Response to Referee #1

General comments: This paper presented the MEGAN-simulated biogenic volatile organic compound (BVOC) emissions in China and analysed the modelled contributions from changes in land cover and climate to the BVOC emissions. The modelled variations in isoprene emissions were further linked to the HCHO vertical column. The paper is well-written and has delivered the message about the potential importance of land cover changes in BVOC emissions in China. The current format of the manuscript has been much focused on analysing the patterns simulated from the four different scenarios, but rather limited in understanding the uncertainties (e.g., uncertainties from satellite products or assigned emission factor or missing PFT) associated with the model simulation. Then when the authors linked their simulated isoprene emission with the HCHO vertical column, the disagreement of these two has been mainly attributed to the AVOC, but I would think there could be also contributions from the uncertainties in the simulated BVOCs. From the maps with simulated BVOCs, I am a bit surprised to see that the north part of China with high LAI showed very low simulated emissions, especially monoterpene. Could this be linked to the misclassification of forest type? Then in the east and/or at least North China Plain area, there is wide distribution of crops. Are crops specifically considered in MEGAN? In general, a map showing the spatial distribution of PFTs could be very useful for readers. I also think it is crucial to compare the modelled emissions with a few sites' measurement data to illustrate the performance of the model before digging into analysing the changes of the emission patterns at the national scale and further linking to the HCHO column data.

Response: Thank you so much for your precious time and your comments. We will follow your suggestion and add more discussion about the uncertainties by comparing with other studies and adding extra experiments. In addition, some necessary information, e.g. PFT spatial distribution, will also be presented in the revised paper. We will also try to find some in-situ measurements from previous literatures to validate the model. Currently, we haven't finished the revision of paper, so we will only response the discussion of ACP and introduce our direction of revision. The final response will be submitted with the revised paper.

Specific comments:

P2 L5-6, please indicate at which spatial scale we can see cropland dominates the reduction of isoprene.

Response: Thank you for your comments. We will add this part in the revised paper.

P2 L10, the authors mentioned that the greening in China has been linked to "maintain and expand forests". Did they change plant species when expanding forest? And can you see this level of land use change in the MODIS PFT product?

Response: Thank you for your comments. Currently, distinguish the specific species of trees using MODIS since the spatial resolution of MODIS sensor is not high enough to do so. So, we can't see the species-level change through the MODIS PFT. Our estimation is mainly based on the PFT level change.

P3 L2, suggest to delete "accurately". You have not evaluated the modelled BVOC against the measurements.

Response: Thank you so much for your advice, and the word "accurately" will be deleted in the revised paper.

P4L2-4, here you might need to specify where these emission factors are from? How much of these emission factors covered the measurements from China? I did a quick google search and could already see some measurement data available for different ecosystems in China.
https://www.sciencedirect.com/science/article/pii/S1352231017302947
https://www.sciencedirect.com/science/article/pii/S1352231015305173
https://www.sciencedirect.com/science/article/pii/S0269749119346081?via%3Dihub

Response: Thank you so much for your comments. The emission factors in this study are the default values of the MEGAN 2.1 provided by Guenther et al. 2012. Since we didn't have an ability to distinguish the species of the trees using the MODIS images, we didn't consider using the species-based emission factors. It is true that this will induce the uncertainty of emission amount, and we will add some discussion for this in the revised paper. However, this work is focusing on the impact of land cover change and vegetation biomass change on BVOC emission in China, so using the default emission factor could help to discuss the change of BVOC.

P4 L8, "The Cce(=0.57) is a factor to xx" what does this mean?

Response: As described by Guenther et al. (2006), the C_{ce} is a parameter in MEGAN model that sets the emission factor to unity at the standard conditions. It has no physical meaning and was used to normalize the emission factors. We will state it more clearly in the revised paper.

P4 L9, How can LAI define leaf age in MEGAN?

Response: Thank you so much for your comments. The leaf-age factor,γ_{age}, in MEGAN is described in detail in Guenther et al. (2006). For the evergreen canopies, γ_{age} is constant. For the deciduous canopies, the leaves are divided into four stages of new leaf, growing leaf, mature leaf and old leaf since the emission capacity of leaf is diverse with leaf age(Guenther et al., 1991;Monson et al., 1994;Guenther et al., 2006). According to Guenther et al. (2006), the γ_{age} is defined as:

$$\gamma_{age} = F_{new}A_{new} + F_{gro}A_{gro} + F_{mat}A_{mat} + F_{old}A_{old}$$

where A_{new}, A_{gro}, A_{mat} and A_{old} are the relative emission rates for new, growing, mature and old foliages. F_{new}, F_{gro}, F_{mat} and F_{old} are the fractions of different sorts of leaves and are defined by the change of LAI between the current time step (LAIc) and the previous time step (LAIp). F_{new}=0, F_{gro}=0.1, F_{mat}=0.8 and F_{old}=0.1 when LAIc equals LAIp. When LAIp> LAIc, the fractions in different stages are as:

$$\begin{cases} F_{new} = 0 \\ F_{gro} = 0 \\ F_{old} = [(LAIp - LAIc)/LAIp] \\ F_{old} = 1 - F_{old} \end{cases}$$

In the cases of LAIp<LAIc, the fractions are calculated as:

$$\begin{cases} F_{new} = 1 - (LAIp/LAIc) \\ F_{gro} = 1 - F_{new} - F_{mat} \\ F_{mat} = LAIp/LAIc \\ F_{old} = 0 \end{cases}$$

. More details can be found in Guenther et al. (2006), and we will add some brief introduction into the revised paper.

