



# The Polar Regions

High School Grades

## Lesson Summary

Students will learn about the Polar Regions and find and classify images of different changing polar landscapes.

## Prior Knowledge & Skills

- Analytical skills
- Responsible internet search skills

## AAAS Science Benchmarks

### Historical Perspectives

*Moving the continents*

## NCGE Geography Standards

### The World in Spatial Terms

*Standard 3*

### Places and Regions

*Standard 4*

### Physical Systems

*Standard 8*



**Teaching Time:** 2 -3 hours

## Materials

- Computer with internet access
- Books, magazines, or newspapers (optional)

## Advanced Planning

**Preparation Time:** ~10 minutes

1. Review the instructions
2. Gather the necessary supplies.

## Recommended Reading: (attached)

- Theoretical Section:
  - The Arctic: A frozen ocean surrounded by continents
  - The Antarctic: A frozen continent surrounded by ocean
  - The polar climate
  - Flora and fauna

Teaching dossier produced by the International Polar Foundation

<http://www.polarfoundation.org/>

<http://www.educapoles.org/>



# The Polar Regions

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## Theoretical section

### The Arctic: a frozen ocean surrounded by land

On the northernmost region of the planet is the Arctic; an ocean surrounded by continents. The North Pole is situated close to the center of this ocean, known as the *Arctic Ocean*, most of which is covered by a permanent layer of sea ice.

The most commonly accepted frontier of the Arctic is the line within which the temperature never exceeds 10°C during the hottest month (July). In the land areas, this isotherm pretty much corresponds with the extreme northernmost tree line, i.e. the frontier between *taiga* (conifer forests) and *tundra* (vegetation consisting of lichens, mosses, small flowering plants and a few occasional dwarf trees).

The Arctic consists therefore both of the Arctic Ocean, which opens on one side to the North Atlantic and on the other to the North Pacific via the Bering Straights, and lands surrounding this ocean. These land masses are covered with tundra or with an ice cap, the largest of which is the Greenland ice cap.

The Arctic Ocean covers a surface of around 13 million km<sup>2</sup>. The total surface area of the Arctic is 21 million km<sup>2</sup> (just over twice the size of the United States).

Some 75% of the Arctic Ocean is covered by a permanent layer of sea ice, consisting of sea ice many years old. Driven by the wind, the pack drifts in a clockwise direction. The ice is generally between 3 and 3.5 m thick, but plates of ice can rise up to form local crests of 10 to 20 m.

By the end of the warmer northern summer (June to August), the sea ice is reduced to permanent pack formation begins again with the cooling of the atmosphere. Sea ice then forms on the open water until it covers the entire Arctic basin, the Hudson Bay, and the straits leading to the Northern Pacific and the Northern Atlantic. Ice formation is greatest between November and April.

