Italia in Antartide *Italy in Antarctica*
Panoramica della mostra

In occasione della **47ª Riunione Consultiva del Trattato Antartico (ATCM**, Milano 23 giugno-03 luglio 2025) la **Commissione Scientifica Nazionale per l'Antartide (CSNA)** ha promosso una mostra scientifica dedicata alle attività del nostro **Programma Nazionale di Ricerche in Antartide (PNRA)**.
L'esposizione, collocata in un'area di grande visibilità all'interno della sede del convegno, ha l'obiettivo di offrire ai Delegati dei 56 Paesi partecipanti una panoramica d'insieme sul contributo italiano alla ricerca antartica, con particolare attenzione agli aspetti più rilevanti per il Sistema del Trattato Antartico.
La mostra, finanziata dal **Ministero dell'Università e della Ricerca (MUR)**, è curata dal **Museo Nazionale dell'Antartide (MNA)** e dal **Consiglio Nazionale delle Ricerche (CNR)**, in collaborazione con **ENEA** e l'**Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS)**.
La mostra è dedicata al Prof. Francesco Francioni e al Dr. Marino Vacchi, per il loro straordinario contributo agli studi antartici, in particolare nell'ambito dell'ATCM e della CCAMLR.

DESCRIZIONE SINTETICA
L'ingresso all'esposizione è segnato da un pannello introduttivo che ripercorre le tappe salienti del PNRA e ne delinea in dettaglio le strutture operative e i ruoli organizzativi. La mostra si sviluppa poi attraverso 6 pannelli tematici che illustrano e raccontano le ricerche italiane di rilevanza per l'ATCM. A completare l'allestimento, una serie di tre grandi pannelli affiancati, ciascuno di 3x4 metri, che mostrano immagini suggestive di paesaggi e attività di ricerca in Antartide, capaci di trasmettere l'importanza e l'impegno scientifico che caratterizzano il lavoro del PNRA nel continente più remoto della Terra.
I pannelli tematici sono organizzati secondo i seguenti argomenti:

1 - Infrastrutture e alcuni risultati scientifici in Antartide
Vengono descritte la Stazione Mario Zucchelli che ospita fino a 124 persone durante l'estate, con laboratori e osservatori permanenti per studi multidisciplinari; la Stazione Concordia, base permanente italo-francese a 3.200 m di quota; il rompighiaccio Laura Bassi utilizzato per ricerche oceanografiche e geofisiche e la nuova aviopista di Boulder Clay a supporto della logistica. Tra i successi scientifici, vengono descritti l'esperimento BOOMERanG che ha fornito immagini dell'universo primordiale, la realizzazione di carte geologiche, geomorfologiche e geomagnetiche in scala 1:250.000 del Nord Victoria Land; la mappatura radar del substrato roccioso (BEDMAP), che ha portato alla scoperta di numerosi laghi subglaciali; le perforazioni sedimentarie (Cape Roberts e ANDRILL) per studiare l'evoluzione climatica e tettonica dell'Antartide negli ultimi milioni di anni.

2. ASPA e Ross Sea Region Marine Protected Area
Viene illustrato l'impegno italiano, in collaborazione con Cina, Corea del Sud e Stati Uniti, nell'istituzione e gestione di quattro Aree Antartiche Specialmente Protette (ASPA) caratterizzate da ecosistemi unici e vulnerabili, come la colonia di pinguini imperatore di Capo Washington, gli habitat bentonici ricchi di specie chiave come il bivalve *Adamussium colbecki*; l'unica area nota di riproduzione del pesce *Pleuragramma antarcticum*, etc.
Viene inoltre descritto il contributo dell'Italia allo studio e monitoraggio della più grande Area Marina Protetta del mondo istituita nel 2016 nel Mare di Ross.

3 – Biodiversità ed ecologia degli ecosistemi antartici
Il pannello illustra con alcuni esempi la grande biodiversità dell'ambiente costiero. Descrive l'adattamento di alcune specie estreme, mostra ambienti sottomarini con spugne giganti, pesci e specie bentoniche, sottolineando l'importanza delle reti trofiche e dei modelli predittivi negli studi volti alla conservazione della biodiversità antartica.

4 – Contaminazione e protezione ambientale
Approfondisce le sfide legate all'inquinamento emergente: microplastiche, nanoparticelle, nuovi inquinanti organici persistenti. Si evidenziano le fonti antropiche e naturali e il loro trasporto attraverso aria, neve, mare e ghiaccio. Viene descritto l'impatto biologico della contaminazione anche a livello cellulare. Si sottolinea l'interazione con il cambiamento climatico. Il pannello illustra inoltre l'importanza delle banche dati e campioni condivise a livello internazionale. Viene evidenziata la rilevanza della ricerca nel contesto del Protocollo di Madrid, centrato su politiche di protezione ambientale in Antartide.

