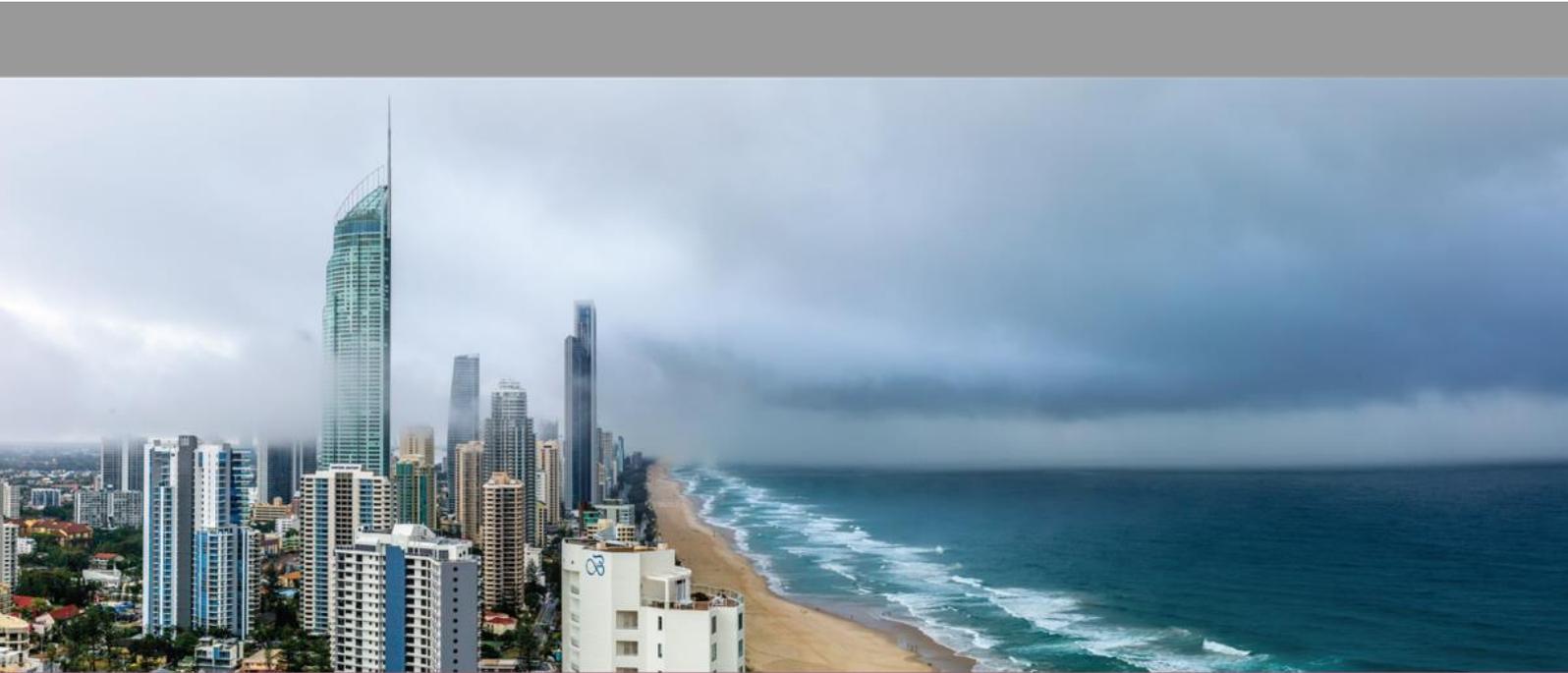




**Earth Systems and
Climate Change
Hub**

National Environmental Science Programme



Research Plan

VERSION 4

November 2017



Australian Government



National
**Environmental
Science
Programme**

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Certification of Research Plan

Hub Leader Certification

As the Hub Leader, I certify that:

- the research projects contained in the Research Plan are linked to the Activity Outcomes for the Earth Systems and Climate Change Hub as outlined in the Funding Agreement;
- the research projects in the Research Plan address the NESP Research Priorities for Earth Systems and Climate Change Hub;
- funds are available to meet all approved projects and the additional projects included in this Research Plan; and
- this Research Plan was prepared in consultation with the Hub Steering Committee.

Signed:



Acting Hub Leader Name: Dr Geoff Gooley

Date: 27 November, 2017

Hub Steering Committee Chair Certification

As the Hub Steering Committee chair, I certify that:

- this Research Plan was prepared in consultation with the Hub Steering Committee;
- any issues of concern or matters raised during Hub Steering Committee meetings or the Department during its assessment process have been adequately resolved, amended or incorporated into this Research Plan; and
- this Research Plan was endorsed by the Hub Steering Committee on 27 November, 2017.

