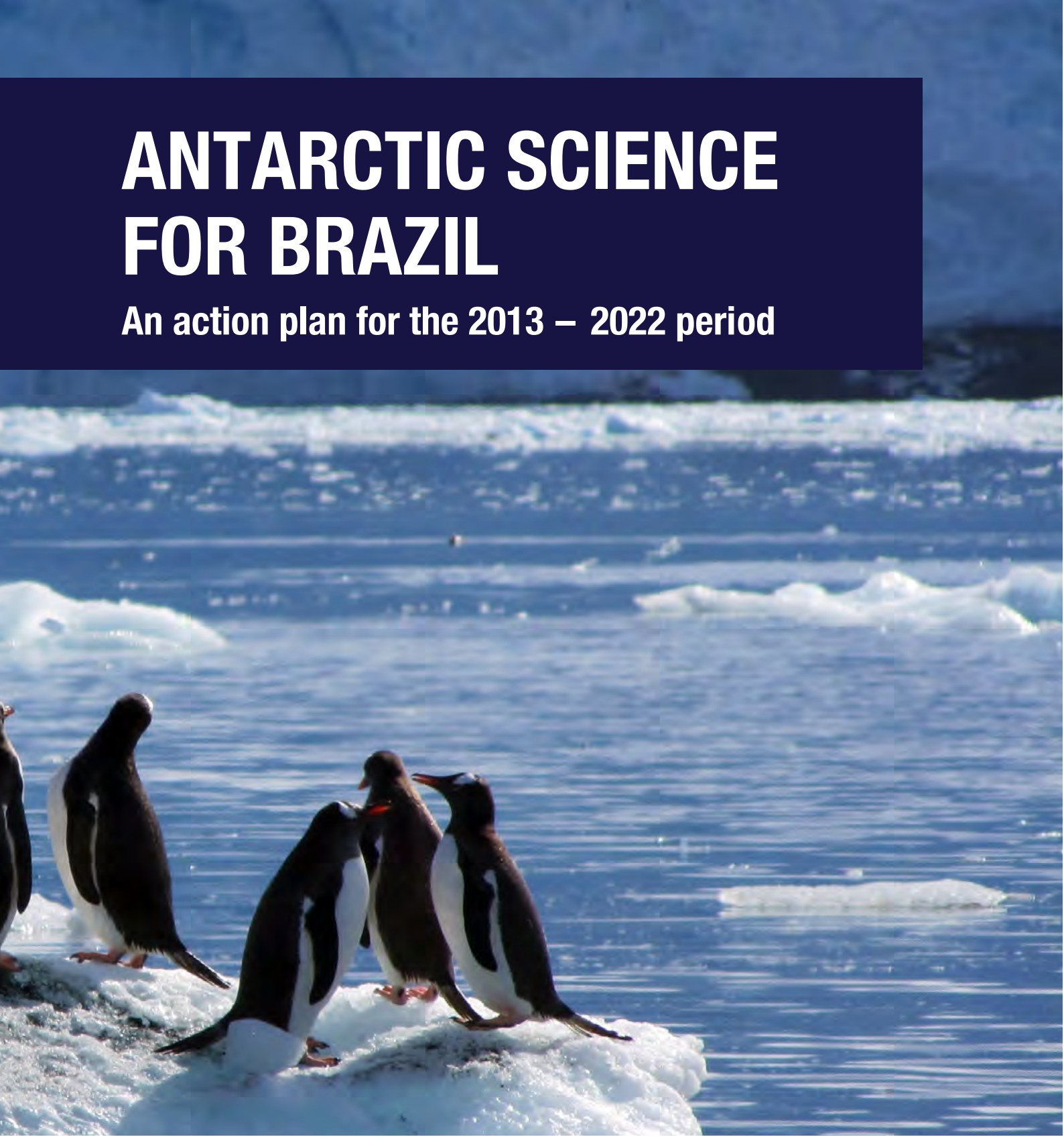
# ANTARCTIC SCIENCE FOR BRAZIL

## An action plan for the 2013 – 2022 period



Brazilian National Committee on Antarctic Research
Coordination for Ocean Affairs and Antarctica
Secretariat for Policies and Programmes on Research and Development (SEPED)
**Ministry of Science, Technology and Innovation**

**Brasilia, 2013**

Federative Republic of Brazil

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**Cover**: Gentoo penguins (*Pygoscelis papua*) over a berg bit. Photo: Adriana Dalto (UFRJ).

**Below**: Polar Ship Almirante Maximiano, Brazilian Navy. Photo: FURG.

# Antarctic Science for Brazil

## An action plan for the 2013 – 2022 period


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# PRESENTATION

**Antarctic Science for Brazil - an Action Plan for the period 2013 – 2022.**

The year of 2013 was marked, in the history of Brazilian Antarctic Program – PROANTAR, as a moment of renovated enthusiasm and concrete accomplishments, after 30 years of activities, made in 2012.

The ultimate goal of PROANTAR is to generate high-level scientific information about Antarctica and its connections with the Earth System, involving cryosphere, oceans, atmosphere and biosphere. It is within this context that one of the objectives of the National Strategy for Science, Technology and Innovation for the period 2012-2015 (ENCTI) highlights the promotion and expansion of research activities of international excellence and recognition over the Antarctic region and its adjacent area, emphasizing its implications for the South Atlantic.

The generation of new scientific knowledge ensures Brazil's active role in the decision making process on environmental conservation procedures and the future of the Antarctic continent and the Southern Ocean, in accordance with article IX of the Antarctic Treaty. The implementation of the features contained in the document "Antarctic Science for Brazil - an Action Plan for 2013 – 2022" will promote Brazil as a country to become internationally recognized for its high scientific performance in Antarctic research in that region and in the Southern Ocean. The five programs will be implemented in a sustainable manner, so as to investigate past, present and future environmental processes of impact to the polar region and its implications to South America. These programs can also contribute to an increased role of Brazil in the "Antarctic Treaty System", in particular, in the context of the Scientific Committee on Antarctic Research (SCAR), together with ongoing international cooperation within South American nations.

The definition of a scientific agenda for PROANTAR, as stated by this Action Plan, allows Brazil to clearly define its objectives pertaining to Antarctic research, from the strategic standpoint of view. It also seeks better opportunities and conditions for a sustained financial support devoted to science and research projects, notably under the aegis of National Institutes of Science and Technology (INCTs) dedicated to Antarctic research.

The presence of Member States in Antarctica started slowly, and fully oriented to an economic-territorialist dimension, but nowadays, the environmental and scientific dimensions are the ones to prevail and predominate in the Antarctic Treaty System negotiations. In this spirit, the scientific segment becomes an essential tool for the global process of decision making activities in Antarctica, and strengthens the strategic role of the Ministry of Science, Technology and Innovation (MCTI) in Brazil, as part of PROANTAR.

Finally, I wish to convey my congratulations to the Brazilian National Committee on Antarctic Research (CONAPA) for the excellent work done for the delivery of this Action Plan, that shall be fully implemented during the period of 2013-2022.

**Carlos A. Nobre**

Secretariat for Policy and Programmes on Research and Development (SEPED)

Ministry of Science, Technology and Innovation

# SUMMARY

Antarctica is one of the most vulnerable regions to climatic variations at the global scale, and the atmospheric, biological, cryospheric and oceanic processes that take place in the region directly affect the Brazilian territory. This document proposes the creation of "five scientific research thematic programs" that explore connections between Antarctic and South American environments, with a particular emphasis on processes that affect Brazil. Such programs also seek to increase Brazil's role in the Antarctic Treaty System, in particular, the Scientific Committee on Antarctic Research (SCAR)*. Programme 1 "The role of the cryosphere in the Earth system and interactions with South America" will investigate the relationship between Antarctica and the Southern Hemisphere climates, with an emphasis on the South American continent and the evolution of biogeochemical processes over the past 12,000 years. Programme 2 "Biocomplexity of the Antarctic ecosystems, their connections with South America and climate change" will give attention to the origin and evolution of Antarctic biodiversity; its distribution (past and present) and the relationships between the organisms and the environment that contribute to our understanding of the biological connections between Antarctica and South America. Finally, it will monitor the consequences of regional and global climate change and anthropogenic impacts on these ecosystems.

Programme 3 "Climate Change and the Southern Ocean" is designed to investigate physical and biogeochemical processes associated with changes in the Southern Ocean circulation and its interaction with the sea ice and ice shelves, which may have an impact on the Brazilian and the South Atlantic climates. Programme 4 "Geodynamics and geological history of Antarctica and its relations with South America" will integrate geoscientific studies to understand the mechanisms that led to the present geographical configuration of Antarctica since the fragmentation of the Gondwana continent, its isolation, and the environmental consequences resulting from tectonic, paleogeographic and climatic changes occurring over the geologic time.