5 – Dalle Alpi all'Antartide: il ruolo nelle perforazioni glaciali
Qui si illustra la continuità tra le perforazioni alpine e i grandi progetti polari: GRIP in Groenlandia, EPICA, TALDICE, Beyond EPICA, con i loro obiettivi paleoclimatici. Si spiegano le tecnologie di carotaggio e i risultati ottenuti nei tre siti principali: Talos Dome (alta risoluzione, ultimi 340 ka), Dome C (carota di 3.270 m, 800 ka), Little Dome C (Beyond Epica Oldest Ice, >1.2 Ma). Si sottolinea il successo e la rilevanza delle perforazioni nella ricostruzione dei cicli climatici. Viene illustrata la complessità logistica dei progetti di perforazione del ghiaccio della calotta ed evidenziata l'importanza della collaborazione internazionale.

6 – Osservatori permanenti in Antartide
Il pannello presenta la rete di 15 osservatori distribuiti tra Mario Zucchelli, Concordia e i mari di Ross e Scotia dedicati a studi di meteo-climatologia, geomagnetismo, fisica dell'alta atmosfera, mareografia, gravimetria, sismologia, oceanografia, vulcanologia, microbiologia, chimica dell'atmosfera, monitoraggio solare, permafrost e vegetazione. Ogni osservatorio è descritto brevemente e vengono messe in evidenza l'utilità dell'integrazione dei dati con reti internazionali e l'importanza della condivisione scientifica.

Italy in Antarctica

MUR
Ministero dell'Università e della Ricerca

PROGRAMMA NAZIONALE DI RICERCHE IN ANTARTIDE
ITALIANTARTIDE

Consiglio Nazionale delle Ricerche

ENEA
ITALIAN NATIONAL AGENCY FOR NEW TECHNOLOGIES, ENERGY AND SUSTAINABLE ECONOMIC DEVELOPMENT

OGS Istituto Nazionale di Oceanografia e di Geofisica Sperimentale

MNA

MAIN STEPS

On March 18, 1981 Italy signed the Antarctic Treaty, and became a Consultative Party in 1987.
On 1985 the Italian National Antarctic Research Program (**PNRA**) was instituted, and the first scientific expedition conducted.
On 1986 the construction of the **coastal station** in the Terra Nova Bay area was initiated, Since 1987 the station is operational during the austral summers. In 2003 it was dedicated to the memory of **Mario Zucchelli** for his leadership and dedication to the Antarctic Program.
On 1991 the National Museum for Antarctica (**MNA**) was established.
In 1994 in the frame of a cooperative agreement between France and Italy the construction of the continental **Concordia station** at Dome C on the polar plateau was initiated.
Since 2005 Concordia station is operational **all-year round**.

GOVERNANCE

The **Ministry of Foreign Affairs and International Cooperation** is responsible for the representation of Italy within the Antarctic Treaty System.

The **National Antarctic Research Program (PNRA)** coordinates and supports Italian scientific research activities in Antarctica. It operates under the authority and oversight of the **Ministry of University and Research** and its governance involves several institutions with different roles and responsibilities.

The **National Scientific Commission for Antarctica (CSNA)**, appointed by the Minister of University and Research, has strategic advisory responsibilities and act as the body representing Italy at SCAR. It is composed of 13 members representing the wider scientific community, the logistics entity and experts from various ministries.

The **National Research Council (CNR)** is responsible for ensuring and coordinating the planning and conduction of scientific research activities. The CNR also oversees the dissemination of research results and the management of scientific data.

ENEA, the **National Agency for New Technologies, Energy and Sustainable Economic Development**, is in charge of operational planning and the technical-logistical management of research activities in Antarctica. It oversees the logistics for the implementation of scientific projects and the maintenance of facilities and instruments installed at Antarctic stations. It is responsible for safety and environmental protection in Antarctica.

The **National Institute of Oceanography and Applied Geophysics (OGS)** is responsible for the technical and scientific management of the icebreaker vessel Laura Bassi. The vessel plays a crucial role in supporting Italy's polar research program, providing logistical support and enabling scientific research.

The **National Museum for Antarctica (MNA)** is in charge of maintaining, studying, and enhancing the value of samples collected during scientific expeditions and any other data and evidence relating to Italy's research in Antarctica. The various repositories provide the archiving and lending of mineralogical, lithological (both terrestrial and extraterrestrial), and glaciological specimens, marine sediments, biological materials and water samples. The Museum is also responsible for promoting the dissemination of the results of scientific activities conducted in Antarctica.

The PNRA benefits from the logistic support of the **Ministry of Defense** that provides expert personnel for safety, weather forecasting, the control of flight operations and supports the expedition with its own Hercules C-130 aircraft.

Research projects are funded through calls launched by the **Ministry of University and Research**, and are open to researchers from Italian public research institutions and universities.

Italy in Antarctica

pnra.aq

Credits

italiantartide

italiantartide

ItaliAntartide

Italy in Antarctica
Scientific contributions to the Antarctic Treaty System

The Italian National Antarctic Research Program (PNRA) is celebrating 40 years of its presence on the continent. Over this time, PNRA has advanced scientific knowledge of Antarctica through a wide range of research projects and collaborations at both national and international levels.

The present panel outlines the infrastructures in Antarctica, the overall scientific priorities, and some of the past national and international research highlightsof the Program.

In the following panels, we will focus on some of the projects most relevant for their contribution to the Antarctic Treaty System.

