



National Environmental Science Programme

**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

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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.

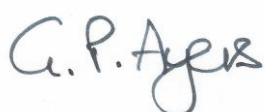
Signed: 

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: 

Hub Steering Committee Chair Name: Dr Greg Ayers

Date: 21/05/2021

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## 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***

#### **ACCESS model**

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.

#### **Improved global ocean monitoring**

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***

#### **National Centre for Coasts and Climate**

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:

<b>Milestone</b>	<b>Description</b>	<b>Due Date</b>	<b>Status</b>
26	Delivery of Annual Progress Report 5 and Financial Information to the Department (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 (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.	<b>100%</b>	
2. Percent of projects approved under RPV6 in which research-users were actively involved in project design.	<b>100%</b>	
3. Number of research outputs provided to end users <b>on time</b> <sup>1</sup> and as identified in the Research Plans.	<b>279</b>	
4. Proportion of research outputs provided to end users <b>on time</b> and as identified in the Research Plans.	<b>95%</b>	
5. Number of instances of where the hub has used NESP-generated information from another NESP hub.	<b>0</b>	<p>The Hub primarily uses climate and weather-related data and information, which are not generated by other NESP Hubs.</p> <p>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.</p> <p>The Hub has also actively collaborated with all the other NESP Hubs on the cross-Hub Integrated Environmental Assessment Project (CS 6.4).</p>
6. Number of peer reviewed NESP-funded publications during the reporting period.	<b>352</b>	
7. Number of NESP research citations in other researchers' publications during the reporting period.	<b>12,990</b>	
8. Number of researchers, including PhD and Post-Doc positions engaged as a result of NESP (total, Full-time equivalent) during the reporting period.	<b>155 researchers 135 FTE total</b>	
9. Number of data sets provided to the Hub, or made publicly available, by third parties	<b>&gt;50</b>	The Hub uses a wide variety of climate and weather datasets to inform its research. These include

<sup>1</sup> On time – delivered on the date the outputs were expected to be delivered  
July 2021  
ESCC Hub Final Report

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.	<b>&gt;70%</b>	<p>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.</p> <p>However, researchers may make this data available to other researchers on request.</p> <p>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.</p>
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.	<b>88%</b>	<p>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.</p> <p>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.</p> <p>A list of all Hub-funded journal articles is provided on the <a href="#">ESCC Hub publications webpage</a>.</p>
12. Number and FTE of Indigenous people employed in a project (separate into full and part time positions).	<b>4 Indigenous people; 1.2 FTE</b>	<p>2017 1 at 0.25 FTE  2018 1 person at 0.25 FTE  2019 1 person at 0.2 FTE</p>

Key Performance Indicator	Hub Result for entire activity period (1 Jan 2015 - 30 June 2021) (Numerical only)	Explanation (if any)
		<p>2020 1 person at 0.5 FTE</p> <p>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.</p>
13. Number of Indigenous researchers/graduates/post-graduate/PhD/Post Doc Positions in projects.	<b>1 person at 0.2 FTE</b>	
14. Number of Indigenous people trained in the use of environmental management tools and techniques.	<b>N/A</b>	<p>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.</p>
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).	<b>0</b>	<p>The Hub has provided Indigenous stakeholders with opportunities to inform potential climate change information and tools through:</p> <ul style="list-style-type: none"> <li>• 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</li> </ul>

Key Performance Indicator	Hub Result for entire activity period (1 Jan 2015 - 30 June 2021) (Numerical only)	Explanation (if any)
		<p>following the recently completed Gathering.</p> <ul style="list-style-type: none"> <li>• The KE4CAP workshop, part of the NCSAC consultancy, to discuss the delivery of climate 'intelligence' platforms for Australia.</li> </ul>
<p>16. Number and type of communication products that have been used to communicate research with Indigenous people.</p>	<p><b>13</b></p>	<ul style="list-style-type: none"> <li>• National Indigenous Dialogue on Climate Change and the workshop report includes all 50 Indigenous workshop participants as authors (1)</li> <li>• National First Peoples Gathering on Climate Change and the report which will include all participants as authors (1)</li> <li>• Co-produced presentations between scientists and First Nations people for the NFPGCC (8)</li> <li>• K'gari and climate change activity literature review (1)</li> <li>• Co-design, cross cultural communication and climate change: considerations for engaging with First Nations peoples (1)</li> <li>• Co-produced communication products and a video from the National First Peoples Gathering on Climate Change (still in development)</li> <li>• Indigenous perspectives of risk workshop with Malgana and workshop report co-authored with Malgana people (1)</li> </ul>
<p>17. Number of research, knowledge sharing and communication events held with Indigenous communities.</p>	<p><b>19</b></p>	<p>The Hub has been engaging with First Nations peoples in a two-way co-design process which is a continual knowledge sharing process.</p> <p>The Hub has facilitated Traditional Owners to communicate their knowledge and experience of climate change by:</p> <ul style="list-style-type: none"> <li>• the Indigenous perspectives of risk workshop.</li> <li>• facilitating Traditional Owners to attend and present at the Australian Meteorological and Oceanographic Society (AMOS) Conferences in Darwin in 2019, 2020 and 2021.</li> <li>• facilitating Traditional Owners to attend the Hub's Canberra Roadshow in September 2019 and engage with policy makers.</li> </ul>

Key Performance Indicator	Hub Result for entire activity period (1 Jan 2015 - 30 June 2021) (Numerical only)	Explanation (if any)
		<ul style="list-style-type: none"> <li>• 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.</li> </ul>
18. Number of public events, conference presentations, jointly authored/published papers with Indigenous participants/contributors.	<b>13</b>	<ul style="list-style-type: none"> <li>• National Indigenous Dialogue on Climate Change and the workshop report includes all 50 Indigenous workshop participants as authors.</li> <li>• National First Peoples Gathering on Climate Change and the report, which will include all participants as authors.</li> <li>• Co-produced presentations between scientists and First Nations people for the NFPGCC.</li> <li>• K'gari and climate change literature review.</li> <li>• Co-design, cross cultural communication and climate change: considerations for engaging with First Nations peoples.</li> <li>• Co-produced communication products and a video from the National First Peoples Gathering on Climate Change (still in development).</li> <li>• Indigenous perspectives of risk workshop with Malgana and workshop report co-authored with Malgana people.</li> <li>• First Nations presentations at AMOS 2019, 2020 and 2021, plus side events.</li> </ul>

### ***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.