Part 1.
Why sites like South Pole and Herc Dome matter for understanding Antarctic climate variability

Eric J. Steig
Quaternary Research Center and Department of Earth and Space Sciences, University of Washington
Jacobel, Welch, Steig, Schneider, 2005 reported basic site characteristics and a 300-year isotope record.
Hercules Dome and South Pole: blank spot on the map of long ice core records in Antarctica

Nicholas et al, 2008
Hercules Dome and South Pole: blank spot on the map of long ice core records in Antarctica

“West Antarctic accumulation, East Antarctic temperature”

Nicholas et al, 2008
Climate variability comes in spatial patterns

ECHAM 4.6 with climatological SST as boundary condition; observed SST in central tropical Pacific

Antarctic T response

Ding et al., Nature Geoscience, 2011
Response to SST forcing in the central tropical Pacific

200 hPa response to SSTs in the central tropics only

Antarctic T response

ECHAM 4.6 with climatological SST as boundary condition; observed SST in central tropical Pacific

Ding et al., Nature Geoscience, 2011
Response to SST forcing excluding the central tropical Pacific

ECHAM 4.6 with observed SST as boundary condition; climatological

200 hPa response to SSTs outside the central tropics

Antarctic T response

Ding et al., Nature Geoscience, 2011
Ensemble response to idealized $1\sigma$ anomalies in the central tropics

*the central tropical Pacific is a key region for West Antarctica*

ECHAM 4.6 response to simple SST pattern in central tropical Pacific
a) Model response to Indian Ocean SST (JJA Z200 and surface Temp/SLP)

b) Model response to ENSO SST (JJA Z200 and surface Temp/SLP)
1980, an extreme climate anomaly: max. $\delta^{18}O$, min sea ice, max circulation anomalies

*Küttel et al., in review*
Spatial pattern of 1980 anomalies
SSTs and West Antarctic $\delta^{18}$O

![Graph showing SSTs and West Antarctic $\delta^{18}$O over time.](image)

- Isoptope or temperature anomaly (per mil or °C)
- Decades: global SST
- Annual d18O
- Tropical Pacific
- Central tropical Pacific
Even on long timescales, climate variability comes in patterns.
Existing East Antarctic ice cores all look the same! What will South Pole look like?

Declining Holocene temperature
Summary

- The dominant influence on Antarctic climate is different in different locations. The response to the same forcing is different in different locations. This is true all timescales.

- ITASE cores are already out of date (2010 was the warmest summer on record at South Pole, for instance)

- South Pole and Hercules Dome are climatically distinct from other East Antarctic sites.

- WAIS Divide will not be the last word on WAIS – we need multiple cores to get the full spatial picture. There may be Eemian ice Herc Dome.
Alpine Ice Coring: Studies at Combatant Col
British Columbia, Canada

Combatant Col site
COMBATANT COL SITE
(51.39°N, 125.22°W), 3000m asl

Annual snow accumulation not great (~30 cm water equivalent per year)

Ice is deep (250-300 meters)

Relatively easy to get to and work in

Established NSF science support

Relatively simple, laminar ice flow

Strong chemical signals in snowpack

(The) lights go out every winter

Accessible by helicopter

Strong tents a different story…
COMBATANT COL SITE
(51.39°N, 125.22°W), 3000m asl

Surface snowmelt common

→ Not destructive, and useful as a summer indicator
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Surface snowmelt common

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Annual snow accumulation high, but...

→ Ice is deep (250-300 meters)

Dust peaks every Spring-Summer, from forest fires and Asian sources

April 2001 event, NASA SeaWiFS
COMBATANT CHEMISTRY

High resolution imaging for melt layer analysis

Ultra-trace continuous flow analysis of chemical species in water

THIS MAKES THE DIFFERENCE AND BRINGS **USEFUL** ALPINE ICE CORE RECORDS TO THE TABLE
Soot (ppb) vs. Depth (meters)
Accumulation history at Combatant Col
Problem: water prevented us from reaching bedrock.
Summary

- Temperate sites such as Mt. Waddington (Combatant Col), McGall Glacier (Alaska), Fremont Glacier (Wyoming), have more potential than once thought. High resolution chemistry shows annual layer is preserved.
- Drilling in these locations probably requires new technology