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ARC Centre of Excellence for Climate Extremes

Annual Report 2025



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Annual Report 2025

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Acknowledgment of the Traditional Owners

The ARC Centre of Excellence for Climate Extremes respectfully acknowledges the Traditional Owners of Country throughout Australia. We pay our respects to their Elders past, present and emerging, and recognise their continuous connection to Country and the contributions and sophistication of traditional knowledge.

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The ARC Centre of Excellence for Climate Extremes improved Australia's national capacity to understand the processes underlying climate extremes and the broader effects of weather and climate on our lives and society.

Our Research and Success

The year 2025 represents the last year of significant resourcing for the ARC Centre of Excellence for Climate Extremes for 2025. Multiple outcomes were achieved through 2025 in part linked with initiatives that were realised, in part linked with delays in publication and in part linked with Research Fellow and PhDs continuing through most of the year.

There were some major outcomes worthy of noting to the ARC. One of our highest profile outcomes was a book led by Chief Investigator Associate Professor Andrea Taschetto titled *Meteorology and Climate of the Southern Hemisphere* and published by Cambridge University Press. This represented a huge body of work and provides a reference text for many years to come.

We are also proud of multiple papers led by Research Fellows and PhD students – highlighting personal leadership, excellence and impact. Examples include the following:

Chiara Holgate led a Nature Communications review into the mechanisms behind Australian droughts and how these differ significantly across the continent.

Holgate, C.M., Falster, G.M., Gillett, Z.E., Goswami, P., Grant, M.O., Hobeichi, S., Hoffmann, D., Jiang, X., Jin, C., Lu, X. and Mu, M., 2025, Physical mechanisms of meteorological drought development, intensification and termination: an Australian review. *Communications Earth & Environment*, 6, 220.

PhD Student Claire Yung led a 28-author article summarising results from the international Ice Shelf - Ocean Model Intercomparison Project now under review with *The Cryosphere*. We congratulate Claire on what is an incredible contribution for a PhD student.

Yung, C.K., Asay-Davis, X.S., Adcroft, A., Bull, C.Y., De Rydt, J., Dinniman, M.S., Galton-Fenzi, B.K., Goldberg, D., Gwyther, D.E., Hallberg, R. and Harrison, M., 2025, Results of the second Ice Shelf–Ocean Model Intercomparison Project (ISOMIP+), *EGUsphere*, 2025, 1-50.

Neil Malan led a paper focussed on marine heatwaves which can cause devastating impacts on marine organisms. The nomenclature proposed in this paper seeks to provide a common language for understanding subsurface marine heatwaves enabling interdisciplinary studies to quantify their impact.

Malan N., Sen Gupta, A., Schaeffer, A., Zhang, S., Doblin, M.A., Semolini Pilo, G., Kiss, A.E., Everett, J.D., Behrens, E., Capotondi, A., Cravatte, S., Hobday, A.J., Holbrook, N.J., Kajtar, J.B., and Spillman, C.M., 2025, Lifting the lid on marine heatwaves, *Progress in Oceanography*, 239, 103539, <https://doi.org/10.1016/j.pocean.2025.103539>

Another important paper, currently nearing publication, focussed on our mechanistic understanding of marine heatwaves, something that requires robust frameworks for detection, tracking, and attribution. By explicitly linking evolving marine heatwave entities to their physical drivers, the method proposed in this paper advances the mechanistic characterisation of marine heatwaves, enhances understanding of their spatiotemporal dynamics, and informs prospects for improved prediction.

Zhao, Z., Holbrook, N.J., Capotondi, A., Cravatte, S., Kajtar, J.B., Sen Gupta, A., Behrens, E., Doblin, M.A., Feng, M., Kiss, A.E. and Spillman, C.M., *Toward a mechanistic characterisation of marine heatwaves*. Submitted to *Scientific Reports* (submitted 10 September 2025, revised 30 December 2025).

