What Antarctic Science is Funded by National Antarctic Programs?

International Planning for Antarctic and Southern Ocean Science at the Dawn of the 21st Century

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Future directions in Antarctic and Southern Ocean science will in large part be determined by current and planned investments by National Antarctic Programs, the global funders of Antarctic research. In order to provide a sound basis for projecting what the Antarctic science landscape will look like in two decades, it is important to understand the strategies and research that are presently supported, or planned, in the next 10 years by those that manage and allocate financial resources. While current research provides the "stepping stones" to the future, it can be assumed that unforeseen discoveries and technological advances may re-direct international scientific efforts and focus in unexpected ways that may not be predictable. This review of recent funding trends provide a prism to view the future but are not intended to restrict or inhibit an expansive and imaginative look beyond the horizon.

[This review is by MC Kennicutt II, D Liggett, C Havermans, and R Badhe]

INTRODUCTION

For more than five decades, Antarctica and the Southern Ocean have been a geographical focus for scientific investigations that range in subjects from genomics to astrophysics. The International Geophysical Year 1957-1958 marked the beginnings of the modern era of Antarctic science and a permanent presence of scientists at stations across Antarctica. Antarctica has been, and remains, of great scientific interest heightened by geopolitical aspirations (see e.g. Bergin et al, 2013; Fogarty 2011). Science is often the instrument for projecting national interests in Antarctica while also serving as a source of knowledge to influence and inform public policy-making (Elzinga 2009). This has never been more important as the pressures and stresses on Antarctic continue to mount and the political and international context becomes increasingly complex (Chown et al., 2012; Hemmings, 2009; Dodds, 2010; Joyner, 2011). Global resources for Antarctic science have witnessed disproportionate and unprecedented pressures due to the cost of conducting science in such a remote and distant location during the recent global economic downturn as national investments of all kinds are critically judged on return and value (Brady, 2012a).

Antarctica is the only continent and ocean on Earth set aside for scientific investigations, cooperation, and peace by international agreement. Since the signing of the Antarctic Treaty in 1959 by twelve (12) states, the contextual framework that the Treaty Parties operate within has become increasingly multi-dimensional and multi-faceted over the intervening decades. In the last half-century, thirty-eight (38) more states have acceded to the Treaty, the Treaty has evolved into a System of conventions and protocols, and an ever increasing number of scientists, support personnel, tourists, vessels, and air transports visit the region each year. Conventions have been adopted to protect marine mammals (seals) and birds (petrels, albatrosses) and other marine living resources. A Protocol on Environmental Protection to the

Antarctic Treaty was adopted in 1991 in response to a failed convention regulating mineral resource exploitation and increasing calls for the protection and conservation of Antarctica. This so-called "Madrid Protocol" included the creation of the Committee on Environmental Protection (CEP), a major innovation and refinement of how Antarctica is internationally managed through consensus.

In 2013, the Antarctic Treaty had fifty (50) signatory parties. There were thirty-seven (37) national and nine (9) International Council of Science (ICSU) members of the Scientific Committee on Antarctic Research (SCAR) and twenty-eight (28) national members of the Council of Managers of National Antarctic Programs (COMNAP). There have been thirty-six (36) Antarctic Treaty Consultative Meetings (ATCM), sixteen (16) CEP meetings, thirty-two (32) SCAR Delegates Meetings, and twenty-five (25) COMNAP Annual General Meetings between 1961 and 2013. Central to these activities is the conduct, support and management of science and research south of 60° S Latitude.

THE REVIEW

In this review, national strategic planning documents and other reports are summarized to define international trends and themes that have and will guide investments in Antarctic science early in the 21st century and beyond. National scientific agendas vary widely as priorities are set by each nation in response to national needs, interests, resources, and scientific and logistical capabilities. The motivations for maintaining a scientific program and presence in Antarctica differ amongst nations fundamentally influencing the magnitude, structure and type of investments. How scientific programs are administered, managed, and funded is also variable from one country to the next reflecting cultural differences in the conduct of science and differing views of Antarctica and its intrinsic value. Over the years, common scientific themes have been emerged as the focus for the extensive and far-reaching scientific investigations conducted in the region.

This summary defines the near-term directions of Antarctic and Southern Ocean science to inform the "1st SCAR Antarctic and Southern Ocean Science Horizon Scan". The objective of the Science Horizon Scan is to identify the most important scientific questions that should be addressed by research in, and from, Antarctica in two decades. The method of "Horizon Scanning" will be used to develop a collective community view of what the most important scientific questions in Antarctic and Southern Ocean science will be. It is expected that Horizon Scan outcomes will assist national programs in aligning future investments in Antarctic research and infrastructure to most effectively address those research questions that the community believe are of highest priority and greatest urgency.

WHY DO NATIONS INVEST IN ANTARCTIC AND SOUTHERN OCEAN SCIENCE?

In the late 1700s, the 1800s and early 1900s; profits derived from the harvesting of natural resources were major drivers of human activities in Antarctica, particularly the Southern Ocean. These efforts were focused on commercial harvesting of seals, whales, krill, and fishes. In the early 1900s, "Heroic Age" expeditions to Antarctica conducted scientific studies and/or collected scientific data but in most cases science was not the primary purpose. Expeditions during the

"Heroic Age" were largely driven by national pride, geopolitical interests, and/or personal achievement of geographic "firsts" (Dodds 2012).

The IGY 1957-1958, the signing of the Antarctic Treaty in 1959 and the Treaty's entry into force in 1961 dramatically changed how and why nations invest in the Antarctic scientific enterprise. Geopolitical aims and territorial claims spurred the funding of research in the southern Polar Regions that outstripped expected scientific returns. In some cases science was an afterthought and often used to project geopolitical aims and objectives. By the close of the 20th century, Antarctic and Southern Ocean research had matured and were gaining credibility based more and more on scientific outcomes and advancements in knowledge. This change in perception and emphasis is exemplified by the promulgation of, support for and successes of the International Polar Year 2007-2008. In particular, the increasing recognition of the role of Antarctica and the Southern Ocean in the Earth and global climate system elevated the importance of understanding Antarctica and its linkages to global systems (Turner, et al., 2009). The awaking and growing concern of the public in regard to the threat of climate change brought about an unprecedented focus on Antarctic and Southern Ocean research and the Polar Regions in general as we entered the 21st century.

