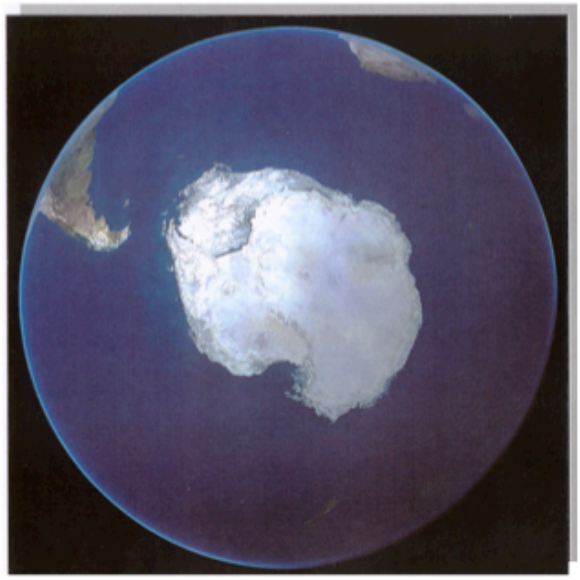
Abridgment of Renewal Proposal

Priority Program of the German Research Foundation (DFG SPP 1158)

"Antarctic Research with Comparative Investigations in Glaciated Areas of the Arctic"



Coordinators: Prof. Dr. Martin Melles, University of Cologne (Chief Coordinator)
Prof. Dr. Sieglinde Ott, University of Düsseldorf (Biology)
Dr. Hartmut Hellmer, AWI Bremerhaven (Physics / Chemistry)
Dr. Andreas Läufer, BGR Hannover (Geosciences)

Contact: Prof. Dr. M. Melles, University of Cologne, Institute of Geology and Mineralogy, Zülpicher Str. 49a, D-50674 Köln, Tel.: 0221 470 2262, Fax: 0221 470 5149, E-Mail: mmelles@uni-koeln.de

DFG-SCHWERPUNKTPROGRAMM 1158
ANTARKTIS FORSCHUNG
mit vergleichenden Untersuchungen in arktischen Eisgebieten

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Summary

Due to the eminent importance of the polar regions in the Earth system, great international efforts are made today to better understand the environmental settings, to decipher the rates of change on different temporal and spatial scales, and to quantify the mass and energy exchange with lower latitudes. A profound understanding of these settings and processes can only be achieved by coordinated research, involving all natural scientific disciplines, which in the polar regions - more than in other regions - depends upon the logistic opportunities and a specialised scientific infrastructure.

For 30 years coordinated German polar research is supported by the German Research Foundation (´Deutsche Forschungsgemeinschaft´= DFG). It takes place within the framework of a Priority Program (´Schwerpunktprogramm´, SPP), which for a short time was transferred to a so-called Coordinated Program (´Koordiniertes Programm´). From the very beginning these programs followed multi-disciplinary approaches, divided into the scientific disciplines Physics/Chemistry, Biology, and Geosciences. They were inured in particular to the benefit of polar researchers at German universities, which due to these programs were able to use the polar infrastructure provided by the Alfred Wegener Institute for Polar and Marine Research (AWI) in Bremerhaven and the Federal Institute for Geosciences and Natural Resources (´Bundesanstalt für Geowissenschaften und Rohstoffe´, BGR) in Hannover. In the beginning, the coordinated DFG funding was restricted to Antarctica and the Southern Ocean, but was expanded to comparative research in the Arctic in 1997.

With this proposal we aspire the continuation of the DFG-SPP „Antarctic research with comparative investigations in glaciated areas of the Arctic“ (´Antarktisforschung mit vergleichenden Untersuchungen in arktischen Eisgebieten´) by additional six years (2013-2018). The scientific results, obtained during the running program phase (2008-2012) show that in Germany a diversified, highly qualified and motivated group of scientists exists which, supported by the SPP, made significant contributions to several of the pressing scientific questions in international polar research. Due to an intense involvement of the universities, the SPP is the crucial funding tool for educating the next generation of polar scientists in Germany.

The running SPP phase differs from former phases by putting a stronger focus on selected scientific topics and research questions of particular importance and by expanding the program coordination and its external visibility. For the aspired phase we intend to further improve the science and the management of the SPP. Special emphasis is put on strengthening the multi-disciplinarity of the scientific projects. This will be achieved by concentrating on four major research topics, which can be addressed by all three scientific disciplines Physics/Chemistry, Biology, and Geosciences: (i) Development of the Continent, (ii) Gateways to Lower Latitudes, (iii) Dynamics of the Climate System Components, and (iv) Response to Environmental Change.

For numerous, especially young German scientists a continuation of the SPP, based on the successful work during the past 5 years and the modified concept for the next program phase, is the only possibility to make significant contributions to the pressing science questions in polar research. Only the SPP can assure that coordinated, increasingly multi-disciplinary polar research is successfully continued with the involvement of the universities and federal research institutes. The leading position of Germany in polar research, achieved over the past decades by a significant financial and personal engagement, and the reliability of German polar scientists in international programs can be sufficiently maintained and further expanded only by a SPP being in a strong situation.

1 Introduction

1.1 Importance of the Polar Regions in the Earth System

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. On shorter time scales, climate change is mainly controlled by physical and ecological factors, but on longer time scales biogeochemical, geological, and evolutionary factors also play an important role. In order to achieve the goal of comprehensive climate predictions and identification of the consequences for the environment and society, it is necessary not only to develop the requested numerical assimilation and prediction models, but also to establish a comprehensive global observation system and a better understanding of the complex feedback mechanisms in the climate system. This includes geological data, which contribute to our understanding of the history and causes for climate change on longer time scales, as well as of their impacts on the biotic and abiotic environment.

