



**Earth Systems and
Climate Change
Hub**

National Environmental Science Programme



Research Plan

VERSION 6

November 2019



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Introduction

The National Environmental Science Program

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 (NERP) and the Australian Climate Change Science Programme (ACCSP) – 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.

The role of the Earth Systems and Climate Change Hub

The goal of the Earth Systems and Climate Change (ESCC) Hub is to ensure Australia's policies and management decisions are effectively informed by Earth systems and climate change science now and into the future (Figure 1).

The Hub will achieve this by building a national partnership, with world-leading capability in multidisciplinary Earth system science and modelling that provides Earth system and climate information in support of a productive and resilient Australia.

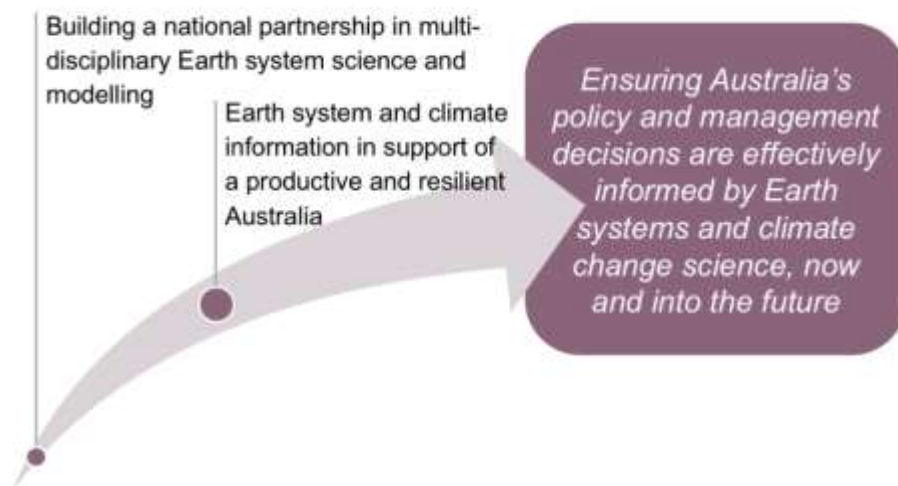


Figure 1. Earth Systems and Climate Change Hub goal

The Hub will deliver knowledge, information, and data products and services to ensure that environmental decision-making is informed by an understanding of Australia's past, current and future climate.

Consistent with the Hub's stated goal and intended outcomes, the objectives of the Hub are, through world class research, to:

- a) lead the further development of a world-competitive, national Earth system and climate modelling capability (the Australian Community Climate and Earth System Simulator, ACCESS) to deliver weather and climate predictions and projections for the Australian community
- b) advance understanding of Australia's climate variability, extremes and associated drivers
- c) develop and strengthen stakeholder relationships, and support informed management and evidence-based decision-making
- d) facilitate outreach and communication of science products and services to target next/end-users.

In addition, the Hub has supported the University of Melbourne to establish the National Centre for Coasts and Climate (NCCC). The Hub continues to support research under the NCCC which focuses on the areas of blue carbon, coastal erosion and dune sensitivity and innovative solutions for coastal defence.

History of Australian Earth systems and climate research

The NESP is an amalgamation of the NERP and the Australian Climate Change Science Program (ACCSP).

The ACCSP was a three-decade research program funded by the Australian Government with matching co-investment by CSIRO and the Bureau of Meteorology. It built much of Australia's Earth system and climate science capability. This capability has been significantly augmented in recent years by the universities—especially through the previous Australian Research Council Centre of Excellence for Climate System Science (ARCCSS) and the current Centre of Excellence for Climate Extremes (CLEX). It is this capability and history of collaboration that led to a consortia partnership, led by CSIRO, being successful in the competitive tender process to form the current ESCC Hub.

The ACCSP also provided the foundation for several complementary initiatives over the past decade or so, including: (i) CSIRO and Bureau strategic investment in developing ACCESS (from 2005 to the present); (ii) regional climate programs such as the South-Eastern Australia Climate Initiative (SEACI), the Indian Ocean Climate Initiative (IOCI) and Pacific–Australia Climate Change Science and Adaptation Planning program (PACCSAP); (iii) the NRM Regional Projections project that culminated in the delivery of the Climate Change in Australia (CCiA) information and website (www.climatechangeinaustralia.gov.au) in 2015; and (iv) investment in state-based regional climate projections research programs such as TasFutures, Goyder, Queensland, VicCI and NARCLiM.

This evolution from ACCSP to NESP, along with the capability and experience built through the ACCSP and allied climate programs, has the following important implications for the Hub:

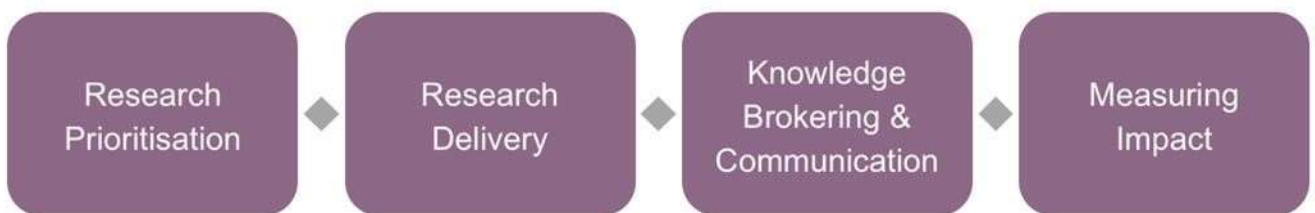
- With the ACCSP contract ending in mid-2016, the Hub's substantive research only began in the second half of 2016. The Hub's funding profile and research delivery reflects this 'ramp up' in research effort during the period covering RPV2 and RPV3, which has contributed to more stakeholder focused outputs in RPV4 onwards.
- The Hub is very fortunate to be able to build on these past investments, especially the ACCSP capability and research legacy. This significantly enhances the Hub's ability to address its research priorities and objectives and complement the overarching goals of the NESP.
- The corollary to this is the opportunity for the Hub to ensure that significant national benefit derives from this prior investment and research strength. The Hub will, where appropriate, ensure that 'lessons learned' from these earlier programs are incorporated into our research delivery, communication and knowledge brokering and path-to-impact.

Purpose of the Research Plan

This Research Plan has been developed by the ESCC Hub, in consultation with the Department of the Environment and Energy (the Department) and other key stakeholders.

The purpose of the Research Plan is to outline:

- the research priorities the Hub is funded to investigate
- the research projects that will address these priorities
- how the output of the research will be communicated and brokered to key stakeholders
- how the impact of the research will be measured
- how the Hub will work collaboratively within and across hubs.



This Research Plan includes details on 18-month projects approved under RPV5 (July 2019 – December 2020) in Attachment A.

This Research Plan also provides appropriate details on the management and governance of the Hub, including outlining the broader funding profile, key staff and research organisations, and the risks needing to be monitored to ensure success.

Hub administration and governance

Hub leadership and governance

The Hub Leadership Team (HLT) and Hub Program Management Team (HPMT) collectively have responsibility for overseeing the Hub's research delivery and operational management and administrative activities.

Research activities are structured via an agreed research project portfolio endorsed by the Hub Steering Committee (HSC) and approved by the Department.

Figure 2 illustrates the Hub's governance structure, along with our key partners and associates.

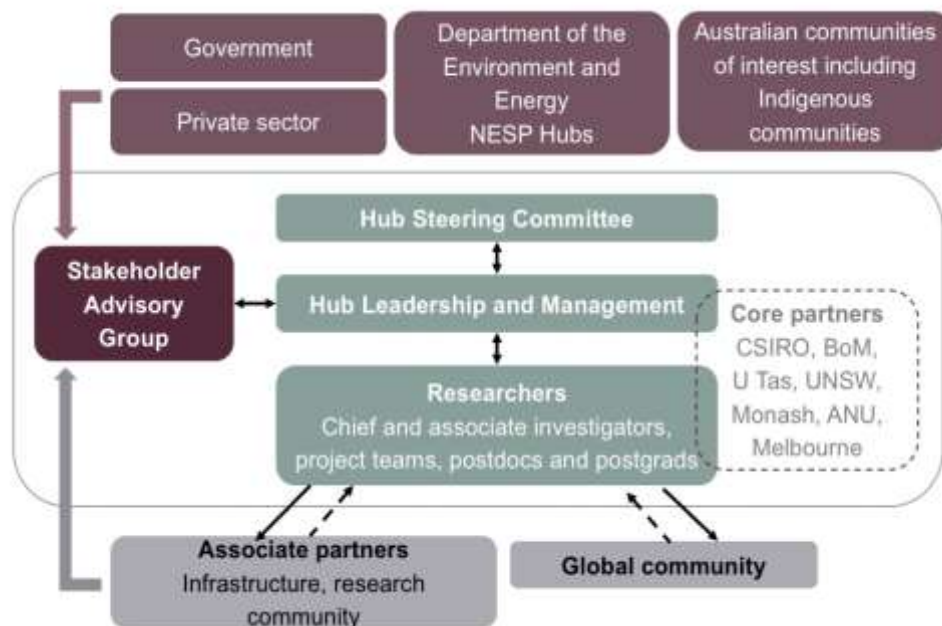


Figure 2: Earth Systems and Climate Change Hub governance

Hub Leadership and Program Management Teams

The Hub Leader, Professor David Karoly (CSIRO), working together with the other members of the HLT and the HPMT, has accountability for overall Hub performance, including research delivery and associated milestone compliance and day-to-day management and administration of all Hub activities across all partners.

The HLT meets monthly and is comprised of the Hub Leader, the Hub Program Manager/Deputy Hub Leader (Dr Geoff Gooley) and three Hub partner representatives: Dr Scott Power (Bureau of Meteorology), Dr Dewi Kirono (CSIRO) and Professor Nathan Bindoff (University of Tasmania, representing the university partners).

The HPMT comprises Professor David Karoly (Hub Leader), Dr Geoff Gooley (Program Manager/Deputy Hub Leader, and primary contact for monitoring and evaluation and data and information management activities), Ms Mandy Hopkins (knowledge exchange specialist and primary contact for Indigenous engagement activities), Ms Sonia Bluhm (knowledge exchange specialist and primary contact for communication) and Ms Marian Sheppard (program support). The HPMT, known as 'Hub Central', meets weekly.

The Hub has developed guidelines detailing duties and expectations for the Hub Leader, HLT and HPMT. This includes the procedure for replacing any members of these teams, temporarily or permanently.

Hub Steering Committee

The Hub Steering Committee (HSC) meets three to four times a year and provides strategic oversight of the Hub's performance against its objectives. The roles, responsibilities and membership of the HSC are outlined in its terms of reference, and include:

- ensuring the alignment of research activity to the policy needs and interest of the Department and other key stakeholders
- connecting the Hub's research questions, activities and outputs to relevant research activity and policy initiatives outside the Department
- overseeing the development and implementation of the Research Plan, including the review and amendment of the Research Plan, as required
- directing, and endorsing, the development, and delivery of any reporting, monitoring and evaluation requirements under this agreement
- reviewing, monitoring and guiding project performance.

In 2018, the Hub recruited an Indigenous representative to incorporate an Indigenous voice at the governance level and to guide the strategic direction of Hub activities.

The Hub's HSC Chair, Dr Wendy Craik resigned after serving for more than three years, finishing in the role in January 2019. Dr Greg Ayers assumed the role of Chair of the Hub's Steering Committee on 1 February 2019.

Hub Stakeholder Advisory Group

The Hub has identified over 200 external institutions, agencies and individuals who meet the Hub's definition of a stakeholder i.e. *any group or individual who has an interest in, or use for, the best available Earth system and climate change science*. These stakeholders encompass all levels of government, NGOs, Indigenous communities, peak bodies, private companies, research agencies and broader research communities, including other NESP Hubs. They are drawn from many sectors, including emergency services, environment, agriculture, fisheries, forestry, water, health, energy, defence, transport, infrastructure, finance, insurance, foreign affairs and trade, tourism and resources.

Given that a single forum cannot practically represent the interests of all these stakeholders, they have been prioritised and organised under six Target User Groups in RPV5 onwards; federal government, state government, local government, government authority agencies, the financial services sector and Indigenous communities. These user groups represent the key stakeholder groups the Hub is currently engaging closely with, and through which the Hub can most effectively deliver impact across its five climate challenge (outcome) areas. The Hub primarily engages with these six Target User Groups at a Hub level through research facilitation activities, knowledge exchange, stakeholder engagement activities and Indigenous activities. The Hub also engages with these user groups at the level of the science capability projects, with Hub-level coordination and oversight.

More information on the Target User Groups and knowledge exchange and communication activities is provided under the Stakeholder Engagement and Communication sections of this Plan.

Responsibility within the Hub for the prioritised allocation of resources for stakeholder engagement sits collectively with the HLT, the HPMT and the project Lead Chief Investigators (LCIs), guided by the HSAG and the Hub's Communication and Knowledge Brokering Strategy and the Evaluation Planning Framework and associated action plans.

The HSAG provides governance oversight of the Hub's external stakeholder engagement arrangements to ensure these arrangements are effective, efficient, fair, equitable consistent and timely. This group comprises of up to 10 individuals who have been identified and appointed because of their acknowledged expertise and/or professional interest and networks relevant to the Hub's research domains – especially the Hub's designated outcome areas. HSAG meets three to four time a year and facilitates the Hub's engagement with the broader stakeholder community. The timing of the HSAG meetings is aligned to the HSC meetings. Note that the HSAG has an independent chair, Mr David Carter, who also serves on the HSC.

