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***Inquiry into the importance of Antarctica to Australia's national interests***

The Australian Meteorological and Oceanographic Society (AMOS) welcomes the opportunity to comment on the importance of Antarctica to Australia's national interests.

AMOS (http://www.amos.org.au) is an independent society representing the atmospheric and oceanographic sciences in Australia. It has over 400 members drawn from the Bureau of Meteorology, CSIRO, the university sector, other State and Federal agencies (including the Australian Antarctic Division), as well as the private sector. The Society covers both meteorology and oceanography, noting that:

- 'meteorology' in its broadest sense includes the sciences of weather, climate and atmospheric composition; and
- scientific study of 'climate' requires integrated study of the atmosphere, ocean, land, cryosphere and biosphere.

Our vision is *"To advance the scientific understanding of the atmosphere, oceans and climate system, and their socioeconomic and ecological impacts, and promote applications of this understanding for the benefit of all Australians."*

AMOS has long recognised the importance of Antarctica to Australia's economy and society. This is reflected in our position and expert statements, which can be found on our website (https://www.amos.org.au/about/statements-2/), and from which we draw upon in making this submission.

Australia is uniquely vulnerable to the effects of global warming. Changes to the Antarctic system contribute directly to these vulnerabilities, and Antarctic research is required to inform policy makers about their likely effects. From our expert statement on climate change (2021): '*Australia is highly vulnerable to the impacts of climate change, with many regions expected to experience intensified droughts or floods, increased heatwaves and extended bushfire seasons as well as increased coastal erosion and inundation due to sea level rise. Ocean warming and acidification will threaten coral reefs and other marine ecosystems'*. In this respect, the *value* of Antarctica, and Antarctic research, to the Australian economy and society goes beyond direct contributions to GDP. We live on a planet that is complex and connected, and understanding each aspect is essential to our prosperity.

**Executive summary of recommendations**

Given the clear importance of Antarctic research to Australia's national interests detailed in the following sections, AMOS states that;

- As a key component of the global climate system and a pristine and vulnerable ecosystem, Antarctica has intrinsic value to the Australian people.
- Antarctic change represents a large risk to Australia's economy and society through its potential contribution to sea-level rise, to changing weather patterns, the consequences of damage to its ecosystems for the region and globe, and the role of the surrounding oceans in carbon uptake. This risk cannot be understated.
- Knowledge and data drawn from Antarctic observations and research helps to inform Australian planning and decision making at short (weather forecasts), medium (climate projections) and long-term commitment (sea level rise) time scales. The continuation and enhancement of long-term Antarctic observations and research is critical to Australia's preparedness.
- Deployable scientific platforms, including the *RSV Nuyina* as well as land-based and flight infrastructure, must be funded and available to scientists for realistic periods of time in order to address urgent research.
- Certainty in funding and planning at timescales appropriate to the scale of research is required to achieve scientific outcomes, such as those that will be proposed by the upcoming Australian Antarctic Decadal Plan.
- Continued funding of model infrastructure is essential not only to improve model prediction and projections, but to ensure we are gaining the most value from the observations that are collected.
- Collaboration between Governmental agencies and universities to ensure continuous long-term funding of research, and alignment of research capacity to undertake research of the highest strategic priority, must be recognised and formalised.
- Transparent allocation of resources and accommodation of the competing funding needs of Antarctic logistics and scientific research is required in order to allow reliable and consistent research programs to be planned and maintained.

**The value of Antarctic research to Australia**

The Antarctic Treaty reserves Antarctica for 'peace and science'. It is often said that science is the currency of the Treaty system; strong science is key to a strong system and securing Australia's place in it.

Over the last 60 years, Australia has become a leading Antarctic research nation. Australian Antarctic atmosphere, oceans and climate systems researchers are world leading in their excellence and innovation in describing, understanding, and modelling Antarctica's effect on the globe and Australia specifically. For example:

- Australian research has demonstrated that ice cores from Law Dome in Australian Antarctic Territory yield insights into mainland Australia's drought and rainfall spanning 2000 years, extending well before the commencement of instrumental records (Vance et al., 2015; Udy et al, 2022). This work has highlighted that parts of Australia have likely experienced 'mega-droughts' spanning multiple decades at multiple times. This work is now informing development of Australia's water security plans.