Finally, Programme 5 "Dynamics of the Antarctic upper atmosphere, geospace interactions, and connections with South America" will investigate the dynamics and chemistry of the upper atmosphere and the impact of stratospheric ozone depletion on the Antarctic climate and its associated ecosystems. It will also consider the effects of the Sun-Earth interactions and the impact of high-energy astrophysical phenomena.

This Action Plan also comments on four points to ensure the quality of the S&T actions within the Brazilian Antarctic Programme (PROANTAR) over the next ten years: (1) recommendations for attention given to other areas of research, including emerging topics that are not included in the five proposed programs; (2) studies on the connections to the Arctic; (3) training needs for Antarctic specialists and their subsequent absorption in education and research centres in the country; and (4) the dissemination and social inclusion of the knowledge generated by PROANTAR.

* SCAR is an interdisciplinary committee of the International Council for Science (ICSU), and it is charged with the initiation, promotion and coordination of scientific research in Antarctica. SCAR actions are conducted by scientists nominated by their respective Antarctic research national committees.

Besides fulfilling its scientific role, SCAR also provides objective and independent scientific advice to the Antarctic Treaty Consultative Meetings (ATCM) and other organizations on issues of science and conservation affecting the management of Antarctica and the Southern Ocean.

# INTRODUCTION

After thirty years of existence, it is time to assess and restructure the objectives and scientific goals of the Brazilian Antarctic Programme (PROANTAR). Throughout this period, the performance of Brazilian researchers in the Antarctic region guaranteed the right of the nation to participate in decisions about the political future of almost 7% of the Earth's surface. Scientific advances in the period demonstrated the relevance of the region to the South American environment; however, there are still many knowledge gaps on polar processes affecting Brazil.

This document, prepared as determined by the Secretariat for Policies and Programmes on Research and Development (SEPED) of the Ministry of Science, Technology and Innovation (MCTI) to the National Committee on Antarctic Research (CONAPA), defines the priority areas for investigation through the presentation of five thematic research programmes, which should be reviewed five years after their implementation. In common, these programmes prioritise the exploration of the connections and the interactions between the Antarctic and South American environments, with an emphasis on the processes that affect the Brazilian territory. Therefore, this document is not intended to revise the PROANTAR but to define the next steps in Brazilian Antarctic science.

The working group responsible for this proposal assumes that only one cutting-edge, scientific program, with international participation, would strengthen the role of Brazil in the Antarctic Treaty System.

## VISION

**Become an internationally recognised nation for its high scientific performance in the Antarctic region and in the Southern Ocean, implement thematic programs in a sustainable manner, and investigate environmental processes and the present, past and future relationships between the South American continent and the polar regions.**

## MISSION

**Develop a research programme of excellence concerning the Antarctic region and its connections with the Atlantic Ocean and South America, helping to ensure the permanence of Brazil as a consultative member of the Antarctic Treaty.**

# RELEVANCE OF THE ANTARCTIC SCIENCE

In the global environmental system, the polar regions are just as important as the tropics. The Antarctic region, due to the presence of 90% of the planet's ice mass volume, is the Earth's main energy sink, and it plays an essential role in atmospheric and oceanic circulation and, consequently, in the Earth's climate system. It is one of the most vulnerable regions to climate variations, connected with processes occurring at lower latitudes, particularly in the South American atmosphere and the surrounding oceans. Regarding the tropics, high latitudes are connected with the genesis and dynamics of cold air masses generated on the Southern Ocean that, in the synoptic scale, advance into subtropical South America, producing low temperature events and frost in the southern states of Brazil (the "friagens" or cold fronts can reach the south of the Amazonia region). It should be mentioned that Brazil is geographically the seventh closest country to the Antarctic continent.

The sensitivity of the region to environmental changes is emphasised by various findings: (1) the depletion of the stratospheric ozone still achieves records over Antarctica (the "ozone hole"); (2) the surface and intermediate layers of the Southern Ocean are warming faster than in other oceans, and there are already indications of the transfer of these signals to the deep cells of the global ocean circulation; (3) the northern Antarctic Peninsula (the mildest sector of the continent) recorded the largest global increase in the mean surface temperature over the last 60 years (approximately 3 °C); (4) simultaneous to this warming, the distribution areas of various animal species, occurring on the west coast of the Antarctic Peninsula, are advancing more to the South; and (5) the Antarctic ice sheet shows a negative overall mass balance, contributing to the sea level rise.

Antarctica is a place for unprecedented experiments that are only possible because of its unique environmental characteristics: (i) its ice sheet, which reaches nearly 5,000 metres thick; (ii) a high continent with a dry atmosphere; (iii) seafloor and oceanographic processes under the sea ice cover that are still unknown, with endemic fauna and flora; and (iv) the presence of over 400 subglacial lakes featuring a new environment. These conditions allow researchers to obtain the most detailed record on climate and atmospheric chemistry variations over the past 800,000 years (from ice cores studies), search and register new animal species at the bottom of the Southern Ocean (specifically below ice shelves and areas permanently covered by sea ice), identify extremophiles in the Antarctic ice sheet, and conduct bioinvasion studies with the identification of invasive species, as well as detailed investigations of geospace impacts on the Earth's atmosphere dynamics by installing some of the most advanced telescopes in the geographic South Pole and by the investigation to detect subatomic particles (neutrinos).

With a perspective centred in South America, the proximity of the Antarctic region to Brazil is evident. The red dots indicate Brazilian cities with institutions that conduct Antarctic research. The location of the Comandante Ferraz Antarctic Station (EACF, 62°05'S, 58°24'W) is marked by a yellow dot on King George Island, north of the Antarctic Peninsula. The blue dot on the continent marks the location of the Criosfera 1 scientific module (84°00'S, 79°30'W). Source: Centro Polar e Climático (UFRGS).

In short, due to geographical proximity and peculiarities of the processes involving the physical and biotic environment, Antarctica directly affects South America. Conducting a cutting edge national scientific programme is therefore essential for advancing our knowledge of the Antarctic-Brazil environmental relationship, emphasising climatic and biodiversity issues.

# ANTARCTIC POLITICAL LEADERSHIP AT THE BEGINNING OF XXI CENTURY

Antarctic science has a strong political component arising from the peculiarities of the Antarctic Treaty, which, in Article IX, requires that Contracting Parties that become members by adhesion (the Brazilian case) should conduct "...substantial scientific research activity..." to retain their right to vote in the meetings that decide the future of the region, i.e., the future of the entire region south of latitude 60°S, approximately 34 million square kilometres*. Over the past decades, with the new international political framework after the Cold War, the emergence of the issue of global environmental change and internal modifications to the Antarctic Treaty System (ATS), as well as the creation of the Protocol on Environmental Protection to the Antarctic Treaty

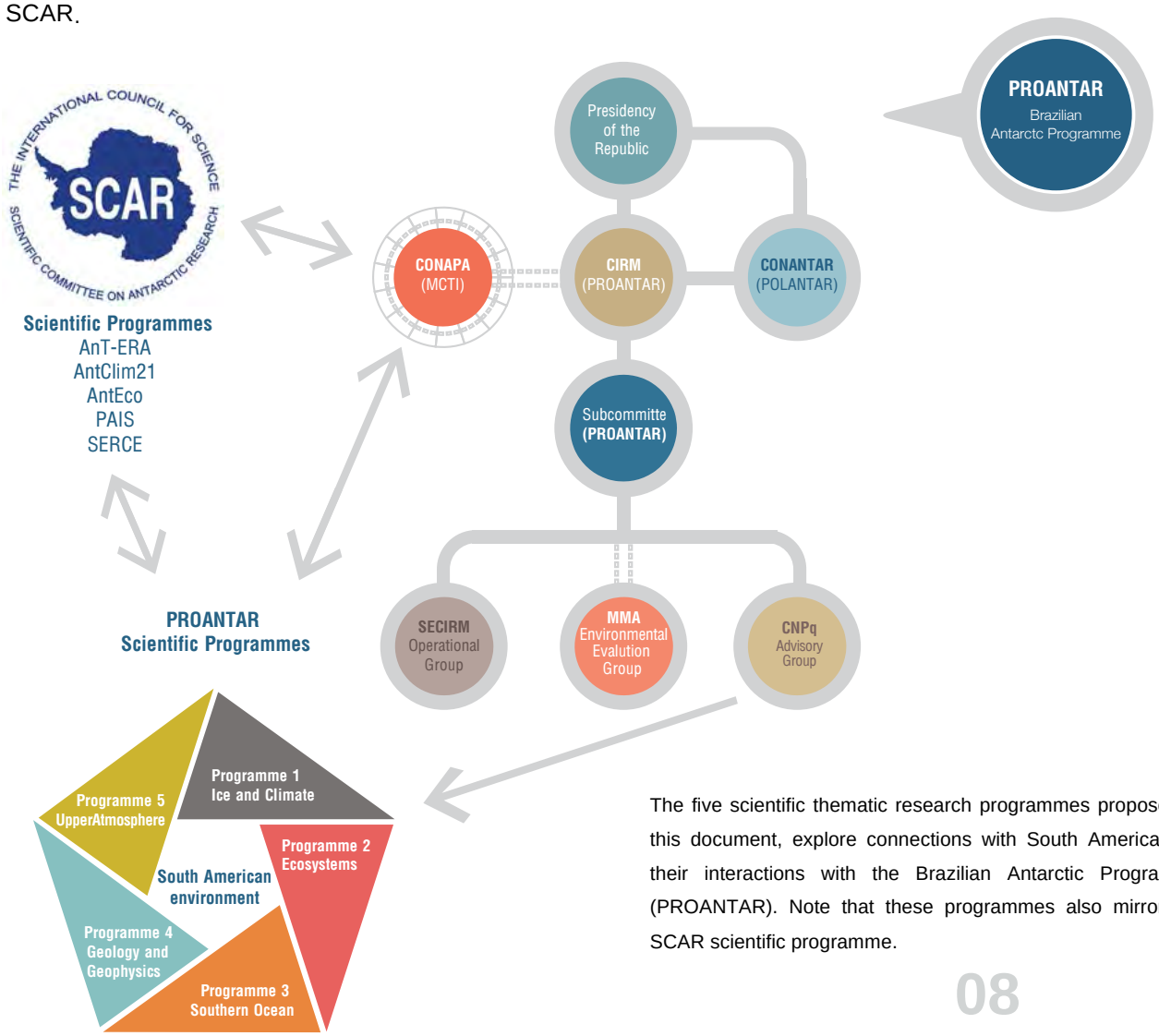
* This is the area in which the Antarctic Treaty applies and represents 7% of the Earth's surface. To the scientific community, the Antarctic Polar Region describes the entire area south of the Antarctic Polar Front Zone (mean position around 58°S), covering 45.6 million square kilometres (almost 9% of the planet's surface).