Today there are a wide variety of motivations for national investments in Antarctic and Southern Ocean science. These can be divided in politico-strategic motivations, security-related motivations, and/or the quest for knowledge (science for science's sake). Politico-strategic motivations range from maintaining a presence in support of territorial claims to the desire for international esteem generated by demonstrated scientific excellence, environmental stewardship, and/or collaboration and partnerships through science. Security-related motivations include those focused on economic security such as the pursuit of opportunities arising from fisheries, bioprospecting, tourism, other forms of resource exploitation (i.e., oil, gas and minerals), the development of gateway cities, and/or addressing increasing concerns about the resilience of a state's economy in the face of environmental change. The later motivation includes environmental security issues related to the consequences of environmental change on societies and standards of living, how (or if?) these impacts can be mitigated, and what might be the most effective adaptive strategies. The "quest for knowledge" motivations include "frontier science" or "cutting edge science" and research for the sake of discovery and knowledge. This is embodied in research addressing the importance of Antarctica and the Southern Ocean in the global climate system.

National Investments in Antarctica can be substantial and partially reflect the cost of operating in a distant location and often harsh environment (Figure 1).

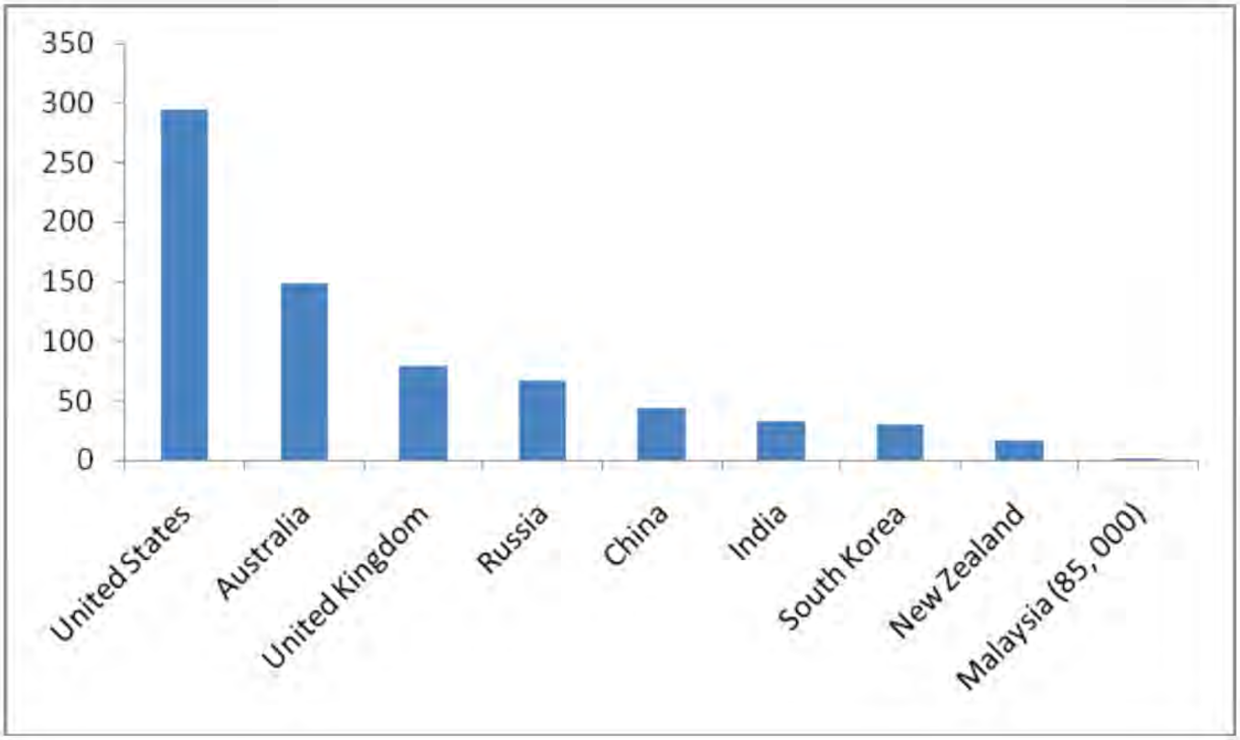

Figure 1: Comparative investments (millions of U.S. dollars) in Antarctic science in 2010 (from Brady, 2012b).

Example excerpts from "purpose" statements for the national Antarctic scientific programs demonstrate the range of justifications for national investments in Antarctic science (also see the summary of mission statements – Appendix I):

- "To address our effort in pursuit of reaching the political aims that our country has on Antarctica, in particular the recognition of sovereignty on the Argentine Antarctic Sector… To maintain the Argentine scientific presence in Antarctica."
- "As we observe how rapidly and profoundly our planet is changing, the need to better understand how Antarctica and the Southern Ocean influence the functioning and resilience of the earth system, and how they will respond to future changes, has become urgent. For Australians, added impetus is provided by the fact that what happens to the frozen continent and the Southern Ocean will have profound impacts on Australia."
- "Finland takes part in the decision making of the Antarctic Treaty System. Finland supports and actively develops comprehensive protection of the Antarctic region's environment."
- "The understanding and prediction of climate change, which is triggered by both natural processes and anthropogenic activities, are fundamental preconditions for a sustainable development of our society….The polar regions play a special role in the expanded Earth system and its climate." (Germany)
- "(The) Cryosphere has a large effect on the predictability/variability of weather and climate through various feedbacks (e.g. ice-albedo), and knowledge of the cryosphere is vital at many levels of decision-making." (India)

- "Japanese Antarctic research programs in the polar regions are becoming increasingly important for monitoring the earth's environment."
- "The Korean government sees its expansion into Antarctica and the Arctic as part of its path to a greater global leadership role." (Seungryeol, 2011)
- "New Zealand research programs in Antarctica have underpinned New Zealand's interests in Antarctica by providing a credible presence in the Ross Dependency, by contributing to the protection of the unique Antarctic environment, and by supporting the Antarctic Treaty System."
- "The Institute provides the Norwegian state with expert and strategic advice concerning polar issues represents Norway internationally in various contexts, and functions as Norway's environmental authority in Antarctica….. The results from research and monitoring projects are passed on to Norway's central administration, research collaborators, expert groups, schools and the general public."
- "Strengthen the economic capacity of Russia through the use of biological resources available in the Southern Ocean and complex investigations of Antarctic mineral, hydrocarbon and other resources."
- "We must understand Earth System Science if we are to plan a sustainable future. The polar regions (Arctic and Antarctic) provide exceptional research opportunities – as laboratories for studies of ecosystems, biological extremes, evolution and geological processes, and as a platform for observations into near-space…. We provide a national capability for reliable and independent policy advice through science, long-term monitoring and surveys. The UK Government expresses its interests in the Antarctic region through us. We also put into practice Government policies on topics such as commercial exploitation and relationships between science and society."
- "The State Program objectives are to provide fundamental and applied research in Antarctica, to maintain effectively Akademik Vernadsky Antarctic station, to fulfill commitments of Ukraine in accordance with the Antarctic Treaty, and to evaluate biological and mineral resources in Antarctica based on scientific approach."
- "Antarctica and the Southern Ocean are intimately involved in global processes that provide the key to understanding those changes….. Antarctica and the Southern Ocean comprise an unparalleled natural laboratory in which to study a multitude of constantly changing conditions…. Although Antarctica and the Southern Ocean are physically distant from the Northern Hemisphere, they are directly connected to the entire global climate system…) (USA)