Signed:



Hub Steering Committee Chair Name: Dr Wendy Craik

Date: 27 November, 2017

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.

Role of the Earth Systems and Climate Change Hub

In the context of the intended NESP outcomes, the goal of the Earth Systems and Climate Change (ESCC) Hub 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 (Figure 1).

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

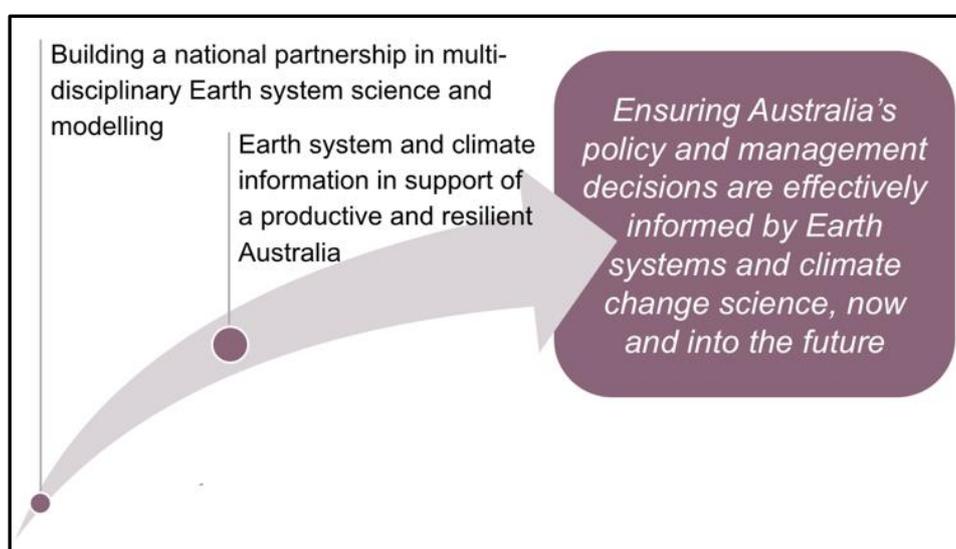


Figure 1: Earth Systems and Climate Change Hub goal

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.

It will build a national climate Earth system and climate simulation capability in ACCESS (the Australian Climate Community Earth System Simulator); ensure the provision of nationally coordinated climate information for use across NESP and the broader stakeholder community; support the University of Melbourne to establish a National Centre for Coasts and Climate (NCCC); and undertake research that informs low-cost abatement options.

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

- lead the further development of a world-competitive, national Earth system and climate modelling capability (ACCESS) to deliver for weather and climate predictions and projections for the Australian community
- advance understanding of Australia’s climate variability, extremes and associated drivers

- develop and strengthen stakeholder relationships, and support informed management and evidence-based decision-making
- facilitate outreach and communication of science products and services to target next/end-users.

History of Australian Earth system and climate research

The NESP is an amalgamation of the NERP and the ACCSP. The ACCSP was a three-decade research program funded by the Australian Government with matching coinvestment 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 as a result of the Australian Research Council Centre of Excellence for Climate System Science (ARCCSS). It is this capability and history of collaboration that led to a consortia partnership, led by CSIRO, being successful in a competitive tender process to form the current ESCC Hub.

The ACCSP also provided the foundation for several complementary initiatives over the last 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 delivering 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 (e.g. 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 and this Research Plan V4:

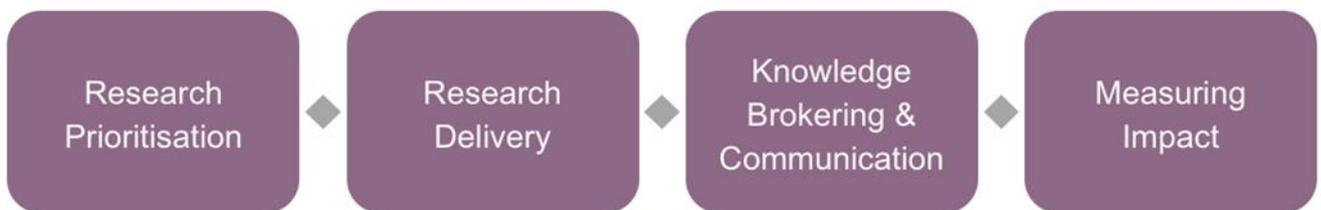
- a) With the ACCSP contract ending in mid-2016, the Hub’s substantive research only began in the second half of 2016. The Hub’s funding profile and research delivery reflects this ‘ramp-up’ in research effort during the period covering RPV2 and RPV3 leading into RPV4.
- b) The Hub is very fortunate 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.
- c) 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 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 Hubs will work collaboratively within and across Hubs



This Research Plan also provides appropriate detail 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.

