

Response to Referee 1

The referee comments are shown in black and are numbered sequentially as [R1-#1], [R1-#2], etc. Our responses are shown in blue.

We thank the referee for the careful and constructive review. In response to the comments, we will add (1) new age-based comparisons with other Greenland ice cores and a comparison with decadal-scale accumulation and isotope variabilities during the global warming era; and (2) a new analysis of post-eruption $\delta^{18}\text{O}$ and snow-accumulation responses. We will also clarify the method and the figures as described below.

[R1-#1] 'Comment on egusphere-2026-3602', Anders Svensson, 22 Aug 2026

The manuscript constructs a monthly-resolved time scale for the Greenland South East Dome II ice core covering the period 1871-2020 CE. The site is among the highest snow accumulation sites in Greenland and therefore uniquely suited for high-resolution studies. The study sets the foundation for interpretation of the highest resolved ice core records from Greenland covering the industrialisation and is thus both timely and important. The manuscript is well written and generally convincing in its argumentation.

I have just a list of minor comments for the authors to consider:

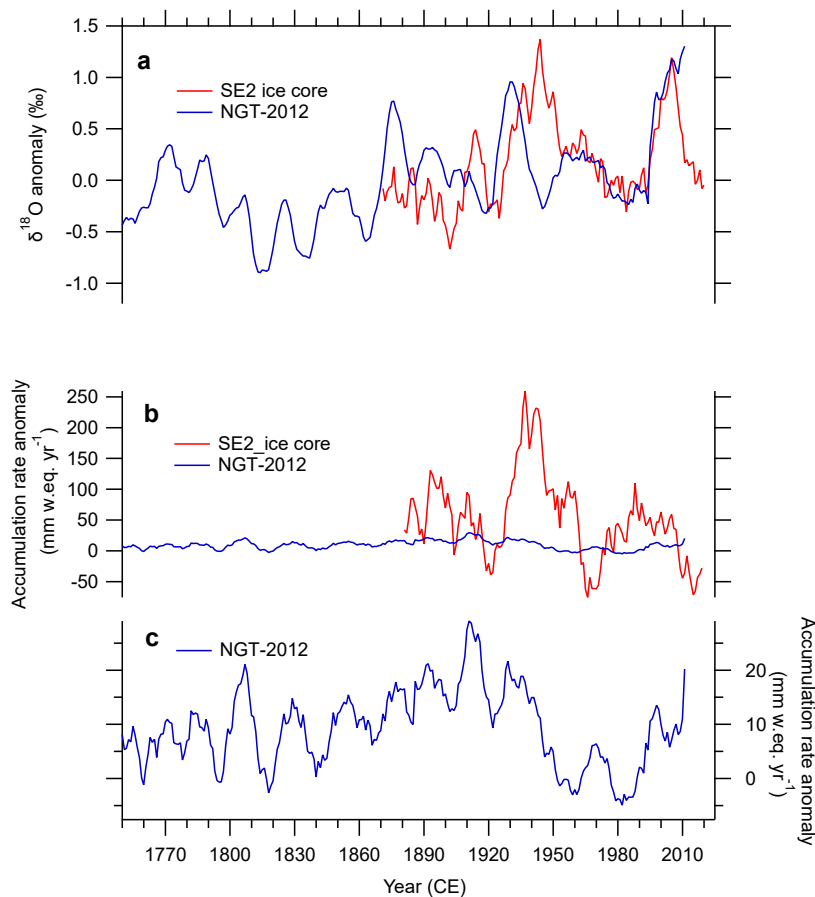
We thank the referee for the careful and constructive review and for the helpful suggestions to improve the manuscript.

[R1-#2] Considering the pressing issue of global warming and the significant changes currently seen all over the arctic, it is surprising to me that no changes are seen for the SE dome II core in terms of accumulation (Fig. 8) or isotopic warming (Fig. 2 + 5). I'm not saying it is wrong, but I think it would be justified to comment on Hörhold et al. (2023) and the trend observed there?

The present study focuses on chronology, and we are preparing a detailed climatic/isotopic interpretation of the SE2 $\delta^{18}\text{O}$ & d-excess record separately. However, we agree with the referee that comparing the NGT-2012 record of Hörhold et al. (2023) helps place recent SE2 variations in context.

We therefore made a new figure comparing long-term anomalies for SE2 and the NGT-2012 ("new Fig. A3" below). First, the 11-year running mean of SE2 $\delta^{18}\text{O}$ shows a recent increase, which is difficult to recognize in Fig. 2 and 5 because of the high temporal resolution of our data. The $\delta^{18}\text{O}$ records show several similar decadal-scale variations, including positive anomalies around the early

2000s. NGT-2012 ends during the recent positive anomaly in 2011, whereas SE2 extends to 2020 and shows a subsequent decline. For accumulation, the 11-year running mean reveals substantial decadal- to multidecadal-scale variability in SE2, but direct comparison is less straightforward because SE2 accumulation is substantially higher than in the NGT-2012 stack. However, when the NGT-2012 record is shown on an expanded scale, both records exhibit decadal- to multidecadal-scale variability. Hörhold et al. (2023) also emphasized the large uncertainty in the NGT-2012 accumulation reconstruction. We will add this new figure and briefly discuss these results in the revised manuscript.



