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SRP: AnT-ERA SG: LS
Person Responsible: Julian Gutt



SCAR Delegates Meeting 2020

Antarctic Thresholds – Ecosystem Resilience and Adaptation (AnT-ERA) **Final report (2013-2020)**



Summary

Report Authors:

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Introduction/background to the programme:

AnT-ERA was launched in 2013 with the mission to facilitate multinational inclusive research on primarily, but not exclusively, climate-driven biological processes in Antarctic ecosystems. This included marine, terrestrial and limnetic systems and covered all levels of biological organisation from molecules to entire ecosystems.

Major achievements and legacies:

AnT-ERA focussed on the multifold exchange of experience and results at conferences, on capacity building during courses and research visits; as well as on conceptual brainstorming and synthesizing workshops, including the publication of their output. We formed an open network of experts in Antarctic ecology, who actively cooperated in fundamental, interdisciplinary and stakeholder-orientated research. Our support was inclusive in terms of ethnic affiliation, gender, stage of career and the highest possible diversity of newly emerging or small national programmes.

Final procedural recommendations to Delegates:

We kindly ask the Delegates for a formal approval of our activities.

SCAR could make climate-change induced hazards of Antarctic ecosystems a focus of future research initiatives. SCAR could also play an active role in contributing ecological knowledge from Antarctic ecosystems to large international frameworks and assessments such as the UN Global Ocean Assessment, IPBES, IPCC, and the UN Decade of Ocean Science.

Main report

Original rationale and objectives

AnT-ERA was launched in 2013 to facilitate multinational, inclusive and cross-disciplinary **research on biological processes in Antarctic ecosystems**. It was based on the general agreement that stresses on Antarctic ecosystems result from **global climate change**, which includes extreme events, as well as from other human impacts. Consequently, Antarctic ecosystems are changing, some at a rapid pace, while others are relatively stable.

A comprehensive understanding of ecosystem functioning was considered to be essential for advances in Antarctic-specific fundamental research, global assessments, and various applied aspects. Our foci were all levels of biological organization ranging from within-cell molecular processes, species performance, adaptation, population and community dynamics as well as thresholds of Antarctic ecosystems. Such processes are also key to informing wider ecological debate about the nature of stability and potential hazards across the biosphere, especially in case of environmental changes. They are also considered to be an important basis to develop scenarios for the future of Antarctic biotas, as well as terms of ecosystem functions and services.

We included findings from marine, terrestrial and limnetic systems attempting to carry out also cross-ecosystem studies to identify generalities or system specific peculiarities. We aimed to bring the most diverse experts together and to support Early Career Scientists towards the research in any of the above addressed themes and meet the demands mentioned.

Main scientific achievements

AnT-ERA was a unique programme because of the integration of scientists and science across ecosystems (ocean, ice, land) and across various levels of biological organization, adding creativity to each scientific output. All objectives were achieved particularly during these main events with their output:

(1) The **final AnT-ERA synthesis workshop** in 2019 on *Biological Processes in Antarctic Ecosystems* in Coimbra aimed to assemble and structure the main scientific findings within the scope of AnT-ERA of the past decade (chairs: J Xavier, E. Isla, J. Gutt). They ranged from findings on changing biogeochemical cycles and further development of research on adaptation to sea-ice related results, to threatened endemic species and newly discovered habitats. The main conclusion is that there is increasing evidence of increasing anthropogenic stress to Antarctic ecosystems. However, if we like it or not, among species and their populations there are losers but also winners of climate change - suggesting that ecosystem functions can be reduced and intensified. The ten main messages synthesized in this project will be published in 2020 in a comprehensive review paper in *Biological Reviews* and communicated to media and stakeholders.

(2) During the 2018 OSC a half-day **discussion on Antarctic and Arctic Ecosystems** was chaired by AnT-ERA (J. Gutt) and the IASC/Marine Working group (M. Kedra & L. Cooper) with approx. 100 participants. The protocol provided insights into generality and uniqueness of both polar ecosystems across various ecosystem components and key ecological species.

