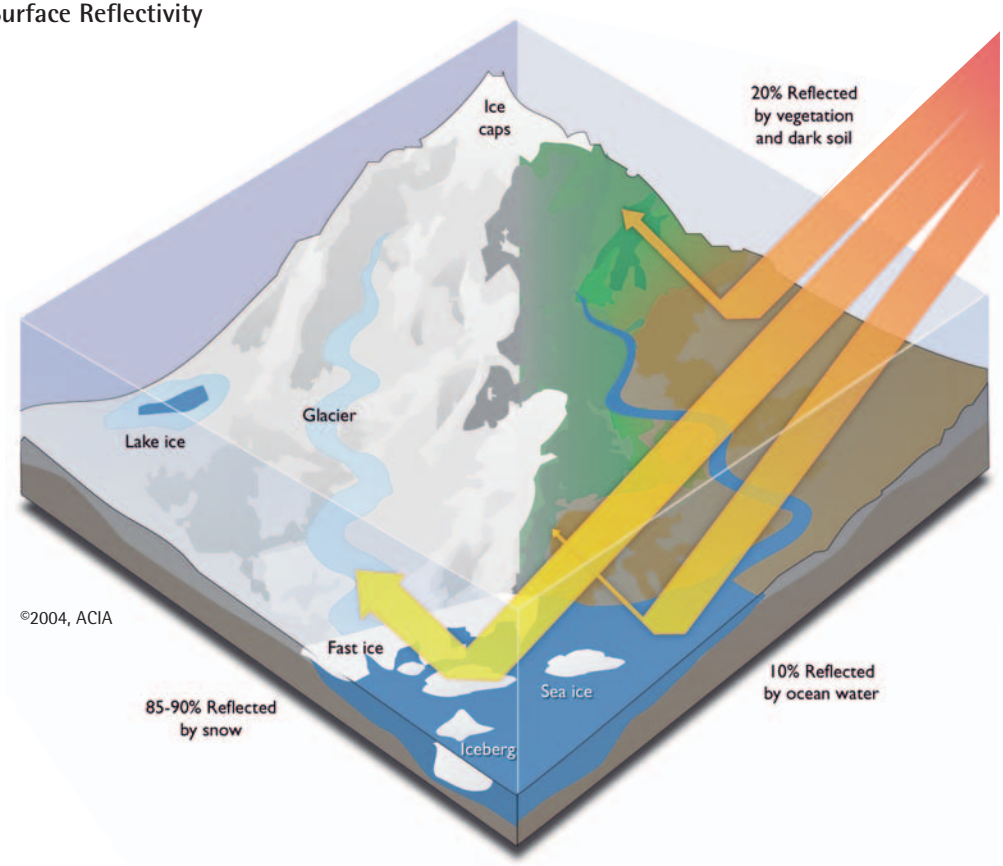
IMPACTS OF A WARMING ARCTIC

2 Arctic warming and its consequences have worldwide implications.

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...

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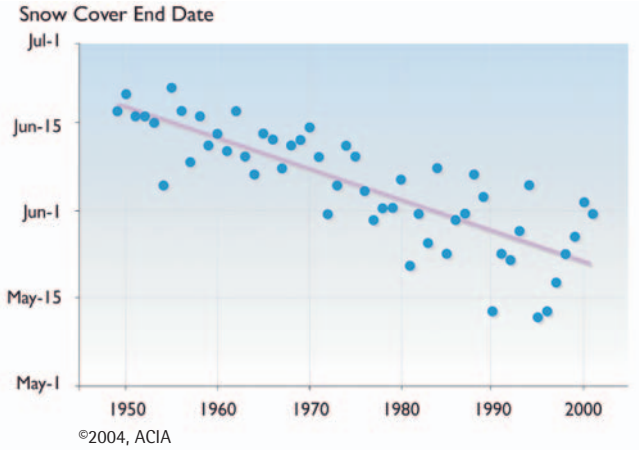
Observed Snow Cover Change Barrow, Alaska



Snow cover extent over arctic land areas has decreased by about 10% over the past 30 years, with the most visible change being an earlier disappearance of snow in spring. One local example is shown in the graph above, for Barrow, Alaska. Over the past 50 years, the snow cover end date has shifted to about one month earlier.

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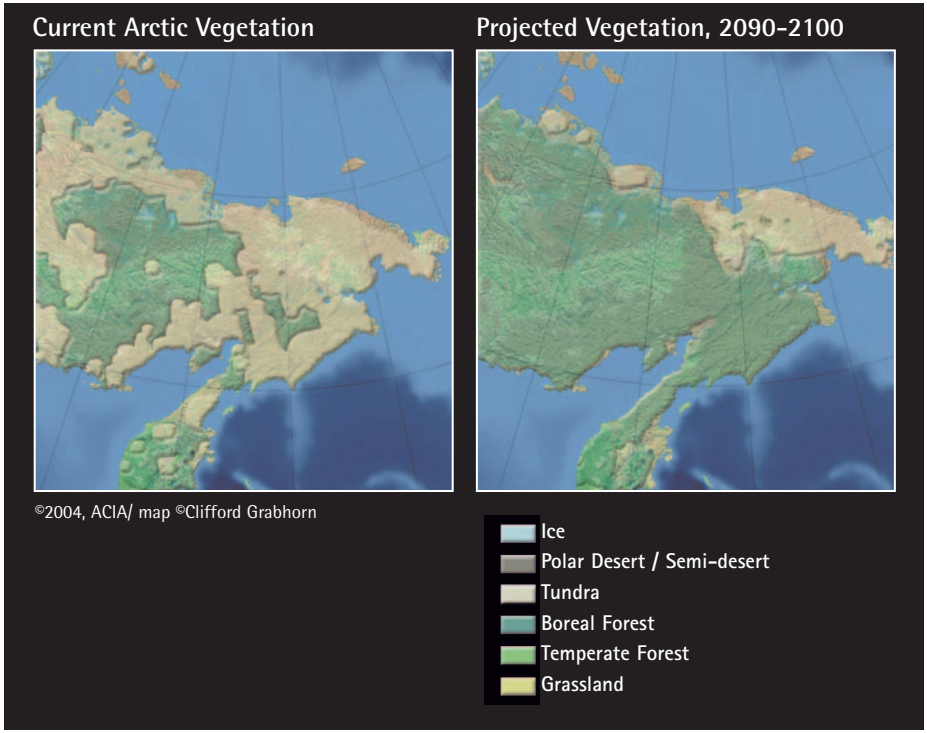

