GreenFacts
Facts on Health and the Environment

Scientific Facts on

Arctic Climate Change

Source document:
ACIA (2004)

Summary & Details:
GreenFacts

Context - Our climate is already changing, particularly in the Arctic where permafrost is melting, glaciers are receding, and sea ice is disappearing.

Changes in the Arctic will not only affect local people and ecosystems but also the rest of the world, because the Arctic plays a special role in global climate.

How has the climate changed in the Arctic so far, and what future changes are expected?

This Digest is a faithful summary of the leading scientific consensus report produced in 2004 by the Arctic Climate Impact Assessment (ACIA):
"Impacts of a Warming Arctic: Arctic Climate Impact Assessment"

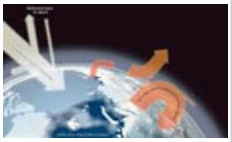
The full Digest is available at: https://www.greenfacts.org/en/arctic-climate-change/

This PDF Document is the Level 1 of a GreenFacts Digest. GreenFacts Digests are published in several languages as questions and answers, in a copyrighted user-friendly Three-Level Structure of increasing detail:

- Each question is answered in Level 1 with a short summary.
- These answers are developed in more detail in Level 2.
- Level 3 consists of the Source document, the internationally recognised scientific consensus report which is faithfully summarised in Level 2 and further in Level 1.

All GreenFacts Digests are available at: http://www.greenfacts.org/

1. Introduction: Global climate change and the Arctic region


Greenhouse effect
[see Annex 7, p. 13]

1.1 **The world's climate is changing**. On average, the temperature on the Earth's surface has increased by 0.6°C (1°F) over the last two centuries. *1 [see Annex 2, p. 8] Most of the warming observed in the past 50 years is attributed to human activities and particularly to the burning of fossil fuels.

Information on past climatic conditions obtained from ice cores and other sources shows that the current increase in global temperatures goes beyond natural climate variability. In the Arctic, average temperatures have risen almost twice as fast as in the rest of the world and climate changes are particularly intense. Changes in the Arctic climate will also affect the rest of the world through increased global warming and rising sea levels.

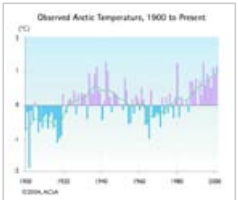
1.2 **The Arctic region is the area around the North Pole, essentially an ocean surrounded by land.** In the far north, the Arctic is mostly covered by snow and ice, whereas the southernmost part is covered by boreal forests. In between, there is a wide expanse of tundra. The Arctic is home to an array of plants, animals, and people that survive in some of the most extreme conditions on the planet and that are uniquely adapted to such conditions. Climate change, pollution, and growing resource use are factors that put an increasing pressure on fragile Arctic populations and ecosystems.

1.3 **The Arctic region is home to almost four million people**, including an increasing majority of non-indigenous settlers. The Arctic includes Greenland, Iceland, and the northern parts of Norway, Sweden, Finland, Canada, Russia, and the United States. Economically, the region depends largely on natural resources, ranging from oil, gas, and metal ores to fish, reindeer and birds. Recently, the tourism sector has also grown in many parts of the Arctic.

2. How is the climate changing in the Arctic?

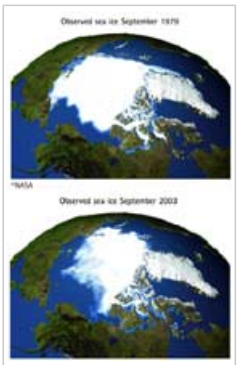
Arctic climate is now warming rapidly and much larger changes are projected.

2.1 Evidence of the recent warming of the Arctic is provided by: records of increasing temperatures; melting glaciers, sea ice, and permafrost; and rising sea levels.


Arctic temperatures, 1900-present
[see Annex 3, p. 9]

2.2 Global temperatures are expected to increase further during the 21st century. In the Arctic, this warming is expected to be substantially greater than the global average, and the following changes are expected over the current century * [see Annex 2, p. 8] :

- The average annual temperatures are projected to rise by 3 to 7 °C (5 to 13°F), with the greatest warming occurring in the winter months
- Precipitation is projected to increase by roughly 20%.
- Sea ice is expected to continue to decline significantly, reflecting less solar radiation and thereby increasing regional and global warming.
- The area of Arctic land covered by snow is expected to decrease by 10 to 20%.

