Response to Referee #2:

The submitted manuscript presents a new data library of species-specific BVOC emission rates in China. The authors describe the statistical method of assigning emission rates to individual plant species based on field measurements. They also provide the final dataset with emission rates of isoprene, monoterpenes and sesquiterpenes for 599 plant species. I consider these efforts essential for the improvement of regional BVOC emission modelling as they can reduce errors introduced when global databases are used. This is demonstrated in the results where the authors apply their emission rates to modelling with the MEGANv3.2 model and show improved spatial correlation of BVOC emissions in China with satellite observations when compared to the use of a global library. The methods are described in sufficient detail and the results support the presented conclusions.

Response:

Thank you for your positive and constructive comments. In this revision, we have strived to achieve the greatest improvement and hope you agree with our modification.

Specific comments

1. Section 3.1 on conversion of basal emissions - if there was a need to convert units of basal emissions from ug m^{-2} h^{-1} to ug g^{-1} h^{-1}, could the authors please specify what values of specific or dry leaf matter (g/m^2) they used in conversion?

Response:

Thank you for your valuable suggestion. In this study, it was necessary to convert basal emission rates from a leaf area basis (μg m^{-2} h^{-1}) to a leaf mass basis (μg g^{-1} h^{-1}), the conversion was performed using the specific leaf area (SLA, in cm^2 g^{-1}) of the corresponding plant species. The SLA values applied in this conversion were not a single universal value but were instead compiled by individual plant species.

Firstly, for plant species whose emission rates were based on our own measurements, we utilized SLA values calculated by the general relationship between leaf area (LA) and leaf dry weight (LDW). Besides, for emission rates compiled from the literature, we first searched for the original publication. If the SLA value was provided therein, it was adopted directly to maintain consistency with the reported emission data. If the source literature did not include SLA value, we conducted an extensive additional review of published studies to obtain a representative SLA value derived from measurements on the same species within China.

In line 158-164, "The specific leaf area (SLA) values used for conversion were species-specific. For our measurements, we utilized SLA values derived from the general relationship between leaf area and leaf dry weight. For literature-sourced emission rates, we preferentially used SLA values from the original publication when available; otherwise, we obtained representative SLA values from measurements of the same species in China through an extensive literature review (Ghirardo et al., 2016; Ren et al., 2014; Wang et al., 2017)." is added.

References:

Ghirardo, A., Xie, J., Zheng, X., Wang, Y., Grote, R., Block, K., Wildt, J., Mentel, T., Kiendler-Scharr, A., Hallquist, M., Butterbach-Bahl, K., and Schnitzler, J.-P.: Urban stress-induced biogenic VOC emissions and SOA-forming potentials in Beijing, Atmos. Chem. Phys., 16, 2901–2920, https://doi.org/10.5194/acp-16-2901-2016, 2016.

Ren, Y., Ge, Y., Gu, B., Min, Y., Tani, A., Chang, J.: Role of management strategies and environmental factors in determining the emissions of biogenic volatile organic compounds from urban greenspaces, Env. Sci. Technol, 48, 6237–6246, https://doi.org/10.1021/es4054434, 2014.

Wang, C., Zhou, J., Xiao, H., Liu, J., Wang, L.: Variations in leaf functional traits among plant species grouped by growth and leaf types in Zhenjiang, China, J. Forestry Res., 28 (2), 241–248, https://doi.org/10.1007/s11676-016-0290-6, 2017.

2. Section 3.3.1 is a bit hard to comprehend, it could be reduced and clarified or perhaps visualized.

Response:

Thank you for this constructive suggestion. As recommended, we have thoroughly revised Section 3.3.1 to enhance its clarity and readability. Also, Figure S2 is changed to show the composition of vegetation types in each emission category.

