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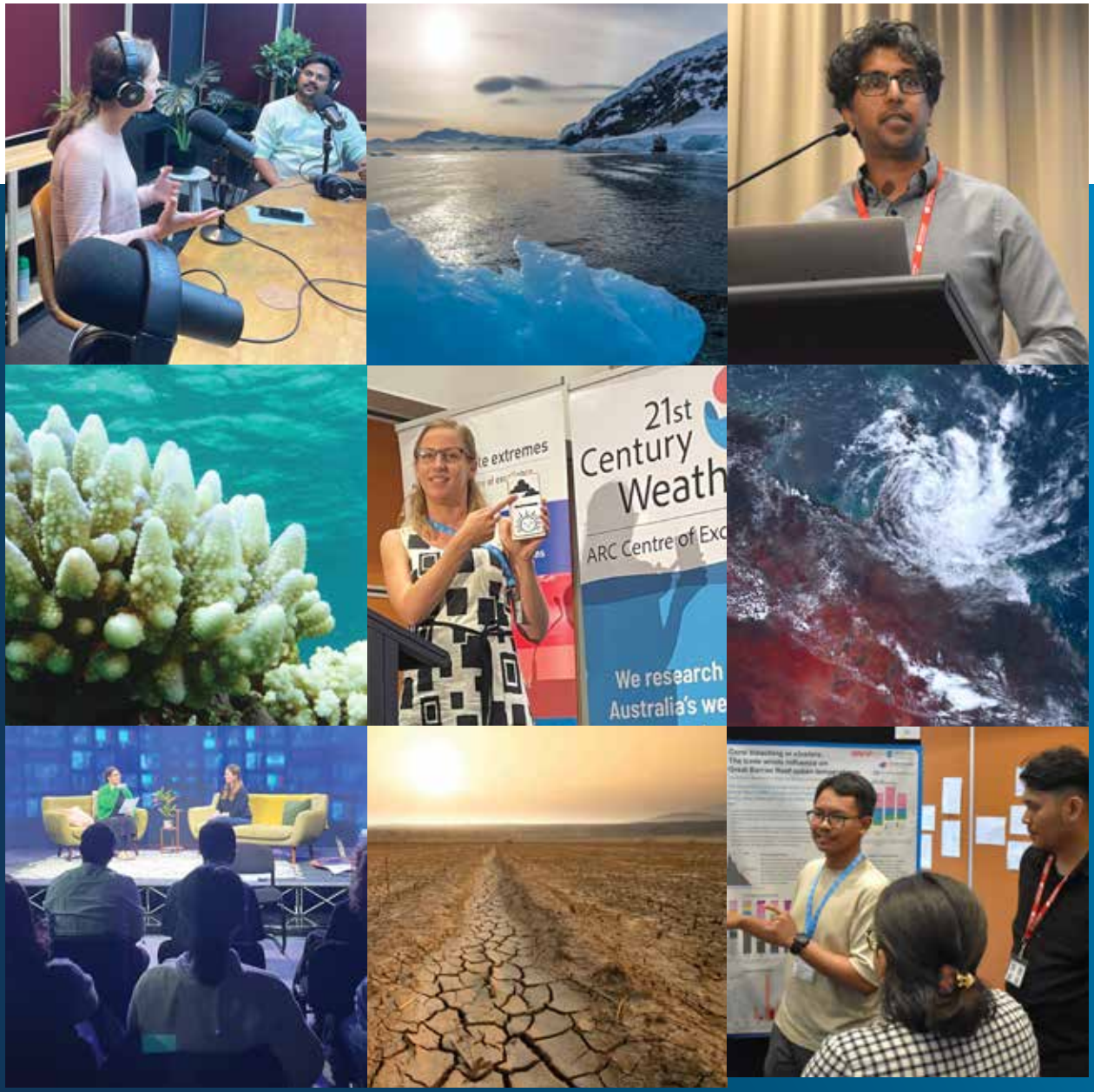
climate extremes
ARC centre of excellence

Annual Report 2024

ARC Centre of Excellence for Climate Extremes



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The ARC Centre of Excellence for Climate Extremes reduces Australia's economic, social and environmental vulnerability to climate extremes.

We do this by

- developing and leading fundamental climate science;
- improving the predictions of extreme weather and climate events;
- fostering collaborative science between five of Australia's leading universities and our Partner Organisations;
- training and investing in the climate science leaders of the future; and
- sharing our knowledge with governments, policymakers, industry and the community.

The ARC Centre of Excellence for Climate Extremes is financially supported via a Major Investment Grant (CE170100023) from the Australian Research Council (ARC). The Centre is financed and hosted by UNSW Sydney. Collaborating institutions are Monash University,

the University of Melbourne, the Australian National University and the University of Tasmania. The Centre also received financial support from the New South Wales Research Attraction and Acceleration Program, the New South Wales Department of Climate Change, Energy, the Environment and Water, the Department of Agriculture, Water and the Environment, the Bureau of Meteorology and Sydney Water.

The ARC Centre of Excellence for Climate Extremes acknowledges the Traditional Owners of Country throughout Australia. We pay our respects to Elders past and present.

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Victoria Ticha (or otherwise attributed)

Report

Vilia Co, Melissa Hart, Angela Kaplish, Taira Malby-Freckleton, Simon Parsons, Paola Petrelli, Andy Pitman, Victoria Ticha, Susana Widjaja and Chief Investigators

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UNSW SYDNEY · MONASH University · THE UNIVERSITY OF MELBOURNE · Australian National University · UNIVERSITY of TASMANIA

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Who we are

The Australian Research Council **Centre of Excellence for Climate Extremes** is the world's first fully integrated centre focused explicitly on the understanding and prediction of climate extremes.

We research the processes causing climate extremes and build this understanding into the Australian prediction systems, thereby improving our capability to predict extremes into the future.

Climate extremes are high-impact events that can range in time scales from minutes to centuries.

They are estimated to have cost the global economy **US$2.4 trillion** between 1979 and 2012 alone.

By improving our capability to predict these extremes we will inform strategies and policies to minimise these huge sums and **reduce national and global vulnerability to climate extremes** and their potential costs.

Our unique focus is a response to the World Climate Research Programme's identification of climate extremes as a Grand Challenge.

This reflects the importance of climate extremes to society, the scientific challenges associated with the understanding and prediction thereof and the lack of major, coordinated activities worldwide to address them.

Thanks to a 30-million-dollar investment from the Australian Research Council (ARC) and collaboration between leading Australian and international research partners, the ARC Centre of Excellence for Climate Extremes accepts the challenge set by the World Climate Research Programme and leads the charge on this globally significant problem.

2024 in Summary

World Class Research

184
papers published

16.3%
of our publications are in the top 10% most cited worldwide

70.2%
of our publications are in the top 10% journals

50%
of PhDs identified as women, reflecting a 50/50 gender split

Outstanding Environment

26
PhD completions

9
Master graduations

162
attendees of the jointly run workshop with 21st Century Weather annual workshop

86%
of Centre leaders identified as women

Strong Impact and Engagement

220,000
website views

96,000
new website visits

16
inquiry submissions and briefing notes published

400
media mentions

Winners of the 2024 ARC Centre of Excellence for Climate Extremes Prizes

Director's Prize:
Knowledge Broker Team, Angela Kaplish, Alice Wilson, Georgina Harmer

Best paper by a student:
Jacob Weis

Best paper by an Early Career Researcher:
Dr Zoe Gillett

Outreach Prize:
Yuxin Wang, Jiaxin Shi, Darren li Shing Hiung, Shujing Zhang and Dr Zijie Zhao

From the Director

Welcome to the final annual report of the ARC Centre of Excellence for Climate Extremes. Over the years, the Centre has made remarkable progress in advancing Australia's ability to understand the processes driving climate extremes, and 2024 was no exception. Our efforts addressed critical challenges such as extreme rainfall, droughts and heatwaves, along with their societal impacts. By leveraging cutting-edge tools, including machine learning, and supporting activities around developing high-resolution climate models, we deepened our understanding of extreme events in a rapidly changing climate.

The past year also highlighted the strength of collaboration. The Centre delivered approximately 20 knowledge brokerage products – including briefing notes and government submissions – tailored to stakeholders, many of which were specifically designed for government and industry audiences. These outputs, shaped by the contributions of students, postdocs and chief investigators, helped influence policy discussions. They also demonstrated the Centre's ability to translate complex science into accessible, actionable insights for decision-makers, ensuring maximum clarity and real-world impact.

The outcomes of our graduate development program were remarkable. Under Professor Melissa Hart's transformative leadership, 26 PhD candidates and nine masters students graduated in 2024 alone, while countless early career researchers benefited from a program that set new standards for excellence. These achievements reflect our dedication to cultivating the next generation of leaders in climate science.

Our publication record was equally impressive, with over 184 research papers, including several syntheses that united entire research themes. These included groundbreaking studies of marine heatwaves, droughts and extreme rainfall, laying a strong foundation for future scientific inquiry and decision making. Gender equity and cultural change were central to our successes. By year's end, 86 percent of our Centre leaders identified as female, thanks to early leadership and sustained efforts. This milestone set a new benchmark for inclusivity in Australian climate science.

As we conclude this chapter, we pass the baton to the ARC Centre of Excellence for 21st Century Weather. Building on our foundations, the new Centre will address critical questions about weather systems, high-impact events, and their societal implications. With ambitious goals in model development and partnerships, the new Centre is poised to lead efforts in understanding weather as both a hazard and a resource.

The year 2024 showcased the best of what we achieved: impactful research, transformative training and a vibrant, collaborative community. Thank you to everyone who contributed to this extraordinary journey. As one chapter ends, another begins, and we wish the new Centre and its researchers every success!

Best wishes,

Professor Andy Pitman
Director, ARC Centre of Excellence for Climate Extremes

From the Chair of the Advisory Board

Today, as I write my last report as chair of the ARC Centre of Excellence for Climate Extremes, I reflect on the incredible achievements of this final year. The Centre's work this year reinforced its role as a leader in addressing the critical challenges of the processes underpinning climate extremes. This work has left a lasting impression, and it has ramifications for how Australia and the world face our climate future.

What struck me most about 2024 was the demonstrable strength of the Centre's people. The creativity and determination of our researchers, from students to senior leaders, shone through in everything they did. Their ability to tackle complex problems collaboratively, and to produce valuable insights and usable products, has been remarkable to witness.

This year also stood out for the way the Centre engaged with decision-makers and the community at large. From policy submissions to public discussions, our researchers and their wisdom brought clarity to pressing climate issues and ensured their work reached the wider community. Their dedication to making a difference has been inspiring.

Two important things have struck me about the Centre. The first is the way the whole organisation has cared about its members and supported them. The second is quality of leadership in all areas of the Centre's work. In its governance and practice, the Centre mentored and built its own leadership cohort. The Centre's considerable success is in no small part due to these facts.

As we step into a new chapter for climate research with the establishment of the ARC Centre of Excellence for 21st Century Weather, I am confident that the Centre's contributions will resonate far into the future.

It has been a great privilege to serve as chair during this extraordinary year, and for all the past years. I am deeply grateful to everyone who made 2024 such a fitting conclusion to this remarkable journey.

Dr Tony Press AO
Chair, ARC Centre of Excellence for Climate Extremes Advisory Board

Strategic Plan

Our Vision: Our Centre will transform the understanding and modelling of climate extremes, including their dependence on climate change and variability, to advance scientific understanding and assist decision-makers.

Our Research
We will be a world-leading research centre contributing a significant advancement of knowledge

Our Influence and Outreach
We will have influence and impact beyond academia to have a lasting legacy

Our People
We will demonstrate a commitment to diversity, excellence and community

Strategic Objectives	Success strategy	Strategic foci	
World class research focused on climate extremes	Our research program's success will be measured and reported via the quantity and quality of our publications	1.1	Focus on four key programs: • Weather and Climate interactions • Attribution and Risk • Drought • Ocean Extremes
		1.2	An uncompromising focus on excellence
		1.3	Leadership in national model development and collaboration
		1.4	Fundamental research into climate variability and change
An outstanding environment for all Centre activities	We will measure and report our effectiveness in achieving an exemplar environment for all students and staff	2.1	Enhanced Researcher Development Program to mentor and train the next generation
		2.2	Proactive Equity, Diversity and wellbeing initiatives
		2.3	Ensure early career representation at all levels of Centre activities
		2.4	Foster a culture of community and belonging across the Centre
		2.5	Post-COVID-19 accelerated recovery strategies
Transform collaboration at all scales	We will measure and report the breadth and depth of our collaboration	4.1	Maintain structures that avoid silos
		4.2	Conduct national workshops and training programs
		4.3	Strategic cross-institutional research team
		4.4	Interact with our Advisory Board on key strategic issues
		4.5	Post-COVID-19 accelerated recovery strategies
Exceptional research infrastructure	We will measure and report our effectiveness at maintaining research infrastructure	3.1	The Computational Modelling Systems Team provides advice on modelling and data systems
		3.2	Secure and collaborative relationships with NCI and the ACCESS NRI
		3.3	Be an exemplar for data delivery
		3.4	Develop tools for research that are sustainable beyond the Centre's lifetime
		3.5	Lead collaboration to build the next generation climate model
Research that engages and has impact	We will measure and report our effectiveness in influence and outreach	5.1	Maintain a knowledge brokerage team to facilitate stakeholder engagement
		5.2	Be an influential and dominant voice in key areas of climate extremes
		5.3	Plan and communicate for influence and impact
		5.4	Promote climate science in secondary school STEM subjects
		5.5	Post-COVID-19 accelerated recovery strategies
Identify gaps in our research, training, infrastructure, influence and outreach and seek additional funding to resolve them			

Organisational Chart

Governance

ADVISORY BOARD
Tony Press

Executive Management

DIRECTOR
Andy Pitman

DEPUTY DIRECTOR
Julie Arblaster

GRADUATE DIRECTOR
Melissa Hart

CHIEF OPERATIONS OFFICER
Vilia Co

COMPUTATIONAL MODELLING SYSTEMS LEADER
Paola Petrelli

ENGAGEMENT & IMPACT LEADERS
Angela Kaplish
Victoria Ticha

Research Programs

5 RESEARCH PROGRAMS


Weather & Climate Interactions


Attribution & Risk


Drought


Ocean Extremes


Modelling

Workgroups and Committees

OPERATIONS

COMPUTATIONAL MODELLING SUPPORT

MEDIA

COMMITTEES & ECR REPRESENTATION

KNOWLEDGE BROKERAGE TEAM

Governance, Management and our Commitment to Equity, Diversity and Inclusion

The Australian Research Council (ARC) Centre of Excellence for Climate Extremes has a robust and efficient governance structure. Our governance model ensures participative decision-making by all Centre members, via our committees for early career researchers, infrastructure, diversity and culture, as well as our seminars and engagement and impact activities. Each committee presents recommendations to the Centre Executive and provides updates to monthly chief investigator meetings. In addition to these internal structures, the Centre of Excellence receives guidance and strategic advice from its Advisory Board.

Centre Advisory Board

The ARC Centre of Excellence for Climate Extremes is overseen by an Advisory Board, which is chaired by distinguished scientific leader Dr Tony Press. The Centre's Advisory Board provides strategic oversight and advice to the Centre of Excellence, as well as monitoring the Centre's performance against its stated Key Performance Indicators. In 2024, as it was the Centre's final year of operation, the Centre engaged in one-on-one consultations with our Advisory Board members to seek their valuable input and guidance as needed.

Advisory Board Members in 2024

Dr Tony Press AO FAIIA, Adjunct Professor, UTAS, Australian Antarctic Program Partnership (Chair)

Dr Tony Press is an adjunct professor at the Australian Antarctic Program Partnership and the Institute for Marine and Antarctic Studies at the University of Tasmania. He served as the chief executive officer of the Antarctic Climate and Ecosystems Cooperative Research Centre from 2009 to 2014. Dr Press has had a long career in science, natural resource management, public administration and international policy.

Dr Press was the director of the Australian Antarctic Division from 1998 to 2009. He chaired the Antarctic Treaty's Committee for Environmental Protection (CEP) from 2002 to 2006. He was Australia's representative to the CEP and alternative representative to the Antarctic Treaty Consultative Meetings from 1999 to 2008. He was Australia's commissioner for the Convention on the Conservation of Antarctic Marine Living Resources from 1998 to 2008. In 2014 he provided the Australian Government with the Australian Antarctic Strategy and 20 Year Action Plan.

Dr Jaci Brown, Research Director, CSIRO Climate Science Centre

Dr Jaci Brown is currently the interim lead of the National Environmental Science Program's Climate System Hub. The hub provides research to advance the understanding of Australia's climate, its extremes and associated drivers. This research will directly inform climate adaptation solutions for Australia. Jaci's substantive role is as the Research Director for the Climate Intelligence Program in CSIRO's Environment Research Unit.

Ian T. Dunlop, Independent Advisor & Commentator, Climate Change & Energy

Ian Dunlop is a Cambridge-educated engineer, formerly a senior executive in the international oil, gas and coal industries. He chaired the Australian Coal Association in 1987-88. From 1998 to 2000 he chaired the Australian Greenhouse Office Experts Group on Emissions Trading, which developed the first emissions trading system design for Australia. From 1997 to 2001 Ian was chief executive officer of the Australian Institute of Company Directors. He has a particular interest in the interaction of corporate governance, corporate responsibility and sustainability.

Ian is Chair of the Australian Security Leaders Climate Group, a member of The Club of Rome, a member of the Advisory Board of the Planetary Health Equity Hothouse at ANU, and Chair of the Advisory Board of the Breakthrough National Centre for Climate Restoration. He advises and writes extensively on governance, climate change, energy and sustainability.

Danielle Francis, Manager Policy and Strategy, Water Services Association of Australia

In her 20 years in the Australian water industry, Danielle has led communications, regulatory, pricing, stakeholder and strategy portfolios to help the industry deliver valued services to the community.

Today Danielle's focus is on the following: shaping the policy landscape; influencing national policies and strategies for the water industry, including the National Water Agreement; managing the 'all options on the table' portfolio, as well as water-for-growth and placemaking initiatives; and leading on climate change adaptation and mitigation strategies, including support for renewable energy and the emerging circular economy.

Dr Greg Holland, Senior Scientist Emeritus, National Center for Atmospheric Research, Boulder, USA; President Mornington Peninsula Landcare Network

At the US National Center for Atmospheric Research (NCAR), Dr Holland was previously director of NCAR's Earth System Laboratory and the Capacity Center for Climate and Weather Extremes. He has served on a number of committees and review boards for the National Oceanic and Atmospheric Administration, the US National Academies, NASA, Zurich Insurance and Willis Insurance. He chaired the Tropical Meteorological Program of the World Meteorological Organization for 12 years.

He is currently President of the Mornington Peninsula Landcare Network, which coordinates all Landcare activities across the Mornington Peninsula.

Dr Holland has moved from his past climate and extreme weather research focus into biodiversity and ecosystem services. He holds a PhD in Atmospheric Science from Colorado State University. He is a fellow of both the American Meteorological Society and the Australian Meteorological and Oceanographic Society.

Professor Dane McCamey, Pro Vice-Chancellor (Research), UNSW Sydney

Professor Dane McCamey is Pro Vice-Chancellor (Research) at UNSW Sydney. His research interest is in condensed-matter physics, in particular the role that spin (a quantum property of subatomic particles) plays in the function of optoelectronic materials and devices. His research spans from fundamental investigation of quantum properties through to applications in photovoltaics and quantum technologies. Prior to his current role, Prof McCamey was deputy dean of Research and Enterprise for UNSW Sydney Science and also served as deputy director of the ARC Centre of Excellence in Exciton Science.

Matthew Riley, Director, Climate and Atmospheric Science, NSW Department of Climate Change, Energy, the Environment and Water

Matthew Riley is Director of Climate and Atmospheric Science at the NSW Department of Climate Change, Energy, the Environment and Water, where he leads its Climate Change Adaptation, Impacts and Risk research program. Matthew is also the Director for the NSW and Australian Regional Climate Modelling Project. He leads net zero emissions modelling for the NSW Government, delivering advice on greenhouse gas emissions reduction targets and net zero policies and programs. In addition, Matthew is responsible for the operation of the NSW Air Quality Monitoring Network, NSW Air Quality Forecasting and leads the NSW Government's air quality research program. Matthew has over two decades of experience in urban meteorology, climatology and air-quality measurement.

Kathryn Smith, Assistant Secretary, National Adaptation Policy Office

Kathryn Smith is Assistant Secretary at the National Adaptation Policy Office, which is part of the Climate Change Group in the Department of Climate Change, Energy, the Environment and Water. In that role, Kathryn is responsible for Australian Government climate adaptation policy, climate services policy and climate science coordination.

Dr Bertrand Timbal, Head of Research, Bureau of Meteorology

Dr Bertrand Timbal moved to Australia and joined the Bureau of Meteorology in 1996, after completing his PhD at the French National Met Service (Meteo-France) in 1994. After a three-year stint leading the climate branch at the Centre for Climate Research Singapore, Dr Timbal re-joined the Bureau in 2020 as the General Manager for the research program, Science and Innovation Group. In this role, he leads a program of 130 scientists, support scientists and science managers delivering along the four objectives of the Bureau's Research and Development Plan.

Centre Executive

The Centre Executive is composed of the Centre Director, who carries overall responsibility for day-to-day leadership of the ARC Centre of Excellence for Climate Extremes and its research; the Deputy Director; the Chief Operations Officer; the Graduate Director; the Manager of the Computational Modelling Systems team; and the leaders of the Engagement and Impact team.

Each of the Centre's research programs has a pair of co-leaders who set and monitor yearly and longer-term research priorities. All Chief Investigators meet monthly to discuss Centre business and cross-nodal research activity and initiatives.

Centre Committees

To maximise the effectiveness of the ARC Centre of Excellence for Climate Extremes as a cohesive entity, we have established three key committees that report to the Centre Executive, each with an important and specific remit to enhance collaboration across the Centre and drive focus in key areas of our Centre strategy namely, equity and diversity; outreach and pathways-to-impact; and infrastructure and technology.

Diversity and Culture Committee

Chair: Melissa Hart (UNSW Sydney)

Members: Hooman Ayat (UniMelb), Isabelle Greco (UNSW Sydney), Todd Lane (UniMelb), Nicola Maher (ANU), Fadhlil Rizki Muhammad (UniMelb), Andy Pitman (UNSW Sydney), Jenny Rislund (UNSW Sydney), Martin Singh (Monash), Greeshma Surendran (UNSW Sydney) and Andrea Taschetto (UNSW)

The Centre of Excellence is committed to providing an unrivalled working environment for its students and staff. Consequently, we're implementing measures that enhance the diversity of our staff and student populations and proactively ensuring we build and maintain an equitable culture.

The Diversity and Culture Committee provides advice and recommendations to the Centre Director and Centre Executive on matters pertaining to equity, diversity and Centre culture, including mental health and wellbeing. The committee leads Centre-wide initiatives and drafts policies and procedures within its sphere of influence. The committee's activities are based on research and on benchmarking of best practice in the equity, diversity and culture landscape in Science, Technology, Engineering and Mathematics and in higher education generally.

Infrastructure Committee

Chair: Paola Petrelli (UTAS)

Members: Gab Abramowitz (UNSW Sydney), Craig Bishop (UniMelb), Dietmar Dommenget (Monash), Jason Evans (UNSW Sydney), Wilma Huneke (ANU), Neil Holbrook (UTAS), Ramkrushnbhai Patel (UTAS)

The Infrastructure Committee's primary role is to aid the Computational Modelling Systems (CMS) team in the prioritisation and delivery of the services it provides. This includes facilitating discussion and decision-making around which modelling systems and data sets should be considered in or out of scope, as well as identifying emerging modelling systems or data sets that offer new opportunities for the Centre of Excellence. The committee is also tasked with helping the CMS team allocate, compute and store resources in regard to Centre research programs – particularly where there are competing requests – as well as liaise with National Computational Infrastructure and other relevant national infrastructure bodies.

These roles are intended to help maintain strong communication between Centre researchers and the CMS team, as well as support the latter in prioritising competing requests for its time.

Engagement and Impact Committee

Chair: Angela Kaplish (UNSW Sydney)

Members: Nerilie Abram (ANU), Ailie Gallant (Monash), Zoe Gillett (UNSW Sydney), Amelie Meyer (UTAS), Laure Poncet (UNSW Sydney), Kim Reid (Monash), Victoria Ticha (UNSW Sydney), Alice Wilson (Monash)

The Engagement and Impact Committee at the Centre of Excellence brings together some of Australia's most talented policymakers, media and communications specialists, science communicators, content makers and designers, and more, to ensure that the essential science of climate extremes is heard by the people who need to know.

The committee advises and collaborates with the Centre's Engagement and Impact team to deliver training, resources and opportunities for Centre researchers to share their work and expertise with government, industry and the community.

