# National Environmental Science Program
# Earth Systems and Climate Change Hub

# FINAL REPORT
# 1 January 2015 – 30 June 2021

**Hub Name (full activity title):** Earth Systems and Climate Change Hub

**Host organisation:** CSIRO

**Key Contact:** Professor David Karoly

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**Other consortium partners/subcontractors/research organisations:**

Bureau of Meteorology, Australian National University, Monash University, University of NSW, University of Melbourne, University of Tasmania. Federation University is a subcontractor.

# Hub Leader Certification

As Hub Leader, I certify that I have taken adequate steps to reasonably assure myself that:

- each required report component is attached;
- the contents of each component of the report is complete and accurate in all material respects;
- funds have been used for the purpose for which they were provided and all funding conditions have been met, Recipient and Other Contributions have been received, and appropriate oversight has been maintained of Hub projects, their progress, performance and budgets during the reporting period;
- all relevant risks to project delivery have been notified to the Department in this and previous reports and that appropriate steps are being taken to manage those risks;
- the Hub and its sub-contractors have current workers compensation and public liability insurances, as required under the Funding Agreement; and
- any unallocated funds have been identified for refund to the Department.

Signed: David Karoly

Hub Leader Name: Professor David Karoly

Date: 21/05/2021

# Hub Steering Committee Chair Certification

As steering committee chair, I certify that any issues of concern or matters raised during Steering Committee meetings where the Final Report was discussed have been adequately resolved, amended or incorporated into the Final Report submitted to the Department.

Signed: G. P. Ayers

Hub Steering Committee Chair Name: Dr Greg Ayers

Date: 21/05/2021

# Contents

# Letter from the Hub Leader

Australia relies on world-leading climate change science to help manage the influence of a variable and changing climate on our environment, economy and communities. As a partnership between the CSIRO, the Bureau of Meteorology (BoM) and five universities, the Earth Systems and Climate Change Hub (the Hub) in the Australian Government's National Environmental Science Program (NESP) has been the cornerstone of this research.

The Hub was established in 2015 to ensure Australia's policy and management decisions were effectively informed by Earth systems and climate change science. It quickly positioned itself as a trusted source of information, capable of delivering important benefits to government, the private sector and the wider Australian community. The Hub has worked collaboratively with the five other NESP-funded research hubs, supporting decision-makers to better understand, manage and conserve Australia's environment.

Over the course of the Hub's six-year history, it has delivered critical knowledge in the field of climate change projections; improved understanding of coastal hazards, climate variability and extreme events; and has refined Australia's national climate modelling capability. Much of this science is responsible for the real on-ground outcomes delivered through the Hub, including establishing a new research facility for coastal protection and carbon sequestration, the National Centre for Coasts and Climate (NCCC). The Hub has also played an important role in translating climate change data and information into a framework for understanding risk and disclosure in the business and finance sector.

A key priority for the Hub has been to ensure that climate change information, tools and advice meet the needs of the end-users and supports decision-making. The Hub covered significant ground in establishing respectful partnerships with First Nations people and showed the value of co-designing climate change research with a variety of environmental and industry managers. The impact stories in Attachment B provide examples of the Hub's co-designed processes and products, and their impact.

Multiple researchers from the Hub were involved as Lead Authors in three Special Reports from the Intergovernmental Panel on Climate Change (IPCC) during 2018-2020. Hub researchers were also involved in the first volume of the IPCC Sixth Assessment Report *Climate Change 2021: The Physical Science Basis*, to be released in July 2021. These contributions give credibility to, and confidence in, Australian climate science. These comprehensive assessments have also provided valuable guidance to the Australian Government on climate change science.

The Hub's dedicated researchers also demonstrated remarkable flexibility and resilience by providing critical input into the extreme events that unfolded over the past 18 months. This included delivering insights into policy development in the aftermath of Australia's Black Summer in 2019-20, and flagging an unprecedented opportunity during the COVID-19 pandemic to slow the upward trajectory of global carbon emissions. These achievements will have longevity and impact well beyond the lifetime of the Hub.

I am confident that the Hub's work will play a critical role in the coming decades in ensuring climate change science is developed for the benefit of all Australians. Already we have seen evidence of how the Hub's research and engagement activities have helped to inform decision-making, policy and management processes in Australia. This includes the foundational climate change research the Hub has delivered which will underpin current and future initiatives, such as the Australian Climate Service.

I wish success to the new NESP Climate Systems Hub, and would like to thank the ESCC Hub's partners, collaborators and stakeholders for the opportunity to advance understanding and management of Australia's changing and variable climate.

Professor David Karoly, Earth Systems and Climate Change Hub Leader

# Research

## *Achievement of hub outcomes*

The Hub's activity outcomes, as reported in the Funding Agreement with the Department of Agriculture, Water and the Environment at Schedule 2, Activity 1.3, are:

- *Building national capacity to understand and predict climate variability and extremes in Australia and their broad implications for the environment and society.*
- *Capacity to model past, present and future climate, including understanding and modelling drivers of Australia's climate system to support informed management and decision making.*
- *Developing Australia's capacity to model future climate with a particular focus on projections and scenarios that inform coastal impacts and coastal erosion. This includes research into coast and climate interactions through a nationally co-ordinated approach.*

### *Building national capacity*

Indigenous engagement

Collaboration between First Nations people and the Hub has resulted in innovative ways of developing and using climate change science to make it relevant and accessible to all peoples. A co-design process has underpinned much of this work. This co-design process has helped the Hub build strong relationships with Indigenous stakeholders that will benefit future climate research and adaptation projects.

The Hub's Indigenous engagement strategy focused on building strong, trusted and sustainable relationships with First Nation's people to develop a better understanding of their priorities and build capacity. To do this, a First Nation peoples led Steering Committee, with representatives from around Australia, was formed to convene the 2018 National Indigenous Dialogue on Climate Change. The Dialogue was held on Yorta Yorta Country and built on a previous workshop convened by the National Climate Change Adaptation Research Facility (NCCARF) and Yorta Yorta Nation Aboriginal Corporation. Building on the success of the Dialogue, an expanded 10-member Steering Committee was established to convene the National First Peoples Gathering on Climate Change in March 2021. The Gathering brought together more than 100 Traditional Owners and ten climate scientists to share knowledge and build lasting connections. The Steering Committee also provided important advice on protocols for researchers seeking to work with First Nations communities. In addition, it provided strategic input on the climate data and information needs of First Nations people into other Hub activities, such as an international workshop in Melbourne that informed the National Climate Services Advisory Committee (NCSAC) climate services report.

Building climate science capability

Recognising the value of the Hub's extensive climate change information and services, the Hub worked with stakeholders to upskill their climate literacy and understanding of climate change science. The Hub found that building the climate science capability of our stakeholders enabled them to more confidently access, use and incorporate our science into their work. Climate literacy workshops were held with a wide variety of the Hub's target stakeholders, from energy network stakeholders and mango growers to Indigenous stakeholders. These workshops revealed knowledge gaps in participant's understanding of climate change science. They also highlighted the strong need and desire for more guidance, tools and expert advice on using climate change science in decision-making processes.

The Hub also focused on upskilling our researchers to improve their ability to understand and communicate with decision-makers across government and business. These skills will stand our researchers in good stead for future stakeholder engagement activities and in raising awareness of the utility of climate change science in assessing climate risks and vulnerabilities.

In particular, the Hub provided unique stakeholder engagement opportunities for its PhD and early career researchers. An example of this are the ‘Young Professional’ events the Hub co-organised with young professionals from across a wide range of private and public sectors, including banks, insurance, local government and more. These events provided an opportunity for young professionals from both the research and industry fields to network and collaborate on innovative solutions to hypothetical climate-related challenges. These, and other events developed by the Hub, aimed to assist our next generation of leaders in building strong and lasting relationships and capacity across sectors.

## *Capacity to model past, present and future climate*

<u>ACCESS model</u>

A completely new version of the Australian Community Climate and Earth System Simulator (ACCESS-CM2) global climate model was developed by the Hub. This was used to supply simulations to the sixth phase of the international Coupled Model Intercomparison Project (CMIP6) that feeds into the IPCC assessments. So far, there have been more than 9.4 million downloads of ACCESS-CM2 datasets from the international CMIP6 data servers from across the globe.

ACCESS model outputs are also used to generate more refined climate data through ‘dynamical downscaling’ for the Australasian region. Downscaled projections provide regional climate information at local decision-making scales. Hub research has highlighted the value of using regional, high resolution climate models to downscale coarse resolution climate projections to better understand Australia’s future climate. Hub research found that regional climate modelling provided particular value in Australia over the Alps, Tasmania and near coastlines. The resulting higher resolution climate information can help to inform location-specific risk assessments and adaptation activities.

<u>Improved global ocean monitoring</u>

The Hub has provided leadership in the generation of high-resolution ocean datasets with improved quality control procedures, which are relied on by the research and wider communities. The resulting high-quality products form the basis of all gridded ocean data products such as the World Ocean Atlas (National Oceanographic Data Center, USA). Hub participation has been vital for the coordinated development of the ocean information that underlies forecasting of climatic variations and information for researchers, decision-makers and the recent IPCC Special Report on the Ocean and Cryosphere in a Changing Climate. The reanalysis of ocean data by Hub researchers has revealed new understandings of how ocean variables, for example sea surface salinity, can be used to inform weather and climate forecasting and prediction.

## *Developing Australia's capacity to model future climate*

<u>National Centre for Coasts and Climate</u>

The National Centre for Coasts and Climate (NCCC) was established under the Hub. The NCCC has improved knowledge and provided resources on nature-based methods for coastal hazard risk reduction and co-produced the first guide for the use of nature-based methods in Australia. The NCCC has engaged with local communities through citizen science and stakeholder engagement activities to improve the mapping of coastal erosion hotspots along the Victorian coastline, and to better understand the drivers of past erosion events. This will provide insights into the resilience of coastlines to future erosion events. The NCCC has also advanced the understanding of blue carbon ecosystems and their ability to sequester carbon for mitigation benefits. In particular, a consistent new recommended method of measuring blue carbon has been developed. Being able to better measure blue carbon is a key challenge for the inclusion of blue carbon into carbon credit schemes.

Future extreme sea level events

Researchers in the Hub have improved understanding of how marine and coastal extremes are changing under a warmer climate. This included an upgrade to the high-resolution sea level rise calculator tool ‘Canute’ (Canute3.0), which features new sea level rise projections as well as information on extreme sea level events. Canute3.0 allows coastal practitioner to explore the impact of extreme sea level events in protected harbours and open ocean beaches around the coastline of Australia.

More information on the outcomes and applications of the Hub’s research is provided in the impact stories at Attachment B.

The Hub’s showcase synthesis report also provides an overview of the key achievements and successes of the Hub over its lifetime. This report can be accessed via the hub’s website at: https://nespclimate.com.au/landofextremes/.

## *Research projects*

Attachment A lists the projects funded under the ESCC Hub and provides information on the project status, information on outputs and links to products for all projects (where available). Exceptions to the NESP Data Management and Accessibility Guidelines are also noted here.

# Performance against milestones

## *Performance against Funding Agreement milestones*

All milestones for the reporting period, and to date, have been met as per Funding Agreement Milestones 1--30.

Milestones 1-25 were reported in Annual Reports between 2015 and 2019. These milestones have been met and approved by the Department.

Milestones 26-30 are detailed below:

| Milestone | Description | Due Date | Status |
|---|---|---|---|
| 26 | Delivery of Annual Progress Report 5 and Financial Information to the Department<br>(Period covered 1 Jan – 31 Dec 2019) | 6 April 2020 | Met |
| 27 | Acceptance of Annual Progress Report 5 and Financial Information by the Department | | Met |
| 28 | Delivery of Interim 2020 Annual Report to the Department<br>(Period covered 1 Jan – 31 Aug 2020) | 6 October 2020 | Met |
| 29 | Acceptance of Interim Report by the Department | | Met |
| 30 | Delivery of Final Report to the Department | 21 May 2021 | Met |

## *Performance against the Research Plan milestones*

Information on project progress and performance is provided in Attachment A.

# Measuring success

The National Environmental Science Program (NESP) is a long-term commitment to support environmental and climate research. The key objective of the NESP is to improve our understanding of Australia's environment through collaborative research that delivers accessible results and informs decision making. The focus of NESP is on practical and applied research that informs on-ground action and that will yield measurable improvements to the environment.

The Program builds on its predecessors - the National Environmental Research Program and the Australian Climate Change Science Program – in securing for decision makers the best available information to support understanding, managing and conserving Australia's environment.

The NESP is delivered through multi-disciplinary research hubs or consortia, hosted by Australian research institutions.

The NESP seeks to achieve its objective by supporting research that:

- is practical and applied and informs on-ground action
- addresses the needs of the Australian Government and other stakeholders by supporting and informing evidence-based policy and improving management of the Australian environment
- is innovative and internationally recognised
- enhances Australia's environmental research capacity
- is collaborative and builds critical mass by drawing on multiple disciplines, research institutions and organisations to address challenging research questions
- produces meaningful results accessible to government, industry and the community
- includes synthesis and analysis of existing knowledge
- builds relationships between scientists and policy-makers to encourage collaborative problem solving on environmental issues.

NESP end-users are a broad range of stakeholders whose decisions may impact on the environment, and include the Australian Government, state governments, industry, business, community groups and Indigenous land managers (or Indigenous Communities).

The intended outcomes of the NESP are:

- Enhanced understanding of, and capacity to manage and conserve Australia's environment.
- Improved climate and weather information for Australia through a greater understanding of the drivers of Australia's climate.
- Timely research that is used by policy and decision-makers to answer questions and provide solutions to problems.
- Research outcomes that are communicated clearly to end-users and the general public, and stored in a manner that is discoverable and accessible.

## *Table A: Quantitative performance measures*

| Key Performance Indicator | Hub Result for entire activity period (1 Jan 2015 - 30 June 2021) (Numerical only) | Explanation (if any) |
|---|---|---|
| 1. Percent of projects (active or completed in the reporting period) for which there is a research-user actively engaged in the project. | **100%** | |
| 2. Percent of projects approved under RPV6 in which research-users were actively involved in project design. | **100%** | |
| 3. Number of research outputs provided to end users **on time**[1] and as identified in the Research Plans. | **279** | |
| 4. Proportion of research outputs provided to end users **on time** and as identified in the Research Plans. | **95%** | |
| 5. Number of instances of where the hub has used NESP-generated information from another NESP hub. | **0** | The Hub primarily uses climate and weather-related data and information, which are not generated by other NESP Hubs.<br>However, extensive cross-Hub collaboration has occurred over the lifetime of the Hub. For example, the Hub collaborated with the Marine Biodiversity Hub on the Indigenous perspectives of risk activity (CS 5.5) and with the Threatened Species Recovery Hub on the greater glider activity (CS4.4). In both cases, the ESCC Hub's climate information was used to inform discussions and environmental outcomes.<br>The Hub has also actively collaborated with all the other NESP Hubs on the cross-Hub Integrated Environmental Assessment Project (CS 6.4). |
| 6. Number of peer reviewed NESP-funded publications during the reporting period. | **352** | |
| 7. Number of NESP research citations in other researchers' publications during the reporting period. | **12,990** | |
| 8. Number of researchers, including PhD and Post-Doc positions engaged as a result of NESP (total, Full-time equivalent) during the reporting period. | **155 researchers 135 FTE total** | |
| 9. Number of data sets provided to the Hub, or made publicly available, by third parties | **>50** | The Hub uses a wide variety of climate and weather datasets to inform its research. These include |

[1] On time – delivered on the date the outputs were expected to be delivered

| Key Performance Indicator | Hub Result for entire activity period (1 Jan 2015 - 30 June 2021) (Numerical only) | Explanation (if any) |
|---|---|---|
| for the purposes of informing NESP research. | | datasets created both within Australia and internationally. The exact number of data sets used by the Hub is hard to calculate, so an estimate has been provided. |
| 10. Percentage of data sets made publicly available under open licence by the Hub. | **>70%** | Some 'draft' datasets resulting from Hub research such as blue carbon, coastal erosion and ecological engineering research are not suitable for public access. These datasets are draft research products and so are exempt under the NESP data management guidelines. This approach has previously been discussed, and agreed, with the Department.<br>However, researchers may make this data available to other researchers on request.<br>In addition, some outputs from models (simulations, code and model development) are accessible to the ACCESS research community with NCI codes and may not be considered 'publicly' available. Again, this approach has previously been agreed with the Department and reflects international climate model data storage and accessibility approaches. |
| 11. Percentage of NESP research outputs (including publications, data and metadata) that are discoverable and accessible in accordance with NESP data accessibility requirements and the funding agreement. | **88%** | As noted above, some draft or experimental datasets and model simulation outputs resulting from Hub research are not suitable for public access. Researchers may make this data available to other researchers on request.<br><br>Some publications are published in journals with an embargo outside the 12-month period set in the NESP guidelines, these are made available on the Hub's website or partner agencies repositories where copyright permissions allow. Some publications are still in review and were not publicly available at the time of reporting.<br><br>A list of all Hub-funded journal articles is provided on the ESCC Hub publications webpage. |
| 12. Number and FTE of Indigenous people employed in a project (separate into full and part time positions). | **4 Indigenous people; 1.2 FTE** | 2017 1 at 0.25 FTE<br>2018 1 person at 0.25 FTE<br>2019 1 person at 0.2 FTE |

| Key Performance Indicator | Hub Result for entire activity period (1 Jan 2015 - 30 June 2021) (Numerical only) | Explanation (if any) |
|---|---|---|
| | | 2020 1 person at 0.5 FTE<br><br>The Steering Committee for the National First Peoples Gathering on Climate Change has provided direction on designing the Gathering, advice on climate information, data and products that communities may need and guidance on the cultural protocols in holding the Gathering. The Steering Committee has also been a reference group for including First Nations people in broader Hub activities. Although not employees, the Hub did pay a sitting fee to the committee members for their participation. |
| 13. Number of Indigenous researchers/graduates/post-graduate/PhD/Post Doc Positions in projects. | **1 person at 0.2 FTE** | |
| 14. Number of Indigenous people trained in the use of environmental management tools and techniques. | **N/A** | Throughout its life, the Hub has engaged with representatives of First Nations communities to identify how the often highly technical data and information produced by Hub research can be tailored for use by these communities in environmental management, and to provide evidence of climate change impacts to advise planning. The Hub has provided opportunities for First Nations people to participate in strategic development for climate services in Australia, for example through the Knowledge Exchange for Climate Adaptation Platforms (KE4CAP) workshop in March 2019. |
| 15. The number of management tools for Indigenous waters and land that benefitted from NESP research and outcomes (including but not limited to Plans of Management for IPAs, Co/Joint managed parks, Marine Park Plans of Management, Conservation Agreements). | **0** | The Hub has provided Indigenous stakeholders with opportunities to inform potential climate change information and tools through:<br>• The First Peoples National Gathering on Climate Change that was co-developed with an Indigenous-led Steering Committee and featured a program to facilitate co-designed communication materials incorporating. The aim was for these communication materials to inform decisions in Communities around environmental management and adaptation decisions. The products are still in development |

| Key Performance Indicator | Hub Result for entire activity period (1 Jan 2015 - 30 June 2021) (Numerical only) | Explanation (if any) |
|---|---|---|
| | | following the recently completed Gathering.<br>• The KE4CAP workshop, part of the NCSAC consultancy, to discuss the delivery of climate 'intelligence' platforms for Australia. |
| 16. Number and type of communication products that have been used to communicate research with Indigenous people. | **13** | • National Indigenous Dialogue on Climate Change and the workshop report includes all 50 Indigenous workshop participants as authors (1)<br>• National First Peoples Gathering on Climate Change and the report which will include all participants as authors (1)<br>• Co-produced presentations between scientists and First Nations people for the NFPGCC (8)<br>• K'gari and climate change activity literature review (1)<br>• Co-design, cross cultural communication and climate change: considerations for engaging with First Nations peoples (1)<br>• Co-produced communication products and a video from the National First Peoples Gathering on Climate Change (still in development)<br>• Indigenous perspectives of risk workshop with Malgana and workshop report co-authored with Malgana people (1) |
| 17. Number of research, knowledge sharing and communication events held with Indigenous communities. | **19** | The Hub has been engaging with First Nations peoples in a two-way co-design process which is a continual knowledge sharing process.<br><br>The Hub has facilitated Traditional Owners to communicate their knowledge and experience of climate change by:<br>• the Indigenous perspectives of risk workshop.<br>• facilitating Traditional Owners to attend and present at the Australian Meteorological and Oceanographic Society (AMOS) Conferences in Darwin in 2019, 2020 and 2021.<br>• facilitating Traditional Owners to attend the Hub's Canberra Roadshow in September 2019 and engage with policy makers. |

| Key Performance Indicator | Hub Result for entire activity period (1 Jan 2015 - 30 June 2021) (Numerical only) | Explanation (if any) |
|---|---|---|
| | | • supporting the Steering Committee meetings held in 2019-2021 for planning of the 2021 National First Peoples Gathering on Climate Change. The NFPGCC Steering Committee held 12 meetings, and additional meetings were held between scientists and Traditional Owners to develop presentations using traditional knowledge and ESCC Hub climate information. |
| 18. Number of public events, conference presentations, jointly authored/published papers with Indigenous participants/contributors. | **13** | • National Indigenous Dialogue on Climate Change and the workshop report includes all 50 Indigenous workshop participants as authors.<br>• National First Peoples Gathering on Climate Change and the report, which will include all participants as authors.<br>• Co-produced presentations between scientists and First Nations people for the NFPGCC.<br>• K'gari and climate change literature review.<br>• Co-design, cross cultural communication and climate change: considerations for engaging with First Nations peoples.<br>• Co-produced communication products and a video from the National First Peoples Gathering on Climate Change (still in development).<br>• Indigenous perspectives of risk workshop with Malgana and workshop report co-authored with Malgana people.<br>• First Nations presentations at AMOS 2019, 2020 and 2021, plus side events. |

## *NESP impact stories*

NESP impact stories are provided at Attachment B. These stories showcase the contribution of NESP funded research to the environment, the economy, society, culture, public policy, quality of life, beyond contributions to academia.

# Financial Information

## *Financial reporting*

Expenditure of NESP funds in 2020 on Hub activities was $4.826 million. This is $276,000 greater than NESP grant funds received over this period, but $291,000 less than the revised RPV6 budget. Hence, at the end of 2020, there was still a substantial underspend of $687,000 NESP funds. Over 2020, the cash and in-kind contributions for Hub activities from Partners were $5.632 million, more than matching the NESP funding.

Total expenditure of NESP Hub funds from 2015 to December 2020 on Hub activities was $22.69 million - close to the budget figure of $23.9 million. Over the same period, the contributions of cash and in-kind expenditure from Partners was $25.835 million - more than matching the expenditure of NESP funds.

There have been significant impacts and delays in some Hub activities associated with the responses to COVID-19, which are outlined in Attachment A. The Hub consulted with the Department on variations to RPV6 and a no-cost extension of some Hub activities was approved (primarily Indigenous engagement activities and case studies) until March or June 2021.

