Dear Professor West,

Thank you for your decision to publish our paper subject to some further minor revisions. Please find below our responses and actions with respect to your requests.

Editor comment:
Your responses to Referee #1 seems adequate and appropriate. For Referee #2, I am not so sure that your responses are adequate, and Referee #2 says that they are not willing to review the paper again. Rather than asking a different reviewer, I'll ask that you follow up on your responses to Referee #2. In particular:
1) "There are lots of information but less organized. The figure quality also needs to be improved." Please clarify what you've done to address this comment.

Response:
Unfortunately, Referee #2 did not provide any specific examples of how they believe our paper could be better organised. In addition, we point out that Referee #1 was entirely happy with the organisational aspect since they graded our paper "excellent" for the review question "Are the scientific results and conclusions presented in a clear, concise, and well-structured way?". There is therefore the risk that in trying to second-guess the concern of Referee #2 we make modifications that would degrade the presentation experience for Ref #1, ourselves, and other readers of our paper. Having said that, during the revision process we did make a few presentational changes that we believe both slightly shorten and enhance the paper's organisation: specifically, we moved both the original Figures 3 and 13 to the Supplementary; we moved some text that related to measurements that was previously in a result section into the methods section; we moved the original Table 5 to the end of Section 2.5; and we provided a revised overview preamble to the whole results section.

Our action concerning the comment on clarity of some of the figures is given in the response that follows.

Editor comment:
2) Regarding several figures and the comment "the labels are overlapped and hard to tell" you state that you tried to create the figures differently but were not successful. I agree that these plots look unprofessional and are hard to interpret. There are not so many points that I would think you could change the location of some labels by hand using some figure editing software to make it more clear, even if you are not able to do so through your plotting software. Please consider again whether such changes might be able to improve the figure.

Response:
This comment relates to the attempt to include individual site labels next to each data point on scatter plots of observed vs modelled concentrations for a given atmospheric species. We firmly wish to retain figure panels that have equal x and y axis so that the line of observed and modelled equality is at an intuitive 45 degrees through the panel. However, for some species the concentrations vary very little from site to site causing many data points to overlap or be very close to each other. In most of these scatter plots there are too many closely spaced data points to fit in labels for all of them as well. Our solution is therefore to remove all labels except for those marking data points that are specifically discussed in the text. Namely, Figure 3, 4, 8, 11, 12, and 15 in the main paper are all updated to reflect this revision. All the site names and their respective data values for each figure panel are now included in tables in the Supplement (i.e., Tables E1, E2, E3, F1, F2, F3, G1) so that readers have access to all the quantitative information. The corresponding Supplementary table numbers have now been added to each figure caption.

To illustrate, Figure 11 in the revised manuscript Sect. 3.2.1 (also provided below for your reference) omits all data labels except for DE0007R for isoprene, an outlier that significantly weakens the linear correlation.