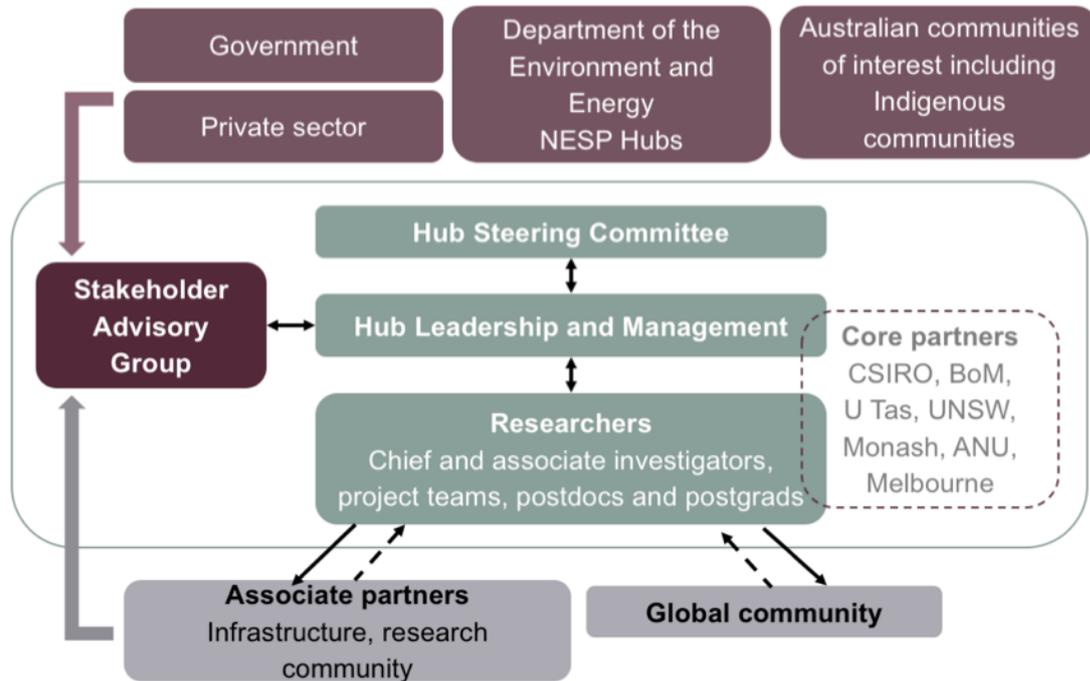


Figure 2: Earth Systems and Climate Change Hub Governance

Hub Leadership and Program Management Teams

The Hub Leader, 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 Acting Hub Leader is Dr Geoff Gooley, from CSIRO, pending appointment of a permanent Hub Leader by the CSIRO Climate Science Centre (expected to be in place to oversee commissioning and implementation of RPV4 in January 2018).

The HLT is comprised of the Hub Leader, the Hub Program Manager and three Hub partner representatives: Dr Aurel Moise (Bureau of Meteorology), Dr Dewi Kirono (CSIRO) and Professor Nathan Bindoff (University of Tasmania, representing the university partners).

The HPMT comprises Dr Geoff Gooley (Program Manager), Ms Mandy Hopkins (Knowledge Broker), Ms Marian Sheppard (Program Support Officer) and Ms Karen Pearce (Communication Advisor). Mandy and Geoff are also the Hub's primary contacts for coordinating Hub-level data and information management, and communication and knowledge brokering activities.

The Hub has developed guidelines detailing duties and expectations for the Hub Leader, HLT and HPMT (Appendix 1). This includes the procedure for replacing any members of these teams, temporarily or permanently.

Hub Steering Committee

The Hub Steering Committee (HSC) meets on a quarterly basis 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 (Appendix 2), 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.

Hub Stakeholder Advisory Group

The Hub has identified over 200 institutions, agencies and individuals who are external to the Hub and 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 collectively 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, the Hub has developed a two-tiered external stakeholder engagement approach. The 200 or so identified external stakeholders form a Hub Stakeholder Reference Network (HSRN), which provides the primary register of stakeholders who will be the focus of the Hub's ongoing external stakeholder engagement. This focus will be appropriately prioritised across the HSRN in terms of allocation of dedicated resources for communication and knowledge brokering on the basis of the following categories:

- The Department and the Minister for the Environment and Energy
- Other target next/end-users for which the ESCC Hub has an existing and/or proposed project/case study collaborative link, including:
 - relevant Australian Government departments and associated ministers
 - other relevant state and local government departments
 - relevant private sector organisations and individuals
 - other NESP Hubs and research organisation partners.

