We thank the anonymous Reviewers for the insightful comments and suggestions that provided us with the opportunity to improve our article. Our responses to the specific comments and changes made in the revised manuscript are provided below.

Reviewer 1 comments

1. The introduction provides a relatively brief overview of the sources and environmental significance of oxygenated monoterpene alcohols in the ambient atmosphere. It is recommended to supplement this section with information on their major emission sources and typical concentration levels to enhance the practical relevance of the study. Furthermore, the rationale for selecting the three model compounds (fenchol, borneol, and menthol) is insufficiently justified. The representativeness of these compounds should be clarified from the perspectives of structural characteristics and atmospheric relevance.

2. The end of the introduction should more clearly outline the research objectives and main contents of this study to improve structural clarity. Some transitions between paragraphs appear somewhat abrupt; transitional sentences may be added to strengthen logical coherence. Meanwhile, the overall background description could be appropriately condensed to highlight the research gap and its connection to the present work, thereby making the introduction more concise and focused.

Author's response: We thank you for these comments. Because both comments refer to the introduction, a combined response and the description of specific changes in this section are provided.

Changes in the manuscript: The introduction was expanded, thoroughly revised, and restructured. More transitional and introductory sentences were added.

The new structure is as follows: general information about SOAs, atmospheric concentrations of SOAs and emission fluxes of SOA precursors, including monoterpenes, oxygenated monoterpenoids and terpenoic alcohols, followed by emission sources of terpenoic alcohols and their emission fluxes. Then, commercial uses of terpenoic alcohols are discussed, and their relevance for indoor air chemistry and particle formation. Afterward, SOA formation mechanisms are discussed, including gas and aqueous SOAs, pointing out the knowledge gaps in $_{aq}$SOAs formation from monoterpenoids and terpenoic alcohols.

The statement on the aims of this work at the end of the Introduction was also expanded to better justify the selection of fenchol, borneol, and menthol as model precursors, in the context of their atmospheric abundance and structural features, representative of other primary and secondary monoterpenoids.

The following references were added in the introduction, reporting emission fluxes, sources, atmospheric concentrations, and SOA yields and formation mechanisms from monoterpenoids and TAs, as well as supporting atmospheric relevance and representativeness of the investigated terpenoic alcohols:

Matasyoh et al., 2007; Fares et al., 2011; Kim et al., 2010; Joutsensaari et al., 2015; Yuan et al., 2025; Kivimäenpää et al., 2016; McKinney et al., 2011; Li et al., 2020; Fares et al., 2012; Dickinson et al., 2022; Kelley et al., 2025; Abatzoglou et al., 2025; Bhatia and Letizia and Api, 2008; Bhatia et al., 2008; Shakil et al., 2026; Klein et al., 2016; Singer et al., 2006; Angulo Milhem et al., 2021; Rosales et al., 2022; Mellouki and Wallington and Chen, 2015; Wang et al., 2024b; Ceacero-Vega et al., 2012; Mehra et al., 2020; Wu et al., 2024; Amorim et al., 2020; Witkowski et al., 2023; Bleier and Elrod, 2013; Lai et al., 2025; Sander, 2023; Jenkin, 2004; Glasius et al., 2000.

3. The description of the product quantification method is relatively brief. The qualitative basis, quantification methods, and calibration curves for GC-MS and LC-MS analyses are not fully provided. It is recommended to further clarify the selection of quantitative standard reference materials and the sources of uncertainty.

Author's response: We agree that the description of product identification and quantification lacked necessary detail. At the same time, please note that quantification methods, analysis conditions, standards used to quantify the products of OH reaction with terpenoic alcohols, concentrations of standards used to prepare the calibration curves, and linear coefficients of determination (R^2) values for each standard are all provided in the electronic supplement in section S2.1 in Tables S1- S3.

Changes in the manuscript: Section 2.4 (now section 2.5) was revised and expanded to include more details about the identification and quantification methods used. The reader is now directed to Tables S1- S3 for quantitative parameters. A justification for the selection of surrogate standards used for quantification of specific products was also added, as suggested by the Referee:

"At the same time, the majority of non-acidic products were quantified with GC-EI/MS using 2-hydroxy-3-pinanone, camphorquinone, and camphanediol as surrogate standards (Tables S1-S3), which were assigned to specific products with similar structural motifs and close retention times."