A paper led by Chenhui Jin (formerly a CLEX PhD student and now a Research Fellow with the ARC Centre of Excellence for the 21st Century Weather) highlighted how understanding of weather systems can help explain observed rainfall changes

Jin, C., Gallant, A.J.E., Parker, T. & Reeder, M.J., 2025, Weather systems and their contribution to seasonal rainfall in Australia. *Quarterly Journal of the Royal Meteorological Society*, 151, e5013, <https://doi.org/10.1002/qj.5013>

A major paper, led and primarily written by ECRs brought together our understanding of weather and climate interactions for the extreme rainfall events of 2022. It was published in February 2025 and has already received 7 citations.

Reid, K.J., Barnes, M.A., Gillett, Z.E., Parker, T., Udy, D.G., Ayat, H., Boschat, G., Bowden, A., Grosfeld, N.H., King, A.D., Richardson, D., Shao, Y., Teckentrup, L., Trewin, B., Hope, P., Zhou, L., Borowiak, A.R., Holgate, C.M., and Isphording, R.N., 2025, A Multiscale Evaluation of the Wet 2022 in Eastern Australia. *J. Climate*, 38, 909–929, <https://doi.org/10.1175/JCLI-D-24-0224.1>

As part of his PhD, Fadhil Muhammad examined the impacts of tropical atmospheric waves on rainfall in northern Australia. A key finding being that the superposition of waves can have a substantial impact on the likelihood of heavy rain. For example, The MJO increases the chance of heavy rain by up to 2.8 times, but when combined with equatorial Rossby waves, leads to 4.5 times increase in the chance of heavy rain.

Muhammad, F.R., Vincent, C., King, A., and Lubis, S.W., 2025, The role of convectively coupled tropical waves in drier and wetter seasons in northern Australia. *Geophysical Research Letters*, 52, e2025GL115049, <https://doi.org/10.1029/2025GL115049>

Research Fellow Chris Chambers explored the role of SSTs in the intensification of an East Coast Low using the AUS2200 convection-permitting configuration of the ACCESS model. He found that the SST anomalies during the event led to a stronger and slower moving cyclone, in comparison to climatological SSTs.

Chambers, C., Huang, Y., Roberts, D., 2025, The impact of sea surface temperatures over the Coral Sea on the warm core intensification of a Tasman Sea cyclone. *Quarterly J. Royal Meteorological Society*, <https://doi.org/10.1002/qj.70085>

PhD student Larry Ger Aragon examined the cloud properties during marine cold-air outbreaks in the Arctic and sub-Arctic regions using recent aircraft observations over the Nordic seas and Labrador Sea. He found that the liquid cloud droplets in high-latitude marine clouds are generally smaller in size and more reflective than the current assumptions in weather models.

Aragon, L.G.B., Crosier, J., Connolly, P.J., Huang, Y., May, P.T. and Abel, S., 2025, Characterizing the shape of cloud particle size distributions in high-latitude marine cold air outbreaks. *Journal of Geophysical Research: Atmospheres*. <https://doi.org/10.1029/2024jd043033>

In a series of studies PhD student Thi Lan Dao explored the mechanisms by which rainfall in Northeast Australia, including coastal rainfall, is modulated by local and large scale forcings, including the MJO. Among other things, she found that the MJO's influence on convective rainfall is generally stronger than its impact on stratiform rainfall, but the response is spatially inhomogeneous due to local forcings.

Thi, L.D., Vincent, C., Huang, Y., Peatman, S.C., Soderholm, J.S., Birch, C.E., and Roberts, D.S., 2025, Joint modulation of coastal rainfall in northeast Australia by local and large-scale forcings. *Quarterly J. Royal Meteorological Society*. <https://doi.org/10.1002/qj.70027>

Thi, L.D., Vincent, C., Huang, Y. and Soderholm, J.S., 2025, Modulations of local rainfall in northeast Australia associated with the Madden Julian Oscillation. *Quarterly J. Royal Meteorological Society*. <https://doi.org/10.1002/qj.4995>

Research Fellow Yawn Shao developed a method to post-process daily precipitation projections from 28 CMIP6 models over Australia, introducing a new mean adjustment procedure to eliminate negative precipitation values while ensuring that both the mean and variability of the final series aligns with the observations in the historical training period. When applied to future precipitation projections for Australia, the adjusted outputs show pronounced increases in prolonged dry periods and maximum 1-day and 5-day precipitation amounts under the high-emission scenario relative to the low-emission scenario.

