# Australian Antarctic Program Partnership

# Two-year Workplan

# 1 July 2023 – 30 June 2025

## Summary of proposed two-year workplan (1 July 2023 – 30 June 2025)

The Australian Antarctic Program Partnership (AAPP) is a partnership of Australia's leading Antarctic research institutions supported by the Australian Government Antarctic Science Collaboration Initiative (ASCI) through the Department of Industry, Science, and Resources (DISR). The objectives of the program are:

- to support research that aims to understand the role of the Antarctic region in the global climate system and its implications on marine ecosystems.
- to enable the AAPP to undertake collaborative science, research and innovation activities under the Australian Antarctic Science Strategic Plan and Australian Antarctic Strategy and 20 Year Action Plan.
- to secure Antarctic science jobs in Hobart.

The two-year workplan for 1 July 2023 – 30 June 2025 is described below. This workplan is delivered across three themes in seven projects and managed by a Science Management Team. It is supported by a more detailed 10-year plan that includes activities, participants, alignment, project objectives and outcomes, and methodology over the full ten years of the AAPP.

This two-year workplan is derived from the seven project plans which are reviewed and varied (if required) each year. The two-year workplan includes changes to the availability of resources for the completion of fieldwork (e.g. delays due to COVID-19, delays in the commissioning of *RSV Nuyina* and scheduling for the MNF *RV Investigator*). The two new Australian Research Council funded Special Research Initiatives (ACEAS and SAEF) and their work have also been taken into account and also potential new investments by the AAPP partners. The revised fieldwork plans were completed in collaboration with the Australian Antarctic Division (AAD), ACEAS and SAEF and are reflected in the 23-25 AAPP workplan.

The details of the Australian Antarctic Strategy and 20 Year Action Plan released in 2022 have also been taken into account in the AAPP workplan for years 5 and 6.

The focus of the Australian Antarctic Program Partnership remains firmly unchanged in direction and scope from the original application.

Guidance for the two-year workplan for years 5 and 6 has been sought from the Australian Antarctic Science Council. The guidance was based on this workplan for years 5 and 6 and a two-page summary. The workplan for years 5 and 6 is complementary and coordinated with the two SRI's and the AAD's approved research plans.

The two-year workplan for years 5 and 6 is planned to be approved by the AAPP Management Committee on 5 May 2023 and will be submitted along with the biennial progress report to DISR on 30 July 2023.

Risks remain in the overall program, although reduced relative to the 21-23 two year workplan. Fieldwork using the CSIRO *RV Investigator* are now approved for the current period. The plans for the Antarctic field programs are approved but logistics support has been incomplete from COVID-19, lack of logistics for some terrestrial campaigns, cancellation of one voyage due to repairs to the RSV Nuyina and for the 2024/2025 Denman Marine Science Voyage still has a dependency on the remaining commissioning process of the *RSV Nuyina* in 2022/2023. Many of the other risks noted in the 6-monthly progress reports to DISER have been mitigated by active engagement and coordination by AAPP staff with the two SRI's and the AAD.

## Theme 1: Antarctica's influence on climate and sea level

*Summary Theme 1*

The workplan for the three projects (Atmosphere; Ice Cores; and Ice Shelves) in Theme 1 are given below.

*Project 1 – Atmosphere*

The key science questions for this project are:

- What are the most important deficiencies in weather and climate models that hinder the accurate representation of cloud, radiation and precipitation over the Southern Ocean and Antarctic regions and how are these processes likely to change in a warming climate?
- What are the fundamental properties of aerosols over the Southern Ocean, how do emissions from ocean biota lead to aerosol formation and modification, and how do these properties subsequently affect the properties of clouds, precipitation and the surface energy balance?
- What is the role of ubiquitous super-cooled liquid water clouds in driving the surface radiation biases over the Southern Ocean, and how can we improve their representation in models?