The Department of the Environment and Energy

The Department of the Environment and Energy has responsibility for managing the National Environmental Science Program, including the approval of this Research Plan, assessment of progress of projects under this Research Plan and payment of any funding associated with the Hub agreement.

Importantly, the Department is a key next/end-user of research under the NESP and works closely with the Hub and other key stakeholders in determining and negotiating the delivery of research under the Hub's annual Research Plan.

The Minister

The Minister for the Environment and Energy provided approval to fund the ESCC Hub and has authority to approve major changes to the scope and funding allocation to the Hub and to endorse annual versions of the Research Plan.

Research priorities

The ESCC Hub is committed to a body of activity that includes short and long-term research projects and associated research facilitation activities. Each activity year the Department will work with the Minister, the Hubs and other key stakeholders to identify and refine research priorities. Projects developed under the ESCC Hub align with these priorities.

This research prioritisation is a rolling process and key milestones in each activity year, like the Annual Progress Report and submission of the next Research Plan, will inform the process.

This constant consideration and evaluation of research output and impact builds confidence in the performance of the Hub and the effectiveness of the program. It also provides the basis for the flexibility needed in the ESCC Hub to engage in new themes of research in an adaptive manner and ensures that the Hub's focus is fixed on the delivery of relevant and practical research.



Broadly, the research priorities for the ESCC Hub are:

a) *Building the utility of Earth systems and climate change information*

1. Work with our partners and NESP to establish a National Centre for Coasts and Climate and continue to collaborate with the National Centre for Coasts and Climate as it undertakes climate change research and activities, including blue carbon research.
2. Engage with stakeholders to ensure that the information is being provided in a manner which supports decision-making and is meeting the needs of end-users including business, government and Indigenous people. This includes contributing Australian and Southern Hemisphere climate information, analysis and expertise to global initiatives such as the Intergovernmental Panel on Climate Change and climate modelling projects (e.g. Coupled Model Intercomparison Project) to ensure that Australia benefits from the international analysis efforts that shape global discussions on climate change.
3. Collaborate across NESP hubs to ensure that Earth systems and climate change research informs the broader program. This would include provision of nationally consistent and targeted regional climate projections and information relevant to specific issues, such as threats to marine and terrestrial ecosystems and ocean acidification and the cumulative impacts of climate change and other environmental pressures.
4. Develop and enhance Australia's national capability in Earth system and climate simulation through ongoing improvement of the Australian Community Climate and Earth System Simulator (ACCESS) in the areas of accessibility and simulation performance.

b) *Improving our understanding of how the climate system may change in the future.*

1. Investigate how human activities will continue to influence the carbon cycle and change the chemistry and physical state of our oceans, atmosphere and terrestrial systems.
2. Improve understanding and simulation of Southern Hemisphere climate drivers in our climate models (especially ACCESS) to increase our confidence in projections of likely future climate change at multi-annual to multi-decadal time scales. Improve our understanding of how climate variability (e.g. El Niño–Southern Oscillation) and the

frequency, intensity and extent of extreme events (e.g. tropical cyclones and droughts) may change in the future.

3. Further develop our ability to simulate and provide regional information on future climate, from years to decades.
4. Consider low likelihood but high impact consequences of climate change for Australia to improve risk management decisions.
5. Use improved climate projections and understanding of the drivers of climate to inform understanding of climate and coastal interactions.

c) *Improving our observations¹ and understanding of past and current climate*

1. Use observations of greenhouse gases and the Australian regional carbon budget to track changes and improve our understanding of how the different components of the natural and human elements of the carbon cycle interact and influence each other.
2. Identify how the different scale drivers of the climate system interact in the Southern Hemisphere to generate our past and current climate.
3. Improve analysis methods used for Australian climate change research and examine the current and past patterns and trends in climate variability and extremes in the Southern Hemisphere, with an emphasis on the Australian region, including the ocean.
4. Analyse robust observational records of our atmosphere, oceans, cryosphere and terrestrial systems to undertake detection and attribution studies in order to identify and explain significant changes in our current climate.

From these priorities, cross-cutting issues across NESP specifically relevant to the ESCC Hub indicate that research undertaken under all Hub priorities should:

- consider the impact of climate change in the research design, delivery and recommendations, as appropriate
- consider the social and economic value of the environmental asset/s and research outcomes, as appropriate
- where possible, and where other considerations are equal, be targeted at areas with high conservation value such as National and World Heritage places and Ramsar wetlands
- be designed with consideration of how it may interest and integrate with the priorities of other NESP Hubs.

¹ This priority does not imply that the Hub undertakes primary observations. It is primarily a user of observations that are the responsibility of others. This includes national research infrastructures, such as the Marine National Facility (Investigator), Integrated Marine Observing System (IMOS), and Terrestrial Ecosystem Research Network (TERN), as well as operational agencies such as the Bureau of Meteorology and Australian Antarctic Division.

Progress towards addressing research priorities

The Hub has made significant progress in 2019 towards addressing its research priorities through its science capability projects, case studies and Indigenous activities.

Research projects 2.1 to 2.11, which began in RPV2 in July 2016, concluded in June 2019 producing a wide range of outcomes which contribute to the Hub's progress towards the research priorities. A list of completed research projects and outputs funded under the ESCC Hub is available on the Hub's website, www.nespclimate.com.au.

A new series of 18-month research projects 5.1 to 5.9 (Attachment A) started in July 2019, building on the earlier projects with a greater emphasis on research synthesis and path to impact.

Expected outputs and outcomes

The expected outcomes of the NESP are to produce research that:

- a) enhances our understanding of Australia's environment, climate and weather
- b) is communicated clearly to relevant stakeholders and the general public
- c) is discoverable and accessible
- d) informs decision-making and addresses environmental priorities.

Research under the NESP is expected to inform policy and program delivery within the Department of the Environment and Energy. More broadly, it will engage and inform all key stakeholders with an interest in the outputs of environmental and climate science research, including state and local governments, business and industry, community groups, Indigenous land managers (or Indigenous communities) and education institutions.

Hub outputs and outcomes

In the context of these NESP outcomes, the Hub's goal (see also Figure 1) is:

To ensure that Australia's policies and management decisions are effectively informed by Earth systems and climate change science, now and into the future.

Achieving this goal requires a portfolio of integrated research across the land, oceans and atmosphere domains; using modelling, simulations, projections, process studies and analyses of observations; and ensuring the provision of information to next- and end-users, and other stakeholders.

Within the scope of the Hub's research priorities, Hub-level outcomes were determined to better focus the Hub's research portfolio. These were based on information contained in relevant national strategies and plans, including: Australia's national science and research priorities [2015]; the National Marine Science Plan [2015]; the National Climate and Resilience and Adaptation Strategy [2015]; the former National Climate Change Science Framework [2009]; and relevant end-user needs assessments (some of these were done by the Hub partners).

Through this process, the Hub identified the top five climate challenges facing Australia as the Hub's outcomes (Figure 3). The Hub's portfolio of research projects is designed to address these

outcomes at a sectoral level and thereby deliver impact and benefit for Australia. Additional and important climate challenges, in the health, heritage, infrastructure, and national security/defence sectors, are also acknowledged and will be indirectly addressed by the Hub's research to varying degrees.

These five ESCC Hub outcomes are being continually validated through our stakeholder engagement, including end-users at federal, state and local government level, natural resource management (NRM) groups, Indigenous communities and the private sector. To date, the outcome areas for the Hub have resonated strongly with our stakeholders.



Figure 3: Earth Systems and Climate Change Hub climate challenges (outcomes)

In addition to these five sectoral-focussed outcomes are a further four, largely Hub-centric cross-cutting and capability-oriented outcomes that were identified in Research Plan V1:

- A national climate and Earth system simulation capability providing Australia with the ability to prepare and plan for, and manage, the societal, economic and environmental risks associated with climate variability and change.
- Nationally consistent and targeted climate information (data, knowledge and products) for the Australian region that informs and provides the evidence base for:
 - o adaptation, planning, and mitigation responses and decision-making.
 - o decision-making to enhance resilience, productivity and better manage climate risk.
- Enhanced end-user capacity in the effective use of Hub research outputs.
- A vibrant and critical mass of Australian capability in Earth system and climate science; deeply engaged with global climate research activities that deliver benefit to Australia.

All outcomes align strongly with the following adaptation principles that underpin the Australian Government's National Climate Resilience and Adaptation Strategy:

- *Good adaptation avoids passing risks onto future Australians* – this requires future projections of climate that allow the consequences of future greenhouse gas emissions scenarios to be quantified, and to inform society about its adaptation and mitigation choices.
- *The changing climate is considered when making decisions now and into the future.*
- *Decisions are informed by the best available information.*

Target User Group outcomes and impacts

Leveraging off the learnings from the research and stakeholder engagement undertaken as part of RPV2, 3 and 4, in RPV5 the Hub identified six Target User Groups to focus its knowledge exchange, stakeholder and Indigenous engagement activities and associated communication activities and thereby to facilitate path-to-impact for the Hub. The user groups include federal, state and local governments, government authority agencies, the financial services sector and Indigenous communities.

A suite of tailored outputs will be produced by the Hub to address the priority data and information needs of these user groups, which in turn is expected to realise multiple impacts over the short-to-medium term (within the life of the Hub) and also the medium-to-longer term (beyond the life of the Hub). The outputs are specifically designed to align with and be informed (if not produced directly) by the Hub's research projects and will also be facilitated by one or more customised research facilitation activities (i.e. indigenous activities, case studies or engagement activities) undertaken in collaboration/active participation with the user groups. A list of the Hub's current research facilitation activities can be found at [Attachment B](#).

The expected impact from the Hub's Target User Groups will be the primary (but not only) unit of measurement for the Hub's impact evaluation, which will be implemented according to the Hub's Evaluation Planning Framework and associated action plan.

ESCC Hub program logic

The detailed program logic for the Hub (*Appendix 1*) and the summary schematic in Figure 4 show how the Hub's research links to its goal, research priorities and outcomes.

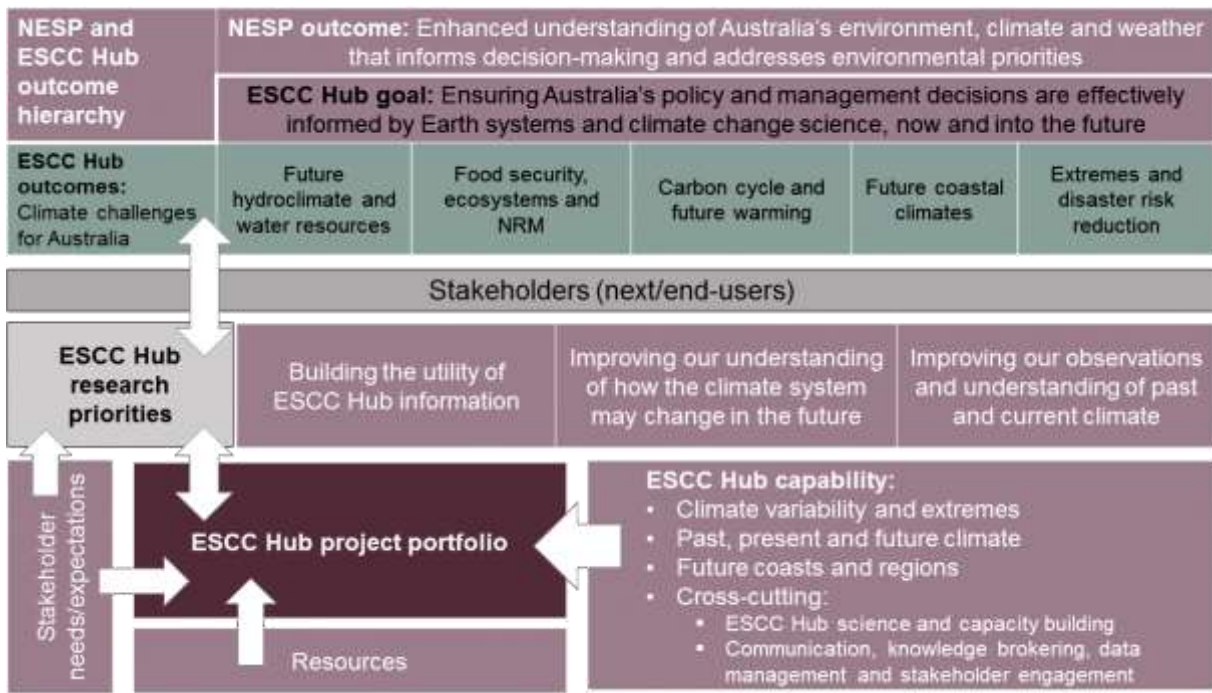


Figure 4: Summary schematic of NESP Earth Systems and Climate Change Hub program logic

The program logic also describes the core capability within the Hub, which is critical to delivering the outcomes and providing flexibility. The project research areas are all strategically important priorities for the partner agencies, meaning that the Hub leverages significant research capability from the partners. This critical mass of core capability is also one of the Hub's approaches to managing the risks associated with key skills and expertise). Each of the partners is committed to maintaining a critical mass capability in those priority research areas that underpin the capability research projects proposed in RPV6.

