Antarctica on the edge

highlights of the SCAR Scientific Research Programme Antarctic Climate Change over the 21st Century

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SCAR AntClim21

Antarctic Climate Change over the 21st Century (AntClim21) focussed on the critical issue of estimating how the Antarctic climate system may change over the 21st century.

Although the focus was on physical components of the system, specifically atmosphere, ocean and sea ice, strong links across disciplines led to some of the most exciting and high impact science.

Key to making scientific progress has been the evaluation of climate models against observations and reconstructions of the past, ranging from the modern instrumental period to longer-term paleo-reconstructions.

This document summarises the major achievements of AntClim21 both scientifically and in terms of community outreach and capacity building.

Credit: British Antarctic Survey

Credit: NASA MODIS Image 11 July 2005

AntClim21 structure

Theme 1: Quantification of Antarctic climate variability

Theme 2: Climate model verification for the Antarctic region

Theme 3: Antarctic climate projection and impacts to 2100 AD and beyond

Improved projections

Credit: British Antarctic Survey

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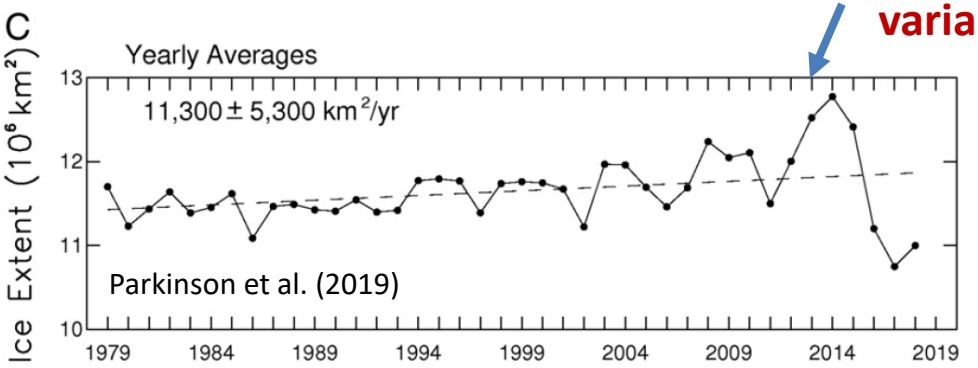
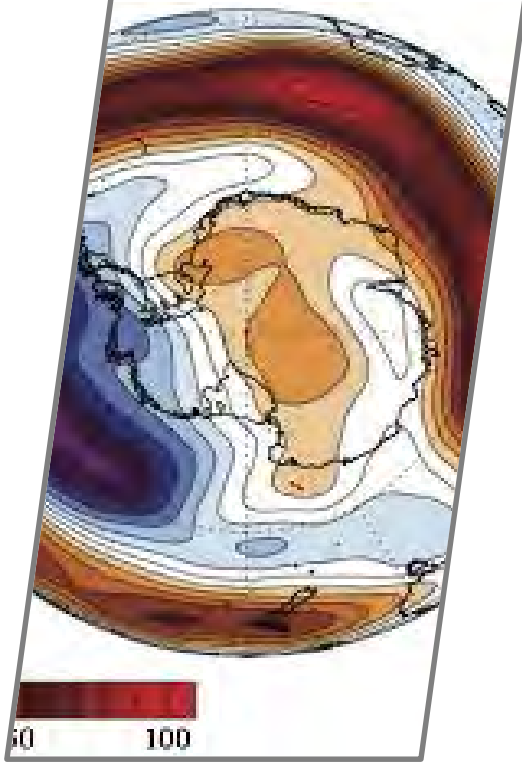
A highly variable system

Theme 1: Quantification of Antarctic climate variability

2013 AntClim21 workshop on variability



Satellite-observed annual mean Antarctic sea ice extent



Credit: Mayewski et al. (2015)

In 2013 AntClim21 held a workshop on Antarctic climate variability. One of the outcomes was a paper on 'Potential for Southern Hemisphere climate surprises' (Mayewski et al., 2015). The paper warns of unexpected events in the future based in a large part on knowledge of past variability gained from multiple sources ranging from modern reanalyses to ice core proxies. A subsequent example is the strong atmospheric variability that contributed to the sudden and unexpectedly rapid decline in Antarctic sea ice in 2016.