Priorities

The PNRA scientific priorities have changed over time. For 2024-2026 they are summarized as follow (see QR code for details)

- ✓ Land/Ice/Climate interaction
- ✓ Astronomy, astrophysics and space weather
- ✓ Life in Antarctica
- ✓ Human Impact and Environmental contamination
- ✓ Biomedicine and psychology
- ✓ Data Collection and dissemination
- ✓ Teaching Training and Information

Infrastructures in Antarctica

Mario Zucchelli Station (Ross Sea): with 7,500 m² of space for labs, storage, utilities, and accommodations, this summer facility hosts up to 124 people. In addition to laboratories equipped for chemical, biological, geological, and electronic analyses, the Mario Zucchelli Station has a computing room and an aquarium. There is also an astronomical observatory and permanent observatories for the study of Earth's magnetism, the ionosphere, seismic movements, tides, geodetic references, and meteorological variables.

Boulder Clay Airstrip: a new gravel runway 2,200 metres long and 60 metres wide near Mario Zucchelli Station, already operational for Twin Otter aircraft and successfully tested with a C-130. It was built to replace the increasingly unreliable sea ice runway.

Concordia Station: built at Dome C at an altitude of 3,200 meters and more than 1,000 km inland, is a year-round facility established in collaboration with France, representing a major technological challenge due to its remote location and extreme environmental conditions. It accommodates up to 32 people (16 during winter overing). Concordia station provides a unique chance to study "science at the edge of the world". Research topics spans life and atmospheric sciences, astronomy, glaciology, space weather, and Earth studies, climate change. Additionally, Concordia Station serves as a vital testing site for experiments supporting human space exploration and astrobiology, closely tied to advances in biomedicine.

Laura Bassi Icebreaker: designed as a special oceanographic research vessel combining both cargo and scientific research capabilities in an optimal way. She accommodates up to 50 scientists, and is equipped for geophysical, biological, and oceanographic studies, with significant cargo capacity for logistical support.

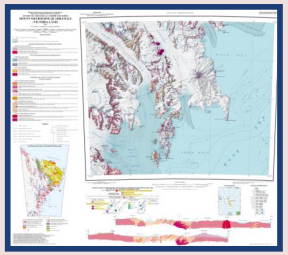
The icebreaker was named after Laura Bassi (1711–1778), who, at the age of 21, became the first woman in the world to be appointed a university professor of physics, as a tribute to women in science and to promote gender equality in research.

Portrait of Laura Bassi, Carlo Vandi mid 18th century
MEUS - European Museum of Students, Bologna

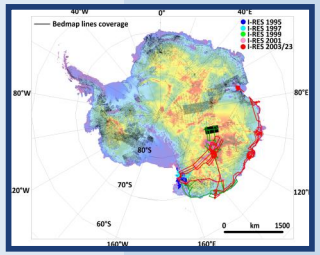
Research highligths

The international **BOOMERanG** (Balloon Observations Of Millimetric Extragalactic Radiation and Geophysics) experiment, a collaboration among Italy, USA, UK, and Canada, consists of a highly sensitive microwave telescope, carried above the Earth's atmosphere by a stratospheric balloon. It produced, for the first time, a detailed image of a region of the universe so distant that its light took 13.7 billion years to reach us, offering a glimpse into its truly primordial conditions.
The BOOMERanG measurement indicated that most of the mass-energy in the universe does not interact with light: it is therefore dark matter or dark energy, both still unknown.
It was launched twice into the Antarctic stratosphere, in 1998 and 2003.

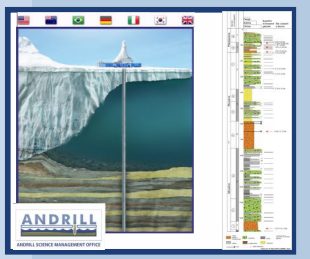
Geological and Geophysical Survey: the PNRA has produced 9 geological, 3 geomorphological, 5 geomagnetic 1:250.000 maps of northern Victoria Land. The geological maps represent the Italian contribution to the Italian-German GIGA Map project, which comprises about twenty 1:250,000 USGS Quads covering the entire northern Victoria Land, an area approximately the same size of Italy. The geological surveys and the collection of rock samples, followed by laboratory analyses, have made it possible to determine the nature of the rocks, the geometry and relationships of geological structures, and to reconstruct and date major geological events. The nature and physical properties of non-outcropping rocks have been characterized using seismic and acoustic recordings, as well as magnetic, gravimetric, and geodetic measurements. Comparison with equivalent parameters measured on ice-exposed outcrops has enabled the development of large-scale geological and structural models for otherwise inaccessible regions of the continent.