The Hub's research project portfolio has been developed as an integrated body of work to ensure that, collectively, all projects deliver to the Hub outcomes described in Figure 4. Several projects deliver path-to-impact through other projects via next-users rather than directly to end-users. Furthermore, the outputs from some projects primarily address just one or two outcomes, while the outputs from other projects addresses multiple outcomes.

The proposed research projects (outlined in [Attachment A](#)) represent what can be achieved with the funding available. While some projects may seem ambitious in terms of their goals, in fact the research proposed is often modest given the magnitude of the challenge and the potential for on-ground impact. The Lead Chief Investigators, HLT and partners have carefully reviewed the project proposals to ensure that the research can be delivered within the time and resource constraints of the Hub.

It is important to note and recognise that many of the Hub's projects (e.g. projects on ocean change, ACCESS and carbon sinks and sources), while coherent and self-contained, are part of a larger effort within the partner agencies and the broader Australian research community. This means that the Hub's research relies on outputs from other programs or organisations (i.e. ocean observations from the Integrated Marine Observing System, IMOS), and research by other research organisations and programs are in turn reliant on the research outcomes from the Hub.

Outputs from the Hub are targeted towards meeting the needs of key stakeholders (both next and end-users) and support our goals and outcomes. They broadly fall into two categories:

- **Outputs that provide scientific and technical information and credibility:** Enhanced models; data and information; analyses, simulations and projections; data access and analysis tools; journal publications, technical reports and high-value information products.
- **Outputs that support the Hub’s communication, knowledge exchange, outreach and capacity development:** Stakeholder engagement activities, websites and content; non-technical summaries, brochures and reports; multi-media content and training; postgraduate and professional development and training; professional and public fora (training workshops, seminars, conferences, etc.).

Table 1 describes the generic types of research outputs that will be delivered, either through the research projects and/or via the Hub’s research facilitation activities (described in [Attachment B](#) and in the Hub’s Communication and Knowledge Brokering and Indigenous Engagement and Collaboration strategies).

Output types 1–4 primarily address the specific scientific and technical needs of next/end-user. In RPV5 onwards, the Hub’s output types increasing address the more general communication, knowledge brokering, and outreach needs of next/end-users, types 4–7.

Table 1: Earth System and Climate Change Hub outputs

Type of output	Purpose	Comments
1. Research publications a) Journal papers b) Conference papers c) Technical/summary reports	<ul style="list-style-type: none"> • Peer review – establish quality and credibility of Hub research • Communication and exchange of knowledge 	<ul style="list-style-type: none"> • Publicly available, via links available on ESCC Hub website
2. Data a) Model data – hindcasts, current assessments and future projections as digital datasets, maps and similar visualisation products b) Observed data – past and current c) Application-ready datasets d) Information products	<ul style="list-style-type: none"> • Peer review – establish quality and credibility of data and information products • Deliver credible, peer-reviewed information for scientific assessments, impact assessment, adaptation planning and mitigation responses • Data available for other users 	<ul style="list-style-type: none"> • Publicly available, via links on ESCC Hub website • Information products may be a combination of modelled and measured data, along with additional analyses, to transform these data into information
3. Model system, components and tools a) Enhanced or new model versions and/or systems b) Enhanced or new sub-models, modules and/or parameterisations c) Diagnostic tools and/or frameworks	<ul style="list-style-type: none"> • Benchmarking to evaluate model performance and establish credibility • Credible future climate simulations for research; assessment of Australia’s future climates under different economic and emissions scenarios; and input into regional climate projections for impact assessment, adaptation planning and mitigation responses 	<ul style="list-style-type: none"> • Australia’s national weather and climate model system (ACCESS) is the only global model developed in the Southern Hemisphere. • Where possible, participate in national or international benchmarking activities, including submission of ACCESS simulations to the CMIP6 coupled

	<ul style="list-style-type: none"> • Improve model competitiveness, availability and accessibility for researchers and/or end-users 	climate model intercomparison.
<p>4. Communication and knowledge products</p> <ol style="list-style-type: none"> a) Targeted information products b) Brochures c) Research facilitation/engagement activities d) Newsletters (including The Chirp) e) Tailored products to support Indigenous engagement, capacity building and research 	<ul style="list-style-type: none"> • Communication and knowledge exchange • Building knowledge and understanding • Deliver credible, peer-reviewed information for impact assessment, adaptation planning and mitigation responses 	<ul style="list-style-type: none"> • Products will be made available via the ESCC Hub website and stakeholder networks. • Social media will be used to promote products and stakeholder engagement activities. • Products will be derived from research project materials as appropriate.
<p>5. Communication and engagement activities</p> <ol style="list-style-type: none"> a) Regular engagement with stakeholder networks. b) Research facilitation/engagement activities c) Workshops and conferences d) Seminars and forums e) Science informing policy events f) Briefings <p>6. Tailored activities to support Indigenous engagement, capacity building and research</p>	<ul style="list-style-type: none"> • A more active way to share and exchange knowledge and information – either to a general or specific audience – that facilitates co-production, feedback, problem-solving and value-adding. 	<p>The Hub is holding:</p> <ul style="list-style-type: none"> • annual, targeted workshops • briefings to the government, states, business sector and other key stakeholders • regular engagement with key stakeholders to either exchange knowledge or to co-produce knowledge and information.
<p>7. Training</p>	<ul style="list-style-type: none"> • Building the capacity of our next-users, end-users, general public and Indigenous communities to: <ul style="list-style-type: none"> ○ understand the current state of climate change science ○ effectively utilise the information provided by our Hub and other knowledge providers • effectively use Hub models, data and other products 	<ul style="list-style-type: none"> • For postgraduates: training activities will ‘piggy-back’ on the world-class training activities that the ARC CLEX already provide. • For stakeholders: training activities will be provided through our stakeholder networks as appropriate and affordable.

Communication and knowledge brokering

Integral to the success of the NESP in influencing decision-making is the clear and effective communication and brokerage of research outputs to key stakeholders. The Hub has developed and maintains a Communication and Knowledge Brokering (C&KB) Strategy that is available on the

Hub's website at <http://nespclimate.com.au/governance-and-reporting/>, and is underpinned by an internal action plan which describes detailed activities and products in more detail.

The strategy:

- strongly aligns with this Research Plan
- describes how the Hub will facilitate knowledge sharing between researchers and end-users
- includes activities that bring researchers, policy-makers and environmental managers together to facilitate evidence-based decision-making
- details the research products and communication material to be developed by the Hub
- describes how data produced by the Hub will be stored and made accessible to the general public
- identifies the Communications and Knowledge Brokering roles associated with these activities.

The purpose of the Hub C&KB Strategy is to:

- guide the development of strategic, proactive communication and knowledge exchange activities with key stakeholders, including target next/end-users and associated decision-makers
- increase awareness, build support, exchange information and facilitate outreach and maintain engagement with these stakeholders and the broader research and general community in delivery of ESCC Hub projects and activities, and the NESP more generally
- facilitate development and management of productive stakeholder relationships, including collaborative partnerships where appropriate, in delivery of ESCC Hub research projects and activities
- facilitate (i) implementation of the Hub's Indigenous Engagement and Collaboration Strategy (ii) implementation of the ESCC Hub Evaluation Planning Framework, (iii) adoption of key ESCC Hub outputs by next/end-users, and (iv) management of attendant ESCC Hub operational risks
- facilitate realisation of agreed strategic ESCC Hub research outcomes and impacts (i.e. path-to-impact), including successfully meeting and where appropriate adding value to stakeholder expectations.

The specific objectives of the C&KB Strategy are to:

- promote and communicate the aim, objectives, activities and outputs of the ESCC Hub Research Plan through development of clear, targeted and accurate ESCC Hub communication products and services focussed on needs of next/end-users and other stakeholders [**communication**]
- manage the knowledge generated by the ESCC Hub including relevant data, information and associated products and services in a way that is secure, discoverable and accessible, and which meets agreed standards of quality assurance and control [**knowledge exchange**]
- develop and manage key stakeholder relationships and where appropriate collaborative partnerships to ensure that communication and knowledge brokering activities are

strategically targeted to facilitate adoption and realisation of specified ESCC Hub outcomes and impacts [**stakeholder engagement**].

In this context, the C&KB Strategy is a key strategic document that is directly linked to the Hub's Indigenous Engagement and Collaboration Strategy and Evaluation Planning Framework (EPF), all of which inform the implementation of the Hub's annual Research Plan. As for the C&KB Strategy, the Hub's EPF also underpins the Hub's flexibility and responsiveness to accommodate changing priorities on an annual basis (e.g. through the operational development and implementation of annual research facilitation activities), in addition to the Hub's commitment to facilitating innovation and continuous improvement in research project-based service delivery.

All communication and knowledge brokering functions and activities are directed and coordinated at the Hub level by the Hub Leadership and Program Management Teams. Delivery of general communication and knowledge brokering activities is primarily undertaken at the Hub level, and specific research-related communication and stakeholder engagement activities primarily undertaken at the project level. This approach ensures that individual research project outputs are appropriately targeted at next/end-user needs, consistent with broader provisions of the Hub's Research Plan and associated project portfolio. All research projects feature specific deliverables designed to contribute to the successful implementation of the Hub's C&KB Strategy and the realisation of the Hub's specified outcomes and a tangible path-to-impact.

Research facilitation: knowledge exchange, co-production and communication activities

The proposed research facilitation activities (outlined in [Attachment B](#)), which involve knowledge exchange, co-production and communication activities and associated deliverables for RPV6, are focused on addressing the needs of the six Target User Groups (Figure 5) through the lens of the Hub’s five designated national climate challenges (outcomes). This ensures specific outputs of the underpinning science capability projects will be focussed, centrally coordinated, operationally consolidated and ultimately optimised to address the key needs of the user groups. These activities will also serve as an important adjunct to the Hub’s proposed impact evaluation. More specifically, the reaction of the Target User Groups to these activities will form the basis of the unit of management for evaluating Hub level impacts.

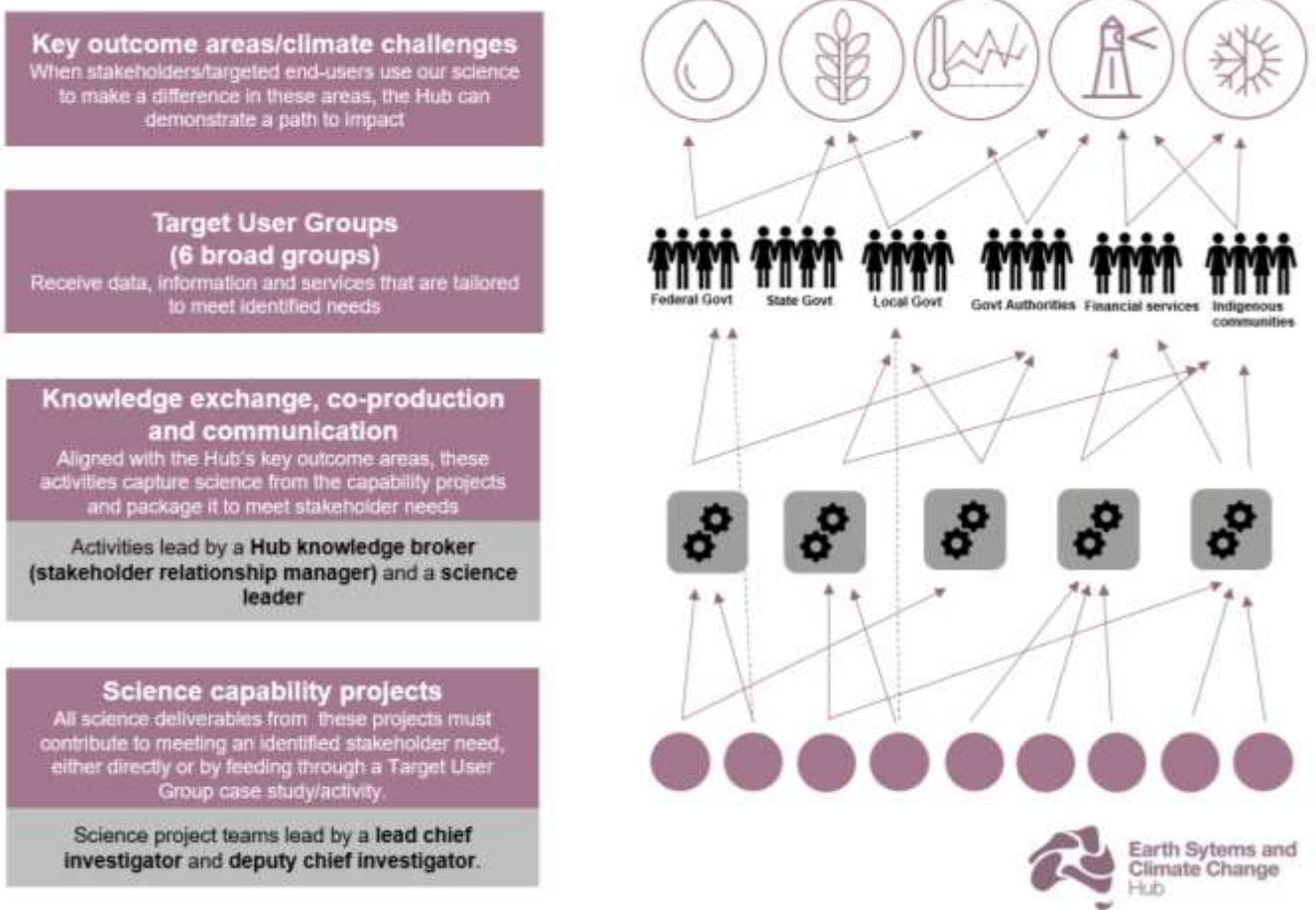


Figure 5: Schematic of ESCC Hub path-to-impact via its six Target User Groups

Figure 6. below provides an overview of the specific end-user organisations identified under these six groups.