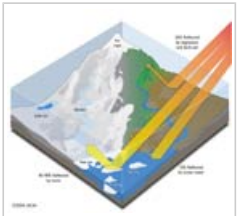

Sea-Ice extent, 1979-2003
[see Annex 4, p. 10]

These projections assume a gradual warming. However, abrupt and unexpected changes cannot be ruled out.

3. How will Arctic warming affect the rest of the planet?

Arctic warming and its consequences have worldwide implications.

Changes in the Arctic can influence the global climate through three major mechanisms.


Changes in surface reflectivity
[see Annex 6, p. 12]

3.1 The amount of the **sun's energy reflected back to space** decreases as snow and ice melt, leading to a more intense surface warming.

3.2 The melting of Arctic ice and increased regional precipitation can add freshwater to the oceans, and potentially affect **ocean currents** in the North Atlantic.

3.3 As warming progresses, more **greenhouse gases could be released** into the atmosphere by the thawing of the permafrost. However, warming can increase biological growth, and thus absorption of CO_2.

3.4 By 2100, melting of Arctic glaciers alone will have contributed to a sea level rise of roughly 5 cm out of the projected 10-90cm total rise for this century. *2 [see Annex 2, p. 8] Melting of the Greenland ice sheet may increase this number significantly.

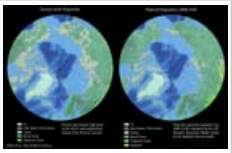

Melt of glaciers can contribute to sea level rise

3.5 Access to Arctic resources is likely to be affected by climate change, including: wildlife, such as whales, seals, birds, and fish sold on world markets; and oil, gas and mineral reserves.

Arctic ecosystem changes will have an impact on a global scale, notably by affecting migratory species' summer breeding and feeding grounds.

4. How will the vegetation be affected by Arctic warming?

Arctic vegetation zones are likely to shift, causing wide-ranging impacts.


Projected changes in vegetation
[see Annex 5, p. 11]

4.1 The Arctic region has three main types of vegetation: polar deserts in the north, boreal forests in the south, and tundra in between. Rising temperatures are expected to favor a northward expansion of boreal forest into the tundra, and of tundra into the polar desert.

4.2 The **expansion of forest is likely to amplify global warming**, because the newly forested areas are darker than the tundra they replace, and absorb more of the sun's energy. However, this can be somewhat counterbalanced by the fact that they also take up more carbon from the atmosphere.


Forest fires could become more frequent

4.3 Due to the warming, **insect outbreaks** will increasingly disturb large areas of forest. Most scenarios project more **forest fires** in all ecosystems.

4.4 Climate change is expected to increase the range of **crops** that can be grown in the Arctic and to extend the growing season. However, problems caused by insects, diseases, and weeds are likely to worsen.

5. How will animals be affected by Arctic warming?

Animal species' diversity, ranges, and distribution will change.


Polar Bears depend on sea ice for their survival

5.1 Many Arctic animals, such as polar bears, seals, walruses, and seabirds, rely on the sea's biological productivity and on the presence of sea ice, both of which are highly dependent on climatic conditions.

5.2 Changes in sea surface temperatures or currents could have a strong effect on Arctic **marine fish stocks**, which are an important food source for the world and play a vital role in the region's economy.


Arctic Marine Food Web
[see Annex 1, p. 8]

5.3 Rising temperatures could have both positive and negative impacts on the **aquaculture** of salmon and trout, which is a major industry in the Arctic.

5.4 A decline in certain types of vegetation would affect the animals that feed on them (such as lemmings or reindeers). In turn, predators (such as foxes or birds of prey) and human communities that depend on these animals would be affected.

5.5 Freshwater ecosystems, such as rivers, lakes, and wetlands are home to a variety of animals. They would be affected by increases in water temperature, thawing of permanently frozen ground, and ice cover breaking up earlier in spring.

6. How will settlements and infrastructures be affected by Arctic warming?


Coastal communities face increasing exposure to storms

6.1 **Many coastal communities and facilities face increasing exposure to storms.**

Rising temperatures are modifying the Arctic coastline and are expected to change it even more in the future. Sea level rise is likely to cause flooding of marshes and coastal plains and accelerate beach erosion. Some towns and industrial facilities are already suffering severe damage as a result of erosion, and are now facing the prospect of relocation.