“New Fig. A3” . Comparison of decadal-scale $\delta^{18}\text{O}$ and accumulation variability between the SE2 record and the NGT-2012 Greenland stacks

(a) Eleven-year running-mean $\delta^{18}\text{O}$ anomalies for the SE2 ice core from 1871 to 2020 CE (red) and the NGT-2012 Greenland isotope stack from 1750 to 2011 CE (blue). **(b)** Eleven-year running-mean accumulation anomalies for SE2 (red) and the NGT-2012 accumulation stack (blue). **(c)** The NGT-

2012 accumulation anomaly shown in panel (b), plotted on an enlarged y-axis scale for clarity. Following Hörhold et al. (2023), all anomalies are calculated relative to the 1961–1990 mean, and eleven-year running means were calculated using the minimum-slope boundary constraint.

We will add the following new paragraph at the end of accumulation section 3.3.1.

“To highlight decadal-scale variability, we calculated 11-year running means of accumulation and $\delta^{18}\text{O}$. The smoothed SE2 accumulation record shows substantial variability but no persistent increase toward the present (Fig. A3b). Hörhold et al. (2023) examined accumulation using the NGT-2012 multi-core stack from central and northern Greenland. Because both the mean accumulation rate and the amplitude of accumulation variability are substantially larger at SE2, direct comparison of the absolute anomalies is difficult. The NGT-2012 record is therefore also shown on an enlarged scale (Fig. A3c). Although NGT-2012 accumulation appears to increase after 2000, Hörhold et al. (2023) emphasized the relatively large uncertainty of the reconstruction. The SE2 $\delta^{18}\text{O}$ record shows a broadly similar long-term increase and pronounced decadal-scale variability to the NGT-2012 isotope stack over the past 150 years, including positive anomalies in the early 2000s, followed by a decline after its maximum around 2010 (Fig. A3a).”

[R1-#3] The authors are carefully comparing their new time scale to that of NEEM-S1, which is fine, but I think it is also relevant to compare to the more recent GICC21 time scale (Sinnl et al., 2022) that is valid for many other Greenland ice cores? GICC21 is mentioned in the manuscript, but there is no comparison or commenting made. For the GICC21 time scale a number of significant ammonium tie points are listed in Sinnl et al., 2022, supplementary folder 3) Tie-points. Are those tie points also present in SE dome II?

The consistency of the previous SE2 chronology based on H_2O_2 with GICC21 was evaluated using volcanic horizons, and agreement was within one year (Kawakami et al., 2023). Our new isotope-based age scale is consistent with the H_2O_2 -based age scale within one year. This provides indirect evidence that SE2025iso is also consistent with GICC21 at the annual scale. We will clarify this comparison in the revised manuscript.

Within the SE2 interval, only five NH_4^+ tie points are listed in the Supplement of Sinnl et al. (2022). We also inspected an unpublished SE2 NH_4^+ record (Iizuka, personal communication). Several of these tie points appear to correspond to NH_4^+ peaks in SE2, but additional NH_4^+ peaks are also present, making one-to-one identification ambiguous. We cannot identify these tie points unambiguously from NH_4^+ alone. Other markers would be needed to check the matches. We will also

add a statement to the revised manuscript noting that future multi-proxy comparisons, including volcanic and aerosol markers, may provide additional constraints for synchronizing SE-Dome with Greenland-wide ice-core chronologies.

We will add the following sentences in Section 3.4.2.

“The previous H₂O₂-based SE2 chronology was compared with GICC21 by Kawakami et al. (2023) and agreed within one year with the GICC21 age scale of Sinnl et al. (2022). “

“Future multi-proxy comparisons using volcanic horizons and aerosol markers such as NH₄⁺ peaks, which were used as supporting tie points in GICC21 (Sinnl et al., 2022), may provide additional constraints for synchronizing SE-Dome with Greenland-wide ice-core chronologies. “

[R1-#4] Figure 1 is great, but it is hard to see what exactly is the precipitation at SE-Dome. Maybe you can mention the value in the caption?

We will add the mean ERA5 precipitation at the SE-Dome site (967 mm yr⁻¹ for 1979–2014) to the Figure 1 caption. This value slightly differs from that reported in Table 1 because the two values are averaged over different periods.

[R1-#5] In line 165, a precipitation factor of 1.2 applied for ECHAM6-wiso. Any comment on the reason for this correction? Is it a general issue for the model precipitation over Greenland or is it a local issue, e.g. due to lack of model resolution? If it is a more general issue, it would demonstrate the need for more ice-core based accumulation records to be obtained from Greenland.

The factor 1.209 corrects the underestimation of precipitation by ECHAM6-wiso at SE-Dome. As shown in our Figure 1, SE-Dome lies within a steep spatial precipitation gradient in southeast Greenland. We therefore attribute the mismatch primarily to the model’s difficulty resolving this strong local precipitation gradient. Our analysis cannot determine whether ECHAM6-wiso has a systematic precipitation bias across Greenland, so we treat this factor as a site-specific correction. The correction is required for the SNOWISO experiment because underestimated accumulation would produce an unrealistically thin simulated snowpack and thereby bias isotope diffusion. More ice-core-based accumulation records, particularly along steep precipitation gradients in high-accumulation regions, would help evaluate such regional model biases.

We will revise the sentences in L165–167, as follow:

“To correct the underestimation of precipitation by ECHAM6-iso at SE-Dome, which would otherwise underestimate snow-core length and associated isotope diffusion, modeled precipitation was scaled by a constant factor of 1.209 derived from the regression slope between observed annual accumulation and modeled precipitation over 1991–2019. The bias likely reflects the difficulty of resolving the steep spatial precipitation gradient around SE-Dome.”