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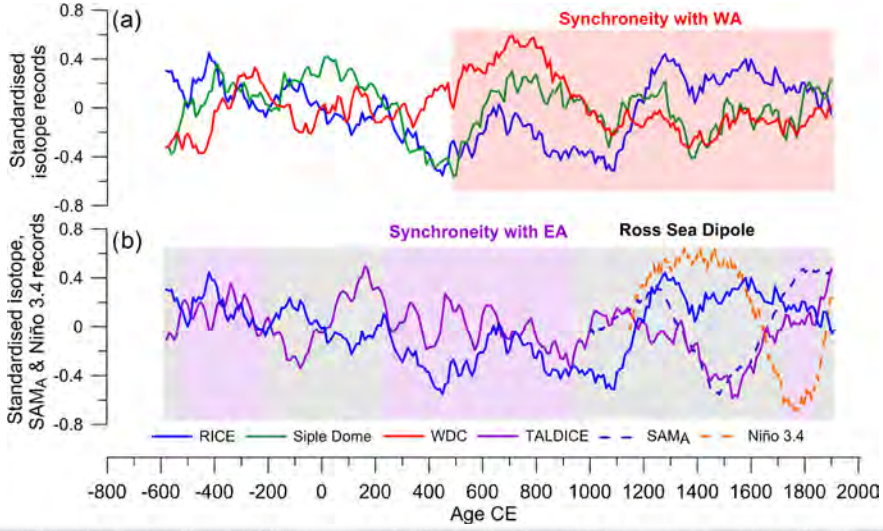
A highly variable system

Theme 1: Quantification of Antarctic climate variability

Linking modern observations with past reconstructions is key to quantify and understand natural climate variability and assess the emergence of anthropogenic influences. A 2,700 year record revealed that for most of the period the eastern Ross Sea warmed while West Antarctica cooled, known as the Ross Sea Dipole. This illustrates the complexity of regional Antarctic change and the importance of extensive and diverse climate records.

Credit: Nancy Bertler



Phasing of multi-decadal and centennial climate temperature Variability at a range of Antarctic sites along with major climate indices. Bertler et al. (2018)

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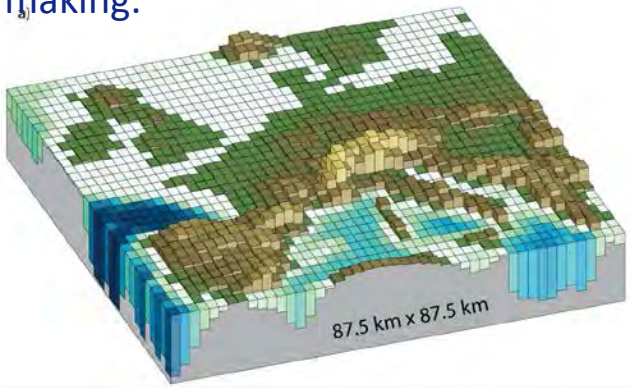
Identifying and developing the best tools

Theme 2: Climate model verification for the Antarctic region

Combining observations and models (theory) is of fundamental importance to science. Climate models will never exactly match reality, but it is important that they provide useful information on real-world behaviour of the climate system. This requires both assessment to inform the best use of existing climate models and development of the next generation.

For AntClim21 the main focus was the question of how climate may change over the 21st century. In this context priorities were to support informed decision making.

Credit: NASA Apollo 17



IPCC AR5 Figure 1.14

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A multi-disciplinary community-based perspective to climate model evaluation

Theme 2: Climate model verification for the Antarctic region

Credit: David Ainley

The **#GreatAntarcticClimateHack** was a pioneering hybrid meeting held both online and in person at Scripps Institution of Oceanography, 9–12 October 2017 (Khan et al., 2018). It was aimed discussing and deciding on metrics to help evaluate and thus improve the next generation of climate projections that form part of the scientific basis of IPCC reports. Key aspects of the workshop were:

- Community agreement on a set of metrics for climate model evaluation.
- Multi-disciplinary participation - oceanography, glaciology, atmospheric research, aquatic biogeochemistry, and biology.
- Capacity building, with attendees including researchers from more than 17 countries and a high proportion of early career scientists (29 from 92). Approximately half of all attendees joined remotely.

