We are very grateful to Anonymous Referee #1 for his specific and valuable suggestions on our manuscript. The manuscript has been modified. In the following, the comments from Referee #1 are in black, and our responses are in blue.

RC1: 'Comment on egusphere-2026-769', Anonymous Referee #1, 06 Apr 2026

An et al. provide a volcanic record for the past 4ka from Dome A. The record is based on sulfate measurements and volcanic matching to the WAIS Divide ice core. The identification of volcanic events follows established methods and seems robust. The dating also appears reasonable. The record is largely similar to other Antarctic ice core records, while raising some intriguing questions about the relative magnitude of deposition around Antarctica.
Thanks for the comments.

The main question I had while reading this manuscript is why more effort was not put into matching the volcanic events with Dome C and South Pole (SPICEcore) , in addition to WAIS Divide. Yes, WAIS Divide has the benchmark chronology, but it has been transferred to the volcanic events at both Dome C and South Pole, which are both considerably closer to Dome and more similar in climate characteristics. That, the volcanic matching to Dome C and South Pole should be more robust. Both cores have publicly available sulfate data (https://www.usap-dc.org/view/dataset/601850 and https://www.usap-dc.org/view/dataset/601759).
Thanks for the suggestion. Volcanic signal matches to the Dome C and South Pole ice core records have been added as follows.

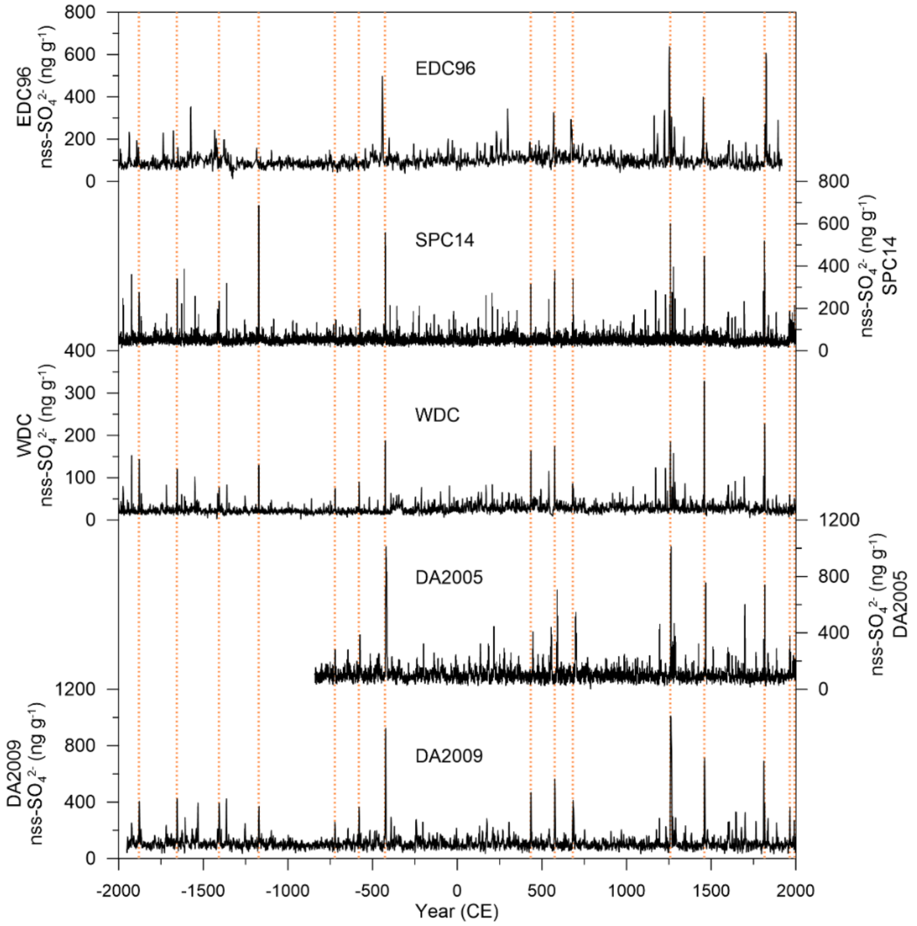

Figure S1: Non-sea-salt sulfate ($nssSO_4^{2-}$) concentration records from five Antarctic ice cores between 2000 BCE and 2000 CE. The records (line in black) are from: DA2009 (Dome A; this study), DA2005 (Dome A; Jiang et al., 2012), WDC (WAIS Divide; Cole-Dai et al., 2021), SPC14 (South Pole; Brandis, 2022), and EDC96 (Dome C; Castellano et al., 2005; Severi et al., 2020). The orange dashed lines indicate the 15 tie-points of volcanic matching between the DA2009 and WDC records.

