Dear editor and reviewers,

Thank you for your fast review in the second round and the comments to revise the manuscript. We corrected the manuscript according to the specific comments from the reviewer reports in the revised version that is marked up and uploaded.

Concerning the SVM method to estimate the eruption latitudinal band, we rewrote the section as shown below. Please let us know if the text has improved.

Best regards, the authors

Point-to-point replies:

All three reviewers are generally happy with the revised document, I thank you for your work in addressing the the comments of the first round. All three reviewers did however point out a few technical/minor corrections, which I ask you to correct or address before final publication. Please see the reviewer reports for the specific comments.
The most significant comment is from reviewer 1 and is related to the use of SVM to estimate the eruption latitude range. I do agree that it would be useful to include a little more detail on the method and result. For example, how does the resulting distribution (NH/Tropics/SH) compare to other reconstructions (e.g., for the past 2500 years)? A sentence or two on the strengths and weaknesses of your new method would also be welcome.

The text now looks as follows: 'The volcanic sulfate deposition in Greenland and Antarctica shows a distribution pattern related to the latitudinal band of the eruption site (Fig. 1) (Marshall et al., 2019). To estimate the latitudinal band of bipolar volcanic eruptions of unknown origin, we applied the Support Vector Machine (SVM) classification model of Hastie et al. (2009) and Vapnik (1998) that is based on a kernel function generation and logistic regression. The model was trained using 4 eruptions from the last glacial period and 17 eruptions from the last two millennia for which the eruption site is known from the deposit tephra in the ice (Fig. 1(b) and Table S6). The input values of each eruption for the model on the training set are the average Greenland sulfate deposition, the average Antarctic sulfate deposition and the latitudinal band of the eruption site (above 40°N, 40°N-40°S, or below 40°S). The cross-validation is performed on the training set consisting of 10% of the total training eruptions selected at random. Then, this trained model is applied to give a best estimate of the latitudinal band of the bipolar eruptions for which the eruption site is unknown. The model output parameters - kernel scale, box constraints and Bayesian optimization - show that the model has good performance (Fig. S4). Due to the low number of known volcanoes erupted in the high latitudes of the Southern Hemisphere, the method does not allow unambiguous identification of eruptions potentially located in this region. The bipolar eruptions of unknown origin are thus predicted into two latitudinal bands – above 40°N (NHHL) and below 40°N (LL or SH) (Table S5). The latitudinal band assignment for the four bipolar eruptions at the onset of the Younger Drays period (Table S5) is similar to that expected from comparing the relative sulfate deposition in Greenland and Antarctica (Abbott et al., 2021). A weakness of the method is that the training set mostly consists of volcanic eruptions for which the sulfate deposition is much smaller than that of the large eruptions occurring during the last glacial period. Details of the SVM method are provided in Hastie et al. (2009), page 17.'.

Some other technical comments specifically related to this aspect of the work:
1. At line 310, you mention the 21 eruptions used to train the SVM. You reference table S6, but these are also shown in Fig 1b, correct? If so, it would be useful to refer to the figure also.

Indeed, done.

2. At line 312 of the tracked changes document, "The cross-validation used for tuning the algorithm is 10-fold partition for each evolution." does not make any sense to me. Can this be made clearer?

Removed.

3. I was surprised to see the Unidentified large event at 38.1 kaBP on Figure 6 plotted as a SH extratropical event, since the description of the SVM method said it can only assign either north or south of 40N. At around line 645, it appears this event is suggested to likely be a low latitude event, while in the caption for figure 6 it is said to be "very likely from Southern Hemisphere". Perhaps I have missed some discussion elsewhere but this seems to be a contradiction.

Thank you for picking this error up. Indeed, the 38.1 ka eruption is very likely to be tropical. It is the 46.68 ka event that has two times higher sulfate deposition in Antarctica than in Greenland that we wanted to mention as likely originating in the SH. The figure is now corrected.

4. The caption for Fig 6 says: "Volcanoes that erupted sites are predict above 40°N are marked at 40°N", however, on the plot, those events seem to be plotted at around 50°N.

Corrected.