In many of these documents, the broader justifications for investments in Antarctic in terms of questions directly relevant to society are left unsaid as these are primarily science planning documents. The relevance of the knowledge to be gained through research in Antarctica is often stated as a primary justification for investment. The importance of the roles of the southern Polar Regions in the Earth and climate systems is a common justification invoked for investments. Traditional connections to the reasons to conduct research; such as economics, capacity building, pursuing sustainable development, improving or maintaining standards of living, and benefiting the daily lives of people (especially those far from Antarctica) are often un- or under-stated. There are a few notable exceptions in the case of national Antarctic programs primarily directed at supporting resource extraction activities and /or territorial claims. In many cases, the use of science to support policy making within the context of the Antarctic Treaty System is given only scant recognition mostly due to the segmentation and isolation of these communities within countries. This is in direct contrast to the growing and accelerating need for authoritative, objective scientific advice to inform international policy debates and decision-making.

The Council of Managers of Antarctic Programs (COMNAP) has created a directory of descriptions of national Antarctic programs that provides useful overviews of current activities and investments in Antarctic science (https://www.comnap.aq/Members/SitePages/Home.aspx).

BROADER SOCIETAL BENEFIT

Over the last decade or so, the aspirations of scientists in the Antarctic and Southern Ocean have been more effectively embedded in the visions and goals of international organizations such as the International Council of Science (ICSU) and global programs focused on major environmental issues. The International Polar Years 2007-2008 was jointly endorsed and sponsored by ICSU and the World Meteorological Organization (WMO). Global scientific organizations and programs provide a framework that ties the outcomes of Antarctic science closely with society-relevant goals. ICUS's mission (2006) is to strengthen international science for the benefit of society by mobilizing the knowledge and resources of the international science community to:

- Identify and address major issues of importance to science and society.
- Facilitate interaction amongst scientists across all disciplines and from all countries.
- Promote the participation of all scientists–regardless of race, citizenship, language, political stance, or gender–in the international scientific endeavor.
- Provide independent, authoritative advice to stimulate constructive dialogue between the scientific community and governments, civil society, and the private sector.

SCAR's 2006-2011 strategic plan explicitly embraced these grander goals in its vision statement:

> "SCAR's strategic vision is for a world where the science of the Antarctic region benefits all, excellence in science is valued and scientific knowledge informs policy. SCAR's mission is to be the leading non-governmental, international facilitator and advocate of research in and from the Antarctic region, to provide objective and authoritative scientific advice to the Antarctic Treaty and others, and to bring emerging issues to the attention of policy makers."

SCAR's strategic plan calls for a broadening of the audience for scientific advice beyond the Antarctic Treaty System to include global programs and advisory bodies such as the Intergovernmental Panel on Climate Change (IPCC) and the United Nations Framework Convention on Climate Change (UNFCC). In justifying national participation in Antarctic science, linkages to broader societal goals and benefits are invoked as reasons for investments and the International Polar Year 2007-2008 effectively laid out these constructs.

THE CURRENT FOCUS OF ANTARCTIC SCIENCE

Antarctic and Southern Ocean science and research is unique in that it is geographic and not discipline focused. As such, nearly all disciplines of natural, physical, and social sciences are being pursued under the mantle of Antarctic science. In recognition of the cost of conducting research in Antarctica and the Southern Ocean, national programs often invoke a pre-requisite that the science to be pursued should primarily be science that can be best conducted in Antarctica (i.e., "… research that relies on the unique characteristics of the Antarctic continent as a platform from which to support research…, US NSF web site). The principle is that science that can be conducted less expensively elsewhere on the planet should be.

A brief look back at the justifications for the International Polar Year 2007-2008 provides insight into the science that was used to justify this unprecedented and sustained investment in polar science in general and Antarctic science in particular. Focusing on the Antarctic, the special importance of the Polar Regions, translation of this into six scientific themes, and the reason for a sense of urgency was summarized. These justifications and themes remain largely relevant today and resonate with many national strategic science plans.

"The scope of science for the International Polar Year 2007–2008" (Allison et al., 2007)
• They are presently changing faster than any other regions of the Earth, with regional and global implications for societies, economies and ecosystems. This change is particularly evident in widespread shrinking snow and ice.
• Processes in polar regions have a profound influence on the global environment, and particularly on the weather and climate system. At the same time, the polar environment is impacted by processes at lower latitudes. Examples include the formation of the ozone hole and the accumulation of pollutants in the Arctic environment.
• Within the polar regions lie important scientific challenges yet to be investigated and unique vantage points for science. The regions beneath the polar ice sheets and under the ice-covered oceans remain largely unknown. Many of the new scientific frontiers in the polar regions are at the intersection of traditional scientific disciplines.

The Scientific themes for IPY 2007–2008	
Status: to determine the present environmental status of the polar regions	**New frontiers**: to investigate the frontiers of science in the polar regions
Change: to quantify and understand past and present natural environmental and social change in the polar regions and to improve projections of future change;	**Vantage point:** to use the unique vantage point of the polar regions to develop and enhance observatories from the interior of the Earth to the sun and the cosmos beyond
Global linkages: to advance understanding on all scales of the links and interactions between polar	**The human dimension**: to investigate the cultural, historical and social processes that shape the

regions and the rest of the globe, and of the processes controlling these	sustainability of circumpolar human societies and to identify their unique contributions to global cultural diversity and citizenship.
The Urgencies of the IPY (IPY web site, Antarctica only)	
Changing Snow and Ice: IPY occurs amidst abundant evidence of changes in snow and ice: reductions in extent and mass of glaciers and ice sheets, reductions in area, timing, and duration of snow cover, and reductions in extent and thickness of sea ice. Changes in snow cover and sea ice have immediate local consequences for terrestrial and marine ecosystems. Permafrost, an additional form of ice that influences nearly 25% of the northern hemisphere landmass, also shows substantial decomposition due to warming climate. Permafrost degradation affects local ecology and hydrology as well as coastal and soil stability	**Global Linkages:** Changes in the large ice sheets will impact global sea level, affecting coastal cities and low-lying areas. Changes in snowfall and shrinkage of glaciers will influence millions of people whose daily use of water for personal consumption or for agriculture depends on snowpack and glacial sources. Thermal degradation of permafrost will mobilize vast reserves of frozen carbon, some of which, as methane, will increase the global greenhouse effect. Changes in sea ice combined with enhanced river inputs of freshwater will lead to substantial changes in ocean circulation. Warming of polar oceans, coupled with changes in ice coverage and river run-off, will alter marine ecosystems with consequences for globally-significant fisheries.
Discovery: For a majority of participants, IPY stimulates a sense of urgency and discovery. What secrets, what clues to the planet	

The following is a meta-analysis at the international level is based on national funding trends to describe the expansive landscape that is modern Antarctic research. Quantification of investments in particular research topics is not attempted as this information is difficult, if not impossible, to obtain and the nature of shared logistics often makes it difficult to assign expense to individual programs or projects. Often national strategic plans do not explicitly exist or are not readily available. Overarching themes enunciated in the most recent planning documents include both topical and disciplinary focus.

