Dear Editor,

Many thanks for considering our manuscript for publication. As you will see we have implemented all the constructive and helpful comments received from the two referees, which have contributed to improve the quality of our manuscript. Please find below replies to their queries and the indications of how we implemented their suggestions in the revised manuscript. We also attach a revised manuscript with track changes to easily identify the changes made.

We hope that our revision is adequately replying to the queries of the referees. In particular we would like to highlight the inclusion of i) particle size patterns of dust and comparison with that of dust emitting sediments, and ii) a larger focus on the dust emitting processes. Both, issues requested by referee #1.

With very kind regards,

Adolfo Gonzalez-Romero on behalf of all co-authors

REPLIES TO QUERIES FROM REFERES AND INDICATIONS OF HOW SUGGESTIONS ARE IMPLEMENTED IN THE REVISED VERSION

REFEREE #1

Many thanks for your valuable and helpful comments, which have contributed to improve the quality of our manuscript. Please find below our answers to your comments and an explanation of the changes in the revised version of the manuscript (text in blue).

GENERAL COMMENTS

R#1: The manuscript has a strong focus on earth surface processes and there are no observations and only little discussions on interactions with the atmosphere or dust emission in the studied regions. In my opinion, the manuscript could be improved and be of greater interest to ACP readers if the authors make an effort to better link their findings to dust emission processes and properties of airborne dust. The discussions on explaining observed particle size distributions, for instance, ignore any influence of dust emission and deposition (from the atmosphere rather than water) previous to the sampling. (The timing of the sampling could make this irrelevant, but this information is lacking in the sampling description.) Other examples of information and discussions that could complement the manuscript are given in the specific comments below.

The frequency and duration of the flooding events is poorly described/quantified in the manuscript. It is unclear how often these events occur, how long they last and when these are followed by dust emission events. Moreover, it is not clear what occasional descriptions such as 'daily recurrence' are based upon. What measurements or observations do you have to support this statement? This is an important aspect and needs to be explained more thoroughly.

Reply: We thank reviewer 1 for the valuable comments, which have helped us improving the quality of the manuscript. These general comments have been addressed as follows:

1) Links between sediments and the emitted properties of dust: This study is part of a larger effort derived from the intensive wind erosion and dust emission campaign conducted in Dyngjusandur that specifically tackles the aspects highlighted by the reviewer. Currently we have a series of companion papers submitted or in advanced state of preparation, which focus on the dust emission and emitted PSD (Dupont et al., submitted; González-Flórez et al, in prep), and the single-particle composition, size, shape, and mixing state of the freshly emitted dust (Panta el al., in prep) in Dyngjusandur. In González-Flórez et al. (in prep) we provide a detailed analysis of the emitted PSD and its relationship with the PSD of the parent sediment in the region.
   Our focus in this paper is to provide a detailed account of the properties and distribution of dust-emitting sediments in the Jökulsá á Fjöllum basin, encompassing Dyngjusandur, and in other dust hotspots in Iceland.
2) Flooding and dust emission cycles: Following the recommendation of reviewer 1, in the revised version of the paper we have linked our findings with the observed flooding and dust emission cycles. We have used time series of temperature, winds, volumetric soil moisture, and flooding and rain events recorded during the campaign to describe the cycles of glacier melting, flooding, sediment discharge, drying and dust emission in Dyngjusandur. Two new sections have been added to the revised manuscript: Section 2.3, which describes the new measurements analysed, and Section 3.1 in Results and

Discussion (including new Figure 3), which provides a through description of the cycles recorded during the campaign. We really acknowledge this suggestion by the reviewer as we think the new sections have made the paper more comprehensive and readable.