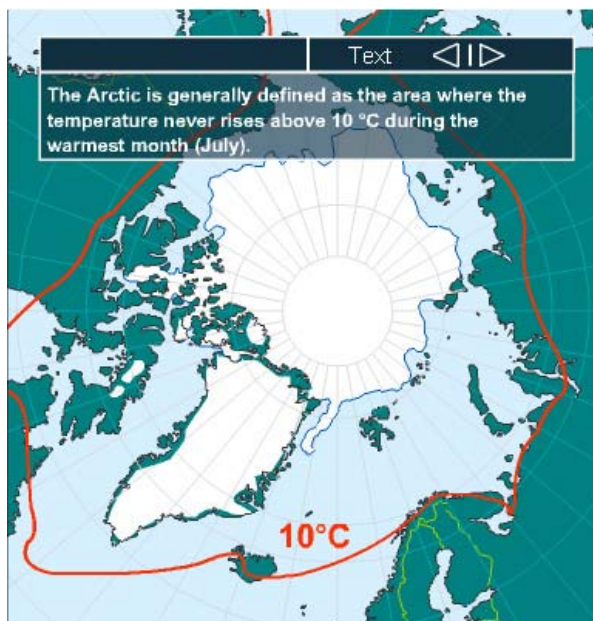


Figure 1 – Limits of the Arctic<sup>1</sup>

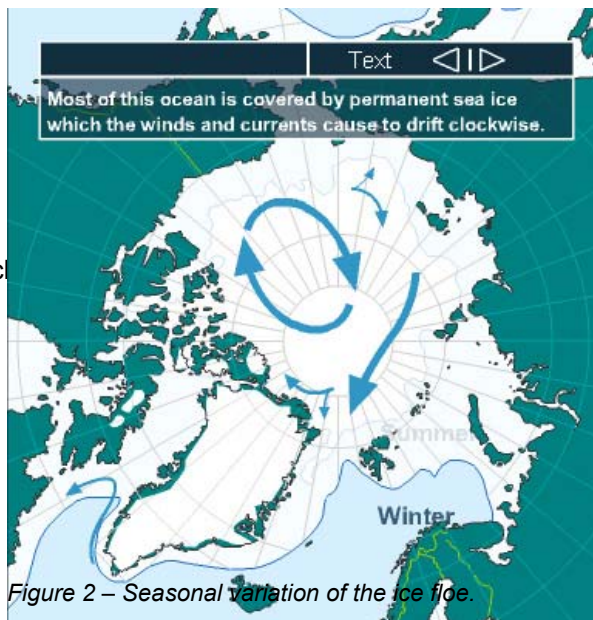


Figure 2 – Seasonal variation of the ice flow.

<sup>1</sup> All illustrations in this dossier are taken from animations that can be viewed on the Educapoles site: [www.educapoles.org](http://www.educapoles.org)



It should be noted that the Scandinavian coasts remain ice-free the whole year round. This is because the waters are warmed by the northern branch of the warm Gulf Stream current.

When the sea water freezes, part of the salt is expelled. This passes through the ice into the water that has not yet frozen, producing very cold, over-salted and therefore denser water under the ice flow. This *heavy* water plunges towards the bottom of the ocean to feed a deep current of cold water which runs across the world's oceans, surfacing in the Pacific and Indian Oceans, and then continuing into the North Atlantic. This immense conveyor belt or *thermohaline circulation* regulates the Earth's climate by permitting the exchange of heat between the poles and the tropical regions. The existence of the Arctic and Antarctic sea ice is therefore vital for the balance of the Earth's climate.

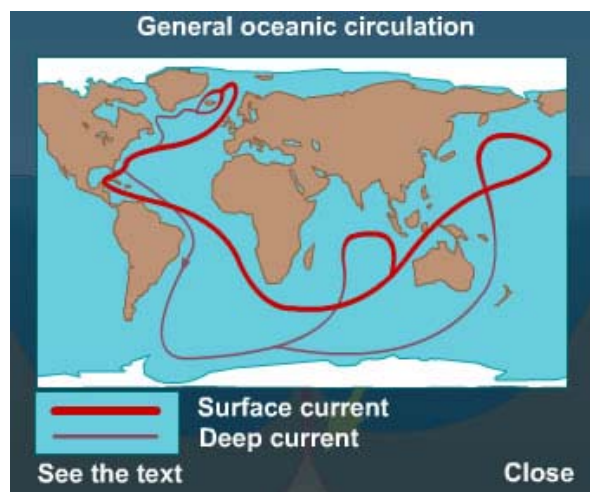


Figure 3 – Thermohaline circulation

Current global warming could interrupt the formation of deep water and arrest part of the thermohaline circulation.

### The Antarctic: a frozen land surrounded by ocean

To the south, the Antarctic is a continent, larger than Europe, consisting of a rocky base covered by an ice cap (or *inlandsis*). This iced-over continent is approximately centered on the geographic South Pole and surrounded by the vast *Southern Ocean*.

The total surface area of the Antarctic continent, extended locally by huge platforms of floating ice, is 14 million km<sup>2</sup> (about 1.5 times the size of the United States). Rare rocky mountains called *nunataks* emerge from the ice cap. Bare, dry rock and sterile soil represent just 2% of the surface area of this ice continent. The average thickness of the polar cap is 2300 m, rising to a maximum of 4800 m. The average height of the Antarctic continent is 2400 m, the highest average height for any continent.

