Polar Science – Perspectives from the Royal Society Global Environmental Research Committee

This paper has been produced following a science meeting of the Royal Society Global Environment Research Committee (see 'context' on page 3), and provides an overview of that discussion. It does not seek to represent the views of the Royal Society or to produce a comprehensive overview of the science, but instead to highlight some specific areas of potential interest to researchers, funders and government.

Polar Science: executive summary

GERC identified five key areas for Polar Science where further study or significant investment is important, and a further five thematic challenges that cut across a range of science questions.

Key priorities for study are: the polar ice sheets and their contribution to sea-level change; sea ice change; the widespread impacts of melting permafrost including on regional hydrology and the carbon cycle; marine ecosystem change and opportunities for cross-research council and industrial partnership; and improved representation of processes in climate models.

Cross-disciplinary themes identified include: the need for definition of baselines, including from palaeo data; better temporal and spatial sampling distribution, and use of technologies; the vital nature of international co-operation in Polar Science; and the need for multi-disciplinary approaches to understanding multiple and complex stresses in the polar environment.

Introduction

The Polar Regions play a critical role in global processes:

- they are an important part of the climate system;
- the ice sheets at the poles will be the dominant influence on sea level rise in the coming centuries;
- changes in sea ice can fundamentally affect air-sea interactions and regional climate, including that of Europe;
- the Southern Ocean plays a disproportionate role in global biogeochemical cycles including taking up a significant fraction of CO_2 released by humans;
- the Southern Ocean marine ecosystems provides a unique set of environmental adaptations and has undergone significant overfishing and climate-related stress;
- the Arctic is home to native peoples and reduced sea ice opens it up for greatly increased shipping transit and for resource exploitation, including oil and gas.

The UK has great strength in Polar Science, both in NERC Research Centres and in Universities. The UK occupies a prominent leadership role in and has recently invested in major international programmes (eg NERC-NSF Thwaites Glacier programme) and in future capability, especially a new Polar ship, the *RRS Sir David Attenborough*, and research station development in Antarctica.

Science issues

GERC discussion identified five of the most important areas of polar research:

1. ***Sea level rise***: The West Antarctic and the Greenland ice sheets and near-polar glaciers will increasingly dominate the projection of cryospheric contribution to sea level change. Approaches to understand the contribution of both, the two polar ice sheets and the near polar glaciers, to sea level rise are distinctly different:
    - The ice sheets require process models, underpinned by field observations to parametrise processes in the ice sheet and its forcing mechanisms.
    - In contrast, the understanding of small near-polar glaciers' contribution may be more fruitful if viewed as a big data problem using statistical approaches.

    Elements of both approaches are necessary to understand the evolution at the ice-ocean boundary; increasing co-operation between glaciological and oceanographic communities is required here. A

particular concern is that the Greenland and West Antarctic Ice Sheets may reach a point where rapid or irreversible change occurs, exceeding planning estimates of sea level change (the Thwaites programme addresses this). There is need for verifiable sea level projections up to (and ultimately beyond) 2100.

2. ***Impacts of melting permafrost***: The Arctic permafrost is changing rapidly and with a range of impacts. The temporal and spatial patterns of this change are not well understood due to significant temporal and spatial under-sampling of a large region. Changes to permafrost will have severe impacts on Arctic hydrology (including precipitation patterns) in addition to those on the carbon cycle. The potential knock-on effects on ecosystems and human activity are not yet established.

3. ***Representation of processes in climate models***: The representation of the Polar Regions in global climate models is still an area for development. Ongoing challenges include capturing seawater properties in ocean models, modelling processes of heat transport onto the continental shelf, the representation of sea ice, teleconnections to mid-latitudes, and modelling the atmospheric boundary layer and clouds. Some of these are being directly addressed through the Year of Polar Prediction and through the international MOSAIC programme. There is also an opportunity to better link the climatic and glaciological communities in the Arctic, particularly around study of the Greenland Ice Sheet.

4. ***Polar marine ecosystems*** are highly adapted to their environment and are particularly vulnerable to climate change. These ecosystems are key players in marine geochemical cycles, recycling carbon and other nutrients, and projecting the likely change is a challenge. There is an opportunity in UKRI for cross-research council approaches to understanding and exploiting the specialist adaptations, including potential biotech industrial involvement. Linkages between nearshore ecosystems within 5km-10km of the coast and the offshore systems, both behaving very differently, is poorly understood. Better data and modelling on how they interact are needed.

5. ***The key role of sea ice***: a wide range of studies are identifying sea ice as a key constituent of our understanding of the polar environment. Changes in sea ice extent and thickness are having direct impacts on oceanography, atmospheric climate, terrestrial systems, ecosystems, as well as humans and their built infrastructure. The many implications of rapid Arctic change require urgent assessment while the representation of Antarctic sea ice in models remains poor, hampering projections of future change.

The discussion also raised five key linking themes that apply to several areas of Polar Science:

1. ***Baselines***: There is an urgent need to define baselines for a range of environments (marine, terrestrial, ice) and across a wide spatial scale. A full understanding of change and rates of change will be undermined if we do not establish these baselines, as a record of the start of the Anthropocene. In most parts of the polar regions significant environmental change is underway and so although contemporary snapshots are still important there is a recognition of an important role for palaeo-science to provide baselines from the recent (centuries to few millennia) geological past.

2. ***Temporal and spatial improvements in sampling, and use of technology:*** Understanding ongoing change and its impacts requires a commitment to monitor change at regular intervals. Our understanding of the Polar Regions is biased towards the summer months and is often spatially restricted around particular facilities. There is an opportunity for more intensive use of technologies, such as autonomous devices, remote sensing and a pressing need for better sampling during winter. Advanced engineering developments have been important in driving forward the science in key areas but the committee also noted the potential for lower cost, lower-tech approaches, particularly where these can allow widely distributed ('swarm') or repeated measurements. The tagging of seals for collecting oceanographic data is a notable example. The need for transformative technology to address environmental science challenges in the Polar Regions is a major opportunity for cross-disciplinary work and GERC noted such funding sources as the Industrial Strategy Challenge Fund.

3. ***International co-operation***: The UK is a world leader in Polar Science, exemplified by the many leading roles that UK scientists play in working groups of SCAR (Scientific Committee on Antarctic Research), but the widespread nature of change and its environmental impacts, along with the costs of providing infrastructure and deploying scientists and technologies to the Polar Regions means that international collaboration is necessary. Two key priorities emerge, namely the need to be able to respond nimbly to

international opportunities, and enhanced access to international facilities, especially in the Arctic where the UK currently only has one station.

4. ***Beyond disciplinary science:*** the committee noted that an increasing amount of work on the Polar Regions is being carried out by those who might not identify as 'polar scientists', and welcome this expansion of the community tackling Polar Science challenges. Moreover, increased co-operation between science and social sciences is likely to be required to fully understand impacts of environmental change, particularly in the Arctic.

5. ***The role of multiple stressors***: The requirement for multi-disciplinary approaches was also noted in understanding multiple stressors on environmental systems: we have only limited understanding of the role of multiple stressors in the marine and terrestrial environments but there is growing recognition that there are likely to be important compounding effects.

The context for Global Environmental Research Committee reports

The Royal Society's Global Environment Research Committee (GERC) is charged with advising the Royal Society, and interacting with research councils, the environmental science community and other bodies. To do this, it is undertaking a rolling series of reviews of areas of science within its remit. The areas it has identified are (in alphabetical order): Air quality, Biodiversity, Carbon and other biogeochemical cycles, Climate, Natural resources (including land use) and food, Oceans, Polar science, and Water. In each area, GERC uses its own expertise, and that of a number of invited experts to consider the questions:

1. What are the hot research topics in this area at present?

2. What is the status of UK science within this area?

3. What are the most pressing research needs in the next 5-10 years?

4. Are there specific areas where UK science should be focussed to meet these needs?

5. How should priority topics be incorporated into multidisciplinary (funded across research councils) issues that Future Earth and its UK committee should consider?

This paper results from the discussion about polar science, held in October 2018. In addition to contributions from its regular and co-opted members, the committee was advised in person by Prof Lloyd Peck (British Antarctic Survey), Prof Ian Renfrew (UEA), Dr Kate Hendry (University of Bristol), Prof Mary Edwards (University of Southampton, Prof Karen Heywood (UEA) and Prof David Vaughan (British Antarctic Survey). The resulting paper evidently represents only a snapshot of issues, and is not a comprehensive survey of the science area. Exclusion of a topic from this document does not negate its importance, and many areas that are already under intense research are not highlighted here. It does not represent the view of the Royal Society, but puts a spotlight on some trends that will inform future activity by the Royal Society, UKRI, and UK Future Earth.