These maps of current and projected vegetation in the Arctic illustrate that forests are projected to overtake tundra and tundra is projected to move into polar deserts. These changes will result in a darker land surface, amplifying warming by absorbing more of the sun's energy and creating a self-reinforcing feedback loop.

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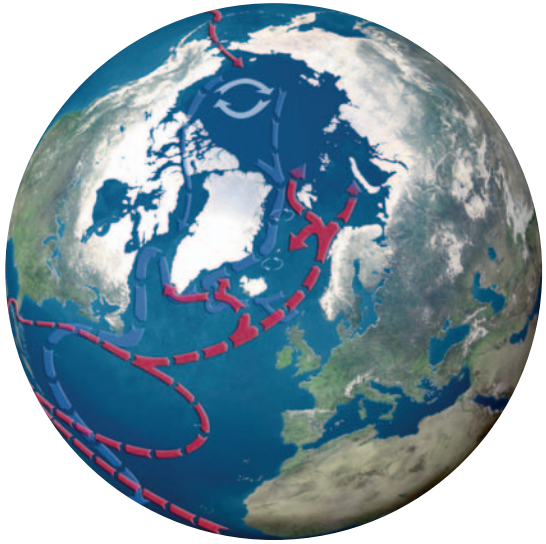
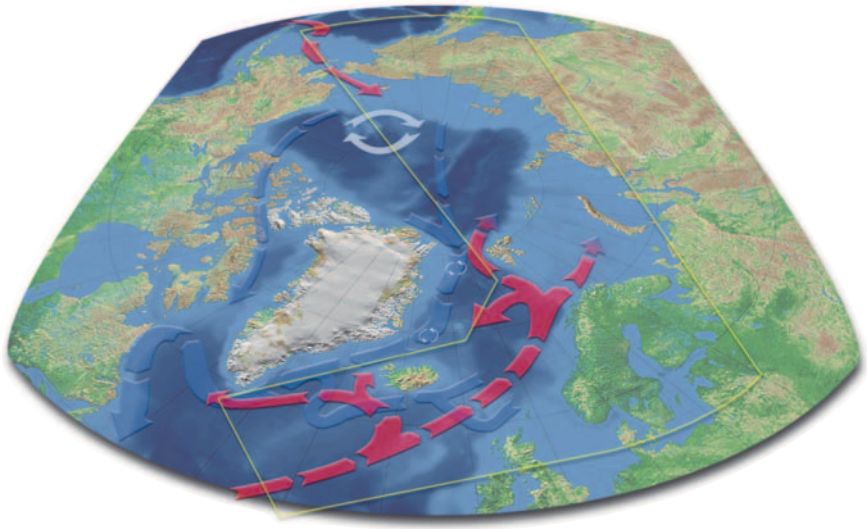
Global Thermohaline Circulation



