THE BELGIAN ANTARCTIC PROGRAMME

1985 - 2002

Findings of the evaluation panel

- *Final report* -

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1 INTRODUCTION

The purpose of this introductory chapter is to set the scene for the evaluation of the Belgian Antarctic Programme 1985-2002 by presenting successively: the physical environment of the Antarctic and what makes the pursuit of Science in that remote part of the world so attractive; the logistical constraints imposed by the combination of distance and extreme conditions; the international arrangements, of which research is an element; and finally, why an evaluation was needed and how it was organised.

1.1 Research in the Antarctic

The Antarctic continent and its coastal seas provide unique opportunities for scientific research that cannot be performed elsewhere on Earth. Scientists have obvious reasons to be attracted to Antarctica. The continent is huge; its environment is pristine and uncontaminated; the whole area, despite its remoteness and extreme climate conditions, offers exciting challenges for research that has important implications for the future of our planet.

Box 1.1 Some facts about the Antarctic

The size of the continent is 13,200,000 km^2, 1.5 times Europe, 10 % of the Earth's land surface. Some 90 % of the world's freshwater reserves are contained in Antarctic ice. Average temperatures range from –75°C in Winter to –35°C in Summer. Since it is so dry in Antarctica, there is very little moisture in the air, and so the average annual rainfall at the pole is a mere 2.5 cm. Winds of 320 kph have been recorded which are conditions for the most violent storms and roughest seas in the world. Antarctica's cover of ice, averaging 2,000 m in thickness, with a maximum of about 4,500 m, is the planet's greatest land-based archive of data on past climates.

Biology and ecology, climatology and glaciology, upper atmosphere physics, geology and geophysics: these disciplines of science are among the most actively pursued in the Antarctic. Being extremely rich in marine life, the surrounding seas are obvious targets for research on marine organisms and on the functioning of interdependent ecosystems. Indeed, the first "scientific" observations made in the area during the late 18th and 19^{th} centuries were linked to the observation of whales and seals during hunting expeditions. Nowadays, more and more issues are emerging under the general heading of "Global Change", demonstrating the vital importance of this continent (and of the Arctic as well) in the Earth's climate system. Climate is controlled by insolation and complex interactions of atmosphere, ocean and ice. Concern about climate changes and their causes, whether natural or anthropogenic (e.g., the accumulation of greenhouse gases) is increasing within society. We need to understand the processes at work in order to reconstruct past climates and forecast future trends with their consequences, such as warming, sea levels rise, changes in the distribution of fisheries, vegetation, crops and pathologies. The study of ice cores collected to depths over 3,000 m under the EPICA Programme (European Programme of Ice Coring in Antarctica) may allow the reconstruction of climate records as far back as 500,000 years.

In the land-based research stations, scientists work on a wide variety of projects ranging from routine measurements (e.g. monitoring of ecosystems, air, sea, climate) to basic research. Today there are 42 winter stations operated by 18 different countries (Figure 1.1). There is also a large number of summer (ice-free) field stations, most of which are concentrated to the Antarctic Peninsula and the nearby islands.

In such a remote and hostile environment, co-operating on science work and on the related logistics is a necessity. A substantial amount of scientific work in the Antarctic is performed through international programmes. The EPICA programme is a striking example, although not the only one. It is also important to stress the vital role of day to day co-operation between research stations.

1.2 Logistics for Antarctic research

The logistic organisation of research activities in Antarctica is a complex and expensive endeavour. Its costs and complexities are influenced by many factors. Several options exist for Antarctic research, among them:

- marine expedition without land-based activity or supporting land-based field activity;
- research stations for year-round activity or summer operations;
- land expedition to parts of the continent (with temporary bases) that can be reached by international co-operation in sea and also air transport such as from South Africa to the new airfield in Dronning Maud Land and from Christchurch to McMurdo.

To give actual costs of Antarctic logistics is not easy or very meaningful, because many factors are involved and vary with time and with the type of construction, the size of the activity, the country involved, and the location of the activity. There are research stations that have been built half a century ago where a continuous upgrading has been done, and stations that have been maintained for many years with very little modification or upgrading in time and this changes considerably the real cost of the infrastructure.

Selection of a region and of the site of a research station are influenced by a number of factors, among them:

- the proximity to other stations with which there is scientific or logistic co-operation;
- the distance of the site from one of the Antarctic gateways (harbour cities located in areas comparatively close to Antarctica, such as Ushuaia in Argentina, Punta Arenas in Chile, Christchurch in New Zealand, Cape Town in South Africa);
- the region and the site selected enables the performing of useful and interesting research;
- the site selected is not too difficult to reach.

Given the size of the Antarctic continent there is a large variety of possible locations more or less easy to reach and this can influence the cost of building a research station and the running costs of its operation. If the station is not on the coast but inland on the Antarctic Plateau, such as the station Concordia, being built at present by France and Italy, the cost of transporting the materials for the construction is much higher than for any other location. Countries with large Antarctic organisations and with a number of stations already in operation have a large pool of experienced personnel in service and this may help in reducing the costs. If the site selected for the station is on the seacoast, a transport/research ship may be desirable or even indispensable. Some countries have their own vessel(s), e.g. UK, USA, Russia, Germany, Spain, France, Japan, South Africa, South Korea, Argentina, and China. Other countries charter vessels.

A station needs more people for its use than a ship and this has a bearing on the costs for equipping, maintaining, refuelling and supplying. Cargo and supplies are carried usually by ship from outside Antarctica. Many Antarctic research programmes use ships to support their research stations. The cost of using a ship is high, but a ship gives very high flexibility to operations. A ship can transport personnel, fuel, and all sort of equipment and can perform scientific work such as oceanography and marine geophysics. The cost of the charter of a ship is a function of the size, its characteristics, the equipment carried, the personnel and cargo carrying capacity. Many countries use for Antarctic work also ships of their national navies and this may reduce the costs considerably. A new possibility has opened up for air-transport of personnel and limited supplies from Cape Town to Dronning Maud Land, but more extensive freight must be brought by ship to the continent. In a purely indicative way the cost of the charter of a large ice reinforced ship for six-seven months may be between two and three million USD. To this it will be necessary to add the cost of equipping the ship with scientific equipment, if the ship is also used for research.

Another factor that may change considerably the costs of running a station is if the station is operational year round or summer only. The choice may depend on the type of research to be performed. Coastal stations in Antarctica have ice in front of them for most of the winter period and, therefore, a number of scientific activities cannot be performed between March and October. Only in the northern Antarctic Peninsula is sometimes possible to sail to and from coastal stations also in winter. Most year-round stations have a winter occupancy about one tenth of that in summer. In the northern part of the Antarctic Peninsula winter occupancy and summer occupancy are almost the same. A number of Antarctic stations have a helicopter or a light plane to widen the range of research activities. This is expensive but in many cases it allows a considerable broadening of the scientific activities.

The cost of building a small research station for 15-20 people in a site not presenting unusual characteristics could be of the order of one million USD, including electricity generating capacity, heating system, water distillation capacity, radio system and the cost of carrying material to Antarctica. This is, however, a very rough estimate. Other costs connected with Antarctic research stations are those of the day-to-day running and maintenance, the cost of personnel, of its training.

The area of Antarctica where the cost of a research station would be probably the smallest is the northern part of the Antarctic Peninsula. It is close to the southern tip of Latin America, only 1,000 km from Cape Horn and Tierra del Fuego, and is very crowded with stations (see Figure 1.1). As a final consideration, one should say that selecting a site for a research station in Antarctica is a delicate and important question; it has to be done with great care because once selected it is not easy or economical to go somewhere else to do research in another area.

The availability of a vessel allows the performance of research work at sea. As an example, the ship chartered by the Italian Antarctic Research Programme for a number of years has been used for transporting supplies, equipment, fuel for the base, and personnel. It is also used for oceanographic work in the Ross Sea. Hydrographic surveys are done during transit from and to New Zealand, where expedition members arrive from Europe on commercial flights. Of course, not all countries need a large vessel and then the cost is proportionally lower.

The best way to discuss in more detail logistics and their cost is to participate to the meetings of COMNAP/SCALOP that are attended by all governments, Antarctic expedition leaders and logistic specialists (see Section 1.3).

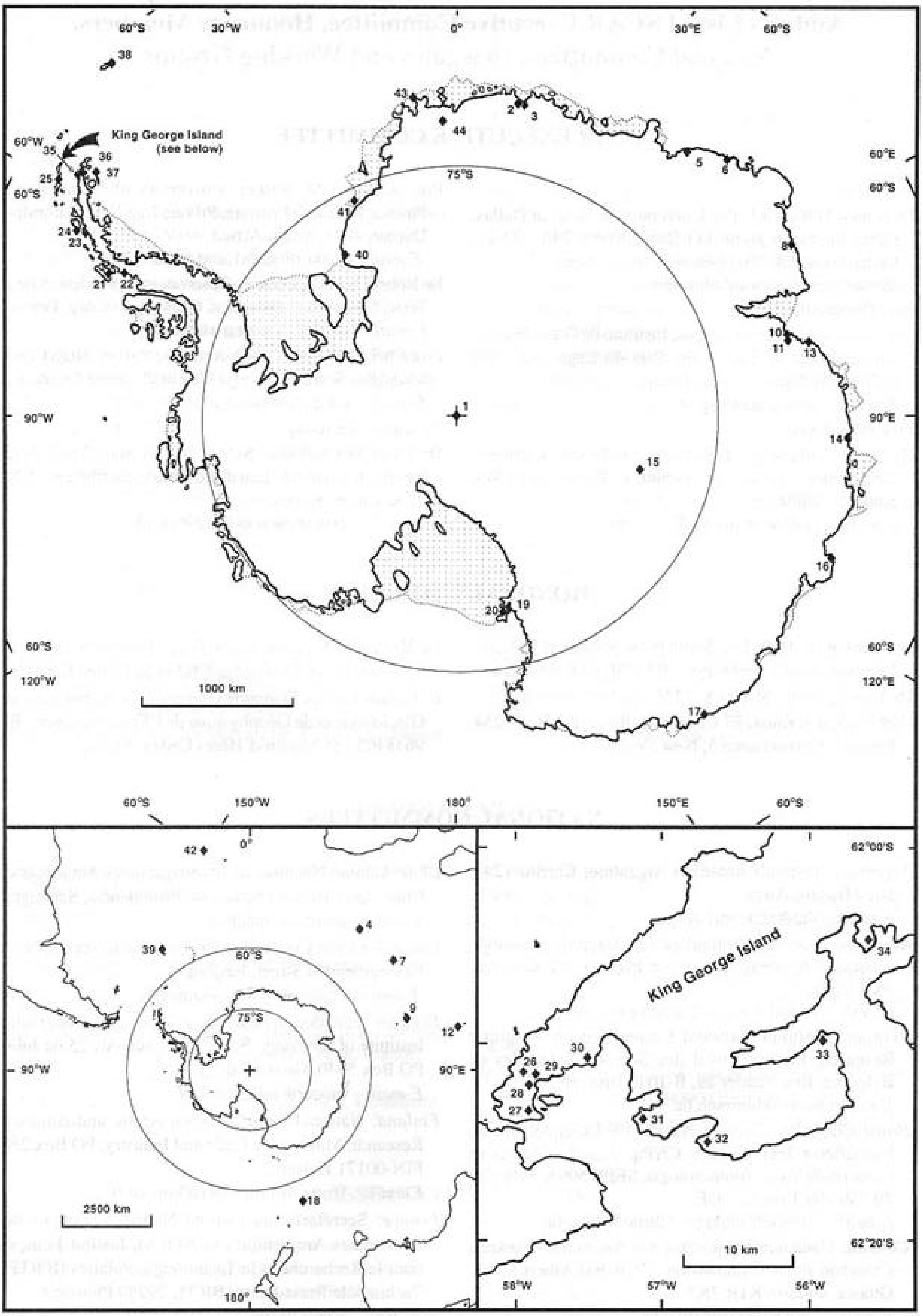


Fig. 1.1 Antarctica with the winter research stations as operational in 2000 (Source: SCAR). Legend of the numbers can be consulted in Annex 1.1.

1.3 The Antarctic Treaty System

Nowadays, research in the Antarctic cannot be performed without an official involvement of a country. This section, therefore, briefly summarises the legal and organisational setting of undertaking (research) activities in this area.

The continent of Antarctica and its surrounding seas, i.e. the polar area south of 60° South Latitude, including all ice shelves and islands, are subject to a treaty system under international law. This **Antarctic Treaty System (ATS)** is the complex of arrangements aiming at the regulation of the international relations among its members within the **Antarctic Treaty Area (ATA)**. The heart of the system is the **Antarctic Treaty (AT)**; its primary purpose is to ensure "in the interest of all mankind that Antarctica shall continue forever to be used exclusively for peaceful purposes and shall not become the scene or the object of international discord". The AT provides for "freedom of scientific investigation in Antarctica, promotes international co-operation in scientific investigation in Antarctica", prohibits the establishment of military bases, but allows the use of military personnel and equipment for logistic support to scientific research, prohibits the testing of nuclear weapons and the disposal of radioactive waste. It also provides for the right of inspection of research stations and of ships and aircraft for exchange of information and verification of the Treaty and the Madrid Protocol (see below). Article IV of the Treaty "freezes" the question of territorial claims in Antarctica and states that "no new claim or enlargement of an existing claim to territorial sovereignty in Antarctica shall be asserted while the present Treaty is in force". The ATS is regarded as a very successful model for international co-operation outside the UN. Its 44 member states represent about two-thirds of the world's human population (Box 1.2).

Box 1.2 The current 44 Antarctic Treaty member states

The original signatories to the Treaty were the 12 nations (Argentina, Australia, **Belgium**, Chile, France, Japan, New Zealand, Norway, South Africa, USSR, UK, USA) that were active in Antarctica during the International Geophysical Year (1957-1958) and that accepted the invitation of the USA to take part in the conference in Washington at which the Treaty was negotiated in 1959. It entered into force in 1961. These signatories became the original 12 Consultative Parties.

15 additional nations (Brazil, Bulgaria, China, Ecuador, Finland, Germany, India, Italy, the Netherlands, Poland, Peru, South Korea, Sweden, Spain, Uruguay) have achieved consultative status by acceding to the Treaty between 1983 and 1990 and by conducting scientific research in Antarctica. Russia carries forward the signatory privileges and responsibilities of the former USSR.

Another 17 nations that have acceded to the Treaty (Austria, Canada, Colombia, Cuba, Czech Republic, North Korea, Denmark, Greece, Guatemala, Hungary, Papua New Guinea, Romania, Slovak Republic, Switzerland, Turkey, Ukraine, Venezuela) agree to abide by the Treaty and may attend consultative meetings as observers.

The steering body in the ATS is the **Antarctic Treaty Consultative Meeting (ATCM)**, a conference with, at present, 27 of the 44 member states including Belgium, that have consultative status under Article IX of the AT, i.e. a right to participate in the decision-making at these meetings. These **Consultative Parties** have demonstrated a special interest in Antarctica by conducting substantial scientific research activities. From 1961, meetings have been held approximately every other year, but since 1993 annually. These meetings are held in order to exchange information, discuss matters of common interest, and formulate recommendations and measures in furtherance of the principles and objectives of the Treaty. Issues looked at so far are, in particular, improvement of scientific co-operation, e.g. in the fields of meteorology, telecommunications, ice warning, hydrography and air traffic safety, and environmental protection. Belgium hosted the 3rd and 13th ATCM in 1964 and 1985.

Apart from the Treaty itself, other important components of the ATS are the CCAS (Convention on the Conservation of Antarctic Seals, 1978), the CCAMLR (Convention on the Conservation of Marine Living Resources, 1982), the Protocol on Environmental Protection to the Antarctic Treaty, the so-called Madrid Protocol, signed in 1991 and in force from 1998 after ratification by all signatories.

The Madrid Protocol establishes a number of environmental principles and stresses the need for international scientific and logistic co-operation in Antarctica, the evaluation of the environmental impacts of proposed activities, and environmental monitoring. Also the need to establish emergency response action for responding promptly to environmental emergencies is clearly stressed. The most significant decision relates to the ban on all activity other than scientific research relating to the Antarctic's mineral resources. The Annexes give specific guidance on the preparation of environmental impact assessments, protection of fauna and flora, waste management, marine pollution, and on specially protected areas. Two additional annexes are in preparation, one on Liability for environmental damage in Antarctica and one on Tourism. Together with Australia, France and Italy, Belgium played an important role in supporting the establishment of the Protocol, in particular introducing many procedures.

The Madrid Protocol had also the effect of broadening considerably the scope of the Treaty inspections. In the last ten years inspection teams have added to the checklists for inspections a number of points dealing with compliance with the Protocol. Within the context of transparency of the ATS, the ATCM promotes the organisation of inspections by member states to other member states. In 1999, Belgium and France undertook a joint inspection of scientific and logistic facilities of Australia (stations and vessel). Although the Madrid Protocol entered into force only in 1998, special attention was paid to the implementation of the Protocol's provisions in the inspected sites. The report includes observations and recommendations, and was presented in the 2001 ATCM meeting in St. Petersburg, Russia.

In order to oversee implementation of the Protocol, an institution was created: the **Committee on Environmental Protection (CEP)**[1]. Worthwhile noting is that the ATS itself does not yet have a permanent secretariat to handle administrative duties. Furthermore, provisions for an annex to the Protocol on liability for environmental damage were left to a future annex. The Protocol intends for the CEP to be advisory to the ATCM on many issues concerning implementation. This advisory function is particularly relevant in terms of Environmental Impact Assessments which have a key potential role in ensuring that Antarctic operations are planned and carried out according to the letter and spirit of the Protocol. Following the ATCM requirement for a national CEP contact point, the OSTC is subsidizing an official Belgian contact point at the research institute of one of the project grantees since 2001 for an initial period of two years. A further (permanent) financing will depend on the outcome of an evaluation at the end of this period.

The International Geophysical Year (1957-1958) that included a major Antarctica component resulted in good scientific results and international co-operation. Encouraged by this success and in order to ensure the valuable activities initiated here, the International Council for Science (ICSU) set up a special committee on Antarctic research that evolved into the

[1] http://www.cep.npolar.no

Scientific Committee on Antarctic Research (SCAR)[2]. Its main purpose is to provide a forum for scientists of all countries with research activities in the Antarctic to discuss their field activities and plans and to promote collaboration between them (initiation, promotion and co-ordination of scientific research). The experience and expertise of an international mix of scientists has made SCAR an important source of advice to the ATS on many matters, e.g. the many international agreements treating the protection of the ecology and the environment.

Members of SCAR are the National Committees of national scientific academies or Research Councils of nations that are active in Antarctic research, relevant ICSU Scientific Unions, and Associate Members (national scientific organisations that plan to become active in Antarctic research). In Belgium, the National Committee on Antarctic Research is part of the Royal Belgian Academy of Sciences (Annex 1.2 presents its members). SCAR Delegates meet biennially to determine policy and strategy. Scientific matters are discussed in seven permanent Working Groups: Biology; Geodesy and geographic information; Geosciences; Glaciology; Human biology and medicine; Physics and chemistry of the atmosphere; Solar-terrestrial and astrophysical research. Belgium is active in six of them (see Annex 1.2). There are currently also five Groups of Specialists: Antarctic neotectonics (ANTEC); Environmental affairs and conservation (GOSEAC); Global change and the Antarctic (GLOCHANT); Seals; Subglacial Antarctic lake exploration (SALE). They are created in response to specific scientific problems with a life span of 10 years in which to complete their tasks.

Apart from the above legal setting and SCAR, the **Council of Managers of National Antarctic Programmes (COMNAP)**[3] is also part of the ATS. Membership is open to the national organisation responsible for planning and conducting that nation's research in the Antarctic, provided the national government is a party to the AT and the country is actively engaged in research in the Antarctic. Established in 1988, COMNAP assembles managers of national agencies responsible for the conduct of Antarctic operations in support of science. It convenes every second year to discuss Antarctic activities, to exchange information on the actual implementation of the programmes. Sometimes industry specialists may take part if the need arises, in order to clarify matters when new equipment or instruments are foreseen. A special reference should be made to SCALOP, the Standing Committee on Antarctic Logistics and Operations, one of the five committees of COMNAP. This committee provides technical advice on Antarctic logistics and operations, investigates and, where necessary, arranges for research on operational problems, and addresses technical and operational matters of mutual interest to national operators. Both SCAR and COMNAP are important because they promote discussion of common problems and give the opportunity of planning possible form of co-operation among countries.

Worthwhile mentioning is also the **International Association of Antarctica Tour Operators (IAATO)**[4]**.** Founded by private tour operators in 1991, IAATO is dedicated to appropriate, safe and environmentally sound private-sector travel to the Antarctic. With tour vessels of individual companies used to also ship scientists and supplies, it provides logistical support to the national Antarctic programmes. It is also present at the ATCM's.

[2] http://www.scar.org
[3] http://www.comnap.aq
[4] http://www.iaato.org

1.4 Evaluation of the Belgian Antarctic Programme

The Belgian Scientific Research Programme on the Antarctic was initiated in 1985: its "raison d'être" was fundamentally political (see Ch. 2). After more than 15 years of continuous operation and periodic adaptations, a debate is developing within the political and scientific arenas of the country on the suitability of pursuing this effort and, if so, in what form. In order to reach a decision, authorities need to be enlightened on the performance of the Programme to date. Accordingly, OSTC has commissioned a panel of five foreign experts to evaluate the scientific results and the management of Belgian Antarctic research since the inception of the Programme. Specific issues to be addressed are the appropriateness of the Programme, its impact and the effectiveness of its implementation. The panel did not feel mandated to comment on the suitability of the Programme as an instrument of Belgian foreign policy.