Membership of GERC (including co-opted members) at the time this topic was discussed (Oct 2018) was: Prof Eric Wolff FRS (chair), Dr Kirsti Ashworth, Prof. Mike Bentley, Dr Maria Dornelas, Prof Pierre Friedlingstein, Prof Joanna Haigh FRS, Dr Kate Hamer (NERC), Prof Gideon Henderson FRS, Dr John Ingram, Prof Corinne Le Quéré FRS, Prof Yadvinder Mahli FRS, Prof Paul Monks, Prof Peter Smith FRS, Prof Martin Solan, Prof Chris Thomas FRS. Dr Holly Winton acted as Secretary. Incoming members Prof Harry Bryden FRS, Prof Sue Hartley and Prof Louise Heathwaite also attended the discussion.

UKNCAR Reporting Template

Provide up to two pages of information following the structure below, only filling out those sections where there is new information to report.

1. Principal UK Researchers	*Claire Allen (BAS); Mike Bentley (Durham); Tina van De Flierdt (Imperial); Jane Francis (BAS); Jenny Gales (Plymouth); Kate Hendry (Bristol); Javier Hernandez-Molina (RHUL); Claus-Dieter Hillenbrand (BAS); Julian Dowdeswell (SPRI); Rob Larter (BAS); Erin McLymont (Durham); Vicky Peck (BAS); Tim van Peer (Southampton); Clive Oppenheimer (Cambridge); Richard Sanders (NOCS); Daniela Schmidt (Bristol); John Smellie (Leicester); James Smith (BAS); Pippa Whitehouse (Durham); Jo Johnson (BAS); John Woodward (Northumbria); Teal Riley (BAS).*
2. Major activities and progress since previous year involving UK personnel/infrastructure	**International Thwaites Glacier Collaboration (ITGC):** The second ITGC cruise took place on RV Nathaniel B Palmer in Jan-Mar 2020 (cruise NBP20-02). Rob Larter, Claus-Dieter Hillenbrand, Kelly Hogan and Elaine Mawbey from the PICC team participated, together with PICC PhD students Becky Hopkins (Southampton) and Jim Marschalek (Imperial). James Smith accompanied an ITGC field team that worked on the Thwaites Eastern Ice Shelf and successfully recovered a suite of sediment cores from beneath the ice shelf via hot water drilled holes. Jo Johnson (UK PI of ITGC Geological History Constraints project) and John Woodward visited the Hudson Mountains to collect samples for further exposure age studies and conduct ground-penetrating surveys to locate future shallow drilling sites where bedrock can be sampled. **AntVolc:** AntVolc was exceptionally well represented in scientific meetings during 2019, including sessions convened at EGU (Austria), ISAES (South Korea) and IUGG (Canada). Following the highly successful AntVolc session at the SCAR-OSC at Davos in 2018 (83 abstracts submitted), we are increasingly encouraging both Antarctic and Arctic research presentations in our sponsored sessions, where appropriate. A comprehensive review volume (a GeolSocLond Memoir) on '*Antarctic volcanism: 200 million years of subduction, rifting and continental break-up*', conceived & led by J Smellie, is now completed and shall be published in 2020 (subject to Covid consequences). A second, new volume sponsored by AntVolc, on '*the Antarctic mantle*' was begun during 2019, with publication intended probably in 2022. One of the invited lead authors is Philip Leat (BAS, UK). The volume shall also be published as a GeolSocLond Memoir. **SERCE:** Successful 2019-20 field season for NERC-funded project to use GPS to measure bedrock deformation across Antarctica in response to ice sheet change. 23 out of 28 instruments now transmit data automatically via iridium. Data are open access, facilitating research into ice sheet-solid Earth interactions across the international research community. Project has taken on instruments that were previously deployed under US and Australian programs, and considerable international collaboration still exists in association with running this GPS network. **Other projects:**

	Teal Riley conducted fieldwork on the magmatism of NW Palmer Land on the Antarctic Peninsula and published papers on the Proterozoic magmatism of the Haag Nunataks, the magmatism of the Weddell Sea, the geochronology and magmatism of the northern Scotia Sea, and a summary paper on West Antarctica. AWI ran a drilling cruise using the MEBO drill to the Amundsen Sea, with CD Hillenbrand on board and several UK geoscientists working on samples. They cored strata that included a new section of mid-Cretaceous sediments containing in situ rootlets of plants. This is the highest latitude record of Cretaceous terrestrial sediments. A reconstruction of the Cretaceous forests was painted by James Mackay and featured in a Nature article (Klages et al 2020).
3. Major future initiatives and actions involving UK personnel/infrastructure	In late 2020 the new UK Icebreaker RRS *Sir David Attenborough* is planned to set sail for nine months of sea trials in northern seas, followed by a season of logistics and testing in Antarctica. The ship should available to support geoscience cruises in the polar regions in future.
4. Policy outcomes	**SCAR White Paper:** Alex Burton-Johnson chaired a session and side meeting for the geothermal heat flow sub-group at ISAES XIII (Incheon, 2019), and is organising an online session and meeting for the 2020 SCAR OSC. • Burton-Johnson, A., Dziadek, R., Martin, C., 2020. Geothermal heat flow in Antarctica: current and future directions. Cryosphere Discuss. • Burton-Johnson, A., et al. The SERCE Geothermal Heat Flow Sub-Group, 2020. Antarctic Geothermal Heat Flow: Future research directions. SCAR-SERCE White Paper. **Geological Heritage and Geoconservation:** <u>Output 1</u>. Only six Antarctic Specially Protected Areas have been designated to protect geological features as the primary value under protection. The Committee for Environmental Protection (CEP) asked SCAR to provide advice on how Antarctic geological heritage could be protected. At a meeting hosted by the British Antarctic Survey in Cambridge (March 2020), the Action Group tested its methodology for identifying and classifying features of potential geological heritage value within the Treaty area. Antarctica's first Geosite, representative of the Cretaceous-Palaeogene Transition, was identified on Seymour Island, northern Antarctic Peninsula (see Hughes et al., 2020). Subsequently, a SCAR Working Paper to the Antarctic Treaty Consultative Meeting that describes the methodology was drafted, but unfortunately was not submitted due to the cancellation of the meeting. It is hoped that the paper will be submitted by SCAR to the next ATCM in Paris in 2021 (ATCM XLIV). <u>Output 2</u>. The Action Group has finalised development of a 'SCAR Code of Conduct on Geosciences Field Research Activities in Antarctica'. Following receipt of further formal comments by Parties, the Code of Conduct was to be submitted to the ATCM in June 2020 as a Working Paper for endorsement though Resolution. This has been delayed until the Paris ATCM in 2021. • Kevin A Hughes, Luis Carcavilla, Alistair Crame, Enrique Díaz-Martínez, David Elliot, Jane Francis, Jerónimo López-Martínez, Marcelo Reguero. (2020). Seymour (Marambio) Island: an outstanding example of Antarctic geological heritage. Antarctic Science 32: 167.

5. Selected publications	• Klages, J.P., & the Science Team of Expedition PS104 (including Bohaty, S.M., van de Flierdt, T., Larter, R.D., Smith, J.A.,) 2020. Temperate rainforests near the South Pole during peak Cretaceous warmth. Nature, 580, 81–86. • Kirkham, J.D., Hogan, K.A., Larter, R.D., Arnold, N.S., Nitsche, F.O., Golledge, N.R. & Dowdeswell, J.A. 2019. Past water flow beneath Pine Island and Thwaites glaciers, West Antarctica. The Cryosphere, 13, 1959–1981. • Larter, R.D., Hogan, K.A., Hillenbrand, C.-D., Smith, J.A., Batchelor, C.L., Cartigny, M., Tate, A.J., Kirkham, J.D., Roseby, Z.A., Kuhn, G., Alastair G.C. Graham, A.G.C. & Dowdeswell, J.A. 2019. Subglacial hydrological control on flow of an Antarctic Peninsula palaeo-ice stream. The Cryosphere, 13, 1583–1596. • Smith, J.A., Graham, A.G.C., Post, A.L., Hillenbrand, C.-D., Bart, P.J. & Powell, R.D. 2019. The marine geological imprint of Antarctic ice shelves. Nature Communications, 10, 5635 (2019). • Jordan, T.A., Riley, T.R., Siddoway, C.S., 2020. The geological history and evolution of West Antarctica. Nat. Rev. Earth Environ. 1, 117–133. • Riley, T.R., Carter, A., Leat, P.T., Burton-Johnson, A., Bastias, J., Spikings, R.A., Tate, A.J., Bristow, C.S., 2019a. Geochronology and geochemistry of the northern Scotia Sea: A revised interpretation of the North and West Scotia ridge junction. Earth Planet. Sci. Lett. 518, 136–147. • Riley, T.R., Flowerdew, M.J., Pankhurst, R.J., Millar, I.L., Whitehouse, M.J., 2020. U-Pb zircon geochronology from Haag Nunataks, Coats Land and Shackleton Range (Antarctica): constraining the extent of juvenile Late Mesoproterozoic arc terranes. Precambrian Res. 105646. • Riley, T.R., Jordan, T.A., Leat, P.T., Curtis, M.L., Millar, I.L., 2020b. Magmatism of the Weddell Sea rift system in Antarctica: Implications for the age and mechanism of rifting and early stage Gondwana breakup. Gondwana Res. 79, 185–196.
6. Funding awards	
7. Points for discussion at UKNCAR meeting	*N/A*

SCAR Life Sciences Group – updates for UKNCAR meeting June 2020

- SKAG: Annual SKAG meetings (2nd meeting in Concarneau, France, June 2019). All tasks proposed during the AG have been implemented and the "synthesis" paper from these tasks have been submitted to Nature Communications Earth & Environment in May 2020. They also developed and are currently maintaining and updating a webpage: https://www.scar.org/science/skag/home/

- ANTOS (see https://www.scar.org/science/antos/antos-resources/): Held a trans-Tasman workshop in August 2019 to facilitate protocol development of ANTOS baseline survey protocols. The Italian National Antarctic Programme installed new ANTOS Tier 1 systems in four Terra Nova Bay locations during 2019/20. The total number of on-line terrestrial ANTOS systems is eight now. ANTOS Survey II was launched in April 2020 to gain more detailed information on the data stream available and participants views on the uniqueness/value of the sites.