I would also be interested in seeing the patterns of volcanic events in the sulfate records matched instead of just the inferred event fluxes. Matching of individual events is less compelling, especially when very large events like Tambora can be missing the Dome A record and the 1809 Unknown vent is larger. This raises the possibility of mis-identification, and additional figures and support for the matching of patterns of events would be help establish the specific reliability of the Dome A timescale.

Thanks for the suggestion. The overall pattern of volcanic events derived from the sulfate records is illustrated in Figure S1 above, while detailed features of the tie-point events are presented in Figure S2-S7 below.

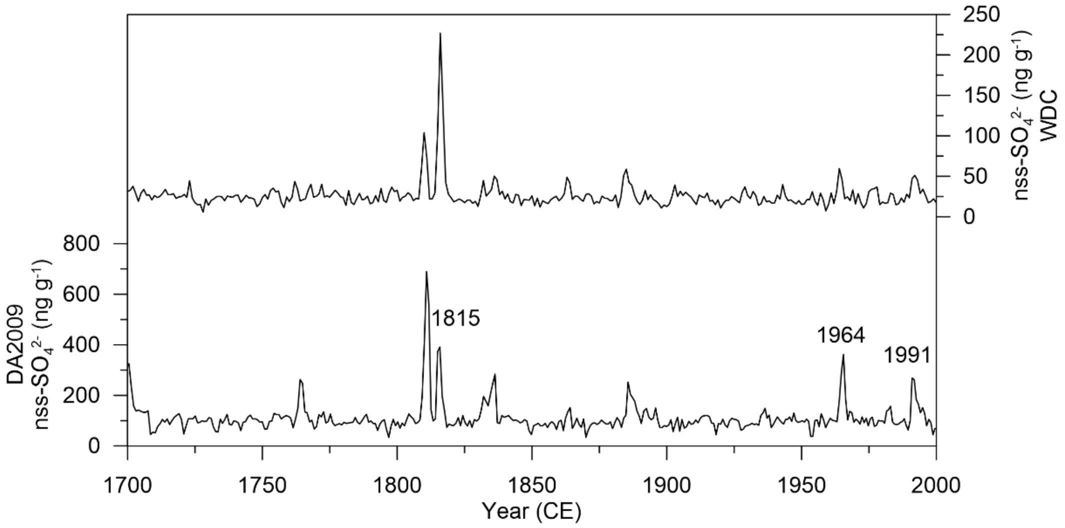

Figure S2: Non-sea-salt sulfate ($nssSO_4^{2-}$) concentration records from DA2009 (bottom) and WDC (top) ice cores between 1700 and 2000 CE showing the year of volcanic tie-points.

