Author comments:
We thank the reviewer for taking the time review the manuscript and provide thoughtful and constructive feedback. All comments and suggestions have been addressed, please see the below replies in blue italicized text.

Reply to anonymous reviewer (RC2):

The manuscript by Harlan et al. presents a complete and thoughtful investigation of cryptotephra preserved in Mount Brown South ice core layers. They assess the presence of volcanic ash in ice layers, propose potential volcanic sources and aim to characterise transport pathways in a data-sparse region of Antarctica. This manuscript is interesting and relevant and should be considered for publication in Climate of the Past. However, some points need to be discussed before acceptance for publication in Climate of the Past.

> *We thank the reviewer for the positive review and thorough comments, which will strengthen our manuscript.*

Main comments:

- A low-resolution screening was first applied to identify the presence of tephras in bulk samples which analysed a small cross-section (2cm^2) of the MBS-Main core. Then, only samples with tephras were explored in the same layers of MBS-Alpha, this time analysing a larger cross-section (10cm^2). The manuscript discusses in depth the layers with cryptotephras in MBS-Alpha, however, there is no mention of the number of cryptotephras found in MBS-Main or discussion about potential misses of cryptotephra layers in MBS-Main due to the small cross-section analysed. Presenting the results from MBS-Main and discussing potential limitations due to the small cross-section used for the low-resolution screening will help to improve the manuscript.

> *While we agree that presenting the full results from the MBS-Main sampling would strengthen the results here, there were a number of complications with the MBS-main analysis. Due to the small cross section outer edge sample available, we were not able to follow adequate sample cleaning/decontamination procedures. We were therefore not able to constrain the potential for contamination both in terms of potential transfer from one core depth to another and from general lab contamination debris obscuring potential tephra and limiting our ability to form robust identifications. Additionally, due to the sample preparation methods used for the MBS-Main samples, we were not able to reliably section the tephra grains for SEM/EPMA analysis and were thus required to rely only on optical microscopy for these samples. We will update the text to clarify these limitations and provide as much detail from MBS-Main as we are able. Despite these limitations, we were able to use the samples from MBS-Main as a valuable screening tool guiding our subsequent resampling of the MBS-Alpha core.*
>
> *We will clarify the limitations faced with the MBS-Main samples in the text, and better describe the valuable role they played in guiding our high-resolution sampling strategy.*

- The manuscript describes the method used to sample cryptotephras. Samples were melted inside Whirl-pack bags and then centrifuged inside centrifuge tubes. While moving samples with low-concentration insoluble particles from one container to another, there is always a risk of leaving some of these particles behind, potentially biasing the sample that will finally be analysed. Were there any measures in place to ensure that cryptotephras were not left behind while preparing the samples? Adding this information or including this subject as a potential limitation will help improve the manuscript.

We took careful precautions to ensure the transfer of as much material as possible by rinsing all whirl-pak bags and glass/plasticware (including centrifuge tubes and transfer pipettes) multiple times with ultrapure water to capture as many particulates as possible from the samples. We will update the methods with more detail on the steps taken to prevent loss of tephra in the sample preparation.

- The manuscript discusses the presence of small numbers of cryptotephras found in scattered MBS-Alpha layers. The temporality of these layers indicates these particles are not linked to specific eruptions. Based on this evidence, the authors classify them as background cryptotephra. While these particles could be background cryptotephra, in the absence of more information, they could also be contamination introduced while handling or in the lab environment. Were there any measures or protocols followed while processing the samples which can ensure that those particles were originally inside the ice? Adding this information or including this subject as a potential limitation will help improve the manuscript.

Careful decontamination processes were taken during the cutting and bagging of the MBS-Alpha ice samples, which were not possible with the MBS-Main samples. MBS-Alpha samples were cut and decontaminated (removal of the outer layer of ice from each sample using a ceramic blade as described in line 115) under a laminar flow hood in the cold room. The cutting surface and blades were wiped clean with isopropanol between each individual ~5 cm sample, and both the ceramic blade used and the cutting surface (a clean, new plastic cutting board) were changed and washed with ultrapure water between samples from each meter of core (e.g. a freshly washed blade and cutting board were used for samples from MBS-Alpha 14, and then washed before decontamination of samples from MBS-Alpha 15).