[R1-#6] In line 176, the Nye model correction to the accumulation is mentioned. Would be good to mention somewhere how important this correction is for the oldest part of the record, e.g. in terms of percentage change of accumulation.

At the deep part of the accumulation record (1872 CE), the Nye-model correction increases the reconstructed annual accumulation from 1.23 to 1.51 m w.e. yr⁻¹, corresponding to an increase of approximately 22%. We will add this information to Sect. 2.5.

“At the oldest part of the accumulation record (1872 CE), this correction increases the reconstructed annual accumulation from 1.23 to 1.51 m w.e. yr⁻¹, corresponding to an increase of approximately 22%.”

[R1-#7] In the caption of Figure 2, it would be good to specify which model simulation the red curve shows.

We will revise the Figure 2 caption to specify the isotope-enabled model simulations represented by the red curve.

“The red line shows the isotope-enabled model simulations: IsoGSM20c run for 1871–1979 CE, the mean of IsoGSM3 and MIROC5-iso for 1980–2017 CE, and IsoGSM4 for 2018–2020 CE. “

[R1-#8] Comparing the depth and age scales in Fig. 2, it appears there is a large variability in the annual layer thickness for the SE dome cores. Would it make sense to look at the annual layer distribution profile for SE2 and compare it to those of the other cores? I’m thinking along the lines of Fig. 7 in Andersen et al. (2006). Are the SE2 annual layer thicknesses log normal distributed (as we

see for many other Greenland ice cores) and is the standard deviation larger for SE2 than for NGRIP as Fig. 2 indicates?

We examined the distribution of annual accumulation rates for SE2 (1871–2019 CE). The standard deviation is 0.209 m w.e. yr⁻¹ (CV = 19%). The distribution is approximately symmetric on the linear scale and is well represented by a normal distribution (Fig. [R1-#8] below). A Shapiro–Wilk test does not reject normality for either the original data ($p = 0.50$) or the logarithmically transformed data ($p = 0.43$). Thus, over this interval, the SE2 distribution does not show a clear preference for a lognormal over a normal distribution. The large absolute variability of SE2 is consistent with Andersen et al. (2006), which found that accumulation variability increases with mean accumulation rate; the mean accumulation at SE2 is much higher than at NGRIP. We will add sentences on this point to Sect. 3.3.1 and cite Andersen et al. (2006).

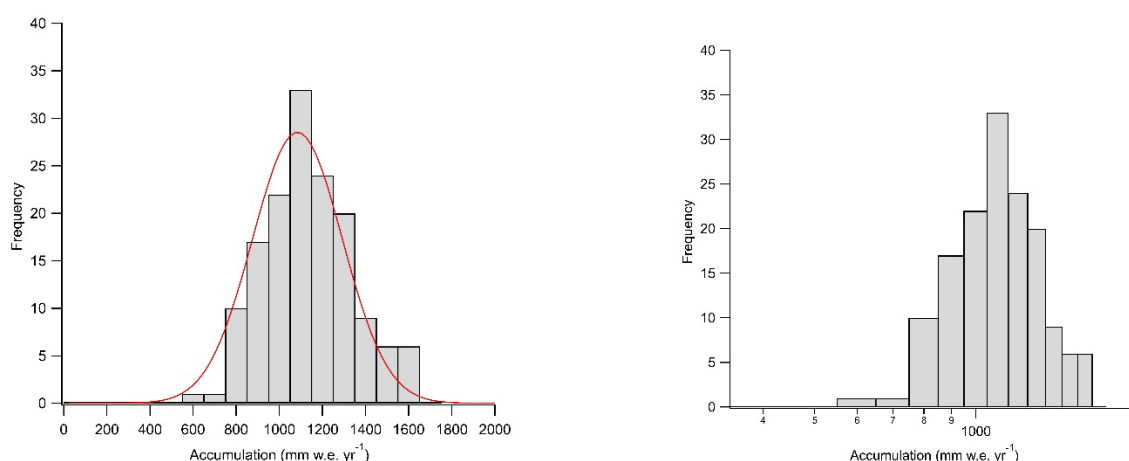


Figure [R1-#8]. Distribution of annual SE2 accumulation rates for 1871–2019 CE. (a) Distribution on a linear accumulation scale; the red curve shows a normal distribution calculated from the observed mean and standard deviation. (b) The same distribution plotted on a logarithmic accumulation scale.

We will add the following sentences.

“The standard deviation of annual accumulation is 0.21 m w.e. yr⁻¹, corresponding to a coefficient of variation of 19%. The distribution is approximately symmetric and does not show a clear preference for a lognormal over a normal distribution, unlike the tendency toward lognormal distributions reported for several Greenland ice cores (Andersen et al., 2006). The relatively large absolute variability is consistent with the general increase in accumulation variability with mean accumulation rate across Greenland ice cores (Andersen et al., 2006).”

[R1-#9] Around line 240, the visible melt layers in the core are mentioned. The 2012 melt layer is situated in ice corresponding to the month of February. Is this suggesting the melting occurred in February?

Thank you for pointing this out. The 2012 melt feature is not confined to ice corresponding to February; it extends from February to July 2012 on the SE2025iso age scale. The upper part corresponds to July, and the deeper part to progressively earlier months, consistent with downward percolation and refreezing of summer meltwater within snow deposited earlier in the year. Thus, the February age does not indicate melting in February. Importantly, the melt features occupy only part of the core, and we took samples for $\delta^{18}\text{O}$ analysis from portions without visible melt features.

We will add the following sentences in Sections 2.1 and 3.1.2.

