

The background of the entire page is a stylized map of the Arctic region, composed of various geometric shapes in shades of blue, light blue, and pink. The word "ARCTIC" is centered over this map in a large, dark blue, sans-serif font.

ARCTIC

An interactive journey to the North Pole



**Consiglio Nazionale
delle Ricerche**

The scientific exhibition “Arctic. An interactive journey to the North Pole”

designed and realized by



Communication Unit

Department of Earth System Sciences and Environmental Technologies

Research Institute on Terrestrial Ecosystems

Institute of Polar Sciences

Institute for Educational Technology

Materials taken from the interactive exhibition
Arctic. An interactive journey to the North Pole
articomostra.cnr.it

The exhibition

Climate change today represents a crucial challenge for the future of the Earth System, and the Arctic is the region of the Planet where it occurs more rapidly than elsewhere. Global warming has a tremendous impact on ice-covered surfaces, in particular on the generation and expansion of marine ice, on the retreat of glaciers and the thawing of permafrost. These phenomena have important implications on the increase of areas of vegetation and tundra, on animal life and on the whole Arctic ecosystem. This process has economic, social and geopolitical impacts that go well beyond the borders of the Arctic.

For this reason, the Arctic region can be considered a great natural laboratory to study these processes. Through hands-on and multimedia installations, interactive experiments, scientific equipment, scale reproductions, documents, objects and expressive images, the exhibition guides the public to the discovery of the Arctic, its peculiarities and the observable phenomena.

The description of the geographical characteristics, with reference to the discoveries and to the indigenous communities, is followed by an overview of the mechanism regulating the distribution of energy on the Planet and the way it affects the polar areas and by an explanation of phenomena such as aurora borealis, midnight sun and ozone depletion (commonly known as ozone 'hole').

The exhibition continues by focusing on the main research activities that Italy carries out in the Arctic, particularly in Ny Ålesund, in the Svalbard Islands, where Cnr manages the "Dirigibile Italia" research station. The exhibition ends with a description of the international organizations which manage the scientific and political planning in the Arctic. The exhibition, which involves various Cnr Institutes, represents a great opportunity to understand the activities of Italian researchers working in the Arctic.

The exhibition consists of four areas: 'The Arctic in the global system', 'Research: Observe and Understand the Arctic system', 'Vulnerability and resilience', 'Governance in the Arctic'. Each area is integrated by explanatory panels with written texts, images, graphics, videos and interactive exhibits.



In brief

Interactive exhibition on the Arctic and related Cnr research activities
Scientific areas: physics of the Earth, marine biology, ecology
Layout: 23 luminous displays, exhibits, prototypes and installations



Technical requirements

Areas from 300 to 600 m², standard electrical connections, water nearby
Set up time: 3 days. Dismantling time: 2 days
The exhibition involves scientific explainers



Target

The exhibition is aimed at an audience of all ages and recommended for schools of all levels



We were in...

National preview: Genova, Palazzo Ducale Loggia degli Abati, Festival della Scienza 2016
Foligno, Palazzo Brunetti Candiotti, Festa di Scienza e Filosofia 2017
Naples, Futuro Remoto and Città della Scienza 2017
Milan, University of Milano - Bicocca 2018
Venice Mestre, Ca' Foscari University 2018
Rome, Salone dello Studente 2018
Settimo Torinese, Ecomuseo del Freidano 2019

artico.itd.cnr.it

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The first staging of the exhibition,
Palazzo Ducale, Genoa 27th October – 6th November 2016

The Arctic in the global system

Climate change and global warming currently represent a crucial challenge for the future of our planet. In this framework, the Arctic plays a major role due to its geographical characteristics and its almost uncontaminated environment and is considered, by the international scientific community, as a perfect natural laboratory for research and study on climate change.

Here, ecosystem, ice expansion, flora and fauna and local populations are severely affected by human activities, with important economic, social and geopolitical consequences that go far beyond the Arctic borders.

Thus scientific research in the Arctic has become crucial for the prevention and study of the impact of climate change on the environment and on local populations.

The role of Arctic regions is becoming more and more important because of the increasing availability of significant mining resources (gas and oil) and of new commercial maritime routes, inevitably correlated to the contraction of the polar cap.

The international scientific community is currently asked to identify sustainable solutions that take into account the complexity of processes, interactions, dynamics and repercussions of human economic and political choices on the global system.

It is necessary to increase and integrate observation and monitoring activities in order to better understand the Arctic system, the quality of forecasts of meteorological and climatic models, and the role of Arctic regions in the global Earth system.



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Geography of the Arctic

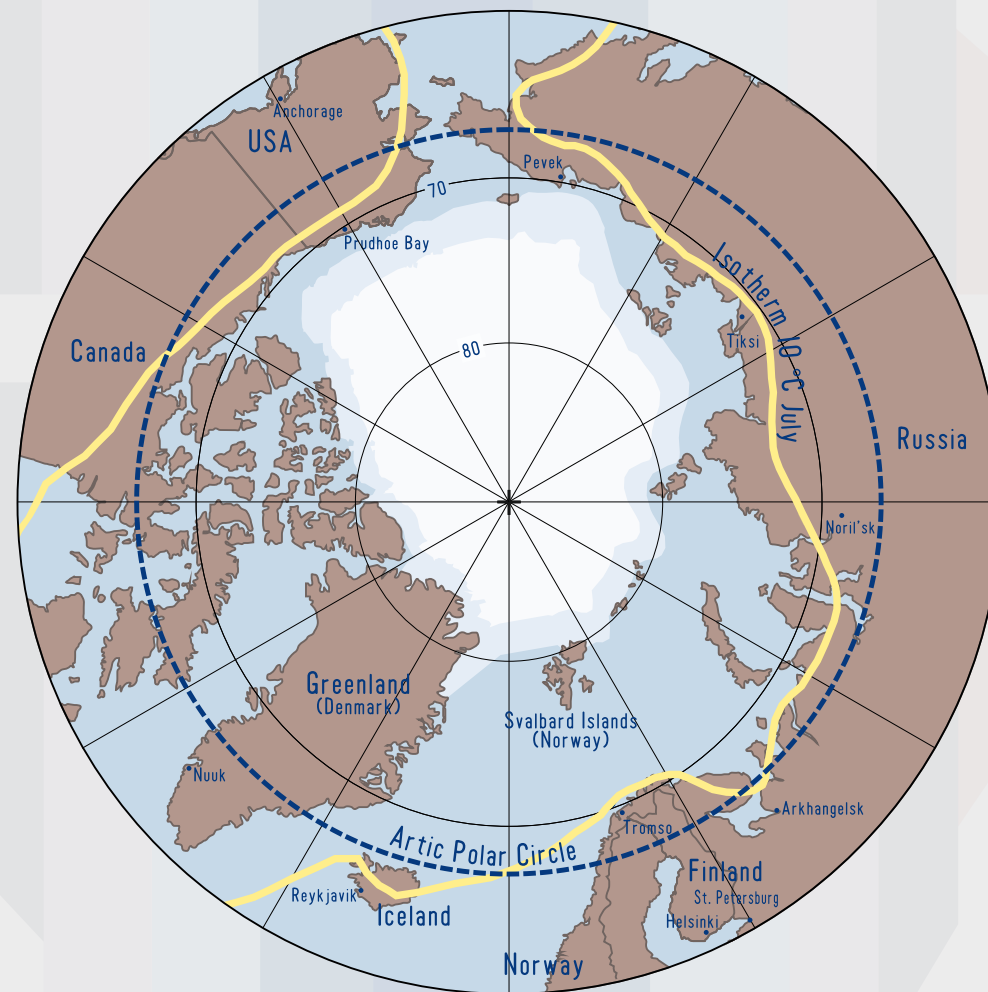
The Arctic is the region of the Earth that surrounds the North Pole. Since it has an imprecise extension, it is conventionally defined as the northern area of the Arctic Circle, above the latitude of $66^{\circ}33'39''$ North. Alternatively, it is defined as the region where the average temperature in July does not exceed 10°C .

This region is not really a continent, like Antarctica, as it is made up of the Arctic Ocean and the northernmost parts of the Asian and American continents. The States that are part of the Arctic region are: Canada, Denmark (with Greenland and Faroe Islands), Finland, Iceland, Norway, Sweden, Russia and the United States.

The icy surface of the Arctic Ocean, known as the Arctic shell, is a floating area that is extremely important for the climate system of the planet. Its extent and position vary depending on the seasons and on sea currents and are therefore affected by recent global climate change.

The Arctic climate is characterized by long cold Winters and short fresh Summers. Temperature in Winter can drop below -58°C , while in Summer it ranges from -10 to 10°C . During this time a large area of the Arctic Ocean becomes navigable.

Due to the inclination of the Earth's rotation axis, during Summer (i.e. from April to September), in this region, the sun remains above the horizon line at varying degrees depending on the proximity to the geographic pole; this phenomenon is called "Midnight Sun". In the remaining months darkness prevails, becoming total darkness in Winter, the so-called "Polar Night". Areas of research are mainly the Svalbard Islands - where the Italian laboratory "Dirigibile Italia" is located - and Siberia, Alaska, Greenland and the Canadian Arctic Archipelago.





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The populations of the Arctic

The native populations of the Arctic regions have always lived on hunting, fishing, harvesting or breeding, using materials and resources available in their territories. However, colonization has led the majority of these communities to abandon, completely or in part, their original lifestyle. Although today some populations are trying to recover customs and traditions, the culture of reindeer breeders, of marine mammal hunters and of men living in harmony with the environment is likely to disappear.

INUIT

Population: about 120,000
Language: Inuit, English, French, Danish and others

The Inuit, also known as Eskimo, are the native inhabitants of the Arctic coast regions of north America and of the north-eastern part of Siberia. They are traditionally devoted to hunting, especially of marine mammals, and fishing. Typical Inuit buildings in Canada and Greenland were the igloos, hemispheric huts made of snow blocks.



SAMI

Population: about 75,000
Language: Sami, Russian, Swedish, Finnish, Norwegian

The Sami people, also known as Lapps, are traditionally nomad reindeer breeders. They still maintain a strong cultural identity today, but they also take advantage of the services that the various Governments offer them.



YUPIK

Population: about 24,000
Language: Yupik, English, Russian

The Yupik are an indigenous population living mainly along the west coast of Alaska and are often included with the Inuit in the group of the so-called Eskimo. Their lifestyle and economy are traditionally based on hunting and fishing.



NENETS

Population: about 40,000
Language: Nenets, Russian

The Nenets are a native Russian population and are divided into several local groups, geographically distant from each other. The largest group is the Tundra Nenets which occupies the northernmost areas and whose main activity consists in breeding large herds of reindeers.