Arctic Thermohaline Circulation



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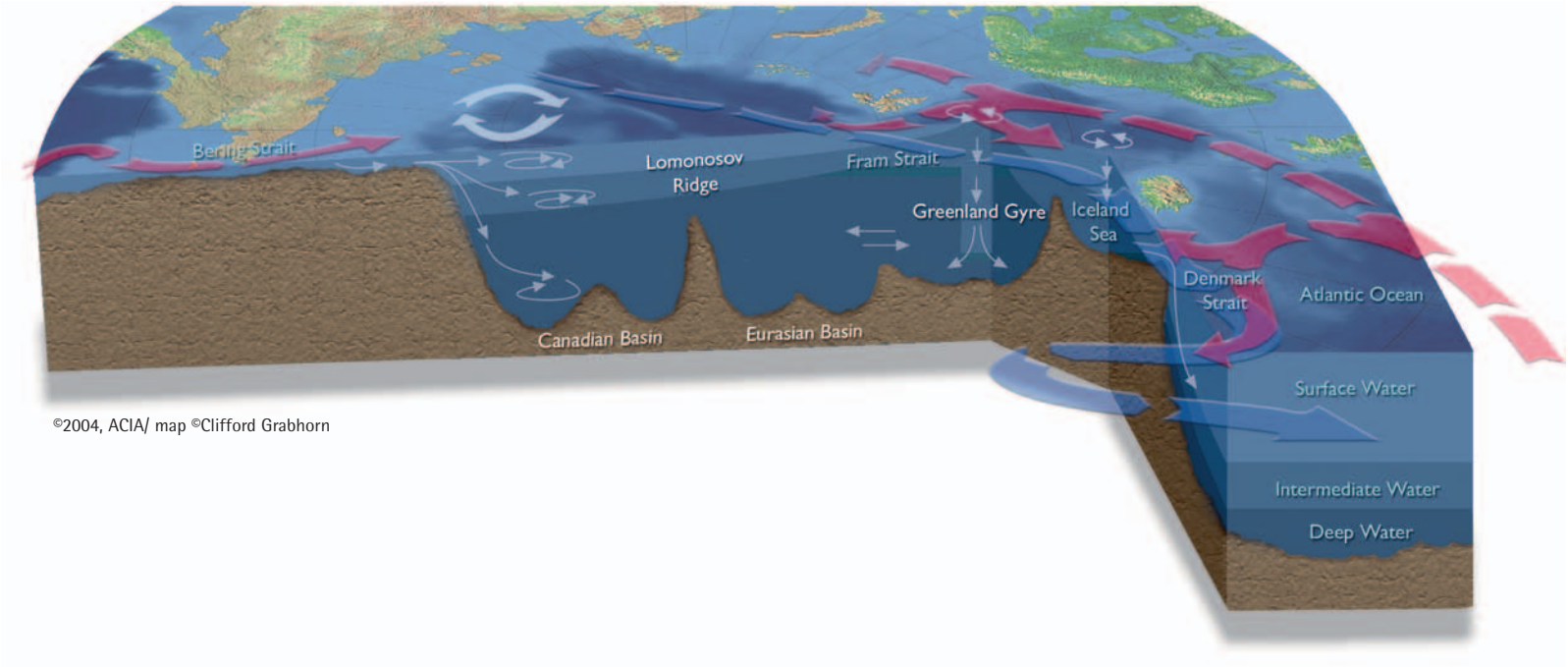
Arctic Thermohaline Circulation (cross section)



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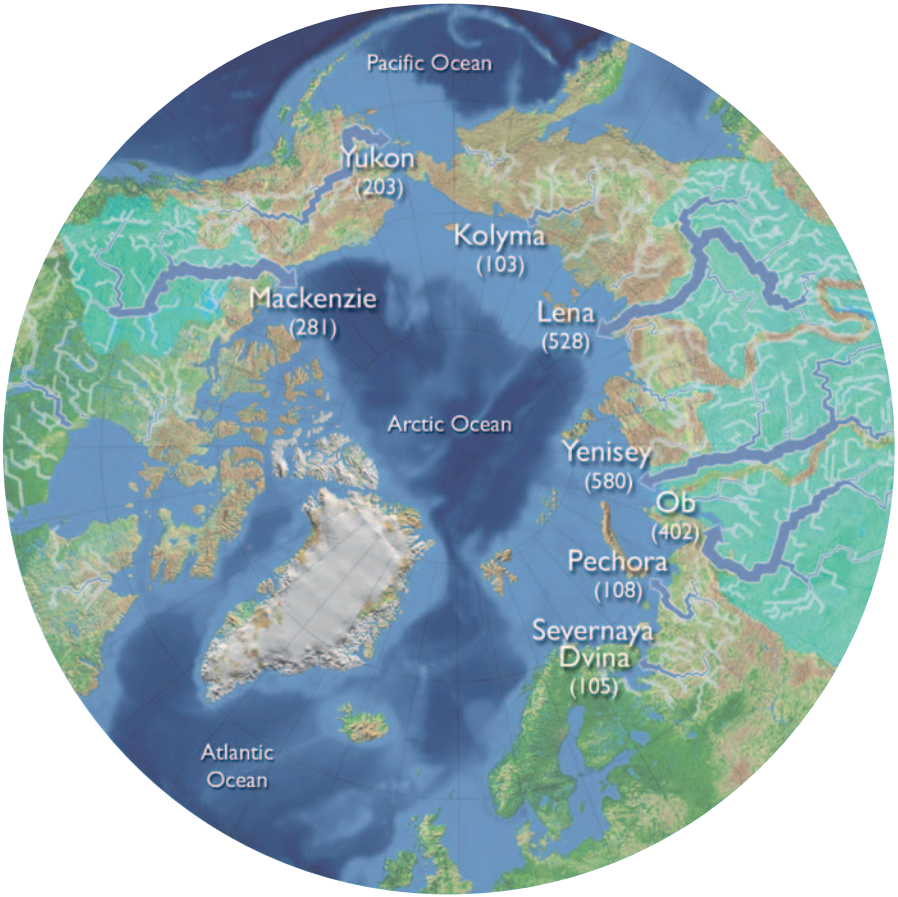
Major Arctic Rivers



This map illustrates the major river networks of the Arctic. The thickness of the blue lines represents the relative river discharge, with the thickest lines indicating the rivers with the largest volume. The numbers on the map are in cubic kilometers per year.