“The melt layers were spatially localized within the core (Kawakami, 2023), and samples for $\delta^{18}\text{O}$ analysis were taken from portions without visible melt features. “

“The 2012 melt event itself occurred in summer, and the extension of melt features into layers dated back to February reflects downward percolation and refreezing of meltwater in snow deposited earlier in the year.”

[R1-#10] Figure 6 is great, but wouldn't it make more sense to show the same time period for all the cores, so that we can directly see the better temporal resolution of the SE2 core? E.g to have age on the x-axis rather than depth? The differences shown now for the same depth interval mostly reflects the different snow accumulation at the different sites (as well as thinning)? Maybe you did this already and it was not illustrative for some reason?

We chose a depth axis for Fig. 6 because we wanted to compare signal preservation at similar burial depths. Depth-based and age-based comparisons each have advantages and limitations. A same-depth comparison is appropriate for evaluating how differences in accumulation rate affect annual-layer thickness and the preservation of multi-month signals at comparable burial depths. In contrast, a same-age comparison allows direct comparison over the same climatic interval, but the corresponding layers occur at substantially different depths because the cores were drilled in different years and have different accumulation rates. This depth difference can lead to different degrees of post-depositional diffusion and vapor exchange. After trial and error, we chose the depth-based comparison and created Fig. 6 to visualize the effect of accumulation rate on signal preservation at comparable depths.

To address the reviewer’s suggestion, we also prepared same-age comparisons. Because burial depth is a key limitation of this approach, we compared two calendar intervals representing substantially different depth ranges. Beyond illustrating temporal-resolution differences, this figure reveals interesting similarities between the Dye-3 and SE2 cores (e.g., 1971-1974, 1952-1954, 1918-1925). We will add these new comparisons to the Appendix, which provide a complementary assessment of temporal resolution across the cores. We retain the depth-based comparison in Fig. 6 and have clarified the rationale in Sect. 3.2.1.

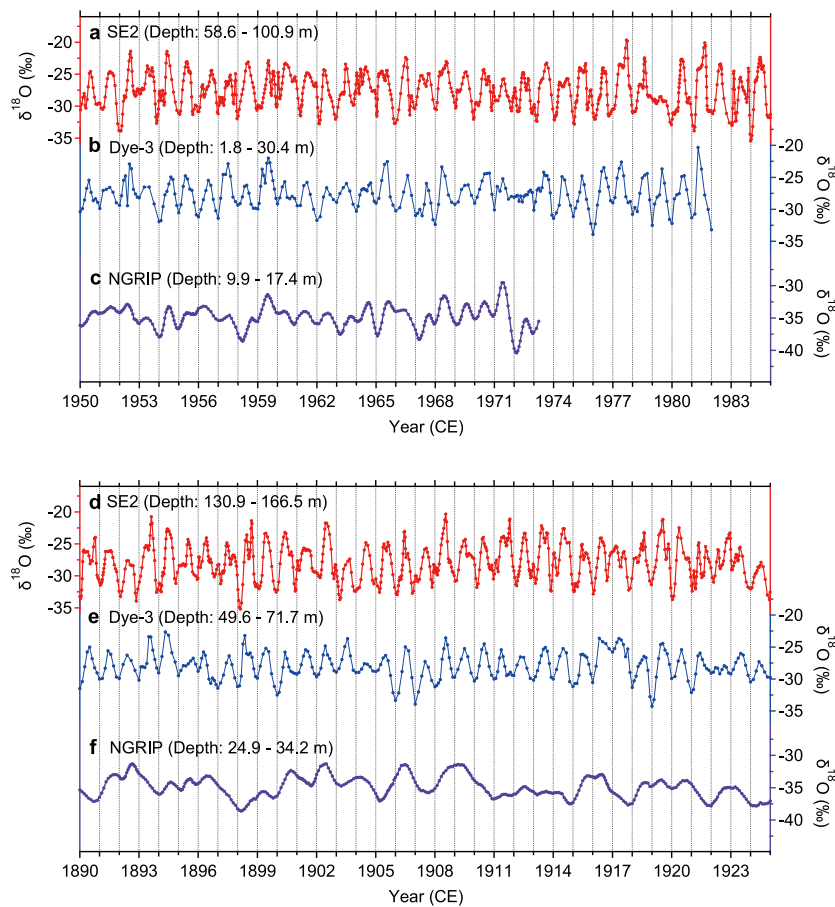


Figure A2. Age-based comparison of $\delta^{18}\text{O}$ variability in the SE2, Dye-3, and NGRIP ice cores at two depth ranges. Panels (a–c) show the overlapping records available for the three cores, and panels (d–f) show an older interval during 1890–1924 CE. The corresponding depth ranges are indicated in each panel. Because the cores were drilled at different times and have different accumulation rates, layers of similar calendar age occur at substantially different depths. The uppermost depths differ because the publicly available datasets begin at different depths.

“For comparison, we also plotted the $\delta^{18}\text{O}$ records on a calendar-age axis for two age ranges representing different depths (Fig. A2). In the younger comparison, Dye-3 also preserves intra-

annual variability, and SE2 and Dye-3 show broadly similar intra-annual structures during several intervals, for example, 1952–1954 and 1971–1974. Similar structures are also observed around 1918–1925 in the older comparison. At greater depths, however, intra-annual variability is more clearly resolved in SE2 than in Dye-3 and NGRIP (Fig. A2 d-f). Notably, the SE2 layers spanning 1890–1924 CE correspond to depths of 130.9–166.5 m, compared with 49.6–71.7 m in Dye-3 and 24.9–34.2 m in NGRIP, yet SE2 still preserves distinct multi-month variability. This result further supports the preservation of intra-annual $\delta^{18}\text{O}$ signals at the high-accumulation SE-Dome site even at depths exceeding 100 m.”

