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. Line numbers in this document refer to the revised manuscript.

Authors' comments:

We would like to thank the reviewers for reviewing the revised manuscript and providing thoughtful feedback. Here, we address the remaining comments from Reviewer 1, both below and in the manuscript text. Replies to the reviewer comments are provided in blue italicized text below.

Reply to Anonymous Referee 1:

Thank you for addressing my comments so far. I apologize for being the unrelenting reviewer, but it is still not clear to me how HYSPLIT factors into the initial low-resolution sampling plan for MBS-Main as stated. The approach to me still seems in line with previous studies where low-resolution screening across a large portion of the core is used to guide higher resolution sampling. This is my only qualm, and I would not feel so strongly about it if it were not emphasized as a new/improved approach in the abstract ("We utilize a novel cryptotephra sampling plan, integrating ice core data, HYSPLIT air parcel trajectories, and known eruption records"), conclusion ("We developed a sample depth selection strategy for identifying potential ice core depths containing cryptotephra in an East Antarctic ice core using a combination of ice core chemistry, known eruption events, and atmospheric transport modeling."), discussion ("Here, we have incorporated recent advances in atmospheric modeling that enable the hindcasting of atmospheric circulation processes relevant to the deposition of cryptotephra (over the satellite era). This allowed the development of a more efficient sampling strategy for the MBS ice core…"), and elsewhere throughout. Without those statements, I would not have any problems with publication, as the tephra identification and linkages to sources is robust.

> *Thank you for the thoughtful feedback. We have further revised the text in response to the specific comments below.*

First, do the depths/ages chosen for low-resolution screening in MBS-Main (which go on to underpin all the subsequent higher resolution tephra analyses) all align with meridional transport per lines 126 to 127? If so, how were the 40 years' worth of 6 hourly trajectories evaluated for meridional transport? Visually? An algorithm? A previous study (e.g. the HYSPLIT clusters from Jackson et al, 2025)? If ~65% of the MBS-Main core (65 samples @ ~16.5 cm = 10.7 m out of the ~16 m (4.25 to ~20 m) corresponding to the satellite era) was used for the low-resolution screening, does this imply that ~65% of the time there was meridional transport to the site? Please specifically explain how HYSPLIT was used to guide the sampling depths chosen.

> *The HYSPLIT trajectories were one of three criteria used in our sampling strategy. While HYSPLIT is often used as a tool for validation of ice core cryptotephra correlations, its use in targeting sampling is uncommon, and therefore notable in our methods. Favorable transport*

conditions were cross-referenced with recorded regional eruption events and considered alongside volcanic signatures in the ice chemistry record of MBS. The three criteria were used in conjunction with each other, however additional samples were chosen based on compelling volcanic signals in the ice core chemistry record and/or known significant eruption events. Text has been added to the Atmospheric Circulation Modeling and Ice Core Sampling sections to describe in more detail how favorable transport was assessed, and clarify that trajectory analysis was one element of our multi-pronged sampling strategy (lines 109-125).

To clarify further, HYSPLIT trajectories were used both to guide the sampling as well as to validate the proposed tephra correlations. We have updated the text to clarify the two distinct usages of HYSPLIT and how we defined "favorable transport" conditions as a component of our sampling strategy.

Second, why is it assumed that meridional transport is the most favorable condition for tephra deposition? Doesn't the identification of Erebus as one of the two confirmed tephra matches contradict this? Isn't Erebus to MBS completely zonal transport? Figure 10 shows that Erebus is in the >0.1% trajectory zone which is essentially all regions south of ~45-50 deg S (a huge area). So while transport of Erebus ash is consistent with HYSPLIT in retrospect, how can HYSPLIT be used as a tool for informing tephra sampling beforehand when such a large region is in play according to its trajectories? HYSPLIT doesn't seem to be a useful forecasting tool for this case.