In line 275-292, “To characterize the emission capacities of different vegetation types, the number of plant species in each emission category were counted, taking the results with R-value = 1 for example (Figure S3). The plants were furtherly divided into nine types: evergreen broadleaf trees, deciduous broadleaf trees, evergreen coniferous trees, deciduous coniferous trees, evergreen broadleaf shrubs, deciduous broadleaf shrubs, evergreen coniferous shrubs, crops and herbs. For the isoprene emission, 57% of the total plant species had the low and moderate intensity by being in categories IV, V and VI. The plants were mainly (69%) evergreen broadleaf trees, deciduous broadleaf trees, and evergreen broadleaf shrubs. Crops performed uniform distribution across emission categories II to VI, with low and moderate intensity, while herbs evenly distributed across emission categories I to X except category II. For the monoterpene emission, 53% of the total plant species (mainly evergreen broadleaf trees, deciduous broadleaf trees, evergreen broadleaf shrubs, and deciduous broadleaf shrubs) fell into categories V, VI, and VII, which could be defined as moderate intensity. Comparatively, fewer plant species (7% of the total) had higher emission intensities (locating in categories IX, X and XI). Herb species mostly (67%) had moderate and high monoterpene emission intensities (locating in categories IV, VII, and VIII), and crop species mostly (85%) had low and moderate emission intensities (locating in categories III to VII). For the sesquiterpene emission, 52% of the total plant species had a low intensity by being in categories I and II. The plants were mainly (78%) evergreen broadleaf trees, evergreen coniferous trees, deciduous broadleaf trees, and crops. Evergreen broadleaf shrub species mostly (56%) had a low sesquiterpene emission intensity (locating in category II), emission rates of crop species mostly (69%) located in categories II and V, with low emission intensities. Deciduous broadleaf trees and deciduous broadleaf shrubs performed uniform distribution across emission categories I to VIII.” is changed to “To characterize the emission capacities of different vegetation types, the number of plant species in each emission category was counted, with R-value = 1 as an example (Figure S2). First, most plant species (57%) exhibited low-to-moderate isoprene emission intensities (Categories IV–VI). This emission profile was predominantly observed in evergreen broadleaf trees, deciduous broadleaf trees, and evergreen broadleaf shrubs, which together accounted for 69% of the species in these categories. Crops were uniformly distributed across Categories II–VI (low-to-moderate), whereas herbs showed a wide distribution, spanning all categories except Category II. Besides, monoterpene emissions were primarily characterized by moderate intensity (Categories V–VII), encompassing 53% of all species. Key contributors included evergreen broadleaf trees, deciduous broadleaf trees, and both evergreen and deciduous broadleaf shrubs. In contrast, only a small fraction of species (7%) displayed high emission intensities (Categories IX–XI). Most herb species (67%) showed moderate-to-high monoterpene emissions (Categories IV, VII, and VIII), while the majority of crop species (85%) fell into the low-to-moderate range (Categories III–VII). As for sesquiterpene emissions, over half of the plant species (52%) demonstrated low sesquiterpene emission intensities (Categories I–II), primarily consisting of evergreen broadleaf trees, evergreen coniferous trees, deciduous broadleaf trees, and crops. Deciduous broadleaf trees and shrubs showed a relatively uniform distribution across Categories I–VIII.”.

In line 293-298, “Generally, most plant species performed low and moderate intensity of isoprene. Specially, broadleaf plants mostly had a moderate emission intensity, while coniferous plants mostly had a lower intensity. For the monoterpene emission, both broadleaf and coniferous plants mostly had a moderate emission intensity. For herbs, the emission intensity of isoprene and monoterpenes varied greatly and covered low, moderate, and high levels. While the emission intensity of sesquiterpenes was relatively lower for most plant species, particularly trees and crops.” is changed to “In general, most plant species emit isoprene at low to moderate intensities. Specifically, broadleaf plants predominantly exhibited a moderate emission intensity, whereas coniferous plants were mostly characterized by low-intensity emissions. Regarding monoterpenes, both broadleaf and coniferous plants primarily showed a moderate emission intensity. In contrast, herbaceous plants displayed a wide range of emission intensities for both isoprene and monoterpenes, covering low, moderate, and high levels.”.