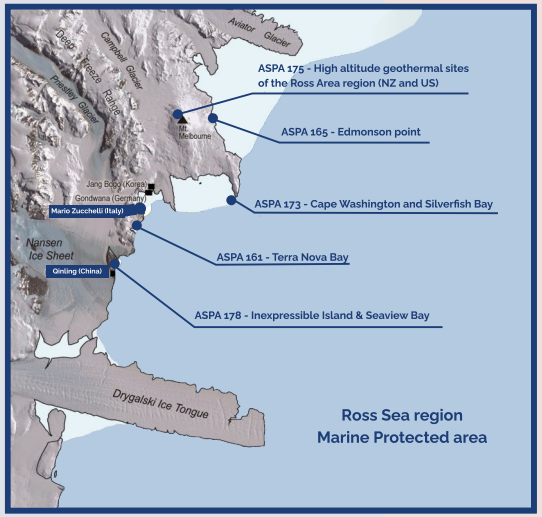
BEDMAP is an international project whose goal is to describe the surface elevation, ice thickness, and seafloor and subglacial bed elevation of the entire Antarctic region south of 60°S.
Since 1995, PNRA has contributed with over 38,000 km of airborne radar surveys over the East Antarctic Ice Sheet (EAIS). PNRA radar data (I-RES legend) identified the deepest point of the Aurora Trench, where ice thickness reaches 4,755 m (118.328°E, 76.054°S), ranking among the five thickest measured by RES systems. Additionally, 30 new subglacial lakes were discovered in the Vostok–Dome C area. PNRA RES data are available at https://ires.ingv.it/index.php/en/.



PNRA played an active role in **Cape Roberts Project**, which brought together scientists from Australia, Germany, the UK, the NL, Italy, New Zealand, and the US and in the Antarctic DRILLing project **(ANDRILL)**, a collaboration among Germany, Italy, New Zealand, and the US.
These projects were designed to reconstruct Antarctic's Cenozoic climatic and tectonic evolution by drilling and coring sedimentary sequences off-shore the Ross Sea coast beneath sea-ice and ice shelves. The cores provided critical insights into past ice sheet dynamics, sea-level fluctuations, and the response of the Antarctic environment to global climate change during the past 13 million years (ANDRILL) and from 34 to 17 million years ago (Cape Roberts Project). The ANDRILL project was the first to successfully recover high-quality deep cores from beneath the floating Ross ice shelf, pushing the boundaries of Antarctic drilling technology. The PNRA also conducted 10 campaigns of preliminary geophysical survey essential for the identification of the drilling sites.



ASPAs and the Ross Sea region Marine Protected area



In collaboration with China, the Republic of Korea and the US, Italy contributed to the establishment, and plays an active role in the management, of four ASPAs in northern Victoria Land.

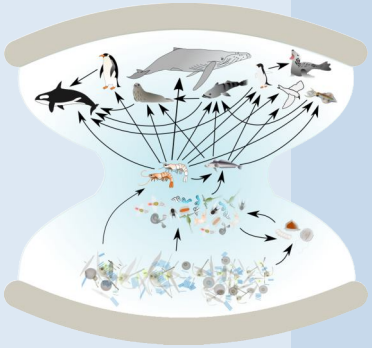
Mario Zucchelli Station, situated on the coast within the Ross Sea region Marine Protected Area, the largest marine protected area in the world established by CCAMLR in 2016, supports numerous research activities contributing to studies on biodiversity, ecosystem dynamics, microbial and biogeochemical processes, and environmental change.

ASPA 161 – Terra Nova Bay (Italy) is home to rich benthic and coastal marine ecosystems.

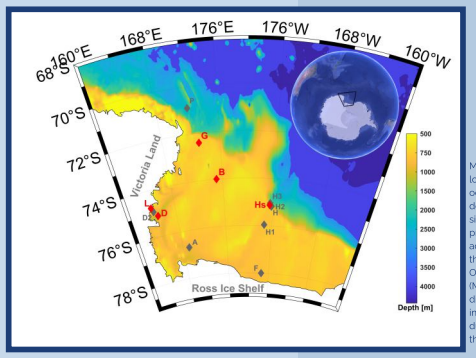
ASPA 165 – Edmonson Point (Italy) is one of the best examples of Antarctic terrestrial biodiversity and is used as a benchmark for ecological and climate change studies.

ASPA 173 – Cape Washington and Silverfish Bay (Italy, United States) is one of the largest colonies of emperor penguins accessible for direct scientific observation and the only known nursery area for the Antarctic silverfish (*Pleuragramma antarcticum*).

ASPA 178 – Inexpressible Island and Seaview Bay (China, Italy, Republic of Korea) supports significant populations of Adélie penguins (*Pygoscelis adeliae*) and South Polar skuas (*Stercorarius maccormicki*).



Rich and intact, the Ross Sea ecosystem functions as a **wasp-waist ecosystem** where mid-trophic species (krill and Antarctic silverfish) control the food web dynamics, influencing both the lower and higher levels. Sustained by high primary production, the Ross Sea ecosystem have a **full suite of top predators** including marine mammals, penguins, seabirds, and large fishes.



Map of the Ross Sea with the location of all the oceanographic moorings deployed in the Ross Sea since 1995 by PNRA-funded projects. The five currently active moorings managed by the PNRA's permanent Marine Observatory in the Ross Sea (MORSea) are shown as red diamonds. Grey diamonds indicate moorings deployed during past PNRA projects that are no longer active.

Italian research on the Ross Sea continental shelf contributes to the study of biodiversity and ecosystem dynamics. Key study areas include fish demography and life history, the distribution and abundance of benthic and planktonic invertebrates, krill acoustic mapping, and feeding interactions under varying sea ice conditions. Habitat analyses, using bathymetric data, ROV surveys, and underwater photogrammetry, provide crucial insights into biodiversity and ecosystem dynamics.

