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Atmospheric Chemistry and Physics Discussions

Interactive comment on "How emissions, climate, and land use change will impact mid-century air quality over the United States: a focus on effects at National Parks" *by* M. Val Martin et al.

Anonymous Referee #1

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The paper presents a modeling study investigating the influences of future changes of emissions, climate and land use on air quality in the US National Parks. The authors analyze the future changes in surface ozone and PM2.5 along the RCP4.5 and RCP 8.5 projections in 2050 compared to the present day. They find that while PM2.5 is significantly reduced in the future for both RCP scenarios, surface ozone improves for RCP4.5 but deteriorates in RCP8.5 for some regions. While several studies analyzed future ozone and PM2.5, the novelty of this manuscript is that they separate the individual effects. The paper is well written, analysis is sound and the results are important. However, a number of revisions should be made before the paper is acceptable for

publication in Atmospheric Chemistry and Physics.

My main comment is that not enough validation/error analysis was presented for the simulated W126 ozone index, which the authors use to conclude on potential violations of the secondary standard in the future. Models are known to have large errors when simulating this metric (e.g., Tong et al. , 2009; Hollaway et al. , 2012) and the discussion on uncertainty for the modeled results is essential. This is especially true, as the authors conclude that the modeled MDA8 for the summer are biased and these errors are likely to amplify for the modeled W126 metric. Indeed, the simulated present-day W126 values presented in Table 4 are extremely high – how do these compare to observations? E.g., for Shenandoah NP the authors have 66.5 ppm-hrs. The CASTNET annual reports (http://epa.gov/castnet/javaweb/docs/annual_report_2010.pdf) list W126 at Shenandoah NP as low as 10ppm-hrs in 2010 and 4ppm–hrs in 2009, much lower than simulated in this paper. The authors should either discuss these errors and how they may affect their conclusions on W126 projections or remove Figure 12 and associated discussion.

Other comments:

p 26495, line 19: The sentence "Our study. . ." doesn't fit well with the conclusions before or after. Also, if true, it is rather consistent with many previous works showing that AQ is primarily driven by anthropogenic emissions changes, thus reducing the novelty of this work or the conclusion that climate change and land use are factors that "need" to be considered.

p 26499, lines 5-7: Did the authors find that the effects of emissions, climate change, and land use interact in a strongly nonlinear fashion? Or could one have estimated the results of treating all of these components together from previous works that have treated them individually? The former would support the novelty of this work.

p 26502, lines 1-4: It is difficult to believe that the changes in land use or climate have negligible effects on soil NOx or fertilizer NH3 emissions, which are likely to be

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important for the air quality in National Parks. Can the authors provide more justification for their assumptions? Is there a previous work citable here?

p 26502, lines 15-19: Please add description for the “2050 Total Change” simulation.

p 26503, lines 3-4: What was the data coverage for the monitoring sites during the 1998-2010 period?

P 26504, lines 1-2: While mostly true, this statement exposes a larger problem. The forward model performance can/has been evaluated via comparison to observations. The model sensitivity (i.e., response of the model to changes in emissions or climate) however has not been evaluated, and that is what the authors base their main conclusions on. Thus they really need to consider the validation of their model sensitivities. Below are a couple of major issues with regards to ozone.

First, recent work (Parrish et al., JGR, 2014) has shown that CAM-Chem’s response of O3 to changes in emissions underestimates observed responses. How does this impact the projections presented here?

Second, treatment of ozone chemistry (particularly organic nitrates) can drastically alter the sign of the sensitivity of air quality models to changes in VOC emissions (see Mao et al., JGR, 2013, Fig 8). Does the CAM-Chem chemical mechanism lead to positive or negative sensitivities w.r.t. changes in isoprene emissions? How does the response of O3 to NOx in this model compare to others?

I suggest at the very least a considerable discussion of these sources of uncertainties, as they are critical for interpretation of the results from this single model.

p 26506: Please clarify how climate-driven biogenic emissions were calculated in the “Land Use” change simulation, which used the 2000 climate. Were they pre-calculated using the 2050 climate first?

Figures 2, 6: The model’s horizontal resolution is 1.9x2.5 degrees. The plotted maps however show features on a much finer scale, perhaps due to interpolated contours.

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The authors should state this in the Figures' captions, as it can be misleading otherwise.

p 26513 and Figure 10: Figure 10 presents the annual mean MDA8 ozone, but it would be more informative and relevant to present estimates on the changes in summertime MDA8.

p 26513, line 8: "daily surface ozone" is too ambiguous, as there can be a number of daily surface ozone metrics.

p 26513, line 16: In my understanding "reducing emissions" is inaccurate here, as in addition to the reduced anthropogenic emissions these simulations include emissions from biomass burning plus varying concentrations of methane.

p 26514, lines 7-10: From Figure 10 the perturbation due to climate appears to be smaller (1%) compared to land use, which is opposite to what is said in the text.

Table 1: The units of concentrations are given as "(ppm)". However, the values for N2O and CH4 are given in ppb.

Table 3: I presume that the 2050 methane concentrations were used for both the "2050 Total" and "Emissions" simulations, but this information is currently missing. I suggest adding another row to the table with "Methane" and/or state this in the text.

Figure 12: From caption alone it's not clear whether the presented values are the means for the whole regions or sampled only at the locations of National Parks.

Minor comments:

p 26505, line 10: Please replace "than" with "to".

p 26507, line 6: Please change to "Interestingly".

p 26507, line 4: Please remove "s" in "The RCP8.5 scenarios".

p 26514 , line 9: Please change to "counterbalanced".

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Figures 6, 8, caption: Please remove coma after “individual perturbations (b)”

Figure 12, caption: Missing “s” in “grey area represent”.

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