Early Career Researcher Committee

Chairs: Georgy Falster (ANU), Jemma Jeffree (ANU), Doug Richardson (UNSW Sydney)

Members: Tahereh Alinejadtabrizi (Monash), Alexander Borowiak (UniMelb), Ashneel Chandra (UMelb), Matt Grant (UNSW Sydney), Jarrah Harrison-Lofthouse (UniMelb), Rachael Isphording (UNSW Sydney), Dongqi Lin (Monash), Clemente Lopez-Bravo (UNSW Sydney), Sramana Neogi (Monash), Polina Sholeninova (ANU), Jiaxin Shi (UTAS), Nayan Talmale (UniMelb), Zijie Zhao (UTAS)

The Early Career Researcher Committee's mission is to facilitate, encourage, and contribute to the development of all early career researchers (ECRs) at the Centre of Excellence. The committee is composed of at least one student and at least one postdoctoral representative from each of the Centre's five partner institutions.

Committee members have an opportunity to:

- help shape Centre professional and social events to reflect their and their fellow ECRs' needs and goals,
- gain leadership experience, and gain insight into how the Centre operates.

Centre Operations Team

The transformative research that the Centre of Excellence continues to deliver is supported by a dedicated team of professional staff led by Chief Operations Officer, Vilia Co.

The operations team is further comprised of Senior Project Officer Jenny Rislund (UNSW Sydney), Finance Officer Susana Widjaja (UNSW Sydney), Node Administrators Sushila Desai (UTAS), Mary Hapel (ANU) (left the centre in mid-2024), Silvana Katragadda (Monash), Taira Malby-Freckleton (UNSW Sydney) and Simon Parsons (UniMelb).

Leadership Development

We are strongly committed to providing leadership training, mentorship, guidance and opportunities for all ARC Centre of Excellence for Climate Extremes researchers, including our students and early career researchers (ECRs), along with our professional and technical staff.

Our Centre is unique among Australian Centres of Excellence in appointing a dedicated, full-time senior Graduate Director to build a fully integrated leadership and professional development program for our staff and students.

What our Centre offers far exceeds a typical 'mentoring program' in both scale and ambition. We provide bespoke, end-to-end support for our graduate students and ECRs, via the following:

- individual training-needs analyses;
- support for internships;
- a curated calendar of annual workshops, addressing both scientific and professional skills; and
- access to funding to support research visits to nodes and Partner Organisations, summer schools and other career-enhancing opportunities.

Furthermore, our students and ECRs are represented via our Early Career Researcher Committee, with an ECR representative attending Chief Investigator meetings. That committee also organises professional development and training events, including dedicated events at the national Australian Meteorological and Oceanographic Society's annual meetings. It helps facilitate dedicated ECR funding applications that enable our researchers to lead small projects that expand beyond the scope of their research programs.

Our Engagement and Impact team delivers training and creates opportunities for Centre researchers and students to boost their skills in government relations, policymaking, industry engagement, science communications, media commentary, public speaking and more. The team focuses on fostering the next generation of leaders in engagement and impact through long-term skill building.

Equity, Diversity and Inclusion

Our Centre fosters a culture of diversity and inclusion.

Our goal is to make the Centre of Excellence a forward-thinking organisation that enables all staff and students, regardless of background, to do their best work in a professional and compassionate environment. Our equity plan is an ambitious document to guide the Centre's efforts to fulfil our aim of being an exemplar in this space. We are serious about creating a respectful research environment for our diverse population of researchers, to ensure our staff and students can reach their full potential, and we are equally committed to making a meaningful contribution to addressing historical prejudices and inequality in Science, Technology, Engineering and Mathematics disciplines.

Research Ethics and Intellectual Property

The ARC Centre of Excellence for Climate Extremes is committed to uncompromisingly high standards of professional conduct and rigour in all activities, including all aspects of our research.

Arguably, few disciplines receive as much public scrutiny as climate science. Accordingly, climate scientists have long embraced openness, accountability and an open-source approach to their work. This ensures originality and reproducibility of research, adherence to proven methodological frameworks and rigorous data-management practices. Adherence to Findability, Accessibility, Interoperability and Reusability (FAIR) is normal practice in our field; indeed, we have been influential in driving this agenda, including in the production of recent Academy of Science reports. All new staff and students at the Centre of Excellence receive information on the ethical conduct of research as part of their Centre induction, and reminders of this responsibility are periodically circulated.

Intellectual property customarily relates to inventions as opposed to discoveries. Research in our Centre is driven by our overarching goal to better understand the physical processes in the global climate system that contribute to extremes across scales of time and space. In other words, we are a Centre of Excellence focused primarily on discovery.

Globally, the climate science community has always worked from a foundational premise that all our work is open source and shared, such that others may build on work that has preceded their own, without restriction beyond the norms of attribution. Thus, code, data, models and so on are openly shared, and we benefit from this by having access to data and models that would be impossible for Australia to develop independently. By returning our contributions into that system, we provide the rationale for the rest of the world maintaining, in turn, open access to their data and models. Accordingly, we place greater emphasis on proper data management – including publishing data and code – than on traditional notions of intellectual property.

This approach to open-source development of our models and tools that assist us in interrogating model output is made explicit in the Centre's inter-institutional agreement. The agreement also offers an intellectual property framework to follow if, at any point, the Centre developed an invention or product that meets the standard definitions of intellectual property.

Consequently, intellectual property is a low priority in climate science – to raise this priority would break our capacity to engage internationally and access data and models developed by the climate science community. However, we recognise that around half of our graduates leave academia and research to take positions in government or industry where intellectual property considerations may be material. We are therefore developing an internal training module on intellectual property that is specific to the uniquely open-source approach taken by researchers in our field.

Chief Investigators

Director
Professor Andy Pitman AO

Professor Andy Pitman was born in Bristol and was awarded a bachelor's degree with honours in physical geography and a PhD in Atmospheric Science by the University of Liverpool, UK. He also holds a Postgraduate Certificate in Educational Leadership from Macquarie University. He has been at UNSW Sydney since 2007. He was the director of the Australian Research Council (ARC) Centre of Excellence for Climate System Science (2011–2017) and is now Director of the ARC Centre of Excellence for Climate Extremes.

Prof Pitman's research focus is on terrestrial processes in global and regional climate modelling, model evaluation and earth systems approaches to understanding climate change. His leadership, collaboration and research experience is extensive both nationally and internationally. Between 2004 and 2010 he convened the ARC Research Network for Earth System Science, which facilitated interaction between individuals and groups involved in climate system science. He is a member of the Australian Community Climate and Earth System Simulator initiative, the Academy of Science National Committee for Earth System Science and the NSW Minister for Climate Change Science Advisory Committee. He is also heavily engaged in e-research, including most recently on the taskforce assessing the roadmap for national research infrastructure.

Internationally, Prof Pitman is closely affiliated with the World Climate Research Programme (WCRP). He was a long-term member and former chair of the WCRP's Land Committee for the Global Land Atmosphere System Study. As co-chair, he jointly led one of the first major international intercomparison exercises: the Project for the Intercomparison of Land Surface Parameterization Schemes, which is supported by the WCRP and the International Geosphere Biosphere Programme. He also sat on the Science Steering Committee of the Integrated Land Ecosystem-Atmosphere Processes Study and is currently co-coordinator of the Land Use Change: Identification of Robust Impacts project.

Prof Pitman is a regular invitee for keynote presentations and is a passionate communicator about science, contributing regularly to the media on the science of climate change. He was a Lead Author for the Intergovernmental Panel on Climate Change (IPCC) 3rd and 4th Assessment Reports, contributing to the award of the Nobel Peace Prize to the IPCC in 2007. He was review editor of the 2013 IPCC report. He has also contributed to the Copenhagen Diagnosis, an Australia-led update of the science of climate change. Prof Pitman has held editorial positions with the *Journal of Climate* and the Annals of the Association of American Geographers' *Journal of Geophysical Research-Atmospheres*, and he is currently an associate editor for the *International Journal of Climatology*.

Prof Pitman was appointed an Officer of the Order of Australia in 2019. Other awards and accolades he has received include: The Royal Society of Victoria's Medal for Excellence in Scientific Research (2019), NSW Scientist of the Year Award (2010), the Australian Meteorological and Oceanographic Society (AMOS) Medal (2009), the Dean's Award for Science Leadership at Macquarie University (2005), the Priestley Medal for Excellence in Atmospheric Science Research (2004) and the Geoff Conolly Memorial Award (2004). Prof Pitman jointly won the International Justice Prize for the Copenhagen Diagnosis (2010) and was among Sydney Magazine's list of the 100 most influential people (2010). He is a fellow of AMOS and of the American Meteorological Society. In 2024 he was appointed to the NSW Net Zero Commission.

Prof Pitman has a long track record of nurturing early career researchers and has supervised multiple PhD students through to successful completion. He has published over 200 papers in peer-reviewed journals and has authored 20 book chapters.

Deputy Director
Professor Julie Arblaster

Professor Julie Arblaster's research interests lie in using climate models as tools to investigate mechanisms of recent and future climate change, with a focus on shifts in the Southern Hemisphere atmospheric circulation, tropical variability and climate extremes. She is particularly interested in the interplay between the predicted recovery of the Antarctic ozone hole over coming decades and greenhouse gas increases in future climate projections, with its potential impacts on the surface ocean circulation and sea ice. Her recent work has also focused on explaining extreme events in Australia, such as record-breaking temperatures and rainfall, in terms of both the role of human influences on climate and the diagnosis of the climate drivers. Prof Arblaster's research incorporates the use of observations, multi-model data sets and sensitivity experiments with a single model. Her strong collaboration with the National Center for Atmospheric Research in the U.S. and participation in various international committees and reports enhances her engagement with the latest advances in climate research internationally.

Prof Arblaster is a fellow of the Australian Meteorological and Oceanographic Society and was awarded their Priestley Medal in 2018 as well as the 2014 Australian Academy of Science Anton Hales Medal for research in earth sciences. She served as a Lead Author of the Intergovernmental Panel on Climate Change 5th Assessment Report and was on the scientific steering committee for the World Meteorological Organization/ United Nations Environment Programme Scientific Assessment of Ozone Depletion. Prof Arblaster is also a member of the World Climate Research Programme Coupled Model Intercomparison Project panel and the Australian Academy of Science National Committee on Earth System Science.

Graduate Director
Professor Melissa Hart

Professor Melissa Hart leads the researcher development program at the ARC Centre for Excellence in Climate Extremes. This program includes a national, cross-institutional graduate program which has reimagined the traditional Australian PhD. With a vital combination of breadth, depth, support and collaboration, the program has provided over 400 PhD students with the skills, knowledge and experience fundamental to developing world-leading climate science leaders equipped for employment across a range of sectors.

Prof Hart's leadership has been recognised via a UNSW Sydney Vice-Chancellor's Award for higher-degree research leadership and she has been profiled in the Higher Education Supplement of *The Australian* newspaper. Internationally, she has represented Australia at World Meteorological Organization symposiums on challenges of contemporary meteorological education, and co-chairs the steering committee of the World Climate Research Programme training academy.

Prof Hart's research looks at the impact of cities on climate and climate on cities, as well as the meteorological controls on air pollution. A strong advocate for gender equity in science, she is a past chair of the Australian Meteorological and Oceanographic Society's Equity and Diversity Committee and a proud participant of the 2018 Homeward Bound Women in STEMM leadership initiative.

Professor Nerilie Abram

Professor Nerilie Abram uses paleoclimate records to study how Earth's climate has behaved in the past in order to provide a long-term perspective on recent climate change. She has a particular focus on reconstructing climate variability in the tropical Indian Ocean and Antarctica and studying how this impacts Australia's rainfall patterns. Prof Abram's work also involves proxy-model comparisons to assess forcing mechanisms behind natural and anthropogenic climate changes and to help test climate model performance in historical and last-millennium experiments.

Professor Abram has held Future Fellow and QEII fellowships from the Australian Research Council and she received the Dorothy Hill Award from the Australian Academy of Science for her research achievements. She was a Coordinating Lead Author of the Intergovernmental Panel on Climate Change Special Report on the Ocean and Cryosphere in a Changing Climate, released in September 2019. In 2024 she was elected as a fellow of the Australian Academy of Science.

Professor Gab Abramowitz

Professor Gab Abramowitz's primary research interest is in evaluating computational models in climate science, ecology and hydrology. Currently his research focuses on two main areas: defining and accounting for model dependence in multi-model, ensemble climate prediction; and standardising model evaluation in land surface research.

Climate research teams share literature, data sets and even sections of model code. To what extent, then, do different climate models constitute independent estimates of a climate prediction problem? What is the most apropriate statistical framework with which to define model independence? What are the implications of ignoring model dependence for future climate projection?

Prof Abramowitz is also leading the development of modelevaluation.org, a web application that provides automated land surface, hydrological and ecological model evaluation tools as well as observational data sets. He is a member of the Global Energy and Water Cycle Experiment Global Land-Atmosphere System Study panel.

Professor Lisa Alexander

Professor Lisa Alexander holds a BSc (Hons) and MSc in Applied Mathematics from Queens University Belfast and a PhD in Climate Science from Monash University. She previously worked as a research scientist at the UK Meteorological Office Hadley Centre, including a year on secondment at Australia's Bureau of Meteorology.

Prof Alexander's primary research focuses on understanding the variability and driving mechanisms of climate extremes. Of particular significance is her ongoing work assessing global changes in temperature and rainfall extremes, which has contributed significantly to the Intergovernmental Panel on Climate Change (IPCC) assessments.

Prof Alexander was awarded the 2011 Priestley Medal by the Australian Meteorological and Oceanographic Society (AMOS) and the 2013 Australian Academy of Science Dorothy Hill Award for her contribution to this field of research. In 2020 she became a fellow of AMOS. She has contributed to IPCC Assessment Reports since 2001, including the Special Report on Extremes, and as a Lead Author of the IPCC's 5th Assessment Report. Prof Alexander has also spent many years chairing World Meteorological Organization expert teams and has sat on many international steering committees, including the International Association of Meteorology and Atmospheric Sciences Executive Committee. She currently serves as an officer on the Joint Scientific Committee of the World Climate Research Programme.

Professor Craig Bishop

Professor Craig Bishop completed his PhD in Applied Mathematics at Monash University. His innovative ensemble-based data assimilation and ensemble-forecasting techniques are now widely used by leading environmental forecasting agencies in several countries. Prof Bishop has held positions at the University of Reading, the NASA Goddard Space Flight Center, Pennsylvania State University's prestigious Department of Meteorology and the Marine Meteorology Division of the Naval Research Laboratory (NRL) in Monterey, California. There he garnered six outstanding-contribution awards, three NRL Alan Berman publication awards and an NRL Edison Patent Award.

Prof Bishop's positions of service to the climate and weather community include serving as co-chair of the World Meteorological Organization's Working Group on Predictability, Dynamics and Ensemble Forecasting; associate editor of the *Quarterly Journal of the Royal Meteorological Society;* and chair of the Science Steering Committee of the Joint (NASA, National Oceanic and Atmospheric Administration, US Navy, US Air-Force, National Science Foundation) Center for Satellite Data Assimilation. He was elected to the International Commission on Dynamical Meteorology in 2010 and as a fellow of the American Meteorological Society in 2012.

Prof Bishop returned to Australia as Professor of Weather Prediction at the University of Melbourne, in June 2018. His research in Australia has focused on using observations to improve estimates of past, current and future weather and climate. At the ARC Centre of Excellence for Climate Extremes, he leads research focused on using historical observations to improve ensembles of climate projections for differing emissions scenarios. The research has yielded new techniques that significantly improve the mean and variance of ensemble projections as well as the temporal correlations of daily weather extremes in individual climate model projections.

Professor Dietmar Dommenget

Professor Dietmar Dommenget completed his Diploma (MSc) in Physics at the University of Hamburg. He was awarded a PhD by the Max-Planck Institute for Meteorology, in 2000. He joined the ECCO (Estimating the Circulation and Climate of the Ocean) project in a postdoctoral position at the Scripps Institution of Oceanography in La Jolla, California, to study the predictability of El Niño with an adjoint data-assimilation scheme. After three years in California he returned to Germany in 2003 for a fixed-term faculty position as a junior professor (lecturer) in the Meteorology department at the Helmholtz Centre for Ocean Research, Kiel. Since 2010, Prof Dommenget has been at Monash University in the atmospheric and climate science group of the School of Earth, Atmosphere and Environment.

Prof Dommenget's research focuses on large-scale climate dynamics and climate modelling. He works with climate models at all levels of complexity. Most of his work centres on the development, conducting and analysis of coupled general-circulation models, but he has also developed simple conceptual models of natural climate variability. Most of his work focuses on sea surface temperature variability in the tropical and extratropical oceans.

Prof Dommenget is most widely known for his work on the interpretation of patterns and modes of climate variability. His most recent projects focus on El Niño, climate model developments and climate change. He developed a new type of climate model for the conceptual understanding of the climate response to external forcing, which is a fast and simple tool for researchers, students and the public to understand the interactions in the climate system. An outreach program based on this is called the Monash Simple Climate Model.

Professor Jason Evans

Professor Jason Evans completed his undergraduate degrees in physics and mathematics at Newcastle University in 1996 and earned his PhD in Environmental Management from the Australian National University in 2001. He then spent six years as a postdoctoral and then research fellow at Yale University in the USA. In 2007, he returned to Australia to take up a position in the Climate Change Research Centre at UNSW Sydney, where he remains today.

Prof Evans' expertise is in the area of regional climate, land-atmosphere interactions, the water cycle and climate change. His focus is on regional climate change and its impacts. His research program brings together advanced modelling tools with extensive observational data sets, with an emphasis on satellite-based, remotely sensed earth observations.

Prof Evans was a Lead Author on the Intergovernmental Panel on Climate Change (IPCC) Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems. He is on the Science Advisory Team for the Coordinated Regional Climate Downscaling Experiment, an element of the World Climate Research Programme. He was an editor of the *Journal of Climate* from 2016 to 2022. In 2020 Prof Evans was elected a fellow of the Modelling and Simulation Society of Australia and New Zealand, and in 2021 he received their Biennial Medal for outstanding contributions to modelling and simulation over a sustained period. He was also elected a fellow of the Royal Society of New South Wales in 2021.

Associate Professor Ailie Gallant

Associate Professor Ailie Gallant is an associate professor in the School of Earth, Atmosphere and Environment in the Faculty of Science at Monash University. Her research focuses on drought and on precipitation variability and precipitation extremes. A/Prof Gallant's most recent research interests include understanding what causes droughts to start and end, with a particular focus on the role of changes in weather systems during droughts.

A/Prof Gallant is a chief investigator for both the ARC Centre of Excellence for Climate Extremes and the ARC Centre of Excellence for the Weather of the 21st Century. She is also the Monash node lead of the National Environmental Science Program Climate Systems Hub.

Professor Andy Hogg

Professor Andy Hogg completed his undergraduate degree in physics at the Australian National University in 1996 and was awarded his PhD in Geophysical Fluid Dynamics from the University of Western Australia in 2002. He then spent three years as a postdoctoral fellow at the Southampton Oceanography Centre, where he developed a new, high-resolution coupled ocean-atmosphere model. In 2004 he returned to ANU to take up a position as an Australian Research Council (ARC) postdoctoral fellow. He is currently based at ANU's Research School of Earth Sciences.

Prof Hogg's research interests centre on physical processes governing the ocean and climate. His work within the ARC Centre of Excellence for Climate Extremes is focused on understanding ocean-atmosphere interactions in the Southern Ocean, particularly the exchange of heat, momentum and carbon between different components of the climate system. He plays a key role in developing tools to understand the climate system at progressively finer scales.

Prof Hogg is now Director of the Australian Community Climate and Earth-System Simulator-National Research Infrastructure, funded by the National Collaborative Research Infrastructure Strategy to develop Australia's climate modelling capability.

Professor Neil Holbrook

Neil Holbrook is Professor of Ocean and Climate Dynamics within the Institute for Marine and Antarctic Studies at the University of Tasmania (UTAS). He co-leads the ARC Centre of Excellence for Climate Extremes Ocean Extremes research program and is the Centre's UTAS node lead.

Prof Holbrook's research concentrates on developing process-based understanding and improved knowledge of the predictability of ocean and climate extremes, focusing on marine heatwaves (MHWs) – the ocean analogue of atmospheric heatwaves that can have devastating impacts on life in the sea. Prof Holbrook has been a critical player in pioneering our understanding of marine heatwaves. He designed and led the first global assessment of the drivers of marine heatwaves, which elucidates the potential predictability of enhanced or suppressed MHW likelihoods associated with large-scale climate modes. The outcomes of this research have set the baseline for future studies of MHW processes and predictability and led to a follow-up article advancing the thinking around MHW processes, predictability and prediction.

Recently, Prof Holbrook led a study of MHW impacts/projections in the tropical western and central Pacific Island nations and their communities. He co-leads an international Working Group on MHWs and is also a member of the international Climate Variability and Predictability Research Focus on Marine Heatwaves in the Global Ocean.

Prof Holbrook is an elected fellow of the Australian Meteorological and Oceanographic Society and an associate editor of the *Journal of Southern Hemisphere Earth Systems Science*. He is a former president of the International Commission on Climate of the International Association of Meteorology and Atmospheric Science/International Union of Geodesy and Geophysics (2011–2019) and an associate editor of the *Journal of Climate* (2006–2008). He also led Australia's National Climate Change Adaptation Research Network for Marine Biodiversity and Resources (2009–2013).

Prof Holbrook is recognised as a Clarivate Highly Cited Researcher (2021–2023) and was named on the Reuters list of 1000 most influential climate scientists (2021).

Dr Yi Huang

Dr Yi Huang is a senior lecturer in climate science at the School of Geography, Earth and Atmospheric Sciences, the University of Melbourne. Her research seeks to address some of the fundamental yet climatically important questions that underpin the understanding of atmospheric processes, Earth's energy budget and the water cycle. For example: How do clouds and precipitation modulate the Earth's climate system? What processes control the properties of clouds and precipitation? How do these processes differ geographically? Dr Huang addresses these questions through a combination of targeted field observations, remote-sensing data (including machine learning), deep theoretical understanding and high-resolution numerical modelling. Ultimately, her work aims to harness the critical knowledge that will help improve weather and climate predictions at multiple scales.

Dr Huang's main research interests are Southern Hemisphere meteorology and cloud and precipitation physics. Her projects involve the employment of in-situ/aircraft measurements, remote-sensing (space-borne and ground-based) observations, historical observations, reanalysis data sets and state-of-the-art numerical simulations, in order to understand clouds and precipitation generated by the Southern Hemisphere extratropical weather systems, how they link to Australian rainfall – including extremes – and how they differ from their Northern Hemisphere counterparts (such as the North Atlantic and North Pacific oceans). In addition, Dr Huang has developed interest and expertise in boundary layer meteorology, air-sea interaction, and mountain meteorology – for example, orographic precipitation across south-eastern Australia. She has also conducted applied research in collaborations with several domestic industry partners, including Snowy Hydro and Hydro Tasmania.

Professor Todd Lane

Professor Todd Lane was awarded his PhD in Applied Mathematics from Monash University in 2000, having completed his bachelor's degree in 1997. He was a postdoctoral fellow with the National Center for Atmospheric Research (USA) from 2000 to 2002 and a staff scientist there from 2003 to 2005. He joined the University of Melbourne in 2005, where he is now a professor and Deputy Dean of the Faculty of Science. Between 2010 and 2014 he was an Australian Research Council Future Fellow.

Prof Lane's primary research focus is on atmospheric processes. He is internationally recognised as an expert on tropical thunderstorms, atmospheric waves and turbulence. He has made important contributions to many aspects of mesoscale meteorology, convective cloud dynamics and high-resolution atmospheric modelling. Prof Lane's research at the ARC Centre of Excellence for Climate Extremes is within the Weather and Climate Interactions research program, where he conducts research on extreme rainfall and fronts. He uses high-resolution regional atmospheric models to determine the mesoscale processes controlling extremes, to help better understand and predict them.

Prof Lane has held numerous leadership positions, including president of the Australian Meteorological and Oceanographic Society (AMOS) (2014–015), chair of the American Meteorological Society's (AMS) Committee on Mesoscale Processes (2012–2015) and editor of *Monthly Weather Review* (2016–2018). He has received awards from AMS, the Australian Academy of Science and NASA and is a fellow of AMOS.

Dr Nicola Maher

Dr Nicola Maher completed her PhD at UNSW Sydney in September 2016, with a thesis entitled "Natural drivers of interannual to decadal variations in surface climate". For this work she won the Uwe Radok Award for the best PhD thesis awarded in 2016 in Australia in the fields of meteorology, oceanography, glaciology or climatology. She was then awarded an Alexander von Humboldt Postdoctoral Fellowship to move to Germany to work at the Max-Planck Institute for Meteorology. In this position, Dr Maher was the manager of the institute's Grand Ensemble, and she used Single Model Initial-Condition Large Ensembles (SMILEs) to understand the role of internal variability and model-to-model differences in driving uncertainty in future projections. In 2020, Dr Maher accepted a Cooperative Institute for Research in Environmental Sciences Visiting Postdoctoral Fellow position at the University of Colorado, Boulder, USA, where she used SMILEs to study the impact of the El Niño Southern Oscillation (ENSO) on North America and how ENSO itself might change in the future. Since June 2023 she has been a research fellow at the Australian National University, where she is undertaking research on an Australian Research Council Discovery Early Career Researcher Award.