Since 1994, PNRA oceanographic moorings in the Ross Sea have provided long-term data essential for understanding shelf water conditions and biogeochemical cycles, now serving as a key resource for assessing environmental states and trends in the protected area.

ASPA 161 is protected for its high biodiversity, undisturbed benthic habitats, and the presence of key species that sustain essential ecological functions. Among these, the Antarctic scallop *Adamussium colbecki* plays a central role reaching high biomass and density. The image depicts three common species along the coasts of Terra Nova Bay: the bivalve *Adamussium colbecki* (E. A. Smith, 1902), the starfish *Odontaster validus* Koehler, 1906 and the sea urchin *Sterechinus neumayeri* (Meissner, 1900) (on the right, covered in algae).

ASPA 165 – Since 1994, researchers have monitored the Adélie penguin (*Pygoscelis adeliae*) colony by recording nests, eggs, and chicks during the breeding season to estimate population size and survival rates in relation to climate change. Alongside demographic data, ecotoxicological analyses are conducted using non-destructive methods on biological samples to assess exposure to organic contaminants and their effects on the species and ecosystem. The data are regularly submitted to CCAMLR under the CEMP (CCAMLR Ecosystem Monitoring Program), supporting international efforts to monitor the health of the Antarctic marine ecosystem.

ASPA 173 - Emperor penguin (*Aptenodytes forsteri*) colony at Cape Washington is one of the largest known in Antarctica. Estimates indicate that the colony comprises between 13,000 and 25,000 breeding pairs, representing approximately 8% of the global emperor penguin population. This ASPA also includes the only known nursery area of the Antarctic silverfish (*Pleuragramma antarcticum*). In the austral spring, large numbers of developing eggs and newly hatched larvae are found embedded in the platelet ice. Silverfish is crucial to the survival of many Antarctic predators.

Biodiversity and Ecosystem Dynamics

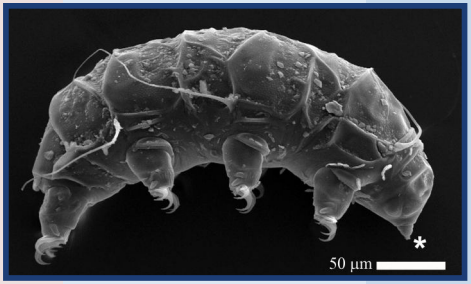
Mario Zucchelli Station offers unique opportunities to investigate and monitor biodiversity and ecosystem functioning under changing climate.

The presence of a polynya (a marine area permanently free of ice) has allowed the development of a unique ecosystem in terms of biodiversity. In coastal areas during the summer season, meltwater from ice allows the development of algae, mosses, and lichens, which create habitats for small organisms adapted to extreme conditions, such as tardigrades, nematodes, rotifers, mites, and springtails.

In the last decade, key research themes have included microbial ecology, energy transfer in terrestrial and marine food webs, and organisms adaptation to extreme environments.

Studying the ecophysiology of individual organisms and monitoring the response of the food web to ongoing global changes are essential tools for developing models of transformation of the Antarctic ecosystem and designing mitigation and conservation interventions.

Inland pool sampling activity: A water sample was collected for field salinity measurement. The microbial substrate was aseptically sampled and preserved for subsequent biodiversity analysis and microbial enrichment attempts.



The tardigrade *Mopsechiniscus franciscae*, shown under a scanning electron microscope. The asterisk marks its mouth, used to pierce plant or bacterial cell walls to extract contents. Tardigrades can survive extreme conditions - including high radiation, vacuum, and high and very low temperatures - by entering a cryptobiotic state. Their exceptional resilience has inspired technologies for preserving DNA, organs, and possibly delaying aging.

The ecology of Antarctic seals is closely linked to local environmental conditions, particularly the dynamics of sea ice and climate, and is affected by their variations. Preliminary results highlight a genetic and dietary difference between the Weddell seal colonies studied at Terra Nova and those at McMurdo.

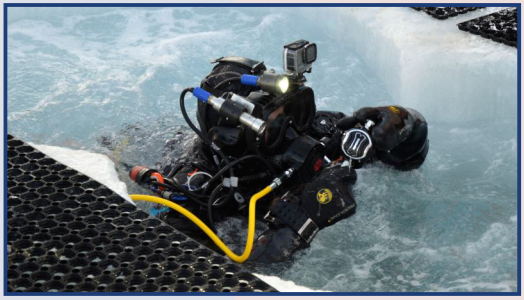
Scientific scuba diving is carried out to collect biological samples for food web studies and to document marine biodiversity in its natural environment. Giant individuals of the sponge *Mycale acerata*.

White blooded icefish (*Chionodraco hamatus*). Unique among vertebrates, icefish lacks hemoglobin, resulting in clear, "white" blood. This loss is offset by unique physiological adaptations, making the icefish an iconic example of evolutionary change and a valuable model for investigating biological adaptation.

