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Reply to: Complexities between plants and the atmosphere

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REPLYING TO B. Wang et al. *Nature Geoscience* https://doi.org/10.1038/s41561-019-0413-8 (2019)

Wang et al.[1] raise concerns that our conclusion of enhanced primary productivity due to diffuse radiation fertilization from biogenic volatile organic carbon (BVOC) emissions[2] may be premature because of the complex biosphere–atmosphere interactions and the large uncertainty range of BVOC emissions. We are thankful for the positive comments on our paper and are pleased to provide clarifications of the issues raised.

Our analysis included uncertainties associated with model parameterizations, examining a range of secondary organic aerosol (SOA) formation rates to capture uncertainty in both BVOC emissions and SOA yields. We consequently reported a range of resulting net primary productivity (NPP) enhancements (0.76–1.61 PgC yr^{-1}), showing that the overall effect of BVOCs on the carbon cycle is a gain of carbon to plants, rather than a loss. We argue that, to a large extent, the uncertainty in BVOC emissions is captured by our sensitivity simulations. It is the SOA that is ultimately responsible for the diffuse radiation fertilization effect, and our simulations covered SOA production totals ranging from 17 to 100 Tg yr^{-1}, reflecting the 13–121 Tg yr^{-1} range reported in a major model intercomparison study[3].

In our opinion, comparing the estimated changes in NPP or BVOC emissions against the uncertainty in the corresponding absolute values adds little to our analyses and does not mean that the feedback is unimportant. For example, radiative forcing from anthropogenic CO_2 emissions is similar in magnitude to the uncertainty in measurements of the Earth's radiative budget, but this does not imply that CO_2 radiative forcing is not important. Also, our estimated gain value of 1.07 refers to a 10% increase in BVOC emissions. We do not say that this automatically applies to the effect of all BVOC emissions, as the relationship between NPP changes and BVOC emission changes is not linear.

We agree that since we are not running a dynamic vegetation model, we are not able to simulate any shifts in species that may occur in response to changing environmental conditions. Capturing the full suite of interactions between BVOCs, climate and plants is indeed an exciting research frontier. However, as rightly pointed out by Wang et al., vegetation representation schemes such as the one employed in our work are well suited to modelling primary productivity. Thus, we believe that while the development of Earth system models will allow a better analysis of this fully coupled system, our work offers an important step forwards in exploring the complex set of interactions between plants, BVOC and the atmosphere.

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Author contributions

A.R. wrote the manuscript. All authors contributed to scientific discussions and commented on the manuscript.

Competing interests

The authors declare no competing interests.

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