General Comments

Jeong et al. investigated the impact of drought on isoprene and air quality in South Korea using OMI formaldehyde (HCHO) observations and GEOS-Chem modeling. They validated two existing drought algorithms for isoprene emissions using OMI HCHO data. Furthermore, they constrained isoprene emissions during drought using an inverse modeling approach with OMI HCHO. The topic is within the scope of ACP, and the manuscript is well organized. However, I have some concerns about the methods and techniques that need to be addressed before it can be further evaluated.

1. Bias correction of the OMI HCHO product. The author used a single correction factor of 1.28, derived from the comparison of airborne HCHO measurements from KORUS-AQ, to adjust the OMI HCHO product (Zhu et al., 2020). However, other studies using measurements from airborne platforms, FTIR, and MAX-DOAS suggest a negative bias in the OMI HCHO product when HCHO levels are high and a positive bias when HCHO levels are low (Müller et al., 2024;De Smedt et al., 2021). This phenomenon is also indicated in the reference cited by the author to justify the correction factor used (Zhu et al., 2020). I would suggest that the author consider using a different correction approach (e.g., the method in Müller et al. (2024)) for comparison considering the uncertainties from the single field campaign.

2. The impact of drought or water stress severity. The impact of water stress on isoprene emissions depends on the severity of the drought. In general, water stress can increase isoprene emissions by elevating leaf temperature through stomatal closure. However, as the drought becomes more severe, the carbon substrate supply for isoprene is cut off, leading to a decrease in emissions, as observed in field studies (Potosnak et al., 2014;Seco et al., 2015). However, the authors did not distinguish between different levels of drought severity. Therefore, I believe it is necessary to conduct an analysis based on a finer classification of drought levels.

3. The simulation of drought. Wang et al. (2022) demonstrated that the performance of drought simulations directly affects how well the model simulates the impact of drought on isoprene emissions. The authors used the soil moisture stress (βt) from the Hadley Centre Global Environment Model version 2–Earth System Model (HadGEM2-ES). However, they did not provide any information about the model's performance in capturing changes in soil moisture or water stress. Therefore, I would suggest validating the model's soil moisture or water stress simulations in the same scale of their comparison like weekly before analyzing the HCHO simulations.

4. Poor statistics. The only statistical analysis applied in the paper is the comparison of mean values, which is not sufficient for the audience to understand the analysis and the uncertainties behind these comparisons. I will provide more specific guidance on this part in my minor comments.

Minor comments.

Line 27: The estimation by Guenther et al., 2012 is suggesting that isoprene accounts for 50% of global BVOC emission. However, I also believe this number is quite uncertainty. So I would say 50-70% in a relatively safe way.

Line 32: Stomatal conductance" and "photosynthesis rate" are two related terms, and I don't think the statement here is correct for explaining the drought impact on isoprene emissions. In addition, Seco et al. (2022) discusses the high temperature sensitivity of isoprene in the Arctic, so I have no clue why this reference is included here.

Line 104: Please provide the referene for the OMI HCHO dataset you used.

Table 1. Please provide the standard deviation of your model results as well as the OMI HCHO column concentration, and conduct a significance test for your mean comparison.

Line 195: I assume monoterpenes and sesquiterpenes are grouped into the lumped alkenes. As indicated in Figure S3, isoprene emissions are far higher than those of other terpenoids. Could you provide more vegetation information (e.g., broadleaf and conifer tree fractions) to explain this?

Figure 6/7 and ozone/PM2.5 validation: The comparison here is quite generic and lacks details. The authors compared the model with the in-situ measurements. The only comparison presented is the Mean Bias (difference in mean values). I think some scatter plots of the model and observations on a weekly scale could be useful to understand the change in model performance after improving the model emissions using the OMI satellite data. Besides the common statistical metrics like R^2, RMSE, ME, and MB, a significance test should be conducted to determine if the improvement in emissions is statistically significant.

Equation 7 and Figure 8. The analysis here is confusing. I think the authors are arguing that drought stress is the main driver of the isoprene emission bias. However, the analysis focuses on temperature. Although high temperatures often coincide with drought in many cases, there are two drivers of vegetation water stress: one is the high Vapor Pressure Deficit (VPD) caused by a dry and hot atmosphere, and the other is dry soil conditions, which determine the water supply for plants. Additionally, long-lasting droughts are mainly controlled by a lack of water. However, the equation and analysis here use the soil moisture parameter (βt) as the indicator of drought severity but use temperature as the input for addressing the isoprene emission bias. This raises the question: is the bias caused by drought, or temperature, or both?

Reference

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