The expenditure of NESP funds in the period until May 2021 is still being managed carefully in consultation with the Department. Expenditure on the National First People's Gathering in March 2021 is still being finalised, together with expenditure on synthesis brochures and the Hub's showcase synthesis report. Based on current information and delays in Indigenous engagement activities, the underspend of NESP funds is likely to remain substantial at the end of June 2021. Management and allocation of these funds is being actively discussed with the Department.

The Hub's planned CLIMATE 2020 conference has been impacted by the continuing challenges of COVID-19 and the date moved to March 2022 (and renamed to CLIMATE 2022). The CSIRO Climate Science Centre has agreed to take over the organisation of CLIMATE 2022 and will continue discussions with the Organising and Program Committees to see if holding the conference is still a viable option considering the continuing impact that COVID-19 is having on the country.

## Earth Systems and Climate Change Hub 2021 Final Report

| Project Number | Project Name | Project Summary | Project Leader | Lead Organisation | Approved Funding Research Plan Versions 1-6 | | | | | Start Date | Completion Date | Outputs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | NESP Funding* $ | Other Cash Contributions* $ | Other In-Kind Contributions* $ | Total Other Contributions* $ | Total Budget* $ | | | Outputs | Link to output |
| **COMPLETE RESEARCH PROJECTS** | | | | | | | | | | | | | |
| 1.1 | Current Capability and Future Directions Assessment | This project has informed the development of the ESCC Hub's long-term research delivery through an assessment of current capability and future directions for the Earth Systems and Climate Change Hub science and services. The assessment examined current research and outreach capability and future directions, with an emphasis on how the Hub's key partners can best respond to target stakeholder gaps, needs and associated national priorities. The assessment was conducted by Scientell Ltd Pty. | Geoff Gooley | CSIRO | 72,453 | 0 | 72,640 | 72,640 | **145,093** | 01.07.2015 | 31.12.2017 | Assessment report conducted and compiled by Scientell Ltd Pty which outlines the current capability and future directions of Earth Systems and Climate Change research and provides feedback on Hub activities, and suggested future directions. | http://nespclimate.com.au/current-capability-and-future-directions-assessment/ |
| 1.2 | Project 1.2 - Stakeholder and Indigenous Engagement | Communication and Knowledge Brokering budget | Helen Cleugh | CSIRO | 80,200 | 0 | 80,200 | 80,200 | **160,400** | 01.01.2016 | 31.12.2016 | N/A | N/A |
| 1.3 | Low coast abatement options: scoping workshop and report | Low cost abatement options: Scoping Workshop and Report | Helen Cleugh | CSIRO | 18,262 | 0 | 18,262 | 18,262 | **36,524** | 1/07/2015 | 31/12/2016 | N/A | N/A |
| 2.12 & 1.4 | Sea Level Projections for NCCARF | This project provided NCCARF with the latest projections of sea-level rise for each coastal local government area in Australia, including all mainland and Tasmanian Councils and the Torres Strait Islands. Information was communicated through guidance material and stakeholder workshops. The project ensured current knowledge was delivered to the community, particularly coastal planners and managers, in a coherent and efficient manner to aid in decision making and planning for future coastal change. The project did this by using the latest regional climate projections for Australia and, working with NCCARF, included these projections in NCCARF's new coastal tool, CoastAdapt. This tool is an excellent information delivery tool, and has been shown to be used extensively by coastal councils and other coastal planners, managers and relevant governments. Inclusion of project information into CoastAdapt has greatly increased uptake of Hub research across the community. | Kathleen McInnes | CSIRO | 25,044 | 0 | 25,044 | 25,044 | **50,088** | 1/09/2015 | 30/12/2016 | Updated sea level rise projections incorporated into the NCCARF coastal planning tool, CoastAdapt | https://coastadapt.com.au/tools/coastadapt-datasets |
| N/A | PhD's and Vacation Scholarships (outside Projects; includes SO) | This is not an actual project but contributes to salaries/costs of PhD students outside project funding. | | | 33,287 | | 205,850 | 205,850 | 239,137 | 01.07.2016 | 30.06.2019 | Supports PhDs within the Hub to participate in Hub run or supported events, particularly those with a stakeholder focus. Provides capacity building and stakeholder engagement experience for PhDs. | N/A |
| 2.1 | Preparing ACCESS for CMIP6 | ACCESS is Australia's global climate model, which provides climate simulations for the Intergovernmental Panel on Climate Change assessment reports, including the upcoming sixth assessment report. Given its importance to Australia's climate preparedness and resilience, ACCESS needs to be an internationally benchmarked, world-class global climate modelling capability that is significantly more accurate than other global climate models for the Australasian and Southern Hemisphere region. Participation in the Climate Model Intercomparison Project (CMIP) provides this benchmarking. It also supports Australia's effective management of climate risks and opportunities, and engagement with future climate assessments. This project has achieved these outcomes by preparing and submitting ACCESS model simulations into CMIP6 to benchmark ACCESS's performance and suitability for application across the NESP ESCC Hub and the broader climate change science research community. Submission of ACCESS simulations into CMIP6 also allows them to be included in IPCC assessment reports for used by governments across the world. | Simon Marsland | CSIRO | 975,000 | 0 | 994,750 | 994,750 | **1,969,750** | 01.07.2016 | 30.06.2019 | Kiss AE, Hogg AMcC, Hanna Nh, Dias FB, Brassington G, Chamberlain MA, Chapman C, Dobrohotoff P, Domingues CM, Duran ER, England MH, Fiedler R, Griffies SM, Heerdegen A, Heil P, Holmes RM, Klocker A, Marsland SJ, Morrison AK, Munroe J, Oke PR, Nikurashin M, Pilo GS, Richet O, Savita A, Spence P, Stewart KD, Ward ML, Wu F, Zhang X. 2019. ACCESS-OM2: A Global Ocean-Sea Ice Model at Three Resolutions, Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2019-106, Geosci. Model Dev | https://doi.org/10.5194/gmd-2019-106 |
| | | | | | | | | | | | | Griffies SM et al. 2016. OMIP contribution to CMIP6: experimental and diagnostic protocol for the physical component of the Ocean Model Intercomparison Project. *Geoscientific Model Development*, 9, 3231–3296, doi:10.5194/gmd-9-3231-2016 | https://www.geosci-model-dev.net/9/3231/2016/ |

| Project Number | Project Name | Project Summary | Project Leader | Lead Organisation | Approved Funding Research Plan Versions 1-6 | | | | | Start Date | Completion Date | Outputs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | NESP Funding* $ | Other Cash Contributions* $ | Other In-Kind Contributions* $ | Total Other Contributions* $ | Total Budget* $ | | | Outputs | Link to output |
| | | | | | | | | | | | | ACCESS Post Processor (APP) software from CMIP5 ACCESS1.0 and 1.3 submissions, for use in ACCESS-CM2 and ACCESS-ESM1.5 CMIP6 submissions | |
| | | | | | | | | | | | | Science webinar: Ensuring Australian climate model simulations inform global climate assessments | http://nespclimate.com.au/ensuring-australian-climate-model-simulations-inform-global-assessments/ |
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| Project Number | Project Name | Project Summary | Project Leader | Lead Organisation | Approved Funding Research Plan Versions 1-6 | | | | | Start Date | Completion Date | Outputs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | NESP Funding* $ | Other Cash Contributions* $ | Other In-Kind Contributions* $ | Total Other Contributions* $ | Total Budget* $ | | | Outputs | Link to output |
| | | | | | | | | | | | | ESCC Hub webinar: Atmosphere, aerosols and ACCESS | http://nespclimate.com.au/webinar-atmosphere-aerosols-access/ |
| | | | | | | | | | | | | ESCC Hub blog: Something in the air | http://nespclimate.com.au/something-in-the-air/ |
| | | | | | | | | | | | | Ziehn T, Chamberlain M, Lenton A, Law R, Bodman R, Dix M, Wang YP, Dobrohotoff P, Srbinovsky J, Stevens L, Vohralik P, Mackallah C, Sullivan A, O'Farrell S, Druken K. 2019. CSIRO ACCESS-ESM1.5 model output prepared for CMIP6 CMIP. Version YYYYMMDD[1].Earth System Grid Federation. https://doi.org/10.22033/ESGF/CMIP6.2288 | https://doi.org/10.22033/ESGF/CMIP6.2288 |
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| | | | | | | | | | | | | Dave Bi presentation to the Working Group on Coupled Modelling (WGCM) | https://www.wcrp-climate.org/images/modelling/WGCM/WGCM21/10oct/02-10-ACCESS-WCRP-WGCM21.pdf |
| 2.2 | Enhancing Australia's capacity to manage climate variability and climate extremes in a changing climate | Climate extremes such as heatwaves, floods and droughts in Australia cause high economic, agricultural and human costs. Managing the risks – and reducing the costs – associated with climate variability and extremes requires a transformation in our current understanding of the influence of climate change now and into the future. This project has analysed past climate variability and extremes to significantly enhance our understanding of the underpinning mechanisms and processes. It has focused on longer timescale extremes such as extended heatwaves, floods and droughts and the historical record of tropical cyclones; with the aim of informing the development of robust projections that will help Australia prepare for and respond to climate variability, extremes and change in the future. | Pandora Hope | Bureau of Meteorology | 1,838,475 | 0 | 2,075,394 | 2,075,394 | **3,913,869** | 01.07.2016 | 30.06.2019 | Chung CTY, Power SB, Sullivan A, Delage F, 2019. The role of the South Pacific in modulating Tropical Pacific Variability, Scientific Reports, doi:10.1038/s41598-019-52805-2 | https://www.nature.com/articles/s41598-019-52805-2 |
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| | | | | | NESP Funding* $ | Other Cash Contributions* $ | Other In-Kind Contributions* $ | Total Other Contributions* $ | Total Budget* $ | | | Outputs | Link to output |
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| | | | | | NESP Funding* $ | Other Cash Contributions* $ | Other In-Kind Contributions* $ | Total Other Contributions* $ | Total Budget* $ | | | Outputs | Link to output |
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| | | | | | NESP Funding* $ | Other Cash Contributions* $ | Other In-Kind Contributions* $ | Total Other Contributions* $ | Total Budget* $ | | | Outputs | Link to output |
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| 2.3 | Towards an ACCESS decadal prediction system | The marine, agriculture, energy and water sectors have consistently requested climate information at multi-year to decadal timescales. However, Australia capability is only just being developed in our predictive capability at these timescales. This project developed forecasting capability specific to filling the critical gap between seasonal climate predictions and multi-decadal climate projections, within ACCESS. The project advanced the initial steps in developing Australia's forecast capability on the decadal scale, and has improved understanding and simulation of Southern hemisphere climate drivers. The project has, as an example and tester, focused on delivering targeted stakeholder products to inform marine and agriculture policy and adaptive management strategies, through assessment of marine temperature extremes which have large impacts on marine life and fisheries. | Neil Holbrook | UTAS | 410,000 | 0 | 673,633 | 637,633 | **1,047,633** | 01.07.2016 | 30.06.2019 | Factsheet: Earth Systems and Climate Change Hub. 2019. Understanding marine heatwaves | http://nespclimate.com.au/wp-content/uploads/2019/05/A4-2p-ccs-brief_marineheatwaves_web.pdf |
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| | | | | | | | | | | | | ESCC Hub science webinar: Ocean temperature extremes | http://nespclimate.com.au/towards-predicting-ocean-temperature-extremes/ |
| 2.4 | Changing oceans and Australia's future climate | Global warming is ocean warming: over 93% of the extra heat stored by the Earth over the past 50 years is found in the ocean. To interpret past changes and better predict changes in the climate we need to understand how the ocean takes up | Steve Rintoul | CSIRO | 1,050,146 | 0 | 1,209,970 | 1,209,970 | **2,260,116** | 01.07.2016 | 30.06.2019 | Updated Argo Australia profiles | National Centers for Environmental Information, NESDIS, NOAA https://data.nodc.noaa.gov/cgi-bin/iso?id=gov.noaa.nodc:0170893 |

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| | | we need to understand how the ocean takes up heat, and how ocean heat uptake may change as the planet warms. Projections of future warming, sea level rise and water availability for Australia and our region can be improved by ensuring that ocean heat uptake is well represented in climate models. This project used observations and models to provide these improvements; underpinning a more resilient Australia. | | | | | | | | | | Cyriac A, McPhaden MJ, Phillips HE, Bindoff NL, Feng M. 2019 Seasonal Evolution of the Surface Layer Heat Balance in the Eastern Subtropical Indian Ocean. Journal of Geographic Research – Oceans. 10.1029/2018JC014559 | https://eprints.utas.edu.au/31743/1/134365%20-%20Seasonal%20evolution%20of%20the%20surface%20layer%20heat%20balance%20_accepted%20manuscript.pdf |
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| | | | | | | | | | | | | New version of iQuOD global ocean historical data set with new bias corrections completed | |
| | | | | | | | | | | | | Ocean Model equilibration period and runs and climate change scenarios complete at 1° and 0.25° resolution and stored in NCI Research Data Collection (Hogg/Stewart) | https://doi.org/10.4225/41/5a2dc8543105a |
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| | | | | | | | | | | | | IQuOD database products | http://iquod.github.io/ |
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| | | | | | | | | | | | | ESCC Hub science webinar: IPCC and our changing oceans | http://nespclimate.com.au/the-ipcc-process-and-our-changing-oceans/ |
| | | | | | | | | | | | | ESCC Hub science webinar: ocean heat uptake | http://nespclimate.com.au/webinar-ocean-heat-content/ |
| | | | | | | | | | | | | Project 2.4 synthesis video | https://www.youtube.com/watch?v=5aluNcWzx9I |
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| 2.5 | Improving Australia's Climate Model (ACCESS) | ACCESS equips Australia with a global climate modelling capability that is uniquely concerned with the weather and climate of the Australasian and Southern Hemisphere region. The key outcome is a national preparedness that enables Australia to better manage weather and climate impacts, including future risks and opportunities; saving lives, resources and money. This project has significantly enhance ACCESS's accuracy by improving its simulation of critically important climate processes in the Australasian region, focussing on rainfall and weather extremes. It has facilitated the robust predictions needed for adaptation and emissions policies, and delivered an enhanced modelling system to the Hub and broader community. | Harun Rashid | CSIRO | 1,494,551 | 0 | 1,635,511 | 1,635,511 | **3,130,062** | 01.07.2016 | 30.06.2019 | Colman RA, Brown JR, Franklin C, Hanson L, Ye H, Zelinka MD, 2019, Evaluating cloud feedbacks and rapid responses in the ACCESS model. Journal of Geophysical Research, doi:10.1029/2018jd029189 | https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2018JD029189 |
| | | | | | | | | | | | | Singh MS, Warren RA, Jakob C, 2019. A Steady-State Model for the Relationship Between Humidity, Instability, and Precipitation in the Tropics, Journal of Advances in Modelling Earth Systems, doi:10.1029/2019MS001686 | https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2019MS001686 |
| | | | | | | | | | | | | Warren RA,Singh MS, Jakob C. 2020. Simulations of Radiative-Convective-Dynamical Equilibrium. Journal of Advances in Modeling Earth Systems, 12(3) DOI: 10.1029/2019MS001734 | https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2019MS001734 |
| | | | | | | | | | | | | Protat A, Klepp C, Louf V, Petersen WA, Alexander SP, Barros A, Leinonen J, Mace GG, 2019. The Latitudinal Variability of Oceanic Rainfall Properties and Its Implication for Satellite Retrievals: 1. Drop Size Distribution Properties, Journal of Geophysical Research -Atmospheres, doi:10.1029/2019JD031011 | https://eprints.utas.edu.au/33248/ |
| | | | | | | | | | | | | An improved version of ACCESS with significant reduction in tropical rainfall errors and improved simulations of the Madden-Julian Oscillation | Model code is available at the UM code repository: https://code.metoffice.gov.uk/svn/roses-u/a/r/1/7/9/trunk Output data is available on NCI mass data storage system at: pbd562/short/archive/ar179-pd-n216-crashed0409/history |
| | | | | | | | | | | | | Timmermann A, et al. 2018. El Niño–Southern Oscillation complexity. Nature, 559, 535-545, doi: 10.1038/s41586-018-0252-6 | http://nespclimate.com.au/wp-content/uploads/2016/03/Timmermannetal_ENSO-Complexity_Nature18_Preprint.pdf |
| | | | | | | | | | | | | Dataset: Version 1 of the diagnostic toolkit | https://accessdev.nci.org.au/trac/wiki/access/access_DiagnosticToolsV1 |
| | | | | | | | | | | | | Zhou XB, Alves O, Marsland SJ, Bi DH, Hirst AC. 2017. Multi-decadal variations of the South Indian Ocean subsurface temperature influenced by Pacific Decadal Oscillation. Tellus Series a-Dynamic Meteorology and Oceanography 69. doi:10.1080/16000870.2017.1308055 | https://www.tandfonline.com/doi/full/10.1080/16000870.2017.1308055 |

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| | | | | | NESP Funding* $ | Other Cash Contributions* $ | Other In-Kind Contributions* $ | Total Other Contributions* $ | Total Budget* $ | | | Outputs | Link to output |
| | | | | | | | | | | | | Wheeler MC, Zhu HY, Sobel AH, Hudson D, Vitart F. 2017. Seamless precipitation prediction skill comparison between two global models. Quarterly Journal of the Royal Meteorological Society, 143, 374-383, doi:10.1002/qj.2928 | https://climateextremes.org.au/wp-content/uploads/2019/06/1-Seamless-Precipitation-Prediction-Skill.pdf |
| | | | | | | | | | | | | Zhu HY, Maloney E, Hendon H, Stratton R. 2017. Effects of the changing heating profile associated with melting layers in a climate model. Quarterly Journal of the Royal Meteorological Society 143, 3110-3121. doi: 10.1002/qj.3166 | https://rmets.onlinelibrary.wiley.com/doi/abs/10.1002/qj.3166 |
| | | | | | | | | | | | | Luhar AK, Galbally IE, Woodhouse MT, Thatcher M. 2017. An improved parameterisation of ozone dry deposition to the ocean and its impact in a global climate-chemistry model. Atmospheric Chemistry and Physics, 17, 3749-3767, doi:10.5194/acp-17-3749-2017 | http://www.atmos-chem-phys-discuss.net/acp-2016-844/ |
| | | | | | | | | | | | | Rashid H, Zhu H and Sun Z (2017) Initial documentation of key systematic errors in a high resolution (60 km grid) version of the current ACCESS atmospheric model. Earth Systems and Climate Change Hub Technical Report No. 1, NESP Earth Systems and Climate Change Hub, Australia. | http://nespclimate.com.au/wp-content/uploads/2018/05/ESCC-R001-ACCESS-1705.pdf |
| | | | | | | | | | | | | Zhu H, Jakob C, Ma Y, Warren R, Santra A, Yorgen S and Sun Z. 2018. A comprehensive report of model systematic errors in the latest ACCESS climate models. Earth Systems and Climate Change Hub Report No. 3, NESP Earth Systems and Climate Change Hub, Australia | http://nespclimate.com.au/wp-content/uploads/2016/03/ESCC-R003-ACCESS-1806.pdf |
| | | | | | | | | | | | | Blog on improving ACCESS | http://nespclimate.com.au/improving-tropical-rainfall-simulations-in-our-national-climate-model/ |
| | | | | | | | | | | | | ESCC Hub science webinar: Australia's national climate model | http://nespclimate.com.au/australias-national-climate-model-access-development-and-application/ |
| | | | | | | | | | | | | Rashid HAH, Hirst AC. 2016. Mechanisms of improved rainfall simulation over the Maritime Continent due to increased horizontal resolution in an AGCM. Climate Dynamics, 49, 1747–1764, doi:10.1007/s00382-016-3413-z | https://link.springer.com/article/10.1007/s00382-016-3413-z |
| | | | | | | | | | | | | Nguyen H, Protat A, Zhu HY, Whimpey M. 2017. Sensitivity of the ACCESS forecast model statistical rainfall properties to resolution. Quarterly Journal of the Royal Meteorological Society, 143, 1967-1977, doi:10.1002/qj.3056 | https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/qj.3056 |
| | | | | | | | | | | | | Rashid HA, 2020. Delving deeper into Australia's national climate model: the Australian Community Climate and Earth System Simulator (ACCESS), NESP Earth Systems and Climate Change Hub Report No. 12, NESP Earth Systems and Climate Change Hub, Australia. | http://nespclimate.com.au/wp-content/uploads/2020/03/ESCC_R012_March-2020.pdf |
| | | | | | | | | | | | | Project 2.5 synthesis video | https://www.youtube.com/watch?v=E8aPJG2ni9Y |
| | | | | | | | | | | | | Dataset: Model code for improved ACCESS version 1 | NA |