Shao, Y. and Bishop, C.H., 2025, Improving CMIP6 projections of daily precipitation using a mean-adjusted time variability correction technique. *Climate Dynamics*, 63, 260, <https://doi.org/10.1007/s00382-025-07731-7>

Former research fellow Hooman Ayat completed a study, using the AUS2200 version of the ACCESS model, of the meteorological conditions leading to enhanced fire danger during the 2019/2020 Black Summer fires. He identified that during the fires downward transport and mixing played a key role in reducing surface specific humidity, causing localised drying and rapid changes in fire danger. He showed that much of this dry air originated in the upper-troposphere over the Southern Ocean, being transported downwards over SE Australia as part of a large-scale meteorological feature and then being mixed from the mid-troposphere to the surface by boundary layer processes.

Ayat, H., Lane, T.P., Wales, S., Reeder, M.J., and Huang, Y., 2025, Rapid surface drying during the Black Summer bushfires in Australia: Insights from high-resolution simulations. *Journal of Geophysical Research: Atmospheres*, 130, e2024JD041706, <https://doi.org/10.1029/2024JD041706>

Two other areas of note were progressed in 2025. CLEX continued to examine the use of AI and Machine Learning in climate science. Two example publications are:

Rampal N., Gibson P.B., Sherwood S., Abramowitz G., Hobeichi S., 2025, A Reliable Generative Adversarial Network Approach for Climate Downscaling and Weather Generation, *J. Advances in Modeling Earth Systems*, 17, e2024MS004668, <https://doi.org/10.1029/2024MS004668>

Richardson, D., Hobeichi, S., Sweet L.-B., Rey-Costa, E., Abramowitz, G. and Pitman, A.J., 2025, Predicting Australian energy demand variability using weather data and machine learning, *Environmental Research Letters*, 20, 014028. <https://doi.org/10.1088/1748-9326/ad9b3b>

We also worked in areas of impact including on economics and specific meteorological hazards including the effectiveness of natural hazard warnings using data-driven approaches. Examples include:

Saunders, K.R., Forbes, O., Hopf, J.K., Patterson, C.R., Vollert, S.A., Brown, K., Browning, R., Canizares, M.A., Cottrell, R.S., Li, L., Kim, C.J.S., Stewart, T.P., Susilawati, C., Zhao, X., and Helmstedt, K.J., 2025, Data-driven recommendations for enhancing real-time natural hazard warnings. *One Earth*, 8, 101274. <https://doi.org/10.1016/j.oneear.2025.101274>

Neal T., Newell B.R., and Pitman A., 2025, Reconsidering the macroeconomic damage of severe warming, *Environmental Research Letters*, 20, 044029. <https://doi.org/10.1088/1748-9326/adbd58>

Raupach, T.H., and Aldridge, J., 2025, Changes in hail damage potential in major Australian cities with global warming, *Geophysical Research Letters*, 52, e2025GL117676. <https://doi.org/10.1029/2025GL117676>

Richardson, D., Ribeiro, A.F.S., Batibeniz, F., Quilcaille, Y., Taschetto, A.S., Pitman, A.J., Zscheischler, J., 2025, Increasing fire weather season overlap between North America and Australia challenges firefighting cooperation. *Earth's Future*, 13, e2024EF005030. <https://doi.org/10.1029/2024EF005030>

There are also multiple examples of Chief Investigator-led major papers. For example, Professor Nerilie Abram led a Nature Partner Journal Climate Action paper, building a framework to quantify the regional and global climate impacts of individual fossil fuel projects as a mechanism to support more informed decision-making by policy makers.

Abram, N.J., Maher, N., Perkins-Kirkpatrick, S., Falster, G.M., Hughes, T.P., Meissner, K.J., Slater, L.J., King, A.D., Pitman, A.J., Moon, G. and Morgan, W., 2025, Quantifying the regional to global climate impacts of individual fossil fuel projects to inform decision-making. *npj Climate Action*, 4(1), p.92.

A/Professor Andrea Taschetto led a major review paper focussed on the El Niño–Southern Oscillation.