Dr Maher's research investigates drivers of observed climate and projected climate changes in climate models. She is interested in large-scale modes of variability, such as ENSO. Her research additionally focuses on how variables such as temperature and precipitation – with its potential impacts on global population – may change in the future. Dr Maher has worked on understanding uncertainties in climate model projections, largely using SMILEs. Her work aims to understand where uncertainty comes from with the aim to reduce it. Dr Maher's current research focuses on understanding the dynamics, impacts and future projections of variability in the Pacific Ocean, with a focus on how changes in this region may affect Australia.

Dr Amelie Meyer

Dr Amelie Meyer completed her PhD in 2014 at the University of Tasmania, on the topic of ocean circulation, mixing and internal waves in the Southern Ocean. Dr Meyer then undertook a postdoctoral fellowship at the Norwegian Polar Institute in Tromsø, Norway, working on changing ocean-ice interactions in the Arctic. She is currently a senior research fellow at the University of Tasmania, looking at how sea ice and the ocean interact in order to better explain declining sea ice trends in the Southern Ocean.

Funded by an ARC Discovery Early Career Researcher Award fellowship for her research on polar oceans, Dr Meyer collects scientific observations in the Arctic and Antarctic. This work has taken her to remote places where she hasspent a total of 180-plus days on both research vessels and on sea ice.

Dr Meyer is a strong advocate for science communication and outreach. In 2019 she was awarded the Tasmanian Young Tall Poppy Science Award.

Associate Professor Negin Nazarian

Associate Professor Negin Nazarian, Scientia Senior Lecturer at UNSW Sydney, is a recognised leader in the urban climate community. Nationally, she serves as a chief investigator at the ARC Centre of Excellence for Climate Extremes and the ARC Centre of Excellence for Weather of the 21st Century – both prestigious hubs renowned for their groundbreaking research and influence on climate science in Australia. Internationally, she chairs the board of Urban Environment at the American Meteorological Association, playing a pivotal role in advancing urban climate research and networks on a global scale.

Associate Professor Nazarian's expertise as an urban climatologist focuses on understanding the complex interactions between the built environment and climate, and she has a keen interest in how these dynamics impact people.

Her notable accolades include the prestigious 2023 Timothy Oke Award for Original Research in urban overheating as well as the 2024 NSW Young Tall Poppy Award, highlighting her pioneering contributions to the field. Dr Nazarian leads the Climate-Resilient Cities (CRC) research lab at UNSW Sydney, a multidisciplinary team dedicated to addressing the pressing challenges of urban climate and focusing in particular on urban heat exposure and ventilation. The CRC's mission is to advance urban climate modelling, refine urban canopy parameterizations and employ urban climate informatics to enhance our understanding of human exposure to urban climate challenges. Prior to her tenure at UNSW Sydney, Dr Nazarian served as the Singapore-MIT Alliance for Research and Technology (SMART) Scholar, following her graduation from the University of California San Diego.

Professor Sarah Perkins-Kirkpatrick

Professor Sarah Perkins-Kirkpatrick completed her PhD at UNSW Sydney in 2010. Based at the Fenner School of Environment and Society at ANU, she is the Deputy Director of Engagement and Outreach in the ARC Centre of Excellence for 21st Century Weather and a chief investigator in the ARC Centre of Excellence for Climate Extremes. She is also the Vice President of the Australian Meteorological and Oceanographic Society. Prof Perkins-Kirkpatrick's work investigates heatwaves globally and in Australia, including past and future changes, interactions with other climate extremes and the impacts on human health. Her latest research is exploring heatwaves in a net-zero world, as well as future projections of heat stress based on physiological limits. She also has interests in the attribution of climate extremes and their effect on climate change, particularly the impacts associated with human health and well-being.

Prof Perkins-Kirkpatrick was the recipient of the 2014 Director's Prize from the ARC Centre of Excellence for Climate System Science and the 2016 Australian Meteorological and Oceanographic Society Early Career Researcher Award. In 2021 she won the Australian Academy of Science Dorothy Hill Medal, as well as the Australian Meteorological and Oceanographic Society Communications and Outreach Award. She was listed as a Clarivate highly cited researcher in 2021, 2022 and 2023.

Professor Michael Reeder

Professor Michael Reeder completed a PhD in Applied Mathematics at Monash University before holding postdoctoral positions at the University of Munich (Germany) and the NASA/Goddard Space Flight Center (USA). Prof Reeder's research is focused principally on the dynamics of weather-producing systems, and he has published on a wide variety of topics, including fronts, tropopause folding, extra-tropical cyclones, Rossby waves, heat waves, tropical cyclones, gravity waves, solitary waves, convection, boundary layers, the Hadley and Walker circulations and bushfires. Prof Reeder is a fellow of the Australian Meteorological and Oceanographic Society (AMOS), the inaugural winner of the Zillman Medal (AMOS) and the Loewe Prize (Royal Meteorological Society, Australian Branch), and he has given the AMOS Clarke Lecture. He is a past president of AMOS, past chair of the Expert Group on Weather and Weather Prediction and has held memberships on several Australian Research Council (ARC) bodies: the ARC Centre of Excellence Advisory Selection Committee and the ARC College of Experts' Physics, Chemistry and Geosciences Panel. Prof Reeder has been the principal supervisor for more than 50 graduate students.

Dr Kate Saunders

Dr Kate Saunders is a lecturer in the Department of Econometrics and Business Statistics at Monash University. Her primary focus is on statistical modelling of climate extremes and understanding how the probability of extreme events might be influenced by natural variability and climate change. Other interests include statistical post-processing of meteorological forecasts, quality control of meteorological data and how to estimate the risk posed by compound weather events. Dr Saunders' research improves our understanding of the probability of extreme climate/weather events and helps us to make informed decisions about natural disaster risk.

Dr Callum Shakespeare

Dr Callum Shakespeare was awarded his PhD from the Department of Applied Mathematics and Theoretical Physics at the University of Cambridge, in 2015. Since then he has worked at the Australian National University, initially as a postdoctoral fellow, before becoming a continuing academic, in 2023. Dr Shakespeare currently leads the Climate and Fluid Physics research group and the Climate and Fluid Physics Laboratory at the ANU.

Dr Shakespeare's research spans oceanography, atmospheric science and air-sea interactions, using a combination of mathematical theory, numerical modelling and laboratory experiments. He is particularly well known for his theoretical work on fine-scale ocean processes such as submesoscale eddies, fronts and internal waves. Dr Shakespeare also leads the ANU's core 2nd-year Climate Science course and convenes the ANU Research School of Earth Sciences honours program.

Professor Steven Sherwood

Professor Steven Sherwood was awarded his PhD in Oceanography from the Scripps Institute of Oceanography, University of California, in 1995. He carried out postdoctoral research at Victoria University of Wellington (NZ), from 1996 to 1997 and was a research scientist at the NASA-Goddard Earth Sciences and Technology Centre from 1998 to 2000. In 2001 he joined the faculty of Yale University, where he later rose to the rank of professor. At the beginning of 2009 he moved to Australia, where he is a professor at – and former director of – the Climate Change Research Centre at UNSW Sydney, and where he was an ARC Laureate Fellow from 2015 to 2020.

Prof Sherwood has made significant contributions to the understanding of moisture-related processes in the atmosphere. His areas of study include atmospheric humidity; convective systems; interactions between clouds, air circulation and climate; remote sensing of storms; and observed warming trends.

Prof Sherwood was a Lead Author of the chapter on Clouds and Aerosols in the 2013 Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report, Working Group I, and a Contributing Author to the IPCC's previous report in 2007. He currently serves on the review board of the journal *Science* and co-chairs the World Climate Research Programme's Lighthouse Activity on Safe Landing Climates.

Dr Martin Singh

Dr Martin Singh is a senior lecturer in the School of Earth, Atmosphere and Environment at Monash University. He obtained his PhD from the Massachusetts Institute of Technology and was a postdoctoral researcher at Harvard University before his appointment at Monash in 2017.

Dr Singh's research interests are in atmospheric dynamics and climate change. He is particularly interested in the influence of cloud and precipitation processes on atmospheric circulations of a wide range of spatial scales. Understanding the role of such moist processes in determining the climate is an important step toward predicting the possible impacts of human-induced global warming.

Professor Peter Strutton

Professor Peter Strutton received his bachelor's degree with honours in marine science from Flinders University of South Australia, in 1993, and went on to complete his PhD in Marine Science in 1998. He then left Australia to take up a postdoctoral researcher position with the Monterey Bay Aquarium Research Institute in California, a post he held until 2002. From 2002 to 2004 he was an assistant professor with the State University of New York's Marine Sciences Research Centre, and from 2004 to 2010 he was assistant, then associate professor at Oregon State University's College of Oceanic and Atmospheric Sciences. In 2010 Prof Strutton returned to Australia on an Australian Research Council (ARC) Future Fellow grant, and since then he has been associate professor then professor at the Institute for Marine and Antarctic Studies, University of Tasmania.

Prof Strutton's research focuses on biological oceanography and his standing as an Antarctic and Southern Ocean scientist is recognised internationally. He has considerable expertise on how modes of variability – such as El Niño and internal ocean waves – affect nutrients in the ocean, biological productivity and carbon cycling. In the ARC Centre of Excellence for Climate Extremes, Prof Strutton contributes to the Ocean Extremes research program, in particular to projects in the area of ocean variability – physical, biological and chemical. He concentrates on the drivers of observed changes in biogeochemical cycles, including oxygen, carbon and nutrients, with a recent and continuing focus on eddies.

Prof Strutton is an experienced supervisor and mentor of early career researchers. He currently oversees two postdoctoral researchers and several PhD and honours students. He has an extensive publication record that spans work on Antarctica to the tropical Pacific and the Labrador Sea. He is a past editor for the journal *Geophysical Research Letters* and a former leader of the Bluewater and Climate Node for Australia's Integrated Marine Observing System. Prof Strutton has also served on the scientific steering committee for the Tropical Pacific Observing System (tropicalpacific.org). He is currently the head of the Oceans and Cryosphere Centre at the Institute for Marine and Antarctic Studies at UTAS.

Associate Professor Andrea Taschetto

Associate Professor Andrea Taschetto investigates the mechanisms by which the oceans affect global and regional climate, using observations and numerical models. Her work looks at the impact of sea surface temperature variability on precipitation over Australia and elsewhere. She is interested in the mechanisms of the different types of El Niño Southern Oscillation; specifically, how these influence atmospheric circulation, interact with other oceanic basins and affect extreme events such as droughts and heavy rainfall.

A/Prof Taschetto was awarded the Australian Academy of Science Dorothy Hill Award in 2016 for her contribution to the climate science field. She was awarded an Australian Research Council (ARC)

postdoctoral fellowship in 2010 and an ARC Future Fellowship in 2016. She was a council member of the Australian Meteorological and Oceanographic Society and is currently a co-chair of the Climate and Ocean: Variability, Predictability, and Change (CLIVAR) Pacific Regional Panel and a member of the Tropical Basin Interactions Research Foci. She is an editor of the Journal of the Southern Hemisphere Earth Systems Science. She is also affiliated with the National Environmental Science Program (NESP) Climate Systems Hub.

Dr Anna Ukkola

Dr Anna Ukkola's research focuses on understanding the effects of climate change, human activities and increasing atmospheric carbon dioxide on vegetation and water resources. In particular, she is interested in how the frequency and intensity of drought is changing in Australia and globally. Her research combines climate and land surface modelling with observations, including remote sensing, hydrological and climate data and flux tower measurements.

Dr Claire Vincent

Dr Claire Vincent is a senior lecturer in the School of Geography, Earth and Atmospheric Sciences at the University of Melbourne. Her research interests include tropical weather and climate variability, extreme rainfall and the variability of renewable energy resources. She is particularly interested in the different scales of variability in the weather and climate system, and the ways in which these scales interact to create extreme weather. Dr Vincent completed her PhD at the Technical University of Denmark in 2010, where she examined the mesoscale variability of wind resources.

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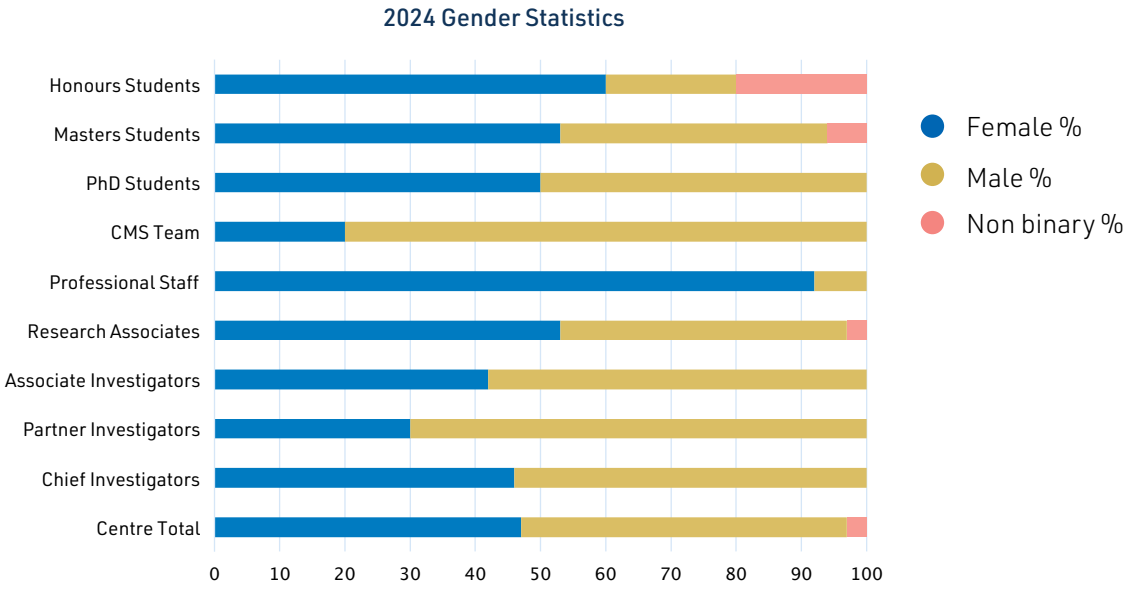
* Asterisked staff have left their roles in 2024, asterisked students have graduated or submitted in 2024

2024 Gender Metrics



The ARC Centre of Excellence for Climate Extremes is committed to creating a diverse and equitable working environment. Since the commencement of the Centre, we have increased the proportion of women chief investigators from 22 percent to 46 percent. This is a notable achievement in the physical climate sciences. We are training the next generation of research associates (53 percent women) in a wide range of scientific, professional and leadership skills, to provide them a strong foundation to become the leaders of tomorrow in whatever sector they choose for their future careers.

Our Partners

Administering Institution

UNSW Sydney

Collaborating Institutions

The Australian National University

Monash University

The University of Melbourne

The University of Tasmania

Australian Partner Organisations

Bureau of Meteorology

CSIRO

National Computational Infrastructure

The Department of Climate Change, Energy, the Environment and Water (DCCEEW)

Risk Frontiers

Sydney Water

International Partner Organisations and Collaborators

ETH Zurich (Switzerland)

Geophysical Fluid Dynamics Laboratory (USA)

LMD – Centre National de la Recherche Scientifique (France)

Max-Planck Institute for Meteorology (Germany)

NASA-Goddard Space Flight Center (USA)

National Center for Atmospheric Research (USA)

UK Meteorological Office (UK)

The University of Arizona (USA)

The ARC Centre of Excellence for Climate Extremes has a large network of Partner Organisations, both in Australia and overseas. Each of our partners was carefully chosen for the expertise and resources they contribute to the overall research and outreach objectives of the Centre and the climate research community at large. Our Partner Organisations enable us to collaborate on cutting-edge science and model development and to advance our engagement and impact ambitions.

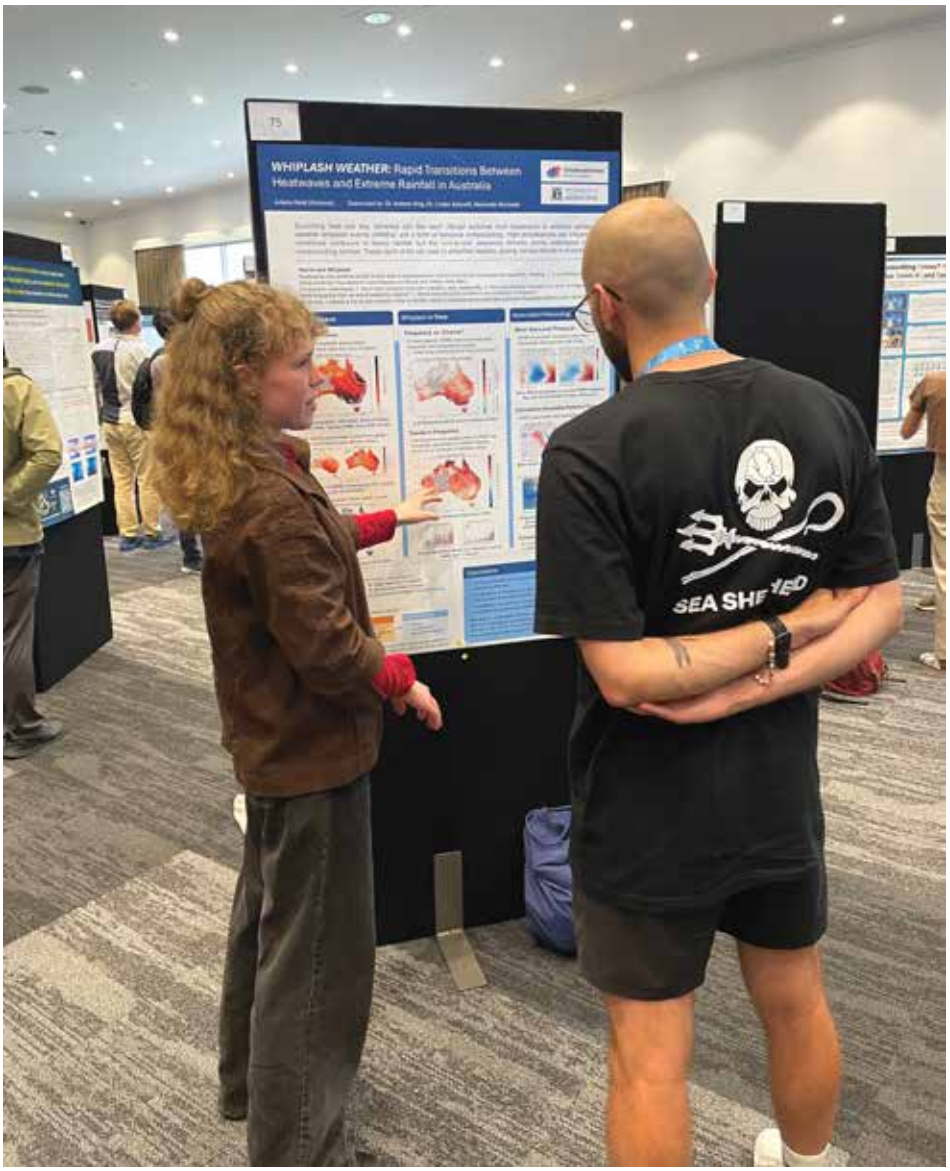
Climate science leaders of the future

Researcher Development Program

The ARC Centre of Excellence for Climate Extremes Graduate and Researcher Development Program developed national capacity in climate science by training and mentoring the next generation of researchers. It equipped them with the intellectual and technical expertise required to take on the research challenges of the future.

The program encompassed fundamental research and communication skills, as well as professional development, mentoring and leadership opportunities, and it involved all Centre researchers. The program complemented opportunities offered at university Partner Organisations. It also included tailored research training for postgraduate and honours students, which formed the Graduate Program. Both of these programs were coordinated by former graduate director, Professor Melissa Hart, who also acted as a point-of-contact, advisor and advocate for the Centre's students and postdoctoral researchers.

Prior to the closure of Centre operations in December 2024, Professor Hart moved to her new position as Associate Director, Training and Leadership at the new ARC Centre of Excellence for 21st Century Weather, based out of the University of Tasmania.



Winter School 2024

The winter schools at the ARC Centre of Excellence for Climate Extremes were the cornerstone of its Graduate Program. The aim was to graduate students with highly specialised knowledge in their own area of research, as well as a broad understanding of the discipline as a whole. And the Centre's winter schools provided this opportunity. The theme of the winter school changed each year and shifted from broader, relevant-to-everyone topics, to more focused topics requiring prerequisite knowledge.

The 2024 winter school, themed **Weather and Climate Interactions**, was held in collaboration with the new ARC Centre of Excellence for 21st Century Weather. This topic is crucial, as climate represents the collective behaviour of individual weather systems, making these systems the fundamental building blocks of climate. The relationship is reciprocal, as the frequency and intensity of weather systems are also influenced by the overarching climate.

The 2024 winter school focused on how extreme weather relates to various weather systems, the physical mechanisms involved and the potential effects of climate change on these mechanisms. Consisting of a series of lectures and interactive activities, the 2024 winter school also included a full day visit to the Bureau of Meteorology.

March Training Week

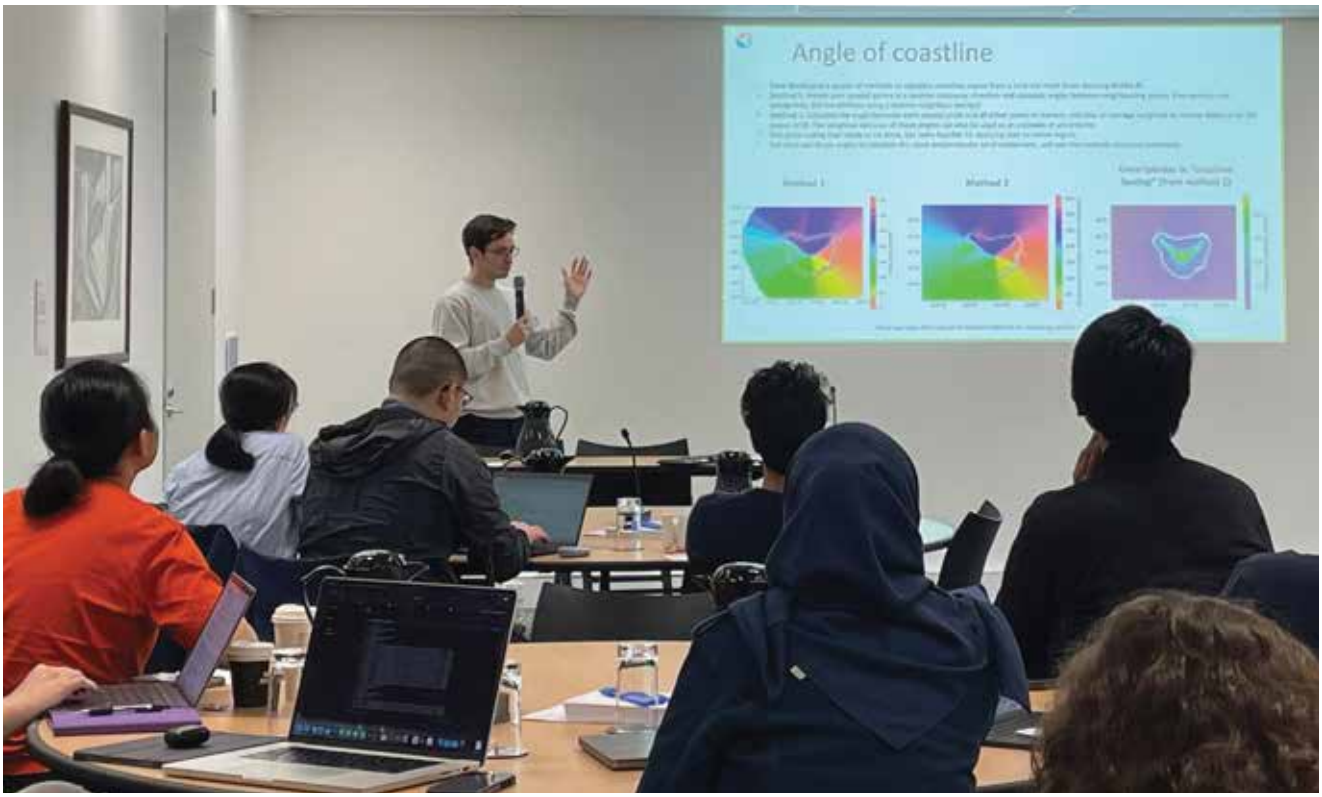
The March Training Week featured a series of workshops designed to enhance skills across multiple areas essential for climate science and research. Key sessions included a Machine Learning Science Workshop, led by Dr Sanaa Hobeichi, a post-doctoral researcher in the Centre, with support from the UNSW AI Institute, the UNSW Climate Change Research Centre and the UNSW Data Science Hub.