Current and short-term (next 10 years) focus for Antarctic and Southern Ocean science funding is summarized by analyzing the strategic plans and recent science reports to SCAR (see Tables in Appendix II). The breadth of Antarctic science is expansive ranging from genomics at the molecular level to astrophysics. As a first-order attempt to categorize and characterize the international portfolio of Antarctic and Southern Ocean science, the SCAR general themes of Geo-, Life, and Physical Sciences are used. The groups and programs supported by SCAR within this framework provide insight into the topics the community believes is important as the formation of these groups are proposed and supported by the community.

Keywords that occur most often are predominantly in the geo- and physical sciences and include: geology (14, 42%), geodesy (12, 36%), glaciology (14, 47%), atmospheric science/meteorology (17, 52%) and oceanography (10, 30%). This weighting of projects toward these fields and/or research topics is most likely a reflection of the historical interests and strengths in these areas within SCAR and national programs. These keywords are also broad and capture large numbers of sub-topics. In addition, the keywords climate change and ecosystems occurred in 17 (51%) and 19 (58%) of 33 reports, respectively.

Geosciences (see Appendix III)

[SCAR groups and programs in the Geosciences: geology, solid Earth Science, paleoclimate (sediments), seafloor properties, geodesy, and permafrost]

[Select Geosciences key words from National SCAR science reports (n= number of programs indicating a project/program with each key word in its title – out of 33 reports; sub-topics): permafrost (n=5), volcanology (n=3), geology (n=14; marine geology and Cenozoic geology), paleontology (n=2), geodesy (n=12), seismology (n=5), tectonics (n=4), meteorites (n=2), marine sediments (n=1), geophysics(n=6; marine), and stratigraphy (n=3)]

Major research themes in the Geosciences include: global change, tectonics, geological evolution and history, and geology and geophysics. The Geosciences include paleo- to modern processes such as tectonic evolution, land forms, and both hard rocks and marine sediments. Modelling of the Earth System is a major geosciences focus and interlinking of models to provide more realistic forecasts and predictions is a major thrust.

Life Sciences (see Appendix IV)

[SCAR groups and programs in the Life Sciences: biology/ecology (marine/terrestrial/freshwater), biodiversity, biogeochemistry, human biology and medicine, bird and mammals, ecosystem processes, paleobiology, biogeography, physiology/adaptations, microbiota, and genomics/proteomics]

[Select Life Sciences key words from National SCAR science reports(n= number of programs indicating a project/program with each key word in its title – out of 33 reports; sub-topics):: ichthyology (n=3; fishes), sea birds (n=10; penguins and fossil), mammals (n=6, seals, whales, top predators), microbes (n=10 ecosystems, biodiversity, fungi, marine), marine benthos (n=7; biodiversity), zooplankton (n=1), physiology (n=7; terrestrial, penguins, fishes, and plankton), plankton (n=6), living resources(n=2; krill), genomics (n=6; marine, and microbes), freshwater ecosystems (n=8; ecology and biodiversity), evolution (n=3), biodiversity (n=4), ecosystems (n=19; marine, terrestrial, marine biology, birds, and deep sea), and biotechnology/bio-prospecting (n=1).

Major research themes in the Life Sciences include: global change, conservation, biodiversity, ecology, biological evolution, organismal physiology, adaptation, biological oceanography and marine biology. Life sciences research spans the molecular to population levels and includes marine, terrestrial and freshwater environments.

Physical Sciences (see Appendix V)

[SCAR groups and programs in the Physical Sciences: glaciology, cryosphere (ice, ice sheets, ice shelves, sea ice, snow), atmospheric sciences/chemistry, meteorology, climate/paleoclimate (ice cores), astronomy and astrophysics, near Earth space science, and remote sensing]

[Select Physical sciences key words from national SCAR science reports (n= number of programs indicating a project/program with each key word – out of 33 reports; sub-topics): UV-radiation (n=4), climate change (n=17), chemical pollutants (n=9; atmosphere, greenhouse gases, and snow), ozone (n=7), glaciology (n=14; ice sheets), astrophysics/astronomy (n=7; Ice Cube and astrobiology),, atmosphere/meteorology (n=17; climatology, physics, aerosols, weather, and sea ice), snow (n=6),, space physics (n=3), and oceanography (n=10)]

Major Physical Sciences themes include oceanography, glaciology, astronomy and astrophysics, atmospheric science and climate, tectonics, and near-earth space. Glaciology includes ice sheet dynamics and mass balance, interactions with the ocean, sea level, and subglacial aquatic environments. Oceanographic research includes all the sub-disciplines of biology, physics, geology and chemical including the open ocean, coastal seas and sea ice. The atmospheric sciences include the topics of meteorology and climatology, climate, atmospheric chemistry and aerosols, and air- sea interactions. Several national programs have major astronomy and astrophysics facilities (i.e., telescopes, sensor observing arrays and systems, and cameras) and programs conducted from Antarctica and pursue mainstream research objectives as enunciated by the broader astronomy and astrophysics community including the collection and study of meteorites.

Other Themes

There is growing a social sciences, humanities, arts and history community. SCAR interests in the Social Sciences and Humanities include: psychology, history, archaeology, small/isolated community studies, heritage preservation, creative arts, education, and tourism. Several national programs support major medical and human biology programs that study humans in remote, isolated and harsh environments as well as manage the practical dimensions of deploying people in remote areas. In the SCAR designations these programs come under the Life Sciences.

Cross-cutting Themes

As in most modern Earth System science, Antarctic science has a major focus on climate change and its impact on the geological, physical and bio-spheres. Climate is addressed at many spatial and temporal scales and includes ground and satellite observations and acquisition and analysis of ice and sediment core paleoclimate records. Cross-cutting efforts are common and interdisciplinarity is fundamental. Modelling of all parts of the Earth System is a major focus and inter-linking of models to provide more realistic forecasts and predictions is a major thrust. The study of ice in all of its forms is often captured under the general term "cryosphere" and cryospheric research cross-cuts many disciplines and includes ice sheets, ice shelves, ice streams, sea ice, fresh water ice, snow, subglacial environments, and permafrost.

