ACEAS

Australian Centre for Excellence in Antarctic Science

ACEAS 2024
ANNUAL REPORT HIGHLIGHTS

Director's Message

2024 was very positive for ACEAS and built strongly on the work of previous years. Our overarching goal is to help communities prepare for climate risks emerging from East Antarctica and the Southern Ocean through integrating knowledge of the region's ocean, atmosphere, cryosphere, and ecosystems.

It was a big year for major fieldwork. The Denman Terrestrial Campaign was a collaboration with the other major Australian Antarctic programs – SAEF, AAPP and AAD – and the largest terrestrial science program undertaken by Australia for many decades – possibly ever. The AAD contributed significantly with planning, aircraft and field support. At Bunger Hills, nine out of 13 ACEAS expeditioners were women.

It was a successful year of collaboration. ACEAS co-hosted the Australian Antarctic Research Conference, held in Hobart in November. It was jointly sponsored by AAPP, SAEF and the AAD. ACEAS sponsored 27% of 460 conference registrations. This was the first national Antarctic conference in more than a decade, and allowed our scientists to discuss Antarctic science in a time of abrupt change.

We also co-hosted our second Early Career Researcher and PhD training school with AAPP. More than 40 participants took part in a five-day, sea level change-themed workshop at Triabunna on Tasmania's east coast, featuring scientific lectures, career guest speakers, professional development and team-building activities.

We look forward to again building on this year's success, in 2025.

Matt King – Director

Chair's Message

After commencing in late 2021, the work of ACEAS is now at full speed, revealing processes and change that has never been seen before.

The fieldwork ACEAS researchers have undertaken is in literally unmapped regions. Combined with novel analysis of satellite datasets and world-leading predictive models, the work is shedding new light on change underway, change that is yet to come, and how those changes affect us here in Australia, the Pacific, and the planet.

One of the unique aspects of university-based programs like ACEAS is that they train generations of researchers who will go on to be world-leading scientists and find careers in academia, industry, and government. The high quality of the training in ACEAS is producing some of the most exceptional researchers and ambassadors for Antarctica.

Looking forward, 2025 will see the ACEAS team provide more than half of the researchers on board *RSV Nuyina*, Australia's new and world-leading science icebreaker. They will travel to the Denman Glacier – a glacier system that on its own could raise global sea levels by 1.5m. It is astonishing we know so little about it nor why it has recently retreated several kilometres.

The work of ACEAS is critical to Australia's leadership in Antarctica and the future of Australia's weather and coastlines. Policymakers very much need the insights ACEAS is providing.

Unfortunately, the work of ACEAS will not continue beyond mid 2026 unless new funding is identified. In a time of dramatical global change, Australia and the planet cannot afford Australian Antarctic commitment to dwindle.

Mary O'Kane – Chair

Credit: Pete Harmsen / AAD

Report Highlights

34 postdoctoral researchers employed

20 top-up scholarships for PhD students

ACEAS is celebrating the dramatic increase (from 1 to 15) in the number of female Professors who are Chief Investigators of ACEAS

124 researchers sponsored to attend the Australia Antarctic Research Conference

13 workshops and sessions for ECR development

Co-created the 'Opening the Floodgates' science briefing on present and future sea level rise, accompanied by a website and briefings with politicians

Contributed to the Scientific Committee for Antarctic Research (SCAR) scientific research programs, notably the SCAR INSTANT program

With AAPP, produced a seminar series hosted by the Department of Climate Change, Energy, the Environment and Water (DCCEEW) on ACEAS research

5,400+ social media followers

11,800+ website visits

137 journal articles published. Including 23 in high-profile journals / almost 100% in top-quartile discipline journals

36 participants in major international fieldwork programs

ACEAS researchers took part in the selection of the ice sheet module for the Australian Earth-System Simulator (ACCESS) by NCRIS ACCESS-NRI

Contributed to updated information paper 'Understanding Future Sea-level Change Around Antarctica' presented at Antarctic Treaty Consultative Meeting (ATCM)