Activities and deliverables for years 5 and 6 are:

- Collection and analysis of new ship deployments to address observational gaps identified in Years 1-4 (including the RV Investigator MISO and Cape Grim baseline voyages early 2024 and winter 2025; RSV Nuyina Denman Glacier voyage 2025, To provide new insights into Southern Ocean atmospheric processes and the large-scale conditions that drive surface radiation errors.
- New U.S Department of Energy Atmospheric Radiation Measurement (ARM) land-based field campaign CAPE-K (Tasmania) will provide 18 months of data from April 2024 for studying the seasonal cycle of clouds, aerosols and precipitation and to understand processes and their interactions and provide the data for evaluating high-resolution model simulations.
- Finalize development of new parameterizations to represent the sulphur cycle, sea spray aerosol and the link between aerosols and ice nucleating particles in the CASIM aerosol-cloud scheme.
- Sensitivity experiments on aerosol, cloud and precipitation parameterizations with revised version of ACCESS-AM2 (from work in Years 3-4) to further evaluate ACCESS and fine-tune the new parameterizations.
- Implement the regional version of the UM model that includes the new Cloud Aerosol module (CASIM) scheme and use this to run simulations over key areas, such as MISO voyage, Davis, Cape Grim. Evaluate these simulations against the new datasets as a path toward improving parameterisations within the UM.

Although an extensive set of observations has been collected during recent field campaigns, some key data gaps have already been identified around the production of biogenic cloud condensation nuclei and ice nucleating particles from the upper ocean and its role in cloud

life cycle. The need for a more statistically significant characterization of the latitudinal and seasonal variability of the atmospheric properties has also been identified. Our plan is to address these known observational gaps during the lifetime of this project.

The years 5 and 6 plan are as follows:

- RSV Nuyina Denman Glacier voyage (2025) to collect more observations, including adjacent to the Antarctic coastline, to investigate the respective roles of phytoplankton, sea ice, and the Antarctic land mass emissions in aerosol production and resulting cloud and precipitation properties.
- RV Investigator MISO voyage in Jan-Mar 2024 to investigate why aerosol, cloud properties and surface shortwave radiation biases in ACCESS are different north and south of the Polar Front, and to determine the respective roles of biological versus sea salt emissions in aerosol production and resulting cloud and precipitation properties.
- U.S Department of Energy Atmospheric Radiation Measurement (ARM) Mobile Facility (AMF) CAPE-K deployment at Cape Grim for 18 months starting in April 2024 to collect long-term observations of aerosol, cloud and precipitation properties to better understand the seasonal cycle of these properties and how models do capture this seasonal cycle.

*Project 2 – Ice Cores*

The key science questions for this project are:

- What does the ice core record of past climate and carbon dioxide concentrations spanning more than 800,000 years reveal about climate and climate-carbon feedbacks?
- How did the partitioning of carbon between different sinks (ocean, terrestrial, atmosphere) change (in volumes and rates) in the past (as resolved by isotopes of $CO_2$ and $CH_4$)?
- What are the implications for future climate, sea-level and ice sheet stability that emerge from the oldest ice record, and what do past interglacial conditions indicate as potential analogues of future warming?
- What does the late Holocene record of Antarctic climate reveal about links between high latitude climate and the dominant climate modes that influence Australia? What does this show about the range of natural variability of Australian hydroclimate and other variables, and how does present climate compare to long-term pre-industrial climate?
- What does the record of recent millennia show for key environmental parameters and climate forcings? (e.g. snow accumulation, sea-ice, aerosols, dust, volcanism, solar activity and greenhouse gases)

Activities and deliverables for years 5 and 6 are:

- Traverse for the Million Year Ice Core (MYIC) begins, with upper sections of the core available for evaluation against Dome C and Dome Fuji records and for study of the Last Interglacial period years (moved from years 3 and 4 due to delays in field logistics in mobilising the traverse and occupying the MYIC site).
- Synthesis of climate records spanning the past 2000 years derived from the East Antarctic International Ice Sheet Traverse and other ice cores.

- Detailed process studies, analysis of back-trajectories and development of proxies to elucidate the links between Antarctic and Australian climate, including the influence of climate modes and teleconnections.

