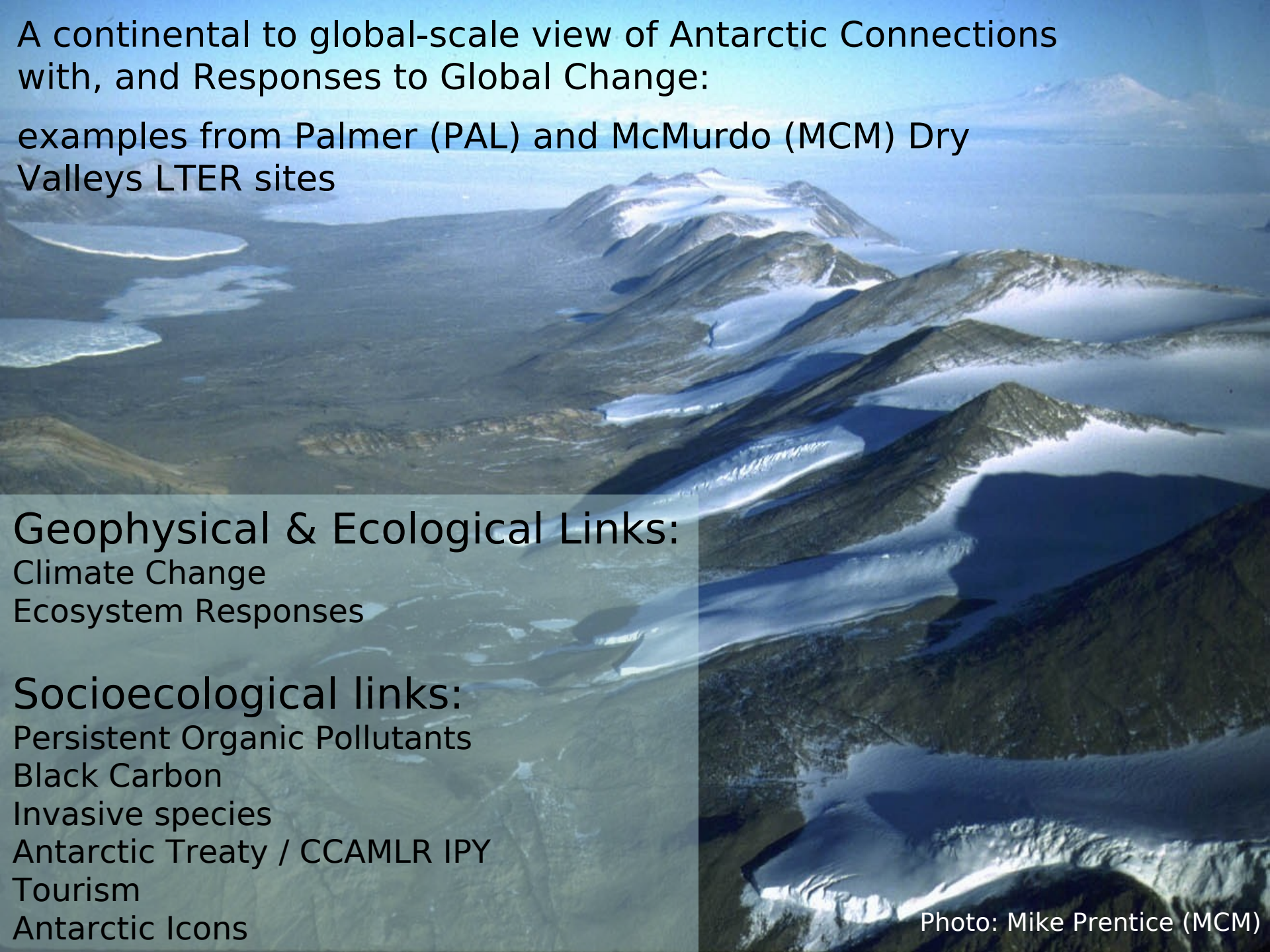


Antarctica: Global Connections and Impacts

Hugh Ducklow
LTER Mini-Symposium
28 February 2008
Washington DC



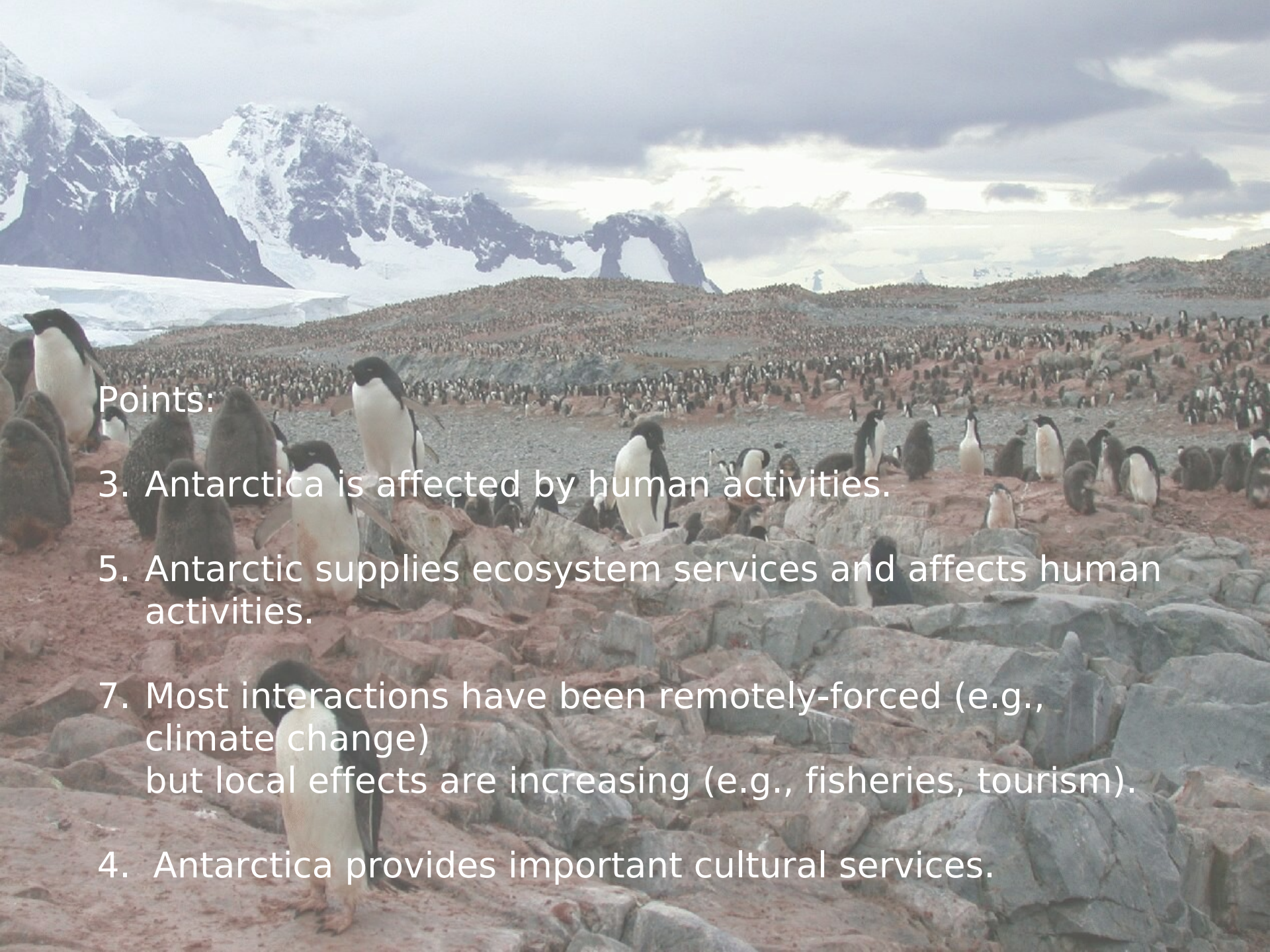


A continental to global-scale view of Antarctic Connections with, and Responses to Global Change: examples from Palmer (PAL) and McMurdo (MCM) Dry Valleys LTER sites

Geophysical & Ecological Links:
Climate Change
Ecosystem Responses

Socioecological links:
Persistent Organic Pollutants
Black Carbon
Invasive species
Antarctic Treaty / CCAMLR IPY
Tourism
Antarctic Icons

Photo: Mike Prentice (MCM)

A large colony of penguins, likely Adelie penguins, is gathered on a rocky, reddish-brown shore. In the background, there are snow-capped mountains and a cloudy sky. The penguins are scattered across the landscape, with some standing on the rocks in the foreground and others forming a dense group further back. The scene is set in a cold, high-latitude environment.

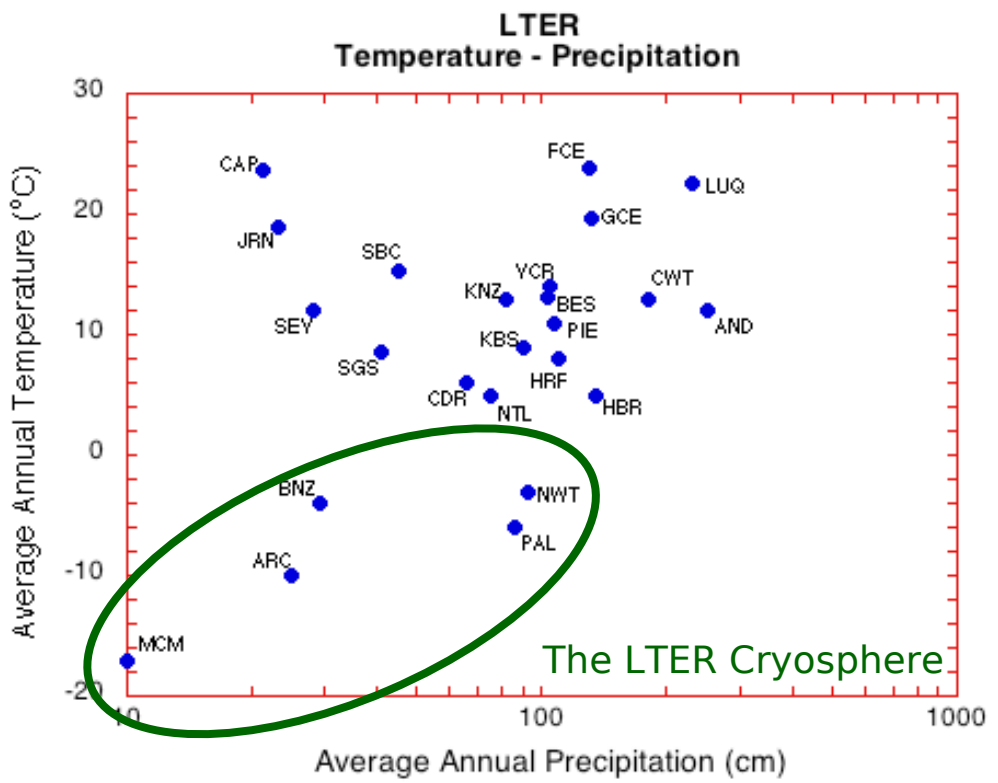
Points:

3. Antarctica is affected by human activities.

5. Antarctic supplies ecosystem services and affects human activities.

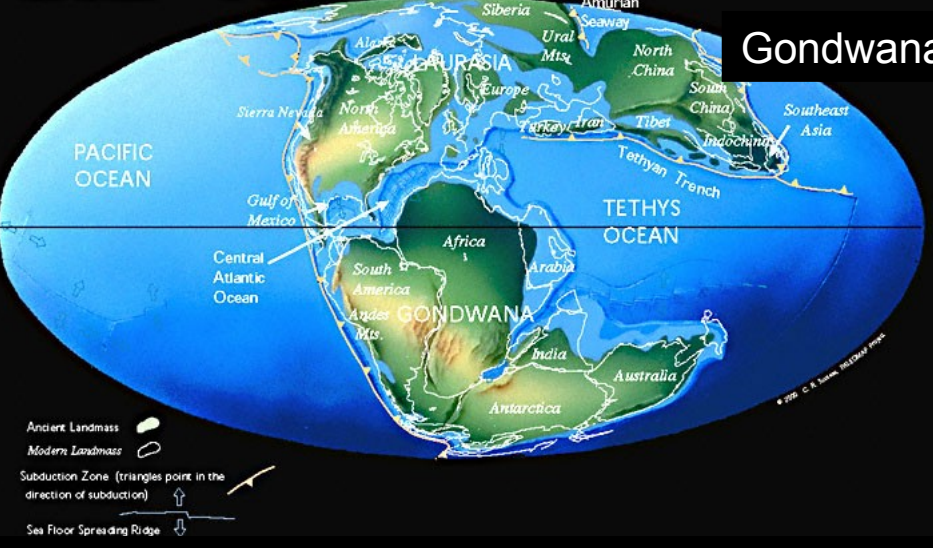
7. Most interactions have been remotely-forced (e.g., climate change) but local effects are increasing (e.g., fisheries, tourism).

4. Antarctica provides important cultural services.

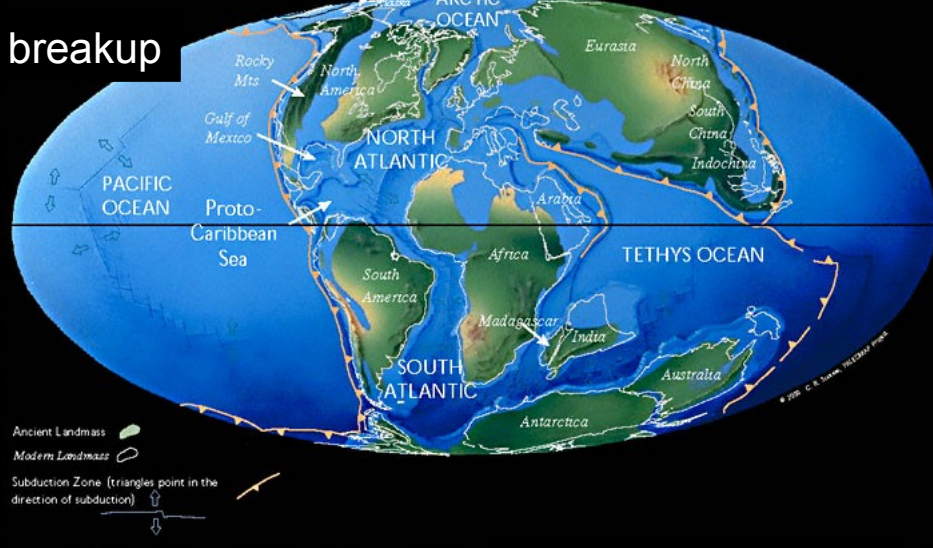


The Isolation of Antarctica, 100 to 20 Ma. (<http://www.scotese.com/earth.htm>)

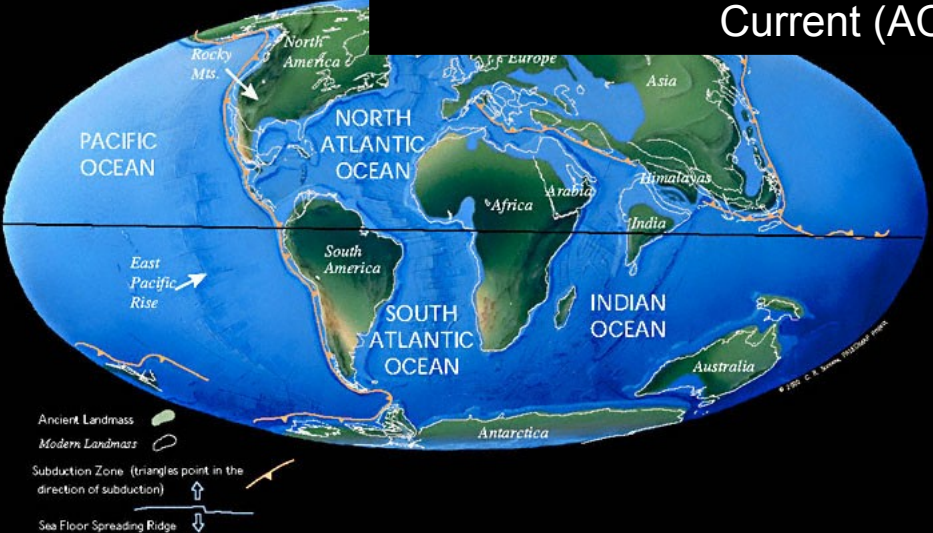
Late Jurassic 152 Ma



Late Cretaceous 94 Ma



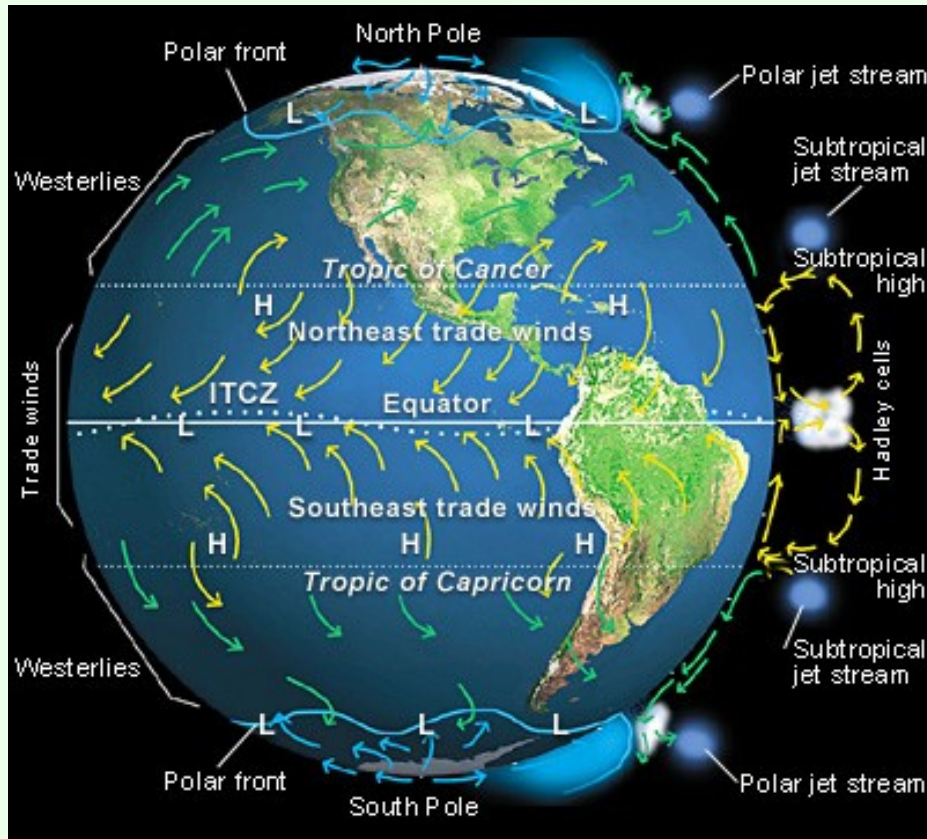
Middle Eocene 50.2 Ma



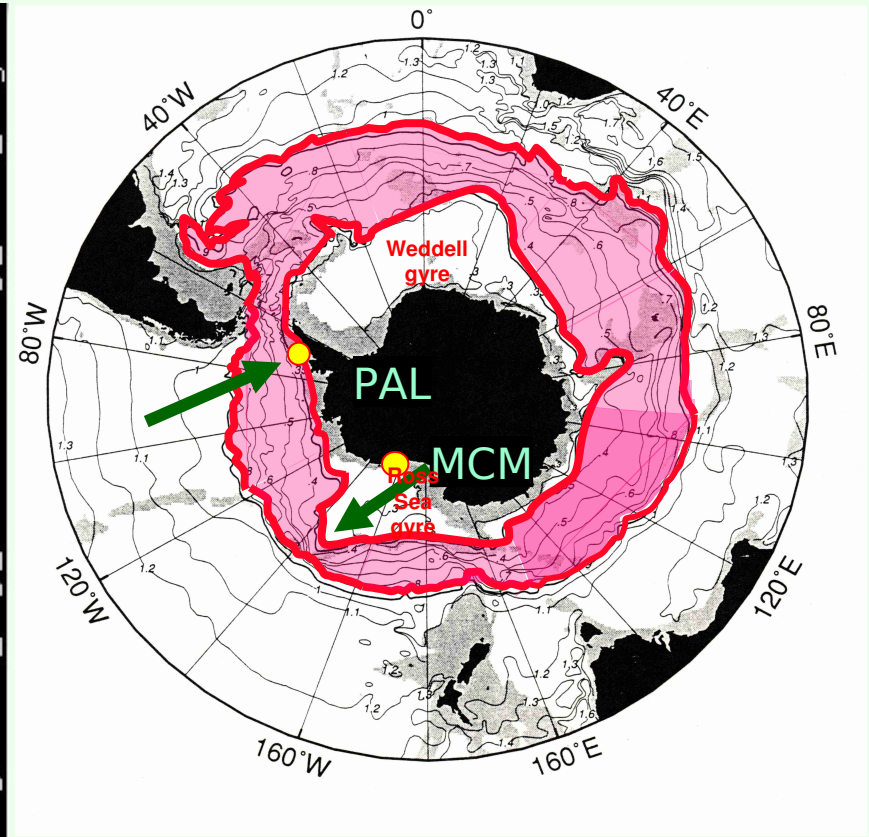
Idle Miocene 14 Ma



Part 1. What is the influence of climate change and anthropogenic processes on Antarctica?



