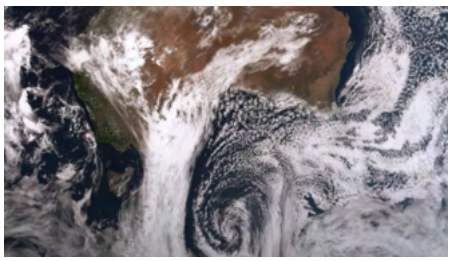
RESEARCH AND IMPACT REPORT 2019–2023

Pack ice and sunset (photo: Sachie Yasuda)

The Australian Antarctic Program Partnership will improve our understanding of the role of Antarctica and the Southern Ocean within the global climate system and its implications for marine ecosystems.

Antarctica's influence on climate and sea level

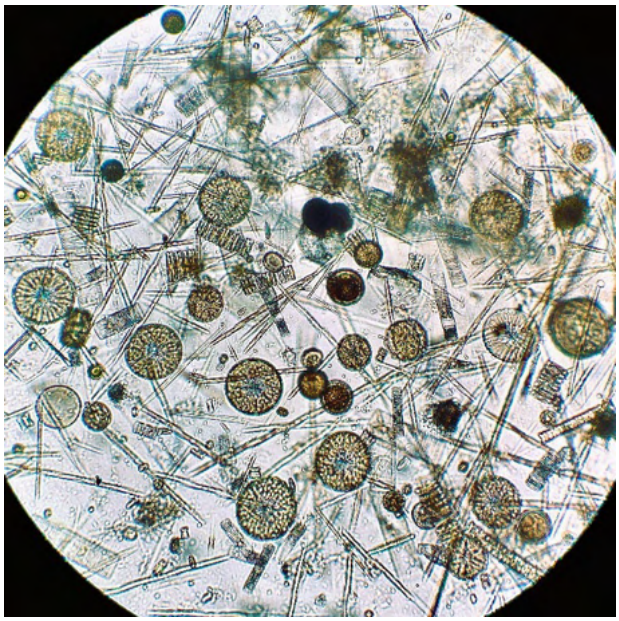


Antarctica and the Southern Ocean play a major role in global climate and have a strong influence on weather and climate in Australia. The future of the Antarctic ice sheet will determine global sea level rise.

Understanding how ocean, atmosphere and ice interacts is important for improved weather forecasts, climate prediction, emission targets, coastal management and water security in Australia.

Atmosphere

We fill in the gaps of climate models to better represent the role of clouds over the Southern Ocean and the small airborne particles (aerosols) that seed them. Clouds in the Southern Ocean are different from elsewhere in the world because they are seeded by aerosols from the ocean itself, such as sea spray and sulfuric gases emitted by some phytoplankton.



Our atmosphere team is analysing atmospheric observations collected from ships, aircraft and satellites to quantify key aerosol, cloud and precipitation properties, and the surface 'radiation budget' south of 40°S. We use machine learning to more accurately simulate the amount of solar energy entering the Southern Ocean, so improving computer models.

We launched an initiative called PICCAASO, standing for '**P**artnerships for **I**nvestigations of Clouds and the biogeo**C**hemistry of the **A**tmosphere in **A**ntarctica and the **S**outhern **O**cean.' The aim is to encourage and improve global coordination and collaboration of research campaigns on Antarctic stations, in the air and at sea by sharing resources, ideas, and data.

Ice cores

We read the gases and chemicals trapped in ice cores to provide historical records of past climate and understand the links between Australian and Antarctic climates. From ice cores, we have extended Australian rainfall records to 2000 years — showing that eastern Australia's drought risk is greater than thought — and can reconstruct wind speeds, temperatures and sea-ice extent in East Antarctica over the last 2000 years.

One of our PhD students is tracing volcanic ash in an ice core from coastal East Antarctica to extend the volcanic record of Heard and McDonald Islands and see if their eruptions are a source of iron fertilising the adjacent Southern Ocean.

Following the first traverse to the Million Year Ice Core site, we are establishing a new gas lab in Hobart to analyse the ice cores that will come from Little Dome C over the next few years.

Ice shelves

We investigate the vulnerability of ice shelves in East Antarctica to warming and how they lose ice through melting and calving. Over the next few fieldwork seasons, we plan to measure ice motion and melt on Denman Glacier, Vanderford Glacier and Amery Ice Shelf.