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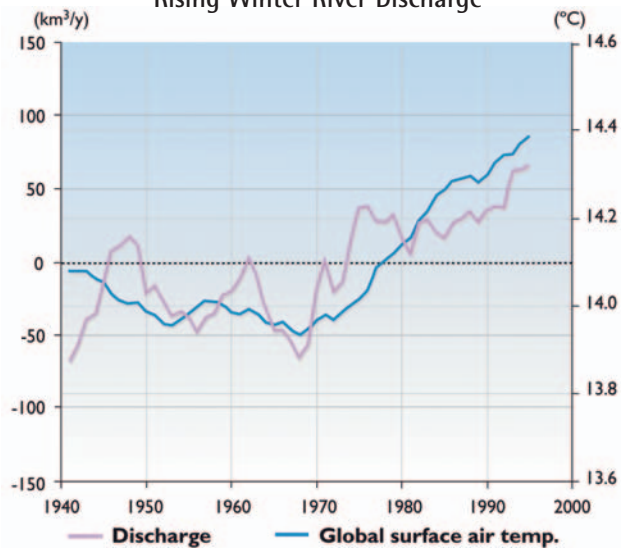
Rising Winter River Discharge



The purple line shows departures from the long-term average of annual Eurasian river discharge, and the blue line shows changes in global average surface air temperature.

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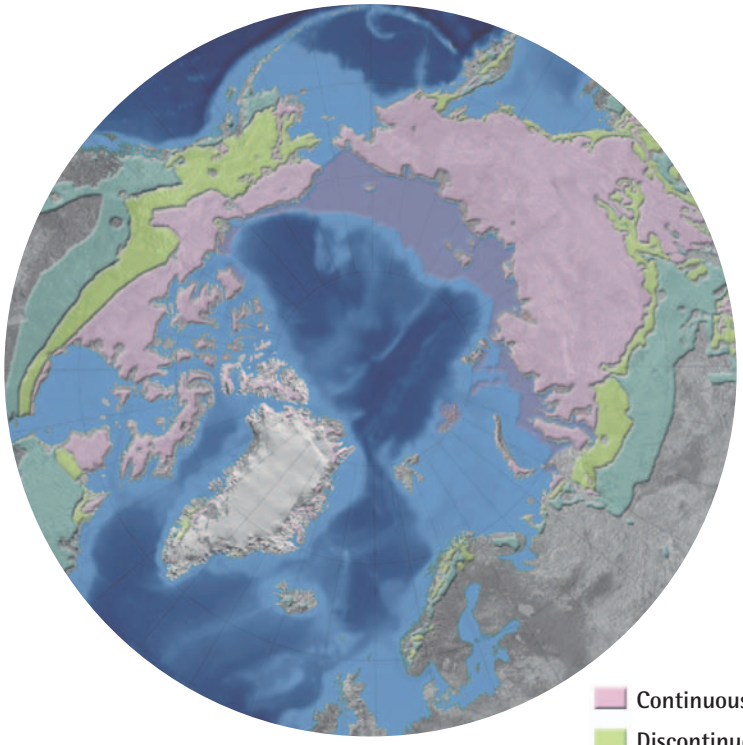
Observed Permafrost Regions

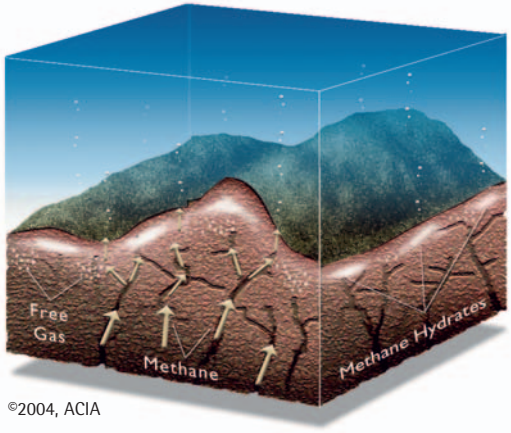


©2004, ACIA/ map ©Clifford Grabhorn

Continuous
Discontinuous
Sporadic
Subsea

Subsea permafrost in the Arctic occurs in the wide continental shelf area. Narrow zones of coastal permafrost are probably present along most arctic coasts.

Subsea Methane Hydrates



©2004, ACIA

Vast amounts of methane, in a solid icy form called methane hydrates or clathrates, are trapped in permafrost and at shallow depths in cold ocean sediments. If the temperature of the permafrost or water at the seabed rises a few degrees, it could initiate the decomposition of these hydrates, releasing methane to the atmosphere.