Typographic errors in exponent values (concentration ranges) in Tables S1 – S3 were also corrected. Furthermore, a discussion of uncertainties arising from the use of authentic and surrogate standards was added in Section 2.9.

"The uncertainty associated with the use of authentic standards was derived as 2σ values from triplicate experiments and usually did not exceed 10%. At the same time, the use of surrogate

standards introduces a significantly higher uncertainty. However, because the yields initially obtained using surrogate standards were further adjusted based on experimental data, a 30% uncertainty was imposed on all product yields lacking authentic standards; this value was increased to 50% for the yields derived only from kinetic models (section 2.7).“

4. In Chapter 3, Sections 3.1–3.3 discuss in detail the reaction mechanisms of fenchol, borneol, and menthol with hydroxyl radicals, respectively. It is recommended to reorganize and consolidate these sections, either merging the mechanisms of individual compounds into a single section or setting them as subsections. Subsequently, the title of Section 3.4 remains “Mechanism of OH reaction with fenchol, borneol, and menthol,” which is highly repetitive of the preceding sections. However, the actual core content of this section mainly focuses on the summary and comparison of product yields as well as the analysis of gas-water phase differences, which belongs to comparative analysis or comprehensive discussion.

Author’s response: We agree with this comment; section 3 was not well organized, and the discussion was poorly structured and highly repetitive in many places. At the same time, we believe that it is important to discuss each precursor separately. Such a discussion enables other researchers to compare their data with the results of our work, as some may be interested in only one terpenoic alcohol studied in our work.

Changes in the manuscript: Section 3 was revised and reorganized as follows:

Product analysis is now discussed in Section 3.1. Moreover, a new Section 3.2 was added as suggested by the Referee, discussing general mechanisms and the reasoning behind proposing specific reaction pathways, particularly SAR results. As such, the SAR figure for TA was moved from the SI into Section 3.2. Moreover, tables S4-S6 were added in the SI, with SAR results for all reactants included in the proposed mechanisms.

Following the addition of section 3.2, mechanisms for fenchol, borneol, and menthol are now discussed in subsections 3.2.1-3.2.3, which were revised and shortened accordingly.

Product yields are now discussed together for all precursors in the revised section 3.3 to avoid unnecessary repetitions, which was renamed “Product yields and comparison with the gas-phase data”.

Product symbols were changed to M1, B1 and F1 for menthol, borneol, and fenchol, respectively, in the main text and in the SI, to further increase readability.

5. The paragraph division is overly fragmented, with many paragraphs consisting of only one or two short sentences, which affects reading coherence. It is recommended that the authors systematically integrate the entire manuscript, merging short paragraphs with similar themes and continuous logic into complete paragraphs containing 3-8 sentences.

Author's response: We agree with this comment.

Changes in the manuscript: Paragraph division was revised in the entire manuscript, particularly in sections 3.2.1-3.2.3, and revised by merging shorter paragraphs.

6. The manuscript identifies multiple oxidation products; however, the formation pathways of some secondary products are mainly inferred from mechanistic considerations. It is recommended to further support these proposed pathways by incorporating temporal evolution trends or changes in relative signal intensities.

Author's response: We agree that the description and discussion on reaction mechanisms lacked necessary detail. The general process was as follows: temporal evolution of the reactants, their formation yields, exact and nominal masses, and structural features were obtained from chromatographic analyses. These data were combined with SAR predictions (intramolecular selectivity) to propose structures and possible formation mechanisms of the detected products. Based on these data, the pathways of formation and interconversion of the detected products were elucidated. When adjusting the model, the yields of the primary ketones (fenchone, menthone, camphor), quantified using authentic standards, were not changed, and yields of all other products, quantified with surrogate standards, were adjusted by fitting their simulated temporal evolution to experimental data obtained from GC/MS measurements. For terpenoic acids, which lacked measured temporal evolution, their relative yields were adjusted based on relative signal intensities from the LC/MS measurements.

Changes in the manuscript: Section 2 was largely revised to better explain how the proposed reaction pathways were derived.