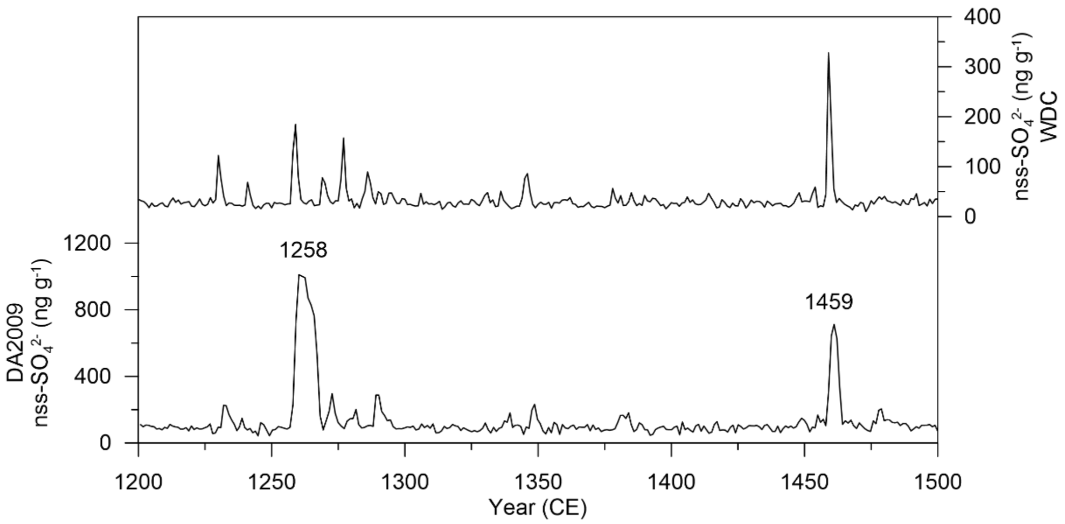

Figure S3: Non-sea-salt sulfate ($nssSO_4^{2-}$) concentration records from DA2009 (bottom) and WDC (top) ice cores between 1200 and 1500 CE showing the year of volcanic tie-points.

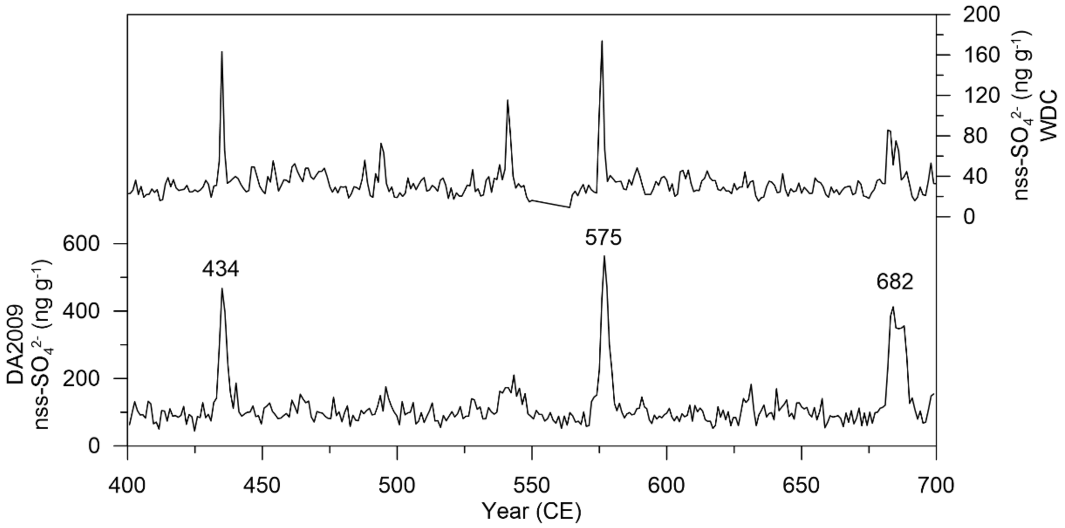

Figure S4: Non-sea-salt sulfate ($nssSO_4^{2-}$) concentration records from DA2009 (bottom) and WDC (top) ice cores between 400 and 700 CE showing the year of volcanic tie-points.

