

AAPP Progress Report January-June 2022

Milestone number	Milestone name and description	Due date
002	Antarctica's influence on Climate and Sea Level	30/06/2029

(4000 max)

The three projects in milestone 2 have delivered new information and progressed our understanding of clouds near Antarctica, preparation of the Million Year Ice Core, and ice shelves dynamics. Subtle biases in the best available reanalysis products near the coast of Antarctica are being tackled using machine learning techniques with 25 years of incoming shortwave radiation data (ships, stations data) over the Southern Ocean to improve upon the ERA5 radiation product. There is also extraordinary value in existing observations and planned future observations from upcoming Southern Ocean research campaigns by Australian and international collaborators, and the AAPP is leading a community paper for the future analysis of these data to address the AAPP milestone around clouds, phytoplankton and sea-spray emissions. Detecting biases in Australia's ACCESS model is also a critical element of the AAPP work and has been evaluated against satellite observations. Planning continues for the MIZ voyage, including co-ordinating the atmospheric observing instruments (clouds, aerosols, precipitation, plus in-situ balloons) to be deployed.

The AAPP is a significant contributor the Australian Antarctic Division's Million Year Ice Core (MYIC) project. Over the last summer, the pilot hole drilling and borehole casing was delayed due to poor weather and COVID complications. However, testing of the new Eclipse drill and reamers for the pilot hole was performed and has proved useful for troubleshooting. As part of the preparations for the kilometres of ice core, a new mass-spectrometer has been installed and commissioned at our partner CSIRO Aspendale site for analysis of gases in modern era ice cores. This work has been accelerated by arrival of new staff member (Menking, located at Aspendale). Progress continues on the development of the Continuous Flow Analysis system, another key component, in preparation for the large volume of ice cores coming as part of this project. With collaborators, AAPP ice cores staff have published two papers on Dansgaard-Oeschger and Heinrich events. Our work on past climate records for the past 2000 years continues. Isotope analysis and dating of DE08-OH ice core has been completed. Dating of the Mount Brown South core has progressed and AAPP contributor (Etheridge) has been invited to join a US proposal on atmospheric emissions and oxidation using Greenland ice. He also contributed to a publication in Nature communications on how sunlight-driven nitrate loss records variations in the Antarctic surface mass balance, critical component of sea-level.

A feature of the ice shelves project is the unique network of instruments observing and tracking the thinning of Antarctic ice shelves and changes to the ice shelf cavity. We had a very successful field season installing a prototype instrumented platform including autonomous radar and GPS. The equipment is continuously returning data allowing testing of power and telemetry systems. We have also submitted an AAS in support of further deployments on the Denman/Shackleton Ice Shelf system (AAS 4629) and a NERC

Geophysical Equipment Facility application for Denman work in 2025. This fieldwork is complemented with two research papers, one on an exploration of the thermal structure of the Amery iceshelf from borehole and simulations and a second paper on the Thwaites Glacier understanding its deformation using a simple flow relation for ice instead of the earlier parameterisations. Ocean tides can also affect the ice mass loss from an ocean cavity beneath an ice shelf through ocean driven melt. These papers give insight to the sensitivity of future sea-level. This question has been addressed for the whole of Antarctic ice shelves, thus taking into account the different tidal strength and cavity geometries. Finally, a new PhD student has been recruited to work on calving of ice-shelves and ice-ocean interactions in Wilkes Land.

Milestone number	Milestone name and description	Due date
003	The Future of Antarctic Sea Ice Krill and Ecosystems	30/06/2029

(4000 max)