6.2 **Reduced sea ice is very likely to increase marine transport and access to resources.**

A further decline in the area of Arctic sea-ice will extend the navigation period and allow better accessibility by ship around the Arctic Basin and probably open new shipping routes.

6.3 **Thawing ground will disrupt transportation, buildings, and other infrastructure**

The melting of the permafrost layer poses significant engineering challenges for roads, buildings, pipelines, and industrial facilities. New construction will require deeper foundations, thicker insulation, and other preventive measures that will increase construction costs.

7. How will people and their environment be affected by Arctic warming?

7.1 **Indigenous communities are facing major economic and cultural impacts.**

The many indigenous communities whose cultures and activities are shaped by the Arctic environment are facing new challenges because of climate change, in addition to those posed by current social, economic, and political conditions. They find weather less stable and predictable, and are affected by changes in snow and sea ice.

7.2 **Elevated ultraviolet radiation levels will affect people, plants, and animals.**

The increase of ultraviolet (UV) radiation reaching the Earth's surface as a result of the thinning of the ozone layer has negative effects on humans, animals and plants in the Arctic, particularly in the spring when living organisms are most vulnerable.


Rovaniemi, capital of Finnish Lapland, one of the largest cities north of the Arctic Circle

7.3 **Multiple influences interact to cause impacts to people and ecosystems**.

The ability of the Arctic populations to cope with the impacts of climate change will be greatly affected by political, legal, and socioeconomic factors such as growing populations, urbanization, or self-determination movements.

8. What changes are expected in specific areas of the Arctic?

In a region as large as the Arctic, there are significant sub-regional variations in climate. Recent warming has been more dramatic in some regions than in others. Moreover, local features of the natural world and societies create differences in what impacts will occur and which will be most significant locally.

The Arctic Climate Impact Assessment (ACIA) focuses on four sub-regions and considers a series of key impacts:

- **impacts on the environment**, such as changes in habitats and in the geographic spread of plant and animal species,
- **impacts on the economy**, such as changes in access to resources, and
- **impacts on people's lives**, such as effects on traditional lifestyles or damage to infrastructure.

Sub-region I: From East-Greenland to Northwest Russia [see https://www.greenfacts.org/en/arctic-climate-change/l-2/8-regional-changes.htm#1]

Sub-region II: Siberia [see https://www.greenfacts.org/en/arctic-climate-change/l-2/8-regional-changes.htm#2]

Sub-region III: From Chukotka to the Western Canadian Arctic [see https://www.greenfacts.org/en/arctic-climate-change/l-2/8-regional-changes.htm#3]

Click on any sub-region above to view the key impacts in that region.

Sub-region IV: Central and East Canadian Arctic and West-Greenland [see https://www.greenfacts.org/en/arctic-climate-change/l-2/8-regional-changes.htm#4]

9. How can future assessments be improved?

The Arctic Climate Impact Assessment (ACIA) represents the first effort to comprehensively examine climate change and its impacts in the Arctic region, bringing together the findings of hundreds of scientists and the insights of indigenous people.

There remain important gaps in knowledge that will require improved long-term monitoring, studies of ecosystem processes, climate modeling, as well as analysis of impacts on society. The International Polar Year (in 2007-2009) will be an opportunity to improve our understanding of the impacts of climate change.

10. Conclusion

Climate change presents a major and growing challenge to the Arctic and the world as a whole. Implications are particularly great for future generations that will face the consequences of current action or inaction.

10.1 Resulting environmental changes will present **risks** as well as **opportunities** across the Arctic. For example, the large reduction in summer sea ice threatens the future of several ice-dependent species but will also increase marine access to resources and population centers.

10.2 The scenarios used in this assessment assume that changes will be gradual. However, because of the complexity of the Earth's climatic system, major **surprises** are possible if

climate evolves differently. Ocean currents, in the North Atlantic might undergo major changes with wide-ranging consequences for climate.