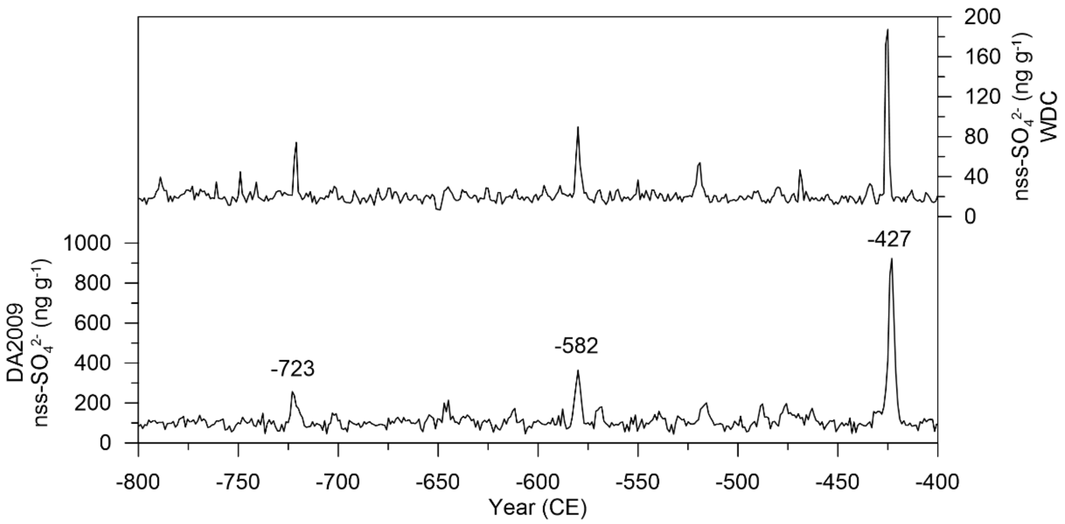

Figure S5: Non-sea-salt sulfate ($nssSO_4^{2-}$) concentration records from DA2009 (bottom) and WDC (top) ice cores between 800 and 400 BCE showing the year of volcanic tie-points.

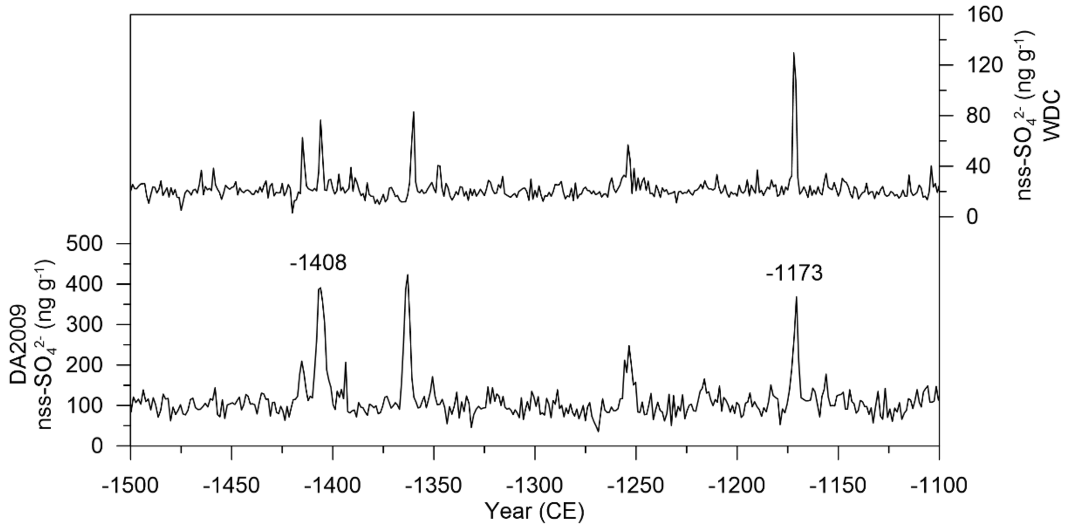

Figure S6: Non-sea-salt sulfate (nssSO_4^{2-}) concentration records from DA2009 (bottom) and WDC (top) ice cores between 1500 and 1100 BCE showing the year of volcanic tie-points.