Internationally, we are part of an initiative that set out future directions for researching ice-ocean melt, and we are helping to build a network called NECKLACE to collect radar data on ice-shelf melt rates right around Antarctica. We have also been collecting airborne radar data over crevasse fields in New Zealand to develop systems that could be used for field safety applications.

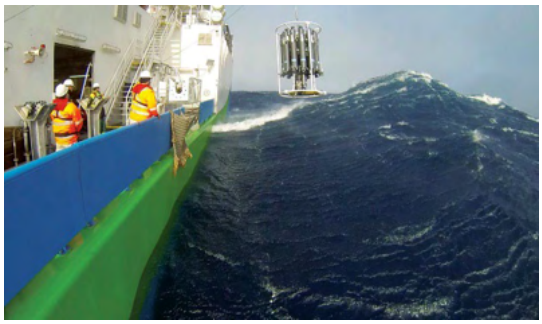
Might less sea ice mean ice shelves are more exposed to ocean swells? For the first time, we demonstrated a link between reduced sea-ice extent and the number of ice-shelf calving events.

Nature and impacts of Southern Ocean change

The Southern Ocean alone absorbs 16% of our global CO_2 emissions, and between 2005 and 2017, 45–62% of Earth's heat gain. As a major sink for storing human-caused heat and carbon, the Southern Ocean is very influential in the climate system as a buffer against global heating.

Our research seeks to know how the environment is changing and assess the impacts on climate, sea level, sea ice, and marine ecosystems.

Oceanography



The Antarctic Circumpolar Current (ACC) is the boundary between warm northern and cold polar waters that blocks heat from being carried poleward.

Antarctica is losing mass as warmer waters erode it from below. We want to know how changes in ocean circulation and temperature will affect East Antarctic ice shelves by understanding the factors that regulate poleward ocean-heat transport across the Southern Ocean to cavities under ice shelves.

'Standing meanders' are a key component of the ACC circulation system. These snaking currents are energetic hotspots, and we're investigating how they influence the mixing of heat and carbon.

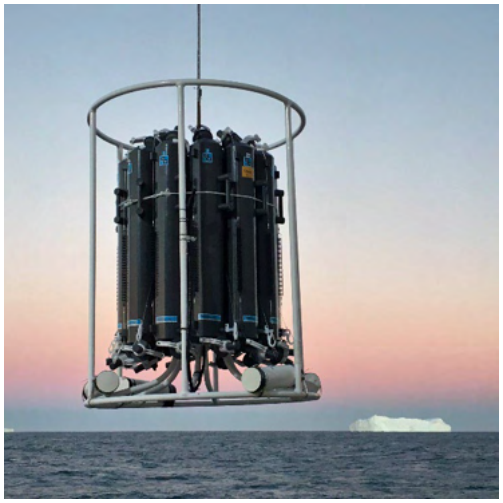
We complement ship-board sampling with autonomous profiling floats capable of profiling the full ocean depth, to provide year-round observations of the East Antarctic sector of the Southern Ocean.

By using Deep Argo floats, we track the passage of Antarctic Bottom Water to the abyss and monitor the 'overturning circulation' that is crucial for driving global currents.

We are also working with the new SWOT satellite, jointly developed by NASA and the French space agency CNES, to observe the Southern Ocean from space in unprecedented resolution.

Biogeochemistry

We assess changes in the biogeochemical environment of the Southern Ocean by comparing new observations to past measurements. Using BGC-Argo floats, moorings, gliders and CTD samples, we measure heat and CO_2 uptake, dissolved oxygen, the progress of ocean acidification, and the supply and distribution of trace elements like iron (a key micro-nutrient that regulates the productivity of Southern Ocean ecosystems).



AAPP researchers found that the iron content of smoke from the Black Summer bushfires in 2019–2020 caused phytoplankton concentrations to double between New Zealand and South America, until the bloom area became bigger than Australia — and lasted for four months.

This research linking forests, wildfires, phytoplankton growth, the iron-limited Southern Ocean and Earth's climate is important for a warming world of more frequent and intense fire events.

In the ocean's 'biological carbon pump', carbon is taken from the atmosphere by microscopic plants, or phytoplankton, and then transferred to deep storage by the zooplankton that graze on them.

AAPP has been awarded an ARC Discovery grant for a project on zooplankton and ocean productivity in a changing climate. Understanding how iron is cycled through zooplankton will help quantify current and future patterns of ocean productivity critical for environmental and economic predictions.