Figure 6: ESCC Hub Target User Groups

The organisations identified under these Target User Groups represent a sub-section of the Hub’s stakeholder network. The Hub does not have the resources to engage with all identified stakeholders. The end-users and stakeholders captured under the user groups are actively engaged with the Hub, have identified information, guidance or training needs which the Hub can assist with and have been assessed as providing strong path-to-impact outcomes. In many cases these research facilitation activities will act as pilot activities, where methodologies, products and guidance are developed and tested. Once developed, these methodologies and products may be rolled out to a broader cross-section of Hub stakeholders in RPV6 and beyond. In this way these activities, which are developed with and for specific and limited stakeholders, can be used by more stakeholders in the future, thereby extending the benefit, value and reach of these activities.

Delivering Hub impact through research facilitation activities

Since 2017 (RPV3) a suite of Hub and project-level research facilitation activities have been implemented on an annual basis alongside existing research projects.

The purpose of the research facilitation activities is to develop (in partnership with stakeholders) additional outputs (i.e. products and services) that are tailored to the specific needs of target stakeholders to facilitate path-to-impact for the Hub’s existing portfolio of research projects. In practice, the research facilitation activities (which include Indigenous activities, case studies and engagement activities) are typically low-cost activities and outputs (\$10–50K) funded on a

discretionary basis by Hub central. Most of these activities are linked to one or more research projects, with input from project researchers.

Like the research projects, individual research facilitation activities are not intended to deliver impact in isolation, rather they contribute to the overall path-to-impact of the Hub.

These activities are also a key feature of the Hub's approach to supporting innovation and maintaining flexibility from year to year in order to respond to new and emerging priorities and opportunities identified by both the Department and key stakeholders.

The research facilitation activities are not defined as research projects for the purposes of the annual Research Plan development and approval process, rather an enhancement to and implementation of communication and knowledge brokering functions of the research projects and the Hub more generally.

Under RPV6 these case research facilitation activities (including Indigenous activities) have been identified through stakeholder engagement and discussions with key stakeholders both at the Hub and research project level.

Data accessibility

The NESP guidelines expect that all information (including research data) produced under the program is made publicly and freely available on the internet. The ESCC Hub recognises the need to promote open access to public sector and publicly funded information.

The Hub's approach to data and information management is covered in its Data Management Plan, which is available on the [Hub's website \(www.nespclimate.com.au\)](http://www.nespclimate.com.au).

The Hub is committed to ensuring that all data and information are discoverable by and available to stakeholders. Appropriate protocols have been developed to ensure that publications, products and metadata statements for each project are completed, collated and catalogued as per NESP guidelines. The Hub aims to make the metadata statements available on its external website in accordance with Departmental arrangements for NESP. The Hub leadership will also work with partner agencies to ensure consistency with relevant agency-specific data and information management arrangements.

The Hub ensures all peer reviewed journal articles produced by the Hub are made publicly available on the Hub's website, in accordance with the archive and open data access policies of each journal. In general, where a final publication cannot be made publicly available, a pre-print or authors manuscript will be made available.

Where appropriate, the Hub will use existing research infrastructure, developed under NCRIS, ACCSP and ANDS to curate and, where appropriate, distribute ESCC datasets. This specifically includes: the Earth Systems Grid at the NCI for CMIP data; IMOS and TERN data portals for oceans and terrestrial data; the Carbon Observatory for carbon cycle information; and CSIRO's Cape Grim greenhouse gas data website.

The Hub has also ensured that an inventory of ACCSP datasets is accessible to next- and end-users via a link on the ESCC Hub website to the ACCSP website, where the ACCSP metadata catalogue is stored so that these data are also curated and potentially available for further use. This IP resource is considered a critical and highly valuable input to the Hub's knowledge value chain.

The Hub will also be enhancing model systems—specifically ACCESS—with the goal of ensuring ACCESS can be used by the research community and model simulations are accessible. It is not envisaged that the ACCESS model will be publicly available, although those components developed within Australia are already open source (e.g. the CABLE [Community Atmosphere Biosphere Land Exchange] land surface model).

Monitoring and evaluation

NESP monitoring and evaluation plan

The NESP Monitoring & Evaluation (M&E) Plan provides the framework through which the progress and success of the Hub will be measured. It will enable clear performance assessment via a common set of high-level indicators used across the program, along with qualitative, narrative based reporting of project progress and impact.

Key M&E performance indicators for each NESP Hub will be aligned to a number of key themes:



Two important elements of the M&E Plan are annual project reporting and the biennial program evaluation.

Project and financial reporting

Under the terms of the NESP funding agreement, the following reports are required to be submitted to demonstrate Hub performance and project progress:

- **Annual progress report:** to be submitted in April of each year and describes, in quantitative and qualitative terms, the progress of work against the Research Plan.
- **Financial information and audit:** submitted with the annual progress report to show, amongst other matters, the budget and actual income and expenditure of the Hub, and in summary the other cash contributions and in-kind support.
- **A final report:** submitted at the conclusion of all Hub activity.

NESP evaluations

Two evaluations were scheduled as part of the program. The mid-term evaluation used data from Research Plans, annual progress reports, surveys, interviews and focus groups and was completed in 2018. It made some suggestions for improvement but demonstrated that the program is on track to meet its outcomes. A final evaluation is scheduled for the program conclusion.

Performance measures

The single key performance indicator for the NESP in the Department of the Environment and Energy's Annual Report is quantitative assessment that measures whether projects have at least one research user who is reporting that research outputs are being used for decision-making.

ESCC Hub Evaluation Planning Framework

The Hub's Evaluation Planning Framework (EPF) is designed to complement the overarching NESP M&E Plan relevant to all hubs. Specifically, the ESCC Hub's EPF outlines the process of developing and implementing evaluation planning at both Hub and project-level (including case studies and engagement activities). The framework ensures the process is outcome-focussed, targeted at next-users and end-users, and delivers measurable impact.

The EPF features both a schematic 'program logic' (also referred to as a 'theory of action', provided in *Appendix 1*), and key evaluation questions (KEQs), which define the critical success factors relevant to all aspects of Hub operations (day-to-day through to whole-of life), including:

- Hub administration, including general management and coordination
- implementation of the Hub's research project portfolio
- communication and knowledge brokering
- stakeholder engagement
- risk management
- realisation of sustainable, longer-term strategic outcomes and path-to-impact.

The EPF, through design and implementation of a specific Hub-level M&E action plan, also provides real-time performance monitoring and management through progress reporting, and review of how the Hub will assess and report on its strategic path-to-impact across its portfolio of integrated projects and associated research facilitation activities.

In this context, the EPF is a key strategic document directly linked to the C&KB Strategy and the Indigenous Engagement and Collaboration Strategy, all of which inform the implementation of the Hub's annual Research Plan. As for the C&KB Strategy, the Hub's EPF also underpins the Hub's flexibility and responsiveness (e.g. through the operational development and implementation of annual research facilitation activities – see previous section) to accommodate changing research priorities on an annual basis, in addition to the Hub's commitment to facilitating innovation and continuous improvement in research project-based service delivery.

The Hub-level M&E action plan is updated by the Hub on an annual basis and provides relevant input to facilitate implementation of the NESP M&E Plan, specifically the delivery of the Biennial

Evaluation Report. As previously stated, it also ensures that the Hub’s research is continually informed by stakeholder needs (as in the following summary schematic).



As a part of this, all RPV6 projects are required to submit annual work plans describing their objectives, tasks and outputs. Operationally, these work plans will feed into the Hub’s internal quarterly progress reports and annual reporting to the Department. They also enable the Hub to monitor resourcing, and track progress in a measurable way.

The project work plans, and progress reports, are the primary means by which the Hub monitors project performance in terms of milestone compliance, as well as through review and analysis of stakeholder gaps and needs and communication and knowledge brokering activities. Consistent with the EPF requirements, this information feeds back into and takes direction from the Hub’s C&KB and Indigenous Engagement and Collaboration strategies throughout the life of the Hub, at both a Hub and project level.

As previously explained, the primary unit of management/assessment for evaluating the Hub’s path-to-impact as part of RPV6 will be the reaction of the six Target User Groups around which the Hub will tailor specific knowledge exchange, co-production and communication research facilitation activities.

Collaboration and partnerships

The NESP encourages a collaborative, multi-disciplinary approach to environmental research. Key to the success of the Hub will be the capacity to foster partnerships across hubs and with a wide range of relevant research stakeholders.

Table 2 identifies those partners and stakeholders with whom the Hub has previously or currently engaged. This list has grown and matured throughout the life of the Hub.

Table 2: Hub collaborations and partnerships. The Hub has had face-to-face contact with all partners and stakeholders listed in this table

Programs or agencies who are non-funded partners providing research capability and/or represent key next- and end-users				
Partner	Relationship to ESCC Hub	Role (institution, program, individual)	Expertise	Alignment to Hub goals
Integrated Marine Observing System (IMOS)	Director is a member of the Hub Steering Committee (HSC)	Program: Provides critical research infrastructure to Hub research	Ocean observing infrastructure	Critical to ocean observations; which underpin several outcomes and research priorities
National Computational Infrastructure (NCI)	Member of ACCESS Advisory Group (Bureau, CSIRO, Universities are part of this)	Program: Provides critical research infrastructure to Hub research	High Performance Computing for ACCESS modelling; CMIP model and observed data storage	Critical to ACCESS development and use; CMIP6 participation; and delivery of climate information
ARC Centre of Excellence for Climate Extremes	Director of Centre is a member of Hub Steering Committee (HSC); CIs are involved in Hub projects	Institutional: ARC-funded centre providing underpinning climate system science to Hub research	Climate systems science, climate extremes	Aligned to some research priorities
Australian Antarctic Division (AAD)	AAD program leader for Antarctica and the Global System; member on HSC	Program: CRC and AAD potentially both users and providers of Hub research	Antarctic and Southern Ocean – cryosphere processes	Aligned to some research priorities; complementary research goals
National Climate Change Adaptation Research Facility (NCCARF)	Director is a member of HSAG	Program: Both a next- and end-user of Hub research. NCCARF also connects the Hub's research to broader end-user communities	Adaptation to climate change, with a focus on the coastal zone, especially sea-level rise impacts	Aligned to some research priorities; complementary research goals
Magalana Aboriginal Corporation	Interim steering committee member for the Second National Indigenous Dialogue on Climate Change	Agency: stakeholder group with whom we are developing Indigenous engagement activities	Traditional owners and Indigenous knowledge; climate change; natural resource management	Aligned to Hub's Indigenous engagement goals and objectives

Partner	Relationship to ESCC Hub	Role (institution, program, individual)	Expertise	Alignment to Hub goals
Banjelungup Aboriginal Corporation	Interim steering committee members for the Second National Indigenous Dialogue on Climate Change	Individual and institutional	Traditional owners and Indigenous knowledge; climate change; natural resource management	Aligned to Hub's Indigenous engagement goals and objectives
Central Land Council	Interim steering committee members for the Second National Indigenous Dialogue on Climate Change	Agency: stakeholder group with whom we are developing Indigenous engagement activities	Traditional owners and Indigenous knowledge; natural resource management	Aligned to Hub's Indigenous engagement goals and objectives.
Yorta Yorta Nation Aboriginal Corporation	Co-leaders of the 2018 National Indigenous Dialogue on Climate Change and Interim steering committee member for the Second National Indigenous Dialogue on Climate Change	Agency: stakeholder group with whom the Hub is developing Indigenous activities	Traditional owners and Indigenous knowledge; natural resource management	Aligned to Hub's Indigenous engagement goals and objectives.
Mackay Traditional Owners	Stakeholders and collaborators on Indigenous engagement Interim steering committee member for the Second National Indigenous Dialogue on Climate Change	Agency: stakeholder group with whom we are developing several Indigenous engagement activities	Traditional owners and Indigenous knowledge; natural resource management	Aligned to Hub's Indigenous engagement goals and objectives.
Australian Mango Industry Association (AMIA) and NT Farmers Association	Research end-users and collaborators in RPV5&6 research facilitation activities	Institutional: stakeholders with whom the Hub has developed a relationship with through engagement and research facilitation activities	Agricultural sector	Collaborator in RPV5-6 research facilitation activities and associated knowledge exchange and communication activities

