Climate of the Past Discussions

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Review

Anders Svensson (Referee)

Referee comment on "Frequency of large volcanic eruptions over the past 200□000 years" by Eric W. Wolff et al., Clim. Past Discuss., https://doi.org/10.5194/cp-2022-69-RC1, 2022

The manuscript presents a 200 ka long volcanic record based on a detailed sulfate record from the Antarctic EDC ice core. To my knowledge, it is the first time a continuous volcanic ice-core record of this duration and quality is being published. Despite being based on a single ice core, the record is very valuable, as it provides a homogeneous, long-term record of major global volcanism. The authors are convincingly demonstrating from sulfur isotopic measurements that the majority of the large sulfate spikes in the record have been injected into the stratosphere and thus have a global impact. Furthermore, the peak shape of the sulfate spikes in the ice core record is fairly 'well preserved' as the diffusion of the sulfate ions in the ice is almost compensated by annual layer thickness thinning. The record is most valuable for better estimating the frequency and magnitude of past volcanism as well as for better assessing the likelihood of major volcanic eruptions in the future. The paper is well written, well referenced and clearly illustrated with figures.

A have just a few suggestion for the authors to consider:

The authors do a comparison to well-known, recent, low-latitude volcanic eruptions to make an estimate of the VEI-sulfate deposition relationship (Table 1). Then they move on to discuss the dependence of latitude of the eruptions for the magnitude of the sulfate deposition in Antarctica/EDC. For reference, it may also be relevant to provide an example of a well-known NH high-latitude eruption such as the Okmok 44 BC eruption, if it has an imprint I EDC? Alternatively, a large Icelandic eruption? Or a statement that none of the well-known NH high-latitude eruption can be detected in the EDC record. An example of the imprint of a 'local' Antarctic eruption would also be illustrative. What about a large eruption from Mt Berlin, Mount Moulton, or Mount Takahe? In particular, if one of the larger peaks in the EDC record were related to local volcanism, it would be good to mention, as an analogy to the Icelandic volcanic imprint in Greenland?

It is quite remarkable, that one of the largest known volcanic eruptions of the last glacial

cycle, the Oruanui, Taupo, eruption occurring close to 25.5 ka, is not pronounced in Fig. 5. This eruption that is identified with tephra in the WD ice core (Dunbar et al., 2017) and that is associated with very large sulfate deposition in both WD and EDML is classified as a VEI-8 eruption. How come that this very large SH eruption only leaves a weak sulfate imprint in EDC? Likewise, the largest spike in Fig. 6 occurring around 45 ka is much less pronounced in both the EDML and WD ice cores (Lin et al., 2022) questioning its significance.

With this in mind, the question is how representative the EDC sulfate record is in terms of quantifying global volcanism. For example, I am not convinced that we based on the EDC sulfate record alone can conclude that the Toba 74 ka eruption was not (among) the most significant volcanic climate forcing events of the investigated period, just because it does not show up among the largest spikes in this record. As the authors mention, the sulfate signal of individual eruptions in a single core is subject to great uncertainty.

Clearly, the authors have no direct way to work around this issue, but it illustrates the need to obtain multiple long-term volcanic records from Antarctica. The Dome Fuji ice core or the Vostok ice core should be good candidates for providing additional information about large volcanic eruptions on this time scale. Could also be that the EDC sulfur isotopic results could provide some additional information?

Figure 8 is very interesting. It is good to know that the majority of the large sulfate spikes we see in the EDC sulfate record are associated with large global/stratospheric volcanic eruptions. We are, however, not being provided with much interpretation of the D33S parameter, except that it is a stratospheric injection indicator. Does it mean anything if the parameter is positive or negative? Does the amplitude of the signal have any significance? There seems to be a few extreme values at around 74 ka and 80 ka. Are those related to specific events? I hope we will learn more are about the interpretation of this dataset, if not in the present MS then in a future publication?

Minor comments:

In the introduction, DEP and ECM are mentioned, but what about the use of liquid conductivity or acidity profiles as indicators of volcanism in ice cores?

Would it be possible to include the EDC isotope curve in Fig. 5. to make a reference to climate?

References:

Dunbar, N. W., Iverson, N. A., Van Eaton, A. R., Sigl, M., Alloway, B. V., Kurbatov, A. V., Mastin, L. G., McConnell, J. R., and Wilson, C. J. N.: New Zealand supereruption provides time marker for the Last Glacial Maximum in Antarctica, Scientific Reports, 7, 10.1038/s41598-017-11758-0, 2017.

Lin, J., Svensson, A., Hvidberg, C. S., Lohmann, J., Kristiansen, S., Dahl-Jensen, D., Steffensen, J. P., Rasmussen, S. O., Cook, E., Kjær, H. A., Vinther, B. M., Fischer, H., Stocker, T., Sigl, M., Bigler, M., Severi, M., Traversi, R., and Mulvaney, R.: Magnitude, frequency and climate forcing of global volcanism during the last glacial period as seen in Greenland and Antarctic ice cores (60–9 ka), Clim. Past, 18, 485-506, 10.5194/cp-18-485-2022, 2022.