Getting marine carbon cycling right in our climate models needs better understanding of how quickly zooplankton eat phytoplankton.

AAPP research with our partners is filling knowledge gaps about zooplankton grazing rates so we can improve projections of future climate states and food security.

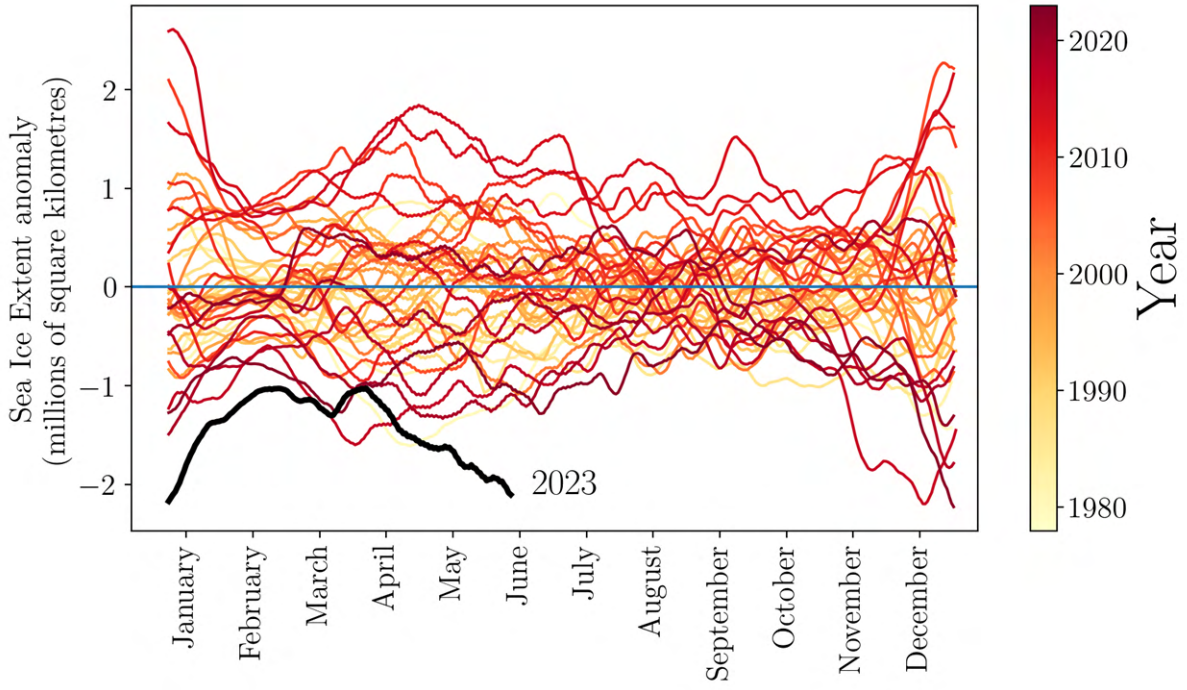
Future of sea ice, krill and ecosystems

Changes in Antarctic sea ice can have a global impact on heat balance and ocean circulation. Sea ice is also critical habitat for krill, a keystone species of the Southern Ocean.

How Antarctic sea ice is changing and why, and what this means for the broader marine ecosystem, remains poorly understood. This is critical information for Australia to effectively manage the challenges of future climate variability and change, as well as Marine Protected Areas and fisheries (such as setting krill catch limits).

Sea ice

An interactive Antarctic map called 'Nilas' has been developed to enhance climate research in the sea-ice zone and assist voyage planning. It brings together historical and near-real-time data Southern Ocean data on sea ice, chlorophyll (a proxy for phytoplankton production), and sea-surface temperature around Antarctica.



A cross-project team is reviewing the physical and biological impacts of the extreme lows in Antarctic sea-ice extent we have been tracking over recent years, and assessing the role of the Southern Ocean in sea-ice change and variability using climate and ocean-sea ice models. We are working to

communicate the significance of our science and inform policy makers about the implications of these changes.

Our sea-ice scientists have led the first-ever broad review of Antarctic 'landfast' ice — the critically important but often overlooked stationary sea ice fastened to the coast. Their research also shows a dramatic crash in the extent of landfast ice in 2022. Much of the ice lost had been present for the previous 20 years.

Krill and ecosystems

We conduct lab-based experiments on diatoms and other key phytoplankton groups from the subpolar and polar ocean to provide insights into their comparative physiology, as well as pilot studies to determine important zooplankton groups (in addition to krill) that can be maintained in culture in labs or onboard a ship.