The polar regions play a special role in the expanded Earth system and its climate. Due to their physical settings, in particular the high reflectivity of the ice and snow cover for solar radiation, they convey the temperature contrast to the tropics and thus maintain the global atmospheric and oceanic circulations. The physical peculiarities are also responsible for a specific flora and fauna on the polar regions. Polar organisms are well adapted to the harsh environmental conditions, being highly specialised to low temperatures, strong seasonality, and frequent deficiency in food sources. The organisms very sensitively react on climate change and, therefore, function as effective climate indicators. Furthermore, the atmosphere and ocean have a strong impact on the mass balance of the polar ice sheets with consequences for global sea level due to their influence on the ice sheet dynamics.

The global significance of the polar regions is also evident from the fact that 90 % of the ocean volume (i.e. the cold ocean deep water) are connected with only 10 % of the ocean surface, with the largest portion of these ´ventilation windows´ located in the polar regions. In consequence, the Southern Ocean is believed to act as a ´biodiversity pump´, since the deep-water flow from this region allows larvae and early development stages of organisms to reach marine environments further to the north. Other examples for the global importance of the polar regions are the formation of cold air masses over the strongly reflecting snow and ice fields, the specific chemical transformations in the stratosphere during winter, the formation of deep and bottom water masses, the variability of the sea-ice cover and thickness, and the release of freshwater by glaciers and ice sheets.

The polar sea ice has a strong impact on the interaction between ocean and atmosphere, but also plays an important role for the fresh-water flux at the ocean surface. In addition, sea ice constitutes an important habitat for many marine organisms. Thus, changes in sea-ice cover extensively influence these highly specialised ecosystems. In return, sea-ice physics, in particular radiation properties and thermodynamic processes, can significantly change depending on the organisms living in the sea ice.

Continental ice masses, besides their importance for the climate system, also represent a unique climate archive on Earth. The ice provides direct evidence for the trace-gas composition of the paleo-atmosphere, reaching up to 800,000 years back into Antarctica's past. In addition, it allows for the reconstruction of temperature and precipitation changes on the ice sheets with an excellent temporal resolution. Complementary information, concerning ice sheet dynamics and the development of the periglacial areas, can only be achieved from

geological archives, in particular sediment cores from the marine realm and from lakes in presently unglaciated coastal areas, and from rock exposures on land. The biological and geological information stored in these archives provides comprehensive information on the climatic and environmental history of the polar regions. This includes paleo-geographical information concerning the opening and closing of surface and deep-water passages, crucial for the understanding of the global energy and mass transports.

The outlined importance of the polar regions within the Earth system was extensively stressed during the fourth International Polar Year (IPY), which was set up for the period March 2007 to March 2009 by ICSU (International Council for Science) and the WMO (World Meteorological Organization). The IPY led to a significantly enhanced cognition of polar topics in the public. In addition, the IPY fostered the intensification of the international polar research and an enhanced coordination of scientific activities, including the bundling of international resources for a first-time acquisition of synoptic, bipolar data sets. The SPP “Antarctic Research” played a significant role for the German contribution to the IPY and the results obtained are considered as contribution to this SPP renewal proposal.

1.2 History and Relevance of the Priority Program

Following the Second World War, international polar research revived particularly during the International Geophysical Year 1957/58. In the beginning, Germany´s contribution was rather limited. Based on collaborative research activities of the German Democratic Republic (GDR) with the Union of Soviet Socialist Republics (USSR) in Antarctica, the GDR became member of the Antarctic Treaty System (ATS) in 1974. Starting in the 1970th, the Federal Republic of Germany (FRG) conducted first marine-based expeditions and geological fieldwork in both Antarctica and the Arctic, to a large extent led by the BGR in Hannover. In 1978, the DFG became a member of the Scientific Committee on Antarctic Research (SCAR) and launched a national SCAR commission. The BGR conducted its first expedition of the GANOVEX program in the austral summer of 1979/80 with the construction of the Lillie-Marleen Hut in northern Victoria Land. Subsequently, between 1980 and 1982, the Alfred Wegener Institute for Polar Research (AWI) was founded and the research icebreaker „Polarstern“, the permanent station „Georg von Neumayer“ and the aircrafts „Polar 2“ and „Polar 4“ were put into operation. This laid the foundation for the ATS membership of the FRG in 1981.

In parallel, the DFG established the SPP „Antarctic Research“ in 1981. One motivation for the SPP was to provide a tool that allows as many scientists as possible from German universities and research institutes to use the infrastructure provided by AWI and BGR for research activities in the polar regions. The SPP was initially funded for three periods of five years duration. In 1997, the SPP was converted to the Coordinated Program “Antarctic research with comparative investigations in glaciated areas of the Arctic”, in order to support the expansion of German polar research into the Arctic, also reflected by the admission of Germany to the „International Arctic Science Committee“ (IASC) in 1990. The restriction of the SPP to comparative investigations in the Arctic was due to the easier accessibility of many regions in the high-northern latitudes, and existing alternatives for funding, e.g. by the German Federal Ministry of Education and Research (´Bundesministerium für Bildung und Forschung´, BMBF) in the Siberian Arctic and Arctic Ocean. In 2003, the Coordinated Program was converted back to a Priority Program.

