The manuscript titled "Satellite-based evidence of dust emission over Northern Canada" by Ashpole and Wiacek attempted to use multiple satellite products including MODIS, VIIRS, and CALIOP to detect the frequency of occurrence of dust events for mapping possible dust sources. I think the methods to detect dust sources are generally adequate and useful for identifying dust sources. Different from another reviewer, I personally think using the Deep Blue over the land make sense since the authors are looking for dust sources from the land and not from the water bodies. I think this paper is helpful for constraining Canadian dust sources using a suite of satellite retrievals, and the study is helpful for the dust community. I have some general comments below, and I would suggest accepting this manuscript after a major revision.

We thank the Anonymous Reviewer for their work on our paper.

Major comments:

Line **224**: I would imagine that using 0.2 or an even smaller DOD threshold for FoO is needed for HLD sources like Canada. Using 0.5 as a threshold may miss out a lot of small local dust sources.

We experimented with various thresholds briefly, like other investigators that we referenced for this method, and added more to this discussion to Section 3.1. We settled on a threshold of 0.5 because it corresponds to strong dust emission events and it has DOD greater than typical values of thin cirrus cloud optical depth (COD), which ranges between 0.03 and 0.3 (Pierce et al., 2010). In future work this balance between finding weaker dust sources while avoiding thin cirrus contamination can be explored more fully; in this work, we have added a series of figures to the supplementary material that depict FoO DOD sensitivity to the threshold, i.e., 0.1, 0.2, 0.3, 0.4, 0.5, as well as the FoO of extreme DODs (DOD > 2 and DOD >3).

The difference between $DOD_{PG16}$ and $DOD_{B16}$ are not clear to the reader. The authors need to give more details on the differences between them and why the occurrence of $DOD_{B16}$> 0.5 are generally lower than that of $DOD_{PG16}$>0.5.

We revised and improved text relating to the above, also in response to RC 1.

Line **317**: I am not convinced that VIIRS mixed aerosols are mostly dust in Canada. They mentioned Kok (2011) but Kok showed that most emitted dust are coarse dust, not fine dust. They should stick with VIIRS dust (instead of VIIRS mixed aerosols) when interpreting possible dust sources.

We revised the text to note this limitation of VIIRS AT_MIXED more clearly. In Figure 6, where we compare SI, MODIS and VIIRS, only VIIRS_dust is used to help interpret possible dust sources.

Line **335**: The authors used aggregated CALIOP aerosol vertical profiles with a coarse resolution of 5°x2°. A finer resolution might be needed for detecting smaller and local dust events.

While this is a valid point, the sampling of the narrow laser (70-m footprint) makes the CALIOP dataset spatially sparse, even as it provides unprecedented 'curtain' views of aerosols along the orbital track. We revised the discussion of CALIOP data products' horizontal resolution in Section 2.1.3 and also the discussion of the limitations of the CALIOP-based results in Section 3.3. This point was also raised by RC 1 and addressed in our response there.

Line **336**: How did the authors exclude the diamond dust (ice crystal that are mistaken as dust) mistaken by CALIOP? There could be quite some precipitation in the summertime Arctic.

This comment was brought up also by CC 3, who pointed us to literature on the likelihood of occurrence of diamond dust as "60% of the time in winter, but hardly ever occurs in summer" (Zamora et al., 2022, ACP). We added this to our discussion of CALIOP results and noted where diamond dust may be occurring still (over Greenland), based on a consideration of mean atmospheric temperature fields and ice nucleation mechanisms.

Figure **5**: It looks like to me that CALIOP dust aloft be transported from elsewhere (e.g., the lower latitudes). How do you separate local sources from regional transport?

We cannot differentiate local from transported dust based on the data; we can only make some inferences that low altitude dust, within 1-2 km of the surface is more likely to be locally sourced, especially in the dust emitting season that we sample (JJA). Dust emission and transport to North America from Asia often involves warm conveyor belt uplift mechanisms and is unlikely to be found in these low regions (e.g., Wiacek et al., 2010). We revised and expanded wording relating to the discussion of dust aloft (> 2.5 km) in the text concerning Figure 5.

Line **351**: The authors used two satellite instruments (MODIS and VIIRS) to generate two FoO maps. It is not clear to the reader which one is better for use. The authors should explain more on the pros and cons of each of them and how people can combine them to better constrain the Canadian dust sources.

We revised the manuscript to stress that we originally added VIIRS and CALIPSO products to 'verify / evaluate' our main (semi-quantitative) results in a *qualitative* sense. We converted the quantitative MODIS AOD product to DOD, then ran the threshold analysis on DOD values to tally extreme dust events over 20 years. We only use the qualitative VIIRS and CALIOP aerosol 'type' products to corroborate the spatial locations of potential dust sources determined using the MODIS data.

To speak to the main point above, we agree that there are underlying VIIRS and CALIOP quantitative AOD and DOD data products that one could combine. The *selection* of the optimal sensor and retrieval algorithm for HLD detection is one complex matter, but not as complex as *combining* these products consistently, e.g., does one use MODIS AOD from the retrieval algorithms Deep Blue, Dark Target, or MAIAC? Or does one use VIIRS AOD? Often this question is settled pragmatically, depending on which time period one is interested in. CALIPSO is yet a different sensor (active lidar), providing vertical aerosol information and AOD.

This is the first study to use the Deep Blue MODIS data in the Arctic to detect potential dust sources in a systematic, long-term and spatially extensive way. Future work is needed to repeat and expand this work with other sensors and retrieval products. We have added this to our Concluding discussion.

Line **433**: I would say that the climate change impacts on FoO is not clear from the time series in Fig. 7. I wonder what drives the interannual variability. Are there correlations between the wind / temperature / snow cover time series and the FoO time series?

We agree that this temporal signal is not very clear in Figure 7. We investigated the correlations between the FoO of DOD and AOD greater than 0.5 and wind, soil temperature, soil moisture and snow cover (from 20 years of ERA 5 fields) and included these results in the supplementary material. There was a significant ($p < 0.05$) and negative ($R = -0.5$) correlation only with FoO AOD (not FoO DOD) and snow cover.