Another window on what the Antarctic scientific community sees as the most important and pressing scientific questions are the newly approved SCAR Scientific Research Programs (SRPs). These programs are community generated, developed, and implemented. SCAR does not fund science so its major research programs are a collective reflection of the funding that either is or is expected to be available through National Antarctic programs in the near-term future (summaries are taken directly from the SCAR web site):

- ***Astronomy & Astrophysics from Antarctica*** *(AAA)* aims to coordinate astronomical activities in Antarctica in a way that ensures the best possible outcomes from international investment in Antarctic astronomy, and maximizes the opportunities for productive interaction with other disciplines.
- ***State of the Antarctic Ecosystem*** *(AntEco)* has been designed to focus on patterns of biodiversity across terrestrial, limnological, glacial and marine environments within the Antarctic, sub-Antarctic and Southern Ocean regions, and to provide the scientific knowledge on biodiversity that can be also used for conservation and management. In essence we propose to explain what biodiversity is there, how it got there, what it does there, and what threatens it. A primary product of this program would be recommendations for its management and conservation. Biological diversity is the sum of all those organisms that are present in an ecosystem, that dictate how ecosystems function, and that underpin the life-support system of our planet.
- ***Antarctic Thresholds - Ecosystem Resilience and Adaptation (AnT-ERA)*** will examine the current biological processes in Antarctic ecosystems, to define their thresholds and thereby determine resistance and resilience to change. Such processes depend on a cascade of responses from the genomic and physiological through organismic and population to the ecosystem level. The extreme environment and marked difference in community complexity between the polar regions and much of the rest of the planet may mean that consequences of stress for ecosystem function and services, and their resistance and resilience, will differ from elsewhere. Polar ecosystem processes are therefore key to informing wider ecological debate about the nature of stability and change in ecosystems. The main goal of AnT-ERA is to define and facilitate the science required to determine the resistance, resilience and vulnerability to change of Antarctic biological systems. In particular, the science needs to determine the likelihood of cataclysmic shifts or "tipping points" in Antarctic ecosystems.
- ***Antarctic Climate Change in the 21st Century (AntClim^{21})*** will deliver improved regional predictions of key elements of the Antarctic atmosphere, ocean and cryosphere for the next 20 to 200 years and to understand the responses of the physical and biological systems to natural and anthropogenic forcing factors. A primary form of data that we see being used by AntClim21 are the global coupled atmosphere-ocean model runs that form the basis of the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC). Palaeo-reconstructions of selected time periods, recognized as past analogues for future climate predictions, will be used to validate model performances for the Antarctic region.
- ***Solid Earth Responses and influences on Cryospheric Evolution (SERCE)*** aims to improve understanding of the solid earth response to cryospheric and tectonic forcing. SERCE will:
  - Identify and develop key disciplinary and interdisciplinary science components of a science program aimed at advancing understanding of the interactions between the solid earth and the cryosphere, including glacial isostatic adjustment

(GIA) and ice mass change and the influence of solid earth parameters (heat flow, disposition of sediments) on ice sheet dynamics;

- Communicate and coordinate with other international groups investigating ice mass change, ice sheet contributions to global sea level rise, glacial isostatic adjustment models of Greenland and other ice caps, and other pertinent research efforts;
- Work with SCAR action/expert groups and research programs to promote interdisciplinary science using POLENET data;
- Provide an international framework for maintaining, and potentially augmenting, the remote autonomous POLENET infrastructure after the International Polar Year (IPY).

CONCLUDING REMARKS

The investment in and mix of science topics pursued by individual countries is diverse and changes with time. Some countries have dedicated funding and organizations for Antarctica (and polar) research while other scientists compete directly with general science calls for funding. The topical focus of Antarctic science within a country is often determined by the individual scientific interests and expertise. In some countries science directions are driven by “proposal-pressure” and vetted by peer-review whereas others are more “top-down” driven by national scientific agendas. While much of Antarctic science is conducted by interdisciplinary and international teams there are also many single investigator projects conducting research on focused research questions.

The portfolio and breadth of international Antarctic and Southern Ocean science is diverse and expansive. Individual countries do not try to pursue all potential scientific directions and make funding decisions based on national and geopolitical interests tempered by the level of national investment and where they believe they can make the greatest impact.

Collectively, international Antarctic and Southern Ocean science has never been more relevant to major international debates on the future of the planet’s environment and the impacts of humans. While current research provides the “stepping stones” to the future, it can be assumed that unforeseen discoveries and technological advances may re-direct international scientific efforts and focus in unexpected ways that may not be predictable.

The future influence, global importance, value and impact of knowledge created by Antarctic science and research will be largely dependent on decisions regarding ongoing and future investments in studies that capitalize on the unique place on Earth that Antarctica and the Southern Ocean occupy.

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Appendix I

Summary of Mission Statements in National Antarctic Programs

Country					
Argentina	To provide and maintain the national capacity of carrying out scientific researches and technological developments in Antarctica	To conduct and/or to coordinate scientific researches, observations and long-term monitorings, as well as cartography works in the Argentine Antarctic Sector	To provide a national reference centre for the international cooperation and the coordination of scientific programmes in Antarctica	To promote the knowledge of the Argentine Antarctic Sector and the development of new Antarctic technologies	To create a staff of highly qualified researchers and technicians, recognised at the international level, being able to represent the country in international discussion forums on Antarctic matters and to counsel the different powers of the National Government on matters concerning their speciality and safeguarding the national interest on this matter
	To create in the Community an awareness of belonging of the Argentine Antarctic Sector through the promotion of the science and technology through the Science and the Technology, by consolidating and increasing the titles that support our claim of sovereignty	To represent the interest of the Argentine Republic in Antarctica the titles that support our claim of sovereignty	To reach through the Science and the Technology the international recognition on the activities carried out by our country in Antarctica	To become a centre of professional excellence, including qualified human resources on Antarctic matters	To promote the sustainable national development through Antarctic scientific researches and technological developments.
Australia	The plan establishes the framework for Australian Antarctic research	A need to prioritise within and across themes.	Welcome and support involvement by Australian and international scientists willing to contribute toadvancing Australia's interests in the Antarctic	High priority will be placed on collaboration	Founded on scientific excellence
	Emphasis will be placed on the relevance of the research to policy makers and end users, and to broader outreach of research results to the public and other stakeholders.				
Belgium	A glimpse of Belgian efforts and achievements in the IPY.				