Additional events included a Scientific Paper Writing Workshop: Level Up Your Academic Writing, facilitated by Steve Danczak from CSIRO Publishing; a Building a Community of Care session, which focused on resilience skills and was led by Beth Hill, Program Development Coordinator at Psychology for a Safe Climate; and a Data Visualisation and Communication Workshop, facilitated by James Goldie, Data and Digital Storytelling Lead at 360info.

The week was focused on sessions that emphasised preparing postdoctoral researchers for post-Centre career paths, including a career exploration session led by Emily Chang, Partner and Co-Founder of Cruxes Innovation, and an engagement and impact session led by Alice Wilson, a Centre Knowledge Broker. These sessions equipped participants with tools and strategies for resilience, effective communication, and career advancement well beyond the Centre's closure.

Undergraduate Scholarships

The scholarships at the Centre of Excellence have provided outstanding undergraduate students with an introduction to both the Centre and climate extremes research. Students were situated at our node universities and national Partner Organisations and undertook a six-week project, supervised by our postdoctoral researchers, which gave them vital supervisory and research leadership experiences. Almost half the Centre's undergraduate scholars have continued on to further study, and some have even published their research projects in leading international journals.



Climate extremes research in 2024

The following chapters outline just a fraction of the exceptional research undertaken by scientists at the Centre over the past year.

Weather and Climate Interactions Research Program

The climate is the aggregate of individual weather systems. From this perspective, weather systems are the building blocks of the climate. Of course, the connection is not one way, since the frequency and amplitude of various weather systems are themselves modulated by climate.

The Weather and Climate Interactions research program at the ARC Centre of Excellence for Climate Extremes investigated climate, particularly climate extremes, through a weather-focused lens. Researchers concentrated on the physical mechanisms responsible for extreme weather in the tropics and extratropics and examined how climate change affected these mechanisms. Understanding how weather changed as the world warmed, particularly how extreme weather evolved, was recognised as a crucial aspect of how climate change impacted people, the economy and the environment.

Project 1

Fronts are perhaps the only weather systems implicated in heat, wind and precipitation extremes. To illustrate this point, consider the following:

- The most catastrophic fires in recent history in southern Australia have been associated with extreme, but shallow, dry cold fronts that form along the southern coastline
- Melbourne's record maximum temperature preceded the passage of the extreme cold front on Black Saturday
- Frontal systems commonly provide the uplift needed to produce extreme precipitation.

Our research into extratropical extremes is guided by the overarching question:

What controls the strength, frequency and path of fronts in the Australian extratropics, and how do these factors affect extremes?

Project 2

Tropical lows are among the most important rain-bearing weather systems in the northern half of the continent. For example, in northern Australia, around half of all summertime rainfall is associated with them. Moreover, tropical lows are commonly implicated in rainfall extremes – the east-coast flooding of 2021 being a recent catastrophic illustration.

These considerations motivate our second overarching research question:

What causes the long-lived, heavy rains in tropical and subtropical Australia?

2024 Update

In 2024, the Weather and Climate Interactions program researchers made significant progress with very high-resolution modelling of weather and climate over all of Australia. These are some of the largest simulations ever run at high resolution over Australia and have allowed examination of multi-scale processes.

The Centre's researchers, along with the Centre's Computational Modelling Systems team, ran multiple simulations of the Madden Julian Oscillation under different El Niño Southern Oscillation phases and used them to examine differences in mesoscale coastal processes. They also used high-resolution models to understand detailed, extreme-fire-weather processes and explored the role of sea surface temperature anomalies in initiating extreme precipitation. With several studies that use and illustrate these modelling efforts, the output of the simulations will be made available as a large data set as a lasting legacy for use by the community.

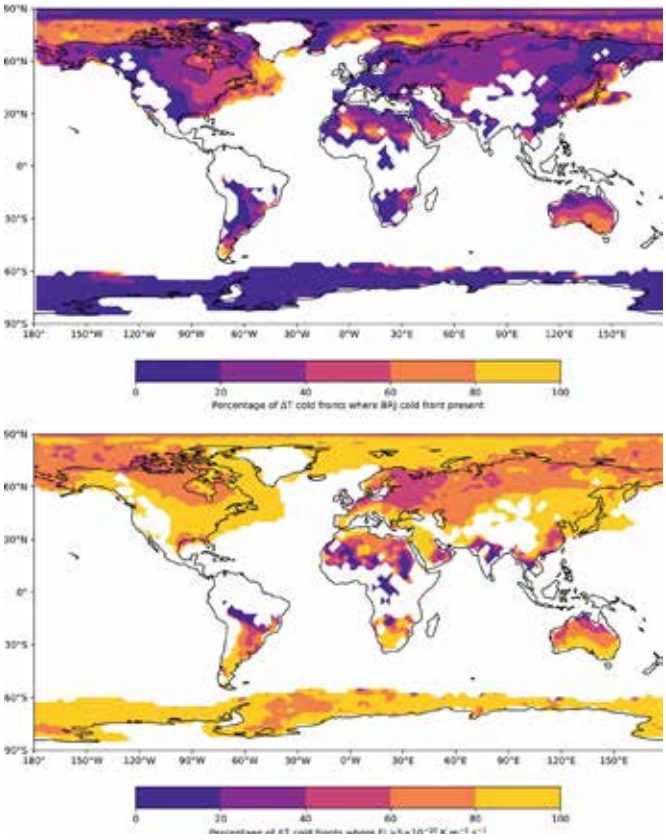
In October, the Weather and Climate Interactions program held its final workshop at the Monash City Conference Centre in Melbourne, Victoria. As part of the workshop, training was provided on the analysis and physics of the program's high-resolution models, so that the Australian climate community is better equipped and trained in the science of our modelling systems. The training was run by Centre postdoctoral researcher, Dr Chris Chambers, Dr Chermelle Engel from the Australian Community Climate and Earth System Simulator (ACCESS) National Research Infrastructure and Dr Charmaine Franklin from the Bureau of Meteorology.

Below are just some of the research program's highlights from the past year.

Research Snapshot

Dr Malcolm King led a study, together with professors Michael Reeder and Christian Jakob, looking at ways to detect cold fronts in climate model data and in observations. They developed a method that could work consistently on both observations from weather stations and on gridded climate model data of various resolutions. Their method was based on detecting changes in daily maximum temperature, and they showed that their method had good agreement with previously developed frontal detection methods.

The authors discovered that there is a large spread in the number of fronts detected by different climate models, with the median annual number of fronts detected in the period October – March ranging from zero to 13 in different models. They also found that there are weak but statistically significant trends in the number of fronts observed at some weather stations, including weak positive trends over the southeast mainland and weak negative trends over western Australia and northern Tasmania. This work makes a significant contribution to our understanding of how to interpret cold fronts in future climate projections.



King, M.J., Reeder, M.J. & Jakob, C. (2024) Strong temperature falls as a cold frontal metric in Australian station observations, reanalyses and climate models. *Quarterly Journal of the Royal Meteorological Society*, 150(765), 4788–4805. Available from:https://doi.org/10.1002/qj.4841

Research Snapshot

As part of his PhD project, Fadhlil Muhammad examined the ways in which tropical waves influence the rainfall in northern Australia. This work was supported by Fadhlil's supervisors, Dr Claire Vincent and Associate Professor Andrew King, as well as collaborator Professor Sandro Lubis. Fadhlil applied new methods to detect tropical waves over Australia. These waves cause large regions of either unusually rainy or unusually dry conditions to move across the northern part of Australia, travelling either from east to west or from west to east. For example, the authors found that some waves can cause the average daily rainfall to increase by up to seven millimetres per day and the chance of extreme rainfall to become 2.4 times as likely as normal.

The research also highlighted that when more than one type of wave is influencing an area at the same time, the chance of extreme rainfall is even higher than for either wave on its own, and that the co-occurrence of the wet and dry phases of two different waves can reduce the chance of extreme rainfall relative to the wet phase of a single wave. This work is a clear demonstration of the interacting roles of weather systems operating over different spatial areas and different time scales and suggests that these interactions could be important for projections of the future climate.

Muhammad, F. R., C. Vincent, A. King, and S. W. Lubis, 2024: The impacts of convectively coupled equatorial waves on extreme rainfall in northern Australia. *Journal of Climate*, 37, 5973–5993, https://doi.org/10.1175/JCLI-D-24-0042.1.

Research Snapshot

Masters student Ruchit Kulkarni from the University of Melbourne is exploring the weather systems that drive extreme rainfall in New South Wales. Under the supervision of Dr Linden Ashcroft and Associate Professor Danielle Verdon-Kidd from the University of Newcastle, Ruchit is looking at the agriculturally vital region of the state west of the Great Dividing Range.

Ruchit is using historical weather records from the 19th century starting as early as 1858. He is diving into the past to find the lost and forgotten storms, with the help of weather diaries, newspaper cuttings, hand-drawn weather synoptic charts and instrumental daily rainfall records provided by the Bureau of Meteorology. His study is exploring widespread extreme rainfall events and isolated extreme rainfall events separately.

By clustering the movement of the widespread events, Ruchit has identified six dominant patterns of extreme rainfall over western New South Wales. Each of these patterns show different seasonality signals, indicating they may be driven by different types of weather systems. On other hand, isolated extreme rainfall events seem to peak during austral summer, suggesting a smaller scale influence.

Ruchit's next steps are to find out which weather systems drive the six widespread extreme rainfall patterns in the state. By extending analysis to the present, he aims to find out how these weather systems have changed over the past 170 years in terms of frequency, intensity and duration. The study provides long-term insights into extreme rainfall records, providing valuable knowledge for improving predictions and responses to extreme rainfall events in future.

Early Career Researcher: Tahereh Alinejadtabrizi – Monash University

Tahereh Alinejadtabrizi is completing her PhD at Monash University with the ARC Centre of Excellence for Climate Extremes. Her research focuses on low-level clouds over the Southern Ocean, one of climate models' biggest sources of uncertainty.

"Employing all of the different kinds of available data sets together to try and understand cloud processes is really interesting to me. It allows me to use my creativity and bring innovation."

Tahereh's research has examined how aerosols interact with shallow clouds over the Southern Ocean. She utilised available precipitation information, aerosol records and satellite data, employing machine learning to understand the low-level cloud morphology in the area.

The findings from her latest study are useful for understanding the aerosol budget over the Southern Ocean, allowing the simulation of low-level clouds with much better accuracy. "We found the cloud properties are really sensitive to the amount of aerosols over the Southern Ocean. We also saw that rain plays a role in washing the aerosols out of the sky. As the rain falls, it takes aerosols with them, removing them from the atmosphere."

Alinejadtabrizi, T., Lang, F., Huang, Y. et al. Wet deposition in shallow convection over the Southern Ocean. npj *Clim Atmos Sci* 7, 76 (2024). **https://doi.org/10.1038/s41612-024-00625-1**

Attribution and Risk Research Program

The Attribution and Risk research program at the ARC Centre of Excellence for Climate Extremes has improved the understanding of changes in climate extremes, such as heatwaves, extreme rainfall and droughts. It is clear that anthropogenic climate change is already influencing some aspects of these extremes and will continue to do so in the future. Attributing the cause of these changes and assessing their future risk is key to reducing the vulnerability of our natural and economic systems to these events.

For example, 2023 saw an extraordinary year of record-breaking temperatures around the world, which continued into the first half of 2024. The 12 months to June 2024 saw globally averaged surface temperatures all exceed 1.5°C above the pre-industrial period. While breaking records is not unexpected due to the build-up of greenhouse gases in the atmosphere, the magnitude by which the records were broken has led to questions of whether the warming is accelerating and what this might mean.

The Attribution and Risk program's researchers have been communicating their scientific understanding of these events to both the public and policymakers while advancing our knowledge through scientific research.

Project 1

How do the relative roles of large-scale, regional and local-scale processes and their interactions shape Australian extremes and govern their changes?

Project 2

Can machine learning/ statistical approaches be used to improve the representation of scale interactions, processes and projection of the risk of extremes?

2024 Update

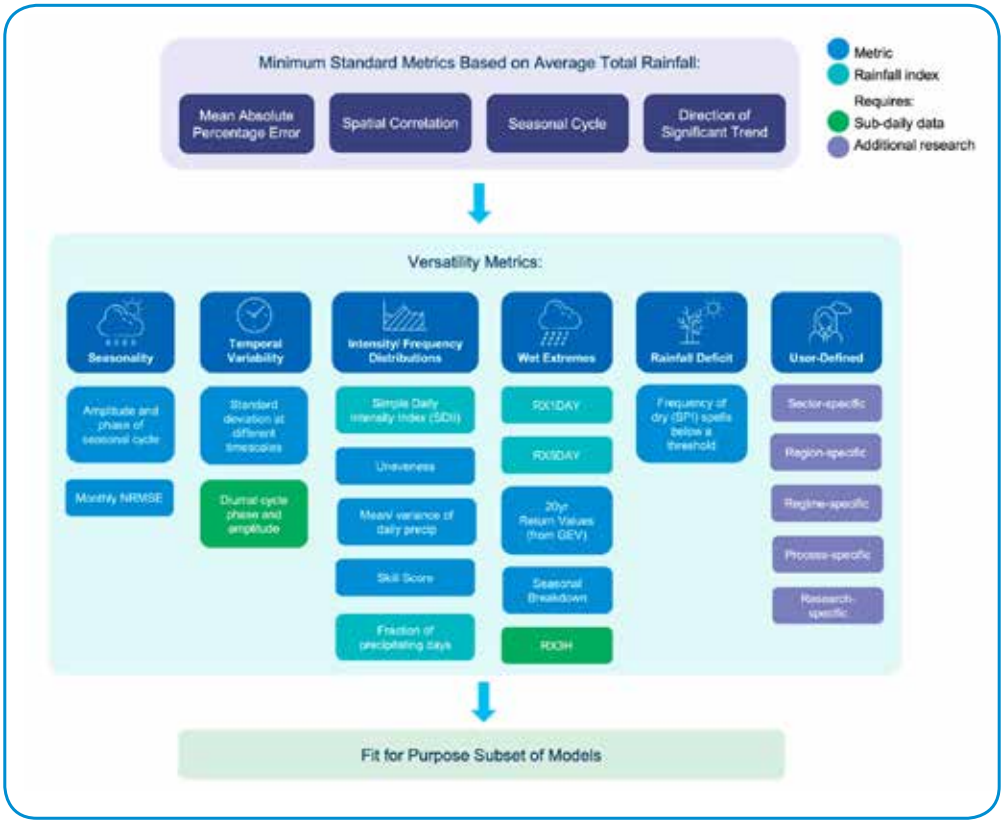
Throughout the year, the Attribution and Risk program has continued its work on understanding the processes responsible for climate extremes in Australia, along with developing advanced statistical tools to improve our modelling and assessment of risk.

Key activities included a workshop that was held in May to highlight the program's latest research and to outline progress in understanding, attributing and projecting extremes over the lifetime of the Centre. Specifically, the sessions covered process understanding, risk, machine learning, attribution, recent extremes, climate variability and observations and modelling of extremes. The workshop ended by discussing key new directions the research has taken, including some of the legacies of the program, and identified a number of opportunities moving forward.

A noteworthy legacy of the program has been the creation of a 'Dashboard' designed to help users monitor and analyse key climatic trends over Australia. It focuses on a number of extremes, including the Hottest Day, Coldest Night and Wettest Day, to provide a clear view of climate patterns from 1910 onwards.

The dashboard provides interactive time series and trend maps to offer insights into over a century's worth of data, illustrating how these extremes have evolved both temporally and spatially. The dashboard has simplified complex climatological data to help with research, policy development or education, and it is hoped that it will continue to be updated despite the Centre's closure.

Below are a few more research highlights from the past year.



Research Snapshot

PhD student Rachael Isphording published a paper outlining a standardised framework for benchmarking precipitation from downscaled models. Perhaps surprisingly, there is no standardised way to assess regional climate model precipitation output. Because of this, it can be difficult to make a one-to-one comparison of their performance between regions or studies, or against coarser-resolution global climate models.

Rachael has therefore developed the first steps toward establishing a dynamic, yet standardised, benchmarking framework that can be used to assess model skill in simulating various characteristics of rainfall, with the benefit that it can be applied to regional climate model simulations at any spatial domain.

This framework has innumerable applications to underpin scientific studies that assess model performance, inform model development priorities and aid stakeholder decision-making, by providing a structured methodology to identify fit-for-purpose model simulations for climate risk assessments and adaptation strategies.

Isphording RN, Alexander LV, Bador M, Green D, Evans JP, Wales S. A standardized benchmarking framework to assess downscaled precipitation simulations. *Journal of Climate*. 2024 Feb 15;37(4):1089–110. https://doi.org/10.1175/JCLI-D-23-0317.1

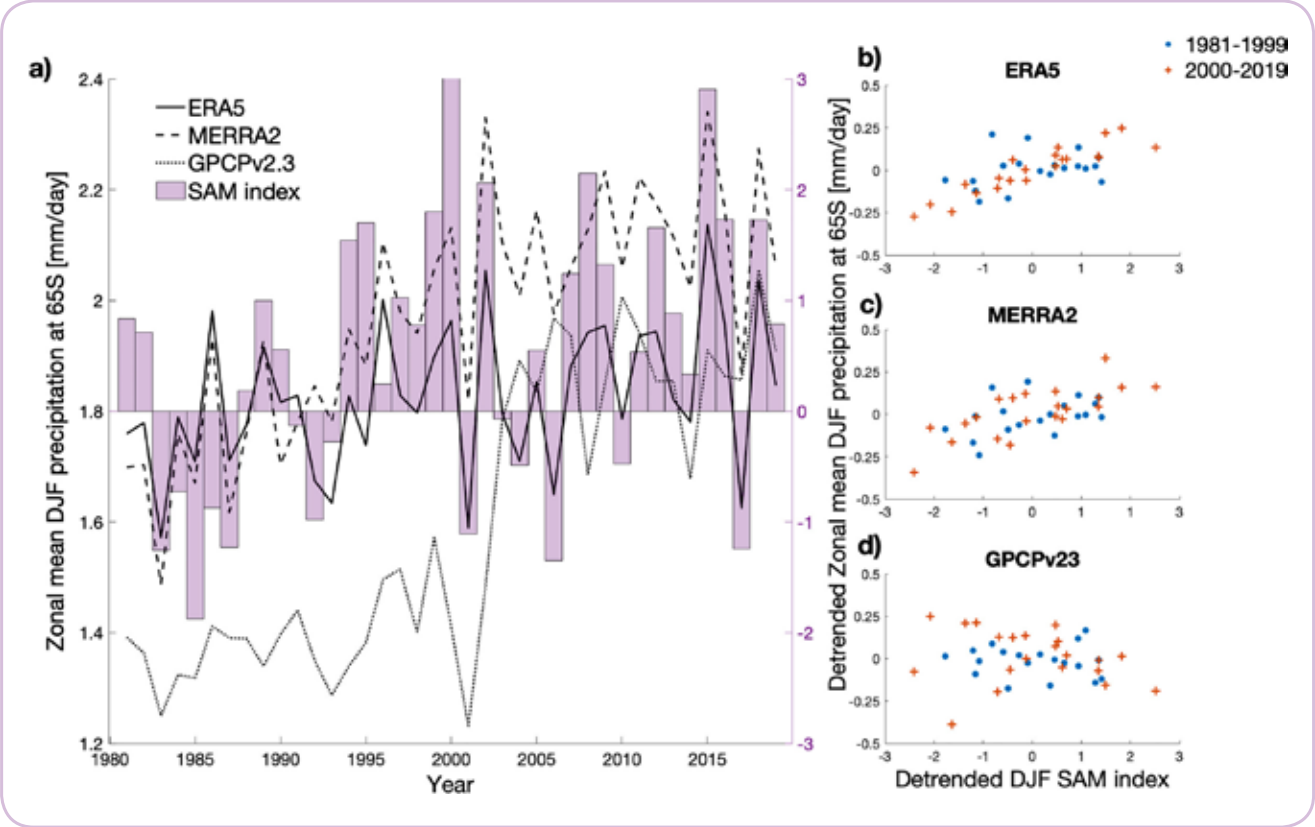
Research Snapshot

The Southern Ocean is a critical region for global and Australian climate. Yet little is known about how extremes in temperature and rainfall are changing there, partly due to a paucity of observations. Researcher Dr Kim Reid published a paper with co-authors examining trends in Southern Ocean precipitation from all available satellite and reanalysis products over the satellite era.

The authors found trends in the satellite products are likely artefacts due to sensor changes, highlighting the need for improved long-term observational data sets in this region and a more consistent relationship between precipitation and dynamical changes in reanalysis products.

The understanding of extreme precipitation was further improved through research led by PhD student Valentina Ortiz-Guzmán, who found that a wave pattern in the atmosphere, the zonal wavenumber 3, has a significant impact on southeastern South America in austral summer.

Reid, K. J., Arblaster, J. M., Alexander, L. V., & Siems, S. T. (2024). Spurious trends in high latitude Southern Hemisphere precipitation observations. Geophysical Research Letters, 51(6), e2023GL106994. https://doi.org/10.1029/2023GL106994



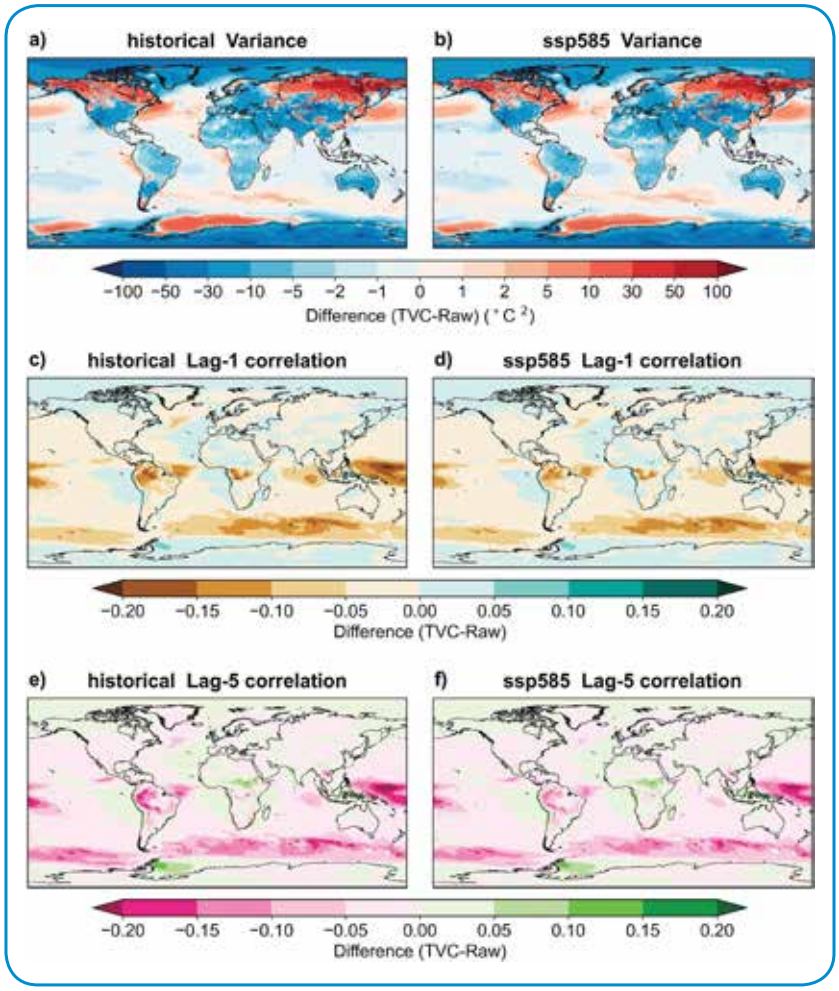
Research Snapshot

Several publications in 2024 addressed the question of whether machine learning/statistical approaches can be used to improve the representation of scale interactions, processes and projection of the risk of extremes. For example, postdoctoral researcher Dr Yawen Shao led a paper outlining a novel Time Variability Correction (TVC) method to improve a model's ability to accurately represent covariance at and between differing time scales.

Using the latest global coupled model (Coupled Model Intercomparison Project-6) the Centre's researchers were able to show that, on global scales, models generally misrepresent temporal variances for maximum temperature by a considerable margin, particularly at 183-, 92- and 46-day time scales. Their proposed method corrects these temporal covariances while preserving the essential time-event sequence of the model simulations. By imparting more realistic temporal-correlations to model series, TVC is expected to improve the projections of extreme events such as heatwaves. The Python codes for the TVC paper have also been published.

Dr Shao and Centre Chief Investigator Craig Bishop also spearheaded the CMIP-projection Constraining Methods Intercomparison Project. This initiative aims to coordinate and compare various ensemble post-processing methods to improve multi-model ensemble projections of future climate and extremes. Initial discussions have taken place, with contributions from international experts.

