Referee 1:

This paper presents the results of a systematic aerosol dispersion and air quality modeling exercise based on the 2018 Camp Fire in northern California. A careful analysis is given, using a combination of satellite and surface measurements over the duration of the fire. There is a great need to analyze and improve such models, to provide reliable air quality forecasting. This work is worthy of publication in ACP in my opinion. I hope the notes below offer some avenues for minor improvements.

We appreciate the reviewer's valuable comments and constructive suggestions. We have carefully revised the manuscript according to these comments. Point-by-point responses are provided below. The reviewer's comments are in black, our responses are in blue, and the quotes from our manuscript are in italics.

1. Lines 110 to 116. I'm not clear what values were selected for some of the parameters in Equation 1, and the degree to which uncertainty in these parameters affects the final model results. This is only partly addressed in Section 4.2; presenting what was learned about emissions process modeling in more detail might be helpful.

The physical meaning and values of the parameters in the wildfire emission have been further elaborated on Page 5:
"*for a certain species η, α_{veg} is the carbon density (the mass of burnable above-ground biomass per unit area of vegetation), β_{veg} is the combustion factor, EF_{veg} is the emission factor by species and vegetation type, and a_{fire} is the burning area of each fire pixel. Vegetation type is generated from the MODIS data following IGBP land cover classification. Vegetation type-specific emission factors (EF_{veg}) and combustion factors (β_{veg}) are derived from Ward et al. (1992) and Andreae and Merlet (2001). Vegetation type-specific carbon density (α_{veg}) is based on Olson et al. (2000) and Houghton et al. (2001).* "

2. Lines 122-123. Wildfires tend to have a very distinct diurnal cycle. Especially given the extensive modeling effort performed here, using a 13:30 local time sample as diurnally representative might not be the best assumption. There also might be MODIS FRP data at 10:30 am as well as nighttime sampling for this fire.

We agree with the reviewer that the diurnal cycle of wildfires can be important in simulating fire-related aerosol formation. However, the current fire emission module used in this study, the "PREP-CHEM-SRC-1.5", averages all fire detections from satellite within one day and does not provide diurnal information, even though the VIIRS satellite provides one daytime retrieval and one nighttime retrieval of active fire count. We have added a statement in the discussion on Page 13 "*Future studies are needed to further improve the present modeling framework to simulate wildfires. Some wildfires exhibit a distinct diurnal cycle, but the current fire preparation module does not utilize the time information of nighttime fire radiative power measurements by the polar-orbiting satellites*".

3. Lines 144-146. The Camp Fire reportedly also burned the town of Paradise, California between 8 and 10 November 2018. Does urban structure represent a land cover type that should be included in the simulation, as it can produce very different emissions from grassland or forest?

We have added a statement in the discussion on Page 13 "*Also, the current land cover and vegetation type data are still relatively coarse in spatial resolution and classification accuracy, which cannot fully resolve a small town in a rural area. In fact, the Camp Fire reportedly burned the town of Paradise, California between 8 and 10 November 2018. The town of Paradise covered 11,614 acres which corresponds to about 7.6% of the total burned area. This discrepancy definitely contributes to the uncertainty in the fire emission preparation. Additional verification of input fire data sources, such* *as FINN, and their implementation in the WRF-Chem plume rise model is needed for studies of the vertical structure*".

4. Lines 274-278. Given the assumptions required to perform the TROPOMI ALH retrieval, it might be worth comparing the results with any height retrievals from MODIS/MAIAC (Lyapustin et al. 2019, doi:10.1109/LGRS.2019.2936332) or MISR or CALIPSO. The comparison might help quantify measurement uncertainty. Line 285. Is the TROPOMI ALH actually accurate to 100 m?

We have now clarified that the median error of TROPOMI over land is about 1.75 km (Nanda et al., 2020), so most model-obs. differences are within that retrieval bias. We do not find the plume height products about the Camp Fire from either MODIS/MAIAC or MISR in the public domain, so we leave this satellite intercomparison task for the future study. We have added a statement in the discussion on Page 13 "*The recent TROPOMI aerosol layer height product shows promise as an analytical tool, but requires further development of the method by which it can be directly compared to WRF-Chem. Given the assumptions required to perform the TROPOMI ALH retrieval, more research is needed to compare that product with any height retrievals from MODIS/MAIAC (Lyapustin et al. 2019), MISR (Kahn, 2020), and CALIPSO*".

