Climate changes in the Arctic:

Consequences for the rest of the World

Currents keep Europe warm.

The Gulf Stream is a warm current flowing from the Caribbean to Europe. Its temperature varies from 18°C to 28°C, and the volume of water it discharges can reach 100 times that of all the rivers of the world put together. It also warms the air in Europe. Indeed, without it winters in Western Europe would be as cold as in Quebec.

Monitoring the ice situation and the development of ice around the poles has high priority, not only in Europe, but worldwide. Many institutes conduct research programmes connected to ice only, while others are committed to programmes connected to ice, climate and climate development. What do they commonly conclude, if anything? In short, the development of the arctic climate has greatly influenced the climate worldwide, and much of the key to understanding the climate processes is found in the Arctic areas, and – new knowledge is greatly needed.

This article is based on several articles published at: www.nasa.gov/centers/Goddard/earthandsun/

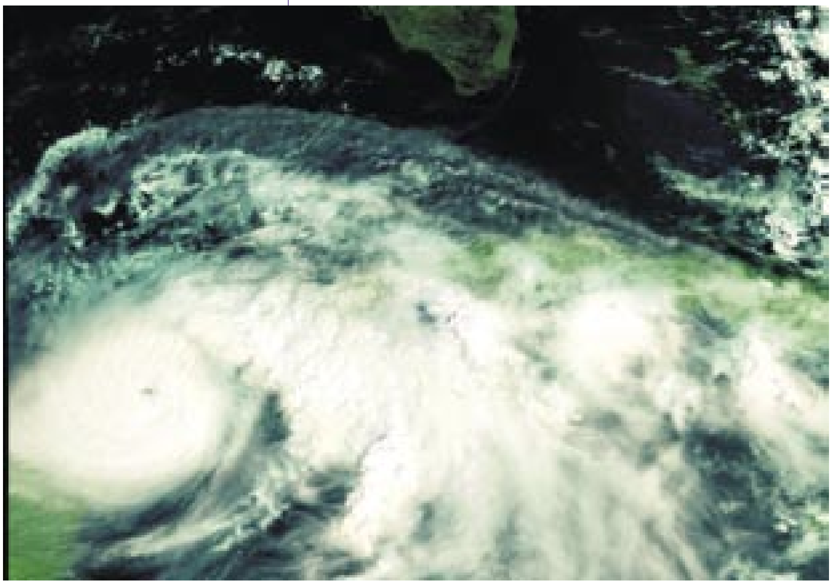
Greenland's Ice Thinning More Rapidly at Edges

Monitoring of ice and following the developing is important because ice regulates Earth's climate by reflecting most of the Sun's energy back out to space. Also, when ice melts or produces icebergs at its edges, it rises sea levels.

Researchers recently used the method of radar altimetry to assess ice changes in Greenland. The study, primarily funded by NASA, found that ice thinned along the coastlines between 1997 and 2003 much more substantially than it had in the past. As the ice thinned, losing much of its volume to the surrounding seas, Greenland's contribution to sea level rise almost doubled between from the mid-1990s to the early 2000s. The mid-90s data showed this contribution was about 0.13 mm per year. In the period between 1997 and 2003, the melt-water addition from Greenland into the oceans rose to 0.25 mm per year.

It is also found that while most of the coastal ice had thinned, ice thickened by about a meter between 2002 and 2003 in Southeast Greenland. In the period between 1993 and 1997, this area had been thinning by 10 to 40 centimetres per year. The sudden thickening was due to some unusually large amounts of snowfall. While up to a meter of snowfall a year would not be out of the ordinary for the area, around 3 meters of snow fell between May 2002 and May 2003. This was the largest amount of snowfall that has been observed in the area, by a long shot. Ice cores from nearby areas show that in the past 100 years there has never been this much snowfall in a single year.

The same study reports that the ice cover in the higher elevations of central Greenland has stayed mostly in balance over the last few decades. And since the mid-90s elevations below 2000 meters have steadily thinned. But the unusually heavy snowfall complicates the understanding of how climate change affects the ice sheet.



Significant changes in the Arctic environment could lead to dramatic swings in weather and climate patterns across the rest of the globe, Here the Hurricane Isidora near the coast of Florida. Photo: ESA/Meris

Fastest Glacier in Greenland Doubles Speed

Researchers who study Earth's ice and the flow of glaciers have been surprised to find the world's fastest glacier in Greenland doubled its speed between 1997 and 2003.

The finding is important for many reasons. For starters, as more ice moves from glaciers on land into the ocean, it rises sea levels. Jakobshavn glacier is Greenland's largest outlet glacier, draining 6.5 percent of Greenland's ice sheet area. The ice stream's speed-up and near-doubling of ice flow from land into the ocean has increased the rate of sea level rise by about .06 millimetres per year, or roughly 4 percent of the 20th century rate of sea level increase.

The researchers found the glacier's sudden speed-up also coincides with very rapid thinning, indicating loss of ice of up to 15 meters in thickness per year after 1997. Along with increased rates of ice flow and thinning, the thick ice that extends from the mouth of the glacier into the ocean, called the ice tongue, began retreating in 2000, breaking up almost completely by May 2003.

