Subannual Ice Core Measurements of Sulfate Aerosol from 1995 to 2023

Drew Pronovost[1], Ursula A. Jongebloed[1], Andrew Schauer[1], Salima "Marky" Mayanja[1], Jihong Cole-Dai[2], Derek Brandis[2], Nathan Chellman[3], Rachel Moore[4], Ben Riddell-Young[5], Becky Alexander[1]

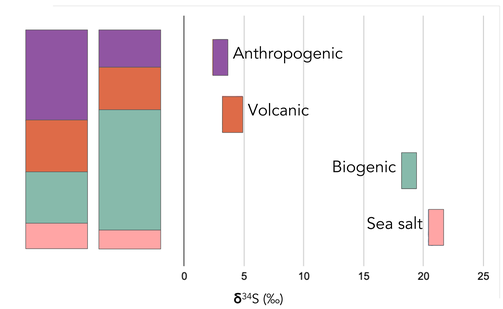
(1) University of Washington, (2) South Dakota State University, (3) Desert Research Institute, (4) Georgia Institute of Technology, (5) NOAA Global Monitoring Laboratory

Core Info

Shallow core taken from near Summit Station, which is typically representative of Europe and North America emissions.

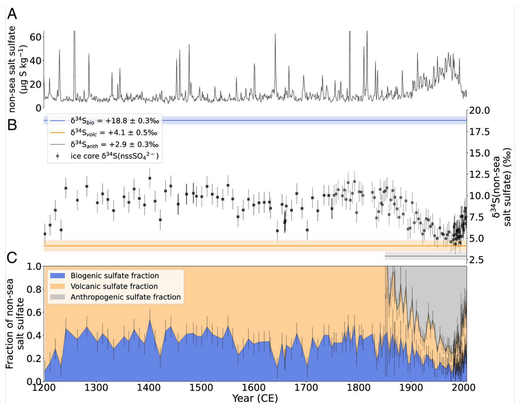
Subannual measurements were made from 1995 to 2022.

This allows for estimates of seasonal resolution.



Sulfur isotopes allow us to attribute the sulfur to its source.

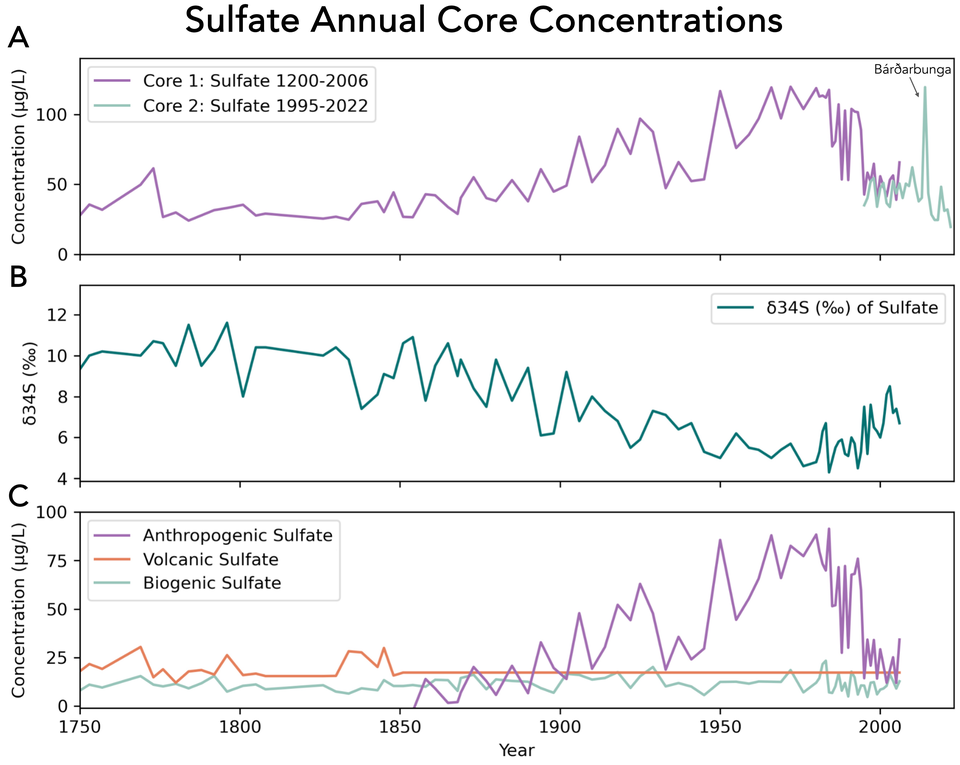
Differing sources have different implications for climate.



From Jongebloed et al 2023 (1). **A)** Total non-sea salt sulfate, **B)** $\delta^{34}S$ from non-sea-salt sulfate, **C)** Fraction by source.

