Review of "Revised estimate of particulate emissions from Indonesian peat fires in 2015," by Kiely et al.

This paper revisits estimates of smoke emissions from the Indonesian fires of 2015. As is well known, fire emission inventories are highly uncertain, with large discrepancies among them. Here the authors take the FINN emissions as a base case, and then attempt to improve these emissions. Fire emissions from peatland is expected to be a large contributor to smoke in this region, but the standard FINN inventory does not consider emissions from peatland. In addition, the depth of peat burned, a quantity governed by soil moisture, may influence the magnitude of smoke emissions in this region. To address these weaknesses in the FINN inventory, the authors do the following sensitivity studies: (1) adding the peat emissions from the GFED inventory to FINN, (2) recreating peat emissions with land cover maps, and (3) using remotely sensed soil moisture to constrain the magnitude of peat burned. While the base FINN simulation underestimates observations, all three efforts listed above improve the model match with observed surface PM and with aerosol optical depths (AOD). Sensitivity study #3 comes the closest to observations. The authors estimate that vegetation and peat fires increased $PM_{2.5}$ concentrations over Sumatra and Borneo during September and October 2015 by > 125 μg m^{-3}. Such a heavy particulate burden has large significance for human and ecosystem health.

The paper is excellent, in my view, and should be published after the following comments are addressed.

Main comment.
On page 16, the authors claim that PM emissions in GFED4 are underestimated because emission factors for peat combustion are too small. In my view, the authors cannot so easily dismiss the large role of clouds and haze in these or any smoke underestimates. GFED4 relies in part on area burned in constructing emission inventories, as well as on active fire information. FINN relies only on active fire information. Both kinds of data can be obscured by clouds and haze. (See for example Kaiser et al., 2012.) The authors should be aware that the interference from clouds and haze can vary strongly from month to month and from fire to fire, depending on meteorology and the magnitude of the fire itself. Cusworth et al. (2018) found that emissions from agricultural fires in India were more strongly underestimated during high fire years. At least two fire emission inventories, GFAS and QFED, make cloud-gap adjustments to account for fires obscured by clouds/haze.

Indeed the variation of the cloud/haze interference could explain the inability of simulations in this work to capture the lack of temporal trend from September to October in the observations. The observations show relatively similar values of surface $PM_{2.5}$ and AOD in both months (Figures 5b and 6b), while all three sensitivity simulations show as much as double the value in September as in October. Applying GFAS emissions to their model, Koplitz et al. (2015) captured the observed lack of trend from September to October in monthly mean $PM_{2.5}$ values over Singapore.

Minor comments.

Page 5. The text says that the model meteorology is allowed to run freely through the month, and then is reinitialized at the beginning of the month. Is that right? Would this approach lead to a discontinuity in meteorology at monthly intervals? Maybe a reference would be helpful.

Page 5. In the FINN+GFEDpeat simulation, is there concern that the inventory double-counts emissions? In this inventory, the GFED peat emissions are added to the FINN vegetation emissions.

Page 6. Citing Tansey et al. (2008), the authors state that "60% of burned areas did not have an identified hotspot, implying an area burned per MODIS hotspot of approximately 40 ha." Are these fires in Indonesia only?

Page 9. The text states, "Fires can inject emissions above the surface." The author should clarify that they mean the surface layer of air, which is xx meters in the model.

Page 11. What exactly comprises $PM_{2.5}$ in the model? Is this mainly BC and OC?

Page 12. The authors should consider including emissions of BC and OC in Table 4.

Page 13, Figure 2. The plots would be easier to interpret if low values were colored white.

Page 14, Figure 3. The caption should state what region is shown.

Page 15, Figure 4. The caption should provide the temporal correlation of modeled values and measurements for these two sites.

Page 15. The text states, "The overestimation in September could also be due to an issue with fire detection. Syaufina and Sitanggang (2018) found that only hotspots which last for 3 days indicate fires, something which is not considered when calculating the emissions." This doesn't seem right. Agricultural fires in particular may last just hours. Indeed, a problem with active fire detection is that the satellite overpass time may miss a short-lived fire, giving rise to the phenomenon that the authors note on page 6, with some burned areas not associated with any hotspot. In any event, if a hotspot lasts less than 3 days and is not a fire, what else could it be?

Page 18, Figure 6b. Wrong unit is given.

Page 19, Figure 7. Again the authors should consider using a white color for very low values so that other colors stand out.

Page 19, Figure 8. Colors in color bar are hard to see. Bar should be fatter.

Page 20, Line 11. "Effected" should be "affected."

Pages 20-21, Conclusions. The authors should consider briefly discussing the merits of other emission inventories used to simulate agricultural fires in Indonesia (e.g., GFAS).

Supplement page 3, Figure S3. Caption should state region shown. Also some statistics should be provided regarding the match between model and observations.

Supplement page 4-5, Figure S5-S6. Comment same as for Figure 7.

References.

Cusworth, D.H., et al., Quantifying the influence of agricultural fires in northwest India on urban air pollution in Delhi, India, Env. Res. Let., 13, 2018.

Kaiser, J.W., et al., Biomass burning emissions estimated with a global fire assimilation system based on observed fire radiative power, Biogeosciences, 9, 527–554, 2012.

Koplitz, S. N., et al., Public health impacts of the severe haze in Equatorial Asia in September-October 2015: Demonstration of a new framework for informing fire management strategies to reduce downwind smoke exposure, Environ. Res. Lett., 11, 094023, 2016.