Taschetto, A.S., McGregor, S., Dommenget, D. et al., 2025, Climate impacts of the El Niño–Southern Oscillation on Australia. *Nature Review Earth & Environment*. <https://doi.org/10.1038/s43017-025-00747-x>

We are also delighted to celebrate other successes:

- CLEX-Chief Investigator Professor Nerilie Abram (ANU) has been appointed as the Australian Antarctic Program’s new Chief Scientist.
- CLEX-Chief Investigator Professor Neil Holbrook was awarded the Clarivate Highly Cited Researcher award in the field of Geosciences.
- CLEX-Chief Investigator Professor Todd Lane (UMEL) named fellow of the American Meteorological Society.
- CLEX-Chief Investigator Dr Nicola Maher (ANU) was selected as a Contributing Author for the Seventh Assessment Report of the IPCC.
- CLEX-Associate Investigator Dr Adele Morrison (ANU) received the International Association for the Physical Sciences of the Oceans Early Career Scientist Medal.
- CLEX-Chief Investigator Scientia Associate Professor Negin Nazarian (UNSW) received the Global Environmental Change Early Career Award from the American Geophysical Union (AGU) Sept 2025.
- CLEX-Chief Investigator Professor Sarah Perkins Kirkpatrick (ANU) was selected as a Coordinating lead author for the Seventh Assessment Report of the IPCC.
- The CLEX-ANU team, in collaboration with ACCESS-NRI and the wider ocean modelling community, has supported the release of a ‘beta’ version of Australia’s next generation global ocean-sea ice model (known as ACCESS OM3). This model has new features which make it superior to the previous generation of models.
- Dr Georgy Falster: one of only four Australian and New Zealand scientists to win a 2025 L’Oréal-UNESCO For Women in Science fellowship. These awards - as well as being prestigious, generous, and highly competitive - come with the opportunity to mentor the next generation of scientists through the For Girls in Science forum.

2025 Higher Degree by Research Submissions

Australian National University	
<i>Student Name</i>	<i>Study Program</i>
Barnes, Ashley	PhD
Lilley, Lucinda	PhD
Meng, Hangyu	PhD
Sweetman, James	PhD
Monash University	
<i>Student Name</i>	<i>Study Program</i>
Palmer, Lucinda	Masters
Aneeshkumar Kurup, Arathy	PhD
Liqui Lung, Franciscus	PhD
Priya, Priyamvada	PhD
Roy, Raina	PhD
University of Melbourne	
<i>Student Name</i>	<i>Study Program</i>
Huyen Luong, Thi Thanh	Honours
Kulkarni, Ruchit	Honours
Zhou, Yifan	Masters
Andarini, Dita	Masters
Aragon, Larry Ger	PhD
Cassidy, Liam	PhD
Borowiak, Alexander	PhD
Dao, Thi Lan	PhD
University of New South Wales	
<i>Student Name</i>	<i>Study Program</i>
Anand, Ananya	Honours
Liu, Ying Lung	PhD
McKenna, Sebastian	PhD
Ortiz Guzman, Valentina	PhD
Rampal, Neelesh	PhD
Robinson, Fiona	PhD
Schmidt, Christina	PhD
Singh, Tanya	PhD
Surendran, Greeshma	PhD
Wang, Lingfei	PhD
Zhang , Xinyue	PhD
University of Tasmania	
<i>Student Name</i>	<i>Study Program</i>
Fierro Arcos, Denisse	PhD
Han, Meng	PhD
Jakes, Maya	PhD
Pang, Chengyuan	PhD
Wyatt, James	PhD
Yang, Xiang	PhD

Graduate Training and Development

1. Research Fellow Workshop

This collaborative workshop brought together CLEX postdocs and 21st Century Weather research fellows to foster cross-centre engagement and knowledge exchange. Participants explored key themes including skills and knowledge sharing, research collaboration, and tool development. Sessions also focused on strategies for effective collaboration and leadership, and on translating research into impact, strengthening ties between the two Centres and enhancing collective research outcomes.