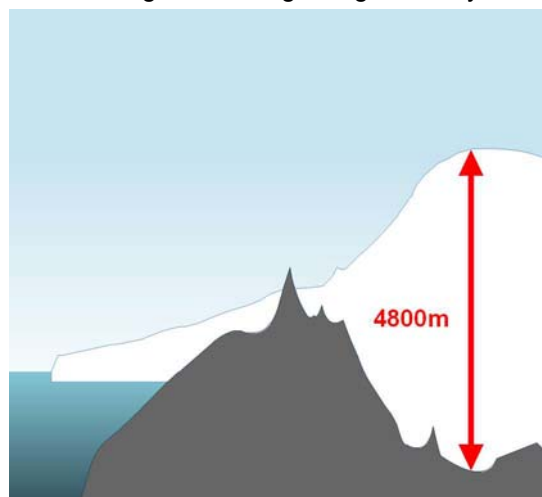


Figure 4 – Cross-section of the Antarctic ice cap

The climate in the eastern part of the Antarctic continent is extremely severe. That of the Antarctic Peninsula, the finger pointing towards South America, is more mild. In the Southern Ocean are a few uninhabited islands, the so-called *Subantarctic Islands*, which abound with animal life.





Antarctica is mainly a continent. Its coastline, in the form of rocks or ice, represents a precise edge. However the outer limit of Antarctica really is in the oceanic realm. Some say that this limit is the hydrological frontier formed by the “*Subtropical convergence*” which runs in a wavy line around latitude 40° south. Crossing it from the Pacific, Atlantic or Indian ocean, one notes a sudden fall in temperature of around 4°C. These cold waters have a total extent of 75 million km<sup>2</sup>.

A second hydrological frontier delineates the truly polar waters generally known as the Southern Ocean: this is the “*Antarctic convergence*” running between 50° and 60° south. Here the water temperature changes suddenly from 4°C to below 2°C, which corresponds roughly to a 10°C surface air temperature in February. The Southern Ocean has an area of 45 million km<sup>2</sup>.

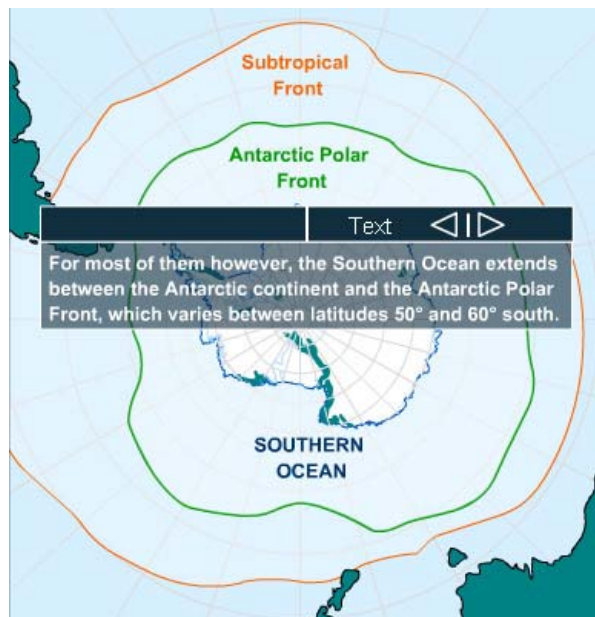


Figure 5 – Limits of Antarctica

During the winter, the temperature drops and the ocean surface freezes over; the Antarctic sea ice covers a gigantic area which can reach 20 million km<sup>2</sup>. The surface of Antarctic ice is then more than doubled, preventing any ship from reaching the coast during winter, and cutting off the continent completely for several months. In summer (December to February), the warming breaks up the sea ice, leaving only a narrow and discontinuous belt of ice around the continent. During the southern summer, the Antarctic Peninsula is almost free of sea ice. The minimum extent of the ice is in February, the maximum in September.

