Good Morning
Good Morning
Preliminary Findings of the ACIA Open Science Meeting
Study of Environmental Arctic Change (SEARCH)
Seattle, Washington
October 26, 2003
Arctic Climate Impact Assessment

Mandated by the Arctic Council

Implemented by the IASC, AMAP, and CAFF
A Progress Report on the Scientific aspects of the Assessment including some Preliminary Results
The past decades have witnessed substantial changes in climate and UV across the Arctic region. Is there documented evidence of these Changes?
Changes across many sectors of Arctic

- Plants & Vegetation
- Ocean & Climate
- Snow & Ice
- Forest & Grassland
- Fish, Sea Birds & Marine Mammals
- Permafrost & Tundra
- Freshwater, Lakes & Rivers
- Wildlife & Waterfowl
- Indigenous Culture
- Sea Ice & Icebergs
- Land Use & Agriculture
- Human Health
Snow and Ice

- The September ice extent in the Beaufort and Chukchi seas was 25% below the prior minimum value over the 45-year record.
- Sea-ice extent in the Bering Sea has been reduced by about 5% over the last 40 years, with the steepest decrease occurring in the late 1970s.
- The sea ice thickness decrease is greatest in the central and eastern Arctic and less in the Beaufort and Chukchi seas.
- Observations at Barrow, Alaska, on the Beaufort Sea coast, showed sea ice to be only 1.4 m thick in 1998, compared with its normal thickness of 1.7-1.8 m; this is thinner than ever observed.
Historical scientific and indigenous knowledge indicate that Arctic animals, plants and micro-organisms have migrated northward with climate warming during the recent warming and increased precipitation.

There has been an increase in plant growth and a lengthening of the active growing season.

Overall, the vegetation is more lush, plentiful and diverse in the 1990s compared to earlier cooler decades in the western Canadian Arctic -- these findings have been noted by the local residents and through scientific research.
**Permafrost and Tundra**

- The Arctic has been an overall significant sink for CO2 over historic and recent times, but new data suggest that the tundra has changed to a pattern of net loss of CO2.

- Borehole measurements in continuous permafrost have shown warming of up to 2-4°C in northern Alaska over the last 80-100 years.

- The thawing of permafrost in the boreal forest is beginning a slow transformation from one ecosystem into another, i.e. from forest into wetlands and eventually into grasslands.

- Indigenous peoples in Alaska have reported substantial thawing of the permafrost.
Since the early 1990s northern latitudes have experienced up to 20% reductions in ozone and over 40% increases in UV, with resultant direct impact on human health, e.g., increases in skin cancer.

Human health issues, particularly diet, diseases, and pollutants, are increasingly being examined for their connections to climate and UV increases, though it is not clear if such exist.
Sea Ice and Icebergs

- Sea ice extent has decreased by about 2.9%/decade throughout the Arctic since 1979 and summer sea ice thickness has decreased by as much as 40% since the 1950’s.

- The September ice extent in the Beaufort and Chukchi seas was 25% below the prior minimum value over the 45-year record.

- Sea-ice extent in the Bering Sea has been reduced by about 5% over the last 40 years, with the steepest decrease occurring in the late 1970s.

- Observations at Barrow, Alaska, on the Beaufort Sea coast, showed sea ice to be only 1.4 m thick in 1998, compared with its normal thickness of 1.7-1.8 m; this is thinner than ever observed.
The availability of marine mammals for subsistence is reduced, due to shifts in oceanographic and sea ice conditions.

A warmer climate with milder winters and less (or unstable) sea ice has also affected the safety for hunting marine mammals.

Recent decreases in anadromous fish stocks, which are an important food component of Native peoples, have affected the latter's dietary and economic well-being.
“We cannot make predictions anymore. We don't know if the water is going to freeze or not. We used to know what was going to happen at certain seasons but, with all the changes in the climate and the different qualities of water, we can't make those predictions anymore.”

Helen Atkinson, Chisasibi
Voices from the Bay
Observed Changes in the Arctic:

- Increases in precipitation
- Winter temperatures increasing
- Thawing of previously frozen ground
- Variations in the ranges of animals and ecosystems
- Increases in storm surges and coastal erosion
- Reduced sea ice thickness and extent
- Increased river flows in Siberia
- Warming of the Arctic Oceanic waters
- Record low level of stratospheric ozone
- Increases in ground levels of ultra violet radiation
ACIA Arctic Climate Impact Assessment

Arctic Climate Impact Assessment (ACIA) has a responsibility to:

• **Evaluate and synthesize knowledge on climate variability, climate change, and increased UV radiation and their consequences, and**

• **Provide useful and reliable information to the governments, organizations and peoples of the Arctic region in order to support policy-making processes, and to the Intergovernmental Panel on Climate Change (IPCC) to be used in its future work on climate change issues.**
ACIA To Address Four Basic Questions:

• What are the past and present indicators of changes in climate and ultraviolet radiation?
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• What are the possible impacts due to changes in climate and UV in the future?
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- What are the past and present indicators of changes in climate and ultraviolet radiation?
- What are the possible changes in the future?
- What are the possible impacts due to changes in climate and UV in the future?
- What recommended policy actions and coping strategies should be considered by the Arctic Nations and Peoples?
ACIA's Unique Approach

Science Insights

Indigenous Perspectives

Integrating Insights and Knowledge from these Perspectives
Integration of ACIA with Ongoing Assessments and Related Activities with an Arctic Focus

- Arctic Human Development Report
- IPCC (Intergovernmental Panel on Climate Change)
- Montreal Protocol and Ozone Assessment
- Millennium Ecosystem and Biodiversity Assessment
- AMAP Assessment
- CAFF Studies and Programs
Arctic Climate Impact Assessment
An Update of Preliminary Results and Observations
October 2003
Temperature Reconstruction: Northern Hemisphere

- Instrumental data (AD 1902 to 1999)
- Reconstruction (AD 1000 to 1980)
- Reconstruction (40 year smoothed)

1998 instrumental value

Last 200 Years

Trends over the Past 1000 Years
There is increasing interest in the stability of deep water formation in the North Atlantic that controls climate and has a substantial influence on the climate in Europe.
Simulated Water Volume Transport Change

Atlantic Ocean

Note Downward Trend beginning in late 1970’s

Nine (9) Models
Both models project substantial further retreat of sea ice through the 21st century, with complete loss of summer Arctic sea ice in the Canadian model by 2095. Sea ice outputs were not available for the Hadley scenario, but a reconstruction based on sea-surface temperature shows a 40 to 50% loss of summer sea ice by the 2090s.

Note: These are projections for Estimates of Summer Sea Ice
Glaciers around the World are Receding

Source: IPCC 2001
Receding Glaciers in Svalbard and others in North Atlantic Region

A Closer View

Length (Unit is 1 km)

1500 1600 1700 1800 1900 2000

Hansbreen, Svalbard
Paierl, Svalbard
Storglacìären, Sweden
Engabreen, Norway
Nigardsbreen, Norway
Leirufjardarjokull, Iceland
Vatnajökull, Iceland
Tsoloss, Canadian Rockies
Wedgemount, Canadian Rockies

Source: IPCC 2001
Arctic Surface Air Temperature

60N - Pole: Change from 1990-1999 Average (deg.C)

Authors conclude that models suggest a warming across the Arctic that is 2-3 times that of the global increases (IPCC).

3.5° C to almost 6° C By 2100
Spacial Scale Matters

Projected Warming
0.7°C/Decade

Low resolution global estimate of temperature change in Norway

High resolution global estimate of temperature change in Norway
NCAR Ensemble Simulations

Global Average Temperature

- Observations
- (Natural) volc+solar
- (Anthropogenic + Natural) volc+solar+ghg+so4

Anomalies from 1890-1919 (°C)

Year:
- 1900
- 1920
- 1940
- 1960
- 1980
- 2000
Observed Climate Changes in the Arctic

- The overall trend for the Arctic is a substantial warming of nearly twice the global average over the last few decades.
- The climate of the Arctic has been changing rapidly during the last few decades.
- The observed temperature trends over the three-decade period from 1971-2000 range from a 3°C warming in Alaska, Northern Canada, and Eurasia/Siberia, to some cooling of 0.5°C in southern Greenland/Labrador.
- Precipitation has increased in most parts of the Arctic, ranging from a 10% to 30% increase during the last 30 years.
- The year-round ozone trend over the Arctic is about –3% per decade for the 1979-2000 period (about 7% accumulated loss). The spring (March) ozone trend is about –5% per decade for the 1979-2000 period (11% accumulated decline). During episodes that may last for up to two weeks, the ozone values has been 40-45% below normal levels (March-April 1997).
Projected Future Changes on Land and in the Oceans

- The model projections indicate an intensification of the recent trends through the 21st century, although the rates of the projected changes vary among the models. The models project a 21st century decrease of sea ice by more than 50% in summer, and permafrost degradation over 10-20% of the present permafrost area and a movement of the permafrost boundary northward by several hundred kilometers.

- Increased river runoff is projected to reduce the salinity of the Arctic Ocean, which is very likely to affect sea ice formation, salinity anomalies, and ice export.

- Northward shifts and changes in the timing of fish migration are likely to occur. Increases in fish catches are also possible.

- Annual river runoff is projected to increase by 5-25%, and earlier break-up of rivers and lakes and later freeze-up, and a sea-level rise of several tens of centimeters due to oceanic warming and glacial melting are also projected.

- Forests are expected to replace a significant proportion of the tundra during the 21st century.