5. Line 282. Figure 9 is first referenced after Figures 10, 11, and 12. Probably warrants re-numbering.

We have re-ordered the figures as suggested.

6. Lines 337-339. There are notable uncertainties in the satellite estimates of smoke emissions. For example, the satellite results are not species-specific, relatively coarse pixel resolution contributes, etc. The factor of 5 adjustment from Archer-Nicholls et al. is not unusual, and is an indication of the underlying limitations.

We agree with the reviewer on the satellite product uncertainty and it has been thoroughly discussed in the manuscript.

7. Given the complexity of the problem, I understand why you perturb individual factors in this study. As you have built an advanced modeling capability to assess smoke dispersion for air quality applications, I'm wondering whether testing at least a few combinations of the main factors might yield some additional insights. There are likely some non-linear interactions among mechanisms, and if the goal is to improve air quality prediction, this might be important.

To address the reviewer's comment about the non-linearity of different factors in regulating the fire-related PM pollution, we have added a new experiment by jointly perturbing two chosen factors, i.e. emission flaming factor and aerosol radiative feedback. We compare the results from this joint perturbation experiment with those from each individual perturbation experiment and the linear sum of the two. A new Figure 14 is provided with a new paragraph of discussion.

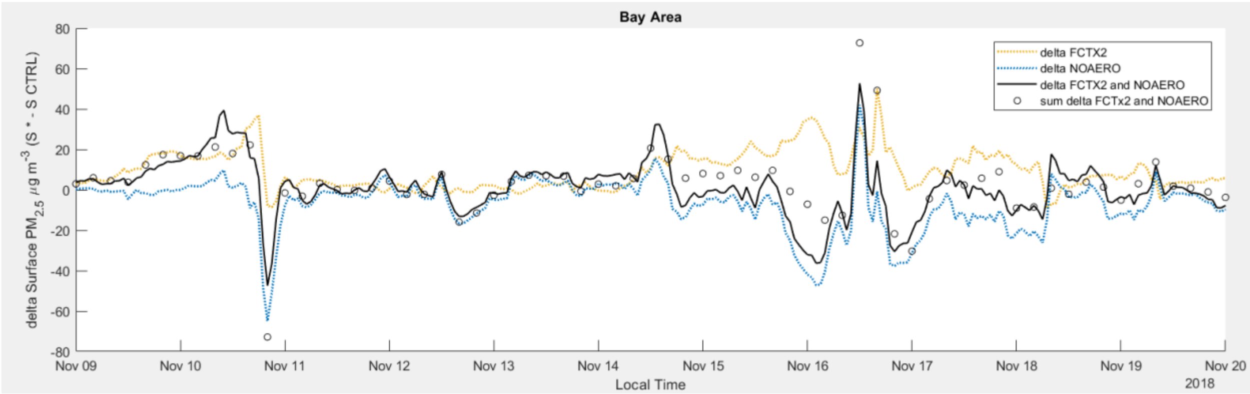

Fig. 14. Comparison of the effects on PM2.5 simulations in the Bay Area from the individual factor perturbation experiments and the joint perturbation experiment.

We have added a new discussion on Page 12 "*To test the linearity of different factors in regulating the fire-related PM pollution, we choose two factors, emission flaming factor and aerosol radiative feedback, and conduct a new experiment by jointly perturbing these two. We compare the results from this joint perturbing experiment with those from each individual perturbing experiment and the linear sum of the two in Figure 14. It shows that for the most times, the effect of joint perturbation is close to the sum of the two individual effects (the black line follows well with the black circles), indicating that the relatively good linearity and additivity holds between those two factors in a general sense. The exception occurs under the extreme conditions. During Nov. 14-18 when the plume was thick and PM2.5 concentration was highest in the Bay Area, the aerosol radiative feedback dominates, and the effect of joint perturbation is close to the aerosol radiative effect (the black line follows well with the blue dotted line)*".

We have also added a statement in the conclusion and discussion section on Page 13 "*Given the complexity of the problem, here we mainly perturb individual factors in this study. Future studies can test different combinations of the main factors identified by the present study, which can yield additional insights about non-linear interactions among different processes related with fire emission and transport*".