Response to the editor’s and reviewers’ comments point-by-point

Editor's comments:

General comments. Figure 1a may contain a territory that is disputed according to the United Nations. If and when the manuscript is accepted for final revised publication, you will be asked to choose one of the following options: (a) you could remove the disputed territory from the map and submit new figure files, or (b) we could add a statement that some figures contain disputed territories.

Response: Thank you for your guidance regarding Figure 1a. We have revised Figure 1a as requested.

We should also point out that in response to Reviewer 2’s comment that “Figure 1a did not present the original results and mainly supports the introduction, and Figure 1b provided minimal information and could be completely removed,” we have revised Figure 1 as follows: Figure 1b has been removed, and Figure 1a has been relocated to the Supplementary Materials and renumbered as Figure S1c.

Furthermore, to better support the introduction, Figure S1 in the Supplementary Materials has been expanded and now includes: (a) annual average $PM_{2.5}$ concentration trends in China and Nanchang from 2013 to 2023 (Figure S1a), and (b) daily $PM_{2.5}$ concentration variations during the winter of 2023–2024 (Figure S1b).

These changes are detailed in Figure S1 of the Supplementary Materials.

Reviewer 1:

General comments. In this article, the authors present one year of daily speciated organic aerosol measurements taken in Nanchang, China. They collected filters using high-volume samplers which were analyzed offline. The authors then performed source apportionment which revealed large contributions of primary anthropogenic sources. The authors describe the behavior of each component class, describing correlations between species, concentration ratios and the influence of seasonality. The largest concentrations were observed in the winter and autumn seasons, driven by coal combustion and biomass burning although individual pollution episodes were correlated with increased SOC indicating implying fast processing. While a minor component, biogenic aerosols contributed a larger fraction of the aerosol in the summertime.

The content of the article and the scientific analysis is well within the scope of ACP. Although the data analysis methods are not novel, the article adds to compounding evidence of anthropogenic POA and SOA contributing to wintertime pollution events. I believe the conclusions are consistent with the data obtained and methods described in previous work.

Structurally the paper is sound, the abstract is a good summary of the contents, the authors cite proper and relevant references, and the language is fluid and easy to read. I believe the article can be published in ACP after minor revisions:.

Specific comments 1. Figure 2 I believe $PM_{2.5}$ and OC/EC in panel b can be separated into a panel c to aid clarity.

Response: Thank you very much for your suggestion. In the revised manuscript, we have separated the $PM_{2.5}$ and OC/EC data from panel b into new panels a and b, respectively, to improve the readability and clarity of the figures. The original panel a has been renumbered as panel c, and Figure 2 has been renumbered as Figure 1.

These changes are detailed in Figure 1 of the revised manuscript.

Specific comments 2. Figure 4 and 7 the yellow markers on a white background are difficult to see. Changing them to red or adding a black border would improve readability.

Response: Thank you for your comment regarding Figures 4 and 7. In the revised manuscript, the yellow markers in these figures have been changed to red to improve readability. Additionally, Figures 4 and 7 have been relocated to the Supplementary Materials and renumbered as Figures S3 and S5.

Specific comments 3. The wintertime pollution events are under analyzed. While the authors described the correlations observed for SOC in Figures 9 and 10 there is no comparison between the overall composition of the aerosol during these events and the rest of the winter and the year overall. Figure 8 shows wintertime concentrations are driven by POC but does not show the overall contributions during pollution events, SOC being a minor component in the average wintertime data.

Response: Thank you very much for your valuable comments. We have carefully addressed your concerns regarding the under-analysis of wintertime pollution events. In the revised manuscript, we have conducted a more detailed analysis of organic aerosol composition and source contributions specifically during winter pollution events and compared these to the remainder of the winter and the full sampling period. The key revisions include:

1. Expanded Analysis:

We performed comparative analyses of organic composition, pollution characteristics, and source contributions for: (a) the entire sampling period, (b) winter pollution periods, (c) the remainder of the winter season, and (d) individual pollution episodes.