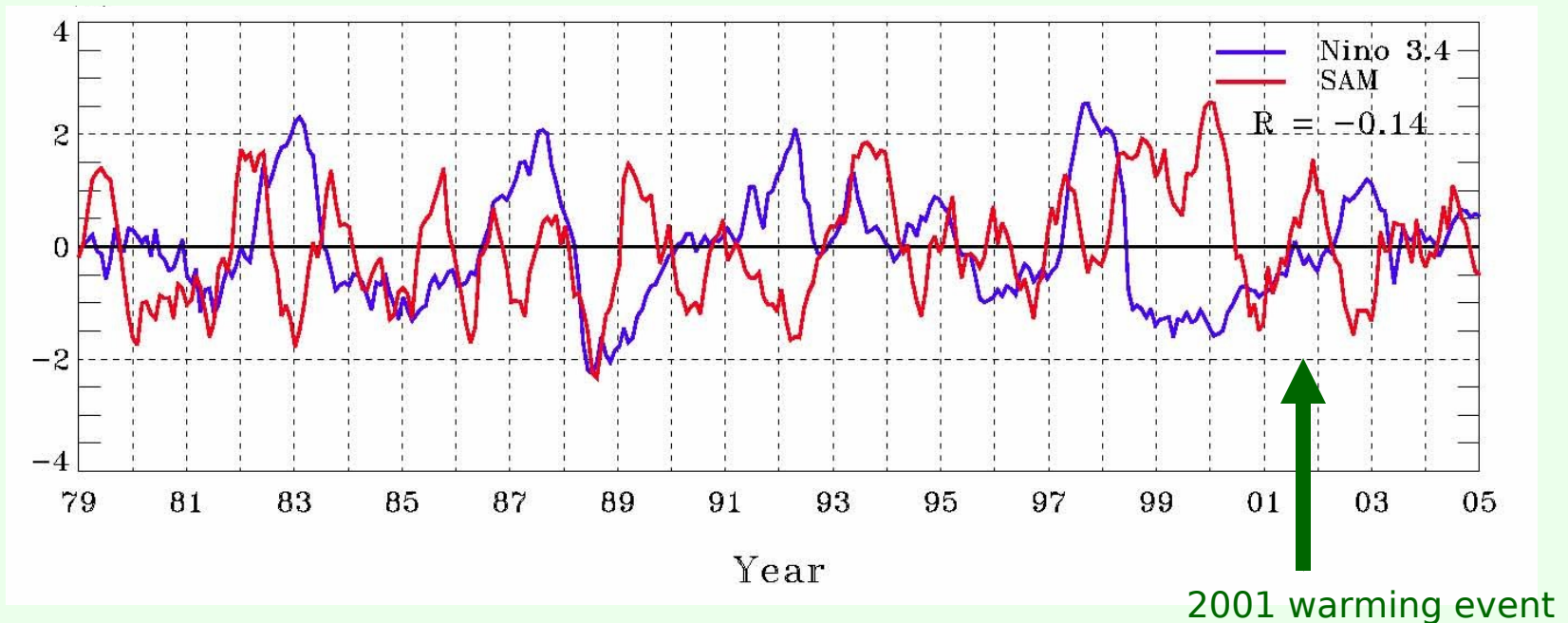
Atmospheric circulation:
Isolating effect of Polar Front



Ocean circulation:
Antarctic Circumpolar Current
Heat input to Peninsula

The Southern Annular Mode (SAM): a hemispheric-scale pattern of climate variability describing non-seasonal anomalies in sea level pressure, temperature, winds and precipitation (*like El Nino but different*).

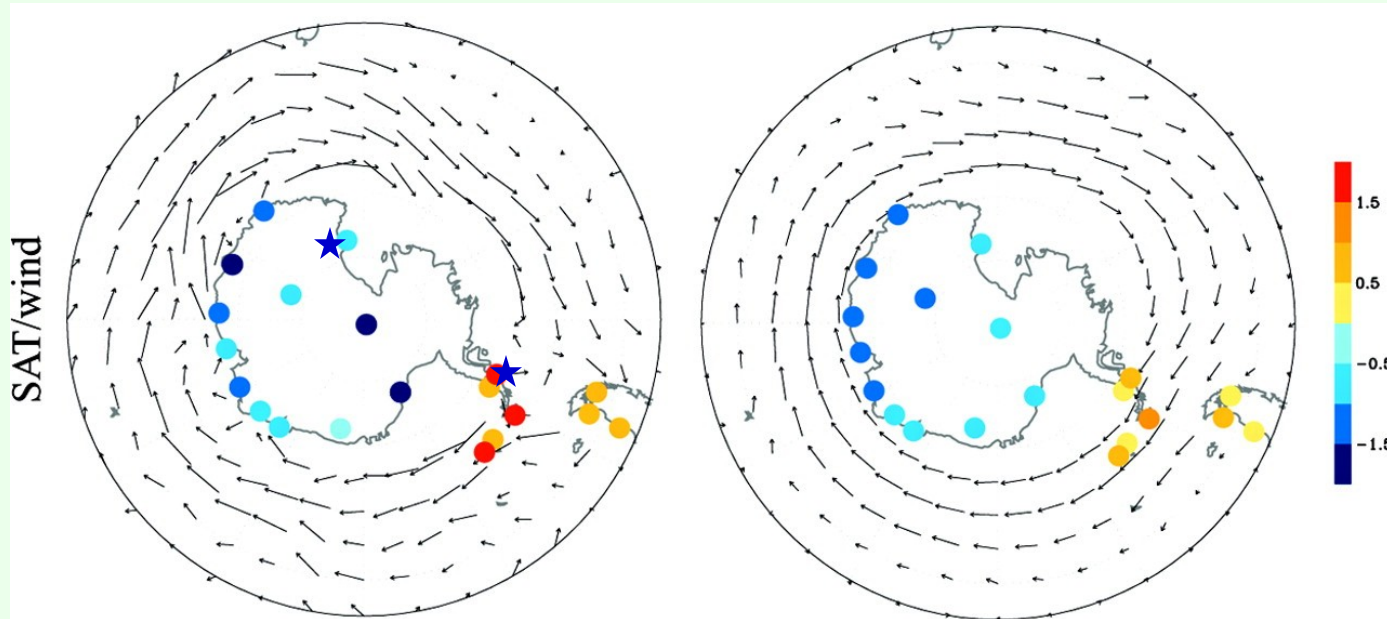
Positive SAM: low pressure over pole, high pressure over subtropics. Negative ENSO: reinforces +SAM conditions



Positive SAM is associated with warming and stronger westerly winds on the Peninsula and with cooling in the Ross Sea/McMurdo region (MCM story to follow).

Trend

Congruent with SAM

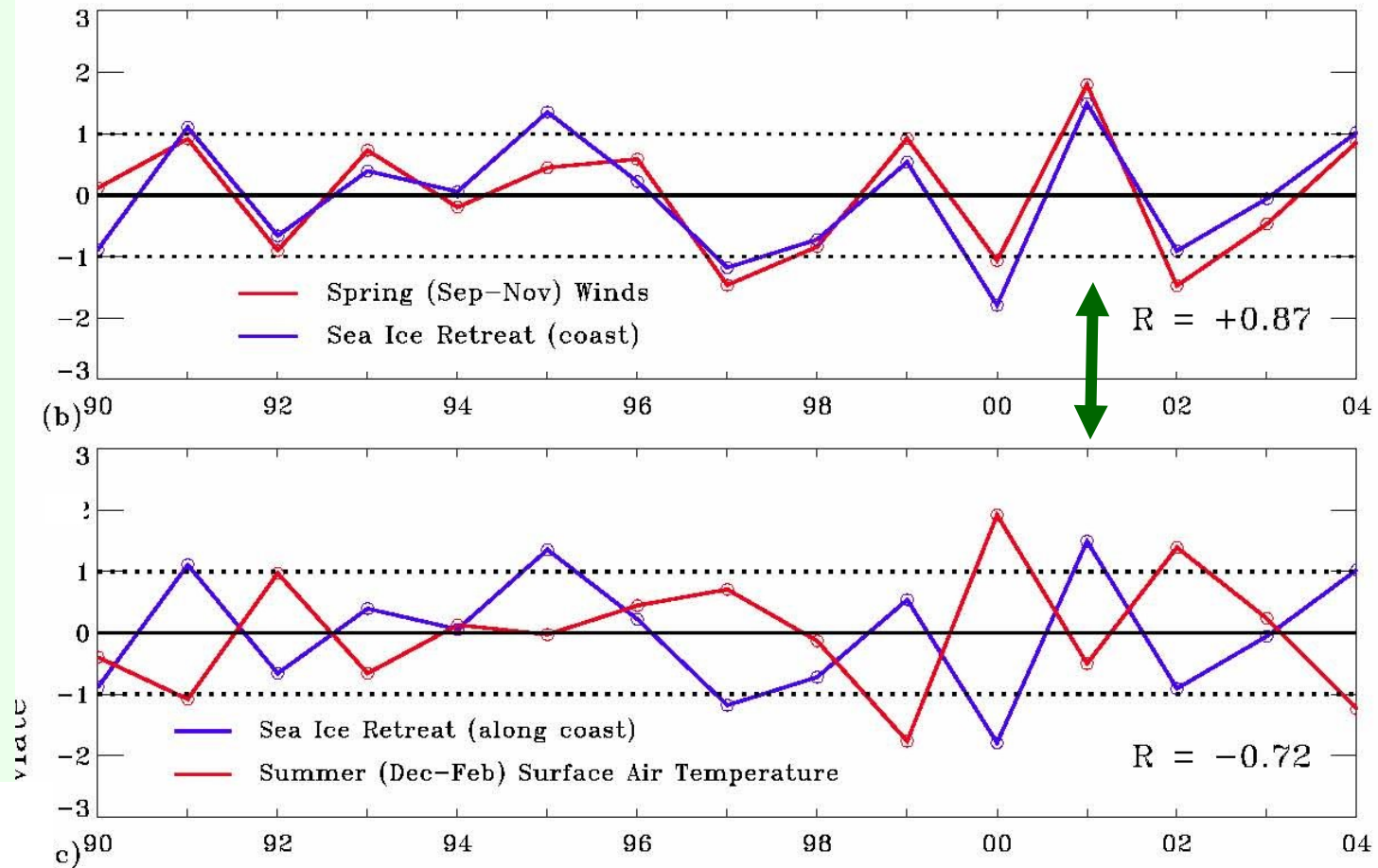


1969-2000 surface temperature trends (dots) and
1979-2000 trends in 925-hPa winds (arrows):