Box 1.3 Specific questions addressed by the OSTC to the panel

- What are / have been the setting and impact of the different programmes, taking into account the national and international context at the time of operation?
- What is / has been the added value of the federal Antarctic Programmes in the Belgian scientific landscape in specific and within an international scientific context in general?
- Is it relevant to maintain in the future (from 2006) a federal support to Antarctic research, characterised by financial support to research networks within the framework of a pluri-annual research programme?
- What should be the form and objectives of such a new programme (e.g., support to decision-making in the short and long term) within national and international context?
- What should be the characteristics of federal intervention in an eventual new Antarctic sciences programme (networking, funding mechanisms, thematic orientations, differentiation intervention mechanisms, ...)

The panel evaluated all finished projects financed by OSTC since 1985 as well as the management of the Programme, including logistical aspects. It was supported by a team of two consultants. The experts gave a global scientific appreciation of the research projects on the basis of the final project reports of Phases I-IV, publication lists and the proposals of the selected projects of Phase V, thereby focusing on the following key issues: (a) have the right scientific questions been addressed?; (b) technical aspects (equipment, use of logistics); (c) quality of science (state-of-the-art, design, intellectual level); (d) output and impact (publications, impact on international community)?; (e) wider context (matching OSTC aims, collaboration with international programmes); (f) general comments.

The main tasks of the consultants were: liaison with OSTC; collecting relevant documentation (general and specific information, calls for proposals, project reports and publications); preparing base documents (programme history, based on internal and published OSTC documentation; dynamics of research teams and project data, based on project contracts and reports); carrying out and transcribing oral interviews (held with all project co-ordinators since 1985, members of the Programme Steering Committee, the Royal Belgian Academy of Sciences, OSTC programme staff); helping the panel design the evaluation methodology and fulfilling other requests. Their assistance has been invaluable and is gratefully acknowledged.

The above material enabled the panel to widely discuss on the questions as presented in Box 1.3 and to elaborate on the current evaluation report. The panel held three meetings at the OSTC in Brussels between October and December 2001. Members communicated extensively by e-mail. A first draft of the report was issued on the OSTC web-site [5] for comments in June 2002 and the panel would like to thank all those who took the initiative to respond. Based on these comments, the final version was submitted in July 2002.

[5] http://www.belspo.be/antar

2 BELGIAN RESEARCH IN ANTARCTICA

At the onset of this review of Belgian Antarctic research, due tribute should be paid to the *Belgica* expedition of 1897-1899, the first one to winter over in Antarctica. The earliest expedition was presumably that of James Cook in 1773, but with the Belgian expedition, Adrien de Gerlache and his companions, by collecting observations in many areas of knowledge, could arguably be regarded as the initiators of Antarctic research. Belgian interest in the continent is rooted in that epoch-making expedition. And because his team of 19 included 10 non-Belgians, one can say that de Gerlache also pioneered the international approach of Antarctic work that was to become the rule more than 50 years later.

Revival of Belgian interest in Antarctic science coincided with the preparation of the International Geophysical Year 1957-1958. Belgium was one of the founding members of SCAR. Annual expeditions were organised during the periods 1958-1961 and 1963-1970. International co-operation began to build up and Belgium co-organised with the Netherlands seven expeditions between 1963 and 1967. The King Baudouin base at the coast facing Africa (see Figure 1.1) had been founded in 1958 but was already closed temporarily in 1961 and finally in 1967, due to budget restrictions. Until 1970, three more Belgian expeditions took place, hosted by the South African Antarctic base. After that, and for over a decade, a few Belgian scientists took part individually in expeditions from other countries (Argentina, France, Japan, USA). Overall however, Belgian involvement in Antarctica had declined.

Recognising the need to promote the credibility of Belgium in the Antarctic Treaty System (ATS) by performing a certain degree of scientific activities, the Belgian government decided in 1985, on the initiative of the Ministry of Foreign Affairs who was an official member of the Antarctic Treaty Consultative Meeting (ATCM), to implement the first of what later proved to be a series of national multi-annual "**Scientific research programmes on the Antarctic**". It is important to stress here the political dimension of the Programme. Scientific research in Antarctica cannot be dissociated from the geopolitics of the Antarctic Treaty (AT): it enables peaceful, non-conflictual occupation of the land, and it confers international legitimacy to the right to manage the area in the interest of mankind. The decision of Belgian authorities to support Antarctic research must be seen in the context of the time. Around 1980, international interest over the Antarctic was being revived, including new challenges for science in that region and the interest of many countries to become a member of the AT. Belgium was to host the 13th ATCM meeting in 1985 and this opportunity was used to reactivate Belgium's scientific commitment in that region and to show its sincere commitments to the ATS. Although Belgium did not have any political or economic aspirations, it wanted to maintain its role within the ATS: Belgium is after all a founding member of the AT (1959). Discussions on the possible exploitation of Antarctic mineral resources were active and closely followed by the Ministry of Foreign Affairs. By 1989 however, total protection of Antarctica, excluding all economic perspectives, had become the international creed: the Ministry recognised this and took a central part in the negotiation of the Madrid Protocol, thereby actively assisted by the OSTC. This Protocol drastically changed the way science should be performed. It states that any activity relating to mineral resources, other than scientific research, is banned, and that all activities, including science, must be assessed for their environmental impact before they can be undertaken.

The multi-annual co-ordinated research programmes on Antarctica of the OSTC was started in 1985 and was organised in various phases. The broad objectives of the research programmes have remained essentially the same throughout and are shown in Box 2.1.

Box 2.1 Broad objectives of the Belgian Antarctic Programme since 1985

Science policy:

- to strengthen Belgian expertise, particularly in those areas of science where Belgian teams were known to be strong;
- to increase the visibility of Belgium in the ATS;
- to bring scientific added value to ongoing research from university teams, by appropriate action in management and co-ordination.

Scientific challenges:

- to contribute to the rational management of Antarctica's environment and natural resources;
- to assess the consequences at the world scale of major natural processes occurring in the Antarctic and surrounding ocean.

To date, four successive Phases have been implemented and a fifth Phase has recently started. Table 2.1 shows that throughout these Phases the theme titles have undergone some changes and are currently included into the headings "Global Change" and "Biodiversity". The themes can be brought under four disciplines which form the basis of the current evaluation:

- Marine biology and biogeochemistry
- Glaciology and climatology
- Hydrodynamics and sea-ice
- Marine geophysics

Table 2.1 Overview of the five Phases of the Belgian Antarctic Research Programme

Phase		Budget			Projects			Participants	
		category	total Meuro	%	themes	no.	% of budget	teams (no.)	institutes (no.) [1]
I	1985 – 1989	projects	1.43	84.1	Glaciology and climatology	5	52.0	10	6 u
		extension	-	-	Plankton ecology	3	28.8		1 r-pu
		campaigns	0.27	15.9	Marine geochemistry	1	9.6		
		total	**1.71**	**100**	Marine geophysics	1	9.6		
II	1988 – 1992	projects	1.54	85.0	Glaciology and climatology	5	50.5	11	6 u
		extension	-	-	Plankton ecology	3	28.8		1 r-pu
		campaigns	0.27	15.0	Marine biogeochemistry	1	9.6		
		total	**1.81**	**100**	Marine geophysics	1	11.1		
III	1992 – 1996	projects	2.54	70.1	Marine biogeochemistry and	4	50.3	9	5 u
		extension	0.80	22.1	ecodynamics				1 r-pu
		campaigns	0.28	7.7	Glaciology and climatology	3	32.5		
		total	**3.63**	**100**	Marine geophysics	1	9.6		
					Hydrodynamics	1	7.6		
IV	1997 – 2001	projects	4.83	84.6	Marine biota and Global Change	4	60.9	14	5 u
		extension	0.48	8.4	Palaeo-environmental records				3 r-pu
		campaigns	0.40	7.0	Dynamics of the Southern Ocean	4	32.6		
		total [2]	**5.71**	**100**		1	6.5		
V	2001 – 2005	projects	3.96	89.2	Climate and atmosphere	3	68.9	13	5 u
		extension			Biodiversity	1	31.1		2 r-pu
		campaigns	0.48	10.8					
		total [3]	**4.45**	**100**					
Total	1985 - 2005	projects	14.31	82.7		42		20	6 u
		extension	1.28	7.4					3 r-pu
		campaigns	1.70	9.9					
		total	**17.30**	**100**					

1 Institute category: u = university r-pu = public research institute
2 A separate budget of 0.5 M euro was earmarked for EPICA (European Project on Ice Coring in the Antarctic)
3 The figures do not reflect the whole of Phase V, because this phase is not yet completed

Source: OSTC contracts and internal documentation

An in-depth analysis about the details of the above Table is given in Chapter 4.

The contents of the **first Phase of the Belgian Antarctic Programme** were drafted by OSTC, based on ideas provided by the Belgian and foreign scientific community. Each of its four broad themes was intended to meet internationally recognised scientific priorities and focus on the study of basic mechanisms responsible for the functioning of major natural systems and on their mathematical modelling. The focus on oceanography was meant to facilitate access to foreign logistics, because these are easier to implement with ships than with land-based research stations, and would allow synergy with North Sea research on which Belgian scientists had been very active at least since 1970.

In Phase I, there was no Call for Proposals. Projects were prepared in close consultation between OSTC and leading scientists, some of whom were already active in Antarctic research and others were at that time active in the OSTC Programme "North Sea". All projects had a 3-year duration. Annex 2.1 provides the list of projects, promoters and corresponding grants.

Since the International Geophysical Year, international co-operation has been considered important for meaningful research in the Antarctic. As a result, Belgian scientists and policy-makers have devoted significant efforts to forging co-operative links abroad. An important opportunity presented itself when EPOS, the "European Polarstern Study", an activity of ESF's "Network on Polar Science" ([6]), was launched in the late 1980's: four projects of the new Belgian Programme were integrated in the EPOS campaign.

In fact, all Phase I projects – and indeed all projects of subsequent Phases – were carried out by participation in campaigns organised by other countries, based on the availability of vacant space on research vessels and in bases. Frequent sharing of facilities, even during the same campaign periods, took place over the years. Belgian researchers had to adapt to foreign campaign rules. In doing so, they did not jeopardise their research objectives and may even have obtained impetus for new research topics.

Table 2.2 Overview of campaigns and the corresponding host countries undertaken during the five Phases of the Belgian Antarctic Research Programme

Phase	Campaigns (no.)	Institutes (no.)	Host countries
I	11	4	Australia, France, Germany, Japan, UK
II	8	4	Australia, France, Germany, Italy, Japan
III	13	4	Chile, France, Germany, Italy, New Zealand, Spain, UK
IV	17	5	Australia, France, Germany, Japan, New Zealand, Spain, UK, USA
V	4	4	Australia, Germany, New Zealand, UK
Total			

Source: OSTC

Remarks: Most frequent partnerships were with Germany, France and Italy.
Because Phase V has just started, not all campaigns are known yet.

By 1988, the initial Phase of the Programme had already brought encouraging scientific results, Belgian scientists had entered successful partnerships with teams from other countries, in particular through participation in EPOS. The case for science-based protection

[6] ESF is the European Science Foundation: http://www.esf.org

and management of Antarctica was increasingly felt at international level, while Belgium wished to maintain its stand in the ATS. Accordingly, the government decided in 1988 to implement a **second 3-year Phase of the Programme**. Continuity was emphasised and the 4 research areas (glaciology and climatology, plankton ecology, marine geochemistry and geophysics) remained the same. OSTC again wrote the Programme in consultation with leading scientists. Similarly, there was no Call for Proposals. Initially, most projects were planned for 3 years. Seven of them were extended in time in order to avoid gaps with subsequent Phase III activities (Annex 2.2).

The decision to launch a **third 3-year Phase** was taken in 1991. The broad research areas took into account the emergence of Global Change issues and were formulated as follows:

- ecodynamics of the Southern Ocean and interactions with the climate;
- evolution and protection of the marine ecosystem;
- role of the Antarctic in Global Change.

These areas encompassed the four themes of the previous Phases as mentioned in Table 2.1 and in the OSTC publications of final project results.

For the first time, a Call for Proposals was held and the system of peer review was introduced. Projects were planned initially for 3 years. All of them were extended in time and with additional funding (see Annex 2.3), taking into account the scheduling of international campaigns and the need to bridge the gap with Phase IV that was being planned.

Following on the UN conference in Rio de Janeiro (1992), the concept of sustainable development invaded the political agenda of many nations, including Belgium. **Phase IV** of Belgian Antarctic research, although drafted as a new stand-alone Phase, was ultimately placed under the umbrella of a new structure of OSTC-supported activities, the **"Scientific Support Plan for a Sustainable Development Policy (SPSD)"**. Because this Plan was continued into a second phase, the launch of the Plan is now referred to as SPSD-I. The "Antarctic share" of the SPSD-I research budget was 8.3 % (see Table 2.3).

Table 2.3 Research budget distribution of SPSD-I (1996 – 2001)

Programme	Budget	
	(MEURO)	%
Global change	15.9	27.6
North Sea	10.5	18.2
Mobility	7.8	13.5
Earth observation	5.0	8.7
Levers	5.7	9.9
Antarctica	4.8	8.3
Food	4.4	7.6
Supporting actions	3.5	6.2
Total:	**57.5**	**100**

Note: The SPSD was approved by the Council of Ministers in 1996, for a period of 5 years together with a budget of 68.3 million Euro, of which 15.8 % was reserved for management and valorisation of research results. The Table shows what the Programmes received for project financing. Campaign costs are not included.

Although sustainable development as such is not mentioned explicitly in the objectives nor in the strategy of the ATS, the underlying concept is fully in line with the System's preoccupations. Indeed, Antarctica is a model area to test and implement on a large scale the concept of sustainable development.

Among the innovations introduced by SPSD, one notes: i) research has among its goals to provide support for political decision making, ii) the need to identify human impacts on the environment, and iii) the requirement for multidisciplinarity, combining the results of socio-economic studies with those of research on natural processes. SPSD enhances the involvement of Belgian science within the Belgian obligations, towards the Climate Convention (Rio and Kyoto), the Biodiversity Convention, and the Antarctic Treaty.

The objectives of Phase IV were somewhat re-phrased with respect to earlier Phases:

- to develop a research effort within the spirit of the ATS;
- to contribute to the development of science-based conservation and management and to the understanding of interactions between Antarctica and the global environment;
- to ensure an operational interface with the ATS in matters requiring scientific knowledge.

The main research topics as shown in Table 2.1 were:

- marine biota and global changes;
- dynamics of the Southern Ocean;
- palaeo-environmental records (including participation in the European EPICA project, i.e. European Programme of Ice Coring in Antarctica).

A Call for Proposals was published in 1996 and the submitted proposals were evaluated by international peer review. Campaigns were supported through a contribution to the operational costs of EPICA and to the individual projects. Projects were planned for 4 years but most of them were extended in time, with additional funds, to bridge any gap with the launch of Phase V (Annex 2.4).

The SPSD was continued in a second phase, **SPSD-II (2001-2005)** with similar objectives as SPSD-I, but with a different architecture. It consists of three major parts:

Table 2.4 Structure of SPSD-II

<table>
<tr><th>Part</th><th>Research priorities</th><th>Extra</th></tr>
<tr><td>Sustainable production and consumption patterns</td><td>General problematics
Energy
Transportation
Agri-food</td><td rowspan="2">Mixed actions</td></tr>
<tr><td>Global Change, Ecosystems and Biodiversity</td><td>Atmosphere and climate
Ecosystems
Biodiversity</td></tr>
<tr><td>Supporting actions</td><td>Summary of information relating to Sustainable Development and integration of research results
Access to information – development of information systems – support to the databases
Consultation, participation and evaluation</td><td></td></tr>
</table>

The first (socio-economics) and second (natural sciences) parts are complementary and are connected by so-called “Mixed actions” allowing an integrative research within interdisciplinary research projects. “Supporting actions”, to integrate the first two areas and to translate the findings for governmental and societal use, remains a separate activity in the third part.

It is intended to strengthen the communication between researchers and decision-makers by the setting up User Groups for each of the projects (in SPSD-I, this was only partly organised). SPSD-II departs significantly from its predecessor by abandoning the notion of a separate Antarctic Programme. Antarctic research is now closely linked to Global Change and Biodiversity issues and falls under two actions of part 2: atmosphere and climate, biodiversity (terrestrial and marine ecosystems).

Table 2.5 Research budget distribution of SPSD-II (2001 – 2005)

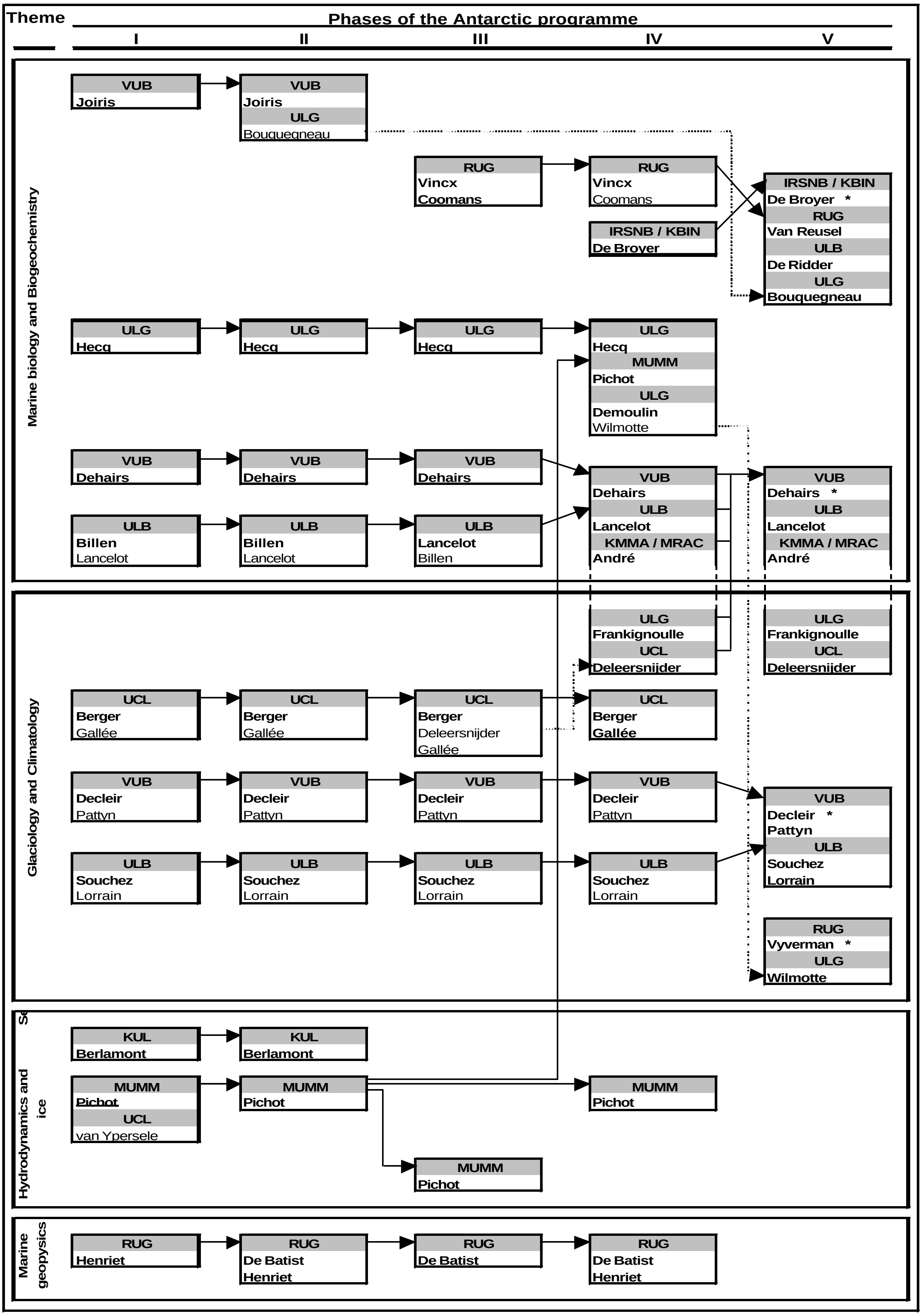
Programme	**Budget**	
	(MEURO)	**%**
Sustainable production and consumption patterns	22.1	38.1
Global Change, Ecosystems and Biodiversity	33.5	57.8
Supporting actions	2.4	4.1
Total:	**57.9**	**100**

Note: The SPSD-II which was approved by the Council of Ministers in 2000 for a period of 5 years with a budget of 64.5 million Euro, of which 10.2 % was reserved for management and valorisation of research results. The Table shows what the Programmes received for project financing. Campaign costs are not included.

With regard to Antarctic topics, three Calls for Proposals were scheduled: in 2000 (atmosphere and climate) and 2001 (marine biodiversity); a final Call is foreseen for 2002 (biodiversity). The budget allocation for Antarctic research is similar as that of SPSD-I, i.e. 4.8 million euro (without campaigns). Due to a delayed approval of the proposals from the first Call by the Minister of Science Policy, a late start of the projects was foreseen and, a request for an extension in time was expected at the end of the project. An extra administrative period of 3 months was, therefore, included at the start of the project (Annex 2.5)

Summarising the above information, Table 2.6 shows the main thematic domains and the evolution of the involvement of Belgian scientists in the Antarctic Programme. Three clear trends emerge: a continuous support to most of the teams in the first three phases, the formation of (interdisciplinary) networks in SPSD and the decline of two themes. A detailed analysis of these developments is given in Chapter 4.

Table 2.6 Dynamics of the research teams involved and their thematic interest



Notes: Team leaders are indicated in "bold".
In case of networks, the co-ordinator is indicated in **bold** and *

3 ACHIEVEMENTS OF THE BELGIAN ANTARCTIC PROGRAMME

3.1 Scientific output

Scientific contributions were assessed using a wide range of information: final reports of Phases I-III, annual and final reports of Phase IV (the final reports became available during the current evaluation), proposals of Phase V, publication lists and selected papers specially submitted by project leaders for the current evaluation, searches of electronic data bases, citation analyses and interviews with experts in the relevant fields of science. Although the Belgian Antarctic programme comprises four distinct Phases, with a fifth recently started, in most cases research themes or research groups have tended to follow a linear evolution with time. In Table 2.5, this linear trend stands out clearly for research teams in Phases I to III and remains perceptible in Phases IV and V despite a number of regroupings. The trend is similar for the main research themes, although not really at the level of individual projects (see Annex 3). For this reason the reviews given hereafter are organised by theme rather than by Phase.