Early July, new delays have occurred in the commissioning of the RSV Nuyina. The impact of the delays is not understood for the 22/23 season and is discussed below. We had thought that the past delays in the fieldwork at Casey Station (Antarctica) had been overcome. The uncertainty with the new delays affect project progress of an AAPP PhD student and AAPP Research Associate (Dalman, Wongpan) and an international collaboration (Australia-Germany-NZ collaboration) for new airborne (EM) data to have been collected both of pack ice and fast ice thickness distributions off Davis Station (Antarctica). Extensive preparations for the Marginal Ice Zone voyage are underway, now scheduled for 2023/24 and with the planned level of time. This voyage will be the first sea-ice fieldwork since the 2012 SIPEX voyage. The key risk is the commissioning of the science equipment on the RSV Nuyina ready for this first science voyage. Several workshops were held with MIZ participants. In support of this work, a suite of Marginal Ice Zone papers has been submitted or published. Our fast ice milestones are progressing well with a AAPP led fast ice review paper submitted and our work on estimating ice algal production in Circum-Antarctic landfast sea ice during 2005-2006 has also been submitted. Two highlights of this milestone are high impact publications on change and variability in Antarctic coastal exposure from 1979–2020 by ocean waves (Reid and Massom) and from our time series of fast ice to provide a new analysis of calving of icebergs and ice shelf area (Greene et al 2022, Nature). The 2021/2022 summer season had an anomalously low sea-ice extent. It has been the subject of significant media coverage and new work on the drivers and impacts of the last season record low (Hobbs et al). On the longer timescale, results on Antarctic Ocean and sea-ice interactions and their role on multi-month predictability of sea ice have been published (Libera et al 2022). We contributed to the annual state of climate report on seasonality of sea-ice extent (Reid et al). In earlier reports, the sea-ice group led a project in artificial intelligence to classify sea-ice in the marginal ice zone based on data from IceCube, a low earth orbit nano-satellite. This work is now complete. Dr Meiners is co-leading with WHOI on organising the prestigious Gordon Research Conference on Polar Marine Science. Finally, we are also leading (Wongpan) the Southern Ocean Collection special issue in Frontiers for Young Minds.

The results of the TEMPO voyage (see earlier progress reports) are coming to fruition. We have new understanding of krill biomass distributions in our region of Antarctica (CCAMLR Division 58.4.2 -55°E to 80°E, Cox et al. 2022). The mooring deployed during this experiment is revealing new information, allowing video records of krill to be directly connected echosounder targets and thus providing an empirical relationship between observed krill swarms and their acoustic properties (Smith and Cox). This new result extends earlier modelling of krill and how the quality of the sea-ice habitat influences the breeding and maturation success of krill (Veytia et al 2022). The SOLACE voyage (see earlier progress reports) is also producing key results on the competition between heterotrophic bacteria and phytoplankton for iron (Strzepek and Boyd), on the deep chlorophyll maxima (Boyd and Strzepek) and on the co-limitations on phytoplankton from Fe/Mn and light differences. Against the milestones of the AAPP in this theme there has been a culmination of research outputs from the first few years of the AAPP including 6 new publications focussed on bacteria and phytoplankton responses from laboratory and fieldwork. This theme has been active in PhD supervision with several student papers published or in review. This theme also welcomes new staff member Dr Smith.

Milestone number	Milestone name and description	Due date
004	The Nature and impacts of Southern Ocean change	30/06/2029

(4000 max)

The AAPP supports the longest time series of measurements for the understanding of interannual and decadal variability of CO₂ uptake in the Southern Ocean. Our most recent fieldwork recovered the 10th air-sea flux and biogeochemistry mooring, and the 23rd sediment trap mooring and deployed next year's moorings. We are now evaluating the decadal changes in CO₂ seasonality from this time series site (Shadwick et al 2023). Indeed, there is an unexpected amplification of the seasonal CO₂ cycle at this site and a manuscript comparing air-sea CO₂ flux in the Subantarctic from mooring, profiling float and ship-based observations is in preparation (Wynn-Edwards et al). These mooring data with other ship and surface measurements partially supported by the AAPP (and IMOS) were also contributed to the new release of the global atlas of carbon measurements. To further support this milestone, a new PhD Student (Xiang Yang) started in January 2022 and is focusing on identifying links between the Southern Annular Mode and interannual changes in productivity, air-sea flux, and carbon export in the Subantarctic. While the AAPP leads a strong observational program on the carbon pump, theoretical evaluation of the role of grazing by zooplankton in marine biogeochemical-ecosystem models for their correct representation in the biological carbon pump (Rohr et al, in revision) and whether the current climate models used in global climate studies are biased by these marine zooplankton (Rohr et al, submitted). We are also interested in deep ocean reservoirs of iron as a critical micronutrient. AAPP PhD student Chris Traill is working with historical trace metal data from SR3 voyages to examine the importance of iron supply and its impact on carbon cycling in the Southern Ocean south of Tasmania. This is being achieved through collation of iron and carbon data sets in a water mass framework. We also combined ocean