(3) An interdisciplinary SCAR cross-programme **brain storming workshop** on *Interactions between Biological and Environmental Processes* was held 2015 in Barcelona (chairs: J. Gutt, E. Isla et al). Representatives of the SCAR Research

Programmes AntEco, AntClim²¹, ICED, BEPSII, PAIS, EGBAMM, and of IPCC discussed changes people were seeing currently and options for research perspectives. Having the other active research programmes present really exposed participants to differences people were seeing with change - magnifying our view of what was happening and how we should consider future interdisciplinary research for Antarctica. The results were published in a conceptual paper in "Marine Genomics".

(4) A **post-expedition workshop** (*Polarstern 81*) was organized by AnT-ERA and held 2014 in Dijon, France, which resulted in a special volume of "Polar Biology".

(5) In 2014 an **outlook workshop** on *Molecular and genetic advances to understanding evolution and biodiversity in the polar regions* reviewed the major output of the SCAR SRP EBA and paved the way for AnT-ERA. It was organized by G. di Prisco and the AnT-ERA Scientific Steering Committee (SSC) in Napoli, Italy. The output of the workshop was published in a special volume of "Marine Genomics".

Delivery against original implementation plan

Research activities carried out under the umbrella of AnT-ERA largely followed the original implementation plan.

(1) Within the Scientific Steering Committee (SSC) we had a relatively good **gender balance** with five women being SSC members. The SSC comprised two APECS representatives, leading to a full integration of **Early Career Scientists** in all our activities, liaison persons to AntEco, which guaranteed **multiple links between both biological SRPs**, and to ANTOS as well as ICED with **successful cooperation** between AnT-ERA and these other initiatives.

(2) AnT-ERA organized a **cross-disciplinary** workshop (see above).

(3) The chairs/co-chairs of AnT-ERA and AntEco led a plenary session during the Biology Symposium in Leuven to comprehensively discuss **the future** after the AnT-ERA/AntEco era within the entire SCAR biology community.

(4) The total budget reflects the support of mainly **Early Career Scientists** and capacity building, but also the communication within the SSC to guarantee the success of AnT-ERA (see below).

(5) **Syntheses** were conducted during workshops in Napoli and Coimbra (see above).

(6) The **website** highlighting examples of scientific results and other information was successful until 2017 with approx. 100,000 hits. Due to capacity limitations it was not maintained after a new release using a new software. General communication, including job opportunities and announcements of scientific events, especially for Early Career Scientists, continued using the **mailing list** with approx. 520 members.

(7) The AnT-ERA community provided research highlights on the impact of climate change on Antarctic biotas – forming the basis for biological contributions to the publicly available, regular **updates of the ACCE report**, co-authored by J. Gutt and G. di Prisco and reported to the ATCM.

Several actions and contributions to various initiatives informing stakeholders and supporting cross-disciplinary discussions **exceeded our plans**. These included:

- contributions to the Global Assessment of **IPBES**;
- contributions to the popular scientific side events of the **UNFCCC** conferences in Paris and Marrakech;
- leading a workshop on *Antarctic and Arctic Ecosystems* in cooperation with IASC/Marine Working group in 2018 as side event of the **OSC**.

Main education, outreach and capacity building achievements

Education

AnT-ERA's main education event was a spring course on *Biological Processes in Antarctic Ecosystems* in Buenos Aires, Argentina, in 2018. The course was organized by the AnT-ERA chair, taught by ten AnT-ERA lecturers, hosted by the Instituto Antártico Argentino (I. Schloss) and supported by AnT-ERA travel grants. Forty-four graduate, PhD students and post-docs from ten countries participated.

A course on *Fjord Ecosystem and Climate Change* in 2018 at Friday Harbor Laboratories was supported by travel funds for students and organized by an AnT-ERA SSC member (G. R. Smith).

Workshops directed to *Polar Educators International*, both internationally (Portugal 2013, Germany 2015, Italy 2017, UK 2019) and nationally (Portugal 2014, 2016, 2018 and 2020), were co-organized by a SCAR CBET AnT-ERA SSC member (J. Xavier).