- All other registered HSRN organisations/individuals

Dealing with the Hub on behalf of, and in the best interests of the HSRN, is the Hub Stakeholder Advisory Group (HSAG). The primary role of the HSAG is to have governance oversight of the external stakeholder engagement arrangements of the Hub to ensure that such arrangements are effective, efficient, fair and equitable. This group comprises up to 10 individuals who have been identified and appointed because of their acknowledged expertise and/or professional interest in those research domains of relevance to the Hub – especially the Hub’s designated outcome areas. Meeting on a quarterly basis, the HSAG facilitates the Hub’s engagement with the broader stakeholder community, using the HSRN as its ‘eyes and ears’ into stakeholder needs and views. The timing of the HSAG meetings is aligned to the HSC meetings.

The Terms of Reference for the HSAG, and its composition, are provided in Appendix 3. Note that the HSAG has an independent chair, 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 Department of the Environment and Energy provided initial approval to fund the ESCC Hub. The Minister has delegated his authority to approve major changes to the scope and funding allocation to the Hub, to the Science Partnerships Section First Assistant Secretary. The Minister approved Version 1 of this Research Plan and will be provided both draft and final versions for all subsequent annual versions for his information.

Research priorities

The ESCC Hub is committed to a body of activity that includes short and long-term research projects and associated case studies. Each activity year the Department of the Environment and Energy will work with the Minister, the Hubs and other key stakeholders to identify and refine research priorities and develop projects that 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. The Biennial Program Evaluation, which will review the impact and success of the NESP, also plays an important role in informing research priorities.

This constant consideration and evaluation of research output and impact will give confidence in the performance of the Hub and the effectiveness of the program. It will also provide the basis for the flexibility needed in the ESCC Hub to engage in new themes of research in an adaptive manner, and thus ensures that the Hubs’ focus is fixed on the delivery of relevant and practical research.



Broadly, the NESP 2017 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 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. the 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 The Hub has confirmed that this priority does not imply that the Hub undertakes primary observations – especially those that are the responsibility of operational agencies such as the Bureau of Meteorology.

List of research projects

Please refer to Attachment A of this Research Plan Version 4 (RPV4) for new and existing approved projects and case studies.

Expected outputs and outcomes

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

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

Research under the NESP is expected to inform the policy and program delivery of 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 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: the National Marine Science Plan [October 2015]; Australia's national science and research priorities [May 2015]; the National Climate and Resilience and Adaptation Strategy; the former National Climate Change Science Framework; 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 proposed 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. For example, the jurisdictions welcomed the sectoral focus on water resources; ecosystems, resource management and food

security; coasts; and extremes (especially fire weather). The ACT, SA, Victoria and WA jurisdictions have all identified these as key areas for their adaptation strategies.