ALEUTS

Population: about 18,000
Language: Aleutian, English, Russian

The Aleuts are the indigenous population of the Aleutian Islands. Despite external influences, they have maintained a traditional lifestyle fishing and hunting marine mammals until the early 20th century. Today, the Aleuts essentially live on commercial fishing and seals hunting.



TUNGUSIC PEOPLES

Population: about 90,000
Language: Tungusic language, Russian, Chinese

Tungusic peoples include a number of peoples or ethnic groups originally speaking Tungusic languages, spread on a very large territory including Siberia, Mongolia and northern China. They are traditionally hunters and reindeer breeders. Some southern groups breed horses and sled dogs.



YAKUTS

Population: approximately 450,000
Language: Sakha, Russian

The Jakuts, also known as Sakha, are a Turkic speaking ethnic group from Sakha Republic, in northern Siberia. They are divided into two groups on the basis of geography and economy. Northern Jakuts are traditionally semi-nomad hunters and reindeer breeders, while the Southern Jakuts live on cattle breeding, especially horses and cattle.



KOMI

Population: approximately 290,000
Language: Komi, Russian

The Komi, also known as Zyrians, are an ethnic group predominantly located in the Komi Republic, in Russia. Traditionally distributed along the banks of the rivers, they lived in communities of large families of 30-40 people and their economy was based on hunting and fishing. Since the 18th century, agriculture and breeding have also been introduced.



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Arctic explorations

1596

The Dutch explorer Willem Barents observes and describes the west coast of Svalbard Islands for the first time

1607

The English explorer Henry Hudson, on board of the "Hopewell" ship, reaches the latitude of 80° 23' North

1773

Constantine John Phipps, aboard the "Rachorse" vessel, reaches the latitude of 80° 48' North

1827

William Edward Parry, during an expedition on sleds, arrives at a latitude of 80° 45' North

1893

Fridtjof Nansen, Nobel Peace Prize in 1922, organizes an expedition on sleds reaching 86° 14' North

1899

Luigi Amedeo of Savoy Duke of the Abruzzi, aboard the "Stella Polare" ship, arrives at the latitude of 86° 34' North, never reached before by any expedition

1909

American Robert Peary claims to have reached the North Pole in an expedition on sleds, but recent studies show that he only approached it, arriving at a few tens of miles from the goal

1926

Umberto Nobile, Roald Amundsen and Lincoln Ellsworth fly over the North Pole on board of the "Norge" airship, for the first time in history

1928

Nobile, on board of the "Italia" airship, overflies the North Pole for the second time. During the return journey however, the airship falls on the polar pack ice

1948

Soviet Aleksandr Kuznecov lands with a plane nearby the North Pole and reaches it on foot

1959

The American Submarine "Skate" emerges at the North Pole

1968

Ralph Plaisted conquers the North Pole on snowmobile and is the first surface traveller to whom the certainty of the result has been acknowledged

Arctic explorations

Umberto Nobile and the conquest of the North Pole by airship

In the years 1926 and 1928 two extraordinary Italian ventures were accomplished by means of two airships, “Norge” and “Italia”, designed and commanded by Engineer Umberto Nobile, general of the Royal Air Force.

The 1926 expedition, funded by the Italian government and the American tycoon Lincoln Ellsworth, was organized by the Norwegian explorer Roald Amundsen, already protagonist of major ventures including the conquest of the South Pole in 1911. On April 10th, the “Norge” airship took off from Ciampino Airport in Rome heading to Kings Bay, on the Svalbard Islands. After several breaks for supplies and crew changes, it reached the North Pole on May 12th.

In 1928, Umberto Nobile tried to repeat the enterprise with the “Italia” airship, organizing a scientific mission with scientists and crew largely composed of Italians. The aircraft departed from Baggio airfield in Milan on April 15th and reached Kings Bay on May 6th. The Arctic exploration was carried out in three flights, during which data and information were collected and their contribution to scientific research is still relevant, especially in the field of meteorology and geography. During the last flight, due to adverse weather conditions, the “Italia” airship fell in the polar pack ice. Part of the crew was dragged away with the airship casing, which was no longer found. Nobile and the survivors sheltered under the field tent coloured with red aniline in order to make it visible, in fact it became famous as the “Red Tent”. The Ondina 33 field radio, supplied directly by Marconi to Nobile, was repaired and the S.O.S. signals were randomly intercepted by an amateur radio in Russia. This allowed recovery through a rescue operation involving 6 nations, 22 aircrafts, 18 ships and over 1,500 men. In this circumstance Roald Amundsen, who also took part to the rescue operation, lost his life.

Researches ended on July 12th, 1928 with the recovery of the last survivors by the Russian ice breaker ship “Krassin”.



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ITALIA

ARCTIC

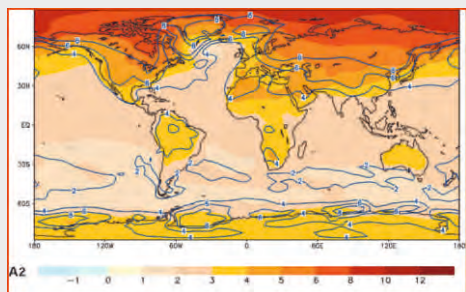
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The model of the airship "Italia"

The Arctic and the Earth's climate system

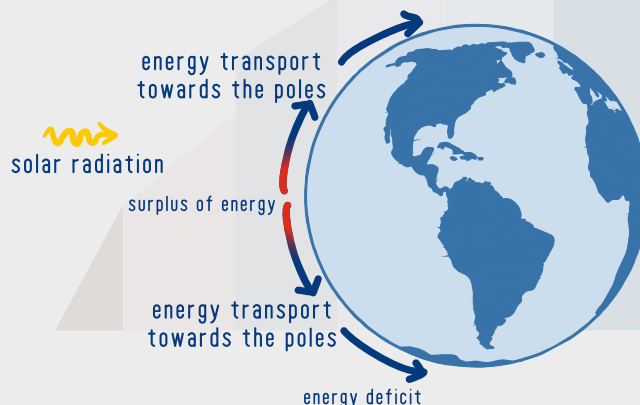
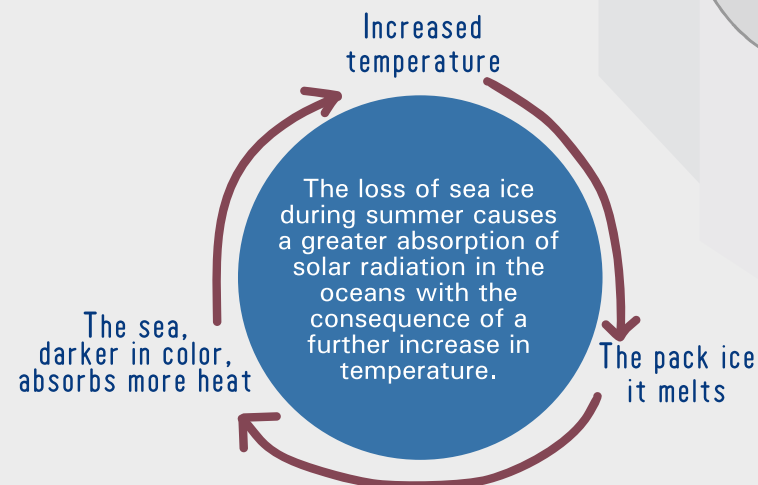
The Earth's climate system is a complex structure whose elements - atmosphere, hydrosphere, cryosphere, lithosphere and biosphere - exchange energy and matter.

The energy that drives the climate system comes from the Sun which heats the equatorial regions more than the polar ones. The atmospheric circulation, along with ocean currents, is responsible for transporting heat surplus from the tropics to the poles.

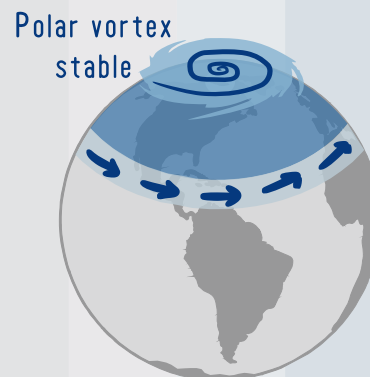


Previsione della variazione di temperatura della superficie terrestre relativa al periodo 2071-2100 rispetto alla media calcolata nel periodo di riferimento 1969-90

In autumn, the heat stored in the oceans is released into the atmosphere. This **extra heat** helps to modify the atmospheric circulation and increase the probability of extreme events, such as floods, droughts, hurricanes, etc.

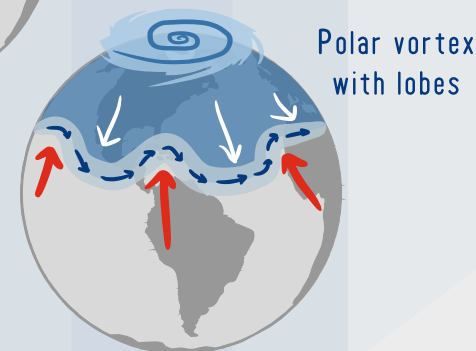


Polar environmental conditions are particularly sensitive to climate changes which are amplified, faster and more evident than in other areas of the Earth. In the Arctic, the rise of temperature over the past hundred years has been nearly double the global average of the planet.



The polar atmosphere is confined to a swirling motion called **polar vortex**. Due to the global warming, the rotation speed of the vortex decreases in winter causing the formation of cold air lobes that detach and moving towards the middle latitudes can spread to the United States, Siberia and Europe, including Italy. This phenomenon can lead to paradoxical situations, such as the one that occurred in February 2018, where temperatures in Europe rapidly dropped by tens of degrees, while in the Arctic circle temperatures were even above zero.

It is now clear that what happens in the Arctic does not remain confined to the Arctic and the processes that take place in that region have strong implications on the entire planet.



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Il livello del mare è un indice molto sensibile per l'ambiente climatico. Il riscaldamento globale ha infatti, come conseguenza, l'aumento della temperatura superficiale degli oceani. L'acqua si riscalda e si espande, provocando un innalzamento del livello del mare. L'aumento del livello del mare è uno dei rischi più gravi per le zone costiere. L'innalzamento del livello del mare può causare l'erosione delle spiagge, l'inondazione delle zone basse e l'aumento della salinità delle acque sotterranee. L'innalzamento del livello del mare può anche causare l'aumento della frequenza e dell'intensità delle ondate di mare.

