Summary of changes made in response to Referee #1 (Dr. Patrice de Caritat)

> Once again, I wish to thank Dr. de Caritat for his thoughtful questions, comments, and edits. Working through them undoubtedly improved the clarity of the paper.

I have marked many (mostly minor) comments in the edited PDF, which should make the paper clearer to the reader.

> I incorporated the vast majority of these. As nearly all were small, I do not include details here. However, a few comments did require more than simply a word change. My responses to those include:
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> - There was confusion about which soil samples were analyzed for some steps. I realize this has to do with the fact that the original soil sample was analyzed for grain size distribution and fertility values, but a finer settled subsample was later analyzed for chemistry and isotopes. In the revision, I endeavored to refer to the initial sample as the "bulk" sample, and clearly state (Line 184)[1] that all subsequent analyses were conducted on the settled fine fraction, referred to as the "soil" sample.
> - I mentioned what approximate particle size class is represented by the settled sample (Lines 179-180).
> - I added labels to the states of Idaho, Nevada, and Utah on the Figure 1 map, as well as the Great Salt Lake.
> - I provided the additional information requested in the tables (lat/long datum, cut-offs for grain size categories, etc.).
> - I added more details to the site descriptions to unify their presentation (Lines 60-128)

1. I would like to see a more detailed description of the meteorological conditions of the area, particularly where it comes to wind and aridity parameters (dominant wind directions, strengths, seasonality; precipitation and humidity values, seasonality?).

> Because local climatic data are not available for these sites, I extracted values for mean annual temperature and monthly precipitation for each location from the interpolated 800-m PRISM climate dataset, 1991-2020 (now mentioned in Lines 56-59). I added these data, along with a derived metric for seasonality of precipitation, to Table 1 and to the site descriptions in the text. This permits a broad comparison of climatic conditions at the 6 sites (which is warmest, which is wettest, which receives most precipitation in winter vs. summer, etc).

2. This should logically extend to what is known of the geochemistry and mineralogy of the most obvious source areas for eolian dust likely to be transported over, and deposited on, the mountain region considered. Here I would like the authors for instance make use of the USGS soil geochemical landscape survey dataset.

> As noted in my initial response, identification of likely source regions, and analysis of the properties of surficial sediments in them, is beyond the scope of the investigation presented here, which is focused on the mountain soils themselves. Potential source areas for 2020-21 dust were

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[1] Line numbers refer to the document with changes accepted

evaluated in a separate manuscript published recently in Environmental Research Letters. I added reference that study in Lines 54-55.

3. The paper is quite long and much detail could be placed in the supplement. For instance the Methods could almost entirely be moved there, with minimal loss of readability.

According to the guidance provided for the journal SOIL about what types of information should be conveyed in the main text, and what is appropriate for presentation in an appendix, "…all material required to understand the essential aspects of the paper such as experimental methods, data, and interpretation should preferably be included in the main text." The SOIL editor has recommended, and I agree, that our methods section should remain in the body of the paper.

Changes made in response to Referee #2 (Dr. Ruth Heindel)

> Once again, I wish to thank Dr. Heindel for her thoughtful comments that were very helpful in revising this manuscript.

My main comment has to do with making the site variability more apparent in the text, tables, and figures. The site numbering system is not very intuitive, so it was challenging for me to remember which site was which when working through the manuscript. This is especially the case for all of the figures where the sites are numbered from highest to lowest (even though this does not seem to correspond to any site characteristics). I think it would help if the sites could be arranged from east to west (as they are described in the Study Area section), and if the bedrock could somehow be indicated on the figures – this would be especially helpful for Figures 5 and 11.