2. Figure Revisions:

In Figure 9 (now Figure 6 in the revised manuscript), we include comparisons of SOC correlations with source contributions across the above periods.

Figure 10 (now Figure 7) presents linear correlations between SOC and both temperature and NO_2

for these specific timeframes.

Figure 8 (now Figure 5) provides comparisons of POC and SOC contributions from different sources during winter pollution periods versus the rest of winter.

A new Supplementary Figure S6 shows source contributions of POC and SOC during individual winter pollution episodes.

3. Expanded Discussion:

We expanded the discussion in Section 3.6, "Characteristics of organic aerosols during winter pollution," to include these comparative correlation analyses.

For example: "However, winter presents a different scenario. Regardless of whether it is during the winter pollution periods or other times in winter, POC did not maintain good consistency with the changes in the total OC content and $PM_{2.5}$ mass, whereas SOC remained synchronized with their variations (Figure S9). This phenomenon is particularly pronounced during individual pollution episodes in winter (Figure S9). Correlation and redundancy analyses further revealed that source-specific SOC, derived using the tracer methods, and the total SOC, calculated using the EC-based method, exhibited significant positive correlations with the measured OC ($r > 0.6$, $P < 0.05$) and significantly contributed (> 40%, $P < 0.05$) to their variations in entire winter pollution periods and individual pollution episodes (Figures 6b and 6d–6l). Given the relatively small number of nonpolluted days in winter and their scattered distribution across different dates, the correlations and contribution levels were not as evident during the remainder of the winter season (Figures 6c). These findings indicate that on shorter timescales, particularly during brief PM pollution episodes lasting several days, SOC was a critical factor influencing the total OC content and $PM_{2.5}$ mass. " **(lines 555–566, pages 21–22)**
"The increased SOC concentration may be associated with elevated temperatures and NO_x concentrations during winter pollution episodes. This inference was supported by a significant linear positive correlation between temperature, NO_2 concentrations, and SOC concentrations observed during entire winter pollution periods and individual pollution episodes (Figures 7b and 7d–7l). An increase in short-term solar radiation intensity and oxidant levels have been shown to accelerate SOC formation (Fry et al., 2009; Ng et al., 2017; Li et al., 2018; Ren et al., 2019). Nevertheless, the contribution of POC should not be underestimated as its levels remained relatively high throughout the winter. This elevated POC concentration can also promote SOC transformation (Weber et al., 2007; Carlton et al., 2010; Hoyle et al., 2011; Srivastava et al., 2022). Although a negative correlation between temperature and SOC concentrations is observed on an annual timescale (Figure 7a), high NO_2 levels are also associated with high SOC concentrations over longer periods. The negative correlation between temperature and SOC concentrations on an annual scale mainly arises because emission sources and SOC transformation products decrease during warmer seasons, whereas they increase in colder seasons, especially winter (Haque et al., 2019; Fan et al., 2020). Outside pollution periods in winter, variations in temperature and NO_2 concentrations are minimal, which limits their promoting effect on SOC concentration increases (Figure 7c)." **(lines 567–581, page 22)**

We also expanded the discussion in Section 3.5, “Source apportionment of organic carbon and aerosols” to include these comparative analyses.

For example: “During winter, including both pollution episodes (Winter-P) and the remainder period (Winter-R), the contribution proportions of two anthropogenic POC sources (biomass and coal combustion, 34%–36%) and anthropogenic SOC precursors (toluene and naphthalene, 6%–7%) were consistently higher than the annual averages (27% for these two anthropogenic POC and 5% for anthropogenic SOC) (Figure 5f). This trend was even more pronounced during individual pollution episodes (Figure S6), with anthropogenic POC contributions reaching 31%–42% and anthropogenic SOC contributions increasing to 6%–9% (Figure S6f). These findings suggest that POC from coal and biomass combustion, along with SOC originating from toluene and naphthalene, may be key drivers of wintertime organic aerosol pollution.” **(lines 512–520, page 20)**