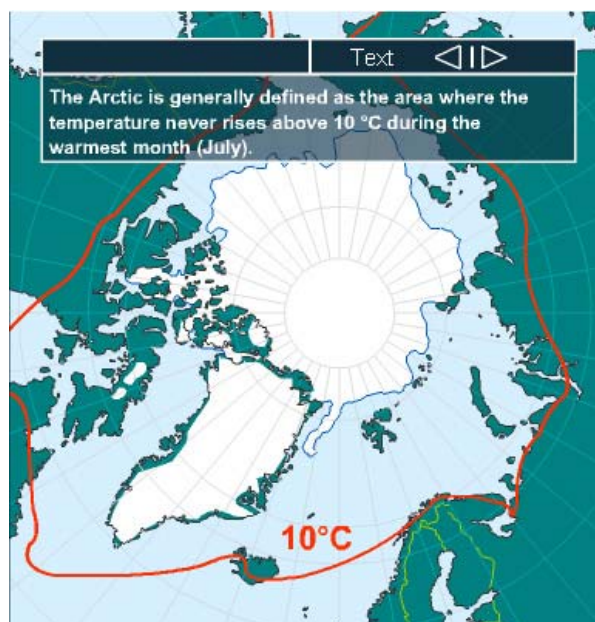


Figure 6 – Limits of the Arctic



The winds (the roaring forties and the howling fifties) which swirl around the Antarctic without encountering any obstacles engender a powerful ocean current around the continent, known as the *Circumpolar Antarctic Current*. This sea current, which is 200 to 1000 km wide (between 60° and 40° south), flows in a wavy line over 24,000 km, carrying between 130 and 180 million m<sup>3</sup> of water a second (around 1000 times the flow of the Amazon). It is the largest sea current on our planet and advances at an average speed of 2 km/h. Despite this current that can completely isolate the Antarctic, the Southern Ocean is the scene of major exchanges between the cold coastal waters and the warmer waters coming from the middle latitudes. The formation of sea ice during the winter also makes the Antarctic the other major source of sea-bottom cold water for thermohaline circulation.

## The polar climate

The main characteristics of the polar climate are both the degree of cold, and also its duration. Seasons are reduced to a long, freezing winter, part of it in continuous night, and 3 months of cool summer.

Another characteristic of the polar climate is the frequent winds, in particular the “katabatic winds” which can reach record speeds and dramatically increase the intensity of the cold. Blowing from the center of an inlandsis, very cold katabatic winds are carried by gravity down the sides of the ice cap arriving at ferocious speeds at the coasts (record measured in the Antarctic: 320 km/h). These winds, which can be continuous, upset animal and human activities, and can dislocate the sea ice in mid-winter. In the polar regions, the main precipitation takes place along the coast. On the inlandsis or on the north pole sea ice, it is very limited and essentially in the form of ice flakes which sparkle in the sun; water vapor there is almost non-existent (an annual equivalent of just 2 to 5 cm of rain falls in the Antarctic inlandsis, less than in the Sahara).

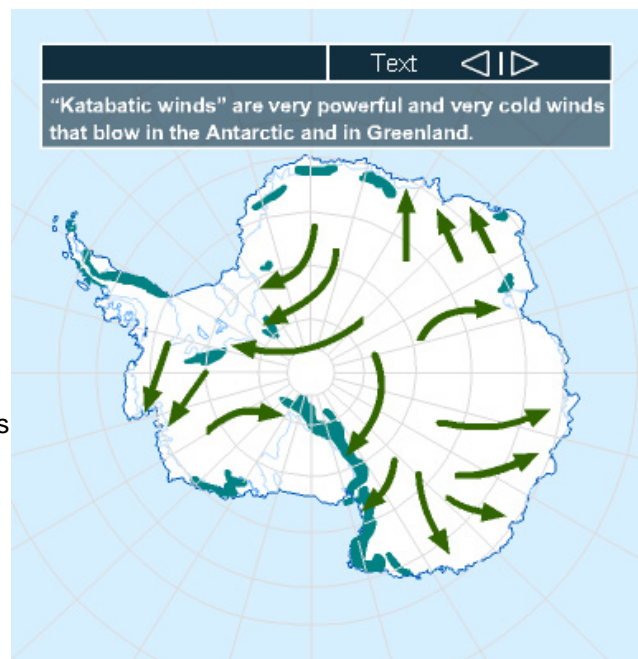


Figure 7 – The katabatic winds

The record low temperatures belong to the ice caps. Inside the Antarctic inlandsis, the average temperature is -40 to -70 °C in winter, and -15 to -35°C in summer. The lowest temperature on record is -89.2°C, measured at Russia's Vostok station on 21 July 1983!