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| 2.6 | Regional Climate Projection Science, Information and Services | Key stakeholders have indicated that they want credible and salient projections to underpin adaptation. However, there are a few areas where uncertainties remain, data are inadequate for impact assessment, and uptake has been limited. This project has begun initial steps for planning and development of new projections that maintain credibility and salience. This project has enhanced uptake of climate projections information through improved products and services for targeted stakeholders. Research has also constrained uncertainty and improving confidence in projections, and the project has begun to lay the groundwork for the next generation of regional projections. | Michael Grose | CSIRO | 1,668,750 | 32,625 | 1,339,096 | 1,371,721 | **3,040,471** | 01.07.2016 | 30.06.2019 | Grose MR, Syktus J, Thatcher M, Evans JP, Ji F, Rafter T, Remenyi T. 2019. The role of topography on projected rainfall change in mid-latitude mountain regions. Climate Dynamics, 1-16, doi:10.1007/s00382-019-04736-x | http://nespclimate.com.au/wp-content/uploads/2019/05/10.1007_s00382-019-04736-x.pdf |
| | | | | | | | | | | | | Our changing climate: how will rainfall change in Northern Australia over this century? | http://nespclimate.com.au/wp-content/uploads/2018/06/Northern-Australia-6pp_WEB.pdf |
| | | | | | | | | | | | | Colman R, Power SB. 2018. What can decadal variability tell us about climate feedbacks and sensitivity? *Climate Dynamics* . doi: 10.1007/s00382-018-4113-7 | http://nespclimate.com.au/wp-content/uploads/2019/05/Colman-and-Power-2018.-Decadal_Jan_2018_revised.pdf |
| | | | | | | | | | | | | Brown JR, Moise AF, Colman RA. 2017. Projected increases in daily to decadal variability of Asian-Australian monsoon rainfall. Geophysical Research Letters, 44, 5683–5690. doi:10.1002/2017GL073217 | http://nespclimate.com.au/wp-content/uploads/2016/03/Brown_et_al-2017-Geophysical_Research_Letters.pdf |
| | | | | | | | | | | | | Risbey JS, Grose MR, Monselesan DP, O'Kane TJ, Lewandowsky S. 2017. Transient response of the global mean warming rate and its spatial variation. Weather and Climate Extremes, doi:10.1016/j.wace.2017.11.002 | https://www.sciencedirect.com/science/article/pii/S2212094716300494 |
| | | | | | | | | | | | | Zhang H., Y. Zhao, A. Moise, H. Ye, R. Colman, G. Roff, M. Zhao 2017. On the influence of SST warming intensity/patterns for uncertainties in CMIP5 model rainfall projections: An AGCM study. Climate Dynamics. | http://nespclimate.com.au/wp-content/uploads/2016/03/Post-print-Zhang-et-al-2017.-accessSST.pdf |
| | | | | | | | | | | | | Brochure 'Our changing climate: Using climate change information to 2030' | http://nespclimate.com.au/wp-content/uploads/2017/10/Using-climate-change-information-to-2030.pdf |
| | | | | | | | | | | | | Grose MR, Colman RA, Andrews T. 2018. What climate sensitivity index is most useful for projections? Geophysical Research Letters. 45(3), 1559-1566. | http://nespclimate.com.au/wp-content/uploads/2016/03/Grose_et_al-2018-Geophysical_Research_Letters.pdf |
| | | | | | | | | | | | | ESCC Hub Science Webinar: Northern Australian rainfall change | http://nespclimate.com.au/how-will-rainfall-change-in-northern-australia-over-the-coming-century/ |
| | | | | | | | | | | | | Brochure: Our changing climate: Southern Australia rainfall – long-term trends and future projections | Our changing climate: Southern Australia rainfall – long-term trends and future projections |
| | | | | | | | | | | | | ESCC Hub blog: Northern Australia rainfall changes | http://nespclimate.com.au/how-will-rainfall-change-in-northern-australia-over-this-century/ |
| | | | | | | | | | | | | ESCC Hub blog: Long term trends and future projections of rainfall in Southern Australia | http://nespclimate.com.au/long-term-trends-and-future-projections-of-rainfall-in-southern-australia/ |
| | | | | | | | | | | | | ESCC Hub weblog: State of the Climate Report 2018 | http://nespclimate.com.au/state-of-the-climate-2018-bureau-of-meteorology-and-csiro/ |
| | | | | | | | | | | | | ESCC Hub science webinar: regional projections | http://nespclimate.com.au/the-why-how-and-when-of-producing-climate-projections-in-australia/ |
| | | | | | | | | | | | | Climate Change in Australia (climate projections website) | www.climatechangeinaustralia.gov.au |
| | | | | | | | | | | | | Training sessions on the Climate Change in Australia website with end-users | N/A |
| | | | | | | | | | | | | The Conversation' article: Grose M, Bettio L. 2018. State of the Climate 2018: Bureau of Meteorology and CSIRO. | https://theconversation.com/state-of-the-climate-2018-bureau-of-meteorology-and-csiro-109001 |

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| | | | | | | | | | | | | Brochure: Towards the next generation of climate change projections for Australia – summary of a proposed approach and timeline for a new future suite of climate change projections. | http://nespclimate.com.au/wp-content/uploads/2019/07/ESCC-NetGen-4pp_web.pdf |
| | | | | | | | | | | | | Di Virgilio G, Evans JP, Di Luca A, Olson R, Argüeso D, Kala J, Andrys J, Hoffmann P, Katzfey JJ, Rockel B. 2019. Evaluating reanalysis-driven CORDEX regional climate models over Australia: model performance and errors, Climate Dynamics, doi: 10.1007/s00382-019-04672-w | http://nespclimate.com.au/wp-content/uploads/2019/05/2.6_DiVirgilio_et_al_8Feb2019_preprint.pdf |
| | | | | | | | | | | | | Grose MR, Foster S, Risbey JS, Osbrough S, Wilson L. 2019. Using indices of atmospheric circulation to refine southern Australian winter rainfall climate projections, Climate Dynamics, pp1-13, doi: 10.1007/s00382-019-04880-4 | https://link.springer.com/article/10.1007%2Fs00382-019-04880-4 |
| | | | | | | | | | | | | Grose MR, Risbey JS, Whetton PH. 2016. Tracking regional temperature projections from the early 1990s in light of variations in regional warming, including 'warming holes'. Climatic Change, 140, 307–322, doi:10.1007/s10584-016-1840-9 | https://link.springer.com/article/10.1007/s10584-016-1840-9 |
| | | | | | | | | | | | | Science webinar: Climate Thresholds – an easy way to explore future climate extremes | http://nespclimate.com.au/climate-thresholds-an-easy-way-to-explore-future-climate-extremes/ |
| | | | | | | | | | | | | NextGen Projections workshop summary report | http://nespclimate.com.au/wp-content/uploads/2018/06/ESCC-R005-NextGen-projections-180629.pdf |
| | | | | | | | | | | | | Project 2.6 synthesis video | https://www.youtube.com/watch?v=ItDgWa7YiSY |
| | | | | | | | | | | | | ESCC Hub science webinar: Climate Analogues Tool | http://nespclimate.com.au/climate-analogues-a-way-to-experience-the-future-climate/ |
| 2.7 | Refining Australia's Water Futures | Information about, and analyses of, future water availability are critical for water resources planning and investment decisions. However credible and consistent projections for a range of hydroclimate variables are not currently available. This project has improved our national modelling capability to simulate how changes in climate and land-use will affect Australia's hydroclimates and water resources into the future. As part of this activity the project team engaged with stakeholders to ensure that the projections are both relevant and useful to sectors that are significantly affected by climate and water, such as (but not limited to) agriculture. | Dewi Kirono | CSIRO | 600,000 | 0 | 1,201,467 | 1,201,467 | **1,801,467** | 01.07.2016 | 30.06.2019 | Chiew FHS, Zheng H, Potter NJ, Ekstrom M, Grose MR, Kirono DGC, Zhang L, Vaze J. 2017. Future runoff projections for Australia and science challenges in producing next generation projections. Proceedings of the 22nd International Congress on Modelling and Simulation, Hobart, December 2017, pp. 1745–1751. | http://www.mssanz.org.au/modsim2017/L16/chiew.pdf |
| | | | | | | | | | | | | Cernusak LA, Haverd V, Brendel O, Thiec DL, Guehl JM, Cuntz M. 2019. Robust response of terrestrial plants to rising CO2, Trends in Plant Science, 24(7), pp. 578-586, 10.1016/j.tplants.2019.04.003 | http://nespclimate.com.au/wp-content/uploads/2019/05/2.7_Cernusak_etal_2019_Accepted-version.pdf |
| | | | | | | | | | | | | Kirono DGC, Grose MR, Hennessy KJ. 2017. Increasing risk of months with low rainfall and high temperature in southeast Australia for the past 150 years. Climate Risk Management, 16, 10–21, doi:10.1016/j.crm.2017.04.001 | https://www.sciencedirect.com/science/article/pii/S2212096316300717 |
| | | | | | | | | | | | | Chiew FHS, Zheng H and Potter JP. 2018. Rainfall-Runoff Modelling Considerations to Predict Streamflow Characteristics in Ungauged Catchments and under Climate Change. Water, 10, 1319 | https://www.mdpi.com/2073-4441/10/10/1319 |
| | | | | | | | | | | | | Ekström M, Gutmann ED, Wilby RL, Tye MR, Kirono DGC. 2018. Robustness of hydroclimate metrics for climate change impact research. Wiley Interdisciplinary Reviews: Water, doi:10.1002/wat2.1288 | https://onlinelibrary.wiley.com/doi/epdf/10.1002/wat2.1288 |
| | | | | | | | | | | | | Project 2.7 synthesis video | https://www.youtube.com/watch?v=hvoLGqchTws&t=42s |

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| | | | | | | | | | | | | ESCC Hub science webinar: water futures under climate change | http://nespclimate.com.au/water-futures-under-climate-change-science-applications-and-challenges/ |
| 2.8 | Extreme Weather Projections | Extreme weather events such as tropical cyclones, east coast lows, thunderstorms, and extreme fire weather incur economic costs associated with property, environmental and human impacts (injury, displacement and death). Effective disaster risk reduction, emergency response, infrastructure design/operation, planning and policy making all require information about how these extreme events will change in the future. Research under the project filled critical knowledge gaps around extremes, and improve understanding of existing and projected characteristics of these extreme events. The projected used this new knowledge to improve simulations and projected changes in these extreme events and, through ongoing and effective stakeholder engagement, transform the research into targeted, useful and application-ready information. | Andrew Dowdy | Bureau of Meteorology and CSIRO | 1,526,250 | 152,625 | 1,665,540 | 1,818,165 | **3,344,415** | 01.07.2016 | 30.06.2019 | Fire weather dataset products, i.e. maps etc. | http://www.bom.gov.au/jsp/ncc/climate_averages/ffdi/index.jsp |
| | | | | | | | | | | | | Chand SS, Dowdy AJ, Ramsay HA, Walsh KJE, Tory KJ, Power SB, Bell SS, Lavender SL, Ye H, Kuleshov Y, 2019. Review of tropical cyclones in the Australian region: Climatology, variability, predictability, and trends, Advanced Review, doi: 10.1002/wcc.602 | https://onlinelibrary.wiley.com/doi/full/10.1002/wcc.602 |
| | | | | | | | | | | | | Ashcroft L, Dowdy AJ, Karoly DJ, 2019. Historical extreme rainfall events in south-eastern Australia, Weather and Climate Extremes, doi:10.1016/j.wace.2019.100210 | https://www.sciencedirect.com/science/article/pii/S221209471930009X |
| | | | | | | | | | | | | Dowdy AJ, Ye H, Pepler A, Thatcher M, Osbourgh SL, Evans JP, Di Virgilio G, McCarthy N. 2019. Future changes in extreme weather and pyroconvection risk factors for Australian wildfires. Nature Scientific Reports, 9:10073, doi:10.1038/s41598-019-46362-x | https://www.nature.com/articles/s41598-019-46362-x |
| | | | | | | | | | | | | Terrasson A, McCarthy N, Guyot A, Dowdy A and McGowan H. 2019. Wildfire and Weather Radar: A Review. Journal of Geophysical Research – Atmospheres, doi: 10.1029/2018JD029285 | http://nespclimate.com.au/wp-content/uploads/2019/05/2.8_Terrasson_et_al-2019-Journal_of_Geophysical_Research__Atmospheres.pdf |
| | | | | | | | | | | | | Earth Systems and Climate Change Hub. 2019. Bushfires and climate change in Australia. | http://nespclimate.com.au/wp-content/uploads/2019/11/A4_4pp_brochure_NESP_ESCC_Bushfires_FINAL_Nov11_2019_WEB.pdf |
| | | | | | | | | | | | | Earth Systems and Climate Change Hub. 2019. Thunderstorms and climate change in Australia. | http://nespclimate.com.au/wp-content/uploads/2019/11/A4_4pp_brochure_NESP_ESCC_Thunderstorms_Nov11_2019_WEB.pdf |
| | | | | | | | | | | | | Earth Systems and Climate Change Hub. 2019. East coast lows and climate change in Australia. | http://nespclimate.com.au/wp-content/uploads/2019/11/A4_4pp_brochure_NESP_ESCC_East_Coast_Lows_Nov11_2019_WEB.pdf |
| | | | | | | | | | | | | Earth Systems and Climate Change Hub. 2019. Tropical cyclones and climate change in Australia. | http://nespclimate.com.au/wp-content/uploads/2019/11/A4_4pp_brochure_NESP_ESCC_Tropical_Cyclones_FINAL_Nov11_2019_WEB.pdf |
| | | | | | | | | | | | | Cavicchia L, et al. 2019. A physically-based climatology of Australian east coast lows occurrence and intensification. Journal of Climate, doi:10.1175/JCLI-D-18-0549 | https://journals.ametsoc.org/doi/abs/10.1175/JCLI-D-18-0549.1 |
| | | | | | | | | | | | | Bell SS, Chand SS, Tory KJ, Turville C, Ye H. 2019. Eastern North Pacific tropical cyclone activity in historical and future CMIP5 experiments: assessment with a model-independent tracking scheme, Climate Dynamics, doi: 10.1175/JCLI-D-18-0549 | https://journals.ametsoc.org/doi/abs/10.1175/JCLI-D-18-0549.1 |
| | | | | | | | | | | | | Tropical Cyclone Portal | https://shiny.csiro.au/Tropical-Cyclone-Projections-Portal/ |
| | | | | | | | | | | | | McCarthy N, Dowdy AJ, Richter H, McGowan H, Guyot A, 2019. Weather Radar Insights Into the Turbulent Dynamics of a Wildfire-Triggered Supercell Thunderstorm, Journal of Geophysical Research-Atmospheres, doi:10.1029/2018JD029986 | https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2018JD029986 |

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| | | | | | NESP Funding* $ | Other Cash Contributions* $ | Other In-Kind Contributions* $ | Total Other Contributions* $ | Total Budget* $ | | | Outputs | Link to output |
| | | | | | | | | | | | | Bell SS, Chand SS, Camargo SJ, Tory KJ, Turville C. 2019. Western North Pacific Tropical Cyclone Tracks in CMIP5 Models: Statistical Assessment Using a Model-Independent Detection and Tracking Scheme, Journal of Climate. | https://doi.org/10.1175/JCLI-D-18-0785.1 |
| | | | | | | | | | | | | Science webinar: Tropical cyclones in the Australian region – past, present and future | http://nespclimate.com.au/tropical-cyclones-in-the-australian-region/ |
| | | | | | | | | | | | | Chand, Tory, Ye and Walsh, 2016. Projected increase in El Nino-driven tropical cyclone frequency in the Pacific. Nature Climate Change, 10.1038/nclimate3181 | https://www.nature.com/articles/nclimate3181?proof=true |
| | | | | | | | | | | | | Raavi PH and Walsh KJE. 2020. Sensitivity of tropical cyclone formation to resolution-dependent and independent tracking schemes in high-resolution climate model simulations. Earth and Space Science Journal, Vol 7, Issue 3, doi: 10.1029/2019EA000906 | https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2019EA000906 |
| | | | | | | | | | | | | Bates B, Dowdy AJ, Chandler R, 2017. Lightning Prediction for Australia Using Multivariate Analyses of Large-Scale Atmospheric Variables, Journal of Applied Meteorology and Climatology, 57, 525-534. doi: 10.1175/jamc-d-17-0214.1 | http://journals.ametsoc.org/doi/abs/10.1175/JAMC-D-17-0214.1 |
| | | | | | | | | | | | | Dowdy A. 2017. Climatological variability of fire weather in Australia. Journal of Applied Meteorology and Climatology, doi:10.1175/JAMC-D-17-0167.1. | http://journals.ametsoc.org/doi/10.1175/JAMC-D-17-0167.1 |
| | | | | | | | | | | | | Dowdy AJ, Catto JL. 2017. Extreme weather caused by concurrent cyclone, front and thunderstorm occurrences. Scientific Reports, 7, doi:10.1038/srep40359 | https://www.nature.com/articles/srep40359 |
| | | | | | | | | | | | | Lim EP, Hendon H, Boschat G, Hudson H, Thompson D, Dowdy A, Arblaster J 2019. Australian hot and dry extremes induced by weakenings of the stratospheric polar vortex, Nature, 12, 896–901, doi: 10.1038/s41561-019-0456-x \| Abstract | https://www.nature.com/articles/s41561-019-0456-x |
| | | | | | | | | | | | | Dowdy AJ, Fromm MD, McCarthy N. 2017. Pyrocumulonimbus lightning and fire ignition on Black Saturday in southeast Australia. Journal of Geophysical Research—Atmospheres, 122(14), 7342-7354, doi: 10.1002/2017JD026577 | https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2017JD026577 |
| | | | | | | | | | | | | McCarthy N, McGowan H, Guyot A, Dowdy A. 2017. Mobile X-Pol radar: A new tool for investigating pyroconvection and associated wildfire meteorology. Bulletin of the American Meteorological Society. doi: 10.1175/bams-d-16-0118.1 | https://journals.ametsoc.org/doi/pdf/10.1175/BAMS-D-16-0118.1 |
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| 2.9 | Risk assessment of future carbon sources and sinks | This project has investigated and assessed the potential for current carbon abatement by revegetation and conservation in Australia, with an emphasis on their potential vulnerability under future climate change, and long-term carbon-climate feedbacks. The project delivered data products showing national and global carbon budget trajectories (CO2 and CH4), and how these track the pathways needed for global climate stabilisation by the end of the 21st century. These products were delivered in stakeholder-relevant formats, suitable for use by government agencies, business and enterprises, and the broader community. | Pep Canadell | CSIRO | 900,000 | | 1,028,751 | 1,028,751 | **1,928,751** | 01.07.2016 | 30.06.2019 | Zhang XZ, Peng SS, Wang YP, Silver JD, Piao SL, Rayner PJ. 2019. Greenhouse gas concentration and volcanic eruption dominated the variability of terrestrial carbon fluxes uptake over the last millennium. Journal of Advances in Modelling Earth Systems. doi:10.1029/2018MS001566 | https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2018MS001566 |
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| | | | | | | | | | | | | Project 2.9 synthesis video | https://www.youtube.com/watch?v=l8tiBq7-Hts |
| 2.10 | Coastal Hazards in a Variable and Changing Climate | Coastal erosion and inundation will be influenced by changes in sea levels and waves. Over $226 billion in Australian assets could be at risk from a 1.1 m increase in sea level (a high-end projection for 2100). However, the projected changes and their coastal impacts remain uncertain and controversial. This project has improved understanding of past, and develop projections for future, changes to coastal stressors (sea level, | Kathleen McInnes | CSIRO | 1,240,000 | 36,625 | 1,470,372 | 1,506,997 | **2,746,997** | 01.07.2016 | 30.06.2019 | O'Grady JO, McInnes KL, Hemer MA, Hoeke RK, Stephenso A, Colberg F, 2019. Extreme water levels for Australian beaches using empirical equations for shoreline wave setup. Journal of Geophysical Research- Oceans | https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2018JC014871 |

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| | | future, changes to coastal stressors (sea level, storm surges and waves) and their physical impact. Through engagement with end-users in government and industry, the project has tailored and delivered it's outputs in ways that ensure Australians can plan effectively for coastal change. | | | | | | | | | | Morim, Hemer et al., 2019. Skill and uncertainty in surface wind fields from general circulation models: Intercomparison of bias between AGCM, AOGCM and ESM global simulations, International Journal of Climatology, doi: 10.1002/joc.6357 | https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/joc.6357 |
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| | | | | | | | | | | | | Science webinar: Understanding future extreme sea levels – tools and information to support coastal management | http://nespclimate.com.au/understanding-future-extreme-sea-levels-tools-and-information-to-support-coastal-management/ |
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| | | | | | NESP Funding* $ | Other Cash Contributions* $ | Other In-Kind Contributions* $ | Total Other Contributions* $ | Total Budget* $ | | | Outputs | Link to output |
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| | | | | | | | | | | | | Progress of digitalisation of imaged charges presented at AMOS. Digitisation of registers back to 1900, QC of all digitised data and preliminary analysis of extremes | https://theconversation.com/climate-change-may-change-the-way-ocean-waves-impact-50-of-the-worlds-coastlines-121239 |
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| 2.11 | Establishment of the National Centre for Coasts and Climate – Phase 1 | The growing economic and population concentration in Australia's coastal areas, and their increasing exposure to flooding and inundation due to climate change, are leading to emerging challenges for coastal development. This project has established the National Centre for Coasts and Climate (NCCC), and initiated its mission to deliver outcomes-focussed research, by identifying: (1) the value of blue carbon in mitigating climate change, (2) the dynamic responses of coastal landform systems to waves and inundation and improve predictions of the impacts of sea-level rise, and (3) the approaches needed to integrate ecological engineering into planning decisions to improve the adaptive capacity of coastal and marine ecosystems to respond to climate change. | Stephen Swearer | University of Melbourne | 1,050,000 | 265,327 | 1,899,587 | 2,164,914 | **3,214,914** | 01.07.2016 | 30.06.2019 | Science webinar: The causes of coastal erosion | http://nespclimate.com.au/the-causes-of-coastal-erosion/ |
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| | | | | | | | | | | | | Morris RL, Bilkovic DM, Boswell MK, Bushek B, Cebrian J, Goff J, Kibler KM, La Peyre MK, McGlenachan G, Moody J, Sacks P, Shinn JP, Sparks EL, Temple NA, Wlaters LJ, Webb BM, Swearer SE. 2019. The application of oyster reefs in shoreline protection: are we over-engineering for an ecosystem engineer? Journal of Applied Ecology, doi: 10.1111/1365-2664.13390 | https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/1365-2664.13390 AB228:AB229AB231AB227:AB228AB228:AB232AB231AAB228:AB234+AB227:AB228 |

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| | | | | | NESP Funding* $ | Other Cash Contributions* $ | Other In-Kind Contributions* $ | Total Other Contributions* $ | Total Budget* $ | | | Outputs | Link to output |
| | | | | | | | | | | | | Kennedy DM, McInnes K, and Ierodiaconou D. 2019. Understanding Coastal Erosion on Beaches: A guide for managers, policy makers and citizen scientists. National Centre for Coasts & Climate, The University of Melbourne | http://onlinelibrary.wiley.com/doi/10.1111/1745-5871.12265/full |
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| | | | | | | | | | | | | Earth Systems and Climate Change Hub. 2019. Coastal erosion under a changing climate | http://nespclimate.com.au/wp-content/uploads/2019/05/2.11_1_A4_4pp_Brochure_Coastal_Erosion_NCCC_ESCC_Feb26_2020_WEB.pdf |
| | | | | | | | | | | | | Earth Systems and Climate Change Hub. 2019. Climate change and blue carbon in Australia | http://nespclimate.com.au/wp-content/uploads/2019/05/2.11-1_A4_4pp_Brochure_Blue_Carbon_in_Australia_NCCC_ESCC_Feb26_2020_WEB.pdf |
| | | | | | | | | | | | | Understanding coastal erosion on beaches: A guide for managers, policy makers and citizen scientists | http://nespclimate.com.au/wp-content/uploads/2019/11/Understanding-Coastal-Erosion-on-Beaches_updatedNov19.pdf |
| | | | | | | | | | | | | Ecological Engineering Data Collection - Meta-analysis data for nature-based coastal defence studies; Wave attenuation for kelp, mangroves, seagrass, saltmarsh and mussel reefs; Sediment accumulation using rSETs, sediment traps, pins, beach profiling and drone surveys for mangroves seagrass, saltmarsh and mussel reefs; ecological data (vegetation and biodiversity characteristics) for kelp, seagrass, saltmarsh, mangroves. | N/A |
| | | | | | | | | | | | | Oliver TSN, Kennedy DM, Tamura T, Murray-Wallace CV, Konlechner TM, Augustinus PC, Woodroffe CD. 2018. Interglacial-glacial climatic signatures preserved in a regressive coastal barrier, south-eastern Australia. *Palaeogeography, Palaeoclimatology, Palaeoecology* , 501, 124 – 135, doi:10.1016/j.palaeo.2018.04.011 | https://ro.uow.edu.au/smhpapers/5390/ |
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| | | | | | | | | | | | | Morris RL, Konlechner TM, Ghisalberti M, Swearer SE. 2018. From grey to green: Efficacy of eco-engineering solutions for nature-based coastal defence. Global Change Biology, 1-16, doi: 10.1111/gcb.14063 | http://nespclimate.com.au/wp-content/uploads/2016/02/Morris-From-grey-to-green_-efficacy-of-eco-eng.pdf |
| | | | | | | | | | | | | Coastal Erosion Data Collection - Georectified aerial photos, digitised shorelines, EPR of change of shoreline position; UAV derived pointclouds, digital surface models and orthophotos of sites; RTK-GPS derived cross-shore profiles; GPS co-ordinates of sampling locations; ecological data (vegetation cover, species richness) for foredunes; database of past erosion events, Victoria Coast; database of known erosion sites, Victoria Coast. | N/A |