Shao, Y., Bishop, C. H., Hobeichi, S., Nishant, N., Abramowitz, G., & Sherwood, S. (2024). Time variability correction of CMIP6 climate change projections. *Journal of Advances in Modeling Earth Systems*, 16(2), e2023MS003640. https://doi.org/10.1029/2023MS003640



Early Career Researcher: Sanaa Hobeichi – UNSW Sydney

Dr Sanaa Hobeichi is completing her postdoctoral research at UNSW Sydney, focusing on developing machine learning methods for climate and weather applications. Machine learning is a subfield of AI, which involves identifying meaningful patterns and structures in data and using the information to make predictions.

Dr Hobeichi explained: "With its capacity to process complex climate data, AI can predict high-impact events, helping decision makers prepare for and mitigate local climate risks. The strength of AI lies in its ability to model complex, nonlinear interactions in climate data, offering predictions that help us understand regional risks and respond more effectively to climate change."

Dr Hobeichi also recently contributed to research demonstrating that machine learning could be applied to capture the spatial characteristics of extreme weather with more skill than existing climate models.

"Machine learning can be considerably more skilful in capturing the spatial characteristics of extreme events than existing models."

Dr Hobeichi's work has helped show how machine learning methods can get around the large amount of computational power required to run climate models, presenting a more affordable way to support resilience and adaptation planning. She has also written a commentary about a new AI-powered weather and climate model, published by *The Conversation*.

Rampal, N., and Coauthors, 2024: Enhancing Regional Climate Downscaling through Advances in Machine Learning. *Artif. Intell. Earth Syst.*, 3, 230066, **https://doi.org/10.1175/AIES-D-23-0066.1.**

Drought Research Program

The Drought research program at the ARC Centre of Excellence for Climate Extremes has been focused on understanding what determines the onset, persistence and termination of drought. We are particularly interested in understanding this for the 2017–2019 NSW drought – and into the future.

Project 1

What determines the onset, persistence and termination of drought?

Large-scale climate modes, such as El Niño and positive Indian Ocean Dipole events, are often linked to increased drought risk in parts of eastern Australia. However, the weather processes connecting these broad-scale distant features to local rainfall are unclear.

Project 2

Why did the 2017–2019 drought in eastern Australia develop and what made it so impactful?

This case study has focused the combined efforts of the Drought program with a diversity of research being done to define the characteristics, the small- and large-scale drivers, and the predictability, of the Tinderbox Drought (the 2017–2019 NSW drought).

For example, did interactions between the land and the atmosphere intensify the hot and dry extremes towards the end of the Tinderbox Drought and also during Australia's Black Summer fire disaster that punctuated the end of this severe drought?

2024 Update

2024 was a good year for recognition of outstanding achievements by members of the Drought program. PhD student Xinyue Zhang won the People's Choice Poster Prize at the 'UNSW Science Postgraduate Research Showcase 2024'. The Centre's chief investigators were also acknowledged for their contributions to climate science by the Australian Academy of Science, with Associate Professor Ailie Gallant being awarded the Dorothy Hill Medal and Professor Nerilie Abram being elected as a fellow of the Australian Academy of Science. Centre Director Andy Pitman was appointed as Net Zero Commissioner in NSW.

In an effort led by the Centre's Dr Chiara Holgate, a research fellow at ANU, the program's researchers combined forces to write a group paper on drought in Australia. It brought together a concise summary of what had been learned about droughts during the life of the Centre, covering how droughts work and how they are likely to change in the future. This effort was also the subject of a workshop held in Canberra in June. The paper, completed before the end of the year, provides a comprehensive overview of the progress made by the Drought program, and is due to be published in the near future.

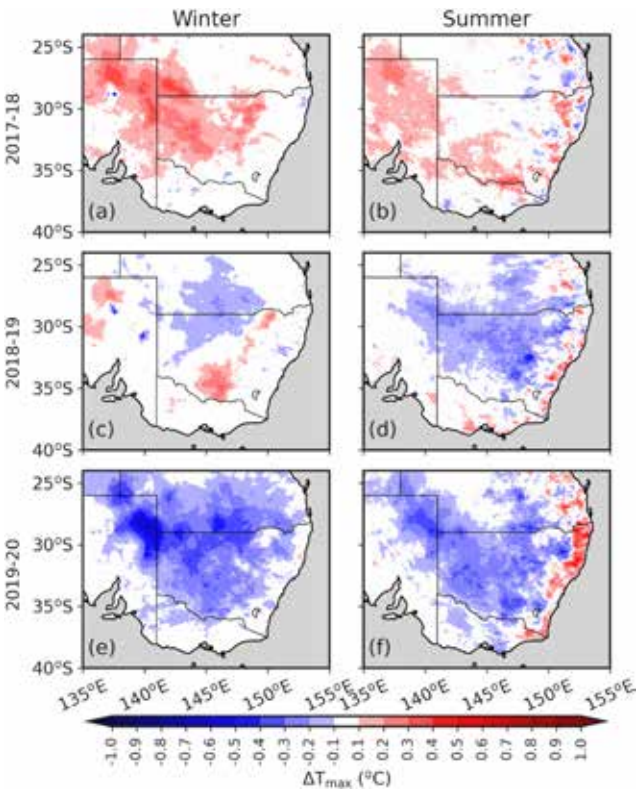
Members of the Drought program published several notable papers. One of these included a comprehensive paper examining the characteristics and causes of southeast Australia's Tinderbox Drought (2017 to 2019) which preceded the Black Summer fire disaster. The paper's lead author was Dr Anjana Devanand, a postdoctoral researcher based at UNSW Sydney.

Below are a few more of the Drought program's highlights from the past year.

Research Snapshot

Research led by Dr Mengyuan Mu, a postdoctoral esearcher based at UNSW Sydney, found that groundwater plays an integral role in land-atmosphere interactions by connecting the subsurface storage of water to transpiration via interactions with the root zone.

Maximum air temperatures were reduced by up to three degrees Celsius at the surface and up to one degree Celsius through the atmospheric boundary layer, pointing to the important influence of groundwater on heatwave intensity.



Mu, M., Sabot, M. E., Ukkola, A. M., Rifai, S. W., De Kauwe, M. G., Hobeichi, S., & Pitman, A. J. (2024). Examining the role of biophysical feedbacks on simulated temperature extremes during the Tinderbox Drought and Black Summer bushfires in southeast Australia. Weather and Climate Extremes, 45, 100703. https://doi.org/10.1016/j.wace.2024.100703

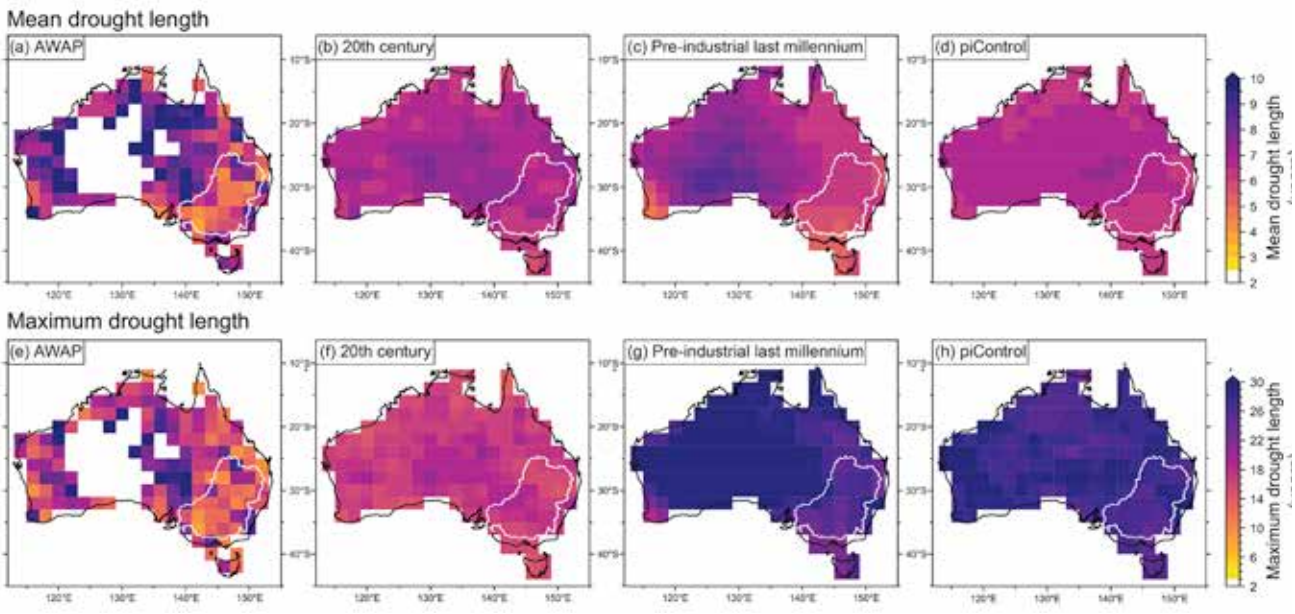
Research Snapshot

Work led by Dr Georgy Falster, a research fellow based at ANU, found droughts during the 20th century to be longer than those in pre-industrial times in southwestern and eastern Australia, suggesting an emerging human influence on our climate has already made southern parts of Australia more drought-prone.

The research also found that natural variability can produce "mega-droughts" lasting 20 years or more in Australia, even without the influence of climate change exacerbating droughts.

The research was widely reported on by several major Australian media outlets.

Falster, G. M., Wright, N. M., Abram, N. J., Ukkola, A. M., and Henley, B. J.: Potential for historically unprecedented Australian droughts from natural variability and climate change, Hydrol. Earth Syst. Sci., 28, 1383–1401, https://doi.org/10.5194/hess-28-1383-2024, 2024.



Early Career Researcher: Matt Grant – UNSW Sydney

PhD student Matt Grant is studying how Australian droughts have changed over time by analysing historical data. His research aims to measure and better understand the patterns and trends in droughts observed in Australia. By considering three key drought types (meteorological, agricultural and hydrological), his research, alongside that of others from the Centre's Drought program, has produced a comprehensive overview of how droughts have been changing in Australia.

Their main findings show that, across most of the country, both time and area under drought have been declining since the early 20th century. However, in more recent decades, these two metrics have been increasing in most regions. These observed fluctuations, though often significant, are unlikely to be outside the natural variability of Australia's climate.

"I think most people I tell are surprised by the decline in droughts over the last century or so, but I think it just highlights the variability naturally present in Australia," Matt said.

"The fact that droughts have been increasing in recent decades is definitely concerning, especially since we are seeing increases over some of the most important agricultural regions. '

Grant, M. O., Ukkola, A. M., Vogel, E., Hobeichi, S., Pitman, A. J., Borowiak, A. R., and Fowler, K.: Historical trends of seasonal droughts in Australia, *EGUsphere* [preprint], **https://doi.org/10.5194/egusphere-2024-4024**, 2025.

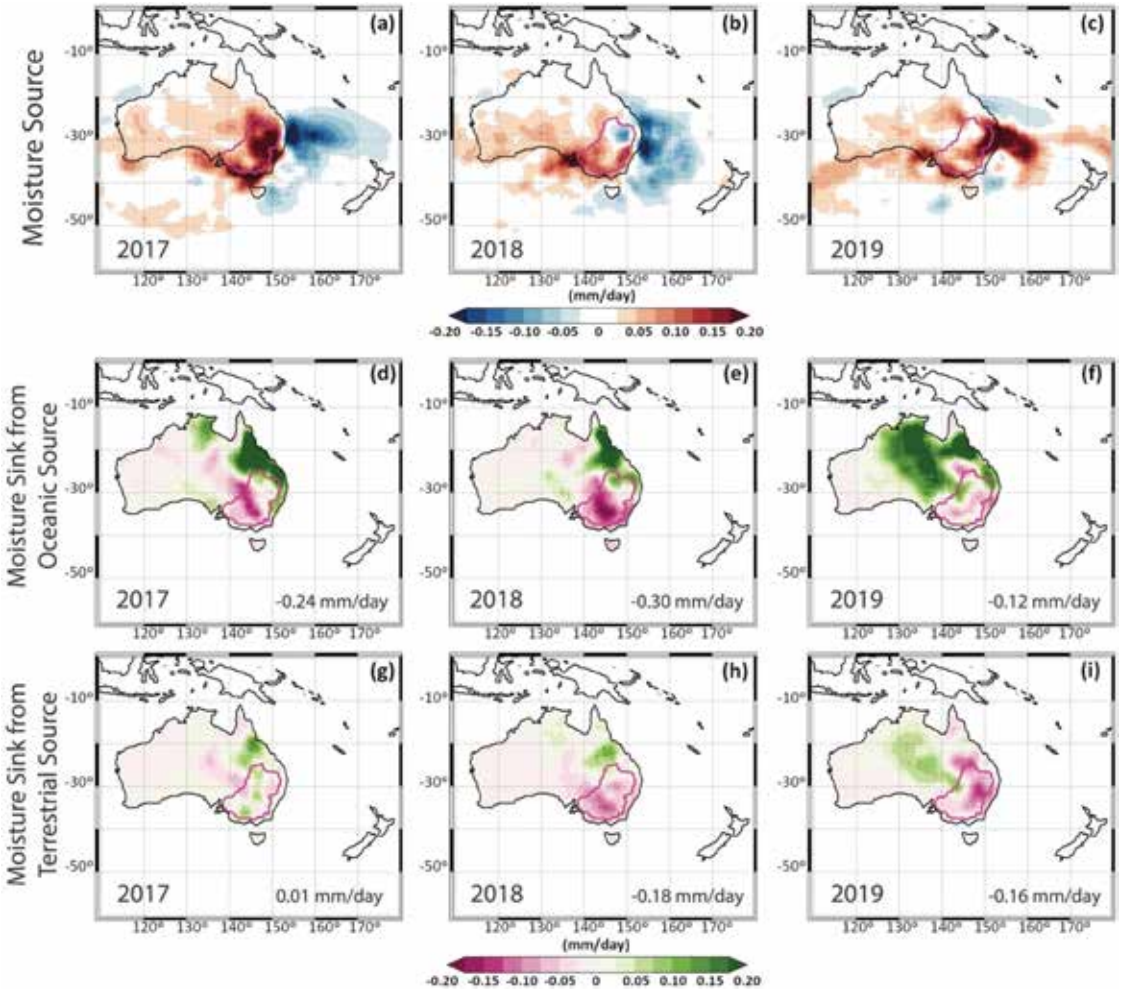
"Continuing to monitor these changes going forward is extremely important, [as] then we might be able to discern whether this recent increase is simply a natural fluctuation or an anthropogenically influenced trend."

Research Snapshot

Associate Professor Dr Andrea Taschetto led a study exploring moisture sources for rain that fell in the Murray-Darling basin during the Tinderbox drought. This work used a back-trajectory model to calculate where the air came from and how it accumulated water vapour during its journey.

The study showed rainfall moisture supply from the Tasman Sea was substantially lower in 2017 and 2018, with much of this moisture transported northward toward the Maritime continent. The study also showed that local processes are crucial in explaining the onset and development of the drought.

Taschetto, A. S., Stojanovic, M., Holgate, C. M., Drumond, A., Evans, J. P., Gimeno, L., & Nieto, R. (2024). Changes in moisture sources contributed to the onset and development of the 2017-2019 southeast Australian drought. *Weather and Climate Extremes*, 44, 100672. https://doi.org/10.1016/j.wace.2024.10067



Ocean Extremes Research Program

Marine heatwaves and mesoscale (circa 10 to 100 kilometres) ocean physics have a profound impact on the marine environment. They affect ocean physical properties like temperature, mixing, eddies and fronts. These processes in turn impact plant and animal physiology and nutrient availability, with consequences at all levels of the ocean food chain.

Marine heatwaves also interact with atmospheric physics, while ocean biology and chemistry are at the core of the carbon cycle – all with consequences for future climate trajectories. The Ocean Extremes research program at the ARC Centre of Excellence for Climate Extremes answers the following questions:

Project 1

Marine heatwaves: How can we best model and predict marine heatwaves?

Project 2

Mesoscale ocean processes: How do energetic features like eddies and fronts interact with other climate extremes?

Project 3

Biogeochemistry: What are the current and future roles of mesoscale physics and biogeochemistry in the climate system?

2024 Update

Building on the progress made in 2023, the Ocean Extremes program deepened its investigation into marine heatwaves, Southern Ocean biogeochemistry and climate dynamics.

A number of program researchers also co-authored the Centre's final briefing note, which examined marine heatwaves. Written by Jiaxin Shi, Darren Li Shing Hiung, Dr Yuxin Wang, Shujing Zhang, Dr Zijie Zhao and Professor Neil Holbrook, the briefing note outlines key aspects of marine heatwaves, including their underlying causes, the role of climate change in driving their frequency and intensity and strategies for mitigating their impacts. The contributing early career researchers also won a prize at the annual CLEX Workshop for their engagement in this work.

The biogeochemistry component of the Ocean Extremes program also achieved notable success, driven largely by student contributions. Dr Jakob Weis completed his PhD in March, with a chapter on Southern Ocean dust impacts on productivity forming part of his thesis, published in Nature (highlighted elsewhere in this newsletter). His research showcased the value of the growing biogeochemical float array in the Southern Ocean for quantifying large-scale climate interactions.

PhD student Kai Yang made significant strides in ocean fronts research. His first thesis chapter, published in Communications Earth & Environment, examined global trends in ocean fronts in a warming climate. His findings revealed that hotspots in equatorial and subtropical gyres experienced declines in frontal activity and chlorophyll concentration, while high-latitude hotspots showed increases in both. These findings underscore the societal and economic importance of ocean fronts, particularly in regions of significant global fish catch.

Former students continued to excel post the Centre's shutdown. Dr Clara Vives secured a postdoctoral appointment at the University of Copenhagen; Dr Guillaume Liniger joined the Monterey Bay Aquarium Research Institute; and Dr Yuxin Wang commenced a postdoctoral fellowship at the University of Hawaii, in December 2024.

There were also several notable events. The biennial Ocean Sciences Meeting in New Orleans (February) provided an excellent opportunity to showcase the program's research, with presentations from Professor Peter Strutton,

Dr Ramkrushnbhai Patel and PhD student Kai Yang. At the Asia-Oceania Geosciences Society Meeting in Pyeongchang, Republic of Korea, Shujing Zhang, Dr Yuxin Wang and Professor Neil Holbrook presented their work, with Prof Holbrook convening the marine heatwaves session. Another major event was the European Geophysical Union 2024 Conference, which highlighted the program's contributions to understanding large-scale climate interactions. Prof Holbrook was also an invited speaker at the PICES-2024 Conference in Hawaii, a keynote speaker at the Centre's final annual workshop and a co-convenor of the marine heatwaves session at the European Geophysical Union conference earlier in the year. Below are just a few more research highlights.

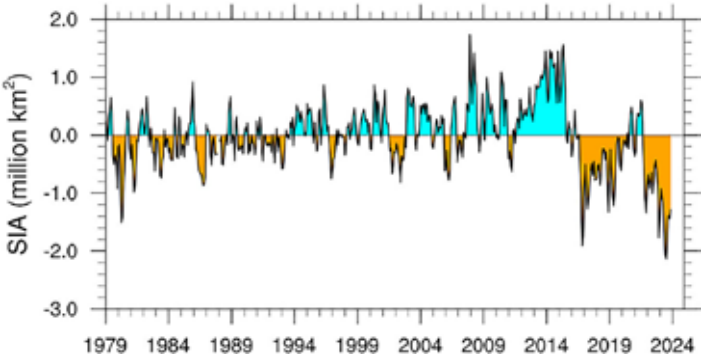
Research Snapshot

Antarctic sea ice has shown unprecedented declines since 2016, marking a potential regime shift. A four-decade positive trend in sea ice abruptly ended, with three extreme ice loss events in 2016, 2022 and 2023. Winter 2023 sea ice levels also plummeted to record lows, sparking questions about the resilience of Antarctic sea ice.

Research led by Dr Will Hobbs, with colleagues Dr Amelie Meyer and postdoctoral fellow Dr Guillaume Liniger, analysed observational data, revealing nearly doubled summer sea-ice variability in the last decade. Additionally, sea ice memory (autocorrelation) increased significantly, suggesting a critical transition. These findings, coupled with greater spatial coherence, align with signs of a regime shift.

The study points to interactions with the upper ocean, rather than atmospheric drivers, as the likely cause of these changes. While the mechanisms remain uncertain, this work challenges long-held assumptions about Antarctic sea ice resilience and highlights the need to better understand its future trajectory.

Hobbs, W., and Coauthors, 2024: Observational Evidence for a Regime Shift in Summer Antarctic Sea Ice. *J. Climate*, 37, 2263–2275, https://doi.org/10.1175/JCLI-D-23-0479.1.



Research Snapshot

A study led by Dr Jakob Weis revealed that windblown dust supplies iron, a crucial micronutrient, supporting a third of phytoplankton growth in the Southern Ocean. Phytoplankton play a critical role in the global carbon cycle, storing carbon as they photosynthesise and sink to ocean depths after death.

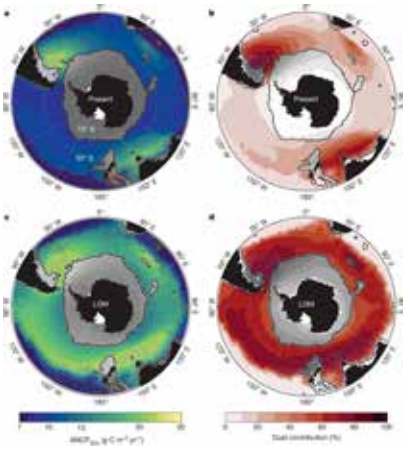
"Dust from land fertilises around a third of Southern Ocean phytoplankton growth, significantly enhancing the ocean's capacity to store carbon," explained Dr Weis.

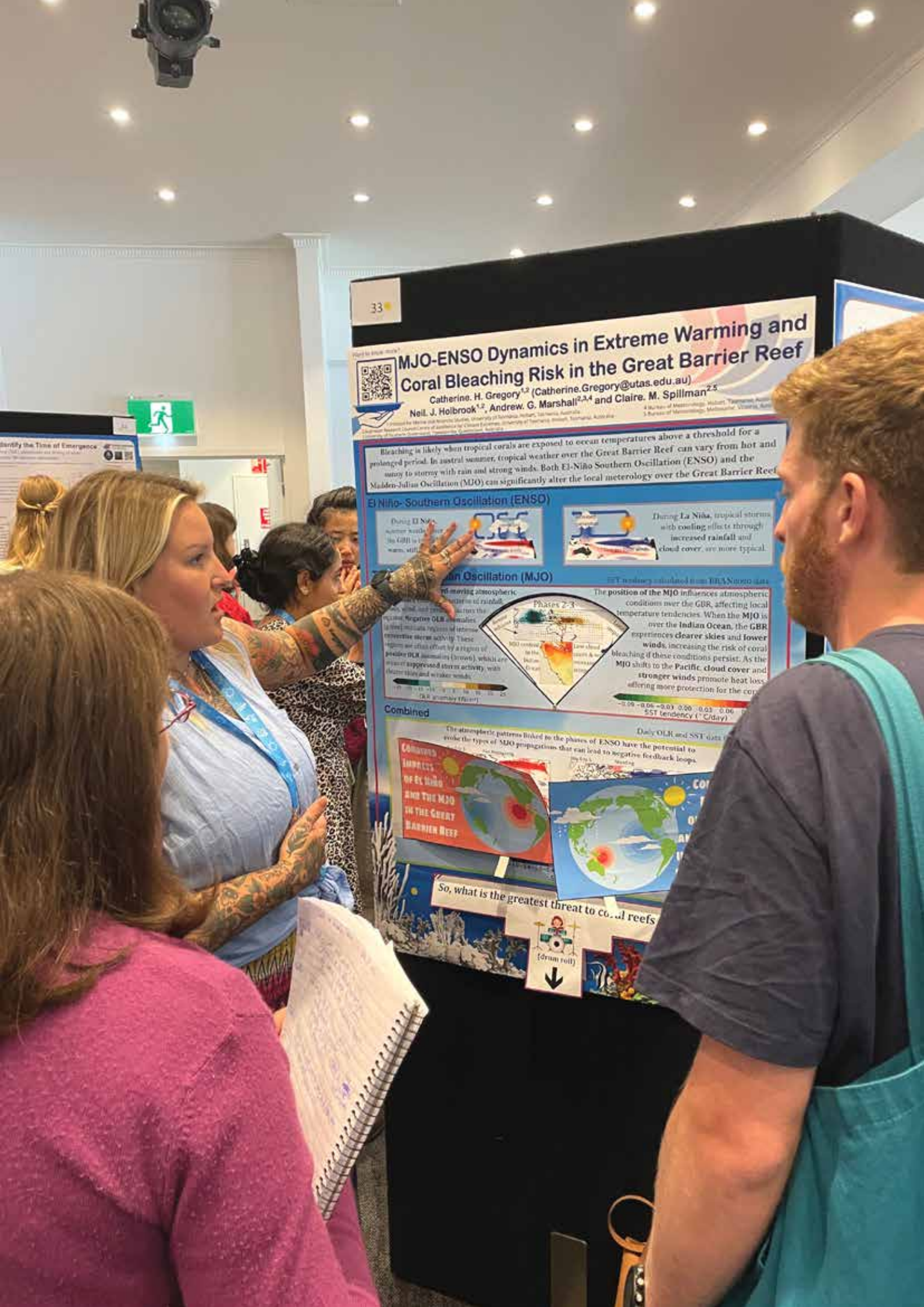
The study combined 11 years of biogeochemical argo float nitrate data with dust simulations, showing dust-iron's substantial contribution to net community production (Australian NGO Cooperation Program). During the Last Glacial Maximum, when dust deposition was 40 times higher, phytoplankton growth was twice today's levels.