Il cambiamento climatico, in una delle regioni artiche in cui si è avuto un effetto considerevole sul livello del ghiaccio della Groenlandia, lo scioglimento dei ghiacci non si ferma e si accelera: in particolare, nel 2012, i permafrost in Siberia e il scioglimento del fudo di ghiaccio sono stati allarmanti. La riduzione estiva della barriera marginale. Questo perché i ghiacci che si sciogliono e si sgombrano e quindi impediscono con il livello del mare. La osservazioni da terra, aereo, e satellitare mostrano che le calotte di ghiaccio della Groenlandia sono in continua e stabile diminuzione, quando il clima era più freddo di quanto non sia oggi, le perdite di ghiaccio si andranno ancora.

Un terzo di questa perdita è causato da un aumento della viscosità della superficie. Si stima che fra i ghiacciai che scendono come fiumi, trasportano i ghiacciai, si versano, la perdita di questi. Tuttavia poco tempo fa si pensava che causa principale del aumento del flusso fosse la riduzione degli apporti naturali per gli ghiacciai australi. Sui ghiacciai è stato osservato che il fenomeno di variazione di pressione che si verifica in prossimità dei ghiacciai, può aumentare della temperatura e si assomiglia a quello che si verifica nei ghiacciai che si fondono e si fondono la corrente termica, come avviene in un lago di una sottigliezza. Con questo, il ghiaccio della superficie può aumentare del 50 per cento.



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The exhibit "The seasons and the ecliptic"

Global warming, glaciers and sea levels

The sea level is a very sensitive indicator of **climate change**. Consequences of global warming are in fact the melting of glaciers, the loss of mass of the continental ice sheet and the thermal expansion of the oceans, i.e. the phenomenon whereby the volume of a liquid increases with increasing temperature. Each of these factors has contributed significantly to the **rise in the level of the oceans**. On the other hand, the melting of the ice pack has no effect on the sea level. Floating ice is made up of frozen sea water, therefore its melting does not produce changes in volume.

Climate change in the Arctic region has already had a considerable effect on sea level, through the **contraction of Greenland cap**, the ice melting in Alaska and the Svalbard, the warming of the Arctic Ocean and the permafrost melting in Siberia.

Terrestrial, aerial, and satellite observations show that Greenland **ice cap is losing mass**. One third of this loss is caused by an increase in surface melting. The other two thirds are due to the acceleration of the movement of glaciers that flow like rivers towards the sea, conveying huge ice masses into the ocean.

2001



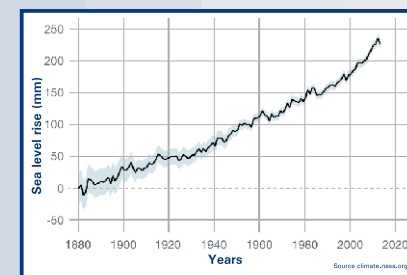
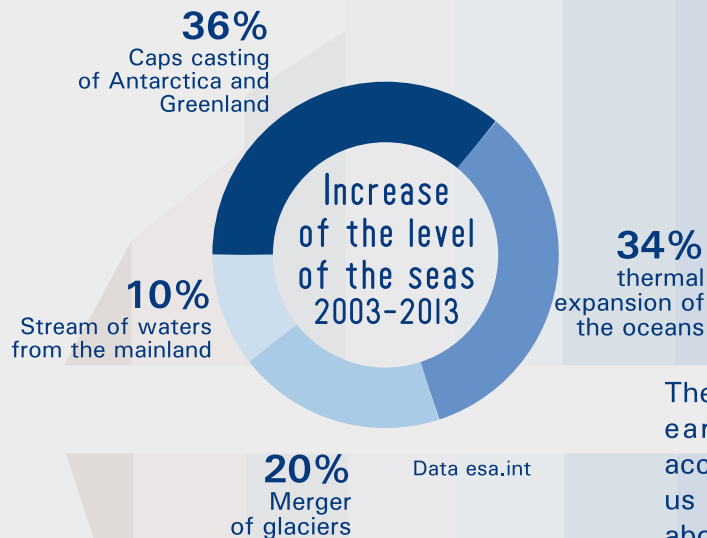
2010



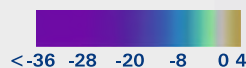
2015



Retreat of glaciers
in the Ny Ålesund fjord



The average sea level has **risen** since the early 1900s and its growth rate is accelerating. Satellite measurements show us that the **average sea level** has risen by about 95 mm from 1993 to the end of 2019. The sea level growth rate is currently 3.3 mm per year.

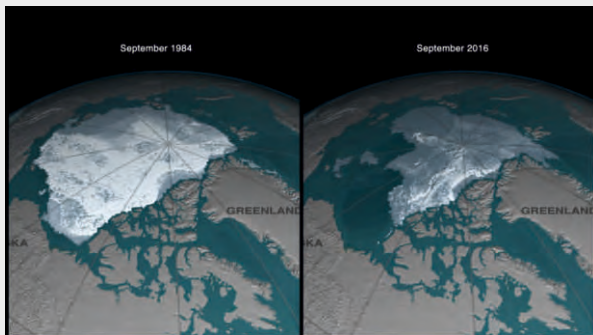


Ice cap thickness variation in meters

In the Arctic region, **Greenland** is the ice-covered territory most at risk. Its ice sheet has a mass of 3 quintillion kilograms. Since the 1970s, when the climate was colder, ice loss has increased by about 200 billion tons per year with peaks of up to 12.5 billion tons per day, as it happened on August 1st, 2019. Greenland entire ice sheet melting could cause **global sea levels** to rise by 7.4 meters.

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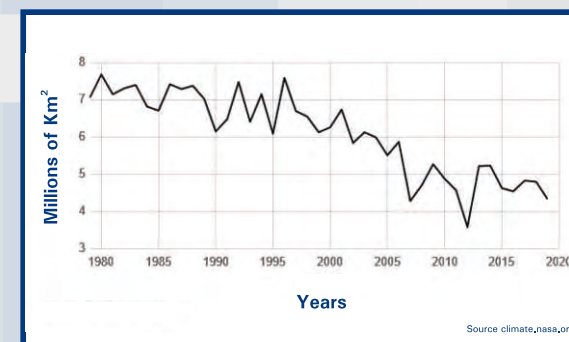
Sea ice: observations and forecasting models



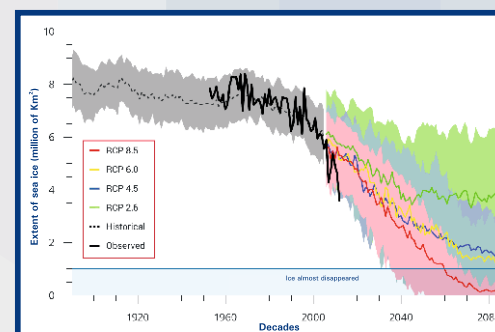
The arctic ice pack is the sea ice cover of the Arctic Ocean and adjacent seas. The extent of the ice pack has a seasonal variability throughout the year: it is greater during the cold season and lower in summer. In recent decades, as an effect of global warming, a marked **reduction** in the extent and thickness of sea ice in the Arctic Ocean has been observed in all seasons with particular evidence in September.

The effects of climate change in the Arctic are happening with unexpected speed and the **forecast models** are still not able to correctly estimate the trend of summer reduction of the ice pack pointed out by the observations. Several projects, including the Coupled Model Intercomparison Project (CMIP5) and the Coordinated Regional Climate Downscaling Experiment (CORDEX) program, are involved in designing projections of future Arctic climate scenarios. Unfortunately, due to the complexity of the Arctic system and despite the developments in climate modelling over the last 40-50 years, it is not possible to move from possible projections to actual forecasts.

The graph shows the **decreasing trend of the sea ice** extent in the Arctic between 1900 and 2100 obtained using the most recent climate projection models (CMIP5) and assuming four different scenarios of greenhouse gas emissions (RCP). The coloured lines represent the average values of the extent of sea ice in millions of km^2 . The dashed black line indicates the average result of simulations based on historical reconstructions up to 2005. The solid black line shows the actual data observed over the period 1953-2012. The coloured bands around the average values represent the uncertainty of the projection that grows the further we move forward in time. However, all projections, even with different margins of uncertainty, indicate an Arctic almost completely out of summer ice before the end of the century.



The graph shows the change in the average extent of Arctic sea ice in September, derived from satellite observations.



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Observe and understand the Arctic system

The Arctic is a particularly fragile region where environmental changes take place at a faster rate than in other parts of the planet. We speak of “Arctic acceleration” to describe the ongoing changes that are leading to the melting and the rapid decline of Arctic ice, with important consequences on the global climate, ecosystems and biodiversity.

Global climate models show that polar regions play a crucial role in the climate system: what is happening in the Arctic region has a major influence on the rest of the Earth system. On the other hand, in the Arctic, changes are such to cause more and more problems to infrastructures, with significant social and economic impacts.

The effects of such changes on a global scale require greater awareness of politicians and public opinion. It is necessary to improve knowledge of the Arctic system as a whole, in order to find reliable and sustainable solutions.

There is an urgent need to increase observations in the Arctic, through monitoring activities aimed at improving the quality of climate models forecasts and better understanding the Arctic system and its role within the Earth system. The extent of environmental and socio-economic changes observed in the Arctic requires a significant commitment, especially to anticipate changes and develop actions of adaptation rather than looking for late replies.

Observations in polar regions are heavily dependent on the availability of adequate observation infrastructures such as research stations, icebreaker ships, mobile platforms (ships, planes, satellites), both for long-term observations and for short-term campaigns. A complex modelling is also necessary, able to realistically represent the large number of existing processes and interactions to provide timely information to people living in the Arctic and to policy makers.

In this framework, it is necessary to strengthen and improve international collaborations in order to gather the various observation potentials, data assets and analytical methods to enhance our ability to anticipate local, regional and global processes.





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Italian research in the Arctic

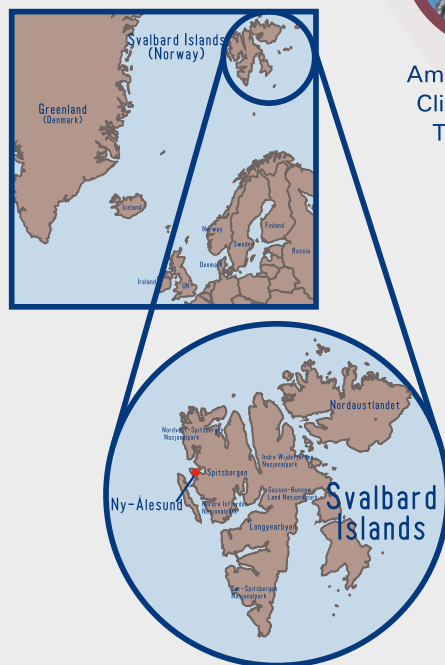
After Umberto Nobile expedition in 1928, Italy affirmed its presence in the Arctic in the second half of the 1990s with the construction of a **scientific research station** in the village of Ny Ålesund, located in the Svalbard Islands. The station, financed and managed by the National Research Council of Italy (Cnr) and inaugurated in **1997**, was given the name of “**Dirigibile Italia**” in memory of Umberto Nobile’s mission.