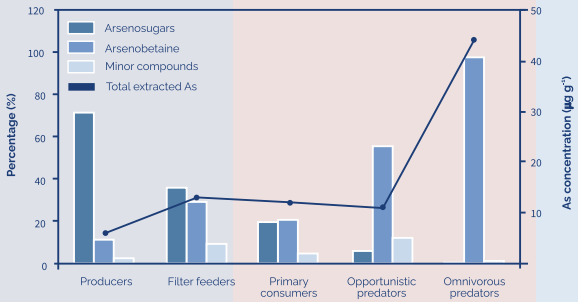
Starfishes *Odontaster validus* and sea urchins *Sterechinus neumayeri*. Submerged rocks are so cold that water in direct contact with them freezes forming extraordinary and delicate ice structures called "Anchor Ice".

Commitments to contamination studies in Antarctica

The assessment and mitigation of the chemical contamination in Antarctica are major protection issues, which are increasingly complicated by the emerging of new pollutants (e.g. microplastics, nanoparticles, new organic persistent pollutants) and the complex biogeochemical cycling of chemicals in a global changing scenario.



Collection of marine organisms under the ice by scuba diving



Distribution of arsenic species through the trophic levels

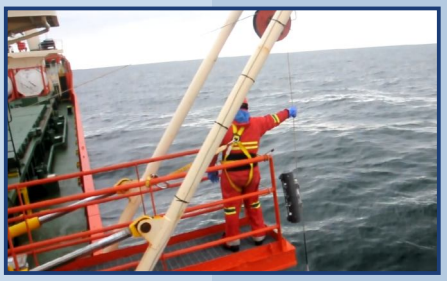
Research Priorities on Chemical Contamination

- **Sources** — Differentiate local/remote & natural/anthropogenic contamination
- **Transport, accumulation and transformation** — Study movement, accumulation, and transformation in ecosystems under climate influence
- **Interfaces** — Analyze transfer between air/snow and sea/ice compartments
- **Atmospheric Input** — Monitor aerosols and deposition patterns linked to climate variability
- **Biological Impact** — Assess effects on organisms at cellular, species and ecosystem levels
- **Climate Change** — Evaluate influence on micropollutant bioavailability and food web transfer
- **Monitoring** — Foster transnational & pan-Antarctic data/sample sharing networks
- **Specimen Banks** — Support long-term studies through harmonized archival systems

Seawater sampling at Tethys Bay

Snow pit sampling at Dome Concordia

Seawater sampling aboard the oceanographic ship



From the Alps to Antarctica
Italy's role in climate research

In the early '80s of last century, it became clear that cores of polar ice would be an important tool in paleoclimate research. Snow precipitations in such cold areas accumulate over time, preserving many of their physical and chemical characteristics such as aerosols, POPs, dust, and volcanic ashes. Furthermore, at depth, following the transformation of snow into ice, part of the air is trapped as bubbles. Through detailed analysis of the ice cores, researchers can reconstruct temporal variations in temperature, atmospheric greenhouse gas concentrations, environmental changes in surrounding continental areas, and episodes of volcanic activity.

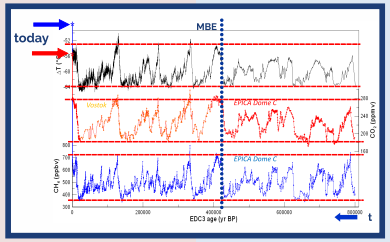
Italy's expertise in ice drilling and coring has deep roots in earlier campaigns carried out in the Alps, and the participation in the European Project GRIP in Greenland, well before the launch of the EPICA project.

Italy contributed to various international ice drilling projects in Antarctica. **EPICA (European Project for Ice Coring in Antarctica)** was the first major ice core initiative promoted and conducted by Italian scientists. Supported by the European Commission, the project involved twelve institutions from ten European countries: Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Sweden, Switzerland, and the United Kingdom. It carried out two drilling campaigns on the Antarctic plateau: one at Dome C (DC) and another at Dronning Maud Land (DML).

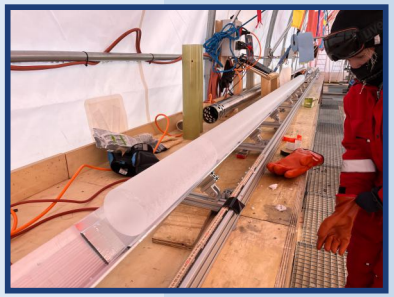
The subsequent ice coring initiatives with Italian contributions developed along two different perspectives: a) ice-coring areas with a high accumulation rate, allowing higher-resolution paleoclimate studies, such as the coastal Talos Dome, and b) drilling in the interior of the continent, in low accumulation areas, looking for ice older than 800,000 years, such as Little Dome C. The two initiatives were **TALDICE** and **Beyond EPICA** respectively.

TALDICE (TALos Dome Ice CorE) was a European ice core research project involving Italy, France, Germany, Switzerland, and the United Kingdom under the leadership of Italian scientists and logistically supported by PNRA. The project began in 2004 and continued for four summer seasons until 2008. The project successfully recovered a 1,620-meter-deep ice core from Talos Dome, an ice dome located on the edge of the East Antarctic Plateau, in the Ross Sea sector, recording in detail the climate and environmental history of the last 340,000 years.