The findings underscore how future changes in dust deposition, driven by global warming and land-use changes, could impact ocean productivity, ecosystems and fisheries. By integrating this relationship into global climate models, researchers can better predict how dust-driven fertilisation affects atmospheric carbon dioxide levels.

The research, published in Nature, was conducted by scientists from the Centre, Institute for Marine and Antarctic Studies, Australian Centre for Excellence in Antarctic Science, Australian Antarctic Program Partnership and CSIRO.

Weis J, Chase Z, Schallenberg C, et al (2024) One-third of Southern Ocean productivity is supported by dust deposition. *Nature* 629: 603–608. https://doi.org/10.1038/s41586-024-07366-4

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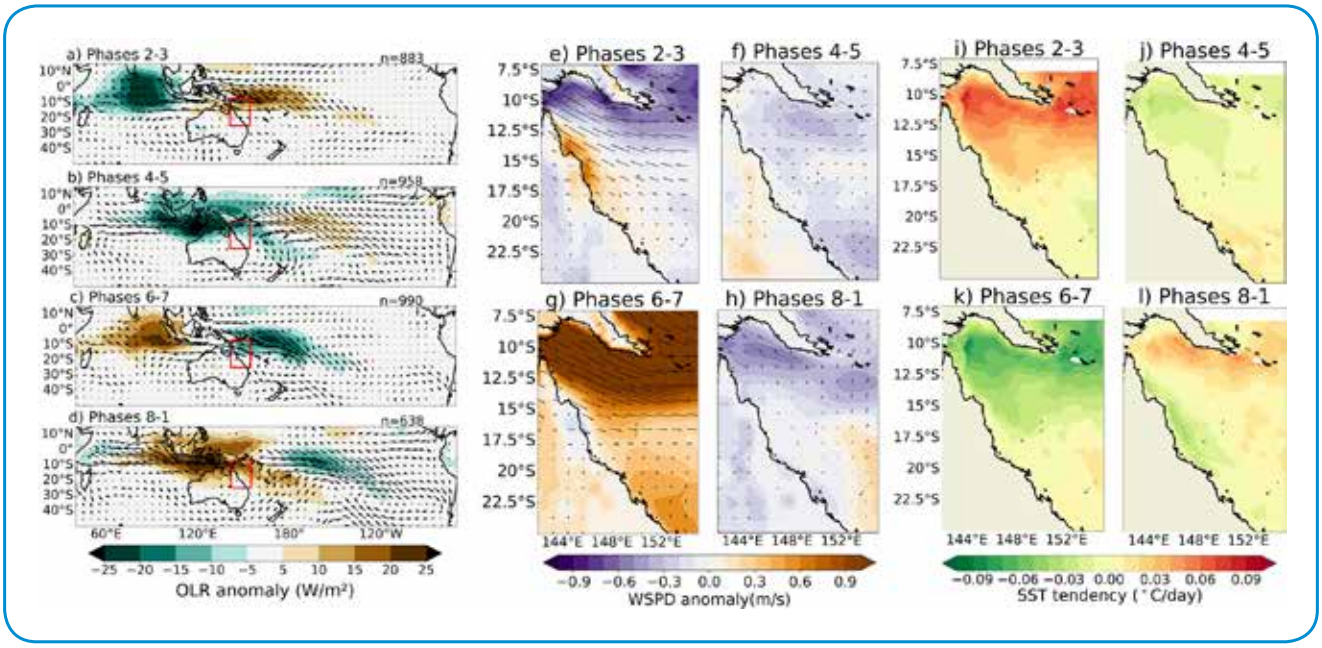
MJO-ENSO Dynamics in Extreme Warming and Coral Bleaching Risk in the Great Barrier Reef
Catherine. H. Gregory[1,2] (Catherine.Gregory@utas.edu.au)
Neil. J. Holbrook[1,2], Andrew. G. Marshall[2,3,4] and Claire. M. Spillman[2,5]
Bleaching is likely when tropical corals are exposed to ocean temperatures above a threshold for a prolonged period. In austral summer, tropical weather over the Great Barrier Reef can vary from hot and sunny to stormy with rain and strong winds. Both El-Niño Southern Oscillation (ENSO) and the Madden-Julian Oscillation (MJO) can significantly alter the local meterology over the Great Barrier Reef.
El Niño- Southern Oscillation (ENSO)
During La Niña, tropical storms with cooling effects through increased rainfall and cloud cover, are more typical.
Oscillation (MJO)
The position of the MJO influences atmospheric conditions over the GBR, affecting local temperature tendencies. When the MJO is over the Indian Ocean, the GBR experiences clearer skies and lower winds, increasing the risk of coral bleaching if these conditions persist. As the MJO shifts to the Pacific, cloud cover and stronger winds promote heat loss, offering more protection for the coral.
Phases 2-3
Combined
The atmospheric patterns linked to the phases of ENSO have the potential to evoke the types of MJO propagations that can lead to negative feedback loops.
So, what is the greatest threat to coral reefs
[drum roll]

Research Snapshot

Catherine Gregory, a PhD student at the University of Tasmania, has been studying the causes of extreme ocean warming events around Australia. Her research, published in Climate Dynamics, examines how regional marine heatwaves are influenced by climate modes like El Niño Southern Oscillation (ENSO) and the Madden Julian Oscillation (MJO). The study also highlights the combined impacts of these modes in critical regions, including the Great Barrier Reef.

A follow-up paper in Geophysical Research Letters reveals how the MJO, a slow-moving equatorial storm system, can disrupt ENSO-driven weather patterns in the Great Barrier Reef. This interaction has significant implications for coral health. The findings are summarised in the briefing document, Climatic Factors Affecting the Great Barrier Reef, providing valuable insights into the climatic influences shaping one of Australia's most vital ecosystems.

Gregory, C. H., Holbrook, N. J., Spillman, C. M., & Marshall, A. G. (2024). Combined role of the MJO and ENSO in shaping extreme warming patterns and coral bleaching risk in the Great Barrier Reef. Geophysical Research Letters, 51(13), e2024GL108810. https://doi.org/10.1029/2024GL108810



Modelling Research Program

Climate models are the main tool available to climate scientists around the world to predict future changes in the ocean-atmosphere-land system, and these are widely used to study climate processes. Climate modelling also underpins much of the research performed throughout the ARC Centre of Excellence for Climate Extremes.

The Modelling research program improved Australia's climate/atmospheric model, the Australian Community Climate and Earth System Simulator (ACCESS), for the benefit of the research and prediction across our Centre and across the nation.

PROJECT 1: AUS2200

High-resolution regional atmospheric modelling

PROJECT 2: ACCESS-CM2-025

Developing Australia's coupled modelling capacity

2024 Update

In 2024, the Modelling program prioritised the following: improving the resolution of climate simulations; enhancing the representation of processes in models; comparing model outputs with observations; and making models – and their outputs – more accessible for researchers. These tools provided critical support for advancements across the Centre's other research programs. Given the Centre's closure, a significant focus was placed on training up early career researchers and winding down projects.

In September 2024, the Modelling program, in collaboration with ACCESS-NRI (the latter being the National Research Infrastructure) and CSIRO, hosted the CMIP7 ESMValTool Hackathon and Training Day. This event offered participants practical experience using the ESMValTool for climate model evaluation and diagnostics, specifically for models contributing to the upcoming Coupled-Model Intercomparison Project-7 (the afore-mentioned CMIP7). Participants also engaged in discussions about integrating community input into evaluating Australia's contributions to CMIP7.

By fostering technical expertise, collaboration and strategic planning, the Modelling program's progress under-scored the team's dedication to advancing climate science and strengthening Australia's role in global climate model intercomparison projects.

Another key focus was improving the AUS2200 modelling suite, progressing towards greater flexibility and efficiency. The team developed the ability to select boundary conditions from ERA5, ERA5LAND, and/or BARRA(-2), providing users with greater adaptability to different datasets. Additionally, the model's efficiency was improved substantially – achieving a speedup of 10 to 18 times. The model and experiment setup were thoroughly documented.

With support from the CMS team and ACCESS-NRI, sixteen simulation experiments have been successfully completed and published vai NCI (DOI: 10.25914/w95d-q328). The dataset includes 180 days of Austral summer simulations that captured three full Madden-Julian Oscillation (MJO) cycles, the 2019/2020 Black Summer bushfires, and record-breaking extreme rainfall events. A platform/system was developed to capture, advertise, document, and evaluate available cases through engagement with the wider community.

Research Snapshot

At the 2024 winter school, Dr Yi Huang, a senior lecturer and chief investigator at the Centre, highlighted the transformative potential of high-resolution climate models in addressing key challenges in weather and climate science. These cutting-edge models overcome the limitations of traditional frameworks, which often struggle to simulate mesoscale phenomena such as East Coast Lows, tropical cyclones and severe weather.

Dr Huang showcased several recent and significant applications by Centre researchers, including simulations of the 2019–2020 Black Summer bushfires, which revealed how boundary layer dynamics intensified fire conditions, and the 2016 East Coast Low, where warm ocean currents were shown to influence rainfall patterns. These advancements have cemented the Centre's role as a leader in high-resolution atmospheric modelling, positioning this approach as a critical tool for future breakthroughs in climate science.

By offering unprecedented precision and fostering interdisciplinary collaboration across computational and atmospheric sciences, the Centre is paving the way for innovative solutions to global climate challenges. Watch the full recording here.

Research Snapshot

In 2024, AI, particularly machine learning, was transformative in advancing climate modelling at the Centre. Researchers leveraged AI to address computational challenges, enhance the accuracy of simulations and improve insights into extreme weather events.

Machine learning models were integrated to reduce the computational intensity of regional climate models, enabling faster and more energy-efficient simulations. These models also enhanced the representation of small-scale processes, such as cloud formation, and improved the modelling of complex relationships between climate variables. Additionally, AI was employed to develop early warning systems for extreme events such as floods, droughts and bushfires, helping communities better prepare for climate risks.

The Centre has made significant strides in exploring these applications while addressing challenges like data limitations and ensuring that AI complements traditional climate modelling approaches. Dr Sanaa Hobeichi, a researcher currently working in this area, wrote about the latest research developments in *The Conversation*. Read her analysis here.

Hobeichi S; Abramowitz G; Sen Gupta A; Taschetto AS; Richardson D; Rampal N; Ayat H; Alexander LV; Pitman AJ, 2024, 'How well do climate modes explain precipitation variability?', npj *Climate and Atmospheric Science*, 7, http://dx.doi.org/10.1038/s41612-024-00853-5

Early Career Researcher: Liam Cassidy – University of Melbourne

Liam Cassidy is completing his PhD at the University of Melbourne. His work uses climate models to better understand global and regional climate change during net zero and net negative greenhouse gas emissions futures.

"Exploring possible large-scale and regional changes in our climate system in response to net zero is an important emerging area of research."

"It is very exciting to work on the forefront of climate science focused on net zero because I believe discovering and communicating our early findings and challenges might help guide future research directions around the question of what reaching net zero might mean for the health and safety of communities around the world," Liam said.

Liam's research found that it is expected there will be a decrease in the frequency of heat extremes over most land areas after net zero, emerging within 25 years. These changes are regionally dependent, with some regions projected to experience up to a 40 percent reduction while others may see minimal changes. Some of these findings were included in a recent briefing note on **Understanding Net Zero**.

Cassidy, Liam & King, Andrew & Brown, Josephine & Macdougall, Andrew H & Ziehn, Tilo & Min, Seung-Ki & Jones, Chris. (2023). Regional temperature extremes and vulnerability under net zero CO 2 emissions. *Environmental Research Letters*. 19. **DOI:10.1088/1748-9326/ad114a**

Research Snapshot

Led by Centre researchers, AUS2200 is a community-based project that aims to develop high-resolution regional modelling capacity at 2.2km grid spacing across Australia and surrounding ocean using ACCESS. This project has been instrumental in the study of extreme events like floods and bushfire weather, while deepening our understanding of Australia's unique climate challenge.

The project provides a common platform that facilitates research and model-development activities that advance scientific understanding of important atmospheric processes across a wide range of scales, from continent-wide to kilometre-level.

The project's monthly meetings, led by Centre Chief Investigator Dr Yi Huang, were regularly attended by Centre researchers and colleagues from the Bureau of Meteorology, NCI and the Australian Embroidery, Screen Print & Sublimation.

Computational Modelling Systems

The Computational Modelling Support (CMS) team provided technical support with climate model configuration, data analysis and data management to researchers in the ARC Centre of Excellence for Climate Extremes. The team offered support through a help desk and hosted a weekly CodeBreak online session.

The CodeBreak sessions included short training on a variety of topics and provided an opportunity for the team to work one-on-one with researchers to solve their coding issues. Blog posts, training materials and other documentation were also key ways the team supported the community, ensuring frequently asked questions were addressed efficiently and effectively.

2024 Update

The CMS team spent most of the year focused on ensuring the longevity and usability of the extensive software, data and documentation it manages, in preparation for the conclusion of the Centre's activities.

Early in the year, the team produced a detailed risk assessment on storage and data management after the Centre's closure. This included ensuring that data stored by the Centre's researchers at the National Computational Infrastructure (NCI) would remain accessible even after projects wrapped up.

As part of these efforts, a new web-based dashboard was developed to monitor computational and data storage usage at both group and individual levels. This dashboard, designed with a user-friendly interface, was built to update automatically and could be adapted for new projects or different facilities. By utilising inexpensive cloud resources, the dashboard required minimal maintenance and was expected to be a valuable tool beyond the Centre's lifespan.

The CMS team also undertook a comprehensive reorganisation of the Australian Community Climate and Earth System Simulator ACCESS) Earth System Model components. The review identified relevant configurations, updated outdated ones and unified the codes into a single repository. This streamlined approach simplified future maintenance, making it easier to transfer updates across configurations. CMS team member Holger Wolff worked closely with ACCESS-NRI (the latter the National Research Infrastructure) to ensure the final product met their criteria, as ACCESS-NRI was slated to take over maintenance of some configurations.

The CMS team also addressed the future of the Python Conda environments, a service supporting over 700 users at NCI. Recognising its value, team members ensured this service would continue post-Centre-operations by creating detailed documentation to aid in its maintenance and management during the transition.

The CMS team published the AUS2200 and Pacemaker simulation data and finalised the ACCESS post-processor tool, ensuring that the wider climate community could access both. The Community Atmosphere Biosphere Land Exchange (CABLE) integration was also nearly completed in 2024, but further work awaits Dr Ramzi Kutteh, with new improvements to CABLE already planned.

In September, the team participated in another ACCESS-NRI workshop, which provided an opportunity to discuss new collaborations with ACCESS-NRI and reconnect with researchers. Throughout the year the team continued to liaise with ACCESS-NRI and the new ARC Centre of Excellence for 21st Century Weather to ensure a smooth transition, making certain that the services and data valued by researchers would remain available into 2025.

By the end of 2024, these initiatives had successfully positioned the tools and resources of the Centre of Excellence for Climate Extremes for sustained impact, extending their utility to researchers and collaborators well beyond the Centre's active years.

Highlights

Advancing the CABLE Model

Computational physicist Dr Ramzi Kutteh continued providing invaluable support to the CABLE model community. After completing the integration of the Groundwater module, Dr Kutteh has continued helping the ACCESS-NRI Land team to improve the overall model code, using the extensive knowledge he acquired in the previous project.

Dr Kutteh continues contributing to the documentation and he also helped discover and resolve bugs and inconsistencies in the main model code. This requires patient and painstaking work, rarely acknowledged but essential to the model producing scientifically robust and reliable results.

Focus on Machine Learning and Other Training

The Centre's Early Career Researchers Committee provided some feedback to the CMS team by requesting more training around machine learning topics. Dr Kutteh and Dr Sam Green have prepared and delivered a series of short tutorials on Python packages used for machine learning. These were given during the regular Wednesday Code Break sessions and the recordings are available online on the CMS Youtube channel. Dr Green also continued collaborating with Dr Sanaa Hobeichi and others at UNSW Sydney to help port machine learning projects to GPU-based software.

The team has also organised a series of Xarray tutorials, experimenting with a new format wherein attendees could go through training material available online at their own pace, and then the Code Break session was used to review it and discuss any questions attendees had.

Generating User-Friendly ACCESS Model Output

The program led by Dr Paola Petrelli and Dr Sam Green continued to improve the ACCESS Model Output Post-Processor (MOPPeR). This tool provides a user-friendly interface to post-process the complex output generated by the ACCESS model. A new, improved version, which provides a complete mapping of the model output to Coupled Model Intercomparision Project (CMIP), was published. In particular, the software can now be deployed as a Python package, and we will soon be able to make it available in the shared environment. More land, ocean and sea ice mappings have been added, together with corresponding functions to calculate derived variables. These tools have been tirelessly tested for their usability, ease of use and robustness.

It was also confirmed that ACCESS-MOPPeR will be used to post-process the Australian contribution to the next CMIP phase, as it has been endorsed by the CMIP-7 Consortium.

Data highlights

For the last two years the lead of the aforementioned program, Dr Paola Petrelli, chaired a working group focusing on improving access to climate data across institutions. The group, which included members from CSIRO and the Bureau of Meteorology, concluded its work by publishing a report and a synthesis of their findings. The report draws on learnings from specific initiatives, both in Australia and overseas, to comment on overall data management strategies that can be adopted to improve data accessibility for climate science researchers in Australia.

The scope of the report includes governance and technical issues related to data management, as well as data licensing and administrative obstacles to accessing data and sharing data between Australian institutions. The synthesis summarises the key recommendations and aims to provide the basis for collaboration between Australian climate research and data-provider communities for better data sharing.

Connecting climate science to Australians & beyond

Engagement and Impact at the ARC Centre of Excellence for Climate Extremes

Climate science is a fundamental part of protecting and enhancing the resilience of communities against the extremes of climate change. Floods, fires, heatwaves, storms, and rising oceans – **extreme events** – are becoming increasingly widespread with every fraction of warming.

Climate scientists are increasingly sought after by governments, industry and decision-makers seeking help and advice in preparing for the decades ahead. The ability to look ahead and plan for the future has become more critical than ever.

The Engagement and Impact team at the ARC Centre of Excellence for Climate Extremes brought together some of Australia's most talented policymakers, media and communications specialists, science communicators, content makers, designers and more, to ensure that the essential science of climate extremes **is heard by the people who need to know.** The team trained researchers in engagement and impact skills so they can be recognised by decision-makers as

Trusted • Respected • Legitimate • Credible • Reputable

The Centre's researchers achieved this by

- providing expert comment to international and Australian media;
- making submissions to government inquiries and processes;
- producing and appearing in web and social media content;
- meeting with decision-makers directly to educate them about climate science; and
- producing resources for school teachers to incorporate climate science into their syllabi.

The Engagement and Impact team provided the training, structure and support that enabled Centre researchers to undertake these activities both during their time at the Centre and well into the future.

Knowledge Broker Angela Kaplish discussing the State of Weather and Climate Extremes Report with Senator David Pocock

Case Study: The State of Weather and Climate Extremes Report for 2023

Building on the success of previous years, the flagship State of Weather and Climate Extremes Report was once again a Centre standout event for Engagement and Impact.

The aim of the report was to provide a summary of selected significant extreme weather and climate events which occurred across Australia in 2023, including a description, explanation and understanding of the causes thereof. The report also highlighted selected international extreme events, including an analysis of current Antarctic weather.

The report has assisted policymakers and the general public in understanding the complexity and nature of contemporary climate extremes. It also provides the Centre's early career researchers with a chance showcase their expertise in analysing key weather and climate extremes from 2023.

One example of the analysis of an extreme event comes from ocean researchers Dr Zijie Zhao, Dr Christopher Aiken, Dr Ramkrushnbhai Patel and Professor Neil Holbrook. They describe how ocean temperatures in 2023 were unusually hot and that a concerning number of marine heatwaves is likely to have negative impacts on marine ecosystems and fisheries. Accompanied by tailored graphics, and reported concisely and in an easy-to-understand format, the report makes climate information more accessible while also informing its readers.

Published in February 2024, the report gained national and international coverage. Australian Associated Press syndicated news of the report's release as well as other news outlets, including Channel 9, Win News, the Conversation, the *Daily Mail, The Courier Mail* and UNDRR (an online platform for the United Nations Office for Disaster Risk Reduction). The report was distributed on LinkedIn, other social media and multiple radio news bulletins, including Mix 94.5 Perth Radio, Triple M Geraldton Radio and Mix FM Sunshine Coast.

The Centre's team attended a climate resilience hearing at the Victorian Parliament.

The report was presented to Senator David Pocock and distributed amongst government departments both at state and federal level, with a briefing to the Assistant Minister for Climate Change and Energy, Senator the Hon Jenny McCallister.

As well as an information source, the report provides opportunities for the Centre's researchers to talk to policymakers as well as other, new audiences. The Centre received an invitation from the federal Department of the Treasury to present the outcomes of the report at the whole-of-government Climate Change Modelling Working Group. Many thanks to Dr Andrew King for delivering this presentation.

Case Study: Engaging with Government

Governments use parliamentary inquiries and consultations to gather facts and hear from stake-holders and other allied experts on various topics on the policy agenda. Inquiries analyse the evidence provided in order to draw conclusions and report back to the government on the inquiry topic. Experts are sometimes called to appear before inquiry committee members for further questioning.

In February 2024, the Centre of Excellence was called to give evidence at the Inquiry into the Climate Change Amendment (Duty of Care and Intergenerational Climate Equity) Bill 2023. This followed a submission from the Centre's early career researchers, who wrote in support of the bill and urged the inquiry 'to act and ensure that we, as the next generation, can believe in a brighter tomorrow.'

Dr Nicola Maher, a chief investigator and former student at the Centre, gave evidence to the committee as a representative of the Centre's young scientists. Dr Maher described how it was difficult to consider what 1.5 degrees Celsius means, and that describing impacts is a more tangible way of communicating climate science. Watch it here: ParlView | Video 2209481 (aph.gov.au)

The Centre also put forward joint submissions with the ARC Centre of Excellence for 21st Century Weather on a range of other topics in 2024.

The Climate Change Authority's consultation 2024 Issues paper: Targets, Pathways and Progress provided a chance for both Centres to outline Australia's international obligations for emissions reduction in line with Article 4 of the Paris Agreement – that is, an emissions reduction target of 74 per cent below 2005 levels by 2030, with net-zero emissions reached by 2035.

The evidence collected in this consultation forms part of advice on emissions reduction targets for Australia's next Nationally Determined Contribution under the Paris Agreement and advice for the Minister for Climate Change and Energy's Annual Climate Change Statement (2023 Annual Progress Report).

Federally, both Centres submitted to the Inquiry into the Importance of Antarctica to Australia's National Interests. At a state level, they made a joint submission to the Victorian Inquiry into Climate Resilience.

What is a policy submission?

Policy submissions give experts, advocates and lobbyists an opportunity to participate in the decision-making process by providing advice and recommendations to government and regulatory bodies.

Policy submissions are often made in response to issues, policy proposals or reports established by governments/parliaments or as a requirement of legislation.

Writing policy submissions is a key skill for researchers to ensure quality scientific advice is taken into consideration as governments and policymakers create and monitor laws in relation to climate, weather and the related fields of science.

The knowledge brokers Angela Kaplish and Alice Wilson are active members of the National Partnership for Climate Projections. This is a voluntary collaboration which includes states, territories, peak science bodies and the Australian Government. The collaboration aims to guide a national approach to Australian climate projection science and provide information on climate projections.

The knowledge brokers also hold regular meetings across government, namely with the Climate Change Authority; the Australian Climate Service; the Depart-ment of Climate Change, Energy, the Environment and Water; the Murray Darling Basin Authority; and the National Environmental Science Program.

Dr Nicola Maher, a chief investigator and former student at the Centre, giving evidence at the Inquiry into the Climate Change Amendment (Duty of Care and Intergenerational Climate Equity) Bill 2023 in February 2024.

The Engagement and Impact team engaged with policymakers at the 'Powered by UNSW' 75th Anniversary Showcase at Parliament House.

Pictured from left to right: UNSW Sydney Professor Ben Newell (Psychology), UNSW Sydney Professor Lisa Alexander (Climatology), UNSW Sydney Lead Knowledge Broker Angela Kaplish, Minister for the Environment the Hon. Tanya Plibersek MP and UNSW Vice-Chancellor and President Professor Attila Brungs.