Such experiments enable us to determine the present-day physiological capacity of Southern Ocean and sea-ice lifeforms and their resilience to change, and also to explore how linkages within food webs — such as between predators and prey — will be influenced by environmental change.

We are analysing data collected by KOMBIs, the Krill Observational Mooring for Benthic Investigation. Carrying echosounders, cameras, acoustic recorders and a range of sensors, these landers sit on the seabed during the winter to record the movements and behaviour of krill and their predators. We are building sophisticated models to simulate the energetics and habitat over the full life-cycle of krill populations in East Antarctica.

Our scientists are authors of a global review on monitoring and modelling marine zooplankton, warning that without knowledge about the impacts of predicted climate change on their populations, the future for entire ocean ecosystems and commercially important fisheries remains unclear.

FIELDWORK

Since 2019...

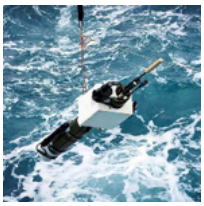
Completed voyages and expeditions

TEMPO
(Trends in Euphausiids off Mawson, Predators, and Oceanography)
2021

Investigating the distribution, density and connectivity of populations of Antarctic krill, to better understand the distribution and contribution of deep-sea krill to overall krill biomass.

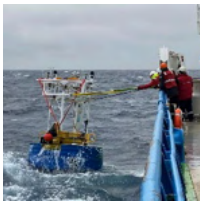
SOLACE
(Southern Ocean Large Areal Carbon Export)
2021

Developing an approach to quantify the changing effectiveness of CO_2 sequestration by the ocean's biological pump, using satellites, floats and autonomous vehicles.



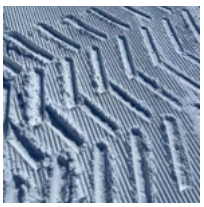
SOTS
(Southern Ocean Time Series)
2021/2022/2023

The Southern Ocean Time Series site southwest of Tasmania comprises several automated moorings including a deep ocean sediment trap mooring, a surface biogeochemistry mooring and an air-sea flux mooring.



MYIC
(first traverse of the Million Year Ice Core project)
2023

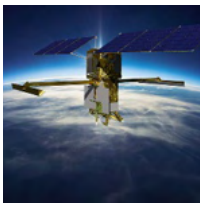
Drilling a three-kilometre deep ice core from Little Dome C between now and 2027, which the AAPP will help analyse for a potential climate record extending more than one million years into the past.



Planned voyages and expeditions

SWOT
(Surface Water Ocean Topography)
Nov 2023

From ocean observations, the voyage will validate the SWOT satellite measurements and analyse sea-surface height across a wide swath for the first time.



MISO
(Multidisciplinary Investigations of the Southern Ocean)
Jan 2024

A 59-day voyage on RV *Investigator* of multidisciplinary research activities linking physics, biogeochemistry, plankton, aerosols, clouds, and climate of Southern Ocean.