Today, the SPP ensures access for German scientists to a variety of polar research platforms. For 30 years R.V. “Polarstern” has provided the necessary infrastructure for all kinds

of marine-based research in both polar oceans. In 2006, the possibility for polar marine research was enlarged by the R.V. "Maria Sybilla Merian”, a smaller vessel designed to operate in the marginal sea-ice zone. In addition, land stations are available in both high-latitude hemispheres. In Antarctica, “Neumayer Station III”, on the Ekström Ice Shelf fringing the northeastern Weddell Sea, conducts perennial observatories for meteorology, air chemistry, ocean acoustics, and geophysics. The “Kohnen Station”, set up at 2892 m altitude in Dronning Maud Land, East Antarctica, to serve as a logistic base for ice drilling activities within the scope of the European Project for Ice Coring in Antarctica (EPICA), now is the base for further meteorological, geophysical, and glaciological activities on the East Antarctic Ice Sheet. The “Dallmann Laboratory”, which is located on King George Island to the northwest of the Antarctic Peninsula and jointly operated with Argentina and The Netherlands, represents a base for shallow water biology research. In addition, the summer station “Gondwana“ of the BGR serves as base camp for geoscientists working in the Ross Sea sector of Antarctica. In the Arctic, the “Koldewey Station” in Ny Ålesund, Svalbard, and the “Samoylov Station” in the Lena Delta, Laptev Sea, which are operated in cooperation with France and Russia, respectively, provide manifold opportunities for research activities comparative to those in Antarctica.

Besides these national facilities, German scientists can also use the infrastructure of other countries active in the polar regions via proposals to the SPP. This takes place in small, bilateral co-operations up to large, multi-national research projects. Amongst the latter are glaciological and geological drilling projects (European Project for Ice Coring in Antarctica, EPICA, Antarctic Geological Drilling Program, ANDRILL, Integrated Ocean Drilling Program, IODP), marine-biological programs (Evolution and Biodiversity in the Antarctic, SCAR-EBA, Census of Marine Life, CoML, and ANtarctic benthic DEEP-sea biodiversity: colonisation history and recent community patterns, ANDEEP), and the marine biogeochemical program GEOTRACES.

During the past 30 years, coordinated funding by the DFG ensured that a large number of German scientists from almost all natural scientific disciplines and from various universities and non-university research institutions were able to make major contributions to the pressing scientific questions regarding the polar regions. The DFG provided not only the necessary financial resources for the research, but also the framework for its coordination and the international involvement. The same could not have been accomplished by the individual grants program of the DFG. In addition, the brisk participation of universities caused the admission of specific polar research topics to many curricular of undergraduate and graduate teaching. This resulted in the availability of a sufficient number of well educated, highly qualified and motivated young scientists ready to address the increasing tasks of polar research. The coordinated DFG programs thus significantly contributed to the very good international recognition of German polar research over the past three decades.

2 Conception and Goals for the Funding Period Applied (2013 - 2018)

The running funding period of the SPP ends on 31. Dec. 2012. Considering the still existing, in some areas even increased demand to carry out polar research, and its special dependency on a coordinated approach under the utilisation of the logistics provided by AWI and BGR, we see the compelling necessity to renew the SPP by another 6 years. The new funding period shall start on 1. Jan. 2013.

2.1 Overall Conceptual Design

Despite the overall progress of the running SPP phase, we recognise that only a small number of projects has directly addressed the important interdisciplinary research topics “System Coupling Processes” and “Climate Change: Past - Present - Future” in the intersection of the scientific disciplines (cf. Fig. 3 and Chapter 2.2.4). Besides, only a minority of scientists so far has made use of the opportunity to combine their projects to bundles that address wider research topics. Consequently, we see the need to further encourage the coordinated, interdisciplinary research in the SPP. This shall particularly be achieved by reduction and reorientation of the major research topics, which no longer are disciplinary in nature, but instead aim on providing important contributions to the four overarching, interdisciplinary research topics “Development of the Continent“, “Gateways to Lower Latitudes”, “Dynamics of Climate System Components”, and Response to Environmental Change” (Fig. 17).

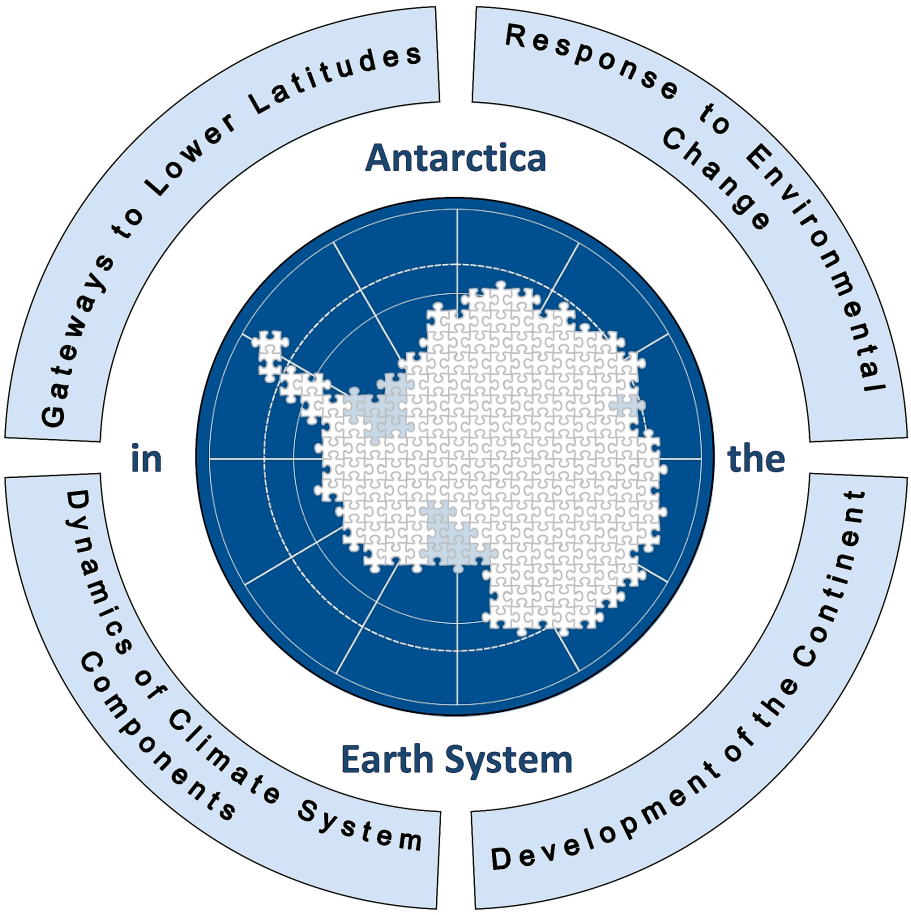

Fig. 17: Overarching interdisciplinary research topics concerning the role of “Antarctica in the Earth System”, which shall be addressed in the next SPP phase (2013 - 2018).