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| | | | | | | | | | | | | Morris RL, Bishop MJ, Boon P, Browne NK, Carley JT, Fest BJ, Fraser MW, Ghisalberti M, Kendrick GA, Konlechner TM, Lovelock CE, Lowe RJ, Rogers AA, Simpson V, Strain EMA, Van Rooijen AA, Waters E, Swearer SE. (2021) The Australian guide to nature-based methods for reducing risk from coastal hazards. Earth Systems and Climate Change Hub Report No. 26. NESP Earth Systems and Climate Change Hub, Australia. | https://nespclimate.com.au/wp-content/uploads/2021/05/Nature-Based-Methods_Final_05052021.pdf |
| | | | | | | | | | | | | Blue Carbon Data Collection - Collection comprises of: Literature database for systematic literature reviews and meta data extraction. Raw field sediment core profile data to determine carbon stocks, carbon accumulation rates, organic matter composition from py-GC-MS, sedimentation data from rSET, sediment traps and sediment pins; raw greenhouse gas flux data from chamber and tower measurements; Images, areal images for monitoring and digital elevation models of sites, photo points, photo quadrants, Rhizotron images for root growth analysis. | N/A |
| | | | | | | | | | | | | Project 2.11 synthesis video | https://www.youtube.com/watch?v=0zoxqNUXi1k |
| | | | | | | | | | | | | ESCC Hub science webinar: nature based opportunities for adaptation in the coastal zone | http://nespclimate.com.au/nature-based-opportunities-for-climate-adaptation-in-the-coastal-zone/ |
| 5.1 | ACCESS evaluation and application | Climate and Earth system models are important tools for understanding and predicting climate variability and change. This project will use ensemble simulations with different ACCESS model versions to demonstrate how the ACCESS model developments and CMIP6 benchmarking undertaken in previous Hub projects can be applied for next and end users. The project will use various simulations to support other Hub projects under RPV5. It will also support these projects by providing multi-decadal simulations of the ACCESS atmospheric model at relatively high spatial resolution (useful for regional applications). The project will highlight the application of ACCESS model versions by quantify the biophysical and biogeochemical effects and socio-economic cost of various land management strategies for Australia and regionally under low and high emissions scenarios. This information could be used by land managers when developing cost effective strategies to reduce greenhouse gas emissions and/or store carbon on the land. | Harun Rashid | CSIRO | 951,563 | 0 | 951,563 | 951,563 | **1,903,126** | 01.07.2019 | 31.12.2020 | Yeung N, Menviel L, Meissner K, Ziehn T, Chamberlain M, Mackallah C, Druken K, Ridzwan SM. 2019. CSIRO ACCESS-ESM1.5 model output prepared for CMIP6 PMIP. Version YYYYMMDD[1].Earth System Grid Federation. https://doi.org/10.22033/ESGF/CMIP6.13701 | https://doi.org/10.22033/ESGF/CMIP6.13701 |
| | | | | | | | | | | | | Ziehn T, Dix M, Mackallah C, Chamberlain M, Lenton A, Law R, Druken K, Ridzwan SM. 2020. CSIRO ACCESS-ESM1.5 model output prepared for CMIP6 DAMIP. Version YYYYMMDD[1].Earth System Grid Federation. https://doi.org/10.22033/ESGF/CMIP6.14362 | https://doi.org/10.22033/ESGF/CMIP6.14362 |
| | | | | | | | | | | | | Zhu HY, Smith RK. 2020. A case-study of a tropical low over northern Australia. Quarterly Journal of the Royal Meteorological Society. | https://rmets.onlinelibrary.wiley.com/doi/abs/10.1002/qj.3762 |
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| | | | | | | | | | | | | Dix M, Bi D, Dobrohotoff P, Fiedler R, Harman I, Law R, Mackallah C, Marsland S, O'Farrell S, Rashid H, Srbinovsky J, Sullivan A, Trenham C, Vohralik P, Watterson I, Williams G, Woodhouse M, Bodman R, Dias FB, Domingues C, Hannah N, Heerdegen A, Savita A, Wales S, Allen C, Druken K, Evans B, Richards C, Ridzwan SM, Roberts D, Smillie J, Snow K, Ward M, Yang R, 2019. CSIRO-ARCCSS ACCESS-CM2 model output prepared for CMIP6 CMIP. Version YYYYMMDD[1].Earth System Grid Federation. https://doi.org/10.22033/ESGF/CMIP6.2281 | https://doi.org/10.22033/ESGF/CMIP6.2281 |
| | | | | | | | | | | | | Ziehn T, Chamberlain M, Lenton A, Law R, Bodman R, Dix M, Wang YP, Dobrohotoff P, Srbinovsky J, Stevens L, Vohralik P, Mackallah C, Sullivan A, O'Farrell S, Druken K, 2019. CSIRO ACCESS-ESM1.5 model output prepared for CMIP6 CMIP. Version YYYYMMDD[1].Earth System Grid Federation. | https://doi.org/10.22033/ESGF/CMIP6.2288 |
| | | | | | | | | | | | | Ziehn T, Chamberlain M, Lenton A, Law R, Bodman R, Dix M, Wang YP, Dobrohotoff P, Srbinovsky J, Stevens L, Vohralik P, Mackallah C, Sullivan A, O'Farrell S, Druken K, 2019. CSIRO ACCESS-ESM1.5 model output prepared for CMIP6 ScenarioMIP. Version YYYYMMDD[1]. Earth System Grid Federation. | https://doi.org/10.22033/ESGF/CMIP6.2291 |
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| | | | | | | | | | | | | MacDougall AH, Frölicher TL, Jones CD, Rogelj J, Matthews HD, Zickfeld K, Arora VK, Barrett NJ, Brovkin V, Burger FA, Eby M, Eliseev AV, Hajima T, Holden PB, Jeltsch-Thömmes A, Koven C, Mengis N, Menviel L, Michou M, Mokhov II, Oka A, Schwinger J, Séférian R, Shaffer G, Sokolov A, Tachiiri K, Tjiputra J, Wiltshire A, Ziehn T. 2020. Is there warming in the pipeline? A multi-model analysis of the Zero Emissions Commitment from CO2. Biogeosciences, 17, 2987–3016, 2020 https://doi.org/10.5194/bg-17-2987-2020 | https://doi.org/10.5194/bg-17-2987-2020 |
| | | | | | | | | | | | | ACCESS training workshop AMOS 2021 | https://www.youtube.com/watch?v=tw05r9-o_SI&t=5024s |
| | | | | | | | | | | | | Bodman RW, Karoly DK, Dix MR, Harman IN, Srbinovski J, Dobrohotoff PB, Mackallah C. 2020. Evaluation of CMIP6 AMIP climate simulations with the ACCESS-AM2 model, Journal of Sthrn Hemisphere Earth Systems Science | https://doi.org/10.1071/ES19033 |

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| | | | | | NESP Funding* $ | Other Cash Contributions* $ | Other In-Kind Contributions* $ | Total Other Contributions* $ | Total Budget* $ | | | Outputs | Link to output |
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| | | | | | | | | | | | | Science webinar: Ensuring Australian climate model simulations inform global climate assessments | http://nespclimate.com.au/ensuring-australian-climate-model-simulations-inform-global-assessments/ |
| | | | | | | | | | | | | ESCC Hub Climate Matters webinar: ACCESS evaluation and application | https://www.youtube.com/watch?v=EiE4XzwUJKI |
| 5.2 | Understanding climate variability and change - past, present and future | Australians have managed in a variable climate for thousands of years, but opportunities exist to further apply our scientific understanding of climate variability and change to help water, ecosystem, food resource and disaster managers understand and act on their climate risks. This project will undertake the underpinning climate science research to provide information and data on Australia's variable and changing climate and how climate drivers are expected to change in the future. This information can then be used in targeted tools, guidance and communication products to inform and advise relevant stakeholders. The project will also build on previous Hub research to further develop attribution of extreme events methods and systems, and will provide attribution statements for forecasted events as they occur. This will allow better understanding of the role climate change plays in individual extreme events, and how these events are likely to change as the climate continues to warm. | Christine Chung | BoM | 992,250 | 0 | 992,250 | 992,250 | **1,984,500** | 01.07.2019 | 31.12.2020 | Holmes RM, Zika JD, Ferrari R, Thompson AF, Newsom ER, England MH. 2019. Atlantic Ocean Heat Transport Enabled by Indo-Pacific Heat Uptake and Mixing. Geophysical Research Letters, doi: 10.1029/2019GL085160 | https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2019GL085160 |
| | | | | | | | | | | | | Cai et al. 2020. Climate impacts of the El Niño–Southern Oscillation on South America. Nature Reviews Earth & Environment, doi: 10.1038/s43017-020-0040-3 | https://www.nature.com/articles/s43017-020-0040-3 |
| | | | | | | | | | | | | Grose MR, Black MT, Wang G, King AD, Hope P, Karoly DJ. 2020. The warm and extremely dry spring in 2015 in Tasmania contained the fingerprint of human influence on the climate. J. South. Hemisph. Earth Syst. Sci. doi: 10.22499/3.6901.011 | https://www.publish.csiro.au/ES/ES19011 |
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| | | | | | | | | | | | | Wang G, Cai W, Santoso A. 2019. Stronger increase in the frequency of extreme convective El Nino than extreme warm El Nino under greenhouse warming, Journal of Climate, 10.1175/JCLI-D-19-0376.1 | https://journals.ametsoc.org/view/journals/clim/33/2/jcli-d-19-0376.1.xml |
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| | | | | | | | | | | | | Ng, B. et al. 2020. Impacts of low-frequency internal climate variability and greenhouse warming on the El Niño-Southern Oscillation. Journal of Climate. doi:10.1175/JCLI-D-20-0232.1 \| Abstract | https://doi.org/10.1175/JCLI-D-20-0232.1 |
| | | | | | | | | | | | | ESCC Hub science webinar: Flash drought. Ailie Gallant (Monash University) and Tess Parker (University of Melbourne). | http://nespclimate.com.au/science-webinar-flash-drought-in-australia-rapid-and-devastating/ |
| | | | | | | | | | | | | Parker T, Gallant A, Hobbins M and Hoffman D. 2021. Flash drought in Australia and its relationship to evaporative demand. Environmental Research Letters | https://iopscience.iop.org/article/10.1088/1748-9326/abfe2c |
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| | | | | | NESP Funding* $ | Other Cash Contributions* $ | Other In-Kind Contributions* $ | Total Other Contributions* $ | Total Budget* $ | | | Outputs | Link to output |
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| | | | | | | | | | | | | Geng T, Cai W, Wu L. 2020. Two types of ENSO varying in tandem facilitated by nonlinear atmospheric convection. Geophysical Research Letters, 47, doi: 10.1029/2020GL088784 | https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2020GL088784 |
| | | | | | | | | | | | | Data: ACCESS-CM2j model output (runs aa848 and aa841) | Simulations available only to the ACCESS research community to conduct experiments. |
| | | | | | | | | | | | | Regridded CMIP5/6 monthly datasets | This dataset is available at the National Computing Infrastructure (NCI) under the lp01 project. |
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| | | | | | | | | | | | | Ng, B. et al. 2020. Impacts of low-frequency internal climate variability and greenhouse warming on the El Niño-Southern Oscillation. Journal of Climate. https://doi.org/10.1175/JCLI-D-20-0232.1 | https://journals.ametsoc.org/view/journals/clim/34/6/JCLI-D-20-0232.1.xml |
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| 5.3 | Regional climate change projections science and delivery | To make evidence-based decisions about climate change and to manage climate risks Australia needs access to credible, up-to-date and relevant information and data on future climate change. This project will enhance the functionality of the current suite of national climate change projections (delivered through the Climate Change in Australia website) to improve the accessibility and scope of the projections for existing next- and end-users of climate projections in several key fields. The project will also allow new and emerging users (e.g. the finance sector) to better integrate climate projections into their area of interest through the provision of guidance, training and tailored information and datasets to meet their specific needs. In addition, the project will build the underpinning projections science and modelling to support and build towards a future major release/update of national projections, setting up future and ongoing success in this arena. | Michael Grose | CSIRO | 730,078 | 13,322 | 716,757 | 730,079 | **1,460,157** | 01.07.2019 | 31.12.2020 | Colman RA, Soldatenko S. 2020. Understanding the links between climate feedbacks, variability and change using a two-layer energy balance model. Climate Dynamics, 54, 3441–3459. | https://link.springer.com/article/10.1007/s00382-020-05189-3 |
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| | | | | | | | | | | | | Data product: Code to produce data associated with Grose et al 2020 "Insights from CMIP6 for Australia's future climate" published via Zenodo https://doi.org/10.5281/zenodo.3698369 and hosted on NCI's gitlab. | https://git.nci.org.au/ct5255/cmip6-analysis and via https://doi.org/10.5281/zenodo.3698369 |
| | | | | | | | | | | | | Data tool: Global warming levels: 1850-2100, Australian CCiA regions and states. | https://www.climatechangeinaustralia.gov.au/en/changing-climate/future-climate-scenarios/global-warming-levels/ |
| | | | | | | | | | | | | Grose MR et al. 2020. Insights from CMIP6 for Australia's Future Climate. Earth's Future, Vol 8. Issue 5. | https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1029/2019EF001469 |
| | | | | | | | | | | | | Grose MR. 2019. Just how hot will it get this century? Latest climate models suggest it could be worse than we thought. The Conversation | https://theconversation.com/just-how-hot-will-it-get-this-century-latest-climate-models-suggest-it-could-be-worse-than-we-thought-137281 |

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| | | | | | | | | | | | | Grose MR, Trewin B, Ashcroft L, King AD, Hawkins E. 2020. Australian warming: observed change and global temperature targets. Geophysical Research Letters | https://doi.org/10.1002/essoar.10503758.1 |
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| | | | | | | | | | | | | Future climate in Australia under Paris Agreement global targets (1.5°C and 2°C global warming since pre-industrial). | https://www.climatechangeinaustralia.gov.au/en/changing-climate/future-climate-scenarios/global-warming-levels/ |
| | | | | | | | | | | | | Science webinar: Insights into Australia's future climate from new global climate modelling | http://nespclimate.com.au/insights-into-australias-future-climate-from-new-global-climate-modelling/ |
| | | | | | | | | | | | | NESP Earth Systems and Climate Change Hub. 2021. New global climate models and what they say about projections of Australia's future climate. | http://nespclimate.com.au/wp-content/uploads/2021/04/ESCC_CMIP6-new-modelling_Factsheet.pdf |
| | | | | | | | | | | | | NESP Earth Systems and Climate Change Hub. 2021. Reframing climate change projections for global warming levels. | https://nespclimate.com.au/wp-content/uploads/2021/05/ESCC_Global-warming-level-projections_Factsheet.pdf |
| | | | | | | | | | | | | Science webinar: Assessing future climate risks and adaptation options for Australian water systems | http://nespclimate.com.au/assessing-future-climate-risks-and-adaptation-options-for-australian-water-systems/ |
| 5.4 | Water futures under climate change | Robust projections of water futures are important for impact assessments and developing adaptation options in the water and related sectors. This project will develop a framework that integrates climate and hydrological science and modelling to deliver the next generation of water projections. This will be based on outputs from previous Hub research as well as research and initiatives across Australia (e.g. Victorian Water and Climate Initiative, Bureau of Meteorology Hydrological Projections initiative). Guidance tailored to different uses and different sectors will be provided for developing projections of a range of hydrological characteristics/metrics, including long-term averages, low flow, high flow, and drought indices. The project will engage closely with stakeholders (focussing on the MDBA and WA DWER) to ensure that the framework and the knowledge produced are directly adopted by the end-users. | Dewi Kirono | CSIRO | 262,500 | 0 | 525,000 | 525,000 | **787,500** | 01.07.2019 | 31.12.2020 | Zheng H, Chiew FHS, Potter NJ and Kirono DGC. 2019. Projections of water futures for Australia: an update. Proceedings of the 23nd International Congress on Modelling and Simulation, Canberra, December 2019, pp. 1000 –1006, | https://doi.org/10.36334/modsim.2019.K7.zhengH |
| | | | | | | | | | | | | Kirono DGC, Round V, Heady C, Chiew FHS, Osbourgh S. 2020. Drought projections for Australia: Updated results and analysis of model simulations. Weather and Climate Extremes, 30, doi;10.1016/j.wace.2020.100280 | https://doi.org/10.1016/j.wace.2020.100280 |
| | | | | | | | | | | | | Science webinar: Assessing future climate risks and adaptation options for Australian water systems | http://nespclimate.com.au/assessing-future-climate-risks-and-adaptation-options-for-australian-water-systems/ |

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| | | | | | | | | | | | | NESP Earth Systems and Climate Change Hub. 2021. Projections of water futures for Australia. Earth Systems and Climate Change Hub, Australia. | http://nespclimate.com.au/wp-content/uploads/2021/04/ESCC_Projections-of-Water-Futures_Brochure.pdf |
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| | | | | | | | | | | | | Climate impact on the reliability of farms dams and environmental flow in Western Australia. A fact sheet | |
| | | | | | | | | | | | | ESCC Hub Climate Matters webinar: Towards meeting user needs - water futures | https://www.youtube.com/watch?v=Tb9jli5_hCM |
| 5.5 | Extreme weather hazards in a changing climate | Many of the earliest and most significant effects of a changing climate are experienced through changes in hazardous weather events. However there are considerable scientific knowledge gaps around this, with a clear need for enhanced guidance and products to enable effective evidence-based planning. This project will deliver knowledge products addressing identified needs around four key types of hazards: tropical cyclones; bushfire hazards; east coast lows hazards; and thunderstorm hazards. The project will deliver science translation outputs which build on previous Hub research, as well as new analysis, to develop and deliver (in direct consultation with primarily existing stakeholder networks) a range of targeted communication tools and research synthesis products. | Andrew Dowdy | BoM | 667,735 | 40,268 | 627,466 | 667,734 | **1,335,469** | 01.07.2019 | 31.12.2020 | Giovanni Di Virgilio, Andrew Dowdy, Jason Evans, Jason Sharples, and Rick McRae. 2019, Climate change will make fire storms more likely in south-eastern Australia. The Conversation | https://theconversation.com/climate-change-will-make-fire-storms-more-likely-in-southeastern-australia-127225 |
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| | | | | | | | | | | | | Cavicchia L, Pepler A, Dowdy AJ, Evans JE, 2020. Future Changes in the Occurrence of Hybrid Cyclones: The Added Value of Cyclone Classification for the East Australian Low-Pressure Systems, Geophysical Research Letters, (47)6, doi: 10.1029/2019GL085751 | http://nespclimate.com.au/wp-content/uploads/2021/02/cavicchia-et-al-2020-grl-accepted-version.pdf |
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| | | | | | | | | | | | | Dowdy AJ, Soderholm J, Brook J, Brown A, McGowan H. 2020. Quantifying hail and lightning risk factors using long-term observations around Australia. Journal of Geophysical Research: Atmospheres, doi:10.1029/2020JD033101 | https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1029/2020JD033101 |
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| | | | | | | | | | | | | Science webinar: Tropical cyclones in the Australian region – past, present and future | http://nespclimate.com.au/tropical-cyclones-in-the-australian-region/ |
| | | | | | | | | | | | | ESCC Hub Climate Matters webinar: Extreme weather hazards under a changing climate | https://www.youtube.com/watch?v=-IBXEcMsKoA&t=10s |
| | | | | | | | | | | | | Bell SS, Chand SS, Turville C. 2020. Projected changes in ENSO driven regional tropical cyclone tracks, Climate Dynamics, 54(3-4), pp. 2533-2559, doi:10.1007/s00382-020-05129-1 | https://link.springer.com/article/10.1007%2Fs00382-020-05129-1 |
| | | | | | | | | | | | | Threatened Species and ESCC Hub webinar series: Lessons from the fires: A biodiversity and climate perspective | https://www.nespthreatenedspecies.edu.au/events/climate-change-fire-and-biodiversity-webinar-series |
| | | | | | | | | | | | | NESP Earth Systems and Climate Change Hub. 2021. Intense east coast lows and climate change in eastern Australia | http://nespclimate.com.au/wp-content/uploads/2021/04/ESCC_Intense-east-coast-lows_Brochure.pdf |
| | | | | | | | | | | | | NESP Earth Systems and Climate Change Hub. 2021. Tropical cyclones and climate change in the Great Barrier Reef region. | http://nespclimate.com.au/wp-content/uploads/2021/04/ESCC_Tropical-cyclones-in-the-GBR_Brochure.pdf |
| | | | | | | | | | | | | Deo A, Chand SS, Ramsay H, Holbrook NJ, McGree S, Magee A, Bell S, Titimaea M, Haruhiru A, Malsale P, Mulitalo S, Daphne A, Prakash B, Vainikolo V, Koshiba S. 2021. Tropical cyclone contribution to extreme rainfall over southwest Pacific Island nations. Climate Dynamics, doi:10.1007/s00382-021-05680-5 | https://doi.org/10.1007/s00382-021-05680-5 |
| | | | | | | | | | | | | NESP Earth Systems and Climate Change Hub. 2021. Fire-generated thunderstorms and climate change in Australia | https://nespclimate.com.au/wp-content/uploads/2021/05/ESCC_Fire-Generated-Thunderstorms_Brochure.pdf |
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| 5.6 | The carbon budget of continental Australia and possible future trajectories | While climate change policies seek to manage the net emissions of greenhouse gases, large uncertainties remain on how the carbon budget can be best managed to reduce emissions, increase carbon sinks and protect existing carbon stock. This project will provide the most internally consistent carbon budget for Australia to date, enabling reported emissions to be put in the context of a century-long assessment of Australian carbon stocks and fluxes, including legacy fluxes from past land-clearing and disturbance by wildfire. The project will also provide projections of how Australia's carbon budget may change under a range of climate and land-use scenarios. The projections will be consistent with the Australian National Outlook integrated assessment modelling for Australia. | Pep Canadell | CSIRO | 393,750 | 0 | 393,750 | 393,750 | **787,500** | 01.07.2019 | 31.12.2020 | Peters et al. 2019. Carbon dioxide emissions continue to grow amidst slowly emerging climate policies, Nature Climate Change. 10.1038/s41558-019-0659-6 | https://www.nature.com/articles/s41558-019-0659-6 |
| | | | | | | | | | | | | Friedlingstein et al. 2019. Global Carbon Budget 2019, Earth Systems Science Data, 11, 1-56. doi:10.5194/essd-11-1-2019 | https://www.earth-syst-sci-data.net/11/1783/2019/ |
| | | | | | | | | | | | | Science webinar: Disentangling environmental and human drivers of carbon dioxide uptake and release on land | http://nespclimate.com.au/disentangling-environmental-and-human-drivers-of-carbon-dioxide-uptake-and-release-on-land/ |
| | | | | | | | | | | | | Saunois et al. 2020. Global Methane Budget 2000-1017. Earth Syst. Sci. Data, 12, 1561–1623, | https://essd.copernicus.org/articles/12/1561/2020/essd-12-1561-2020-discussion.html |
| | | | | | | | | | | | | Pep Canadell, Ann Stavert, Ben Poulter, Marielle Saunois, Paul Krummel, Rob Jackson. 2020. Emissions of methane – a greenhouse gas far more potent than carbon dioxide – are rising dangerously. The Conversation | https://theconversation.com/emissions-of-methane-a-greenhouse-gas-far-more-potent-than-carbon-dioxide-are-rising-dangerously-142522 |