A general comment is needed here. Belgium has a small scientific community. This means inevitably that unless an individual scientist makes a personal decision to change field completely (and this is rarely fully successful for a whole suite of reasons, both scientific and social), any new phase of work must be evolutionary, building on existing strengths and previous work. This can still be innovative, but it would be unreasonable to expect a small community to make a significant contribution to every new international scientific initiative. Belgium scientists have nevertheless maintained an excellent record of continued contribution to some of the important problems of the moment. In comparison with many other nations of comparable size, Belgium actually has had an impact which is impressive. It does, however, not have the major outlay on logistic costs that most comparably sized nations do. Moreover, the new round of proposals is notable for the balance between building on existing expertise and branching out into novel areas of work.

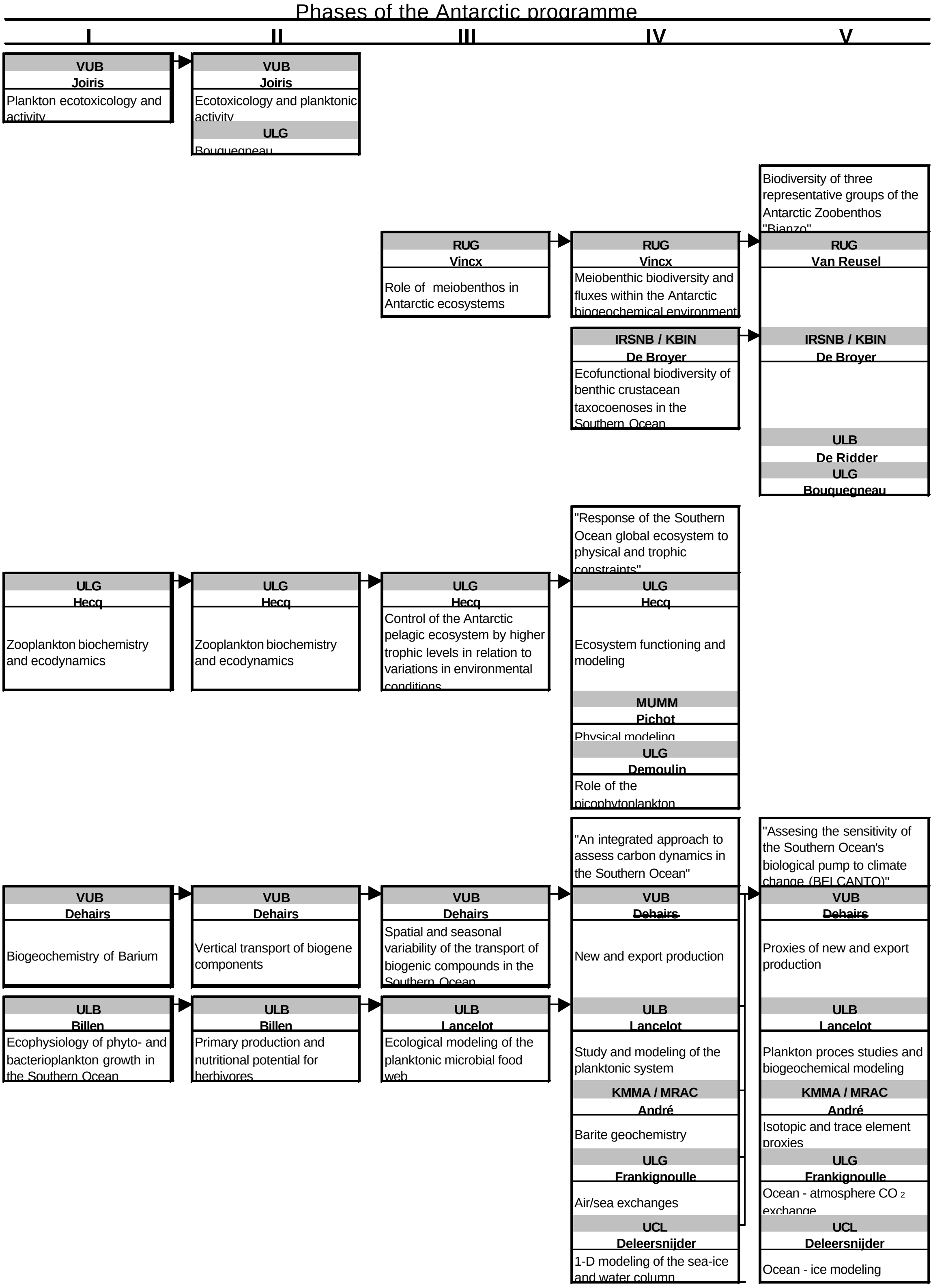
Whether the four programme themes, taken together, form or not a consistent "Programme" is largely immaterial. They were imposed both by the nature of major scientific challenges in the Antarctic and by the expertise that was available in Belgium at the onset of the Programme, and they did match several priorities of the international science community. As can be seen hereafter, the scientific quality of the projects has overall been very good. Some of the projects had even a major international impact.

With regard to publication output in peer-reviewed journals, there is a time lag, sometimes considerable, between actual research work and publication of related papers. There are certainly interesting papers (about to be) published well after the contractual research work, but in many cases, however, such information was not available. Other important information missing in the project reports are the educational output (e.g. theses) and other outputs (e.g. careers). These limitations should be taken notice of when reading the assessments hereafter. These productivity outputs were, however, not explicitly asked for by the OSTC until Phase V, but could still have been mentioned more clearly by the authors of the reports.

The text of sections 3.1.1-3.1.4 hereafter is quoted or summarised from the evaluation reports provided by the thematic experts (see Annex 3).

3.1.1 Marine biology and biogeochemistry

Box 3.1 Dynamics of projects in Marine biology and biogeochemistry



The topics covered under this heading were (Box 3.1): biogeochemical modelling, based on the coupling of biological processes to hydrodynamics and incorporating sea-ice; the ecological role of amphipods, an important group of bottom-living crustaceans; zoo-plankton and the use of lipid bio-markers to characterise food-web dynamics; field and laboratory investigations of sea-bottom communities and their functioning; the incorporation of barium geochemistry into a general picture of Southern Ocean euphotic zone dynamics; and finally pollutant and seabird distribution patterns.

- The biogeochemical modelling (Lancelot, Billen, ULB) work has tackled the front-rank oceanographic problems of the day, and has brought great credit to Belgian science. The SWAMCO model (Seawater Microbial Community Model) was first developed for the Atlantic sector of the Southern Ocean, and validated with high quality observational data from the 1992 JGOFS cruise. From the start, model development coupled biological processes to hydrodynamics and there was explicit incorporation of sea-ice, thus ensuring that the work reflected to current international thinking on pelagic ecology. Although, as with all Belgian sea-going scientists, this research group has perforce worked where cruises were already going, the leading nature of the work has resulted in their being invited onto all of the important Southern Ocean research cruises, and to take an active role in shaping the science of those cruises. The SWAMCO model used in the important international Southern Ocean Iron Enrichment Experiment SOIREE was the first published biogeochemical model for polar waters to specifically include iron limitation. The publication rate has been good, in high quality journals.

- The research on amphipods (De Broyer, IRSNB/KBIN) has made a substantial and significant contribution to international work on the ecology of the Antarctic sea-ice zone. Amphipods are unusually dominant and ecologically important in the Antarctic compared to the rest of the world; this project has been impressive in terms of the amount of information generated and by establishing the infrastructure needed to facilitate further research. Notable work on basic taxonomy laid the foundation for work on important ecological and evolutionary questions such as the role of amphipods in the Southern Ocean ecosystem and the physiological mechanisms underpinning regulation of amphipod size. The research group has established an attractive web-site, and developed useful links with key groups elsewhere, notably in Poland and Germany. The establishment of an Antarctic Marine Biodiversity Reference Centre devoted to amphipod crustaceans augurs well for future research in this field and should serve as a model for all workers on Antarctic groups. Publication output is strong with significant international impact.

- The work by Hecq (ULG) has focused on zooplankton and on the use of lipid and phytopigment biomarkers to characterise food-web dynamics. Whilst the concept underpinning the project is not novel in itself, Belgian efforts have provided the most extensive and coherent body of work in this area for the Southern Ocean. Highlights have been the use of autotrophic pigment signatures to define different biogeochemical areas within the Southern Ocean, and the innovative use of biomarkers to demonstrate differences in food-web dynamics between Marginal Ice Zone and sub-polar waters. Particular emphasis has been placed on physical controls and, latterly, on formalising the understanding in a simple mixed-layer ecosystem model. The publication output has been sound without being spectacular. The model appears to have made less impact than the work on biomarkers and would benefit from improved validation.

- The work of Vincx (RUG) on sea-bottom fauna ("benthos") is more descriptive and less groundbreaking, but nonetheless a thorough and comprehensive research involving the application and adaptation of approaches and techniques previously developed for northern hemisphere studies. A great deal of detailed work was done in the evaluation of field assemblages of (meio)benthos both in deep water and the low subtidal, and also in laboratory experiments on feeding, respiration and nutrient fluxes between sediment and water column. Used techniques were standard but appropriate. Publication output has been solid, generally in front-rank journals. While much effort has gone into collecting data on field populations and environmental variables, the subsequent correlational analysis has lacked depth. The use of foreign logistics has been good and the project, together with the research on amphipods (see above), has made important contributions to the international EASIZ (Ecology of the Antarctic Sea-Ice Zone) programme of SCAR.

- The barium geochemistry project (Dehairs, VUB) could seem at first rather uncritical to an understanding of the Antarctic system, but has developed beyond initial expectations. It has provided important insights into such diverse topics as the variability of Antarctic Bottom Water formation, spatial variability in primary production and the parametrisation of euphotic zone models; the work has increasingly been integrated with that of other Belgian teams active on Southern Ocean biogeochemistry. Techniques used have been state-of-the-art and the publication output has been strong.

- As for the relatively small-scale project on ecotoxicology and seabirds (Joiris, VUB), it has certainly produced worthwhile results, despite its somewhat over-diversified and disjunct nature which makes it very difficult to assess overall. The work involved the transfer to the Southern Ocean of a scientific and analytical approach developed in the North Sea. It comprised such diverse topics as the analysis of samples for a range of pollutants (PCBs, pesticides, heavy metals) using standard methodologies, seabird distribution (comparing patterns in the Arctic and Antarctic), bacteria in the Southern ocean, oxygen and carbon dioxyde dynamics. Techniques utilised were up to date and the publication output is broadly adequate. The international impact has not been as strong as that of larger projects.

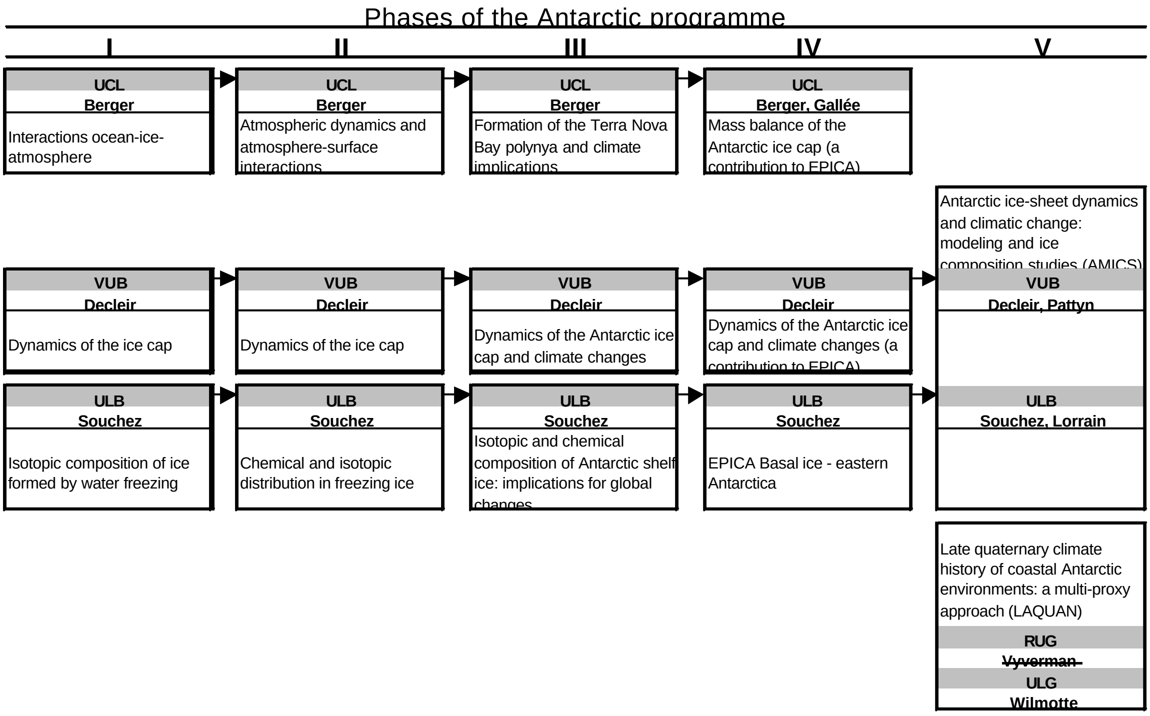
A notable feature of Belgian work on biological oceanography has been the creation in Phase IV of a number of integrated multidisciplinary teams, in strong contrast to the more linear evolution which characterised Phases I to III. This approach has brought strong benefits to the science and has continued into Phase V with multidisciplinary teams being created to investigate Antarctic biodiversity (BIANZO) and the biological oceanography of the Southern Ocean in relation to climate change (BELCANTO).

3.1.2 Glaciology and climatology

The three topics covered under this heading were (Box 3.2): ice studies and isotopic composition of ice, ice cap dynamics, and numerical simulations of the air-sea interactions. The project leaders are veteran Antarctic researchers with a strong record of publications prior to the start of the OSTC Programme.

The glaciology-climatology research was dominated by mathematical modelling, perhaps reflecting difficulties of fieldwork due to the lack of national logistic provision. The predictive capabilities of the models are generally good. It is very important that this activity goes hand in hand with field studies to ensure the best possible conceptual understanding of processes involved as well as the definition of realistic model boundary conditions.

Box 3.2 Dynamics of projects in Glaciology and climatology



- The ice studies (Souchez, ULB) have developed in a clear and rational way, starting from early work on ice from a Brussels lake. In Phase III, the main aim was to determine the thermodynamic conditions prevailing at the ice shelf/ocean interface and their implications for global change, while in Phase IV, the main goal was to analyse air bubbles contained within basal ice from Dome C. Sampling and analytical techniques were novel, and isotope determinations involved collaboration with renowned laboratories in France and Italy. An important aspect of this work consisted in the comparison of results from EPICA and Vostock cores. The project has a strong publication record and has contributed significantly to the international visibility of Belgian Antarctic science.

- The ice dynamics team (Decleir, VUB) combined the skills of a geographer with mathematical modellers. The project started in Phase I with the testing of a 2-D model of ice-flow lines and expanded through the successive Phases to produce a detailed description of the ice sheet and outlet glaciers, and of their dynamics. In Phase III, important results have been produced on the following topics: simulation and palaeoreconstruction of the last glacial period, responses of the ice to climatic variability over the past 200,000 years, and the influence of coastal ice dynamics on the interpretation and dating of deep ice cores from inland. Huybrechts' 3-D model of ice cap development in relation to temperature regime is particularly impressive and has proved to be a valuable contribution to the debate on the connection between ice cap dynamics and sea-level rise. Its mathematical formulations and realistic predictions of Antarctic ice sheet melting due to global warming are highly regarded by the international scientific community. They have been used repeatedly in the strategic planning of international scientific drilling campaigns, under such joint ventures as the Ocean Drilling Programme (ODP) and the SCAR Antarctic Offshore Seismic Stratigraphy Project (ANTOSTRAT), to obtain critical geologic ground truth for the evolution of the Antarctic cryosphere. The publication output has been very good.

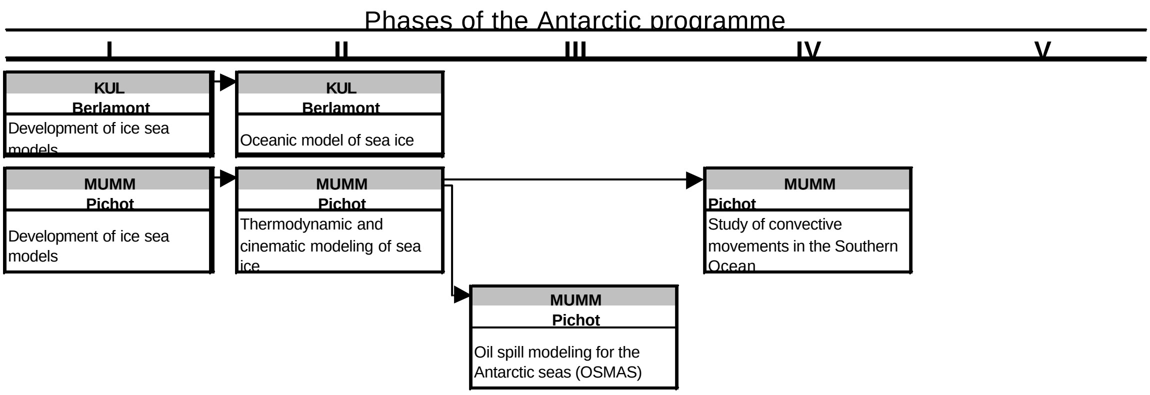
- The air-sea interactions team (Berger, Gallée, UCL), comprising meteorologists and modellers has made valuable contributions to the understanding of katabatic winds and, from Phase II onwards, of coastal polynyas. Work in Phase III included the simulation of polynya seasonal evolution in relation to atmospheric CO_2 concentration. In Phase IV the mesoscale atmospheric model was developed further. The work on polynya has highlighted the powerful energy exchanges which characterise the margins. The project overall shows a nice balance between thermodynamics and modelling, while it must be said that the publication output appears somewhat modest.

- Antarctic coastal lacustrine and lake systems hold important archives on climate change referring to the physical, chemical and biological environment. This new Phase V project (Vijverman, RUG; Wilmotte, ULG) will look into microbial registers as quantitative indicators of environmental impact. Working closely within an international network, the project will be innovative with respect to the development of molecular markers for biodiversity estimations and its application to the estimation and evaluation of palaeoclimatic records. Part of the project will be the comparison of methodologies applied in AMICS (Decleir, Souchez), such as isotopic registers, which on its turn highlights the complementarity and multidisciplinarity of the Belgian Antarctic Programme. In addition, the collected registers (data sets) will be calibrated too, thereby creating archives for the project databank.

In conclusion to this section, it should be noted that the few Belgian research groups that are active in glaciology and climatology have complementary research interests, particularly those concerned with dynamics of the ice-sheet. A combination of the modelling excellence with the long-term vision of the more experienced field scientists would contribute towards the OSTC goal of linking different research institutes to generate powerful and high quality scientific teams.

3.1.3 Hydrodynamics

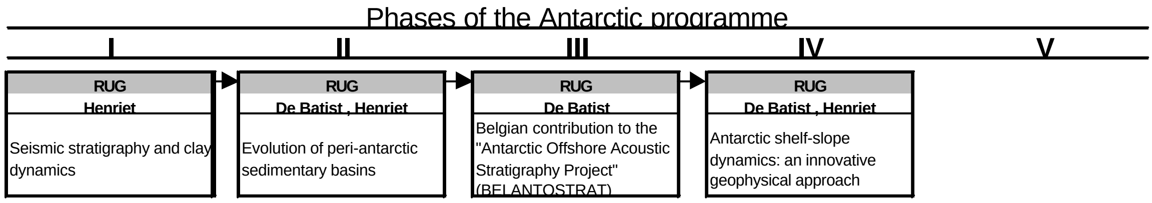
Box 3.3 Dynamics of projects in Hydrodynamics



The research (Berlamont, KUL; Pichot, MUMM, see Box 3.3) has been aimed at developing a numerical model for surface currents in the Weddell Sea and a sea-ice model that would be able to reproduce the main features of the annual cycle of ice extent and ice thickness. The research has produced a first order model for ice drift in the Weddell Sea, but the degree of refinement and validation is modest considering the time over which the activity has taken place (13 years) as well as viewed in light of the extensive modelling work by other international groups, particularly in Germany. The modest publication record leaves an impression of low priority being awarded to the topic. Despite this reservation, the project has useful spin-offs: modelling of sea ice extent and thickness has been applied to research addressing both physical constraints on ecosystem dynamics as well as dispersal of potential oil spills. In collaboration with the British Antarctic Survey, Belgian investigators took part in the forecasting of sea-ice conditions and weathering of a major spill in the Weddell Sea.

3.1.4 Marine geophysics

Box 3.4 Dynamics of projects in Marine geophysics



The focus of marine geophysical research (Henriet, De Batist, RUG) has been the sedimentary record and sedimentary processes on the Antarctic continental margin that relate to the glacial history of the continent, as well as aspects of the origin of some tectonic structures of the margin.