Outreach and capacity building

AnT-ERA contributed to popular articles in the Antarctic Environments Portal (AEP) particularly on the vulnerability of Antarctic biotas and biodiversity (J. Gutt, V. Cummings, T. McIntyre, L. Peck, I. Schloss).

In terms of outreach to the society and especially, but not exclusively, academic education, AnT-ERA SSC members contributed very actively to uncountable traditional and electronic articles, gave interviews (also from the Antarctic) and held lectures to inform a very wide audience about the value of healthy Antarctic ecosystem functions and anthropogenic threats.

A large number of individual **mini-travel grants** underlines the intense support of **Early Career Scientists**, who got the opportunity to learn new methods, present their results at conferences and discuss plans and results with experienced colleagues (for the budget see below).

Several AnT-ERA SSC members were directly involved in SCAR Capacity Building, Education and Training in supporting fellowships and awards evaluations (aiding the SCAR secretariat).

An AnT-ERA SSC member (J. Xavier) was Chair of the ATCM Workshop on Education and Outreach in ATCM Bulgaria 2015, and involved in the coordination of the Intersessional Contact Group on Education of the ATCM. He undertook presentations and co-organized workshops directed to early career scientists with the Association of Polar Early Career Scientists (APECS), both internationally (APECS World Summit Bulgaria 2015 and Switzerland 2018, APECS Workshop SCAR Biology - Belgium) and nationally (APECS workshops Portugal 2013 - 2019).

Partnerships made and support received

Since most of the SCAR/AnT-ERA budget was spent to support communication among Early Career Scientists and mid as well as late career scientists most of the scientific work was financed by national research programmes and a variety of national and international funded projects. An outstanding example was the financial support of the workshop in 2014 in Napoli by the national Italian Antarctic programme. AnT-ERA expresses its great appreciation for this support!

We cooperated with the "other" SCAR biology SRP, AntEco, as it was planned from the beginning. Partial overlap also existed between ANTOS and AnT-ERA.

Many experts from the AnT-ERA community still contribute substantially to the MEASO initiative, which will soon publish a variety of comprehensive reviews on Antarctic marine ecosystems for stakeholders and a summary for policy makers.

AnT-ERA SSC members are leading coordinators within the Southern Ocean Observing System (SOOS), from which both initiatives benefited.

Other international initiatives, which benefited from the cooperation with us and *vice versa* such as ACCE, IPBES, CCAMLR, UNFCCC, IPCC are mentioned above.

Other legacies

The plenary discussion during the SCAR Biology Symposium in Leuven, Belgium, co-chaired by the AnT-ERA chief officer provided the basis for new SCAR initiatives and proposals.

Five AnT-ERA SSC members joined the 1st SCAR Antarctic and Southern Ocean Horizon Scan and co-authored the published results (D. Wall, I. Schloss, L. Peck, J. Xavier, J. Gutt).

AnT-ERA SSC members actively contributed to the 2017-2022 SCAR Strategic Plan with an intense discussion during the 2015 EXCOM meeting in Tromsø.

Following national and international rules, AnT-ERA scientists uploaded their data and results to international data bases such as ANTABIF (SCAR-MarBIN, biodiversity data), PANGAEA (primarily environmental information), GenBank (genetic sequences) information, Polar Data Centre (BAS) and NCBI SRA (Bethesda, Maryland, USA). Therefore, results elaborated under the umbrella of AnT-ERA were made available for any scientific and other serious use available. When such primary data were analyzed, results were published in peer-reviewed scientific journals.

AnT-ERA scientists contributed to the designation of the MPA in the Ross Sea, to the proposals for the MPAs in the East Antarctic and Weddell Sea and to the planning of a proposal for the region West of the Antarctic Peninsula.