- EGBAMM: The Retrospective Analysis of Antarctic Tracking Data synthesis paper and its companion data paper published in Nature and Nature Scientific Data, respectively, showing areas of ecological significance to a suite of marine predators. In parallel, Important Marine Mammal Areas for the Southern Ocean have been finalized and 13 new IMMAs are soon to be integrated to the eAtlas of the IUCN task force on marine mammal protection.

- The SCAR-IAATO systematic conservation planning (SCP) in Antarctic Peninsula is progressing with series of workshops to identify values, currently being held.

There will be more details on the LS document currently in preparation.

SCAR Executive Committee Meeting 2019

Plovdiv, Bulgaria, 29-31 July 2019

Physical Sciences SG

2018-19 Report

Report Author(s)

David H Bromwich (USA), Adriana Gulisano (Argentina), Steven Colwell (UK)

Summary paragraph

Highlights for the Sub-Groups are given below under “What has been achieved”. Individual Sub-Group reports have also been uploaded to the Google Drive. Most EGs and AGs are delivering on their activities proposed at Polar2018 in Davos, Switzerland. There are too many EGs and AGs under the PS umbrella and termination of dormant groups will be recommended to the SCAR Delegates in Hobart 2020.

The two-term appointments of the Chief Officer and Secretary will be completed at the SCAR Meeting in Hobart 2020, and candidates are being recruited.

Sub-group updates

Please include any information that has changed since the SCAR 2018 Delegates Meeting, following the headings below.

Sub-group – what has been achieved?

Sub-group	Activity
IPICS EG	Oldest Ice Initiative Vigorously Continues.
GRAPE EG	Working on proposal for new Scientific Research Program, "RESOURCE".
ISMASS EG	ISMASS continues to be involved in intercomparison projects such as ISMIP6 (climate and ice sheets), MISOMIP (ocean and ice sheet). Several members of ISMASS are members of the PPG AISSL (Antarctic Ice Sheet Dynamics and Global Sea Level)
SORP EG	Extensive planning for upcoming meetings has occurred. Task Teams have been appointed to facilitate activities.
ANTOS EG	SCAR Integrated Science for the Sub Antarctic ISSA Workshop October 10-13, 2018. Matching funding has been obtained through an internal grant to Sharon Robinson (ANTOS Committee Member) from the University of Wollongong (~$28K) to develop an ANTOS terrestrial survey protocol. The Italian National Programme has supported one of its researchers to install 4 new ANTOS Tier 1 systems at 4 locations near Terra Nova Bay.
ASPECT EG	ASPeCt continues to work on its database of ship-borne sea ice observations.
FRISP EG	Nothing reported.
OpMet EG	Actively participated in the Workshop on Antarctic Meteorology and Climate in Charleston, South Carolina, June 25-27, 2019.
ACCE EG	Nothing reported.
Remote Sensing AG	Communication with the European Space Agency (ESA) since 2016 resulted in a regular coverage of Antarctic coastline by Sentinel-2 every 10 days from September 2018 to April 2019.
ACA AG	ACA AG met during 2019 EGU Meeting.
SnowAnt AG	Nothing reported
PACT AG	Finalizing a manuscript for submission to Atmospheric Chemistry and Physics detailing the AG outcomes.
TATE AG	TATE sponsored a half -day workshop on TATE research topics on 20 June 2019 in conjunction with 8th Malaysian International Seminar on Antarctica. A report on the TATE workshop will be published in Advances in Polar Sciences after the workshop. TATE group also contributes to a session on "Tropical and Antarctic Teleconnection and Antarctic Climate Change" in ISAES2019 meeting to be held at Songdo Convensia in July 2019.
AntArchitecture AG	*AntArchitecture* Workshop at International Glaciological Society Symposium "Fifty Years of Radioglaciology" at Stanford University, 8 July 2019. This will form the main

	assembly point in 2019 for the international *AntArchitecture* community to discuss progress and plan delivery over the forthcoming year in advance of the SCAR Delegates Meeting in Hobart.
ANGWIN AG	ANGWIN Journal of Geophysical Research joint special issue (Atmospheres and Space Physics) fully launched in January 2019: 10 papers on ANGWIN science: https://agupubs.onlinelibrary.wiley.com/doi/toc/10.1002/(ISSN)2169-8996.ANGWIN1
EOG AG	Nothing reported.

More details provided in the individual group reports.

Sub-group – what lies ahead?

Sub-group	Activity
ACA AG	Development of cloud observation database

Budget

Changes to planned use of funds for 2019 and 2020

Year (YYYY)	Purpose/Activity	Amount (in USD)	Contact Name	Contact Email
Total				

Membership

Changes to Sub Group Leadership since 2018 Delegates Meeting report

Role	First Name	Last Name	Affiliation	Country	Email	Date Started	Date Term is to End

*Please identify early-career researchers with * in first column*

SCAR Fellowship Reviewers
Please list any people (name and email address) volunteered by sub-groups who would be willing to serve as reviewers for the next few years, along with 1-3 keywords on their principal expertise.

First Name	Last Name	E-mail	Principal Expertise

Additional information (optional)

Outreach, communication and capacity-building activities
Brief highlights of any activities undertaken since the SCAR Delegates Meeting in 2018.

Notable Papers

1. Sutter, J., Fischer, H., Grosfeld, K., Karlsson, N.B., Kleiner, T., Van Liefferinge, B., Eisen, O., 2019. Modelling the Antarctic Ice Sheet across the Mid Pleistocene Transition - Implications for Oldest Ice. The Cryosphere Discuss. 2019, 1-24.

   Planning for Oldest Ice Initiative of IPICS.

2. Edward Hanna, Frank Pattyn, Francisco Navarro, Vincent Favier, Heiko Goelzer, Michiel R. van den Broeke, Miren Vizcaino, Pippa L. Whitehouse, Catherine Ritz, Kevin Bulthuis, Ben Smith (submitted to Earth Science reviews): Mass balance of the ice sheets and glaciers – progress since AR5 and challenges.

   This article is the outcome of the ISMASS workshop held in Davos in June 2018. Title: “Update on mass balance of Greenland and Antarctica (linkages between data and models)”.

3. Harris, C et al..: Environmental guidelines for operation of Remotely Piloted Aircraft Systems (RPAS): Experience from Antarctica. Biological Conservation. (in press).

   Key publication from Remote Sensing AG.

4. Moffat-Griffin, T. (2019) An introduction to atmospheric gravity wave science in the polar regions and first results from ANGWIN. Journal of Geophysical Research: Atmospheres, 124. 1198-1199. https://doi.org/10.1029/2019JD030247

   This paper introduces the JGR ANGWIN special issue (that came about as a result of the 3rd ANGWIN workshop). It also provides an overview of ANGWIN.