(or Madrid Protocol), gave Antarctic science a prominent role in political decisions about the region. Today, the influence of a country in ATS is linked to the quality of its scientific research programme. Thus, a relevant national performance in the Scientific Committee on Antarctic Research (SCAR), an interdisciplinary body of ICSU (International Council for Science), which has the responsibility to promote, develop and coordinate scientific research in Antarctica by providing independent scientific advice, reinforces indirectly the status of the country in the ATS.

In short, Brazil will reach an Antarctic protagonism that is proportional to its relevance on the international scene only when exhibiting a cutting-edge scientific programme that is well-structured, managerial and financially.

# THEMATIC RESEARCH PROGRAMMES

Five thematic programmes of interrelated research are proposed to answer questions that advance our knowledge about the connections between the Antarctic and Brazilian environments. These programmes propose to investigate scientific issues of regional and/or global importance and interact with each other. Achieving the goals of these programmes will substantially improve the quality of the national Antarctic intellectual production, acquiring a major role in international Antarctic forums in the process, particularly in SCAR.




The five scientific thematic research programmes proposed in this document, explore connections with South America and their interactions with the Brazilian Antarctic Programme (PROANTAR). Note that these programmes also mirror the SCAR scientific programme.

# PROGRAMME 1

## The role of the cryosphere in the Earth system and its interactions with South America

### General objective

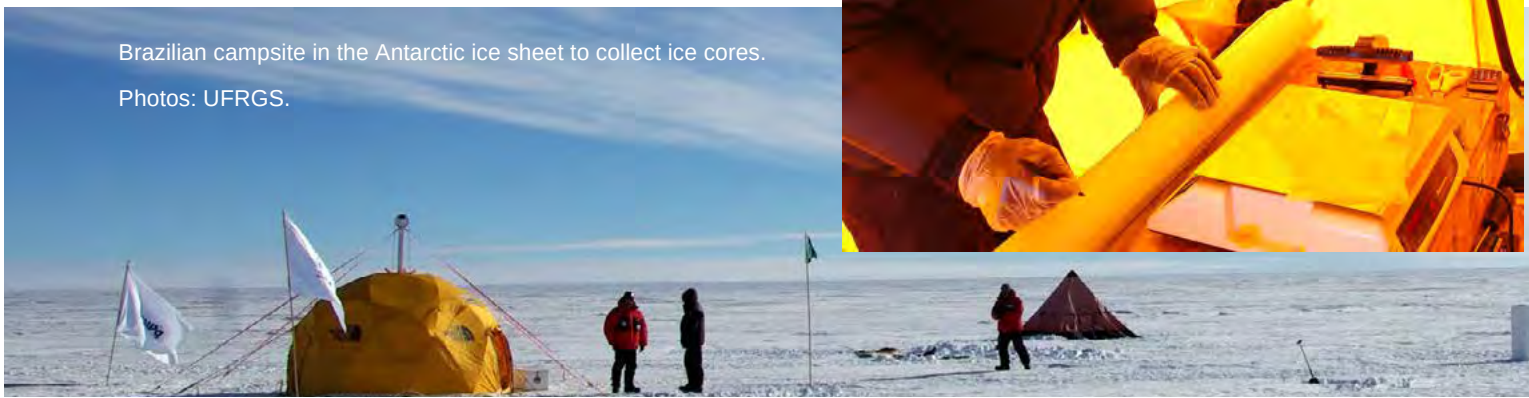
Investigate the role of the Antarctic cryosphere in the climate of the Southern Hemisphere, with an emphasis on the South American continent, in the present, in the near past and trends for the future, as well as the atmospheric chemistry evolution.

### Goals

- Investigate connections between the coupled atmosphere-cryosphere-Antarctic ocean system and the meteorological and climatic processes in South America (with an emphasis on Brazil) and the South Atlantic;
- Investigate the anthropic impact over the atmospheric chemistry of the Southern Hemisphere high latitudes;
- Investigate the effects of the Antarctic regional climatic variability over the South Hemisphere and their relationship to extreme events;
- Investigate the relationship between the Antarctic sea ice variability and the Southern Hemisphere climatic evolution during the last 12,000 years;
- Model and develop scenarios for cryospheric responses to climate changes over the next 100 years and the consequences for the Brazilian environment, particularly on cold front dynamics and sea level rise;
- Integrate data from ice cores, glacial sediments and geomorphologic observations to advance our knowledge of Antarctic glacier variations during the Quaternary;

### Milestones

- Implement a national system for monitoring and evaluating the state of ice masses and permafrost in a latitudinal transect spanning the Andes and Antarctica;
- Maintain and expand the glaciological and atmospheric chemistry research on the West Antarctica Ice Sheet;
- Establish a network of atmosphere and weather monitoring stations from 85°S to the north of the Antarctic Peninsula, linked to the South American network;
- Establish the National Ice Core Laboratory;



Brazilian campsite in the Antarctic ice sheet to collect ice cores. Photos: UFRGS.

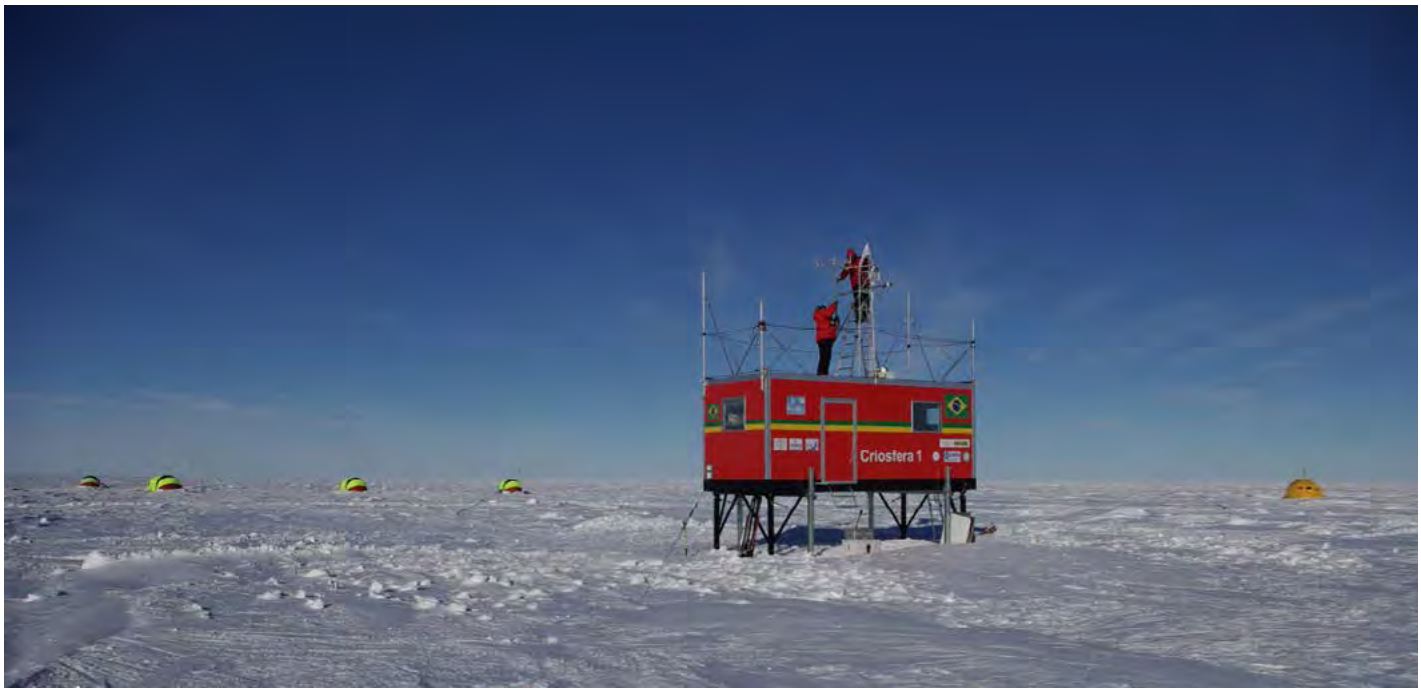
- Maintain and strengthen a national network for permafrost monitoring in Antarctica and the Andes, evaluating responses to climate change;
- Recovery of Antarctic weather, climate and paleoclimate datasets produced by Brazil and create a database.