biogeochemical modelling with new observations of detritus Fe from the abyssal Southern Ocean to assess the impact of hydrothermal iron supply estimated from either ridge spreading rate or helium amounts on Southern Ocean export production (Tagliabue et al 2022). Oceanographic standing meanders in the Macquarie Ridge region are hot spots for poleward heat transport and provide new insights into the large-scale circulation. A new approach using satellite altimetry and observed along stream anomalies of temperature and salinity in this standing meander allowed the key dynamical terms and vorticity balance of this meander to be diagnosed (Meijer et al 2022). Variations of the winds also play a role in dynamics of this meander and has been tested in a simplified high-resolution model (Xihan and Nikurashin, submitted). At even finer scale, new estimates of the turbulent mixing variability in this standing meander of the Southern Ocean have been made (Cyriac et al 2022) and a new study of inertial waves in the same meander (Cyriac et al 2022, in submission). This work was highlighted at the Multiscale Dynamics in the Southern Ocean workshop with key AAPP staff attending (Zhang, Spence, Phillips, and Foppert). A critical issue in the future of Antarctic ice sheet is the way heat is transported by the ocean across the Antarctic continental shelf. Fieldwork planning and science workshops for the Denman region are underway (AAPP, ACEAS and SAEF are involved). Our AAPP staff have participated in a review of the East Antarctic Ice Sheet (Stokes et al 2022 Nature). The Antarctic coastline supports barotropic Kelvin waves and their propagation was the subject of a recent paper (Webb et al 2022). One of the challenges from IPCC is understanding the atmospheric drivers of sea-ice extent and its long-term trends. New work with AAPP contributions shows that the trend in the Southern Annular Mode does not explain the observed long-term expansion of sea-ice extent (Polvani et al 2022). AAPP staff led and presented at sessions at the ICHSMO conference.

Milestone number	Milestone name and description	Due date
005	Two (2) yearly workplans	1/5/2021

(4000 max)

The next two yearly workplan is due July 2023 for the forward two years of the project, i.e., July 2023 – June 2025.

Where applicable, describe any project activities completed during the reporting period that are not captured in the table above: (5000 max)

Fieldwork: Nine Australian Antarctic Science requests were lodged in the month of February (2022), at relatively short notice. These were all AAPP priority projects. The AAPP field program is becoming more complete and is clearly an ambitious plan over the period of the AAPP (June 2029). These applications are additional to the applications for the Marine National Facility in the last progress report. There is some fieldwork for which AAS requests have yet to be lodged. The outcome of these nine AAS requests is not yet known but is expected in early 3rd quarter of this year. More complete details can be found at this [link](#), including the co-investigators and the international collaborators as well as the specific goals. These 9 projects cover most of the planned field work for the AAPP. There are a couple of exceptions, projects for the later years around drift ice need also to be included.

Applications for the next round of AAS requests will be called again about 18 months in advance of the field season. The February round of AAS grants was a restart of the AAS systems after many years of uncertainty around fieldwork due to the delays in the delivery of the RSV Nuyina and other logistical constraints in the funding and support for the Antarctic Science. In the context of the AAPP, this round of applications means that almost all of the AAPP ambitions for field work in Antarctica and that need the resources of the Australian Antarctic Division have been lodged. The priority projects beyond 2025 have yet to be assessed in the AAS scheme, but it does mean that logistics have greater clarity on future AAPP requirements. These nine requests are seeing the completion of the request for the main field work and is inch-by-inch reducing the program risks from field work.

The Digital Antarctica project is coming to completion. The final workshop has been held and the reports are complete and will be published on the AAPP website. The final summary and recommendations are attached and summarised below. A distribution to relevant stakeholders has been established and will be implemented in late July 2022 with continued support from AAPP for knowledge transfer (until September 2022). This project was part of the original ASCI grant application.

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

In late 2020, the Digital Antarctica Reference Group (DARG) was created from representatives of the AAPP partner organisations, to align stakeholder organisations in the definition and progress of Digital Antarctica. Participation in the reference group has been consistent over the 2 years, and there has almost always been a representative from each partner organisation in the group.

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 are:

A1. High-level Scope – A high-level understanding of the scope, based on early discussions with the Digital Antarctica Reference Group; B1. High-level Current State – A high-level snapshot of what each of the partner organisations do, and how they manage data; A2. Refined Scope – A deeper understanding of the scope, delving into some of the concepts touched on in the high-level document; B2. Refined Current State – Having established the scope of Digital Antarctica, this document takes a deeper look at what each data centre does with in-scope data. It also collates those data to provide an overall picture of the Antarctic data landscape; C. Requirements – A list of requirements that a fully realised Digital Antarctica solution should meet; and D. Summary and Recommendations – A document summarising the activities of the project and providing recommendations for moving forward (and as a draft, attached to these papers).