In line 19-21 of revised supplementary information, Figure S2 is changed.

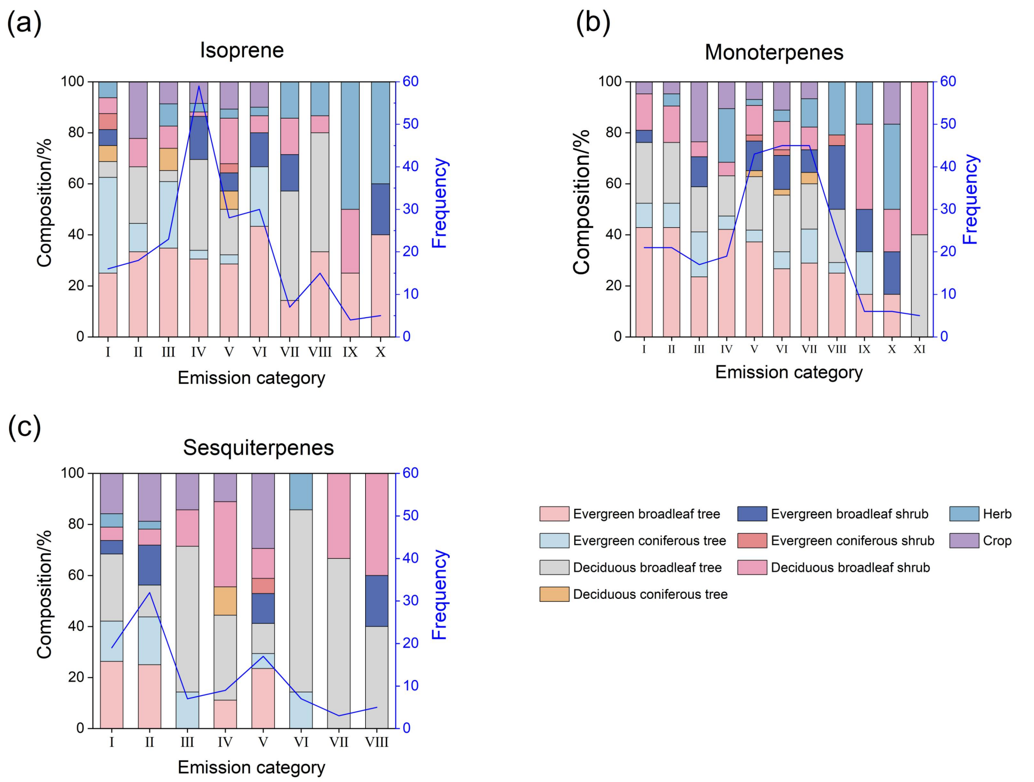

Figure S2. Composition of vegetation types and frequency statistics of plant species within each emission category of isoprene (a), monoterpenes (b), and sesquiterpenes (c).

3. In the modelled domain, what proportion of the area was covered with the emission rates with R-value 1?

Response:

Thank you for your insightful question. Following your comment, we have conducted a detailed analysis of the area coverage based on different vegetation types (trees, crops, shrubs, and herbs) rather than providing a summarized value, as we believe this offers a more accurate and detailed explanation. The key results are as follows.

For trees and crops, emission rates with R-value = 1 cover 93% of the total tree area and 94% of the total crop area in the domain. For shrubs and herbs, the coverage of R-value = 1 is lower, accounting for 34% and 21% of their respective coverage areas. This is a common challenge in regional BVOC modeling, as comprehensive field measurements for all shrub and herb species are often limited. Despite the scarcity of direct measurements of R-value = 1 for shrubs and herbs, their overall impact on the total BVOC emission is minor because of their low emission potential. This transparent assessment significantly enhances the confidence in the simulation results. Also, we have added a corresponding explanation in the manuscript to clear this point.