## Rationale and relevance

Antarctica is dominated by its huge ice sheet of 13.8 million square kilometres, the Earth's main climate energy sink, controlling the mean sea level and forming the majority of the water on the ocean bottom (along with the sea ice belt that surrounds it). This ice mass also provides the best technique for the reconstruction of the climatic history and chemistry of the atmosphere via the ice core studies. Still, for the correct interpretation of the ice core record, the study of atmospheric aerosols in the Antarctic continent is essential. Monitoring stations in remote areas plays a fundamental role in more precisely determining the periods of atmospheric residence, dilution and transport of aerosols and gases on a global scale, particularly between South America and Antarctica. In the current scenario of planetary climate change and variability, the Southern Hemisphere stands out as the major controller of the atmospheric circulation in the middle and high latitudes in response to the strong presence of the Antarctic circumpolar vortex; that, in turn, results from the presence of the largest ice mass (the Antarctic ice sheet). This circumpolar vortex influences the mean atmospheric circulation coming from the west, extending from the surface to the stratosphere in the Southern Hemisphere. Climate connections between the tropics and high latitudes can promote climatic changes and variability in the Antarctic region, as well as changes in the regional climate that can influence the climate in the Southern Hemisphere, thus, contributing to South American climate variability.

Cold air masses affecting the Brazilian territory are controlled by the expansion and contraction of the Southern Ocean sea ice cover extent. Therefore, promoting research and monitoring of the Antarctic sea ice extent is essential for understanding its evolution and variability and the development of climate change scenarios for the Southern Hemisphere, with an emphasis on Brazil.

Simultaneous air and snow sampling under ultra-clean conditions. These studies are essential to quantify the transport of pollutants from South America to Antarctica. Photo: Jefferson C. Simões (UFRGS).




Scientific module "Criosfera 1", installed in the Antarctic ice sheet (84°00'S, 79°30'W) in the summer of 2011/2012. This module is fully automated and used for monitoring atmospheric chemistry and meteorological analysis. In the background is the campsite for researchers working in the module. Photo: UFRGS.

## Interactions with international scientific programmes

This proposal is concatenated to the objectives of the new SCAR programme Antarctic Climate Change in the 21st Century (AntClim21). It will also be a Brazilian contribution to the International Partnership on Ice Core Sciences (IPICS) of PAGES (Past Global Changes)/International Geosphere-Biosphere Programme (IGBP), particularly to the last 2,000 years array. The frozen soils component will contribute to the Antarctic and Sub-Antarctic Permafrost, Soils and Periglacial Environments (ANTPAS) programme.

## Interactions with programmes and actions in the nation

This programme mutually strengthens the National Institutes of Science and Technology (INCTs) of the Cryosphere (INCT da Criosfera), Antarctic Environmental Research (INCT APA) and the INCT for Climate Change, while also contributing to the actions of the Brazilian Panel on Climate Change (PBMC).

## Expected products

- Integration of the Antarctic sea ice extent variability in climatic models for South America, improving weather and climate forecasting of cold fronts advancing over Brazil;
- Completion of a shallow ice core transect, representing the last 2,000 years history of the Antarctic climate and its atmospheric chemistry, linked to similar studies along the Andean cordillera, which explore teleconnections with South America;
- Determination of the trajectory and dispersion of pollutants from South America to the interior of Antarctica, particularly for by-products generated from biomass burning;
- Interpretation of changes in atmospheric circulation, air temperature and Antarctic sea ice extent over the past 50 years, delimiting the natural and anthropogenic factors;
- Production of scenarios about the consequences of the Antarctic ice partial melting for sea level along the Brazilian coast, with an emphasis on the Antarctic Peninsula studies.

# PROGRAMME 2

## Biocomplexity of Antarctic ecosystems, their connections with South America and climate change

### General objective

The main objective is to investigate the origin and evolution of Antarctic biodiversity, their distribution and the relationships between organisms and the environment through long-term interdisciplinary research in terrestrial and marine environments, which will contribute to the understanding of the biological connections between Antarctica and South America, as well as the consequences of regional and global climate change and the recent anthropogenic influence for the biota.

### Goals

- Investigate the life cycles, physiology and autoecology of organisms, using-long term datasets to identify the structure and function of terrestrial and marine Antarctic ecosystems;
- Investigate the biodiversity, evolution, present patterns of distribution, abundance, and adaptations of organisms to the polar environment and their connections to South America;
- Identify, at morphological and molecular levels, endemic, cryptic, invasive, and key species as indicators of environmental change;
- Characterise and develop habitat models to understand and predict populations and community responses to climate variability and change, serving as an instrument of environmental management in Antarctic and sub-Antarctic regions;
- Assess the presence of invasive species and their potential effects on Antarctic communities;
- Evaluate biochemically molecular components of organisms at the base of the food chain to understand the dynamics of precursor and essential components for marine life in the Antarctic region;
- Investigate the processes and effects of the current rising temperatures and ocean acidification over the food chain and biogeochemical cycle in the Antarctic and sub-Antarctic regions;
- Investigate the effect of increased solar radiation on Antarctic organisms;
- Investigate the flow of matter and energy, as well as the biogeochemical cycles, including the carbon balance in Antarctic and sub-Antarctic regions;

Launching a Remotely Operated Vehicle – ROV in shallow waters of Admiralty Bay, King George Island. Photo: Adriana Dalto (UFRJ).

- Determine the primary production and evaluate the interactions among different trophic levels, with the aim of developing numerical models to assess nutrient transference and predict the effects of environmental changes;
- Infer phylogenetic relationships of organisms and determine their geographical distribution in Antarctica and their connectivity to South America on different time scales;
- Assess the plasticity of molecular, physiological and phenotypic processes in polar organisms;
- Investigate the biotechnological potential in Antarctic environmental matrices and organisms by taking the conservation of natural resources into account;
- Develop and implement new technologies for remote sensing in the terrestrial and marine environments, mapping subaquatic populations to understand the migration processes of animals to the Antarctic region;
- Investigate the Antarctic microflora environment to identify endemic and exogenous microorganisms and to understand the dispersion and survival mechanisms in remote areas of the continent;
- Assess the structural features of biochemical components with high performance under low polar temperatures;
- Conduct genome sequencing of the Antarctic flora and fauna and describe their protein and lipid relationships;
- Monitor and evaluate the direct and indirect occurrences of marine debris (particularly plastics) in the Antarctic ecosystem.

Sampling of red algae in the intertidal zone of King George Island. Photo: Nair Yokoya (Institute of Botany, SP).

Studies on seabird populations in the King George Island. Photo: André Lanna (UFRJ).

## Milestones

• Consolidating the knowledge of the biology and ecology of the polar species to subsidise risk assessments of alien species in Antarctica under a scenario of environmental changes;
• Structuring and strengthening the reference centres for concentrating information and biological collections of Antarctic organisms (current and fossil);
• Understanding the role of environmental changes in the functioning and services of Antarctic ecosystems.

## Rationale and relevance

Antarctica and the Southern Ocean are the centres of evolutionary divergence and adaptation to extreme environments. However, changes in environmental conditions (warming of the regional atmosphere, ozone depletion, the introduction of alien species, the global transport of contaminants, increased public visitation and extraction of natural living resources), which are unprecedented in both magnitude and rate, particularly in western Antarctica and the Antarctic Peninsula, potentially lead to long-term substantial changes in the biological communities and the functioning, services and integrity of the ecosystems. The consequences of these alterations can only be understood by elucidating how historical changes have affected communities in the geologic and recent past and by obtaining present reference data.