Researchers at NASA's Jet Propulsion Laboratory, Pasadena, California, have used satellite and other data to observe large changes in both speeds and thickness between 1985 and 2003. The data showed that the glacier slowed down from a velocity of 6700 m/year in 1985 to 5700 m/year in 1992. This latter speed remained somewhat constant until 1997. By 2000, the glacier had sped up to 9400 m/year, topping out with the last measurement in spring 2003 at 12,600 m/year.

This finding suggests the potential for more substantial thinning in other glaciers in Greenland. Other glaciers have thinned by over a meter a year, which the researchers believe is too much to be attributed to melting alone. One thinks there is a dynamic effect in which the glaciers are accelerating due to warming.

Other airborne laser altimetry measurements of Jakobshavn's surface elevation showed a thickening or building up of the glacier from 1991 to 1997, coinciding closely with the glacier's slow-down. Similarly, the glacier began thinning by as much as 15 meters a year just as its velocity began to increase between 1997 and 2003.

The acceleration comes at a time when the floating ice near the glacier's calving front has shown some unusual behaviour. Despite its relative stability from the 1950's through the 1990s, the glacier's ice tongue began to break apart in 2000, leading to almost complete disintegration in 2003. The tongue's thinning and breaking up likely reduced any restraining effects it had on the ice behind it, as several speed increases coincided with losses of sections of the ice-tongue as it broke up. Recent research in the Antarctic Peninsula showed similar increases in glacier flow following the Larson B ice shelf break-up.

Observations and computer models have long proven that the Arctic plays an important role in maintaining a stable climate on Earth. However, significant changes in the Arctic environment, especially those over the past decade, could lead to dramatic swings in weather and climate patterns across the rest of the globe, with potentially far-reaching consequences for ecosystems and human populations.

Ground-based surface temperature data shows that the rate of warming in the Arctic from 1981 to 2001 is eight times larger than the rate of Arctic warming in the past 100 years. There have also been some remarkable seasonal changes. Arctic spring, summer, and autumn have each warmed, lengthening the seasons when sea ice melts from 10 to 17 days per decade.

Recently a research study discovered that the total Arctic sea ice extent and area decreased respectively by 30,848 km2/year and 35,372 km2/year using ice data between 1978 and 2002, derived among others from NASA's Nimbus 7 satellite. And, if the current trends continue, Arctic sea ice will become much thinner in winter and almost non-existent in the summer, in keeping with increased greenhouse loading in the atmosphere.

The Arctic is so important to the world's climate because it acts as the "collection bed" for the world's excess energy. In an attempt to balance energy across the Earth's surface, heat is constantly being transported through atmospheric circulations and ocean currents from the equator to the poles where it is ultimately released out to space.

But if the climate continues to warm faster in the Arctic than at lower latitudes, this transfer of heat will slow down, weakening overall atmospheric circulation. The weakening circulation would alter storm tracks, and their intensity, but the most profound impact would be on temperature. Oceans are capable of holding a tremendous amount of heat and moisture, which when transferred through its surface to the atmosphere, can significantly alter temperature and pressure patterns.

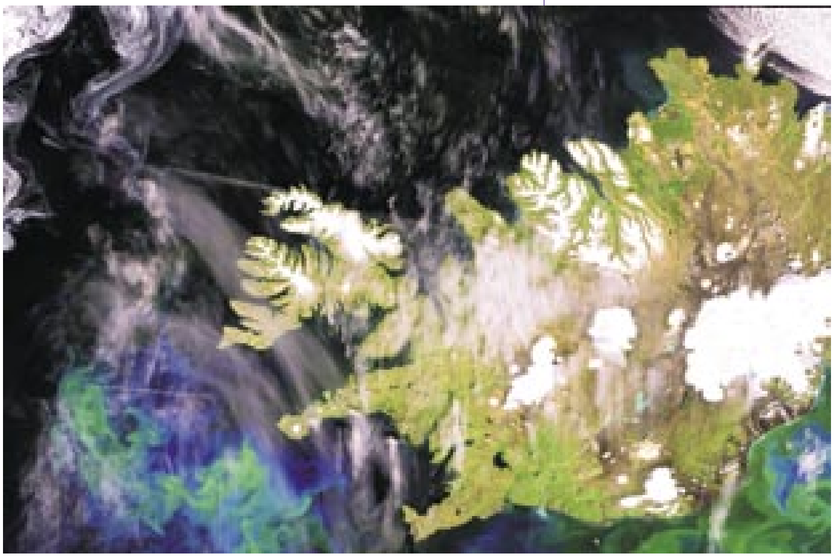
Some scientists speculate that as low-latitude surface waters warm, forces like the El Niño-Southern Oscillation (ENSO) will strengthen and become even bigger players in the world's climate. El Nino (EN) is signalled by a warming of the ocean surface off the western coast of South America every 4 to 12 years when cold, nutrient-rich water does not come up from the ocean bottom. It causes die-offs of plankton and fish and affects Pacific jet stream winds, altering storm tracks and creating unusual weather patterns in various parts of the world. Southern Oscillation (SO) refers to a seesaw of high and low pressure that varies between Tahiti and Darwin, Australia.