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#Great Antarctic Climate Hack

#Great Antarctic Climate Hack

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Ross ice shelf

NASA images courtesy Jeff Schmaltz, MODIS Rapid Response Team at NASA GSFC

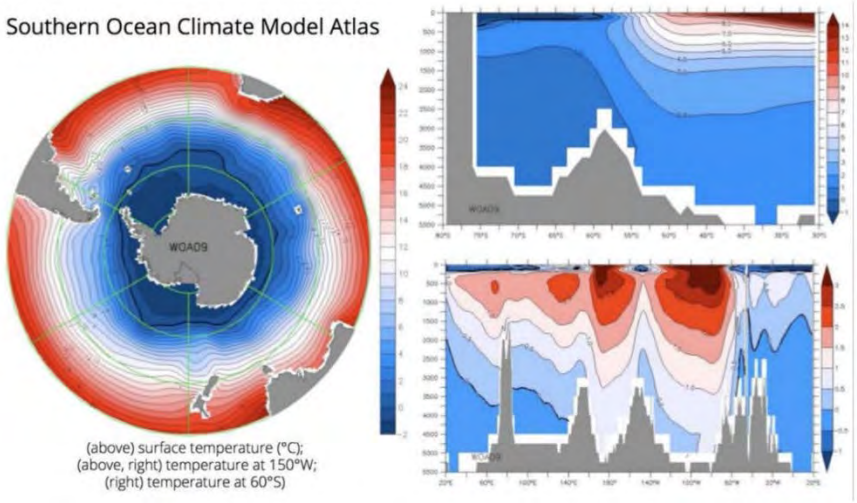
Harnessing major advances in observations and modelling

Theme 2: Climate model verification for the Antarctic region

New metrics for the evaluation of climate models against the latest observational data have provided a clearer picture of the strengths and weaknesses of climate models and priorities for making future improvements (Russell et al., 2018). This research fed into the current IPCC AR6 report and also involved a strong link with the Southern Ocean Carbon and Climate Observations and Modeling (SOCCOM) project.

Credit: SOCCOM

The Southern Ocean Climate Model Atlas developed in collaboration with SOCCOM.



(above) surface temperature (°C); (above, right) temperature at 150°W; (right) temperature at 60°S)

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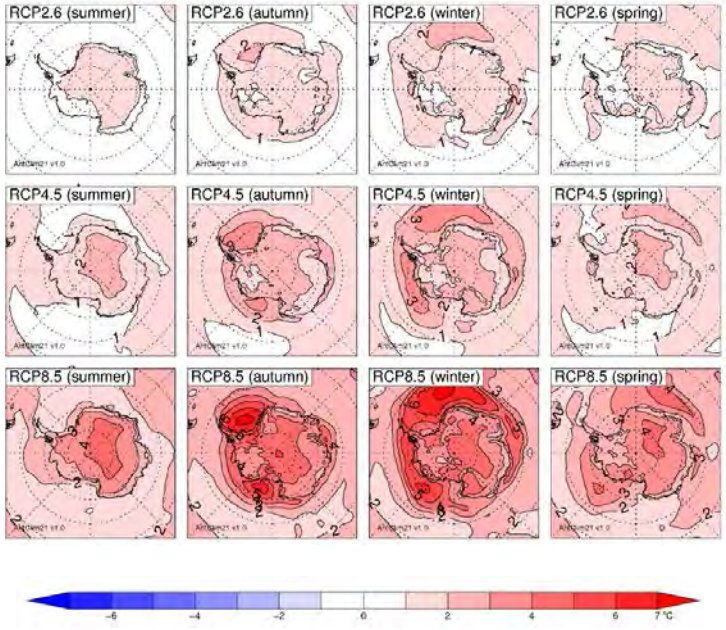
SOCCOM

What does the future hold?