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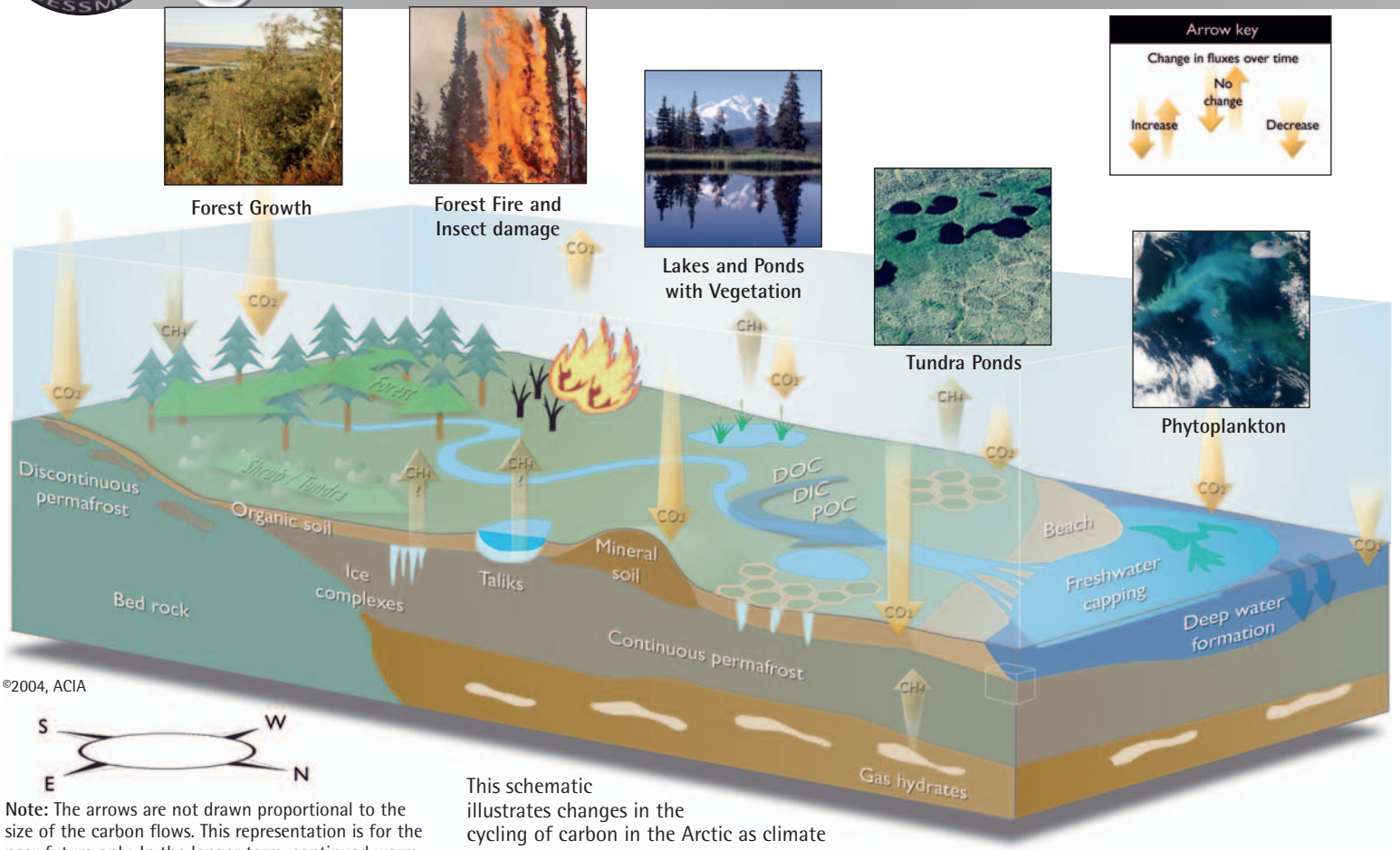

Note: The arrows are not drawn proportional to the size of the carbon flows. This representation is for the near future only. In the longer term, continued warming would be expected to dry out many lakes and ponds and soil moisture could become too great or too little to support forest expansion, resulting in large releases of carbon to the atmosphere.

This schematic illustrates changes in the cycling of carbon in the Arctic as climate warms. For example, beginning at the left of the figure, the boreal forest absorbs CO_2 from the atmosphere and this is expected to increase, although forest fires and insect damage will increase in some areas, releasing more carbon to the atmosphere. Increasing amounts of carbon will also move from the tundra to ponds, lakes, rivers, and the continental shelves in the form of carbon dissolved in water (dissolved organic carbon (DOC), dissolved inorganic carbon (DIC), and particulate organic carbon (POC)).

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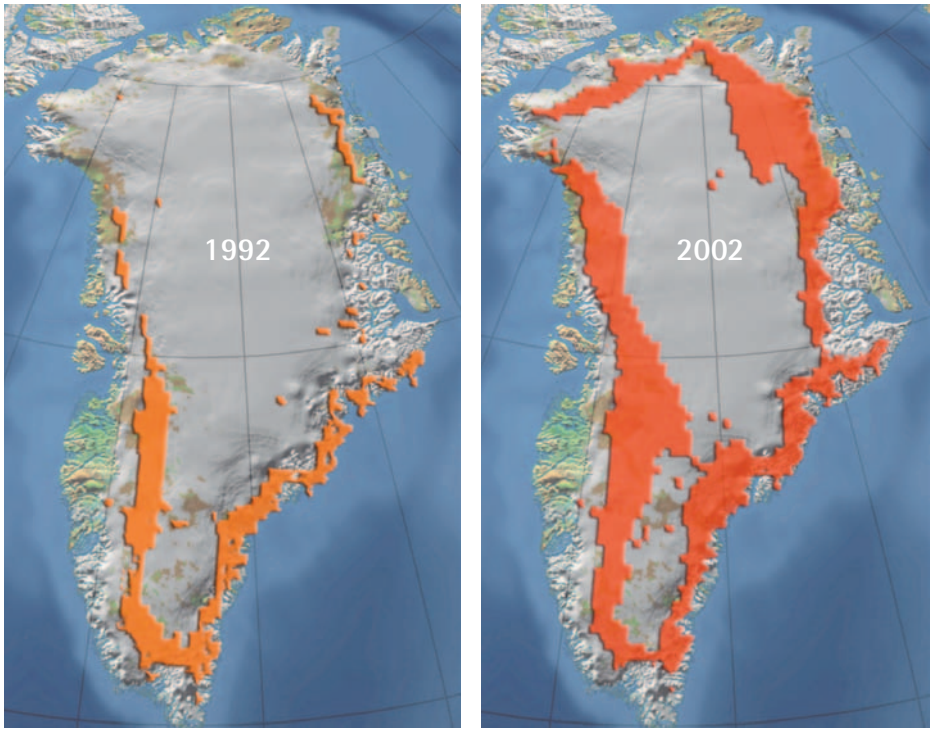
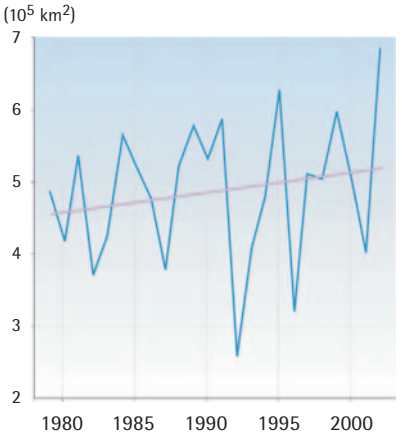
Greenland Ice Sheet Melt Extent