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| | | | | | | | | | | | | Le Quéré C, Jackson RB, Jones MW. et al. 2020. Temporary reduction in daily global CO2 emissions during the COVID-19 forced confinement. Nature Climate Change, doi: 10.1038/s41558-020-0797-x | https://doi.org/10.1038/s41558-020-0797-x |
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| | | | | | | | | | | | | Datasets: Global Carbon Budget 2020 | https://doi.org/10.18160/GCP-2020 |
| | | | | | | | | | | | | Yun JM, Jeong SJ, Ho CH, Park HY, et al. 2020. Enhanced regional terrestrial carbon uptake over Korea revealed by atmospheric CO2 measurements from 1999 to 2017. Global Change Biology, 26:3368–3383. | https://onlinelibrary.wiley.com/doi/10.1111/gcb.15061 |
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| | | | | | | | | | | | | Friedlingstein P, O'Sullivan, M, Jones M, et.al. 2020. Global Carbon Budget 2020, ESSD, doi:10.5194/essd-12-3269-2020 | https://essd.copernicus.org/articles/12/3269/2020/ |
| | | | | | | | | | | | | Threatened Species and ESCC Hub webinar series: Carbon sequestration & biodiversity: valuing & managing carbon-rich systems | https://www.nespthreatenedspecies.edu.au/events/climate-change-fire-and-biodiversity-webinar-series |
| | | | | | | | | | | | | ESCC Hub Climate Matters webinar: Counting the cost of carbon emissions | https://www.youtube.com/watch?v=G2nqUbCoGx4 |
| | | | | | | | | | | | | Pep Canadell, Corinne Le Quéré, Glen Peters, Pierre Friedlingstein, Robbie Andrew, Rob Jackson, and Vanessa Haverd. 2019. Global emissions to hit 36.8 billion tonnes, beating last year's record high. The Conversation | https://theconversation.com/global-emissions-to-hit-36-8-billion-tonnes-beating-last-years-record-high-128113 |

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| 5.7 | Tracking ocean change: ocean observations and models | Changes in ocean heat and salinity affect the modes of climate variability that dominate Australia's climate, and impact on the frequency and magnitude of extreme events. To understand how the oceans may impact Australia's climate, it is important to understand how and why oceans are changing and how we can better project future changes. This project will improve, extend and deliver high quality ocean data which is vital for assessing ocean change. Analysis of ocean temperatures and salinity will be undertaken using ocean observations and model experiments to track and understand observed changes, and to identify and understand the key mechanisms of ocean heat uptake in our oceans. Model improvements will also be provided under the project to improve how ocean heat uptake is represented in ACCESS and other climate models, thereby improving climate change projections. | Bernadette Sloyan | CSIRO | 482,344 | 0 | 482,344 | 482,344 | **964,688** | 01.07.2019 | 31.12.2020 | Kennicutt MC, Bromwich, Liggett D, Njastad B, Peck L, Rintoul SR, Ritz C, Siegert MJ, Brooks CM, Cassano J, Chaturvedi S, Chen D, Dodds K, Golledge NR, Le Bohec C, Leppe M, Murray A, Chandrika Nath P, Raphael MN, Rogan-Rinnemore M, Schroeder DM, Talley L, Travouillon T, Vaughan DG, Wang L, Weatherwax AT, Yang H Chown SL. 2019. Sustained Antarctic Research: A 21st Century Imperative, One Earth Review, doi: 10.1016/j.oneear.2019.08.014 | https://www.sciencedirect.com/science/article/pii/S259033221930020X?via%3Dihub |
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| | | | | | | | | | | | | Rathore S, Bindoff NL, Ummenhofer CC, Phillips HE, Feng M. 2020. Near-Surface Salinity Reveals the Oceanic Sources of Moisture for Australian Precipitation through Atmospheric Moisture Transport, Journal of Climate, doi:10.1175/JCLI-D-19-0579.1 | http://ecite.utas.edu.au/141162 |
| | | | | | | | | | | | | Science webinar: Overview of the IPCC Special Report on the Oceans and Cryosphere in a Changing Climate | http://nespclimate.com.au/overview-of-the-ipcc-special-report-on-the-oceans-and-cryosphere-in-a-changing-climate/ |
| | | | | | | | | | | | | Hub Science Webinar: Australia's boundary current pathways to the deep ocean. | http://nespclimate.com.au/australias-boundary-current-pathways-to-the-deep-ocean/ |
| | | | | | | | | | | | | Chapman CC, Lea M, Meyer A. et al. 2020. Defining Southern Ocean fronts and their influence on biological and physical processes in a changing climate. Nature Climate Change,10, 209–219, doi:10.1038/s41558-020-0705-4 | https://www.researchgate.net/publication/339464542_Defining_Southern_Ocean_fronts_and_their_influence_on_biological_and_physical_processes_in_a_changing_climate |
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| | | | | | | | | | | | | Arroyo MC, Shadwick EH, Tilbrook B, Rintoul SR, Kusahara K. 2020. A continental shelf pump for CO2 on the Adélie Land coast, East Antarctica. Journal of Geophysical Research: Oceans, 125, e2020JC016302, doi: 10.1029/2020JC016302 | https://doi.org/10.1029/2020JC016302 |
| | | | | | | | | | | | | Marin M, Feng M, Phillips HE, Bindoff NL. 2021. A Global, Multiproduct Analysis of Coastal Marine Heatwaves: Distribution, Characteristics, and Long-Term Trends, Journal Of Geophysical Research-oceans, | https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2020JC016708 |
| | | | | | | | | | | | | Rathore S, Bindoff NL, Phillips HE, Feng M. 2020. Recent hemispheric asymmetry in global ocean warming induced by climate change and internal variability. Nature Communications, doi:10.1038/s41467-020-15754-3 | https://www.nature.com/articles/s41467-020-15754-3 |
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| | | | | | | | | | | | | Stewart KD, Hogg Amc, England MH. 2020. Response of the Southern Ocean Overturning Circulation to Extreme Southern Annular Mode Conditions, Geophysical Research Letters, 47 (22), doi: 10.1029/2020GL091103 | https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2020JC016354 |
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| | | | | | | | | | | | | Cowely, R., 2021 International Quality-controlled Ocean Database (IQuOD) v0.1: the temperature uncertainty specification. Frontiers in Marine Science, in preparation | https://doi.org/10.3389/fmars.2021.689695 |
| | | | | | | | | | | | | Tan Z, Reseghetti F, Abraham J, Cowley R, Chen K, Zhu J, Zhang B, Cheng L. 2021. Examining the Influence of Recording System on the Pure Temperature Error in XBT Data. Journal of Atmospheric and Oceanic Technology, doi:10.1175/JTECH-D-20-0136.1 | https://journals.ametsoc.org/view/journals/atot/aop/JTECH-D-20-0136.1/JTECH-D-20-0136.1.xml |
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| | | | | | | | | | | | | NESP Earth Systems and Climate Change (ESCC) Hub. 2021 Ocean knowledge supporting climate decisions. ESCC Hub Report No. 27. Earth Systems and Climate Change Hub, Australia. | https://nespclimate.com.au/wp-content/uploads/2021/06/ESCC_5.7_Ocean-knowledge-informing-climate-decisions.pdf |
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| | | | | | | | | | | | | Wallace LO, van Wijk EM, Rintoul SR, Hally B. 2020. Bathymetry-constrained navigation of Argo floats under sea ice on the Antarctic continental shelf. Geophysical Research Letters, 47, doi: https://doi.org/10.1029/2020GL087019 | https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2020GL087019 |
| 5.8 | Marine and coastal climate services for extremes information | Coastal and marine managers, engineers, industries and finance organisations have a keen interest in sea level rise and extreme sea levels. Information on marine heat waves is of key importance to fisheries and aquaculture industries. Relevant information targeted towards these end-users will deliver tangible benefits to the nation as climate risks become better understood and managed. This project will investigate and analyse a range of coastal and near-shore variables, such as sea level trends, current and future marine heat waves, extreme sea level, waves, estimates of ocean mass increases and the effects of wind, waves, sea level rise and storm surge on sediment compartments. The project will consolidate this information and previous information developed under previous Hub research and deliver the information through a platform that hosts a range of tools and data delivery mechanisms. Project researchers will work closely with key stakeholders in the development of the platform to ensure the information is readily available and other coastal tools are adequately linked in to enhance end-user understanding of past variability and future changes in events that cause extreme impacts in the coastal zone. | Kathleen McInnes | CSIRO | 656,250 | 19,031 | 637,219 | 656,250 | **1,312,500** | 01.07.2019 | 31.12.2020 | Marshall AG, Hemer MA, McInnes KL, 2019. Australian blocking impacts on ocean surface waves, *Climate Dynamics* , doi:10.1007/s00382-019-05058-8 | https://link.springer.com/article/10.1007/s00382-019-05058-8 |
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| | | | | | | | | | | | | Data set: Morim, J., Trenham, C., Hemer, M., Wang, X., Mori, N., Shimura, T., Timmermans, B., Mentaschi, L., Casas-Prat, M., Semedo, A., Dobrynin, M., Camus, P., Bricheno, L., Feng, Y. and Erikson, L. COWCLIP2.0 ocean wave climate and extremes statistics from CMIP5-driven wave models. Australian Ocean Data Network https://dx.doi.org/10.26198/5d91a9d00d60d (2019). | http://thredds.aodn.org.au/thredds/catalog/CSIRO/Climatology/COWCLIP2/catalog.html<br>And S3: http://imos-data.s3-website-ap-southeast-2.amazonaws.com/?prefix=CSIRO/Climatology/COWCLIP2/ |
| | | | | | | | | | | | | Dataset: CAWCR Global wind-wave 21st century climate projections.<br>Hemer, Mark; Trenham, Claire; Durrant, Tom; Greenslade, Diana (2015): CAWCR Global wind-wave 21st century climate projections. v2. CSIRO. Service Collection. https://doi.org/10.4225/08/55C991CC3F0E8<br>Available via CSIRO DAP THREDDS server. | http://data-cbr.csiro.au/thredds/catalog/catch_all/CMAR_CAWCR-Wave_archive/Global_wave_projections/catalog.html |
| | | | | | | | | | | | | Data product: Scientific data analysis code: marine heatwave detection<br>Release marineHeatWaves v0.16 · ecjoliver/marineHeatWaves · GitHub | Available via Github:<br>https://github.com/ecjoliver/marineHeatWaves<br>Last tagged release: v0.16:<br>https://github.com/ecjoliver/marineHeatWaves/releases/tag/v0.16 |
| | | | | | | | | | | | | Dataset: Extreme Water Levels for Australian Beaches using Empirical Equations for Shoreline Wave Setup<br>Citation: O'Grady, Julian; McInnes, Kathy; Hemer, Mark; Hoeke, Ron; Stephenson, Alec; Colberg, Frank; Trenham, Claire (2019): Extreme Water Levels for Australian Beaches using Empirical Equations for Shoreline Wave Setup. v1. CSIRO. Data Collection. https://doi.org/10.25919/5d1137055c162 | https://doi.org/10.25919/5d1137055c162 |
| | | | | | | | | | | | | Dataset: CAWCR Wave Hindcast – Aggregated Collection.<br>Durrant, Thomas; Hemer, Mark; Smith, Grant; Trenham, Claire; Greenslade, Diana (2019): CAWCR Wave Hindcast - Aggregated Collection. v5. CSIRO. Service Collection. http://hdl.handle.net/102.100.100/137152 | https://data-cbr.csiro.au/thredds/catalog/catch_all/CMAR_CAWCR-Wave_archive/CAWCR_Wave_Hindcast_aggregate/catalog.html |

| Project Number | Project Name | Project Summary | Project Leader | Lead Organisation | Approved Funding Research Plan Versions 1-6 | | | | | Start Date | Completion Date | Outputs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | NESP Funding* $ | Other Cash Contributions* $ | Other In-Kind Contributions* $ | Total Other Contributions* $ | Total Budget* $ | | | Outputs | Link to output |
| | | | | | | | | | | | | Echevarria ER, MA Hemer, NJ Holbrook and AG Marshall, 2020: Influence of the Pacific-South American modes on the global spectral wind-wave climate. Journal of Geophysical Research – Oceans, 125, e2020JC016354, https://doi.org/10.1029/2020JC016354. | https://eprints.utas.edu.au/34539/ |
| | | | | | | | | | | | | O'Grady J, Babanin A, McInnes K. 2019. Downscaling Future Longshore Sediment Transport in South Eastern Australia, Journal of Marine Science and Engineering, 7 (289), doi:10.3390/jmse7090289 | https://doi.org/10.3390/jmse7090289 |
| | | | | | | | | | | | | ESCC Hub Climate Matters webinar: Changing coastal hazards | https://www.youtube.com/watch?v=LUPSIx2DZjY |
| | | | | | | | | | | | | Smith GA, Hemer M, Greenslade D, Trenham C, Zieger S, Durrant T. 2020. Global wave hindcast with Australian and Pacific Island Focus: From past to present. *Geoscience Data Journal* , doi:10.1002/gdj3.104 | https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/gdj3.104 |
| | | | | | | | | | | | | Shimura T, Hemer M, Lenton A, Chamberlain MA, Monselesan D. 2020. Impacts of Ocean Wave-Dependent Momentum Flux on Global Ocean Climate. *Geophysical Research Letters,* doi: 10.1029/2020GL089296 | |
| | | | | | | | | | | | | Morim, J., Trenham, C., Hemer, M., Wang, X., Mori, N., Shimura, T., Timmermans, B., Mentaschi, L., Casas-Prat, M., Semedo, A., Dobrynin, M., Camus, P., Bricheno, L., Feng, Y. and Erikson, L. 2019. COWCLIP2.0 ocean wave climate and extremes statistics from CMIP5-driven wave models. Australian Ocean Data Network https://dx.doi.org/10.26198/5d91a9d00d60d | https://dx.doi.org/10.26198/5d91a9d00d60d |
| | | | | | | | | | | | | Updated sea level rise calculator tool, Canute3.0. | https://shiny.csiro.au/Canute3_0/ |
| | | | | | | | | | | | | Li Z, NJ Holbrook, X Zhang, ECJ Oliver and EA Cougnon, 2020: Remote forcing of Tasman Sea marine heatwaves. Journal of Climate, 33, pp. 5337-5354, doi: 10.1175/JCLI-D-19-0641.1 | https://eprints.utas.edu.au/33432/ |
| | | | | | | | | | | | | McInnes K, Kajtar J, Holbrook N, Hemer M, Hernaman V. 2021. Coastal climate services: A review of needs for coastal, marine and offshore applications. Earth Systems and Climate Change Hub Report No. 18, NESP Earth Systems and Climate Change Hub, Australia | https://nespclimate.com.au/wp-content/uploads/2021/06/ESCC_Coastal-climate-services_Report-18-.pdf |
| | | | | | | | | | | | | NESP Earth Systems and Climate Change Hub. 2021. Marine heatwaves in the Tasman Sea: future projections. | https://nespclimate.com.au/wp-content/uploads/2021/05/ESCC_Marine-heatwaves_Tasman-Sea_Factsheet.pdf |
| | | | | | | | | | | | | NESP Earth Systems and Climate Change Hub. 2021. Understanding future extreme sea level events for Sydney's beaches and harbour. | https://nespclimate.com.au/wp-content/uploads/2021/05/ESCC_Extreme-sea-level-events-for-Sydney_Factsheet.pdf |
| | | | | | | | | | | | | NESP Earth Systems and Climate Change Hub. 2021. Climate change services for Australia's blue economy. | https://nespclimate.com.au/wp-content/uploads/2021/05/ESCC_Climate-services-for-Australias-blue-economy_Factsheet.pdf. |
| | | | | | | | | | | | | NESP Earth Systems and Climate Change Hub. 2021. Insights into updating and using sea-level rise projections | https://nespclimate.com.au/wp-content/uploads/2021/05/ESCC_Sea-Level-rise-projections_Factsheet.pdf |
| | | | | | | | | | | | | NESP Earth Systems and Climate Change Hub. 2021. Marine heatwaves off Western Australia: future projections. | https://nespclimate.com.au/wp-content/uploads/2021/04/ESCC_WA-marine-heatwaves_Factsheet.pdf |

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| | | | | | **NESP Funding* $** | **Other Cash Contributions* $** | **Other In-Kind Contributions* $** | **Total Other Contributions* $** | **Total Budget* $** | | | **Outputs** | **Link to output** |
| | | | | | | | | | | | | Science webinar: Impacts of climate change and variability on ocean waves | http://nespclimate.com.au/impacts-of-climate-change-and-variability-on-ocean-waves/ |
| 5.9 | Natural habitats for coastal protection and carbon sequestration (NCCC - Phase 2) | Living shorelines have the potential to play important roles in climate mitigation and adaptation because of their ability to sequester carbon and/or reduce the threats of coastal erosion and flooding. However knowledge gaps remain around the value of natural habitats for coastal protection and carbon sequestration. This project will investigate the amount of carbon fixed by these natural habitats and ecosystems (blue carbon) and evaluation the potential for these ecosystems to contribute to national carbon accounting. To better understand the response of dune vegetation to event-scale extremes and the resulting consequences to coastal erosion, project researchers will undertake high resolution field surveying . The project also aims to develop the first national assessment of sediment accumulation, shoreline changes and wave attenuation from soft, hybrid and hard engineering solutions to provide local governments with the knowledge needed to inform coastal planning. | Stephen Swearer | University of Melbourne | 525,000 | 132,663 | 438,500 | 571,163 | **1,096,163** | 01.07.2019 | 31.03.2021 | O'Connor JJ, Fest, BJ, Sievers, M, Swearer, SE. Impacts of land management practices on blue carbon stocks and greenhouse gas fluxes in coastal ecosystems—A meta-analysis. Glob Change Biol. 2020; 00: 1– 13, doi: 10.1111/gcb.14946 | http://nespclimate.com.au/wp-content/uploads/2019/05/5.9_BCR-ms_GCB_v5_pre_print.pdf |
| | | | | | | | | | | | | ESCC Hub/NCCC. 2020. Understanding shoreline change on the Victorian coast: Apollo Bay, Great Ocean Road | http://nespclimate.com.au/wp-content/uploads/2020/07/A4-2p-NCCC-ApolloBay_WEB.pdf |
| | | | | | | | | | | | | ESCC Hub/NCCC. 2020. Understanding shoreline change on the Victorian coast: Cowes, South Gippsland | http://nespclimate.com.au/wp-content/uploads/2020/07/A4-2p-NCCC-cowes_WEB.pdf |
| | | | | | | | | | | | | ESCC Hub/NCCC. 2020. Understanding shoreline change on the Victorian coast: Inverloch, South Gippsland | http://nespclimate.com.au/wp-content/uploads/2020/07/A4-2p-NCCC-Inverloch_WEB.pdf |
| | | | | | | | | | | | | ESCC Hub/NCCC. 2020. Understanding shoreline change on the Victorian coast: Mounts Bay, Great Ocean Road | http://nespclimate.com.au/wp-content/uploads/2020/07/A4-2p-NCCC-MountsBay_WEB.pdf |
| | | | | | | | | | | | | ESCC Hub/NCCC. 2020. Understanding shoreline change on the Victorian coast: Ocean Grove, Barwon Coast | http://nespclimate.com.au/wp-content/uploads/2020/07/A4-2p-NCCC-OceanGrove_WEB.pdf |
| | | | | | | | | | | | | ESCC Hub/NCCC. 2020. Understanding shoreline change on the Victorian coast: Port Fairy | http://nespclimate.com.au/wp-content/uploads/2020/07/A4-2p-NCCC-PortFairy_WEB.pdf |
| | | | | | | | | | | | | ESCC Hub/NCCC. 2020. Understanding shoreline change on the Victorian coast: Lady Bay, Warrnambool | http://nespclimate.com.au/wp-content/uploads/2020/07/A4-2p-NCCC-warrnambool_WEB.pdf |
| | | | | | | | | | | | | ESCC Hub/NCCC. 2020. Understanding shoreline change on the Victorian coast: Anglesea, Great Ocean Road | http://nespclimate.com.au/wp-content/uploads/2020/07/A4-2p-NCCC-anglesea_WEB.pdf |
| | | | | | | | | | | | | ESCC Hub/NCCC. 2020. Understanding shoreline change on the Victorian coast: Seaspray, East Gippsland | http://nespclimate.com.au/wp-content/uploads/2020/07/A4-2p-NCCC-seaspray_WEB.pdf |
| | | | | | | | | | | | | Morris RL, Graham TDJ, Kelvin J, Ghisalberti M, Swearer SS. 2020. Kelp beds as coastal protection: wave attenuation of Ecklonia radiata in a shallow coastal bay, Annals of Botany, Volume 125 (2), 235–246, doi:10.1093/aob/mcz127 | https://academic.oup.com/aob/article/125/2/235/5551380 |
| | | | | | | | | | | | | Morris RL, Hale R, Strain EMA, Reeves SE, Vergés A, Marzinelli EM, Layton C, Shelamoff V, Graham TDJ, Chevalier M, Swearer SE. 2020. Key Principles for Managing Recovery of Kelp Forests through Restoration, BioScience, biaa058, https://doi.org/10.1093/biosci/biaa058 | https://academic.oup.com/bioscience/article/doi/10.1093/biosci/biaa058/5864934 |
| | | | | | | | | | | | | Morris RL, Bishop MJ, Boon P, Browne NK, Carley JT, Fest BJ, Fraser MW, Ghisalberti M, Kendrick GA, Konlechner TM, Lovelock CE, Lowe RJ, Rogers AA, Simpson V, Strain EMA, Van Rooijen AA, Waters E, Swearer SE. (2021) The Australian Guide to Nature-Based Methods for Reducing Risk from Coastal Hazards. Earth Systems and Climate Change Hub Report No. #. Earth Systems and Climate Change Hub, Australia | https://nespclimate.com.au/wp-content/uploads/2021/05/Nature-Based-Methods_Final_05052021.pdf |
| | | | | | | | | | | | | Morris RL, Graham TDJ, Kelvin J, Ghisalberti M, Swearer SS. 2020. Kelp beds as coastal protection: wave attenuation of Ecklonia radiata in a shallow coastal bay, Annals of Botany, Volume 125 (2), 235–246, doi:10.1093/aob/mcz127 | https://doi.org/10.1093/aob/mcz127 |