2. Graduate Colloquium

Formerly known as the Winter School, the Graduate Colloquium is a cornerstone of 21st Century Weather's Training and Leadership Program, which CLEX PhD students and Research Associates were invited to attend. This year's theme focused on hacking, identifying and fixing bugs, and fostering communication and collaboration among scientists worldwide to advance our understanding of weather science.

The Hackathon, a Digital Earths activity under the World Climate Research Program (WCRP), promotes global collaboration by sharing best practices in process-based analysis of kilometre-scale simulations. Results and discussions were broadcasted in real time, with different international nodes, Australia among them.



3. Scientific Paper Writing Workshop

CLEX was invited to take part in this CSIRO Publishing workshop, which helps participants build the skills and confidence needed to write scientific papers for top journals. The workshop covers the science publishing process, effective writing techniques, drafting and editing strategies, time management, peer review insights, and publication ethics.

4. Communicating with Confidence Workshop

Early career researchers from CLEX were invited to participate in this workshop, led by the 21st Century Weather Engagement Team and senior researchers. Designed to build confidence and practical communication skills, the workshop covered media engagement, presentation techniques, networking, clear communication, handling challenging audiences, and self-leadership.

5. Masterclass in 21st Century Weather

Our ECRs had the valuable opportunity to attend the Extreme Rainfall, Heatwaves, Droughts and Fire Weather Masterclass organised by the 21st Century Weather Centre. Through interactive lectures and panel discussions, experts highlighted the weather systems that drive high-impact events and weather resources and explored how climate change is fundamentally a form of weather change. The sessions also addressed the implications for national adaptation planning and climate risk disclosures, providing our HDRs with critical insights into the links between weather systems, climate variability, and impacts on communities, infrastructure, and ecosystems.

6. Engagement in the 21st Century Weather Annual workshop

The 21st Century Weather Annual Workshop incorporated multiple sessions this year dedicated to working collaboratively to advance work in and across the six Centre Projects as well as time dedicated to our joint Assessment Report initiative. Many of CLEX postdocs and PhD students attended.