[R1-#11] Would a power spectrum comparing the d18O signal of the different cores show us how much better the resolution is for SE2? I’m thinking of something like Bigler et al. (2011), Fig. 7, but in the time domain and for d18O for the different cores. You should be able to resolve much higher frequency signal in SE2 than in the other cores. Just an idea, may not make sense.

We performed a preliminary power-spectral analysis of the $\delta^{18}\text{O}$ records (figure below). The SE2 spectrum retains substantial power at sub-annual frequencies, including periods of approximately 6–9 months, consistent with the multi-month variability seen in the time series. However, quantitatively comparing spectral power among the cores is difficult because the records differ in depth (i.e., drilled in different years) and sampling resolution. Thus, we did not include this spectral comparison in the manuscript for the same reasons described in **[R1-#10]**. We therefore consider the age-based comparison added in response to **[R1-#10]**, but not the spectra in the manuscript. In addition, we will add a sentence and cite Bigler et al. (2011) in the revised Introduction.

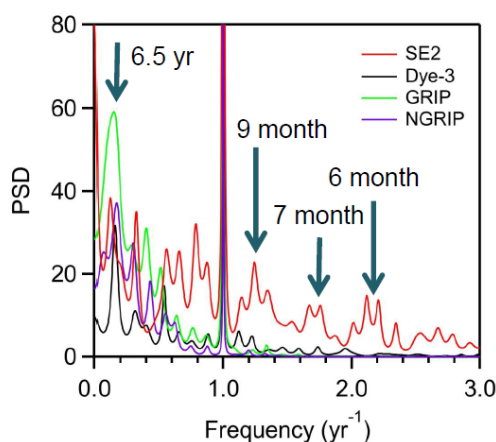


Figure R1-11. Power spectra of $\delta^{18}\text{O}$ records from SE2, Dye-3, GRIP, and NGRIP for 1880–1970 CE. The SE2 spectrum shows substantial power at sub-annual frequencies, including periods of

approximately 6–9 months. Sampling resolutions and ice depths differ among the cores, so the spectra are shown here for qualitative comparison rather than quantitative evaluation.

We will add the following sentence in the Introduction.

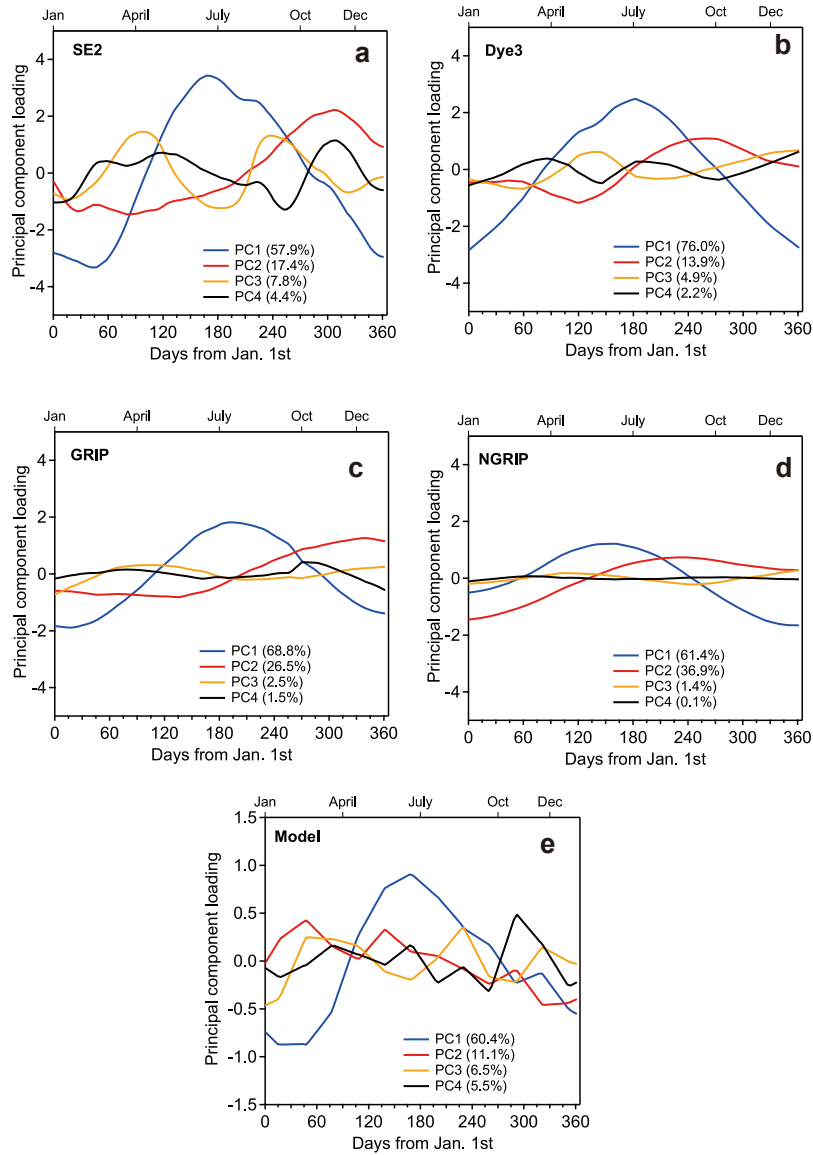
“Optimized CFA systems can achieve millimeter-scale depth resolution, provided that the signals are preserved in the ice (Bigler et al., 2011).”