In line 444-450, "The application of emission rates with R-value = 1 was assessed by calculating the plant species coverage percentage of the total vegetation. Emission rates with R-value = 1 cover a high percentage of the dominant vegetation, specifically 93% of the total tree area and 94% of the total crop area. In contrast, their coverage is substantially lower for shrubs and herbs, with 34% and 21% of their respective areas. This is a common challenge in regional BVOC modeling, as comprehensive field measurements for all shrub and herb species are often limited." is added.

4. As the study also focuses on modelling with the MEGAN model, it would be interesting to see direct comparison of emission rates estimated in this study with those in the MEGANv3 global library (eg. by summarizing key differences) and/or with other available emission inventories.

Response:

Thank you for your valuable suggestion. Due to the unavailability of emission rates in other emission inventories, we compare our localized emission rate library and the MEGANv3.2 global one. Given that MEGANv3.2 often assigns identical data to all species within a genus, the representative emission rate (see Methods) for each genus was compared. Our analysis reveals both consistencies and notable discrepancies. For high-emission genera, the rank order is generally similar. However, the magnitudes often differ substantially. For isoprene, while genera like *Populus* and *Quercus* are high-emitters in both libraries, our localized emission rates for *Populus* (78.51 nmol m^{-2} s^{-1}) and *Salix* (11.64 nmol m^{-2} s^{-1}) differ from MEGAN's global value (37 and 37 nmol m^{-2} s^{-1}, respectively). The contrast is even more pronounced for monoterpenes. Genera *Lespedeza* and *Spiraea* have the highest emission rates in both libraries, but our values (40.87 and 21.0 nmol m^{-2} s^{-1}) are nearly an order of magnitude higher than the global value (5.30 and 2.73 nmol m^{-2} s^{-1}). The emission rates of sesquiterpene show closer agreement in both libraries. In summary, the key finding is that while the two libraries identify similar high-emitting genera, the MEGANv3.2 global emission rates are generally lower than our localized values.

In line 399-410 of revised manuscript, Section 3.3.5 is added as follows:

"**3.3.5 Comparison with global emission rate library of MEGANv3.2**

Comparison between our library and MEGANv3.2 global library was performed. For consistency, the comparison was conducted at the genus level, as the global library often assigns uniform values across species within a genus. Our results revealed consistent identification of high-emitting genera but quantitative differences (Figure S4). For isoprene, while genera like *Populus* and *Quercus* are high-emitters in both libraries, our localized emission rates for *Populus* (78.51 nmol m^{-2} s^{-1}) and *Salix* (11.64 nmol m^{-2} s^{-1}) differ significantly from the global value (37 and 37 nmol m^{-2} s^{-1}, respectively). The discrepancies are even more pronounced for monoterpenes. Genera *Lespedeza* and *Spiraea* have the highest emissions in both libraries, but the localized values (40.87 and 21.0 nmol m^{-2} s^{-1}) are nearly an order of magnitude higher than the global values (5.30 and 2.73 nmol m^{-2} s^{-1}). In contrast, sesquiterpene emissions show closer agreement in both libraries."

In line 25-27 of revised supplementary information, Figure S4 is added.