This prior core shows that anthropogenic sulfate rose during industrialization, falling after clean air legislation, but these trends occur at the very end of the core, making the current state unclear.

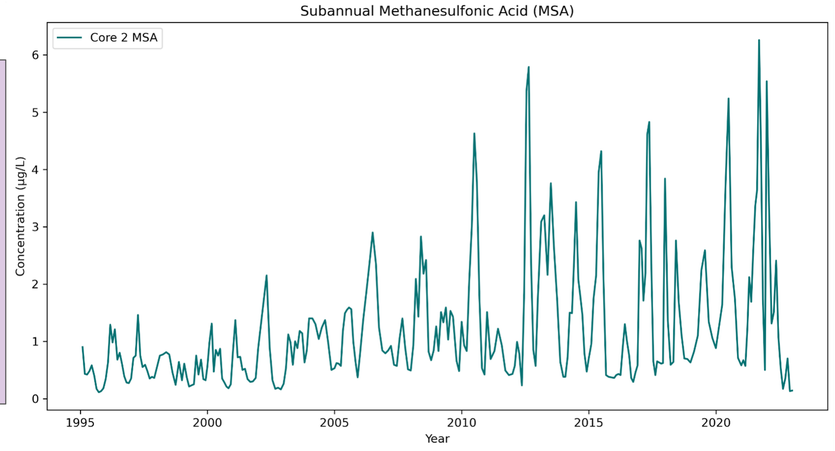
Sulfate Annual Core Concentrations



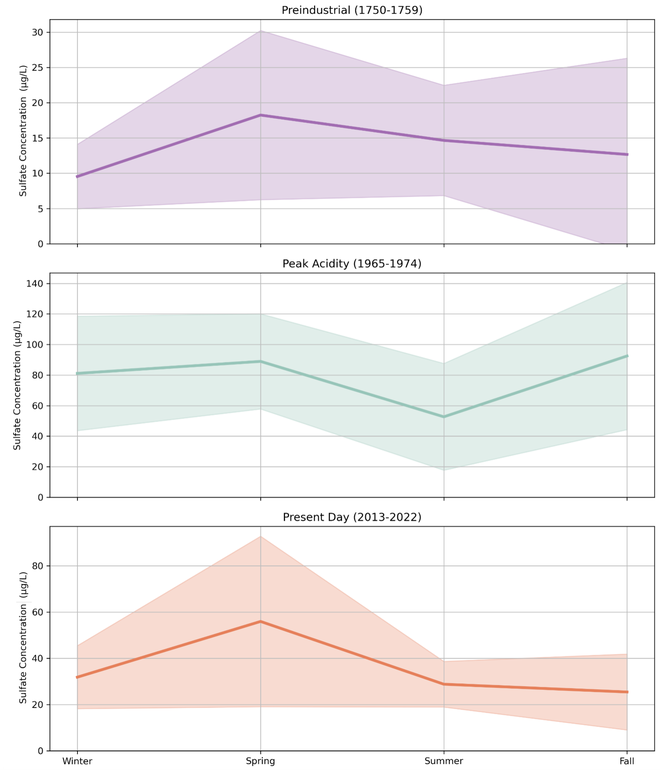
A) Sulfate annual core concentrations have risen since the mid-1800s, falling in the late 20th century. The 2014 peak in sulfate is likely due to the Bárðarbunga eruption in Iceland. Note that years with major volcanic eruptions are excluded from Core 1 (2). **B)** The value of $\delta^{34}S$ fell through the industrial era and rose starting in the 1970s, reflecting the changing influence of anthropogenic sulfate. **C)** Biogenic sulfate remained roughly constant prior to 1850, at which point anthropogenic sulfate grew rapidly until peaking in 1980. Note that starting in 1850, volcanic sulfate is assumed to be constant based on prior concentrations to allow for anthropogenic and volcanic sulfate to be distinguished.

Methanesulfonic acid, MSA, has been used as a tracer for both biogenic sulfate and sea ice extent (3,4), but may be influenced by changes in oxidants.

Since 1995, MSA has increased, showing a strong yearly cycle.



Sulfate Concentration by Season



Major ions were used to distinguish each season: peaks in sodium as a marker for winter, calcium as a spring marker, and chloride/sodium as a summer marker. Each period is examined through a representative decade. Solid line represents seasonal average; shaded region represents standard deviation. Points influenced by the Bárðarbunga eruption were removed.

Future analysis

With the completed core cuts, we will make seasonal measurements of sulfur and oxygen isotopes using an Orbitrap mass spectrometer.

These isotopes will allow us to attribute the fraction of total sulfate that is anthropogenic, biogenic, and volcanic, giving us a better understanding of these changing processes and their climate impacts.

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