These research topics are all of utmost importance for a better understanding of the role of Antarctica in the Earth System. They are so wide that they cannot fully be investigated in the proposed renewal period of the SPP. However, in case of respective applications and funding, it is expected that the SPP can provide significant contributions and in some cases full answers to the specific science questions concerning these topics, which are outlined in the following chapter.

2.2 Scientific Goals

2.2.1 Development of the Continent

- *Formation, Break-up and Fragmentation of Supercontinents*

  Antarctica was at least twice during its geological history an integrated part of larger land masses. The supercontinents Rodinia and Gondwana formed as the result of the collision of several continental fragments and magmatic growth and accretion at 1.1-1.0 Ga and 650-500 Ma, respectively. Disintegration of Rodinia commenced at ca. 800-700 Ma, that of Gondwana at ca. 180 Ma, leading to the opening of the Southern Ocean and today’s continental distribution of the Southern Hemisphere. Taking into account that ca. 98 % of Antarctica is ice-covered and not directly accessible, major questions remain unanswered regarding the geodynamic evolution of Antarctica, in particular concerning: (i) the lithospheric structure and continental fragments of East Antarctica, (ii) the geodynamic processes during Rodinia and Gondwana assembly and disintegration, (iii) the geodynamics of the West Antarctic tectonic blocks, (iv) the subglacial geology of Antarctica, and (v) the geodynamics of Antarctic rift structures and circum-Antarctic sedimentary basins.

- *Climate History of Antarctica*

  Antarctica’s isolated position has resulted from the break-up and continuous fragmentation of Gondwana. It has eventually led to the change from a warm greenhouse to a cold icehouse world around the Eocene-Oligocene boundary with its impact on the global climate system. The influence of the Transantarctic Mountains and other Antarctic mountain chains on the long-term landscape and climatic evolution as a result of the interplay of lithology, uplift/denudation, and tectonics is of fundamental importance for the understanding of the younger (i.e. Cenozoic) history of the Antarctic. The distribution and reasons of Antarctic neotectonic activities play a major role with respect to the dynamics and fluctuations of the West- and East Antarctic Ice Sheets. Since continuous and complete sedimentary rock sequences are lacking or only insufficiently preserved on the Antarctic continent, geoscientific reconstructions have to rely on indirect evidence such as sedimentary drill cores from the circum-Antarctic offshore basins or shelf regions (e.g., ANDRILL). The Quaternary climatic evolution of Antarctica, reconstructed from young sediments (e.g., from in periglacial lakes) and ice cores (from the center and margins of the ice sheets), is fundamental for understanding and modelling future changes.

- *Evolution of the Antarctic Ice Sheet*

  The evolution and dynamics of the Antarctic Ice Sheet in the Cenozoic (e.g., greenhouse/ icehouse transition, Oligocene/Miocene, 12 - 20 Ma interval with the Miocene climatic optimum, Pliocene/Pleistocene transition, Quaternary climate cycles), and the related changes in the neighboring continental and marine environments (e.g., sea level, sea ice and bottom water formation) is intended to remain one major target of SPP. The analysis

shall be complemented by investigations of the reasons for pre-Cenozoic glaciations (e.g., Snowball Earth in the Late Proterozoic, Permo-Carboniferous glaciation). Changes of the Antarctic ice sheets on geological time-scales are preserved in deposits on land as well as the sediments of periglacial lakes and the Southern Ocean. The use of different geogenic archives and high-precision ice sheet models is of major importance for the understanding of the history and the reasons for regional differences in the ice-sheet behaviour, being a precondition for predictions of future scenarios.

- *The Impact of the Isolation of Antarctica on Biological Evolution*

  Extreme environments are important sources of evolutionary novelty partially because they are isolated and stimulate natural selection. Parts of the terrestrial fauna may be ancient and highly isolated suggesting that ice-free refuges must have existed throughout the last 40 million years on the Antarctic continent. In contrast, the marine environment may have been much less isolated than previously thought. Climatic changes may have opened the pathway for invasion of the Antarctic via warmer waters, whilst cooler periods may have been associated with isolation and extinction of cold intolerant species but rapid evolution of groups that could adapt to extremely low temperatures. This suggests that the Southern Ocean and the Antarctic continent act as a source of evolutionary novelty with implications beyond the polar regions. The emphasis of future SPP research will be based on the unique features of the Antarctic as a natural laboratory for studying the impacts of past climate change on evolution in an isolated and extreme environment. The context of historical invasions and extinctions around Antarctica is now particularly crucial in understanding the importance of current terrestrial, freshwater and impending marine introductions.