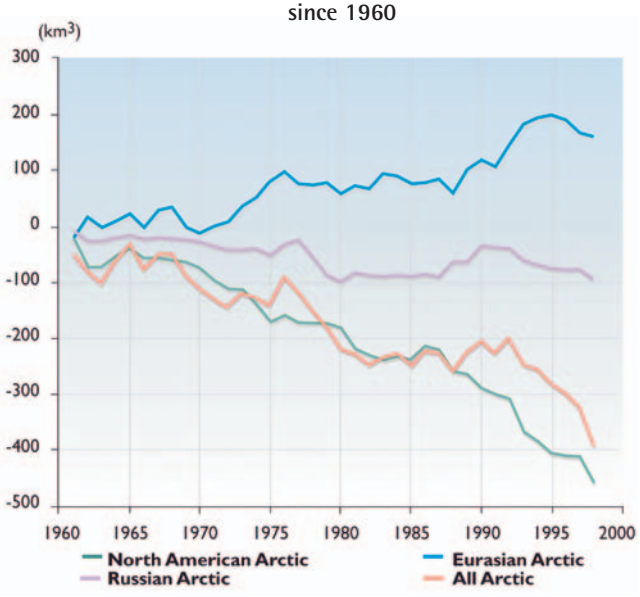


Greenland Ice Sheet Melt Extent
(Maximum melt extent 1979 - 2002)



Seasonal surface melt extent on the Greenland Ice Sheet has been observed by satellite since 1979 and shows an increasing trend. The melt zone, where summer warmth turns snow and ice around the edges of the ice sheet into slush and ponds of meltwater, has been expanding inland and to record high elevations in recent years. When the meltwater seeps down through cracks in the ice sheet, it may accelerate melting and, in some areas, allow the ice to slide more easily over the bedrock below, speeding its movement to the sea. In addition to contributing to global sea-level rise, this process adds freshwater to the ocean, with potential impacts on ocean circulation and thus regional climate.

Cumulative Change in Volume of Arctic Glaciers since 1960



For the Arctic as a whole, there was a substantial loss in glacial volume from 1961 to 1998. Glaciers in the North American Arctic lost the most mass (about 450 km^3), with increased loss since the late 1980s. Glaciers in the Russian Arctic have also had large losses (about 100 km^3). Glaciers in the European Arctic show an increase in volume because increased precipitation in Scandinavia and Iceland added more to glacial mass than melting removed over that period.

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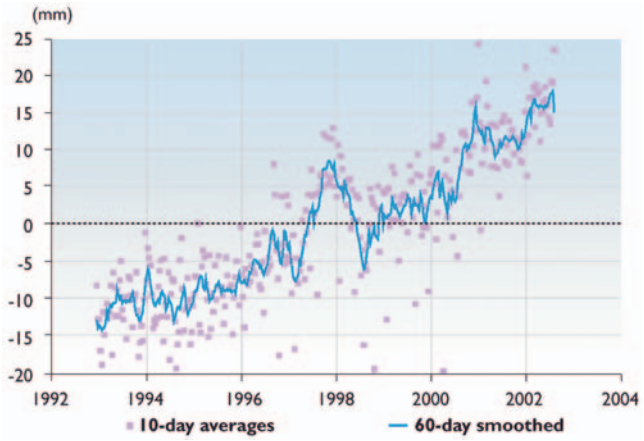
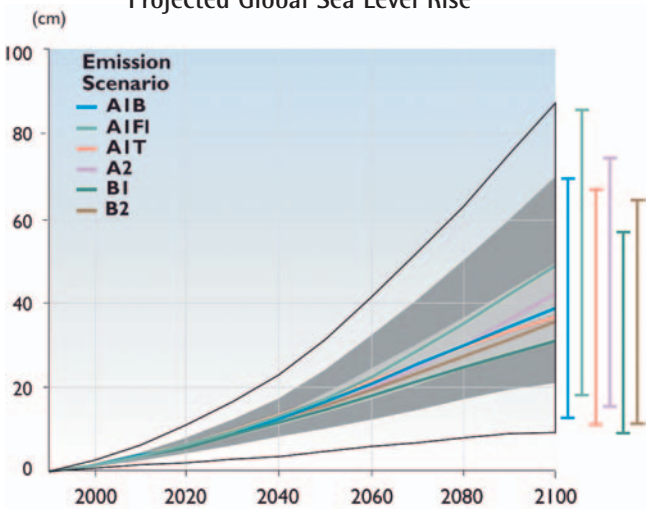
Observed Global Sea Level Rise



These data, from a satellite launched in 1992, show the rise in global average sea level over the past decade.