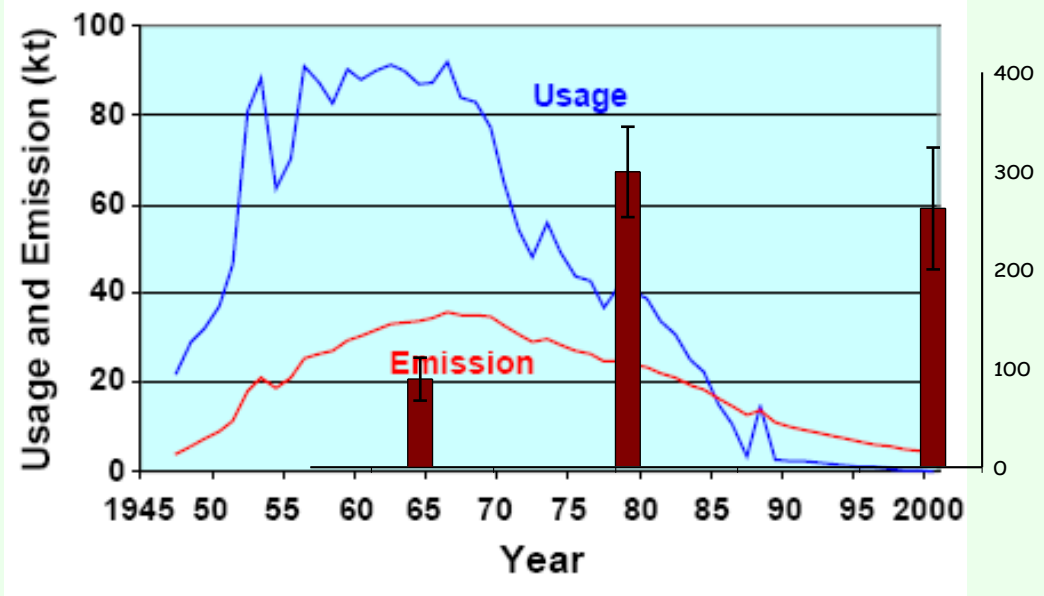
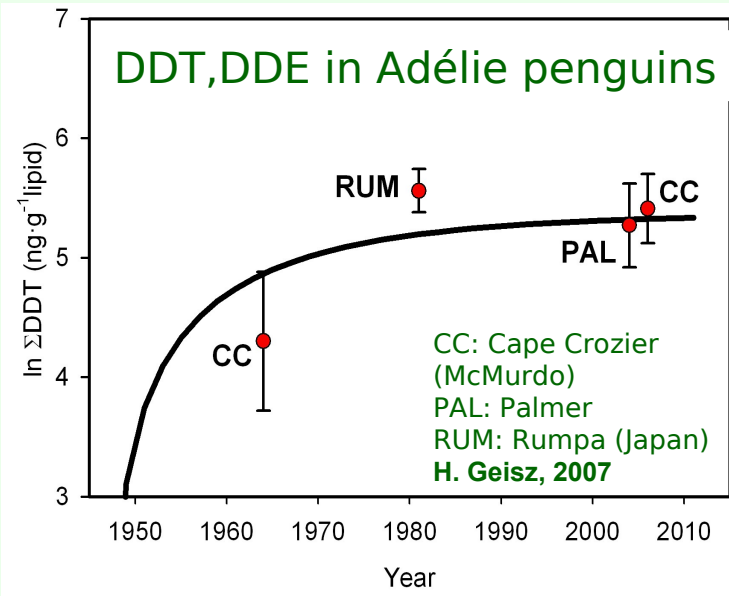
SAM-induced shifts in circulation could account for 90% of
summertime cooling over continent and half of the warming
on the Peninsula

Thompson & Solomon 2002 Science

Sea ice variability along the Peninsula is strongly correlated with winds and temperature (driven by SAM state; PAL story to follow).



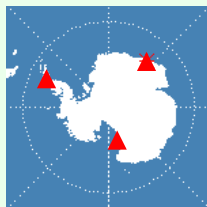
Persistent organic pollutants in Antarctic foodwebs



1976: Risebrough found high levels of DDT in ice layers 0 – 6.0m

2003 Amy Chiuchiolo (PAL, MCM) finds DDTs not detected in air, water, snow or glacier ice cores (1 m)

DDTs were detected in glacier melt-water runoff



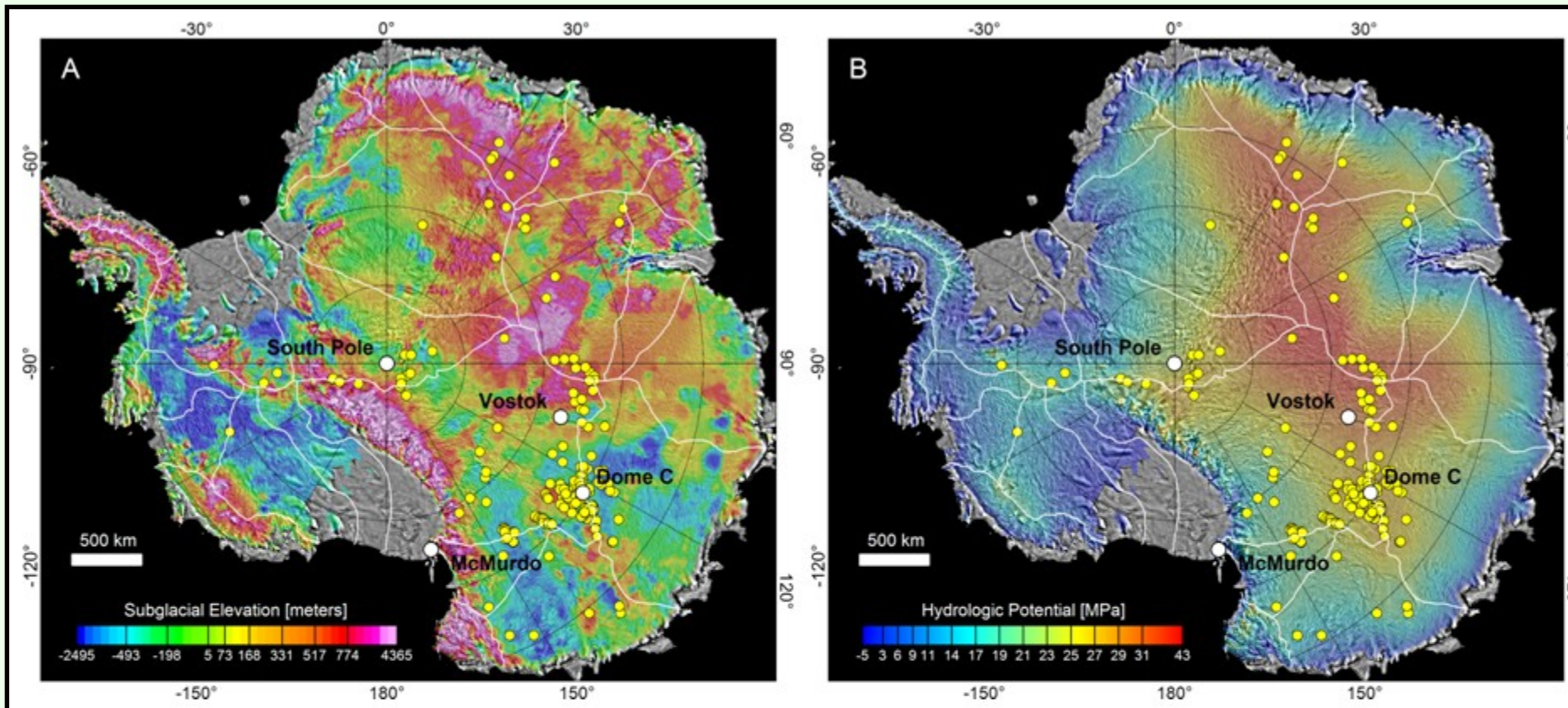
Plankton DDT concentrations show a near shore gradient (i.e., in penguin diet items)

2004-2008: Heidi Geisz (RPSC, PAL) models steady-state levels of DDTs in penguins (bars in right-hand graph)

Retreating glaciers along Peninsula harbor $\sim 4T \Sigma$ DDT, slowly releasing it to the environment.

(research by PAL grad students)

Antarctic Subglacial Lakes (Lake Vostok et al)



Subglacial Lakes (Lake Vostok et al): a vast, interconnected, ancient and nearly unknown ecosystem: now threatened by climate change, movement and change in ice sheets, and human interference.

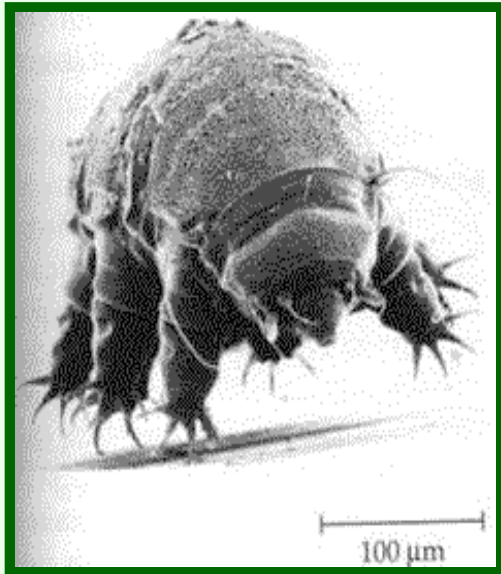
Part 2. How do Antarctic ecosystems respond to climate variability?