Our approach regarding meridional pathways as favorable for tephra transport was guided by previous studies of both the climatology of the MBS site, as well as general moisture transport and accumulation regimes in coastal East Antarctica. Impurity flux/accumulation at MBS is dominated by wet deposition (Crockart et al., 2021), and thus, with appropriate conditions, significant precipitation events would favor tephra deposition. Jackson et al. (2023) highlight the disproportionate role of meridional transport on accumulation at MBS, and Wille et al. (2021) and Turner et al. (2022) emphasize the importance of atmospheric rivers and maritime moisture intrusion on accumulation in the coastal Antarctic - by definition, AR-associated precipitation is meridional (southward) transport (see Wille et al., 2019)

While the previous revision of the manuscript highlighted the somewhat surprising/contradictory nature of finding Erebus tephra based on both our sampling plan as well as the traditional assumptions of the dominant regime of westerly wind transport, we've added text (lines 592-595) to highlight that we were surprised by our finding of Erebus tephra, especially when considering the nature of our sampling plan and expectation that the tephra identified would be more likely to originate from McDonald Islands. While we agree that there is a large region at play for potential transport to MBS, it is worth noting that the frequency area covering Erebus represents less than 1% of trajectories. Additionally, while our sampling plan was based in part on individual successful daily trajectories, the 5 cm samples are presumed to cover weeks to months of accumulation, so it is logical that accumulation sourced during other atmospheric conditions occurring within the sample resolution could be contained in these samples.

HYSPLIT was used here to target meridional transport, and we have taken care in the manuscript to avoid the assertion that this type of sampling plan can be used to capture 100% of all findable cryptotephra in any ice core. The only way to do so would be to comprehensively sample the entire core, which can be prohibitively time consuming and labor intensive. In the discussion section "MBS as cryptotephra archive" we use the success of identifying tephra in the MBS as an argument in favor of further more comprehensive sampling of the MBS cores when time and resources allow, as we have demonstrated in this work that MBS holds significant potential as a cryptotephra archive - a fact that was not necessarily considered, or self-evident during site selection for the ice core.

Third, the implication is that HYSPLIT can be used to strategically guide tephra sampling and therefore reduce the number of required samples for tephra work- a better method per se. But how can an evaluation like this be made without data to compare to from the unsampled ice (presumably corresponding to 'unfavorable' transport conditions) or other studies? The success rate of finding tephra in the HYSPLIT-favorable conditions was ~33% (22 out of 65 samples)- is that a meaningful improvement over studies that have just searched for tephra throughout an entire core?

While it would be interesting and valuable to compare our targeted method to a comprehensive sampling method performed on the same core, this work was part of a project where outside limitations made it infeasible to perform a comprehensive sampling of the entire core. As stated above, we use this work as grounds to advocate for the devotion of resources to further cryptotephra analysis on the MBS cores.

From these comments, we see that providing context of other studies would be helpful in underscoring the success of the methods used. While it may not seem so, identifying tephra in 33% of first-pass samples (and 17% of high-resolution samples) is an exceptionally high success rate compared to many other studies. To provide some context: Cook et al. (2022) used "broad, semi-continuous sampling" for cryptotephra in NGRIP (28 horizons identified out of 546 samples - ~5% success rate) and GRIP (22 horizons identified from 330 samples - ~6% success rate). Coulter et al. (2012) sampled for cryptotephra in a Greenlandic ice core with sampling based on known eruptions and volcanic markers, and found 17 tephra horizons from their 695 samples (~2% success rate). Abbott et al. (2023) employed a very targeted sampling strategy based on known particle count and sulfate chemistry anomalies, targeting 63 events across 2 East Antarctic ice cores, and found 15 horizons (~24% success rate). While none of these studies and sites are directly comparable to MBS, they provide helpful background on the typical success rates in cryptotephra work, even in tephra-rich ice cores from Greenland. We think the 33% success rate for our first-pass sampling is therefore an effective and significant improvement.

We have added text in Section 5.1 (lines 518-524) to contextualize this work in comparison to the tephra sampling efforts presented in other studies.

I apologize if I am missing something, but the way authors state they use HYSPLIT is still not clear or justified as a tool for strategically sampling the ice as written. It seems like revisions are needed to better

justify this approach if the authors insist on keeping it, or minor changes to simply de-emphasize the use of HYSPLIT as a prognostic tool.

> *We hope that the revisions and replies provided here clarify the use of HYSPLIT and the sampling strategy used here more generally. In addition, we have altered the wording in some of the sections highlighted by Anonymous Referee 1 above (lines 5, 525-527, and 652-653), to retain focus on the results of our study, over the evaluation of the specific sampling strategy employed.*

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