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| | | | | | | | | | | | | Konlechner TM, et al. 2020. Mapping spatial variability in shoreline change hotspots from satellite data; a case study in southeast Australia. Estuarine Coastal And Shelf Science, doi: 10.1016/j.ecss.2020.107018 | https://doi.org/10.1016/j.ecss.2020.107018 |
| | | | | | | | | | | | | Fest BJ, Arndt SK, and Swearer SE. A review of sediment carbon sampling methods and their impacts on stock estimates for blue carbon ecosystems. Science of the Total Environment (in revision). | |
| | | | | | | | | | | | | Threatened Species and ESCC Hub webinar series: Building climate resilience through natural habitats | https://www.nespthreatenedspecies.edu.au/events/climate-change-fire-and-biodiversity-webinar-series |
| | | | | | | | | | | | | Hu, Y., Fest, B.J. ,Swearer, S.E. , Stefan, S.K. Fine-scale spatial variability in aboveground and fine root biomass, necromass and sediment organic carbon in a temperate mangrove ecosystem: implications for estimating carbon stocks in blue carbon ecosystems. Science of the Total Environment (in revision) | |
| | | | | | | | | | | | | Morris RL, La Peyre MK, Webb BM, Marshall DA, Bilkovic DM, Cebrian J, McClenachan G, Kibler KM, Walters LJ, Bushek D, Sparks EL, Temple NA, Moody J, Angstadt K, Goff J, Boswell M, Sacks P. Swearer S.E. 2021. Evaluation of wave attenuation and shoreline stabilization by US Atlantic and Gulf coast oyster reef living shorelines. Ecological Applications 9in revision) | |
| | | | | | | | | | | | | ESCC Hub Climate Matters: Natural habitats for coastal protection and carbon sequestration | https://www.youtube.com/watch?v=IjZ7C2QRflc |
| | | | | | | | | | | | | Threatened Species and ESCC Hub webinar series: Building climate resilience through natural habitats | https://www.nespthreatenedspecies.edu.au/events/climate-change-fire-and-biodiversity-webinar-series |
| | | | | | | | | | | | | Morris RL, Boxshall A, Swearer SE. 2020. Climate-resilient coasts require diverse defence solutions. Nat. Clim. Chang. 10, 485–487, doi: https://doi.org/10.1038/s41558-020-0798-9 | https://doi.org/10.1038/s41558-020-0798-9 |
| **RESEARCH FACILITATION ACTIVITIES - RPV5-6** | | | | | | | | | | | | | |
| **CASE STUDIES AND INDIGENOUS ACTIVITIES** | | | | | | | | | | | | | |
| IA 6.1 | Second national Indigenous gathering on climate change - pathway to sustainable relationships (Indigenous Communities) | The 2018 National Indigenous Climate Change Dialogue received positive feedback from Indigenous and non-Indigenous attendees alike. It was agreed that this Dialogue was an important start to the conversation between Indigenous communities, the Hub and climate researchers. To continue this conversation and build on the relationships developed through the 2018 Dialogue and other Hub related Indigenous activities, the Hub has committed to supporting a second gathering in June 2020. In developing the second gathering, important findings from the first event will be considered, including greater representation of Indigenous communities across Australia. To this end, this gathering will be led by an expanded Indigenous Steering Committee who will facilitate the co-development of the gathering in 2020 with Indigenous peoples, scientists and relevant stakeholders, with support from the Hub. | Mandy Hopkins and Marian Sheppard | CSIRO | 300000 | 0 | 0 | 0 | **300,000** | 1/07/2019 | 31/03/2021 | Communiques from monthly Steering Committee meetings are available on case study webpage | http://nespclimate.com.au/supporting-the-development-of-an-indigenous-led-agenda-on-climate-change-knowledge-and-action/ |
| | | | | | | | | | | | | Report of the National First Peoples Gathering on Climate Change | https://nespclimate.com.au/outreach-publications/nesp-escc-report-gathering_web_interactive_4mb/ |
| | | | | | | | | | | | | Summary report of the National First Peoples Gathering on Climate Change | https://nespclimate.com.au/nfpgcc/nesp-escc-summary-report-gathering_web_interactive_2mb/ |

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| CS 6.4 | Integrated Environmental Assessment for Development Decisions (cross-NESP Hub) | Lack of knowledge can hinder decision-making when new opportunities for economic development are being explored. It also leaves industries, financiers and communities uncertain and risk-averse about investment and, importantly, places our environment at risk due to poorly informed decision-making. Integrated environmental assessment (IEA) is an interdisciplinary approach to combine, interpret and communicate information from diverse scientific disciplines and knowledge systems, to support decision making.<br>This collaborative project between all NESP Hubs will develop and demonstrate the value of a holistic approach to providing information for strategic decision-making for sustainable development. It will provide clear guidance to government and stakeholders about the existing information available, data needs, analysis approaches, and governance settings to support Integrated Environmental Assessment for northern Australia. | David Karoly | CSIRO | 39,593 | 0 | 0 | 0 | **39,593** | 1/01/2020 | 31/12/2020 | Workshop session 1: Overview of Intergrated environmental assessment | |
| | | | | | | | | | | | | Workshop session 2: Climate and biodiversity | |
| | | | | | | | | | | | | Workshop session 3: Economic, social and cultural | |
| **Total research facilitation costs** | | | | | **339,593** | **0** | **0** | **0** | **339,593** | | | | |
| **TOTAL RESEARCH COSTS** | | | | | **18,983,481** | **692,486** | **21,360,916** | **22,017,402** | **41,000,883** | | | | |
| **ENGAGEMENT ACTIVITIES**<br>Funded from the Comms & KB component of the budget | | | | | | | | | | | | | |
| EA6.5 | CLIMATE 2021 – a resilient and sustainable Australia | The CLIMATE2021 conference will provide an opportunity for attendees across government, industry and sectors to be provided with a synthesis of research across the climate change science community as a whole to build the capacity of attendees and to be used to inform decisions, policies and products. It will also provide multiple opportunities for networking between researchers, policy-makers, managers and planners, practitioners and communicators to build lasting relationships and partnerships. The conference will bring together researchers and policy makers from across multiple disciplines and may lead to the development of new projects, initiatives, communication products, and help to drive the climate change research agenda. | Mandy Hopkins and Marian Sheppard | CSIRO | 150000 | 0 | 0 | 0 | **150,000** | 1/07/2019 | 31/12/2020 | N/A | http://nespclimate.com.au/climate2021/ |
| EA6.7 | Synthesising research outcomes and impacts under the Earth Systems and Climate Change Hub | The Hub has undertaken world leading climate change science and has engaged with a variety of target user groups and stakeholders over its life time. Synthesising and communicating the outcomes and impacts of these research and knowledge brokering activities is important to show the value of the Hub and the investment provided through both the government and partner organisations. This research facilitation activity will deliver a range of synthesis products and activities across three levels during 2020 and 2021 to showcase the achievements, successes and research findings across the life of the ESCC Hub. | Sonia Bluhm | CSIRO | 65,000 | 0 | 0 | 0 | **65,000** | 1/01/2020 | 30/03/2021 | Whole of Hub synthesis report | https://nespclimate.com.au/wp-content/uploads/2021/06/NESP-Climate-Change-Hub-Climate-Change-in-a-Land-of-Extremes-Report-Web_med-res-1.pdf |
| | | | | | | | | | | | | Final webinar | https://www.youtube.com/watch?v=_zvAMjwAEn8&feature=emb_imp_woyt |
| | | | | | | | | | | | | ESCC Hub legacy site | https://nespclimate.com.au/ |
| **TOTAL HUB FUNDED ENGAGEMENT ACTIVITIES** | | | | | **215000** | **0** | **0** | **0** | **215000** | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **TOTAL ENGAGEMENT ACTIVITY COSTS (EXTERNALLY FUNDED ACTIVITIES NOT INCLUDED IN ATTACHMENT C)** | **0** | **150,000** | **0** | **150,000** | **150,000** | | | | | |

**COMPLETED CASE STUDIES RPV 2-6**

*Funded from the Comms & KB component of the budget*

| Project Number | Project Name | Project Summary | Project Leader | Lead Organisation | Approved Funding Research Plan Versions 1-6 | | | | | Start Date | Completion Date | Outputs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | NESP Funding* $ | Other Cash Contributions* $ | Other In-Kind Contributions* $ | Total Other Contributions* $ | Total Budget* $ | | | Outputs | Link to output |
| 3.1 | Climate change information products for Indigenous communities | In collaboration with the traditional owners of the Mackay region this case study continues to develop a package of 'Climate Change 101' information from across the Hub's research portfolio, for use by champion traditional owners in their outreach activities with the Traditional Owners group. The package includes a PowerPoint slide pack, technical written information and a video. The package has been developed in collaboration with traditional owners to ensure the information is relevant and accessible, and can be communicated by traditional owners to traditional owners. This scientific information, in combination with traditional knowledge from the region, is being used to help Indigenous communities prepare for the impacts of climate change on country. | Mandy Hopkins | CSIRO | 15,000 | | | 0 | **15,000** | 1/01/2017 | 31/12/2018 | Draft Climate Change 101 package (Power point slide) for use by the traditional owners of the Mackay region | N/A |
| 3.2 | Meeting Indigenous priorities for climate change information, capacity building and engagement | Discussing and understanding the climate science information needs of Indigenous communities will enable the Hub to better engage and be useful to these communities now and into the future. In partnership with CSIRO Land and Water's Collaborative and Indigenous Science team, Kimberley Land Council (KLC) and Seed (the Indigenous branch of the Australian Youth Climate Coalition, and Australia's first Indigenous youth-led climate network), the Hub is working to identify Indigenous priorities for climate-change focused information, capacity building and forms of engagement. A national workshop on this topic will be held in November 2018. Outputs from this workshop will provide input into future plans to meet the Hub's Indigenous engagement goal. This activity builds on previous Hub work with Indigenous communities to reach common understanding about priority needs. | Mandy Hopkins | CSIRO | 130,000 | | | 0 | **130,000** | 1/01/2017 | 30/06/2019 | Morgan M, Morgan-Bulled D, Hopkins M, Hill R, Talbot L, Lyons P, Sheppard M, Gorring A, Johnston S, Baldwin L, Karoly D, Bullio R, Bolzenius J, Brady L, Bux J, Clubb K, Clubb R, Clubb Z, Cooper S, Cushion A, Neal DP, Flugge K, Fourmile J, Gilbert J, Gilbert R, Gilbert Z, Gudju Gudju, Jakobi C, James L, Joseph J, Kerr B, Kulka A, Lawerence M, Liezenga K, Locke J, McNeair B, Martin J, Morgan G, Mumbulla M, Pattison A, Pattison M, Power A, Romagnoli Z, Steffensen K, Stuart H, Thompson S, Turpin G, Walker C, Wason S, Watkins S, Willis K, Wilson J, Whyman D, Chung C, Dobrohotoff P, Marsland S, Moise A, Ramsay H, Trenham C, Wilson B. 2019. Workshop Report: National Dialogue on Climate Change. Earth Systems and Climate Change Hub Report No. 11, NESP Earth Systems and Climate Change Hub, Australia. | http://nespclimate.com.au/wp-content/uploads/2019/05/191209-NICCD-report-final.pdf |
| 3.3 | Climate change impacts on inshore aquatic ecosystems and coastal communities in the Torres Strait Islands: A Workshop | Torres Strait Islander stakeholders want to learn more about the interdependencies between climate change and impacts on inshore fisheries, coral reefs, seagrass beds, mangroves and indigenous coastal communities. The Hub is working in partnership with the Torres Strait Regional Authority (TSRA) and Australian Fisheries Management Authority (AFMA) to explore the impact of climate change on marine ecosystems, fisheries and livelihoods in the Torres Strait Island area. Such knowledge would be based on the latest (CMIP5) regional projections for sea-level rise, sea surface temperature and ocean acidification, amongst other variables. | Mandy Hopkins | CSIRO | 5,000 | 5,000 | | 5,000 | **10,000** | 1/01/2017 | 31/12/2018 | Workshop report | http://nespclimate.com.au/wp-content/uploads/2016/03/ESCC-R004-TS-CC-fisheries-workshop-180601.pdf |
| 3.4 | Coastal climate adaptation with City of Greater Geelong | The City of Greater Geelong have expressed a need for additional interpretation and guidance on the selection of extreme sea level and sea-level rise scenarios for use by their coastal managers when using the SWIFT hydrodynamic model. The SWIFT model offers a innovative solution to investigating and mitigating urban flooding under climate change. Data61 have previously engaged with the City of Greater Geelong to investigate future flooding hotspots under extreme events and sea level rise using SWIFT. In this case study the Hub will work with Data61 and the City of Greater Geelong to design appropriate guidance material for the usage of SWIFT. | Mandy Hopkins | CSIRO | 5,000 | | | 0 | **5,000** | 1/01/2017 | 31/12/2018 | Impact story | http://nespclimate.com.au/wp-content/uploads/2019/05/A4-2p-impact-CFAST-WEB.pdf |
| 3.5 | Climate variability and change in Western Australia | The Western Australian Government is working to secure the water supply for Perth and the south-west of the state through a number of initiatives, including reducing water use, increasing water recycling and identifying new water sources (including desalination plants). The Government | Michael Grose | CSIRO | 5,000 | | | 0 | **5,000** | 1/01/2017 | 31/12/2017 | WA Government Stakeholder Engagement and Research Planning/Outreach Workshop | http://nespclimate.com.au/wp-content/uploads/2019/05/A4-2p-impact-CFAST-WEB.pdf |

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| | | (including desalination plants). The Government regularly engages with water users to support these initiatives and to educate and update their stakeholders about the outlook for water availability. Climate change information is an important component of these engagements. The Earth Systems and Climate Change Hub has prepared communication materials to help the Western Australian Government convey information about climate change to their users. | | | | | | | | | | Workshop report from the 2017 meeting in Perth | http://nespclimate.com.au/wp-content/uploads/2016/03/NESP-ESCC-Hub-SWWA-workshop-report-July-2018.pdf |
| 3.6 | Climate Change in Australia mobile website (a prototype) | Stakeholders and everyday Australians are use to accessing information on the go and in the' here and now'. The current suite of climate change projections provide a wealth of state of the art climate change projection information, including maps, tools and educational products. The development of a prototype of a mobile website for these climate change projections would mean that this information could be accessed at any time in any place, and would greatly extend the uptake and use of the climate change projections and research undertaken by the Hub. | Aurel Moise | Bureau of Meteorology | 15,000 | | | 0 | **15,000** | 1/01/2017 | 31/12/2017 | Development of a prototype mobile website/app | http://climate-data.it.csiro.au/webapp/index.shtml |
| 3.7 | Climate Change for Councils (pilot) | Many climate change impacts will be experienced at regional and local levels, so councils may often be best placed to manage these risks. The ESCC Hub is well positioned, both as a producer and curator of the latest climate change science, to empower local councils with the confidence and understanding to use climate change science products to inform their decision making. The Hub will work with one or two regional Victorian councils to develop useful knowledge brokering and communication resources that package climate information for the councils in a way that is useful and accessible for their needs and audiences. These knowledge products will be drawn from across all the Hub's research portfolio. | Mandy Hopkins | CSIRO | 7,228 | | | 0 | **7,228** | 1/01/2017 | 31/12/2017 | Council Roadshow - meetings and discussions were had with 6 councils around how the Hub could engage with them and their climate change information needs | http://nespclimate.com.au/wp-content/uploads/2018/08/A4-2p-impact-LG-CC-info-needs-web.pdf |
| 3.8 | Web delivery portal for coastal hazards information | The CSIRO and ACE CRC web page, http://www.cmar.csiro.au/sealevel/ has been the primary vehicle for communicating sea level science and delivering key data sets to the broader scientific community that were developed as part of the former *Australian Climate Change Science Programme.* This case study significantly upgraded the sea-level web page to a more secure and user-friendly platform and at the same time enhance its utility. This has been done by providing existing extreme sea level information requested by the broader community, providing additional information on coastal hazards, enhancing its user base and creating an effective platform for the delivery of new information that is planned through Project 2.10. | Kathleen McInnes | CSIRO | 10,000 | | | 0 | **10,000** | 1/01/2017 | 31/12/2017 | Web delivery portal for engaging with the coastal community | Sea Level, Waves & Coastal Extremes website |
| 3.9 | Practical and empowering responses to coastal erosion | Local Tiwi Islander people often struggle to relate the big scales of climate impacts science to the local, social and environmental processes that are important and relevant to them. Solutions to climate change impacts in the coastal zone require solutions focused science that co-produces knowledge and practices with relevant stakeholders to inspire and enable local communities to act on their values and goals for the future. Previous engagement with the Tiwi around climate change alarmed local residents and escalated feelings of powerlessness. This case study is worked to educate local communities about climate adaptation and provide practical guidance for what actions can be implemented to help address coastal erosion in the Islands. | David Kennedy and Jon Barnett | University of Melbourne | 5,000 | | | 0 | **5,000** | 1/01/2017 | 31/12/2017 | Tiwi Island workshop report | http://nespclimate.com.au/wp-content/uploads/2016/03/Workshop-report-Tiwi-Islands_Climate-Change-Adaptation-Report.pdf |

| Project Number | Project Name | Project Summary | Project Leader | Lead Organisation | Approved Funding Research Plan Versions 1-6 | | | | | Start Date | Completion Date | Outputs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | NESP Funding* $ | Other Cash Contributions* $ | Other In-Kind Contributions* $ | Total Other Contributions* $ | Total Budget* $ | | | Outputs | Link to output |
| 4.1 | Test case for datasets and information for managing climate risk in the Australian banking and finance sector | There has recently been a new focus and awareness of climate risks for corporate Australia. The finance and banking industries in particular have begun to engage in this area and have expressed a pressing need to assess what climate change risk means for their business. However existing climate change projections information and data are not tailored to their specific needs. This case study tests the utility of climate change projections for the banking and finance sector to demonstrate how climate change projections information can be readily applied to decision-making in these sectors. The case study provides a starting point for a process of partnering and delivering information for this growing need. This case study demonstrates the path to impact of Hub research from Projects 2.6 (regional projections) and 2.8 (extremes projections). | Dr Michael Grose/ Dr Andrew Dowdy | Bureau of Meteorology and CSIRO | 15,000 | | 20,000 | 20,000 | **35,000** | 1/01/2018 | 31/12/2018 | Case study report | http://nespclimate.com.au/wp-content/uploads/2019/07/ESCC-R010-case-study-4.1-report.pdf |
| 4.2 | Potential for carbon abatement by revegetation and conservation in Australia - Stakeholder engagement and status report | Revegetation and conservation in Australia may have great potential to contribute to achieving the mitigation targets of the Paris Agreement. Current estimates of this potential are limited to a few studies, none of which have been able to adequately address the opportunities and limitations of the biophysical and socio-economic worlds. This case study aimed to identify existing vegetation/carbon information and tools available to policy makers, and identify gaps and needs that will inform future research directions. The case study aimed to leverage primarily off activities and outputs (key data and information) being delivered through Project 2.9. | Dr Pep Canadell | CSIRO | 10,000 | | 10,000 | 10,000 | **20,000** | 1/01/2018 | 31/12/2018 | N/A - case study closed. More information available at: http://nespclimate.com.au/understanding-information-needs-for-carbon-policy/ | |
| 4.3 | Communicating projected changes in hydroclimate affecting water supply in South-West Western Australia (SWWA) | This case study develops useful communication products for the Western Australian water sector to facilitate the application of science to water management. In particular, the case study addresses two priority needs 1) demonstration of 'science to management' as an exemplar of the use of existing climate science to inform WA water resource planning and management, and 2) communication products for key stakeholders on climate variability, extremes and reliability of water supply in a changing climate. | Dr Dewi Kirono and Dr Francis Chiew | CSIRO | 5,000 | | 5,000 | 5,000 | **10,000** | 1/01/2018 | 31/12/2018 | Case study report | http://nespclimate.com.au/wp-content/uploads/2019/05/A4-2p-impact-SWWA-WEB.pdf |
| 4.5 | Framework for determining the net socio-economic benefits of Earth systems and climate change science and services | The ESCC Hub supports a diverse portfolio of scientific research and service delivery to address stakeholder needs and to realise outcomes relevant to Australia's national interest. This case study developed a preliminary/ conceptual cost-benefit framework designed to measure the short to long-term value of the Hub's research outputs to the Australian economy and society more generally. It also demonstrates the practical application of this framework as part of a virtual analysis designed to quantify the net social and economic value of the investment into selected areas of ESCC Hub science of direct relevance to selected key stakeholders. | Dr David Newth | CSIRO on behalf of the ESCC Hub partners | 65,000 | | 65,000 | 65,000 | **130,000** | 1/01/2018 | 31/12/2018 | Case study report | http://nespclimate.com.au/wp-content/uploads/2020/04/ESCC-Hub_CS4.5-summary-report.pdf |
| 4.6 | Multi-disciplinary approach to understanding climate change impacts and exploring climate sensitive management solutions for the Great Barrier Reef | Carbon dioxide absorbed into the oceans is driving ocean acidification, which poses a threat to marine ecosystems, particularly reefs. Better regional data on the likely impacts of climate change on the Great Barrier Reef will be important for management and decision making and can be applied to the management of other Ramsar areas. This case study aimed to undertake a multi-disciplinary approach to build consensus amongst stakeholders on how we can move from near-term understanding of climate impacts, to exploring the projected climate future of the Great Barrier Reef under different emissions pathways. The case study aimed to determine the best and most accessible way to present and make this information available to stakeholders. | Dr Andrew Lenton and Dr Mark Baird | CSIRO | 25,000 | | 25,000 | 25,000 | **50,000** | 1/01/2018 | 30/06/2019 | N/A - case study closed | N/A |