1. MCM-Dry Valleys: glacial runoff-induced flooding impacts the soil foodweb

Nematodes (top predators)

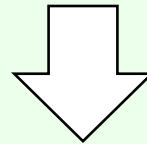
Bacteria, soil algae, mites

Tardigrades (herbivores):



Collembola, protozoans,

Rotifers (herbivores):

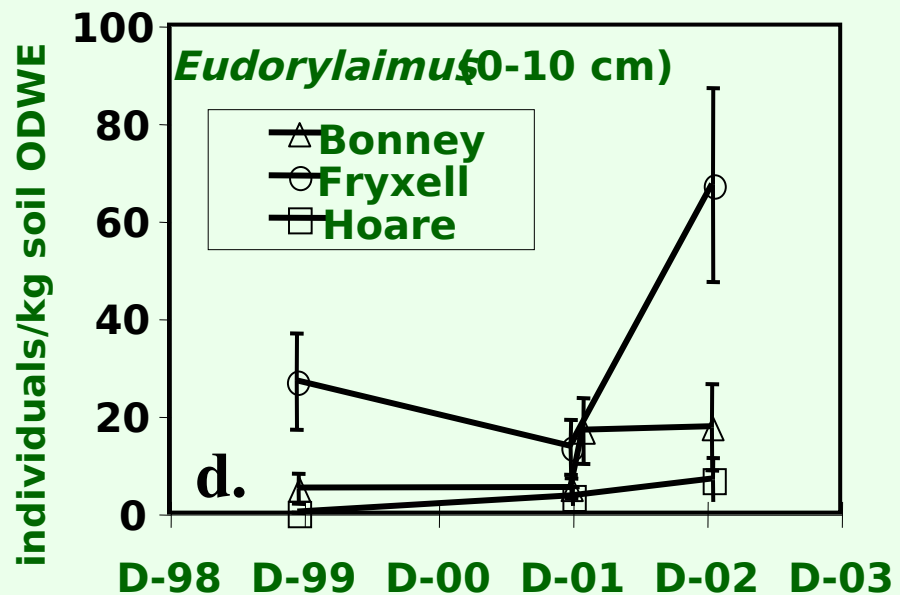
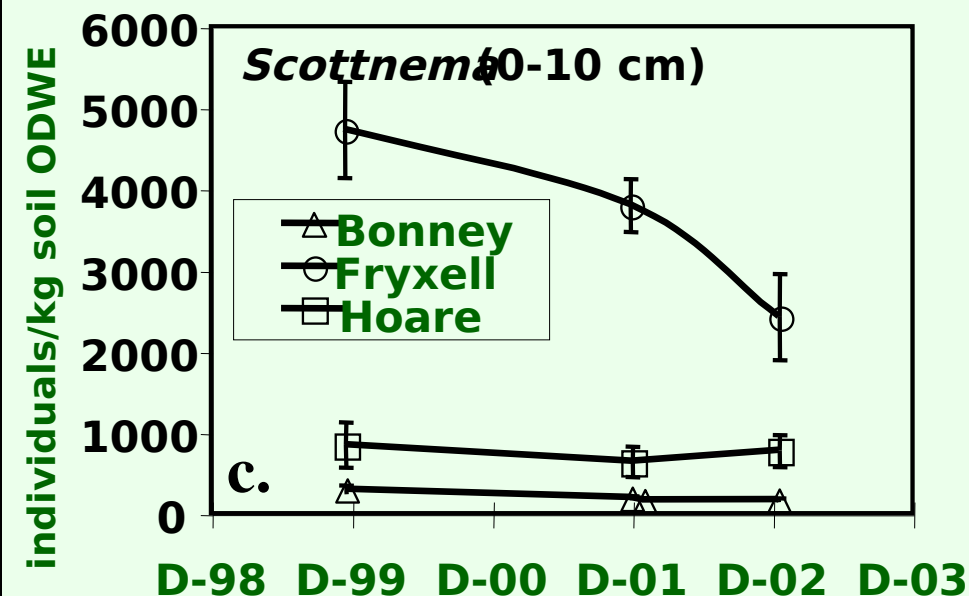
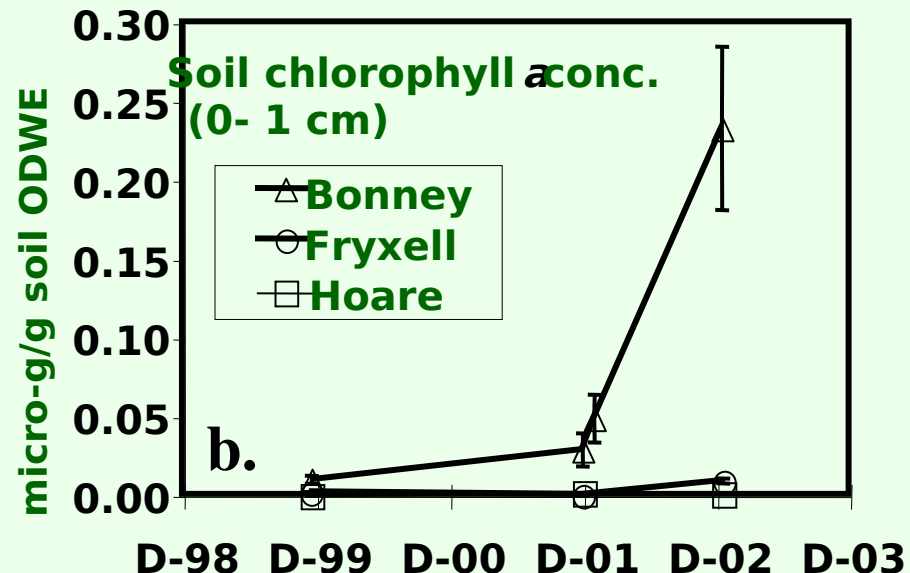
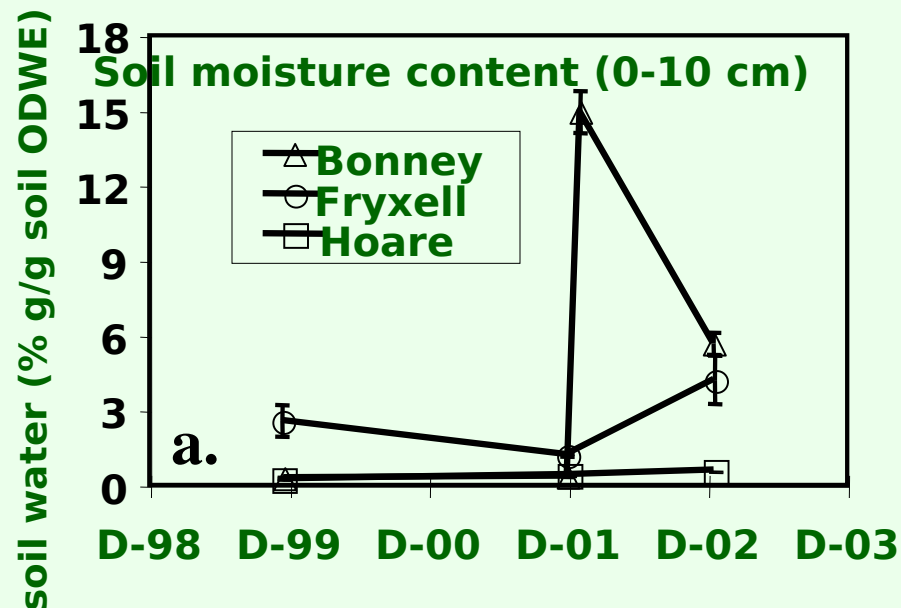


- *Scottnema lindsayae*
- *Plectus antarcticus*
- *Eudorylaimus antarcticus*

2001: Shift from +SAM to -SAM triggered warming, glacier melting and soil flooding in the Dry Valleys