Partner	Relationship to ESCC Hub	Role (institution, program, individual)	Expertise	Alignment to Hub goals
Financial services sector: <ul style="list-style-type: none"> • Australian Institute of Company Directors • Australian Banking Association • Insurance Council Australia • Investor Group on Climate Change • APRA • Australian Securities and Investments Commission • Reserve Bank of Australia 	The Hub has interacted with these stakeholder groups and/or associated focal points via Hub Central, HSAG and some LCIs to determine needs and potential collaborative opportunities	Potential end-users of Hub outputs	Financial services, specifically retail banks, insurance companies/actuaries and super fund managers	Members of the financial sector target user group
QBE	Co-ordinating the Climate Measurement Standards Initiative which the Hub is providing scientific and technical advice through a science advisory group	Institutional:	Facilitating the Hub's interactions with the industry-led Climate Measurement Standards Initiative (CMSI)	Financial sector services research facilitation and associated knowledge exchange activities and communications
Climate Policy Research	Director of this company (Nick Wood) is a sub-contractor/consultant advising and facilitating the Hub's Financial Sector Services target user group activities. Member of the HSAG	Individual and institutional	Providing private sector perspective on managing climate risk and valuation of risk capital	Financial sector services research facilitation and associated knowledge exchange activities and communications

NESP hubs

Partner	Relationship to ESCC Hub	Expertise	Alignment to Hub goals
<ul style="list-style-type: none"> • Clean Air & Urban Landscapes (CAUL) • Marine Biodiversity • Threatened Species Recovery (TSR) • Northern Australia Environmental Resources (NAER) • Tropical Water Quality (TWQ) 	<p>Collaborators on specific areas of research, Indigenous engagement and users of climate knowledge and information.</p> <p>The Hub has organised a variety of cross-hub collaborations in 2018, such as cross-hub business breakfast events at national conferences to showcase the science of the NESP.</p> <p>The Hub organised a cross-hub workshop in 2016 where several research areas of mutual interests were identified, and a set of actions were determined to build the collaboration and path-to-impact for our Hub.</p> <p>Cross-hub collaborative case studies were conducted as part of RPV4 and will be conducted under RPV5.</p>	<p>Primarily urban greenhouse gas emissions and climate change (CAUL); threatened species ecology (TSR); mangrove and coral reef ecology (TWQ); climate impacts (all); and Indigenous engagement (NAER)</p>	<p>Aligned to some research priorities</p>

Government collaborators, with whom the Hub has established links

<p>Federal, state and local government departments; government authority agencies</p>	<p>Federal:</p> <ul style="list-style-type: none"> - Department of the Environment and Energy - Office of Northern Australia - Bureau of Meteorology, Climate Services Group - Home Affairs, National Resilience Taskforce - Department of Agriculture 	<p>States and territories:</p> <ul style="list-style-type: none"> - Vic Dept of Environment, Land, Water & Planning - ACT Climate Change Policy Group - WA Dept of Water and Environmental Regulation - NSW Department of Planning, Industry and Environment - NT Department of Primary Industry and Resources - SA Dept of Environment, Water & Natural Resources - Tas Dept of Primary Industries, Parks, Water & Environment 	<p>Local councils:</p> <ul style="list-style-type: none"> - Hobson Bay Council - Greater City of Geelong council - Bass Coast Shire Council - Kingborough Council 	<p>Government authority agencies:</p> <ul style="list-style-type: none"> - Murray Darling Basin Authority (MDBA) - AFAC - GBRMPA - Torres Strait Regional Authority - World Heritage Committees: Gondwana Rainforests, Shark Bay
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Stakeholder engagement

Effective stakeholder engagement is essential to realising the Hub's goals, outcomes and delivery of tangible, on-ground impact. The primary purpose of the Hub's stakeholder engagement is to inform the Hub's research project portfolio development and implementation in a way that addresses the prioritised needs of target next- and end-users of the Hub's research, information products and services.

The Hub's approach to engaging with both internal and external stakeholders includes the full cycle from engagement to inform research prioritisation, to the delivery of research outputs and ongoing impact evaluation and review. This is the framework that formally captures the commitment to ensuring the Hub's research projects are informed by next- and end-user needs and thereby facilitating tangible path-to-impact. At a Hub level, and for all projects within the Hub, this latter part of the cycle is managed formally as part of the Hub's EPF (see previous section). Its implementation occurs via the associated Hub M&E action plan and systematic progress reporting; and the Hub's respective C&KB and Indigenous Engagement and Collaboration strategies.

The Hub's primary focus is those internal and external stakeholders who are one or some combination of the following points along the 'knowledge value chain':

- a) End-users (typically external to the Hub and the NESP more generally) of the Hub's information products and services, which may have been modified and value-added by next-users.
- b) Next-users of the knowledge and information delivered by the Hub's research – these are often allied researchers, research projects, programs or agencies (including both internal and external to the Hub and the NESP more generally).
- c) Providers (typically external to the Hub and the NESP more generally) of research infrastructure and other inputs to the research undertaken by the Hub.

The Hub recognises that the broader Australian community is also a stakeholder, given the national and global importance of climate change and its high profile in the community. The general public will have access to all Hub products as they are open source. The Hub will invest in developing general communication products for dissemination via traditional and social media (including for example, *The Conversation*, radio and print interviews, targeted magazine articles, etc.). However, given the Hub's limited resources and primary research delivery role, such activities and products will typically be done in liaison with the partner agencies.

The Hub's key internal stakeholders include (see also Figure 2):

- The Hub Steering Committee and Stakeholder Advisory Group
- The Hub Leadership and Program Management Teams
- The Hub's CIs and associated project teams
- The Hub's partner agencies, including those parts of CSIRO and the Bureau of Meteorology who are not within the Hub (e.g. CSIRO Land and Water, CSIRO Agriculture and Food Business Units; Bureau Climate Monitoring and Services etc.) and in the universities (e.g. the Monash Sustainability Institute).

The primary means of engaging with internal stakeholders include:

- Annual workshop(s)
- Quarterly HSC and HSAG meetings
- Monthly HLT/HPMT meetings and weekly HPMT meetings
- Hub SharePoint document and information repository
- Monthly internal newsletter 'ESCCapades'
- Periodic email/webinar briefings to the Hub community by the Hub Leader
- Periodic Lead CI forums
- Quarterly external newsletter 'Teleconnections'
- Briefings

Indigenous engagement

The ESCC Hub is committed to meaningful Indigenous engagement and collaboration during all phases of the delivery of the NESP. Where relevant, due consideration will be given to actively involving key Indigenous stakeholders in research prioritisation, research delivery and, especially, the communication of research output. The Hub's approach to Indigenous engagement is detailed in its Indigenous Engagement and Collaboration Strategy, found on the Hub's website at <http://nespclimate.com.au/governance-and-reporting/>. The vulnerability of some Indigenous communities to climate-related risks, and the potential for adaptation, is well-understood by the Hub. The Hub also understands that Indigenous communities are custodians of a wealth of knowledge about Australia's weather and climate – knowledge that can complement and benefit the Hub's research and impact. In turn the Hub, through its Bureau of Meteorology, CSIRO and university partners, can build upon earlier work with Pacific Island nations and communities, and the Bureau's Indigenous Weather Knowledge (<http://www.bom.gov.au/iwk/>) to ensure effective Indigenous engagement that benefits Australia and Indigenous communities.

The primary goal of the Hub's Indigenous Engagement and Collaboration Strategy is to provide targeted climate information that is relevant and useful to Indigenous Australian communities. The Hub continues the actions undertaken in 2015–2018 to build strong, trusted partnerships with our Indigenous stakeholders and explore ways that traditional knowledge can inform the Hub's research. These partnerships will form the foundation for ongoing collaboration and mutual benefit.

The Hub will do this through participatory approaches to address key climate information gaps and needs of Indigenous Australian communities. Our focus will be on:

- information needed for assessing climate impacts on natural resources, ecosystems and communities
- provision of customised communication products and tools to support decision-making and enhanced adaptation planning.

The Hub will focus on developing targeted partnerships, expertise and products to meet the needs of Indigenous stakeholders through research facilitation and engagement activities with key groups such as the Torres Straits Regional Authority and the traditional owners of the Great

Barrier Reef. Our aim is to provide instructive examples of success that provide the building blocks for future engagement and delivery.

The Hub's Indigenous Engagement and Collaboration Strategy addresses the *NESP Indigenous Engagement Strategy Guidelines*. The guidelines identify five pillars critical to successful Indigenous partnerships:

- Pillar 1: Building trust
- Pillar 2: Respectful interactions
- Pillar 3: Upholding rights
- Pillar 4: Mutual understanding
- Pillar 5: Enduring partnerships

All research that is undertaken, irrespective of its nature, will have an impact on Aboriginal and Torres Strait Islander people and communities, and therefore Indigenous engagement and participation is identified as a cross-cutting theme for all NESP Hubs in the development of research priorities.

Meaningful, thoughtful and appropriately resourced engagement with Aboriginal and Torres Strait Islander peoples will result in benefits to Indigenous Australians and to Australian society. Genuine engagement, participation and communication strategies that are relevant to the culture and views of Indigenous Australians are essential to build strong, effective and mutually respectful relationships.

To ensure that ESCC Hub research is conducted according to the highest ethical standards the Hub will follow the *Guidelines for Ethical Research in Australian Indigenous Studies* published by the Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS) in 2000 and revised in 2011. This document outlines the best standards of ethical research and principles regarding respect for the rights of Indigenous Australians, including their right to full and fair participation in any processes, projects and activities that affect them. Principles from the 2011 AIATSIS guidelines² provide a coherent and clear national standard and have been adopted to assist Hub researchers achieve the highest standards of ethical research.

The guidelines are clear that it is essential that Indigenous people are full participants in research projects that concern them, share an understanding of the aims and methods of the research, and share the results of this work. At all stages, research with Indigenous peoples must be founded on a process of meaningful engagement and exchange between the researcher and Indigenous people. The guidelines also recognise there is no distinction between researchers and Indigenous people – Indigenous people are also researchers.

With this in mind, the Hub will support a number of Indigenous activities under RPV6, as outlined in appropriate research facilitation activity plans in [Attachment B](#).

Activities under this Target User Group plan will be informed by past and current collaborations with Hub Indigenous stakeholders. For example, in partnership with CSIRO Land and Water's Collaborative and Indigenous Science team, Kimberley Land Council (KLC), Yorta Yorta Nation Aboriginal Corporation and Seed (the Indigenous branch of the Australian Youth Climate Coalition, and Australia's first Indigenous youth-led climate network), the Hub has been working

² <http://aiatsis.gov.au/>

to identify Indigenous priorities for climate-change-focussed information, capacity building and forms of engagement.

A National Indigenous Dialogue on Climate Change was held in November 2018 and brought together key Indigenous stakeholders and selected Hub researchers and management staff to discuss information needs and priorities and how the Hub can continue to work with Indigenous communities to co-produce relevant and accessible information and products, as well as continue a meaningful two-way exchange of information and knowledge. The outcomes of the workshop, and previous engagements, are contributing to the Hub’s future plans to meet the Hub’s Indigenous engagement goal. Previous engagement activities which continue to inform the Hub’s Indigenous engagement activities include:

- i. the 2012 workshop run by Monash University and the Yorta Yorta Nation Aboriginal Corporation as part of an NCCARF-funded activity
- ii. NCCARF’s recent initiatives in peer-learning events with Indigenous peoples to underpin further development of their Indigenous Adaptation Research Plan
- iii. 2018 National Indigenous Dialogue on Climate Change
- iv. Past ESCC Hub Indigenous activities and other relevant initiatives.

Funding

The ESCC Hub is supported through funding from the Australian Government’s National Environmental Science Program. Under the Department of the Environment and Energy Portfolio Budget Statements, the NESP provides for around \$142 million over the life of the Program.

Table 3 describes the funding from the NESP available to the ESCC Hub over the life of the Funding Agreement, which ceases on 30 June 2021.

Table 3. ESCC Hub funding summary

	2015 Actual ¹	2016 Actual ¹	2017 Actual ¹	2018 Actual	2019 Budget	2020 Budget	2021 Budget	Total
	\$	\$	\$	\$	\$	\$	\$	\$
NESP Funding ¹	466,000	500,000	7,650,000	5,100,000	5,100,000	4,550,000	550,000	23,916,000

Expenditure of NESP funding under the Hub is expected to be distributed among three main items of expenditure (Research, General Communication and Administration). The funding must be expressed as a percentage of the total for any given calendar year noting that funding for Research must total at least 80% of the funding. The balance (20%) of the funding can be allocated between General Communication and Administration with no more than 10% of the funding being allocated to Administration.

Under the terms of the NESP, the minimum total for recipient and other contributions for the life of the program is 100% of the funds paid by the Department under this agreement.

Hub approach to risk mitigation and management

The Hub's Risk Register is divided into (a) Hub-level risks and (b) risks that have been identified and categorised from the individual research project proposals. These risks will be managed and treated at a whole-of-Hub level. The Hub's Risk Register has been updated to reflect any change in details relating to existing (RPV5) risks, noting that there are no new or emerging risks for RPV6.

A consistent risk management approach implemented across the Hub delivers significant benefits in terms of effectiveness and efficiency; especially as the risks identified by all projects fell mostly into the following five categories:

1. Dependency on project(s), infrastructure and data sources that are funded external to the project and/or Hub and are not always under the control of the project leadership, specifically:
 - IT skills and infrastructure (including the NCI facility at ANU, which provides processing capacity for climate model simulations along with significant data storage capacity)
 - Observational infrastructure
 - Observed and modelled data (including CMIP6)
 - Performance of climate models generally, and especially Australia's climate model, ACCESS.
2. Staffing: Loss of staff with key skills and/or insufficient critical mass of staff.
3. Inadequate Hub-level communication and knowledge brokering, stakeholder and Indigenous engagement, which could limit the effectiveness of these activities at a research project level and/or Hub level (see also risk category #5 below).
4. Resource constraints and stakeholder expectation management.
5. Path-to-impact limited because it will be realised via other projects, Hubs and/or stakeholders (i.e. the project primarily delivers to next rather than end-users), and/or because of misinterpretation and/or miscommunication of results.

