Validation of Mt. Waddington Ice Core Paleoclimate Record

Stable Isotope and Melt Stratigraphy Correlation

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• Ice coring and paleo-temperature
• Project overview
• Sampling methods
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Ice coring and paleo-temperature

- **Question:** What information is stored in annually accumulated layers of snow and ice?
- **Answer:** A lot of things.
  - Carbon dioxide, methane, dust, volcanic horizons….
    And STABLE ISOTOPES

- Isotopic composition of water in snow and ice.
  - This factor depends roughly on air temperature and so can illustrate short-term seasonal variations and long-term average temperature

![Diagram showing annual layers, ice flow, and ice core with thinned layers](image)
Ice coring and paleo-temperature

Oxygen has three stable isotopes: $^{16}\text{O}$, $^{17}\text{O}$, and $^{18}\text{O}$

Combinations important for paleo-temperature:
$\text{H}_2^{16}\text{O}$ and $\text{H}_2^{18}\text{O}$

Lighter oxygen isotope gives $\text{H}_2^{16}\text{O}$ higher vapor pressure than $\text{H}_2^{18}\text{O}$

**Evaporation** results in vapor with less $^{18}\text{O}$ than the original water source
- Vapor is depleted, or isotopically light

And

**Condensation** from vapor contains more $^{18}\text{O}$ than the vapor remaining
- Condensate is enriched, or isotopically heavy
Ice coring and paleo-temperature

- As vapor is transported poleward, cooler temperatures result in continued condensation, therefore enriching condensate and depleting vapor.
- If the average temperature at evaporation source and ice coring site changes, $\delta^{18}O$ in core shifts accordingly.

$$\delta^{18}O_{ice} = \frac{\left(\frac{H_2^{18}O}{H_2^{16}O}\right)_{ice} - \left(\frac{H_2^{18}O}{H_2^{16}O}\right)_{Standard}}{\left(\frac{H_2^{18}O}{H_2^{16}O}\right)_{Standard}} \times 1000\% $$
Ice coring and paleo-temperature

GISP2 $\delta^{18}$O

$\sim 8$-$9^\circ C$ change

Present day $\delta^{18}$O $\approx 0.67\%_0$ per $^\circ C$
Project overview

• 65 meter pilot ice core retrieved
  Summer 2006

• Combatant Col, British Columbia, Canada
Project goals

• Investigating site potential for providing high-resolution climate data for Pacific region
  - Snow accumulation data to compare with other ice cores
  - Decadal-scale climate variations
    (Pacific Decadal Oscillation, El Niño-Southern Oscillation)
  - Precipitation variability relation to large-scale atmospheric circulation

• Isotope and melt stratigraphy correlation would indicate annual layer preservation
  - High $\delta^{18}$O (~high temps) with high melt layer concentration
  - Low $\delta^{18}$O (~low temps) with low melt layer concentration
Sampling process
Logging melt stratigraphy

- Seasonal surface melt preserved
- Qualitative melt index
  - Melt magnitude
    0 1 2 3 4 5
- Regular shifts between high and low melt concentration
  - Summer and Winter
- No evidence that melting influences inter-annual stratigraphy
Combining stable isotopes and melt stratigraphy
Combining stable isotopes and melt stratigraphy

- Preliminary age scale dates core base to 1983
Project summary / status

- Ice core analysis demonstrates inter-annual stratigraphy preservation, despite surface melting.
- Independent confirmation from dust peaks at 1986 and 1993 in DRI data, as well as unambiguous annual peaks.
- Site accumulation rate ~2m/year (ice equivalent), ice depth ~200m (confirmed by ice radar September 2007).
- Age of ice stratigraphy at depth likely 200 to 1000 years BP.
• Proposal submitted to retrieve full core to bedrock
• Potential to gain robust datasets for interpretation of climate variation in the Pacific region
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