Projected Global Sea Level Rise



The graph shows future increases in global average sea level in centimeters as projected by a suite of climate models using six IPCC emissions scenarios. The bars at right show the range projected by a group of models for the designated emissions scenarios.

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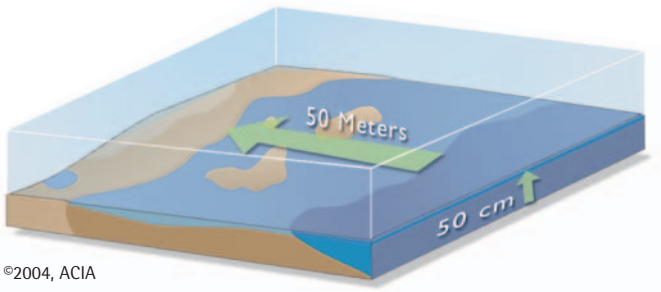
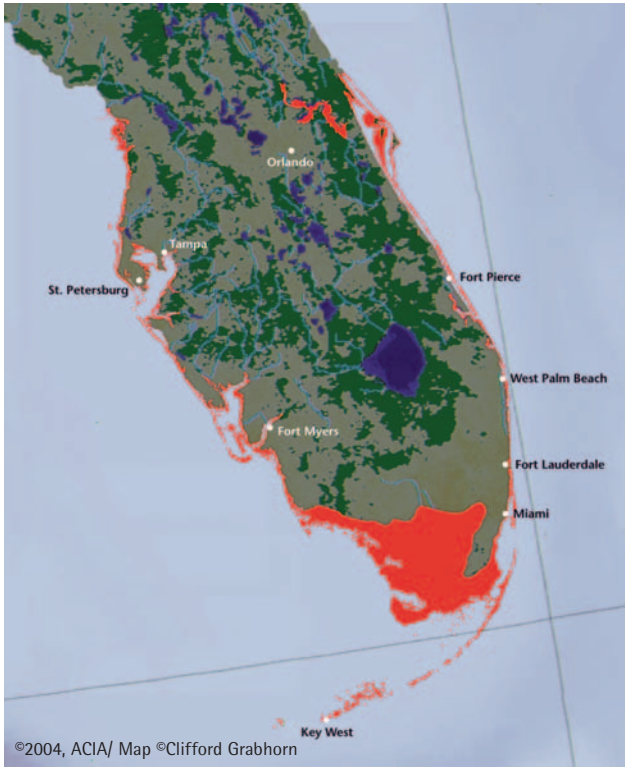
Coastline Retreat with Sea-level Rise



A 50-cm rise in sea level will typically cause a shoreward retreat of coastline of 50 meters if the land is relatively flat (like most coastal plains), causing substantial economic, social, and environmental impacts.

Areas in Florida Subject to Inundation with 100 Centimeter Sea Level Rise



Sea-level rise is projected to have serious implications for coastal communities and industries, islands, river deltas, harbors, and the large fraction of humanity living in coastal areas worldwide. Sea-level rise will increase the salinity of bays and estuaries. It will increase coastal erosion, especially where coastal lands are soft rather than rocky.

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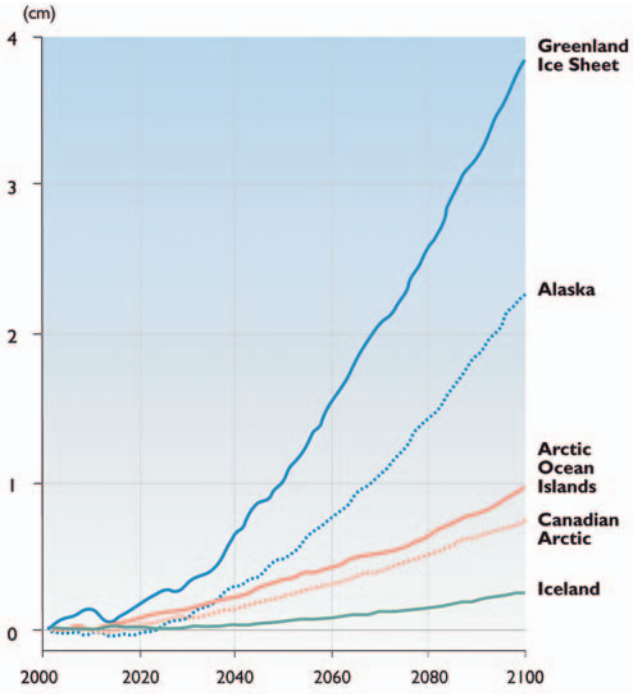
Projected Contribution of Arctic Land Ice to Sea-level Change



This chart compares the projected contributions to sea-level change due to melting of land-based ice in various parts of the Arctic. The Greenland Ice Sheet is projected to make the largest contribution because of its size. Although Alaska's glaciers cover a much smaller area, they are also projected to make a large contribution. The total contribution of melting land-based ice in the Arctic to global sea-level rise is projected to be about 10 cm by 2100. The primary driver of sea-level rise is thermal expansion due to ocean warming, and that is not included in this chart.