Flexibility

The Hub is aware that flexibility in relation to responding to changes in annual research priorities and emerging stakeholder needs and opportunities is important for the Department and the Hub more generally. An example of the Hub's ability to respond to changing stakeholder or departmental needs can be seen by the Hub's renewed focus on climate change impacts and risks for World heritage Areas in Australia. During 2019 this area gained significant importance for both the Department of the Environment and Energy and World Heritage Area managers and committees. The Hub has responded to this new need and is continuing on from RPV5 to undertake a number of research facilitation activities to begin to understand and address this priority need.

The following is a summary of the Hub's approach to ensuring there is adequate flexibility in the Hub's research portfolio:

- 1. Leveraging off past commitments:** The Hub can leverage existing IP from previous investments (e.g. ACCSP), whereby a small amount of discretionary Hub investment can

deliver more immediate stakeholder benefits ('low-hanging fruit'). Such IP is broad-based and has flexibility to meet fit-for-purpose needs while funded NESP projects gain traction and begin delivery.

- 2. ESCC Hub capability and IP:** This extends beyond existing project teams and across all core partners. The Hub is confident it has the capability needed to re-orient its research activities to meet emerging Departmental needs and priorities.
- 3. Research Plan – implementation:** The project and associated research facilitation commitments collectively vary in duration from 12 months to three years, with provision for periodic stop/go reviews where appropriate. This provides the option for re-scoping/re-direction throughout the lifetime of the existing approved projects. The research facilitation activities in particular provide the Hub with a flexible, operational mechanism each year to scope up and resource from Hub Central the delivery of relatively 'low cost' tailored products and services for target stakeholders as an adjunct to the existing research projects. The annual research planning cycle provides the governance and oversight (via the Department and HSC) needed to reinforce this flexibility in terms of re-scoping investment each year.
- 4. Communication and knowledge brokering:** The Hub has some discretionary resources that are available to be committed to activities (including products and services) that emerge from yet-to-be determined next/end-user needs. These typically include annual research facilitation activities (case studies, engagement activities and Indigenous activities) developed as part of the annual research planning process, but where appropriate can also include other discretionary activities proposed and commissioned out-of-session throughout the year.
- 5. Business development and stakeholder engagement:** We are also undertaking a strategic and systematic approach to business development as an integral part of our stakeholder engagement strategy. The purpose is to facilitate new co-investment opportunities to leverage core Hub funding). In practice the Hub has limited capacity beyond the existing commitment of resources from partner agencies. Therefore, it is appropriate that new project and associated co-investment opportunities leveraged off the Hub's existing research projects and stakeholder engagement activities will be addressed by one or more of the Hub's partner agencies, subject to the specific nature of the opportunity and the requisite domain knowledge and associated capability.

To this end the Hub has recognised a new class of 'adjunct' project for which the Hub has been instrumental in facilitating in a manner consistent with the Hub's broad objectives, but for which administratively and operational the implementation is to be the responsibility of the partner agencies. The Hub will seek to realise evidence of path-to-impact as appropriate in association with the relevant partner agencies.

Appendix 1. Earth Systems and Climate Change Hub: Program logic

NESP Goal & ESCC Specific Outcome	To improve our understanding of Australia's environment through collaborative research that delivers accessible results and informs decision-making Improved climate and weather information for Australia through a greater understanding of the drivers of Australia's climate.					
ESCC Hub National Challenges	Hydroclimate & Water Security	Global Warming & the Carbon Cycle	Climate Extremes & DRM	Coastal Climate and Communities	Food Security & NRM	
ESCC Hub Goal	Policy development, planning, management and associated decision-making in Australia effectively and efficiently informed by <i>Earth Systems & Climate Change Science</i> now and into the future					
ESCC Hub Objectives	Through world class research and development, to: <ul style="list-style-type: none"> • lead further development of the national Earth system and climate modeling capability to deliver enhanced climate predictions and projections for Australia • advance understanding of Australia's climate variability, extremes and associated drivers • develop and strengthen stakeholder relationships and support informed management and evidence-based decisions-making, and • facilitate outreach and communication of science products and services to target next/end-users 					
Practice change	Researchers deliver ES&CC science more tailored to needs of target end-users with clearer path-to-impact and outcomes focus	ES&CC science more effectively & efficiently integrated within Australian environmental research landscape	Stakeholders actively engage with the Hub, seek to better understand ES&CC science, develop technical capacity and provide positive feedback and support to Hub	Target end-users routinely access and apply best available ES&CC science capability and knowledge to inform policy development, risk management and associated decision-making		
Key Stakeholders & Target Next/end-users	Statutory Authorities and associated administrative agencies/other entities	Federal, State & Local Government departments/sectors	Australian industry: Financial Services Sector	Australian indigenous communities	Australian and international Earth system and climate change science research community	Other NESP Hubs and climate change consultancy sector
ESCC Hub C&KB Outputs	Case studies, communication and knowledge brokering products/collateral (incl. Hub website/content, non-technical summary reports, multi-media content, training and guidance materials, fact sheets, posters etc), end-user capacity development/training support, postgraduate/early career professional development, professional and public forums (workshops, seminars, symposia etc), governance documentation (incl. Annual Research Plans and associated strategies/action plans, risk register, metadata catalogue, Annual/Final Reports etc)					
ESCC Hub Governance	Hub Program Management Team Program Management & Administration, Communication & Knowledge Brokering, Stakeholder Engagement, Data & Information Management, Monitoring & Evaluation	Hub Leadership Team	Hub Steering Committee	Hub Stakeholder Advisory Group	Hub Lead Chief Investigator Forum Annual Research Plan, Communication & Knowledge Brokering Strategy, Indigenous Engagement Strategy, Evaluation Planning Framework, Annual Workshop & Science Symposium	
ESCC Hub Research Outputs	Enhanced models (higher spatial/temporal resolution, enhanced functionality, reduced bias/error/uncertainty, increased confidence etc), new climate data/information analyses, forecasts & projections, data access, analysis and decision support tools, including portals and website content, scenarios etc; peer-reviewed journal papers, technical reports and associated data/information products, presentations at symposia, conferences and workshops; technical training materials; project progress and completion reports etc					
ESCC Hub Research Priorities	Building the utility of ESCC information		Improving our understanding of how the climate system may change in the future		Improving our observations and understanding of past and current climate	
ESCC Hub Thematic Research Areas	Climate variability & extremes		Past, present & future climate		Future coasts & regions	
ESCC Hub Partners, IP, resources & capacity	Hub consortium – CSIRO, Bureau and Universities Cash/in kind – existing capability and IP, infrastructure, collaborative and stakeholder networks Leveraged off existing capacity, momentum and track record in ACCSP, NRM, PACCSAP, TERN, IMOS, NCI, SEACI, IOCI etc					

Appendix 2. Glossary for Research Plan V6

Acronym	Definition
AAS	Australian Academy of Science
ABA	Australian Banking Association
ACCESS	Australian Community Climate and Earth System Simulator
ACCSP	Australian Climate Change Science Programme
ACE CRC	Antarctic Climate and Ecosystems Cooperative Research Centre
AICD	Australian Institute of Company Directors
ANDS	Australian National Data Service
APRA	Australian Prudential Regulation Authority
ARC	Australian Research Council
ARCCSS	Australian Research Council's Centre of Excellence for Climate System Science (closed in 2018)
ARC CLEX	Australian Research Council's Centre of Excellence for Climate Extreme
Argo	A global array of profiling floats operated by over 25 nations under the United Nations' World Meteorological Organisation and the International Oceans Commission. Argo Australia is a major contributor, funded partially by the Integrated Marine Observing System and partner programs such as the ACE CRC, Bureau of Meteorology and CSIRO. www.argo.net ; www.imos.org.au
ASIC	Australian Securities and Investments Commission
AWRA	Australian Water Resources Assessment (model)
BIOS	Fine-spatial-resolution (0.05 degree) offline modelling environment for Australia, in which predictions of CABLE are constrained by multiple observation types
BoM	Bureau of Meteorology
CABLE	Community Atmosphere Biosphere Land Exchange model
CAPRICORN	Clouds, Aerosols, Precipitation Radiation & Atmospheric Composition over the Southern Ocean
C&KB Strategy	Communication and Knowledge Brokering Strategy
CAUL	Clean Air and Urban Landscapes Hub
CCiA	Climate Change in Australia website (climatechangeinaustralia.gov.au)
CCAM	Cubic Conformal Atmospheric Model (a CSIRO global model that can 'zoom' to high resolution over regions of interest – used to generate downscaled climate projections)
CCHDO	CLIVAR and Carbon Hydrographic Data Office – funded by the US National Science Foundation and operated by the Scripps Institution of Oceanography. CCHDO is the data curator, repository and distribution point for the global GOSHIP program.
CFT	Climate Futures for Tasmania
CLI	Chief Lead Investigator
CMSI	Climate Measurement Standards Initiative
CORDEX	CO-ordinated Regional Downscaling EXperiment

CMIP5, CMIP6	Coupled Model Intercomparison Project 5 and 6
CMOR	Climate Model Output Rewriter
CMSI	Climate Measurement
CSIRO DAP	CSIRO's Data Access Portal – access to publicly available, catalogued and DOI'd data resources. Collections in the DAP are curated for long-term storage and distribution.
DECK	Diagnosis Evaluation & Characterisation of KLIMA
DELWP	Department of Environment, Land, Water and Planning
EPF	Evaluation Planning Framework
ECL	east coast low
ENSO	El Niño–Southern Oscillation
ESCC	Earth Systems and Climate Change
ESCI	Energy Sector Climate Initiative
ESGF	Earth System Grid Federation
ESM	Earth system model
ET-CCDI	Expert Team on Climate Change Detection & Indices
GBRMPA	Great Barrier Reef Marine Park Authority
GCP	Global Carbon Project
GHG	greenhouse gases
GO-SHIP	An internationally coordinated global decadal-repeated survey of ship-based sections of top-to-bottom ocean physical and chemical properties. Australia has contributed to key regional lines via the ACCSP and the ACE CRC. GO-SHIP uniquely monitors the ocean carbon inventory and full depth heat and freshwater budgets, extending below Argo's current operating depth. www.go-ship.org .
HLT	Hub Leadership Team
HPMT	Hub Program Management Team
HSAG	Hub Stakeholder Advisory Group
HSC	Hub Steering Committee
HSRN	Hub Stakeholder Reference Network
ICA	Insurance Council of Australia
IGCC	Investor Group on Climate Change
IMOS	Integrated Marine Observing System – funded by Australia's National Collaborative Research Infrastructure Strategy. IMOS provides partial support for key climate ocean observing systems such as Argo, moored series, some carbon measurements.
IPCC	Intergovernmental Panel on Climate Change
LSAVs	large-scale atmospheric variables
M&E	monitoring and evaluation
MCV	Managing Climate Variability research and development program
MDBA	Murray Darling Basin Authority
MHW	marine heat waves
MOM	Modular Ocean Model (MOM), developed by NOAA GFDL (see below) and is part of the ACCESS system.

NACP	Northern Australia Climate Project
NARCLIM	NSW/ACT Regional Climate Modelling
NCCARF	National Climate Change Adaptation Research Facility
NCCC	National Centre for Coasts and Climate
NCI	National Computational Infrastructure
NCRAS	National Climate Resilience and Adaptation Strategy
NCRIS	National Collaborative Research Infrastructure Strategy
NCSAC	National Climate Science Advisory Committee
NERP	National Environmental Research Program (closed)
NESP	National Environmental Science Program
NOAA	US National Oceans and Atmosphere Administration. NOAA spans operational forecasting and research services across fisheries, weather, oceans and climate. NOAA's many laboratories and arms operate substantial parts of the global climate and ocean observing system and modelling centres.
NOAA GFDL	NOAA Geophysical Fluid Dynamics Laboratory – a key partner in ACCESS as the developer of the ocean model used, the Modular Ocean Model (MOM).
NRM	natural resources management
OTE	ocean temperature extremes
PACCSAP	Pacific-Australia Climate Change Science and Adaptation Planning Program
PEGS	process evaluation groups
POP	Populations Order Physiology (a stand-alone tree demography and landscape structure module for Earth system models)
PCCSP	Pacific Climate Change Science Program
RCP	representative concentration pathways
RPV1, RPV2, RPV3, RPV4, RPV5	Research Plan Versions 1, 2, 3, 4 and 5
SAM	Southern Annular Mode
SCU	Southern Cross University
SEACI	South Eastern Australia Climate Initiative
SOCRATES	Southern Ocean Clouds Radiation Aerosol Transport Experimental Study
TC	tropical cyclones
TERN	Terrestrial Ecosystem Research Network
TRMM	Tropical Rainfall Measurement Mission
UM	Unified Model
UoM	University of Melbourne
UNFCCC	United Nations Framework Convention on Climate Change
VCP19	Victorian Climate Projections 2019
WCRP	World Climate Research Program

Attachment A: Research projects – continued RPV5 projects

Project 5.1 – ACCESS evaluation and application

Project overview

Project details				
Length	Start date	End date	Approval date	Status
18 months	01/07/2019	31/12/2020	12/2018	Approved
Lead research organisations		Project leader		
CSIRO		Harun Rashid harun.rashid@csiro.au (03 9239 4532)		

Australia's national climate model (ACCESS) has been developed to provide us with a global climate and Earth system modelling capability, uniquely focusing on Australia and the Southern Hemisphere. This is important because most other global climate models are developed by Northern Hemisphere countries with a main focus on their own regions. ACCESS can also be used for various climate applications, including estimating the individual and combined effects of different external forcings (i.e. changes in greenhouse gas concentrations and land use) on past, present and future climate variations. In this project, different versions of ACCESS will be used to estimate the climate change signals associated with greenhouse gas and land use changes using ensemble simulations. The ACCESS simulations, combined with multi-decadal simulations from a higher-resolution ACCESS atmospheric model, will directly support other Hub projects under RPV5 by providing means to reduce the effect of internal climate variability to improve climate change estimates.