- The number of species is very likely to increase as new species move in from the south, and their productivity is very likely to increase due to higher temperatures and CO₂ concentrations.

- Freshwater systems in the Arctic are also very likely to experience impacts due to changes in river runoff, river temperatures, and river and lake ice regimes.
A Preliminary Assessment of Impacts on the Environment

- The tree line is expected to move northward and to higher elevations, replacing a significant portion of the existing tundra.
- Increased tree growth in many areas is likely to increase overall carbon storage and provide a greater source of wood products, though in some areas, permafrost thawing will lead to carbon releases.
- Retreating sea ice is likely to reduce the habitat for polar bear, walrus, ice-inhabiting seals, and marine birds, threatening some species with extinction.
- Caribou and other wildlife on land will also be increasingly disrupted as a warming climate alters their food sources, breeding grounds and migration routes. Species ranges are projected to shift northward, both on land and in the sea.
- The summer grazing grounds for caribou/reindeer and the nesting areas of many migrating bird species will thus be compressed. Reduced reflectivity of the land surface due to forest expansion is likely to cause further warming.
- Insect infestations and forest fires are very likely to increase in frequency, severity and duration.
A Preliminary Assessments of Impacts on Human Societies

- The projected sea ice retreat is very likely to seasonally open the Northeast and Northwest Passages, making trans-Arctic shipping during summer economically feasible within a few decades.

- Many indigenous Arctic cultures depend on hunting polar bear, walrus, seals, and caribou, not only for food, but also as a basis for their cultural and social identity. While indigenous peoples have adapted to varying and changing conditions in the past through careful observations and skillful adjustment in subsistence activities and lifestyles, the effects of UV- and climate-induced changes and impacts combined with ongoing social, political, and other environmental stresses will pose serious challenges for them.

- Commercial agricultural crop production is likely to advance northward throughout the century, with some crops now suitable only for the warmer parts of the boreal region becoming suitable as far north as the Arctic circle. The average annual yield for all crops will likely increase.

- Coastal erosion will be a growing problem as rising sea levels and a reduction in sea ice allow higher storm surges to reach shore.

- Climate change is likely to have significant impacts on existing buildings, roads, pipelines, and industrial facilities.

- Increased UV radiation is likely to directly affect health, for example in terms of the increased incidence of skin cancer, cataracts and viral infections, and the effects on the immune system.
### Indigenous Observations

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<th>Parameters</th>
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| **Atmosphere/ Weather/ Winds** | More persistent clouds  
|                           | More warm weather  
|                           | Warmer winters in all the regions  
|                           | More extreme weather  
|                           | conditions in last 10-20 years                                               |
| **Rain/ Snow**            | Less snow than in the past  
|                           | Snow disappears earlier                                                      |
| **Ocean/ Sea Ice**        | There is less sea ice and it is thinner in winter  
|                           | Later freeze-up and earlier break-up                                         |
| **Lakes/ Rivers/ Permafrost** | Water levels are lower                                                      |
| **Vegetation/ Land**      | Treeline is moving north into formerly treeless areas  
|                           | Bushes and willows are getting bigger and taller                             |
Projected Future Climatic Conditions

- The models, averaged, project annual mean temperature increases in the Arctic of about 2.5°C by mid-century and 3.7°C towards the end of the 21st century, and an annual mean increase in temperature of about 5 °C in the central Arctic; projected annual mean for the terrestrial areas could be as much as 8 °C. The temperature increases projected by the five models for the Arctic are nearly twice the projections for global temperatures for the same scenarios.
- Precipitation is projected to increase by about 8% by mid-century and by about 20% towards the end of the 21st century, with more extreme precipitation events, shorter and warmer winters, and substantial decreases in snow and ice cover are among the projected climatic changes.
- The models have not been able to simulate the abrupt changes in climate as detected in the paleo-climate records.
- There is a larger across-model scatter in projected temperatures for the Arctic than for the rest of the globe.
- The climate projections are based on the results of five global models, subjected the emission scenarios developed by IPCC (Scenarios B2 and A2).
- Based on model results, ozone levels are likely to show little sign of recovery for the next two decades.
Contributions on Global-Scales

- The Arctic region plays a substantial role in the global ocean circulation patterns.

- Arctic soils can absorb CO2 or generate CO2, depending on temperature and moisture changes in the Arctic.

- The melting of snow and ice, which exposes darker soils, can amplify warming by absorbing solar radiation rather than reflecting it - this may substantially influence global climate.

- Sea level rise from melting Arctic land ice sheets.
The Arctic is a Preview of Earth's Future Climate

10 Years of Change in Arctic = 25 Years in Rest of the world.
What Documents will ACIA Produce

• **Scientific and Factual Analysis**: A comprehensive analyses of the changes across the Arctic region, past, current, and projections over the decades ahead that integrates both scientific and indigenous knowledge.