*Project 3 – Ice Shelves*

The key science questions for this project are:

- How susceptible are East Antarctic Ice Shelves to changes in climate forcing, from both the ocean and atmosphere?
- What is the ocean-driven and cryosphere-driven mass loss from East Antarctic ice shelves?
- How do dynamical processes in ice shelves, such as calving and fracturing, ice flow and firn compaction, influence ice shelf thickness and buttressing?
- When do we expect to see changes in ice shelf mass budget due to long-term climate forcing emerge from the variability of the system?

Activities and deliverables for years 5 and 6 are:

- Deployment of instrumented platforms on key East Antarctic ice shelves to monitor ice dynamics and ocean-driven melt.
- Assess performance of different models in predicting rates of ice shelf mass loss through iceberg calving and basal melt.
- Multi-disciplinary terrestrial and ship-based field programs, with a focus on ocean-ice shelf interaction, basal melt and water mass formation.

## Theme 2: The nature and impacts of Southern Ocean change

*Summary Theme 2*

The workplan the two projects (Oceanography; and Biogeochemistry) in Theme 2 are given below.

*Project 4 – Oceanography*

The key science questions for this project are:

- How will changes in ocean circulation and temperature affect East Antarctic ice shelves? The project will determine where and how ocean heat reaches East Antarctic ice shelves and provide improved understanding of the factors that regulate poleward ocean heat transport across the Southern Ocean to the ice shelf cavity.
- How will Southern Ocean feedbacks (e.g. changes in ocean heat & carbon uptake, sea ice and freshwater) alter the pace of climate change? The project will assess how and why the ocean is changing with time, identify the processes responsible for heat and carbon uptake and their sensitivity to change in ocean circulation/stratification, and work with the sea ice team to assess the contribution of changes in ocean circulation to change in sea ice.

- What processes and teleconnections link the climates of Australia and Antarctica, and what do they tell us about future change? We will explore the role of teleconnections in driving variations in ocean circulation and water mass formation, and provide measurements of ocean heat content for assessment of SO influence on Australian climate.
- How will the changing physics and chemistry of the Southern Ocean and Antarctica influence marine life? The project will deliver assessments of change in the physical environment (temperature, salinity, currents, stratification, upwelling) of the Southern Ocean, as needed by other AAPP projects.
- What is the cause of persistent biases in climate models (e.g. clouds, sea ice) and how can these processes be better represented in climate models? The project will provide better understanding of how the surface ocean influences the lower atmosphere and sea ice.

Activities and deliverables for years 5 and 6 are:

- Develop new understanding of fine-scale oceanographic processes in the Southern Ocean through remote sensing (i.e. SWOT satellite), targeted in-situ field campaigns, and high-resolution ocean models.
- New insights into ocean – ice shelf interaction and its impacts on basal melt, water mass formation and biogeochemistry, gained from multi-disciplinary field programs near ice shelf fronts and adjoining continental shelf. Targets in might include Amery and Denman glacier/Shackleton ice shelves.
- Assessments of the nature and causes of change in the circulation of the Southern Ocean, based on broad-scale measurements, repeat hydrography, model sensitivity studies and insight gained from process experiments in the ACC.

Timeline of major field programs and logistics required for years 5 and 6:

- West/Shackleton ocean – ice shelf interaction expedition (RSV Nuyina).
- ACC frontal dynamics experiment to coincide with SWOT swath altimeter mission (RV Investigator).
- I9S repeat hydrography (RV Investigator) through the MISO voyage.
- Float deployments to quantify time and space evolution of ocean heat content, including under ice.