- Belgian research within marine geophysics has focused on problems of high priority within international research in Antarctica. In Phases I and II particularly, the topics covered were largely relevant to such major international ventures as the Ocean Drilling Programme (ODP) and the Antarctic Offshore Stratigraphy Project of SCAR (ANTOSTRAT).
- Belgian scientists have made internationally recognised contributions to the interpretation of sedimentary processes on a glaciated continental margin, even though their output in number of publications is modest. They command a thorough understanding of the information potential of seismic data and the geometry of seismic interfaces; as a result, they have presented a well thought-out interpretation of seismic stratigraphy and some bold solutions, particularly for the Weddell Sea continental margin.
- Although the choice of scientific activities was inevitably constrained by participation in foreign expeditions, one would have welcomed more innovation in defining « secondary » research targets with a distinct Belgian contribution, particularly during Phases III and IV. An attempt to develop a single channel deep tow seismic system suited for Antarctic continental margin research was hampered by some unfortunate circumstances in the field. The idea was later been more successfully pursued in work on the North Atlantic margin.
- Belgian participation in this hardware- and field-intensive activity has been achieved through recognition as a scientifically attractive partner for international collaboration. Indeed, the Belgian project on marine geophysics represents a textbook example of international scientific co-operation and sharing of logistic resources. The research team has been invited on the German research vessel *Polarstern* and the Spanish research vessel *Hesperides*. One reason for not pursuing work under Phase V is the current difficulty experienced by AWI, the German partner, in obtaining a national permit for marine geophysical research south of 60° S.

3.2 International co-operation and logistics

Nowadays, all Antarctic scientific activities have become collaborative and multidisciplinary. This, together with the small size of the Belgian scientific community and the lack of national logistic provision, has meant that Belgian scientists have generally established strong links to major European and international programmes. Particularly important in this context are contributions to EPICA (European Programme of Ice Coring in Antarctica [7]), JGOFS (Joint Global Ocean Flux Study [8]) in the Southern Ocean, ODP (Ocean Drilling Programme), and the SCAR programmes EASIZ (Ecology of the Antarctic Sea-Ice Zone) and ANTOSTRAT (Antarctic Offshore Stratigraphy Project). There were also some international campaigns where Belgium was an important participant and contributor, e.g. EPOS (European Polarstern Study), and SOIREE (Southern Ocean Iron Enrichment Experiment).

Oceanography requires access to oceanographic vessels, and this has been a problem for Belgian scientists. Belgium does not possess a research vessel which can undertake scientific work in the Southern Ocean, neither does OSTC pay for logistic support from other national operators. In consequence Belgian oceanographers can only undertake fieldwork when invited onto cruises run by others. Their work is, therefore, constrained to the areas visited by the research vessels of other nations. This has the disadvantage that a research line cannot be developed for a particular area (as might be possible, for example, for work in the North Sea). It may also mean that in some circumstances Belgian scientists may not have priority in the use of instruments and facilities on the ship where they are guests. In the interviews, it was stated that the scientists felt like "free riders". There is also no "footprint" of Belgium: a visiting scientist loses visibility if he is not considered good by the host and, therefore, Belgian support can become wasted (this has not occurred to date!).

These are for sure negative aspects. But there are also positive aspects: working with scientists from other countries has certainly encouraged a general development of widely applicable, rather than site-specific, concepts or models. Involvement in collaborative cruises also allows for more widespread exchange of views and ideas. Another advantage is the flexibility of researchers to join in international campaigns in and around the Antarctica-continent: Belgian scientists have thus experienced various international settings and obtained a privileged global overview of research in the area. A number of successful new co-operations have been developed. Thus the lack of infrastructural support has been the starting point of productive interactions. In addition, having no facilities means less environmental impact. Last, but perhaps not least, the cost of much good and productive research has been small.

That the system has generally worked well is testament to the high quality of the scientific work undertaken by Belgian scientists. Not only have they been invited repeatedly, but also their work has made significant contributions to the overall science programmes. As a single, but not unique, example, the euphotic zone models developed by Belgian scientists have been an essential component of the important international work on the role of iron limitation in the Southern Ocean. Recent iron fertilisation experiments performed by some EU and Pacific countries deserve strong political visibility since their purpose was to test a possible technique

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[7] EPICA is a joint European Science Foundation (ESF) and European Commission (EC) scientific programme, funded by the European Commission's Climate and Environment Programme with national contributions from **Belgium**, Denmark, France, Germany, Italy, the Netherlands, Norway, Sweden, Switzerland, and the United Kingdom.

[8] JGOFS is a core project of the International Geosphere-Biosphere Programme (IGBP) of ICSU.

to increase carbon uptake by the ocean and thus limit the atmospheric content of carbon dioxide, the main greenhouse gas.

In conclusion, the Belgian scientific community is at the forefront of international expertise. There are difficulties in developing, and retaining, a critical mass of scientists in any given area of research. Much to their credit, Belgian scientists have been particularly adept at overcoming this through a combination of long-term collaboration with non-Belgian colleagues and through growing collaboration within Belgium. OSTC, by imposing cross-laboratory links, has promoted these beneficial contacts.

3.3 The visibility of Belgium

The Programme is a scientific research programme. Because increasing and securing Belgium's visibility within the Antarctic Treaty System (ATS) is one of its main objectives, a distinction between scientific activities and political issues is needed. Measuring visibility, however, is not an easy task. Scientific results have often an impact only years after they have been published, i.e. the issue of time constraints plays an important role. Visibility of political matters is even more difficult to assess and is often not recorded but only perceived by individuals. Within the context of the current evaluation, information was mainly gathered from information of OSTC and interviewees in Belgium.

It is important to point out that science in Antarctica has an important political background. Between the end of the XIX century and the first half of the XX seven countries made territorial claims on parts of Antarctica. The Antarctic Treaty (AT), negotiated in 1959-1960, "froze" them and no new claims can be advanced whilst the AT is in force. The Antarctic Treaty Consultative Meetings (ATCM) are in effect meetings of a "virtual" Government of Antarctica and are political and decision-making meetings. Thus, in order to promote visibility, active participation is important. During the preparation of the Protocol on Environmental Protection to the Antarctic Treaty in 1990-1991, Belgium had high visibility at the meetings in Vina del Mar (Chile) and in Madrid (Spain) because of the active participation of its delegates. The impact of this active participation resulted in the agreement on and execution of the Protocol where all activities, including science, have become subject to environmental impact assessments.

In the previous section, it is clearly shown that Belgian scientists and science outputs have been appreciated good to very good within the international scientific community. So, one could say that visibility among scientists is good. Information and results on scientific activities were widely distributed among both national and international political and scientific communities. So, one could say that visibility was delivered. Going back to the beginning, the Programme was purely set up with political arguments to show the ATS that Belgian could be more visible as it was since the creation of the AT in 1959. Although Belgium had its own base, logistics and expeditions between 1958 and 1970, the scientific output during this period was limited. So in 1985, science was used as a political means in order to create political visibility. Some political visibility using science was also used for the Belgian-French inspection and the Belgian CEP web-site.

To some extent Belgian visibility among scientists of several countries is enhanced by the lack of logistics that makes mandatory for Belgian scientists to establish close relationships with their hosts. Therefore a disadvantage becomes an advantage. This is not a minor factor.

The question on what type of Belgian research has had an impact or delivered something so as to support decision-making or policy, a condition as stipulated in the SPSD Calls, is difficult to answer. Some spin-off activities of research to environmental protection were executed. At national level, the need to remain active within the ATS and the research outputs of each Phase of the Programme were primarily used to justify the continuation into a new Phase, so "self-service" can be perceived. Political relevant issues are clearly recognised in Phase V, part of SPSD-II, because general topics as "Global Change" and "Sustainable Development" are used that are accepted by and of concern to politicians and society. Another interesting point to mention here is the obligation to work multidisciplinary and within networks. By doing so, the possibility is there that research outcomes become more understandable and therefore more accessible to a wider audience and this advantage needs certainly to be exploited in order to show the visibility of Belgian science and the use of its outcomes.

4 THE DYNAMICS AND MANAGEMENT OF THE PROGRAMME

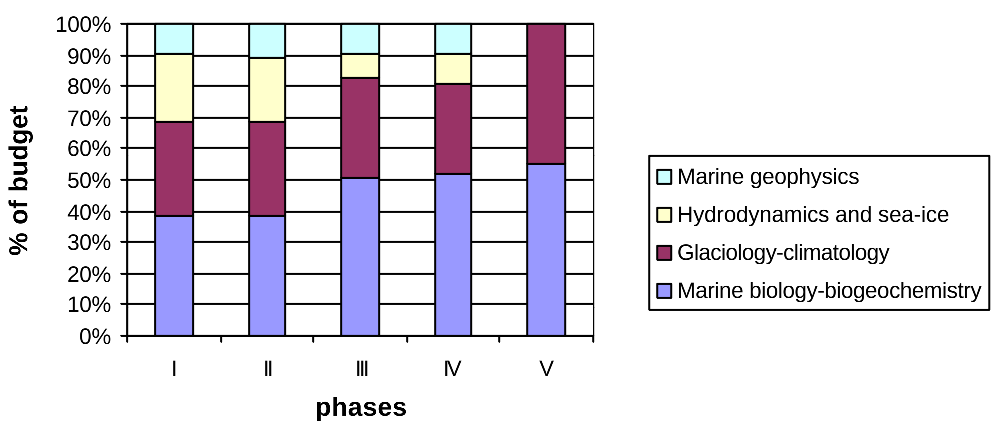
4.1 Dynamics

Since the start of the Antarctic Programme, significant evolutions have occurred with respect to research priorities, participation of research teams, co-operation between teams, size of project grants and duration of projects. The first Phase consisted of teams that were invited by the OSTC to take part in the Programme. The research themes were simply based on the expertise available then. This Phase was continued in its whole into a second Phase. The concept of Calls for Proposals was introduced in the third Phase and marked the start of a series of modifications. Clearly the Belgian scientific community had to become accustomed to the first Call and this explains why the vast majority of research teams remained the same. This was drastically changed as of the fourth Phase. The selection rate diminished per Phase. The priorities in the Calls strongly changed with the introduction of the second umbrella programme SPSD. The Programme budget increased remarkably in Phases III and IV, but has been stabilised in Phase V. Grant averages per team increased too, but decreased however after Phase III. Additional Programme budget was spent on extensions in order to enable teams to bridge the time gap between the end of a Phase and their possible continuation in a new one, representing a significant part of the total project costs.

4.1.1 Dynamics of themes

At the start of the Programme, Belgium had a recent strong curriculum in oceanology thanks to the impulses of the OSTC North Sea Programme that was running since 1970. Geology and meteorology (glaciology) were included because of existing Antarctic experience in Belgium in these areas. The research themes have more or less continued to be the same until Phase IV. Phases IV and V introduced new headings inspired by the UN Climate Convention (Rio and Kyoto) and the Biodiversity Convention. Whilst in Phase IV, the Antarctic Programme, as well as the other SPSD-I programmes, was still recognised as a stand-alone programme with its four main themes (re: Ch. 2), Phase V integrated all stand-alone programmes into two main groups, one of which is "Global Change, Ecosystems and Biodiversity" in which Antarctic research fits. This integration fits well in the philosophy of sustainable development that by definition is a multidisciplinary concept. OSTC wished the environmental themes to fit within the main themes of their various programmes and international obligations in order to strengthen scientific support to decision-making and permit Belgium's scientific potential to be integrated into the major international research networks.

Box 4.1 Dynamics of themes

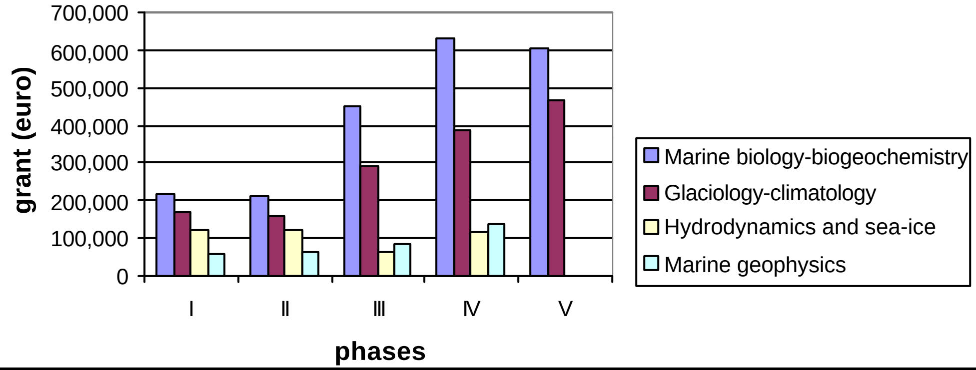


Box 4.1 shows that throughout the Phases, the first two themes have gained importance whereas the last two have decreased and even disappeared in the current Phase. “Biology” and “Glaciology” fit neatly into the Phase V themes. “Hydrodynamics” is not present anymore because of the competition within the current Calls. “Geophysics” does not re-appear because this discipline is not recognised as such within the priorities of the Phase V Calls, but could however fit in the block”atmosphere and climate” (re: Ch. 2). Biology has been supported most strongly throughout. This reflects the importance attached to the areas of marine biodiversity and Southern Ocean biological oceanography by the international scientific community, and the high quality of work in these areas by Belgian scientists.

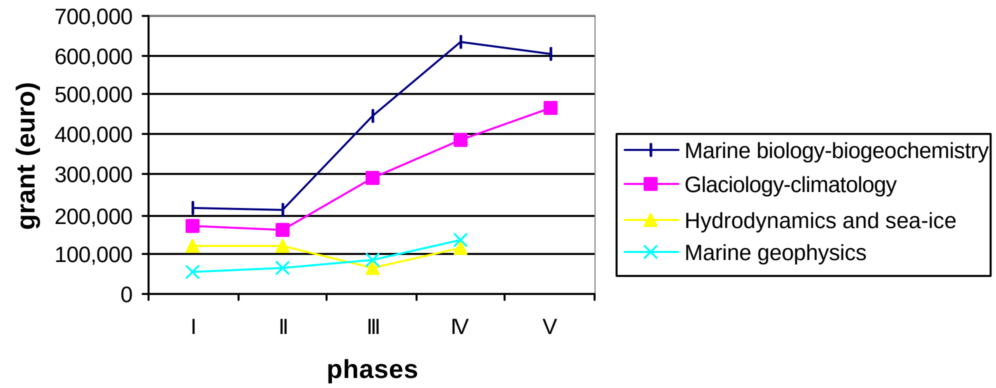
4.1.2 Fluctuations in budgets

The Programme budgets have increased from Phases I to IV and with one more Call for Proposals to come, the total budget of Phase V will be similar to Phase IV. In Boxes 4.2-4.4, the figures displayed are calculated on an annual basis in order to make comparisons possible.

Box 4.2.a Comparison of average annual grants per theme



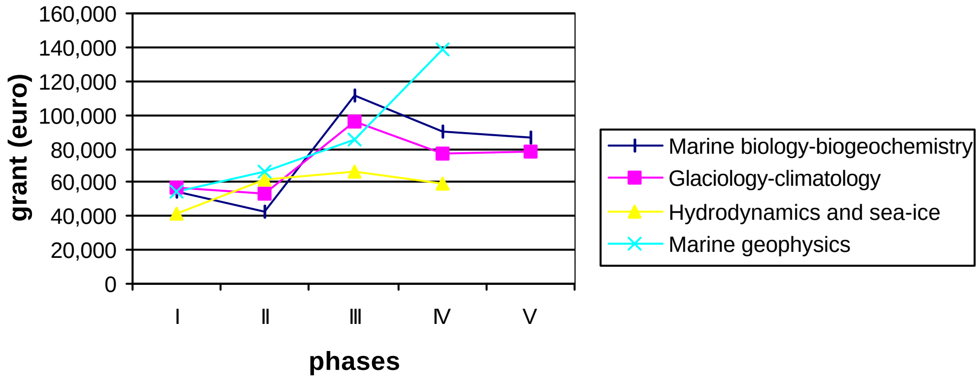
Box 4.2.b Trends in average annual grants per theme



The average size of annual grants (incl. campaigns) per theme fluctuates strongly per Phase. Whilst the transition of Phase I to II shows an overall slight decrease of -2 %, from Phase II to III this was reversed into a +59 % increase and another +43 % from Phase III to IV. The increase was introduced to adapt the project costs to realistic levels. The transition from Phase IV to V shows, however, a decrease of –16 %. This is a preliminary figure only, because not included is the extra expected project from the remaining Call 2002 and possible financial extensions. Since that Call will be concentrated on biodiversity, the figures for “biology” are expected to be increased. The strongest fluctuations over time are observed for “biology” and “glaciology” with a doubling of the budget from Phase II to III, and a tripling since Phase I.

The above evolution is a result of: (a) the construction by the OSTC of the inital Programme; (b) a maintenance throughout Phases II to IV as confirmed by the Calls; (c) changes in Phase V where the focus was limited to atmosphere / climate, ecosystems and biodiversity.

Box 4.3 Average annual grants per team



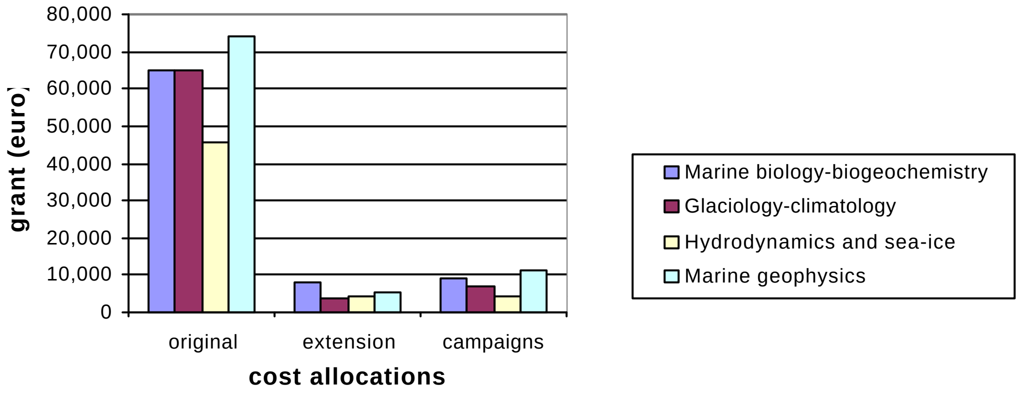
Average annual grants for teams vary strongly per theme. In the first two Phases, the teams from the different themes received approximately a similar grant, varying between 41,000 and 57,000 euro (average: 52,000 euro) and 43,000 and 66,000 euro (average: 51,000 euro) respectively. Within this period the teams from biology and glaciology received a reduced grant and those from hydrodynamics and geophysics an increased one. The third Phase indicates a remarkable budget increase with grants between 66,000 and 112.000 euro (average: 99,000 euro) whereby the average grant is increased with +95 %, varying 8 % for hydrodynamics, 29 % for geophysics, 81 % for glaciology and 160 % for biology! This increase was seen as necessary in order to upgrade the grants to realistic levels. The fourth Phase, however, shows an overall decrease in average grants by -14 % (-20 % for glaciology, -19 % for biology, -10 % for hydrodynamics), but an increase of 63 % for geophysics. The annual grants were between 60,000 and 138,000 euro (average: 85,000 euro). It is expected that for Phase V, the average grants for biology and glaciology will be the same as in Phase IV. Currently, the overall average is 82,000 euro.

The steady increase of grants for geophysics is related to the strong demand of campaigns and especially the building of equipment. Hydrodynamics is merely concentrated on modelling and needs no specific equipment or large campaigns. A strong reduction that has occurred in biology and glaciology after the peak in the third Phase cannot be explained otherwise than by an increase in number of teams through the formation of networks (see Ch. 4.1.3).

Box 4.4 shows that the average original project costs (without campaigns) is around 64,000 euro: hydrodynamics – 46,000 euro; biology and glaciology – 65,000 euro; geophysics – 74,000 euro. Of the total project costs, approximately 10 % were spent on campaigns, varying between 7 % for hydrodynamics and 12 % for geophysics. The difference between the themes is small, but this is due to the fact that campaign costs cover merely the travel of scientists and their equipment to the research vessels or bases operated by other countries. They do not reflect the real costs of the campaigns themselves.

Phase III introduced the provision of extra financial grants for extensions. Since then, these cover about 7 % of the total project costs. All projects received extra finances in Phase III, whereas in Phase IV, this concerned only biology. This latter was due to a not total balance between the homogeneous contents of the Calls and a continuity of research financing which was aimed at during the calendar drafting of SPSD-II. As a consequence, not all "biology" research teams could apply in the new first Call because their research domain appeared only in the second Call. From a financial point of view, the extensions may not be important, but we will see that in terms of time fluctuation, these are very important (see Ch. 4.1.4).

Box 4.4 Variations in cost allocations per theme per team per year



Notes: "Original" refer to the costs as stipulated in the contract, excluding campaigns. "Extensions" were financed separately.

The biggest universities are involved in the Antarctic Programme as can be seen in Box 4.5. Other Belgian universities are clearly absent, e.g. Antwerp, Gembloux, Mons, Namur, etc. Remarkable is the strong involvement of the ULB and VUB research teams. Also remarkable is the involvement of a few public research institutions. Both Dutch and French speaking Communities are equally concerned by Antarctic research.

Box 4.5 Financial grants received by the research institutes since 1985

Institute type	Institute name	Grant per institute: teams no.	Grant per institute: total Euro	Grant per institute: total %
Universities				
	KUL	1	360,177	2
	RUG	3	2,971,591	17
	UCL	2	1.786.085	10
	ULB	3	3,609,860	21
	ULG	4	2,132,265	12
	VUB	3	3,606,639	21
subtotal		***16***	***14,466,617***	***84***
Public research institutes				
	IRSNB / KBIN	1	1,131,424	7
	KMMA / MRAC	1	454,414	3
	MUMM	1	1,210,229	7
subtotal		***3***	***2,796,067***	***16***
Total		**19**	**17,262,684**	**100**

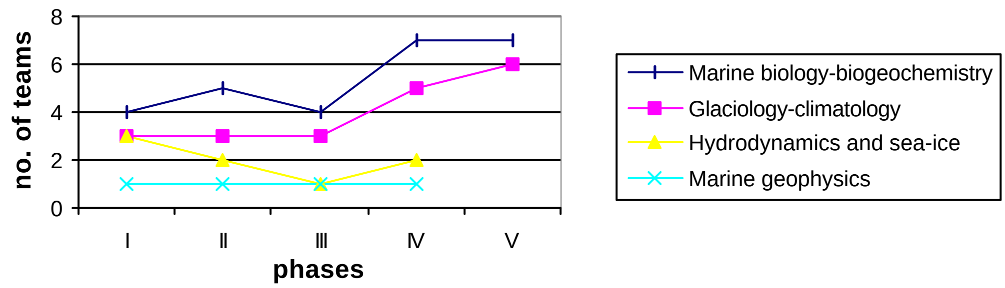
Note: These calculations are based on the project budgets including costs for campaigns. Without these costs, the percentages are approximately the same

Because since its establishment MUMM was brought under several Federal Ministries (now part of IRSNB / KBIN), this research institute is mentioned separately.