2.2.2 Gateways to Lower Latitudes

- *Opening of Major Oceanic Passage Ways*

  The closure and opening of major oceanic passage ways and basins have played a fundamental role with regards to the exchange of oceanic water masses between the world’s oceans and long-term global climate evolution. The exact dating and the reconstruction of the associated geodynamics and palaeogeography are of major importance for the understanding of natural climate change. For instance, the eruption of large volumes of basaltic magma and the emission of greenhouse gases into the atmosphere contributing to the hothouse climate in the Mesozoic was directly related to the separation of Africa and India (e.g., the Kerguelen Plateau). On the other hand, the geodynamic evolution of the southern hemisphere and the opening of the Tasman Gateway and the Drake Passage between Australia, New Zealand, South America and Antarctica, have led to the onset of a new system of oceanic currents, the reduced transport of heat from lower latitudes to the Antarctic, the decrease in atmospheric CO_2 concentrations, and, eventually, the cooling of the continent and the initiation of a first Antarctic ice sheet at the Eo-/Oligocene transition about 34 Ma ago.

- *Impact of Antarctic Climate Change on Global Climate*

  It meanwhile is consensus that climate change in Antarctica, despite the geographical isolation of the continent, is significantly influenced by climate change in lower latitudes and in the Arctic. For instance, comparisons of ice core records from Greenland and Antarctica have shown that temperature variations were opposite on millennial timescales

during the last glacial period, probably due to changes in the thermohaline circulation initiated in the North Atlantic (Bipolar Seesaw). In contrast, relatively little is known, which impact climate change in the Antarctic has on global climate. This shall particularly be addressed in the next SPP phase. Questions of interest are, for instance, the influence of the ozone hole on atmospheric circulation or the influence of fresh-water supply from disintegrating ice shelves on the formation of Antarctic Bottom Water and the associated ventilation of the deep water in the world´s oceans.

- *Sequestration of Climate-Relevant Trace Gases*

  The Antarctic marginal seas are considered as the 'breathing windows' of the deep ocean. The continental shelf/break of the western Weddell Sea is the prime producer of deep waters, which spread north across confining ridges and through guiding trenches to ventilate the lower stratum of the World Ocean. This ventilation is combined with a sequestration of climate-relevant trace gases, primarily carbon dioxide, on time scales of several hundreds of years. The western Weddell Sea and the Antarctic Peninsula are regions facing environmental changes the most, like sea ice retreat, ocean freshening, and ice shelf decay. How, in terms of water mass characteristics, processes, and spatial/temporal scales, these changes influence the deep water formation and thus the ventilation of the lower World Ocean is relevant for understanding the evolution of the global thermohaline circulation and the sequestration of climate-relevant trace gases.

- *Migration of Biota to/from Antarctica*

  Considering the determination of the role of Antarctica and extreme environments in general in evolutionary innovation and generation of global biodiversity as well as the response to climate change research on migration of biota to and from Antarctica are of fundamental importance. It is clear that Gondwana’s fragmentation led to increasing geographical isolation of Antarctica and the initiation of the ACC, which restricted, but not completely inhibited biota exchange. In addition, the continental ice-sheet has expanded and contracted periodically, covering and exposing terrestrial and continental shelf habitats. There were probably refugia for organisms during each glacial maxima, which are not well understood. Introduction of new taxa into Antarctica on the marine site as well as on the terrestrial site are most probably related to cycles of ice sheet and oceanic front movement and to natural dispersal processes such as rafting, hitch-hiking on migrants etc. Additionally, in recent years, humans have become influential both directly by transporting organisms and indirectly by increasing water temperature regime around the Antarctic Peninsula via climate change. The underlying, but poorly studied mechanisms of incursion and excursion events of Antarctic biota will be addressed and focused in the future SPP period to better understand biogeographical distribution patterns, dispersal, and invasions by neobiota.

2.2.3 Dynamics of Climate System Components

- *Ice Sheet Dynamics and Mass Balance*

  The glaciated Antarctic continent and the surrounding circumpolar ocean are part of a unique hydrological cycle with global significance. Changes to the delicate balance between surface accumulation (= *Atmosphere*) and mass flux across the grounding lines have a major impact on ice sheet dynamics (= *Ice*), ocean freshening and related ocean dynamics (= *Ocean*), as well as global sea level rise (= *Society*). The ability for projec-

tions relies on both a comprehensive understanding of the mechanisms presently at work and the knowledge about past ice sheet evolution (see Chapter 3.2.1).

- *Sea Ice, Snow and Associated Biota*

  The sea ice cover in the Southern Ocean is subject to the strongest seasonal variability on Earth. It is formed by the interaction between atmosphere and ocean and, once formed, has a strong influence on the Earth radiation budget as well as on the climate components and the processes controlling the interaction between them. Sea ice accelerates drifting icebergs and serves as a base for snow accumulation, as a habitat for organisms representing the lower food chain, and has the potential for CO_2 sequestration. The physical, chemical, and biological processes associated with sea ice and snow cover, as well as their variabilities through historical and geological times, need to be further investigated in order to better understand and quantify the role of polar sea ice in the global climate system.

- *Warm Water Intrusions onto the Continental Shelf*

  Some ice shelves fringing the Antarctic ice sheet are exposed already to Circumpolar Deep Water with temperatures above 1 ^{o}C. This water mass cascades nearly undiluted from the continental shelf break into 1000-m deep trenches underlying the floating extensions of streams draining the ice sheet. The warm water provides the heat for high basal melting which is responsible for fast grounding line retreat and the acceleration of ice sheet mass loss. The mechanism, forcing warm water onto the continental shelf, is still subject to speculations, might differ between the Antarctic marginal seas, and might change as climate progresses. Their understanding requires further analyses of existing and new oceanographic and glaciological data, and comparisons of the present processes with those reconstructed for the geological past.

- *Climate-Relevant Trace Gases in the Ocean*

  The Southern Ocean serves as a reservoir and conduit for natural and anthropogenic, climate-relevant trace gases, the most important being carbon dioxide. There is a huge variability of processes and fluxes on different spatio-temporal scales. As to the carbon cycle, the debate is ongoing whether the sink for atmospheric CO_2 is and will be diminishing or not. Recent attempts tried to identify processes and quantify fluxes that control the distributions of trace elements and isotopes in the ocean, and to establish the sensitivity of these distributions to changing environmental conditions. This scientific quest has just started and next steps should be cautiously planned to determine the scales of variability and how these are likely to change under future climate change.