Other researchers believe another cyclical atmospheric pressure system, called the Arctic Oscillation (AO) may also be responsible for declining Arctic sea ice. This oscillation refers to a pattern of low- and high-pressure systems between the Arctic and the mid-latitudes. When the oscillation is in its positive phase, as it has generally been in the past 20 years, air pressure tends to be low over the Arctic Ocean. Some scientists theorize that a general warming of the Earth could be pushing the oscillation toward a phase that warms the Arctic. The oscillation helps explain why summer sea ice is thinner than in past years. Since the 1980s, wind changes associated with the oscillation have pushed ice apart and shoved more ice from the Arctic into the Atlantic Ocean between Greenland and Norway.

Research programmes carried out at Georgia Institute of Technology show that AO and ENSO trends cannot explain the recent regional sea ice trends, the research found they do influence the Arctic sea ice to some degree on time scales from year to year. For example, with a positive phase of the AO, they usually observe more ice in the western Arctic and decreased ice coverage in the eastern Arctic. With strong El Nino events, however, there is more ice in both the eastern and western Arctic. The conclusion is that more studies are needed to better understand how regional ice trends might respond to a warmer climate, including less understood large-scale processes such as the Pacific Decadal Oscillation, a long-lived, El Nino-like pattern of Pacific climate variability, and other influences, like river discharge into the Arctic Basin from Russia and Canada and glacier discharge from Greenland.

The global ocean circulation is regulated by cold, dense water that sinks in the Arctic. This water moves south toward the equator and well below the surface in the Atlantic. Upon its circular return northward, it pulls warm tropical water north along the surface, where, like a hot-water heater, it releases heat back into the atmosphere. An influx of fresh water to the Arctic Ocean could prevent the water there from sinking and essentially halt this conveyor-belt-like flow. Changes in ocean currents can greatly complicate overall climate change and, among other things, leave some regions, like England and eastern Canada, much cooler than they otherwise would be.

An important consequence of global warming is the possible reduction in albedo, a measure of the reflection of the Sun's rays back into space. Because of its white colour, snow-covered sea ice reflects most of the incoming solar radiation, which is in part why it is so cold throughout the Arctic region. Melt the snow and ice, replace it with the darker surface of water, and much of the energy will be absorbed leading to warming. Heated oceans in turn will lead to further melting and removal of snow and ice, increasing warming, a "positive feedback" to global warming. It is especially this feedback process that leads to predictions that warming in the Arctic will be more pronounced, fuelling climate changes for other areas of the world. But, it's not quite that simple. Melting sea ice will also leave more of the ocean exposed, increasing evaporation and cloud cover, which can block sunlight and diminish warming.



The global ocean circulation is regulated by cold, dense water that sinks in the Arctic. This water moves south toward the equator through the Denmark Strait between Iceland and Grenland. Photo: ESA/Meris.

Canada's Shrinking Ice Caps

Canada's Arctic region is covered by approximately 150,000 square kilometres of ice. While this land area is tiny compared to Antarctica's 113.5 million square kilometres, and Greenland's 1.7 million square kilometres of ice coverage, it is still quite significant. In the next 100 years, melting glaciers and ice caps outside of Greenland and Antarctica, a significant portion of which includes those in Canada, are expected to rise global sea levels by 20 to 40 centimetres.

Canada's Arctic ice is important because the wide area covered by these ice caps and the dramatic changes that have taken place in the Arctic climate in recent years. Studying this region will help researchers understand how much and in what ways Arctic glaciers and ice caps are contributing to sea level rise.

By making altimeter measurements over many of the Canadian ice caps once in 1995 and repeating them again in 2000, one was able to determine how much the thickness of the ice sheet changed. By combining this information with temperature and precipitation data from weather stations nearby, and several decades of direct measurement of ice growth and shrinkage on certain ice caps, they were able to put these changes in their appropriate climatological context.

Researchers have found an increasing trend in annual temperatures during the second half of the twentieth century. At the same time records showed that accumulation was approximately 15 percent higher during the 1995-2000 time periods than for the 1951-1980 periods. These characteristics contributed to changes in the ice caps in the late 1990s.

The researchers found that in areas where the ice melts very little, there was slight thickening of some ice caps, which could be due to accumulation from increased snowfall; however, overall they found that the ice caps and glaciers were thinning at the lower elevations where melt occurs. In some locations, where the changes were most substantial, this thinning appears to be a continuation of the retreat or melting of glaciers that followed the end of the Little Ice Age -- a period 150 years ago when the Earth was cooler and glaciers were more prevalent. However, the researchers also attributed the melting of the ice caps to the short-term warming trend of the late 1990s, which appears to have been amplified in the Arctic. They determined that the ice loss associated with these combined effects contributed to 0.065 mm/year to sea level rise during the 1995-2000 periods.

This research is significant because it is the first large-scale assessment of Canada's ice cap contribution to sea level rise, which has never been put into a comprehensive picture before. The ice caps in the Canadian Arctic are shrinking, and though they are relatively small compared to areas like Greenland and Antarctica, their short-term contributions to sea level cannot be ignored.