[R1-#12] The mentioning of accumulation rates for the various Greenland ice cores in lines 312-315 would be good to have already for the discussion of Figure 6.

We will move the accumulation rates of SE2, Dye-3, GRIP, and NGRIP to the beginning of the discussion of Fig. 6 so that the differences among the sites are clear before interpreting the isotope records.

[R1-#13] It is mentioned in line 316 that the PCA analysis of the measured seasonal variation is mostly made for evaluating the applicability of the automated layer counting method. However, I would think the analysis is also (or maybe even more so) relevant for understanding the composition of the seasonal signal and maybe also for comparison to model results? How does a similar PCA analysis of the model simulations you are applying for tuning the time scale look like?

We agree that the PCA is also useful for characterizing the seasonal and multi-month structure of the $\delta^{18}\text{O}$ signal. We therefore applied the same PCA to the model $\delta^{18}\text{O}$ used for chronology construction and added the result to Fig. A1. The model PCA shows a structure similar to SE2, with broadly similar peak positions in the principal components. We will revise Sect. 3.2.2 accordingly.



New Fig. A1 (Panel e is newly added)

We will add the following sentence in Section 3.2.2 and revise wording and captions.

“A comparable PCA of the model $\delta^{18}\text{O}$ used for chronology construction shows similar seasonal and multi-month structure, including broadly similar peak positions of PC3 and PC4 (Fig. A1). “

[R1-#14] In Fig. 9, again, it is difficult to see the exact position of SE dome, maybe mention the value for SE-dome in the caption ?

We will add the ERA5 summer–winter precipitation difference at the SE-Dome site to the Figure 9 caption. The mean JJA–DJF precipitation difference over 1979–2014 is –58.5 mm, indicating 58.5 mm greater precipitation in winter than in summer.

[R1-#15] The SE2time2023 time scale is mentioned for the first time in line 426. I think it would make sense to mention this - and if there are other, earlier time scales for the core - already in the introduction? It would also be good to comment on any differences between the two time scales and how important they are.

We will explicitly mention the name of the previous chronology in the Introduction. The main difference relevant to this study is at the intra-annual scale: SE2time2023 assigned H₂O₂ maxima and minima to summer and winter, whereas SE2025iso is based on multi-month $\delta^{18}\text{O}$ pattern matching and does not prescribe the timing of H₂O₂ extrema. As shown in Sect. 3.4.1, this results in a shift of approximately 2–3 weeks in the dating of H₂O₂ maxima and minima. We will add a brief statement clarifying that this difference is small for annual-scale interpretations but important for seasonal to multi-month applications.

We will add the following sentences to Introduction and Section 3.4.1, respectively.

“A previous age scale for the SE2 core, SE2time2023, was constructed from the seasonal cycle of H₂O₂ by assigning its maxima and minima to summer and winter, respectively (Kawakami et al., 2023).”

“This difference is minor for annual-scale interpretations but important for analyses of seasonal to multi-month timing, for which SE2025iso does not prescribe the timing of H₂O₂ extrema.”

[R1-#16] In section 3.4.2 is mentioned that 10 volcanic eruptions have been identified in SE II, but only 5 are shown in Figure 12 and applied for the analysis in Figure 13. Please comment also on Katmai 1912 AD that is identified in most other Greenland ice cores (Sinnl et al., 2022, Supplementary folder 3) Tie-points). Do the not-mentioned 5 eruptions follow the same pattern as discussed in Figure 13?

We clarify that the 10 eruptions refer to those identified in the NEEM-S1 record, of which eight were detected in SE2. Katmai 1912 is one of these eight events and is already listed in Sect. 3.4.2. In the original manuscript, we intended to state that Figs. 12 and 13 focus on five eruptions from remote

regions that show a similar deposition pattern in the SE2 core, but this selection criterion was not sufficiently clear. We have therefore revised the text to make this explicit. Katmai shows a different, more complex pattern: a major sulfate peak occurs shortly after the 1912 eruption, followed by several additional peaks, making it less straightforward to identify which peaks are eruption-derived. Thus, the events not included in Figs. 12 and 13 do not necessarily follow the same pattern.

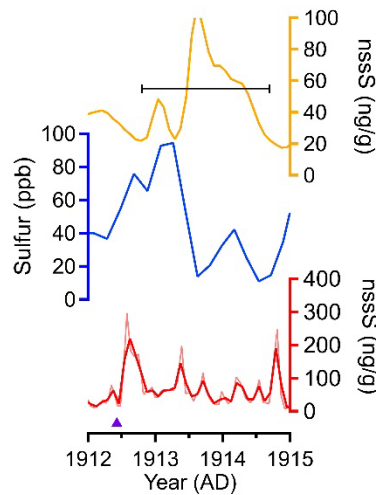


Fig. [R1-#16] Enlarged view around Katmai (1912) eruption (similar to Fig. 12).

We will revise the following sentence in Section 3.4.2.

Original:

“High-resolution sulfate records from the SE2 ice core reveal distinct deposition patterns. Among the volcanic signals, five eruptions from remote regions—Pinatubo, Agung, Krakatoa, Bezymianny, and Ksudach—exhibit similar features in the SE2 core. Comparisons of these five volcanic signals in NEEM-2011-S1 (nss-Sulfur), NGRIP (Sulfur), and SE2 cores (nss-SO₄²⁻) are shown in Fig. 12.”