Theme 3: Antarctic climate projection and impacts to 2100 AD and beyond



Projections of 21st Century change in surface air temperature (°C) from multiple climate models.

New methods were developed that provide more reliable regional 21st century projections of Antarctic climate change. These were used to extract information from the climate model datasets that underpin science evidence for the IPCC process. Projections were produced of variables including temperature (terrestrial and sea surface), precipitation, and winds. See Bracegirdle et al. (2020a, b).

Credit: British Antarctic Survey

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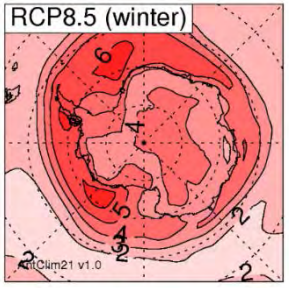
Cross-disciplinary collaboration

Theme 3: Antarctic climate projection and impacts to 2100 AD and beyond

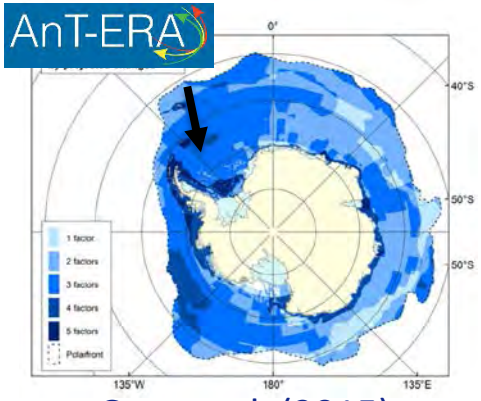


AntClim21 provided expert interpretation of climate projections to support studies on impacts of climate change on ocean ecosystems. Important achievements in this area involved collaboration with other SCAR SRPs:

- Multiple climate change stresses over the Southern Ocean (with SCAR Ant-ERA).
- Future Southern Ocean seafloor climate change (with SCAR AntEco).

Credit: David Ainley

AnT-ERA



Gutt et al. (2015)

Ant Eco
State of the Antarctic Ecosystem

Griffiths et al. (2017)

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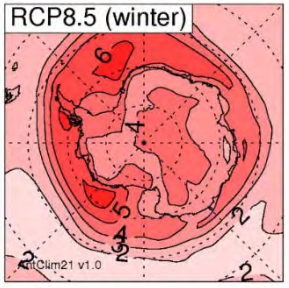
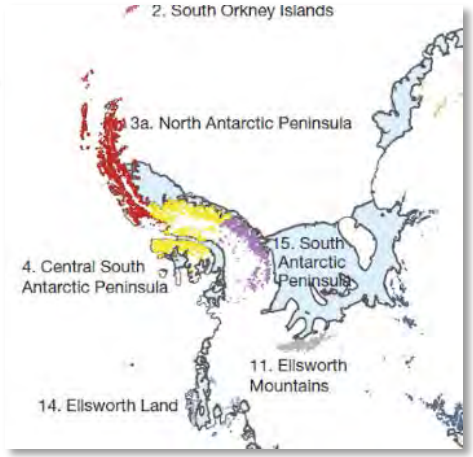
Cross-disciplinary collaboration

Theme 3: Antarctic climate projection and impacts to 2100 AD and beyond



Climate model projections were provided to underpin a study on the potential for future expansion of ice free areas over Antarctica.