Direct support from outside organisations received for your activities
(*Numbered list with values indicated if direct cash support. Please restrict in-kind support to substantive in-kind support only*)

Major collaborations your Science Group has with other SCAR groups and with organisations/groups beyond SCAR
(*Numbered list of substantive collaborations*)

Within SCAR

1. X

Outside SCAR

1. X

UKNCAR Report on SCAR Scientific Research Programme (SRP) Antarctic Climate Change in the 21st Century (AntClim21)

• Principal UK Researchers	*Dr Tom Bracegirdle, Chief Officer*
• Major activities and progress since previous year involving UK personnel/infrastructure	• An AntClim21 CMIP6/IPCC AR6 workshop was held at BAS on 26-28th June 2019. This was an International workshop with approximately 50 attendees, many international but also many from BAS and the UK. The aim of this workshop was to help ensure that the Antarctic and Southern Ocean climate science communities (including the UK) make a significant contribution to the IPCC 6th Assessment Report (AR6). • Three papers that were planned during this workshop are now in press. They all assess aspects of Antarctic climate from output of the climate model dataset that is a key input to the upcoming IPPC AR6 report (references below). The latest indications are that all three are cited in the current draft of WG1 of AR6.
• Major future initiatives and actions involving UK personnel/infrastructure	• AntClim21 is ending this year. A final report to delegates is being prepared. • A more general synthesis report is planned to be written in the autumn. This has been delayed by impacts of Covid-19.
• Policy outcomes	*Citation of recent papers in the upcoming IPCC AR6 report would potentially contribute to the science evidence informing policy in the future.*
• Selected publications (UK authors in bold)	• ***Bracegirdle, T. J., C. R. Holmes, J. S. Hosking, G. J. Marshall, M. Osman, M. Patterson,*** *T. Rackow (2020). Improvements in Circumpolar Southern Hemisphere Extratropical Atmospheric Circulation in CMIP6 Compared to CMIP5. Earth and Space Science, in press. https://doi.org/10.1029/2019EA001065* • ***Bracegirdle, Thomas*** *J., Gerhard Krinner, Marcos Tonelli, F. Alexander Haumann,* ***Kaitlin A. Naughten****, Thomas Rackow, Lettie Roach, Ilana Wainer (2020). Twenty first century changes in Antarctic and Southern Ocean surface climate in CMIP6, Atmospheric Science Letters, in press. https://doi.org/10.1002/asl.984* • *Roach, Lettie A., Jakob Dorr,* ***Caroline R. Holmes****, Francois Massonnet,* ***Edward W. Blockley****, Dirk Notz, Thomas Rackow, Marilyn N. Raphael, Siobhan O'Farrell, David A. Bailey, Cecilia M. Bitz (2020). Antarctic Sea Ice in CMIP6, GRL, published online. https://doi.org/10.1029/2019GL086729.*
• Funding awards	*None*

• Points for discussion at UKNCAR meeting	*Although AntClim21 is ending this year, AntClimNow will, if approved, maintain a strong UK presence in the next phase of SCAR Scientific Research Programmes.*

UKNCAR report on SCAR Programme Planning Group (PPG) Near-term Variability and Prediction of the Antarctic Climate System (AntClimNow)

June 2020

• Principal UK Researchers	*Tom Bracegirdle, co-Chief Officer* *Rachel Cavanagh (BAS), Steering Committee* *Scott Hosking (BAS), member* *Julie Jones (Sheffield University), member* *Andrew Orr (BAS), member* *Doug Smith (Met Office), member* *Liz Thomas (BAS), Steering Committee* *John Turner (BAS), member*
• Major activities and progress since previous year involving UK personnel/infrastructure	• The second year of this two-year proposal-writing group has been spent finalising a Science and Implementation plan that was submitted to SCAR in May. If approved this would become a new Scientific Research Programme with an 8-year duration (subject to a review at 4 years). • More information can be found at https://www.scar.org/science/antclimnow/home/
• Major future initiatives and actions involving UK personnel/infrastructure	• The proposal will undergo an evaluation process before a final decision on approval and budgets will be made in July/August 2020. • If approved AntClimNow would become a new Scientific Research Programme with an 8-year duration (subject to a review at 4 years). •
• Policy outcomes	*N/A*
• Selected publications	*N/A*
• Funding awards	*N/A*
• Points for discussion at UKNCAR meeting	•

UKNCAR Reporting Template - SERCE

Provide up to two pages of information following the structure below, only filling out those sections where there is new information to report.

1. Principal UK Researchers	*Pippa Whitehouse (Joint Chief Officer)* *Mike Bentley (Steering Committee Member)* *Alex Burton-Johnson (Geothermal Heat Flow lead)*
2. Major activities and progress since previous year involving UK personnel/infrastructure	*Lively SERCE/Geothermal Heat Flow Side Meeting held at the 2019 International Symposium on Antarctic Earth Sciences in Incheon, South Korea. Meeting chaired by Alex Burton-Johnson (UK), and attended by ~30 scientists from a wide range of disciplines, countries, and career stages. 6 attendees were from UK institutions, an additional 2 were UK scientists currently employed overseas.* *The 2019 SERCE/POLENET Glacial Isostatic Adjustment training school, coordinated by Pippa Whitehouse (UK), was held in Gävle, Sweden 26-30 August 2019. 28 countries (6 continents) were represented across 41 participants and 16 lecturers, with 4 participants and 2 lecturers based in the UK. Additional UK-based researchers joined via the 'virtual participant' portal. Lectures are online for all to listen to (*http://polenet.org/2019-glacial-isostatic-adjustment-gia-training-school) *A SERCE-funded workshop on 'Glacial Isostatic Adjustment, Ice Sheets, and Sea-Level Change – Observations, Analysis, and Modelling' was held 24-26 September 2019 in Ottawa, Canada. Organising team was Tom James, Glenn Milne, Natalya Gomez (all Canada), Pippa Whitehouse (UK) and Matt King (Australia). 5 of the 65 attendees were from UK institutions. An outcome of the workshop was a list of priority research questions (*https://www.scar.org/scar-news/serce-news/ottawa-gia-workshop/) *Successful 2019-20 field season for NERC-funded project to use GPS to measure bedrock deformation across Antarctica in response to ice sheet change. 23 out of 28 instruments now transmit data automatically via iridium. Data are open access, facilitating research into ice sheet-solid Earth interactions across the international research community. Project has taken on instruments that were previously deployed under US and Australian programs, and considerable international collaboration still exists in association with running this GPS network.*

3. Major future initiatives and actions involving UK personnel/infrastructure	*SERCE is due to end in 2020 but we have been given permission to carry funds over into 2021. Our original scheduled activities for 2020 were: a wrap-up meeting at SCAR2020 and a joint workshop with PALSEA on 'Improving understanding of ice sheet and solid earth processes driving paleo sea level change' (https://palseagroup.weebly.com/). The joint SERCE/PALSEA workshop is now due to take place in September 2021. We anticipate a strong presence of UK scientists at this workshop.* *During 2021, using unspent funds from 2020, we also plan to hold a workshop to discuss the future of the Antarctic-wide GNSS network. Instruments in this network form the backbone of measuring the solid Earth response to cryosphere change, but all are deployed on a time-limited basis via national funding. Around a quarter of the instruments are currently NERC-funded UK infrastructure.*
4. Policy outcomes	*n/a*
5. Selected publications	*Burton-Johnson, A., Dziadek, R., Martin, C., Halpin, J.A., Whitehouse, P.L., Ebbing, J., Martos, Y., Martin, A., Schroeder, D., Shen, W., Ritz, C., Goodge, J., van Liefferinge, B., Pattyn, F., Reading, A., Ferraccioli, F., and the SERCE Geothermal Heat Flow Sub-Group, 2020.* ***Antarctic Geothermal Heat Flow: Future research directions****. SCAR White Paper.*
6. Funding awards	*n/a*
7. Points for discussion at UKNCAR meeting	*SERCE-facing activities within the new INSTANT SRP*

UKNCAR Reporting Template - SERCE

Provide up to two pages of information following the structure below, only filling out those sections where there is new information to report.

1. Principal UK Researchers	*Pippa Whitehouse (Joint Chief Officer)* *Mike Bentley (Steering Committee Member)* *Alex Burton-Johnson (Geothermal Heat Flow lead)*
2. Major activities and progress since previous year involving UK personnel/infrastructure	*Lively SERCE/Geothermal Heat Flow Side Meeting held at the 2019 International Symposium on Antarctic Earth Sciences in Incheon, South Korea. Meeting chaired by Alex Burton-Johnson (UK), and attended by ~30 scientists from a wide range of disciplines, countries, and career stages. 6 attendees were from UK institutions, an additional 2 were UK scientists currently employed overseas.* *The 2019 SERCE/POLENET Glacial Isostatic Adjustment training school, coordinated by Pippa Whitehouse (UK), was held in Gävle, Sweden 26-30 August 2019. 28 countries (6 continents) were represented across 41 participants and 16 lecturers, with 4 participants and 2 lecturers based in the UK. Additional UK-based researchers joined via the 'virtual participant' portal. Lectures are online for all to listen to (*http://polenet.org/2019-glacial-isostatic-adjustment-gia-training-school) *A SERCE-funded workshop on 'Glacial Isostatic Adjustment, Ice Sheets, and Sea-Level Change – Observations, Analysis, and Modelling' was held 24-26 September 2019 in Ottawa, Canada. Organising team was Tom James, Glenn Milne, Natalya Gomez (all Canada), Pippa Whitehouse (UK) and Matt King (Australia). 5 of the 65 attendees were from UK institutions. An outcome of the workshop was a list of priority research questions (*https://www.scar.org/scar-news/serce-news/ottawa-gia-workshop/) *Successful 2019-20 field season for NERC-funded project to use GPS to measure bedrock deformation across Antarctica in response to ice sheet change. 23 out of 28 instruments now transmit data automatically via iridium. Data are open access, facilitating research into ice sheet-solid Earth interactions across the international research community. Project has taken on instruments that were previously deployed under US and Australian programs, and considerable international collaboration still exists in association with running this GPS network.*