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| 4.4 | Climate change impacts on threatened species and ecosystems – preliminary review and scoping | There is a growing body of work on the impact of climate change on threatened species and ecosystems/ecosystem services. However ecological analysis and weather and climate research are often not well connected. This case study demonstrates how the application of the Hub's research in improving understanding of climate feedbacks and key climate processes (including clouds) can be used to assess climate change impacts on threatened species and ecosystems. The Hub partnered with the World Heritage Australia, the NESP Threatened Species Recovery Hub and key agencies (i.e. Qld Herbarium) to bring together complementary skills and expertise in climate change, micro- and meso-scale meteorology, land surface feedback and ecology to address information gaps and needs in two specific areas of interest to key stakeholders: 1) climatic change, cloud caps and cloud forest ecosystems affecting threatened plant communities in the Lamington National Park World heritage Area of SE Qld, and 2) climatic change and the conditions impacting distribution and abundance and critical habitat for the Greater Glider in SE Australia. This case study raises awareness of the importance of factoring in climate change as a key environmental stressor for threatened species. | Dr Rob Colman and Rachel Morgain (TSR Hub) | Bureau of Meteorology and CSIRO | 20,000 | | 20,000 | 20,000 | **40,000** | 1/01/2018 | 30/10/2019 | Gondwana rainforest section - fact sheet and workshop report | http://nespclimate.com.au/wp-content/uploads/2019/03/Gondwana-CC-workshop-report.pdf |
| | | | | | | | | | | | | Determining climate change impacts on Victoria's greater gliders (case study fact sheet) | https://nespclimate.com.au/wp-content/uploads/2019/10/A4-2p-impact-greater-glider-191001-2.pdf |
| CS 5.1 | Understanding the impact of climate change on flowering induction in mango in the Northern Territory | Rising minimum and maximum temperatures will affect flower induction of current commercially produced mango cultivars and those from the National Mango Breeding Program . This case study will provide and support the application of climate change information to the NT mango industry so the precise effects of minimum and maximum temperatures for these cultivars can be determined. This will allow the industry to consider an appropriate management response. To ensure the maximum value is realised from the impact assessment, a climate literacy intervention will also be included based on a workshop and supporting explainer products. | Mandy Hopkins | CSIRO | 40,000 | 0 | 0 | 0 | **40,000** | 1/01/2019 | 31/12/2020 | Workshop report: Impact of climate change on mango production in the Northern Territory | http://nespclimate.com.au/wp-content/uploads/2019/05/NT-mango-expert-meeting-report-WEB.pdf |
| | | | | | | | | | | | | Workshop summary: Impact of climate change on mango production in the Northern Territory | http://nespclimate.com.au/wp-content/uploads/2019/05/A4-2p-workshop-summary-NT-mangoes-WEB.pdf |
| | | | | | | | | | | | | Case study fact sheet: Understanding the impact of climate change on the Northern Territory mango industry | http://nespclimate.com.au/wp-content/uploads/2019/05/A4-2p-cs-factsheet-NT-mangoes-WEB.pdf |
| | | | | | | | | | | | | Final report: Impact of climate change on flowering induction in mangoes in the Northern Territory | http://nespclimate.com.au/wp-content/uploads/2019/05/CC-NT-mango-flowering-TR-final.pdf |
| | | | | | | | | | | | | Fact sheet: Conducting a climate change health check on temperature thresholds for mango production in the Northern Territory | http://nespclimate.com.au/wp-content/uploads/2019/05/A4-2p-IA-process-NT-mangoes_web.pdf |
| | | | | | | | | | | | | Fact sheet: Changing number of suitable days for initiating mango flowering in the Northern Territory | http://nespclimate.com.au/wp-content/uploads/2019/05/A4-2p-IA-results-NT-mangoes_web.pdf |
| | | | | | | | | | | | | Fact sheets: What do fewer inductive days mean for mango cultivars in Katherine | http://nespclimate.com.au/wp-content/uploads/2019/05/A4-2p-mango-IA-results-factsheet-Katherine_web.pdf |
| | | | | | | | | | | | | Fact sheets: What do fewer inductive days mean for mango cultivars in Kununurra | http://nespclimate.com.au/wp-content/uploads/2019/05/A4-2p-mango-IA-results-factsheet-Kununurra_web.pdf |
| | | | | | | | | | | | | Fact sheets: What do fewer inductive days mean for mango cultivars in Darwin | http://nespclimate.com.au/wp-content/uploads/2019/05/A4-2p-mango-IA-results-factsheet-Darwin_web.pdf |
| | | | | | | | | | | | | Clonan M, Hernaman V, Pearce K, Hopkins M, Moise A and McConchie C. 2020. Impact of climate change on flowering induction in mangoes in the Northern Territory, Earth Systems and Climate Change Hub Report No. 16, NESP Earth Systems and Climate Change Hub, Australia. | http://nespclimate.com.au/wp-content/uploads/2019/05/CC-NT-mango-flowering-TR-final.pdf |
| | | | | | | | | | | | | Science webinar: Understanding the impact of climate change on the Northern Territory mango industry | http://nespclimate.com.au/science-webinar-understanding-the-impact-of-climate-change-on-the-nt-mango-industry/ |
| | | | | | | | | | | | | ECOS article: Understanding climate change impacts on mangoes in the Northern Territory | https://ecos.csiro.au/climate-change-nt-mangoes/ |
| | | | | | | | | | | | | Case study technical scope summary | http://nespclimate.com.au/wp-content/uploads/2019/05/Mango-CS-scope-summary.pdf |

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| CS 5.2 | Using climate change information in a Gondwana Rainforest WHA climate change adaptation plan | There are gaps in the scientific understanding of projected climate change impacts on the Gondwana Rainforest World Heritage Area, particularly changes to cloud cover. Cloud cover is an important environmental variable for the property because cloud and fog provide up to half of the annual vegetation water requirements in high elevation forests. This case study will develop lifting condensation level projections, to provide information about changes to the cloud base in a changing climate, to complement existing temperature and rainfall projections. This information can be used to inform the development of a climate change adaptation plan for the Gondwana Rainforests WHA. | Mandy Hopkins | CSIRO | 35,500 | 0 | 0 | 0 | **35,500** | 1/01/2019 | 31/12/2020 | Case study report | http://nespclimate.com.au/informing-world-heritage-area-climate-change-adaptation-planning/ |
| | | | | | | | | | | | | Threatened Species and ESCC Hub webinar series: Evidence based planning for resilient World Heritage Areas | https://www.nespthreatenedspecies.edu.au/events/climate-change-fire-and-biodiversity-webinar-series |
| | | | | | | | | | | | | Science webinar: Informing climate change adaptation planning for the Gondwana Rainforests of Australia World Heritage Area: Melinda Laidlaw (Qld Department of Environment and Science) and Sugata Narsey (Bureau of Meteorology) | http://nespclimate.com.au/science-webinar-informing-climate-change-adaptation-planning-for-the-gondwana-rainforests-whas/ |
| CS 5.3 | TasLab Engage | Extreme climate events impact a number of sectors across Tasmania, including water, agriculture, aquaculture and emergency response. These events are costly and difficult to plan for. Information on the form these extremes might take over the coming years, their past variability and guidance on the use of relevant climate information would assist with planning for these events. TasLab Engage facilitates engagement between industry groups and scientists to understand industry-specific climate sensitivities and identify the relevant climate information required - at the multi-year to decadal timescales. It has the potential to assist with better management of climate sensitive systems and increase resilience to climate extremes in Tasmania. The findings from this case study will directly inform the CSIRO's Decadal Forecast Project to ensure climate information and predictions resulting from this large project are aimed at stakeholder needs. | Sonia Bluhm | CSIRO | 50,000 | 0 | 50,000 | 50,000 | **100,000** | 1/01/2019 | 31/04/2020 | Tozer C, Risbey J, Bluhm S, Remenyi T. 2020. Industry engagement to identify climate sensitive decisions on multi-year timescales: TasLab Engage Final Report. Earth Systems and Climate Change Hub Report No. 13, NESP Earth Systems and Climate Change Hub, Australia. | http://nespclimate.com.au/wp-content/uploads/2020/04/ESCCHub_TasLabEngage_report_Final.pdf |
| | | | | | | | | | | | | Science webinar: 'TasLab Engage': Industry engagement to identify climate sensitive decisions on multi-year timescales - Carly Tozer (CSIRO) | http://nespclimate.com.au/science-webinar-industry-engagement-to-identify-climate-sensitive-decisions/ |
| IA 5.5 | Indigenous perspectives on climate risk (Indigenous Communities) | Indigenous peoples in Australia form the majority of populations in many remote highly vulnerable environments where climate change impacts on their country are already evident, including extreme weather events, climate variability and sea level change. For all Indigenous peoples in Australia, and most globally, climate change compounds over-arching issues of socio-economic disadvantage, chronic poor health, and the burdens of the colonial history of dispossession and hostile policy settings. Indigenous peoples bring a particular perspective of climate risk related to their particular socio-economic, historical, political, cultural and environmental circumstances. This results in perceptions that are often specific to communities and their cultures, places and regions with distinctive community values, resource and policy circumstances. Understanding these risk perceptions can potentially set the foundation for new pathways of research collaboration to better tailor climate science and information to meet Indigenous communities. This is a Indigenous-led project based on two case studies, (Shark Bay World Heritage Site and Central Land Council Ranger Groups community) which will work with Indigenous peoples on two-way sharing of climate risk that will contribute to place-based risk reduction strategies. | Mandy Hopkins and Marian Sheppard | CSIRO | 133,803 | 0 | 0 | 0 | **133,803** | 1/01/2019 | 31/03/2021 | Lyons, I., Harkness, P., Raisbeck-Brown, N. and Malgana Aboriginal Corporation Board, Rangers and Malgana Elders (2021) [Indigenous perspectives of risk. Learning and sharing knowledge for climate change. Workshop report 8th -12th of March 2021. Denham, Western Australia]. Earth Systems and Climate Change Hub Report No. #29. Earth Systems and Climate Change Hub, Australia. | https://nespclimate.com.au/wp-content/uploads/2021/06/ESCC_-Indigenous-perspectives-of-risk_Report-30.pdf |
| | | | | | | | | | | | | Lyons I and Harkness PL (2021) *Sources of resilience, vulnerabilities and uncertainties in Indigenous Peoples' adaptative capability to climate change: A synthesis from recent literature* . Earth Systems and Climate Change Hub Report No. 31. Earth Systems and Climate Change Hub, Australia. | https://nespclimate.com.au/wp-content/uploads/2021/06/ESCC_Sources-of-resilience_Report-31.pdf |
| CS 5.4 | Climate Change Literacy (climate change 101) (State Government/ Local Government) | Stakeholder feedback over the past three years of the Hub indicates that there is still a lot of stakeholder uncertainty about how the climate system works, how the climate is changing and what climate change projections actually tell us. Existing climate change information (e.g. Climate Change in Australia) is not readily accessed, understood and applied to inform decision and policy making. This case study is preparing a climate change capability development package that will consist of a half-day training session and supplementary information materials. The package will provide participants/users with a better understanding of the climate system, an appreciation of climate change science, and the | Mandy Hopkins | CSIRO | 71,250 | 0 | 0 | 0 | **71,250** | 1/01/2019 | 31/12/2020 | NESP Earth Systems and Climate Change Hub. 2020. Building capacity to use climate change information, Earth | http://nespclimate.com.au/wp-content/uploads/2020/05/CC101-Hub-activity-report.pdf |
| | | | | | | | | | | | | Systems and Climate Change Hub Report No. 22, NESP Earth Systems and Climate Change Hub, Australia. | http://nespclimate.com.au/science-webinar-building-partnerships-for-robust-climate-risk-assessments/ |
| | | | | | | | | | | | | NESP Earth Systems and Climate Change Hub. 2020. Climate change in the Northern Territory: state of the science and climate change impacts. NESP ESCC Hub, Australia. | https://nespclimate.com.au/wp-content/uploads/2020/10/ESCC-Hub_Climate-change-in-NT-state-of-the-science-and-climate-impacts.pdf |

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| | | confidence to find and use climate change information to inform decisions. The package includes guidelines for a rapid climate change impact assessment methodology that can be applied across all sectors to co-produce climate change information and facilitate its use in decision making. | | | | | | | | | | Climate Change Literacy sessions have been held with a range of stakeholders including the mango industry, DEWLP, with Australian Government representatives during the Hub's Road Show 23-24 September 2019 | http://nespclimate.com.au/training/ |
| CS 5.6 | Climate measurement standards initiative | In response to the Recommendations of the Task Force on Climate-related Financial Disclosures many organisations in the Australian financial services sector are now beginning to explore the use of science-based scenario analysis of the physical impacts of climate change as part of their strategic planning, risk management processes and financial disclosures. There are however no agreed standards in place to underpin industry efforts and reporting to date is fragmented and inconsistent in scope and quality with respect to use of relevant peer-reviewed science. To support the use of high-quality, science-based climate change data and information to inform such analysis and related decision-making and reporting, the industry-led Climate Measurement Standards Initiative (CMSI) has been formed. The Hub will provide scientific expertise and advise to this initiative to ensure standards and outputs developed under this case study are based on credible and up-to-date climate change science and knowledge. | Geoff Gooley | CSIRO | 150,000 | 0 | 0 | 0 | **150,000** | 1/01/2019 | 31/12/2020 | Earth Systems and Climate Change Hub. 2020. Scenario analysis of climate-related physical risk for buildings and infrastructure: climate science guidance. Technical report by the National Environmental Science Program (NESP) Earth Systems and Climate Change Science (ESCC) Hub for the Climate Measurement Standards Initiative, ESCC Hub Report No.21. | https://www.cmsi.org.au/reports |
| | | | | | | | | | | | | ESCC Hub science webinar | http://nespclimate.com.au/science-webinar-scenario-analysis-of-climate-related-physical-risk-2/ |
| | | | | | | | | | | | | Science webinar: Scenario analysis of climate-related physical risk for buildings and infrastructure – Guidelines from the Climate Measurement Standards Initiative - Sarandjit Paddam (QBE), Micheal Grose (CSIRO) and Andrew Dowdy (Bureau of Meteorology) | http://nespclimate.com.au/science-webinar-scenario-analysis-of-climate-related-physical-risk-2/ |
| CS 5.7 | National Disaster Risk Information Services Capability (NDRISC) Pilot Project (Federal Government) | Increased information on changes in natural disaster risks due to climate change is needed by all sectors of Australian society, business and government to inform their decision-making and planning. The ESCC Hub is participating in a pilot project through the National Resilience Taskforce in the Department of Home Affairs to demonstrate the benefits of considering climate change in a national disaster risk information services capability, using the Australian freight and supply chain network as the example. The goal of the study is to support a business case for longer term funding of NDRISC. | David Karoly | CSIRO | 5,000 | 0 | 0 | 0 | **5,000** | 1/01/2019 | 31/12/2019 | Karoly D. 2021. Input by the Earth Systems and Climate Change Hub into the National Disaster Risk Information Services Capability (NDRISC) Pilot Project, Earth Systems and Climate Change Hub Report No. 24, NESP Earth Systems and Climate Change Hub, Australia. Case study summary report | http://nespclimate.com.au/wp-content/uploads/2021/01/NDRISC-case-study-5.7-report_final_21Jan2021.pdf |
| IA 6.2 | Supporting Indigenous participation at AMOS 2020 conference (Indigenous Communities) | The first ever Indigenous session was held at the 2019 Australian Meteorological and Oceanographic Society (AMOS) conference in Darwin. Traditional Owners were invited to present on their perspective of climate change and risks to their country, as well as community led solutions contributing to climate change mitigation while generating income for communities. This activity will support another Indigenous session to be convened at the next AMOS, February 2020 in Fremantle. The Indigenous discussion and workshop session is entitled 'Cross-cultural communication and climate will enable Indigenous people, their partners and science communication practitioners to share experiences in climate science communication. A workshop report will identify and report on key insights from the session. | Mandy Hopkins and Marian Sheppard | CSIRO | 36,500 | 0 | 0 | 0 | **36,500** | 1/07/2019 | 31/12/2020 | Workshop summary | http://nespclimate.com.au/wp-content/uploads/2020/03/A4-2p-AMOS-TO-workshop-summary.pdf |
| | | | | | | | | | | | | Blog 'Co-design, cross-cultural communication and climate change' | http://nespclimate.com.au/co-design-cross-cultural-communication-and-climate-change/ |

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| CS 6.3 | Adapting to climate change and building resilience in Australian World Heritage properties: using climate change science information and traditional knowledge to inform risk and vulnerability assessments and adaptation planning | The continued protection of World Heritage properties across Australia (and indeed, the world) requires improved understanding about the current and future impacts of climate change on their Outstanding Universal Values, and credible information and risk assessment processes to respond effectively to likely changes and build resilience. World Heritage properties are important assets, with natural sites providing ecosystem benefits, such as water and climate regulation and carbon storage in forested sites. Additionally, their inter-connected cultural heritage values can convey traditional knowledge that builds ecological and social resilience for change. This case study will develop a methodology for using science-based climate change information to inform the development of a climate change risk or vulnerability assessment that can then form the basis for preparation of adaptation plans to build the resilience of World Heritage properties to climate change. | Mandy Hopkin | CSIRO | 150,000 | 0 | 0 | 0 | **150,000** | 1/01/2020 | 31/03/2021 | Hill R, Visschers L (2021) *K'gari and Climate Change Assessment and Planning: Draft Literature Review*. Earth Systems and Climate Change Hub Report No. 28. Earth Systems and Climate Change Hub, Australia. | Coming soon |
| EA6.6 | Improving the functionality, utility and accessibility of information on the Climate Change in Australia (CCiA) website | The Climate Change in Australia (CCiA) website was developed in 2015/16 in consultation with NRM planners to address their climate change information needs. However, almost 5 years later it is clear that the needs of some climate change projections users have changed and grown, with new users emerging with different requirements that were not considered at the time of development. As a result, a refresh to the navigation functions of the website and improved accessibility of key information and data is required. This activity will conduct a user needs survey to determine ways to improve the accessibility of information in the website and will be informed by a user reference group of key stakeholders to test and advise on planned improvements to the website. This activity will also look at partnering with the Electricity Sector Climate Information (ESCI) project to share resources and ensure the needs of the energy sector, as well as other existing user needs, are met. Improving the user experience of the CCiA website and the functionality, utility and accessibility of information, data and tools within the website. This will assist in ensuring that climate change projections information is better able to be applied by target user groups to inform policy development, management planning, and risk assessments. | Sonia Bluhm and Mandy Hopkins | CSIRO | 15,000 | 0 | 0 | 0 | **15,000** | 1/09/2019 | 31/12/2020 | The refreshed website can be accessed via: | www.climatechangeinaustralia.gov.au |
| | | | | | | | | | | | | Blog post: Refreshing the Climate Change in Australia website to make it easier to navigate and find the climate change projections information you need | http://nespclimate.com.au/refreshing-the-climate-change-in-australia-website/ |
| **TOTAL CASE STUDY/TARGET USER GROUP ACTIVITIES COSTS (RPV1-6)** | | | | | **317,228** | **5,000** | **125,000** | **130,000** | **447,228** | | | | |

## Theme title

**Co-produced climate vulnerability and impact assessments for future-proofed industries**

## Theme description

Producing world-class climate science and data is one important step along the path towards a more climate-resilient Australia. The Earth Systems and Climate Change Hub has significantly contributed towards this step. However, climate science and data are certainly not the end of the story. Many Australian stakeholders need support in accessing, understanding, incorporating and using this information for decision-making purposes.

The Hub has therefore focused on co-designing and producing climate information and tools with stakeholders. This has built the capacity of our stakeholders to use climate information to assess their climate vulnerability, impacts and risks. The use of co-design principles in Hub activities has resulted in an increase in the uptake and use of our climate change information, resulting in more informed and prepared industries in Australia.

The Hub has showcased the benefits of co-designing climate change research and communications with industries through a range of activities, including:

- Working with the Northern Territory mango industry to determine future climate risks and thresholds for mango production.
- Collaborating with the Australian financial services sector to produce scientific guidelines for climate-related financial risk reporting and disclosure.
- Co-producing regional climate change projections with World Heritage Area managers on future water availability for the Gondwana Rainforests.
- Conversations with Tasmanian industries to better understand the decisions they make on annual to multi-year timescales that can be influenced by climate outcomes.

## Impact snap shots

*Climate change impacts assessment for the NT mango industry*

Mangoes are the Northern Territory's largest horticultural crop. Mango production depends on flowering of mango trees, which is likely to be affected under a changing climate. Working with the NT Department of Primary Industry and Resources, the Hub carried out an impact assessment to determine future impacts and thresholds for the industry. The assessment suggests a future decline in conditions suitable for triggering flowering, but that the decline will not be the same across the 12 growing regions considered. With this information, the industry can make more informed planning decisions about mango production.

*Climate change science to inform climate-related financial risk and disclosure*

Australia's financial services sector is increasingly considering the physical impacts of climate change on their operations, risk management, planning and financial disclosures. To inform these activities, the Hub provided climate change expertise and data to the industry-led Climate Measurement Standards Initiative (CMSI), which developed science-based standards for scenario analysis of climate-related financial risk and disclosure. The standards allow for better reporting of physical risk, providing better risk information – and so, better decisions – for investors.

*Climate change information for the Gondwana Rainforests of Australia World Heritage Area*

The impacts of climate change are already being experienced in the Gondwana Rainforests World Heritage Area. Rainforest managers need information about future climate conditions, including rainfall and cloud cover, to plan and respond to climate impacts. Working with Gondwana Rainforests managers, the Hub conducted a climate-risk assessment. This indicates that by 2070 the rainforests can expect a continued temperature increase, a decline in humidity and moderate increases in the elevation of the area's cloud base. These impacts may have significant implications for cloud-water dependent species and may increase water stress for some species.

*Working with Tasmanian industry to determine their multi-year climate forecast needs*

Climate information and forecasts on the multi-year to decadal timescales would benefit many Australian sectors and industries, including agriculture, horticulture and water management. This is still an emerging area of global and Australian science capability. The Hub teamed up with the CSIRO Decadal Climate Forecasting Project to facilitate engagement between industry groups and scientists to better understand industry-specific climate sensitivities and identify climate information required for industry decision-making. This valuable stakeholder information will contribute to the development of applications for multi-year to decadal forecasts.

## Research outputs

**Relevant ESCC Hub projects**:

Case study 5.1: Understanding the impact of climate change on the Northern Territory mango industry

Case study 5.6: Climate Measurement Standards Initiative

Case study 5.2: Using climate change information in a Gondwana Rainforests of Australia World Heritage Area climate change adaptation plan

Case study 5.3: TasLab Engage

**Synthesis products and case study reports:**

NT mangoes case study final report: nespclimate.com.au/wp-content/uploads/2019/05/CC-NT-mango-flowering-TR-final.pdf

CMSI science guideline available from: www.cmsi.org.au/reports

Gondwana case study final report: http://nespclimate.com.au/wp-content/uploads/2020/09/Gondwana-LCL-CS-TR-final.pdf

TasLab Engage final report: http://nespclimate.com.au/wp-content/uploads/2020/04/ESCCHub_TasLabEngage_report_Final.pdf

## Images and video

**Related videos:**

No videos available

**Introduction page image:**

**Co-design and co-production of climate change science activities has resulted in multi-benefits for the Earth Systems and Climate Change Hub and our key stakeholders.** *Image: CSIRO*

**Snapshot images:**

Mango industry snapshot: **Climate change is likely to result in a future decline in conditions suitable for triggering mango flowering in some NT regions.** Image: © treetstreet/Adobe Stock


**Financial risk and disclosure snapshot image: Australia's financial services sector is increasingly considering the physical impacts of climate change on their operations and financial disclosures.** *Image credit not required*

**Gondwana Rainforests snapshot: Reduced cloud water inputs in the rainforests, especially during the dry season, may increase moisture stress beyond the tolerance of some species.**
*Image: Laura /Flickr, CC BY 2.0*


**Tasmanian industries snapshot image:** **Stakeholder information on industry-relevant climate information will contribute to Australia’s development of multi-year to decadal forecasts.**
*Image: iStock.com/ekapol*

## Theme title

**Our changing oceans and coasts**

## Theme description

The oceans play a vital role in the Earth's complex and variable climate system. Not only do they support a variety of ecosystems, industries and communities, they also act as the largest sink on Earth, storing heat, nutrients and carbon dioxide. The oceans therefore contribute to efforts to mitigate human-induced greenhouse gas emissions, but this comes at a cost – with significant ocean warming, acidification and changes to circulation affecting Australian coasts through impacts such as sea level rise, marine heatwaves and coastal inundation.