Publications

Journal Articles

- Abhik S.; Dommenges D.; McGregor S.; Hutchinson D.K.; Steinig S.; Zhu J.; Capitanio F.A.; Lunt D.J.; Niezgodzki I.; Knorr G.; Chan W.-L.; Abe-Ouchi A., 2025, Stronger and prolonged El Niño–Southern Oscillation in the Early Eocene warmth, *Nature Communications*, 16, <https://doi.org/10.1038/s41467-025-59263-7>
- Aguiar W.; Morrison A.K.; Huneke W.G.C.; Hutchinson D.K.; Spence P.; Hogg A.M.; Colombo P.; Stewart K.D., 2025, Antarctic Dense Water Formation Sensitivity to Ocean Surface Cell Thickness, *Journal of Advances in Modeling Earth Systems*, 17, <https://doi.org/10.1029/2024MS004913>
- Alinejadtabrizi T.; Huang Y.; Lang F.; Siems S.; Manton M.; Ackermann L.; Keywood M.; Humphries R.; Krummel P.; Williams A.; Ayers G., 2025, Contributions of the synoptic meteorology to the seasonal cloud condensation nuclei cycle over the Southern Ocean, *Atmospheric Chemistry and Physics*, 25, <https://doi.org/10.5194/acp-25-2631-2025>
- Aragon, L.G.B.; Crosier, J.; Connolly, P.J.; Huang, Y.; May, P.T.; Abel, S.J., 2025, Characterizing the Shape of Cloud Particle Size Distributions in High-Latitude Marine Cold-Air Outbreaks, *Journal of Geophysical Research: Atmospheres*, 130, <https://doi.org/10.1029/2024JD043033>
- Barnes M.A.; Reeder M.J.; Ndarana T., 2025, Rossby Wave Breaking Morphologies on the Southern Hemisphere Dynamical Tropopause, *Journal of Climate*, 38, <https://doi.org/10.1175/JCLI-D-24-0461.1>
- Beggs P.J.; Woodward A.J.; Trueck S.; Linnenluecke M.K.; Bambrick H.; Capon A.G.; Lokmic-Tomkins Z.; Peel J.; Bowen K.; Hanigan I.C.; Arriagada N.B.; Cross T.J.; Friel S.; Green D.; Heenan M.; Jay O.; Kennard H.; Malik A.; McMichael C.; Stevenson M.; Vardoulakis S.; Vyas A.; Romanello M.B.; Walawender M.; Zhang Y., 2025, The 2024 report of the MJA–Lancet Countdown on health and climate change: Australia emerging as a hotspot for litigation, *Medical Journal of Australia*, 222, <https://doi.org/10.5694/mja2.52616>
- Benthuisen J.A.; Pattiaratchi C.B.; Spillman C.M.; Govekar P.D.; Beggs H.M.; de Oliveira H.B.; Chandrapavan A.; Feng M.; Hobday A.J.; Holbrook N.J., 2025, Observing marine heatwaves using ocean gliders to address ecosystem challenges through a coordinated national program, *Oceanography*, 38, <https://doi.org/10.5670/oceanog.2025e101>
- Bhagtani D.; McC. Hogg A.; Holmes R.M.; Constantinou N.C.; Khatri H., 2025, Asymmetric Response of the North Atlantic Gyres to the North Atlantic Oscillation, *Journal of Geophysical Research: Oceans*, 130, <https://doi.org/10.1029/2024JC021997>
- Bi Z.; Sun S.; Liu Y.; Sun G.; Mu M.; Li X.; Li J.; Liu Y.; Zhou Y.; Zhou B.; Chen H., 2025, Global changes in potential evapotranspiration (1992–2020) and associated drivers: Shuttleworth–Wallace model-based analysis, *Journal of Hydrology*, 660, <https://doi.org/10.1016/j.jhydrol.2025.133435>
- Blanco J.E.; Caballero R.; Sherwood S.; Alexander L., 2025, Insights into Cloud Albedo Biases from a Cloud–Controlling Factor Framework, *Journal of Climate*, 38, <https://doi.org/10.1175/JCLI-D-24-0260.1>
- Blanco J.E.; Caballero R.; Sherwood S.; Alexander L., 2025, Insights into Cloud Albedo Biases from a Cloud–Controlling Factor Framework, *Journal of Climate*, 38, <https://doi.org/10.1175/JCLI-D-24-0260.1>
- Bowden A.; Jakob C.; Soderholm J., 2025, Stormy Subtropics and Stratiform South: Radar-Based Classification and Analysis of Australian Rainfall Events, *Journal of Geophysical Research: Atmospheres*, 130, <https://doi.org/10.1029/2024JD041790>
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- Cassidy L.J.; King A.D.; Brown J.R.; Ziehn T.; Borowiak A., 2025, Evolution of Heat Extremes Under Net-Zero CO2 Emissions, *Earth’s Future*, 13, <https://doi.org/10.1029/2024EF005399>
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Finance

1. Carry forward from 2024	UNSW	ANU	UMEL	UTAS	Monash	TOTAL
Total	1,849,794	142,200	417,591	370,586	776,870	3,551,856

2. Node Income	UNSW	ANU	UMEL	UTAS	Monash	TOTAL
Total	0	0	0	0	0	0

3. Node Expenditure	UNSW	ANU	UMEL	UTAS	Monash	TOTAL
Personnel	1,187,879	114,728	251,884	9,251	252,933	1,816,676
Scholarship	166,284	38,088	3,507	59,431	15,890	283,200
Consumables and Other	15,219	-11,130	2,198	13,784	-3,465	16,607
Travel	40,797	513	25,246	60,457	88,867	215,880
Total	1,410,179	142,200	282,835	142,923	354,226	2,332,363

4. Carry over surplus/deficit	UNSW	ANU	UMEL	UTAS	Monash	TOTAL
Total	0	0	134,756	227,663	422,645	785,064

In summary, as of 31 December 2025, the financial position of the ARC Centre of Excellence for Climate Extremes Organisational funds is as follows:

Total Lifetime Cash Income	\$8,325,084
Total Lifetime Expenditure	\$7,540,020
Surplus carried forward to 2026	\$785,064



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Research requires data and computational capability. We thank these organisations for making our research possible.



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