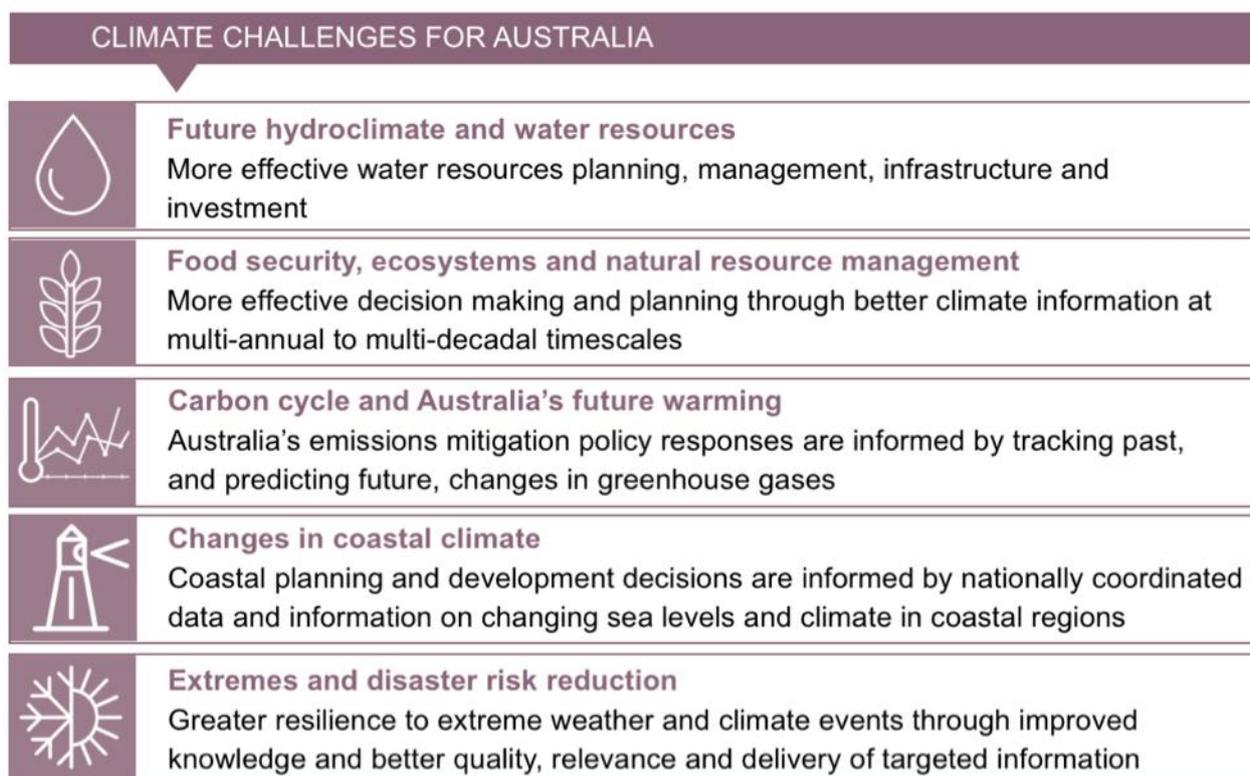


Figure 3: Earth Systems and Climate Change Hub outcomes

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) 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.
- b) Nationally consistent and targeted climate information (data, knowledge and products) for the Australian region that informs and provides the evidence base for:
 - Adaptation, planning, and mitigation responses and decision-making.
 - Decision-making to enhance resilience, productivity and better manage climate risk.
- c) Enhanced end-user capacity in the effective use of Hub research outputs.
- d) A vibrant and critical mass 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.*