*Project 5 – Biogeochemistry*

The key science questions for this project are:

- What drives the unexpectedly large multi-year and decadal changes in the magnitude of Southern Ocean CO2 uptake, and how do they affect our understanding of probable future ocean CO2 uptake?
- What is the specific progress of ocean acidification impacts (lowered pH, reduced carbonate saturation, and higher CO2 availability) and accordingly which regions in the

Southern Ocean and Antarctic coastal waters are likely to be more resilient to ocean acidification?
- Is iron supply or its bioavailability, as key controllers of Southern Ocean productivity, likely to increase over the coming century, and what processes will control this?
- What will be the expected magnitude of change in Southern Ocean primary productivity this century, and what controls this (with Theme 3. Future of Sea Ice, Krill and Ecosystems)?
- How will the transfer of energy from phytoplankton to higher levels in the food web be affected by the impact of biogeochemical change on phytoplankton community structure (with Theme 3. Future of Sea Ice, Krill and Ecosystems)?

Activities and deliverables for years 5 and 6 are:

- Maps of the progress of ocean acidification from BGC-Argo, other observations and models, for use in identification of "hotspots" and "refugia" of ecosystem stress.
- New insights on how changes in ice shelf-ocean processes impact carbon uptake in coastal Antarctica.

The tentative calendar for fieldwork efforts in years 5 and 6 is as follows*:*

| **Voyage** | **Year** |
|---|---|
| GOSHIP/GEOTRACES I9S (MISO) | 2023-24 |
| SOTS | 2023-24 |
| SWOT | 2023-24 |
| Denman Marine | 2024-25 |
| SOTS | 2024-25 |

## Theme 3: The future of sea ice, krill and ecosystems

*Summary Theme 3*

The workplan for the two projects (Sea Ice; and Krill and Ecosystems) in Theme 3 are given below.

*Project 6 – Sea Ice*

The key science questions for this project are:

- How and why is the Antarctic sea-ice environment changing (especially the East Antarctic), how and why will it change in the future, and what are the local and global impacts of that change?
- Where within the Antarctic sea-ice system are the most important changes, both horizontally (i.e., Marginal Ice Zone [MIZ], polynyas) and vertically (e.g., snow cover)?
- How do sea-ice processes and change interact with and affect Southern Ocean water masses, waves, and the (East) Antarctic coastal system (including ice shelves)?

- What are the effects of sea-ice change on primary productivity and biogeochemical processes in the Southern Ocean?

Activities and deliverables for years 5 and 6 are:

- Conduct field programs on East Antarctic fast ice (originally planned for year 2).
- Conduct cross-disciplinary research on the Antarctic MIZ focussing on sea-ice physical processes, ocean processes, and air-sea-ice interactions. (MIZ voyage cancelled, research on MIZ continues, intended for Sep-Nov 2023).
- Seek opportunities to conduct cross-disciplinary sea-ice marine science led by international partners.
- Investigate sea ice-ice sheet linkages around the East Antarctic coast, including the effects of sea ice on iceberg calving - through analysis of satellite data combined with modelling and in situ observations acquired by P3 and P4.
- Prepare for new simulations and analyses of (year-round) in situ observations (i.e., from mass-balance units), aerial and satellite data to quantify the relative contributions of thermodynamic, kinematic and advective processes to sea-ice and snow thickness to explore the oceanic and atmospheric contributions to changes in sea-ice volume.
- High-quality publications delivering against key research questions.
- Contribute to regular public engagement through social, broadcast and print media and educational outreach.

Focus of years 5 to 6:

- Conduct multi-disciplinary sea-ice field campaigns (including on fast ice) to collect in situ data on the coupled system to characterise the ocean-ice-atmosphere-biology-biogeochemistry system.
- Assess key processes driving MIZ conditions, using model outputs and remote sensing data (year 5).
- Use a combination of underway observations and automated in situ sensors to investigate characteristics of the Antarctic sea-ice zone (including the MIZ and sea-ice/wave interaction processes).
- Combine remote sensing products, underway data and results from field experiments to investigate the effects of emerging sea-ice characteristics on primary producers.