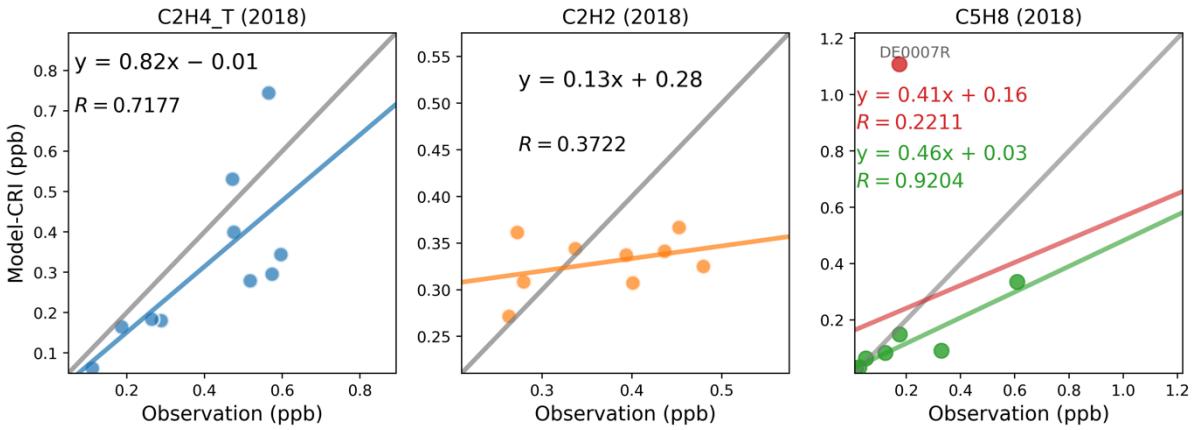

Figure 11. Scatter plots of annual mean modelled and measured ethene, ethyne, and isoprene concentrations in 2018. The term 'CRI' indicates that the model data is calculated using the CRIv2R5Em mechanism. In each plot, the grey line is the 1:1 line, and the other coloured line is the least-squares regression line. For isoprene, the outlier site is plotted in red; the red line is the regression line with the outlier; the green line is the regression line without the outlier. The site codes and their respective data values for each figure panel are provided in Supplement Table F1.

Editor comment:

3) For Referee #2, please consider whether you can make changes to the text of the paper to clarify the issues raised regarding comments #3, 6 and 7. Your written response to the comment makes sense, but no changes were made to the text to clarify these issues for other readers.

Response:

The referee's comment #3 concerns potential bias of meteorology and chemistry affecting the model performance; we provided a comprehensive response to this in our response document.

To further clarify this for other readers, we have added the following text to the main paper Sect. 3.2.4, **lines 581-584**:

"In general, biases in meteorology and chemistry are likely to affect all species uniformly. During winter, the lifetimes of ethene, benzene, and ethyne should become longer to a similar extent, implying that when examining ratios such as ethene-to-ethyne and benzene-to-ethyne, changes in their lifetimes should not significantly impact the results."

The remainder of our original response to the referee's comment #3 is essentially a shorter version of the paragraph also in Sect. 3.2.4 between lines 579-594. To further concentrate the message while avoiding repetition, we have added the following text to the end of this section as a summary, appearing in **lines 615-621**:

"In summary, the key difference is the model's strong agreement with the spatial correlations and time series for ethene and benzene measurements, but not for ethyne. While the modelled ethyne concentrations align closely with measurements during summer, they diverge significantly in winter. In contrast, modelled concentrations of ethene and benzene consistently match observations across all seasons. More importantly, measurement data reveal a strong linear correlation between ethene and ethyne, and between benzene and ethyne, during winter across all sites, suggesting they share common emission sources. However, the model fails to predict this correlation. This discrepancy highlights potential inaccuracies in ethyne emissions, given that all three compounds are commonly emitted from combustion-related activities."

The referee's comment #6 queries the rationale for the choice of the gas-phase chemical mechanisms investigated in our model simulations. Our original response to this comment consists of 2 paragraphs. The first paragraph is essentially a copy-and-paste of sentences in Sect. 2.2 lines 104-121. The second paragraph explains the rationale behind selecting these two mechanisms. To make this message clearer to other readers while avoiding repetition, we have selectively added the following sentences to the revised manuscript Sect. 2.2 **lines 141-151**:

"In summary, the difference between the two mechanisms is that CRIv2R5Em contains a wider array of VOC species and more detailed chemistry compared to the EmChem19rc, thus providing an illustrative example of applying CRI schemes within the EMEP MSC-W model. The rationale behind selecting these two mechanisms was to assess the difference in model performance when employing either scheme. The results of this study (Sect. 3) indicate that the default EmChem19rc mechanism is on a par with CRIv2R5Em. We mainly present results from CRIv2R5Em in this study because we aim to highlight findings using the most elaborate scheme available, which, theoretically, should enhance model performance. Nevertheless, it is crucial to mention that no significant difference was observed between the two schemes in terms of their agreement with measurements at least as regards the measurement data available at this time. However, running simulations with CRIv2R5Em incurs substantially higher computational costs than with EmChem19rc. In other words, this research illustrates that the default EmChem19rc scheme, despite having a smaller set of VOC species and simpler chemistry, offers the advantages of speed and reasonable accuracy. "

The referee's comment #7 suggests some misunderstandings concerning the use of o-xylene as a tracer. To also clarify this for other readers, we have added the following sentences in Sect. 2.2 **lines 136-140** to explain the tracer system using o-xylene as an example:

"For example, benzene is explicitly simulated within the model, meaning that it is processed based on its own individual emissions, thus eliminating the need for a tracer. Conversely, o-xylene is itself a lumped surrogate within the model, which relies on aggregated emissions data. As a result, a tracer OXYL_T is necessary to obtain 'pure' concentrations that can be directly compared to ambient measurements."