This showed that Climate change drives expansion of Antarctic ice-free habitat. Under the strongest forcing scenario, ice-free areas could expand by over 17,000 km^2 by the end of the century, close to a 25% increase. See Lee et al. (2017)



Credit: https://www.science.org.au/curious/earth-environment/amazing-antarctic-moss

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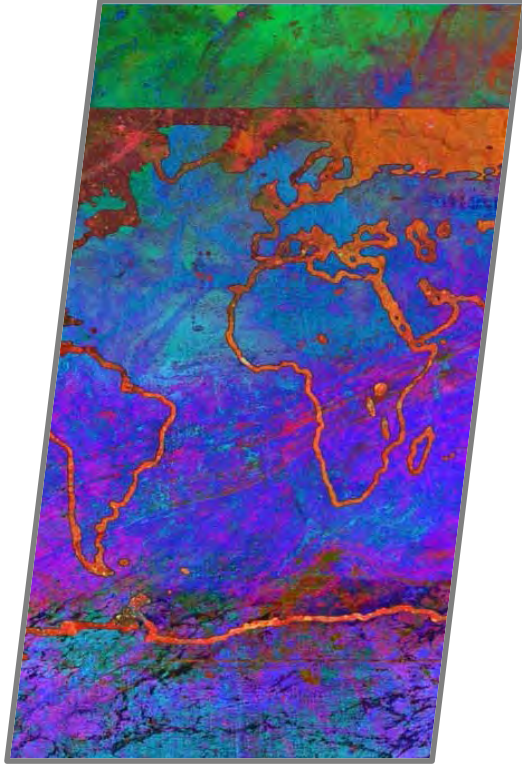
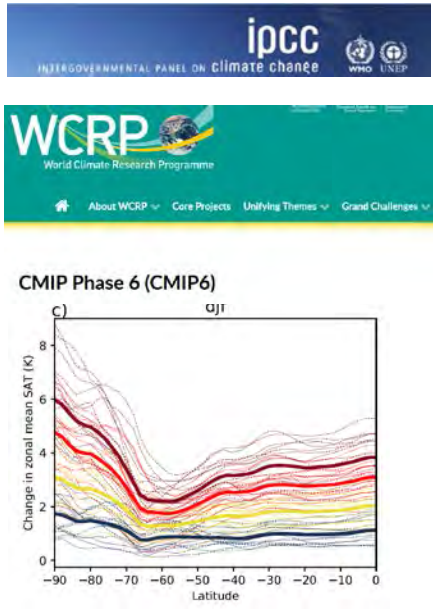
New findings from AntClim21 contributed to IPCC AR6 WG1

Theme 3: Antarctic climate projection and impacts to 2100 AD and beyond

AntClim21 papers provided, or contributed to, the following results that have been included as part of the scientific evidence in the IPCC AR6 WG1 report: (i) Showed that the representation of southern mid-latitude westerlies is improved in the current generation of climate models (Bracegirdle et al., 2020a); (ii) Outlined further improvements and remaining challenges in the representation of sea ice and the Southern Ocean (Beadling et al., 2020; Roach et al., 2020); (iii) Provided an updated assessment of climate projections (Bracegirdle et al., 2020b); and (iv) collaborated on updated sea-level projections through ISMIP6 (Nowicki et al., 2020; Payne et al., 2021).



Credit: IPCC



Projections of 21st Century change in surface air temperature (°C) from multiple scenarios based on CMIP6 data (Bracegirdle et al. 2020b).

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A vibrant international community

AntClim21 workshop on CMIP6 21st century projections and predictions

Aurora Conference Theatre
British Antarctic Survey, Cambridge

19th June 2019

Credit: British Antarctic Survey

During the lifetime of AntClim21 a vibrant international community of Antarctic scientists was developed. This was achieved through workshops, conference sessions and networking events. Support for Early Career Researchers and participants from emerging Antarctic nations helped to increase diversity of the community.

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nature reviews earth & environment

WCRP World Climate Research Programme

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British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

Supporting and encouraging ECRs

Supporting Early Career Researchers (ECRs) was an integral part of AntClim21. Types of support included Steering Committee (SC) membership, travel grants for conference and workshop attendance, networking events, and presentation prizes. An example of success in this regard is the career progression of Dr Alia Khan, who was selected as ECR Representative on the AntClim21 SC.

ECR poster prize award at the 2019 CMIP6 workshop

"In general, the ECR support allowed me to expand my professional Antarctic network, which has been hugely beneficial as I transitioned from a PhD student to Postdoc and now Assistant Professor."
Dr Alia Khan, former AntClim21 ECR representative

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