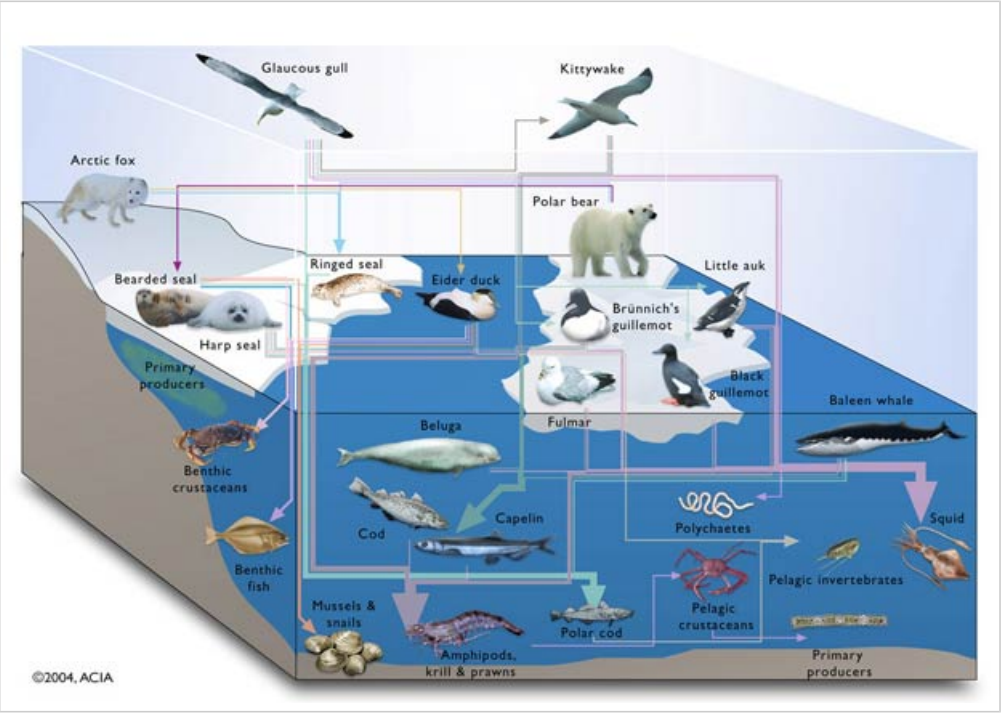
10.3 Impacts of changing climate in the Arctic are already being widely observed and felt. They provide an early indication for the rest of the world of the significance of climate change. The changes will also reach far beyond the Arctic, affecting global climate, sea level, biodiversity, and many aspects of social and economic systems. Climate change in the Arctic thus deserves and requires urgent attention by decision makers and the public worldwide.

The 10 key findings:

Arctic climate is now warming rapidly and much larger changes are projected.	*More in 2 ...*
Arctic warming and its consequences have worldwide implications.	*More in 3 ...*
Arctic vegetation zones are likely to shift, causing wide-ranging impacts.	*More in 4 ...*
Animal species' diversity, ranges, and distribution will change.	*More in 5 ...*
Many coastal communities and facilities face increasing exposure to storms.	*More in 6 ...*
Reduced sea ice is very likely to increase marine transport and access to resources.	
Thawing ground will disrupt transportation, buildings and other infrastructure.	
Indigenous communities are facing major economic and cultural impacts.	*More in 7 ...*
Elevated ultraviolet radiation levels will affect people, plants, and animals.	
Multiple influences interact to cause impacts on people and ecosystems.	

Annex

Annex 1:
Arctic Marine Food Web



Source: ACIA Impacts of a Warming Arctic: Arctic Climate Impact Assessment [see http://www.acia.uaf.edu/pages/overview.html] (2004),
Key Finding #4, [see http://amap.no/workdocs/index.cfm?action=getfile&dirsub=%2FACIA%2Foverview&filename=Finding4%2Epdf&CFID=3348836&CFTOKEN=59197662&sort=default] p.60