Draft final Budget summary (2018-2020)

	2018*	2019	2020
(US\$)	Spent	Spent	Allocated
Total	35,650	28,300	
ECR	35,650**	1,661	
Small & develop. progr.	18,105***		
Unspent (Covid-19)			14,215

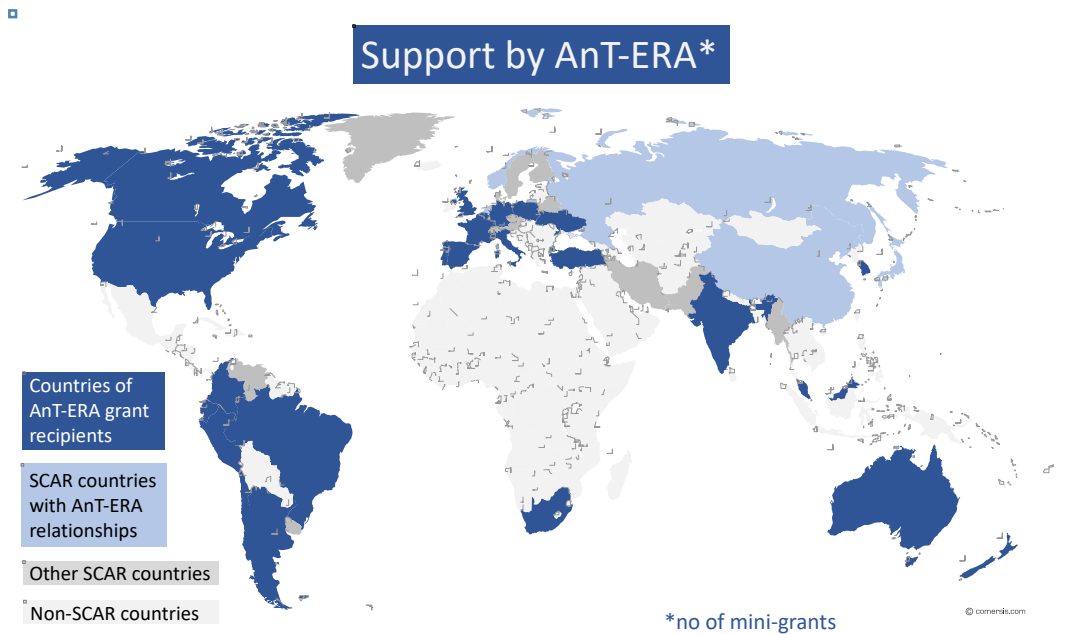
* incl. considerable part of 2017

** less than 50% for lecturers

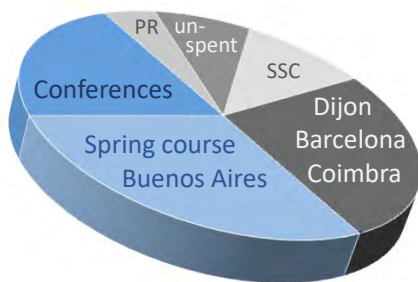
*** Argentina, Brazil, Chile, Ecuador, India, Malaysia, Peru, Turkey, Ukraine.

Draft final Budget summary (2013-2020)

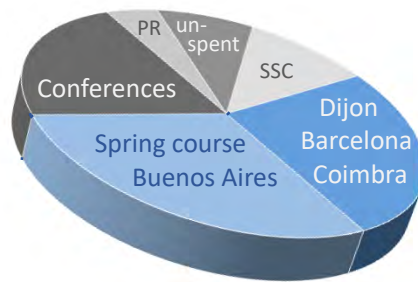
With the exception of the funds not spent as a consequence of the Covid-19 crisis (to be used for other purposes), the total of approximately US \$ 160,000 for the entire AnT-ERA period were used in the way depicted below. Scientists from 25 countries were financially supported.



AnT-ERA budget breakdown, 2013-2020



Early Career Scientists



Unique AnT-ERA events

Final future research recommendations to Delegates

We recommend to continue and in parts intensify the support of climate change related ecological research including Ocean Acidification as a key SCAR activity. A transdisciplinary cooperation between biologists, climatologists, sea-ice researchers and physical oceanographers as well as chemists will be especially challenging in a time when climate change extends in the Antarctic to a circumpolar scale. Research on fundamental biological processes, (e.g., in terms of adaptation of a broad variety of organisms and ice-driven population dynamics to the typical polar conditions, not only of few charismatic species), as well as stakeholder orientated research (e.g., on biogeochemical cycles) is urgently needed and to be internationally coordinated.