	SERCE co-chair (Pippa Whitehouse, UK) delivered a Plenary Lecture at the 2019 International Symposium on Antarctic Earth Sciences, summarising recent SERCE-facing research
3. Major future initiatives and actions involving UK personnel/infrastructure	*SERCE is due to end in 2020 but we have been given permission to carry funds over into 2021. Our original scheduled activities for 2020 were: a wrap-up meeting at SCAR2020 and a joint workshop with PALSEA on 'Improving understanding of ice sheet and solid earth processes driving paleo sea level change' (https://palseagroup.weebly.com/). The joint SERCE/PALSEA workshop is now due to take place in September 2021. We anticipate a strong presence of UK scientists at this workshop.* *During 2021, using unspent funds from 2020, we also plan to hold a workshop to discuss the future of the Antarctic-wide GNSS network. Instruments in this network form the backbone of measuring the solid Earth response to cryosphere change, but all are deployed on a time-limited basis via national funding. Around a quarter of the instruments are currently NERC-funded UK infrastructure.*
4. Policy outcomes	*n/a*
5. Selected publications	*Burton-Johnson, A., Dziadek, R., Martin, C., Halpin, J.A., Whitehouse, P.L., Ebbing, J., Martos, Y., Martin, A., Schroeder, D., Shen, W., Ritz, C., Goodge, J., van Liefferinge, B., Pattyn, F., Reading, A., Ferraccioli, F., and the SERCE Geothermal Heat Flow Sub-Group, 2020.* ***Antarctic Geothermal Heat Flow: Future research directions****. SCAR White Paper.*
6. Funding awards	*n/a*
7. Points for discussion at UKNCAR meeting	*SERCE-facing activities within the new INSTANT SRP*

UKNCAR Reporting Template

Provide up to two pages of information following the structure below, only filling out those sections where there is new information to report.

1. Principal UK Researchers	*Please outline key UK researchers involved in this group and their Committee role* *Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED). ICED is a regional programme of IMBeR (Integrated Marine Biosphere Research) and the Scientific Committee on Oceanic Research (SCOR), and is a SCAR Co-Sponsored programme.* Dr Nadine Johnston (ICED Programme Manager), Dr Rachel Cavanagh (ICED Executive Officer), Prof Eugene Murphy (Chair, ICED Scientific Steering Committee, SSC). All of the activities below have been led/co led by UK representatives of the ICED Programme
2. Major activities and progress since previous year involving UK personnel/infrastructure	• ICED Session at Integrated Marine Biosphere Research (**IMBeR) Open Science Meeting**, Brest, France Jun 2019 and associated MEASO workshop • **UN Decade of the Ocean:** Together with SCAR, the Southern Ocean Observing System (SOOS) and a range of partners, ICED co-organized a Southern Ocean Regional Workshop held during the Annual Geophysical Union Ocean Sciences Meeting (AGU Oceans 2020) on 16th February. As part of a global consultation process in preparation of the United Nation's Decade of Ocean Science for Sustainable Development (2021-2030), the Southern Ocean workshop provided opportunities to further discuss, prioritize and formulate proposals for Southern Ocean initiatives to be framed under the decade. • This workshop was be followed by an ICED session at the **AGU Oceans 2020**, San Diego, Feb 2020 on '*Complexity, connectivity and change in Southern Ocean food webs'*.
3. Major future initiatives and actions involving UK personnel/infrastructure	• Upcoming papers (community-, position, review-etc), including; - Publication of the results of the ICED Marine Ecosystem Assessment of the Southern Ocean (MEASO) (http://www.measo2018.aq/) (Frontiers in Marine Science Special Issue, late 2020) and as a Summary for Policy Makers. - Papers from the ICED Session at the IMBeR OSC 2019 (Frontiers in Marine Science Special Issue, late 2020)

	- SCAR report on Ocean Acidification (Bellerby et al. ICED SSC) - Projections of the future state of Southern Ocean ecosystems: Incorporating uncertainties associated with climate variability and change into CCAMLR's decision making (Murphy et al. in prep., an international collaborative paper from the ICED-CCAMLR Workshop held in April 2018). • TBC Online ICED Session at SCAR OSC, Aug 2020 on '*The effects of change on Southern Ocean ecosystems: understanding, modelling, projecting, and managing change in Southern Ocean species and food webs*' • TBC Online Mini-symposium SCAR OSC 2020 on • ICED contributed to the development SCAR's next generation of scientific research programmes, ensuring that they utilize the outputs of the ICED programme to avoid duplication of effort across the Southern Ocean and wider community, and encourage collaborations in areas of mutual interest across our Priority Research Area. The AntICON proposal was submitted to SCAR at the end of May 2020.
4.	*Any outcome which has led to a change in policy, official guidance or legislation, with key involvement from UK personnel*
5. Selected publications	These 4 papers highlight progress in some key science that have been central to the ICED programme since its inception. **Cavan, E.L., Belcher, A., Atkinson, A., Hill, S.L., Kawaguchi, S., McCormack, S., et al. (2019). The importance of Antarctic krill in biogeochemical cycles. Nature Communications 10(1), 4742. doi: 10.1038/s41467-019-12668-7.** A major objective of ICED has been to develop understanding of the role of biological processes in biogeochcemical cycles in the Southern Ocean. This study synthesizes understanding of the role of Antarctic krill in biogeochemical cycles. They highlight that Anatrctic krill has a prominent role in the cycling of nutrients in the Southern Ocean, but also that much greater understanding is required. They also suggest this role in bioegochemical cycling needs to be explictly considered in fisheries management. The central role of Antarctic krill in Southern Ocean food webs and developing models of their population processes has been a major activity within ICED, which have also emphasized the need for improved understanding of larval recruitment. **Thorpe, S.E., Tarling, G.A., and Murphy, E.J. (2019). Circumpolar patterns in Antarctic krill larval recruitment: an environmentally driven model. Marine Ecology Progress Series 613, 77-96. doi: 10.3354/meps12887.** This paper reports on a modelling study of the processes influencing larval recruitment in Antarctic krill. The study identifies the importance of the

	seasonal location and timing of sea ice as the main limiting factor for successful larval recruitment. The study also highlights the need for improved understanding of the overwintering requirements of larvae together with regional high-resolution studies. **Hückstädt, L.A., Piñones, A., Palacios, D.M., McDonald, B.I., Dinniman, M.S., Hofmann, E.E., et al. (2020). Projected shifts in the foraging habitat of crabeater seals along the Antarctic Peninsula. Nature Climate Change. doi: 10.1038/s41558-020-0745-9.** This paper reports on a multidisciplinary study of the habitat of crabeater seals and the potential impacts of future change. Crabeater seals is a pack ice resident that feeds on Antarctic krill and hence can also provide insights into the distribution of krill. This study developed a foraging habitat model for crabeater seals on the western Antarctic Peninsula (WAP). It also developed projections of potential changes in future crabeater seal foraging habitat and krill distribution in response to projected environmental changes. The study highlights the importance of multidisciplinary analyses of Southern Ocean ecosystems for developing projections of future change, a central goal of the ICED programme; **Cavanagh, R, Johnston, N, Murphy, E and the ICED Scientific Steering Committee (2019). Integrating Climate and Ecosystem Dynamics in the Southern Ocean (ICED) programme: a report on recent joint activities and links between ICED and CCAMLR. WG-EMM-2019/02.** This Working Group paper on ICED-CCAMLR collaborations was submitted to WG-EMM 2019, held in June 2019. This paper highlighted recent ICED research and activities on Southern Ocean ecosystems and change, focusing on areas of interest to CCAMLR and joint ICED-CCAMLR activities, and suggests ways to continue to strengthen the links between ICED and CCAMLR. The paper aimed to encourage CCAMLR involvement in relevant ICED activities to jointly identify, prioritise and address key scientific issue with respect to the management of Southern Ocean ecosystems in the face of change.
6. Funding awards	*Funding received by UK scientists as a result of SCAR activity*
7. Points for discussion at UKNCAR meeting	*Optional*

UKNCAR Reporting Template

Provide up to two pages of information following the structure below, only filling out those sections where there is new information to report.