As the reviewer noted, “Figure 8 shows wintertime concentrations are driven by POC but does not show the overall contributions during pollution events, SOC being a minor component in the average wintertime data.” We have addressed this point with the following explanation and discussion:

“Although the contribution of SOC to OC is substantially smaller than that of POC, the impact of SOC should not be overlooked. First, this study identified only five types of SOC products, and there may be other SOC products—such as liquid-phase SOC products and primary aging SOC products—that cannot be effectively detected using the SOC tracer method (Ding et al., 2014). Therefore, the SOC contribution estimated by the SOC tracer method is likely underestimated. Second, numerous studies have demonstrated that even a small increase in the proportion of SOC during winter pollution periods can worsen OA pollution (Li et al., 2019; Xu et al., 2021; Haque et al., 2023).” **(lines 520–526, page 20)**

For the related content, please see Section 3.5, “Source apportionment of organic carbon and aerosols” **(lines 491–542, pages 19–21)**, Section 3.6, “Characteristics of organic aerosols during winter pollution” **(lines 543–587, pages 21–22)**, Figures 5–7, and Figure S6 in the revised manuscript.

Specific comments 4. Is there a meteorological component to the observed wintertime pollution events? Temperature is correlated with SOC but other details such as windspeed, RH etc. are not mentioned.

Response: Thank you for these valuable comments. We have added Figure S10 in the Supplementary Materials to illustrate the linear correlations between additional meteorological factors—such as wind speed and relative humidity—and SOC during the entire sampling period, the winter pollution period, the remainder of the winter season, and individual pollution episodes. Correspondingly, we have supplemented the discussion in Section 3.6, “Characteristics of organic aerosols during winter pollution.”

Specifically: “Additionally, we analyzed the linear correlations between other meteorological factors and SOC. In particular, we examined the relations between wind speed, relative humidity, and SOC (Figure S10). The results indicated that no clear relation existed between wind speed and SOC. Although relative humidity showed some linear association with SOC during a few isolated pollution episodes, this relation was weak, with relatively large P-values and lacking statistical significance. These findings suggest that temperature and NO_2 concentrations are likely the main meteorological and oxidative factors driving the increase of SOC during winter pollution periods in the Nanchang region."

For the related content, please refer to Figure S10 and Section 3.6, "Characteristics of organic aerosols during winter pollution" **(Lines 581–587, page 22)**.

Reviewer 2:

General comments. This study presents a comprehensive analysis of organic aerosol (OA) sources and their seasonal variations in $PM_{2.5}$ in Nanchang, China, using an integrated approach combining EC-based, tracer-based, and CMB (chemical mass balance) modeling methods. The research makes valuable contributions by quantifying both primary (POC/POA) and secondary (SOC/SOA) organic aerosol fractions, and it highlights the dominance of anthropogenic sources (accounting for 89% of POC/POA), particularly from biomass burning and coal combustion. The observation of rapid SOC formation during winter pollution episodes provides meaningful insights into secondary aerosol chemistry under specific meteorological conditions.

Overall, the study offers strong novelty and scientific value. However, it requires revisions to improve language clarity, methodological transparency, and analytical rigor. I recommend publication after addressing the following comments:.

Specific comments 1. Methodology: A clearer discussion is needed regarding the uncertainties associated with the tracer-based method and the validation of the CMB model. The authors should elaborate on the sources of uncertainty and suggest possible improvements.

Response: Thank you very much for your valuable comments. We have addressed these issues in Section 2.3, "Source apportionment methods," as follows:

"We employed the CMB model (version 8.2) provided by the US Environmental Protection Agency to verify the results calculated using a tracer-based method. This model assumes a CMB between the emission sources and environmental receptors. Thus, the mass of pollutants is not lost during transport from the source to the receptor, and the measured chemical component concentration at the receptor is the linear superposition of the contribution of each source class to the concentration (Stone et al., 2009). The CMB model operates on principles analogous to those involved in the tracer-based method, relying on the mass fractions of characteristic tracers in OC and OAs from emission sources to ascertain the contributions of different sources. Thus, theoretically, the results generated by the CMB model should be consistent with those obtained from the tracer-based method. The tracer-based method and CMB model inherently involve a degree of uncertainty, primarily owing to variability in the mass fractions of representative tracers in OC and OA (f_{oc} and f_{oa}) from the same emission source across different observational studies