Annex 2:
Footnotes

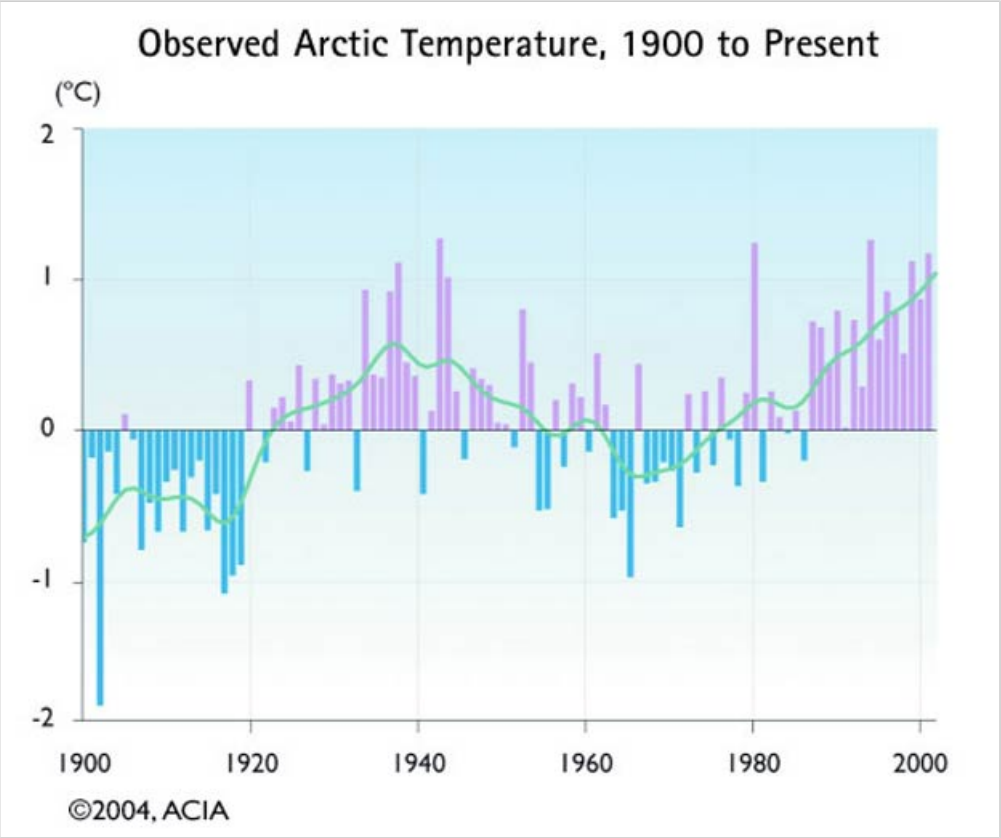
* Note: The ACIA report sourced some of its measurements and projections from the Third Assessment Report (TAR) published in 2001 by the Intergovernmental Panel on CLimate Change (IPCC). In its Fourt Assessment Report (AR4) published in 2007, the IPCC has refined some of the figures. For example,

[1] The IPCC AR4 estimate of the Earth's average global temperature increase is 0.76°C.

[2] The IPCC AR4 projection of sea level rise is 18-59 cm.
GreenFacts' summary of the IPCC AR4 is available at www.greenfacts.org/en/climate-change-ar4/ [see https://www.greenfacts.org/en/climate-change-ar4/index.htm]

Annex 3:
Observed Arctic Temperature, 1900 to Present

Observed Arctic Temperature, 1900 to Present: Annual average change in near surface air temperature from stations on land relative to the average for 1961-1990, for the region from 60 to 90°N.