Revised:

“High-resolution sulfate records from the SE2 ice core reveal distinct deposition patterns. Among the volcanic signals, we selected five eruptions from remote regions—Pinatubo, Agung, Krakatoa, Bezymianny, and Ksudach—that exhibit similar features in the SE2 core. The 1912 Katmai eruption was also detected in SE2 but shows a different pattern: a major sulfate peak shortly after the eruption followed by several additional peaks. Comparisons of the five selected volcanic signals in NEEM-2011-S1 (nss-Sulfur), NGRIP (Sulfur), and SE2 cores (nss-SO₄²⁻) are shown in Fig. 12.”

[R1-#17] If you have the time, because you have such high temporal resolution, could it be that you can see a cooling effect of some of the volcanic eruptions in the $\delta^{18}\text{O}$ signal as in Lohmann et al. (2024), Fig. 4d ? Or maybe in the accumulation? I think if you indicate the position of the volcanic eruptions in Fig. 2 (indicate both time of eruption and time of the sulfate spike), it should be quite easy to judge if there is an effect. Likely, you could indicate the position of the melt layers and see if those occurred in ‘warm’ years (Westhoff et al., 2022)? Probably not. Any effects of the large ammonium tie points, if they are related large NH forest fires (Kjær et al., 2022)?

References:

- Andersen, K.K., Svensson, A., Rasmussen, S.O., Steffensen, J.P., Johnsen, S.J., Bigler, M., Röthlisberger, R., Ruth, U., Siggaard-Andersen, M.-L., Dahl-Jensen, D., Vinther, B.M., Clausen, H.B., 2006. The Greenland Ice Core Chronology 2005, 15-42 ka. Part 1: constructing the time scale. *Quaternary Science Reviews* 25, 3246-3257.
- Bigler, M., Svensson, A., Kettner, E., Vallelonga, P., Nielsen, M.E., Steffensen, J.P., 2011. Optimization of High-Resolution Continuous Flow Analysis for Transient Climate Signals in Ice Cores. *Environmental Science and Technology* 45, 4483-4489.
- Hörhold, M., Münch, T., Weißbach, S., Kipfstuhl, S., Freitag, J., Sasgen, I., Lohmann, G., Vinther, B., Laepple, T., 2023. Modern temperatures in central-north Greenland warmest in past millennium. *Nature* 613, 503-507.
- Kjær, H.A., Zens, P., Black, S., Lund, K.H., Svensson, A., Vallelonga, P., 2022. Canadian forest fires, Icelandic volcanoes and increased local dust observed in six shallow Greenland firn cores. *Clim. Past* 18, 2211-2230.
- Lohmann, J., Lin, J., Vinther, B.M., Rasmussen, S.O., Svensson, A., 2024. State-dependent impact of major volcanic eruptions observed in ice-core records of the last glacial period. *Clim. Past* 20, 313-333.
- Sinnl, G., Winstrup, M., Erhardt, T., Cook, E., Jensen, C.M., Svensson, A., Vinther, B.M., Muscheler, R., Rasmussen, S.O., 2022. A multi-ice-core, annual-layer-counted Greenland ice-core chronology for the last 3800 years: GICC21. *Clim. Past* 18, 1125-1150.
- Westhoff, J., Sinnl, G., Svensson, A., Freitag, J., Kjær, H.A., Vallelonga, P., Vinther, B., Kipfstuhl, S., Dahl-Jensen, D., Weikusat, I., 2022. Melt in the Greenland EastGRIP ice core reveals Holocene warm events. *Clim. Past* 18, 1011-1034.

Following this suggestion and a similar comment from Referee 2 ([R2-#4]), we examined $\delta^{18}\text{O}$ and snow accumulation for the five eruptions shown in Figs. 12 and 13. Aligning the records to eruption dates left the seasonal phases offset among events, and no clear common response emerged. We therefore also aligned the records to the nss-SO_4^{2-} peaks in SE2, which occur in late spring to summer of the year following each eruption.

The $\delta^{18}\text{O}$ composite shows a minimum around the third post-eruption winter, but the response is weak in individual events and its link to volcanic forcing remains unclear. Seasonal accumulation shows a slightly clearer post-eruptive response, with an increase about 2–9 months after the eruptions. This accumulation increase is consistent with simulated post-eruption circulation changes and therefore potentially reflect a volcanic influence.

We will add the following new figures and a short section after Sect. 3.4.2.

“ 3.4.3 Post-Eruption $\delta^{18}\text{O}$ and Snow Accumulation Responses”

To examine possible climate responses following the five eruptions shown in Figs. 12 and 13, we analyzed $\delta^{18}\text{O}$ and seasonal accumulation using the SE2025iso age scale. Alignment to the reported eruption dates showed no clear common response. Because the interval between eruption and sulfate deposition differs among events (Sect. 3.4.2), we also aligned the records to the nss-SO_4^{2-} peak identified in each SE2 volcanic signal, approximately 10–17 months after the reported eruption dates (Fig. 14). This approach is consistent with previous ice-core-based analyses using volcanic sulfate deposition as an event marker (e.g., Sigl et al., 2015). Anomalies were calculated relative to the mean of the three years preceding each eruption. Individual $\delta^{18}\text{O}$ responses are weak, but the composite shows a pronounced minimum at approximately month +19, corresponding to the second winter after the sulfate peak and approximately the third post-eruption winter (Fig. 14a). This timing is substantially later than the negative precipitation $\delta^{18}\text{O}$ anomalies simulated over Greenland during the first post-eruption winter (Stevenson et al. 2019). Given the small amplitude of the anomaly, its delayed timing, and the weak response in individual events, it is unclear whether the SE2 minimum reflects a volcanic influence.

