

Review of “Estimation of black carbon emissions from Siberian fires using satellite observations of absorption and extinction optical depths”

By Konovalov et al. (ACPD 2018)

This manuscript reports on the challenging topic of estimating black carbon emissions due to biomass burning (BB) and its transport into the Arctic, evaluated during the 2012 fire season in Siberia. The authors comment that this topic is particularly relevant because of the implications of black carbon emissions for Arctic climate, while at the same time it is very challenging because direct observations of black carbon aerosol from fires are sparse, in this vast, remote, region. Indirect methods are developed by the authors, combining in novel ways OMI and MODIS satellite observations of (absorbing) aerosol optical depth, together with in-situ observations of aerosol concentrations and optical depths, as well as modeling.

Through combination of AOD and AAOD satellite observations, the authors propose to constrain the modeled elemental and organic carbon concentrations, and in turn their emissions. Because the model AAOD, directly resulting from CHIMERE, was unreliable, the authors use an empirical relationship between AAOD and AOD, as derived from particular AERONET observations of aerosol that have been attributed to BB. Due to the complexity of the study, the authors are careful in deriving their methodology, and describing the uncertainties involved, both from the modeling perspective and from uncertainties associated to the observations. The uncertainty analysis has been further expanded by performing several sensitivity experiments to investigate the contribution of specific sensitivities to the model results.

Hence, I believe this study can be considered as very thorough, providing top-down constraints on BC emissions from BB. These turn out significantly larger than estimated with GFEDv4, which is often used as a reference. The manuscript is also very well written, hence I recommend it for publication after a few minor questions have been addressed.

- Sensitivity to SOA: Authors discuss this subject as a potential uncertainty, although they write that it is not represented in CHIMERE (pp11, line 10). Also authors write that uncertainties in SOA could affect the optimal estimates of F^{OC} (pp 20, l16), they suggest it does not affect BC as long as ‘simulated AOD values are fitted to the AOD observations’. Finally, on pp 27 l14 the authors suggest that this uncertainty could explain some of their differences in OC emissions compared to GFED. I am still not fully satisfied about uncertainties due to this aspect. It is well known that (biomass burning) SOA budgets are poorly constrained (e.g. Spracklen et al., ACP 2011). By not adequately representing them in CHIMERE there is at least uncertainty in dependency of the EC/OC ratio depending on the lifetime of the plume, with fresh plumes, with comparatively little SOA contribution to OC. Can authors please expand on this aspect a bit more? It would be very interesting if the authors are able to test this uncertainty through an actual sensitivity experiment where SOA contribution to aged [OC] would be enhanced.

- Optimization: The authors compute a single monthly mean optimization factors F for the complete region. They find rather different values per month (Table 2). In part this appears to be associated to different type of fires, particularly for grass land compared to boreal forest fires (Fig. 14). I wonder if the method couldn't easily be expanded to optimize these scaling factors but for two sub-regions (e.g. below/above 57N), such that they can better be associated to particular fire types. It would be interesting to see if the scaling factors would then show a more homogeneous value for different months.

Technical comments:

- pp11, l2: "Usually" -> "As usual"
- Konovalov et al. (2017a): Please check and complete reference details
- pp21, l17: "Figure 4" -> "Figure 5"
- pp22, l18: "an artifact of": suggest to change into "enhanced due to"
- pp24, l18 "also" (remove)
- pp26, l 29 "their": to what does this refer to? GFED?
- pp29, l24: "predicated" -> "predicted"
- pp30, l26 "the mean AAOD": consider to change to "the mean observed AAOD"
- pp32, l1 "are" (remove)