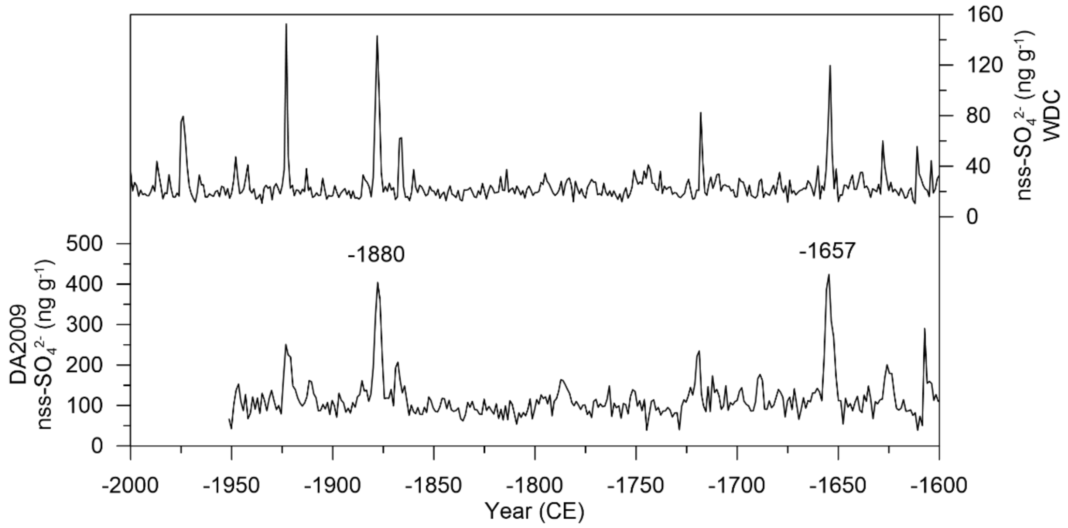

Figure S7: Non-sea-salt sulfate (nssSO_4^{2-}) concentration records from DA2009 (bottom) and WDC (top) ice cores between 2000 and 1600 BCE showing the year of volcanic tie-points.

In conclusion, I recommend publication after some revisions that more fully incorporate at least the Dome C and SPICEcore sulfate records.

Thanks for the comment. The ice core sulfate records from the Dome C and South Pole have been more comprehensively incorporated into the revised manuscript.

General Comments

-Provide density data used to convert to an accumulation rate.

The density data has been shown in figure 6 as follows:

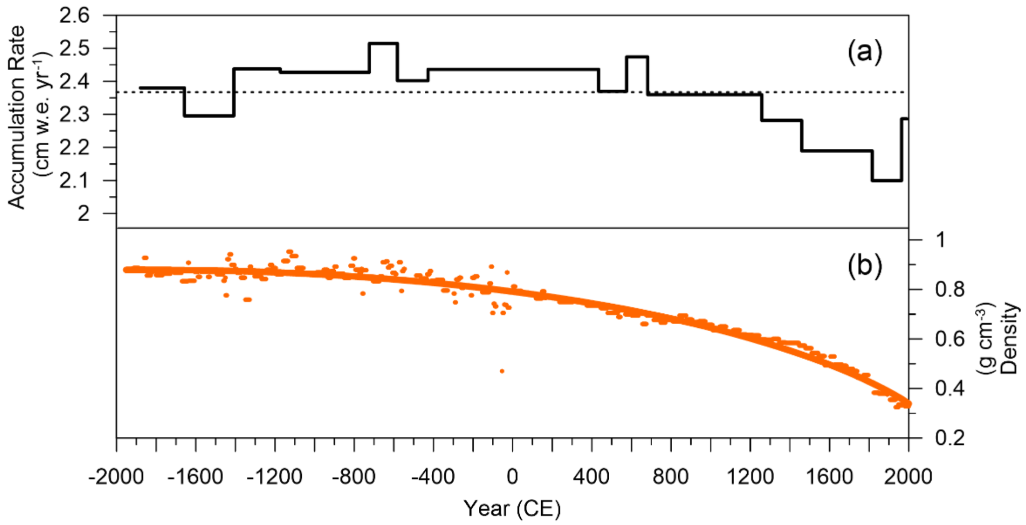

Figure 6: (a): Snow accumulation rates (black solid line) at Dome A over the past 4000 years derived from the DA2009 ice core. Horizontal dashed lines indicate the mean value of the time series. (b): Measured (orange dots) and polynomial-fitted (orange line) ice core density profiles.

Specific comments

L82 – Cole-Dai, 2010 seems like a strange reference for this given how many papers were written before this

Thanks for your comment. We have added a comprehensive review paper by Alan Robock, published in 2000, to our reference list.

L105 – fewer significant figures given measurements precision

Thanks for the comment. We have supplemented the results of linear regression analysis. The revised text is presented below.