• **Overview Document**: A summary that synthesizes the main findings of the assessment for broad readership.

• **Policy Recommendations**: A set of policy/action recommendations, based on the findings from scientific analysis and indigenous insights, to the eight Arctic countries and the indigenous peoples organizations of the Arctic region.
An Overview of the Scientific Report

- **Climate and UV Changes**: An Analysis of Past, Current, and Future Projections of Changes in Climate, Seasonal Variations in Weather Patterns, and Increases in UV Radiation Across the Arctic Region.

- **Responses of the Arctic to Change**: Physical and Biological Systems and their Responses to Changes Across the Arctic Region.

- **Impacts on Residents**: Impact on Residents of the Arctic Region, Their Settlements, Culture, and Activities.

- **Vulnerabilities to Humans**: Vulnerabilities to Human Settlements and their Culture

- **Major Findings**: An Analysis of the Major Findings and a Synthesis of the Insights Obtained.
The Scientific Assessments has been:

- Prepared by over 300 scientists and other experts from Canada, Denmark, Faroe Islands, Finland, Greenland, Germany, Iceland, Netherlands, Norway, Russia, Sweden, UK, and the USA, and
- Independently reviewed by another 225 scientists and other experts from the eight Arctic countries and several other nations.
A remarkable and unique set of meetings occurred in August in Svalbard:

- Research Cooperation
- Study Tour by Ministers of Environment
- Our Arctic Council/SAO and ACIA Informal Meeting

These provided us with a significant opportunity to discuss preliminary results from the Assessment and to integrate that understandings into the Assessment process.
Planning Began in 1997

Proposed by IASC, AMAP, and CAFF, and then

Mandated by Arctic Council October 2000

Now

Submit Final Reports and Policy Recommendations to the Arctic Council in October 2004

Timeline and Schedule for the ACIA

2000  2001  2002  2003  2004

Scientific and Technical Analysis and Assessment

Major External Review

Major External Review

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Emerging Research Priorities

• Process and Context Studies
• Improved Regional Models
• Observing & Documenting Change
• Long Term Monitoring of Changes
• Extending the Capabilities of Impact, Vulnerability, and Resilience Studies
• Integrating Science, Local/Indigenous Knowledge to extend understandings of the human/environment systems
• Strategies for Translating Knowledge and Insights into Actions that Address the Substantial Changes the Science is Increasingly Documenting across the Arctic
Improvements in numerically modeling climate change are needed, as follows:

- Improving the representation of key arctic processes in climate models.
- Improving the treatment of ocean processes in climate models.
- Improving the modeling of feedbacks and interactions.
- Conducting extended ensemble simulations with a representative set of models.
- Developing and using high-resolution coupled regional models.
- Developing and evaluating techniques for downscaling results from models.
Many Arctic processes require further study to improve future climate impact assessments, both through scientific investigations and more detailed systematic documentation of indigenous knowledge. The priorities include:

- Collection of satellite, surface, and paleo data to strengthen the climate record.
- Refining estimates of the role of arctic feedback processes (albedo, clouds, trace gases).
- Studies of how changes in the arctic thermohaline circulation could affect climate and vice versa.
- Determination of the factors affecting the rate and range of possible adaptability of arctic biota.
- Studies of the effects of UV radiation on humans and ecosystems.
- Gathering information on the health status of arctic people.
Long Term Monitoring

Long-term time series of climate and climate-related parameters are rare in the Arctic. The need for continuing long-term monitoring of the following parameters is particularly crucial:

- Upgrading of the climate observing system throughout the Arctic.
- Monitoring of sea ice, snow cover, glacier, and permafrost changes.
- Improving the gauging of the runoff of major arctic rivers.
- Improving capabilities to monitor ocean currents, fronts, hydrographic regime.
- Monitoring selected biological indicators of climate change.
- Monitoring stratospheric ozone levels throughout the arctic regions.
Impacts, Resilience and Vulnerability Studies

Critical needs under this heading include:

- Evaluating approaches for expressing relative levels of certainty and uncertainty.
- Developing linkages between traditional and scientific knowledge.
- Assessing vulnerabilities and cumulative impacts on human societies.
- Assembling and analyzing trends in extreme climate events.
- Preparing scenarios of arctic population and economic development.
- Obtaining a better quantitative understanding of economic impacts.
- Identifying and evaluating potential mitigative and adaptive measures to meet climate impacts.
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- GARP, TOGA, WOCE, and Others
- Global Change Research

**Timelines and Epochs in Scientific Research**

- International Geophysical Year: A Disciplinary Focus
- A Next Phase Epoch: Interdisciplinary Research
- Resource Planning: IGFA
Thank You
ACIA Arctic Climate Impact Assessment

Website: (www.acia.uaf.edu)