Referee 1:

In their manuscript, the authors present an automated dust classification scheme which was developed to identify local dust events. Their approach includes ground-based passive and active remote sensing retrievals, in particular lidar, sun-photometer and optical particle counter (OPC).

Overall, the manuscript is well written, follows a clear structure and the benefit of this approach is visible. I have a few remarks I would like the authors to consider:

General remarks:

- Title: I am wondering whether "Analysis" is the right term for the presentation of the detection algorithm. Maybe "Detection" is better reflecting what is presented here?

  The detection aspect is a point well taken. However, most of our effort was in the analysis: in reaction to the reviewer's comment we changed the title to: "Detection and analysis of Lhù'ààn Mân' (Kluane Lake) dust plumes using passive and active ground-based remote sensing supported by physical surface measurements".

- Limitations of the detection method: Whereas the limitation due to the presence of clouds is discussed and regarded, I am wondering whether there are other limits that affect the applicability respectively the robustness of the dust plume identification. In particular, how sensitive is the approach against (a) atmospheric properties (e.g. humidity, vertical structure) and (b) the intrusion of any other aerosol types (e.g. wild fire burning aerosol)?

  The reviewer will recall our affirmation that the Doppler Lidar is predominantly sensitive to coarse mode particles at its 1.548 μm wavelength. Fine mode particles like smoke are relatively easy to identify from the variation of the CIMEL fine mode AOD and/or from the context (smoke is typically always at higher altitudes: the actual altitude being dependent on the distance from strong fires which we can identify from MODIS hot-spots and whose general circulation pattern we can follow in MODIS imagery products and back trajectory simulations, etc.). Humidity effects on optical measurements are distinctly 2nd order at any distance from local clouds. With respect to the vertical structure of the atmosphere, dust plumes in the lidar profiles are unique and not to be confused with, for example, a stable boundary layer or high altitude smoke.

- Despite the automatic identification of dust events in remote dust source areas is of great interest to the dust research community, the observation site and thus the automatic dust identification retrieval may be of interest to Cal/Val applications for satellite missions (Section 1). Given the spatial heterogeneity of dust event occurrences, which approach will you follow (respectively do you suggest) in order to bridge from the scale at which the local events occur (sub-pixel scale) to the satellite's pixel scale?

  Given the spatial dispersion and heterogeneity of local dust, producing a high spatial-resolution dust-AOD product from high resolution imagery such as that provided by sensors like PlanetScope can be quite instructive. We have tried this for Kluane Lake by calibrating the high spatial-resolution DN values of PlanetScope with the low spatial-resolution AOD products of MODIS). The presence of the lake can also help to discriminate the dust more clearly above the

water. Very local plumes aside, we also seek to better understand the regional scale evolution of dust plumes using low-spatial resolution MODIS-type imagery or geostationary (temporally rich) imagery such as that of GOES series.

Furthermore, we can enhance our understanding of the dust, by utilizing different dimensions of satellite data such as the plume profiling capabilities of MISR and CALIOP (notably as demonstrated by our group in Ranjbar et al., 2020).

- Is the aim of this approach to achieve a 'dust classification' or rather a 'dust plume identification'? I clearly see the latter aim addressed, but would understand 'dust classification' differently. I understand that the term 'dust classification' as used here refers to the identification condition, i.e. can / cannot be remotely sensed. Nevertheless, it might be worthwhile considering clearly defining the meaning of 'dust classification'.

  In fact, we often used the two terms interchangeably. When it was more a question of merely identifying the presence of a dust plume or a cloud, we think that the context of the sentence made that distinction clear.

Detailed comments:

- Some references are missing. They appear several times across the manuscript as "ibid" in the text. Please correct.

  Fair enough: according to the Chicago Style Guide, "the use of "ibid" is now discouraged in favor of shortened citations. "We replaced "ibid" by the actual citation.

- Text and Fig. 2 & 7: The date-time format is quite unusual and across the manuscript somewhat inconsistent. Using one of the standard formats (e.g. date / hour) would be desirable.

  Changed the date-time format as suggested

- Fig. 4: This is a bit cumbersome to read. Being not familiar with the full range of abbreviations used here (DRS, DNRS, DFPC, DGEN, URS, UNRS, RofD), I have to search the document again to identify the meaning of the individual abbreviations. Maybe there is some room in the caption to write them out?

  Point well taken: the acronyms were defined in the figure caption (so that the reader can observe the figure while keeping an eye on the definitions of the subclasses)

- Line 223: "The use of R value as a mean identifying and …"?

  Missing preposition: the text was corrected to ""as a means **of** identifying … "

Referee 2:

This is an original manuscript that discusses a comparison of ground-based passive and active remote sensing retrievals with microphysical measurements of high latitude dust in the Kluane Lake region. It is a valuable contribution and is written in a clear and concise way.

General comments:

- The authors mention obvious limitations of low sample number statistics, yet in my opinion this needs more discussion. How representative are the events captured during the measurement period and thus how broadly could the event-classification scheme be applied here over time/seasons and elsewhere?
  We responded to this comment by appending the following sentence to the 2nd paragraph of Section 4.2.1.: "We believe that this R_{log}-dependent classification approach is as independent as it can be from issues such as instrument calibration or changes in the optical or microphysical strength of the dust plume: the verification of this affirmation in terms of other sites or other seasons is a step that we are actively pursuing."