1. Principal UK Researchers	John Turner, Colin Summerhayes, Tom Bracegirdle, Pete Convey (All members of the ACCE Expert Group)
2. Major activities and progress since previous year involving UK personnel/infrastructure	Input for the 2020 ACCE update Information Paper for the Treaty meeting. Updating of the ACCE wiki at http://acce.scar.org/wiki/Antarctic_Climate_Change_and_the_Environment Working with APECS on the selection of an early career scientist to join the ACCE Expert Group.
3. Major future initiatives and actions involving UK personnel/infrastructure	We are considering the preparation of a major refereed paper on Antarctic climate change and the environment as it's now 10 years since the publication of the original ACCE volume.
4. Policy outcomes	*None*
5. Selected publications	
6. Funding awards	*None*
7. Points for discussion at UKNCAR meeting	*Are there other UK scientists who would like to join the ACCE Expert Group?*

UKNCAR Reporting Template

Provide up to two pages of information following the structure below, only filling out those sections where there is new information to report.

1. Principal UK Researchers	Robert Mulvaney, Eric Wolff and Liz Thomas are all on the IPICS Steering Committee. Mulvaney is the national representative for the UK. Thomas is a specialist representing the 2k project, while Wolff as past chair represents oldest ice. Other scientists from BAS and a number of universities are involved in IPICS activities.
2. Major activities and progress since previous year involving UK personnel/infrastructure	The largest progress since last year is that the European Beyond EPICA (oldest ice) project is now underway. The site (chosen largely through BAS radar work) now hosts a drilling tent, living and sleeping tents. Drilling of the pilot hole and placement of the casing will happen next season. Drilling should be completed in early 2024. Mulvaney and Wolff are on the SC for the project, which is coordinated from Italy. Analysis is underway for the bedrock ice core drilled on Skytrain Ice Rise in 2018/19. This should make a major contribution to the IPICS Last Interglacial project. Other UK field, lab and modelling work is contributing to all IPICS priority projects.
3. Major future initiatives and actions involving UK personnel/infrastructure	New UK fieldwork will contribute to all IPICS priority projects, eg GLACE drilling for 2k, further WACSWAIN work, Keele studies at Patriot Hills, etc.
4. Policy outcomes	-
5. Selected publications	Thomas, E. R., C. S. Allen, J. Etourneau, A. C. F. King, M. Severi, V. H. L. Winton, J. Mueller, X. Crosta, and V. L. Peck (2019), Antarctic Sea Ice Proxies from Marine and Ice Core Archives Suitable for Reconstructing Sea Ice over the past 2000 Years, *Geosciences*, *9*(12), doi:10.3390/geosciences9120506. Rix, J., R. Mulvaney, J. L. Hong, and D. Ashurst (2019), Development of the British Antarctic Survey Rapid Access Isotope Drill, *J. Glaciol.*, *65*(250), 288-298, doi:10.1017/jog.2019.9.
6. Funding awards	BAS is one of the partners in the EU Beyond EPICA project which received €11M under Horizon 2020, the grant started in June 2019.
7. Points for discussion at UKNCAR meeting	IPICS Open Science Meeting to be held in Crans Montana (Switzerland) in October 2020, now scheduled for October 2021.

UKNCAR Reporting Template

Provide up to two pages of information following the structure below, only filling out those sections where there is new information to report.

1. Principal UK Researchers	Steve Colwell
2. Major activities and progress since previous year involving UK personnel/infrastructure	Several members of the group (including myself) were involved in a scoping workshop for the Antarctic Regional Climate Centre (RCC) in Bologna in October 2019. It was agreed that BAS would take the lead on the data section.
3. Major future initiatives and actions involving UK personnel/infrastructure	A concept paper is being prepared that will go to the WMO to get approval for the start of the Antarctic RCC.
4. Policy outcomes	
5. Selected publications	Several members of the group (including myself) were involved in writing the Antarctic section of the BAMS annual state of the climate.
6. Funding awards	
7. Points for discussion at UKNCAR meeting	

UKNCAR Reporting Template – AntVolc activities, April 2019-Mar 2020

Provide up to two pages of information following the structure below, only filling out those sections where there is new information to report.

1. Principal UK Researchers	*John Smellie (Leicester; stepped down as AntVolc Chair in Dec 2018; ex-officio member of Steering Group); Clive Oppenheimer (Cambridge); Alex Burton-Johnson (BAS); Philip Leat (BAS/Leicester)*
2. Major activities and progress since previous year involving UK personnel/infrastructure	Volume on Volcanism in Antarctica (GeolSocLond Memoir) completed; publication in 2020 (Covid permitting). New volume on The Antarctic Mantle in progress (also GSL Memoir).
3. Major future initiatives and actions involving UK personnel/infrastructure	
4. Policy outcomes	
5. Selected publications	**Gray, D.M., Burton-Johnson, A. , Fretwell, P.T.** (2019) Evidence for a lava lake on Mt. Michael volcano, Saunders Island (South Sandwich Islands) from Landsat, Sentinel-2 and ASTER satellite imagery. *Journal of Volcanology and Geothermal Research*, 379. 60-71. 10.1016/j.jvolgeores.2019.05.002 **Riley, Teal , Jordan, Tom , Leat, Philip, Curtis, Mike L., Millar, Ian.** (2020) Magmatism of the Weddell Sea rift system in Antarctica: Implications for the age and mechanism of rifting and early stage Gondwana breakup. *Gondwana Research*, 79. 185-196. 10.1016/j.gr.2019.09.014
6. Funding awards	
7. Points for discussion at UKNCAR meeting	

SCAR Sub-Group	ANTOS
SG	LS
Person Responsible:	Craig Cary and Vonda Cummings

SCAR Delegates Report 2020

ANTOS

2018-2020 Report

Summary (no more than one page)

Report Authors
Craig Cary & Vonda Cummings (NZ)

Summary of activities from 2018-20
Please provide highlights of your groups progress since the SCAR Delegates meeting in 2018, covering major activities/achievements, upcoming activities and key challenges faced.

Major activities/achievements:

1. SCAR Integrated Science for the Sub Antarctic (ISSA) Workshop, October 2018 (Great Barrier Island, NZ). Convened by Gary Wilson and Justine Shaw, representatives of most National Programmes with jurisdiction/management in the Subantarctic attended. ANTOS was presented at the meeting to make the sub-Antarctic island community aware of ANTOS and to solicit participation in the expansion of the ANTOS network to the Subantarctic (Sub-ANTOS). This effort has already proved valuable in that the French attendees have sought support to establish 2-3 Tier 1 ANTOS towers in the Kerguelen Islands.
2. Progressed development of ANTOS baseline survey protocols, to assist new participants in obtaining the critical baseline data needed prior to the installation of a Tier 1-3 system. A trans-Tasman workshop held in August 2019, with partial support from ANTOS, facilitated protocol development. Major funding was obtained through an internal grant to Sharon Robinson (ANTOS Committee Member; (~$28K from University of Wollongong).
3. The Italian National Antarctic Programme supported installation of new ANTOS Tier 1 systems in four Terra Nova Bay locations during 2019/20. These integrate several new sensors to measure the bioactivity of known endolithic communities. Data are being live streamed to the database, bringing the total number of on-line terrestrial ANTOS systems to eight.
4. A Canadian vendor experienced in integrating marine sensor systems in polar environments have agreed to develop a prototype telemetered (iridium) system for the near-shore component of ANTOS. Potential for their direct involvement in ANTOS to assist development of a QA/QC sensor tracking system (as they developed in the Arctic).

5. The ANTOS community was updated on the activities and progress made in 2018 at the Genoa workshop and subsequent ANTOS meeting in Leuven, via a report published on the website in late 2019 (see https://www.scar.org/science/antos/antos-resources/).
6. ANTOS Survey II was designed and was launched in April 2020. It targets participants of the Survey I to gain more detailed information on the data stream available (incl. frequency and duration of measurements, observed environmental/ ecological responses) and participants views on the uniqueness/value of the sites. This will augment and enhance information obtained from Survey I, enabling prioritisation of the ANTOS Sentinel Sites.

Upcoming activities:

1. Selection of ANTOS sites: Survey I and II data will be analysed to determine the identity of 25 priority ANTOS Sentinel Sites. The survey data will be analysed by an ANTOS sub-committee. Site proponents will be notified that their site has been endorsed as an ANTOS Sentinel Site with the hope that this international endorsement will support proposals to their national programmes.
2. Protocol, Guidelines and Technical manuals: Drafts of protocol, guideline, and technical manuals for ANTOS will be reviewed by the community. Virtual working group meetings will be held from mid-2020 to refine working drafts, and the final, peer reviewed versions will be released to the public by Feb 2022.
3. ANTOS Prospectus: Targeting different audiences, including (i) the Antarctic community, (ii) policy makers, and (iii) operators/logistics, and philanthropists. The Prospectus will describe the purpose and value of ANTOS to potential funders.