> In Section 1 (Study Area), I introduce the collectors from southeast to northwest, with frequent reference back to Figure 1, because the geographic pattern seems more useful than the sequential numbering. Everywhere else though, it seems better for simplicity and consistency to present the collectors from 11 to 16, which is the most neutral approach, since the measured mineralogical and geochemical properties don't always vary geographically in a predictable way. It is also tricky that the sites cannot simply be ordered from west to east without overlooking their north-south distribution. I did update Figure 5 with symbols reflecting the bedrock lithology (Line 310), and added codes for the lithologies to Figure 11 (Line 450).

Specific comments:

Line 135: How deep were the soil samples collected? It seems like they were all surface soil samples given the difficulty in sampling soil in this environment, but it would be helpful to state an approximate depth or depth range for the soil samples.

> I added mention to the methods that all samples spanned a depth of 0-20 cm. (Line 158)

Line 170: The sentence about the two size fractions doesn't make sense, or maybe the sentence is missing a phrase. Make sure that it is clear that the <63um fraction was considered most likely to represent exotic mineral dust.

> I rephrased this to make the approach clearer. (Lines 157-158)

Line 183: "composite sample for collector" is a confusing phrase. Rephrase for clarity.

> This is a typo; the word "each" is missing. "This process generated a ~6 g composite sample for EACH collector." (Lines 201-202)

Line 193: There is an extra 'were' in this sentence.

> Easy to fix (Line 211)

Methods in general: This section contains very detailed analytical methods that could be moved into a supplemental file. Also, in the site description, it would be helpful to include information about known sources of dust in the region.

> According to the guidance provided for the journal SOIL about what types of information should be conveyed in the main text, and what is appropriate for presentation in an appendix, "*...all*

material required to understand the essential aspects of the paper such as experimental methods, data, and interpretation should preferably be included in the main text." The SOIL editor has recommended, and I agree, that our methods section should remain in the body of the paper.

Now that the related study presenting information about possible dust sources was recently published in *Environmental Research Letters*, I added reference that work in Lines 54-55.

Lines 343-346: It is unclear which type of samples these values are for. Are you reporting across the dust, soil, and rock samples? Or are these values for one type of sample?

You're right, as written, this is unclear. I reworded this section. (Lines 366-370)

Lines 537-552: It might be helpful to show some of the correlations between soil fertility and dust characteristics – like the correlations mentioned with calcium. For me, this would have been more effective than looking back to Table 2.

The manuscript has a lot of figures already, so I made a composite figure showing many of these relationships to serve as Supplemental Figure 2.

Figure 1: The site locations are shown with yellow stars, not yellow triangles as the caption states.

Thanks for noting that!

Table 1: Include the dates of collection or the length of deployments in the table. It would be helpful if Table 1 could capture all of the deployment information written out in Lines 130-134. It would be helpful to visually see how the 22 samples are distributed across sites and seasons.

I added a new figure (Supplemental Figure 1) to show the deployments and collection dates for all six sites on a common timeline.

Figure 4: Is it possible to use a ternary diagram with lighter cross-hatching? Especially when printed at a smaller size, I am worried about the legibility of the points on top of such a dark background.

Thanks for the suggestion, I lightened the background. (Line 305)

Either Table 2 or Figure 5 could be moved to a supplemental file.

The balance of what to include in the text vs. figures and supplement is always a challenge. I decided to keep this table and figure in the main text because they present the primary data from the soil analyses.

Figure 6: It seems like summer21 samples have considerably more illite, kaolinite, and mica compared to the other dust samples. Is this a real difference, and if so, any ideas about why this might be?

As noted in my initial response, I think this visual distinction (height of the peaks) is related more to the thickness of the sample on the XRD slide: more material = more intense peaks, and for some of the dust samples, there wasn't much to work with (leading to stubby peaks). This is why the XRD data are evaluated as ratios, rather than absolute peak heights.

Table 4: What does the Dust sample with no date refer to? Is this some kind of composite sample?

These are the 2021-22 samples as noted in Line 222.

Figure 11: Use "Site" instead of "Collector" along the x-axis?

I made this change, and also added a code for the lithology at each site. (Line 450)