Polar Science with Global Impact

Sensor Networks in Polar Regions: Urgent Needs, Difficult Challenges

David Carlson, Director
International Programme Office
International Council for Science
and
World Meteorological Organization:
International Council for Science

and

World Meteorological Organization:

» PROCLAIM: International Polar Year 2007-2008
International Council for Science
and
World Meteorological Organization:

▪ PROCLAIM: International Polar Year 2007-2008

▪ CONVENE: Joint Science Committee
International Council for Science and World Meteorological Organization:

- **PROCLAIM**: International Polar Year 2007-2008
- **CONVENE**: Joint Science Committee
- **ESTABLISH**: International Programme Office
IPY THEMES

Draw Scientific and Public Attention to Polar Regions
IPY THEMES

Draw Scientific and Public Attention to Polar Regions

▶ Current Environmental Status
IPY THEMES

Draw Scientific and Public Attention to Polar Regions

- Current Environmental Status
- Recent and Future Changes
IPY THEMES

Draw Scientific and Public Attention to Polar Regions

- Current Environmental Status
- Recent and Future Changes
- Linkages to Global Processes
IPY THEMES

Draw Scientific and Public Attention to Polar Regions

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- Push Scientific Frontiers
IPY THEMES

Draw Scientific and Public Attention to Polar Regions

- Current Environmental Status
- Recent and Future Changes
- Linkages to Global Processes
- Push Scientific Frontiers
- Vantage Point to Earth History and to Space
IPY THEMES

Draw Scientific and Public Attention to Polar Regions

- Current Environmental Status
- Recent and Future Changes
- Linkages to Global Processes
- Push Scientific Frontiers
- Vantage Point to Earth History and to Space
- Understand Social and Cultural Vulnerabilities
Urgent, Significant

IPY PROJECT
Urgent, Significant

IPY PROJECT
Urgent, Significant

International Partnerships

IPY PROJECT
Urgent, Significant

International Partnerships

Builds Connections

IPY PROJECT
Urgent, Significant

International Partnerships

Builds Connections

Store, Share Data

IPY PROJECT
Urgent, Significant

International Partnerships

Store, Share Data

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IPY PROJECT
Urgent, Significant

International Partnerships

Builds Connections

Store, Share Data

Education, Outreach

IPY PROJECT
Urgent, Significant

International Partnerships

Builds Connections

Store, Share Data

Education, Outreach

IPY PROJECT
International Partnerships

Store, Share Data

Expand Polar Community

Urgent, Significant

Builds Connections

Education, Outreach

IPY PROJECT
Percent change of Arctic sea ice area
Percent change of Arctic sea ice area
Percent change of Arctic sea ice area
Percent change of Arctic sea ice area

About 8% decrease per decade
Percent change of Arctic sea ice area
Percent change of Arctic sea ice area

Tipping Point????
POLENET
Antarctica

WHY?
Net ice change = elevation change - crustal movement.

Polar Observing Network
WHY? Net ice change = elevation change - crustal movement.

WHY? Crustal motions may fracture ice sheets.

Thanks to Terry Wilson, OSU
Proposed: POLENET for IPY

U.S. & Intl. Partners

GPS&Seis (backbone)
GPS (IPY, Bbone)
GPS&Seis (on ice)

Thanks to Terry Wilson, OSU
Proposed: POLENET for IPY

U.S. & Intl. Partners

Need: Accurate 3-D motion

Thanks to Terry Wilson, OSU
Challenges:
- Distance
- Polar Night
- Long-term
- Remote
- Reliability
- Weight

Need:
Accurate 3-D motion

Proposed: POLENET for IPY
U.S. & Intl. Partners

Thanks to Terry Wilson, OSU
CCSM3 Modeled Near-Surface Permafrost

- 1980-1999 (20thC)
- 2080-2099 (SRES A1B)
WHY?
Permafrost holds more carbon than temperate & tropical forests
Carbon Pools in Permafrost
Carbon Pools in Permafrost
Need:
Position   Immersion
\( \text{CO}_2, \text{CH}_4 \)   Water pH, OC
Temperature   Humidity
Saturation
Carbon Pools in Permafrost

Need:
Position   Immersion
CO$_2$, CH$_4$   Water pH, OC
Temperature   Humidity
Saturation

Challenges:
Airborne deployment
Heterogeneity
Unstable substrate
Freeze / Thaw
Emerge / Immerse
Communications
Power