(Ding et al., 2012 and 2014). For instance, levoglucosan—a molecular marker for biomass burning—has been found to represent varying proportions of OC in different studies. Andreae et al. (2009) reported a levoglucosan-to-OC ratio (f_{oc}) of approximately 0.1186, with Zheng et al. (2002) observing a higher average value of 0.1258, and Zhang et al. (2007) reported a lower f_{oc} value of 0.082 for biomass burning emissions. Nevertheless, this method has been widely employed to estimate the contributions of various primary and secondary sources to OC and aerosols, yielding relatively reasonable results (Kleindienst et al., 2007 and 2012; Stone et al., 2009; Ding et al., 2012 and 2014; Al-Naiema et al., 2017; Ren et al., 2021; Xu et al., 2021; Haque et al., 2023). To further reduce uncertainty, additional observational studies are essential for identifying representative tracers in emission sources and determining their mass fractions in OC and OA (Oros and Simoneit, 2000; He et al., 2004; Zhao et al., 2007; Zhang et al., 2008; Kleindienst et al., 2012; Andreae, 2019).”

For the related content, please see Section 2.3, “Source apportionment methods” **(Lines 137–157, page 6)** in the revised manuscript**.**

Specific comments 2. Data Presentation: Figures could be improved with clearer seasonal distinctions and inclusion of statistical indicators (e.g., standard deviation, p-values, and confidence intervals). This would enhance the interpretability of seasonal trends and comparisons.

Response: Thank you very much for your comments. We agree that enhancing the clarity of seasonal distinctions and including appropriate statistical indicators will improve the interpretability of our results. In the revised manuscript, we have updated Figures 3–7 (now renumbered as Figures 2–4, S3, and S5) to include standard deviations and to annotate significant seasonal differences with different letters. We used the Tukey test to assess significance at the 95% confidence level.

For example: “Figure 2. Molecular characteristics and seasonal variations of the major polar compounds in $PM_{2.5}$. The bars in the figure show the average concentrations of different compounds for each season, while the caps on the bars represent the standard deviations of these averages. The letters a, b, c, and d above the caps indicate whether the average concentrations differ significantly between seasons. Data points that do not share the same letter are significantly different, whereas those with the same letter are not significantly different, at the 95% confidence level. The Tukey test was used to assess the statistical significance of these differences. It should be noted that the same method was used to compare the statistical significance of differences between the data in the other figures presented later in the article.” **(Lines 1053–1060, page 38)**

“The average concentrations of most FAs were significantly ($p < 0.05$) higher in autumn and winter than in spring and summer (Figure 2a), indicating a substantial increase in fatty acid emissions during autumn and winter. The LFA/HFA and C18:0/C16:0 ratios were lower in autumn and winter than in summer (Figures S3b and S3c).” **(Lines 222–225, page 9)**

Similar modifications and annotations can be found in Figures 3, 4, S3, and S4, as well as in the related discussions of seasonal differences throughout the manuscript.

Specific comments 3. Discussion: The discussion would benefit from expanded comparisons with similar studies conducted in other Chinese cities. Additionally, a more in-depth exploration of the mechanisms behind seasonal variations (instead of merely presenting the results of compounds one by one) should be included.