It is in the hands of the Delegates that SCAR remain the most important international institution and extend its capacities and opportunities **to facilitate climate-related biological research** as a scientific basis for action recommendations to stakeholders and not to leave this important coordination role to other institutions, which are only loosely connected to SCAR.

A possible strengthening of SCAR's role as the leading institution in Antarctic research can be achieved in two ways, namely (1) support of national individual researchers and research institutions to contribute actively to SCAR initiatives, and (2) support of SCAR to detect, what kind of scientific information **global frameworks** such as Global Ocean Assessment, IPBES, IPCC, and the UN Decade of Ocean Science need, and SCAR decision makers motivating researchers to develop the necessary initiatives.

Final procedural recommendations

We thank SCAR and its delegates for the opportunity to benefit in our communication and cooperation from the financial and other support. Furthermore, we would like to remind colleagues, science managers and reviewers that most of the work carried out under the umbrella of AnT-ERA (papers, official traveling) had been carried out on a voluntary basis and with additional support of the national programmes.

The linkages between considerable parts of the scientific communities and AnT-ERA (also other SRPs) worked very well. However, SRPs could improve in some parts from a better connection between Delegates, national programmes and the SRPs.

Reporting should be as efficient and simple (=time saving) as possible.

Evaluations should be as transparent as possible. Criteria should be known to reviewers and scientists being responsible for the reports/programmes. Reviews and reviewers could be made publicly available.

New concepts have to be developed to replace meetings in the past by online video conferences due to Covid-19 and climate protection reasons. Simply to skip small meetings, especially for Early Career Scientists and representatives from small and developing national programmes, and only have larger conferences (again) in the future cannot be a complete solution. Also, holding many more side events during the OSC is not a solution because too many events would temporarily overlap.

Notable Papers, 2013-2021

This is the **main scientific synthesis** and final output of AnT-ERA (SSC members in bold):

Gutt J, Isla E, Xavier J, Adams B, Ahn, I-Y, Cheng C-HH, Colesi C, Cummings V, di Prisco G, Griffiths H, Hawes I, **Hogg I, McIntyre T**, Meiners K, Pearce D, **Peck L**, Piepenburg D, Reisinger R, Saba G, **Schloss I**, Signori CN, **Smith CR**, Vacchi M, **Verde C, Wall DH** 2020. Antarctic ecosystems in transition – life between stresses and opportunities. *Biol Rev*, DOI: 10.1111/brv.12679

In this synthesis ten key messages emerged, which are stakeholder-relevant and/or are supposed to have a high impact for the scientific community. They include altered biogeochemical cycles, climate change hotspots, ocean acidification, ice-related biological fluctuations, unexpected dynamism, range shifts, adaptation and thermal resilience, pollution, endangered endemism and discovery of unknown habitats. Most of the Antarctic biota are exposed to various stresses and considered vulnerable to environmental change, primarily because of their narrow tolerance range, rapidity of change in some regions, projected circumpolar impacts, a low potential for timely genetic adaptation and barriers for ecologically key species to escape.

Further notable publications:

1. **di Prisco G**, Edwards HGM, Elster JE, Huiskes AHL (eds) 2021. Life in extreme environments. Cambridge University Press.

The book contains a variety of scientific articles for a wide readership mostly resulting from the EU Coordination Action of the same name with contributions from AnT-ERA SSC members: Gutt J, Peck LS, di Prisco G, Verde C.