Once finalised, the above documents will be publicly available on the AAPP website. In mid-2022 the Australian Antarctic Division began working on the Integrated Digital East Antarctic

(IDEA) program. The scope of the IDEA project has not been fully explored or defined, but its mission to “facilitate and coordinate the acquisition, analysis and synthesis of Antarctic and Southern Ocean data” aligns with the Digital Antarctica goals, vision, and scope.

With the onset of the IDEA program, the AAPP support continual engagement with the AAPP partners, the AAPP Management Committee members, members of the AASC, and the interim leaders of the IDEA on the transfer of knowledge.

Is the overall project proceeding in line with your project plan and grant agreement?

YES

Identify any changes or anticipated issues.

Comment on any impacts on project timing and outcomes and how you expect to manage these. (5000 max)

COVID-19 risks remain. There have been cancellations of voyages by the CSIRO Marine National Facility (RV Investigator) and this has affected the timing of future fieldwork by introducing delays into the planned AAPP fieldwork activities as these facilities “catchup” on their existing non-AAPP commitments. The AAPP led MISO voyage is now re-scheduled for the 2024 season. COVID-19’s presence in Tasmania means that some fieldwork in 2022 could be affected. An analysis of risks taken on behalf of the management committee also indicate that AAPP’s presence in international meetings and international programs is reduced and consequently the AAPP is “missing in action” in these fora over the last two years. International conference and meeting attendance is just returning in Q3 and Q4 of this year and so this reputational/participation risk is beginning to subside with increased attendance at these meetings.

Delay 2022/23 Season of RSV Nuyina. The largest new issue for the AAPP is the very recent announcement that the RSV Nuyina will be not available for the 2022/23 season. This announcement was made early July by the Director of the Australian Antarctic Division, Kim Ellis. At this stage, this delay in the deployment of the RSV Nuyina only affects the 2022/23 season, and thus not the AAPP’s major field programs that begin in October 2023. However, it does affect 4 AAPP projects, we thought had been solved.

The 4 projects listed for the 2022/23 season, three of which are existing AAS grants and finally the fourth is a new AAS grant request, which is for a very small amount of ship time. The three existing grants are approved but have not been supported with logistics. This new delay compounds an existing problem as reported in earlier progress reports. The new AAS grant request is waiting for approval and is flexible, with advance warning, it can cope with delays or be ready to go.

The AAPP office (along with other groups) are working with the Australian Antarctic Division to see what can be supported from the AAPP (and others).

There has also been a delay in the approval of the fieldwork for the 2023/24. Hopefully this will be resolved by an out of session meeting of the Australian Antarctic Science Council in the third quarter of 2022.

Are there any planned events relating to the project that you are required to notify us about in accordance with your agreement? Provide details of the event including date, time, purpose and key stakeholders expected to attend. (5000 max)

NO

PROJECT OUTCOMES

Outline the project outcomes achieved to date. (5000 max)

The AAPP science projects are aligned with the objectives of the Australian Antarctic Science Strategic Plan.

There are now 20 funded and associated PhD students with AAPP research projects.

During January-June 2022, the AAPP had 28.6 FTE direct funded staff. Staff are receiving awards and succeeding in grants as measures of growing reputation. For example, Dr Wongpan received a JSPS BRIDGE Fellowship to create, sustain and/or strengthen the researchers' network between Australia and Japan for a period of 21 consecutive days at Hokkaido University, Japan.

Researchers participated in several workshops/conference such as the CATCH Open Science Workshop and the Digital Antarctic workshop. The AAPP is sponsoring several conferences/workshops such as the SOLACE workshop (Nov 22), the Gordon Research Conference on Polar Marine Science in 2023, and the 7th Zooplankton Production Symposium to be held in Hobart early 2024.

The AAPP held several online forums during the reporting period. Recordings and details of these forums can be found on the AAPP website: <https://aapppartnership.org.au/forum/>

The AAPP continues to grow its influence through research publications and international collaborations. Through our fieldwork, policy and research forums, and advice to government, the AAPP influences policy and decision making.