4.1.3 Degree of involvement of teams and networking

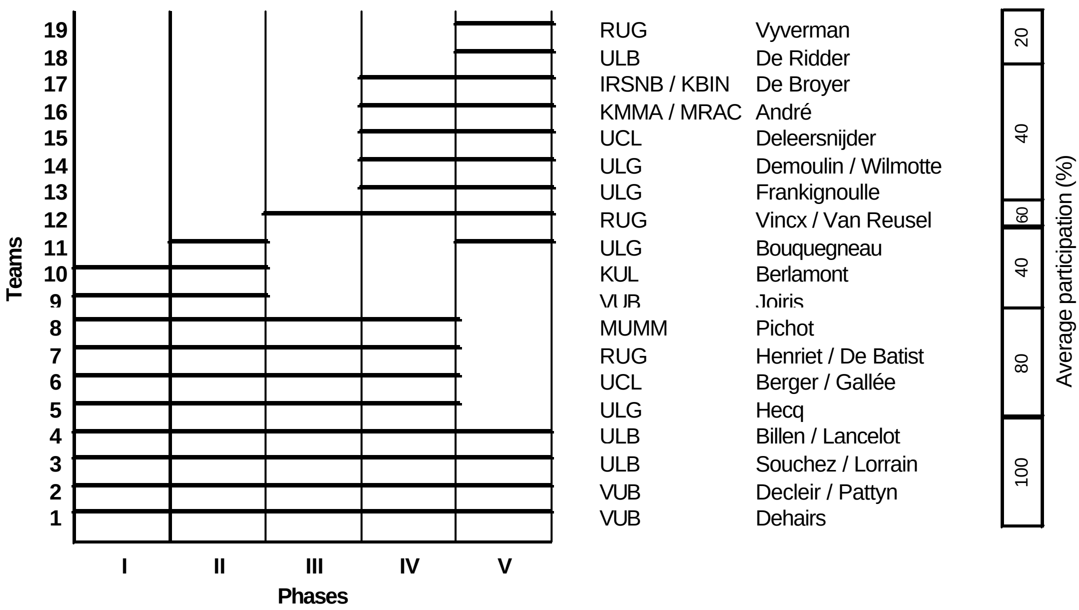
The numbers of participating teams strongly increases with the introduction of SPSD as a result of the requirement of co-operation and demonstrates the evolution of the programme from single teams to more complex collaborations. Box 4.6 shows that biology and glaciology have doubled their number of teams over time. Hydrodynamics and geophysics were more or less centered around one team each and are absent in the current Phase.

Box 4.6 Differentiation in involvement of project teams



Whereas in the beginning, projects were merely implemented by single teams, the fourth Phase shows a strong emphasis on co-operation between universities and research institutes which is fully completed in the fifth Phase with four networking projects. One Call for Proposals remains in Phase V and this will likely result in one extra "biodiversity" project, totalling this Phase with 5 networking projects. So, the Programme has evolved from 1985 with 10 projects of single teams (where one project co-published with another team) to 4 networking projects at present (Boxes 4.7-4.8) and probably 5 with approximately 15 teams in 2003, i.e. after the last Call has been held. This networking is the result of the obligation of OSTC to form networks of multidiciplinary teams. Many of the networks comprise teams that are active within the same thematic area; only one group has been able to attract teams active in different thematic areas (biology and glaciology) (see Table 2.6).

Box 4.7 Dynamics of the teams in the Antarctica Programme (1)



The above data clearly demonstrates that since the introduction of Calls for Proposals in Phase III, the number of new teams is steadily increasing with the greatest refreshment in Phase IV. Precise figures are given in Box 4.8 where data of Box 4.7 are combined with that of Table 2.6. Single team projects were the standard type of projects, but since the SPSD this has been abandoned. Some minor networking projects did exist in the beginning of the Programme, but became the rule in the current Phase. So far, this Phase, comparing with Phase IV, is characterised by one full network continuation; two mergers of single project teams, of which one with additional teams; and one network consisting of one old and one new team. The latter one is the only network where the co-ordinator is a newcomer. The three others have a long experience in Antarctic research.

Box 4.8 Dynamics of the teams in the Antarctica Programme (2)

Organisation of projects	Phases					
	I	II	III	IV	V	total
Granted projects:	10	10	9	9	4	42
- single team projects	9	9	9	7		34
- networking projects	1	1		2	4	8
Participation of teams:						
- total	10	11	9	14	13	57
- new	10	1	1	5	2	19
- abandoning			3		4	7
- re-appearing					1	1
- appearing in more projects	1			1		2
Network configurations:						
- merger					1	1
- merger with enlargement				2	1	3
- one team with enlargement					1	1
- full continuity					1	1
- new						0

Notes: In Phase I, although two teams have separate contracts with the same title (# 7, re: Annex 2.1), separate final reports with varying titles were submitted. This project is, therefore, not reckoned as a network.
The figures represent the situation of April 2002: one Call is still to be held in Phase V.

Starting the Programme with 10 teams, 6 have left and 9 new ones have entered, currently totalling 13 teams. This means an important turnover of teams between the beginning of the Programme and now, even if in terms of topics, we observe continuity. Four teams appear to have a "subscription" on the Antarctic Programme. Together with an increase of 59 % of the average annual grant, one could say that the importance of the Programme has grown.

4.1.4 Ample use of foreign logistics

Belgium has no own logistics for support to Antarctic research (base, vessel, aircraft). Scientists of the Programme are being accomodated in campaigns organised by other countries. Apart from obvious financial reasons, this was a deliberate approach aimed at fitting the Programme in the most recent evolution of Antarctic science philosophy, namely: (a) to foster multidisciplinary joint research efforts in order to efficiently address major topics of international interest; and (b) to avoid duplicating research efforts and concentrating the settlement of basis on the continent.

Concerning logistics, Belgium is familiar with the sharing of facilities from other countries. Box 4.9 shows that in various occasions, especially with Germany and France, the same research vessels were used in the same periods.

Box 4.9 Use of logistical facilities of host countries

Host country	Campaigns with Belgian teams		Campaigns with more Belgian teams	
	no.	no. of Belgian teams involved	no.	no. of Belgian teams involved
European :				
France	5	6	4	3-2-2-2
Germany	16	7	4	2-2-2-2
Italy	9	2	1	2
Spain	2	1		
UK	3	2		
non-European :				
Australia	5	3	1	2
Japan	4	1		
New Zealand	4	1		
USA	2	2		
Total	**50**	**25**	**10**	**8**

Note: The above data refers to the Phases I-IV.
Including projects funded by other sources, the number of campaigns totals 53 (3 extra campaigns were hosted by France) and that of teams involved 27. The topics were dealing with terrestrial ecology and freshwater.

Source: OSTC

The facility sharing of research vessels concerned all teams from biology , but this is inherent in the oceanographic research undertaken. Sometimes, glaciology teams joined the biology teams on vessels in order to arrive on the continent of Antarctica.

4.1.5 Contract extensions

Phases II-IV have made a structural usage of extension. The vast majority of these extensions were intended so as to allow teams interested to participate in the Call for Proposals of a new Phase to bridge the gap between the ongoing and that new Phase. By doing so, they could keep the contractual staff on their payroll in case their proposals were successful. Phases III and IV even provided an extra financial grant for these periods, because the extensions were longer than in previous Phases. The need for such systematic extensions indicates a major structural problem in the planning of the Programme. On the positive side, it also shows good flexibility of OSTC management.

Box 4.10 Extensions as a structural part of the Programme

With an overall extension of 6 %, Phase II was extended with 0.33 year (biology and glaciology). Initially set up for 3 years as in the previous Phases, Phase III was extended to 4 years, i.e. an extra project duration of 37 %. Apparently, Phase IV took this often occurring change during the project period into consideration and introduced longer term projects as of their start with a duration of 4 years, but still implemented an extension with an average of 0.5 year (overall: 10 %). This is not surprising, because this Phase belonged to the 5-year SPSD. Phase V is divided into three parts where projects are envisaged for 4 years. Due to a delay in approval by the Minister of Science Policy in 2002, some projects were, however, a priori extended with 0.25 year in order to backdate the projects with this period so salaries can be paid retroactively. Further details of extensions in time and finances are given in Annex 2.

4.1.6 Variations in success rate of proposals

The first two Phases were characterised by direct invitations from OSTC. Research teams were approached to start a project on a research topic chosen by them within a theme delimited by OSTC and a full continuation was arranged for in the second Phase. Subsequent Phases were organised via Calls for Proposals with a corresponding selection procedure (Box 4.11). The selection rate has been in the order of 50-60 %. This seems high, but the Belgian scientific community interested in Antarctic research is small with approximately 20 potential research teams. Secondly, Phases I-III were organised in such a way that approximately 10 projects should be granted. Phases IV-V show that the budget allows the participation of approximately 15 teams. It then becomes a surprise why the Calls were so detailed, i.e. a well-worked out series of sub-themes. Especially in the first two Calls, the themes were tailored towards the already experienced Antarctic research groups. This situation was abandoned in Phase V where priorities are more concisely described.

Box 4.11 Selection rates in the Calls

Organisation of projects	Phases					
	I	II	III	IV	V	total
Submitted proposals:			16	10	8	34
- single team projects			14	6		20
- networking projects			2	4	8	14
Participation of teams:						
- total			19	18	19	56
- new			11	10	7	28
- abandoning			1		4	5
- re-appearing					1	1
- appearing in more projects				2	1	3
Network configurations:						
- merger					1	1
- merger with enlargement				2	1	3
- one team with enlargement					1	1
- full continuity					2	2
- new			2	2	3	7

Phase	Proposals submitted	Proposals selected	Selection rate %
III	16	9	56
IV	10	6	60
V :	8 :	4 :	50 :
V-a	*5*	*3*	*60*
V-b	*3*	*1*	*33*
V-c		*(1)*	

Phase III consisted of three main themes and seven detailed sub-themes. Including two networking projects, 19 research teams participated. The selected proposals covered all main themes and 4 sub-themes: four in biology and glaciology (mainly dealing with the same sub-theme) and one in hydrodynamics. From those teams active in previous Phases, eight were selected, one was rejected and one did not participate in the Call. Phase IV consisted of three main themes and eight detailed sub-themes. Including four networking projects, 22 research teams participated. The selected proposals covered all main themes and five sub-themes. Three other projects that fell under a sixth sub-theme were already approved by EPICA and needed not to be submitted anymore: they were automatically paid from the Antarctica Programme budget. The main reasons for rejection in the above Calls were that a project was out of scope of the Programme or that it lacked specificity.

Phase V is divided into three Calls: the first enabled three projects to be granted, the remaining two Calls one project each. At first sight, it seems overdone to organise three Calls for selecting five projects only. This fragmentation, i.e. the distribution of themes over time, is due to the annual budget allocations of the OSTC research programmes, one of which is SPSD.

4.2 Operational management

The main actor in the planning and day-to-day management of the Belgian Antarctic Programme is OSTC, the Federal Office for Scientific Technical and Cultural Affairs. OSTC has among its tasks to implement and promote research programmes and activities at Belgian level or within an international framework. In managing Antarctic research, OSTC liaises with several ministries, notably the Ministry of Foreign Affairs that is the main official representative in the ATCM (OSTC being the second one), and acts under the supervision of a Steering Committee, the composition and role of which are spelt out hereafter.

4.2.1 The role of OSTC

Although scientific research on Antarctica was not regarded as a major priority of Belgium at the time of launching the programme, it was opted to execute a programme with a limited scope. The focus was put on the co-ordination of the research, international co-operation and the quality of the teams involved. The scientific objectives were carefully chosen in order to respond to international priorities. The corpus of granted research projects was to form a coherent and complementary assembly in order to maximise the efficiency of the Programme.

For each Phase of the Antarctic Programme, OSTC has followed a well established pattern: writing of Programme contents, launching the Programme (from Phase III with a Call for Proposals), drafting of research contracts, technical and administrative management of the contracts, dissemination of project results, and reporting to ATCM and SCAR.

For the first two Phases, a pragmatic approach was taken in the definition of research areas based upon ideas provided by the scientific community. Project teams were invited on the basis of expertise available in Belgian laboratories. Some of them were already active in the OSTC North Sea[9] research programme, while others had previous experience in Antarctic climate-related research. A reasonable balance of support was ensured throughout the Regions of the country. Although researchers were still informally consulted in the planning of Phases III to V, implementation procedures became more formal with Calls for Proposals and peer-review evaluations. For all Phases, the lists of projects to be retained were endorsed by the Steering Committee (see Ch. 4.2) and approved by the Minister of Science Policy.

Apart from standard administrative regulations, the contracts also specified a number of co-operative links between Belgian teams. Logistical support was given on top of the contracts, and on a case-by-case basis because at the onset of the Programme, there were uncertainties on the exact costs of joining research vessels and bases of other countries. From Phase III, costs for logistics were integrally specified in the contracts. In order to guarantee access to this foreign infrastructure, OSTC made the necessary arrangements in the first Phase. This was subsequently taken over by the scientists themselves.

The main initiatives of OSTC to disseminate results were:

- 9 volumes of research results of Phases I to III, grouped by themes. OSTC intends to continue these publications;
- a national colloquium in 1987;
- a centennial "Belgica" symposium in 1998, co-organised with the Academy of Sciences: proceedings were published at the end of 2001;
- annual reports to SCAR (through the National Committee on Antarctic Research of the Royal Academy);

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[9] This Programme was launched in 1970 and is currently also subject of an external evaluation.

- the creation of a web-site (http://www.belspo.be/antar).

The above project results and event documents, as well as other relevant information on the Programme were widely distributed nationally (e.g. participating and interested scientists, Steering Committee, Academy of Sciences, press, funding agencies, other relevant national organisations) and internationally (e.g. COMNAP members, ATCM members, SCAR, CCAMLR, ESF, EC, international bibliography databases, project reviewers, foreign participants of Belgian teams).

OSTC has demonstrated a good awareness of major trends in international Antarctic research, and has a very good track record of publishing research results in ad-hoc volumes. Belgian scientists have expressed their gratefulness to OSTC for the opportunity to get them involved in Antarctica. The commitment of the programme staff is well acknowledged by the Belgian scientific community. All available evidence points to the crucial role of the programme manager in the early days when the Programme had to be conceived, including the promotion of international contacts and the search for possible spin-offs of projects. The consistency of programme support by OSTC staff remains effective to date.

A few points could be improved nevertheless. Programme staff needs to be optimally informed of each other's activities and on the general context of Programmes: this is certainly a prerequisite for the whole SPSD set-up where integration of themes, multidisciplinarity and co-operation of research teams have become a rule at the project level. With regard to the Calls for Proposals, the addition of Document A and Documents B appears to be somewhat overwhelming for scientists: redundancies on Programme objectives and justifications should be avoided.

With regard to annual and final reporting up to Phase IV, more systematic attention should be given in the future to elementary matters of presentation: some annual reports bear neither dates nor even a reference to Phase IV, and hardly any of those reports mentions such fundamental matters such as the logistics used, the planning of campaigns, publications (published, in press, submitted or to be submitted), training of researchers, organisation of and presentations at seminars, symposia and workshops. A lot of these factual data were only presented in semi-annual administrative reports. Overall, the reporting regime (type of reports, frequency, contents) should be simplified to a single, short, annual progress report and a final full report. Discussions between OSTC and the authors would undoubtedly increase the value of these reports. In fact, scientists expressed a clear need of closer contacts with OSTC and would welcome more information on Belgian science policy and better feedback on research results.

An important issue to raise is the degree of interaction between major political actors in Belgian Antarctic research: OSTC, the Royal Academy of Sciences, the Ministry of Foreign Affairs and the Ministry of Public Health and the Environment. The lack of close ties with the Royal Academy of Sciences, and especially its National Committee for Antarctic Research, strikes the Panel as something of a paradox, since this committee has to forward to SCAR the annual reports that, by the way, are prepared by OSTC, and consists of many members who are also beneficiaries from OSTC grants (see Annex 1.2). While OSTC and the Ministry of Foreign Affairs interacted extensively during the first years of the Programme, particularly during the negotiations of the Madrid Protocol, it seems that contacts have become looser over time. At present, the nature and level of feedback from OSTC to the Foreign Affairs Ministry appear to be limited to the mere provision of briefings to the Ministry of Foreign

Affairs needed for the preparations of the ATCM meetings. Undoubtedly, there exists a willingness among OSTC, the Academy and the Ministry of Foreign Affairs to interact better. Initiatives to rehabilitate the good former interactions should be encouraged.

On the international scene, OSTC is a member of COMNAP. After a long period of absence, OSTC has started to participate only recently. This is an encouraging development, because it increases the visibility of Belgium in the ATS and, more specifically, it provides OSTC with timely information on other countries' plans (e.g. campaigns, vacant space on ships…). It could also be used as a medium to inform on plans of Belgium itself. Belgium is well present in SCAR, because it has representatives in six of its seven scientific Working Groups.

4.2.2 The Steering Committee

In the beginning, a broad interministerial committee was responsible for the follow-up of the Antarctic Programme and the OSTC was ensuring its co-ordination and management. Still active at present, but under a different form, this Steering Committee is composed of representatives of Federal Authorities (OSTC, Ministry of Foreign Affairs, Ministry of Public Health and the Environment) and of some Regional and Community Ministries: the Flemish Community (Departments of Science and Foreign Policy), the Walloon Ministry of Agriculture, and the Ministry of the French Community (Department of Higher Education and Scientific Research). The Committee is mandated to give advice on and to monitor the Antarctic Programme. In principle, its role is many-faceted since it has to link science and policy, advise on project selection, offer suggestions on Programme objectives, co-ordinate various levels of intervention in Belgium, and promote results. In practice, surprisingly, there seems to exist no clear written rules to guide the Committee's work. Furthermore, the Committee comprises no independent active scientists, and this limitation cannot but restrict its potential role.

4.2.3 The User Committees

The concept of User Committees was already existing in SPSD-I, but not applied to Antarctic research until Phase V. For each project, a committee of potential users (national and foreign governmental institutions, industries, other scientists, NGO's, etc.) is set up to actively monitor the research and promote the exploitation of outcomes. The aim is to position each project in the relevant context (strategic, scientific, political, economic, social, institutional, environmental...). User Committees have the potential to bring many benefits to the Programme, but only under two conditions: membership should be expanded and members must display an adequate level of commitment.

From the SPSD contracts, it appears that the membership is restricted in practice to national and foreign universities / research institutes, the Belgian Ministry of Foreign Affairs and the OSTC. Other sectors within society should be encouraged to participate. Since most of the present "users" belong in fact to the same area of competence as the Belgian scientists themselves, it is feared that they will not expand the possible scope and impact of projects towards the public. This being said, identifying potential users from others domains than the project discipline itself or a related discipline, may not be easy.

5 SUMMING UP STRENGTHS AND WEAKNESSES

The two following boxes are intended as an "aide mémoire" on the strengths and weaknesses of the Belgian Antarctic Programme and to serve as an introduction for Chapter 6.

Strengths
Visibility Increasing the visibility of Belgium within the Antarctic Treaty System (ATS) with the launching of a national Antarctica Programme and the participation in the establishment of the Madrid Protocol. **Science policy** Existence of a very long tradition of serious scientific work in the Antarctic. This tradition is one of the longest among the countries active in Antarctic research. Continuity of Belgian Antarctic research: Belgian scientists have been supported by the OSTC since 1985. Strong renewal of research teams since the initiation of SPSD in 1996. Focus on strong areas of Belgian expertise in oceanology and climate-related research. Capacity to adapt to major international trends, in particular the emergence of global important issues (Global Change, Ecosystems, Biodiversity) and the concern for Sustainable Development. **Scientific quality and impact** High quality of the research teams working in the Programme. Internationally recognised quality of most of the Belgian scientific work in Antarctica. Some examples of outstanding science are: ice-dynamics modelling, biogeochemical modelling, food-web dynamics, shelf-slope dynamics. International utilisation of Belgian models and databases. High return of scientific output in relation to limited Programme investments. Some spin-off activities of research to environmental protection. **Co-operation** National consultation of scientists in defining the Programme Phase I contents. Increase in national co-operation through networking of teams in SPSD. Introduction of User Committees in Phase V. Increase in international co-operation: strong links with major European (EPICA) and international programmes (JGOFS, Iron Fertilization Experiments). Strong bilateral links with nations that provide logistical support (vessels, bases) since Belgium does not have own logistics. **Project output and communication** Production and widespread dissemination by OSTC of final project results at the end of each Phase. Informative web-site at the OSTC. **Administration** Little administrative costs: only one desk officer is assigned. Relative flexibility of OSTC procedures (e.g. contract amendments, extensions). Increase of project grants towards realistic levels since Phase III.