To better understand our oceans and how they are changing, the Earth Systems and Climate Change Hub has participated and provided leadership in international and national ocean observation systems and initiatives. These initiatives ensure ocean measurements are coordinated around the world and provide critical long-term observation records for tracking and understanding current and future change.

The Hub has also updated global and regional projections of future sea level rise to take into account new understanding of possible contributions from melting Antarctic ice shelves. These projections, along with research into understanding regional extreme sea level rise, provides critical information to feed into current and future coastal infrastructure and asset planning and protection.

## Impact snap shots

*Ocean monitoring and data analysis to track ocean change*

Monitoring the ocean is vital for managing and mitigating human impacts on our environment and for making climate and weather predictions. Through the Hub, Australia has provided leadership in international ocean observation initiatives and in the production, quality control and analysis of high-resolution ocean datasets. These efforts contribute to a better understanding of many ocean processes such as ocean circulation, temperature, heat uptake, salinity and acidity. They shine a light on how these processes may change in the future and what this means for global efforts to mitigate greenhouse gas emissions.

*Understanding future trends in marine heatwaves*

The Western Australian coast and the Tasman Sea have both experienced their most devastating marine heatwave events within the last 10 years, causing widespread impacts to the local ecology and industries. Hub research shows that for both regions, maximum intensity events are likely to become an annual occurrence under a high emissions scenario by around 2060 (Tasman Sea) and 2100 (WA coast). Information on likely future changes to marine heatwaves enables marine managers to better plan for and manage their future risks.

*Updated sea-level rise projections and a sea-level rise calculator tool for coastal planning*

Up-to-date and accurate information on sea-level rise and regional extreme sea-level events is required to help identify and mitigate risks to coastal infrastructure and ecosystems. Hub researchers contributed to international research on estimating future sea-level rise, including revised contributions from Antarctic processes. These processes are estimated to contribute to sea-level rise by as much as 2.5 metres by 2100, with implications for Australian coasts. The Hub has also updated a sea-level rise calculator tool (Canute3.0) to allow coastal practitioners to explore how extreme sea level events will change at locations around Australia's coastline.

*Supporting the development of Australia's blue economy*

'Blue economy' is an emerging concept which refers to the sustainable use of ocean resources for economic growth, improved livelihoods and ocean ecosystem health. Australia's blue economy industry sectors are all exposed to climate change related risks to associated offshore infrastructure and operations. The Hub has produced a range of climate change projection products to support development of offshore adaptation strategies. Hub products include projected 21st Century changes in extreme sea-levels, winds and surface wave fields under a range of future climate scenarios.

## Research outputs

**Relevant ESCC Hub projects**:

Project 2.4: Changing oceans and Australia's future climate

Project 2.10: Coastal hazards in a variable and changing climate

Project 5.7: Tracking ocean change – ocean observations and models

Project 5.8: Marine and coastal climate services for extremes information

*(Project webpages include a list of publications produced under the projects)*

**Synthesis products:**

Latest brochures:

- Our changing oceans: Australia's contribution to the Global Ocean Observation System
- Marine heatwaves off Western Australia: future projections
- Tasman Sea marine heatwave factsheet
- Wind-Wave climate change along Australia's coast
- Understanding extreme sea level events for Sydney's beaches and harbour
- Ocean knowledge for climate decision (TBD)
- Sea level rise projections (TBD)
- Blue economy (TBD)

Previous products:

- Understanding marine heatwaves

## Images and video

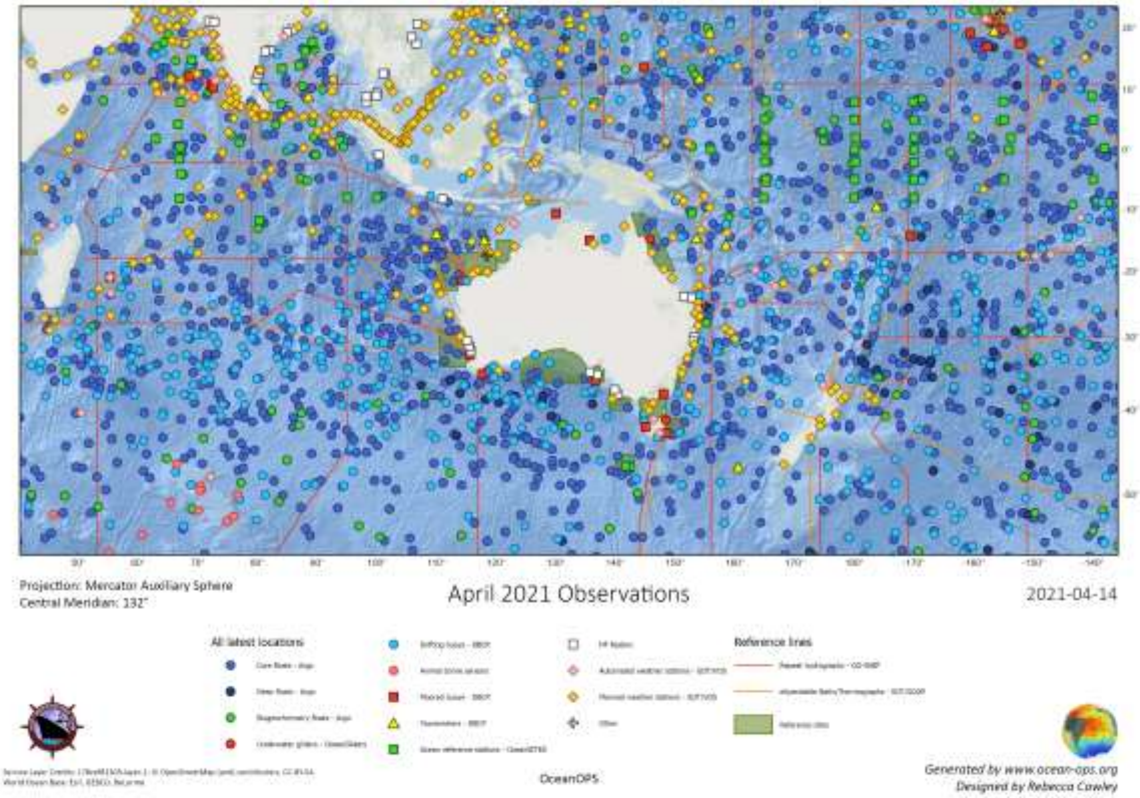
**Related videos:** No videos available

**Introduction page image:**

Ocean measurements are collaboratively undertaken across a range of international initiatives using a variety of measurement instruments. The Hub has supported Australian participation and leadership in these initiatives. Read more in this factsheet.


*Image: CSIRO, CCBY3.0*

**Snapshot images:**




**Ocean monitoring snapshot image: Observing and measuring the ocean requires international collaboration and coordination.** *Image: [www.ocean-ops.org](http://www.ocean-ops.org). Designed by Rebecca Cowley*

**Marine heatwaves snapshot image: Marine heatwave frequency and intensity is projected to increase under a warming climate.** *No image credit required*

Updated sea level rise projections snapshot image: **Up-to-date sea-level rise projections can help to identify and mitigate coastal risks.** *No image credit required*

Blue economy snapshot image: **Climate projections can support development of offshore climate change management and adaptation strategies.** *No image credit required.*

## Theme title

**Towards climate resilient emergency and water management in Australia**

## Theme description

Australia has a variable climate, with a history of bushfires, droughts and extreme rainfall. These climate extremes have far-reaching costs, ranging from financial costs to governments, businesses and households, to environmental impacts, to physical and psychological impacts on individuals.

Under a warming climate, extreme events and water availability are likely to change. To ensure Australia's management activities remain effective and efficient as our climate continues to change, information on Australia's likely future climates is required to provide managers with better quality, relevant and targeted climate change science information and data.

The Earth Systems and Climate Change Hub has investigated changing current and future trends in dangerous bushfire weather and risks, extreme wet and extreme dry periods and events. The Hub has worked with managers to provide climate change information, data and expert advice to feed into emergency and water resource management policies, planning activities and initiatives. The end result? Enhanced climate resilience for Australia's emergency and water management sectors, now and into the future.

## Impact snap shots

*Understanding trends in dangerous bushfire weather to inform emergency management*

Extreme fire weather has also become more frequent and extreme for some seasons and regions of Australia. Hub research has shown a clear link between climate change and bushfire conditions over the past 60+ years. Looking to the future, Hub projections show a clear trend towards more dangerous conditions for bushfires in Australia. The Hub has shared its expert advice and information on bushfire conditions with key emergency management stakeholders, such as the Australasian Fire and Emergency Service Authorities Council (AFAC) for use in their Australian-wide climate policies.

*Supporting the national conversation on changing bushfire weather risks*

The 'Black Summer' bushfire season of 2019/20 was one that few Australians will ever forget. Hub research and expert opinion helped to inform the national conversation about trends in current and future bushfire conditions in Australia. Hub research and researchers were quoted in national and international media, and Hub research was used to inform the Royal Commission into National Natural Disaster Arrangements report. This ensured the national conversation was informed by credible and up-to-date science and encouraged a balanced and informed discussions across Australia.

*Increasing knowledge of current and future extreme wet events*

Climate change will impact the frequency and intensity of extreme events which bring extreme rainfall to regions of Australia, such as east coast lows and tropical cyclones. Hub research has found that while the occurrence of these two types of extremes is projected to decrease slightly, future resulting rainfall is likely to increase in intensity in some regions. This has implications for future flood risk factors in highly populated urban areas, and for water pollution changes in the Great Barrier Reef region due to agricultural runoff. This can lead to the devastation of seagrass in the reef region and cause an increase in crown-of-thorn starfish outbreaks.

*Understanding extreme dry periods for better future water resource management*

For many Australians, the future is going to be hotter and drier. Hub research has shown that under a warming climate Australia will spend more time in drought, with longer and more intense drought conditions, particularly across southern and eastern Australia. There is also likely to be a reduction in streamflow and in mean run-off in southern Australia. The Hub has also investigated the causes of flash droughts in Australia. This research provides decision makers with a glimpse into Australia's possible water futures and equips them with the knowledge to adjust management strategies accordingly.

## Research outputs

**Relevant ESCC Hub projects**:

Project 2.7: Refining Australia's water futures

Project 2.8: Extreme weather projections

Project 5.4: Water futures under climate change

Project 5.5: Extreme weather hazards in a changing climate

*(Project webpages include a list of publications produced under the projects)*

**Synthesis products:**

Latest brochures:

- Fire-generated thunderstorms and climate change in Australia
- Intense east coast lows and climate change in eastern Australia
- Tropical cyclones and climate change in the Great Barrier Reef region
- Drought projections for Australia
- Projections of water futures for Australia
- Flash drought in Australia
- Climate change impacts on the reliability of farm dams and environmental flow in south-west Western Australia (link TBD)

Previous brochures:

- Tropical cyclones and climate change in Australia
- East coast lows and climate change in Australia
- Bushfires and climate change in Australia
- Thunderstorms and climate change in Australia
- Understanding climate change impacts on water resource management in Western Australia

## Images and video

**Related videos:**

Extremes overview video: [Understanding extreme events in Australia]

This video summarises research conducted by Hub researchers on extreme events such as bushfires, tropical cyclones, east coast lows and thunderstorms.

**Video image:**

**Future changes to extreme events will have important consequences for infrastructure, communities and ecosystems in Australia.**
*Image: C.Drummond, NSW Water Research Laboratory*

**Snapshot images:**

Dangerous bushfire snapshot image: **Fire-generated thunderstorms can produce extremely dangerous fire behaviour, with strong, erratic winds and lightning.** *Image: Alex Ellinghausen*

Bushfire national conversation snapshot image: **The Hub's research helped ensure a balanced and informed national conversation during the Black Summer 2019/20 fire season**.
*No image credit required*


**Extreme wet snapshot image:** **Intense east coast lows may lead to more extreme rainfall, increasing the risk of floods.** *Image: iStock.com/Jaykayl*

**Extreme dry snapshot image:** **Flash droughts, with their quick onset, can leave farming communities and natural resource managers underprepared** *Image: iStock.com/VMJones*

## Theme title

**Building strong and lasting partnerships with First Nations people**

## Theme description

First Nations people have managed the land, seas and skies sustainably for thousands of years, with this knowledge passed down from generation to generation. For more than 100,000 years, First Nations people have lived through and adapted to massive climatic changes, from the depths of the last Ice Age to the current inter-glacial period. Today, there is growing recognition that their traditional knowledge can inform the climate science community, as well as provide adaptation and mitigation solutions for Australia.

The Earth Systems and Climate Change Hub has worked with a range of First Nations people and communities to provide opportunities to share their stories and experiences of climate change on Country with policy makers and the climate science community. To do so, the Hub has built strong, trusted and sustainable relationships with First Nations communities around Australia. These relationships have been informed and reinforced by co-design protocols, which have been improved over the life of the Hub through engagement with First Nations people. These protocols will form the foundation for lasting future two-way knowledge exchange between First Nations people and climate scientists. They will also ensure better integration of traditional knowledge and western science to improve understanding of our changing climate.

## Impact snap shots

*Giving First Nations people a voice on climate change and research*

First Nations people are particularly vulnerable to the impacts of human-induced climate change due to their close connection to Country. Tailored and co-produced climate change information can help to inform adaptation planning and decision making in communities to minimise their climate risks. In 2018, the Hub worked with First Nations stakeholders to hold the first National Dialogue on Climate Change. The Dialogue brought to light the importance of protecting and respecting First Peoples Intellectual and Cultural Property, and the need to build ethical frameworks that would ensure reciprocity and mutual respect in research involving First Nations people.

*Developing Indigenous co-design principles for climate change research*

The benefits of incorporating traditional knowledge into western science are obvious, but the steps to do so are not. The Hub supported First Nations people to present their knowledge and experience of research on Country with the climate science community. This discussion led to the development of important protocols to underpin climate change research involving First Nations people. These co-design research protocols offer a framework for ensuring that First Nations people are included in research planning, development and delivery and that research outcomes are mutually beneficial. The protocols were also used to develop a Code of Conduct to guide research being performed on Country.

*National First Peoples Gathering on Climate Change*

After two years of close collaboration with a First Nations-led Steering Committee, the Hub helped to prepare a co-designed framework to deliver the 2021 National First Peoples Gathering on Climate Change. The Gathering brought together over a hundred First Nations people from around Australia. It allowed for robust and passionate discussions of climate change experiences on Country framed around the continuing generational impacts which can be expected. Participants also explored ways in which traditional knowledge and western science could deliver solutions to the impacts of climate change on Country. Watch the 7NEWS Cairns news segment on the Gathering.

*Understanding Indigenous perspectives of risk*

Indigenous peoples across Australia bring a particular perspective of climate risk and resilience related to their socio-economic, historical, political, cultural and environmental circumstances. Risk perspectives are influential in shaping the priorities for adaptation planning. The ESCC and Marine Biodiversity Hubs worked with Malgana people (including elders, board members and Gutharraguda (Shark Bay) rangers) to discuss how traditional knowledge tools and cultural mapping of values on Country can be used to improve the participation and inclusion of Indigenous peoples in understanding and using climate information for the management and protection of Country.

## Research outputs and attributions

**Relevant ESCC Hub projects**:

- Case study 3.2: Meeting Indigenous priorities for climate change information, capacity building and engagement
- Case study 5.5: Indigenous perspectives of climate risk
- Case study 6.1: Second national Indigenous gathering on climate change – pathway to sustainable relationships
- Case study 6.2: Supporting Indigenous participation at the AMOS 2020 conference
- Case study 6.3: Adapting to climate change and building resilience in Australian World Heritage properties: using climate change science information and traditional knowledge to inform risk and vulnerability assessments and adaptation planning

**Synthesis products:**

Previous outputs:

- Workshop Report: National Dialogue on Climate Change
- Co-design, cross cultural communication and climate change: considerations for engaging with First Nations peoples

New outputs:

- National First Nations Peoples Gathering on Climate Change report (TBD)
- Understanding Indigenous perspectives of risk report (TBD)

## Images and video

**Related videos and media:**

- 7NEWS Cairns news segment on the 2021 National First Nations People Gathering on Climate Change: https://www.facebook.com/7NEWSCairns/videos/148454583823779
- NFPGCC video: TBD. This video summarises the discussions and outcomes of the National First Peoples Gathering on Climate Change.

**Introduction image:**


**Creating opportunities for First Nations people to share their experiences of climate change with policy makers and researchers opens up respectful and two-way dialogues.** *Image: Sonia Bluhm, ESCC Hub*

**Snapshot images:**

**2018 Dialogue snapshot: The 2018 National Indigenous Dialogue on Climate Change brought Indigenous communities from across Australia together on Country to discuss their experiences of climate change.** *Image: CSIRO*

**Indigenous co-design principles snapshot: Co-design research protocols offer a framework for ensuring that First Nations people are included in climate research**
*Image: iStock.com/kerriekerr*

**2021 Gathering snapshot:** **The 2021 National First Nations Peoples Gathering on Climate Change allowed for robust and passionate discussions about climate change impacts on Country.** *Image: CSIRO*


**Indigenous perspectives of risk snapshot:** **Risk perspectives are influential in shaping Indigenous priorities for climate change adaptation planning**. *Image: David Karoly, ESCC Hub*

## Theme title

**Protecting Australia's coasts through nature-based methods**

## Theme description

Our coastal environments are being impacted by coastal erosion, inundation and marine heatwaves as the climate continues to warm. Natural, created or restored habitats such as oyster reefs, mangroves and salt marshes have the potential to provide coastal protection, as well as enhance biodiversity and other ecosystem services. These 'living shorelines' also have the potential to play an important role in climate mitigation and adaptation due to their ability to sequester carbon and reduce the threats of coastal erosion and flooding.

The Earth Systems and Climate Change Hub, through the National Centre for Coasts and Climate (NCCC), has researched, developed and trialled on-ground nature-based coastal protection options. This has enabled the Hub to better understand and provide guidance to coastal managers on how and when these management options can be used to protect important coastal ecosystems, enhance Australia's blue carbon ecosystems and better manage coastal erosion.

## Impact snap shots

*Supporting blue carbon ecosystems for climate mitigation benefits*

Vegetated coastal ecosystems are hotspots of atmospheric carbon dioxide storage and therefore act as sources of 'blue carbon'. Hub researchers have developed a recommended new standard method of estimating blue carbon and have evaluated the ability of key coastal management strategies to protect and increase blue carbon storage. As a result, Australia is now closer to including a methodology for blue carbon in carbon crediting schemes, and coastal managers are better able to manage coastal ecosystems for both blue carbon and ecosystem health benefits.

*Understanding past coastal erosion to predict future erosion*

Climate change is likely to increase the vulnerability of Australia's coastline to coastal erosion. Hub researchers analysed past shoreline changes to improve understanding of shoreline resilience to future erosion. This provides coastal managers with a better understanding of how future changes in the frequency and intensity of erosion events will impact the recovery capacity of beaches. The Hub's work also provides coastal management-related insights into the important role of vegetation in mitigating current and future coastal erosion.

*Eco-engineering solutions for coastal hazard risk reduction*

Nature-based coastal protection methods use the creation or restoration of coastal habitats to protect shorelines and, as living systems, they have the ability to adapt to a changing climate and self-repair after storm events. Hub researchers have worked with local stakeholders to develop and trial a number of innovative nature-based methods for coastal hazard risk reduction, including hybrid mangrove planters across three Victorian locations and a shellfish reef in Port Phillip Bay. These approaches were monitored to better understand their effectiveness in the management of the coastlines.

*Australian guidelines on nature-based coastal protection*

Australian coastal decision-makers and managers need clear guidelines for when a soft, hybrid or hard coastal defence approach is most appropriate. The Hub, through the National Centre for Coasts and Climate, has developed the first national guidelines for nature-based methods for reducing the risks of coastal hazards. The guide provides a framework for implementing nature-based methods and conducting benefit-cost analysis, thereby providing a practical tool to support coastal management decisions and promote wider adoption of these methods nationally.

## Research outputs

**Relevant ESCC Hub projects**:

Project 2.11: Establishment of the National Centre for Coasts and Climate – Phase 1

Project 5.9: Natural habitats for coastal protection and carbon sequestration – Phase 2 of the National Centre for Coasts and Climate

*(Project webpages include a list of publications produced under the project)*

**National Centre for Coasts and Climate (NCCC) website:** https://nccc.edu.au/

**Synthesis products:**

- The National Centre for Coasts and Climate: establishment and key research outcomes
- The Australian guide to nature-based methods for reducing the risks of coastal hazards

Previous brochures:

- Climate change and blue carbon in Australia
- Coastal erosion under a changing climate
- Eco-engineering and restoration of coastal habitats in Australia

Factsheets on shoreline change at nine Victorian locations: http://nespclimate.com.au/understanding-shoreline-change-on-the-victorian-coast/

## Images and video

**Related videos:**

Coastal erosion video: https://publish.viostream.com/play/bgoo5gydbr49mf

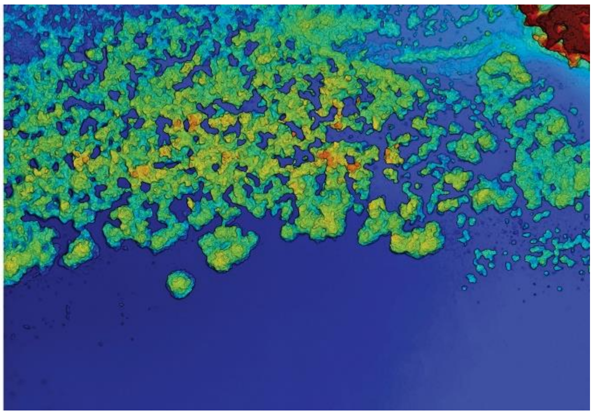
This video summarises research conducted by Hub researchers on coastal erosion.

**Snapshot images:**

**Eco-engineering snapshot image:** **A ‘hybrid’ coastal protection shellfish reef breakwater for erosion control at Portarlington, Port Phillip Bay** *Image: Ralph Roob*

**Australian guidelines snapshot image:** **Three-dimensional concrete Mangrove pods for erosion control at Grantville, Victoria.** *Image: R.Morris*

**Coastal erosion snapshot image:** **Erosional cliffs opposite the Renal Centre in Warrumiyanga, Bathurst Island, Tiwi NT.** *Image: T. Konlechner*



**Blue carbon snapshot image:** **Above-ground carbon stocks can be estimated using 3D maps of canopy structures in blue carbon ecosystems.** *Image: National Centre for Coasts and Climate*

**Coastal video image:** **Erosion alters sand dune vegetation, resulting in potential adverse implications for future coastline resilience.** *Image: David Kennedy*