Response: Thank you for your constructive suggestions. Following your advice, we have made two key improvements:

1. Expanded comparisons with other chinese cities:

We have broadened the discussion to compare our findings with results from studies in other urban areas in China, as well as relevant coastal, marine, and polar environments. For example:

Fatty acids (FAs): "The total FA concentration was in a range of 3.24–657.86 ng m^{-3}, with an average concentration of 196.50 ± 110.92 ng m^{-3}. Similar molecular distribution patterns and concentrations have been documented in urban aerosol studies across China (59–2,090 ng m^{-3}; He et al., 2004 and 2006; Wang et al., 2006; Haque et al., 2019; Fan et al., 2020). In these Chinese cities, FAs are primarily influenced by biogenic sources, including plant releases and biomass burning, as well as fossil fuel combustion and residential cooking. This average concentration generally exceeds those observed for coastal and marine aerosol samples (0.1–160 ng m^{-3}; Kawamura et al., 2003; Wang et al., 2007; Fu et al., 2011), which are primarily influenced by marine biological activities and long-range transport of continental sources." **(Lines 191–198, page 8)**

Fatty alcohols: "The total concentration of n-alkanols was in a range of 5.80–572.01 ng m^{-3} (average = 113.99 ± 92.50 ng m^{-3}). This concentration fell within the range of reported n-alkanol concentrations in urban aerosols in China (3.1–1,301.0 ng m^{-3}; Wang et al., 2006; Haque et al., 2019; Fan et al., 2020) and generally exceeded that of coastal and marine aerosol samples (0.1–19.7 ng m^{-3}; Kawamura et al., 2003; Fu et al., 2011). In urban aerosols of China, fatty alcohols are primarily derived from vegetation releases, biomass burning, and resuspension of soil particles. The fatty alcohols in coastal and marine aerosols are primarily attributed to the long-range transport of terrestrial soil and biomass burning as well as marine biogenic sources." **(Lines 237–244, pages 9–10)**

Biomass burning tracers (e.g., levoglucosan): "Levoglucosan—a prominent biomarker for biomass burning—has been extensively investigated in urban aerosol samples, with concentrations in a range of 22–2,706 ng m^{-3} (Wang and Kawamura, 2005; Wang et al., 2006; Fu et al., 2010; Haque et al., 2019; Fan et al., 2020), indicating the significant influence of biomass burning on the urban atmosphere. The widespread detection of levoglucosan in various environments—including suburban (10–482 ng m^{-3}; Yttri et al., 2007; Fu et al., 2008), marine (0.2–30 ng m^{-3}; Simoneit et al., 2004a; Fu et al., 2011), and polar regions (0–3 ng m^{-3}; Stohl et al., 2007; Fu et al., 2009)—indicates its potential for long-range atmospheric transport. Compared to those of the major polar organic compounds found in marine environments, such as FAs, fatty alcohols, and saccharides, the concentrations of these substances in urban $PM_{2.5}$ are substantially higher. This is primarily attributed to the substantial impact of anthropogenic activities in urban environments—such as vehicle emissions, industrial processes, and residential heating and cooking—all of which can release these major polar components (Wang et al., 2006; Fu et al., 2008; Haque et al., 2019; Fan et al., 2020). In contrast, the organic matter in marine $PM_{2.5}$ originates from relatively simpler sources with lower emissions, mainly influenced by natural processes, including marine biological activity and the long-range transport of continental pollutants (Kawamura et al., 2003; Simoneit et al., 2004a; Wang et al., 2007; Fu et al., 2011).” **(Lines 262–276, pages 10–11)**

SOC marker ratios: “This relatively high C5/MTL, 2-MGA/MTL, or MTL2/MTL ratio observed during the cold season compared to that in the warm season is commonly reported in urban environments across China, including Beijing (Liu et al., 2023), Tianjin (Wang et al., 2019; Fan et al., 2019), Nanjing (Yang et al., 2022), Shanghai (Yang et al., 2022), and Guangzhou (Yuan et al., 2018). This phenomenon is primarily attributed to higher NO_x concentrations and increased aerosol acidity in the cold season versus the warm season in Chinese cities, which promote the formation of secondary C5-alkene triols, 2-MGA, and MTL2.” **(Lines 423–429, pages 16–17)**

2. Expanded discussion of seasonal variation mechanisms:

In addition to comparing seasonal differences, we have analyzed and discussed in detail the mechanisms driving observed seasonal patterns. For example:

Fatty acids (FAs): “The average concentrations of most FAs were significantly ($p < 0.05$) higher in autumn and winter than in spring and summer (Figure 2a), indicating a substantial increase in fatty acid emissions during autumn and winter. The LFA/HFA and C18:0/C16:0 ratios were lower in autumn and winter than in summer (Figures S3b and S3c). This indicated that in autumn and winter, FAs were significantly influenced by terrestrial plant or biomass burning, whereas in summer, they were more influenced by vehicular emissions, marine phytoplankton, and cooking emissions. Conversely, the (C16:1 + C18:1)/(C16:0 + C18:0) values were higher in winter than in summer (Figure S3d). This suggested that unsaturated FAs experienced a greater degree of photochemical degradation during the warm seasons. Unsaturated FAs can be rapidly oxidized by ozone or OH radicals. The higher temperatures, relatively stronger solar radiation, and higher concentrations of O_3 and OH radicals in the summer season will facilitate the oxidative decomposition of unsaturated FAs (Wang et al., 2006; Fan et al., 2020).” **(Lines 222–232, page 9)**

Fatty alcohols: “The average concentrations of most fatty alcohols were significantly ($p < 0.05$) higher in autumn and winter than in summer (Figure 2b), indicating a substantial increase in fatty alcohols emissions during autumn and winter. The LMW/HMW values were relatively low in autumn and winter and higher in spring and summer (Figure S3f). This suggests an increased contribution of soil and marine organisms to n-alkanols in spring and summer. Contributions from plant or biomass burning increased in autumn and winter. In Chinese cities, rising temperatures in spring increase soil microbial activity, with marine air masses exerting a stronger influence during summer, potentially increasing emissions from soil and marine organisms in these seasons. In contrast, autumn and winter coincide with the crop harvest and increased winter heating, leading to likely increases in biomass burning emissions during these periods (Wang et al., 2006; Haque et al., 2019; Fan et al., 2020).” **(Lines 249–257, page 10)**

Biomass burning tracers: “The Lev/OC and Lev% values were higher in autumn and winter than in spring and summer (Figures S3i and S3j), further indicating that biomass burning contributions increased during the cold months. As previously noted, the primary reason for increased biomass burning emissions during the cold season is that autumn marks the crop harvest in China, leading to more straw burning. Furthermore, the temperature decrease in winter results in additional biomass burning for heating purposes.” **(Lines 318–323, page 12–13)**

SOC markers: “In summer, the concentrations of the hydroxy acids exceeded those in other seasons (Figure 3b). A positive correlation was observed between the polyacids and temperature ($r = 0.35–0.51$, $p < 0.01$), suggesting enhanced secondary photochemical oxidation in the warm months. The secondary formation of hydroxy acids in the atmosphere is suggested to be related to the ozone-driven oxidation of organic compounds. Elevated ozone levels and stronger solar radiation during the summer season create more favorable conditions for the secondary production of hydroxy acids (Kawamura and Ikushima, 1993; Kawamura and Sakaguchi, 1999; Claeys et al., 2004).” **(Lines 362–368, page 14)**

Phthalic acid: “The phthalic acid concentrations were higher in autumn and winter, whereas terephthalic acid levels peaked in spring and summer (Figure 3b). This indicates that the secondary transformation of PAHs was more pronounced during the cold months, whereas high temperatures in spring and summer promoted the volatilization and transformation of phthalates from plastic sources. Phthalates are employed as plasticizers in resins and polymers. Because they are not chemically bound to the polymer matrix, they can be easily released into the air through evaporation. Higher ambient temperatures in spring and summer favor phthalate release from the matrix (Wang et al., 2006; Fu et al., 2010).” **(Lines 383–389, page 15)**

SOC marker ratios “The MBTCA/3-HGA value was higher in spring (1.31 ± 0.66) and summer (1.45 ± 0.70) than in autumn (1.09 ± 0.72) and winter (0.88 ± 0.32) (Figure S5e). This suggests that the contribution of α-pinene to monoterpene was higher in spring and summer than in autumn and winter. This phenomenon can be attributed to the association of 3-HGA formation with NO_x-rich environments, where the relatively high NO_x concentrations in autumn and winter (Figure S2) may enhance 3-HGA production. The ratio of the total isoprene to monoterpene oxidation products (Iso/Pine) was lower in autumn and winter than in summer (Figure S5f). This pattern is also commonly observed in other urban environments of China, suggesting that the higher temperatures in summer favored isoprene release (Li et al., 2018; Fan et al., 2020; Liu et al., 2023).” **(Lines 453–460, page 17–18)**

Together, these mechanistic insights highlight how emission sources, atmospheric processing, and seasonal meteorological conditions drive the observed variation in organic aerosol composition.

