ.

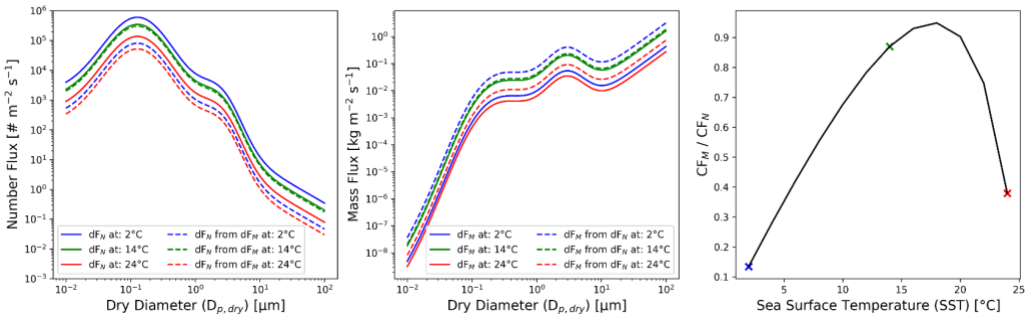
Additionally, could the authors discuss how these new factors differ from previous correction factors adopted in earth system models, such as those presented by Jaeglé et al., Grythe et al., and Sofiev et al.?

The reviewer raises a few excellent points with this critique. Namely, the CF_N and CF_M do not produce mutually consistent results when implemented independently due to the size-resolved weightings. This results in differences when calculating the same end quantity using the different CFs, but these errors are well within an error of magnitude. While this is a concern during implementation, we have clarified this limitation in Sec. 3.6. and repeat your exercise here (figure included below). Further we clarify that we advise the CF_N only be applied to number fluxes, while the CF_M should only be applied to mass or volume fluxes to avoid this issue. Additionally, the CFs are only practical within a given SST range, outside of which they result in negative values. We have addressed this second point and added their constrained SST ranges to the text:

Sec. 3.6., lines 447-452: "The linear CF_N shows good correlation ($R^2 = 0.88$, $p << 0.01$) and is valid across the SST values ranging from freezing (approximately -1.8 °C) to 30 °C. On the other hand, the quadratic CF_M shows adequate correlation ($R^2 = 0.61$, $p < 0.01$) and is valid for SST values between 0.25 and 25 °C. These validity bounds are determined by when the CFs become negative; however, we advise only adapting them to SSTs between 2 and 25 °C, consistent with the conditions here. These CFs mirror the trends of the dominant modes, where F_N is dominated by the accumulation mode, and F_M is dominated by the supermicron mode."

Sec. 3.6., lines 476-485: "These CFs are designed so that the SOARS-derived SST relationships can be adopted to emission schemes regardless of whether they are estimating number or mass (volume) flux. However, one limitation of the presented CFs is that they are not mutually consistent when applied to the same emission scheme. That is to say that applying the CF_N to an SSA number flux emission scheme and then calculating SSA mass will result in a different answer than converting the PNFD to a PMFD and then applying the CF_M. This is due to the drastically different relationships of SSA number and SSA mass. These mismatches can be as large as a factor of 8 for the SSTs around 2 °C, decrease to a minimum of about 1.05 for SSTs

around 18°C, and increase to about a factor of 3 for the highest SSTs. These differences highlight the variability arising from number versus mass measurements and the importance of retaining quantity consistency (i.e., number, surface area, volume, or mass) between measurements, emission schemes, and correction factors. However, these differences are within typical variability across SSA emission schemes and SST dependencies. Therefore, they should still be used to improve simulated SSA emissions."



Your exercise repeated with the Gong (2003) scheme, showing the differences at different temperatures.

We address your additional comment (comparing these CFs to those of Jaeglé et al. (2011), Grythe et al. (2014), and Sofiev et al. (2011)) in the following additions to the text. Of note, the Grythe et al. source function utilizes the SST dependence of Jaeglé et al., so we do not comment on comparisons to Grythe et al. in our additions:

Sec. 3.6., lines 467-474: "Once integrated, these CFs would deviate from the currently utilized SST dependencies of (Jaeglé et al., 2011) and (Sofiev et al., 2011), referred to here by the abbreviations J11 and S11. The CF_M of J11 is similar to our CF_M for SSTs less than 15 °C. For warmer SSTs, our CF_M would drastically decrease mass production, likely decreasing sea salt aerosol optical depth over equatorial regions. The S11 CFs mimic our findings in the Aitken mode (increasing F_N with decreasing SST), but deviate in the accumulation and supermicron modes showing an increase in F_N with increasing SSTs. Therefore, replacing the S11 CFs with ours would decrease SSA number concentrations over warm water, likely outside most of the regions they identified for comparison to satellite retrievals of aerosol optical depth."

Minor comments:

1. Lines 64-65: The statement "typically incorporate a positive correlation with SST (Grythe et al., 2014; Jaeglé et al., 2011; Song et al., 2023)" appears inconsistent with the content in Lines 53–54, where non-monotonic relationships are noted with the same reference: *Jaeglé et al. (2011)*.

Thank you for pointing out this inconsistency. We have adjusted the text throughout to ensure Jaeglé et al. is referenced as showing a positive correlation with SST.

2. Line 355, ‘particles whose emission rates increase with SST (Figure 7a, d)’, figure 7d dose not support this statement.

   Thank you for calling attention to this oversight. Panel d has been removed from this figure reference.

3. Supplement section S5, equations S1 and S2 (lines 72 and 81) should be S2 and S3.

   Thank you for catching this oversight we missed while rearranging the supplement. It has been corrected in the updated version.