EPICA DC achieved a major breakthrough in the reconstruction of past climate dynamics. It was drilled at a site near the Concordia Station (at the time still under construction), and logistically supported by the French-Italian programs. From 1998, during seven drilling summer seasons, a 3,270.20 m long ice core was retrieved. The most significant outcomes of EPICA DC were the reconstruction of eight glacial - interglacial cycles, about 100,000 years long, back to 800,000 years ago - well beyond the age recorded by the famous Vostok drill (440,000 years). Another important result was the demonstration that greenhouse gas concentrations in the present-day atmosphere are without precedent in the last 800,000 years of Earth's climate history (see diagram).



The greenhouse gas record from EPICA DC ice core
No analog of present-day values during the last 800,000 years. CO_2 and CH_4 show lower interglacial concentrations before 400,000 years BP.



Beyond EPICA Oldest Ice project, aimed at retrieving older ice cores to study the glacial history of the Mid-Pleistocene Transition, begun in 2022 and is still underway. This year, the drilling reached the bedrock. The drill site is located at Little Dome C some 40 km away from Concordia Station.

The Beyond EPICA Oldest Ice project represents a major advancement in climate studies. The ice core retrieved - estimated to span over 1.2 million years - provides an unprecedented and continuous archive of Earth's past climate and atmospheric composition. This dataset advances knowledge of long-term climate change, including the critical Mid-Pleistocene Transition.

The project faced extreme logistical challenges, operating in the remote and harsh environment of Little Dome C, Antarctica. Transporting equipment, building and maintaining a fully functioning camp, and conducting deep ice drilling required meticulous planning, advanced infrastructures and strong international coordination.

The Beyond EPICA Oldest Ice project has now reached a crucial milestone with the successful completion of deep drilling to the bedrock at nearly 2,800 meters.

The project, funded by the European Commission, supported by PNRA and coordinated by Italian scientists, brings together twelve Partners and four Third Parties from ten European countries. The project is also supported by national partners and funding agencies in Belgium, Denmark, France, Germany, Italy, Norway, Sweden, Switzerland, the Netherlands, and the United Kingdom.

This project has received funding from the European Union Horizon 2020 research and innovation programme

Permanent observatories in Antarctica

The Italian National Antarctic Research Program (PNRA) has implemented a network of 15 permanent observatories in Antarctica. These are located at the Mario Zucchelli Station (MZS), at the Italian-French Concordia Station, and in the Ross and Scotia seas. Covering a wide range of disciplines, from biology to astrophysics. The data bases of the observatories are available for both the Italian and the international scientific communities.

Operating since 1990 at Mario Zucchelli Station and 2008 at Concordia Station, the **Upper Atmosphere Physics Observatory** studies the ionosphere over Antarctica. It supports research on ionospheric plasma dynamics and space weather impacts. Data are used in forecasting tools and by international groups such as GRAPE, AGATA, and PECASUS, contributing to aviation navigation safety and SCAR initiatives.

The **Italian Antarctic Meteo-Climatological Observatory (IAMCO)**, established in 1985, operates 16 weather stations and 2 radiosondes from Mario Zucchelli Station to Concordia Station. It collects meteorological parameters, cloud characteristics, and snow surface mass balance data. The observatory helps understand Antarctic atmospheric processes and global climate change. Data are shared with the WMO, SCAR, and through public platforms such as www.climantartide.it.

The **Geomagnetic Observatory**, located at Mario Zucchelli Station since 1987 and at Concordia Station since 2005, monitors the Earth's magnetic field. It is part of INTERMAGNET and support studies of Sun-Earth interactions and geomagnetic modeling.

AIR-FLOC (**A**ccurate surface measurements of different parameters at the **I**nte**R**face between the atmosphere and ice/snow surface: radiation **FL**uxes, skin temperatures and precipati**O**n at the plateau station **C**oncordia), at Concordia Station since 2006, is an evolution of the Baseline Surface Radiation Network (BSRN) and measures surface radiation fluxes, albedo, and UV solar spectrum. It monitors ozone levels, snow surface reflectivity, and near-surface atmospheric temperature profiles. The data improve the understanding of energy exchange processes and contribute to radiation and climate modeling efforts in polar regions.

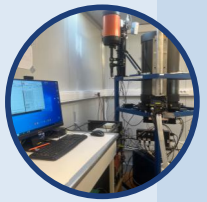
The **Italian Geodetic Observatory in Antarctica (IGOA),** operational since 2007, collects data via GNSS, tide gauges, and gravimetric instruments. It contributes to SCAR's POLENET, SERCE, and GIANT projects. Data support studies on Antarctic tectonics, crustal motion, and cryosphere-solid Earth interactions, refining regional geodetic reference systems.

Seismological Observatory has operated at Mario Zucchelli Station since 1989 and Concordia Station since 2004, using broadband sensors to detect local and global seismicity. It is part of the global seismic network. The STAR observatory at David Glacier, about 200 km from Mario Zucchelli Station, has also been active since 2003, functioning independently to expand regional seismic monitoring capabilities.

SismoAntar, launched in 1992 through Italian-Argentinian cooperation, maintains a seismic network in the Scotia Sea and nearby areas. It continuously records seismic activity, with real-time data transmitted to the Antarctic Seismographic Argentinean Italian Network (ASAIN) and international databases. The observatory plays a crucial role in monitoring Antarctic seismicity and supports European and global geophysical research.