3) Additional information on the size of the emitted dust: While the detailed analysis of the emitted PSD will be provided in Gonzalez-Florez et al. (in prep), in Section 3.2 of the revised manuscript we have added a comparison of the median diameter of the emitted dust (derived from real-time optical spectrometer measurements) and the median diameter of the top sediments in Dyngjusandur over the common size range (0.5 to 40 microns).
4) Discussion of the dust emission and deposition prior to the sampling. We added a discussion on the potential influence of dust emission and deposition on the sediments in Section 3.2 of the revised manuscript. We have termed this latter process as aeolian recycling of fine sediments. Thanks for the suggestion!
5) The timing of the sampling: We added the dates of the sampling and those of the intensive measurements.

SPECIFIC COMMENTS/SUGGESTIONS

R#1.1: Line 105: Other particles, in particular resuspended glacial sediments, that can be deposited on glaciers and become trapped within the ice are relevant as well.
Reply: Thanks for this comment. This text has been added in the introduction (lines 108-113): *"Initially, large volumes of volcanic fine volcanic ash are deposited and trapped by glacier ice over geological epochs, later released as sediment into glacial rivers upon glacier retreat. Moreover, the physical weathering of rocks by glaciers produces a vast amount of silt and sand, transported from beneath glacial margins by glacial rivers (Palacios et al., 2022). Additionally, during dust events, fine dust is deposited and trapped within glacier ice, re-emerging as sediment during melting."*

R#1.2: Line 111: So far there is a strong focus on explaining the presence of sediments, but how important is the climate in this region for dust emissions?
Reply: Thanks for this comment. We added the following text in the introduction (lines 117-120): *"Glaciers like Vatnajökull, Iceland´s and Europe's largest, additionally face significant ice loss due to climate change. Models suggest that warming rates of ≥2°C per century could result in a 50% reduction in ice cap volume and area within 200 years (Flowers et al., 2005), eventually increasing the amount of sediment released into glacial rivers. Besides warming, factors such as volcanic activity contribute to accelerated melting and frequent sediment-laden flooding events, followed by rapid drying and subsequent dust emissions."*

Flowers, G.E., Marshall, S.J., Björnsson, H., & Clarke, G.K.: Sensitivity of Vatnajökull ice cap hydrology and dynamics to climate warming over the next 2 centuries. Journal of Geophysical Research: Earth Surface, 110(F2), 2005.

R#1.3: Line 221: What observations did the dust emission field campaign include?
Reply: Thanks for the comment. We performed a variety of measurements during the field campaign including vertical profiles of wind and temperature, saltation fluxes, size-resolved dust dust concentration, radiative fluxes, volumetric soil moisture content, and more. For the purposes of this paper, as explained above, we now used time series of temperature, wind,

volumetric soil moisture content and size-resolved dust concentration. These measurements are presented and described in Section 2.3 (Methods) and Section 3.1 (Results and Discussion).

R#1.4: Section 2.2 The description of the study site needs more information on the dust activity in this region. 'Which can emit dust under favourable conditions' is too little information to understand the relevance of your study. Please add information on questions like; When is the dust source active? What kind of synoptic conditions? Where and when is the dust generally transported and deposited? (Some of the information in the introduction could be moved or repeated here as well).
Reply: Thanks for this comment. In the revised version of the manuscript, we have added Section 3.1, which describes both the typical synoptic conditions that lead to dust emission in the region and the daily cycles of dust activity during the campaign linked to the cycles of flooding, drying and winds.

R#1.5: Section 2.3 Please describe the sampling in detail. When did you do these field experiments? Were they all sampled simultaneously? How many samples did you take? What does freshly deposited mean? Was there any dust emission previous to the sampling? At what depth did you define 'underlying sediments'?
Reply: Thanks for these comments. In Section 2.1 we included the following (lines 240-243):
"This study presents results from the sediment sampling carried out from August 9 to September 10, 2021 in Iceland. Sampling in the Jokulsá á Fjöllum basin, encompassing Dyngjusandur, took place between August 10 and 12, while samples from other dust emission hotspots across Iceland were collected throughout the extended period."