Planned fieldwork for years 5 to 6:

- Continued operation of multi-disciplinary fast-ice observatories (AAS4506).
- Apr-Nov 2023: Rothera fast ice study on air-sea ice interaction (AAS4506).
- Nov-Dec 2023 [TBC]: Davis integrated fast-ice physical and biological process study (AAS4546); autonomous instruments deployed the previous autumn (moved from years 3 and 4).
- Nov-Dec 2023 [TBC]: Sea ice thickness survey (EM bird), Davis (AAS4496) (moved from years 3 and 4).
- Jan – Mar 2024 (or 2025) DEFIANT participation (AAS 4635, 2 berths for AAD on RSS Sir David Attenborough).
- Pending AAPP negotiations with AAP (AAD SP&C) about logistics support.

- Feb - Apr 2025, Summer Weddell Outflow Study (RV Polarstern, 2 berths for AAD/AAPP)

*Project 7 – Krill and Ecosystems*

The key science questions for this project are:

- How will complex environmental change, driven by alteration of cryospheric and oceanic properties, impact the base of the food web from microbes to krill?
- Will there be winners and losers in response to climate change and what are the ecological ramifications of such shifts for East Antarctica?
- What will be the cumulative effect on sea-ice and water column ecosystems of altered biological performance within the trophic levels of food webs in East Antarctica?
- What is the relationship between krill distributions and sea ice in East Antarctica, and how will it be altered in light of current/projected climate change?

Activities and deliverables for years 5 and 6 are:

- Assess a range of remote sensing approaches to zooplankton e.g., bio-optics (BGC-Argo and satellite LIDAR), bioacoustics (AAD moorings), and image analysis (zoo-scan on gliders) during an Antarctic voyage.
- Conduct experimental manipulations, including competition experiments between krill and other Antarctic zooplankton (salps, pteropods, copepods) under controlled lab conditions.
- Carry out ship-based (e.g., on RV Investigator) environmental manipulation studies using large volume (1000 L) mesocosms to look at across-food web responses to simulation of altered Southern Ocean conditions.
- Perform an inter-comparison on a polar voyage of remote sensing approaches to zooplankton (from copepods to krill) including bio-optics (BGC-Argo and satellite LIDAR) and bioacoustics (AAD moorings), along with image analysis (zoo-scope and its deployment on gliders).
- Validate the multi-trophic trait-based model (developed in years 1-3), and the nested suite of ecosystem models developed at AAD.
- 4D full-life cycle energetics/habitat model developed for krill in East Antarctica; possible deployment and recovery of Prydz Bay bio-acoustic observing system for krill and other organisms.
- Determine experimentally the present-day physiological capacity of Southern Ocean and sea ice biota and whether this reflects the environmental heterogeneity of their habitats and makes them resilient to change.

## Data model for Antarctica (Digital Antarctica)

Digital Antarctica is an agreed standardised framework to facilitate data sharing across multiple Antarctic research organisations in ways that aligns with the FAIR data principles, which advocate that data should be Findable, Accessible, Interoperable and Reusable. The project commenced in July 2020 and wrapped up in July 2022.

In late 2020, the Digital Antarctica Reference Group was created from representatives of the AAPP partner organisations, to align stakeholder organisations in the definition and progress of Digital Antarctica.

Over its course, the project, with the assistance of the reference group, has produced a number of documents describing the current state, scope, and requirements of the project. These can be found on our website: https://aappartnership.org.au/digital-antarctica/

In mid-2022 the Australian Antarctic Division began working on the Integrated Digital East Antarctic (IDEA) program, which came about as part of the 2021 O'Kane review into Australian Antarctic science. The IDEA project mission is to "facilitate and coordinate the acquisition, analysis and synthesis of Antarctic and Southern Ocean data" which aligned with the Digital Antarctica goals, vision, and scope. As such the project deliverables and knowledge has been handed over to the AAD for use in IDEA.

The AAPP looks forward to participating in the IDEA program, and to see the groundwork laid by Digital Antarctica in action.

### Project Management

The AAPP is led and managed by a small team consisting of a Program Leader (0.6FTE), a Business Manager (1FTE), a Communication & Impacts Officer (commenced Nov 2022, 1FTE), and an Administration Officer (0.4FTE).

