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Sulfur isotope compositions of the NEEM ice core reveal glacial-interglacial and millennial-scale variability in the sources of sulfate aerosols

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The sulfur (S) isotope composition of ice cores represents a novel proxy to quantify variability in the sources of atmospheric sulfate. Sulfate aerosols exert a crucial but highly uncertain feedback on the climate system, acting as cloud condensation nuclei and scattering incoming solar radiation. Ice cores from Antarctica indicate that the majority of sulfate aerosols are sourced from marine biogenic activity, with little variability in emissions between glacial and interglacial periods. However, there are currently no published S isotope studies from the Arctic extending beyond the Common Era, and it is unclear how processes could differ between hemispheres. We present a high-resolution S isotope record of the NEEM ice core from Greenland, covering an entire glacial cycle from 0-128 ka BP. S isotope values appear to co-vary with the climate, exhibiting far lighter isotopic compositions during the Last Glacial compared to the Holocene or Last Interglacial. Systematic variability of S isotope values across Dansgaard–Oeschger events and strong linear relationships with water isotope compositions and calcium concentrations of the ice are also observed. We interpret these trends to show climatically controlled changes in the key sources of sulfate reaching the NEEM ice core site. During peak glacial conditions, the budget is dominated by sulfate sourced from terrestrial dust and volcanic emissions, with a negligible marine biogenic component. This finding suggests that we can use S isotopes to identify time periods when the source region for marine biogenic emissions reaching Greenland may have been completely ice-covered. Overall, this study provides new insights into the processes controlling sulfate aerosols in the Arctic and how the S cycle interacts with the climate.