And (lines 283-297):
"The collected samples represent surfaces typically found in dust-emitting and sandy areas across Iceland. These samples comprise the top 1 cm (referred to as top sediment in this study) of recently deposited sediments, typically within a few days of flooding events, originating from dust-emission hotspots. Additionally, samples include underlying sediments located 1 to 5 cm beneath the surface (referred to as fluvial sediments in this study), as well as aeolian ripples found in proximity of these hotspots (Figure 2). Sampling was conducted using a metallic shovel, consistent with the approach described in González-Romero et al. (2023), with a sampling area of 5 cm^2 and a height of 2 cm. Detailed records, including coordinates, photographs of the locations and sampled area, and sample characteristics, were documented. Subsequently, samples were stored in plastic bags and transported to the laboratory. Upon arrival at the the laboratory, samples were dried for 24-48 h at 50 °C and riffled into smaller, equal, and homogeneous sub-samples for further treatment and analysis. A total of 119 samples were collected, of which 45 were selected for comprehensive analysis (29 top sediments, 8 fluvial sediments and 8 aeolian ripples). The remaining samples were subjected to XRD and particle size distribution analysis, although the Fe mode of occurrence was not analyzed in these samples."

R#1.6: Line 369: You may want to comment here already on FDPSD<MDPSD.
Reply: Thanks for this comment. We added (lines 516-518):
"The fact that FDPSD and MDPSD yielded similar mean median diameters indicate a significant level of particle disaggregation, which is unusual for dust-emitting sediments in hot deserts (González-Romero et al., 2023)."

R#1.7: Line 382-387: Then why is the maximum size also larger in FDPSD? And why is this not the case at the two points closest to the glacier? Please extend the discussion.

Reply: Thanks a lot for your comment. We added this text to clarify interpretations (lines 575-598):

"The analysis revealed consistent findings between MDPSD and FDPSD for samples exhibiting relatively fine mean median diameters. However, we note that the MDPSD showed finer particles than FDPSD in samples with finer mean diameters (Figure 5). This discrepancy is likely attributable to the presence of pumice particles. Pumice, characterized by its fragility and low density, is common across Iceland, forming layers several centimetres thick, as observed in Dyngjuvatn. These particles, with sizes ranging from a few microns to approximately 65 µm, are buoyant in water and easily fragmented. This poses a challenge during FDPSD wet analysis, as these water-buoyant particles evade capture within the measurement chamber, because a homogeneous particle dispersion is required. Consequently, FDPSD measurements tend to underestimate the presence of finer pumice particles, resulting in a coarser PSD. Conversely, MDPSD measurements, conducted in dry conditions, circumvent this issue by accurately detecting finer pumice particles. Thus, MDPSD yields a finer median diameter, reflecting the inclusion of these smaller particles in the analysis.

Close to the moraine the energy of the fluviatile system is so high that the pumice particles are transported far from the ice thawing areas. When flooding occurs in the lowlands fluviatile suspended particles are deposited first and the buoyant pumice particles only when ponded waters percolate and/or dry. This leads to a segregation of pumice particles, with a progressive enrichment downstream of the fluviatile system and in ponded lowlands. Furthermore, these processes lead to an enrichment of pumice in the surface of the ponded areas, favouring dust emission of fine and light particles.

However, top sediments near the glacier are more consolidated because in this high-water energy environment the outcrops of fine top sediments layers are the ones exposed by erosion of the old sedimentary sequences composed of a conglomerate in the base, sandy sediments in the middle part and fine ones in the top, but not from the recent flooding. These older top sediments are much more consolidated and, as shown by Figure 5, the averaged mean diameters of the MDPSD are much coarser than those of the FDPSD."

R#1.8: Line 374-406:

a) Do you have any water samples or information on flow speed that help you distinguish the influence of different processes on the size distribution?