- There are some discussions in the manuscript about figures in the supplements that are very hard to follow without the supplement. (Like lines 364-370). The authors should consider adding only conclusions of such events to the text for readability and move further explanations to the supplement.
  In general we made an effort to simplify the text when overly technical attributes could be avoided (see our reaction to your comment below re the excessive usage of symbols and acronyms). In this particular case of the text describing Figure 6, we would argue that the overly technical aspects are already in the supplementary material and that what is left in the main text is already minimal in terms of technical detail. What we did do was to add horizontal and vertical lines to Figure 6 and to the detailed analogue figure in the supplementary material (Figure S4) in order render the symbols and technical text more comprehensible (to visually clarify what we meant by bottoming out and threshold)

- The use of different time scales (UT, UTC, local) is confusing.
  Point well taken: all 6 instances of "UT" in the main text were corrected to "UTC"

Minor comments:

- Line 75 Various explanations; numbering the explanations could make it easier to read
  Good point. We updated the text accordingly : "Various explanations for this discrepancy were offered: these included 1) the notion that Lhù'ààn Mân' plumes are very locally inhomogeneous and that wind direction could influence AERONET dust detection, that 2) the CIMEL instrument missed plumes below its minimum angular elevation, that 3) AERONET sensitivity was frequently too coarse to detect weaker events, that 4) AERONET cloud screening removed 97.8% of dust events and that 5) the CIMEL employed for the analysis (for which data acquisition occurred during the 2018 dust season) was incapable of making nighttime measurements. "

- Line 119; you should define FM in the main text

We inserted an expansion of both FM and CM acronyms and a more detailed opto-physical description of each acronym as footnote where FM and CM are mentioned first.

- Figure 1: DV site position not visible?
  A green star representing the DV location was added to Figure 1

- Figure 3: The background probably also indicates daylight time?
  The brighter gray background indicates the brighter daytime period and the darker background indicates periods when the sun is below 10^{o} elevation.

- Figure 4: Is RofD explained? Please check the duty cycles, the total percentages of events in b1 and b2 for single days sometimes exceed 100% (22, 30 May)?
  The % classification scheme shown on the figure was, in fact, incorrect… we changed it to be coherent with the duty cycle statement in the legend. We replaced the RofD "class" with a direct description "The light grey bars highlight the link between the subclasses and the R_{log} values that served to define those subclasses".

- The number of acronyms and symbols is unnecessarily large and does not support readability.
  We went through the total text with an eye toward the simplification of any excessively technical vocabulary (notably the excessive use of symbols or acronyms). Numerous improvements were made. For example, the discussion of Figure 3 was rendered more visual, mathematical symbols were minimized in the discussion of Figure 4, the graphics of Figure 6 and its discussion were simplified (see above), an attempt was made to eliminate redundant technical text in the discussion of Figures 8 and 9, etc.

Referee 3:

This study presents valuable comparison of in-situ HLD measurements and remote sensing data, which is in good scope with the journal. Such studies are rare for the HLD regions and this study is likely one of the pioneer studies. Authors introduce detailed methods how to compare such data, so in the future, satellite products can be used for better detection of high latitude dust storms and their long range transport, including their potential climate impacts. The paper is clearly written and the figures represent well the analyses. Data can be used for many other studies and modelling. I would recommend publication of this work after some minor revisions related mainly to correct discrepancies in the references (please check if all references are included in the reference list and those from there reference list are listed in the text) and to compare the results with other studies from high latitudes. As there are not many studies on ground based remote sensing from these regions, also studies on general dust storms in low latitudes on comparing the retrievals with in-situ measurements shall be used for comparisons of the results.

We checked carefully and found no discrepancies with respect to the references. We did not add the Baldo et al. (2023) citation (below) because, the general approach reported in Baldo et al. (2020) was entirely sufficient for our purposes (the production of Figure 8 which is, more than anything, dependent on the measured mass mixture of mineral components unique to Kluane Lake).

A new sentence reporting on a local dust optical depth, CALIOP-derived climatology over the Arctic (Kawai et al., 2023) was added to the Introduction (in the paragraph on satellite and airborne remote sensing of local dust).

We also formulated a new short paragraph in the Introduction that was dedicated to the ground-based remote sensing of local dust. This paragraph included a brief discussion of the Yang et al., 2020 paper cited below and an older AERONET study based out of Hornsund in the Svalbard archipelago.

Minor comments:

Consider to add for example comparisons from these studies in high latitudes:

Baldo, C., Formenti, P., Di Biagio, C., Lu, G., Song, C., Cazaunau, M., Pangui, E., Doussin, J.-F., Dagsson-Waldhauserova, P., Arnalds, O., Beddows, D., MacKenzie, A. R., and Shi, Z.: Complex refractive index and single scattering albedo of Icelandic dust in the shortwave spectrum, EGUsphere [preprint], https://doi.org/10.5194/egusphere-2023-276, 2023.

Yang, S., Preißler, J., Wiegner, M., von Löwis, S., Petersen, G.N., Parks, M.M., Finger, D.C., 2020. Monitoring Dust Events Using Doppler Lidar and Ceilometer in Iceland. Atmosphere 11, 1294.