In addition to the decontamination procedures, we also chose to focus our source identification only on samples containing multiple (>3) glass shards of reasonably homogeneous composition, in order to minimize the chances of making source identification claims about artificially introduced particles (contamination).

We will include text (either as a supplementary methods document or directly in the text) to clarify the steps taken to prevent contamination between samples.

- Throughout the manuscript, it is highlighted that MBS has strong teleconnections with low latitudes and is well connected with the southern Indian Ocean. If MBS is so well connected with the Southern Indian Ocean and low latitudes, why are there no cryptotephra layers found for the mentioned Heard Island eruption (1997) and Pinatubo (1991)? Currently, there is no discussion in the manuscript addressing this issue. The unexpected presence of Erebus cryptotephra is discussed and highlighted as an anecdotic case. However, the wide presence of unexpected Erebus cryptotephra highlights more the absence of the eruptions that "should" have been present in MBS layers. The absence of these expected eruptions highlights the transport of cryptotephra to MBS may be highly biased by the occurrence of favourable atmospheric conditions. Incorporating this topic into the discussion section will help improve the manuscript.

Thank you for raising this point. We agree, and were also surprised to find such robust tephra from Erebus and none from a more proximal and "obvious" source like Heard Island! We agree that this highlights the significant role of favorable atmospheric transport conditions in what tephra get deposited at a specific site. We will expand the discussion section to address this.

Minor comments:

Line 26: for reference, specify the distance you are considering when classifying something as distal or ultra-distal.

We will add definitions to the text to this end.

Line 37-38: The Chichon (1982) Eruption is mentioned here but not mentioned again throughout the text. Given its magnitude and relevance, I thought this eruption was going to be discussed as a potential source for the 1985 layer.

While signals from El Chichon 1982 eruption have been reported in Antarctic ice, we do not consider it a potential source as the dating of the MBS cores is robust, with uncertainties less than 3 years at this depth, and we would expect tephra deposition to occur on a much shorter timescale than 3 years.

Line 44: higher resolution or higher accumulation?

Higher accumulation. We will correct the text accordingly.

Line 48 and throughout the text: usually the satellite era is considered as the interval from 1979 to present

We will update the text accordingly.

Figure 1: The text mentions many sites which are not included in this map (e.g. Siple, Vostok, Talos, Law Dome, Puyehue). I suggest incorporating them for the reader to understand where those sites are located.

We will update the map to include additional sites relevant to the text.

Lines 73-74: specify that the units are “meters depth” for all cores, as done for the MBS-Main core

We will correct this.

Lines 75-76: what does IE stand for? Ice equivalent? Please, specify.

Yes - IE is ice equivalent here. We will update the text accordingly.

Lines 79-84 and throughout the text: Please, specify that you are referring to “stable water isotopes”

We will update the text throughout to specify stable water isotopes.

Line 90: Please specify if you refer to marine fertilization or soil fertilization

We are referring here to ocean fertilization. We will specify this in the text.

Line 91: towards

We will correct this.

Lune 94: ~20 meters depth

We will correct this.

Line 106: please, add further details about the containers where the samples were placed. Were those bottles new? Were they pre-cleaned?

As described in the previous comment above, we will expand the text in the methods section to better describe the decontamination and sample preparation procedures used.

Figure 2a: apparently there is no point (4) in the diagram

Thank you for pointing this out. We will correct the figure accordingly.

Line 147: Please, specify which 14 major and minor elements were measured

We will update the text to specify.

Line 157: the text specifies that totals below 60% are considered with caution. It would be useful if those samples were specifically labelled in the text and figures

The few (5 total) samples with totals below 60% are indicated in Table 2, and only one of these low-total samples are included in one of the tephra horizons that we identify a source correlation for (17-9_009). We will update the text to include wording that specifically indicates which samples have low analytical totals and refer the reader to the supplementary information for the analytical totals of all provided measurements.

Line 163: Is there a particular reason why using 1500 AGL instead of other elevation?

