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Insights on the timing, global sulfate lifecycle and climate impact of Earth's largest (pre-) historic volcanic eruptions

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Extratropical volcanic eruptions are commonly thought to be less effective at driving large-scale surface cooling than tropical eruptions, and only the latter are commonly thought to be able to distribute sulfate globally. Here, we test both of these assumptions using a network of ice cores from the polar regions of Antarctica and Greenland covering the past 15'000 years and climate-aerosol modeling. We employ state-of-the-art analyses of trace elements, cryptoptephra and sulphur isotopes (Burke et al., 2019) to gain new insights into the timing of past eruptions, their stratospheric sulphur mass injections and subsequent sulphate aerosol lifecycle. We use this information to estimate the climate impact potential due to negative radiative forcing caused by Earth's largest volcanic eruptions since the last Glacial. Our analysis encompasses over 1'000 eruptions and include the caldera-forming eruptions of Okmok II (Alaska, 43 BCE, VEI=6, 53°N; McConnell et al., 2020), Aniakchak II (Alaska, 1600s BCE, VEI=6, 57°N), Crater Lake (Mazama, Oregon, 5600s BCE, VEI=7, 43°N) and Laacher See (Germany, c. 13 ka BP, VEI=6, 50°N).

We use our reconstructed radiative forcing and the coupled earth system models MPI-ESM1.2 and CESM (version 1.2.2) to analyze the climatic impact caused by these eruptions and compare the simulated temperature response with temperature reconstructions based on ultra-long tree-ring chronologies. Finally, based on these comparisons, we propose a number of stratigraphic age tie-points to anchor ice-core chronologies from Greenland (GICC05) and Antarctica (WD2014) to the absolute dated tree-ring chronology. We thereby aim to improve proxy synchronization

throughout the Holocene -- a prerequisite for detection and attribution studies -- and invite the paleo-climate community to update climate proxy records based on ice cores to the latest chronologies.

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