Therefore, the region is a natural laboratory in which research aiming to understand the effects of the past, present and projected environmental changes on biodiversity, adaptations of organisms and population, as well as the functioning and structure of the ecosystem, should be prioritised.

## Interactions with international scientific programmes

The thematic lines of this programme are in synergy with the main research questions and goals of the new Life Sciences scientific programs of the SCAR, the Antarctic Thresholds – Ecosystem Resilience and Adaptation (AnT-ERA) and the State of the Antarctic Ecosystem (AntEco) and predict interactions with the activities under the scope of the programme Antarctic Climate Change in the 21st Century (AntClim21) and Groups of Experts and Action Groups, such as the Experts Group on Birds and Marine Mammals (EGBAMM), the Continuous Plankton Recorder (CPR) and the Ocean Acidification Action Group.

## Interactions with programmes and actions in the nation

This programme interacts strongly with the two Antarctic National Institutes for Science and Technology (INCTs): the Cryosphere (INCT da Criosfera) and the Antarctic Environmental Research (INCT APA). It also interacts with the INCT for Climate Change, and two of the INCTs for marine sciences (Centre for Integrated Oceanography – INCT/Mar-COI and Oceanographic Processes of the Continental Shelf and Slope – INCT/Mar).

**Expected products**

- Biodiversity management and conservation plans in the geographic for areas where PROANTAR conducts research;
- Review and synthesis of Antarctic biodiversity that identifies the current state of knowledge and priorities for future research;
- Provision of volumes that comprise a synthesis of the knowledge on Antarctic biodiversity and environmental impacts that have been or will potentially be caused by past and future climate changes;
- Integration of knowledge about the marine biome and Antarctic environment to enhance the understanding of the mechanisms by which that region influences the productivity and biodiversity of the oceans along the east coast of South America

Production of knowledge applied to governmental management to subsidise policy and decisions on biological diversity and the sustainable use of marine living resources, as well as advising the positions of Brazilian representatives in international conventions;
• Database on the “Biodiversity and Antarctic Ecosystems” programme within the PROANTAR through collaboration with the (Brazilian) National Laboratory for Scientific Computing (*Laboratório Nacional de Computação Científica* - LNCC), and by interacting with the "Antarctic Biodiversity Information Facility" (ANTABIF);

- Development of ecological models for environmental management of Antarctic and sub-Antarctic regions for comparison with other regions of South America.

Humpback whale (*Megaptera novaeangliae*) with implanted satellite transmitter. Photo: Luciano Dalla Rosa (FURG).

Deploying a satellite transmitter to investigate patterns of habitat use of humpback whales in Antarctica. Photo: Luciano Dalla Rosa (FURG).

# PROGRAMME 3

## Climate Change and the Southern Ocean

### General objectives

To investigate physical and biogeochemical processes linked to the Southern Ocean circulation and its interactions with sea ice that may impact the continental climate, as well as the oceans next to Brazil

### Goals

- To determine the role of the Southern Ocean in the Earth's heat and freshwater balance;
- To monitor the variability of the Southern Ocean branch of the Meridional Overturning Circulation (MOC) cell;
- To investigate the role of the Southern Ocean in the stability of the Antarctic ice sheet and the links with global sea level rise;
- To investigate sea ice cover variability in the Southern Ocean;
- To model and monitor changes in the marine ecosystems due to the increase in $CO_2$ uptake by the Southern Ocean and the possible consequences to global oceans and climate, such as, for example, ocean acidification;

Iceberg tagging with support from the Brazilian Navy personnel on board RS Ary Rongel. Photos: FURG.

- To make projections of the magnitude of environmental changes in the Antarctic region for the next 100 years, taking into account the changes in the fundamental physical forcing, such as greenhouse gases concentration and the recovery of the Ozone hole.

## Milestones

- To define one (or more) oceanographic monitoring sections in the Southern Ocean to remain under Brazilian responsibility that will contribute to the implementation plans of the *Southern Ocean Observing System* (SOOS) and the CLIVAR Programme (*Southern Ocean Panel*);
- To install autonomous recorders to monitor the Weddell Sea dense waters export;
- To consolidate groups that are focusing on observational, remote sensing and modelling aspects of sea ice, ice shelves and ice-ocean interactions.;
- To model the evolution and variability of the Southern Ocean and its interaction with the South Atlantic during the last glacial-interglacial cycles;
- To support innovation and the development of new technological tools to study and monitor the various aspects of the Southern Ocean environment and ecosystems. For example, AUVs (Autonomous Underwater Vehicles), Sea Gliders and Acoustic Techniques (ocean tomography, underwater communication, etc.).

Oceanographic sampling on board Brazilian Navy Polar Ship Almirante Maximiano. Photo: FURG

## Rationale and relevance

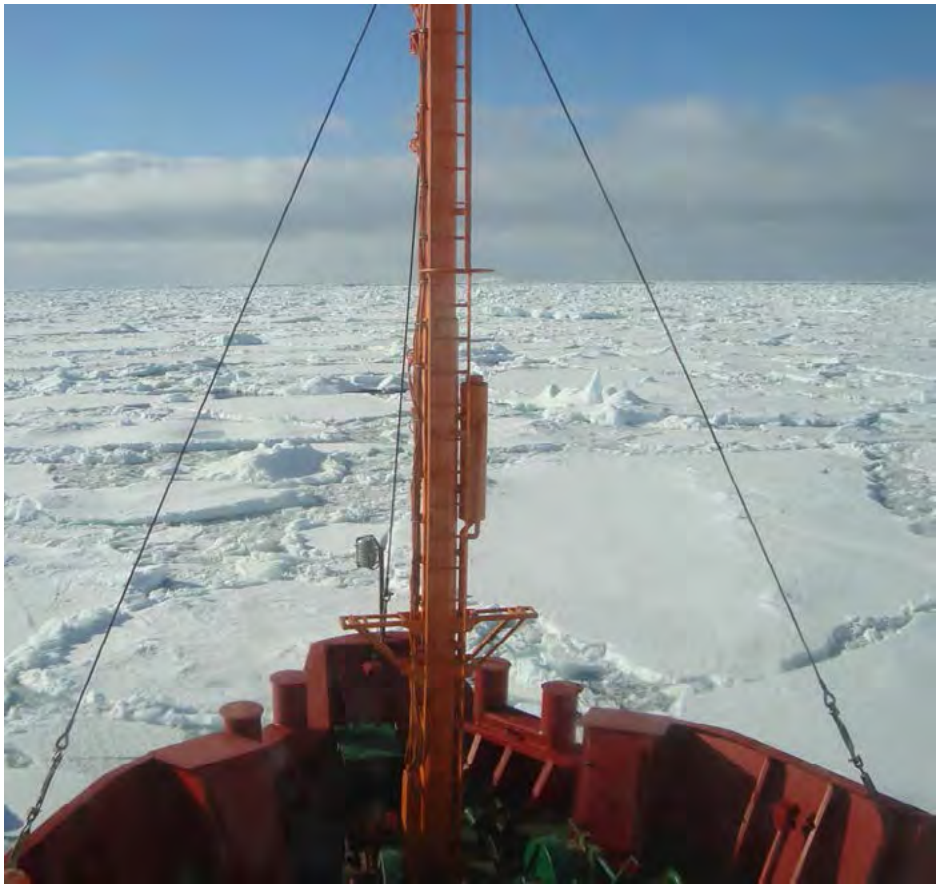
Significant physical and biogeochemical changes are already underway in the Southern Ocean. The surface and intermediate layers (down to 2000 m) are warming at rates that exceed those in the other ocean basins. At the same time, surface salinity in the Antarctic regional seas has been consistently decreasing in several areas, probably as a result of the changes in the precipitation regimes and in the rates of freshwater inflow from ice shelves. Many of those changes have already propagated towards the deep ocean, where significant heating of the Antarctic Bottom Water has been recently reported. Despite the hard evidence, large uncertainties are still associated with the estimates of those alterations, mostly due to the lack of consistent observations and time-series, as well as dedicated modelling experiments. Remote sensing observations reveal important changes in several aspects of the Southern Ocean dynamics, such as sea level rise, regional changes in sea ice extent and meridional changes in the position of the main frontal systems and thus changes in the position of the Antarctic Circumpolar Current main jet.

The increase in $CO_2$ uptake in the oceans is fuelling water acidification and hence decreasing the availability of calcium carbonate, which is important to many marine species. The exact amount of $CO_2$ absorbed by the Southern Ocean is still unknown, but there is evidence that the Southern Ocean ecosystems are among the first to suffer from this excess uptake. Moreover, the Southern Ocean is extremely efficient in absorbing anthropogenic heat and $CO_2$ (approximately 40% of the total $CO_2$ inventory in the global ocean is located south of 30$^{o}$S). Additionally, the Southern Ocean is instrumental for global ocean life, as it is believed that approximately 75% of the primary productivity that takes place to the north of 30$^{o}$S is sustained by nutrients coming from southern latitudes.

