In their manuscript "Contrasting source contributions of Arctic black carbon to atmospheric concentrations, deposition flux, and atmospheric and show radiative effects", the authors Matsui et al. evaluated the source attribution of Arctic BC concentration, deposition and radiative effects based on a global climate model CAM-ATRAS. The headline finding is that BC sources from high and low latitudes exhibit different contributions on Arctic BC loading, as well as its radiative effects. The manuscript is well organized, and the findings appear sound for the most part. The text could use some areas of clarification and potentially additional information. I believe the manuscript will be suitable for publication in *Atmospheric Chemistry and Physics* after the questions and issues below are addressed.

GENERAL COMMENTS

This study used three years of model simulations, but since some local events (e.g. Siberian biomass burning) can have a significant impact on Arctic BC, how representative are these three years, and can these three years be used to represent the Arctic climatology? It would be more helpful if the authors could assess the climatological representativeness of the simulated three years.

The methodological description needs additional work. Specifically, how many bins are used to represent fine particles (from 40 to 1250 nm)? How did you improve the model representation of activation processes in liquid clouds and removal processes in cumulus and mixed-phase clouds? There were 13 simulations, were they all nudged or free runs? How was the RE_{BC_TOA} estimated, was an additional run without the target source BC emission also made? The BC emission data was from GFEDv4, but did your model scale the emissions up as most models? How comparable are the modelled results and observations, are they all corrected for the standard temperature and pressure (STP)? Also, it seems that the decomposition of RE_{BC_TOA} in P8 seems should be included in the method. The calculation of $Height_{BC}$, $Flux_{BC}$, and $Albedo_{BC}$ also should be moved to the methods.

The model has been evaluated with observational data illustrating some of the uncertainties in the model. However, these uncertainties should be briefly evaluated to indicate whether and to what extent they may have an impact on the results.

SPECIFIC COMMENTS

P2 L49, "Unlike atmospheric BC, rain rate in the Arctic varies seasonally, with …". This statement is inconsistent with the "Atmospheric BC mass (M_{BC}) concentration in the Arctic show distinct seasonal variation" at the beginning of the paragraph. Please clarify.

P2 L59. Please define the radiative effect of BC first and be consistent with the IPCC definition, i.e. use RFari or ERFari.

P2 L74. Does the "light absorption efficiency" equal the MAC_{BC} used later in the manuscript? I would suggest that the terminology of this parameter be consistent throughout the article.

P3 L84. “We also show in this study that the light …..”. This sentence is already your conclusion and should not appear in the introduction.

P3L94. Unclear how many bins in the fine particles.

P4 L138. “Figure S1 shows that the difference between ALL BC and the sum of BC tags is large where RE_{BC_SNOW} is large”. Please clarify that you are comparing RE_{BC_SNOW} from ALL BC and BC tags. Also, this statement is not correct; many areas with low RE_{BC_SNOW} also exhibit large differences.

P4 L153. GL from the offline method is also much smaller than that from the online method.

P7 L285. “The largest contribution to Arctic BC” is not correct and inconsistent with the figure caption. Also, as the manuscript focuses on the Arctic, I suggest that Figure 9 be amended to show only the spatial distribution of the largest sources in the Arctic (not global distribution), so that it can be shown more clearly.

P8 L297. Contribution from North America is the largest, and the contribution of Siberia, Europe, and East Asia are the largest? Please clarify.

P8 L314. Should those values be annual mean values?

P8 L321-323. Sedlacek et al. showed that from observations, with the long-time aging, photolysis and other processes can decrease the coating thickness, mainly when the BB particles are transported in the free troposphere (https://agu.confex.com/agu/fm21/meetingapp.cgi/Paper/943236). This is inconsistent with the conclusion here that aging (23-30 days) can increase the coating thickness.

P10 L369. “Because M_{BC_DEP} is highest in summer, the contribution from biomass burning sources to M_{BC_DEP} is larger (16% from Siberia and 8.9% from North America 370 (>50°N)) than that to M_{BC_SRF} and M_{BC_COL}”. This is not clear; here should also mention that biomass burning aerosols in summer is also higher.

P10 L376. Please clarify at which wavelength was the MAC_{BC} caculated.