2. **Xavier JC**, Cherel Y, Boxshall G, Brandt A, Coffey T, Forman J, Havermans C, Jażdżewska AM, Kouwenberg K, Schiaparelli S, Schnabel K, Siegel V, Tarling GA, Thatje S, Ward P, **Gutt J** 2020. *Crustacean guide for predator studies in the Southern Ocean*. Scientific Committee on Antarctic Research, Cambridge, UK

This book is a four-year international effort under the SCAR programmes AnT-ERA, AntEco, EGBAMM and ICED. We reviewed information from > 100 crustacean species in the diet of sub-Antarctic and Antarctic meso- and top predators, to aid scientists working on trophic relationships within the Southern Ocean.

3. Coppola D, Giordano D, Milazzo L, Howes BD, Ascenzi P, **di Prisco G**, Smulevich G, Poole RK, **Verde C** 2018. Coexistence of multiple globin genes conferring protection against nitrosative stress to the Antarctic bacterium *Pseudoalteromonas haloplanktis* TAC125. *Nitric Oxide* 73, 39-51

The genome of the bacterium *Pseudoalteromonas haloplanktis* contains genes encoding distinct globins, supporting the hypothesis of their crucial involvement in protection against oxidative and nitrosative stress in cold and O₂-rich environments.

4. **Cummings VJ**, Hewitt JE, Thrush SF, Marriott PM, Halliday NJ, Norkko AM 2018. Linking Ross Sea coastal benthic ecosystems to environmental conditions: documenting baselines in a changing world. *Frontiers in Marine Science* 5, 232

This analysis links coastal benthic community composition to seafloor habitat and sedimentary parameters and broader scale features in the Ross Sea, encompassing considerable spatial extent and variation in environmental characteristics.

5. **Isla E**, Pérez-Albaladejo E, Porte C 2018. Toxic anthropogenic signature in Antarctic continental shelf and deep sea sediments. *Scientific Reports* 8: 9154

This report shows that anthropogenic organic pollutants reached Antarctic deep sea sediments. Comparatively higher toxic effects were found in the vicinity of the Antarctic Peninsula, where research facilities and touristic activities are concentrated.

6. **Peck LS** 2018. Antarctic marine biodiversity: adaptations, environments and responses to change. *Oceanography and Marine Biology: Ann Rev* 56, 105-236

This review describes the state of knowledge on the biodiversity of the Southern Ocean fauna and on the majority of known ecophysiological adaptations of cold-blooded marine species to Antarctic conditions.

7. **Gutt J, Isla E**, Bertler N, Bodeker GE, **Bracegirdle TJ**, Cavanagh RD, Comiso JC, Convey P, **Cummings V**, De Conto R, DeMaster D, **di Prisco G**, d'Ovidio F, Griffiths HJ, Khan AL, López- Martínez J, Murray AE, Nielsen UN, **Ott S**, Post A, Ropert-Coudert Y, Saucède T, Scherer R, Schiaparelli S, **Schloss IR, Smith CR**, Stefels J, Stevens C, Strugnell JM, Trimborn S, **Verde C**, Verleyen E, **Wall DH**, Wilson NG, **Xavier JC** 2017. Cross-disciplinarity in the advance of Antarctic ecosystem research. *Marine Genomics* 37. 1-17

The paper represents the output of a cross-programme brain-storming SCAR workshop organized under the leadership of AnT-ERA. It describes novel ideas of cross-disciplinary research concepts and sets these in a global context.

8. Knox MA, Andriuzzi WS, Buelow HN, Takacs-Vesbach C, **Adams BJ, Wall DH** 2017. Decoupled responses of soil bacteria and their invertebrate consumer to warming, but not freeze-thaw cycles, in the Antarctic Dry Valleys. *Ecol Lett* 20, 1242-1249

Climate-sensitive daily freeze-thaw cycling negatively affected both trophic levels of the arid soil food webs of the McMurdo Dry Valleys, whereas warming without freezing disturbance negatively affected microbes but tended to promote their predator (microbial-feeding nematode).