Finally, given the importance and vulnerability of the Southern Ocean, changes in the regional atmosphere-ocean-cryosphere coupled system may have profound impacts on the local, regional and even global ecosystems.

## Interactions with international scientific programmes

This programme is in line with the most recent international initiative to study, observe and monitor the Southern Ocean, the Southern Ocean Observing System (SOOS), which was constituted in 2011 under the umbrella of SCAR and the Scientific Committee on Oceanic Research (SCOR). The SOOS scientific community emphasises the necessity of coordinated actions and observations to speed up the understanding of several aspects of the Southern Ocean dynamics and ecosystems and their roles in the global Earth system.



Brazilian Navy RS Ary Rongel, sailing though sea ice. Investigation of the seasonal variability of this ice is essential for improving climate and weather forecasts for Brazil. Photo: FURG.

Gentoo penguins (*Pygoscelis papua*) over a berg bit. Photo: Adriana Dalto (UFRJ).

## Interactions with programmes and actions in the nation

The current programme helps to direct the actions of the two largest Brazilian Antarctic research networks on the Southern Ocean: INCT da Criosfera and INCT APA. Furthermore, the alignment of this programme with the international community, particularly through SOOS, will support other national initiatives and related forums, such as the Brazilian Panel on Climate Change (PBMC), INCT for Climate Change and INCT/Mar (Ocean Research). Those links are expected to grow on various topics, such as sea level rise, Southern Ocean acidification and their impacts in the Brazilian coasts and Economic Exclusive Zone.

## Expected products

- Development and implementation of regional high-resolution models for investigating the interaction and feedback processes in the air-sea-ice system in the Southern Ocean and their interactions with the South Atlantic;
- Quantification of the hydrographic variability of the Weddell Sea, the Western Antarctic Peninsula continental shelf and the Bransfield Strait;
- Quantification of the processes and links between sea ice and the adjacent ocean and atmosphere dynamics, focusing on their implications to regional and global climate;
- Validation of Coupled Climate Models for the Antarctic Region during the 20$^{th}$ century;
- Analysis of climate projection and the impacts of changes in the Antarctic and Southern Ocean environment and the dynamics in the South Atlantic.

# PROGRAMME 4

## Geodynamics and geological history of Antarctica and its relations with South America

### General objective

Promote and integrate geoscientific studies to advance the understanding of the mechanisms responsible for the present geographic configuration of the Antarctic continent, from its formation to the rupture of the Gondwana megacontinent, and its present isolation, along with the environmental consequences for South America resulting from the paleogeographic, tectonic and climatic changes that took place along the geological time, much of them recorded in the fossil flora and fauna.

### Milestones

- Increase the understanding of the role of the Antarctic Region (the land mass and ice cover) on the paleoclimatic and stratigraphic evolution of the South America and the South Atlantic;
- Establish a Brazilian Antarctic Programme geodata base, including petrological, lithogeochemical, paleontological, and geochronological information;
- Effectively broaden the Brazilian geologic research activity to areas of scientific interest in West Antarctic interior.

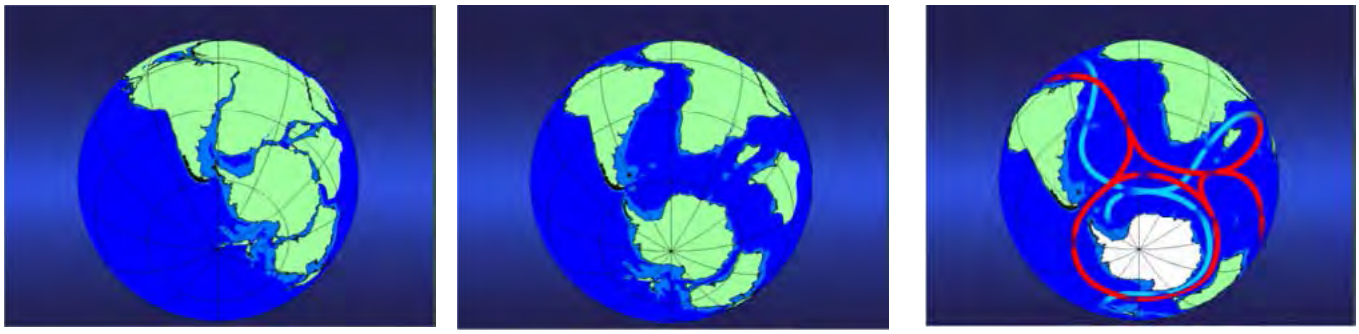
### Goals

- Investigate the record of the Gondwana supercontinent breakup and the impact of the Antarctic geologic compartmentalisation on the South Atlantic opening processes;
- Investigate the Antarctic Cenozoic fossil record, its evolution and adaptation to the climatic/environmental changes;
- Analyse the Antarctic paleoclimatic evolution since the opening of the Drake and Tasmania Straits and its impact on the South Atlantic marine biota;
- Investigate the Antarctic glacial history and its role on the Cenozoic stratigraphic record;
- Characterise the tectonic, stratigraphic, paleo-biogeographical, paleo-oceanographic, paleontological and the sediment signature of Antarctica in the evolution of the South Atlantic Ocean and its connections with the Austral Ocean from its opening to the present day;
- Apply the knowledge of Antarctic paleoclimate, derived from paleontological and paleogeographic studies based on sediment cores, to calibrate climatic, oceanographic and ecologic sensibility to current and future climate changes;
- Investigate correlations between the Antarctica and South America Phanerozoic sedimentary sequences;
- Analyse the stratigraphic evolution of Gondwanic western margin.

## Rationale and relevance

Antarctica was the central part of the Gondwana supercontinent and shared a common geologic history and paleoclimate with the continents in the southern hemisphere. After the fragmentation of the supercontinent, Antarctica and the surrounding seafloor remained under the influence of geologic processes that led to the current physical conformation. Understanding these processes is important for comprehending the geologic and past climatic behaviour, helping to generate scenarios for the future.

The final breakup of the Antarctic - South America connection, approximately 35 million years ago, allowed the establishment of circumpolar circulation that conditioned the Antarctic climate from the late Cenozoic. The characteristics of this movement and teleconnections established between the Antarctic and tropical regions of the Atlantic are factors that control modern climate, which are still poorly understood. The nature of this evolution can be obtained through the integration of fieldwork to obtain information on the tectono-stratigraphic evolution and the depositional environments of Paleozoic and Mesozoic ages in West Antarctica. The impact of these events in the oceans, particularly in the South Atlantic, can be evaluated by studying the geologic and geophysical record. In particular, the tectonic evolution of sea passages (seaways) and the margins of Antarctica in the Scotia Sea, its outlying islands and the Weddell Sea are important for understanding the past links with South America.



**180 million years ago** **90 million years ago** **30 million years ago**

Investigating the rupture processes of the Gondwana continent is essential to understanding the opening of the South Atlantic and its sedimentary basins. Furthermore, it is critical knowledge for understanding how the global climate has come to the current state. Source: SCAR.

The evolution of the biogeographical distribution of lineages that gave rise to the present Antarctic fauna is also a result of these changes, and their study can contribute to the refinement of when, how and where such changes occurred, as well as comparing the survival strategies of the organisms during warmer and colder periods with the present strategies. The interdisciplinary interaction between geological, glaciological, climatological and biological communities will be essential to the advancement of knowledge in this area.

The interest in the geologic evolution of the South Atlantic has gained prominence in recent years due to the discovery of giant oil fields on both sides of this ocean, with petroleum systems that formed from the period immediately preceding the Gondwana breakup and the separation between South America and Africa (lower Cretaceous) to more recent periods of the distinctly marine phase (Cenozoic). Thus, understanding the role of the Antarctic in the evolution of these sedimentary deposits off the Brazilian coast has economic importance, as well as scientific importance.

## Interactions with international scientific programmes

These investigations will contribute to the new SCAR programme Solid Earth Response and Cryosphere Evolution (SERCE) and may be associated with the international ANDRILL Programme (ANtarctic Geological DRILLing), which will perform various geologic drilling in the Antarctic continental shelf to investigate climate variability over the past 56 million years (early Eocene). It is expected to expand joint fieldwork with geologists from the Instituto Antártico Argentino (IAA), the Instituto Antártico Chileno (INACh), the British Antarctic Survey (BAS) and Institut Polaire Français Paul Emile Victor (IPEV).

## Interactions with programmes and actions in the nation

This programme provides interactions with INCT of Tectonics and the two INCTs for the Seas - INCT Mar (e.g., Gondwana project - UFRJ / Petrobras), and CPRM - Geological Survey of Brazil.