- Our ice sheet researchers contributed to the modelling adopted by the IPCC in its most recent projections of global and regional sea-level rise. Australia has $230B of assets at risk of inundation with 1.1m of sea level rise. The IPCC report noted that sea level rise of this magnitude is possible by 2100 and a rise of more than 15 m by 2300 could not be ruled out. The importance of this is further highlighted in our expert statement on sea level rise (2018) *'The largest scientific uncertainties in projecting future sea-level rise relate to the dynamic response of the Antarctic Ice Sheet to warming. These uncertainties mean that there could be a substantially larger rise than currently estimated if there is a rapid response of the ice sheet.'*

- Australian researchers lead investigation of the ocean's role in melting Antarctic ice shelves that buttress the flow of the Antarctic Ice Sheet towards the sea. The intensifying and poleward shifting circumpolar winds (Roaring 40s) over the Southern Ocean have increased heat transport by the ocean circulation to the Antarctic margin (Martínez-Moreno et al. 2021; Foppert et al. 2017). On the continental shelf, glacial melt has accelerated due to intrusions of warm ocean water entering underneath the ice shelves (Herraiz-Borreguero et al., 2022). The wind-driven ocean circulation trends accelerating this melt are expected to persist over the 21st Century as Southern Ocean winds continue to strengthen and shift southwards towards Antarctica (Meredith et al. 2019).

- Australian researchers and infrastructure have led and facilitated pivotal field campaigns to understand and better predict the unique clouds found over the Southern Ocean and Antarctica (e.g., McFarquhar et al. 2021). These clouds have been identified as the largest source of uncertainty in predicting the Earth's energy balance (Zelinka et al. 2020). A better understanding of these clouds is essential for accurate predictions of global temperature rise.

- Our scientists have reported on and begun to understand dramatic new changes and extremes emerging from Antarctica over recent years. In 2022, the Australian Antarctic Territory experienced a heatwave in which temperatures soared to 40 degrees above average (Wille et al. 2024a, 2024b).This is unprecedented in global observational records. In 2023, Antarctic sea ice (frozen ocean) coverage was

exceptionally below average across the year. Australian researchers have identified that Antarctic sea ice is currently undergoing a regime shift, leading the world in this crucial research (Hobbs et al., 2024; Purich & Doddridge, 2023).

Other work by world-leading Australian researchers has identified that the Antarctic limb of the global ocean overturning circulation has likely already slowed down by 30% over recent decades (Gunn et al., 2023) and is expected to slow even further by 2050 (Li et al., 2023), reducing the ocean's capacity to absorb heat and carbon. There is the potential that this circulation could pass a tipping point in the future, beyond which the circulation would remain collapsed for the foreseeable future (Armstrong McKay et al. 2022), with devastating implications for global marine ecosystems, climate and sea-level. Potential tipping point behaviour has also been identified in Antarctic ice sheet mass loss, including parts of East Antarctica which were previously thought to be largely protected from climate and ocean warming (Stokes et al., 2022). Satellite observations show ice loss from Antarctica is accelerating (Otasaka et al. 2023). Century-scale commitments to metre-scale global sea level rises are now unstoppable (IPCC 2021), however simulations of future Antarctic ice loss and sea level rise demonstrate the benefits of rapid emission reductions that limit warming to below the 2°C goal of the Paris Agreement and avoid the worst-case sea level rise scenarios (Stokes et al., 2022).

**A partnership of government and academia**

The work described above and much more is supported by an ecosystem of researchers in the university sector and government. In much of the work, government agencies and university researchers collaborate closely. The Australian Antarctic Division (AAD) leads research focused on our treaty obligations and conservation efforts, long-term monitoring and fundamental research in a few areas of Government priority. Much of Australia's fundamental scientific research on Antarctica and the Southern Ocean is led from the university sector. A smaller volume of work is contributed from other government agencies including CSIRO, the Bureau of Meteorology and Geoscience Australia. The universities are particularly strong in the research which informs on the climatic and environmental impact of Antarctic and Southern Ocean change to Australia, our region and the planet, and in research that supports obligations to the UNFCCC, for example, as well as Treaty obligations.