Case Study: Highlighting the Centre's Researchers

The Knowledge brokerage team also looked closer to home highlighting certain key events in the calendar, including Harmony Day and International Women's Day in March 2024 and Climate Stripes Day in June 2024.

Harmony week was a chance to recognise and celebrate the Centre's students, staff and researchers from diverse cultural backgrounds – to hear, for example, about their experiences of arriving in the Centre and to celebrate the many languages spoken at the Centre.

"Ensuring that no-one feels excluded because of their culture or background is a responsibility for us all in the Centre."

– Chief Investigator Dr Martin Singh

Celebrating International Women's Day is a regular event at the Centre, with ongoing progress: in 2017, 22 per cent of chief investigators were women and 32 percent of PhD students were women. Now, in 2024, its chief investigators at 46 percent women and PhD students at 50 percent women.

"While we've made progress in advancing gender representation, there is still a noticeable absence of women who are navigating other intersectionalities, including diverse cultural backgrounds or where English is a second language. Australia is a multi-cultural nation, so embracing diversity needs a multidimensional lens."

– Chief Investigator
Associate Professor Negin Nazarian

Case Study: Briefing Notes

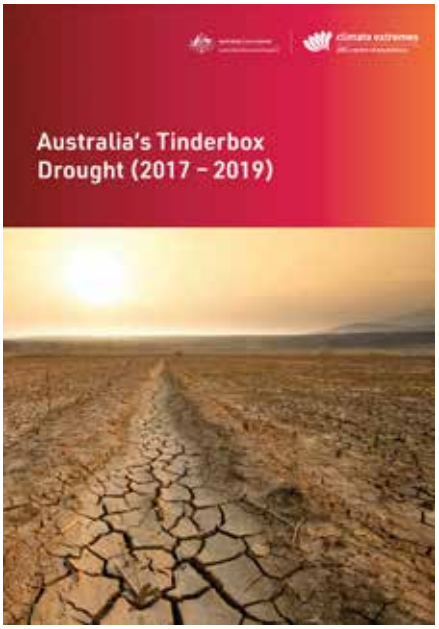
Briefing notes provide explanations, translations and everyday examples beyond the dictionary definition on climate science topics. They provide a vehicle that explores the nuts and bolts of a topic, highlighting topics at the heart of climate science – such as uncertainty or coral bleaching.

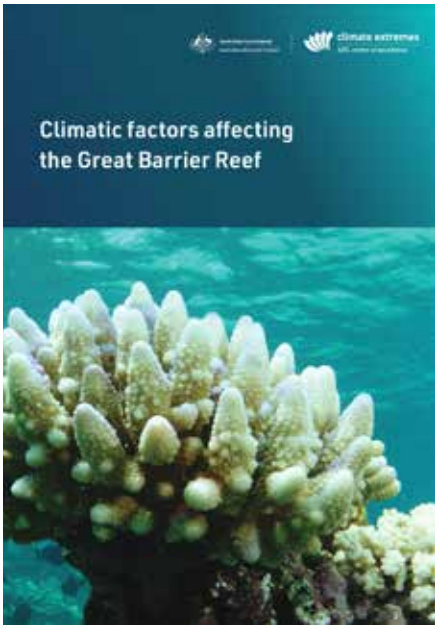
Briefing notes sometimes represent the outcomes from large research projects in a concise and digestible form (The Tinderbox Drought, for example) or represent a recently published paper relevant to current news events (as with the topic nature-based solutions).

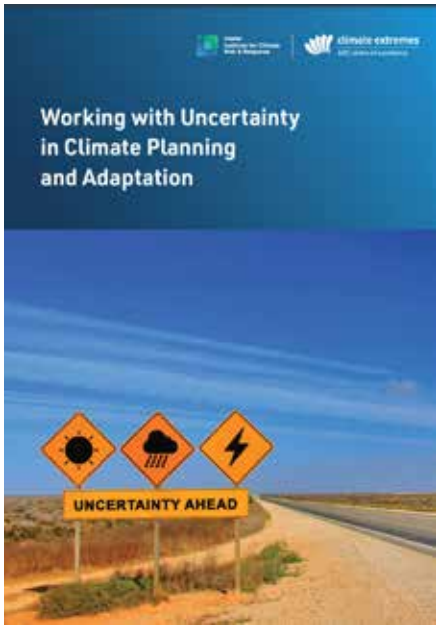
These notes are supplemented using illustrations and infographics which help the reader to visualise complicated descriptions, providing clarity and simplicity to a science topic.

Briefing notes in 2024 so far have sought to go behind major pieces of research and news headlines to provide a deeper dive into a range of topics:

- Tinderbox Drought
- coral bleaching
- uncertainty (in collaboration with the UNSW Institute of Risk and Resilience)
- nature-based solutions







Opposite page:
The Engagement and Impact Team, 2024. From left to right: Angela Kaplish, Alice Wilson, Victoria Ticha, Georgina Harmer, Laure Poncet.

Legacy – Providing Skills and Support for the Future of Climate Science

Reflecting on the 2022–2024 Engagement and Impact Strategy's Success

In 2022 and 2023, the Engagement and Impact team underwent significant changes, with four new engagement and impact experts joining the organisation while the previous team departed for new opportunities. Under the leadership of Lead Knowledge Broker Angela Kaplish, the new team built on the foundation of the previous team's strategy and refocused the Centre's activities to establish a long-lasting legacy for the Centre and its experts.

2. Engagement and Impact Team 2022-2024

Purpose

- **Invest in long term skills.** We can provide access to and support the development of skills in engagement and impact through practical actions and examples.
- **Create opportunities.** We will create platforms, publications and opportunities for Centre experts to showcase their research and be recognised for their engagement and impact skills.
- **Boost confidence.** We will help Centre researchers to feel confident engaging with Government, policy makers, media and industry and how they can do small actions to make their communications more impactful.
- **Celebrate the Centre and our people.** As the Centre comes to a close we will make sure our people and their research is celebrated and recognised.

Our Support

- We will refine the previous Engagement and Impact team's priorities, meeting our promises to our funders, partners and community, while re-focusing on the most effective use of our skills and resources.
- Researchers will have increased their confidence in how to engage in their work and make an impact with stakeholders so that they can continue to show the impact of their research well into the future.
- Researchers can take forward a body of engagement activities and material which exhibits and highlights their skills at the end of the Centre.
- We will provide and prioritise activities that cement the Centre's long term legacy.

Priorities 2022-2024

Influential voices	Creating a profile for the Centre and its researchers to be known as: Trusted, Respected, Legitimate, Credible, Reputable.
Research Engagement	Build ties and connections with Government, Industry and policy makers. Create writing skills opportunities through evergreen content, reactive content and media skills.
Schools Engagement	Climate classrooms workshops + educational resources.

By 2024, these efforts proved highly successful, with Angela and her team leading the publication of a comprehensive legacy report that consolidated the Centre's achievements and impact into a single, cohesive document. The report was widely praised for effectively showcasing the Centre's enduring contributions to climate science, public engagement and policy influence, serving as a valuable resource for researchers, policymakers and the public.

In addition to the report, a new legacy website was developed under the leadership of the Centre's Media and Communications Officer, Victoria Ticha. This website features a streamlined design and user-friendly navigation, ensuring the Centre's legacy is not only preserved but also made easily accessible to a broad audience. The website became a cornerstone for engaging stakeholders, allowing them to explore the Centre's research, initiatives and achievements in an intuitive and visually appealing format. Together, the legacy report and website cemented the Centre's reputation as a leader in advancing climate science and fostering impactful engagement.

Key achievements

To leave a long-term and lasting legacy for the ARC Centre of Excellence for Climate Extremes, the Engagement and Impact team was focused on building long-term skills and support for researchers, beyond the Centre's closure in December 2024.

- **Engaging in the policy process**

  Throughout the year, Centre researchers continued to submit to government and industry inquiries, learning about policy processes and translating science for decision-makers. The Engagement and Impact team also continued producing the Centre's highly regarded briefing notes and reports to assist policymakers in understanding the science of climate extremes.

- **Profiling early career researchers**

  The team also published a range of written and video profiles of early career researchers, teaching them how to be interviewed, promote themselves and prepare for media opportunities as their careers develop.

- **Building long-term communication and media skills**

  The Centre provided researchers with opportunities and training on handling interviews, promoting themselves, building their public profiles and preparing for external media opportunities as their careers progressed. The training, led by the Centre's Media and Communications Officer, Victoria Ticha, emphasised the importance of effectively communicating the significance of their work and distilling complex information for the general public.

- **Training workshops and one-on-one support**

  As well as targeted media training, the Engagement and Impact team delivered career development support and provided one-on-one assistance to Centre researchers at all levels, from helping senior researchers prepare for high-level government consultations to holding coaching sessions for students making their first-ever media appearances.

- **Design, imagery and boosting climate science**

  The Centre's graphic designer, Georgina Harmer, played a significant role in assisting researchers in communicating their research through effective design. Her work had a lasting impact through the development of the Centre's briefing notes, posters, PowerPoint presentations and social media. She also created custom and tailored designs for the Centre's larger reports, such as the annual report and the State of Extremes report. The team continued to support the Centre of Excellence in effectively communicating scientific concepts.

- **Teaching climate science in schools**

  Finally, the Centre's highly successful Climate Classrooms program continued in 2024, led by Dr Sanaa Hobeichi (a former mathematics teacher and now one of the Centre's most valued researchers, based at UNSW Sydney) and the Monash Climate Change Communication Research Hub. Read more about the Climate Classrooms program here.

Read and download the full legacy report published by the Engagement and Impact team here.

Outputs & performance

Publications

Book/Encyclopedia

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Roberts, Dale, Petrelli, Paola, Vincent, Claire. (2024). AUS2200 Unified Model atmospheric simulation of a Madden-Julian Oscillation event during a neutral phase, Jan and Feb 2013, over Australia at 2.2km resolution (v1.0). NCI Australia. https://doi.org/10.25914/gprx-2d45

Roberts, Dale, Petrelli, Paola, Hayat, Hooman. (2024). AUS2200 Unified Model atmospheric simulation of the 2003 Canberra bushfire, over Australia at 2.2km resolution (v1.0). NCI Australia. https://doi.org/10.25914/vhs6-ja29

Roberts, Dale, Petrelli, Paola, Hayat, Hooman. (2024). AUS2200 Unified Model atmospheric simulation of the 2009 Black Saturday bushfires, over Australia at 2.2km resolution (v1.0). NCI Australia. https://doi.org/10.25914/hjy7-jb56

Roberts, Dale, Petrelli, Paola, Hayat, Hooman. (2024). AUS2200 Unified Model atmospheric simulation of the 1980 Ash Wednesday bushfire, over Australia at 2.2km resolution (v1.0). NCI Australia. https://doi.org/10.25914/7wpa-tb70

Roberts, Dale, Petrelli, Paola, Hayat, Hooman. (2024). AUS2200 Unified Model atmospheric simulation of the 1983 Ash Wednesday bushfire, over Australia at 2.2km resolution (v1.0). NCI Australia. https://doi.org/10.25914/9pw2-8b46

Roberts, Dale, Petrelli, Paola, Reid, Kim. (2024). AUS2200 Unified Model atmospheric simulation of the 2022 Brisbane floods, over Australia at 2.2km resolution (v1.0). NCI Australia. https://doi.org/10.25914/abqk-cq07

Impact, Engagement, Awards and Service

Prizes and Awards

Alexander, Lisa: Highly Cited Researcher awards in 2024

Alexander, Lisa: Copernicus Medal 2024

Ashcroft, Linden: Dean's Award for Engagement

Barnes, Ashley: Most Selfless Contributor award by COSIMA

Cheng, Sibyl: 2024 John Church Student Culture Prize

Da Silva, Felipe: Best Student Poster – CLEX Annual Workshop 2024

Gallant, Ailie: Fellow of the Australian Meteorological and Oceanographic Society

Gallant, Ailie: Monash University Vice-Chancellor's award for Research Team of the Year

Gallant, Ailie: Dorothy Hill Medal

Gillett, Zoe: 2024 CLEX Prize for Best Paper by an Early Career Researcher

Grant, Matt: Best PhD presentation at the 2024 Institute for Climate Risk and Response Workshop

Greco, Isabelle: Catastrophe and Risk Symposium research award

Gregory, Catherine: Best Student Poster – CLEX Annual Workshop 2024

Harmer, Georgina: 2024 CLEX Director's Prize for the most outstanding contribution to the Centre

Hogg, Andy: Fellow of the Australian Meteorological and Oceanographic Society

Holbrook, Neil: 2024 Clarivate Highly Cited Researcher (cross-field)

Jakob, Christian: Monash University Vice-Chancellor's award for Research Team of the Year

Kaplish, Angela: 2024 CLEX Director's Prize for the most outstanding contribution to the Centre

King, Andrew: Anton Hales Medal

Li Shing Hiung, Darren Li Chong Youne: 2024 CLEX Engagement and Impact Prize

Lu, Jiachen: Dean's Award for Outstanding PhD Theses 2024

Ong, Qing Yee Ellie: 2024 ACEAS Prize for Best Paper by a Student

McDougall, Trevor: 2025 Alfred Wegener Medal

McGregor, Shayne: Monash University Vice-Chancellor's award for Research Team of the Year

Mora, Camille: The prize for the best 5-minute lightning talk during the ECR Day at the 2024 Institute for Climate Risk and Response Workshop

Nazarian, Negin: 2024 NSW Young Tall Poppy Science Award

Page, Jon: Dean's Award for Outstanding PhD Theses 2024

Quail, Katie: 2024 Climate Change Research Centre Prize for Science Communication, Outreach or Education

Respati, Muhamad Reyhan: Best Student Poster – CLEX Annual Workshop 2024

Schanzer, Thomas Dean: 2024 Climate Change Research Centre Best Postgraduate Review Presentation Prize

Schmidt, Christina: 2024 Climate Change Research Centre Best Postgraduate Review Presentation Prize

Sen Gupta, Alexander: Highly Cited Researcher awards in 2024

Sengupta, Aditya: John and Allan Gilmour Research Award 2024

Sherwood, Steve: Fellow of the American Geophysical Union

Shi, Jiaxin: 2024 CLEX Engagement and Impact Prize

Singh, Martin: Monash University Vice-Chancellor's award for Research Team of the Year

Ukkola, Anna: Fenner Conference for the Environment award

Wang, Yuxin: 2024 CLEX Engagement and Impact Prize

Weis, Jakob: 2024 CLEX Prize for Best Paper by a Student

Wilson, Alice: 2024 CLEX Director's Prize for the most outstanding contribution to the Centre

Zhang, Xinyue: 2024 Climate Change Research Centre Prize for Best Student Paper

Zhang, Xinyue: UNSW Sydney Science Postgraduate Research People's Choice Poster Prize

Zhang, Shujing: 2024 CLEX Engagement and Impact Prize

Zhao, Zijie: 2024 CLEX Engagement and Impact Prize

Alexander, Lisa: Highly Cited Researcher awards in 2024

Engagement with Industry and Government

Alexander, Lisa: Presentation to National Academies of Sciences, Engineering and Medicine (US)

Alexander, Lisa: UNSW Parliament House Showcase – discussions with politicians and advisors about the value of climate research

Arblaster, Julie: Inquiry into Climate Resilience

Ashcroft, Linden: Keynote presentation at the annual Australian Tomato Processing Research Council forum in Echuca, Victoria

Borowiak, Alexander: Presentation to the Climate Change Authority about the evolution of the climate post net-zero

Evans, Jason: Advice on changes in severe storm hazards (and associated uncertainties) to consulting firm Energetics

Evans, Jason: Climate change & energy security – National Security College's executive development program, National Security Foundations States and Territories

Falster, Georgy: Statement to Research Professional News about the Australian government's draft drought plan

Gallant, Ailie: Expert attendee at the Victorian parliament's public hearing for its inquiry into Victoria's climate resilience

Gillett, Zoe: Contributor to the NESP Climate Systems Hub factsheet on "What made eastern Australia so wet from 2020 to 2022?"

Hobeichi, Sanaa: UNSW Future Climate & Clean Energy Expo – as an exhibitor presenting on how AI can help improve our understanding of future regional rainfall and its extremes

Holbrook, Neil: Presentation on Impacts of marine heatwaves on tropical western and central Pacific Island nations and their communities, at Climate Extremes and Coastal Impacts in the Pacific, PICES 2024 Conference, Honolulu, Hawaii

Holbrook, Neil: Presentation at the 2024 International Conference on the Cooperation and Integration of Future Industry, Education, Research and Application of the Ocean Industry, at Qingdao, China

Holbrook, Neil: Presentation at the 21st Annual Meeting of the Asia Oceania Geosciences Society, Pyeongchang, South Korea

Holgate, Chiara: Attendee at water resource modelling meeting for a MDBA/CSIRO briefing

Isphording, Rachael: Presentation on reducing uncertainty in climate projections at the Cross-Systems: Water Security Workshop for the National Climate Risk Assessment

Jakob, Christian: Climate Change Authority's consultation 2024 Issues paper: Targets, Pathways and Progress

Jakob, Christian: Inquiry into the importance of Antarctica to Australia's national interests

Kaplish, Angela: Presentation to National Partnership for Climate Projections Working Group 3 on Engagement and Impact and legacy of CLEX

Kaplish, Angela: Meeting with Net Zero department of DCCEEW to discuss overlapping work

Kaplish, Angela: Provision of State of Weather and Climate Extremes report 2023 to Alicia Payne MP and Sharon Claydon MP

Kaplish, Angela: Presentation on selected briefing notes and State of Extremes report to Greening Australia senior project manager

Kaplish, Angela: Information on the State of Weather and Climate Extremes to Assistant Minister of Climate Change and Energy, Josh Wilson

Kaplish, Angela: Meeting with Climate Change Authority Lead Scientist, Dr Will Howard, outlining new briefing notes

Kaplish, Angela: UNSW Parliament House Showcase – talking to politicians and advisors about the value of climate research

Kaplish, Angela: Meeting with representative leading the government response to the Australian Climate Service

Kaplish, Angela: Meeting with NESP adaptation lead, Sarah Boulter, to discuss CLEX and NESP research activities

Kaplish, Angela: Panel participant at the ANU 3rd year Climate Dynamics course – talking about knowledge broking at CLEX

Kaplish, Angela: National Partnership for Climate Projection working Group 3 – Presentation on engagement and impact on CLEX activities and introduction to the ARC Centre of Excellence for 21st Century Weather

Kaplish, Angela: Meeting with Murray Darling Basin Authority's Climate Risk section on assessing uncertainty and information we can provide

Kaplish, Angela: Meeting with lead scientist at the Climate Change Authority about forthcoming government submission on emissions reduction targets

Kaplish, Angela: Meeting with Climate Adaptation Initiative leader, NESP, to discuss joint opportunities and forthcoming events for CLEX and NESP

Kaplish, Angela: Discussion on joint initiatives with NESP, with NESP Knowledge Broker Ramona Della Pozza

Kaplish, Angela: Provision of the State of Weather and Climate Extremes Report 2023 to director of Climate Adaptation Office at DCCEEW, along with copies of briefing notes

Kaplish, Angela: Presentation of the State of Weather and Climate Extremes 2023 Report to Senator David Pocock

Kaplish, Angela: Meeting with chief engineer from Engineering Australia for greater collaboration and contact with CLEX

King, Andrew: Presentation to Treasury and cross government agency, Climate Change Modelling Working Group, on the State of Weather and Climate Extremes Report 2023

Lane, Todd: Keynote presentation, Qantas Group Safety Conference

Maher, Nicola: Appearance at Senate Environment and Communications Committee to provide evidence on the Climate Change Amendment (Duty of Care and Intergenerational Climate Equity) Bill Inquiry 2023

Meissner, Katrin: Presentation at the ADC Leadership Forum

Meissner, Katrin: Presentation to Infrastructure Victoria

Meyer, Amelie: Hearing of evidence of the Inquiry into the importance of Antarctica to Australia's national interests, at Federal Parliament House

Morrison, Adele: Hearing of evidence of the Inquiry into the importance of Antarctica to Australia's national interests, at Federal Parliament House

Perkins-Kirkpatrick, Sarah: Presentation at USyd on "The Climate of the Future: Can we handle the heat?"

Pitman, Andy: Inquiry into the importance of Antarctica to Australia's national interests

Pitman, Andy: Climate Change Authority's consultation 2024 Issues paper: Targets, Pathways and Progress

Pitman, Andy: The State of Weather and Climate Extremes 2023 report sent to multiple stakeholders on our MailChimp list across government and industry

Quail, Katie: Discussions with members of the Indigenous Land and Sea Corporation following presentation at the AIATSIS summit. Provided advice on how the ILSC could support First Nations' participation and benefit from renewable energy developments on Country

Raupach, Tim: Briefing to Aon global climate team about global hail frequency projections

Raupach, Tim: Briefing to Aon Japan on applications of recent work to analysis of relative hail hazard across Japan

Raupach, Tim: Advice on changes in severe storm hazards (and associated uncertainties) to consulting firm Energetics

Raupach, Tim: Presentation on storms and climate change work to UNSW Climate Connections group (part of the International Universities Climate Alliance)

Raupach, Tim: Participant at UNSW Future Climate & Clean Energy Expo – talking with visitors about work on climate change effects on severe storms

Reid, Kimberley: Expert attendee at the Victorian parliament's public hearing for their Inquiry into Victoria's climate resilience

Reid, Kimberley: Expert attendee at hearing for Victorian Government Inquiry into climate resilience for infrastructure and the built environment

Sherwood, Steve: Climate Change Authority's consultation 2024 Issues paper: Targets, Pathways and Progress

Sherwood, Steve: Workshop with finance industry on economic modelling of climate

Sherwood, Steve: Presentation at USyd on "The Climate of the Future: Can we handle the heat?"

Taschetto, Andrea: Presentation to the Department of Climate Change, Energy, the Environment and Water

Taschetto, Andrea: Presentation to NESP stakeholders from the Western Australia government

Ukkola, Anna: Invited presentation on future drought to BoM hydrology section

Wilson, Alice: Meeting with Yarra City Council's Sustainability team to distribute briefing notes

Wilson, Alice: Meeting with Net Zero department of DCCEEW to discuss overlapping work

Public Talks and School Outreach

Abram, Nerilie: Net-Zero panel member at the CLEX Annual Workshop 2024, presenting on net-zero and climate accountability

Alexander, Lisa: Presentation to the National Academies of Sciences, Engineering and Medicine

Ashcroft, Linden: Moderator at Unimelb alumni event about fire and flood in Australia

Ashcroft, Linden: Presentation to Macedon Landcare group (~100 people)

Ashcroft, Linden: Video content for schools through Yarra City Council

Ashcroft, Linden: Engagement (including Conducting experiments) with toddlers and three-year-olds at Anne Sgro Children's Centre for Careers Week

Ashcroft, Linden: Online discussion with two regional schools as part of the Deadly Science program:

Barnes, Michael: Presenter at the CLEX Annual Workshop 2024 on Theme 2: The role of dynamics in understanding extremes

Borowiak, Alexander: Net Zero panel member at the CLEX Annual Workshop 2024 on the topic presenting on The climate science behind net zero

Chandra, Ashneel: Demonstrator – climate & weather experiments for Indigenous students under the Residential Indigenous Science Experience program

Chung, Christine: Presentation to NESP, "Extreme climate explained: the triple La Niña and extremely wet conditions 2020-2022"

Constantinou, Navid: Invited public lecture on "Oceans in motion: How oceans affect our changing climate" – at the University of Melbourne

Constantinou, Navid: Presenter at the CLEX Annual Workshop 2024 on Theme 3: High resolution modelling to understand extremes

Da Silva, Felipe: Presenter at the CLEX Annual Workshop 2024 on the topic The impact of Antarctic Circumpolar Current on air-sea interaction

Eizenberg, Nathan: Future Science Talks: Comedy Edition – with the Melbourne Comedy Festival

Falster, Georgy: Invited speaker on the TERN webinar Drought – challenges of monitoring and measuring

Grosfeld, Nicholas: Participant in the STEM Pals program

Hobeichi, Sanaa: Presenter at the CLEX Annual Workshop 2024 on Theme 3: High resolution modelling to understand extremes

Hobeichi, Sanaa: Supporter of the Fountain College team from WA, national finalists in an AI-driven climate change competition to refine their idea and develop a prototype

Holbrook, Neil: Keynote presenter at the CLEX Annual Workshop 2024 on Theme 3: High resolution modelling to understand extremes

Holgate, Chiara: Presenter at the CLEX Annual Workshop 2024 on Australian drought: State of the science

Hope, Pandora: Presentation to NESP "Extreme climate explained: the triple La Niña and extremely wet conditions 2020-2022"

Huneke, Wilma: Panel member at the "Science.Art. Film" event

Kaplish, Angela: Attendee at the Climate Tech event to introduce CLEX research to young entrepreneurs working in the climate tech startup space

Lane, Todd: Public panel discussion on Fire and Flood, University of Melbourne

Lane, Todd: Panel discussion member: Climate change in Indonesia and the country's innovative solutions for sustainability.

