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Reply on RC2

Jie Ren et al.

Author comment on "Diagnosing ozone–NO_x–VOC sensitivity and revealing causes of ozone increases in China based on 2013–2021 satellite retrievals" by Jie Ren et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2022-347-AC2>, 2022

We thank the reviewer for the thoughtful and constructive comments, which will greatly assist in revising the manuscript. Here is a short response to the major comments first.

1. Indeed, ozone is produced from NO₂, and continued reduction of NO_x will eventually reduce O₃ concentrations. Our results show that the NO_x-limited regime exists in a large area of China currently, where NO_x reduction is effective in controlling ozone pollution. However, at present, key city clusters and urban areas are dominated by VOC-limited and transitional regimes. If the scheme of no VOC reduction and NO_x reduction only is adopted, the O₃ concentration cannot be effectively reduced until NO_x is reduced to a very low level to lead the O₃ formation regime to shift to NO_x-limited, which requires a very long time and high cost. In contrast, a strong effort to reduce VOCs and increase the VOCs/NO_x reduction ratio is the immediate and effective way to reduce O₃ concentrations.

The results of Wang et al. (2022) show that VOC reduction would significantly decrease O₃, while NO_x reduction would only slightly decrease O₃ at two urban sites in Beijing and Shanghai from June to August after 2019. This is consistent with our findings from April to September in Beijing and Shanghai that VOC reduction is more effective than NO_x reduction for controlling O₃ pollution. We provide the spatial distribution of ozone sensitivity in China, and different regions should adopt different emission reduction strategies.

2. Although the HCHO yields of different VOC species differ, the changes in satellite HCHO can roughly indicate changes in total VOC emissions, which has been applied in several previous studies. (Li et al., 2020; Shen et al., 2019; Zhu et al., 2014)

Our results show that there is no significant overall decrease in satellite HCHO concentrations in most of eastern China since 2013, which is similar to the estimated trends of anthropogenic VOC and biogenic VOC emissions in China (Zheng et al., 2018; Simayi et al., 2022; Li et al., 2020). Biogenic VOC emissions are difficult to control, and anthropogenic VOC emissions are much higher than biogenic VOC emissions in urban areas of China, so it is the lack of anthropogenic VOC emission reduction that has not significantly decreased HCHO.

Overall, the long-term changes in HCHO are driven by several factors, such as anthropogenic and biogenic emissions, OH abundance, and NO_x concentrations, which deserve further investigation in future studies using more adequate observational data. Most relevant to our study is that HCHO has not declined as dramatically as NO₂, i.e., the

overall change in VOC is much smaller than NO_x reductions over the past 9 years.

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