Anthropogenic Acid Deposition in a Southern Greenland Ice Core

Dan Pasteris, Joe McConnell, Ross Edwards, Ryan Banta, Kelley Sterle, Marion Bisiaux

Desert Research Institute, Reno, Nevada

March 17, 2010

www.dri.edu

State of the Arctic Conference, Miami, 2010
Presentation Outline

- DRI Ice Core Lab
- Continuous flow acidity measurement technique
- Ice core results from Southern Greenland
- Comparison with North American acid rain data
Purpose

- Assess the severity of acid deposition in the Arctic.
- Establish a connection with the source region.
- Use ice core acidity as a proxy for acid deposition in North America.
pH and Acidity Definitions

\[ \text{pH} = -\log[H^+] \]

\[ \text{Acidity} = [H^+] - [HCO_3^-] \]

For stable pH and acidity measurements you must control the \( \text{CO}_2 \) concentration!

\[ \text{CO}_2 + \text{H}_2\text{O} \rightleftharpoons \text{H}_2\text{CO}_3 \rightleftharpoons \text{HCO}_3^- + \text{H}^+ \]
pH Measurement

Equilibrate sample with 385 ppm CO₂
Minimize mixing
Ice Core and Acid Rain Sites

Overlap Period: 1978 - 2003

Acid Rain Sites
1978 - present
Acid Rain Site Composite

Spatially representative composite
Ice Core Acidity 1880 - 2010
Act2 Ice Core – North America Correlation

![Graph showing correlation between Act2 Acidity (uM) and Acid Rain Composite (uM). The correlation coefficient is R = 0.74 and p < 0.001.](image)
Detrended Correlation

![Graph showing detrended correlation between Act 2 Acidity and Acid Rain Composite. The correlation coefficient (R) is 0.48 with a p-value of 0.024.](image-url)
Ice Core and Acid Rain Sites
Hubbard Brook, NH
Precipitation pH
Looking beyond Act 2
Summary

• Acidity in ice cores can be accurately measured by continuous flow analysis (± 0.2 μM or 5%).

• Anthropogenic acid deposition in southern Greenland began around 1900, reached a maximum in the 1970s, and has since been dramatically reduced.

• Southern Greenland acidity after 1900 is predominately derived from North America and can be used as a proxy for North American acid deposition prior to 1980.
Thank You!
Charge Balance Verification

- Charge balance accounting of Non-seasalt chemical species

\[
\text{Acy} = \begin{array}{c}
\text{Acid Anions} \\
\text{H}_2\text{SO}_4 + \text{HNO}_3 + \text{HCl}
\end{array} - \begin{array}{c}
\text{Base Cations} \\
\text{CaCO}_3 + \text{NH}_3
\end{array}
\]
Charge Balance Comparison

![Graph showing acidity over time]
Measured vs. Modeled
$\text{CO}_2$ Equilibration Bubbler