The McMurdo Dry Valleys of Antarctica: harshest place on Earth or a polar oasis?

Presented by: Dr. Cristina Vesbach, Dr. Michael Gooseff, and Dr. Jeb Barrett

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The McMurdo Dry Valleys of Antarctica: harshest place on Earth or a polar oasis?
Overview

- Introduction to the Dry Valleys (Vesbach)
- Dry Valleys Hydrology (Gooseff)
- Habitats (Vesbach)
- Soil Environment (Barrett)
- Response to Changing Climate (Barrett)

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• Antarctica is completely covered by snow and ice

√) Yes

x) No
Not what you think…
Dry Valley Research

- The Discovery Expedition (1902)
- International Geophysical Year (1959)
- The McMurdo LTER (1994)
  - Wall, McKnight, Fountain, Lyons, Priscu, Virginia, Doran, Wharton
- Many others
  - Hall, Hendy, Denton, Green, Vincent, Hawes, Howard-Williams, Laybourn-Parry
Dry Valleys hydrologic cycle

Precipitation
Dry Valleys hydrologic cycle

Precipitation

Melt
Dry Valleys hydrologic cycle

Precipitation
Melt
Runoff
Dry Valleys hydrologic cycle

- Precipitation
- Melt
- Runoff
- Evaporation
- Sublimation
Seasonal snow cycle
Seasonal snow cycle
Snow ablation (melt + sublimation)

29 Oct 1999
Snow ablation (melt + sublimation)

06 Nov 1999
Snow ablation (melt + sublimation)

13 Nov 1999
Snow ablation (melt + sublimation)

22 Nov 1999
Snow ablation (melt + sublimation)

08 Dec 1999
Snow ablation (melt + sublimation)
Stream flow comes from glaciers
Green Creek – short stream
Longest record from the longest river

**Onyx River**

- **Lake Vanda**
  - **Lake Brownworth**
  - **Vanda Gauge** (1969-today)
    - Low Flow: 1978 (*NO flow*)
  - **Lower Wright Gauge** (LWRT) (1972-today)
    - Low Flow: 1978
Longest record from the longest river

Onyx River
Longest record from the longest river
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Longest record from the longest river
Onyx River

Gooseff et al., 2007, ISAES
Lake levels are integrators of hydrologic processes

Lake Bonney - January, 2006

Barrett et al., 2009, GCB
Lake levels are integrators of hydrologic processes.
Evaporation/Sublimation

Measured rate:
6.17 mm/d

Gooseff et al., 2003, HP
Where do you find wet soil?
• The closed basin lakes in the Dry Valleys maintain their water levels by stream water inflow and losses of water through:
  A) precipitation
  B) melting ice cover
  C) evaporation
  D) none of the above
Let’s Pause for Questions
Dry Valleys Habitats
Habitats
Glaciers
Cryoconite Holes
Blood Falls
Blood Falls
Streams
There’s life in them thar streams!
Lakes
Lakes
Lake Ice
Lakes-water column

Solutes increase downstream, from glaciers to streams to lakes.

- Salt dissolution
- Mineral weathering
- Evaporative concentration
- Cryo-concentration

2006-07 data
Ice
Plankton
Microbial Mats
Pause for your questions
Dry Valley Soil Environments
Soils of the McMurdo Dry Valleys

- Cold
- Dry
- Saline
- Poorly weathered
- Low organic matter
Patterned ground formations near Commonwealth Glacier, Taylor Valley, Antarctica
Patterned ground formations on Spritzbergen Island, Norway
Heterogeneity of Antarctic Soil Environments is Driven By: Water and Surface Exposure Age.
High and Dry Environments Have Oldest Surface Exposure Ages on Earth.

Up to 3% NO$_3$-N by wt.
Antarctic soils are a model system for understanding life in extreme environments; analog for Martian soils
“We have seen no living thing, not even a moss or a lichen; all that we did find,” …”was the skeleton of a Weddell seal, and how it came there is beyond guessing”

Robert F. Scott, 1903
Antarctic Food Webs Are Simple
(lower biomass and diversity than non-polar ecosystems)

- *Eudorylaimus antarcticus*
- Tardigrades (Water Bears)
- Algae
- Microbial Community
- *Scottenema lindsayae*
- Rotifers

"Antarctica's nematodes are the equivalent of elephants and lions"
- E.O. Wilson
What controls distribution of biodiversity in Antarctica?

Plectus spp.

Wall Nematology Lab

Response to climate variation?

S. lindsayae

Wall Nematology Lab, CSU

Response to climate variation?
Poll Question

What’s going on with Antarctic climate?
A) no observed change
B) warming
C) cooling
Recent Antarctic Climate Change Includes Examples of Warming and Cooling

Source: NASA/GISS 2007
West Antarctica (including the Peninsula) have experienced significant warming since the mid-20th century. Antarctic Peninsula has warmed by +2.0 °C since 1950 with a rate of 0.4 °C per decade (Vaughan et al. 2001).
East Antarctica, including The McMurdo Dry Valleys Experienced A Cold Period Between 1986 and 2002

Cooling temperatures led to:
- Increased ice-thickness on lakes
- Decreased stream flow
- Decreased aquatic NPP

Doran et al. 2002. Nature

Annual = -0.7°C/decade
Summer = -1.2°C/decade
20th Century Lake Levels Rise Provides Evidence of Regional Warming.
Regional Cooling Has Been Linked To Ozone Loss (Thompson and Solomon 2002)

What happens has ozone levels recover?
What Regions of Antarctica Have Exhibited the Most Significant Warming?

A) The McMurdo Dry Valleys
B) East Antarctica
C) The Antarctic Peninsula
What Is the Likely Future Climate For the McMurdo Dry Valleys?

**Observed**

- Sustained periods of warming and *cooling*
- Pulse of meltwater during warming events
- Significant hydrological and ecological responses

**Predicted**

- Sustained periods of warming?
- Increased frequency of melt?
To sum it up…

- Unique communities-dominated by microbes
- Many endemic species
- Perfectly adapted
- One of the most diverse bacterial communities on Earth
- Predicted climate change will affect ecosystem and diversity
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For more info:
mcmlter.org
water.engr.psu.edu/antsnow/

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