Reply: Thanks for this comment. Unfortunately, we do not have access to that specific information. While we directly observed the water flowing from the glacier and we have captured images, we did not measure the water speed or collected water samples. However, close to the moraine and along the fluvial flows towards the flooding plains, evident erosion is observed, indicating a faster water flow compared to the flooding plain. Additionally, after the flooding subsides, there is differential deposition of sediments in the old fluviatile streambeds, resulting in the accumulation of very fine surface sediments when the channels are completely submerged.

b) Would aeolian activity shift the observed size distribution and has this influence been excluded?

Reply: Thanks for this comment. We did not consider this, but in Section 3.1 we added it as a possible process favouring fine top sediment formation. We included the following text (lines 534-541):

"The fine pattern of these surface sediments likely stems from various factors: i) sediments trapped within glacial ice from fine volcanic ash deposits accumulated over the glacier's geological history, along with nearby dust emissions that are released during melting; ii) the transportation of fine sediments from moraines to floodplains via fluvial channels, where further segregation occurs through ponding. During drying phases, finer particles settle atop, following the initial deposition of coarser particles; iii) dust emissions contribute to segregating finer particles on rock surfaces, sediments, and ice, which are then transported to floodplains during subsequent flooding or rain events. We term this latter process as aeolian recycling of fine sediments."

c) Did you observe any layers of sediments similar to 'top sediments' deeper in the soil (if you can call it a soil)? It could be interesting to discuss the frequency of dust emission events and whether top sediments are ever buried or always eroded. You could also elaborate on the frequency and duration of deposition events. How often this area likely is an active dust source region or dust entrainment is prohibited by flooding are important questions, but hardly discussed. Even if observations may be lacking in the current field campaigns, there is literature available that can support such a discussion and can help set the conceptual model in a larger perspective and give the reader a better understanding of this dust source. What is your statement 'flooding events are infrequent' in line 402 based on?

Reply: Thanks for the comment. We refer to Section 3.1 of the revised manuscript for a complete description of flooding and dust emission cycles. We also added this in Section 3.2 (lines 542-551):

"Frequently, layers of former top sediments were buried beneath fluviatile sediments. Flood events led to the inundation of unpaved roads towards the moraine typically in the midday to late afternoon hours. Conversely, when insolation and temperature markedly decreased, these flooding episodes were reduced. Low wind speeds facilitated the preservation of surface sediments, which were subsequently covered by flood deposits during days of minimal water flow, preventing erosion of the now-buried top layers. During the sunny August days, a recurring cycle often ensued: midday to late afternoon flooding followed by drying and dust emission the following day (Figure 3). However, instances of reduced drying due to rain or diminished insolation inhibited dust emission on subsequent days (Figure 3). Additionally, if flooding intensity peaked on a particular day, insufficient drying prevented dust emission the following day."

We also clarified that after the natural dam, flooding events are infrequent because *"The deepening of fluvial channels due to erosion renders the floodplains incapable of inundation. Consequently, there are no floodplains with top sediments available for sampling"*.

d) Line 403: 'Prevalence of fine-grained top sediments ... is rare'. Do you mean spatially or temporally? Could top sediments be eroded by wind before sampling?

Reply: Thanks for the comment, we added 'spatially'. Top sediments cannot be eroded in these places because there are no floodplains that are prone to dust emissions, and the load of water-suspended fine particles is restricted to the incised fluviatile channels.

R#1.9: Section 3.1 Do you have information on size distributions of emitted dust in this region and are they similar?

Reply: Thanks for this comment. In section 3.1, new Figure 3, we provide the times series of size-resolved dust concentration. Also, in Section 3.2 we compare the mean diameters of the dust and the top sediment in the region.