Weaknesses
Visibility Gradual weakening of the visibility of a national Belgian Antarctica Programme within the Antarctic Treaty System (ATS) after the launching of the Programme and the participation in the establishment of the Madrid Protocol. Absence of a clear Antarctic component in the present structure of SPSD-II. Unequal level of participation of Belgian representatives in the ATS meetings. A decrease in national co-ordination between the Ministry of Foreign Affairs and OSTC. **Logistics** Absolute dependence on the logistics of Antarctic research Programmes of other countries. **Science policy** Absence of long-term planning of Belgian Antarctic research due to a lack of commitments from policy-makers and other national authorities. No clear evidence that project results have served to support policies related to the management of the Antarctic. **Project output and communication** Overall, limited international publication in peer-reviewed journals. Hardly any events were organised, such as national conferences (apart from "Belgica" 1994), workshops and seminars. Limited co-operation or communication within networking projects and between projects. **Programme structure and administration** Gaps between Phases resulting in the need for extensions of contracts. Unclear and limited involvement of the Programme Steering Committee. Absence of potentially significant actors in the User Committees. Too fragmented Calls for Proposals in SPSD-II. Excessive and heterogeneous project reporting.

6 BELGIAN ANTARCTIC RESEARCH IN THE FUTURE

6.1 Improving the visibility of Belgium in the Antarctic Treaty System

Belgium is one of the first 12 countries that prepared the Antarctic Treaty in 1959. It had started exploration and research activities already long before and logically wishes to have good visibility in the Antarctic Treaty System (ATS).

Belgium produces good quality science in its Antarctic research as scientists from different countries who had the opportunity of working with Belgian scientists know well. Therefore, a way to enhance visibility is to inform as systematically as possible the ATS about the scientific activity and corresponding results:

- The main gathering of the Antarctic Treaty Countries is the ATCM (Antarctic Treaty Consultative Meeting). It is a large diplomatic meeting, convened every year. In the past Belgium has hosted two of them. An active participation in the ATCM is useful because many aspects of Antarctic activities are discussed there, from juridical and diplomatic aspects to scientific, technical and operational ones. In the ATS there are specialised groups to discuss science (SCAR), operations (COMNAP/SCALOP) and others; often science and operational matters are reported to the ATCM. The presentation at ATCM of information papers on research work done in Antarctica is a logical way of increasing visibility of the Programme. Active participation in the meetings of all groups within the ATS and in the discussions is very informative and beneficial both for the visibility of Belgium and for the Programme itself. Since delegations for the ATCM include members of the Ministry of Foreign Affairs and the Environment too, active participation will also inform relevant Belgian authorities about the workings of the ATS.
- Regarding the participation in COMNAP, Belgium has an obvious interest in keeping informed of all planned Antarctic research, if for no other reasons, in order to identify possible host programmes and seek complementarities of its efforts with those of other countries. COMNAP is an adequate platform to negotiate such co-operations. Recently, a Belgian delegate attended a COMNAP meeting. All future meetings should be attended as well.
- With regard to the participation in SCAR, Belgium is an active member of six out of the seven Working Groups. Given the general organisation of the Programme and the high level and good quality of Belgian research, it is important that its scientists have contacts with their counterparts in Antarctic science. SCAR is an ideal venue for these contacts.
- The effort should be pursued to make the newly CEP national contact point function as optimal as possible.

In addition to the participation in ATCM, COMNAP and SCAR meetings, participation to CCAMLR and to the ESF-European Polar Board should be encouraged too.

6.2 Continuity and identity of Belgian Antarctic Research

Establishing a clear road-map

Although from the interviews with the Belgian scientists it appeared that a stand-alone Programme was clearly wished, this seems not feasible within the current science policy of Belgium. The concept of “Sustainable Development” as currently applied in SPSD offers certainly a good opportunity to continue high-quality research in the Antarctic. One condition, however, is to develop a “road-map” with the aims to clearly set the future science programme in perspective and to provide a long-term overview of the nature of the future funding opportunities and decisions. Such a framework should easily explain to potential candidates where their research ideas fit in throughout the duration of the programme. In addition, such a road map will also serve as a visitors' guide for the national and international (scientific) community that in its turn increases the visibility of Belgian Antarctic science.

Active involvement in the European Research Area
The Belgian Antarctic Programme has worked well and has generated a number of good scientific teams in the country. The report shows that there is a strong case for continuing this research and maintaining the significance of Belgium in international Antarctic science. Belgian Antarctic science surely has a role to play in the new European Research Area (ERA) that is a corner stone of the 6th EU Framework Programme. Among the main objectives of ERA to which Belgium should contribute are the networking of national research activities, the mutual opening up of national programmes, the co-ordinated management of large-scale research infrastructure, and the benchmarking of research and innovation policies. ERA provides a concept for stimulating further national and international networking.

Ensuring long-term commitments
A long-term strategy (10 years) with a corresponding planning of the Programmes (5 years) is needed to put Antarctic research on the (inter)national calendar, to guarantee the Programme stability, and to allow research institutes develop their long-term research strategies. Stability is fundamental to keep research groups together and to help researchers establish national and international links.

The importance of long-term political commitments cannot be over-stressed. The present evolution of environmental sciences relies on long time series of observations (this point has recently been emphasised by ESF[10]). A political commitment for 10 years seems fair, both towards the scientists since research in the Antarctic requires long-term planning and preparation by the research teams, as well as to the outside world to show Belgian's interest and vigour. An overlap between the Programmes is necessary to stabilise the research potential at the institutes and to keep the pace in research developments. Per 5-year period, two rounds of Calls for Proposals with similar budgets can be organised, each of them with project durations of 3-5 years and with overlaps between them in order for the research teams to avoid gaps between the end of a project and the start of a possible new project.

The point of continuity raises some complex issues. Guaranteed funding can lead to a lowering of scientific quality and output. On the other hand, in a system where salaries are paid by the Belgian research programmes, the perceived instability of funding can lead to a loss of individual scientists to more secure environments (as has happened before in the Programme). Any future mechanism for providing greater continuity of funding must also allow for a turnover of staff and a further introduction of new blood into the Programme.

Stepping up the dialogue with scientists
The Belgian Antarctic Programme has initially been set up more or less "bottom up" based upon thematic orientations from the OSTC. Considering the modest size of the Programme, this was probably the best way to operate. The Belgian expertise within these orientations has certainly been strengthened over time, which by the way is one of the main goals of the

[10] ESF Marine Report "Towards a European Marine Research Area" (December 2000), condensed and published as ESF/Marine Board Position Paper no. 3 "Navigating the future" (March 2001); http://www.esf.org

Programme. The approach of consulting scientists prior to the launch of each new Phase of the Programme seems to be weakened in the recent Calls where the priorities are merely adapted to globally recognised trends. Because Belgium knows its strong scientific domains, this attitude can be explained. However, a national dialogue with scientists involved in Antarctic research, regardless their participation in the OSTC Programme, is welcomed in order to be alert on emerging issues, to improve the communication with the scientific community thereby improving the visibility of the Programme, and to motivate the scientists

It is necessary that project results are taken in proper consideration for the subsequent management of the Antarctic Programme in order to involve scientists in the development of the Programme and to increase the integration of the Programme itself.

Tuning national priorities in the international context

Because the Belgian science community is relatively small, not all areas of scientific expertise can be represented. It is therefore important that a mechanism exists to ensure a balance between national strengths and international scientific priorities. Without such a mechanism, there will always be a risk that Belgium could slip from the mainstream of international science. OSTC should give consideration to this danger. Possible options might include a strengthening of the Steering Committee for SPSD II, or an enhancement of the role of the Belgian National Committee for Antarctic Research to place all Belgian Antarctic research in the international context.

The research priorities should continue to be framed in such a way as to fit in international trends and stay aboard of the ATS. This will thus facilitate the recognition of Belgian science and the co-operation with other nations. Care should be taken therefore to identify priorities or parts of these that are complementary with that of other nations. The priorities chosen and the results expected / obtained should be such that they can be used outside the Antarctic continent, more than is presently the case. At present, the output of refereed scientific publications varies widely between different research groups. Stimulating a high output in peer reviewed literature, including co-publications is important to promote the international status of Belgian Antarctic science.

Belgium should seek to hold joint scientific seminars with other countries in order to enhance international co-operation, in particular with a view to share costs and expertise.

Opening up SPSD to bipolar research (Antarctic and Arctic)

Within the current trends spotted around the world, it seems logical to expand the Antarctica Programme with an Arctic component. Relations between those areas are numerous and combining Belgian expertise can only favour research inputs and outcomes of both areas. The Belgian expertise in its strong domains can even be further enhanced with this combination.

An integration into a Polar Programme as part of an overall Sustainable Development Programme could be made possible by the existence of a clear road-map as described above. This would also imply research that is performed outside the OSTC funding mechanism, for which reason OSTC as a Federal institution can play a central role in assembling all research activities that deal with Antarctic / Arctic research at Belgian level.

For an efficient research in the polar zones, it is of prime importance that the Belgian participants know of each other, co-operate where possible and inform each other of all kind of findings. OSTC has to introduce this mechanism clearly in its Call documents, but should also provide an infrastructural support in terms of an informative web-site and an electronic newsletter that is distributed among the Belgian polar research community and other interested scientists.

6.3 Sharing the expenses of logistical support

The Belgian Antarctica Programme operates without any investment in logistics. Belgium is too small to run its own full-scale logistics. As a consequence, its scientists mainly operate as guests of other expeditions. On one side this reduces the cost of the Belgian Programme and eliminates the complexity of implementing logistics. It also stimulates the number of international co-operations with projects of other Programmes. On the other side, it limits the selection of the best possible site for a specific research activity. Nevertheless, something should be done to allow more freedom of action to the Belgian research teams. Considering also the very high real cost of logistics it would be fair to share some of the expenses of the host country which could prevent an embarrassment that one could feel being a "free rider".

Several options should be explored and put forward in Memoranda of Understanding with the partner countries:

- To share the cost of the operation of the ship in proportion to the number of researchers; this can be worked out easily and should not be very expensive.
- To rent a research station for part of the year (has already been done by the Dutch) either in the Peninsula or in other interesting Antarctic locations, e.g. the Ross Sea region.
- To share an operational station with the corresponding costs.
- To partially share research stations that are available for this purpose: one of these will be in the near future "Station Concordia", a French-Italian station at Dome C on the Plateau that should be operational in 2004.
- To offer certain scientific or technical services to the scientific community (e.g. the development of the highly needed SCAR Biodiversity Information Network).
- To contribute by means of particular scientific or logistic equipment to the host expeditions and to offer particular expertise.

It is also worthwhile investigating into the possibilities within ERA to get involved in the co-ordinated management of large-scale research infrastructure to be used for Antarctic research.

The attendance at the Antarctic meetings (ATCM, SCAR, COMNAP) is useful to gather information about developing sharing possibilities.

6.4 Setting up of a national co-ordination mechanism

OSTC is a crucial element within the network of institutions that are supposed to interact in Belgian science: federal Ministries, Regional and Community authorities, the Royal Academy. Efforts are needed to improve the efficiency of the system. This of course has to be a shared responsibility of all organisations concerned. The Programme's Steering Committee may play a strong role here. Fundamentally, this committee is the one mechanism that has the potential to integrate all relevant players within Belgium. Its role, as well as that of OSTC, could be enhanced by the inclusion of active scientists, provided that concerns around conflicts of interest are overcome. This would broaden the base of experience and expertise in this important committee, and thereby strengthen programme management. Similarly, the new User Committees should as far as possible reflect a greater spread of sectors of society than they do at present. Reinforced Steering and User Committees are needed to promote effectively, where possible, the policy relevance of research results.

Currently, there is a willingness among OSTC, the Royal Academy of Sciences and the Ministries of Foreign Affairs and the Environment to better interact than is the case today. A policy document outlining the strengths of Belgian research in Antarctica would be greatly appreciated in the Ministry of Foreign Affairs, as would the provision of more detailed information on the research effort and its ultimate meaning. Indeed, all actors are encouraged to work together towards a fuller recognition of their potential role to promote the international prestige of Belgian science.

By bringing all actors together, extra sources of potential funds could be explored. Indeed, with some of the recommendations made above, in particular with reference to a polar programme and sharing logistical expenses, an increase of the research budget is necessary for running an efficient research efforts. A financial contribution from several Ministries, both at Federal and Regional level, if at all possible in the context of Belgium, would seem a positive signal of commitment from these institutions. The role of the Steering Committee would thus be enhanced.

6.5 Continuous improvement of the operational management quality

The performance of OSTC as manager of the Antarctic Programme is considered as satisfactory. With rather limited resources in staff (one full-time programme manager) and in funds, OSTC has done and is doing its best. Improvements in routine management can easily be achieved, especially with regard to the frequency, format, contents and dissemination of project reports.

OSTC has the important and difficult task of interfacing the scientific and political communities. Its contacts with individual members of the scientific community appear to be good and basically adequate for smooth running of the research contracts. More efforts at active co-ordination of teams, especially through annual workshops, will enhance the co-operative links stipulated in the contracts. Similarly, meeting events at (inter)national level have to be stimulated for an effective exchange of information, dissemination of progress results, future planning, and demonstrating the national character of the science programme. As part of disseminating information to the scientific and political communities, and of organising events, it is necessary to follow-up on the reactions of the recipients / participants in order to feed useful information in the programme management and structure and, of course, to maintain the visibility of Antarctic research. In addition, OSTC should promote the production of education material for schools and the organisation of excursions to research facilities in Belgium. Its web-site needs a continuous updating to accurately inform all interested parties.

In the past, OSTC has involved scientists in the preparation of Programme contents; with the advent of SPSD, and especially SPSD-II where reference to Antarctica is less evident than before, science was fitted within the concept of sustainable development. Without denying the advantages of « Sustainable Development » umbrella, there is a risk that the community of active scientists finds the notion somewhat abstract and loses its feeling of purpose. The Office should seek to counteract this risk, by introducing a clear "road-map" as mentioned in Section 6.4, avoiding unnecessary fragmentation of Calls for proposals and simplifying the corresponding texts, and in general by interacting more in depth with researchers. This interaction can be achieved at the time of Programme launching (the political justifications given in Document A of the SPSD Calls for proposals cannot substitute for information provided directly during dedicated workshops), and subsequently by visits to the researchers and active commenting of project reports. A scientific review is needed at the end of each Phase, not only to see what has been done, but also to disseminate the outcome and as such promoting the research programme, and to assist in establishing future priorities.

The level of commitment of OSTC cannot be doubted. It must be stressed, however, that the presence among the staff of experienced scientists is essential for the scientific credibility of any funding agency. OSTC authorities should consider the example of the USA's NSF, where senior scientists are seconded for a few years from their universities as programme managers. The prestige of OSTC would be greatly enhanced if indeed the Office was perceived as a partner in science rather than a mere funding agency.

6.6 Main recommendations in short

Enhance the visibility of Belgium in the Antarctic Treaty System:

- Participate actively in all meetings of ATCM, SCAR, COMNAP, CCAMLR and ESF-European Polar Board
- Inform as systematically as possible these parties on Belgian scientific activity in Antarctica

Ensure the continuity and enhance the identity of Belgian Antarctic research:

- Build on the concept of Sustainable Development and establish a clear road-map for research in the Antarctic
- Use Antarctic research as a privileged test area for the European Research Area
- Develop a long-term strategy, implying long-term commitments at the policy level, in order to ensure programme stability and secure a place for Belgian Antarctic research on the international calendar

Tune national priorities in the international context:

- Develop a mechanism to ensure a balance between national strengths and international scientific priorities
- In order to achieve this, enhance the role of the SPSD-II Steering Committee and/or of the Belgian National Committee for Antarctic Research

Open up SPSD to bipolar research, i.e. in both polar regions, and integrate with research performed outside the OSTC system

Explore and implement options for sharing with other countries the expenses of logistics

Set up a national co-ordination mechanism:

- Step up the dialogue with scientists at national level: take full account of scientific Programme results in designing the future of Antarctic research
- Promote the most efficient interaction of OSTC, the Academy of Sciences and the Ministries involved (Foreign Affairs, Environment)
- Broaden the composition of and strengthen the Steering and User Committees

Improve operational management quality:

- Seek possible improvements in routine management (e.g. reporting requirements)
- Organise more workshops: workshops with respect to science policy in order to integrate teams, to discuss future policies; international workshops on a particular item enhancing the visibility of a certain topic or project
- Interact more in depth with scientists at the time of programme launching and during the implementation of the contracts
- Consider seconding senior scientists to OSTC
- Avoid unnecessary fragmentation of Calls for proposals

ANNEXES

Annex 1.1 Stations of SCAR Nations operating in the Antarctic

Country	no.	Station name	Latitude
Argentina	40	Belgrano II	77°52'29"S 34°37'37"W
	36	Esperanza	63°23'42"S 56°59'46"W
	32	+ Jubany	62°14'16"S 58°39'52"W
	37	Marambio	64°14'42"S 56°39'25"W
	38	Orcadas	60°44'20"S 44°44'17"W
	22	San Martin	68°07'47"S 67°06'12"W
Australia	16	Casey	66°17'00"S 110°31'11"E
	13	Davis	68°34'38"S 77°58'21"E
	18	* Macquarie Island	54°29'58"S 158°56'09"E
	8	Mawson	67°36'17"S 62°52'15"E
Brazil	34	+ Comandante Ferraz	62°05'00"S 58°23'28"W
Chile	25	Capitan Arturo Prat	62°30'S 59°41'W
	35	General Bernardo O'Higgins	63°19'S 57°54'W
	28	+ Presidente Eduardo Frei	62°12'S 58°58'W
	26	+ Escudero	62°11'57"S 58°58'35"W
China	27	+ Great Wall	62°13'S 58°58'W
	10	Zhongshan	69°22'S 76°23'E
France	7	* Alfred Faure, Iles Crozet	46°25'48"S 51°51'40"E
	17	Dumont d'Urville	66°39'46"S 140°00'05"E
	12	* Martin de Viviès, Ile Amsterdam	37°49'48"S 77°34'12"E
	9	* Port aux Français, Iles Kerguelen	49°21'05"S 70°15'19"E
Germany	43	Neumayer	70°38'S 08°15'48"W
India	2	Maitri	70°45'57"S 11°44'09"E
Japan	5	Syowa	69°00'25"S 39°35'01"E
Korea	31	+ King Sejong	62°13'24"S 58°47'21"W
New Zealand	20	Scott Base	77°50'60"S 166°45'46"E
Poland	33	+ Arctowski	62°09'34"S 58°28'15"W
Russia	29	+ Bellingshausen	62°12'S 58°58'W
	14	Mirny	66°33'S 93°01'E
	6	Molodezhnaya	67°40'S 45°51'E
	3	Novolazarevskaya	70°46'S 11°50'E
	11	Progress	69°23'S 76°23'E
	15	Vostok	78°28'S 106°48'E
South Africa	42	* Gough Island	40°21'S 09°52'W
	4	* Marion Island	46°52'34"S 37°51'32"E
	44	SANAE IV	71°41'S 02°50'W
Ukraine	23	Vernadsky	65°14'43"S 64°15'24"W
United Kingdom	39	* Bird Island	54°00'31"S 38°03'08"W
	41	Halley	75°34'54"S 26°32'28"W
	21	Rothera	67°34'10"S 68°07'12"W
United States	1	Amundsen-Scott	89°59'51"S 139°16'23"E
	19	McMurdo	77°50'53"S 166°40'06"E
	24	Palmer	64°46'30"S 64°03'04"W
Uruguay	30	+ Artigas	62°11'04"S 58°54'09"W

Notes: The stations refer to those that were operational in the Winter of 2000
Stations are numbered clockwise from the Greenwich Meridian
* Stations north of 60°S
+ Stations on King George Island

Source: SCAR (http://www.scar.org)

Annex 1.2 Members of the Belgian National Committee for Antarctic Research and their relations with OSTC and SCAR

Members [1]		Institute		Involvement in OSTC Antarctica programme		Presence in SCAR Working Groups
type	name	name	cat. [2]	phase	status [3]	
fm	Arijs	BIRA / IASB	r-pu			Physics and chemistry of the atmosphere
fm	Berger	UCL	u	I, II, III, IV	CO	
fm	De Batist	RUG	u	II, III, IV	CO	
fm	De Broyer [a]	IRSNB / KBIN	r-pu	IV, V	CO, COn	Biology
fm	Decleir [b]	VUB	u	I, II, III, IV, V	CO, COn	Geodesy and geographic information, Glaciology
fm	Dehairs	VUB	u	I, II, III, IV, V	CO, COn	
fm	Gerday	ULG	u			
fm	Hecq	ULG	u	I, II, III, IV	CO, COn	
fm	Hus	KMI / IRM	r-pu			
fm	Lancelot	ULB	u	I, II, III, IV, V	CO, mCO, P	
fm	Paulissen	KUL	u			
fm	Simon	BIRA / IASB	r-pu			Solar-terrestrial and astrophysical research
fm	Souchez	ULB	u	I, II, III, IV, V	CO, P	
fm	Van Autenboer [c]	LUC	u			Geosciences
fm	Vincx	RUG	u	III, IV, V	CO, mP	
am	Adams	UA-UIA	u			
am	Baquet	UCL	u			
am	Beyens	UA-RUCA	u			
am	De Maziere	BIRA / IASB	r-pu			
am	Fichefet	UCL	u	I, II, III	mCO	
am	Gallée	UCL	u	I, II, III, IV	mCO, CO	
am	Heip	CEMO (NL)	r-pu			
am	Herman	AWI	m		SC	
am	Rasson	KMI / IRM	r-pu			
am	Schayes	UCL	u	I, II, III, IV	mCO	
am	Schockaert	LUC	u			
am	van Ypersele	UCL	u	I, II, III	mCO	

[1] Members :
fm full member
am associated member

[a] Secretary
[b] President
[c] Vice-president

[2] Institute category :
r-pu public research institute (Federal, except Heip)
u university
m ministry (Flemish)

[3] Status in OSTC programme :
CO co-ordinator
mCO member in team of co-ordinator
COn co-ordinator of network
P promotor in network
mP member in team of promotor
SC member of Steering Committee

Annex 2.1 The research projects from the "Scientific Research Programme on Antarctica, Phase I" (1985 – 1988)

No.	Title project	Cat [1]	Promotor	Institute		Grant				Duration		
				name	cat [2]	original	extension	campaigns	total	original	extension	total
						[Euro]				[months]		
1	Biochemistry of the nutrition of phyto- and bacterioplankton	A	Billen	ULB	u	137,829				36	1	37
2	Zooplankton biochemistry and ecodynamics	A	Hecq	ULG	u	137,829				36		36
3	Plankton ecotoxicology and activity	A	Joiris	VUB	u	137,829				36		36
4	Biogeochemistry of Barium	B	Dehairs	VUB	u	137,829				36		36
5	Seismic stratigraphy and clay dynamics	C	Henriet	RUG	u	137,829				36		36
6	Isotopic composition of ice formed by water freezing	D	Souchez	ULB	u	135,970				36		36
7 a	Development of ice sea models	D	Berlamont	KUL	u	158,280				36		36
b	Development of ice sea models	D	Pichot	MUMM	r-pu	156,669				35		35
8	Interactions ocean-ice-atmosphere	D	Berger	UCL	u	158,280				36		36
9	Dynamics of the ice gap	D	Decleir	VUB	u	135,970				36		36
Total						**1,434,312**		**272,000**	**1,706,312**			
Average per team						**143,431**		**272000**	**170,631**	**36**		**36**

[1] Category of research: A Plankton ecology; B Marine geochemistry; C Marine geophysics; D Glaciology and climatology

[2] Institute category: u university; r-pu public research institute

Source: OSTC contracts

Notes: Project # 7 is a consortium of two research teams.
The teams of ULB-Souchez and VUB-Decleir have already been active in the Antarctic before. The other teams have been / are active in the OSTC "North Sea" Programme.
Table 2.1 mentions a total figure of approximately 272,000 Euro for campaign costs.