Ny-Ålesund, which had been a mining village until 1963, was later transformed into an **International Research Base** and CNR became a full member of the Ny-Ålesund International Scientific Community (NISC). Overall, **12 countries** are present in Ny Alesund and each nation has appointed a representative in Ny-Ålesund Science Managers Committee (NySMAC): an international coordinating body for the development of **Ny-Ålesund** as an outstanding site for research in the Arctic, long-term monitoring and promotion of cooperation between different research groups.

Ny-Ålesund is now considered an important scientific **supersite** where it is possible to study the complexity of the climate system and the interactions between its components on an ongoing basis. The site offers the unique opportunity to carry out continuous observations and measurements on the surface, in the soil, on glaciers, in the atmosphere and in the sea with **different techniques** and methodologies that integrate and complement each other in an **international cooperation** framework.



The station Dirigibile Italia managed by the National Research Council of Italy, is a structure of about **330 square meters**, which includes laboratories and offices and can accommodate up to **7 people**.



The research that takes place at the Italian station in the Svalbard Islands include different disciplines

- Chemistry and physics of the atmosphere
- Oceanography and Marine Biology
- Earth-Sun interaction
- Geology and geophysics
- Terrestrial ecosystems and Limnology
- Technological research
- Glaciology and Permafrost
- Human biology and medicine
- Paleoclima
- Environmental studies

Some of these researches are carried out in collaboration with other nations with the aim of integrating and increasing observational skills and knowledge heritage.



Amundsen Nobile Climate Change Tower (CCT)



The Gruvebadet atmospheric laboratory dedicated in the study of aerosol (GAL)



Mooring Dirigibile Italia installed in the Kongsfjorden (MDI)

In 2009, were created three important observation platforms

The CCT and GAL platforms have been created in order to obtain a complete description of the energy balance and a better understanding of the exchange processes between the atmosphere and the surface.

The MDI mooring was installed to measure the composition of the particulate matter and the physicochemical properties of the water column in the fjord overlooked by Ny Ålesund.

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The semi-submersible robot SHARK

The semi-submersible vehicle "Shark" was used in the Summer of 2015 during a scientific campaign conducted at the Kongsfjord fjord in the Svalbard Islands archipelago. The Campaign activities were carried out within the project UVASS (Unmanned Vehicles for Autonomous Sensing and Sampling) of the Svalbard Science Forum.

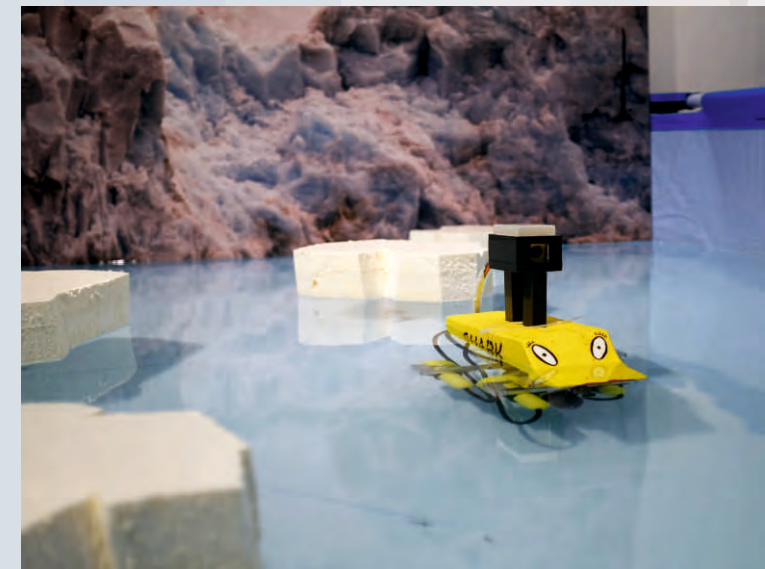
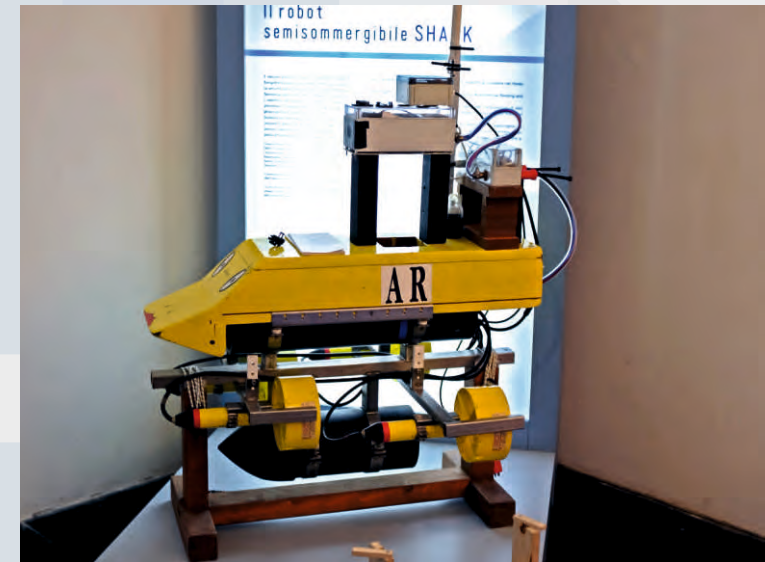
The aim of the project is to employ submarine, surface, ground and airborne robotic vehicles for the acquisition of atmospheric, marine and glacial data in hazardous, hardly accessible or inaccessible areas (for example, near the glaciers' fronts overlooking the sea).

During the scientific campaign, Shark succeeded in making its way into a maze of small and medium sized icebergs to reach and touch the Kronebreen glacier. Along the way, Shark collected 8 bottles of sea water using a sampler mounted on a small towboat and recorded data by means of a CTD (Conductivity, Temperature and Depth) sensor before returning safe and sound to the main boat. The collected data have been used to carry out scientific research in the climatic and microbiological fields.

The vehicle "Shark" was designed, built and operated in Kongsfjorden by CNR-ISSIA (National Research Council - Institute for Intelligent Automation Systems) - U.O.S. Genoa - Research Group "Field and Interaction Robotics" Responsible: Gabriele Bruzzone, members: Marco Bibuli, Giorgio Bruzzone, Luca Caviglione, Davide Chiarella, Roberta Ferretti, Mauro Giacomelli, Angelo Odetti, Andrea Ranieri, Edoardo Spirandelli and Enrica Zereik.

Sampling and analysis of microbiological data were carried out in collaboration with CNR-IAMC (Maurizio Azzaro, Gabriella Caruso and Giuseppe Zappalà).

The activities of the UVASS project were supported by the ARCA project (ARctic present Climate change and pAst extreme events), funded by the Ministry of Education, University and Research.



Materials taken from the interactive exhibition
Arctic. An interactive journey to the North Pole
articomostra.cnr.it

Layers of the atmosphere

Troposphere
0-20 km

Stratosphere
20-50 km

Mesosphere
50-80 km

Thermosphere
80-500 km

Exosphere
500-2000 km

The Earth's atmosphere is the shell of gas that surrounds the planet Earth and allows life as we know it. It consists of layers that are characterized by their composition and the vertical thermal gradient, i.e. the temperature trend with increasing altitude.

The troposphere

It is the lowest layer of the Earth's atmosphere, the one in which we are immersed, where the various gases have the highest concentration. Its thickness varies from about 10 km at the poles to 20 km near the equator. The troposphere is heated by the warmth coming from the surface of the Earth and its temperature decreases as altitude increases along a vertical gradient of 0.6°C per 100 m. In the troposphere there are atmospheric phenomena such as wind, cloud formation, rainfall.

The stratosphere

In this layer, which extends up to 50 km in height, water vapour is almost absent and gases are much more rarefied than in the troposphere. Temperature increases as height increases, due to the presence at around 40 km of a layer of ozone. Ozone has the property of absorbing ultraviolet radiation, producing heat and shielding radiations which might be harmful for life on Earth.

In the stratosphere there are also pearly clouds formed by ice crystals and powders.

The mesosphere

In this layer, which reaches up to 80 km of altitude, temperature again decreases as height increases.

A fundamental characteristic of mesosphere is the extreme rarefaction of the elements.

In this layer "falling stars" originate, they are small meteoric fragments that burn before reaching the Earth, leaving luminous trails.

The thermosphere

The temperature in this layer, which extends beyond 500 km, increases as height increases. In the thermosphere there is an area called ionosphere, characterized by the presence of charged particles, which are formed when the gaseous elements are split by cosmic rays coming from the other stars and the Sun. In this layer the phenomenon of polar aurora occurs.

In the highest part of the thermosphere, several artificial satellites and the international space base are in orbit.

The exosphere

It represents the outer layer of the atmosphere and does not have a true upper limit as it gradually vanishes towards the interplanetary space.

The few gaseous elements are light molecules such as hydrogen and helium present in the exosphere at extremely low percentages.