R#1.10: Line 695-699: This suggested you would see repeating top sediment layers in the deeper samples as well?
Reply: Yes. We added here a summary of the text on this (also see above ·1.8c) (lines 881-886): *"The frequency of flooding was nearly daily under insolation, and this leaves a cyclic pattern (top sediment, fluvial sediments) in the sedimentary record. Thus, in sunny days of August there was a typical daily cycle of midday to late afternoon flooding followed by drying and dust emission the next day. During intensive flooding episodes, a large amount of fine top sediments covers very large surfaces, and if sunny days or adequate synoptic flows occur the subsequent day, high dust emissions are recorded."*

R#1.11: Line 704: Are sedimentation-emission processes repeated daily? Do you have any observations showing frequencies? Previous descriptions gave an impression of longer time intervals.
Reply: Not precisely daily. Flooding happened to more or less extent daily between de moraine of the measurement site, but dust emission depended on the drying and the occurrence of relatively high winds and therefore there were days with no or little dust emission. Please see revised Section 3.1, 3.2 and our answer above in #1.10.

R#1.12: Line 768: The conceptual model explains the availability of fine sediments, not necessarily elevated dust emissions. It would be interesting to add more on dust emissions.
Reply: Thanks, we have extended the discussion in Section 3.7 of the revised manuscript.

R#1.3: Line 775: Please discuss the specific summer conditions that cause daily recurrence of floods.
Reply: Done. Lines 966-968.
"These floods are recurrent under specific summer conditions (high insolation and temperature) causing melting of ice leading to flooding, and fostering particle sedimentation and fractionation. Subsequently, dry weather and high wind patterns facilitate dust emission."

TECHNICAL CORRECTIONS

R#1: Line 52: somewhat confusing whether similarities only refers to the median diameter, please be more specific
Reply: Changed to: Fully and minimally dispersed PSDs and the average median particle diameter evidenced remarkable similarities (56±69 and 55±62 µm).

R#1: Line 109/110: Could be easier to read if you specify 'this process'.
Reply: Addition of "of deposition," to clarify.

R#1: Line 133: You could refer to figure 1 here.
Reply: Added: (both major dust hotspots, Figure 1).

R#1: Line 139: Suggesting an alternative for 'the soils have too much moisture to be able to emit': soil moisture hinders dust emission.

Reply: Changed: After thawing, soil moisture hinders dust emission;

R#1: Line 142: Change 'high winds' to 'high wind speed'
Reply: Changed.

R#1: Line 201: The conceptual model only elaborates the accumulation of fine-grained sediments available for dust emission.
Reply: See the above replies to your queries. Now it contains both accumulation of sediments and processes favouring dust emissions.

R#1: Line 217: remove repetition of intensive?
Reply: Done: wind erosion and dust emission measurement campaign in one location

R#1: Line 222: 300 m away: do you mean 300m upstream?
Reply: Done: situated 300 m upstream from the

R#1: Line 223: change 'Jökulsa water flow' to water?
Reply: Changed: where water can accumulate after flash floods

R#1: Line 261 would indicate >indicates
Reply: Changed.

R#1: Sections 2.4.4. and 2.5 Other section titles refer to what is measured rather than the method. Section 2.4.4 Mineralogy was already discussed in 2.4.2?
Reply: (Lines 435-438) (note updated numbering of the sections due to additions in the revised manuscript) 2.5.4 changed to Electron microscopy of samples. SEM provides size, morphology, mineralogy, and aggregate information at particle level and was used to corroborate the results from the XRD and to see to what extent iron oxides were found in the surface of the particles.

R#1: Line 339: Do you mean subsurface reflectance?
Reply: Changed. Lines 439-440
"While we measured the exposed surface after sampling (below the collected sample), we did not use those measurements as the soils were too saturated to see the mineralogy well."

R#1: Line 405; Maybe simply 'near the sea'?
Reply: True, corrected: Near the sea,

R#1: Line 527 and elsewhere: check the manuscript for consistent spelling of aeolian vs eolian
Reply: Done.

R#1: Line 607: significant … ?
Reply: Thanks, "differences" was added.