ESCC Hub program logic

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

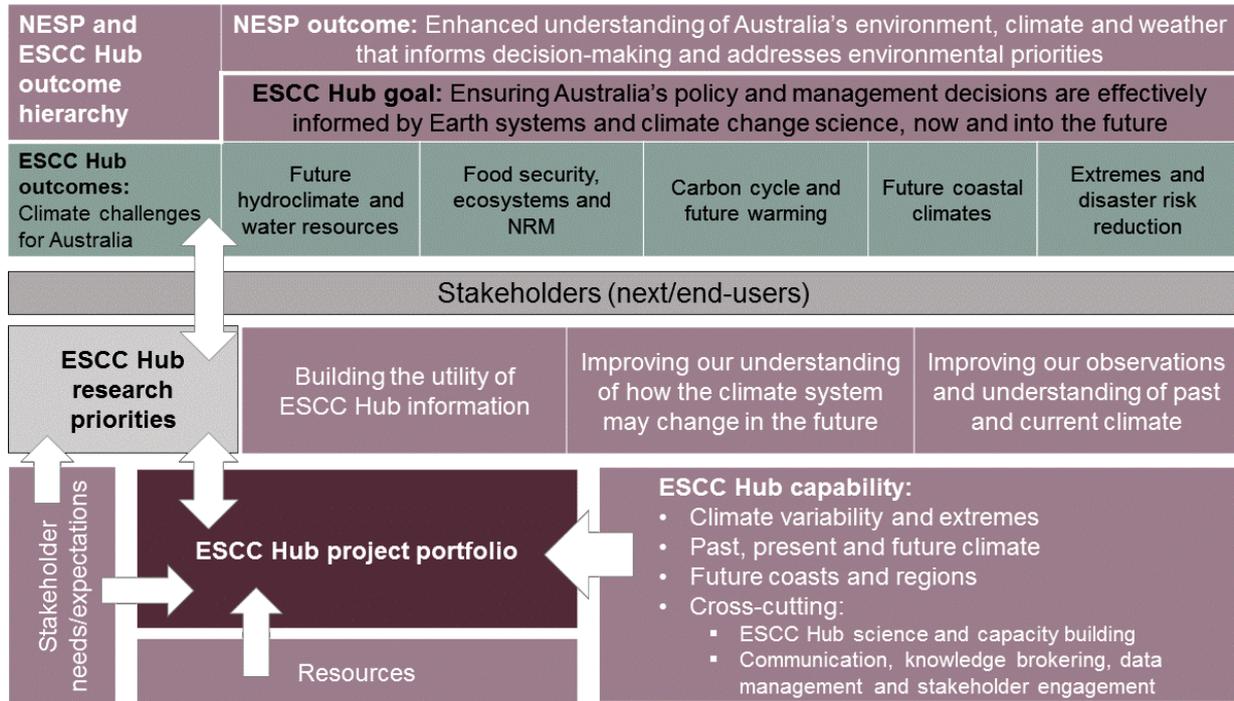


Figure 4: Summary schematic of NESP Earth Systems and Climate Change Hub program logic

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 is able to leverage 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 eleven research projects.

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. There are several projects whose path-to-impact is through other projects, so their delivery is primarily 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 (Figure 5).

A key component of the Hub’s scope of work piloted in RPV3 and now fully implemented in RPV4 is the annual case studies. These case studies are not stand-alone activities, rather are adjunct and otherwise intrinsically linked to the Hub’s core research projects. In this context they are intended to be a key feature of the implementation of both the Hub’s Communication and Knowledge Brokering Strategy and Evaluation Planning Framework, and thereby an important means by which the Hub is to facilitate its expected outcomes and associated path-to-impact.

Figure 5 also illustrates the integrated nature of the research activities, while the matrix in Figure 6 explicitly identifies the inter-dependencies and linkages between the approved RPV2 research projects. Given the highly integrative, inter-dependent and cross-agency collaborative nature of the

research portfolio, the Hub is able to leverage on the complementary capability that resides across the Hub’s partners.

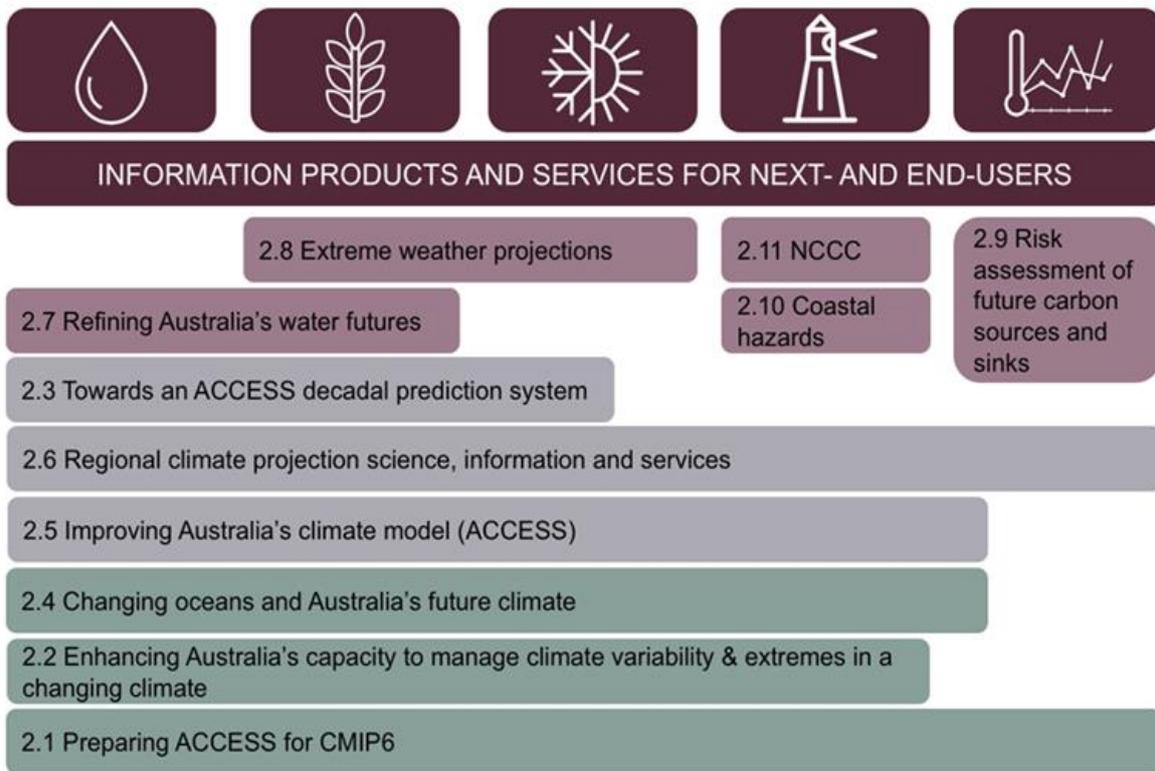


Figure 5: Alignment of Research Plan V2, V3 and V4 research projects to Hub outcomes. Cross cutting projects, with a primarily next-user focus, are positioned towards the lower part of the figure, while more targeted projects with an end-user focus are positioned in the upper part of the figure.

