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Timing of Holocene volcanic eruptions and their radiative aerosol forcing

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Volcanic eruptions play a dominant role in driving climate, in ways beyond the established short-term influence on surface air temperatures. In order to mitigate and adapt to the climate effects of future large volcanic eruptions we need to better quantify the risk of these eruptions including (a) the probability of their occurrence and (b) their expected climatic impact. The observational record of the timing of volcanic eruptions, their locations, magnitudes of sulphate aerosol injection is incomplete which limits our understanding of the sensitivity of the Earth system to volcanism and the vulnerability of social and economic systems to the climate impact of past and future eruptions.
Here we use an array of synchronized, accurately dated, high-resolution ice-core aerosol records from Greenland and Antarctica to reconstruct the timing, sulphur injections and source locations of 850 volcanic eruptions occurring during the Holocene (i.e., the past 11,500 years) to answer the questions:

1) What is the likelihood of a stratospheric sulphur injection as large as that from the colossal eruption of Tambora in 1815 to occur somewhere on the globe within the next 50 years?

2) How has subaerial volcanic activity changed in space and time throughout the Holocene?

3) How did major eruptions affect global climate and humans through time?

We demonstrate in case studies (e.g., McConnell et al., 2020; Pearson et al., 2022) how novel geochemical tools (e.g., sulphur isotopes, cryptotephra) allow to constrain source parameters of the eruptions (location, plume injection height, stratospheric vs. tropospheric aerosol formation) that control their effects on climate, and propose exact dates for the largest eruptions of the Holocene with the help of ultra-long tree-ring chronologies.
Finally, we generate global-scale, space-and-time resolved stratospheric aerosol properties for climate models (HolVol1.0; Sigl et al., 2021; Abbott et al., 2021) to simulate the volcanic influence on Holocene climate evolution and examine to which extent simulated climate responses agree with those inferred from proxy records.

References:

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