Author's response to comments from Anonymous Referee #2:

"Land use change influence on atmospheric organic gases, aerosols, and radiative effects"

by Ryan Vella et al.

We thank editor and referees for taking the time to review our manuscript and for the valuable feedback. Here, the comments from Anonymous Referee #2 (from August 07, 2024) are reproduced in black, while our comments are presented in blue.

From Anonymous Referee #2's response:

The aim of the manuscript is to detail changes in the impacts of biogenic emissions under different levels of deforestation. The global study changes the area of land currently defined as tree plant functional types towards more grass and cropland area as a future world requires more land for agriculture. The authors find that the reduction in biogenic emissions from deforestation lead to associated reductions in secondary organic aerosol production which leads to warming. In an alternative scenario, the impacts of an extreme reforestation scenario are explored where a cooling effect is produced from increased biogenic emissions.

I thank the authors for embedding the figures in the text, this greatly helps the reviewer!

The paper is well within the scope of ACP and I recommend publication after considering a few points.

Thank you for your comments and recommendation for publication. Your concerns are addressed in detail below.

1. Understanding the scenarios

I had real problems understanding the scenarios. I first thought PNV was the current vegetation. An explanation of what potential natural vegetation is would help when it is introduced on line 127 (i.e. the absence of humans).

PNV is now defined in the text. "PNV refers to the type of vegetation that would naturally occur in a specific area under certain climate, soil, and environmental conditions without human influence."

In the methods section it says DCGL is sometimes referred to as ‘present day deforestation’ on line 163. Yet on line 241 it says ‘present-day land cover’. Perhaps this should be called ‘current land cover’? It took me a couple of reads to work this out.

We agree that the term "present-day deforestation" might be misleading. We now only use "present-day land cover" throughout the manuscript.

I guess what I'm trying to get at is the study where we compare the current conditions the world finds itself in with either deforestation of afforestation, as it shows us what differences can be made if we collectively choose to adopt either scenario now. I'm finding the study using PNV confusing as it never existed – certainly not in the years 2000-2012.

We acknowledge the potential confusion stemming from comparisons with different baselines. In the first comparison, PNV serves as the baseline against present-day conditions, while in the second, present-day serves as the baseline against reforested grazing land. The aim of this study is to highlight how current land cover influences BVOC emissions and to assess how an extreme reforestation scenario would perturb these emissions and atmospheric states. We opted to nudge the meteorology over a "random" timeframe (2000-2012) to suppress feedbacks that could complicate the disentangling of climate responses purely resulting from land cover changes. Text has been added in Section 2.3 to address these concerns.

2. Other comments

The responses of PNV and DCL look very similar to me – in figures 3 (e,f) and figure 8 (e,f). Is this because crops are not large bVOC emitters?

The annual cycle of isoprene and monoterpene emissions from PNV and DCL are very similar, differing only in magnitude, particularly in spring and summer (more emissions in PNV compared to DCL). This occurs primarily for two reasons: (1) the perturbation from cropland expansion is relatively small compared to that from grazing land expansion (see Fig. 1), and (2) the impact on BVOC emissions depends significantly on the type of vegetation (PFT) being deforested and its associated emission rates. For instance, the conversion of natural grasslands to cropland would affect BVOC emissions differently than the conversion of tropical rainforests.

And why do the isoprene responses in both figures peak in spring as opposed to summer months?

MEGAN includes a leaf age factor, which accounts for reduced emissions for young and old leaves based on observed LAI change. This explains the slight decrease in MEGAN emissions from April to May to June. This is discussed in more detail in Vella et al. (2023).

Line 166. The years being simulated should be stated at the start of the paragraph (rather than at line 170). And is the same meteorology driving all 3 of your scenarios, or is the model being driven by data from a climate run for an assumed future extreme afforestation run? Some comment on the associated impacts of warming on biogenic emissions and bSOA production is warranted.

The first sentence of the paragraph now specifies the years simulated (2000-2011). Text now highlights that we employ the same climate states in all scenarios, only perturbing land cover.

Figure 1. The unit is 'land transformation faction'. Does this figure already include land that is agricultural, or is this the land that is being changed in the model to crops and grazing land? I was surprised given the large land transformation fraction (what I understand as 'deforestation' from the figure caption) in the mid-USA that we don't see more of an impact there in figures 5 onwards?

Figure 1 shows the land being converted from natural vegetation (PNV) to cropland or grazing land, primarily by removing tree PFTs in these regions. You are correct; this refers to areas of deforestation.

The HYDE dataset highlights significant deforestation signals in the central and northern USA. However, the impact on vegetation changes in the central USA is much weaker compared to the land cover fraction maps. This is because the region is naturally dominated by temperate grasslands, so the effect of deforestation is minimal here (since we are only removing tree PFTs). The more noticeable signal comes from deforestation further north, where temperate forests are being cleared.

The strongest signals in BVOC emissions and aerosol burden are observed in the tropics due to higher BVOC emission rates from tropical forests, which are more productive and diverse compared to temperate or grassland ecosystems. Extensive deforestation in these regions leads to significant reductions in BVOC emissions, which, coupled with the tropical climate's sensitivity to these compounds, greatly impacts aerosol formation. The stronger perturbation in the tropics, coupled with the atmospheric conditions in these regions, results in a comparatively weaker signal at higher latitudes. This same pattern, seen in the USA, also occurs in Europe.

Figures 5 & 6. The line diagrams are missing a legend to distinguish between the colored lines.

The legend for the vertical profile plots is positioned between panels (a) and (e). The figures have been revised to feature larger text, including an enlarged legend for improved visibility.

Line 281. 'by'

This section was revised in response to comments from reviewer 1.

References

Vella, R., Forrest, M., Lelieveld, J., and Tost, H.: Isoprene and monoterpene simulations using the chemistry-climate model EMAC (v2.55) with interactive vegetation from LPJ-GUESS (v4.0), Geoscientific Model Development, 16, 885–906, 2023.