Appendix I

Finland	Finnish Antarctic research in selected areas is at a high international level, recognised as such, and open to new directions	Researchers take advantage of both national and international funding opportunities	Interaction between Antarctic and Arctic region researchers is active	Research is well coordinated nationally and the national funding for research and associated logistics will be at a level suitable for quality research operations	Research results are published in internationally recognised journals and are communicated effectively to a wider audience
	Finland takes part in the decision making of the Antarctic Treaty System.	Finland supports and actively develops comprehensive protection of the Antarctic region's environment			
India	Framework Document 2012-2013	To plan, promote, co-ordinate and execute the entire gamut of polar science and logistic activities of the country in order to ensure a perceptible and influential presence of India in Antarctica, Arctic and to uphold our strategic interests in the global framework of nations in the Southern Continent and the surrounding ocean.	To take up and implement such scientific programmes in the Polar and Southern Ocean regions that will ensure a lead role for India amongst the nations involved in polar and oceanographic research.		
The Netherlands	The South and North Pole areas and the polar oceans play a vital role in changes to the global climate and living environment. These changes have enormous physical, ecological, social and economic consequences.	The Netherlands is a consultative (with voting rights) treaty party in the Antarctic Treaty and is therefore obliged to continue carrying out substantial scientific research on Antarctica			

Appendix I

New Zealand	High-level direction for developing a coherent and dynamic New Zealand Antarctic and Southern Ocean science programme.	Advancing New Zealand's interests through relevant high quality, collaborative Antarctic and Southern Ocean research	The Government expects that Antarctic research will be targeted towards projects that will have clear benefits for New Zealand and contribute to at least one of the three outcomes identified in this framework.	Overall research programmes are expected to be relevant, cost-effective, collaborative and of an international standard.	
Russia	For the development of the Russian Federation's activities in the Antarctic for the period until 2020 and longer-term perspective.	The Antarctic has a huge resource potential	Biological resources available in the Antarctic waters can ensure for the national fisheries a sustainable long-term growth in the harvesting of boiological resources	Russia is objectively interested to keep peaceand stability and maintain conditions for research in the Antarctic	Maintain the Antarctic as a zone of peace, stability,and cooperation and prevent international tensions as well as global threats of natural and climatic origin
	Strengthen the economic capacity of Russia through the use of biological resoruces available in the Southern Ocean, and complex investigations of Antarctic minerals, hydrocarbon and other resources	Emhance the international prestige of the Russian Federation through large-scale political, social, scientific, and environmental measures related to the actvities of Russia in the [Antarctic]			
UK	By 2020 the British Antarctic Survey will be recognised as a world-leading centre for polar research and expertise, addressing issues of global importance.	To address questions of global scientific importance collect new data from land, ice, sea and air using state-of-the-art drilling, satellite, surveying, monitoring, fieldwork and laboratory technology. These will be used to develop new, and enhance existing, computer models. New technologies will be pioneered.	Long-term, quality-controlled and uninterrupted data records are essential to determine both long-term trends and variability in the Earth System by maintaining existing long-term datasets and build on BAS's strong tradition of making such observations.	Data are collected from our research stations, aircraft, ships and field parties, and from autonomous vehicles and instrument platforms.	BAS supports fully the sharing and flow of knowledge, people, skills and expertise both nationally and internationally.
	BAS is committed to explaining its science and operations to as wide an audience as possible.	BAS is committed to delivering science with the minimum environmental impact			

Appendix II

Summary Matrix of Research Themes in Antarctic Strategic Plans

Country	Argentina	Time Period	2011-2021		
Priority Research					
Study of the Global Change phenomena, its causes and consequences on Antarctic systems and its impact on national productive systems	Knowledge and conservation of the Antarctic Natural Resources and associated areas	Development of alternative energies for Antarctic uses	Study of ancient and present physical links between the Argentine Antarctic Sector and southernmost South America		
Research Themes					
Oceans and atmosphere in the polar regions	Answers of the Antarctic ecosystems, depending from and associated to climate change and fisheries: understanding and possibilities of remediation	Climate change, past, present and perspective for the next 100 years	Natural environment changes and the evolution of the Antarctic ecosystems	Monitoring of the Antarctic natural system.	Institutional Strengthening and Capacity building
	Structure and functioning of Antarctic ecosystems, past and present.	Climate Change - Global Change: past, present and future prospects	Physics and Chemistry of the atmosphere, oceans and soils in the Antarctica and adjacent regions	Monitoring of Antarctic natural systems (including environmental and biological monitoring and cartography)	Mineral Resources Antarctic living resources (including bioprospecting)
		Geological evolution of the southern sector of the Antarctic Peninsula	Human adaptations to high latitudes	Impact of human activities in Antarctic ecosystems (including bioremediation and tourism)	History of Argentine activities in the Antarctica

Appendix II

Country	Australia	Time Period	2011–12 to 2020–21
Themes			
Climate Processes and Change	Terrestrial and Nearshore Ecosystems: Environmental Change and Conservation	Southern Ocean Ecosystems: Environmental Change and Conservation	Frontier Science
Research Streams			
The Antarctic ice sheet	Trends and sensitivity to change	Marine ecosystem change	To encourage and support research that falls outside of the priorities within the other thematic areas, but within Australia's national science priorities.
Oceans and marine ice in the Southern Hemisphere	Vulnerability and spatial protection	Wildlife conservation	
Atmospheric processes and change	Human impacts: prevention, mitigation and remediation.	Southern Ocean fisheries	
Antarctic palaeoclimate.		Protecting marine biodiversity.	

Country	Belgium	Time Period	IPY Contributions						
Climate change in the Antarctic	Marine Biodiversity Information Network - SCARMarBIN	The cryosphere under surveillance - Glaciology	Outreach and education	GIANT-LISSA geophysics	Antarctic Population	Terrestrial biodiversity	Aeronomy - modelling the 'chemical' weather, atmospheric chemistry	Astronomy - IceCube	Marine biodiversity
Climatology - The Antarctic ocean CO2 pump	Studying the benthos and its dynamics to foresee the future of marine biodiversity	Modelling the evolution and stability of the Greenland ice sheet.				Microbes from the cold			Fishing for miracles in the deep seas bordering the Antarctic

Appendix II

Country:	Chile	Time Period:	PROCIEN 2012	
Main Themes				
Relationships between South America and Antarctica	Adaptation mechanisms of Antarctic organisms	Abundance and diversity of Antarctic organisms	Global warming and climate evolution	Environment and Other Initiatives
Sub-themes				
Evolution and origins of the Southern biota	Adaptation and functionality	Ecological studies at a community level	Physical variables: land, sea and atmosphere	Organic compounds and environmental monitoring
Geological evolution of Southern landmasses	Biochemical response to stress-induced conditions	Ecological studies at a population level	Effect over marine organisms	Space and Atmospheric Monitoring

Country:	Finland	Time Period:	Funded Research 1998-2005			
Geodesy	Sea-atmosphere interface phenomena	Aerosol research	Space research	Geology	Sea-ice and marine biology	Glaciology
	Antarctic atmospheric research	Ozone- and UV research		Sea geology		Geophysical snow research

Country: India	Time Period: Framework Document 2012-2013
To improve our understanding of Polar Science and its implications for climate change	To conduct survey for assessing non-living resources