Annex 2.2 The research projects from the "Scientific Research Programme on Antarctica, Phase II" (1988 – 1992)

No.	Title project	Cat [1]	Promotor	Institute name	Institute cat [2]	Grant original	Grant extension	Grant campaigns	Grant total	Duration original	Duration extension	Duration total
						[Euro]				[months]		
1	Chemical and isotopic distribution in freezing ice	D	Souchez	ULB	u	147,497				36	3	39
2	Oceanic model of sea ice	D	Berlamont	KUL	u	147,497				36		36
3	Atmospheric dynamics and atmosphere-surface interactions	D	Berger	UCL	u	169,807				36	5	41
4	Dynamics of the ice cap	D	Decleir	VUB	u	147,497				36	6	42
5	Primary production and nutritional potential for herbivores	A	Billen	ULB	u	144,770				35		35
6	Zooplankton biochemistry and ecodynamics	A	Hecq	ULG	u	148,736				36	5	41
7	Ecotoxicology and planktonic activity	A	Joiris	VUB	u	148,736				36	5	41
8	Vertical transport of biogene components	B	Dehairs	VUB	u	148,736				36	1	37
9	Evolution of peri-antarctic sedimentary basins	C	De Batist / Henriet	RUG	u	171,047				36		36
10	Thermodynamic and cinematic modelling of ice seas	D	Pichot	MUMM	r-pu	166,461				35	1	36
Total						**1,540,782**		**272,000**	**1,812,782**			
Average per team						**154,078**		**272000**	**181,278**	**36**	**3**	**39**

[1] Category of research:
- A Plankton ecology
- B Marine geochemistry
- C Marine geophysics
- D Glaciology and climatology

[2] Institute category:
- u university
- r-pu public research institute

Source: OSTC contracts

Note: Table 2.1 mentions a total figure of approximately 272,000 Euro for campaign costs.

Annex 2.3 The research projects from the "Scientific Research Programme on Antarctica, Phase III" (1992 – 1996)

No.	Title project	Cat [1]	Promotor	Institute name	Institute cat [2]	Grant original [Euro]	Grant extension [Euro]	Grant campaigns [Euro]	Grant total [Euro]	Duration original [months]	Duration extension [months]	Duration total [months]
1	Spatial and seasonal variability of the transport of biogenic compounds in the Southern Ocean	A	Dehairs	VUB	u	374,319	139,862	111,552	625,733	36	13	49
2	Ecological modeling of the planktonic microbial food web	A	Lancelot	ULB	u	400,274	109,916	16,113	526,303	36	14	50
3	Role of meiobenthos in Antarctic ecosystems	A	Vincx / Coomans	RUG	u	287,457	65,642	14,874	367,973	36	13	49
4	Control of the Antarctic pelagic ecosystem by higher trophic levels in relation to variations in environmental conditions	A	Hecq	ULG	u	203,868	53,396	48,959	306,223	36	14	50
5	Oil spill modeling for the Antarctic seas (OSMAS)	B	Pichot	MUMM	r-pu	190,878	85,672		276,550	36	14	50
6	Belgian contribution to the "Antarctic Offshore Acoustic Stratigraphy Project" (BELANTOSTRAT)	C	De Batist	RUG	u	235,499	74,418	37,184	347,101	36	13	49
7	Formation of the Terra Nova Bay polynya and climate implications	D	Berger	UCL	u	433,814	151,141		584,954	36	14	50
8	Dynamics of the Antarctic ice cap and climate changes	D	Decleir	VUB	u	198,265	65,072	29,747	293,085	36	13	49
9	Isotopic and chemical composition of Antarctic shelf ice: implications for global changes	D	Souchez	ULB	u	220,625	58,057	22,310	300,992	36	13	49
Total						**2,544,999**	**803,175**	**280,739**	**3,628,913**			
Average per team						**282,778**	**89,242**	**31,193**	**403,213**	**36**	**13**	**49**

[1] Category of research: A Marine biogeochemistry and ecodynamics; B Hydrodynamics; C Marine geophysics; D Glaciology and climatology

[2] Institute category: u university; r-pu public research institute

Source: OSTC contracts

Annex 2.4 The research projects from the “Scientific Research Programme on Antarctica, Phase IV” (1996 – 2001)

No.	Title project	Cat [1]	Promotor	Institute name	Institute cat [2]	Grant original	Grant extension	Grant campaigns	Grant total	Duration original	Duration extension	Duration total
						[Euro]				[months]		
1	Meiobenthic biodiversity and fluxes within the Antarctic biogeochemical environment	A	Vincx	RUG	u	414,577	102,231	44,621	561,429	48	13	61
2	Ecofunctional biodiversity of benthic crustacean taxocoenoses in the Southern Ocean	A	De Broyer	IRSNB / KBIN	r-pu	409,644	222,633	29,747	662,024	48	13	61
3	“An integrated approach to assess carbon dynamics in the Southern Ocean”:											
a	New and export production	A	Dehairs	VUB	u	433,318	4,958	49,579	487,854	48		48
b	Study and modeling of the planktonic system	A	Lancelot	ULB	u	402,455		49,579	452,034	48		48
c	Barite geochemistry	A	André	KMMA / MRAC	r-pu	187,928			187,928	48	2	50
d	Air/sea exchanges	A	Frankignoulle	ULG	u	195,960		32,226	228,186	48		48
e	1-D modeling of the sea-ice and water column	A	Deleersnijder	UCL	u	108,329			108,329	48		48
4	“Response of the Southern Ocean global ecosystem to physical and trophic constraints”:	A										
a	Ecosystem functioning and modeling		Hecq	ULG	u	395,117	105,702	27,268	528,088	48	12	60
b	Physical modeling	A	Pichot	MUMM	r-pu	143,778	35,574	4,958	184,310	48	11	59
c	Role of the picophytoplankton	A	Demoulin	ULG	u	56,396	10,606	4,958	71,960	48	13	61
5	Study of convective movements in the Southern Ocean	B	Pichot	MUMM	r-pu	371,840			371,840	48	**6**	54
6	Mass balance of the Antarctic ice cap (a contribution to EPICA)	C	Berger / Gallée	UCL	u	441,250		4,958	446,208	48	**6**	54
7	EPICA Basal ice – eastern Antarctica	C	Souchez	ULB	u	438,772		61,973	500,745	48	**3**	51
8	Dynamics of the Antarctic ice cap and climate changes (a contribution to EPICA)	C	Decleir	VUB	u	334,656		24,789	359,446	48	**6**	54
9	Antarctic shelf-slope dynamics: an innovative geophysical approach	C	De Batist / Henriet	RUG	u	493,234		61,973	555,207	48		48
Total						**4,827,255**	**481,703**	**396,630**	**5,705,588**			
Average per team						**321,817**	**32,114**	**26,442**	**380,373**	**48**	**6**	**54**

[1] Category of research: A Marine biota and global change; B Dynamics of the Southern Ocean; C Palaeo-environmental records

[2] Institute category: u university; r-pu public research institute

Source: OSTC contracts

Annex 2.5 The research projects from the "Scientific Research Programme on Antarctica, Phase V" (2001 – 2005)

No.		Title project	Cat [1]	Promotor	Institute name	Institute cat [2]	Grant original [Euro]	Grant extension [Euro]	Grant campaigns [Euro]	Grant total [Euro]	Duration original [3] [months]	Duration extension [months]	Duration total [months]
1	a	Late quaternary climate history of coastal Antarctic environments: a multi-proxy approach	A	Vijverman	RUG	u	307,983		29,747	337,730	51		
	b		A	Wilmotte	ULG	u	237,804		14,874	252,678	51		
2		"Assessing the sensitivity of the Southern Ocean's biological pump to climate change":											
	a	Proxies of new and export production	A	Dehairs	VUB	u	350,621		32,226	382,847	51		
	b	Plankton process studies and biogeochemical modelling	A	Lancelot	ULB	u	399,332		32,226	431,558	51		
	c	Isotopic and trace element proxies	A	André	KMMA / MRAC	r-pu	234,259		32,226	266,486	51		
	d	Ocean - ice modelling	A	Deleersnijder	UCL	u	264,106			264,106	51		
	e	Ocean – atmosphere CO_2 exchange	A	Frankignoulle	ULG	u	218,097		23,550	241,647	51		
3	a	Antarctic ice-sheet dynamics and climatic change: modelling and ice composition studies (AMICS)	A	Decleir / Pattyn	VUB	u	388,300		49,579	437,879	51		
	b			Souchez / Lorrain	ULB	u	386,516		61,973	448,489	51		
4	a	Biodiversity of three representative groups of the Antarctic Zoobenthos "Bianzo"	B	De Broyer	IRSNB / KBIN	r-pu	419,567		69,400	488,967	48		
	b			Van Reusel	RUG	u	401,216		56,875	458,091	48		
	c			De Ridder	ULB	u	217,581		56,875	274,456	48		
	d			Bouquegneau	ULG	u	139,009		22,520	161,529	48		
Total							**3,964,390**		**482,071**	**4,446,462**			
Average per team							**304,953**		**37,082**	**342,036**	**50**		

[1] Category of research: A Atmosphere and climate
B Biodiversity (in Call 2001 only)

[2] Institute category: u university r-pu public research institute

[3] Due to a delayed approval of the proposals by the Minister of Science Policy, a late start of the projects was foreseen and, a request for an extension in time is expected at the end of the project. An extra administrative period of 3 months was, therefore, included at the start of the project.

Note: There is still one Call for Proposals scheduled for 2002.

Source: OSTC contracts

Annex 3 Detailed Scientific Reviews

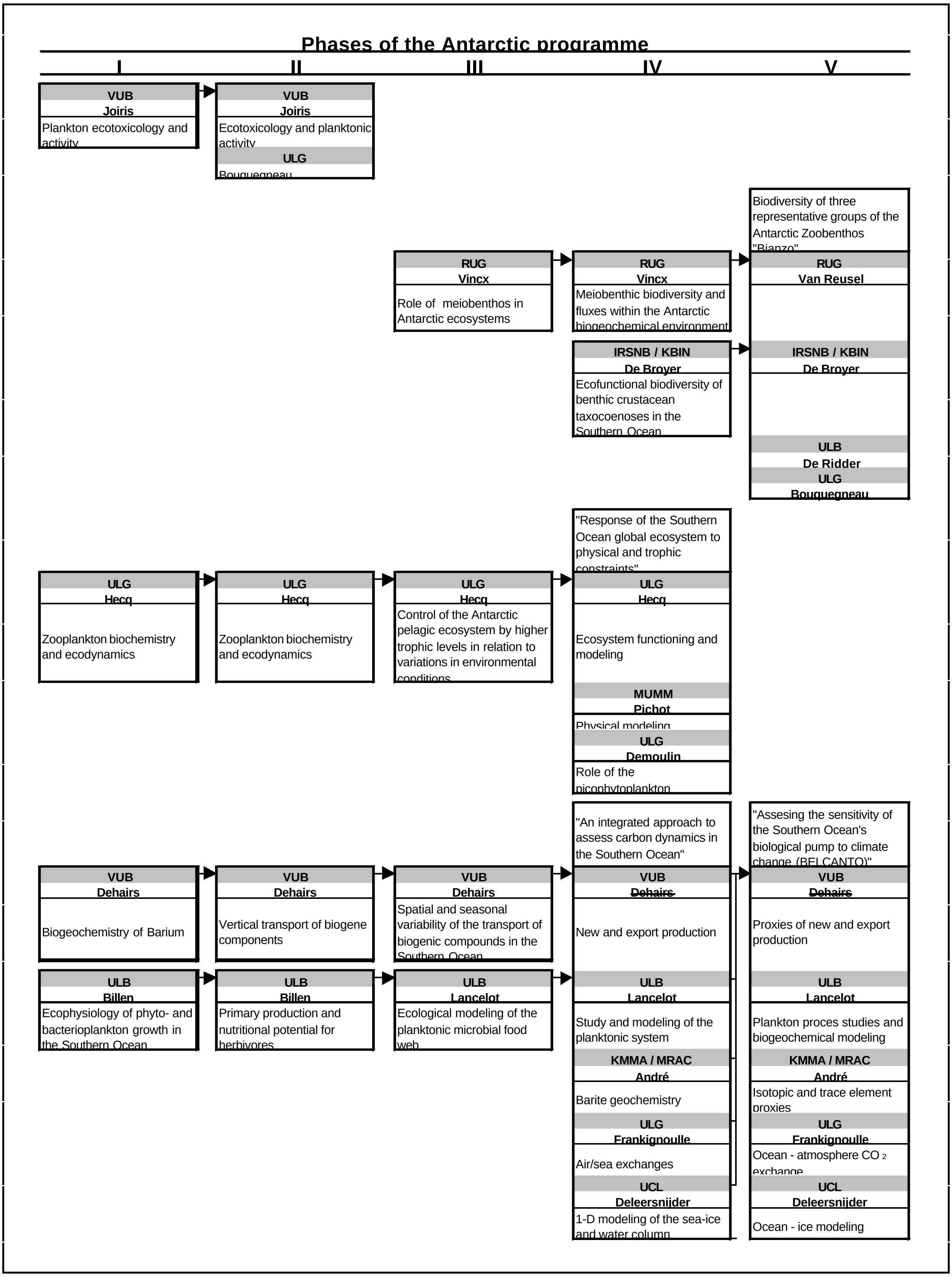
The detailed scientific reviews are distributed over the following themes:

- Marine biology and biogeochemistry
- Glaciology and climatology
- Hydrodynamics and sea-ice
- Marine geophysics

At the top of each section, a box gives an overview of the evolution over time of the research topics undertaken by the several teams. Each research topic continued in a new Phase with slight modifications, thus resulting in a linear trend. Therefore, the reviews discuss each research topic throughout the various Phases as a "long-term" project.

The reviews concentrate mainly on Phases I-IV. Because Phase V has only recently started, no data on project results is yet available, but the research topics are briefly commented on.

Annex 3.1 Marine biology and biogeochemistry



Ecotoxicology and seabirds (Joiris; VUB)
This project involved the transfer to the Southern Ocean of a scientific and analytical approach developed in the North Sea. The work comprised the analysis of samples for a range of pollutants (PCBs, pesticides, heavy metals) using standard methodologies developed elsewhere. This was essentially a 'look and see' approach, although with the explicit aim of testing the generality of concepts developed elsewhere. The patterns observed were very different from those found in the North Sea, with different patterns in different classes of pollutant. These patterns suggest that input of pollutants to the Southern Ocean is both local and global.

In addition to this work on pollutant distribution, there are also publications on seabird distribution (comparing patterns in the Arctic and Antarctic) and on bacteria in the Southern Ocean. There is also work on oxygen and carbon dioxide dynamics and whilst such observations are undeniably important, the interpretation of the data would benefit from consideration of the broader scale of dynamics of the Southern Ocean food web.

The team leader trained as a microbiologist makes the variety of topics covered rather impressive. The varied and disjunct nature of this work makes it very difficult to provide an overall assessment. Work on pollutant distribution patterns is important, particularly in relation to establishing a mechanistic understanding of the global dispersal of different pollutants. It is, however, difficult to assess such descriptive work in the same context as innovative oceanographic science, and perhaps even unfair to attempt such a comparison. It is also important to determine the extent to which Antarctic organisms are more or less able to deal with pollutant burdens, although this latter point has not yet been explored within the Belgian programme.

The techniques utilised in this work were fully up to date, and the interpretation has been set in the wider context of the contemporary knowledge of marine pollutants. The data indicate a low level of pollutant load per unit volume of seawater, but a high level per unit mass of suspended matter. This unusual result would have benefited from further work in a seasonal context, to take account of the very marked seasonal variation in the Southern Ocean.

The publication output is broadly commensurate with the duration of the project and the level of fieldwork, without being particularly strong. The work has made a useful contribution through its careful documentation of pollutant levels, though without breaking new ground. The publications on bacteria and oxygen/carbon dioxide are useful, but do not constitute a significant body of work in themselves.

This project has undoubtedly fulfilled OSTC aims in providing Belgian scientific involvement in areas of science regarded as important at the time. Its small scale has, however, prevented it from having the international impact of larger projects.

Meiofauna (Vincx; RUG)
The meiobenthos group at the University of Gent is a world leading group in its field. Through its energetic leader it has undertaken work on meiofauna all over the world, and the Antarctic studies funded by OSTC thus form part of a wider nexus of work. This diverse and wide-ranging approach to scientific work has both strengths and weaknesses. The strength is that the research group is building a thorough picture of the meiofauna globally, thus providing an important intellectual context for studies in new regions. The potential weakness is that work can start to lack innovation, simply repeating routine or standard studies in new

locations. It then contributes to knowledge by filling in gaps in the broad picture, but does not necessarily advance the field.

The meiofaunal work undertaken in Antarctica essentially involved the application of approaches and techniques developed for northern hemisphere studies, though with sensible modifications to take account of Southern Ocean circumstances. This project has involved a great deal of detailed work in the evaluation of field assemblages of meiobenthos both in deep water and the low subtidal, and also in laboratory experimentation on feeding, respiration and the role plaid in nutrient fluxes between the sediment and water column. Prior to this work almost nothing was known of Southern Ocean meiofauna, and this work established some interesting differences in Antarctic meiofaunal communities compared with those elsewhere. More important was the year-round study undertaken in collaboration with the UK at Signy Island. This study was particularly valuable in demonstrating very high rates of meiobenthic production and remineralisation, as had previously been demonstrated for the microbial fauna.

The techniques used were standard, and all appropriate to answer the questions at hand. Publication output has been solid, especially when taking into account the labour-intensive nature of much work on meiobenthos. The publications have generally been in front rank journals. Overall, however, the work has tended to be descriptive rather than ground-breaking. Much effort has gone into collecting data on field populations and environmental variables, but the subsequent correlational analysis has lacked depth. The laboratory work has been preliminary, with only tentative conclusions. On the other hand, the production of a database of species descriptions, numerical data and a bibliography is a significant achievement which has made a valuable contribution to Antarctic science.

The use made of foreign logistics has been good and the science has made a valuable contribution to the EASIZ (Ecology of the Antarctic Sea-Ice Zone) programme of SCAR.

Amphipod ecology and biodiversity (De Broyer; IRSNB / KBIN)

The team entered the OSTC Antarctic programme at Phase IV following a long and distinguished history of previous Antarctic work. This experience of Antarctica and its benthic ecology allowed the team to tackle important questions from the start.

The project has been concerned with the ecological role of an important group of benthic (bottom-living) crustaceans, the amphipods. Amphipods are unusually dominant and ecologically important in the Antarctic compared to the rest of the world, and this research project has been impressive in terms of the amount of information already generated, and the infrastructure that has been established to facilitate future research. The work has been especially impressive in the area of basic taxonomy (so-called alpha taxonomy). Working with colleagues, especially in Poland, this group has established itself as a world authority with exceptionally careful and thorough work, culminating in a major and definitive taxonomic publication.

Fundamental taxonomy of this sort is often eschewed by funding agencies looking for more immediate returns from short-term work, believing it to be the preserve of museums. The outstanding taxonomic work of this group has not only made amphipods one of the best documented and understood groups in the Southern Ocean, but also laid the essential foundation for tackling important evolutionary and ecological questions.

The ecological work on the role of amphipods in the Southern Ocean ecosystem has been excellent. This work is based on very extensive sampling in a variety of habitats with different gear, providing a very comprehensive picture of the crustacean faunas at these sites. Field data have been used in conjunction with gut-content analysis, aquarium observations of habitat choice and mobility patterns, and field observations on the importance of different food sources, to provide a convincing estimate of the trophic importance of amphipods in the Antarctic ecosystem. Overall the work combines modern concepts with a detailed understanding of the system and the wider context.

Of particular significance has been the innovative work on the physiological mechanism underpinning regulation of size in amphipods. Starting with a specific Antarctic problem (why are a few Southern Ocean marine invertebrates so large?), a mechanism is proposed which may throw fundamental light on factors influencing size in all organisms. The publication of this outstanding piece of work has attracted considerable attention and debate.

A particularly impressive aspect of this project has been its outreach. A very professional and attractive web-site has been established which provides an excellent summary of the work and has broadened the impact of the work significantly. Also impressive has been the way that this relatively small research group has developed links with key groups elsewhere, notably in Poland and Germany. The establishment of an Antarctic Marine Biodiversity Reference Centre devoted to amphipod crustaceans, providing a network of databases, specialist researchers and reference collections, augurs well for the future of research in this field. This sets a high standard for those who work on other groups of Antarctic organisms.