Expected outcomes

Climate models are indispensable for understanding and predicting climate variability; they are also the only tools available for projecting any future climate changes in response to external forcings. Thanks to many years of development, including through previous ESCC Hub ACCESS projects (Projects 2.1 and 2.5), ACCESS can now simulate many important features of global climate and its variability with impressive realism.

This project will deliver enhanced usability of ACCESS through model improvements and ensemble simulations by different versions of the model, which will underpin science activities across all Hub research areas through reduced uncertainties of Australia's climate variability and change, including land carbon budget in a warming world.

ACCESS-CM2 ensemble simulations will contribute to:

- Better understanding of the effects of climate drivers such as ENSO, IOD, SAM on projected rainfall variations over Australia.
- A better estimation of the possible future changes in frequency and intensity of the dominant climate variability modes, such as ENSO and IOD which strongly influence extreme events like drought and flood.
- Produce more informed estimates of changes in regional climate and weather extremes using the ACCESS-CM2 ensemble simulations and multi-decadal simulations from a higher-resolution ACCESS atmospheric model.
- Improve Australia's contribution to CMIP6 by providing additional ACCESS-CM2 ensemble simulations, building on the CMIP6 (single-member) submission under NESP project 2.1.
- ACCESS-ESM1.5 will provide improved information on the climate impacts of future land management.

Project 5.2 – Understanding climate variability and change – past, present and future

Project overview

Project details				
Length	Start date	End date	Approval date	Status
18 months	01/07/2019	31/12/2020	12/2018	Approved
Lead research organisations		Project leader		
Bureau of Meteorology		Christine Chung christine.chung@bom.gov.au (03 9669 4097)		

Despite a rising awareness of general climate change issues, there is still a need for further information and guidance about the effect of human influence on the climate we have seen to date. This will assist Australian stakeholders to reliably understand and frame the role of natural variability and human influence on our climate. It is important that Australian stakeholders have the necessary guidance and tools to manage the country's infrastructure and natural resources to face the challenges of a changing climate.

Expected outcomes

There is currently a lack of targeted tools and appropriately targeted educational guidance about the drivers of Australia's climate variability, El Niño–Southern Oscillation (ENSO), Indian Ocean Dipole (IOD), Southern Annular Mode (SAM) and the Interdecadal Pacific Oscillation (IPO) which affect rainfall patterns, extreme weathers and climate conditions including tropical cyclones, bushfires, flood and drought.

This project enhances the understanding of the dynamics and impacts of Australia's climate drivers through:

- Updated information on the impact of global warming on both ENSO and ENSO's influence on Australian climate using the latest generation (CMIP6) of climate models, including ACCESS.
- Better understanding of the drivers of the variability in the tropical oceans that influence ENSO and the IOD, important climate drivers in Australia's climate, and potential links to surrounding ocean basins.
- Better understanding the influence of decadal variability on Australia's climate to improve the predictability of ENSO and other climate drivers.
- Improved near real-time attribution system based in the attribution method developed under Project 2.2.
- Improved understanding of multi-year to flash drought and the links to ENSO and other climate drivers.
- Provide updated information on decadal variability and links to ENSO. This includes commissioned review papers on IOD and a book on ENSO in a changing climate.

Project 5.3: Regional climate change projections science and delivery

Project overview

Project details				
Length	Start date	End date	Approval date	Status
18 months	01/07/2019	31/12/2020	12/2018	Approved
Lead research organisations		Project leader		
CSIRO		Michael Grose michael.grose@csiro.au (03 6232 5345)		

To make evidence-based decisions about climate change and to manage climate risks, Australia needs access to credible, up-to-date and relevant information 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 projection science and modelling to support and build towards the future major release of new national climate change projections, setting up future and ongoing success in this arena.

Expected outcomes

This project will take the initial steps to tailor climate projections to specific needs and delivery appropriate for climate risk assessment. Enhanced uptake of existing and new projection products and services will allow next/end-users to more fully assess the impact of climate variability and change to inform planning and decision-making. This will improve the scientific evidence supporting important long term investments, with benefits for society, the economy and the environment.

The three main outcomes are:

- Stakeholders in all levels of government, and identified industry stakeholders, understand and have access to relevant information, products and services to support uptake and utility of existing (and upcoming) projections.
- Stakeholders have better understanding of the sources of confidence and uncertainty in projections. Risk management is therefore better informed.
- Preparation for the next set of projections is based on strategic planning, well in advance. This includes progress towards development of new methods and approaches and co-ordinated preparation for new data sources.

Project 5.4 – Water futures under climate change

Project overview

Project details				
Length	Start date	End date	Approval date	Status
18 months	01/07/2019	31/12/2020	12/2018	Approved
Lead research organisations		Project leader		
CSIRO		Dewi Kirono dewi.kirono@csiro.au (03 9239 4651)		

Robust projections of surface water are needed for impact assessment and developing adaptation options in the water and related sectors. The project will develop a framework that integrates climate and hydrological science and modelling to deliver the next generation of national projections of key surface water metrics. The project will also work with state government and federal authority agencies to demonstrate application of water projections to assess impact and adaptation options in water resources management. The project will build on outputs from ESCC Hub research and other hydroclimate initiatives in Australia and elsewhere.

Expected outcomes

Robust projections of water futures are important for impact assessment and developing adaptation options in the water and related sectors. Users include policy makers (government), land and water planning managers (water agencies, catchment management authorities), environmental consultants and other researchers.

Australian hydrology is different to other parts of the globe with a low runoff coefficient, high spatial and temporal variability, and strong ENSO teleconnection, and hence national investment is required to ensure that the nation has the hydrological projections science capability to meet the challenges in Australia. These include needs for:

- delivering next generation climate projections, with CMIP6 and improved climate modelling projections;
- framework to deliver not only climate projections but also national surface water/runoff projections;
- framework to deliver not only averages, but also other key hydrological metrics (e.g. low flows, high flows, drought indices).

In partnership with Project 5.3, this project will develop a framework that integrates climate and hydrological science and modelling to deliver the next generation water projections, as part of the broader next generation of national climate change projections to be released in 2023/24.

The project work in partnership with stakeholders (especially MDBA and WA DWER through case studies) to ensure that the framework and the knowledge produced are directly adopted by the stakeholders, and so demonstrate the application of climate change projections to assess impact and adaptation options in water resources management under a changing climate.

Project 5.5 – Extreme weather hazards in a changing climate

Project overview

Project details				
Length	Start date	End date	Approval date	Status
18 months	01/07/2019	31/12/2020	12/2018	Approved
Lead research organisations		Project leader		
Bureau of Meteorology		Andrew Dowdy andrew.dowdy@bom.gov.au (03 9669 4722)		

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, including around the intersection of climate and disaster risk, with a clear need for enhanced guidance and services to enable effective evidence-based planning. This project will deliver nationally significant knowledge products on natural hazards for the current climate as well as based on future projections. In particular, it will address identified needs around four key types of hazards: tropical cyclone hazards; bushfire hazards; east coast lows hazards; and thunderstorm hazards. To enable the translation of science into effective evidence-based policy, a range of targeted communication tools and research synthesis products will be developed through direct consultation with stakeholder networks.

Expected outcomes

Recent research in the ESCC Hub has examined the phenomena that cause weather hazards, quantifying and communicating the climate change influences on the occurrence of these phenomena. However, significant knowledge gaps exist regarding the associated hazards caused by those phenomena, including around their existing and future characteristics. This includes hazards associated with four major types of extreme weather phenomena:

- Tropical cyclones
- East coast lows
- Thunderstorms and associated hazards
- Extreme fire weather conditions

This project builds on Project 2.8 to examine the hazards and provide hazards information, the primary requirement for climate risk assessment applications, including in relation to the economic, social and environmental impacts of extreme weather hazards.

The outcomes from this project will contribute to greater resilience (prevention, preparedness, response and recovery) to extreme weather and climate events in Australia by developing improved knowledge and decision-support tools on current and future climate hazards associated with tropical cyclones, east coast lows, thunderstorms and bushfires.

The science from this project will enable the development and delivery of new products including improved guidance on weather-related hazards such as extreme winds, rainfall and flood risk, compound events including thunderstorms interacting with extreme bushfire weather/drought conditions ('pyroconvection' risk) as well as other convection-related hazards (e.g., hail and lightning).

Project 5.6 – The carbon budget of continental Australia and possible future trajectories

Project details				
Length	Start date	End date	Approval date	Status
18 months	01/07/2019	31/12/2020	12/2018	Approved
Lead research organisations		Project leader		
CSIRO		Pep Canadell pep.canadell@csiro.au (0408 020 952)		

The Paris Agreement requires the assessment and tracking towards achieving a balance ‘between anthropogenic emissions by sources and removals by sinks of greenhouse gases’, consistent with the well below 2°C target. While climate change policies seek to manage the net emissions of greenhouse gases, large uncertainties remain on how the full carbon budget can be best managed to reduce emissions, increase carbon sinks and protect existing carbon stock. This project will estimate the net carbon balance (carbon budget) of Australia and support the development of an improved global carbon budget including both anthropogenic and natural carbon fluxes. The products will support the policy call to better estimate and track the path towards zero net greenhouse gas emissions. 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.

Expected outcomes

The Paris Climate Agreement requires the assessment and tracking towards achieving a balance ‘between anthropogenic emissions by sources and removals by sinks of greenhouse gases (GHG)’, consistent with the well below 2°C target. It has been recognised that this GHG balance requirement (also called GHG neutrality or zero net emissions) linked to a temperature goal, as in the Paris Agreement, requires the inclusion of anthropogenic and natural fluxes, because both affect the greenhouse gasses in the atmosphere and therefore the likelihood to achieve or surpass a climate stabilisation target. Climate stabilisation at any level requires GHG neutrality.

There are no established global and national approaches on how to assess progress towards the requirement of GHG neutrality (anthropogenic and natural fluxes) in light of changing climate, atmospheric composition, and land use/cover.

To address this lack of information, the project will:

- Develop a comprehensive carbon budget for continental Australia for the most recent decade, and project it into the future using climate scenarios and socio-economic pathways developed by the Australian National Outlook Project. The assessment will focus on carbon stocks and fluxes, natural and anthropogenic, including legacy effects and disturbances.
- Contribute to update and improvement of the global carbon budget as part of the broader investment into the Global Carbon Project, which will provide the global context and links to new datasets, modelling and expertise to be used for the establishment of the continental Australian carbon budget.

Project 5.7 – Tracking ocean change: ocean observations and models

Project details				
Length	Start date	End date	Approval date	Status
18 months	01/07/2019	31/12/2020	12/2018	Approved
Lead research organisations		Project leader		
CSIRO		Bernadette Sloyan bernadette.sloyan@csiro.au (03 6232 5152)		

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 assess how the oceans impact Australia's climate, we need to understand how and why the oceans are changing and how we can better project future changes. This project will improve and deliver high quality ocean data which are vital for assessing ocean change. Ocean observations and model experiments will be used to track and understand ocean changes, and to identify the key mechanisms of ocean heat uptake. Insights gained will be used to improve the representation of heat uptake in ACCESS and other climate models, thereby improving climate change projections.

Expected outcomes

This project will tackle the question: how and why are the oceans changing and how can we better simulate ocean change and its impacts on climate? Several challenges have slowed progress in understanding change in the heat and freshwater balance of the ocean, this project will address these challenges by:

increasing accessibility and quality control of ocean data streams for use by the Australian and international research community

using analyses of ocean observations and model experiments to identify the key mechanisms regulating ocean uptake of heat and freshwater, thereby advancing scientific understanding of the ocean's role in the global energy and water budgets.

enhancing performance of Australia's national climate model ACCESS and other climate models by improving the representation of ocean heat and freshwater uptake

The project will deliver high quality, accessible ocean data sets to be used by researchers studying climate change and its impacts in Australia and around the world. Model improvements will be delivered to developers of ACCESS and international climate models. In turn, climate projections incorporating these improvements will be more reliable and relevant and therefore of more utility to decision-makers in government, industry and the community. Global assessments like the Intergovernmental Panel on Climate Change (IPCC) are another end user of our data sets and analyses.