The exhibit "Polar auroras"



ARCTIC

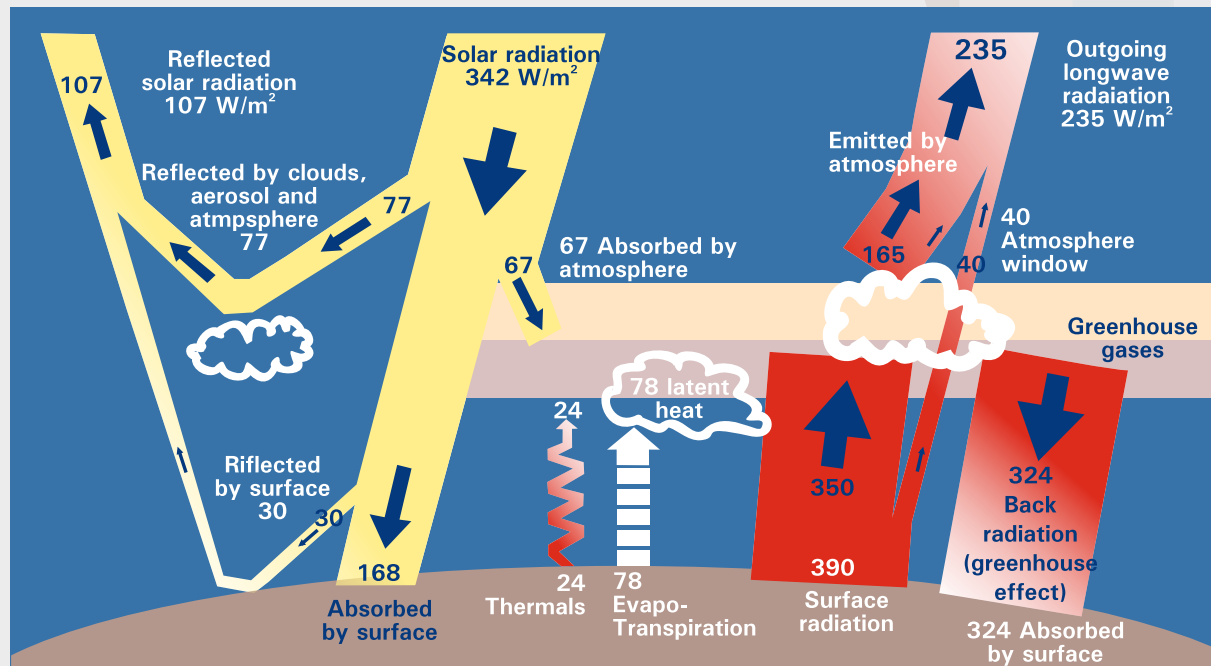
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The troposphere, the boundary layer and the Climate Change Tower

The troposphere is divided into two main layers: **the atmospheric boundary layer** and the free atmosphere. The atmospheric boundary layer is the part of the troposphere directly affected by the earth's surface and whose heights vary from 1 to 3 kilometers. Temperature usually decreases with the altitude. The largest part of life on the planet and the main human activities take place in the boundary layer. In this layer, through mainly vertical and turbulent motions, exchanges of heat, humidity and energy take place between the surface and the free atmosphere. Here the fog is generated, pollutants spread and disperse, winds and clouds are formed.

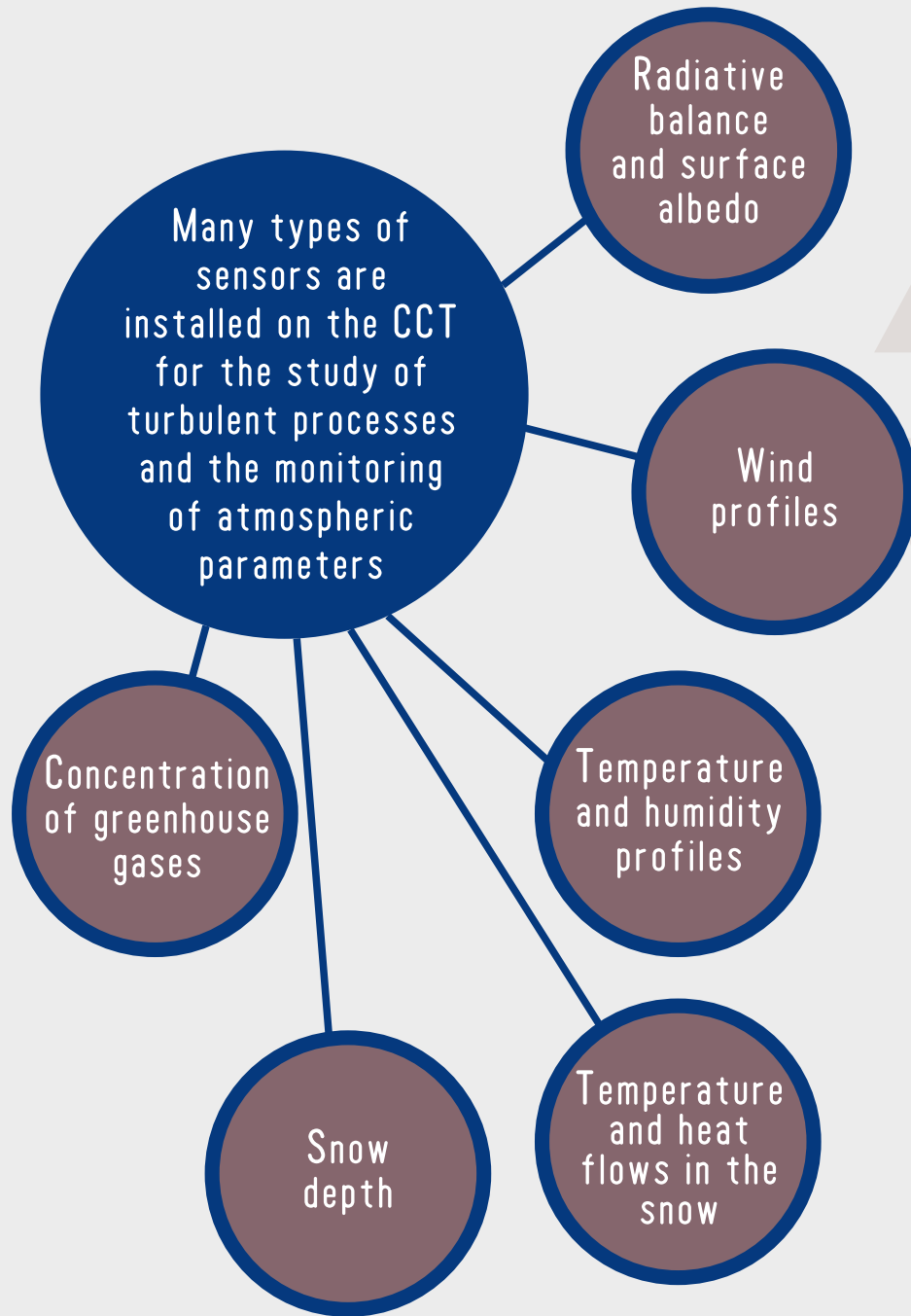
The **free atmosphere** is the part of the atmosphere in which the effect of interaction with the earth's surface decreases, the wind grows with altitude and the temperature constantly decreases by about 6°C every 1000 meters.

Average/global energy balance



The **main agent** of all processes occurring in the troposphere is the solar radiation that reaches the Earth's surface and determines the conditions for their development. Of the approximately 342 Watt /m² that enter, around 235 Watt /m² interact with the atmosphere and the earth's surface and are emitted to space in the form of **thermal radiation**. If this radiation is trapped by the excess of atmospheric gases that absorb thermal radiation (carbon dioxide, methane, water vapor), the so-called greenhouse effect causes the increase in **global warming** of the planet.

The troposphere, the boundary layer and the Climate Change Tower



The atmospheric boundary layer in the Arctic is characterized by **highly stable conditions** that prevent vertical motions carrying the energy from the earth's surface to the free atmosphere. The study of variability of atmospheric parameters therefore requires continuous and accurate measurements. To this aim, CNR installed in Ny Ålesund, about 1 kilometer from the Dirigibile Italia station, an instrumented tower 34 meters tall, called "**Amundsen - Nobile Climate Change Tower**" (CCT). The CCT is a fundamental element to study, in an integrated way, the different components of the **climate system** and their interactions, the exchange processes between the surface and the first meters of the boundary layer and to be able to estimate the variability over long time intervals.





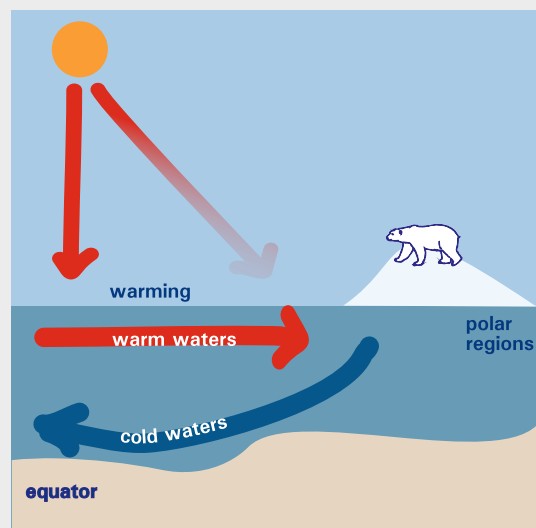
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Waterfalls at the bottom of the ocean

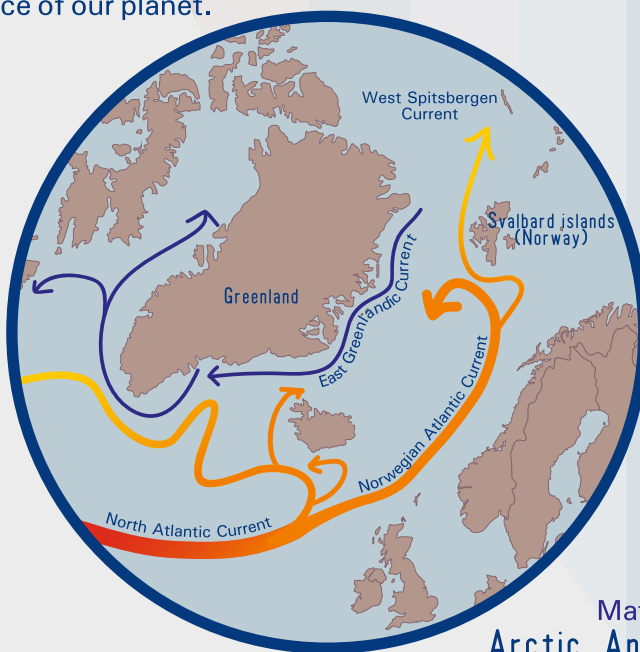
The sea is not made of static water, indeed it is **constantly moving** due to the presence of currents, generated by winds, by the earth's rotation and, above all, by the differences in temperature and salinity of the water.

These last two factors affect the density of the water and it is the different **density** of the oceanic layers that causes their movement. Hot water has a lower density and rises while cold water sinks. Water density also increases as the concentration of mineral salts grows.