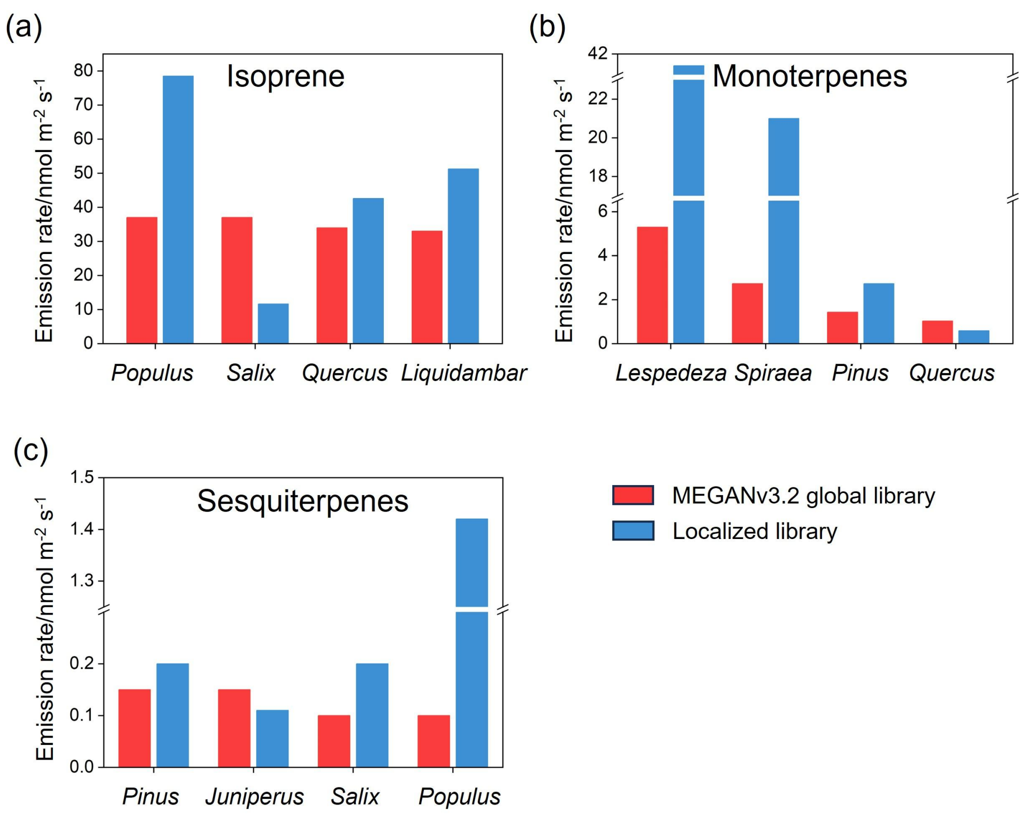

Figure S4. Comparison of emission rates at the genus level between the MEGANv3.2 global library and the localized library developed in this study.

5. Section 4.2, the BVOC emission total in China is presented as 27.7 Tg / year 2020. Could the authors specify the unit, Tg of what? If different BVOC species (with different molecular masses) are to be summed, they need be converted to Tg of carbon before the summation. Please check and correct throughout the text. Same applies to Figs. 5 and 6. Also, if the BVOC split to percentage is to be presented as in Figure S4, first the units need to be harmonised to Tg (C), otherwise the masses are not comparable and the percentage is not valid. How are total BVOC emissions defined, which species are included in the sum?

Response:

Thank you for your critical comment and valuable suggestion regarding the units and summation of BVOC emissions. We agree that for the purpose of summing different BVOC species and calculating percentage contributions, harmonizing the units to a common metric is the scientifically ideal approach. In our study, the total BVOC emissions for China in 2020 was 27.7 Tg year^{-1}, representing the total mass of the emitted compounds (in Teragrams).

Accordingly, the unit of BVOC emissions is "Tg of compound per year". The unit we used mainly because the emissions of all BVOC compounds calculated by the MEGANv3.2 model (including isoprene, 40 monoterpenes, 45 sesquiterpenes, and 113 other VOCs) are measured in terms of mass, the final calculated total BVOC emissions are also based on the mass of the compounds, and we did not calculate them in terms of carbon. Actually, the BVOC emissions could be reported using either the total mass of the compound (Tg year^{-1}) or the mass of carbon (Tg C year^{-1}). Both units are valid and widely used (Wang et al., 2024).

In line 413-414 of the revised manuscript, "MEGANv3.2 was applied to estimate BVOC emissions." is changed to "MEGANv3.2 was applied to estimate BVOC emissions, including 199 compounds (isoprene, 40 monoterpenes, 45 sesquiterpenes, and 113 other VOCs).". In the caption of Figure S5, a note "All percentages are derived from emissions expressed in Tg compound." is added.