Project 5.8 – Marine and coastal climate services for extremes information

Project details				
Length	Start date	End date	Approval date	Status
18 months	01/07/2019	31/12/2020	12/2018	Approved
Lead research organisations		Project leader		
CSIRO		Kathy McInnes kathleen.mcinnnes@csiro.au (03 9239 4569)		

Australia is a coastal nation. Changes in coastal climate, via sea-level, waves and coastal extremes (including marine heatwaves), have broad implications for a range of coastal stakeholders (e.g., marine and coastal industry, coastal infrastructure design and management, coastal environmental management, lending and insurance). Hub research conducted to date has led to improved and new information on how marine and coastal extremes are changing and projected to change in future. In this phase, we will extend this understanding, by investigating and analysing 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. This project will work closely with stakeholders to ensure this research is appropriately consolidated and delivered via a readily available, coproduced range of tools and data delivery mechanisms, to facilitate better understood and managed coastal climate risks in Australia.

Expected outcomes

Delivery of new services requires close interaction with next-users to optimise the tools and delivery mechanisms to support user needs. Targeted stakeholder engagement (carried out through a science outreach activity to run in parallel as a case study) will exhibit Hub gained knowledge, and workshop to refine the information needs of the coastal management, engineering, industries and finance sectors to inform the design and coproduction of the coastal climate information needs and tool development. The new tool, and data and information within the tool, will build on existing information available.

Prototype tool delivery will be to a CSIRO web-based platform in the first instance until such tools are refined and matured, allowing for transfer to mature coastal climate web portals such as CoastAdapt or the CSIRO C-FAST tool, if and when appropriate. The information produced under this project will not in any way duplicate that provided currently on the CoastAdapt web tool but will instead provide additional information and data not currently contained within CoastAdapt, such as wave set up and inundation.

Project 5.9 – Natural habitats for coastal protection and carbon sequestration (NCCC – Phase 2)

Project details				
Length	Start date	End date	Approval date	Status
18 months	01/07/2019	31/12/2020	12/2018	Approved
Lead research organisations		Project leader		
University of Melbourne		Stephen Swearer s.swearer@unimelb.edu.au, 03 8344 6253		

Living shorelines have the potential to play important roles in climate mitigation and adaptation because of their ability to sequester carbon and reduce the threats of coastal erosion and flooding. Unfortunately, many of these habitats have been lost or degraded throughout Australia. While restoration is a clear national priority for biodiversity conservation, there are still key uncertainties regarding the value of natural habitats for coastal protection and carbon sequestration. Building upon Project 2.11, this project will synthesise the outcomes of several demonstration studies in blue carbon, coastal erosion and eco-engineering research into a roadmap that identifies the next steps towards developing national guidelines for coastal habitat restoration and eco-engineering for climate mitigation and adaptation.

Problem the projects is addressing and how it will do this

This project aims to address key knowledge gaps in blue carbon, coastal erosion, and eco-engineering science to improve our understanding of the roles of vegetation in coastal protection and carbon sequestration, and to integrate the knowledge gained from this work, and project 2.11, into a roadmap for developing national guidelines for the implementation of living shorelines for coastal management.

Attachment B: Research Facilitation Activity plans

5.1: Understanding the impact of climate change on flowering induction in mango in the Northern Territory

On-going RPV5 activity

Knowledge broker: Mandy Hopkins (mandy.hopkins@csiro.au)

Rising minimum and maximum temperatures will affect flower induction of current commercially produced mango cultivars and those from the National Mango Breeding Program (a partnership between NT, WA, Qld and CSIRO). 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 appropriate management responses. To ensure the maximum value is realised from the impact assessment, a climate literacy workshop will also be included with supporting explainer products.

More information: <http://nespclimate.com.au/climate-change-impacts-in-the-northern-territory-mango-industry/>

5.2: Using climate change information in a Gondwana Rainforest World Heritage Area climate change adaptation plan

On-going RPV5 activity

Knowledge broker: Mandy Hopkins (mandy.hopkins@csiro.au)

There are gaps in the scientific understanding of projected climate change on the Gondwana Rainforests WHA, particularly changes to cloud cover. This 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 (LCL) projections, to provide information about changes to the cloud base in a changing climate, to complement existing temperature and rainfall projections, that can be used to inform the development of a climate change adaptation plan for the Gondwana Rainforests WHA.

The case study will demonstrate effective climate change adaptation planning for WHAs through co-production of knowledge and information products.

More information: <http://nespclimate.com.au/informing-world-heritage-area-climate-change-adaptation-planning/>

5.4: Climate change 101 toolkit: an introduction to climate change and understanding climate change information

On-going RPV5 activity

Knowledge broker: Mandy Hopkins (mandy.hopkins@csiro.au)

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 tell us. Existing climate change information (e.g. [Climate Change in Australia](#) projections website) is not readily accessible or understood by all

stakeholders, and is often not 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 with a better understanding of the climate system, an appreciation of climate change science, and the 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. By providing targeted foundation climate change information and a practical process for applying climate change information, this toolkit will promote and facilitate the use of climate change information in impact assessments.

More information: <http://nespclimate.com.au/training/>

5.5: Indigenous perspectives of climate risk

On-going RPV5 activity

Knowledge broker: Mandy Hopkins (mandy.hopkins@csiro.au)

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, which often are of more immediate concern in Indigenous peoples' lives. 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 project, based on two case studies, one in the Shark Bay World Heritage Site and another with Central Land Council Ranger Groups community, will work with Indigenous peoples on two-way sharing of climate risk that will contribute to place-based risk reduction strategies.

5.6: Climate Measurement Standards Initiative

On-going RPV5 activity

Knowledge broker: Geoff Gooley (geoff.gooley@csiro.au)

In response to the Recommendations of the Task Force on Climate-related Financial Disclosures (TCFD) many organisations in the Australian financial services sector (FSS) 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. However, there are 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 initiative is a collaboration between insurers, banks, scientists, regulators, reporting standard professionals and industry service providers. It aims to develop open-source

technical, business and scientific standards for measurement of physical climate risk to inform projections of future repair and replacement costs of buildings and infrastructure in Australia.

The Hub will participate in the initiative through supporting functions of the Secretariat and the Scientific Committee. The Committee's purpose is to inform scientific principles and guidelines for standardised analysis and reporting of physical climate risks in order to meet prudential reporting requirements of the industry regulator and expectations of government stakeholders more generally. Other activities will also be undertaken by the Hub leveraging off the CMSI to facilitate an increase in climate change science literacy of industry practitioners, and to identify and address existing and emerging knowledge gaps, including the need for development of climate change sensitive natural catastrophe modeling capability for Australia.

6.1: Second national Indigenous gathering on climate change - pathway to sustainable relationships

New RPV6 activity

Knowledge broker: Mandy Hopkins (mandy.hopkins@csiro.au)

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 change 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 2020 gathering will be led by an expanded Indigenous Steering Committee who will facilitate the co-development of the gathering with Indigenous peoples, scientists and relevant stakeholders, with support from the Hub

More information: <http://nespclimate.com.au/supporting-the-development-of-an-indigenous-led-agenda-on-climate-change-knowledge-and-action/>

6.2: Supporting Indigenous participation at the AMOS 2020 conference

New RPV6 activity

Knowledge broker: Mandy Hopkins (mandy.hopkins@csiro.au)

Due to the positive feedback on the first ever Indigenous session at the 2019 AMOS conference, the Hub has committed to supporting another Indigenous session to be convened at the next AMOS conference in February 2020 in Fremantle WA.

The Indigenous discussion and workshop session at the 2020 AMOS conference is entitled *Cross-cultural communication and climate change*. At the workshop and discussions within this session, Indigenous people, their partners and science communication practitioners will share experiences in climate science communication. The strengths and weaknesses of the different approaches, such as peer-to-peer exchanges, national and local dialogues, Indigenous-led fact sheets and other approaches will be discussed, with an aim to identify and report on key insights about what works and why.

The inclusion of Indigenous sessions at the AMOS conferences represent the first steps towards understanding how western climate change science and traditional knowledge can

interact. The outcomes of the AMOS 2020 conference Indigenous session are likely to inform government thinking and policy decisions on how best to approach the integration of traditional knowledge into western science in the climate change research and policy space.

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

New RPV6 activity

Knowledge broker: Mandy Hopkins (mandy.hopkins@csiro.au)

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. Natural sites provide 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. In this way, World Heritage properties can serve as climate change laboratories to gather and share information on applied and tested monitoring, mitigation and adaptation practices. The global network of World Heritage properties also provides a platform to raise awareness about the impacts of climate change on human societies and cultural diversity, biodiversity and ecosystem services, through the lens of the world's best examples of natural and cultural heritage.

This case study will develop a participatory process and a methodology for using Indigenous ecological and social knowledge and science-based climate change information to inform the development 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.

This work will draw on previous case studies in the Shark Bay and Gondwana Rainforest WHAs. As well as providing a methodology and climate change data, this case study will work with selected World Heritage property managers to:

- build their capacity and capability to use climate change science information to determine the impact of climate change
- enable the sharing and integration of traditional knowledge insights led by Traditional owners
- understand the factors that need to be taken into account to assess climate change risk (e.g. when considering bushfire risk many climate variables and their interactions need to be taken into account, including temperature, rainfall, humidity, wind, etc.)
- apply these considerations in a risk or vulnerability assessment
- develop appropriate climate change adaptation planning and management questions
- access and interpret climate change information to inform their planning and management decisions

The case study will demonstrate the necessity for good climate change science information and literacy and cultural perspectives to underpin climate change risk assessment and

adaptation planning for World Heritage properties, through the co-production of knowledge and information products.

6.4: Integrated Environmental Assessment for Development Decisions (cross-NESP Hubs)

New RPV6 activity

Knowledge broker: David Karoly (david.karoly@csiro.au)

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.

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.

6.5: Climate 2020: a resilient and sustainable Australia

New RPV6 activity

Knowledge broker: Mandy Hopkins (mandy.hopkins@csiro.au)

The Climate 2020 conference will be held in November 2020 in Melbourne. It will provide an opportunity for attendees across government, industry and sectors to be provided with a synthesis of research under the Hub and across the climate change science community 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. The conference is also likely to inform future opportunities and programs related to climate change research and science application.

More information: <http://nespclimate.com.au/climate2020/>

6.6: Improving the functionality, utility and accessibility of information on the Climate Change in Australia (CCiA) website

New RPV6 activity

Knowledge brokers: Sonia Bluhm (sonia.bluhm@csiro.au) and Mandy Hopkins (mandy.hopkins@csiro.au)

The [Climate Change in Australia](http://www.climatechangeinaustralia.gov.au/en/) (CCiA) website (www.climatechangeinaustralia.gov.au/en/) was developed in 2015/16 as part of the

Regional NRM Planning for Climate Change Fund. It was designed in consultation with NRM planners to address their climate change information needs. At the time of development, it was considered a state-of-the-art climate projections portal. 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.

Improving the user experience of the CCiA website and the functionality, utility and accessibility of information, data and tools within the website 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, risk assessment and associated decision-making.

6.7: Synthesising research outcomes and impacts under the Earth Systems and Climate Change Hub

New RPV6 activity

Knowledge brokers: Sonia Bluhm (sonia.bluhm@csiro.au) and Mandy Hopkins (mandy.hopkins@csiro.au)

The Hub has undertaken world leading climate change science research 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. During 2020 and 2021 this engagement activity will deliver a range of synthesis products and activities at the whole-of-Hub level, as well as project and research facilitation level products.

The synthesis products and activities will aim to demonstrate the impact of the Hub as a whole, including highlighting science achievements, stakeholder engagement activities and lessons learnt from the Hub's various research facilitation activities.

6.8: Towards a national climate service capability: a report to the National Climate Science Advisory Committee

Externally funding Hub activity (2019-2020)

Project lead: Geoff Gooley (geoff.gooley@csiro.au)

The National Climate Science Advisory Committee (NCSAC) has asked the ESCC Hub to prepare a report on a proposed development and implementation approach for a national climate service capability for Australia. This capability would provide end-users with science-based data and information tailored to the needs of their respective organisations and sectors for purposes of assessing physical climate risk and informing policy development, management planning, investment and associated decision-making. This capability will strategically align with the key components of the World Meteorological Organization's *Global Framework for Climate Services*, with an emphasis on climate services relevant over multi-decadal (climate change) timescales. The activity includes input from key partners in the Bureau of Meteorology, CSIRO and the university sector, with emphasis on their critical role in provision of comprehensive knowledge brokering and climate services needed by industry, government and the community to manage the physical and financial risks and opportunities of a variable and changing climate, both now and into the future.

6.9: Australia's next generation climate projections: a report to the National Climate Science Advisory Committee

Externally funding Hub activity (2019-2020)

Project lead: David Karoly (david.karoly@csiro.au)

NCSAC has contracted the ESCC Hub to prepare a report on a proposed development and implementation approach for the next generation of national and regional climate change projections for Australia.

The activity includes input from key partners in the Bureau of Meteorology, CSIRO and the university sector, with emphasis on their key role in provision of past climate change projections for Australia.

The report on the program of next-generation national and regional climate projections for Australia will consider:

- relevant market research and stakeholder consultation to inform the work program;
- assessment and utilisation of an expanded range of inputs and methods to use the inputs more effectively, for example, ensemble generation methods and constraints on projection approaches;
- the coordination of new regional modelling and integration for use in national projections;
- significantly enhancing links to climate services and knowledge brokering to the diverse range of stakeholder groups.