P4 L13, Is soil moisture used as inputs for model? If so, please clarify.

Response: Thanks for your comments. The soil moisture is simulated by the WRF model and will be considered in the calculation. We will follow your comments and clarify this part in the revised paper.

P4 L17-18, LAI is a 'modelled' product from other satellite products and potentially has large uncertainty in itself. I wonder if the LAI has been filtered by the quality flags before using as inputs for MEGAN and how the model deals with the LAI gap if there is no data for many 8-days?

Response: Thank you so much for your comments. We used all available values in MODIS LAI products, and we didn't use the quality filter at the first place to ensure the model can be driven by continued LAI field. The model didn't have ability to deal with the LAI gap, but this problem can be solved by using some interpolation technics when preparing the inputs.

P4 L21-23, Could you list what PFTs you have in your simulations (or showing a map), and also how MODIS PFTs were reclassified to the CLM group? I think this information is important for readers to understand the spatial pattern.

Response: Thank you so much for your comments. We will provide the spatial distribution of PFT as well as the method used to convert MODIS PFT to CLM group in this part. Also, we will do some sensitivity tests to discuss the impact of PFT classification system.

P7 L18-19, the reasons why the simulated MT is so much lower than the previous estimations needs to dig in-depth. Like I mentioned early, could it be linked to the misclassification of PFTs or very different emission factors assigned? In Table 3, the modelled isoprene is very low than Li et al., 2013, can the authors describe a bit about why?

Response: Thank so much for your comments. We agreed with your comments. The low estimated monoterpene emission may be induced by the misclassification of PFTs or emission factors. We will double check the PFT classification system and add some sensitivity tests for further discussion. The emission factors used in this study are the default values in Guenther et al., 2012, which may be different from that in Li et al., 2013. We will also do some comparisons to explain the discrepancy between two studies.

P9 L23, might need to add one or two sentences in the method section why $p > 0.9$ is statistically significant. I did not get it here.

Response: Thank you so much for comments. Some corresponding explanation will be given in the revised paper.

P12 L11-12, "The lack of long-term in-situ observations of BVOC in China..." I think this might be the case for most of countries where we don't have dataset being representative at the whole country level, but I think the authors should definitely compare the modelled with in-situ data for a few representative sites to evaluate the model performance. In China, there are some sites where you can find the ecosystem-level BVOC measurement data for comparison, like some links I provided in the previous comments.

Response: Thank you so much for comments. The rare observations limit the validation of MEGAN model in this study. Furthermore, the outputs of MEGAN for BVOCs are canopy level fluxes not concentrations. Although there are some BVOC concentration observations in China, MEGAN model cannot be validated though these observations. But we will try our best to find some ecosystem-level BVOC measurements from the previous literatures to see if there's a chance to validate the model results.

P12 L12-18, this part should be in the method section.

Response: Thanks for your comments. We will find a better way to do that in the revised paper.

P13 L5, ". . . are marked with black dots" it is difficult to see these dots though.

Response: Thanks for your comments. We will find a better way to present the information in the revised paper.

Conclusion, it is rather lengthy at this moment and includes large section of discussion as well. Please make it more concise.

Response: Thanks for your comments. We will try to compress our current manuscript by removing unnecessary information and descriptions to make current contents relatively concise. On the other hand, we will also add more results to investigate the issues like PFT classification and discuss more uncertainties in this study.

Reference

Guenther, A., Karl, T., Harley, P., Wiedinmyer, C., Palmer, P., and Geron, C.: Estimates of global terrestrial isoprene emissions using MEGAN (Model of Emissions of Gases and Aerosols from Nature), Atmos. Chem. Phys, 6, 3181-3210, 2006.
Guenther, A. B., Monson, R. K., and Fall, R.: Isoprene and monoterpene emission rate variability: Observations with eucalyptus and emission rate algorithm development, Journal of Geophysical Research: Atmospheres, 96, 10799-10808, 10.1029/91JD00960, 1991.
Monson, R. K., Harley, P. C., Litvak, M. E., Wildermuth, M., Guenther, A. B., Zimmerman, P. R., and Fall, R.: Environmental and developmental controls over the seasonal pattern of isoprene emission from aspen leaves, Oecologia, 99, 260-270, 10.1007/BF00627738, 1994.