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Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Forest Fire Aerosol – Weather Feedbacks over Western North America Using a High-Resolution, Fully Coupled, Air-Quality Model" *by* Paul A. Makar et al.

Anonymous Referee #1

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This study attempts to evaluate fire-weather feedback processes over Northwestern America using an air quality model. The authors use the GEM-MACH model linked with en experimental configuration of CFEPSv4 as a source of emissions to evaluate how forest emissions impact air quality and weather forecasting performance. The conclusion section suggests that the main objective of the study was to assess if "fully coupled models improve both air-quality and meteorological forecasts". Unfortunately, numerous shortcomings in the deployed methodology make this statement impossible to defend.

First of all, the authors suggest that a fully coupled was used in this study, and try to

differentiate between the fire behavior modeling and coupled air-quality modeling. The authors refer to the very early papers on coupled fire-atmosphere modeling by Clark et al. and Linn et al. that are at that point almost two decades old. Since then, significant progress has been made toward integrating weather-, fire- and air quality models. Fully coupled systems have been in place at least since 2016 (see Kochanski et al. 2016). Unlike the modeling system used in this study, fully coupled models resolve the fundamental interactions between the fire and atmosphere including the plume rise, and the impact of fire released heat and moisture fluxes on local meteorology in line with the chemical transformations of fire emissions. In the context of the fire-atmosphere interactions, the impact of fire heat and moisture fluxes is fundamental and can't be ignored. Multiple papers by Peace at al. 2012, 2015, and 2017 showed that. The presented approach with off-line plume rise calculation neglecting the first-order impact of fires on the atmosphere is not suitable to address the posed question. In fact, the radiative impacts of smoke have been already investigated in the fully coupled framework including resolved fire progression plume rise and chemistry (see Kochanski et al 2019), so the scientific contribution coming from this work due to the use of an overly simplified modeling system is very limited.

The other shortcoming is associated with the lack of proper initialization of the boundary conditions. The authors decided to use two forcing datasets at 10km and 2.5km but did not provide any initialization of the chemical boundary conditions. It is hard to tell if that was the reason for the observed discrepancies between the observed and simulated AOD presented in Figures 14 and 15, but it is evident that the model showed very poor skills in rendering the aerosol optical depth. In the context of that, it is hard to believe in the validity of the presented results and the final message suggesting that fire smoke increased the surface temperature especially when multiple studies published up to date showed something opposite. As a part of the typical smoke shading effect, thick smoke layers tend to decrease incoming solar radiation, induce upper-level warming and low lever colling, increasing atmospheric stability (not decreasing as suggested here). For the discussion of the impact of smoke and aerosols on the boundary layer, I refer authors to Robock et al 1988, 1991, Lareau & Clements 2015, Yu et al. 2002, Jacobson and Kaufman 2006, and Kochanski et al 2019. The extraordinary findings presented in this study suggesting the opposite, require very strong scientific evidence that has not been provided.

I understand the convenience of using operational forecasts for research purposes, but in this case, a robust modeling setup is needed. If the emissions located outside of the computation domain are believed to be important chemical boundary conditions from a global chemical transport model should be used. Also in the light of uncertainties associated with the emission factors, the mixed results presented in the study do not convincingly present the linked simulations as superior to the uncoupled (unlinked) ones. As indicated by the authors the vertical plume distribution is critical in the context of smoke dispersion but also the radiative impacts. A proper plume rise validation should be one of the first steps in this analysis and could shed some light on the reasons for model efficiency in resolving the AOD.

References:

M Peace, G Mills, (2012) A case study of the 2007 Kangaroo Island bushfires. Journal of Wildland Fire 19, 427-448

M Peace, T Mattner, G Mills, J Kepert, L McCaw (2015), Fire-modified meteorology in a coupled fire–atmosphere model, Journal of Applied Meteorology and Climatology 54 (3), 704-720

M Peace, L Mccaw, B Santos, JD Kepert, N Burrows, RJB Fawcett (2017) Meteorological drivers of extreme fire behaviour during the Waroona bushfire, Western Australia, January 2016. Journal of Southern Hemisphere Earth Systems Science 67 (2), 79-106

Kochanski, A. K., Jenkins, M. A., Yedinak, K., Mandel, J., Beezley, J., & Lamb, B. (2016). Toward an integrated system for fire, smoke, and air quality simulations. International Journal of Wildland Fire, 25(5), 534–568. https://doi.org/10.1071/wf14074

Kochanski, A. K., Mallia, D. V., Fearon, M. G., Mandel, J., Souri, A. H., and Brown, T.: Modeling Wildfire Smoke Feedback Mechanisms Using a Coupled Fire-Atmosphere Model With a Radiatively Active Aerosol Scheme, Journal of Geophysical Research: Atmospheres, 124, 9099–9116, 2019.

Lareau, N. P., & Clements, C. B. (2015). Cold Smoke: SmokeâĂŘinduced density currents cause unexpected smoke transport near large wildfires. Atmospheric Chemistry and Physics, 15(20), 11,513–11,520. https://doi.org/10.5194/acpâĂŘ15âĂŘ11513âĂŘ2015

Robock, A. (1988). Enhancement of surface cooling due to forest fire smoke. Science, 242(4880), 911–913. https://doi.org/10.1126/ science.242.4880.911

Robock, A. (1991). Surface cooling due to forest fire smoke. Journal of Geophysical Research, 96(D11), 20869. https://doi.org/10.1029/ 91jd02043

Yu, P., Toon, O. B., Bardeen, C. G., Bucholtz, A., Rosenlof, K. H., Saide, P. E., et al. (2016). Surface dimming by the 2013 Rim Fire simulated by a sectional aerosol model. Journal of Geophysical Research: Atmospheres, 121, 7079–7087. https://doi.org/10.1002/2015JD024702

Yu, H., Liu, S. C., & Dickinson, R. E. (2002). Radiative effects of aerosols on the evolution of the atmospheric boundary layer. Journal of Geophysical Research, 107(D12). https://doi.org/10.1029/2001JD000754

Jacobson, M. Z., & Kaufman, Y. J. (2006). Wind reduction by aerosol particles. Geophysical Research Letters, 33, L24814. https://doi.org/ 10.1029/2006GL027838

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