Specific comments 4. Number of Figures: The manuscript contains as many as ten figures, which is excessive. It is recommended to streamline the number to around five. For instance, Figure 1a does not present original results and mainly supports the introduction; it should be moved to the supporting information. Figure 1b contributes minimal information and could be removed entirely. A similar review should be applied to the remaining figures to ensure only important Figures with enough essential data are included in the main text.

Response: Thank you very much for your comments. In response, we have revised Figure 1: Figure 1a has been moved to the Supplementary Materials to better support the introduction, and Figure 1b has been removed, as it contributed minimal information. Following a thorough review, we have reduced the number of figures in the main text from 10 to 7. Several figures that were previously in the main text have now been relocated to the Supplementary Materials, ensuring that only the most essential data and results remain in the main text.

Specific comments 5. Language and Terminology: The manuscript would be more accessible if complex sentences were simplified and terminology made consistent. For example, the sentence: "The results indicated that the concentrations of fatty acids, fatty alcohols, and saccharides were relatively high, whereas lignin and resin products, sterols, glycerol, hydroxy acids, and aromatic acids were present at low concentrations" (lines 16–18) could be simplified to: "Fatty acids, fatty alcohols, and saccharides showed relatively high concentrations, while lignin, resin products, sterols, glycerol, hydroxy acids, and aromatic acids were low."

Response: Thank you for your valuable suggestion regarding language and terminology. We agree that simplifying complex sentences and ensuring consistent terminology will improve clarity and accessibility. As you suggested, we have revised the example sentence as follows:

Original: "The results indicated that the concentrations of fatty acids, fatty alcohols, and saccharides were relatively high, whereas lignin and resin products, sterols, glycerol, hydroxy acids, and aromatic acids were present at low concentrations."

Revised: "Fatty acids (FAs), fatty alcohols, and saccharides showed higher concentrations than lignin, resin products, sterols, glycerol, hydroxy acids, and aromatic acids;" **(Lines 17–18, page 1)**

We also have carefully reviewed the entire manuscript and made similar simplifications and terminology adjustments throughout to enhance readability and consistency.

Specific comments 6. Statistical Analysis: The manuscript frequently compares data across seasons and sources (e.g., LMW/HMW ratios, mannosan and galactosan concentrations, L/M and M/G ratios in Figures 3–7). However, there is no indication of statistical significance in the text or figures. The authors should include appropriate statistical tests to support these comparisons.

Response: Thank you for your insightful comment regarding statistical analysis. In response, we have revised Figures 3–7 (now renumbered as Figures 2–4, S3, and S5 in the revised manuscript) to incorporate statistical significance indicators. Specifically, we now use different letters above the bars to denote significant differences in seasonal or source-related data, as determined by the Tukey test at a 95% confidence level. Similar modifications and annotations can be found in the related discussions of seasonal differences throughout the manuscript.

Specific comments 7. Line 91: Please provide the sampling flow rate used during the study.

Response: Thank you for pointing this out. We have added the sampling flow rate information to the manuscript. The revised sentence now reads:

“An 8-inch × 10-inch quartz fiber filter (Pall Tissuquartz, USA) was used in a high-volume air sampler at a flow rate of 1.05 ± 0.03 m^3 min^{-1} for sample collection” **(Lines 91–92, page 4).**

The authors would like to express their sincere gratitude to the editor and reviewers for their valuable suggestions and comments, which have greatly improved the quality of this manuscript.