Lane, Todd: Talk on "Climate change and turbulence" at Rotary Club, Frankston

Maher, Nicola: Interview on @XXFM Canberra community radio show about climate science community evidence,] with respect to Intergenerational Equity Duty of Care bill

Maher, Nicola: Presenter at the CLEX Annual Workshop 2024 on Theme 1: Prediction and projection of extremes in a warming world

McGregor, Shayne: Presenter at the CLEX Annual Workshop 2024 on Theme 1: Prediction and projection of extremes in a warming world

Meissner, Katrin: Lecture series presentation to the International Grammar School, Ultimo

Meyer, Amelie: Presentation to students at Telopea School in Canberra as part of the Astrolabe Project. Organised by the French Embassy

Meyer, Amelie: Roving Scientist representative at the Beaker Street Festival in Hobart

Mora, Camille: Net-Zero panel member at the CLEX Annual Workshop 2024, presenting on Loss and damage and climate justice in a net-zero world

Muhammad, Fadhlil Rizki: Invited speaker at the 43rd Indonesian Forum at the University of Melbourne

Muhammad, Fadhlil Rizki: Presenter at the CLEX Annual Workshop 2024 on the Role of convectively coupled equatorial waves on northern Australian rainfall

Nazarian, Negin: Guest speaker at the CLEX Annual Workshop 2024 on Theme 3: High resolution modelling to understand extremes

Perkins-Kirkpatrick, Sarah: Keynote presenter at the CLEX Annual Workshop 2024 on Theme 1: Prediction and projection of extremes in a warming world

Quail, Katie: Engagement with Traditional Owners at the NESP Climate College during their monthly lunchbox webinar

Quail, Katie: Invited speaker at Powering Green Energy on Country event to promote First Nations' participation in, and benefit from, large-scale renewable energy developments

Quail, Katie: Presentation of my research to the wider community at the Mimal Rangers' community night

Raupach, Tim: Presenter at the CLEX Annual Workshop 2024 on Theme 2: The role of dynamics in understanding extremes

Raupach, Tim: UNSW Future Climate & Clean Energy Expo

Reeder, Michael: Keynote presenter at the CLEX Annual Workshop 2024 on Theme 2: The role of dynamics in understanding extremes

Reid, Kimberley: Invited speaker on climate drivers to a U3A group

Roy, Raina: Presenter at the CLEX Annual Workshop 2024, on the topic ENSO modulation of MJO teleconnections in the Southern Hemisphere

Sen Gupta, Alexander: Berowra Fauna Fair

Sen Gupta, Alexander: Presenter to the DCCEEW on marine heatwaves

Sen Gupta, Alexander: Science Week – Dubbo

Strutton, Peter: Net-Zero panel member at the CLEX Annual Workshop 2024, presenting on Efficacy and impacts of marine CO2 removal

Taschetto, Andrea: Presentation to NESP "Extreme climate explained: The triple La Niña and extremely wet conditions 2020–2022"

Taschetto, Andrea: Presentation to the DCCEEW on the El Niño Southern Oscillation impacts on Australian Climate

Taschetto, Andrea: Climate Scientist at UNSW Sydney Open Day

Scientific Leadership and Editorships

Abram, Nerilie: Fellow of the Australian Academy of Science

Abram, Nerilie: Australian Delegate to Scientific Committee for Antarctic Research

Abram, Nerilie: International Liaison Committee, Oldest Ice project

Abram, Nerilie: External Advisory Board, European DEEPICE project

Abram, Nerilie: Member, Climate Crisis Advisory Group

Abram, Nerilie: Member, Australian Antarctic Science Council

Abram, Nerilie: Member, Advisory board ANU Institute for Climate Change

Abram, Nerilie: National Committee for Antarctic Science

Abramowitz, Gab: Member, Scientific Reference panel for private company XDI/ Climate Risk Engines

Abramowitz, Gab: Member, Australian Museum Climate Solutions Centre Advisory Group

Abramowitz, Gab: Member, GEWEX Global Land/ Atmosphere System Study panel

Alexander, Lisa: WCRP Joint Scientific Committee Membership

Arblaster, Julie: Member, Coupled-Model Intercomparison Project panel

Arblaster, Julie: National Committee for Earth System Science

Ashcroft, Linden: Member, AMOS National Council

Brown, Josephine: Chair, Australian Meteorological and Oceanographic Society Expert Group on Climate Variability

Dowdy, Andrew: Member, Stratospheric Nudging and Predictable Surface Impacts, Working Group 2

Evans, Jason: Coordinator of CORDEX Australasia domain

Evans, Jason: Member, WCRP CORDEX Science Advisory Team

Hart, Melissa: Co-Chair WCRP Academy Steering Group

Hart, Melissa: Co-Chair, Steering Group for the World Climate Research Programme Academy Lighthouse Activity

Hart, Melissa: Member, Australian Museum's Climate Solutions Centre Advisory Group

Hart, Melissa: Board member, International Association of Urban Climate

Huang, Yi: Member, International Commission on Clouds and Precipitation

Huang, Yi: Co-Chair, ACCESS-NRI Atmospheric Modelling Working Group.

Jucker, Martin: Member, Scientific Steering Committee on Atmospheric Processes and their Role in Climate

Lane, Todd: Member, Science Advisory Board, Weather and Climate Science for Services Partnership – Southeast Asia

Lane, Todd: Science Review Panel, Weather and Climate Science for Services Partnership – Southeast Asia

Meissner, Katrin: Editorial Board, *Environmental Research Letters*

Meissner, Katrin: Past Global Changes C-Side Working Group Steering Committee

Meissner, Katrin: Past Global Changes PO2 Working Group Steering Committee

Meissner, Katrin: Member, Committee of Experts for the German Excellence Strategy

Meyer, Amelie: Member, Antarctic Women's Network

Meyer, Amelie: Member, International SCOR working group on Analysing ocean turbulence observations to quantify mixing

Perkins-Kirkpatrick, Sarah: Co-Chair, Early Career Scientist Committee, International Association of Meteorology and Atmospheric Sciences

Pitman, Andy: NSW Environmental Protection Authority Climate Change Community and Environment Advisory Group

Pitman, Andy: AMOS Awards committee

Pitman, Andy: Australian Standards Technical Committee on Sustainable Finance

Pitman, Andy: NESP-2 Science Advisory Committee

Pitman, Andy: Independent member, Australian Antarctic Science Council

Pitman, Andy: NSW Net Zero Commission

Pitman, Andy: ACCESS NRI board

Pitman, Andy: Chair, National Committee for Earth System Science

Pitman, Andy: Member, TERN Science Advisory Committee

Raupach, Tim: Member, Fresh Eyes on CMIP Model Evaluation subgroup

Reid, Kimberley: Co-Chair, ACCESS NRI Forecasting and Prediction Working Group

Schofield, Robyn: International Ozone Commission

Sen Gupta, Alexander: Member, National Committee for Earth System Science

Sherwood, Steve: Co-Chair, WCRP Safe Landing Climates Lighthouse

Siems, Steven: Co-Chair, Expert Team on Weather Modification

Singh, Martin: President, Australian Meteorological and Oceanographic Society

Singh, Martin: Member, CLIVAR Climate Dynamics Panel

Singh, Martin: Member, Global Atmospheric Systems Studies Panel

Strutton, Peter: Member, International Biogeochemical Argo Mission Team

Strutton, Peter: Member, Tropical Pacific Observing System Scientific Advisory Committee

Taschetto, Andrea: CLIVAR Tropical Basin Interactions Working Group

Ukkola, Anna: Co-Chair, ACCESS-NRI land working group

Ukkola, Anna: Member, Scientific Advisory Committee for National Computational Merit Allocation Scheme

Vincent, Claire: Member, National Academy of Science National Committee for Earth System Science

Vincent, Claire: ACCESS-NRI Scientific Advisory Committee

Vincent, Claire: Member, American Meteorological Society Mesoscale Processes Committee

Zika, Jan: Member, Australian Academy of Science National Committee for Earth System Science and contributor to NCESS Decadal Plan

2024 KPIs

Performance measure		Target 2024	Achieved 2024
1. Number of research outputs	Annually		
Journal articles		150	184
Book chapters		5	6
Software modules published		2	8
Data sets published		2	22
Facebook posts		52	15*
Centre website updates		25	23
LinkedIn posts		15	80
Science explainer videos		2	7
2. Quality of research outputs	Annually		
Percentage of publications in journals with impact factors greater than 2.0		80	97
Percentage of publications in journals with impact factors greater than 4.0		60	62
Percentage of publications in journals with impact factors greater than 10		10	10
3. Number of conferences held/offered by the Centre	Annually		
National workshop		1	1
International conference/workshop		1	1
Topical/Research program workshops		3	8
Teacher workshop with training material kit		1	1
4. Number of training courses held/offered by the Centre	Annually		
Professional development training in gender equity and diversity		1	1
Professional training for ECRs in engaging with government and decision makers		2	2
Computational skills workshops/tutorials		3	11
Science fundamentals workshops		1	4
Leadership and professional development workshops		1	2
Communications/writing workshops		1	3
Number of centre-wide virtual lectures/seminars		5	39
Percentage of students/ECRs attending researcher development activities		90%	80%
5. Number of additional researchers working on Centre research	Annually		
Postdoctoral researchers		0	5
Honours students		10	2
HDR students		0	11
Associate investigators		3	1
6. Student Completions	Annually		
Number of PhD completions		14	26
Number of Masters by Research completions		4	9
Number of Honours student completions		10	6
Percentage completing PhD students submitting within 4 years (FTE)		100%	80% **

Performance measure		Target 2024	Achieved 2024
7. Number of mentoring programs offered by the Centre	Annually		
We have an integrated researcher development program for HDR students and early-mid career researchers. It includes a personalised skills needs assessment and induction, an annual calendar of workshops and training opportunities, an annual winter school covering science fundamentals, cross-node and partner organisation supervision, and a mentoring circle initiative involving all centre researchers and students allowing a range of mentoring and networking opportunities.		1	1
Percentage of ECRs and HDR students with a completed training needs analysis template		100%	80%
8. Number of presentations/briefings	Annually		
To the public		10	49
To government		10	26
To industry/business/end users		5	16
To non-government organisations		5	3
To professional organisations and bodies		5	6
9. Number of new organisations collaborating with, or involved in, the Centre	Annually	0	0
10. Gender profile by cohort (female/male/any gender)	Annually	F:M:Any	
Graduate students		40:40:20	50:43:07
Research fellows		40:40:20	53:44:03
Senior research fellows		40:40:20	53:44:03
Centre leaders		40:40:20	75:25:00
Administration team		40:40:20	92:08:00
Advisory board members		40:40:20	46:54:00
Keynote speakers at workshops and conferences		40:40:20	50:50:00

* Many individuals migrating to other social media platforms hence, CLEX decreasing our activity on Facebook.

** Exceeded the expected timeframe for their PhD due to the pandemic.

Performance measure		Target 2024	Achieved 2024
ARC Centre of Excellence for Climate Extremes Specific KPIs			
11. Computational Modelling Support	Annually		
Supported climate models served to the community		15	18
New/updated/supported environment for data analysis served to the community		5	11
New/refined/updated data sets served to the community.		8	12
Monthly bulletin to all researchers on CMS-related updates		11	11
Training material produced and delivered		15	17
Percentage of compute time allocation used		95%	87%
12. Researcher Development Program	Annually		
Percentage of students with cross node and/or partner organisation support and project input		80	75
Student/ECR internships in industry/government		2	1
Percentage of students/ECRs making a research visit to other nodes and/or Australian partner organisations		50	12
Percentage of students/ECRs making a research visit to international partner organisations or organisation with a collaborative relationship		30	15
Number of undergraduate summer scholarships offered		15	8
Regular Research Program videoconference meetings p/a		10	40
Media KPIs	**Annually**		
Media releases		15	20
Website – unique hits		45000	190000
Website – page views		55000	447000
CLEX media mentions		300	400
Social media – Twitter (new followers)		600	n/a***
Social media – Facebook (new followers)		400	14****
Social media – LinkedIn (new followers)		30	1240
Additional pathways to impact	**Annually**		
Establishment of significant partnerships			
Data sets provided to or updated for stakeholders		3	3
Briefing notes published		8	11
Number of research program meetings with stakeholder focus			10
Tailored advice provided to stakeholders		5	10
Demonstrated examples of model improvements available for use in national modelling systems		2	2

*** Twitter/X is an unstable/unethical platform now and the associated costs of premium features, new followers are unknown.

**** Facebook severely limits reach unless you pay. The cost benefit is not strong enough.

2024 Financial Statement

Executive Summary

The ARC Centre of Excellence for Climate Extremes formally commenced operations on 4 August 2017. The Centre's financial affairs are conducted within the established procedures, controls and delegations of the relevant universities, and as set out by the Australian Research Council (ARC). This statement provides an analysis of the income and expenditure of the Centre of Excellence.

In 2024, the Centre did not receive any main source of income. The Centre's expenditure was $7,779,895. Personnel accounted for the highest proportion of expenditure of $5,802,868 (74.6%), followed by travel expenditure of $964,437 (12.4%).

Financial Management and Performance

Quarterly financial reporting monitors institutional income and expenditure against the Centre-wide budget. The Centre's Finance Officer prepares consolidated financial statements for review by the Chief Operations Officer and the Director. The Centre-wide finances are discussed at Centre Executive meetings, and financial statements are tabled at Centre Advisory Board meetings.

The Centre meets its annual reporting requirements to the ARC and meets all other reporting obligations set by Partner Organisations that provide financial support.

2024 Income

Other than the interest distribution, UNSW Sydney income was recovered in 2024 and will be reallocated in 2026–2027 to finalise the program. In previous years the Centre derived its income from the ARC, participating universities, the Bureau of Meteorology, the Department of Climate Change, Energy, the Environment and Water (DCCEEW), and the NSW Department of Industry Research Attraction and Acceleration Program (RAAP). Income is summarised by the source in detail in the tables that follow.

1: Australian Research Council Funding

The Centre received no income from the ARC this year, as the final income was received in 2023. The institutions used the carried-over ARC funds for payroll, scholarships, consumables and events, equipment and maintenance and travel.

2: Government Funding

2.1 Bureau of Meteorology

There was no funding received in 2024, as 2023 was the final year of the Bureau's agreed funding. However, in 2024, the carried-over cash contribution was targeted at PhD top-up scholarships for students working collaboratively with the Bureau.

2.2 The Department of Climate Change, Energy, the Environment and Water

There was no funding received in 2024. The carried-over cash investment from DCCEEW supported pathways-to-impact by supporting an improved understanding of climate extremes in NSW and by making this knowledge available to the community and decision-makers in the form that they need.

2.3 NSW Department of Industry RAAP

RAAP funding invests in appointing a Research Fellow to focus on high-resolution modelling of processes relating to climate extremes (e.g. hail, drought processes, vegetation-climate extremes, etc.). The Centre received no income in 2024, the Centre used the carried-over funds from 2023.

3: Collaborating Organisation Funding

Cash contributions to the Centre of Excellence from the Administering Organisation and the Collaborating Organisations amounted to -$221,406 as follows:

UNSW Sydney	-$222,388 *
Australian National University	$0
University of Melbourne	$982
University of Tasmania	$0
Monash University	$0

* *UNSW Sydney income was recovered in 2024 and will be reallocated in 2026-2027 to finalise the program.*

4: In-kind Contributions

In-kind support totalled $7,409,416 in 2024. The Centre is grateful for $6,271,012 of in-kind contributions, provided by the Administering Organisation and the Collaborating Organisations. The contributions are primarily personnel-related and consist of the apportioned salary, on-costs and burdens of faculty members and other university staff members who contribute towards the Centre. Partner Organisations provided additional in-kind contributions of $1,138,404. Again, this was mainly personnel time.

Organisation	In Kind Budget	In Kind Actual
The Australian National University	0	980,648
Bureau of Meteorology	79,314	81,266
CSIRO	179,667	182,270
LMD – Centre National de la Recherche Scientifique	7,817	7,817
Max Planck Inst. For Meteorology	26,250	26,250
UK Meteorological Office	87,500	20,000
Monash University	0	1,383,392
NASA Goddard Space Flight Center	22,377	22,377
National Center for Atmospheric Research	59,489	59,489
National Computational Infrastructure	481,425	413,425
Geophysical Fluid Dynamics Laboratory	17,500	17,500
The Department of Climate Change, Energy, the Environment and Water	182,458	187,055
Risk Frontiers	24,500	24,500
Swiss Federal Inst of Tech	46,083	46,083
The University of Melbourne	0	909,083
The University of Arizona	0	50,372
UNSW Sydney	0	2,450,014
The University of Tasmania	0	547,874
TOTAL	1,214,379	7,409,416

2024 Expenditure

In 2024 the Centre expended $7,779,895 across all funding sources, as analysed below:

Personnel (including on-costs)	$5,802,868	74.59%
Scholarships	$527,087	6.77%
Equipment and Maintenance	$12,704	0.16%
Consumables and Events	$472,800	6.08%
Travel	$964,437	12.40%

2024 Income Vs Expenditure

Income and Expenditure are based on cash and derived from the institutions' general ledgers. The Collaborating Organisations certify income and expenditure by formally acquitting all grants as of 31 December 2024.

The Centre will carry over a surplus balance of $3,551,856 to 2025. The carry-over by institution is as follows:

UNSW Sydney	$1,844,607	surplus
Australian National University	$142,204	surplus
University of Melbourne	$417,590	surplus
University of Tasmania	$370,585	surplus
Monash University	$776,870	surplus

In summary, as of 31 December 2024, the financial position of the ARC Centre of Excellence for Climate Extremes at the conclusion of its final year of operation is as follows:

Total Lifetime Cash Income	$42,680,747
Total Lifetime Expenditure	$39,128,891
Surplus carried forward to 2025 (university funds only)	**$3,551,856**

Finance Tables

CLEx Cash Income & Expenditure

	Actual		
1. Cash Income	**2017**	**2018**	**2019**
Australian Research Council – Centre of Excellence	4,350,000	4,250,000	4,250,001
Australian Research Council – Centres of Excellence Indexation	65,250	128,456	211,645
Bureau of Meteorology	10,000	20,000	30,000
NSW Department of Planning and Environment	100,000	100,000	100,000
NSW Department of Industry/ RAAP	143,000	143,000	142,857
University Node Cash Contributions	1,103,142	1,285,737	1,253,234
Other (Interest Distribution)	0	15,871	19,146
Department of Agriculture, Water and the Environment			4,523
Sydney Water Corporation	0	200,000	0
Total	5,771,392	6,143,064	6,011,406

2. ARC Expenditure	**2017**	**2018**	**2019**
Personnel	114,662	1,941,921	3,354,377
Scholarship	6,358	90,723	158,714
Equipment and Maintenance	0	5,105	33,216
Consumables and Events	16,369	165,632	160,379
Travel – Conference, workshops and meetings (Staff, AI)	12,634	133,395	210,647
Travel – Conference, workshops and meetings (Postdocs and Students)	0	40,497	178,653
Travel – Visitor travel to the Centre and other	1,336	38,236	31,324
Travel – New staff relocation expenses	0	0	0
Travel – Research Visits (Staff, AI)	0	9,585	34,451
Travel – Research Visits (Postdocs and Students)	1,341	380	3,484
Total	152,701	2,425,476	4,165,244

3. Nodes Expenditure	**2017**	**2018**	**2019**
Personnel	65	311,556	615,789
Scholarship	10,706	61,092	132,039
Equipment and Maintenance	6,182	48,972	46,325
Consumables and Events	4,575	43,568	53,831
Travel – Conference, workshops and meetings (Staff, AI)	12,901	49,055	67,758
Travel – Conference, workshops and meetings (Postdocs and Students)	2,969	60,341	104,294
Travel – Visitor travel to the Centre and other	0	9,570	41,971
Travel – New staff relocation expenses	7,354	55,163	22,719
Travel – Research Visits (Staff, AI)	5,132	8,979	22,952
Travel – Research Visits (Postdocs and Students)	0	10,981	13,860
Total	49,885	659,276	1,121,538

Actual					
2020	2021	2022	2023	2024	TOTAL
4,300,000	4,300,000	4,300,000	4,400,001	0	30,150,001
295,388	378,106	420,210	485,419	0	1,984,474
30,000	30,000	20,000	20,000	0	160,000
165,000	300,000	25,000	0	0	790,000
143,000	143,000	143,000	142,143	0	1,000,000
1,236,647	1,600,020	1,111,724	955,985	-221,406	8,325,084
3,087	696	4,770	11,531	3,565	58,666
	4,000	4,000			12,523
0	0	0	0	0	200,000
6,173,122	6,755,822	6,028,704	6,015,079	-217,841	42,680,747

2020	2021	2022	2023	2024	TOTAL
3,350,987	2,992,974	3,418,564	5,236,236	5,299,890	25,709,611
191,388	217,551	311,788	483,134	366,226	1,825,881
12,814	3,500	4,202	20,379	0	79,217
110,198	128,817	297,141	342,573	405,585	1,626,692
48,557	10,454	142,930	348,682	298,929	1,206,228
49,316	26,531	208,137	344,713	558,374	1,406,221
22,335	0	5,966	35,812	35,875	170,885
0	0	0	11,009	-11,009	–
7,153	-2,004	12,647	10,863	2,688	75,383
1,802	0	5,783	12,175	9,390	34,356
3,794,550	3,377,822	4,407,159	6,845,575	6,965,948	32,134,474

2020	2021	2022	2023	2024	TOTAL
475,725	603,844	92,194	-303,296	283,808	2,079,684
120,983	105,712	185,892	7,857	145,862	770,143
17,274	41,776	29,054	24,465	12,704	226,752
48,424	43,636	87,644	97,127	67,215	446,018
21,570	14,943	84,552	96,053	122,434	469,265
18,986	13,011	178,416	146,450	-65,298	459,169
9,881	0	0	2,580	3,388	67,390
2,193	37,490	29,628	4,881	9,813	169,241
4,320	-2,677	11,965	4,672	0	55,343
8,446	1,296	-4,750	0	390	30,223
727,802	859,030	694,595	80,787	580,315	4,773,228

	Actual		
4. Others	**2017**	**2018**	**2019**
Personnel	61,192	192,341	272,939
Scholarship	0	10,000	14,000
Equipment and Maintenance	0	0	0
Consumables and Events	0	0	0
Travel – Conference, workshops and meetings (Staff, AI)	0	0	0
Travel – Conference, workshops and meetings (Postdocs and Students)	0	0	523
Travel – Visitor travel to the Centre and other	0	0	0
Travel – New staff relocation expenses	0	0	0
Travel – Research Visits (Staff, AI)	0	0	0
Travel – Research Visits (Postdocs and Students)	0	0	0
Total	61,192	202,341	287,462

5. Summary Income Vs. Expenditure/Carry Over	**2017**	**2018**	**2019**
ARC			
Total Income	4,415,250	4,378,456	4,461,646
Total Expenditure	152,701	2,425,476	4,165,244
Income less Expenditure	4,262,549	1,952,980	296,402
Nodes			
Total Income	1,103,142	1,285,737	1,253,234
Total Expenditure	49,885	659,276	1,121,538
Income less Expenditure	1,053,257	626,461	131,696
Other			
Total Income	253,000	478,871	296,526
Total Expenditure	61,192	202,341	287,462
Income less Expenditure	191,808	276,530	9,064
Carry over surplus/deficit	5,507,614	2,855,971	437,162

Actual					
2020	2021	2022	2023	2024	TOTAL
338,433	260,881	334,287	362,299	219,170	2,041,543
10,000	79,000	34,000	10,000	15,000	172,000
0	0	0	0	0	–
0	0	0	0	0	–
0	0	0	0	0	–
0	0	7,661	0	-538	7,646
0	0	0	0	0	–
0	0	0	0	0	–
0	0	0	0	0	–
0	0	0	0	0	–
348,433	339,881	375,948	372,299	233,632	2,221,189

2020	2021	2022	2023	2024	TOTAL
4,595,388	4,678,106	4,720,210	4,885,419	0	32,134,474
3,794,550	3,377,822	4,407,159	6,845,575	6,965,948	32,134,474
800,838	1,300,284	313,051	-1,960,156	-6,965,948	0
1,236,647	1,600,020	1,111,724	955,985	-221,406	8,325,084
727,802	859,030	694,595	80,787	580,315	4,773,228
508,845	740,990	417,129	875,198	-801,721	3,551,856
341,087	477,696	196,770	173,674	3,565	2,221,189
348,433	339,881	375,948	372,299	233,632	2,221,189
-7,346	137,815	-179,178	-198,625	-230,067	0
1,302,337	2,179,089	551,003	-1,283,583	-7,997,736	3,551,856*

* The remainder of the program will be finalised using organisational funds

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