A Low Head Member (Polonez Cove Formation) outcrop, King George Island. These rocks record the West Antarctica climatic evolution during the middle Cenozoic. Photo: USP.

**Expected products**

- Advance the knowledge of the role of geological, glaciological and climatological processes in the evolution of fossil and present flora and fauna of Antarctica;
- Paleo-oceanographic reconstruction, including the analysis of the South Atlantic deep waters originating in the Antarctic Region, its role in the sculpture of the South America continental margin and its climatic evolution over geologic time;
- Analysis of oceanic paleoclimate paleocirculation interaction;
- Explanation of the tectonic evolution of the southern portion of Gondwana.
- Kinematic analysis of the separation of Antarctica from South America;
- Integration of geophysical, geological and paleontological studies in Southern Ocean studies to understand its past and present influence on the continental margin and on mineral resources outside the Antarctic region, more specifically on the coasts of South America and Africa;
- Development of a database of georeferenced geological data of the Antarctic continent.

Brazilian geologists examining a Scotia metamorphic complex rock outcrop, in Coronation Island, South Orkneys. The metamorphism and deformation ages are related to pre-breakup events of the Gondwana and the Andean uplift. Photo: Felipe Tavares (CPRM).

A Scotia metamorphic complex rock outcrop, south coast of Coronation Island, South Orkneys. Photo: Luiz Simões (USP).

# PROGRAMME 5

## Dynamics of the Antarctic upper atmosphere, geospace interactions, and connections with South America

### General objective

Investigation of the dynamics and chemistry of the upper atmosphere and the stratospheric ozone depletion impact over the Antarctic climate, considering the effect of Sun-Earth interactions and high-energy astrophysical phenomena. Establishing the role of these processes in long-term climate change in Antarctica and their connections with South America.

### Goals

- Investigation of the upper atmosphere dynamics and chemistry in Antarctica, and its water vapour to support the climate forecast models and its connection with South America;
- Investigation of the role of the ozone depletion in the Antarctic and South American climate;
- Investigation of the vertical coupling and energy exchange among different atmosphere layers to evaluate their role in the characteristics of the ozone depletion;
- Investigation of the Sun-Earth interaction influence in the Antarctic upper atmosphere and its role in long-term climate change;
- Ground-based astronomical observations in the electromagnetic spectral range from the near ultraviolet to microwaves to investigate dark matter, exoplanets and background cosmic noise;
- Astronomical observations in the Terahertz range from stratospheric platforms flying in circumnavigation balloons;
- Monitor the flux of cosmic rays.

### Milestones

- Consolidation of the existing network to monitor the ozone depletion from Antarctica to the south of Brazil;
- Continuation of the investigation of the Sun-Earth interactions and their effects on the dynamics and chemistry of the upper atmosphere in the Antarctic Peninsula, expanding to the continental region, with special attention to the auroral oval, where geospace phenomena impacts over the atmosphere are more pronounced;
- Characterise and model the long-term effects of the Sun-Earth interactions on upper atmosphere dynamics and ozone depletion.

Antennas and the laboratory for ionospheric studies at Keller Peninsula, Admiralty Bay, King George Island, operating near to the Brazilian Comandante Ferraz Antarctic Station.

## Rationale and relevance

Antarctica is an advantageous place to study the nearby geospace because it is a region where the atmosphere is directly connected with the solar wind, which is a beam of charged particles (electrons and ions). Solar particles hitting the terrestrial atmosphere emit lights (auroras) and heat, and their interaction with the magnetic field produces geomagnetic storms, which may disturb shortwave radio transmissions and satellite communications, and may produce fluctuations in the long distance electric energy networks. To better characterise the Sun-Earth interaction, it is necessary to have networks of instrumentation on a large spatial scale, which demand international multi- and interdisciplinary projects. To fully understand the geospace physics, it is also necessary to have simultaneous, coordinated observations in the Arctic and in Antarctica, as well as over the South America sector (where the South American Magnetic Anomaly is located today over southern Brazil).

These inter-hemispheric, coordinated observations are important to understand the effects that disturb our atmosphere local and globally. On the other hand, coordinated observations of different atmospheric layers are necessary to understand their vertical coupling and energy exchange. This information will give a better understanding of the ozone layer dynamics and more accurate weather forecast time and climate models.

Sky conditions in Antarctica, especially on the ice sheet plateau, allow ground base observations with very high transparency in the near ultraviolet to microwave spectral range; thus, it is an excellent place to study dark matter and exoplanets. It is also the most favourable place to detect cosmic rays because of its proximity to the magnetic pole. At higher latitudes, even lower energy cosmic rays can reach the ground more easily than at higher latitudes. Many vanguard astronomical projects are being transferred to the polar regions, particularly to the Antarctica interior, because of these factors.

## Interactions with international scientific programmes

The research themes related to this programme are in accordance with the following SCAR activities: (1) Antarctic Atmosphere: the study of ozone layer and atmospheric waves (Expert Group Interhemispheric Conjugacy Effects in Solar-Terrestrial and Aeronomy Research - ICESTAR), water vapour content studies (Expert Group *GNSS Research and Application for Polar Environment* - GRAPE/SCAR), and cloud cover and long radiation (Action Group *Clouds and Aerosols*). (2) Sun-Earth interactions research, specifically the study of solar phenomena impacts in the terrestrial ionosphere/magnetosphere (GRAPE, ICESTAR and the programme Solid Earth Response and Cryosphere Evolution - SERCE).

In the Astronomy and Astrophysics area, it is possible to have high sensitivity observations to study dark matter and background cosmic noise, search for exoplanets, and detect neutrinos and cosmic rays in the context of the Astronomy and Astrophysics from Antarctic (AAA) programme, along with the study of the solar radiation in the Terahertz frequency range from stratospheric platforms that are flying in circumnavigation balloons.

### Interactions with programmes and actions in the nation

This programme interacts significantly with the two Antarctic INCTs (INCT da Criosfera and INCT APA).

### Expected products

Ionosonde installed at the Keller Peninsula, King George Island, near to the Comandante Ferraz Antarctic Station. Photo: Emília Correia (INPE/UPM).

- Monitoring and modelling the geospace phenomena effects in the terrestrial atmosphere with the objective of forecasting atmospheric disturbances at short and medium time scales, which affect telecommunications, high precision positioning (GNSS), and energy electric blackouts;
- Preventive monitoring of the solar radiation and ozone depletion ("ozone hole") in Antarctica due to atmospheric chemistry changes and to create preventive models about socioeconomic, public health, agricultural and environmental impacts;
- Monitoring of water vapour content, an important greenhouse parameter, to help evaluate its role in long-term climate change.

# NEW RESEARCH AREAS

Over the next ten years, Antarctic science will advance quickly through the intensive use of new technologies. These advances are exemplified by the investigations of more than 400 subglacial lakes, the search for extremophiles in these lake environments and other isolated parts of the continent, the deployment of an astronomical equipment network in the Antarctic plateau, and the use of equipment to monitor the atmosphere around the Antarctic continent. One should also be aware of the research possibilities in the social and human science disciplines, such as archaeology, sociology of science, political geography and international relations, which have become of interest from the International Polar Year (2007-2009) onwards. Investigations into vectors of communicable diseases, Antarctic pathogenic microorganisms, psychology of groups under extreme stress, show the importance of research in the area of Human Biology and Polar Medicine.

Thus, it is recommended that some of the Brazilian Antarctic Programme S&T funds should be dedicated to these new areas of research and innovative projects that are possibly not included in this Plan of Action.

# CONNECTIONS TO THE ARCTIC

The Antarctic scientific community is interested in deepening cooperation with researchers from the Arctic region at the moment that evidence of connections between the two polar regions accumulate, such as the deep ocean circulation, climate variability processes and the Sun - Earth interaction with the atmosphere. In recent years, this interest has intensified in the face of rapid changes in the Arctic, including the abrupt reduction of sea ice cover. Such changes have global implications and offer available models for similar processes that may occur in Antarctica. Thus, SCAR has increased collaboration with the International Arctic Science Committee (IASC), a non-governmental organisation.

These rapid Arctic environmental changes will also affect the global economy, particularly considering the opening of new sea routes (Northeast Passage) and the intense exploitation of mineral resources in the region.

When considering that these environmental changes and the resulting political modifications will have global impacts, it is recommended that Brazil acts as an observer to the IASC, particularly on issues of climate change and geological exploration.

# TRAINING AND INTEGRATION OF ANTARCTIC SPECIALISTS IN THE BRAZILIAN S&T SYSTEM

At this time, the first generation of Brazilian researchers, specially trained in Antarctic science, will be close to retirement age in the next ten years. Some of the emerging areas of polar science still have few or no researchers in Brazil (e.g., experts in modelling sea ice extent variations and its coupling to climate models for Brazil; extremophile invertebrates and many other areas of Polar Biology). Joint action between the Brazilian National Council for Scientific and Technological Development (CNPq) and the Coordination for the Improvement of Higher Education Personnel (CAPES) is necessary to provide training grants dedicated to polar issues or the inclusion of this issue to existing programs such as "Science Without Borders", guaranteeing the continuity of several research groups associated with PROANTAR and increasing its international presence.