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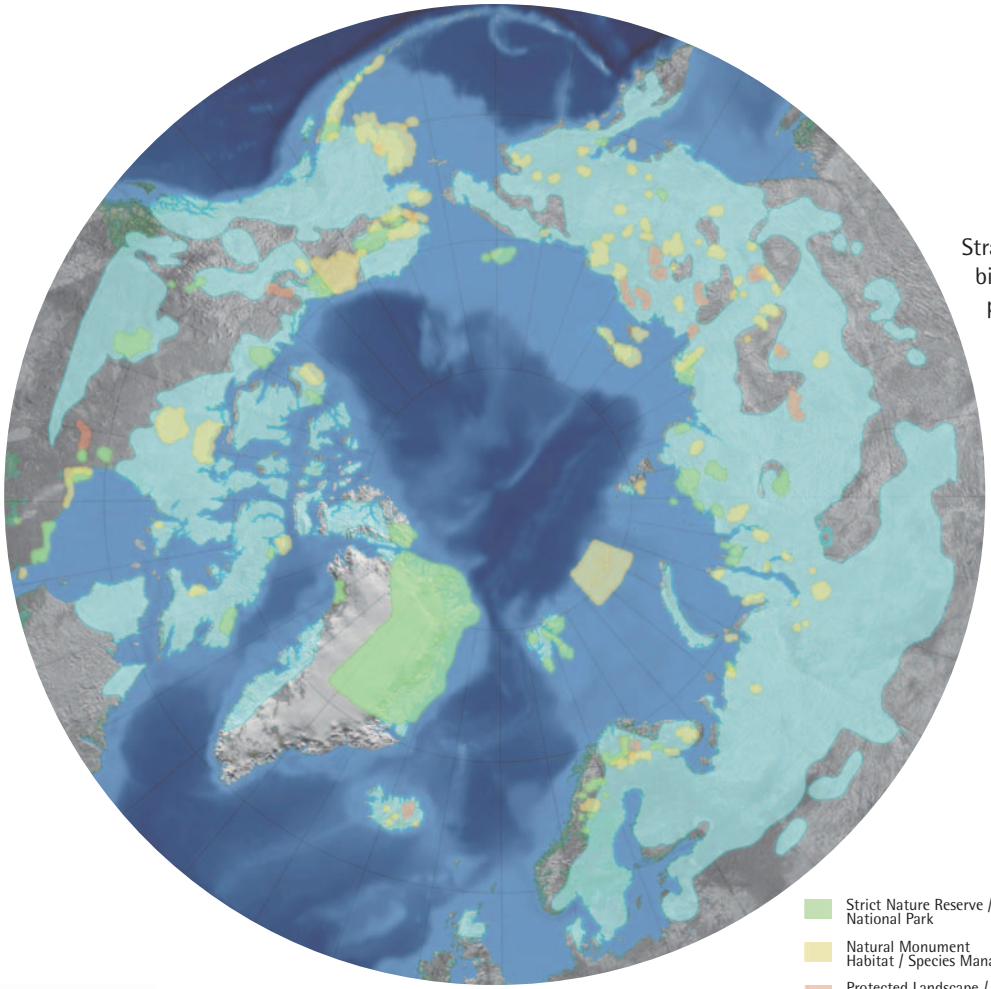
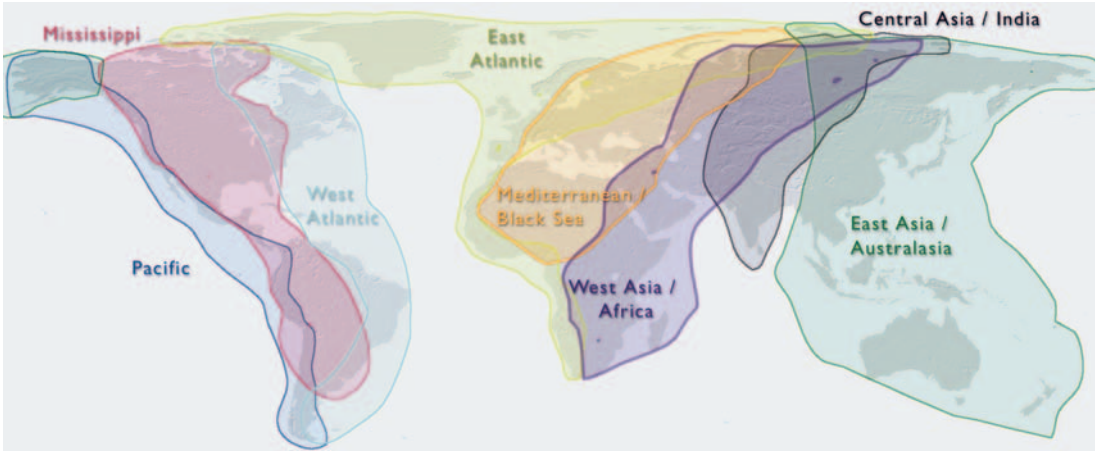
Arctic Protected Areas



Strategies for conserving arctic biodiversity by establishing protected areas are important for defending natural habitats against direct human development, but they do not protect against a changing climate. This map indicates how climate change will affect currently protected areas, putting at risk the living resources these areas were designed to protect.

Migratory Bird Flyways



Several hundred million birds migrate to the Arctic each summer and their success in the Arctic determines their populations at lower latitudes. Important breeding and nesting areas are projected to decrease sharply as treeline advances northward, encroaching on tundra, and because the timing of bird arrival in the Arctic might no longer coincide with the availability of their insect food sources. At the same time, sea-level rise will erode tundra extent from the north in many areas, further shrinking important habitat for many living things. A number of bird species, including several globally endangered seabird species, are projected to lose more than 50% of their breeding area during this century.