Flora Responses to “Wet Event” in Long Term Monitoring Plots

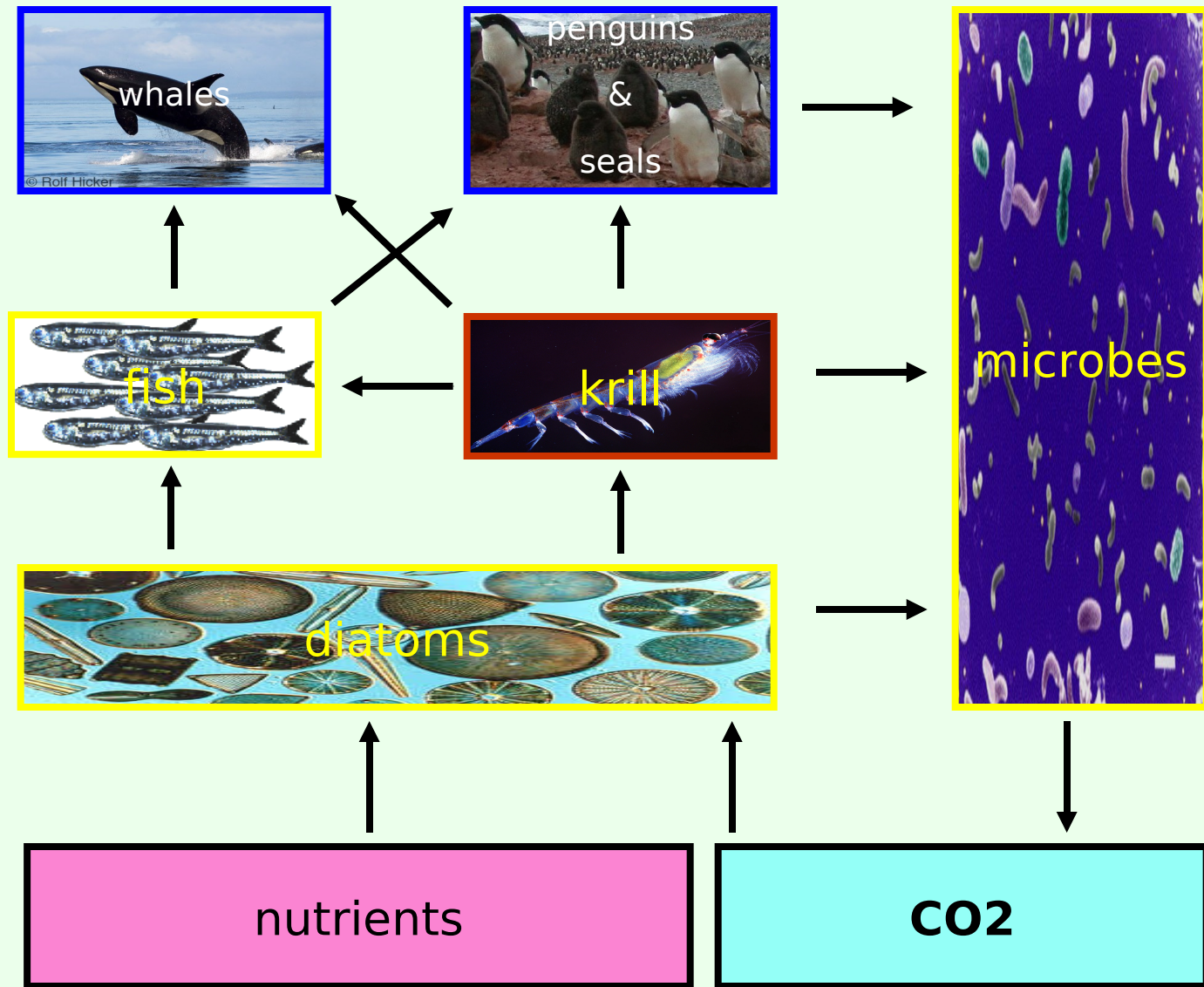


Part 2. How do Antarctic ecosystems respond to climate variability?

2. PAL-Marine Ecosystem response to anomalous wind forcing

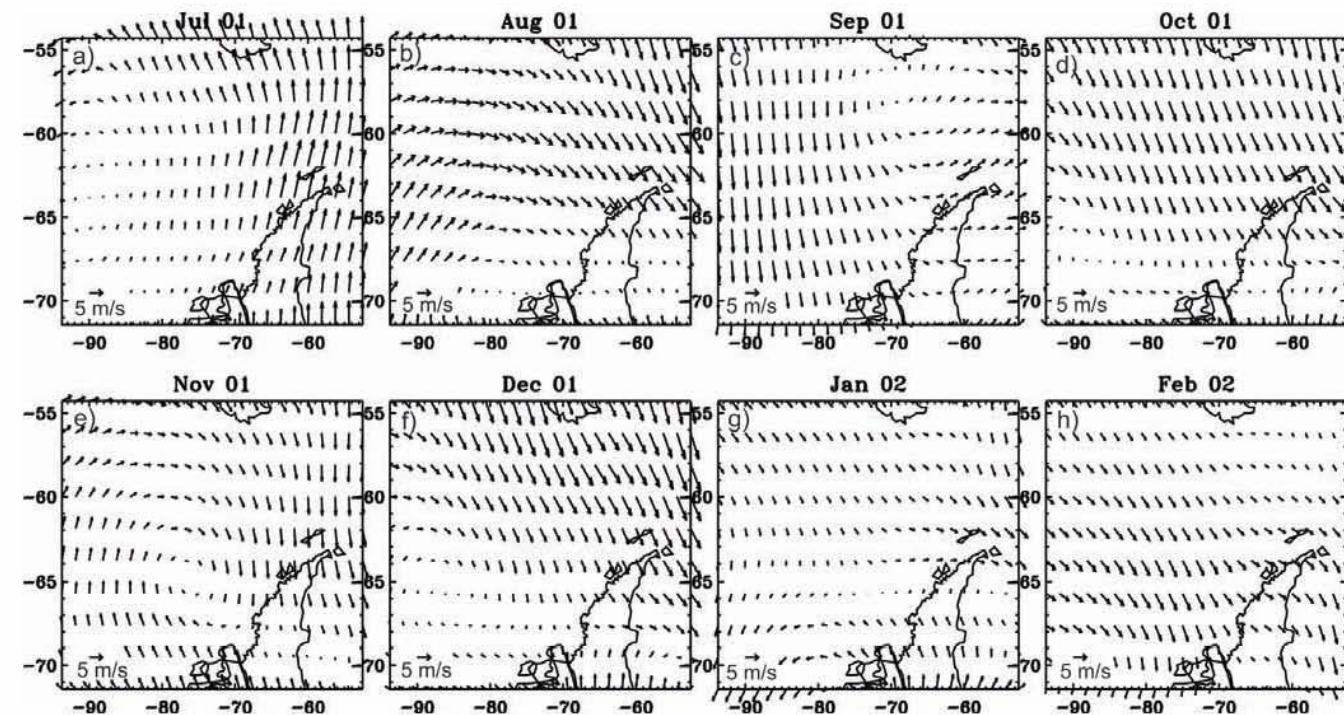
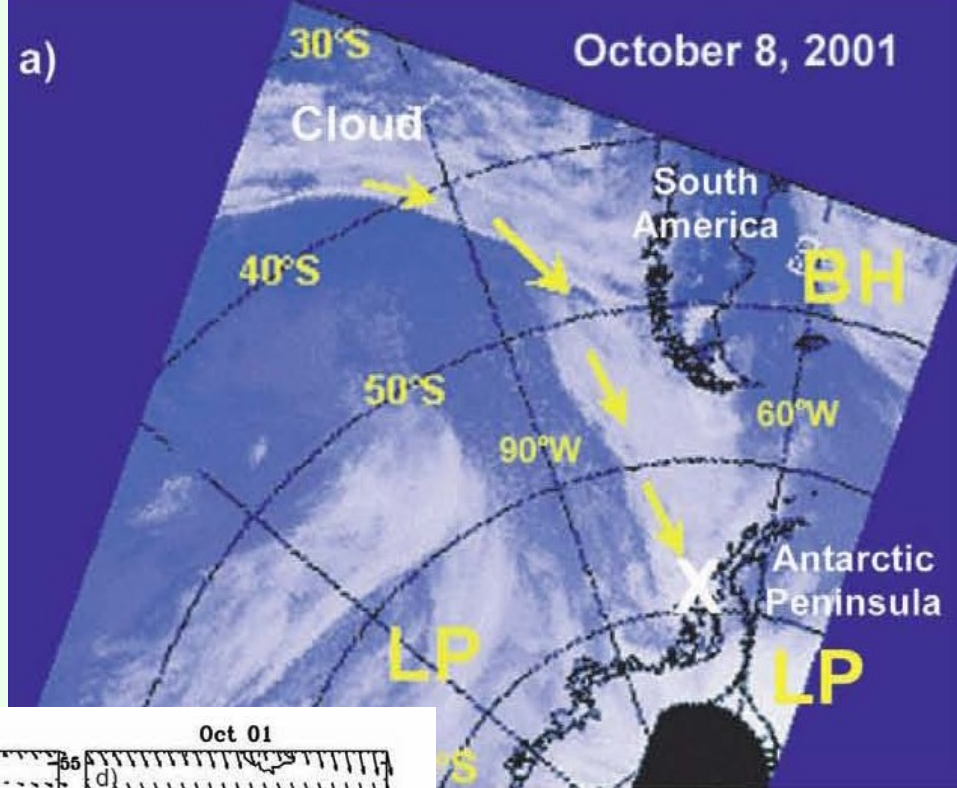


Antarctic marine foodweb in sea ice biome (PAL)

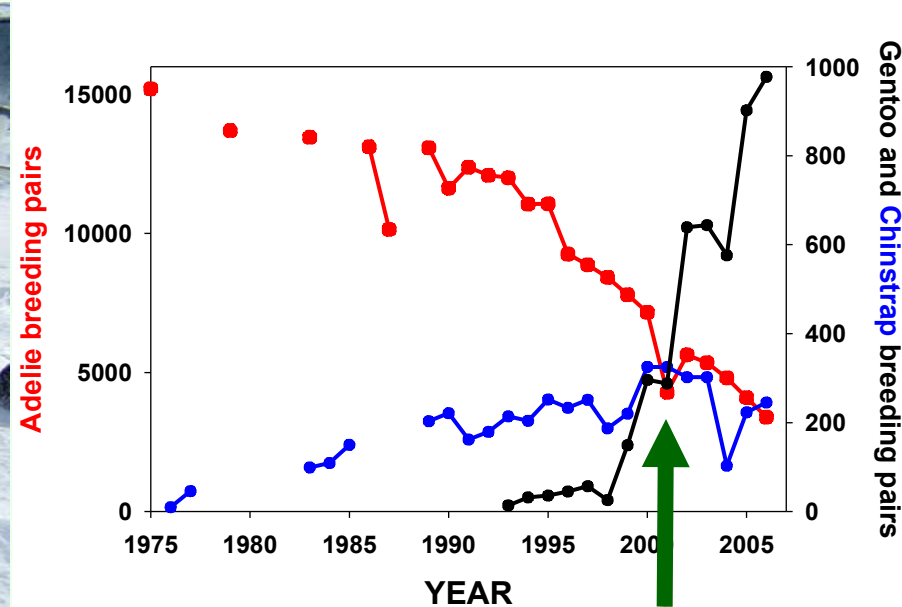


Anomalous NNW winds > 10 m/s
 s Sept 2001 – Feb 2002
 bringing warm, moist air and
 compacting sea ice along WAP.