Almost the entire Antarctic continent has an average annual temperature of -25°C. Only the coasts of the continent (from -15 to -35° C on average in winter and -5 to + 5° C in summer) and the Peninsula (- 7 to - 15° C in winter) have more mild temperatures. Unlike the Antarctic, the temperatures of certain polar regions – northern Norway, Spitzbergen, southwest Greenland, the Aleutian Islands and the sub-Antarctic islands – are made gentler by marine currents with the annual temperature being slightly above zero.

Why is it cold at the poles? Because these regions receive less solar radiation than the rest of the Earth's surface.



- Compared with the Equator, the sun's rays have to travel further through the atmosphere before touching ground. The sun's rays lose more energy by absorption and therefore heat the earth less than at the Equator.
- Once the sun's rays have crossed the atmosphere, they spread out over a wider surface area than those at the Equator. The same area of ground receives more energy at the Equator than at the poles and is heated more.
- The solar radiation reaching the ground is largely reflected by the snow covering the polar region. Snow has a high albedo or reflective power. The Polar Regions therefore reflect the majority of the light rays which already reach them with difficulty. The result is the self-maintenance of cold conditions.



Figure 8 – Spread of the sun's rays

### Flora and fauna

Polar bears live only in the Arctic and penguins only in the Southern Hemisphere, in particular in Antarctica and the Southern Ocean. They can therefore never meet.



Figure 9 – Polar bear and penguin

The polar bear is a mammal. Its favorite habitat is the sea ice that it criss-crosses throughout the year in search of seals. The female bear spends the winter in a den dug into the snow on the side of a hill. It is there that she gives birth to her cubs and begins to raise them.



Figure 10 – Polar bear





Penguins (17 different species in the world) are birds that in the course of evolution have lost the ability to fly in favor of swimming and diving. They retain one characteristic of birds which is that they come on land to lay their eggs and raise their young.

On the Antarctic coasts four species of these sea birds can be observed: emperor penguins, adelic penguins, gentoo penguins and chinstrap penguins.

In French speaking countries, penguins are often confused with razorbills. A razorbill (in French: *pingouin*) is a little migratory bird that can fly and lives close to the Arctic regions, whereas, as already stated, penguins do not fly and live only in the Southern Hemisphere. They can therefore never meet.

### Arctic

The Arctic fauna is both terrestrial and marine.

On the land parts, that is in the tundra, we can find mammals (wolves, foxes, hares, musk oxen, reindeer), numerous bird species, most of them migratory, and several hundred species of insects.

In the sea, whales, seals, walrus, sea birds, fish (including the common Arctic cod) and invertebrates make up an abundant marine fauna.

Finally there is the polar bear, at home both on land and at sea.

There is no plant life on the sea ice, but the Arctic land masses provide the habitat for several hundred species of plants (170 in Spitzbergen, over 500 in northern Norway and Greenland), not counting algae, mosses, lichens and fungus.



Figure 11 – Emperor penguin



Figure 2 – Arctic fauna



## Antarctic

Antarctic land fauna is very limited. The largest land animal is a 6 mm midge. Otherwise the fauna of the Antarctic and the Southern Ocean is marine: penguins, albatross, petrels, seals and whales. The number of species is limited (43 species of birds, the great majority of them sea birds, nest to the south of the convergence, including 7 species of penguins; on the coasts of the continent and the Peninsula we can find 4 seal and 4 penguin species), but the number of animals for one species can be in the millions.

There are also 200 species of fish, some of them particularly well adapted to the cold without hemoglobin which have the ability to produce an anti-freeze. Finally we encounter gigantic shoals of krill, the shrimps which form the basic diet of a large part of the fauna of the Antarctic ecosystem.