The **Marine Observatory in the Ross Sea (MORSea)**, established in 2010, includes five ocean moorings that collect long-term data on temperature, salinity, currents, and biogeochemical parameters in the Ross Sea. These data support climate and ecosystem studies and feed into SOOS, LTER, ARGO, and NOAA-XBT networks. MORSea is the region's longest-standing oceanographic monitoring program.

The **Dome-C HF radars** Dome C East (DCE) and Dome C North (DCN), operational since 2013 and 2019 near Concordia Station, are part of the **SuperDARN** network. They detect ionospheric convection and magnetic reconnection processes. Their data are essential to study solar wind–magnetosphere coupling and are shared daily through the SuperDARN global data mirror system.



The Dome C **Lidar observatory** was re-established in 2017, after earlier operation at McMurdo (1991–2010) and Dome C (2014). It studies polar stratospheric clouds involved in ozone depletion and water vapor reduction. As one of only two Antarctic lidar sites and a primary Network for the Detection of Atmospheric Composition Change (NDACC) station, it provides long-term atmospheric composition data.

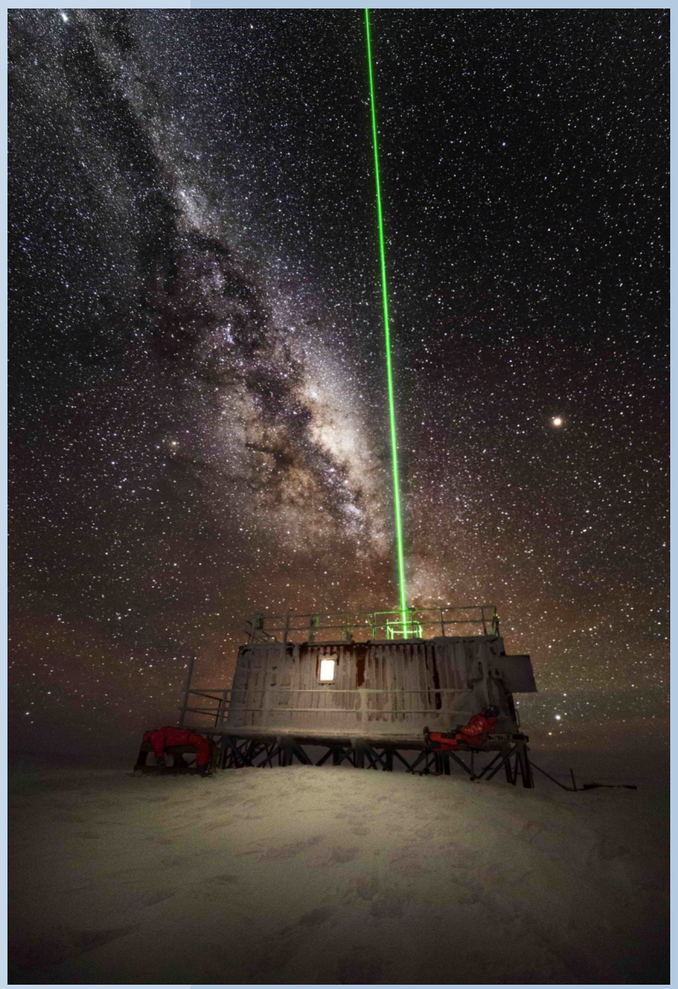
I-VOLCAN, the Italian Volcanological Observatory in Antarctica, was created in 2023 to monitor the Mt. Melbourne and Mt. Rittmann volcanoes. Using a multiparameter network, it collects and shares data with the global community. Its integration with seismic and geodetic networks supports volcanology and multidisciplinary Earth science research.

The **Antarctic Observatory for the Study of Microbial Communities in Soils and Rocks (AMICO)**, active since 2023, monitors Antarctic microbial communities and their environmental responses. Four stations in Victoria Land, aligned with SCAR's ANTOS, record data on air, rock, and soil temperature, humidity, radiation, wind, and soil moisture. The observatory contributes to research on Antarctic ecosystems and environmental change.

Established in 2023 at Dome C, the **Concordia ATmospheric CHemistry – Observatory (CATCH-O)** continuously monitors atmospheric chemistry using both online and offline methods. It tracks chemical species, including ozone and aerosols, contributing to climate change research. It supports paleoclimate projects such as EPICA and BEYOND EPICA and and it is integrated into global networks.

Solaris, launched in 2023, develops a high-frequency solar monitoring system using single-dish imaging at 100 Ghz. Based at Mario Zucchelli Station it operates up to 20 hours per day during the Antarctic summer. Initial results include solar flare tracking. Solaris will provide real-time solar data and space weather services using adapted Antarctic radio telescopes.

PERMafrost and VEGeta-tion NETwork in continental Antarctica (PERMVEGNET) established in the 2022/23 season tracks permafrost dynamics and vegetation across a latitudinal transect between 72° and 77°S in Victoria Land. It contributes to the WMO's Global Terrestrial Network for Permafrost (GTN-P), monitoring active layer thickness, soil temperature, and vegetation change. The observatory provides essential data for understanding permafrost response to climate warming in Antarctica.



Italia in Antartide *Italy in Antarctica*
Immagini della mostra