10-m wind speed and direction anomalies

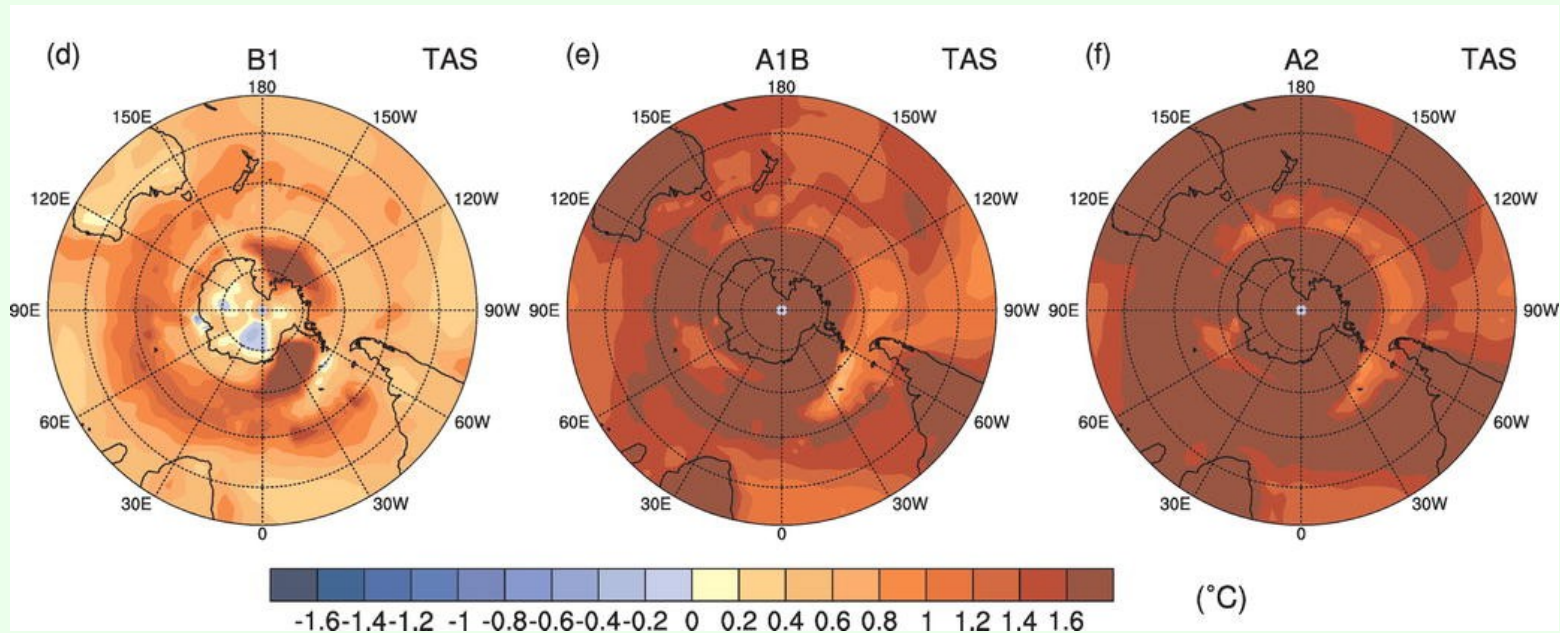


Palmer 2001-02: Heavy spring snowstorms: near- total penguin breeding failure



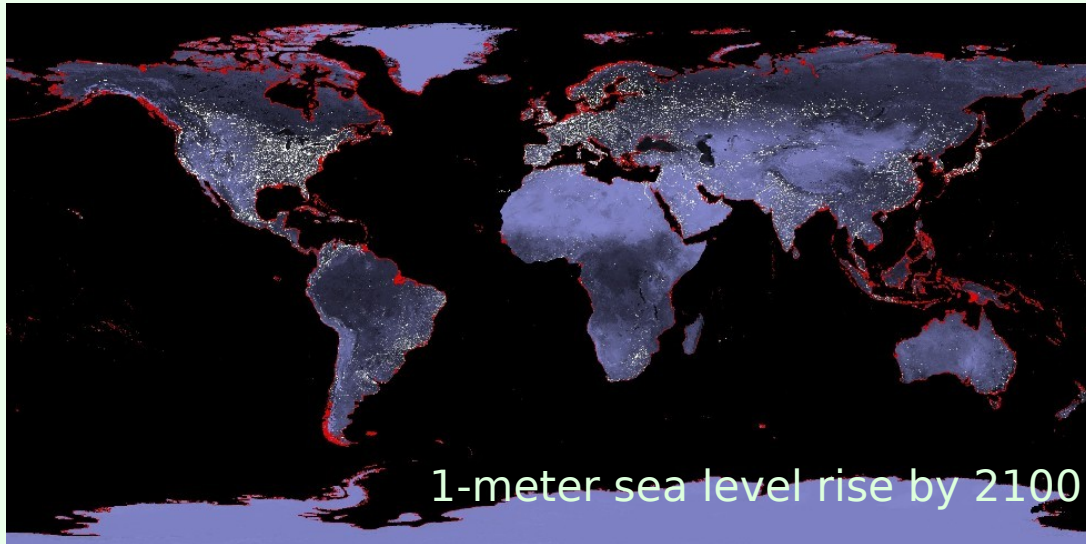
In both systems: remote climate forcing (enhanced by climate change) had negative affects on the apex predators.

Models suggest anthropogenic forcings will tend to enforce the positive SAM state, but regional forcing will overwhelm the cooling tendency and cause the entire continent to warm.

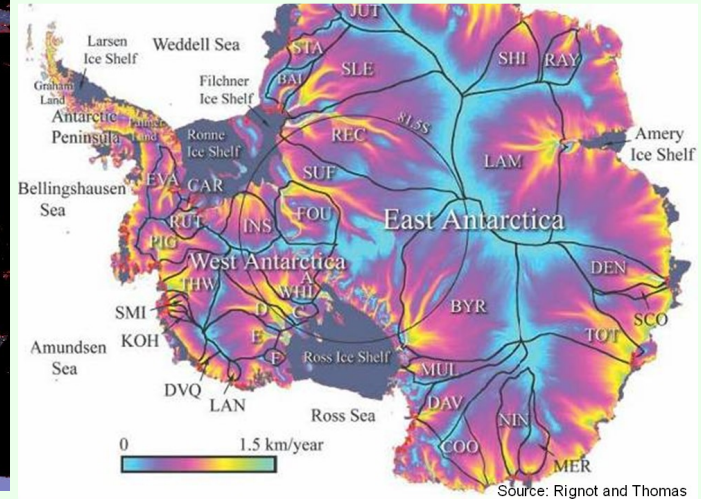


2080-99 minus 1980-99 surface temperature
for SRES Scenarios

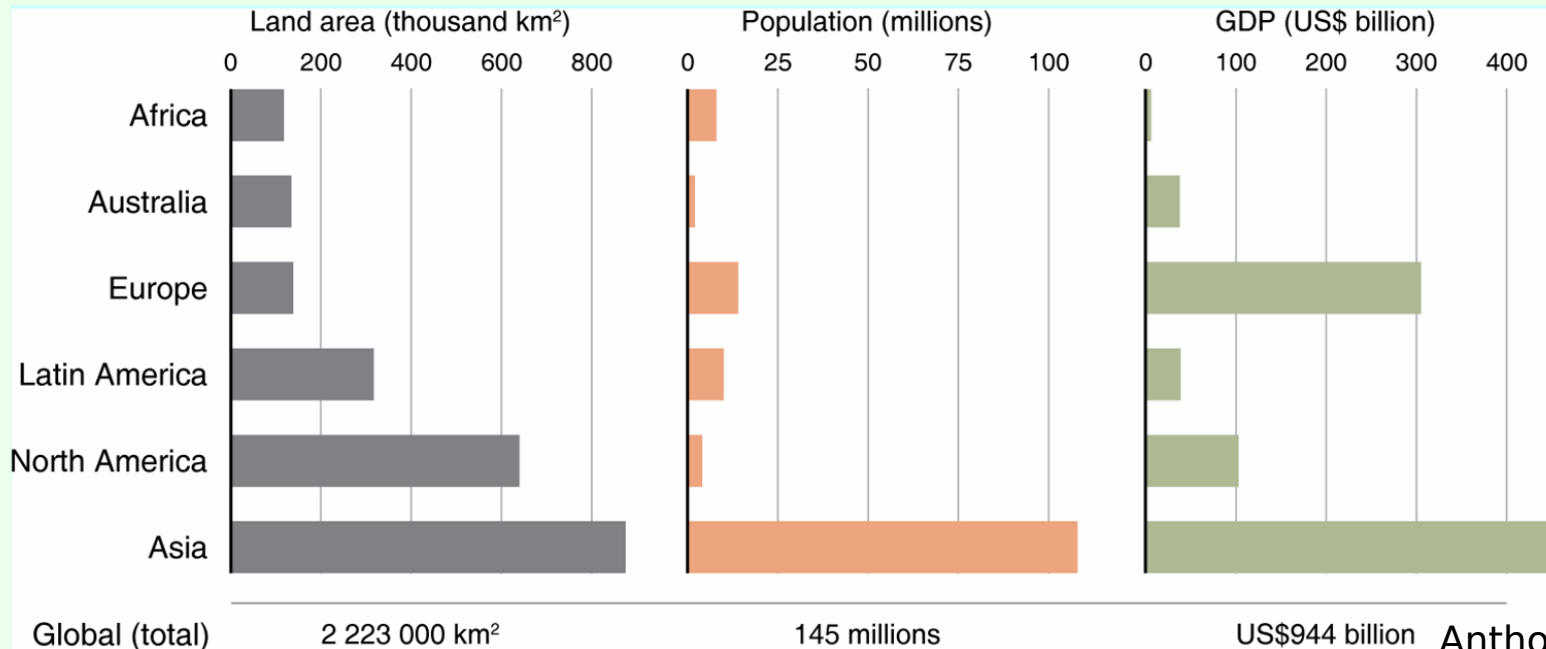
Part 3. What is the impact of Antarctica on the World?