ACEAS researchers participated on the German icebreaker RV *Polarstern* voyage to the Denman Glacier region in early 2024

Created a Legacy and Benefits program, which has competitively awarded $500,000 for projects focused on securing the ongoing impact of our research outside of academia

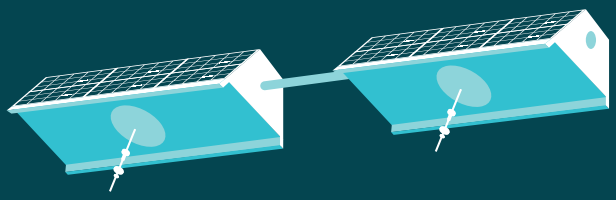
The Denman Terrestrial Campaign. This was the largest terrestrial science program undertaken by Australia for many decades - possibly ever.

PROGRAM HIGHLIGHTS

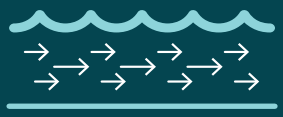
Identified three dominant Antarctic shelf regimes— warm, fresh, and dense – highlighting how the dense regime is disappearing under ongoing climate warming

New sea level reconstructions from 1900 to 2019 refined our understanding of the sea level budget, revealing discrepancies between contributions before and after 1940

New economic evaluations placed a **$180 BILLION** USD per year figure on Southern Ocean CO_2 uptake, emphasising the region's critical role in global ecosystem services



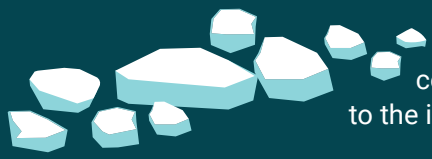
A pioneering global assessment of Antarctic Bottom Water transport variability (via the GRACE satellites) demonstrated how deep ocean flows respond to climatic forcing over the satellite era



New drift studies revealing that floating objects can reach Antarctica from continents north of the Subtropical Front, highlighting unexpected connectivity and biosecurity implications

Developed a novel approach combining ice coring and imaging spectroscopy to determine the impact of light regimes on Antarctic fast-ice algal communities

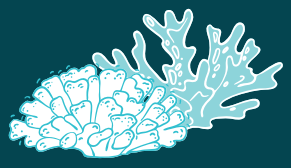
Finalised a protocol for the Southern Ocean Marine Ecosystem Model Ensemble (SOMMEE), an end-to-end ecosystem model designed to assess climate risks under various change scenarios

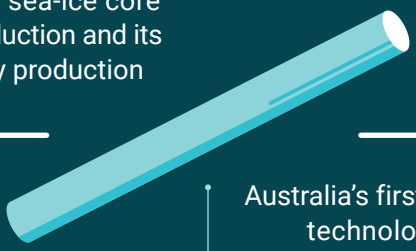


Analysed Antarctic sea-ice extent, concentration and seasonality to contribute to the international State of the Climate reporting

Created the most extensive compilation (> 47,000) of circumpolar benthic images, with more than 3,500 images annotated for seafloor fauna and made available

Completed a compilation of historical sea-ice core data to estimate Antarctic ice algal production and its contribution to Southern Ocean primary production





New modelling tools were developed for tracking meltwater, illustrating how its flow beneath glaciers transports and deposits sediment, influencing marine environments and enhancing coastal change predictions

Australia's first deployment of RAID (rapid) ice drilling technology on Mill Island (Australian Antarctic Territory) positioned ACEAS for detailed future studies of sub-ice chemistry

The release of **BEDMAP-3** and new Denman Trough constraints have greatly improved ice-bed elevations and crustal heat-flow mappings for ice-sheet modelling and stability forecasts

Two consecutive Denman Terrestrial Campaign field seasons collected multi-method geophysical datasets across the Denman Glacier region, archiving data for glacier-structure and GIA studies

Credit: Coti Manassero

Denman Glacier Terrestrial Campaign

The Denman Terrestrial Campaign (DTC) on Australian territory in East Antarctica represents one of the major bodies of fieldwork for ACEAS and is designed to precede the Denman Marine Voyage in 2025. 2024 was a big year and a huge achievement.