Thanks to Peter Kuhry
Greening of the Arctic

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Greening of the Arctic

WHY?
Tundra / sedges changing to shrubs / trees

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Need:
- Micro-radiometry
- Digital imagery
- Photosynthetic Potential
- Micro-Meteorology

WHY?
- Tundra / sedges changing to shrubs / trees

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Need:
Micro-radiometry
Digital imagery
Photosynthetic Potential
Micro-Meteorology

Challenges:
Heterogeneity
Winter survival
Freeze / Thaw
Communications
Power

WHY?
Tundra / sedges changing to shrubs / trees

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Biodiversity Monitoring

**WHY?**
Change in health, vitality of caribou

**Caribou Herd**
Porcupine
Central Arctic
January
Need: Animal physiology
Herd behaviors
Annual census

WHY?
Change in health, vitality of caribou

Caribou Herd
Porcupine
Central Arctic
January
Challenges:
- Communications
- Large areas
- Health sensors
- Annual turnover

Need:
- Animal physiology
- Herd behaviors
- Annual census

WHY?
- Change in health, vitality of caribou

Thanks to Martin Raillard, EC
Hydrothermal Vent Systems (173)

Greenland Ice Discharges (339)
Change & Variability of Arctic Systems (58)
Surging Glaciers (266)
Sea Ice, Icebergs, and Whales (257)

IPY PLANNING CHART
www.ipy.org
30 Sep 2006, Vers 4.3

Both

Earth
Land
People
Ocean
Ice
Atmosphere
Space

Education & Outreach

Arctic

Fish & Mammal Migrations

Antarctic

Earth
Land
People
Ocean
Ice
Atmosphere
Space
Fish & Mammal Migrations
Fish & Mammal Migrations

WHY?
Migrations of temperate species
Fish & Mammal Migrations

WHY?
Migrations of temperate species

Need:
Species abundance
Migratory patterns
Fish & Mammal Migrations

**WHY?**
Migrations of temperate species

**Challenges:**
- Tagging animals
- Transponder lifetimes
- Communications

**Need:**
- Species abundance
- Migratory patterns
Surging Glaciers
WHY?
Rapid retreat of northern glaciers.
Need:
Snow accumulation
Melt rates
Absolute & relative velocities
Surface albedo
Need:
- Snow accumulation
- Melt rates
- Absolute & relative velocities
- Surface albedo

Challenges:
- Reliability
- Cost
- Power
- Multiple scales

Thanks to Matt Heavner
WHY?
Instability of Antarctic Ice Sheets
Amundsen Sea Active Ice Sheets
Amundsen Sea Active Ice Sheets
Need:
Temperature
Salinity
Water velocity
Ice thickness
Biology
Challenges:
- Deployment
- Communications
- Buoyancy
- Complex terrain

Need:
- Temperature
- Salinity
- Water velocity
- Ice thickness
- Biology

Amundsen
Sea Active
Ice Sheets
WHY?
Southern Ocean takes in CO₂
WHY?
Southern Ocean takes in CO₂

WHY?
Complex & heavily exploited ecosystem
Thanks to SEaOS & M. Fedak

Depth

Frontal Crossings: Polar Polar

Sub-Antarctic

Temperature

2004: March April May

Fall Winter

1000 meters

Marine Mammal Explorations

1 November 2006

IPY at Sensor Systems 2006
Thanks to SEaOS & M. Fedak

Marine Mammal Explorations
2004-02-29 09:38:31Z
Tail 300 days
Tail 300 days
Challenges:
Bandwidth & Cost
On-board Processing
Selective Network

Marine Mammal Explorations
Sensor Networks in Polar Regions:

- Little or no communication infrastructure

Antarctic
Sensor Networks in Polar Regions:

- Little or no communication infrastructure
- Harsh environments

Antarctic
Sensor Networks in Polar Regions:

- Little or no communication infrastructure
- Harsh environments
- Limited access
Sensor Networks in Polar Regions:

- Little or no communication infrastructure
- Harsh environments
- Limited access
- High variability, rapid change

Antarctic
Sensor Networks in Polar Regions:

- Little or no communication infrastructure
- Harsh environments
- Limited access
- High variability, rapid change
- Air, land, water & ice

Antarctic
IGY (1957 - 1958) Poster

"Ah, but a man's reach should exceed his grasp, or what's a heaven for?" BROWNING
"Ah, but a man's reach should exceed his grasp, Or what's a heaven for?" BROWNING
Sensor Networks as an IPY Legacy?
Addresses Crucial Issues at a Critical Time

Chance to Build a Very Special Programme
Polar Science with Global Impact