9. **Gutt J**, Bertler N, Bracegirdle TJ, Buschmann A, Comiso J, Hosie G, **Isla E, Schloss IR, Smith CR**, Tournadre J, **Xavier JC** 2015. The Southern Ocean ecosystem under multiple climate stresses - an integrated circumpolar assessment. *Global Change Biology* 21, 1434-1453

Using a cross-disciplinary approach, this paper identified for the first time areas of the Southern Ocean with multiple climate change stressors for the past and future, and assembled pathways of the impact through different ecosystem components.

10. Sahade R, Lager C, Torre L, Momo F, Monien P, **Schloss I**, et al. 2015. Climate change and glacier retreat drive shifts in an Antarctic benthic ecosystem. *Science Advances* 1(10), e1500050

The results show shifts in benthic community composition in a fjord in King George Island / Isla 25 de Mayo after glacier retreat.

11. **Adams BJ, Wall DH**, Virginia RA, Broos E, Knox MA 2014. Ecological biogeography of the terrestrial nematodes of Victoria Land, Antarctica. *ZooKeys* 419, 29-71

The distribution, habitats and ecology of endemic and widely distributed nematodes of Victoria Land are summarized. At smaller spatial scales, populations can have patchy distributions, strongly influenced by specific habitat requirements.

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12. Turner J, Barrand NE, Bracegirdle TJ, Convey P, Hodgson D, Jarvis M, Jenkins A, Marshall G, Meredith MP, Roscoe H, Shanklin J, French J, Goosse H, **Gutt J**, Jacobs S, et al 2014. Antarctic climate change and the environment: an update. *Polar Record* 50, 237-259

Physical, geochemical and biological changes in the Antarctic atmosphere, continent and Southern Ocean resulting from climate change are reviewed for the period after the publication of the ACCE-report in 2009.

Budget

Planned use of remaining funds

Year	Purpose/Activity	Amount (in USD)
2020	Unspent due to Covid-19	14,215

Membership

Leadership

Role	First Name	Last Name	Affiliation	Country	Email	Date Started	Date Term is to End
CO	Julian	Gutt	AWI/HGF	Germany	Julian.gutt@awi.de	2012	2020
SC	Lloyd	Peck	BAS	UK	lspe@bas.ac.uk	2013	2020
SC	Cinzia	Verde	IBBR	Italy	cinzia.verde@ibbr.cnr.it	2013	2020
SC	Byron	Adams	Brigham Univ.	USA	byron_adams@byu.edu	2013	2020
SC	Ian	Hogg	Polar Knowledge	Canada	ian.hogg@polar.gc.ca	2015	2020
SC	Diana	Wall	Colorado State Univ.	USA	Diana.Wall@colostate.edu	2013	2020
SC	Akinori	Takahashi	NIPR	Japan	atak@nipr.ac.jp	2013	2020
SC	Vonda	Cummings	NIWA	NZ	v.cummings@niwa.co.nz	2013	2020
SC	In-Young	Ahn	KOPRI	South Korea	iahn@kopri.re.kr	2015	2020
SC	Craig	Smith	Univ. Hawaii	USA	craigsmi@hawaii.edu	2013	2020
SC	Enrique	Isla	ICM-CSIC	Spain	isla@icm.csic.es	2013	2020
SC	Irene	Schloss	Direccion Nacional	Argentina	ireschloss@gmail.com	2013	2020
SC	Jose	Xavier	Univ. Coimbra	Portugal/UK	xavier@zoo.uc.pt	2013	2020
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SC*	Coleen	Suckling	Bangor Univ APECS	UK	coleenclaire@yahoo.co.uk	2013	2020
SC*	Trevor	McIntyre	Univ South Africa	South Africa	trevmcnt@gmail.com	2013	2020
SC	Guido	di Prisco	IBBR, Napoli	Italy		2013	2019
SC	Sieglinde	Ott	Univ. Düsseldorf	Germany	otts@uni-duesseldorf.de	2015	2019

Early Career Scientists identified with * in first column

Other members

AnT-ERA was an open programme without formal membership. Here we list co-authors of our final synthesis paper, who contributed substantially to its success.

First Name	Last Name	Affiliation	Country	Email
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*Early-career researchers identified with * in first column*