The DTC is three summers long, and the primary research expedition took place from late last year to February 2024. More than a dozen ACEAS scientists collaborated with colleagues from AAPP, SAEF and the AAD. A large camp in the Bunger Hills area was supported by aircraft, and satellite camps were set up, along with many remote research sites.

Why the Denman Glacier? We now know this enormous glacier is susceptible to ice sheet collapse due to warming ocean water accessing a huge cavity beneath it and *melting it from below*. If the Denman Glacier were to melt entirely, it could raise sea levels globally by 1.5 metres. Until the DTC, it was largely unexplored on land.

The mission: to find out the risk of ice mass loss from such a key subglacial basin over the next decades or centuries, and - the potential consequences. Our researchers focused on how much the glacier was melting from below, how much snow falls in its drainage basin, what the shape of the glacier is and the role of the bedrock below, and how it behaved in past periods.

Scientists returned to the Bunger Hills in December 2024 for the DTC's final summer of research. Analysis of magnetic, gravitational, heat production and geological data collected in the field this year, and the discovery of more information about changes to the Denman Glacier - and what they could mean for the future - is ongoing.


Credit: Pete Harmsen/ AAD

ACEAS Research

The Atlantic Meridional Overturning Circulation (AMOC) is weakening

Ground-breaking modelling by ACEAS researchers Assoc. Prof. Laurie Menviel and Dr Gabriel Pontes suggests fresh ice meltwater from Greenland and the Arctic is causing the AMOC–also referred to as part of the global ocean conveyer belt– to slow down. The current is the main driver of northward heat transport in the Atlantic Ocean and sets global climate patterns.

The study shows the AMOC is weakening much faster than previously thought and could slow down by as much as a third within 15 years, significantly affecting climate and ecosystems. Such a change would include faster warming in the southern hemisphere, harsher winters in Europe and a weakening of the northern hemisphere's tropical monsoons.

This research on the slowing of oceanic circulation is described as "the missing piece in the climate puzzle." Previous estimates have not taken the meltwater running into the subarctic ocean into account.

PAPER: Gabriel M. Pontes & Laurie Menviel. (2024) *Nature Geoscience*. 'Weakening of the Atlantic Meridional Overturning Circulation driven by subarctic freshening since the mid-twentieth century.' DOI: 10.1038/s41561-024-01568-1

Antarctica's coasts are vulnerable to hitchhiking pests

A study led by Dr Hannah Dawson in collaboration with fellow ACEAS researchers Prof. Matt England and Dr Adele Morrison reveals Antarctica's unique ecosystems could be threatened by the arrival of non-native marine species and pollution from other continents.

The research shows floating objects can reach Antarctic waters on debris such as plastics and other human-made materials, kelp and driftwood. That includes a range of non-native, small marine invertebrates. If non-native species colonised, they could dramatically alter Antarctica's marine ecosystems.

Scientists previously thought this drift only occurred from remote and unpopulated islands in the Southern Ocean. Significantly, this new modelling shows rafting objects can reach the Antarctic coastline from all southern continents.

PAPER: Hannah R. S. Dawson, Matthew H. England, Adele K. Morrison, Veronica Tamsitt, Ceridwen I. Fraser. (2024) *Global Change Biology*. 'Floating debris and organisms can raft to Antarctic coasts from all major Southern Hemisphere landmasses.' DOI: 10.1111/gcb.17467

Australia may be severely underestimating future bushfire risk

Led by Dr Danielle Udy, this examination of sea salt in Antarctic snowfall found Australia could be underprepared for catastrophic bushfires with the potential to be worse than the 2019/20 Black Summer fires. These weather systems are so large, they can also affect Antarctic weather at the same time.