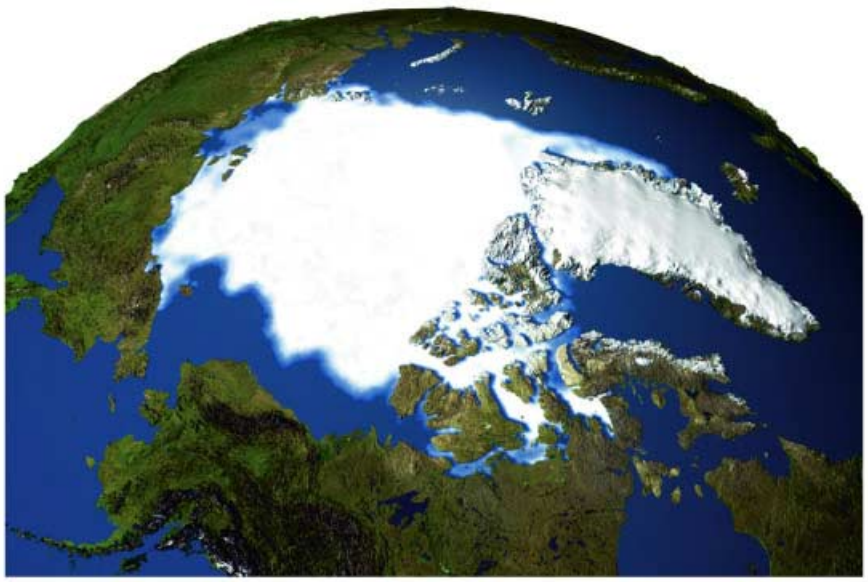


Source: ACIA Impacts of a Warming Arctic: Arctic Climate Impact Assessment [see http://www.acia.uaf.edu/pages/overview.html] (2004),
Key Finding #1, [see http://amap.no/workdocs/index.cfm?action=getfile&dirsub=%2FACIA%2Foverview&filename=Finding1%2Epdf&CFID=3348836&CFTOKEN=59197662&sort=default] p.23

Annex 4:
Observed sea ice September 1979 and September 2003

These two images, constructed from satellite data, compare arctic sea ice concentrations in September of 1979 and 2003. September is the month in which sea ice is at its yearly minimum and 1979 marks the first year that data of this kind became available in meaningful form. The lowest concentration of sea ice on record was in September 2002.

Observed sea ice September 1979



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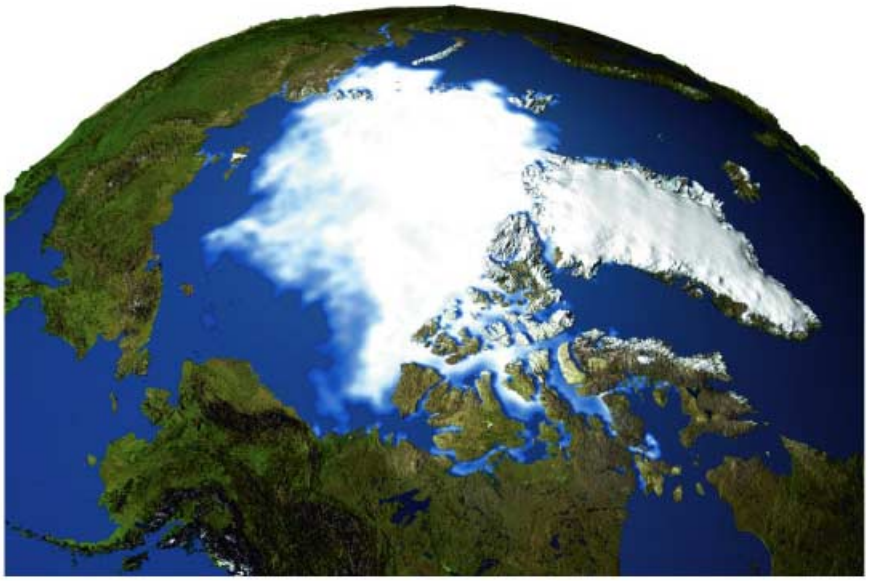
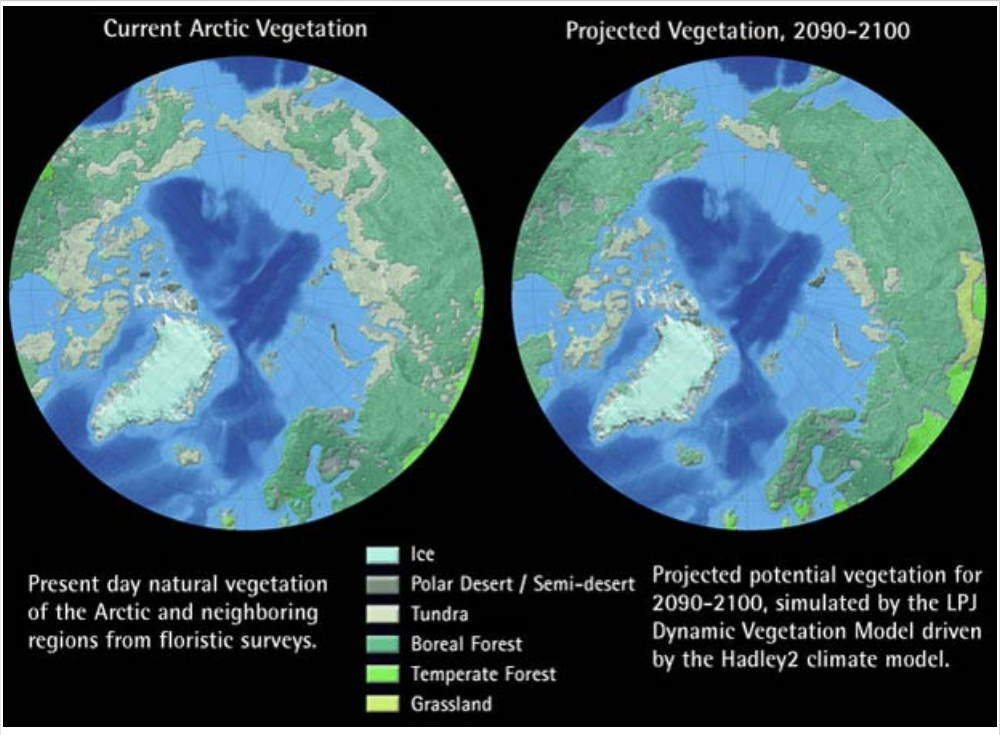
Observed sea ice September 2003



