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Interactive comment on "Adverse Effects of Increasing Drought on Air Quality via Natural Processes" *by* Yuxuan Wang et al.

Anonymous Referee #3

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This study examines the correlations between drought and air pollutants (ozone and PM2.5) in the US. The authors use the linear regression slope derived from drought indices and ozone/PM observations to infer the effects of drought and argue that most chemistry-climate models are not able to reproduce the observed relationships. The authors further apply the observed relationships to climate model projected drought occurrences and attempt to estimate the effects of increasing drought on ozone and PM by 2100 compared to the 2000s.

The manuscript is well structured and readable. However, there is a major flaw in the applied method to quantify the impact of drought. The correlations between drought and ozone reported in this study may reflect the common underlying correlation with air stagnation and temperature rather than a causal relationship of drought on ozone. An inspection of the model differences in their Figure 5 supports this statement. None of

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these models include the effects of soil moisture deficits on BVOC emissions and the reduced efficiency of ozone dry deposition sink to vegetation. Nevertheless, the GISS model with interactive isoprene emissions simulates the SPEI/ozone slope comparable to the observed values over the Southeast. The greater slope simulated in GISS as compared to other models reflects the inclusion of interactive isoprene emissions, which allows the model to simulate ozone enhancements resulting from stronger isoprene emissions during heat waves (see Schnell et al., 2016). Reduced BVOC emissions under drought stress will actually lead to less ozone.

While severe drought can potentially lead to elevated surface ozone by reducing the ozone dry deposition sink to vegetation (see a review by Fowler et al., 2009), this impact has to be demonstrated using a more sophisticated statistical approach (e.g., multi-variate regression) or chemistry-climate model sensitivity experiments to isolate the role of air stagnation and temperature. For example, Lin et al. (2017) showed that reducing ozone Vd by 35% in GFDL-AM3 during the severe North American drought of 1988 simulates 10 ppbv greater ozone enhancements than a BASE simulation with constant Vd, although the BASE simulation still captures observed ozone enhancements during the other warm summers driven by processes other than drought (see their Section 6 and Figs.18 and 19).

Without a more careful attribution analysis to separate the influence of stagnation and temperature, you cannot use the terms like “drought-induced”, “causes of ozone and PM enhancements by drought” or “effects of droughts”. All such terms in the present manuscript will need to be removed or rephrased.

In summary, the analysis presented in the current manuscript shows a correlation between drought indices and air pollutants but not the causal effects of drought on air quality. The derived slope may serve as a useful diagnostic to evaluate the models, as the authors show, but it cannot be used to quantify the impact of drought on air quality.

Relevant references:

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