Key challenges faced:

Every individual involved in ANTOS has been impacted by the COVID-19 Pandemic. Scheduled meetings have been cancelled or postponed due to the closure of boarders and inability to travel. Workshops planned for 2020 will now be rescheduled for appropriate dates from late 2020 through 2021. These workshops were to finalise (i) the KOPRI-hosted database, (ii) the terrestrial and marine technical manuals, (iii) the 25 priority ANTOS Sentinel Sites, (iv) the prospectus that will be used to fund raise for the ANTOS programme, and (v) to present the above to the SCAR community. The COVID impact is likely to put us back about 12 months in our projected spending especially considering the cancellation of SCAR 2020 where we had scheduled a major workshop to present the ASS and manuals. That said, the delay will provide more time for the analysis of the survey data, development of manuals, and prospectus. Our hope would be to launch a fundraising campaign based on these outputs over the next 12 months and to run a comprehensive workshop at the SCAR OSC in 2022.

Summary Budget 2019 to 2022

	2019	2020	**2021**	**2022**
	Spent	Allocated	Request	Request
(US$)	1500	6300	0	8000

Progress to date

Sub-group Outcomes Summary

Sub-group	Activity/Outcome/Benefit/Achievement
ANTOS	ANTOS presented at 2018 ISSC meeting/completed/ expansion of ANTOS network to the Subantarctic (Sub-ANTOS)/interest registered
ANTOS	Trans-Tasman workshop/ANTOS baseline survey protocols/ANTOS Sentinel sites will have a common baseline evaluation/protocols under development (July 2020 end date)
ANTOS	Four new ANTOS Tier 1 systems installed in Terra Nova Bay in 2019/20 /Data are being live streamed to the database/total of eight terrestrial ANTOS systems are now on-line.
ANTOS	Discussions with experienced vendors to integrate marine instrumentation for ANTOS/vendor agreed to develop a prototype telemetered (iridium) system and assist development of a QA/QC sensor tracking system/working towards an off the shelf marine ANTOS tier.
ANTOS	Report to wider SCAR community on ANTOS progress and plans.
ANTOS	ANTOS Survey II designed/survey launched/ detailed information to inform prioritisation of the ANTOS Sentinel Sites/in progress (survey closes June 2020)

Sub-group Cash Flow
(F*rom previous Delegates meeting to date*)

Sub-group	Allocation	Amount spent		
		2018	**2019**	**2020**
ANTOS	17624	3600	1500	900

Future plans

Planned activities in 2020 to 2022

Sub-group	Planned activity
ANTOS	Workshop to analyse Survey I and II data/Selection of priority ANTOS Sentinel Sites (2020-2021)
ANTOS	Multiple workshops to finalise drafts of ANTOS terrestrial and marine protocol, guideline, and technical manuals (2020-2021). These will be reviewed by the community before final versions are released (by Feb 2022)
ANTOS	ANTOS prospectus developed describing the purpose and value of ANTOS to potential funders.
ANTOS	Database meeting – final design and implementation

Planned use of funds for 2020 to 2022

Year (YYYY)	Purpose/Activity	Amount (in USD)	Contact Name	Contact Email
2020	Database meeting (Korea)	2000	Charles Lee & Soon Gyu Hong	charles.lee@waikato.ac.nz polypore@gmail.com
2020	Two Technical Manual meetings (NZ and Canada)	3000	Craig Cary & Charles Lee	charles.lee@waikato.ac.nz vonda.cummings@niwa.co.nz, caryc@waikato.ac.nz
2020	Prospectus development and printing	2000	Craig Cary & Dana Bergstrom	caryc@waikato.ac.nz dana.bergstrom@aad.govt.au
2020	Analyse survey data and prioritise 25 sentinel sites (US)	3000	Byron Adams & Vonda Cummings	byron_adams@byu.edu vonda.cummings@niwa.co.nz
2021	SCAR Biology	1500	Craig Cary & Vonda Cummings	caryc@waikato.ac.nz vonda.cummings@niwa.co.nz
2022	Finalise all documents and hold workshop at OSC	8000	Vonda Cummings & Craig Cary	vonda.cummings@niwa.co.nz caryc@waikato.ac.nz
Total				

Any additional detail on funds usage and desired results/outcomes

Please note that these are wishful projections as much will depend on the global COVID situation and our ability to travel. We will attempt to do as much as we can with teleconferencing but nothing replaces face to face to get action and results.

Percentage of the budget to be used for support of early-career researchers

2020: 20%
2021: 20%
2022: 30%

Percentage of the budget to be used for support of scientists from countries with developing Antarctic programmes

2020: 30%
2021: 30%
2022: 30%

Membership

Leadership

Role	First Name	Last Name	Affiliation	Country	Email	Date Started
Co-Chair	Craig	Cary	U. Waikato	NZ	caryc@waikato.ac.nz	8/2014
Co Chair	Vonda	Cummings	NIWA	NZ	vonda.cummings@niwa.co.nz	8/2014
Sec	*Megumu	Tsujimoto	MPR	Japan	megumutsujimoto@gmail.com	8/2014

Other members

First Name	Last Name	Affiliation	County	Email
Byron	Adams	Bringham Young University	USA	byron_adams@byu.edu
*Charles	Lee	Waikato University	NZ	cklee@waikato.ac.nz
Dana	Bergstrom	Australian Antarctic Division	Australia	dana.bergstrom@aad.gov.au
Dolores	Deregibus		Argentina	dolidd@yahoo.com

Eli	Verleyen		Belgium	Elie.Verleyen@UGent.be
Emmanuelle	Sultan	Museum National d' Historie Meleuelle	France	esulod@locean-ipsl.upmc.fr
Marcela	Libertelli	Instituto Antártico Argentino	Argentina	mlibertelli5@yahoo.com.ar
Peter	Convey	BAS	UK	pcon@bas.ac.uk
Sharon	Robinson	University of Wollongong	Australia	sharonr@uow.edu.au
Soon Gyu	Hong	KOPRI	Korea	polypore@gmail.com
Stefano	Schiaparelli	Unige of MNA	Italy	stefano.schiaparelli@unige.it
Steve	Colwell	PSG rep	UK	src@bas.ac.uk
Mauro	Guglielmin	ANTPAS rep	Italy	mauro.guglielmin@uninsubria.it

*Please identify early-career researchers with * in first column*

Additional information (optional)

Please add any more detail here that you wish, on your subgroup activities, papers published, etc.

Notable Papers

(*Five to ten most notable papers – see the example below, which includes a brief statement (shaded) indicating the link to the group*)

Direct support from outside organisations received for your activities

(*Numbered list with values indicated if direct cash support. Please restrict in-kind support to substantive in-kind support only*)

1. The New Zealand Antarctic Research Institute, instruments and logistics $25K
2. Antarctica New Zealand – subsequent in kind logistics support - ~$50K
3. University of Waikato, New Zealand – instrumentation and salary - ~$30K
4. National Institute of Water and Atmospheric Research, New Zealand - instrumentation and salary - ~$30K
5. ECO-Antarctica – attendance for meeting, workshop, and subsequent follow up work, U. Wollongong, Australia $28K.

Major collaborations your Science Group has with other SCAR groups and with organisations/groups beyond SCAR

Within SCAR

1. ISSA – ANTOS has linked with this programme and hopes to develop a significant extension of the network into the Sub-Antarctic islands

Outside SCAR

1. NZARI – The New Zealand Antarctic Research Institute has co-supported the placement of two ANTOS Tier 1 systems at Cape Adare, Victoria Land. Antarctica New Zealand through the Antarctic Science Platform have agreed to maintain these very remote but critical systems for at least the next seven years.
2. ECO-Antarctica (a project within the U. Wollongong's Global Challenge initiative) –The aims of ECO-Antarctica are to bring together the newly formed trans-Tasman network, understand the current state of monitoring Antarctic ecosystems, to start developing an ANTOS field manual and plan how we move forward in order to develop an Antarctic-wide observing system for near-shore and terrestrial ecosystems.
3. New Zealand Antarctic Science Platform – Science objectives within Project 3 (*Ross Sea Region ecosystem dynamics in a warming world*) include installation of ANTOS tiers to gather biologically relevant environmental information

Outreach, communication and capacity-building activities
Brief highlights of any activities undertaken since the SCAR Delegates meeting in 2018.

Cummings, V.J., Cary, S.C. (2019). ANTOS. Presentation to Trans-Tasman ECO-Antarctica Workshop, Austinmer, NSW, Australia,19-23 August.

Report on the ECO-Antarctica Workshop, prepared for to the Global Challenges Program, University of Wollongong (September 9th 2019). *Copy available on request.*

SCAR fellowship reviewers

As part of SCAR's Capacity Building efforts, such as the Fellowships and Visiting Scholar Awards, we are looking for people from all the SCAR groups to form a 'review panel' so if applications in your field are submitted we have people to contact to help assess relevant applications. Please list one or more people (name and email address) from your group who would be willing to serve as reviewers for the next few years, along with 1-3 keywords on their principal expertise.

First Name	Last Name	Email	Principal Expertise
Craig	Cary	caryc@waikato.ac.nz	Microbial ecology
Vonda	Cummings	vonda.cummings@niwa.co.nz	Marine ecology, benthos, ecophysiology

UKNCAR Reporting Template

Provide up to two pages of information following the structure below, only filling out those sections where there is new information to report.