Section 2.4 (now section 2.5) was expanded to include more details about the identification and quantification methods used.

Section 2.6 was added, describing the SAR model used to derive total and partial $k_{OH_{aq}}$ values for fenchol, borneol, and menthol, and the major products of their reaction with OH. Moreover, Tables S4-S6 were added in the SI with SAR results for all products shown in Schemes 1-7, to better justify proposing specific reaction pathways.

Section 2.7 was expanded to include a much more detailed description of model development.

"Kinetic models of R1–R3 were developed using the observed temporal evolution of the reactants, their formation yields, and reaction pathways proposed based on structural assignments, SAR results, and mechanistic implications."

A more detailed model development description was added in this section:

"Initially, the models were adjusted by fitting the simulated temporal evolution of major (non-acidic) products to the experimental data. To this end, the yields of non-acidic products, quantified using surrogate standards, were adjusted, while the yields of primary ketones, quantified using authentic standards, were kept unchanged. This approach was adopted due to additional uncertainty arising from differences in GC-EI/MS response factors between the surrogate standards and target compounds 96. After adjusting the model, the yields of products formed in low quantities, particularly TACs, were derived using Eq. (1) from their simulated temporal evolution and were subsequently adjusted based on relative signal intensities from the LC-ESI/ToF/MS measurements."

Moreover, a more detailed discussion about uncertainty connected with the use of authentic and surrogate standards was added in section 2.9. In sections 3.2 and subsections 3.2.1-3.2.3, the rationale behind selecting the specific H-atom abstraction sites is now connected with SAR results to strengthen the discussion on proposed mechanisms.

7. For the global contribution estimation, the authors indicate that the global $_{aq}$SOA contribution from the three terpenoic alcohols accounts for less than 1% of total biogenic SOA. However, the estimation relies on considerable uncertainties, the selection of key parameters lacks sufficient justification, and the estimated results are not compared with those from similar studies. It is recommended to supplement scenario analyses to provide a reasonable uncertainty range, connect the global contribution with local importance, and highlight the potentially substantial contribution of $_{aq}$SOA from these terpenoic alcohols in regions with high emissions of oxygenated terpenes.

Author's response: We agree with this comment. In the original manuscript, the global contribution was estimated using a single set of assumptions, while the parameter selection, uncertainty, comparison with related $_{aq}$SOA pathways, and possible local importance were not discussed in sufficient detail.

Changes in the manuscript: Section 4 was substantially revised. Because reliable global emission estimates for individual terpenoic alcohols are unavailable, the $_{aq}$SOA yields obtained in this work were applied to the estimated global emissions of all TAs. Using the estimated TA emission flux, cloud-water availability, the modeled $_{aq}$SOA yields, and the associated uncertainty, the global $_{aq}$SOA production potential was estimated at 0.2 ± 0.1 to 1.5 ± 0.5 Tg yr^{-1}. This value is presented as an

order-of-magnitude estimate rather than a constrained global budget, which would require a separate, dedicated investigation utilizing advanced modeling tools, which was beyond the scope of our work.
The revised estimate is now compared with $_{aq}$SOA formation from α-pinene- and limonene-derived water-soluble oxidation products, glyoxal and methylglyoxal, and the global in-cloud $_{aq}$SOA flux from water-soluble products of isoprene, monoterpenes, and aromatics. These comparisons indicate that the contribution of TAs to the global $_{aq}$SOA flux is relatively small but may still be comparable to individual monoterpene-derived precursors.
A local-scenario discussion was also added, as suggested by the Referee. We now emphasize that the global average may underestimate the importance of TAs near flowering plantations, aromatic vegetation, and disturbed canopies, where oxygenated-terpenoid emissions can increase strongly. In such environments, elevated precursor concentrations, efficient partitioning into atmospheric water, and the modeled $_{aq}$SOA yields of 10–70% may result in a substantial contribution to local BSOA fluxes.

The following references were added to strengthen the revised discussion: Zaragoza et al. (2026), Liu et al. (2012), Richards-Henderson et al. (2014), Hansel et al. (2015), Gentner et al. (2014), Li et al. (2020), and Yuan et al. (2025)