Review for: The importance of the representation of air pollution emissions for the modeled distribution and radiative effects of black carbon in the Arctic

This article studies the effect of the spatial and temporal distribution of emission inventories on the modelled arctic black carbon concentrations in climate simulations. To this end, four different emission inventories have been constructed and ECHAM6.3-HAM2.3 has been used to perform an eleven-year simulation for each of these inventories. The modelled BC concentration profiles have been evaluated against ground-based and aircraft measurements.
In general I find that the paper is well written and the figures are of high quality. I recommend this article for publication in ACP after minor reviews. Please find my comments to the paper below.

Major comments:

1. I found quite a few typos in the text, most of which could be fixed using a simple spell checker.
2. I think in Section 2.2 you could explain the different emission scenarios and the differences between them a little bit better. First off, if I'm not mistaken, the wildfire emissions in ACCMIP are decadal mean values based on GFEDv2, but they nevertheless have a monthly resolution. A big difference between ACCMIP and ECLIPSE is that the latter provides monthly varying emissions for many sectors, while ACCMIP does not. Monthly changing emissions should have an effect on the time evolution of the BC concentrations in the Arctic, especially close to the surface. It is not clear from the text whether the emissions by Huang et al. also provide monthly varying emissions and, if not, how this has been dealt with when combining them with ECLIPSE. Furthermore, it should be noted that emissions with a high spatial resolution only provide limited improvements in the simulations here, as they anyway have to be re-gridded to a T63 resolution.
3. The procedure to calculate the DRE of BC should be explained in more detail (Section 2.4). Did you re-run the simulations without BC emissions, or leave out BC in the radiation calculations? If it was the latter, how was this done? The radiation code in ECHAM uses the aerosol wet diameter and an average refractive index of the aerosol particles (or rather the modes) to read out the optical properties from a pre-computed lookup table. The refractive index used is computed as volume-weighted average over all species in the particle. It therefore feels like one cannot just leave out one species, shouldn't you at least adjust the size of the particle (mode) accordingly?
4. In section 4.1, are the surface station data and the model data that you show collocated in a similar fashion as the aircraft data, or do you indeed show multi-year monthly averages. If the latter, did you constrain the

model data to the years of the observations, or did you use the results of the entire model period?

5. On page 12, in the first paragraph, you discuss how the BC surface concentrations in Summit are so different from all other stations. I have done a plot similar to Figure 6 some years ago to evaluate ECLIPSE and ACCMIP against the same stations (not published) and asked the data providers about the same issue. It was suggested to me that the summer peak in Summit may be due to (local?) wild fire emissions, that might not be captured by observations. If this is the case, the model cannot really be blamed. Another issue is that Summit is situated at an altitude of over 3 km, which may be much higher than the average orographic height of the model grid box in ECHAM. You could try correcting for that by evaluating the modelled BC concentrations in a model level that corresponds to this altitude.
6. I agree that for model evaluation, where simulated concentrations can be compared to observational data with high temporal and spatial resolution, it is important that the emission inventories used also have a high resolution (both in time and space). This is especially true when one wants to improve how physical processes like, e.g. transport and deposition of aerosols, are modelled. However, when studying effects of changing aerosol emissions on climate, a lower resolution may be sufficient. Can you say anything about whether the monthly average arctic BC concentrations change qualitatively when using daily or monthly biomass burning emissions?
7. In the first paragraph of page 14 you briefly comment on the possibility that fire emissions may be artificially diluted in the relatively large model grid box, especially if the fire is small. Additionally to this, the way that fire emissions are inserted in the model may affect BC concentrations. If I am not mistaken, ECHAM distributes all wildfire emissions equally in vertical direction within the boundary layer. I think for monthly average emissions this is a good approximation, but for daily emissions this may lead to too fast vertical mixing. Therefore, thin fire plumes may be impossible to model correctly.
8. In Section 5, I think it would be helpful if you could give an arctic average TOA DRE, maybe in the form atmosphere+surface=total. In the abstract you state that the DRE is as high as 0.8 Wm-2 -- Is this the yearly average for 60°-90°? Also, which scenario does this value correspond to?
9. I see the point of all the panels in Figure 14 having the same data range, but on the other hand this makes it hard to see any features, especially in panels a and c. Also, do the numbers at the colour bars correspond to the centres of the coloured boxes or to the borders between them. In particular, which colour corresponds to zero?

Minor comments:

1. page 2, line 31: Do models really tend to over-estimate BC concentrations at the surface?
2. section 2.3: How long was the spin-up of the simulations?
3. page 6, lines 29--31: Could you try to re-formulate that sentence?

4. page 12, line 17: By time correlation, to you mean the Pearson correlation coefficient of the collocated data?
5. page 15, line 26: The last sentence in this paragraph seems quite redundant to me.
6. page 18, lines 21--24: This may also be a resolution problem, as both the cloud and the smoke plume may not "fill" the entire grid box.