1. Principal UK Researchers	Dr Adrian Fox, BAS. Co-Chief Officer, SCAR Standing Committee on Antarctic Geographic Information (SCAGI).
2. Major activities and progress since previous year involving UK personnel/infrastructure	1) SCAGI meeting held at University of Pisa 3-4 June 2019, including workshops on updating SCAR Air Operations Planning Maps Series and review of place-names guidelines. Meeting Chaired by A. Fox. 2) Publication of 2019 versions of SCAR Air Operations Planning Maps Series. This is a series of maps designed for planning and situational awareness for Antarctic air operations. There is an overview map and 16 maps at 1:1M scale produced as a collaboration between UK (Sheets 1-7), Norway (Sheet 8), Belgium, with Australia (Sheets 9 and 10), and USA (Sheets 11-16). The 2019 issue was a major update with new elevation data based on the Reference Elevation Model of Antarctica (REMA) and Tandem-X radar data from DLR/Airbus. The map data was also available in formats for Avenza and Foreflight tablet apps used by Antarctic pilots. 3) Release on May 12 2020 of V7.2 of the SCAR Antarctic Digital Database, managed by BAS for SCAR. This release included updates to the coastline in the area around Thwaites Glacier (focus of Thwaites Glacier International Collaboration), new data for S. Shetland Islands and S. Orkney Islands, as well as significant improvements to the underlying system and data download facility. 4) A. Fox (who is also Secretary of the UK Antarctic Place-names Committee) contributed to a review of place-names guidelines led by Co-Chief officer Jean-Yves Pirlot (Belgian national mapping agency).
3. Major future initiatives and actions involving UK personnel/infrastructure	Two online meetings planned for 29 and 31 July, times optimised for eastern and western hemisphere. To replace covid-cancelled meeting in Hobart.
4. Policy outcomes	
5. Selected publications	*SCAR Air Operations Planning Maps Series.* *V7.2 of SCAR Antarctic Digital Database.* *https://www.add.scar.org/*
6. Funding awards	
7. Points for discussion at UKNCAR meeting	

UKNCAR Reporting Template

Provide up to two pages of information following the structure below, only filling out those sections where there is new information to report.

1. Principal UK Researchers	UK Polar Network
2. Major activities and progress since previous year involving UK personnel/infrastructure	*Writing Successful Proposals workshop* In September 2019 we ran a workshop on writing successful proposals and a social media for conferences session. *School visits* Since September 2019 we conducted 16 visits to schools across the UK. The visits either entailed workshops or presentations, and focussed on one class, year groups, or sometimes entire schools. *Antarctic Flags and Antarctica Day* Our flag scheme is continuing to increase in popularity. This year 71 schools participated, digitally sending 323 flags from across the world to Antarctica. For Antarctica Day 2019, we ran a social media campaign with a series of posts containing the historic overview, photos and current insights from our fieldwork in Antarctica *Webinar: Antarctic Bursary Information* We hosted a webinar with APECS in January to give information to all early career researchers about the Antarctic Science Bursary. *Webinar: Science outreach in schools* In February 2020 we held a webinar on outreach in schools. The webinar was led by two of our committee; one of whom is a teacher and another a PhD student who worked in polar education for two years beforehand. The webinar had 43 sign ups and 24 watched for the entire session. *APECS International Online Conference* Committee members assisted as presentation judges. *Social media campaigns* Due to the current global pandemic and the cancellation of our festival outreach and other plans, we tried to maintain contact with our network and wider community with a polar Origami Challenge. We have also posted about our

	committee members to highlight the role of early career researchers in science and with the aim of inspiring others.
3. Major future initiatives and actions involving UK personnel/infrastructure	*Social media campaigns* We have plans to run a polar quiz online after our origami challenge is over. We will then run a series of posts with polar media recommendations (podcasts, books, films etc). *A Polar Pint* We planned three polar Pint of Science events, to be co-hosted by the UK Antarctic Heritage Trust, in three cities (Bristol, Cambridge and Edinburgh) on 19th March. These will now be postponed to later in the year or early next year. *Discussions on supporting minorities* We are in discussions with our committee and others on how we can better support minorities in polar science, and this will be a major focus going forward.
4. Policy outcomes	-
5. Selected publications	-
6. Funding awards	-
7. Points for discussion at UKNCAR meeting	-

Report from UK Polar Data Centre (PDC) for UKNCAR 15/06/2020

The UK Polar Data Centre is the UK's National Antarctic Data Centre. It provides a secure long-term repository for polar and cryospheric data. Data are made available, normally using the UK Open Government Licence (http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/), and can be provided with a DOI to allow proper citation of the data. Below are a few updates that are likely to be of relevance to the UK Antarctic community.

Commissioning of NERC Data Centres

NERC has commissioned all of its Data Centres as part of a single National Capability Environmental Data Service. Each data centre remains as a distinct identity under the management of its associated Research Centre but we are aligning policies and procedures where this makes sense. We are also working on ways to increase interoperability between multidisciplinary environmental data sets.

Funding for data accessioning

NERC large and strategic grant funds are top-sliced to form a pot of money which is split among data centres appropriately so that they have the necessary funding to accession data generated from NERC grants. The UK PDC ensures that all relevant polar grants have an active data management plan throughout the project and encourages submission of the data to the PDC at the end of the project. Researchers seeking funding from non-NERC sources for projects that will generate new polar data should consider including costs within the proposal for the UK PDC to accession these data and manage them for the long-term. Advice on this can be sought from Katy Buckland (kabuck@bas.ac.uk).

SCADM

The Standing Committee for Antarctic Data Management has monthly video calls which are attended by Helen Peat. There was a face to face meeting in Helsinki in November 2020 as part of Polar Data Forum III. Three members of the PDC attended this meeting. The terms of reference for SCADM can be found in Appendix A. One of its primary aims is to support National Antarctic Data Centres in making Antarctic data FAIR (Findable, Accessible, Interoperable and Reusable). Finding data is facilitated by the Antarctic Master Directory which is a metadata catalogue provided by NASA's Global Change Master Directory. Work is ongoing to develop a new data discovery tool that can search many data catalogues simultaneously rather than relying on metadata records being compiled in a single catalogue.

SCADM is keen to work more with SCAR's research programmes and can provide data management advice, particularly when the research programme includes development of a data product. You can get in touch with me or the SCADM Chief Officer, currently Johnathan Kool at AADC, if you would like to find out more.

SOOS

A member of the PDC, Petra ten Hoopen is co-chair of the data management subcommittee of the Southern Ocean Observing System (SOOS).

Contribution to international data collaborations

The PDC has published an international compilation of data on krill length frequencies (https://doi.org/10.5285/DFBCBBF9-8673-4FEF-913F-64EA7942D97A); contributed bathymetry data

to the International Bathymetric Chart of the Southern Ocean, International Bathymetric Chart of the Arctic Ocean; exposed more data sets through the Global Biodiversity Information Facility which also makes them available via the SCAR Antarctic Biodiversity Information Facility (e.g. krillbase abundance data, BAS bongo net data) and to SOOS.

Helen Peat 9/06/2020

Appendix A: The Terms of Reference[1] for SCADM are to:

1. Promote long-term preservation and accessibility of data relating to Antarctica and the Southern Ocean in sustainable repositories.

2. Assist in establishing and implementing Antarctic data management policies, priorities and best practices, taking into account and contributing to global best practices.

3. Promote a distributed, interoperable network of accredited National Antarctic Data Centres (NADCs), in accordance with ATCM XXII Resolution 4.1 (1998)[2].

4. Encourage and enable the community to make data Findable, Accessible, Interoperable, and Re-usable according to the FAIR Principles[3] by submission of metadata and data to the Antarctic Data Management System (ADMS).

5. Further develop, design, implement, and improve the ADMS - a system that encompasses the Antarctic Master Directory (AMD), NADCs, other interoperable, networked data repositories, and key data discovery tools.

6. Provide linkages and improve interoperability with other relevant data management systems, initiatives, and repositories; and thereby enhance the accessibility of data relating to Antarctica and the Southern Ocean.

7. Provide guidance to the AMD host.

8. Work with other SCAR groups, Council of Managers of National Antarctic Programs, Committee for Environmental Protection, Commission for the Conservation of Antarctic Marine Living Resources, the Antarctic Treaty Secretariat, and other relevant groups to identify, develop, and publish fundamental datasets of value to the Antarctic Community.

[1] The procedural parts of SCADM's mandate are covered in SCAR's "Rules of Procedure for Subsidiary Bodies", see https://scar.org/scar-library/search/governance/780-rules-of-proc-subsidbodies-aug10/

[2] http://www.ats.aq/devAS/info_measures_listitem.aspx?lang=e&id=258

[3] https://www.force11.org/group/fairgroup/fairprinciples