Along with fellow ACEAS researcher Prof. Nerilie Abram and colleagues, Dr Udy found a weather bridge between the two continents at such times is preserved in ice core records, in the form of sea salt particle (aerosol) concentration.

Further, these records show worse bushfire weather occurred at least seven times in the last 2000 years, and that a decrease in concentration in the Law Dome ice core can be linked to such weather in southeast Australia.

PAPER: Danielle G. Udy, Tessa R. Vance, Anthony S. Kiem, Neil J. Holbrook & Nerilie Abram. (2024) *Nature Communications Earth and Environment*. 'Australia's 2019/20 Black Summer fire weather exceptionally rare over the last 2000 years.' DOI: 10.1038/s43247-024-01470-z

Mareen Loesing

UWA Postdoctoral Research Associate
Antarctic Crustal Geophysics and Bed Evolution

What I do

I examine the conditions at the interface of the Antarctic continent and the overlying ice sheet. I produce maps of the ice-bed interface, including its topography, lithology (rock types) and varying geothermal heat flow. These factors influence ice flow, flow of water underneath and within the ice sheet, and basal melting (melting underneath glaciers and ice shelves).

I integrate multiple datasets using machine learning and probabilistic modelling approaches to generate a regional model of geothermal heat flow. This model can be supplied directly to ice sheet modellers to experiment with how sensitive the ice sheet is to changes.

How I do it

I spend most days at my desk working on numerical models using existing datasets, but sometimes, I'm lucky to conduct fieldwork. As well as being aboard a German research vessel measuring marine sediment temperature profiles, I visited the Denman Glacier in the 2023/24 season as part of the ACEAS Denman Terrestrial Campaign. I collected a transect of gravity measurements across the Denman Glacier, which together with airborne gravity surveys, allowed me to produce a probabilistic topography map. This map is a crucial calibration for my geothermal heat flow model, and ice sheet models. Feeding these hard-won measurements straight into my own models is the most rewarding part of my work.

Exploring some rocky outcrops with fellow geologists, I collected handheld gamma-ray and magnetic-susceptibility readings side by side, seeing how changes in lithology might link to geophysical datasets that I later used for modelling back in the office.

Thoughts on being part of ACEAS

ACEAS turns what could be an individual research effort into a coordinated contribution to Australia's Antarctic science agenda, and that collective momentum has broadened both my technical skill set and my perspective on how fundamental research feeds into larger strategic goals. ACEAS helps me forge exciting collaborations, even though being based in Perth can make collaboration a challenge. The existence of ACEAS allows us to emphasise cross-disciplinary teamwork for high-impact outcomes, in contrast to tendencies in academia to reward sheer publication counts.

Spotlight on our researchers

Tamara Schlosser

UTAS Postdoctoral Research Associate
Marine Ecosystems Remote Sensing

What I do

I study how changes in the ocean environment influence the productivity of phytoplankton — tiny, free-floating organisms that form the base of the marine food web. My expertise lies in understanding vertical mixing in the ocean, and I use this to investigate how shifts in the atmosphere, cryosphere, or ocean circulation can impact phytoplankton and, by extension, the ecosystems that depend on them.

How I do it

Observational data is at the heart of my research, so I'm passionate about fieldwork! At ACEAS, my focus has been on year-round biogeochemical measurements using autonomous Argo floats — a rare and valuable resource in the remote Southern Ocean. However, since my research requires spatial resolutions to ~100m and time to hourly resolution, I fill in the gaps in field observations with numerical models and reanalysis datasets like ERA5.

Thoughts on being part of ACEAS

ACEAS has been one of the most multidisciplinary environments I've worked in, and I've especially valued collaborations with laboratory-based experimentalists. Their work has provided context and clarity to my field observations, leading to deeper insights and fresh perspectives.

I enjoy taking opportunities to present my work and receive feedback, and consider how my research can have impact beyond academia.

Australian Government
Australian Research Council

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