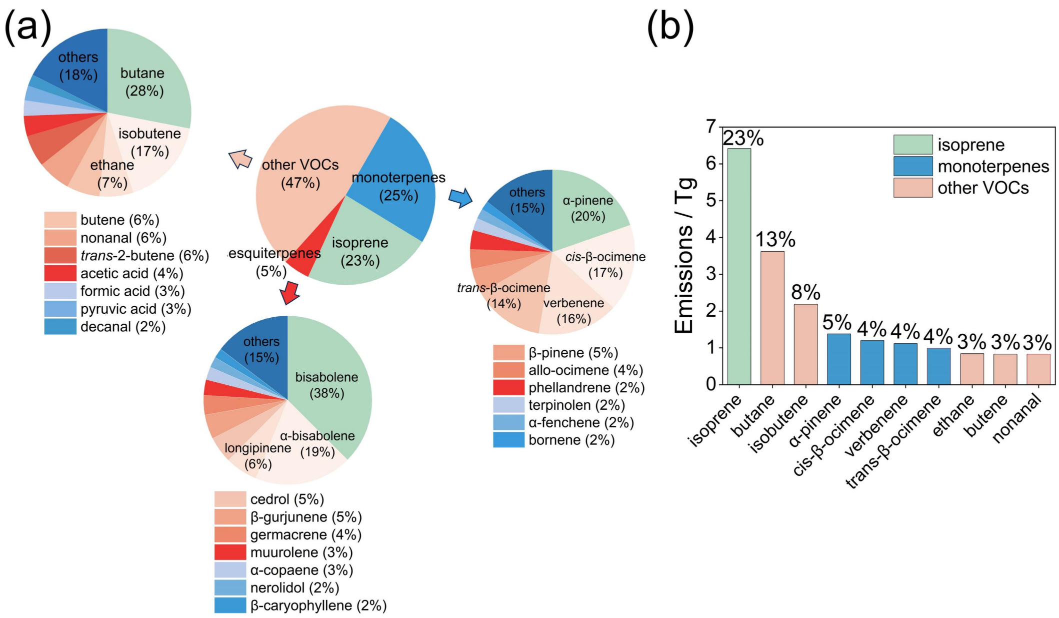

Figure S5. BVOC emission composition and top 10 compounds contributing the most to total emissions (BVOC emission composition of four categories. (isoprene, monoterpenes, sesquiterpenes, and other VOCs), and the top ten compounds of monoterpene, sesquiterpene, and other VOC categories (a); top 10 compounds and their belonging category contributing the most to total emissions(b). All percentages are derived from emissions expressed in Tg compound.)

Reference:

Wang, H., Liu, X., Wu, C., and Lin, G.: Regional to global distributions, trends, and drivers of biogenic volatile organic compound emission from 2001 to 2020, Atmos. Chem. Phys., 24, 3309–3328, https://doi.org/10.5194/acp-24-3309-2024, 2024.

6. Section 4.2 - I'd suggest to move Table S3 from Supplementary material to the main text. It would help the reader to better understand definition of different simulations.

Response:

Thank you for your valuable suggestion. We have moved Table S3 into the main text as Table 1 (now presented in Section 3.2.1, line 231-233).

7. Conclusions section, line 590: The authors say their localized dataset "Undeniably helps to improve the accuracy of the determined emission rates and furtherly the emission estimates." While I think this study as well as database of emission rates is very valuable, this is a rather strong statement. The results presented in the paper do not give a proof of improving the accuracy of the emission rates or estimates. Please rephrase.

Response:

Thank you for your valuable suggestion. As suggested, we have rephrased the conclusion to more accurately reflect what our study demonstrates. The revised text now emphasizes that the using of our localized library will enhance the regional representativeness of the MEGAN model's input for China. Furthermore, the application of our localized emission rate library could simulate the spatial variations of BVOC emissions better, which is supported by the isoprene emissions in July in Simulation 1 correlated stronger with HCHO concentration spatially (correlation coefficient = 0.73, $P < 0.05$) than Simulation 4 (correlation coefficient = 0.67, $P < 0.05$) as presented in Section 4.2.