	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	2.10	2.11
2.1	Grey										
2.2		Grey									
2.3	Purple	Purple	Grey								
2.4	Purple	Purple	Purple	Grey							
2.5	Purple	Purple	Purple	Purple	Grey						
2.6		Purple	Purple		Purple	Grey					
2.7		Purple		Purple		Purple	Grey				
2.8		Purple				Purple	Purple	Grey			
2.9	Purple					Purple	Purple	Purple	Grey		
2.10	Purple	Purple		Purple	Purple	Purple		Purple		Grey	
2.11				Purple						Purple	Grey

Figure 6: Primary linkages and inter-dependencies between Hub projects. (Project numbers are the same as in Figure 5).

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 brokering, outreach and capacity development:** 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 (described more fully in Attachment A) and/or via the Hub communication and knowledge brokering activities (described in the Hub’s Communication and Knowledge Brokering and Indigenous engagement strategies). Output types #1–4 primarily address the specific scientific and technical needs of next/end-users, while types #4–6 primarily address the more general communication, knowledge brokering and outreach needs of next/end-users. They reflect the key activities, methods and deliverables described in the Hub’s Communication and Knowledge Brokering Strategy V4.0 and associated action plan.

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"> • Publically available, via links available on ESCC 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"> • Publically available, via links on ESCC 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 • Improve model competitiveness, availability and accessibility for researchers and/or end users 	<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.

Type of output	Purpose	Comments
<p>4. Communication and knowledge products</p> <p>a) Targeted information products</p> <p>b) Brochures</p> <p>c) Case studies</p> <p>d) Newsletters (including The Chirp)</p> <p>e) Tailored products to support Indigenous engagement, capacity building and research, as appropriate and consistent with the Hub's Indigenous Engagement Strategy</p>	<ul style="list-style-type: none"> • Communication and knowledge brokering • 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 (and other appropriate) website and stakeholder networks. • Some use of social media is envisaged, but only where it is effective. • Products will be derived from Research Project materials as appropriate.
<p>5. Communication and engagement activities</p> <p>a) Workshops and conferences</p> <p>b) Seminars and forums</p> <p>c) Regular 'science informing policy' event</p> <p>d) Briefings</p> <p>e) Regular engagement with stakeholder networks.</p> <p>6. Tailored activities to support Indigenous engagement, capacity building and research, as appropriate and consistent with the Hub's Indigenous Engagement Strategy</p>	<ul style="list-style-type: none"> • A more active way to share knowledge, information – either to a general or specific audience – that facilitates feedback, problem-solving and value-add. 	<p>The Hub is proposing:</p> <ul style="list-style-type: none"> • Annual, targeted workshops • Briefings to the government, states, business sector and other key stakeholders. This includes a regular (six-monthly) briefing to the Minister.
<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 ARCCSS already provide. • For stakeholders: training activities will be provided through our stakeholder networks as appropriate and affordable.

Case studies

Commencing in 2017 as part of RPV3, a suite of new Hub and project level case studies and research activities – collectively hereafter referred to as case studies – have been implemented on an annual basis as an adjunct to the existing/approved research projects (2.1–2.11).

The purpose of the case studies is to develop 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 case studies are operationally linked directly to one or more research projects and are typically low-cost activities and outputs (\$10–50K) funded on a discretionary basis by Hub Central to facilitate outreach (communication and knowledge brokering) to key stakeholders and associated path-to-impact.

Like the research projects, the individual case studies are not intended to deliver impact in isolation, rather they contribute to the overall (cumulative) path-to-impact at Hub level via the designated research projects. On this basis, the case studies 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 latter as determined by direct engagement by the Hub and/or via input from the HSAG). Given this context, the case studies 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 existing approved research projects and the Hub more generally.

The following summary table indicates the cross-linkage and associated interdependencies with existing projects for the new case studies proposed for 2018 as part of RPV4 (black shading = focus projects; grey shading indicates other relevant projects).