"Similar to other sulfate records from inland Antarctica, this profile shows no statistically significant trend. The linear-regression slope for $nssSO_4^{2-}$ versus depth is 0.006 ng g^{-1} m^{-1} ($p = 0.8$), with concentrations ranging from 33.84 to 1010.05 ng g^{-1}."

L117 – Why use WAIS Divide and not EDC, SPICEcore?

Thanks for the suggestion. Volcanic signal matches against the Dome C and South Pole ice core records are included in Figure S1. The WAIS Divide ice-core chronology serves as the benchmark, owing to its high chronological accuracy.

L130 – I don't understand how this is used to determine the dating uncertainty.

No ice layers within our record permit direct absolute dating. Given the well-constrained chronology from Sigl et al. (2016) — with an estimated uncertainty of less than ±5 years for the most recent 2500 years and <0.5% of the age for the remainder of the Holocene — we approximate our dating accuracy by comparing age offsets of moderate-to-large volcanic events (volcanic flux $\geqslant$ 5 kg km^{-2}), excluding established volcanic tie-points, between the two records.

L161 – Table 1 – how do you get the timing to a fraction of the year? Is this from WAIS Dvide? If so, isn't there a good chance the transport times are enough different to affect the precise dating? Need to define timescale

Decimals represent fractional time rather than months within a calendar year. Ages of volcanic chronological tie-points are sourced from the WAIS Divide chronology, in which fractional-year values were not used (Cole-Dai et al., 2021). The remaining ages are obtained through linear interpolation or extrapolation. If fractional-year values were not adopted for our DA2009 record, some adjacent samples would be assigned identical ages. Fractional-year ages are therefore applied to all samples to facilitate discrimination between neighbouring samples. Given that this notation is prone to ambiguity and that none of the identified volcanic events are coeval, we have revised the ages of all volcanic layers to integer values.

L175 – what about local volcanic events in the more active West Antarctica? And I don't think it's that volcanic deposition is different. I think it's that the snow accumulation at Dome A can be disrupted by wind scour/redeposition

Thanks for the comment. We have included the influences of local volcanic events and post-depositional processes in the manuscript, as follows:

"Furthermore, the low-accumulation-rate Dome A site is more susceptible to post-depositional processes such as wind scouring, while the low-elevation WAIS Divide site is more affected by relatively active local minor volcanic eruptions in West Antarctica. Both factors further amplify the aforementioned discrepancies."

L204 – This is a really weird table. I think it would be a lot easier to list the events and put their ranking. This doesn't make much sense to me in table form. Is there a way to show it graphically?

Thanks for the suggestion. We have converted the contents of Tables 2 and 3 into a figure, as shown below:

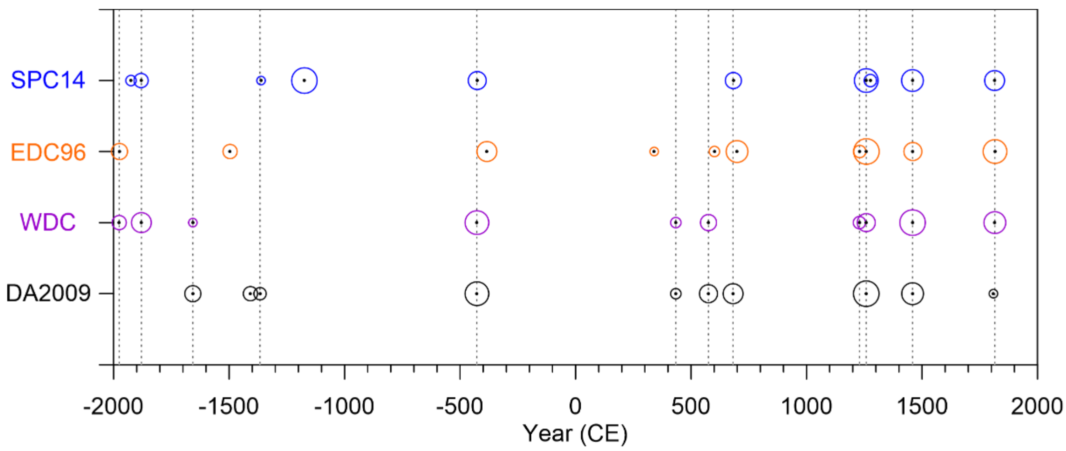

Figure 4: The above bubble plot shows the ten largest volcanic events by volcanic flux in DA2009 (black), WDC (pink), EDC (orange), and SP (blue) ice cores. For each ice-core record, circle size indicates relative volcanic-event intensity (order-of-magnitude ranking only, not absolute flux), where the largest circle represents the strongest event. The circle center (black dot) denotes the event timing, and all records share an identical scaling standard. The grey dashed lines mark volcanic events identified as top-ten magnitude eruptions in a minimum of two ice-core records.

