Greenland ice sheet carries evidence of increased atmospheric acidity

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This ice core from Summit, Greenland, kept in the laboratory of Jihong Cole-Dai at South Dakota State University, provided data that Lei Geng used in his research. Credit: Jihong Cole-Dai

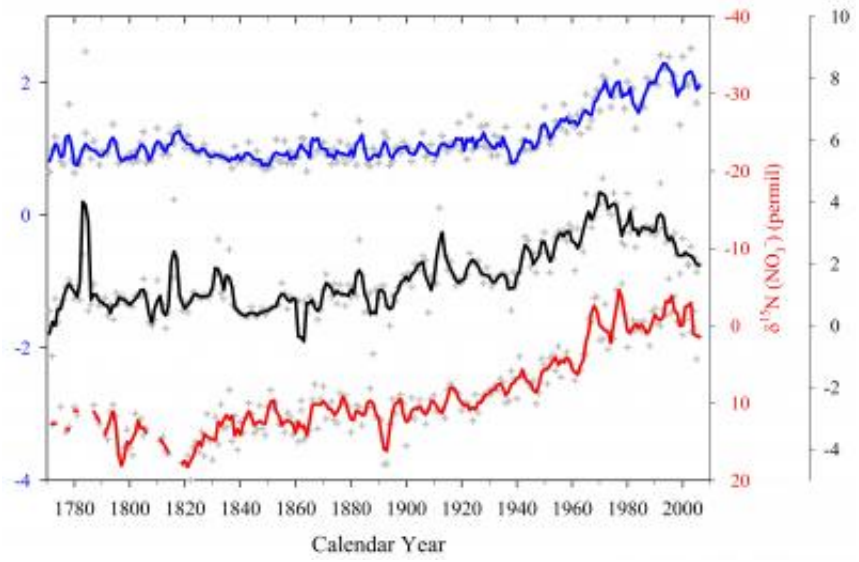
(Phys.org)—Research has shown a decrease in levels of the isotope nitrogen-15 in core samples from Greenland ice starting around the time of the Industrial Revolution. The decrease has been attributed to a corresponding increase in nitrates associated with the burning of fossil fuels.

However, new University of Washington research suggests that the decline in nitrogen-15 is more directly related to increased acidity in the atmosphere.

The increased acidity can be traced to sulfur dioxide, which in the atmosphere is transformed to sulfuric acid, said Lei Geng, a UW

research associate in atmospheric sciences. Following the Industrial Revolution, sulfur dioxide emissions increased steadily because of coal burning.

"It changes the chemical properties of the lower troposphere, where we live, and that can have a lot of consequences," Geng said. He presents his findings Friday (Dec. 7) at the fall meeting of the American Geophysical Union in San Francisco.



Ice core data show concentrations of nitrate (top line), hydrogen ions (middle line) and nitrogen-15 (bottom line) from 1772 through 2006. Credit: Lei Geng/University of Washington

The gradual buildup of acidity in the atmosphere over a century got a boost around 1950 with a sharp increase in nitrogen-oxygen compounds, referred to as NOx, mainly produced in high-temperature combustion such as occurs in coal-fired power plants and motor vehicle engines. NOx is easily converted to nitric acid in the atmosphere, further

increasing the acidity.

NOx carries a chemical signature – the abundance of nitrogen-15, one of two nitrogen isotopes – which changes depending on the source. That means it is possible to distinguish NOx that came from a forest fire from NOx produced as a result of lightning, soil emissions, car exhaust and power plant emissions. The level of nitrogen-15 can be measured in nitrates that formed from NOx and were deposited in ice sheets such as those in Greenland.

Current evidence indicates NOx from coal-fired power plant and motor vehicle emissions likely carries more nitrogen-15 than NOx produced by natural sources, so nitrogen-15 levels in deposited nitrate could be expected to go up. However, those levels actually went down in the late 1800s, following the Industrial Revolution, Geng said. That's because increasing sulfuric acid levels in the atmosphere triggered chemical and physical processes that allowed less nitrogen-15 to remain in vaporized nitrate, which can be carried to remote places such as Greenland.

The growing acidity in the atmosphere was occurring decades before acid rain was recognized as a threat, particularly in industrial areas of North America.

Core samples from Greenland ice sheets reflect a correlation between nitrogen-15 levels and atmospheric acidity, Geng said. Data he studied came primarily from a core that is part of combined research between UW and South Dakota State University, funded by the National Science Foundation.

Geng noted that the core reflects a decline in signals for both NOx and sulfur dioxide emissions in the 1930s, during the Great Depression. The signals increased again following the Depression until the early 1970s, when Western nations experienced an economic downturn and an oil

shortage. Shortly after that, the Clean Air Act in the United States began to have an impact on vehicle and power plant emissions.

"We've seen a huge drop in sulfate concentrations since the late 1970s," Geng said. "By 2005, concentrations had dropped to levels similar to the late 1800s."

Ice core data show nitrate levels have stabilized during that time, he said, because while emission levels from individual vehicles might have decreased substantially, the number of vehicles has increased significantly.

Provided by University of Washington