Source: ACIA Impacts of a Warming Arctic: Arctic Climate Impact Assessment [see http://www.acia.uaf.edu/pages/overview.html] (2004),
Key Finding #1, [see http://amap.no/workdocs/index.cfm?action=getfile&dirsub=%2FACIA%2Foverview&filename=Finding1%2Epdf&CFID=3348836&CFTOKEN=59197662&sort=default] p.25

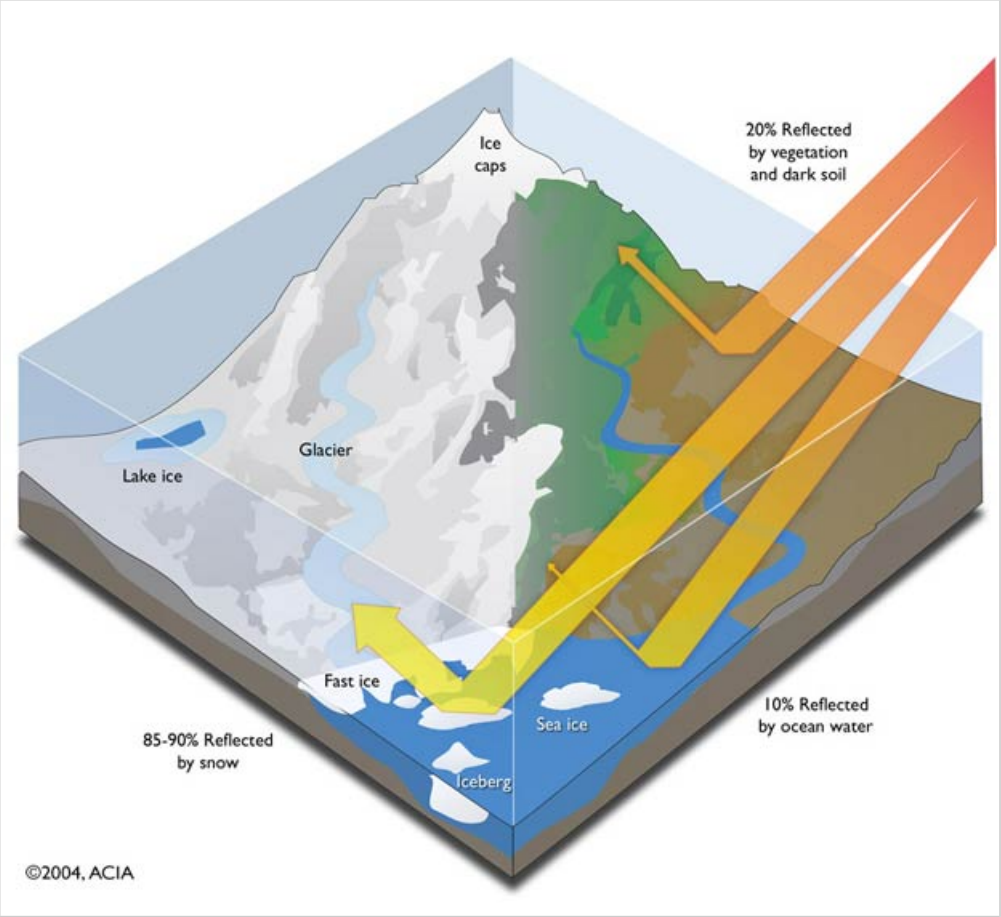
Annex 5:
Projected Vegetation, 2090-2100