In line 654-656, "Undeniably it helps to improve the accuracy of the determined emission rates and furtherly the emission estimates." is changed to Undeniably, it helps improve the regional representativeness of model inputs for China and better captures the spatial variations of BVOC emissions.".

8. Supplement, line 42: Could the authors please add a figure of HCHO values to illustrate the spatial correlation with their results?

Response:

Thank you for your valuable suggestion. The newly designated Figure S7 in the supplementary information explicitly shows the correlation between spatial distribution of observed HCHO VCD and our simulated isoprene emissions across different model scenarios.

In line 37-40 of revised supplementary information, "Figure S7" is added. In the revised manuscript, line 531-533, "The isoprene emissions in July in Simulation 1 correlated stronger with HCHO concentration spatially (correlation coefficient = 0.73, $P < 0.05$) than Simulation 4 (correlation coefficient = 0.67, $P < 0.05$)." is changed to "As shown in Figure S7, the isoprene emissions in July in Simulation 1 correlated more strongly with HCHO concentration spatially (correlation coefficient = 0.73, $P < 0.05$) than in Simulation 4 (correlation coefficient = 0.67, $P < 0.05$).".

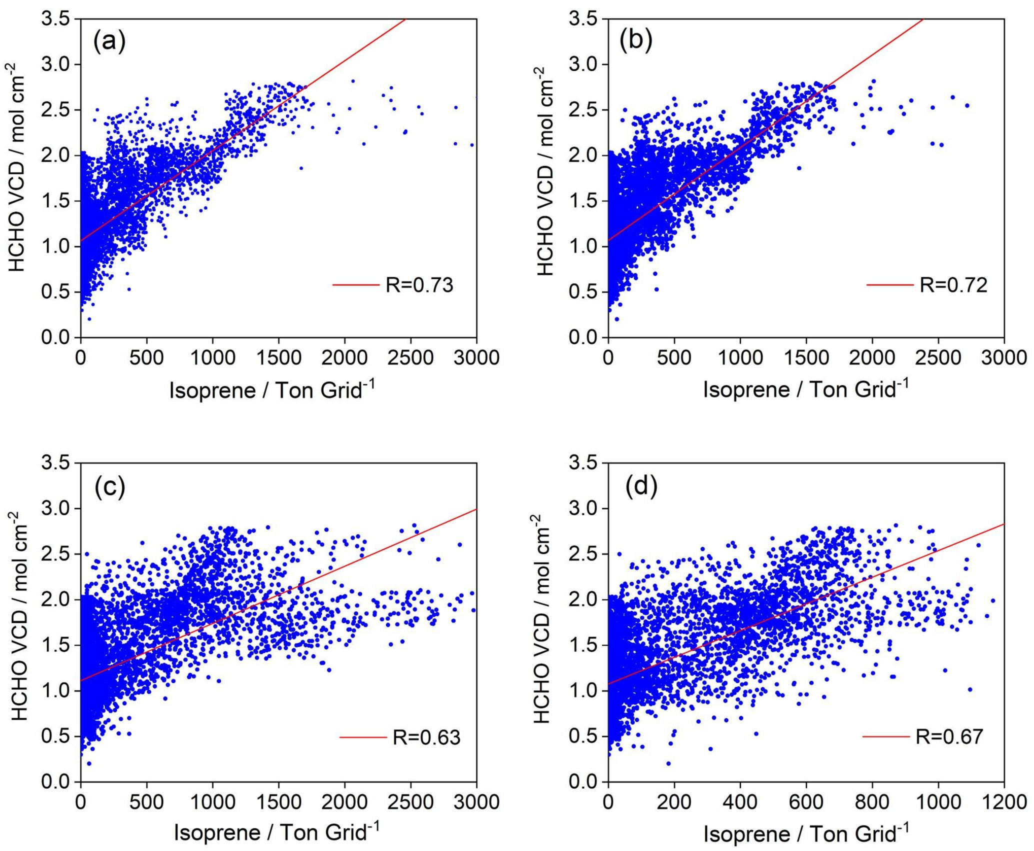

Figure S7. The correlation between isoprene emission and observed formaldehyde (HCHO) vertical column density (VCD) in July 2020 during various simulations. (a–d: Simulation 1 (a), Simulation 2 (b), Simulation 3 (c), and Simulation 4 (d).)

