Dear Editor Sally Ng,

we want to thank Referee #2 for her/his follow-up review, comments and suggestions, which helped to improve the manuscript.

Our response is formatted as follows:

Reviewer's comments
Author's reply
Changes to the manuscript.

All page, line, section and figure numbers in bold refer to the original manuscript, all others to the revised version.

Kollner et al have made useful revisions to their manuscript overview of Arctic single-particle composition during NETCARE flights. In particular, the addition of the sub-potassium particle type (22% of the total) and application of their data analysis approach to these particles was a critical addition. Also, it is important that the composition of another 24% of the particles (ammonium, MSA, and sulfate) is acknowledged, leaving only 16% unclassified. This is an acceptable fraction of unclassified particles. Overall, the many revisions made to the manuscript have significantly improved the work, and these revisions have sufficiently addressed my previous comments and concerns. I only have a few remaining comments, mostly with respect to added text.

Thank you.

Lines 41-42: This new sentence is lacking a reference and is confusing as written, as it states that "the presence of aerosol in Arctic tropospheric layers leading to cooling of the surface beneath by absorbing incoming solar radiation and by reflecting radiation back to space." Certainly reflection would lead to cooling, but absorption should lead to warming. Please clarify sentence and add an appropriate reference.

We added references and re-wrote the sentences as follows:

Lines 41-44: "Second, the presence of absorbing aerosol in Arctic tropospheric layers can lead to warming in the lower troposphere, but to cooling of the surface beneath by absorbing incoming solar radiation in this layer (e.g., Treffeisen et al., 2005; Engvall et al., 2009; Flanner, 2013). The result is an increase in tropospheric stability (e.g., Flanner, 2013)."

Lines 47-49: "In contrast to light-absorbing aerosol, scattering aerosol species, such as sulfate, of both anthropogenic and biogenic origin, exert a net negative shortwave radiative forcing on the Arctic surface by reflecting radiation back to space (Quinn et al., 2008; Yang et al., 2018)."

Lines 53-55: Please add references for these new sentences.

We added the following references:

Lines 53-59: "Aerosol particles, serving as nuclei for water condensation or nucleation of the ice phase, are fundamental to cloud formation (e.g., Lohmann and Feichter, 2005). The effects

of these particles on clouds are important drivers of the Arctic surface energy budget (e.g., Lubin and Vogelmann, 2006; Zamora et al., 2016). It is known that the net radiative effect of Arctic low-level clouds varies significantly with season (Intrieri et al., 2002; Shupe and Intrieri, 2004). Arctic low-level clouds warm the Arctic surface through most of the year. However, for a short period in summer when the incoming solar radiation is maximum over regions with a low albedo, clouds exert a negative radiative forcing on the Arctic surface (Intrieri et al., 2002; Shupe and Intrieri, 2004)."

Lines 504-506: This new sentence states here that "the enhanced abundance of the sub-K particle type…with anthropogenic influence shows that potassium does need not necessarily be linked to a biomass burning source". This is in section 3.3.2 "Vegetation fire and anthropogenic influences on particle composition". While a subset of the sub-K particles were associated with anthropogenic influence rather than wildfires, this does not rule out biomass combustion as the source, rather it only rules out the satellite-detected wildfires as the source. Note that biomass burning particles are the most dominant particle type in the FT outside of the Arctic (see Schill et al. 2020, Nature Geosc.; Pratt and Prather 2010, JGR; Hudson et al. 2004, JGR). I suggest revising the current statement and linking to these previous papers.

We have added the reference Schill et al. (2020) and re-formulated the sentences as follows:

Lines 505-508: "Given that the majority of nss-nitrate-containing particles were internally mixed with potassium (see Sect. 3.1), we have additional indications for their biomass burning origin (Silva et al., 1999; Hudson et al., 2004; Pratt and Prather, 2009; Pratt et al., 2011; Quinn et al., 2002; Schill et al., 2020). The inclusion of nitrate and sulfate with potassium is indicative for atmospheric processing of biomass burning particles while transported into the Arctic."

If possible, I encourage moving the highly useful Fig S11 to the main text. In my opinion, Figures 2 and 4 could be moved to the SI.

We moved Fig. S11 to the main manuscript (new Figs. 12 and 19). Figure 2 was moved into the Supplement (new Fig. S1). We accordingly changed the text in the main document and in the Supplement. We decided not to move Fig. 4 in the Supplement, since this is an essential graph to show the northern hemispheric distribution of the different source locations.

We further added a new reference (Schmale et al. (2021)) to the Introduction (line 116).

We found a few typos in Table 2 that were corrected and marked in the revised version.

Best regards
Franziska Köllner