2.2.4 Response to Environmental Change

- *Detection and Quantification of Change*

  To detect and quantify the environmental changes currently occurring in Antarctica, i.e. under known (measurable) boundary conditions, is essential for predicting the changes to be expected in the future. This requires the deployment and partial improvement of remote sensing tools, e.g., for monitoring sea ice characteristics and the mass balance of glaciers and ice sheets. Changes in oceanic and atmospheric properties need to be monitored by long-term observations, e.g., by means of ocean drifters, gliders, and weather stations and balloons. Analysis of the data obtained more and more requires support from

numerical modelling. For the detection of changes in Antarctic biology, sites need to be revisited and investigated with comparable, standardized methodologies. New techniques such as remote operating vehicles (ROVs) and permanent sea-floor observatories open new opportunities. To compare the present environmental changes with changes in Earth history, geologists have to further develop geological and glaciological proxies for the settings in the past, and to improve existing transfer functions for the quantification of environmental and climatic variables.

- *Relevant Polar Processes*

  A profound appraisal of the environmental settings, relevant in the past, at present, and in the future, requires a thorough understanding of the processes operating in the Earth System. The SPP 1158, therefore, intends to put a strong focus on local impacts particularly important in the polar regions. Examples are, to mention a few, the influence of (i) sea-ice and snow albedo on the radiation balance, (ii) polynyas and leeds on the characteristics of the lower atmosphere, (iii) drifting icebergs on the fertilisation of the upper ocean, (iv) ocean dynamics on feeding grounds of Antarctic mammals, and (v) biological and chemical processes on the carbon cycle in the ocean.

- *Predictions - Based on Numerical Modelling*

  As answer to the 2007 Intergovernmental Panel on Climate Change (IPCC) report, which highlighted ice sheets as the most significant remaining uncertainty in projections of sea-level rise, model activities in polar science are focused on studying the evolution of the polar ice sheets in response to projections of man-made changes in atmosphere and ocean. However, changes of the ice sheets also have a profound feedback on atmosphere, ocean, and the biology therein, due to, e.g., changes in surface topography, surface characteristics, areal extent, and the input of freshwater and sediments. These feedback mechanisms should be studied to fully understand the complex interplay between the climate components in the southern hemisphere but also to assess the impact of environmental changes in Antarctica on the global atmosphere, ocean and life as well as the relevant time scales.

2.3 Integration and Administrative Goals

2.3.1 Relation to Other National Programs

The SPP merges national interests and resources in the polar regions and thus combines and amplifies the scientific activities of various German institutions. An established division of labour exists with BMBF projects, which are primarily conducted in the Arctic (e.g., “System Laptev Sea”, “Taymyr”, “Elgygytgyn”, “Kalmar”). Relations also exist to the DFG-SPP “IODP” (Integrated Ocean Drilling Program), since the IODP has carried out drilling operations with participation of German scientists on the Lomonosov Ridge, cental Arctic Ocean, in 2004 (IODP cruise 302, Arctic Coring Expedition, ACEX) and off Wilkes Land, East Antarctica, in 2010 (IODP cruise 318). In the future, relations might also arise with the SPP “ICDP” (International Scientific Continental Drilling Pogram), if present efforts of ANDRILL (Antarctic Geological Drilling Program) to carry out drilling operations on the Antarctic continent with ICDP funding become realised.

2.3.2 International Collaboration

The topics of the SPP are based on scientific objectives defined by the World Climate Research Program (WCRP), the International Geosphere - Biosphere Program (IGBP) and the Scientific Committee on Antarctic Research (SCAR). These three programs have initiated and established most of the past and ongoing large international research initiatives in Antarctica.

Within the WCRP, the core projects CliC (Climate and Cryosphere) and CLIVAR (Climate Variability and Predictability) are of particular importance for the SPP. CliC focuses on the interaction between the atmosphere, sea ice, and ocean on regional and global scales, as well as the atmospheric processes above the ice sheets and the impact of ice sheet changes on global sea level. CLIVAR, in contrast, puts a particular focus on the role of ocean-atmosphere interactions in the climate system.

Antarctic research topics of the IGBP are predominantly anchored in the core projects IMBER (Integrated Marine Biogeochemistry and Ecosystem Research), LOICZ (Land-Ocean Interaction in the Coastal Zone), and PAGES (Past Global Changes). These projects deal with the marine ecosystem and its variability, the environmental interactions and feedbacks governing coastal system status and changes, and the understanding of past changes in the Earth system, respectively.

Of particular importance for the SPP are the research programs ACE (Antarctic Climate Evolution), AGCS (Antarctica and the Global Climate System), EBA (Evolution and Biodiversity in the Antarctic), and SALE (Subglacial Antarctic Lake Exploration, until 2010) of SCAR. These programs aim on a better understanding of the climatic and glacial history of Antarctica, the nature of atmospheric and oceanic linkages between the climate of Antarctica and the rest of the Earth system, the evolution and diversity of life in Antarctica, and the interplay of biological, geological, chemical, glaciological, and physical processes within subglacial environments, respectively. SCAR recently has launched a new strategic plan (for the years 2011 - 2016) and established four program planning groups, which may develop the next generation of research programs: State of the Antarctic Ecosystem (AntEco), Antarctic Ecosystems: Adaptations, Thresholds and Resilience (AntETR), Antarctic Climate Change in the 21st Century (AntClim21), and Solid Earth Responses and Influences on Cryospheric Evolution (SERCE).