The publication output is strong and has had significant international impact. Though, it is not always easy to distinguish the OSTC-funded component from a long period of Antarctic work. The project has made a very significant contribution to the international EASIZ (Ecology of the Antarctic Sea-Ice Zone) programme of SCAR.

In Phase V, the collaborative project develops previous work (undertaken both within and outside OSTC funding) on Antarctic biological diversity. The project is for genuinely new work (that is, not simply a minor extension of what has been achieved previously), and innovative in its approach to linking macrobenthos and meiobenthos. It links several research groups who previously have been funded separately, and does so in an interesting way. The groups brought together in the BIANZO project have made some of the most novel and important contributions to this field over the past decade. This project fits all of the usual criteria stipulated by funding agencies (innovativeness, high quality, relevance, track-record of researchers, likelihood of advancing the field).

Zooplankton/biochemistry (Hecq; ULG)
Work in this main theme has concentrated on zooplankton and the use of lipid and phytopigment biomarkers to characterise food-web dynamics. Whilst the concept is not novel in itself, Belgian efforts have provided an extensive and coherent body of work in this area for the Southern Ocean. Highlights have been the use of autotrophic pigment signatures to define different biogeochemical areas within the Southern Ocean, and the innovative use of biomarkers to demonstrate differences in food-web dynamics between Marginal Ice Zone (MIZ) and sub-polar waters. The intellectual context for this work has been strong, with particular emphasis placed on physical controls. Thus the dynamics of Circumpolar Deep Water (CDW) are used to explain the different seasonal patterns of macronutrient utilisation in the coastal zone and MIZ, linked in turn to phytoplankton pigment composition. Latterly

there has been a shift towards formalising the understanding in a simple mixed-layer ecosystem model. This incorporates the influence of sea-ice melt, but not ice dynamics on a wider spatial or temporal scale.

The technical aspects of the project have been good, with use of up to date analytical techniques.

The publication output from this project has been sound without being spectacular. There were relatively few publications earlier on, but significant output in 2000. These papers are too recent for any bibliometric (citation) analysis to be meaningful, but the work on lipid biomarkers has made a distinctive contribution from the way it has been set in an oceanographic context. The model appears to have made less impact in the wider community, and would benefit from improved validation. Work for Phase IV involved small-scale refinement of the model, though with welcome involvement of sea-ice specialists.

The project has involved significant international collaboration in fieldwork.

Barium biogeochemistry (Dehairs; VUB)
This project started with an emphasis on collection of data on barium distribution in the Southern Ocean. This is a subject which was being studied by almost nobody else and initially it would seem to have been a case of an analytical technique being taken to Antarctica because it exists rather than because the data are critical to an understanding of the Antarctic system. Development of the approach on subsequent cruises, notably in determining relationships between barium, silicon, salinity and oxygen, however has provided important insights into temporal variation in Antarctic Bottom Water formation, and spatial variability in primary production. This latter work has also involved valuable studies of carbon and nitrogen in isotopes.

Further development of this work involved increasing integration with other teams working on Southern Ocean biogeochemistry. Additional studies of alkalinity and carbon dioxide allowed for parameterisation of euphotic zone models; and in Phase IV this work was integrated with that of Lancelot (ULB), André (KMMA / MRAC), Frankignoulle (ULG) and Deleersnijder (UCL). The techniques used in this work have been state-of-the-art, and the application to Southern Ocean problems has been innovative and productive. Publication output has been strong.

As with other Belgian oceanographers, fieldwork has had to be undertaken in association with colleagues from other nations, giving the team leader little control over research area. The collaboration has been very productive, both with Belgian and international colleagues.

In Phase V, this collaborative project involves a number of workers or groups, many of whom have worked in Antarctica before. Some have made major contributions (Dehairs, Lancelot), whereas others have been more peripheral (Frankignoulle). The project is well designed, and builds on existing strengths to tackle important current problems using state-of-the-art techniques. This project has the potential to make a significant contribution to Antarctic biological oceanography.

Biogeochemical modelling (Billen, Lancelot; ULB)
This project has been most impressive. Essentially a modelling exercise, Lancelot and colleagues have tackled problems which have represented the front-rank oceanographic

problems of the day. The SWAMCO model (Seawater Microbial Community Model) was first developed for the Atlantic sector of the Southern Ocean, and validated with high quality observational data from the 1992 JGOFS cruise. In the early stages of this work the basic features of the Southern Ocean system had been established, but the major drivers controlling phytoplankton growth very unknown. Water column stability had been identified as critical, but the relative importance of this compound with grazing and micronutrient limitation was unknown.

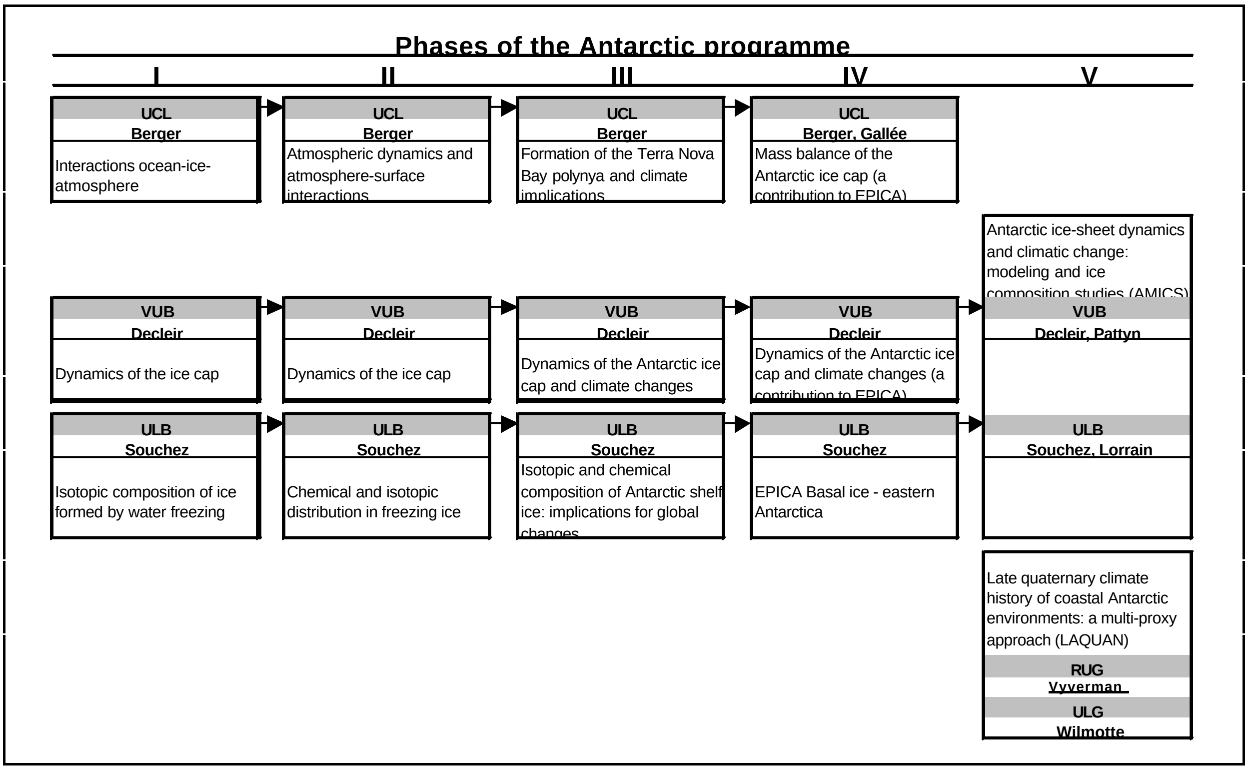
From the start, model development coupled biological processes to hydrodynamics and there was explicit incorporation of sea-ice. This ensured that the work was well developed in relation to current international thinking concerning pelagic ecology. The biological core of the first model (AQUAPHY) was a physiologically-based model of phytoplankton metabolism and this was tested with data from two cruises to Prydz Bay in the late 1980s. This model was then developed, using concepts relating primarily to processes in the marginal ice zone, with validation from data collected during the EPOS study. The resultant SWAMCO model incorporated the original AQUAPHY model, a microbial loop modal, and a one-dimensional hydrodynamical model. Further development of the SWAMCO model involved incorporation of Si and Fe in addition to N and an enhanced representation of size in the microbial compartment. This sequence of models has been utilised in a series of multinational interdisciplinary cruises to a range of locations in the Southern Ocean.

By developing the model in response to the key scientific questions of the day, fieldworkers have been able to utilise modelling to inform the field observational campaign. This approach has allowed Belgian scientists to make a distinctive and distinguished contribution to Southern Ocean biological oceanography. Although, as with all Belgian sea-going scientists, this research group have perforce worked where cruises were already going, the leading nature of their work has resulted in their being invited onto all of the important Southern Ocean research cruises, and to take an active role in shaping the science of those cruises.

The quality of the work has been very high. For example the SWAMCO model used in the important international Southern Ocean Iron Enrichment Experiment (SOIREE) was the first published biogeochemical model for polar waters to specifically include iron limitation. Publication rate has been good, in high quality journals, and the international impact of this work has been high.

This work has brought great credit to Belgian science.

Annex 3.2 Glaciology and climatology



Air-sea interactions and katabatic winds (Berger, Gallée; UCL)

This research group comprises meteorologists and modellers. Already active in Antarctic science prior to the start of the OSTC Antarctic programme, work in Phase I was concerned with air-sea interactions in the coastal zone of Antarctica, and specifically with katabatic winds and bottom water formation.

Continuation took place in Phase II with the production of a mesoscale 3-D primitive equation model of coastal polynyas. In Phase III the 1-D polynya model was extended to a 2-D model, and included simulation of the seasonal evolution of the polynya in relation to atmospheric CO_2 concentration. In addition, atmospheric and polynya models were compared in relation to fragile ice production. In Phase IV the mesoscale atmospheric model was developed with new parameterisation, including representation of snow erosion in relation to snow cover properties and surface turbulent shear stress, and was validated in the French Alps.

The modelling work has produced useful results. Although the project titles of the first three Phases clearly reflect the work undertaken, this can unfortunately not be said for the fourth Phase. Publication output is modest, with six papers over the four Phases.

Basal ice studies (Souchez; ULB)

This project has followed a clear and rational trajectory. Early studies of the isotopic composition of ice formed in a Brussels lake were extended to samples of sea ice and shelf ice from Antarctica. The range of analyses was also extended to include the major cations and anions. In Phase I, investigations about the ice isotopic composition, generated by water freezing in a Brussels lake, have been developed. The experimental tests are crystallographic and chemical analysis in ice samples. In Phase II, investigations focused on ice isotopic composition using samples of sea ice and shelf ice-cores from the Antarctic. The experimental tests were enlarged upon Phase I with ice textural analyses, isotopic profiles and Na profiles using spectrometry, to research in basal ice. The main aim of Phase III was to determine the thermodynamic conditions prevailing at the ice shelf/ocean interface and their implications for global change. In Phase IV the main goal was the analysis of air bubbles contained within ice, specifically basal ice from Dome C in East Antarctica. A major development here was the use of a helium trap for the gases present at very low concentrations in the ice and the subsampling techniques used were novel.

The gases were measured at the ULB, but the isotope determinations involved collaboration with internationally renowned laboratories in France and Italy. An important theme to these studies has been comparison of the EPICA ice core with that recovered at Vostok.

The publication record is strong, with over 20 publications from the OSTC-funded work, in addition to those from earlier work. This has been an excellent and productive project which has contributed significantly to the international visibility of Belgian Antarctic science. Throughout all Phases, the evolution in learning, gaining experience, continuing the established research line, developing objectives with increasing importance and difficulty, demonstrated the team as very consolidated.

Dynamics of the Antarctic ice cap (Decleir; VUB)

This team combines the skills of a geographer with mathematical modellers. In Phase I observations from gravimetric and radio-echo sounding surveys of the Sor Rondane mountains were used to test a 2-D model of ice floe-lines and to develop a 3-D model. The second Phase involved a more detailed description of the ice sheet and its dynamics, with a simulation of the last glacial maximum. This work was continued in Phase III to develop simulation and palaeo-reconstruction of the last glacial period. This involved both remotely sensed data (SPOT images) and field measurements of ice flow.

In Phase IV studies were undertaken of the dynamics of outlet glaciers using satellite interferometry to provide detailed data on ice flow and ice streams, monitoring behaviour over short time spans. In addition these were measurements of the fast-flowing continental ice streams in Dronning Maud Land using time series analysis, lag correlation and fractal analysis. This allowed estimation of local variation in ice sheet behaviour in response to the climatic variability over the past 200,000 years. In addition the influence of coastal ice dynamics on the interpretation and dating of deep ices cores from inland could be estimated.

Publication record has been good if not outstanding (10 publications over the first 4 Phases). The project titles, however, barely address the interesting topics covered in the research and the progress made.

The scientific quality of this project has been excellent, with the ice-cap model of Huybrechts being particularly influential internationally. Huybrechts has developed an important 3-D time-dependent ice sheet model that incorporated basal sliding, isostatic bed adjustment and grounding-line dynamics coupled at the ice shelf. The model has full coupling between the thermal field and ice flow. This is a front-rank model with a strong conceptual basis, and promises much for the future.

The joining of Decleir and Souchez in Phase V into a networking structure is interesting and promising, because the research lines will be continued and complement each other, a great amount of high-level expertise and experience will be combined.

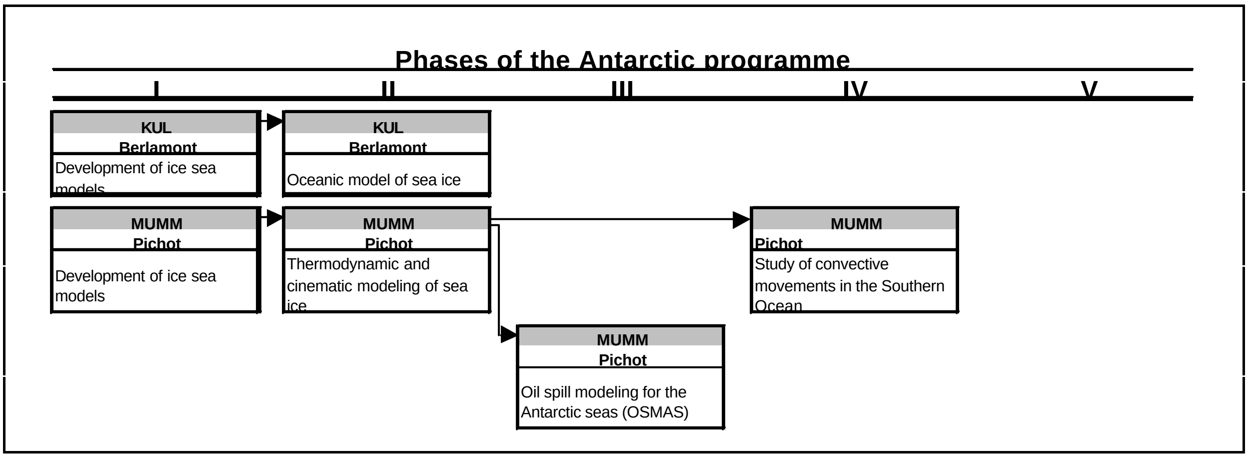
Late Quaternary Climate History of Coastal Antarctic Environment, LAQUAN (Vijverman; RUG, Wilmotte; ULG)

Both team leaders are experts in biodiversity, one of which has previous experience in the Belgian Antarctic Programme. The relation with the domain of Glaciology-Climatology is based on findings of the earlier projects. Antarctic coastal lacustrine and lake systems hold important archives on climate change referring to the physical, chemical and biological environment. The project will look into microbial registers as quantitative indicators of environmental impact. Working closely within an international network (the UK, New Zealand and Australia), the project will be innovative with respect to the development of molecular markers for biodiversity estimations and its application to the estimation and evaluation of palaeoclimatic records.

Part of the project will be the comparison of methodologies applied in AMICS (Decleir, Souchez), such as isotopic registers, which on its turn highlights the complementarity and multidisciplinarity of the Belgian Antarctic Programme. In addition, the collected registers (data sets) will be calibrated too, thereby creating archives for the project databank.

The research will focus on the development and validation of biological markers in order to reconstruct the environmental changes induced by climate (maritime, continental). When working in the Vostok lake with data going back more than 0.5 million years ago, one of the most important discoveries in modern science is likely to occur.

Annex 3.3 Hydrodynamics



Ice-sea models (Berlamont, KUL; Pichot, MUMM)

This project was driven by teams from KUL and MUMM. This research aimed at developing a numerical model for surface currents in the Weddell Sea and a sea-ice model that would be able to reproduce the main features of the annual cycle of ice extent and thickness.

In Phase I, an existing 2-D model was adapted and forced by the monthly averaged wind fields. The model was coupled to sea-ice and the oceanic mixed layer, and its time scale is few days to few weeks. Reasonable agreement was obtained with observed amplitude of extent and thickness of sea-ice. The Weddell Sea polynya was not reproduced by this simple model, as its origin is partly induced by seafloor topography. During Phase II, the circulation model was reported to have been extended to 3-D and the mixed layer parameterization improved.

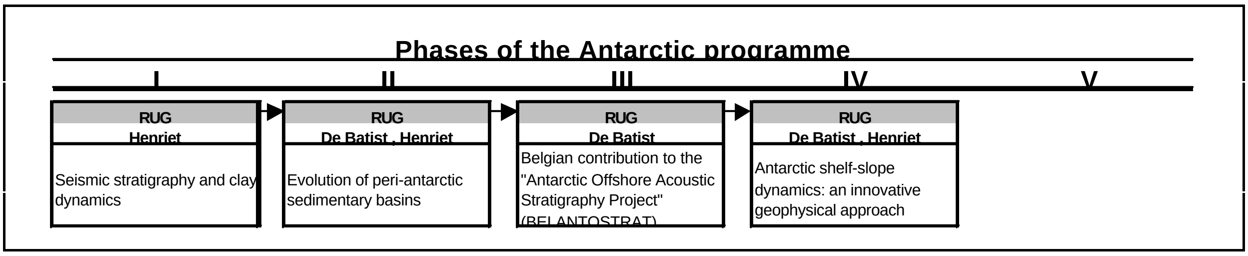
In Phase III, a first application of the modelling scheme was to predict the consequences of a major fuel spill in the Weddell Sea in collaboration with BAS (UK). Forecasts were made of sea-ice conditions and weathering of the fuel. This also involved an effort to verify simulation of sea-ice drift by comparison with observed buoy data.

Phase IV activities involved the same model, with updated and improved climatological and oceanographic input. In 2000, after more than 13 years of activity within the project, the first publication appeared in an international journal following a presentation of the same material at an international conference six months earlier.

The modelling work is of international standard. In each Phase, the stated objectives of the research activity may appear achieved, but the modest publication record (2 over 13 years) leaves an impression of very low priority being awarded to this research activity. Admittedly, the necessary data on sea-ice thickness for calibration of the model are scarce, but little effort appears to have been made to optimize other aspects of the model output. On the positive side are two useful applications of the model; oil dispersal forecast and a coupled physical-ecosystem scenario.

The MUMM-project has been interesting in intellectual terms, and with some useful practical spin-offs. The publication record, however, has been disappointing

Annex 3.4 Marine geophysics



Stratigraphy (Henriet, De Batist; RUG)

The research focussed on unravelling the glacial history of East Antarctica and the Antarctic Peninsula through interpretation of the sediment record related to erosion, transport and deposition in a glacial environment. The research was initially (Phases I and II) concentrated on problems considered of high priority by the international scientific community (Ocean Drilling Programme ODP; the SCAR programme Antarctic Offshore Stratigraphy Project ANTOSTRAT), but has also been of a more general character (tectonics of Antarctic Peninsula and sedimentation in Bransfield Strait).

The primary research tool is marine seismic reflection measurements and the research team commands a thorough understanding of the information potential in the seismic data and the geometry of seismic interfaces. It has presented well thought-out contributions to the seismic stratigraphy and some bold solutions particularly for the Weddell Sea continental margin. The quality of their science is good. This research project represents a text book example of international scientific co-operation and sharing of logistic resources. The research team has been guest investigators in Antarctica on the German research vessel R/V *Polarstern* (4 cruises) and the Spanish R/V *Hesperides* (3 cruises). It has facilitated an internationally recognized Belgian contribution to international Antarctic marine geoscientific research.

Marine geophysical research is a hardware and field-intensive activity. We recognize that participation in foreign expeditions places constraints on the choice of scientific activities, but we would have liked to see more innovation in defining secondary research targets with a distinct Belgian contribution, particularly during Phases III and IV. In this respect, we note a bold initiative to develop a single channel deep tow seismic system suited for Antarctic continental margin research. This was, however, hampered by some unfortunate circumstances in the field. The idea was later been more successfully pursued in work on the North Atlantic margin. A working tool would present the Belgian research group as an attractive partner for international co-operation and we strongly support this way of thinking.

Phase I was the first major project of Renard Centre of Marine Geology during its start-up Phase. Subsequently, aspects of the geology of the European continental margin became the focus of its research. Particularly after 1995, the activity at the centre has increased and involved up to twenty staff and students, with only two being permanently employed by the university. A stated reason why further involvement in Antarctic research during Phase V is not pursued, is the current difficulty being experienced by AWI, an important co-operative German partner, in obtaining a permit from its national authorities for marine geophysical research south of 60° S. However, the co-operative work with Spanish scientists on Antarctic cruises with R/V *Hesperides* works well.

The publication record is characterised by two substantial contributions during Phase II, but only one in each of the subsequent Phases with a team member as first or second author. The written contributions during the later Phases are more abstracts, short notes or as the last entry on multi-author contributions. In total the publication record is modest.