R#1: Line 692; Why not add this information in the field description?
Reply: Relocated to line 231-232 and removed from the conceptual model.
Line 256-261: "The Bárðarbunga eruption and subsequent formation of the Holuhraun lava field (from July 29, 2014, to February 27, 2015 covering an area of 85 km2; Geiger et al., 2016) resulted in a natural dam that intercepted thee basin´s flow approximately 16 km downstream

from Vatnajökull, leading to the formation of the ephemeral Dyngjusandurvatn lake (referred to in this study as Dyngjusandur). This area experiences, recurrent flooding events every summer (Figure 1)"
Line 875-877: "In the Jökulsá á Fjöllum basin, this scenario is generated thanks to the natural dam created after the Bardabunga eruption, when fluvial channels deposit large volumes of sediments across Dyngjusandur, a flat and extensive region (Figure 15)."

R#1: Line 718: minerally=minimally?
Reply: Corrected

R#1: Figure 1: the black polygon marking the Holuhraun lava field is not visible in the figure. Please mention the dots/pointers in the caption. The zoom on region a) is different to the main figure, please correct.
Reply: (Line 1451) Thanks for your suggestion, the colour of Holohraun has been changed, we mentioned the dots of the samples in the caption and changed the scale.

R#1: Figure 6: Please add the number of samples for each sediment type in the caption or legend.
Reply: (Line 1361) Thanks for your suggestion, we added the number of samples in the caption of Figure 7 now after new Figure 3 added.

R#1: Figure 8: Please add a compass or arrow indicating North
Reply: (Line 1470) Thank you for your suggestion, we added the north arrow.

R#1: Figure 10: Distinguish between bars and numbers in the caption.
Reply: We rephrased the caption of the Figure for clarification Lines (1361-1636).
"Average percentage of FeS, FeM, FeD and FeA with respect to total Fe content for the Jökulsá á Fjöllum basin in bars (Y-axis) for top sediments, sediments and ripples. The respective amounts are also indicated in terms of mg/g, where the denominator refers to g of sediment."

R#1: Tables 1/2/3: From what I understand Table 3 repeats all values from tables 1 and 2, why not omit tables 1 and 2?
Reply: (Lines 1488-1527) Totally agree, thank you for your comment, we have removed Table 1 and Table 2.

REFEREE #2

Many thanks for your valuable and helpful comments, which have contributed to improve the quality of our manuscript. Please find below our answers to your comments and an explanation of the changes in the revised version of the manuscript (text in blue). Furthermore, you might easily identify changes in the manuscript with track changes.

GENERAL COMMENTS

The manuscript by González-Romero et al. provides a detailed description and analysis of in-situ data taken during one of the FRAGMENT field campaigns. This one took place in different dust sources in Iceland. The samples analysis includes particle size distribution for minimally and fully dispersed aggregates, mineralogical composition, in particular Fe content and its mode of occurrence, and mineral sorting by spectroscopy. The physical properties of dust from the different sources are then compared, as well as with data collected during the FRAGMENT campaign in Moroccan Sahara. Their analysis allows them to develop a conceptual model for dust emission from an Icelandic dust hotspot. Major results from this work include the fact that there is little difference between minimally and fully dispersed samples, which is indicative of weak cohesion between particles, and the potential to easily emit dust without the need of sandblasting process. As we could expect from a volcanic region, dust emitting sediments consist primarily of black volcanic glass. An interesting result is the contrast of Fe-content between Morocco and Iceland. While hematite and goethite are predominant in Morocco, it is replaced by magnetite in Iceland. The results have important implication for dust impacts in the Earth's climate systems: atmosphere, ocean and cryosphere.

Although the paper contains a lot of technical descriptions, it reads easily with captivating results. I could not find any sections needing clarification.

Reply: Thanks a lot for your positive feedback. We have updated the minor comments you suggested in the revised manuscript.

Minor comments

R#2: I would remove "but" Line 92.
Reply: Done, thanks

R#2: I would change Line 607 to "Our findings reveal significant differences between…"
Reply: Added, thanks

R#2: I would recommend publication of the manuscript in its present form.
Reply: Thanks