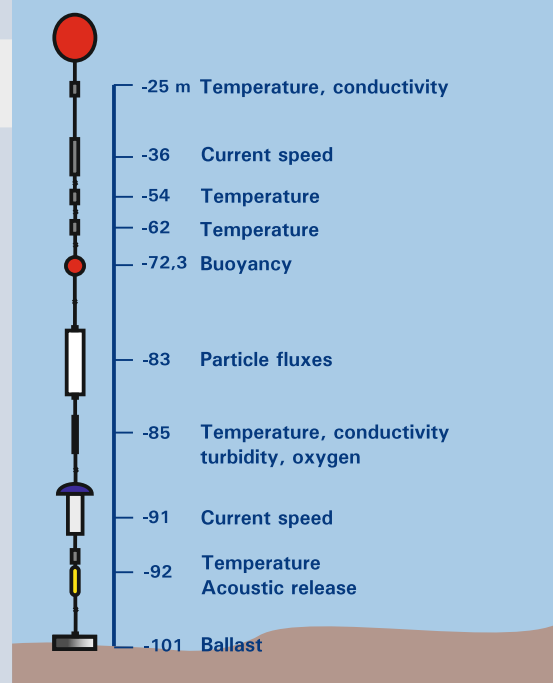


One of the main currents affecting the Arctic region is the West Spitsbergen Current, which goes up the Fram Strait and generates warm intrusions within the fjords of Svalbard, among which the Kongsfjorden. Here the National Research Council of Italy installed the permanent underwater measurement system for this hot water vein called **Mooring Dirigibile Italia** (MDI). The data collected are used to establish the amount of heat that is transferred through the ocean from the equator to the poles, a fundamental aspect of the heat balance of our planet.

Ocean currents carry heat from the equator to the poles and act as an engine for the global climate. The fundamental principle is the following: water cools at the poles interacting with the atmosphere and falls towards the ocean trenches; the warm surface water of the equator is drawn towards the poles creating currents, such as the famous **Gulf Stream**, which warms the coasts of Northern Europe. One of the dangers of global warming concerns the slowing down of this mechanism: if the Poles heat up they become less efficient engines and all the rest of the circulation becomes less efficient, losing its role as a climate reliever.



Scheme of the Mooring Dirigibile Italia



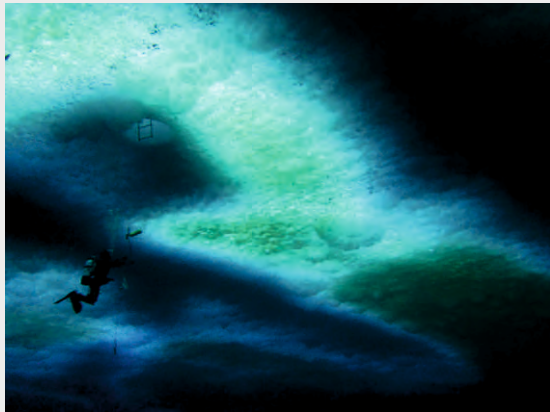
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The Arctic: an ecosystem at risk

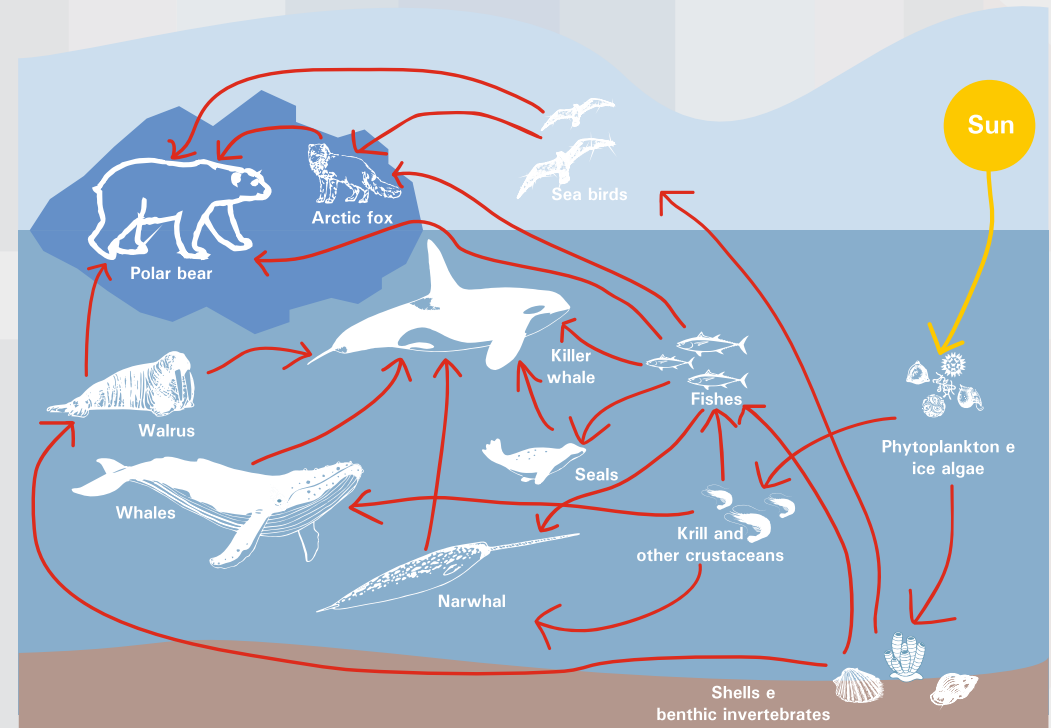
The Arctic ecosystem presents a very delicate balance between animals, plants and the environment. It is populated by highly specialized organisms that are particularly vulnerable to climate change.

The marine ecosystem

The Arctic Ocean is the smallest and shallowest of the five ocean basins on Earth. Many organisms live here, from microscopic bacteria, plankton and algae, to large animals such as whales, seals and polar bears. In spring and summer, many birds migrate to the Arctic to take advantage of the available food. Phytoplankton, made up of microscopic bacteria and algae, is at the base of the **Arctic food chain**.



Credits: Andrew Thurber, Deep sea and polar biology



Since the Arctic Ocean is covered with ice for most of the year, some **microalgae** are also found inside and on the submerged surface of the ice. They are called ice algae. During late winter and spring, large communities of these algae blooms inside and on the surface of the sea ice. As the ice melts, the algae are released into the waters and are consumed by plankton and small fish. Ultimately, these organisms are eaten by all the larger organisms. The reduction in thickness of **sea ice**, as well as the timing of its melting in spring and freezing in autumn, can affect the productivity of algal communities and, consequently, the organisms that feed on it, causing dramatic changes throughout the ecosystem.

The Arctic: an ecosystem at risk

Plants as sentinels of climate change

The Arctic landscape offers a variety of **terrestrial ecosystems**, from the Brooks Mountains in North America, to the huge ice cap of Greenland, to the tundra of northern Siberia.

Although there are some forests near the Arctic Circle, the arctic flora is generally limited to herbaceous plants, mosses and lichens. Since they cannot move, plants must necessarily adapt to the climatic and environmental conditions of the place where they were born. This makes them very useful for studying the impacts of climate change, especially in areas subject to extreme conditions such as polar regions. For this reason, CNR researchers have installed monitoring areas for **plant biodiversity**. In addition, measurements of carbon dioxide fluxes are carried out to quantify the progress of the photosynthesis and respiration processes of plants and their contribution to controlling the amount of carbon dioxide in the atmosphere.



Measurements of carbon dioxide flows on *Cassiopeia tetragona*, one of the most characteristic shrub species of Arctic vegetation.

Traveling over time to discover how climate has changed

The Arctic: a world in the north of the world where man is a guest and where the environment is tough, selective and hostile. However, if the presence of man is difficult, the result of his activities, whether local or coming from other parts of the planet, can easily influence these remote areas. It is therefore important to recognize the impact of human activities on the Arctic environment, both to assess the global spread of contaminants and to better understand the variations in time of these substances and their impact on the climate.

In order to carry out this study, it is necessary to have some kind of evidence preserved over time that allows us to 'read' the climatic and environmental history of the Planet. Snow represents this kind of evidence: an important environmental archive that allows us to measure the impact of human activity. In the Arctic, where snow is preserved year after year with little or no melting, sampling snow from a trench or picking up an ice core sample means taking a trip back in time. Studying the chemical composition of snow and ice layers allows us to define changes in the climatic conditions of the past and to see the rise and variation of human-induced contamination on the atmosphere.

Nature also makes its part: volcanic eruptions, large fires, extreme weather events can be recognized in these environmental archives and give information on global atmospheric circulation.

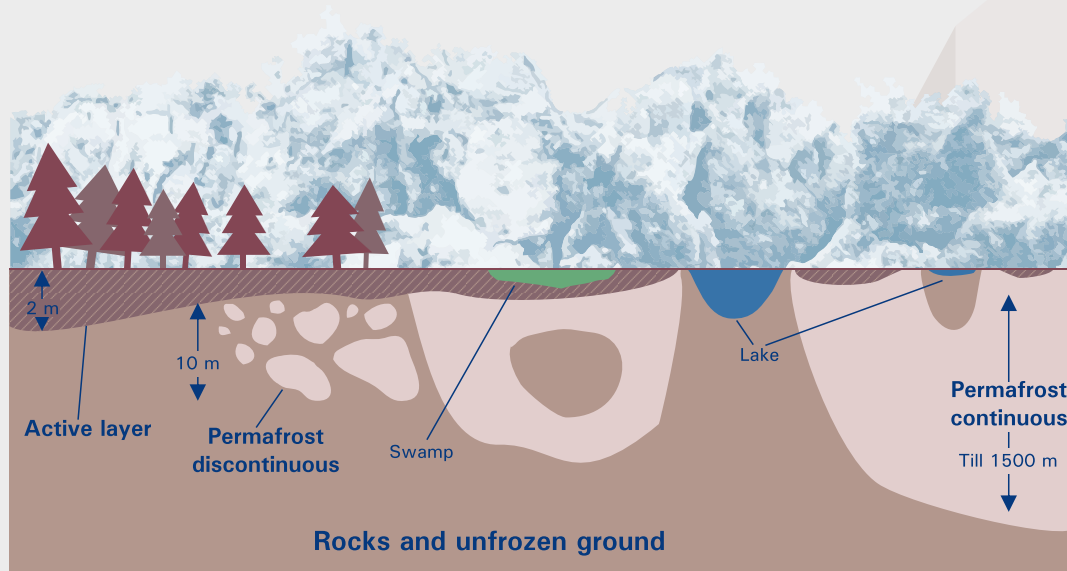
Ice core samples, which reach far into the depths of a trench, allow to go back thousands of thousands of years, opening up a window on climate change occurred in the past and delivering a comparison term to study and understand current climate change.