2.3.3 Promotion of Young Researchers

Due to the extensive participation of scientists from universities, the SPP 1158 constitutes the crucial instrument for promoting German students to become engaged in polar research. At the universities, topics specific for polar research are integrated in many curriculars in undergraduate and graduate teaching. Students get also sensitised to the importance and particular role of the polar regions by their involvement in research projects as student research assistants (Studentische Hilfskräfte, SHK) or within the scope of their Bachelor, Master, or Diploma Theses, in some cases including the participation on polar field campaigns. In many cases students with such background later on make their PhD on polar topics, either directly at a university or in collaboration between a university and a non-university research facility such as AWI or BGR (cf. List of Postgraduate Theses in Attachment 5). Several of the current SPP applicants in this way have become involved and partly or totally kept in polar research.

The SPP thus ensures that a sufficient number of well-educated, highly qualified young researchers is available to address the increasing tasks of polar research also in the future. The frequently interdisciplinary nature of the SPP projects, which almost exclusively are carried out in close international collaboration, qualify young researchers evolving from such projects also for a variety of other academic challenges. It can be observed that alumni with postgraduate theses in polar research have prospects of success well above average on the employment market.

2.3.4 Established Coordination Procedures

Within the scope of the running SPP phase (2008 - 2012) the formerly established coordination activities have significantly been improved (see Chapters 2.1.2 and 2.1.3). The following procedures and activities have been proved and tested, and thus are intended to be kept in the aspired new SPP phase (2013 - 2018).

Support of Review Process

The review process benefits from the reports provided by the SPP coordinators to the evaluation committee concerning the general feasibility of the projects applied with respect to logistics, duplication of efforts, and existing or missing coordination with other projects. These reports during the past years have become shortened and homogenised, thus providing major information in a rather condensed way. In addition, the review process today benefits from the compulsory questionnaires for the applicants and for the reviewers, which were developed in the course of the running SPP phase, as well as the earlier submission deadline, extending the period available for the collection of external reviews, and the extended application period, reducing the number of proposals to be examined.

Coordination, Internal Communication and Collaboration

The SPP in the running phase for the first time was focused on a number of selected reseach topics (see Fig. 3), which are changed and significantly reduced in the aspired SPP phase (see Fig. 17). This has led to the fact that the coordination today is not restricted to support of the administrative handling but also includes scientific guidance of the priority program. The latter particularly takes place during the annual coordination workshops. These workshops also function as an important tool for fostering the internal communication, enhanced since 2011 by the inclusion of poster presentations of running SPP projects. Further improvements of the information flow within the SPP community in the course of the running SPP phase came from the regularly distributed circulars and the establishment of the SPP web pages. Besides, the program-internal collaboration was supported by the opportunity to link SPP projects in project bundles, the involvement of universities was fostered by the restriction of applications from non-university institutions, and the SPP was made competitive to other programs by increasing the salary of PhD students. Finally, the compatibility of family and career (Vereinbarkeit von Familie und Beruf) is supported by the DFG by supplementary funds handled by the SPP coordination office.

External Presentation and Public Relations

The external visibility of the SPP has significantly increased by press releases and public talks, by the development of a program flyer, by the contribution to a BMU brochure, by the execution of the report colloquium within the scope of an international conference, and in particular by the development and constant maintenance of the SPP web pages (www.spp-

antarktisforschung.de). The number of calls of the web pages (see Fig. 2) clearly shows that the pages are not only visited by SPP scientists but also extensively by external users.

Documentation of Activities and Results

Due to the personnel support provided to the SPP coordinators (scientific assistant and student assistant, see above), the administrative handling, the activities, and the scientific outcome of the SPP since 2007 are properly documented. Major results are continuously made available to the science community and public via the SPP web pages. The degree of documentation strongly benefits from the established obligation to store the scientific data achieved into a freely accessible database, the required statement of its fulfilment in the compulsory questionnaire for the applicants, and the function of the scientific assistant Oliver Stock as the liaison person between the SPP community and the database PANGAEA.

2.3.5 Aspired Modifications

Despite the progress made in the current SPP phase, based on a large number of modifications (see Chapter 2.1.3), most of which we intent to keep (see Chapter 3.3.4), we see the necessity to further improve the SPP in the aspired next phase in the following three fields.

Participation of Coordinators on the Evaluation Committee Meetings

The contribution of the coordination team to the review process in the SPP 1158 so far is restricted to a proper documentation of the proposals submitted, written reports provided to the evaluation committee concerning the feasibility of the projects applied, and (since 2010) an introductory talk at the beginning of the evaluation committee meeting. The rest of the meetings then took place without the involvement of the coordinators. They left the room but kept available to answer program-related questions, which, however, virtually never became posed.

According to our experience from the running SPP phase, the decisions of the evaluation committee in a very limited - but still too high - number of examples did not consider unambiguous statements in the reports of the coordinators (e.g., concerning the resubmission of an already funded proposal and a proposed project that could not be carried out due to the absence of the required logistics). In addition, the significantly restricted research topics and associated science questions in the aspired next SPP phase (see Chapter 3.2), in difference to previous phases, demands active scientific guidance that requests a detailed understanding of the compatibility of the proposed projects, which can probably best be provided by the coordination team.

Due to these two reasons, the coordinators insist on participating the evaluation committee meetings. To be clear, we do not intent to decide on the proposals, this is the challenge of the evaluation committee, but we intend to make sure that the decisions made are based on full knowledge of the coordinators´ perceptions.