Country	Japan	Time Period	NIPR Research Plan 2012-2103		
Space and Upper Atmospheric Sciences	**Meterology and Glaciology**	**Geosciences**	**Biosciences**	**Polar Engineering**	**Advanced Research Project**
Links between space and the Earth observed by remote sensing	Climate and environmental system of Earth	Geology, geomorphology, and solid earth science	Study of present and past to identify future changes in polar ecosystems	Technical challenges in Earth's polar regions	Predicting the future of Earth's environment
Aurora, solar wind, magentosphere and ionosphere	Past, present and future climate change	Post glacial rebound, seismic phenomena, geodynamics	Biological oceanography, vertebrate ecology, terrestrial ecology		
Middle and upper atmosphere observations		Orgin and Evolution of solar material, Meteorites			

Country:	The Netherlands	Time Period:	Master Pool position-NL 2010-2014
Ice, climate and sea level	**Polar oceans**	**Polar ecosystems**	**Human sciences and changes in polar areas**
Modelling of the polar climate	Global change and the polar oceans	Effects of climate change on terrestrial ecosystems	Consequences for indigenous societies
Observational research and remote sensing	Lack of iron and light for algal growth	Relationship between biodiversity and functionality and the possible disruption of this	Economies versus sustainability
Ice cap models	Uptake of CO2, ocean acidification and methane emission	Sea ice, polar food chains and plasticity of habitat use	Consequences for exploration and exploitation of natural resources
Palaeoclimatic reconstruction		Influence of climate changes on migratory birds	Consequences for the existing legal frameworks
Evolution and dynamics of the polar ice caps on geological timescales			

Country	New Zealand	Time Period	2010-2020		
Climate, Cryosphere, Atmosphere,and Lithosphere	Improved understanding of the past and current state of Antarctica, its significance and implications of the role of Antarctica in global change, and implications of global change for Antarctica	To improve understanding of Antarctic and Southern Ocean responses to past climate conditions and enhanced modelling of the Antarctic and Southern Ocean impact on, and response to, climate change and variability.	To improve understanding of the role of the cryosphere, with emphasis on the Ross Sea region, including understanding of processes likely to affect global and regional sea levels.	To improve understanding of the Antarctic atmosphere's response to global change and its effect on New Zealand	To quantify Antarctica and the Southern Ocean's role in global biogeochemical cycles.
Inland and Coastal Ecosystems	Improved understanding of inland and coastal ecosystems of the Ross Sea region leading to enhanced knowledge, conservation and protection priorities in Antarctica.	To improve understanding of inland and coastal3 Antarctic ecosystems including biodiversity, bio-geochemical processes and ecosystem functioning, as well as their potential responses to environmental change in the Ross Sea region.	To better understand how closely coupled Antarctic ecosystems interact.	To increase understanding of how the Antarctic environment (inland and coastal) may respond to climate change and other human impacts.	
Marine Systems	Improved conservation and resource management of the Antarctic marine environment.	To assess population status for a range of species and their role within the Ross Sea ecosystem.	To improve understanding of the biodiversity and marine ecosystems in the Ross Sea region.	To improve understanding of the oceanography, bathymetry and hydrography of the Ross Sea.	To understand how the marine environment and marine food webs may respond to climate change and ocean acidification.

Appendix II

Country:	Russia	Time Period:	Until 2020			
Full assistance to maintaining and progressive development of the Antarctic Treaty System	Assessment of the role and place of Antarctica in global climate change	Ensuring the activties of the Russian federation in space	Assessment of marine biological resorucesof the Antarctic on the basis of research on prediction of their expected amount to ensure cost-effective fisheries	Physical and geophysical invetigations of mineral and hydrocarbon resources on the continent of Antarctica and in surrounding seas.	Development of integrated Antarctic Research; geological and geophysical investgations, global climate change study, and investigation of subglacial Lake Vostok	Protection of the Antarctic environment

Country:	Sweden	Time Period:	2011-2015
List of funded projects		Antarctic Marine Science: Physical Oceanography	Land-based science: fossil record, atmospheric radar, paleo-biogeography and climate, glaciology, and Antarctic terrestrial flora and fauna

Appendix II

Country	UK	Time Period	by 2020	
Chemistry and Past Climate	To understand what controlled the timing and strengths of the major climate shifts of the last million years and beyond, particularly the shifts from glacials (ice ages) to interglacial warm periods	To use the warmest periods of the last million years to tell us about the likely response of the polar regions to future climate change	To determine how sea ice responded to past climate change and assess how this fed back into atmospheric chemistry and ocean circulation	To produce detailed records of climate change in the Antarctic Peninsula region over the last 2,000 years
Climate	To explain changes in atmospheric circulation, temperatures and sea-ice extent in both polar regions over the past 50 years and to determine how much of this change is due to human activity and how much is a result of natural factors (including solar variability)	To improve the representation of polar climate processes in large-scale models, using targeted observations	To improve climate predictions in the polar regions on the space and timescales needed by the international scientific community (including glaciologists, oceanographers and biologists)	To maintain a programme of high-quality, long-term observations in the Antarctic using instruments at BAS research stations and remote field sites
Ecosystems	To understand what determines the ability of species to adapt to change through genetic, physiological and ecological processes across a range of marine and terrestrial ecosystems	To develop quantitative descriptions of the life-cycles of species to determine their likely response to environmental change	To determine the resilience of polar ecosystems to past and current climate change to predict how they may respond in the future	To provide data and policy advice on key species and whole ecosystems to underpin further development of sustainable fisheries management in the Antarctic and beyond – fulfilling UK obligations under the Antarctic Treaty
Icesheets	To improve understanding of the ocean-atmosphere and bed interactions controlling ice-sheet flow and ice-sheet evolution	To build and apply a robust mathematical and numerical framework for computer simulation of ice-sheet change and sea-level rise	To determine current glacial change in the critical areas of the polar ice sheets	To establish improved histories of ice-sheet change to provide context and constraint for future projections
Polar Oceans	To explain the processes that drive and close the overturning circulation in the Southern Ocean	To determine the impact of, and the feedback between, the ocean and ice shelves	To understand the physical drivers of changes in the marine environment, and the likely implications for climate	To determine the impacts that changes in the polar regions have on the Earth System via ocean circulation

Country:	**Ukraine**	**Time Period:**	**2011-2020**
Geological and geophysical research for revealing and evaluation of hydrocarbon resources (oil and gas), sources of mineral and raw materials (gold, diamonds, uranium etc.);		Physical research (hydrometeorological, oceanographic, geospace) for reviewal of the state of marine environment and the upland, the upper atmosphere and geospace	Biological and medical and physiological research for determination of the structure and functions of Antarctic organisms, their resistance to extreme factors at molecular – genetic level, production of bioactive substance producers and technologically prospective strains of microorganisms for their further application in medicine and industry