Increasing movement in Ice Sheets



Global impact of 1-meter SLR:



Part 4. Antarctica and Society

Quick Impressions:

Tourism

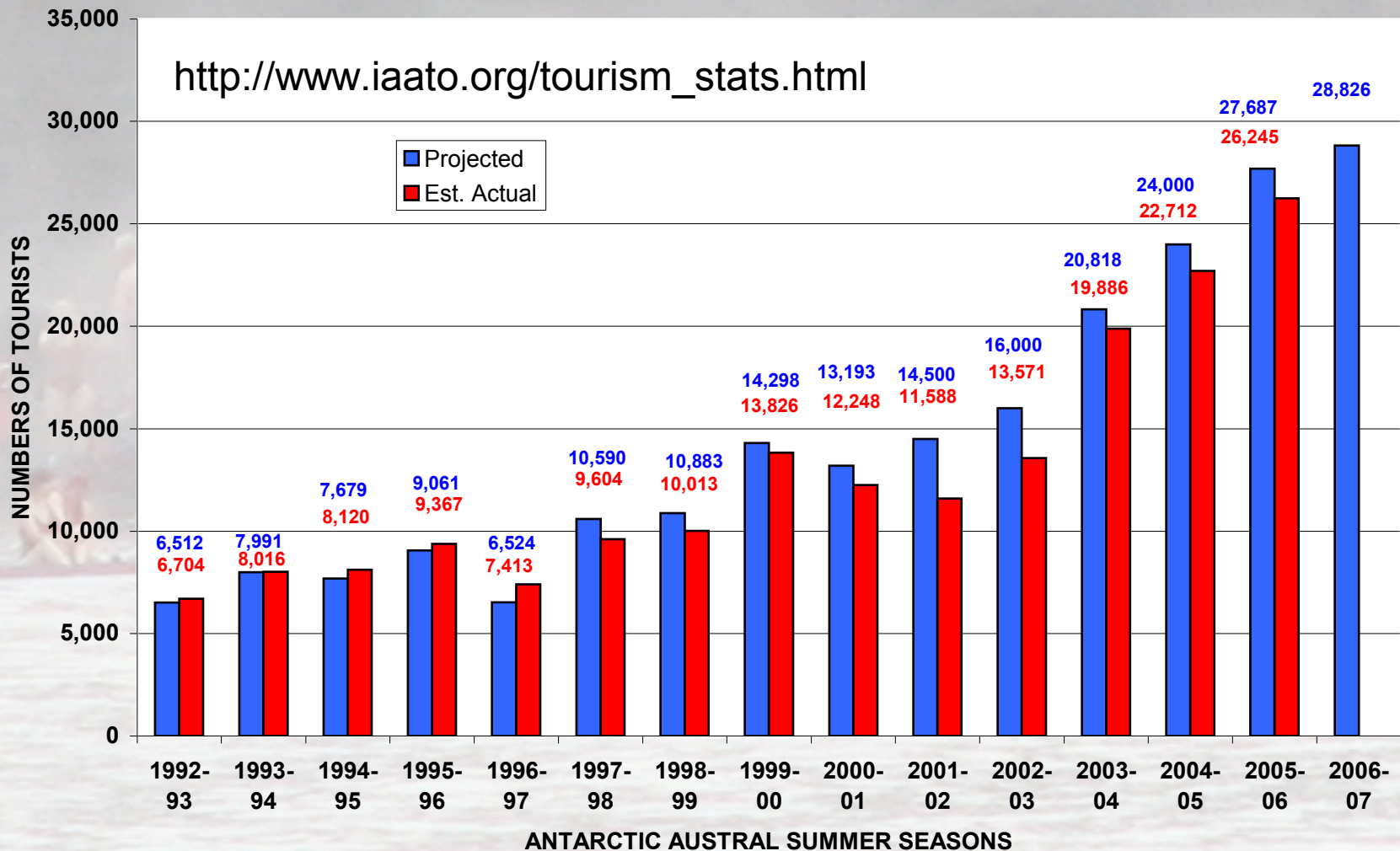
Antarctic Treaty

Mass media and culture



1992-2007 ANTARCTIC TOURIST TRENDS - Landed

[Includes Ship and Land-based passenger numbers. 1997-98 onwards includes commercial yacht activity.]





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Antarctica Cruise Disaster Raises Tourism Concerns

John Roach
for National Geographic News
November 27, 2007

Cruise ship accidents in Antarctica may be "inevitable," at least one expert says.

The current surge in polar tourism and a reported increase in icebergs are raising safety and environmental concerns—which were brought boiling to the surface by this past weekend's sinking of the M.S. *Explorer*.


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Video: Antarctic Rescue
(November 26, 2007)

Geographic Ship First to Scene of
Antarctic Sinking November 26,
2007)

(Related photo gallery: Antarctic wonders lure cruise tourists.)

All 154 passengers and crew aboard the *Explorer* were safely plucked from lifeboats after bobbing in relatively calm seas for about five hours Friday morning. No one was injured.

Some experts consider the ship's demise a fluke—it was built to ply icy waters and was helmed by an experienced captain.

Nevertheless, the Antarctic tourism boom of recent years has made for an accident waiting to happen, according to sea explorer and writer Jon Bowermaster, a National Geographic Society Expeditions Council grantee.

Bowermaster was on the first vessel to arrive on the accident scene—the *National Geographic Endeavour*, operated by the Lindblad Expeditions cruise company in partnership with the National Geographic Society.


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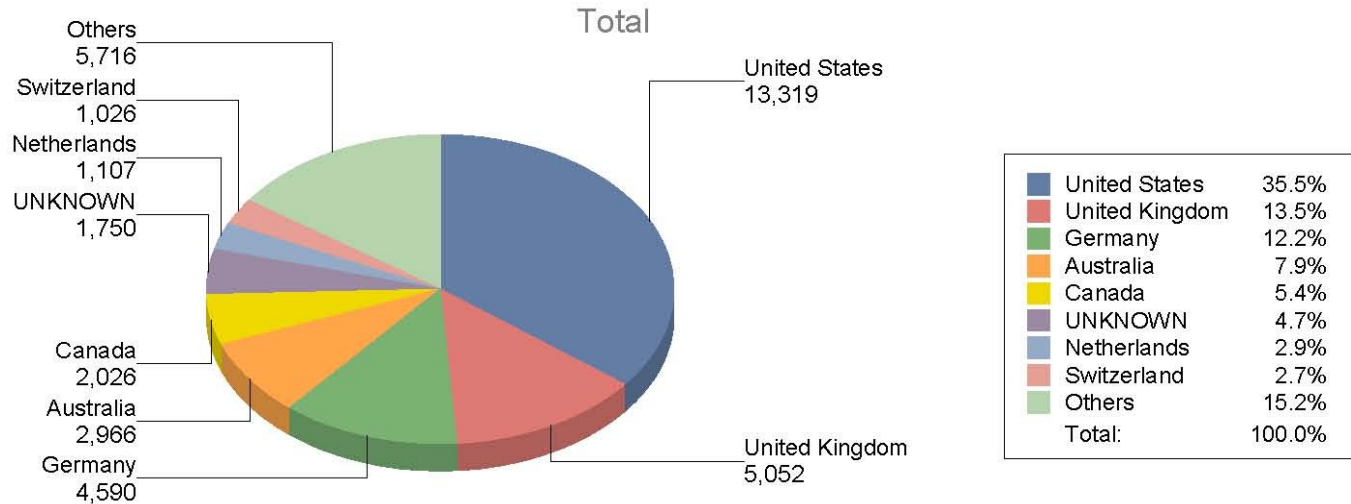


Photos: Bizarre New Dinosaurs Found in Sahara



Telescopes Spot Early Galaxy Forming

2006-2007 TOURISTS BY NATIONALITY



37,552 SEABORNE, AIRBORNE, LANDED & CRUISE ONLY TOURISTS

These 37,552 tourists made 407,509 visits to Antarctic sites in 2006-2007.

Palmer Station, with a maximum size of 45, and a total resident population of 125, had 4537 total visitors (1106 landed) – that is, almost 10 years of resident-equivalents in 2006-07. For the entire continent the 37,000 visitors far outnumbered the 4000 program residents.

The Human Colonization of Antarctica

National Claims not recognized by Antarctic treaty
Many research stations: not all do “research”
Varying standards of environmental stewardship





Antarctic Treaty

The primary purpose of the Antarctic Treaty is to ensure "in the interests of all mankind that Antarctica shall continue forever to be used exclusively for peaceful purposes and shall not become the scene or object of international discord."

- Prohibits military activity, except in support of science;
- Prohibits nuclear explosions and the disposal of nuclear waste;
- Promotes scientific research and the exchange of data
- Holds all territorial claims in abeyance.
- Applies to the area south of 60° South Latitude, including all ice shelves and islands. Signed: 1959. Entered into force: 1961
- A model of global-scale governance (46 nations:

Argentina, Australia, Austria, Belgium, Belarus, Brazil, Bulgaria, Canada, Chile, China, Colombia, Cuba, Czech Republic, Denmark, Ecuador, Estonia, Finland, France, Germany, Greece, Guatemala, Hungary, India, Italy, Japan, Korea DPRK, Korea ROK, Netherlands, New Zealand, Norway, Papua New Guinea, Peru, Poland, Romania, Russian Federation, Slovak Republic, South Africa, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom, United States, Uruguay, Venezuela

Antarctic Treaty

Protocol on Environmental Protection to the Antarctic Treaty (Madrid, 1991)

Convention for Conservation of Antarctic Seals (London 1972)

Convention for Conservation of Antarctic Marine Living Resources (Canberra 1980)

Convention on the Regulation of Antarctic Mineral Resource Activities (Wellington 1988), negotiated between 1982 and 1988, will not enter into force.





Antarctica in Popular Culture:

Penguins: iconic species of climate change

Do these portrayals influence public opinion?

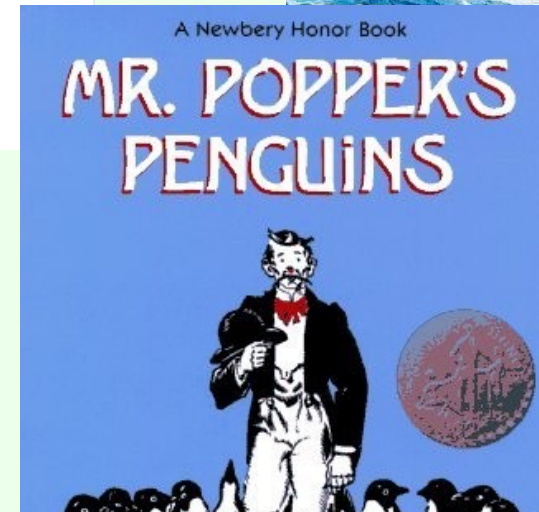
How do we perceive Antarctica?



IS NOW!

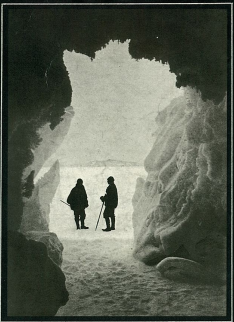
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THE WORST JOURNEY IN THE WORLD



Apsley Cherry-Garrard



Antarctica as a symbol of human endurance, and as a scientific frontier