L209 – This sentence needs to be reworded

We have revised the sentence, as quoted below:
"Long term variations in volcanic frequency and flux are of particular interest. On the one hand, they may reflect how volcanic activity responds to continental ice volume and sea level changes driven by climatic shifts (Rampino et al., 1979; Zielinski, 2000; Castellano et al., 2004). On the other hand, their cumulative effects could modulate long term climate trends (McGregor et al., 2015)."

L225 – I'm concerned that the volcanic frequency and flux cannot be used to reliably indicate an increase in the past millennium. For the two higher resolution cores, WDC and SP, the frequency of events does not stand out as being statistically significant. For the flux, there Is evidence of rapid diffusion in the firn, which would lead to older (deeper) events being broader in width, and thus having less sulfate cross the threshold, making them appear smaller. I'm concerned that in the low accumulation cores, DA and EDC, this is a preservation issue rather than a reliable signal. At the least, these conclusions should be tested statistically and issues discussed.
Thanks for the comment. We have analyzed more records and discussed possible influencing factors. The revised text is as follows.
"To facilitate comparison across different sites, millennial volcanic frequency and flux values from DA2009, WDC, EDC, and SP were normalized by the total for each record over the past 4000 years. The normalized frequency results indicate that 1000-2000 CE is the most volcanically active millennium in the DA2009, WDC, and EDC ice cores, with the strongest peaks observed in DA2009 and EDC (Fig. 5a). Although the SP core ranks this period as the second highest in frequency, its flux pattern is consistent with the other records. Similarly, normalized sulfate flux values show a clear millennial-scale maximum during 1000-2000 CE across all four cores (Fig. 5b). These findings seem to indicate that the period 1000–2000 CE is characterized by the strongest volcanic activity of the past 4,000 years, both in terms of eruption frequency and sulfate deposition across Antarctica.
To investigate whether the above phenomenon is widespread, we compiled ice core volcanic records from five additional Antarctic sites: DSS (Law Dome; Plummer et al., 2012), SDMA (Siple Dome; Kurbatov et al., 2006), DT-401 (East Antarctic Plateau; Ren et al., 2010), VK16 (Vostok; Veres et al., 2023), and DML05 (Dronning Maud Land; Traufetter et al., 2004). Owing to the limited temporal coverage of these records, a full analysis spanning the entire past 4000 years was not feasible. However, evidence from DA2009, WDC, and EDC records indicates that volcanic intensity during the 1000–1 CE period was comparable to or higher than that of the preceding two millennia (Fig. 5). Accordingly, characterizing the variation patterns over the past two millennia can largely validate the aforementioned hypothesis. We then compared the frequency and flux of volcanic events between the 2000–1000 CE and 1000–1 CE intervals across these records. Our results show that for the five sites (Law Dome, Siple Dome, DT-401, Vostok and DML05), the ratios of volcanic event count in the 2000–1000 CE interval to those in the 1000–1 CE interval are 1.31, 1.22, 1.90, 1.11 and 1.72, respectively. The corresponding ratios of volcanic sulfate flux are 1.80, 1.63, 1.88, 2.22, and 1.86, respectively. This finding provides robust evidence that, within the context of the past 4000 years, the peak volcanic intensity recorded in Antarctic ice cores during the 2000–1000 CE interval is a widespread phenomenon.
To determine whether this phenomenon reflects genuine volcanic activity, we must further account for the influences of other factors such as accumulation rate and diffusion. High accumulation

rates enhance wet deposition, which in turn elevates the flux of volcanogenic sulfate. However, at least in the DA2009 record, the 2000–1000 CE interval is characterized by relatively low accumulation rates (see next section for detailed discussion). Diffusion reduces the amplitude and broadens the width of sulfate peaks in older ice layers, which may result in the underdetection of volcanic events or underestimation of volcanic flux. If diffusion were the primary controlling factor, a progressive declining trend would be expected, yet no such trend is observed in Figure 5. Furthermore, previous research has demonstrated that the effective diffusivity of sulfuric acid in Antarctic ice cores is sufficiently low that Holocene volcanic events are not significantly impacted by diffusion (Fudge et al., 2024).

