Manuscript response file for ESSD-2024-335 "High resolution continuous flow analysis impurity data from the Mount Brown South ice core, East Antarctica"

In this file, referee comments are in black text, with authors' response in blue italicized text. Tracked-changes document is provided, produced using latexdiff.

Authors' comments:

We would like to thank both reviewers for taking the time to provide thorough reviews of the revised manuscript. We appreciate the constructive feedback provided. The comments and suggestions have been addressed both below and in the manuscript text, please see the below replies in blue italicized text, in addition to the revised manuscript.

Reply to anonymous reviewer #1:

This my second review of this paper (Reviewer #1). The revisions have strengthened the tephra geochemical measurements and linkages, which I thought were already quite robust. My issue is still with the way the atmospheric modeling is framed, which in the revised manuscript is emphasized as having a major role in guiding the tephra sampling. See comments below as it not clear to me how HYSPLIT factored into the sampling strategy. It is clear how HYSPLIT was used to assess if the tephra identification, once made, is realistic.

> *We thank Reviewer 1 for the feedback. It is clear from these comments that some clarification is required in the text about how the HYSPLIT atmospheric trajectory modeling influenced the sampling process. HYSPLIT trajectories were used to determine target timesteps for events (independent of the signals used in ice core chronology development) which would be promising to sample for "unlikely" cryptotephra (e.g. those not necessarily associated with a sulfate/conductivity or particle anomaly). These timesteps were translated to the ice core age/depth, based on the published chronology, to guide sampling depths ranges.*
>
> *Text has been added to section 2.2 to help clarify the way HYSPLIT was used in this study. We address this further below, as it relates to the specific comments about lines 495-504.*

Line 495-504. This (new) paragraph doesn't add up to me. Please detail how your approach is different than the "time-consuming, comprehensive sampling" you mention. Isn't that exactly what has been done here? You used low-resolution screening in the MBS Main core (ie comprehensive sampling) to identify more specific targets in the MBS-Alpha core. This is Figure 2. Then you used the tephra geochemistry to ID the most likely volcano, and atmospheric modeling to ensure that cryptotephra from that eruption could realistically be transported to MBS. Unless I am missing something, the atmospheric modeling did not help target specific sampling depths as implied by the writing. "Atmospheric-transport focused sampling" is also mentioned on line 514 and throughout the discussion.

> *First, we would like to clarify that the first-pass screening sampling was not a comprehensive sampling of every cm of the core. We see now that this was not clear in the methods section as written, and have added text to clarify that broad sample depth ranges were selected from the*

main core based on HYSPLIT trajectory analysis, and these sections were used in the first-pass coarse-resolution sampling to be used to target further sampling from the Alpha core.

We have added text to sections "Atmospheric circulation modelling" and "Ice core sampling" that describes in more detail how the HYSPLIT trajectories were used to guide the selection of samples used in the first-pass "screening" sampling. This should provide clarity on the sampling strategy used, and the use of trajectory modeling in the process, as well as provide context for the section noted above (lines 496-504), such that it makes sense to leave that section of the text as-is.

Line 520- "The size of the eruption and location of the volcano have typically been the criteria guiding sampling" should be refined. While many studies are designed to search for known eruptions in polar ice, there are many that seek to identify the source of large sulfate anomalies in the ice that do not have known sources (often the presence/absence of insoluble particles associated with a sulfur peak also factors in (eg Abbott et al., 2024, Gabriel et al., 2024, Hutchinson et al., 2024a,b, Plunkett et al., 2023)). So for known events, the size/location of the eruption itself is important, but for unknown eruptions it is often solely the magnitude of the observed sulfur anomaly in the ice that is the factor (since the location is often not known at the time of sampling). Just a subtle difference, I suppose.

We thank the reviewer for raising this subtle but important omission. We have added text to reiterate the use of sulfate and insoluble particles in other ice core tephra studies. The text now reads as follows at lines 522-524: "... In the case of known eruptions, the size of the eruption and the location of the volcano are often the criteria guiding the sampling of Antarctic ice core for tephra and crypotephra, while unknown eruptions are often identified through the presence of associated sulfate and/or insoluble particle anomalies*.…"*

Other Comments

Line 22- 'typically ash sized' - what does that mean more specifically? And this contradicts line 31 that says they are typically micrometer-scale volcanic glass shards (e.g. cryptotephra) which I would agree more with. Would it make more sense to just say "the use of visible tephra and microscopic cryptotephra"?

*As the term is used here, ash is defined in the volcanology community as any tephra smaller than 2 mm (McPhie et al., 1993). Text has been added to clarify this size range definition for "ash sized." (Text now reads: "*typically ash sized (≤ 2 mm; McPhie et al. (1993))*"*

Section 2.4- I commented on this in the previous review and I still stand by my previous comment that this whole section could be a sentence or two. There is nothing wrong with just saying "the approximate seasonal timing of eruptions was estimated by linear interpolation between austral summer peaks in sulfate/Cl and austral winter peaks in Na". Nothing else said here is unique to MBS…all ice cores have variability in annual accumulation that make seasonal evaluation uncertain.