Establishment of Working Groups to the SPP Research Topics

Taking (i) the scientific foci put on four multidisciplinary research topics to be addressed in the aspired SPP phase (see Chapter 3.2), (ii) the rather low numbers of both project bundles and multidisciplinary research projects that could become established during the running SPP phase (see Chapters 2.1.3 and 2.2.4), and (iii) the hitherto limited compilation of SPP results into publications that address wider research questions (see Chapter 2.2), we see the

necessity for significantly enhanced collaboration within the SPP. This cannot be provided by the annual coordination workshops alone.

Therefore, we intend to establish working groups on each of the four major research topics of the aspired SPP phase. The working groups shall each consist of the SPP applicants and employees working on the respective topics, and be coordinated by one of the four SPP coordinators, respectively, which function as the speakers of the working groups. The groups shall conduct annual meetings (two half days each) independent on the coordination workshops, with the necessary travel money provided through the coordination grants. Further communication amongst the working groups shall be fostered by the SPP web pages, with internal parts providing individual list servers to be used, for instance, for the exchange of data, to address questions to specialists, and to adjust individual scientific goals and procedures. The working groups in the course of the SPP phase shall merge selected data to peer-reviewed publications that provide significant contributions to the research questions of each of the four research topics. The respective papers shall be submitted latest by the end of the aspired SPP phase (i.e. in 2018).

Increasing the SPP Awareness Level

In the running SPP phase the awareness level of the SPP in the German science community has significantly increased, due to a variety of activities by the coordination team (see Chapters 2.1.2 and 2.1.3). This is apparent in the large number of applicants that have submitted proposals to the DFG for the first time, and in the significantly increased volume of funds requested by the proposals submitted in 2011 (see Chapter 2.1.1). Nevertheless, we intent to further increase the SPP awareness level by the following activities.

Special sessions shall be setup on large international conferences (e.g. EGU, AGU, ISAES, IGC, IPY Conferences) on the research topics of the SPP, jointly with international co-conveners of particular scientific standing in the respective fields. This would support the networking of SPP scientists with international research groups dealing with the same topics and may potentially result in special journal issues on these topics co-edited by SPP coordinators /working group speakers.

In the aspired SPP phase (2013 - 2018) the German Society of Polar Research (´Deutsche Gesellschaft für Polarforschung´, DGP) will hold three International Polar Conferences, the first in spring 2013 (in Hamburg), the second in autumn 2015, and the third in spring 2018. Taking into account the experiences and the success of the 2010 conference (in Obergurgl, Austria, see Chapter 2.1.2), it is intended that the SPP contributes to all these conferences by series of special sessions with invited talks that present highlights of the SPP outcome. These contributions could function as Report Colloquia of the SPP, which consequently would be spread over three events in the next SPP phase, compared to only one event in the running phase.

The visibility of the SPP on national conferences thus far, besides distributed talks of SPP scientists, was restricted to irregular distributions of the program flyer. Where possible, we intent to inform about the SPP in booths, where additionally posters can be presented and a SPP representative is available to answer program-related questions.

3 Acronyms Used in the Proposal

ACC	=	Antarctic Circumpolar Current
ACE	=	Antarctic Climate Evolution
ACEX	=	Arctic Coring Expedition
AGAP	=	Antarctica’s Gamburtsev Province
AGCS	=	Antarctica and the Global Climate System
ANDEEP	=	Antarctic Benthic Deep-Sea Biodiversity Project
ANDRILL	=	Antarctic Geological Drilling Program
AntClim21	=	Antarctic Climate Change in the 21st Century
AntEco	=	State of the Antarctic Ecosystem
AntETR	=	Antarctic Ecosystems: Adaptations, Thresholds and Resilience
ATS	=	Antarctic Treaty System
AWI	=	Alfred Wegener Institute for Polar and Marine Research
BGR	=	Federal Institute for Geosciences and Natural Resources
BMBF	=	German Federal Ministry of Education and Research
CliC	=	Climate and Cryosphere
CLIVAR	=	Climate Variability and Predictability
CoML	=	Census of Marine Life
DAMOCLES	=	Developing Arctic Modelling & Observ. Capabil. for Long-term Environm. Studies
DFG	=	German Research Foundation, Deutsche Forschungsgemeinschaft
DGP	=	German Society for Polar Research, Deutsche Gesellschaft für Polarforschung
EAAO	=	East African-Antarctic Orogen
EBA	=	Evolution and Biodiversity in the Antarctic
EPICA	=	European Project for Ice Coring in Antarctica
ESF	=	European Science Foundation
GANOVEX	=	German Antarctic North Victoria Land Expedition
GEOMAR	=	Hemholtz Centre for Ocean Research Kiel
GEOTRACES	=	International Program to Study the Cycling of Trace Elements in the Ocean
IASC	=	International Arctic Science Committee
ICDP	=	International Continental Scientific Drilling Programm
ICSU	=	International Council for Science
IGBP	=	International Geosphere - Biosphere Program
IMBER	=	Integrated Marine Biogeochemistry and Ecosystem Research
IMCOAST	=	Impact of Climate Induced Glacial Melting on Marine Coastal Systems in WAPR
IODP	=	Integrated Ocean Drilling Program
IPY	=	International Polar Year
LA SCAR	=	Landesausschuss SCAR/IASC
LOICZ	=	Land-Ocean Interaction in the Coastal Zone
PAGE21	=	Changing Permafrost in the Arctic and its Global Effects in the 21st Century
PAGES	=	Past Global Changes
SALE	=	Subglacial Antarctic Lake Exploration, until 2010
SCAR	=	Scientific Committee on Antarctic Research
SCAR-EBA	=	Evolution and Biodiversity in the Antarctic
SERCE	=	Solid Earth Responses and influences on Cryospheric Evolution
SPP	=	DFG Priority Program (´Schwerpunktprogramm´)
WAIS	=	West Antarctic Ice Sheet
WCRP	=	World Climate Research Programme
WMO	=	World Meteorological Organization