9. Please double check for language and typing errors, some of which are pointed out below.

Response:

Thank you for your meticulous review and pointing out these language and typographical errors. We apologize for the oversight and we have carefully checked the entire manuscript and corrected all the specific errors listed, as well as other minor issues we identified during a thorough proofreading. The changes made to each point are detailed below. Besides, English throughout the manuscript is edited by Elsevier Language Editing Services. The certificate is as follows. The changes caused by the revision of English are not marked in revised manuscript, and are not listed here due to the limited space.

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- Line 19: pose -> poses

Response:

Thank you for your valuable suggestion. In line 18 of revised manuscript, “pose” is changed to “poses”.

- Line 20: exited -> existed

Response:

Thank you for your careful review and valuable suggestion. We are sorry for this spelling error. After edited by Elsevier Language Editing Services, “exited” is changed to “exists” in line 19 of revised manuscript.

- Line 104: on -> of

Response:

Thank you for your valuable suggestion. In line 99 of revised manuscript, “on” is changed to “of”.

- Line 151: environment -> environmental

Response:

Thank you for your valuable suggestion. In line 155 of revised manuscript, “environment” is changed to “environmental”.

- Line 162: remove space after)

Response:

Thank you for your valuable suggestion. In line 167 of revised manuscript, the space after “)” is removed.

- Line 200: rates(a-e -> rates (a-e

Response:

Thank you for your valuable suggestion. In line 213-214 of revised manuscript, “rates(a-e” is changed to “emission rates observed by dynamic (left column: a, c, e) and static enclosure techniques (right column: b, d).”.

- Line 254: were -> was

Response:

Thank you for your valuable suggestion. In line 278 of revised manuscript, “were” is changed to “was”.

- Sentence on lines 413-416 is somewhat unclear and possibly missing a verb

Response:

Thank you for your valuable suggestion. We are sorry for the unclear description of the simulation setups. Following your advice, we have added a verb and rewritten the sentence to clarify the objectives.

In line 458-460 of revised manuscript, "To investigate the impact of emission rates in different quality on the BVOC emission estimates, the results of Simulation 1 and 3, which was set by applying the emission rates with R-value = 2 preferentially, then supplemented by those with R-value = 1." is changed to "Simulation 3 also employed the full localized library but favored R-value = 2 data and supplemented it with R-value = 1. This design enabled a controlled assessment of data quality influence through comparison with Simulation 1."

- Line 461: less -> lower

Response:

Thank you for your valuable suggestion. In line 516 of revised manuscript, "less" is changed to "lower".

- Line 524: emission -> emissions

Response:

Thank you for your valuable suggestion. In line 583 of revised manuscript, "emission" is changed to "emissions".

- Sentence on lines 528-529 is somewhat unclear.

Response:

Thank you for your valuable suggestion. We agree that the original description of the simulation setups was unclear. Following your advice, we have now completely rewritten the section as follows.

In line 589-592 of revised manuscript, "The above made the similar national total BVOC emissions and spatial accuracy of the two simulations." is changed to "Notably, similar national total BVOC emissions and spatial accuracy were observed between Simulations 1 and 2 because most of the species (84%) with emission rates of R-value = 2 were herbs, whose coverage was limited.".

- Sentence on lines 547-549 - missing verb.

Response:

Thank you for your valuable suggestion. In line 608-610 of revised manuscript, “Based on this, a localized plant species-specific BVOC emission rate library for China, including isoprene, monoterpene, and sesquiterpene emission rates for 599 plant species.” is changed to “Based on this, a localized plant species–specific BVOC emission rate library for China was developed, including isoprene, monoterpene, and sesquiterpene emission rates for 599 plant species.”.