Back trajectories were initiated at 1500 m AGL, which at the MBS site, corresponds to approximately 3500 m ASL. A starting height of ~1500 above the ice core site was selected to reduce impacts on the trajectory due to interaction with the surface topography of the surrounding area and minimizes the chance of the long (10-day) trajectories "hitting the ground" and losing accuracy.

Line 169: The line starts stating that there were glass shards in 48 out of 70 samples, however, after SEM analyses, this number fall to 29. This suggests that the initial 48 samples had, in fact, "potential glass shards". Please, consider correcting this at the beginning of the paragraph

We will update the wording to specify potential glass shards here.

Figure 5: there are no details about how the nssSO4 was calculated. if it was calculated using Na+ or Cl-

The non-sea salt sulfate was calculated following Plummer et al., (2012): nssSO2− 4 = [total SO2− 4] − (0.1201 − r)· [Na+]. We will add text to section 3.3 to specify the calculation used.

Line 261: for temporal reference, consider adding the dates when the eruptions happened

We will add the respective dates for the two eruptions.

Line 291: identified, instead of identify

We will update the text accordingly.

Lines 309-331: If MBS is so well connected with the Indian Ocean, why are there no cryptotephras from Pinatubo or Heard island?

We were also surprised to find such robust tephra from Erebus and none from a more proximal and "obvious" source like Heard Island, or a globally significant eruption like Pinatubo. We argue that this highlights the significant role of synoptic-scale favorable atmospheric transport conditions in what tephra get deposited at a specific site. We will expand the discussion section to address this.

Line 398: were instead of are

We will update the text accordingly.

Line 432: Consider specifying a year for Krakatau and a year for Tarawera, as they happened during different years

Thank you for catching this error! We will update the text to include the correct eruption years for the specific eruptions.

Line 442: consider adding "is viable" after MBS

We will update the text accordingly.

Lines 444-470: Evidence presented in this manuscript supports Erebus cryptotephra made it to MBS. Did other, closer cores (e.g. Talos, Taylor, Gv7) have 1985 Erebus cryptotephra?

While we are not aware of other cores containing (crypto)tephra from the 1980s eruptive activity of Mt. Erebus, there are several potential correlations of tephra to other periods of Mt. Erebus eruptive activity in more proximal sites (including Narcisi et al., 2010, Iverson et al., 2014, and Harpel et al., 2008)

Line 463: consider replacing "satellite image evidence" with "remote sensing evidence"

We will update the text accordingly.

Line 471: tephra or cryptotephra?

Cryptotephra - this will be specified in the text.

Line 481: The line states that there is a cluster of 14 shards, but Table 1 shows only 13

This is a mistake and will be corrected in the revised text.

References:

Harpel, C., Kyle, P., and Dunbar, N.: Englacial tephrostratigraphy of Erebus volcano, Antarctica, Journal of Volcanology and Geothermal Research, 177, 549–568, *https://doi.org/https://doi.org/10.1016/j.jvolgeores.2008.06.001, volcanology of Erebus volcano, Antarctica, 2008.*

Iverson, N. A., Kyle, P. R., Dunbar, N. W., McIntosh, W. C., and Pearce, N. J. G.: Eruptive history and magmatic stability of Erebus volcano, Antarctica: Insights from englacial tephra, Geochemistry, Geophysics, Geosystems, 15, 4180–4202, https://doi.org/https://doi.org/10.1002/2014GC005435, 2014.

Narcisi, B., Petit, J. R., and Delmonte, B.: Extended East Antarctic ice-core tephrostratigraphy, Quaternary Science Reviews, 29, 21–27, https://doi.org/10.1016/j.quascirev.2009.07.009, 2010.

Plummer, C. T., Curran, M. A. J., van Ommen, T. D., Rasmussen, S. O., Moy, A. D., Vance, T. R., Clausen, H. B., Vinther, B. M., and Mayewski, P. A.: An independently dated 2000-yr volcanic record from Law Dome, East Antarctica, including a new perspective on the dating of the 1450s CE eruption of Kuwae, Vanuatu, Climate of the Past, 8, 1929–1940, https://doi.org/10.5194/cp-8-1929-2012, 2012.