This distinctive partnership should be recognised and strengthened. At present, the partnership is only supported via short to medium term funding programs (3-7 years typically, and at most 10 years), dispersed over multiple separate initiatives, making long-term measuring, modelling, and planning difficult to coordinate and limited in scope. It also impacts Australia's ability to train and retain the expert workforce it requires to undertake this important and impactful research.

The Australian Government, through the Australian Antarctic Science Council, is developing a new Australian Antarctic Science Decadal Plan. The early development of this plan has engaged widely with researchers across academia and government, and we welcome this broad consultation to develop the highest priority science for Australia to conduct in the Antarctic over the coming decade. Given the rapid changes emerging in Antarctica as described above, we urge the Government to adopt a plan that is ambitious in terms of advancing our understanding of the Antarctic and Southern Ocean climate system and its impacts on Australian climate, sea level rise as relevant to Australia and our regional

neighbours, and ecosystem change. This will allow Australia to exert international leadership, including within the Australian Antarctic Territory.

**Importance of sustained observations and monitoring of the ocean and atmosphere**

Long-term (multidecadal) observations in key regions, supplemented by intensive field campaigns to understand processes, will be critical to understanding, detecting, and predicting physical and ecosystem change in Antarctica and the Southern Ocean. For example, Australia recently launched its largest ever deep-field program to understand the Denman Glacier in East Antarctica. Denman Glacier has barely been visited by Australian researchers since the days of Mawson, and yet this one glacier holds enough ice to raise global sea levels by 1.5 m.

Australia's ability to deploy and maintain long-term observational systems across the vast geographical scales required is currently poor. Over recent decades observational networks have degraded, especially those large distances from our three coastal Antarctic stations, such as the Automatic Weather Station network. The importance of long-term and sustained Antarctic observations to Australia is clearly demonstrated by the work by Soldatenko et al. (2018) who showed that the weather balloons launched from the four Australian Antarctic bases (including Macquarie Island) had the most impact of all Australian weather balloons in reducing forecast error for Australia. To meet international atmospheric monitoring obligations, Australia must fund long-term, high quality observations.

The foreshadowed East Antarctic Monitoring Program, led by the AAD, would enable a recovery from the decline in observational networks and indeed place Australia as a leader in long-term observations. This program is not fully funded, and we urge the Government to implement this program.

We also highlight relevant portions of our Position Statement on International Cooperation and Data Sharing in Meteorology and Oceanography (2019): '*With growing national and international concern about climate change, it is especially important that Australia maintains and enhances its national climate observing networks and data archives as part of the comprehensive Global Climate Observing System needed to support the UN Framework Convention on Climate Change. Observations for climate monitoring need to be of the highest quality and consistency as they provide the baseline to which more numerous, but often less accurate, observations (such as those from lower quality, amateur and 'big-data' sources) can be anchored. Indeed conventional baseline data are also needed to ensure the calibration of satellite and other observational data essential to the accuracy of numerical weather prediction systems, used for real-time operations, reanalysis and research.'*

**The need for financial confidence and long-term planning horizons**

Long term monitoring must be supplemented by detailed investigations in key locations. Antarctic fieldwork requires confirmation of plans many years in advance. All leading Antarctic nations plan their campaigns 3-5 years in advance, with tentative planning even earlier. Likewise, the most ambitious research in the lab or in developing Earth system models is only possible with long-term funding at scale.

With regard to fieldwork, Australia is not presently able to plan on the timescales of other nations. AAD science and science logistical support funding is pending annual budget approval. However, Antarctic field work is a logistical challenge, and plans often have to be modified or delayed, possibly by a year or two, due to weather, sea-ice conditions or other

unforeseen circumstances. This is not well served by typical Government budgets and discourages international collaboration. The national interest would be best served if AAD funds could be ring-fenced and rolled between years.

Likewise, university-based programs of research are required that are coordinated, aligned with strategy, and funded over the timescales that match the Decadal Plan. The universities currently deliver two-thirds of Australia's Antarctic research outputs; this is currently supported by Government time-limited funding of no more than $20M/yr , and commonly lasting only 3 years. In April 2023 the Australian Antarctic Science Council provided recommendations to the government on an Australian Antarctic Science Funding Model that includes the recommendation that current terminating funding measures for Antarctic science should be made ongoing at their current annual levels (indexed).