While we understand that all ice cores have some variability in annual accumulation rates, it became clear during chronology development that the MBS cores have a much higher variability

in annual layer thickness than even we expected for a coastal site. In the 20 m Alpha core, the annual layers vary from 0.226 m to 0.854 m thick (firn depth).

Previous analyses of the MBS cores have shown that accumulation at the MBS site is disproportionately driven by extreme precipitation events. Jackson et al. (2023) found that extreme precipitation events at MBS (on average 6% of days) account for over 50% of annual snowfall, and extreme events are responsible for 88% of the inter-annual variability in accumulation. This means that extreme events are overrepresented in the ice that makes up the MBS cores, meaning that linear interpolation is a more flawed than usual method for this site (and all sub-annual dating should be taken with a large grain of salt).

We have added some clarifying text to this point, and rearranged and shortened this section, removing unnecessary text to keep the section as brief as possible, while reiterating the extreme caution that must be taken when considering the sub-annual dates presented in this work.

Line 352- Typo- "see section ??"

Corrected

Line 513- Typo- "?"

Corrected

Abbott, Joseph R. et al., Mid-to Late Holocene East Antarctic ice-core tephrochronology: Implications for reconstructing volcanic eruptions and assessing their climatic impacts over the last 5,500 years, Quaternary Science Reviews, Volume 329, 2024, https://doi.org/10.1016/j.quascirev.2024.108544.

Gabriel, I., Plunkett, G., Abbott, P.M. et al. Decadal-to-centennial increases of volcanic aerosols from Iceland challenge the concept of a Medieval Quiet Period. Commun Earth Environ 5, 194 (2024). https://doi.org/10.1038/s43247-024-01350-6

Hutchison, W., Gabriel, I., Plunkett, G., Burke, A., Sugden, P., Innes, H., et al. (2024). High-resolution ice-core analyses identify the Eldgjá eruption and a cluster of Icelandic and trans-continental tephras between 936 and 943 CE. Journal of Geophysical Research: Atmospheres, 129, e2023JD040142. https://doi.org/10.1029/2023JD040142

W. Hutchison, et al., The 1831 CE mystery eruption identified as Zavaritskii caldera, Simushir Island (Kurils), Proc. Natl. Acad. Sci. U.S.A. 122 (1) e2416699122, https://doi.org/10.1073/pnas.2416699122 (2025).

Plunkett, M. Sigl, J. R. McConnell, J. R. Pilcher, N. J. Chellman, The significance of volcanic ash in Greenland ice cores during the Common Era. Quaternary Science Reviews 301, 107936 (2023).

Jackson, S. L., Vance, T. R., Crockart, C., Moy, A., Plummer, C., and Abram, N. J.: Climatology of the Mount Brown South ice core site in East Antarctica: implications for the interpretation of a water isotope record, Climate of the Past, 19, 1653–1675, https://doi.org/10.5194/cp-19-1653-2023, 2023.

Reply to anonymous reviewer #2:

Thank you for replying and addressing all of my comments. I recommend this manuscript to be accepted for publication in Climate of the Past after addressing these minor comments:

We thank the reviewer #2 for the feedback, and have addressed the minor comments as described below.

1. Please include a legend and a scale bar in Figure 1.

*A scale bar has been added to the map. Caption has been updated to specify the symbology of the map (caption now reads: "*Map of Antarctica showing the location of the ice core sites (blue circles) and volcanic regions of interest (red triangles) relevant to this study*.").*

2. In the caption for Figure 1, please explain why some elements are grayed out.

*This has been clarified in the caption (caption now reads: "...*Locations directly related to this study (Mount Brown South, McDonald Islands, Erebus, and Cerro Hudson) are shown in bold colors/text*.")*

3. There is a symbol for the Roosevelt Island ice core in Figure 1, but it is not labeled. I suggest either removing the symbol or adding a corresponding label.

Label has been added to the map.

4. Line 60 states that the core is 290 m, while Line 81 indicates is 294.785 m depth. Please verify the consistency of these lines.

These two statements are correct as written. In line 60, the length of the MBS-Main core is approximated as 290 m. The core, however, was not drilled from the surface, and as such, at line 81, it is stated that the MBS-Main core is 4.25-294.785 m depth (which is a length of 290.535 m). The top 4.25 m depth was not included in the main core, as the drill required a trench to be dug to accommodate the tilting of the drill tower. This depth is covered by the corresponding shallow cores (Alpha, Bravo, and Charlie), which were drilled from the surface (using a handheld Kovacs core drill).

*To provide additional clarity at line 60, the text has been updated to read "*The Mount Brown South (MBS) ice cores, comprising an intermediate ice core (~290.5 m in length) and three surface cores (~20 - 26 m in length)*..."*

5. I noticed several question marks ("?") throughout the revised manuscript. Please consider addressing these before final submission (e.g., see lines 402 and 700 in the manuscript with track changes).

These typos have been corrected.

6. Lines 578-579: "We expect that other cryptotephra layers exist in the MBS-Alpha ice core, transported atmospheric pathways not highlighted here," please check if this sentence is clearly written.

*Thank you for pointing this out. We agree that the original wording was not clear. The text has been updated to read as follows: "*We expect that other cryptotephra layers exist in the MBS-Alpha ice core, transported by atmospheric pathways not used to guide the sampling performed in this study*."*