In summary, the 2000–1000 CE interval is the millennium with the highest volcanic intensity over the past 4000 years. This pattern is not only a widespread phenomenon across Antarctic ice core records, but also most likely represents genuine volcanic activity. Our results also support the previous findings that volcanic activity has increased in the past 2000 years compared with the previous 2000 years (Kurbatov et al., 2006; Castellano et al., 2005; Cole-Dai et al., 2000)."

L236 and Figure 5 – the accumulation history is interesting. First, it would be good to show and post the density data and determine the uncertainty. I wonder if the recent decrease is because of poor core recovery leading to densities that are too low. This should be considered and discussed.

Thanks for the suggestion. We have added a comparative analysis of accumulation rate versus density. The relevant revisions are detailed as follows.

"Variations in accumulation rate are governed by natural processes, yet the derived results can also be biased by sampling and measurement procedures. Substantial loss of snow-ice material during coring and sampling can yield markedly low density estimates, which in turn produce artificially low accumulation-rate values. To rule out this sampling-related artifact, we examined the density dataset of this ice core. The raw measurements (orange dots, Fig. 6b) show an overall stable trend without obvious outliers. To further mitigate potential biases originating from sampling and measurement, we performed a polynomial fit to the raw density data (orange line, Fig. 6b), and adopted this fitted curve for calculations of water-equivalent depth and accumulation rate. Density values along the fitted profile range from 0.34 to 0.88 g cm^{-3}. At the ice layer corresponding to the prominent drop in accumulation rate at 1258 CE, the density is 0.60 g cm^{-3}. Collectively, the influence of density artifacts on accumulation-rate reconstructions can be largely excluded."

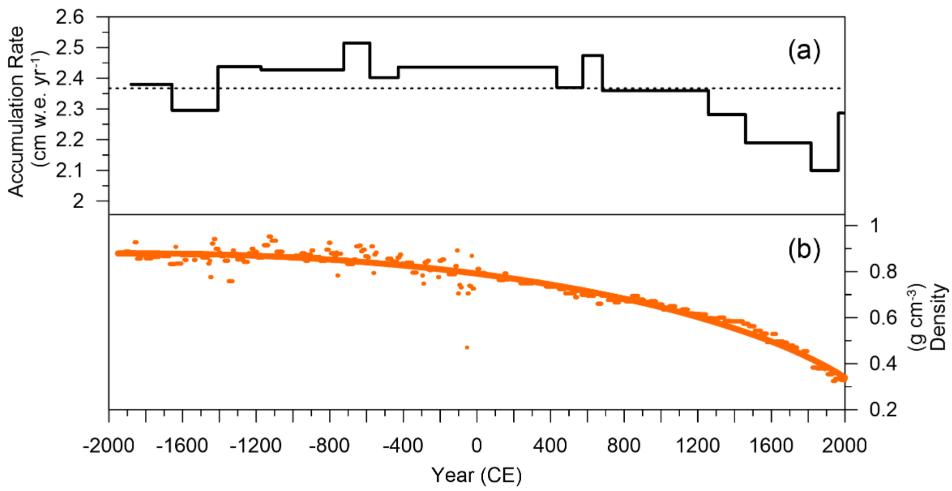

Figure 6: (a): Snow accumulation rates (black solid line) at Dome A over the past 4000 years derived from

the DA2009 ice core. Horizontal dashed lines indicate the mean value of the time series. (b): Measured (orange dots) and polynomial-fitted (orange line) ice core density profiles.

Data Availability – I appreciate the data being publicly available. I was able to download it without problem.

Thanks for the comment.

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