Dear reviewer:

Thank you for your comments concerning our manuscript (ID: egusphere-2022-552). Those comments were very helpful for revising and improving this manuscript, as well as for providing important guidance to our study. We have considered the comments carefully and will make enough changes to the manuscript. The responses to the reviewer's comments are provided in blue, as follows.

The manuscript describes a study of Arctic sea ice cores, collected from a series of research cruises, to determine optical properties of sea ice and their general variability across 2008-2016. I found the manuscript mostly quite well written, with a pleasingly broad range of cited prior literature. The results emerged from a long period of arduous fieldwork and present a consistent message on the evolution of Arctic sea ice when compared to other field work and remote sensing studies on the topic. Some concerns remain, mainly on the generalization of results to pan-Arctic scale and some aspects of the presentation. If the authors can address them, reaching publishable quality should be possible.

Major comments:

1. Sections 2.3 and 4 were difficult to follow in terms on what is actually done to arrive at Fig 7, and what the results actually represent. There are several concerns here:

- How specifically is the interannual albedo of ice calculated?

The ice optical properties are calculated through the radiation transfer model. The input parameters include the grided ice thickness (from remote sensing data, see Section 2.3) and inherent optical properties (from the ice cores data). We have now introduced the process more clearly in the method section.

- What does it represent – the (mean?) broadband albedo of pure ice derived from all ice cores of each year?

Here, the observed ice microstructure from ice cores was employed to estimate ice optical properties. The impurity and ice surface properties (such as a snow layer or melt ponds) were not considered here. Thus, these results are based on an ideal situation, and could not be fully representative of the real situation. What we focus on was the effects

of the ice microstructure on their optical properties. We have supplied some relevant information in the related section.

- Is it equivalent to black-sky albedo, where atmospheric conditions would not matter? The text around lines 93-101 suggest that white-sky albedo is being derived, but is it broadband? The text says so, but line 101 also contrasts itself by stating that only the narrow PAR band was studied.

Considering the generally cloudy weather in Arctic summer, the estimated albedo in the present study was white-sky albedo. Generally speaking, its value is slightly larger than the black-sky albedo. What we wished to express was that these optical properties were integrated in the PAR band. Related descriptions have been modified to reduce any ambiguity.

- ECMWF provides quite a few irradiance data, what is specifically the data source here?

The EAR5 monthly averaged surface downward shortwave radiation flux (https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-single-levels-monthly-means?tab=form) were employed in this study. More descriptions have been supplied in the data section.

- The same for NSDIC sea ice concentration, did you use the old and outdated version 1 of NSDIC-0051? There is an update, which should be applied in all new studies: https://doi.org/10.5067/MPYG15WAA4WX

Yes, we have used the updated version in the revised manuscript.

The generalization part here is the major weakness of the manuscript and either requires considerable attention to improve it, of removal if improvements are not feasible.

1. Result figures 2-8 are not clear – for one, choosing to use red and green lines with the same markers renders the figures indistinguishable for color-blind readers. Also, the blue color chosen is very similar to the green, making it difficult to distinguish which is which even for me with normal color vision. Also, it would be clearer if the subplots such as Fig 3 had their own titles (e.g. "V_a" for Fig 3a), since each studied variable is given its own subplot anyway, so the legend does not have to repeat the variables, but would suffice to simply indicate the layer coloring.

These figures will be redrawn in the revised manuscript. The color of lines, figure titles, and legends have been modified to make them clearer.

2. The result figures display uncertainty ranges which are sometimes defined in caption and sometimes not. Consistency is needed. Also, the associated text only makes note of changes in e.g. IOPs but does not analyze the significance of the changes in relation to their uncertainty. For instance, is the 7.5% increase in Va between 2008 and 2016 a significant change when compared to the uncertainty range (standard deviation) of the samples? This treatment of uncertainty should be a part of all analyses done in the manuscript.

   The definition of uncertainty ranges in captions will be supplied.
   We have also supplied more descriptions related to the uncertainties of the ice properties from the view of temporal and spatial variations. To reduce the impact of temporal variations in the ice cores on the ice microstructure, we have pre-processed the ice core data. The ice cores in each year have now been allocated different weights according to their sampling date. However, precisely understanding the effects of spatial variations was a big challenge because there was little quantitative knowledge about them. Instead, we have quantitatively analyzed their effects on interannual changes. Subsequently, the analyses and some conclusions have been reworded accordingly.

Minor comments (line):

ln 60: August is hardly the beginning of the melting season for Arctic sea ice, rather the opposite?

According to the melt data from NASA, the ice cores in the present manuscript were all sampled in the late melting season, where the sea ice has been melting for a while (~58 days). We have rewritten this sentence in the revised manuscript.