Reviewer ID#
Manuscript No.: ACP-2021-876
Authors: Olga B. Popovicheva et al.
The title of manuscript: **Siberian Arctic Black carbon: gas flaring and wildfire impact**

General comments:

The Arctic has warmed three times more quickly than the planet as a whole, as the most sensitive area for climate changes. To understand the impacts of BC emissions on the arctic from source regions, particularly from the Siberian Arctic, the authors reported new measurements of equivalent BC (eBC) concentrations for the period of 2019-2020, carried out at the recently established station "Island Bely" which is at the Siberian gateway of the highest anthropogenic pollution to the Russian Arctic.

Through coupling with FLEXPART Lagrangian particle dispersion model and the most updated BC emission inventories for anthropogenic and biomass burning sources, a detailed aerosol aging spectrum, the source region attribution and the source sector apportionment have been investigated for the entire period as well as for the pollution episodes. This is a nice work showing that the observations verified the model simulations and the emission inventories, as well as that the model was able to provide detailed source attributions in terms of emission regions and sectors. Interesting results include

1) Russian emissions dominate during the entire year, while European and Asian emissions contributed up to 20% in the cold period.
2) the annual contribution from anthropogenic sources is dominant, ranging from 75 to 80%;
3) FLR and BB emissions contribute the largest share of EBC to the "Island Bely" during the cold (by FLG) and warm (by BB) period, respectively;
4) Gas flaring (FLG) is dominant during cold season (Nov – May) over all the anthropogenic sectors ranging from 47 to 68%;
5) Biomass mass burning played the biggest role during warm seasons (Jun- Oct.), contributing ~ 80% as the maximum in July;

Those results have improved the source apportionment of Siberian arctic BC, particularly for gas flaring and wildfire impact. This manuscript should be accepted for publication with minor revisions (see the specific comments below).

It would be nicer if the contents in sections 3.2, 3.3 and section 4 are presented further succinctly in the revised version.

Specific comments:

L37: Based on Table S2, the maximum value of BB is in **July** instead of June.

L38-L39: Based on Table S4, for the BB events during warm seasons, the AEE varies between P2 (BB: ~ 64%) and P6 (BB: > 99%), ranging from 0.8 to 1.35. This suggests that AAE is not a sensitive tracer for distinguishing BC between anthropogenic and biomass burning sources. This sentence needs to be rephrased.

L148-L151: This sentence is not well expressed and please re-phrase it.

L222-L224: I am wondering why the authors use 1500 kg/m3 as BC density instead of 2000 kg/m3.

L263-L266: I am wondering whether the authors use two biomass burning emission inventories (GFED v4.1 and CAMS GFAS). Are there any comparison results between the two inventories?

L374-L377: I am wondering if it is possible to provide the uncertainties of the model results in Table S1, S2 and S3.

L396-L397: It is not convinced that the observed AAE values in this study are sensitive to BB influenced in both cold and warm seasons (Table S4).

L405-L406: How about the results by FLEXPART with GFED v4.1?

L408-L410: Should the "Figure 5b" be replaced by "**Figure 4c**" for monthly median contribution of sources to BC in the cold period?

L525: Typo (?): please replace "ageing" with "aging".

L543-L544: This sentence needs to be rewritten. It has been observed that while the AAE value is between 1- 1.35, the BC could be also influenced dominantly by FLG (Table S4).

L862-L874: Is it possible to have the data plotted in Figure 4b, 4d included in individual Tables of the supplement as the Table S1 for Figure 4c? Each of the Tables should also include corresponding AAE values.

L892: At the end of line, the "(bottom row)" is missing.