Seasonal accumulation shows a clearer response. The largest positive anomaly occurs at approximately month -8 relative to the nss-SO_4^{2-} peak, corresponding to approximately 2–9 months after the eruptions (Fig. 14b). This timing is consistent with North Atlantic circulation and precipitation anomalies simulated several months after the Pinatubo eruption (Barnes et al., 2016). Berdahl et al. (2018) identified 1963–1964 and 1991–1992, coinciding with the Agung and Pinatubo eruption periods, respectively, as periods with an extremely westward Icelandic Low. Such conditions are associated with enhanced moisture transport and precipitation in southeast Greenland, although Berdahl et al. (2018) did not attribute them to volcanic forcing. In comparison, three-year mean accumulation changes after Agung and Pinatubo vary in magnitude and sign among Greenland ice-core sites (Zheng et al., 2023). The five-event SE2 composite therefore resolves a short-lived accumulation increase that is not apparent from multi-year averages. Although the limited number of events prevents attribution to volcanic forcing, the result illustrates the utility of the multi-month chronology for resolving transient climate variability.

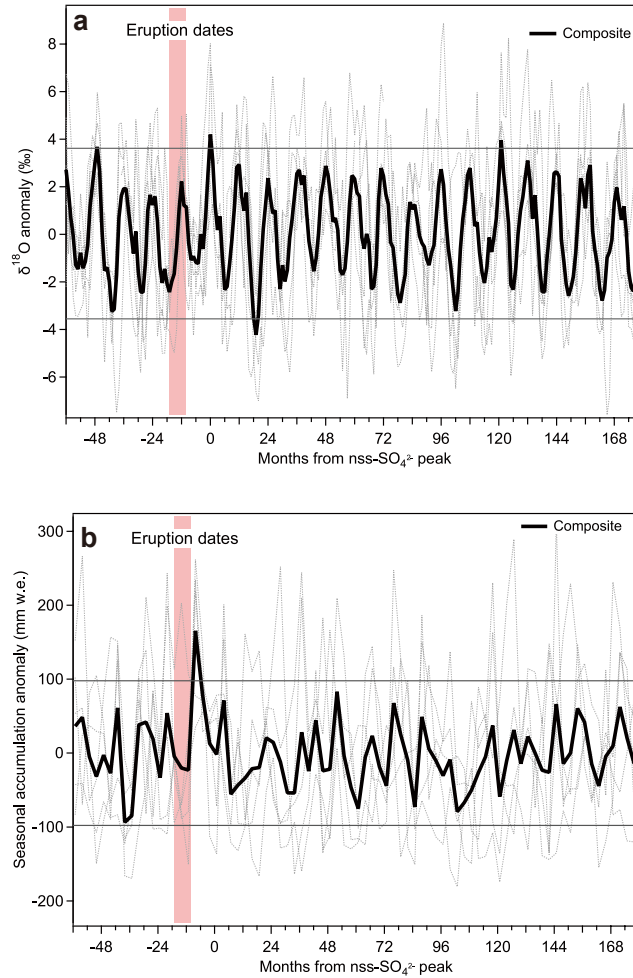


Figure 14. Post-eruptive changes in $\delta^{18}\text{O}$ and seasonal accumulation at SE-Dome aligned to the nss-SO₄²⁻ peak in the SE2 core. (a) Monthly $\delta^{18}\text{O}$ anomalies and (b) seasonally resolved accumulation anomalies for the five eruptions shown in Figs. 12 and 13. Anomalies are calculated relative to the mean over the three years preceding each eruption. Thin lines show individual eruptions, and the thick black line shows the composite mean. Time zero denotes the nss-SO₄²⁻ peak in SE2. The shaded vertical band indicates the range of eruption dates relative to the sulfate peak. “

Regarding the melt layers, their climatic significance has been examined using the same SE2 core by Kawakami et al. (2023). They showed that melt-layer “thickness” is significantly correlated with summer positive degree hours from ERA5, supporting the interpretation of melt layers as indicators of warm summers, consistent with Westhoff et al. (2022). An event-by-event comparison between melt layers and $\delta^{18}\text{O}$ would require a separate assessment of how the SE2 $\delta^{18}\text{O}$ record relates to summer temperature, which we did not evaluate in the present study. We therefore refer to the existing melt-layer analysis rather than adding a new $\delta^{18}\text{O}$ –melt comparison.

Finally, regarding the large NH_4^+ events, we agree that they may reflect major boreal forest fires, as discussed by Kjær et al. (2022). This interpretation is also plausible for SE-Dome because independent biomass-burning tracers in the SE-Dome ice core have been shown to record major fire events in eastern Canada (Parvin et al., 2019). We have added these references to the revised manuscript.

We will add the following sentences:

In Sect. 3.1.2.

Original: “Melt layers and nuclear test markers support the accuracy of the SE2025iso age scale at seasonal to annual timescales.”

Revised: “Melt layers, which indicate anomalously warm summers in Greenland ice cores (Westhoff et al., 2022), and nuclear test markers support the accuracy of the SE2025iso age scale at seasonal to annual timescales.”

In Introduction.

“ Large NH_4^+ peaks can record boreal forest-fire events (Kjær et al., 2022). ”

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