The AAPP Program Leader manages the Science Management Program budget.

Activities and deliverables for years 5 and 6 are:

- Travel and accommodation:
    - Continue to support researchers to attend national and international scientific conferences/workshops to foster and strengthen collaboration.
- Visiting Fellowship Program
    - Re-commence the visiting fellowship program (post travel restrictions) to create a vibrant exchange of scientists.
- Scholarship top-ups:
    - Continue to support AAPP top-up scholarships stipends. Late 2021, the decision was made to offer 25 top-ups (pre-award) over the life of the program to match with the 25 UTAS scholarships.
- Staff Training:
    - Continue to support staff to undertake training and partake in workshops that directly supports the achievement of project outcomes.
- Science Conference Sponsorship:
    - Continue to sponsor and support conferences and workshops. Scheduled for year 5 are:
        - The SOOS Open Science Symposium 14-18 August 2023, in Hobart;
        - The AAPP Symposium 17-18 October 2023, in Hobart; and
        - The ICES-PICES 7th International Zooplankton Production Symposium 17-22 March 2024, in Hobart.
- Publications

    - Continue to support publications of high quality and high impact research articles.
- Communications and Impact:
    - Communicate AAPP research activities and outputs widely and effectively. This is done through:
        - AAPP website updates and stories;
        - Quarterly AAPP e-newsletter, called 'Southern Signals';
        - Synopses in plain English of the latest research in forms like briefings, position analyses or report cards;
        - Seminars/webinar with focus on impacts and policy;
        - Stories to media, and platforms like *The Conversation*;
        - Social media posts (twice weekly); and
        - Media training and practical skill-building for staff and students.
    - Highlight AAPP Impacts, KPI's and outcomes. This is done through:
        - Creating AAPP research impact plan; and
        - Using established reporting tool to track research impact, eg. track publications and their use in policy related documents.

## Budget – Years 5 and 6

| ELIGIBLE EXPENDITURE SUMMARY BY RESEARCH THEME | | Year 5 Revised Budget | Year 6 Revised Budget |
|---|---|---|---|
| | | 2023/24 | 2024/25 |
| | | $ Ex GST | $ Ex GST |
| **Theme 1: Antarctica's influence on climate and sea level** | | | |
| Labour - Research | | 1,044,520 | 868,032 |
| Plant and Equipment | | - | - |
| Research Operating | | 335,182 | 131,018 |
| | **Total** | **1,379,702** | **999,050** |
| **Theme 2: Nature and impacts of Southern Ocean change** | | | |
| Labour - Research | | 1,770,450 | 1,870,411 |
| Plant and Equipment | | 450,000 | 150,000 |
| Research Operating | | 118,098 | 58,484 |
| | **Total** | **2,338,548** | **2,078,895** |
| **Theme 3: Future of sea ice, krill and ecosystems** | | | |
| Labour - Research | | 947,327 | 1,070,139 |
| Plant and Equipment | | - | - |
| Research Operating | | 322,545 | 186,449 |
| | **Total** | **1,269,872** | **1,256,588** |
| **Total All Research Themes** | | | |
| Labour - Research | | 3,762,297 | 3,808,582 |
| Plant and Equipment | | 450,000 | 150,000 |
| Research Operating | | 775,825 | 375,951 |
| | **Total** | **4,988,123** | **4,334,533** |
| **Project Management** | | | |
| Labour - Project Management | | 221,026 | 226,552 |
| Operating - Project Management | | 32,773 | 33,428 |
| | **Total** | 253,799 | 259,980 |
| **Travel and Accommodation** | | | |
| | **Total** | 146,128 | 149,051 |
| **Administration** | | | |
| | **Total** | 335,338 | 348,326 |
| **Audit cost** | | | |
| | **Total** | 10,000 | - |
| **Other Eligible Expenditure (Ex Research Operating)** | | | |
| | **Total** | 513,429 | 505,232 |
| | | | |
| | **TOTAL** | **6,246,816** | **5,597,121** |