Country	**United States**	**Time Period**	**The Future!**	
Global Change	How Will Antarctica Contribute to Changes in Global Sea Level?	What Is the Role of Antarctica and the Southern Ocean in the Global Climate System?	What Is the Response of Antarctic Biota and Ecosystems to Change?,	What Role Has Antarctica Played in Changing the Planet in the Past?
Discovery	What Can Antarctica and the Southern Ocean Reveal About Past Climates?	How Has Life Adapted to Antarctica and the Southern Ocean Environments?	What Can the Antarctic Platform Reveal About the Interaction Between the Earth and the Space Environment?	How Did the Universe Begin, What Is It Made of, and What Determines Its Evolution?
Opportunities to Enhance Research in Antarctica and the Southern Ocean	Collaboration	Energy, Technology, and Infrastructure,	Education	Observing Network with Data Integration and Scientific Modelling

Countries with limited information, or information not in English:

Brazil, report in Portuguese
Canada, 2003 workshop report
Ecuador, Time period 2010-2014, report in Spanish
Italy, Strategic Plan 2012-2014, report in Italian
Spain, General Research Plan 2013-2016, report in Spanish

Keywords in SCAR National Science Activty Reports - Geosciences

Country	Year	Permafrost	Volcanology	Geology	Paelontology	Geodesy	Magnetics	Siesmology	Tectonics	Meteorites	Marine Sediments	Geophysics	Stratigraphy
Argentina	2010-2011	X	X	X	X	X	X	X					X
Australia	See Strategic Plan												
Belgium	2010-2011					X			X	X			
Brazil	2009-2010												
Bulgaria	2007-2008	X		X									
Canada	2011-2012										X		
Chile	2009-2010		X				X						
China	2010-2011					X	X						
Denmark	2011-2012					X	X					X	
Ecuador	2010-2011				X	X						X	
Finland	2011-2012					X			X				
France	2010-2011		X	X			X	X					
Germany	2011-2012												
India	2011-2012			X		X	X						
Italy	2011-2012	X		Cenzoic		X	X	X					
Japan	2011-2012			X									
Korea	2010-2011			Marine			X			X			
Malaysia	2008-2009												
Monaco	2011-2012												
Netherlands	2011-2012			X									
New Zealand	2011-2012			X		X							
Norway	2011-2010			Sub-ice				X					
Pakistan	2009-2010												
Peru	2008-2009												
Poland	2011-2012								X			X	X
Portugal	2009-2010	X	X										X
Romania	NA												
Russia	2011-2012					X			X			Marine	
South Africa	2009-2010												
Spain	2010-2011	X		Marine		X	X	X				X	
Sweden	2007-2008												
Switzerland	2009-2010			X									
UK	2011-2012			X									
Ukraine	2011-2012			X								X	
United States	See Strategic Plan												
Uruguay	2011-2012					X							

Appendix IV

Keywords in SCAR National Science Activty Reports - Life Sciences

Country	Year	Icthyology	Sea Birds	Mammals	Microbes	Marine Benthos	Zooplankton	Physiology	Plankton	Living Resources	Genomics	Freshwater Ecosystems	Evolution	Biodiversity	Ecosystems	Bio-technology Bio-prospecting
Argentina	2010-2011	X	X	X	X	X	X	X	X	X	X				X	
Australia	See Strategic Plan													X		
Belgium	2010-2011					Biodiversity						X			Marine Terrestrial	
Brazil	2009-2010															
Bulgaria	2007-2008										X				X	
Canada	2011-2012		X	Seals	Ecosystems			Terrestrial			X				Marine	
Chile	2009-2010			Seals	Biodiversity	X		X	X	krill	Marine		X	X	Terrestrial	X
China	2010-2011															
Denmark	2011-2012															
Ecuador	2010-2011				Biodiversity						Microbes				Marine	X
Finland	2011-2012														Marine Biology	
France	2010-2011			Top Predators				Penguins					X			
Germany	2011-2012														Deep sea	
India	2011-2012														Marine Biology	
Italy	2011-2012															
Japan	2011-2012											Ecology				
Korea	2010-2011															
Malaysia	2008-2009														X	
Monaco	2011-2012		X												Birds	
Netherlands	2011-2012				X			X	X						Marine	
New Zealand	2011-2012		X		Fungi			Fishes				Biodiversity			Terrestrial	
Norway	2011-2010		X													
Pakistan	2009-2010															
Peru	2008-2009		X			X										
Poland	2011-2012		Fossil			X									X	
Portugal	2009-2010	Fishes	X													
Romania	NA															
Russia	2011-2012											X			X	
South Africa	2009-2010															
Spain	2010-2011	X	Penguins	Seals	X	X		Plankton	X		X	X			Marine	
Sweden	2007-2008				Marine				X							
Switzerland	2009-2010															
UK	2011-2012		X						X			X	X	X	X	
Ukraine	2011-2012			Seals/Whales	X									X	X	
United States	See Strategic Plan															
Uruguay	2011-2012				X	X		X				X			Terrestrial	

Keywords in SCAR National Science Activty Reports - Physical Sciences

Country	Year	UV Radiation	Climate Change	Chemical Pollutants	Ozone	Glaciology	Astrophysics/Astronomy	Atmosphere/Meteorology	Sea Ice	Snow	Space Physics	Oceanography	Alternative Energy	Human Impacts
Argentina	2010-2011	X	X	X	X								X	
Australia	See Strategic Plan													
Belgium	2010-2011	X	X	Atmosphere		X	X	Climatology						
Brazil	2009-2010													
Bulgaria	2007-2008		X											
Canada	2011-2012			GHG	X			X	X					
Chile	2009-2010	X	X	X		X								
China	2010-2011				X	X	X	Physics						
Denmark	2011-2012													
Ecuador	2010-2011			X		X				X			X	X
Finland	2011-2012	X	X		X	Ice sheets		Climatology	X	X	X			
France	2010-2011		X	In Snow		X	X	Aerosols		X		X		
Germany	2011-2012						Ice Cube							
India	2011-2012			Atmo		X		X		X	X	X		
Italy	2011-2012		X		X	X	X	Physics	Biology					
Japan	2011-2012							X						
Korea	2010-2011								X			X		
Malaysia	2008-2009		X	X										
Monaco	2011-2012													
Netherlands	2011-2012		X	X		X		Weather	X					
New Zealand	2011-2012		X			X		X	Biology			X		
Norway	2011-2010		X			X		X				X		
Pakistan	2009-2010											X		
Peru	2008-2009							Aerosols						
Poland	2011-2012		X											
Portugal	2009-2010		X											
Romania	NA													
Russia	2011-2012		X					X		X				
South Africa	2009-2010													
Spain	2010-2011					X	Astrobiology					X	Telecom	X
Sweden	2007-2008		X		X		Icecube	Aerosols		X		X		
Switzerland	2009-2010		X			X								
UK	2011-2012		X		X	X		X			X	X		
Ukraine	2011-2012							X						
United States	See Strategic Plan													
Uruguay	2011-2012							X				X		X