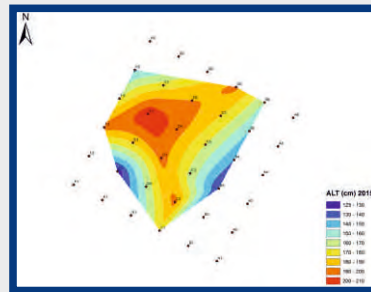
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The permafrost degradation

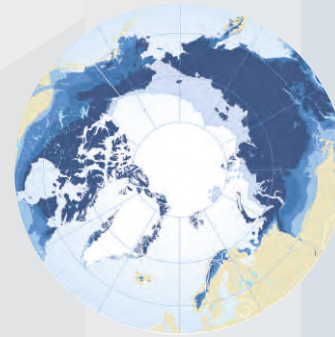
Permafrost is frozen soil that maintains a temperature below 0 ° C for at least two consecutive years. Hence the word permafrost: **"perma"** + **"frost"**, which means **"permanently frozen"**. The surface layer of the permafrost, called the **active layer**, can temporarily thaw during summer, allowing plants to grow and animals to find food.



The thickness of the active layer and the temperature of the permafrost are considered **climate indicators** by the World Meteorological Organization. In Ny-Ålesund, Cnr researchers have set up a grid on the ground measuring 50x50 meters, in which the temperature and thickness of the active layer are **constantly monitored**, which are very variable even at short distances. In addition, to monitor the permafrost temperature, a 50-meter-deep drilling was made to measure the temperature at different depths.



Thickness of the active layer in the Ny-Ålesund grid



- Continuous permafrost
- Permafrost discontinuous
- Sporadic permafrost
- Isolated patches
- Subsea permafrost

Permafrost can be found on land and below the ocean floor. It covers nearly **23 million** square kilometres in the Northern Hemisphere, roughly one sixth of the land areas on our planet.



Littoral erosion and retreat along the coast lines

A consequence of global warming is the reduction and degradation of permafrost, with the consequent increase in the thickness of the active layer. The effects of permafrost degradation are manifold and should not be underestimated



Land subsidence in the plain with the formation of ponds and marshes. This phenomenon is called "thermokarst"



Release of carbon contained in the buried organic matter. Once thawed, the organic matter decomposes producing carbon dioxide and methane. The amount of these gases trapped in the permafrost is really great: it could double the greenhouse effect, thus amplifying global warming



Collapse of buildings and infrastructure



Landslides and flows in mountainous areas

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Vulnerability and resilience

The Arctic ecosystem depends on a delicate balance between animals, plants and environment. As a result, it is particularly vulnerable both to climate change and to the increase of population and human activity.

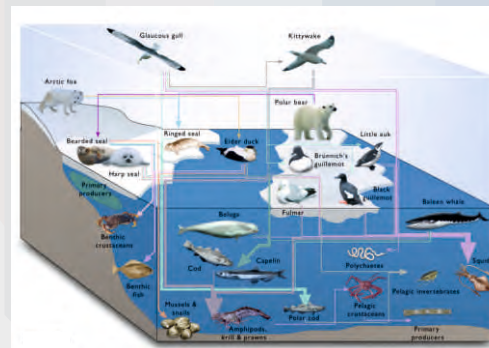
Such vulnerability should be taken into account if we want the Arctic to develop in a sustainable way.

Understanding vulnerability and resilience of environments and societies in a 'globalized' Arctic requires stronger international scientific cooperation and the contribution of non-Arctic States and organizations. New markets for Arctic resources and related activities such as commerce, tourism and transport are likely to emerge faster than the necessary infrastructure both on land and on the sea. This growth, together with technological innovation, is crucial to strengthen resilience of Arctic communities and ecosystems and requires a collaborative approach between scientists, governments and industry. An effort focused on:

- Research of methodologies for the sustainable exploitation and management of resources (living and mining), development of risk-based analysis and full understanding of the consequences of continuous exploitation;
- Assessment of the impacts of climate change and human activities on biodiversity, of the consequences for ecosystems in terms of goods and services and of the social impacts of the ongoing changes;
- Understanding extreme weather events and their ecological and social impact;
- Development of integrated sustainability indicators to assess the conditions and dynamics of socio-ecological systems;
- Identification of sustainable development strategies for urban areas and their infrastructures, considered that warming of the Arctic region and greater accessibility will cause the Arctic urbanization process to continue.

The need for mutual knowledge transfer between the scientific community and the indigenous and local populations of the Arctic, with particular attention to traditional and local knowledge, is a key element for a sustainable development and to enhance resilience of the system from the major changes likely to happen in the near future.

A great effort is needed to incorporate traditional and local knowledge and to involve northern and Indigenous communities in the definition of priorities, in planning and producing research collaboratively. In this way, dissemination of knowledge is promoted and access to data and research results is ensured. It is therefore essential, in this context, that indigenous, non-indigenous researchers, decision makers and indigenous residents of the Arctic cooperate to improve knowledge and to guide development, also by adopting common principles to inspire both research and strategic choices.





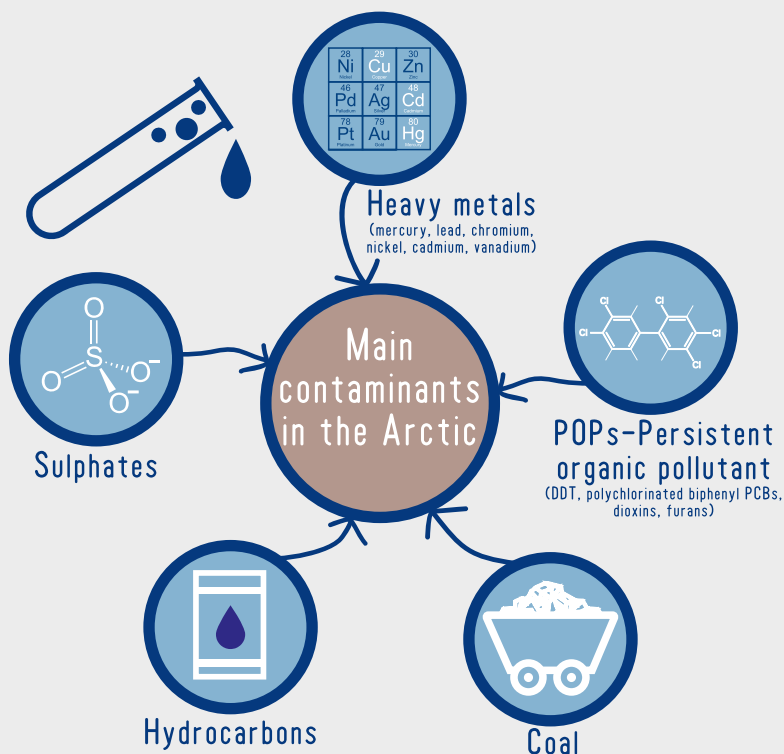
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Chemical pollution in the Arctic

The Arctic is not a major source of environmental contaminants. However, even this remote region of the Earth is not immune to the effects of pollution. Chemical contaminants, wastes of industrial activity, urbanization, fires in Europe, Asia and North America are released into the air and sea and transported north to the polar region through ocean currents and atmospheric circulation.

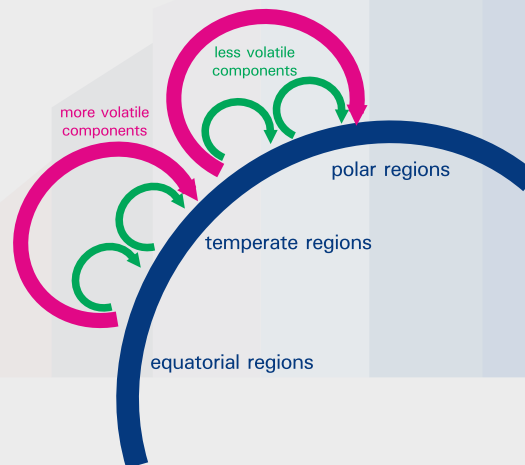
The breakup of the Arctic vortex between February and March opens the way to the arrival of pollutants and generates the phenomenon known as **Arctic Haze**. It is a reddish haze which, in spring, appears in the atmosphere at high latitudes, due to air pollution produced by human activities.



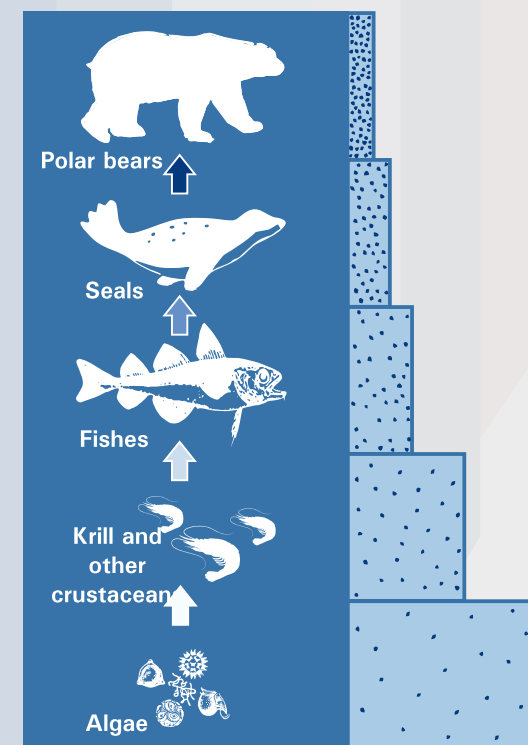
Due to the particular environmental conditions in the Arctic, such as reduced sunlight, extensive ice cover and low temperatures, **contaminants degrade much more slowly** than in warmer climates, settling on the snow and concentrating in the ice.

In spring, when the ice melts, toxins are dumped into the sea and absorbed by the algae that bloom during this period. Toxic substances, in particular POPs and heavy metals, thus enter the food chain, passing from algae to plankton, to fish and, therefore, to the larger fauna. As they eat contaminated prey, animals at the top of the **food chain**, such as polar bears, seals and whales, accumulate higher and higher levels of toxins in their fatty tissues.

The Inuit of Canada and Greenland, who hunt seals and polar bears, also have higher levels of contaminants in their blood and mother's milk than the inhabitants of more southern areas.



Some highly polluting elements such as the so-called POPs (Persistent Organic Pollutants) can reach the Arctic from very distant areas through the phenomenon known as the "**grasshopper effect**". After repeated evaporation, condensation and deposition processes, these **volatile pollutants** move from low to high latitudes, with a 'hopping' movement.



