Climate change: an Antarctic perspective

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Scientific Committee on Antarctic Research
The monitoring of global warming

Change in global mean surface temperature (°C)

- +0.6°C since the 1960s
- +0.8°C since the 1880s
Global versus regional warming

Trends in surface temperature from 1955 to 2005 (°C)

Complex recent temperature evolution in Antarctica
Why?
Links between Antarctica and the global climate system
Links between Antarctica and the global climate system
Antarctica: a key climate area

- The « cold point » of the climate system

- Around Antarctica: intense exchanges between ocean, sea-ice and atmosphere

- Antarctic ice cap:
  - The largest freshwater reservoir (70% of the Earth’s freshwater, ~60 m of global sea-level)
  - The long term memory of the climate system
Sampling the cold point of the global climate system
Hidden inside the ice
Climatic information preserved in the ice

Water isotopic composition
- Past local temperature changes
  Antarctic climate change

Ice chemistry
- Impurities transported by the atmosphere
  Dust, aerosols, pollution…
  Volcanism, solar activity (climate forcings)

Air trapped in the ice
- Atmospheric composition
  Greenhouse gases
Recent completion of drilling projects

**Byrd**
- 1968
- 2164 m
- 80 000 years

**EPICA Kohnen Station**
- Jan. 2006
- 2774 m
- 500 000 years?

**EPICA Dome C**
- Dec. 2004
- 3270 m
- 800 000 years

**Dome F**
- Jan. 2006
- 3029 m
- 1 000 000 years?

**Vostok**
- 1996
- 3623 m
- 400 000 years
Operational Support - The National Antarctic Programs and COMNAP

Council of Managers of National Antarctic Programs

- The National Antarctic Programs (NAPs):
  implementing and managing national activities in Antarctica

- Major activity: direct operational support to scientific projects

- NAPs together in COMNAP to:
  - improve their ability to conduct their respective operations effectively and efficiently
  - promote and facilitate collaboration on operational projects of mutual interest

- Indirect, but immediate and tangible effect for science:
  improved support of scientific projects by National Programs
Deep drilling projects: need for intense operational support

The example of EPICA Dome C

- Climatic and geographic constraints: 3233 m elevation, -54.5°C, 75°S, 123°E
- Transport by traverses: 1200 km from DDU
- Window for summer field work: 8 to 10 weeks
- Drilling capability: 0 to 250 meters per week
- Equipment required: 1000 tons, 7 convoys
- Personnel required: 8 drillers, 20 scientists

European Project for Ice Coring in Antarctica
Support by 10 national programs (Belgium, Denmark, France, Germany, Italy, The Netherlands, UK, Norway, Sweden, Switzerland), the European Commission (5th and 6th PCRDT) and European Science Foundation
EPICA deep drilling

1996/1997: casing 130m
1997/1998: 364m
1998/1999: 781m
2000/2001: 1459m
2001/2002: 2864m
2002/2003: 3201m
2004/2005: 3270m

EDC96

1999/2000: casing
2004/2005: 3270m
Paleothermometry

\[ \delta^{18}O \] vs Surface temperature (°C)

- TNB-DC 1998-1999
- DDU-DC 1995-1996
- Mirny Vostok
- DDU-DC 1971-1973
- IAEA
Climate records in Dome C deep ice

Warmer

Colder
Rapid climate changes in Antarctica

Age (thousand of years ago)
Temperature history at Dome C (as a function of time)

Ice ages each 100,000 years

Very long warm period ~400,000 years ago

Changes in the intensity of warm periods: why?
Ice ages: orbital theory
Orbital theory: our past and our future
Insights for the future

Our future: a «super-interglacial» period
Evolution of greenhouse gases
Evolution of greenhouse gases

- Stable relationships between past Antarctic temperature changes and global greenhouse concentrations: carbon cycle « feedbacks »

- It remains a challenge to explain the natural carbon cycle (the EPICA challenge)

- Unprecedented change in the atmospheric composition due to human activities in the industrial era
Simulated future climate change in central Antarctica

\[ y = 1.16 \]
\[ R^2 = 0.8 \]
Simulated past and future climate change in central Antarctica

Since last ice age (duration 10 000 years)
+ 8.5°C

2xCO₂ minus today (duration 70 years)
+ 2.5°C

4xCO₂ minus today (duration 140 years)
+ 6.0°C
Conclusions

- Antarctica is a crucial area for extracting key information about past climate and environmental change.

- Extracting this information generally requires very significant coordinated national operational supports (COMNAP).

- Antarctica is experiencing large changes today that are expected to increase with the increasing human emissions of greenhouse gases (+20% since 1990).

- The Antarctic environment and biodiversity are particularly vulnerable to climate change and human pressure.
Climate change in Antarctica: key uncertainties

- Large areas of Antarctica still unknown
- Current and past evolution of Antarctic ice cap mass balance
- Evolution of Antarctic climate at time scales of decades
- Regional changes in Pacific, Indian, Atlantic sectors
- Antarctic climate change prior to 800 000 years
Perspectives

- 2007-2009: International Polar Year
  Coordinated traverses: surface and bedrock characteristics, recent climate change

- IPICS: International Partnership for Ice Core Science
  http://www.nicl-smo.unh.edu/IPICS/
  sponsored by NSF/OPP and European Polar Board.
IPICS

- Ice coring scientific objectives are increasingly complex
  - More cores to see spatial patterns
  - Deeper and older cores, in more difficult places
  ➔ International cooperation can help meet these goals

- Informal international planning group
  - Discussing long term new ice coring projects
  - Representatives from 18 countries: Australia, Belgium, Canada, China, Denmark, France, Germany, Italy, Japan, Korea, Netherlands, New Zealand, Norway, Russia, Sweden, Switzerland, United Kingdom, United States
  - Involves representatives of operational support, science, drilling
  - Co-chairs: Eric Wolff (BAS), Ed Brook (OSU)

  - Support from NSF OPP, European Polar Board
  - IPY Endorsement
  - Affiliation to PAGES and SCAR
IPICS

- The oldest ice core: A 1.5 million year record of climate and greenhouse gases from Antarctica.

- The last interglacial and beyond: A northwest Greenland deep ice core drilling project.

- The IPICS 40,000 year network: a bipolar record of climate forcing and response.

- The IPICS 2kyr array: a network of ice core climate and climate forcing records for the last two millennia.
Ongoing and future projects

- Current ice cores
- In preparation
- Future projects
- Lack of information
Why look for climate change prior to 1 million years?

Past climates are essential to test and improve the understanding of climate change mechanisms including feedbacks between the global carbon cycle and climate.

Need understanding of the shift from small ice ages with periodicities of 40,000 years to large ice ages with periodicities of 100,000 years: natural carbon cycle?
Take home messages

- Antarctica will continue to warm with profound implications for global sea level.

- Our models of future climate change need improving using targeted ice coring programmes to give more reliable predictions on which to base decision making.

- Only in Antarctica can we gain the long term data we need for this, so more investment is required in ice coring and climate modeling to ensure accurate predictions of future change.