Source: ACIA Impacts of a Warming Arctic: Arctic Climate Impact Assessment [see http://www.acia.uaf.edu/pages/overview.html] (2004),
Key Finding #3, [see http://amap.no/workdocs/index.cfm?action=getfile&dirsub=%2FACIA%2Foverview&filename=Finding3%2Epdf&CFID=3348836&CFTOKEN=59197662&sort=default] p.47

Annex 6:
Surface Reflectivity

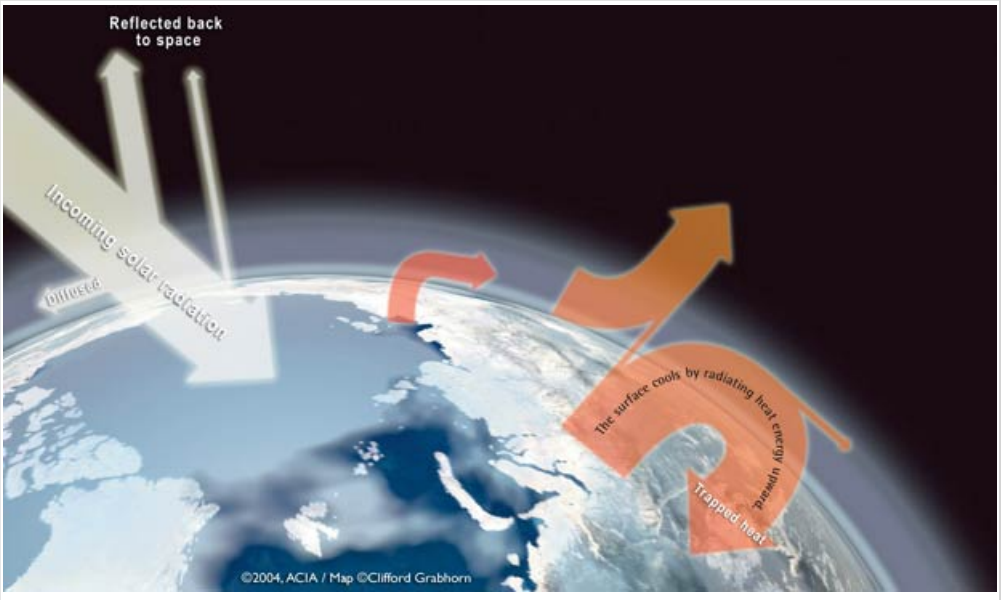
Sea ice covered with snow reflects about 85-90% of sunlight, while ocean water reflects just 10%. Thus, as sea ice melts, revealing more and more of the ocean beneath, the increasing absorption of solar radiation adds to global warming, which causes more melting, which in turn causes more warming, and so on…



Source: ACIA Impacts of a Warming Arctic: Arctic Climate Impact Assessment [see http://www.acia.uaf.edu/pages/overview.html] (2004),
Key Finding #2, [see http://amap.no/workdocs/index.cfm?action=getfile&dirsub=%2FACIA%2Foverview&filename=Finding2%2Epdf&CFID=3348836&CFTOKEN=59197662&sort=default] p.34

Annex 7:
The Earth's Greenhouse Effect

The Earth's Greenhouse Effect: Most of the heat energy emitted from the surface is absorbed by greenhouse gases which radiate heat back down to warm the lower atmosphere and the surface. Increasing the concentrations of greenhouse gases increases the warming of the surface and slows the loss of heat energy to space.



Source: ACIA Impacts of a Warming Arctic: Arctic Climate Impact Assessment [see http://www.acia.uaf.edu/pages/overview.html] (2004),
Context: Global Climate Change, [see http://amap.no/workdocs/index.cfm?action=getfile&dirsub=%2FACIA%2Foverview&filename=ArcticImpactsa%2Epdf&CFID=3348836&CFTOKEN=59197662&sort=default] p.2

Partner for this publication

The Levels 1 & 2 of this study are summaries of "Impacts of a Warming Arctic", a report published in 2004 by the Arctic Climate Impact Assessment (ACIA).

The summaries were produced by GreenFacts in collaboration with the International Polar Foundation.