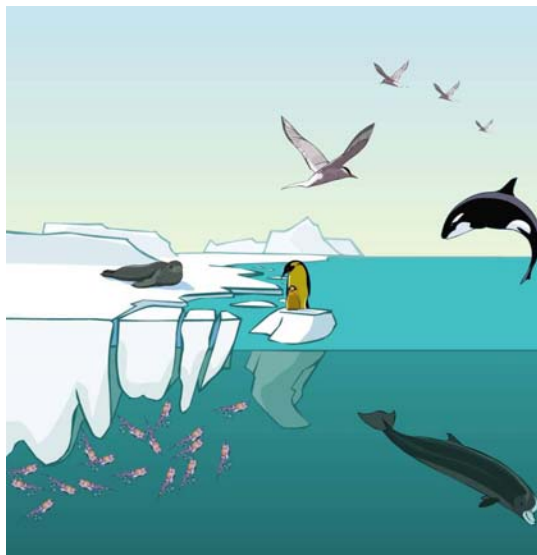


Figure 3 – Arctic fauna

When it comes to flora, there are just two species of flowering plants (in the Antarctic Peninsula where the climate is milder). The sole terrestrial vegetation is composed of lichens and mosses growing on stones and rocks. In the eastern part of the continent, where the weather is severest, 30 species of moss and 125 lichen species have been recorded. On the more temperate west coast of the Antarctic Peninsula and on the neighbouring islands, around 85 moss species and 150 lichen species have been counted. On the other hand, the marine plant life in the form of phytoplankton is much more diversified, in particular the sea algae which the krill feed on. There are even *ice algae*, which grow in the sea ice during the autumn and spring, and then release from the ice in summer in the meltwater.



## Suggested activities

### Research questions and suggested areas of study

#### ***What do polar landscapes resemble, are they unchangeable?***

Do you know what landscapes can be encountered in the Polar Regions? Do these landscapes consist solely of ice?

- Find photos of landscapes of every kind: Antarctic landscapes, Arctic landscapes, ice caps, sea ice, tundra, but also Alpine glaciers, temperate regions, coasts, hot deserts. In groups identify these different landscapes. Ask the pupils to classify them into different categories and to explain their choices. Rank these landscapes by order of heat, humidity and vegetation type.

Do you think that landscapes are unchanging, that they do not change? Have you already seen large rocks at the bottom of cliffs? Where do they come from?

- Simulate sea and air erosion on a rock, by making an experimental model with modelling clay, sand and water.

#### What action can I undertake in my region?

- Create an exhibition on the Polar Regions
- Invite a polar explorer to come and present a film or an audiovisual presentation.
- Collect money to “adopt” a whale, through an NGO which is studying or protecting cetaceans.



## 5 Resources

### Websites

- <http://www.educapoles.org> : EducaPoles, the educational site of the International Polar Foundation, proposes pedagogical activities on Polar Regions and climate warming.
- <http://www.athropolis.com/links/arctic.htm> - Arctic Information for Kids - Arctic Information for kids - from Athropolis: Why is the Arctic cold? Permafrost, precipitation, plants of the North, Inuktitut and more.
- <http://www.arctic.noaa.gov/education.html> - Arctic theme page of NOAA: This section of the NOAA website is presenting a list of themes for the Kids about the Arctic.
- <http://www.aad.gov.au/default.asp?casid=3249> - Australian Antarctic Data Centre fact files: These Fact Files provide a good departure point to explore the natural history, geography, environment, science and other human activity in one of the world's most remote region: Antarctica.
- <http://www.antarctica.ac.uk/Resources/schoolzone/index.html> - British Antarctic Survey's school zone: The British Antarctic Survey is putting a lot of Antarctic resources at the disposal of teachers and kids. Both geographic and scientific aspects of the 6th continent are covered.
- <http://classroomantarctica.aad.gov.au/> - Classroom Antarctica: Australian website full of wonderful thematically-ordered resources regarding the Antarctic (Antarctic treaty, Exploration, Antarctic ecosystem, Climate system and Antarctica, ...). The fauna descriptions are particularly impressive and well illustrated.