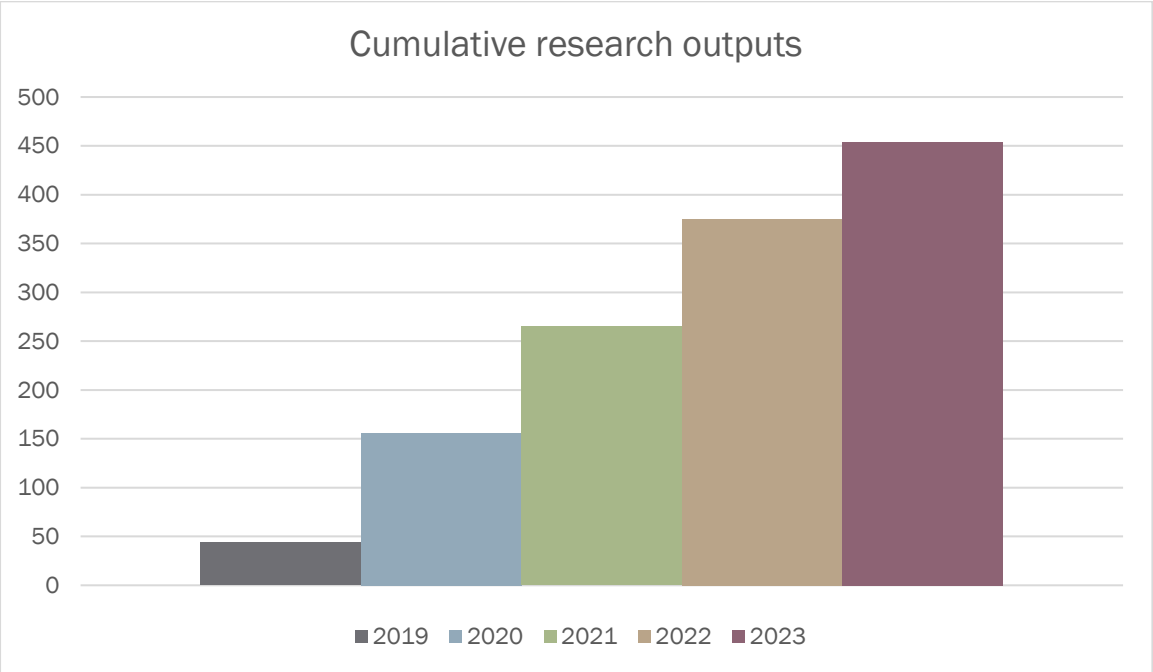
Denman Glacier
2024

Denman Glacier has potential to be one of the fastest retreating glaciers in east Antarctica — this fieldwork will investigate what's happening on both the floating ice shelf and in the ocean underneath, at the same time.

PUBLISHING AAPP RESEARCH

Journal articles, briefings, papers, chapters, and datasets by year

2019	2020	2021	2022	2023 (to Oct)
44	**112**	**109**	**110**	**79**



ON TOPIC

Research publications by AAPP projects, 2019–2023 (to Oct)

Atmosphere	Ice cores	Ice shelves	Oceanography
50	**57**	**49**	**76**

Biogeochemistry	Sea ice	Krill and ecosystems	Total number of publications
88	**89**	**123**	**454**

(note: 78 publications cover more than one project)

TELLING THE WORLD

AAPP media coverage, 2019–2023 (to Oct)

Newspaper articles	Radio stories	TV reports	Magazine features	Online stories	Podcasts
42	**51**	**20**	**25**	**149**	**6**

USE OF AAPP RESEARCH IN POLICY REPORTS

Number of AAPP publications cited since 2019

State Government (e.g. Vic and NSW climate reports)	**18**
Federal Government (e.g, State of the Environment)	**42**
International (e.g. IPCC, CCAMLR)	**162**

PRESENTATIONS AND OUTREACH

2019–2023 (to date)

National conferences	**54**
International conferences	**116**
Elected reps & govt departments	**13**
Professional bodies and NGOs	**3**
Industry and business groups	**6**
General public	**13**
Schools	**15**
Seminars	**22**

THE POWER OF PARTNERSHIPS

AAPP contributors by home institution, 2023

96
in-kind staff

32
in-kind staff

24
in-kind staff

3
in-kind staff

Australian Ocean Data Network

2
in-kind staff

VALUE-ADDING

Grants secured by AAPP participants, 2019–2023

National $32.8M

International $1.3M

CREATING SCIENCE JOBS IN HOBART

Target: around 260 FTE-years over the 10-year grant period

	2019-2021	2021-2023
Researchers	**14** (+7 for TEMPO voyage)	**20**
Professional/technical	**11**	**14**
Casual	**3**	**8**
TOTAL	**35**	**42**

TRAINING NEW SCIENCE GENERATIONS

2019–2023

PhD students (total of 25 over 10 years) **19**

PhD students with AAPP top-up scholarships **16**

WORKING WITH PARTNERS

Since 2019...

97% of our papers have been published with national and international collaboration, written with a total of 2187 authors

85 collaborative relationships with national and international organisations

The Australian Antarctic Program Partnership is funded by the Australian Government Department of Climate Change, Energy, the Environment and Water through the Antarctic Science Collaboration Initiative.

Australian Government
Department of Climate Change, Energy, the Environment and Water

The Australian Antarctic Program Partnership is led by the University of Tasmania, and includes the following partner agencies:

Australian Antarctic Program Partnership

University of Tasmania IMAS Institute for Marine and Antarctic Studies

Australian Government Department of Climate Change, Energy, the Environment and Water Australian Antarctic Division

Australian Antarctic Program

CSIRO

Australian Government Bureau of Meteorology

IMOS Integrated Marine Observing System

Australian Government Geoscience Australia

Tasmanian Government