The lack of opportunity for Antarctic specialists in Brazilian educational and research institutions is worrisome. Few early career scientists

are able to continue their research on Antarctic themes. Therefore, it is important to ask the Ministry of Education (MEC) to encourage Federal Institutions of Higher Education (IFES) to hold contests for professors in Antarctic disciplines.

The proponents of this plan note that investment in these two actions, which include staff training and public competition for university positions, is low. The allocation of training grants and job placement for specific Antarctic disciplines within the period of this Action Plan would prove to be of significant value for our research development.

# DISSEMINATION AND SOCIAL INCLUSION OF KNOWLEDGE

It is essential to increase the visibility of the scientific part of PROANTAR, both in the Brazilian society and the international scientific community. In particular, it is important to strength the presence and relevance of Antarctic themes within government research funding agencies, apart from scientific societies. In fact, after thirty years, the programme still lacks the actions needed to disseminate its activities and scientific advances. In this sense, the development of an integrated media plan (using the various platforms, media and social networks), which is directed to the domestic audience as well as the general public, is essential to strengthen the visibility of scientific production promoted by PROANTAR.

Of course, for increased visibility in the scientific community, an increase in the publications of our Antarctic research results in international journals with high impact factors is essential. On this point, funding agencies should give more weight to proponents of new projects with Antarctic scientific production of high-impact. The new call for proposals should have the widest possible dissemination among national scientific societies, ensuring greater transparency and opportunity, as well as involving new researchers and research groups.

These new projects should have associated education and outreach components, including, for example, dissemination in the electronic media, social networks and distance education projects at high school and university levels.

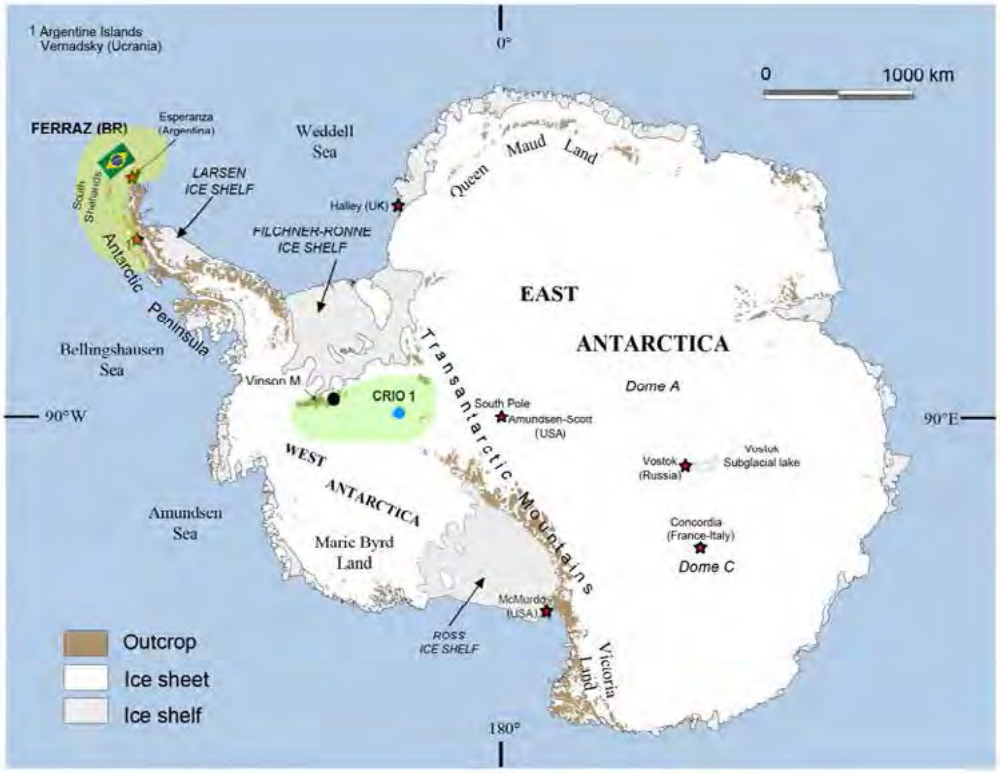
All of the listed actions will be more effective if they are supported by national scientific associations, such as the Brazilian Academy of Sciences (ABC), the Brazilian Society for the Advancement of Science (SBPC) and the Association of Polar Early Career Scientists - Brazilian committee.

The Antarctic continent and Brazil at the same geographic scale. Source: Centro Polar e Climático (UFRGS).

# LIST OF ACRONYMS

| | |
|---|---|
| AAA | Astronomy and Astrophysics from Antarctic/SCAR |
| AnT-ERA | Antarctic Thresholds – Ecosystem Resilience and Adaptation/ SCAR |
| ANTABIF | Antarctic Biodiversity Information Facility |
| AntClim21 | Antarctic Climate Change in the 21st Century/ SCAR |
| AntEco | State of the Antarctic Ecosystem/ SCAR |
| ANTPAS | Antarctic and Sub-Antarctic Permafrost, Soils and Periglacial Environments/ SCAR |
| APECS - Brazil | Association of Polar Early Career Scientists - Brazilian committee |
| CAPES | Coordination for the Improvement of Higher Level Personnel/Ministry of Education |
| CENPES | Research Centre Leopoldo Américo Miguez de Mello, Petrobras |
| CLIVAR | Climate Variability and Predictability/ World Climate Research Programme |
| CNPq | Brazilian National Council for Scientific and Technological Development |
| CPR | Southern Ocean Continuous Plankton Recorder/ SCAR |
| EGBAMM | Expert Group on Birds and Marine Mammals/ SCAR |
| FURG | Federal University of Rio Grande |
| GNSS | Global Navigation Satellite System |
| GRAPE | Global Navigation Satellite Systems Research and Application for Polar Environment)/ SCAR |
| IASC | International Arctic Science Committee |
| ICESTAR | Interhemispheric Conjugacy Effects in Solar-Terrestrial and Aeronomy Research/ SCAR |
| IFES | Federal Institutions of Higher Education |
| INCTs | (Brazilians) National Institutes of Science and Technology |
| INCT APA | National Institute of Science and Technology of Antarctic Environmental Research |
| INCT da Criosfera | National Institute of Science and Technology of the Cryosphere |
| INPE | (Brazilian) National Institute for Space Research |
| IPICS | International Partnership on Ice Core Sciences (PAGES-IGBP) |
| MCTI | Ministry of Science, Technology and Innovation |
| PAIS | Past Antarctic Ice Sheet Dynamics/ SCAR |
| SCADM | Standing Committee on Antarctic Data Management)/ SCAR |
| SCAGI | Standing Committee on Antarctic Geographic Information)/SCAR |
| SCAR | Scientific Committee on Antarctic Research / International Council for Sciences (ICSU) |
| SCOR | Scientific Committee on Oceanic Research/ International Council for Sciences (ICSU) |
| SERCE | Solid Earth Response and Cryosphere Evolution/ SCAR |
| SOOS | Southern Ocean Observing System |
| ATS | Antarctic Treaty System |
| UERJ | State University of Rio de Janeiro |
| UFRGS | Federal University of Rio Grande do Sul |
| UFRJ | Federal University of Rio de Janeiro |
| UPM | Mackenzie University - São Paulo |
| USP | University of São Paulo |

# MAP OF THE BRAZILIAN ANTARCTIC PROGRAMME OPERATION AREA




**Map of Antarctica:**

Area of expertise of the Brazilian Antarctic Programme (PROANTAR) in maritime Antarctica (in yellow). A Brazilian flag on King George Island identifies the site of the Comandante Ferraz Antarctic Station (62°05'S, 58°24'W). This proposal also includes the maintenance of the Brazilian geoscientific research conducted within the Antarctic ice sheet (area marked in green) from the Union Glacier runway (marked with black dot) and including support to the Module "Criosfera 1" (Crio 1, blue dot, 84°00'S, 79'30°W). Source: Centro Polar e Climático (UFRGS).

Antarctic Emergency Modules at the site of the Comandante Ferraz Antarctic Station, Admiralty Bay, King George Island, installed in the summer of 2012/2013. Source: SECIRM.

Back cover: Scientific camping side in the Antarctic ice sheet (79°S). Photo: Jefferson C. Simões (UFRGS).

Below: 3D-Vision of the new Comandante Ferraz Antarctic Station to be built at Admiralty Bay, King George Island. Source: Estúdio 41 Arquitetura.

Ministry of
**Science, Technology and Innovation**