**The urgency of remote fieldwork on the ocean and land**

It is essential that the Inquiry know that the most pressing large-scale science does not occur at Australia's three coastal Antarctic stations. The most vulnerable ecosystems, the changing sea ice, and the unknown risk of rapid deglaciation can only be studied by remote fieldwork, often in locations Australia has rarely ventured to but still within Australian Antarctic Territory or adjacent seas.

Australia's new icebreaker *RSV Nuyina,* combined with *RV Investigator,* provide internationally leading capability in ocean science. *RV Investigator* can travel to the sea ice edge (and has done so, for example the recent, highly successful, Multidisciplinary Investigation of the Southern Ocean voyage), but only *RSV Nuyina* can break through the ice and traverse the sea ice zone.

It is now seven years since Australia last undertook a major marine science voyage in the sea ice zone. This gap, partly due to the transition to the *RSV Nuyina*, has occurred at a time when sea ice is transitioning to a new regime and new observations are urgently required on the state of the ocean, ice, atmosphere, and marine ecosystems. *RSV Nuyina* was designed as a major scientific capability for Australia and was delivered in 2021, but it is yet to undertake a large-scale marine voyage, with the major Marginal Ice Zone voyage cancelled in late 2022, undoing years of planning for both Australian and international scientists.

*RSV Nuyina* is available for marine science 'up to 60 days' per year, including up to 20 days to transit to the study site. The opportunity for Australia's researchers to exploit the enormous investment in the science capability of *RSV Nuyina* is therefore extremely limited. It is vital that we ensure Australia's Antarctic bases are resupplied regularly. Unfortunately, this means that science time is the only flexible component of *RSV Nuyina*'s schedule. Inevitably, this leads to a reduction in Australia's capability to carry out research into pressing environmental questions with far reaching implications relevant to Australia.

We therefore argue that Australia needs a second ice breaking vessel to deliver supplies to the bases to allow the world's most capable scientific icebreaker to focus on gaining new knowledge of Antarctica and the Southern Ocean for Australia and the planet. Until that occurs, optimising the available ship time so that a reliable and consistent research program can be maintained and used for long term planning is essential. Separation of responsibility for operating the ship and prioritising resources should be investigated.

Likewise, on land, accessing the most remote regions relies on AAD provision of aircraft for weeks, which often conflicts with station logistical needs, or is only available once or twice per decade. This further inhibits scientific research in the Australian Antarctic Territory.

Australian experiences and commitment to marine science contrasts with other nations. In recent years, Japan, Germany, and China, for example, have undertaken remote and extensive fieldwork along the coastline of Australian Antarctic Territory, including the vulnerable Totten and Denman Glacier regions.

**Essential developments in Earth system modelling**

AMOS welcomes recent Government investment to begin to include ice sheet processes in our national Earth system model through the NCRIS-funded national research infrastructure (ACCESS NRI). This addition places Australia at the lead of other nations and recognises that changes in the ice sheet today and in the future will have profound effects on our regional and global climate. However, at present there is very little long-term government support for scientific climate model development. Alongside the inclusion of ice-sheet processes, there is the requirement for continuous model improvement in order to provide accurate and timely climate information and projections to stakeholders, and to maintain Australia's climate modelling capability at a world-class level. Australia urgently needs a strategy for climate modelling, spanning a long-term plan for model development, including a plan for training and retaining researchers with the appropriate skills and expertise, and support for international coordinated modelling activities such as the Coupled Model Intercomparison Project.

As our submission makes clear, a strong, well-funded, and reliable Antarctic research program is essential for Australia's future prosperity and national security. We urge the government to carefully consider the recommendations given in the summary at the beginning of this submission.

Yours sincerely,

Dr Martin Singh
AMOS President

AMOS Position Statement on Climate Change
https://drive.google.com/file/d/1ocr7-2M9WuwWzG3wol79jtT8lTAjnAeb/view?pli=1

AMOS Position Statement on Sea Level Rise
https://www.amos.org.au/wp-content/uploads/2018/12/AMOS_SeaLevelChange_Statement_FINAL-3.pdf

AMOS Position Statement on International Cooperation & Data Sharing in Meteorology and Oceanography
https://drive.google.com/file/d/1R55aiF0GD99n0mR-kOwiZx04OEZfpB1W/view

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