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Gruvebadet atmospheric laboratory, dedicated to the study of the atmospheric composition with focus on the aerosol. The laboratory, opened in 2010 by CNR, is in the building that once housed the Ny-Ålesund **miners' showers**. Hence the name: Gruve = mine, badet = bathroom in Norwegian



ARCTIC

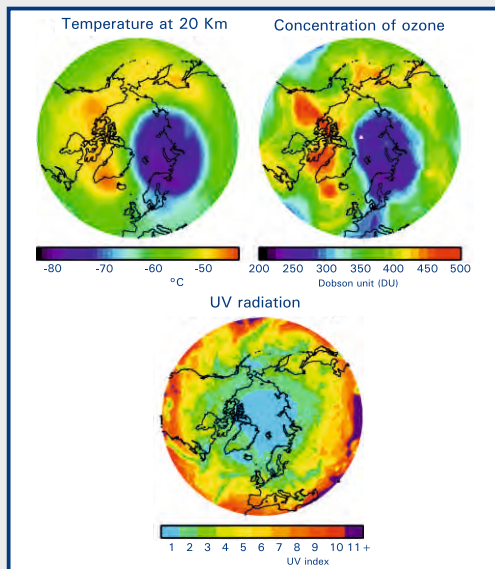
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The stratosphere, the ozone layer and the depletion process

The **stratosphere** plays a fundamental role in the life of the Planet. In fact, this layer is characterized by the presence of ozone, a minor gas mainly found between 15 and 30 kilometres altitude. Thanks to its ability to absorb radiation in the ultraviolet (UV) spectral band, **ozone** provides a shield against UV-C and part of the UV-B radiation, harmful to living organisms on Earth. However, the absorption of radiation implies the heating of this atmospheric layer so that, up to 50 kilometres altitude, temperature increases with height.

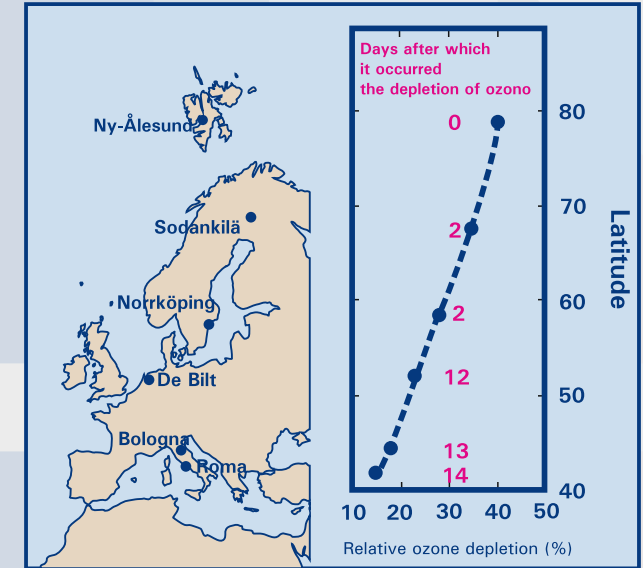


Ozone (O_3) is a very unstable gas whose molecules are made up of three oxygen atoms that combine through a series of photochemical reactions. The total concentration of ozone in the atmosphere (TOC) is the result of many of these reactions and dynamic processes. The seasonal trend of **atmospheric ozone concentration** is characterized, in the medium and high latitudes of the northern hemisphere, by a spring maximum of about 400 DU (Dobson unit) and an autumn minimum of 270-300 DU. The distribution of ozone at a global level is determined by the movement of air masses with a higher concentration of ozone from tropical regions to mid-latitudes and polar areas.



The concentration of ozone in the Arctic measured on April 2, 2011. Inside the polar vortex, temperatures are colder and ozone is greatly reduced

In the polar regions, the thermodynamic characteristics of the troposphere and stratosphere favour the generation of **polar vortexes** during winter. Within these vortexes, chemical reactions and dynamic processes cause a significant reduction (**depletion**) of atmospheric ozone which depends on the stability of the vortex itself. For example, in Antarctica the vortex is very stable and the depletion is wide. In the Arctic, on the other hand, the vortex is less stable and consequently the ozone depletion is less significant.



However, in 2011, the polar vortex in the Arctic was so strong and stable as to create an appreciable reduction of ozone levels. Satellite images show that, starting from the typical 400 DU, the TOC values in March have dropped to a level of about 280 DU, which means over 40% less.

Observations showed that **this reduction was not limited to the Arctic**. In Rome, for example, the ozone depletion occurred about two weeks later and reached a value of about 15% compared to the values in the Arctic. Such ozone depletion can cause an increase of almost 21% of UV radiation, to which our skin is sensitive. In the Arctic, such an increase in UV radiation was about 85%. What happened in 2011, and to a lesser extent repeated in subsequent years, confirms that it is necessary to constantly monitor ozone levels in polar regions.

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The Arctic: a disputed region

Climate change and the reduction of arctic sea ice have turned the Arctic into a new area of conquest and frontier for the economic world trade development. The geopolitical value of the Arctic region is due to two particular issues: **natural**



Natural resources

the Arctic holds 30% of natural gas reserves, 15% of undiscovered global oil reserves and 15% of global fish resources. It also has **large stocks of minerals**, including not negligible quantities of the so-called rare earths, which have become accessible and exploitable thanks to the improvement of extraction techniques and technologies.



Naval routes

The thinning and reduction of the ice sheet makes the hypothesis of a commercial exploitation of the two Arctic Sea routes, currently accessible only for a few weeks in the summer season, ever more achievable. These are the **north-west passage**, through the Canadian Arctic Archipelago, and the **north-east passage**, along the coasts of Siberia. For this reason, Arctic countries are making claims for sovereignty over international territories. Canada, Denmark and Russia claim it is their territorial waters so they would legitimately collect tolls.



- Northwest Passage (NWP)
- Northeast passage (NEP)

- limit of 200 nautical miles
- offshore borders by bilateral agreements

Territorial claims (over 200 nautical miles)

- Usa
- Canada
- Russia
- Denmark
- Norway
- Not claimed

Territorial disputes in progress

- 1 Border demarcation between Alaska (United States) and Canada in the Beaufort Sea
- 2 Control and management of the north-western sea route (between USA and Canada)
- 3 Sovereignty on the islet of Hans between Greenland (Denmark) and Canada
- 4 Border demarcation between Russia and Norway in the Barents Sea

Many States are willing to extend their area of influence beyond the borders regulated by international conventions, claiming portions of the Arctic under the limits of the undersea continental shelves. The Arctic is perceived as a **geopolitical frontier**, where both the states bordering it and the more distant ones have exploitation projects.



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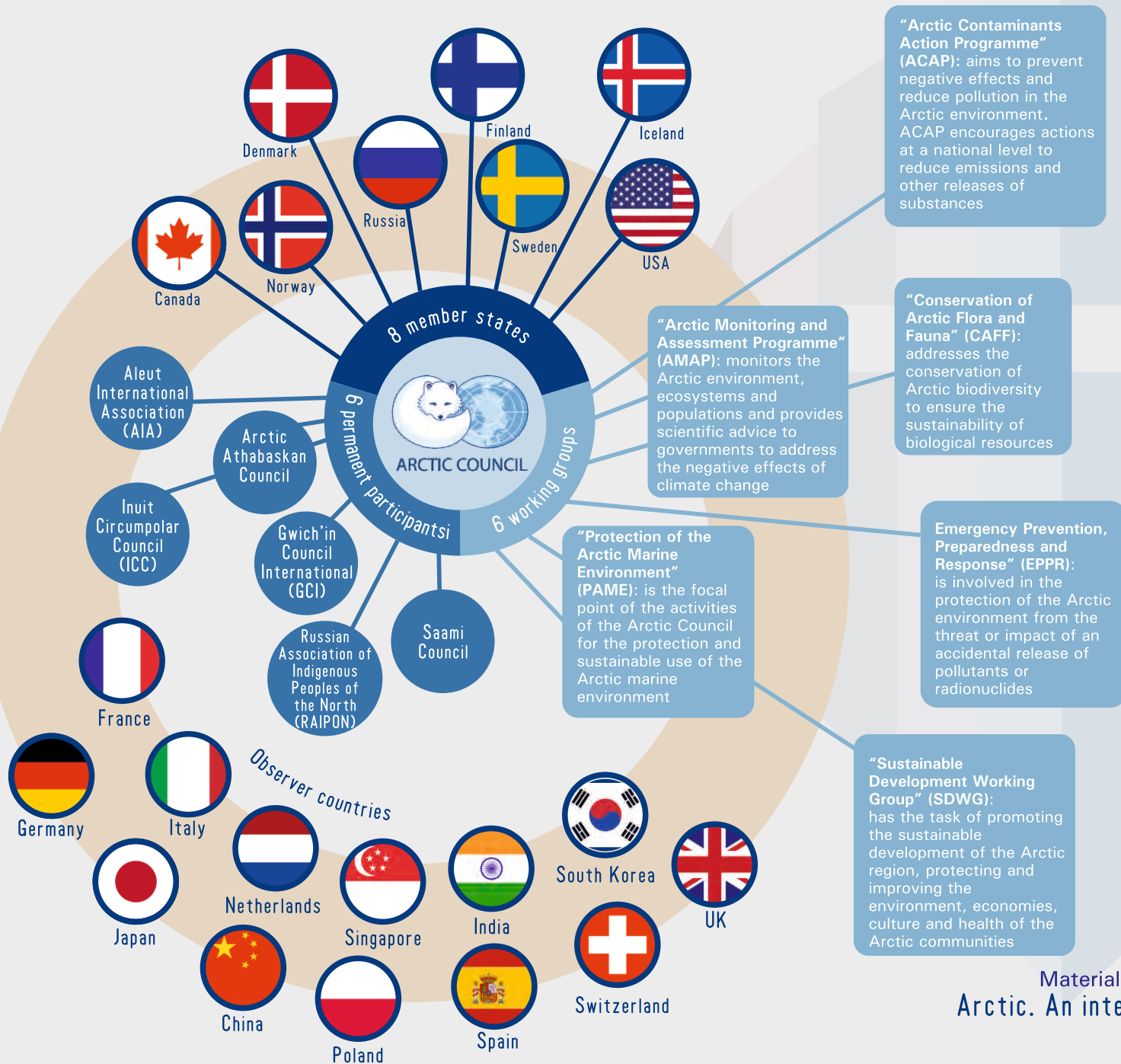
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The Arctic Council



Unlike Antarctica, the Arctic is not governed by a specific international treaty. Its legal regulation is subject to the various jurisdictions of the States surrounding the Arctic seas in the international legal framework of the United Nations Conference on the Law of the Sea (UNCLOS) and other specific international treaties.

The Arctic Council, born in 1996, is the main intergovernmental organization to promote cooperation among the Arctic States, indigenous communities and the people of the Arctic on the issues of sustainable development and environmental protection in the region.

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The project team at the inauguration of the exhibition,
Palazzo Ducale, Genoa 27th ottobre - 6th novembre 2016

Thank you Angelo
The exhibition is dedicated to you