Case Study	Project										
	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	2.10	2.11
4.1		Grey				Black	Grey	Black	Grey	Grey	
4.2	Grey				Grey	Grey	Grey	Grey	Black		
4.3						Grey	Black				
4.4		Grey				Black	Grey	Grey			
4.5	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey
4.6		Grey				Black	Grey	Grey		Grey	Grey

Communication and knowledge brokering

Integral to the success of the NESP in influencing decision-making is the clear and effective communication and knowledge brokering of research outputs to key stakeholders from the Hub’s approved research projects and associated case studies in order to facilitate path-to-impact for the Hub. These activities are guided by the ESCC Hub Communication and Knowledge Brokering (C&KB) Strategy and associated Action Plan. The purpose of the C&KB Strategy is to:

- guide the development of strategic, proactive communication and knowledge brokering 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 Strategy (ii) implementation of the ESCC Hub Evaluation Planning Framework/Monitoring and Evaluation (M&E) Action Plan, (iii) adoption of key ESCC Hub outputs by next/end-users, (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 focused 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 brokering**]
- 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 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 case studies – see previous section), 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 knowledge brokering 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. Indeed, all 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.

Data accessibility

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

The Hub's approach to data and information management is covered in Section 5.1 of the Hub's C&KB Strategy V3. The Hub is committed to ensuring that all data and information data are discoverable by and available to, stakeholders. Accordingly, appropriate protocols have been developed to ensure that metadata statements for each project are completed, collated and catalogued as per NESP guidelines.

The Hub aims to make the metadata catalogue 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.

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 (see Project 2.9); and CSIRO’s Cape Grim greenhouse gas data website.

The Hub anticipates playing a role in coordinating data curation and distribution across these complementary agencies and initiatives, but this vision has not yet been articulated via any formalised plan. The Hub committed to ensuring that an inventory of ACCSP datasets is made accessible to next- and end-users via an appropriate ESCC Hub website link to the ACCSP website, where the new ACCSP metadata catalogue has now been posted so that these data are also curated and potentially available for further use. This is being achieved via an activity being done under the auspices of the ACCSP in coordination with the Hub to develop a curated record of all data collections and models from at least the last three years of the ACCSP. 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 publically available although those components developed within Australia are already open source (e.g. the Land Surface Model, CABLE [Community Atmosphere Biosphere Land Exchange]).

Monitoring and evaluation

NESP monitoring and evaluation plan

The NESP Monitoring & Evaluation Plan (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.

Biennial evaluation

Under the Portfolio Budget Statements for the Environment Portfolio, the single key performance indicator for the NESP is biennial qualitative assessments that show Departmental staff, state governments, business, community groups and others are using research output from the NESP to inform policy development.

The outcomes and findings of the Biennial Evaluation will inform and direct the future delivery of the program, including the research priorities. The biennial review will be used to inform the review and evaluation of the NESP after two and four years as requested by the Minister in making his funding decision for the NESP.

Under the terms of the funding agreement, the ESCC Hub is required to participate in any program evaluations or reviews planned during the life of the NESP.

The Hub M&E Plan features both a schematic 'program logic' (also referred to as a 'theory of action'), which is provided in Appendix 4, 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.

Hub Evaluation Planning Framework

The Hub's Evaluation Planning Framework (EPF) sits within the Hub but otherwise is designed to complement the overarching NESP Monitoring and Evaluation (M&E) Plan relevant to all Hubs. Specifically, the ESCC Hub's EPF outlines the process by which both Hub and project level (including case studies) evaluation planning is developed and implemented in a way that is outcome focussed, targeted at next-users and end-users, and delivers measureable impact.

The EPF, through design and implementation of a specific Hub-level M&E Action Plan, also provides for real-time performance monitoring and management, progress reporting and review, along with, how the Hub will assess and report on its strategic path-to-impact across its portfolio of integrated projects and associated case studies.

In this context, the EPF is a key strategic document that is directly linked to the C&KB Strategy and the Indigenous Engagement 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 case studies – 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.

In practice, the Hub-level M&E Action Plan is updated by the Hub on an annual basis and therefore also provides the relevant input to facilitate implementation of the NESP M&E Plan, specifically including 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 RP V4 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. These annual 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 the ongoing process of stakeholder gaps and needs review and analysis, communication and knowledge brokering. Consistent with the EPF requirements. This information feeds back into and takes direction from the Hub's respective C&KB and Indigenous Engagement Strategies throughout the life of the Hub, at both a Hub and project level.

Collaboration and partnerships

The NESP encourages a collaborative, multi-disciplinary approach to environmental and climate science 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 4 identifies those partners and stakeholders with whom the Hub has already engaged in 2015 and 2016. This list has grown and matured throughout RPV2 (2016) to RPV4 (2018) and will continue to be refined throughout the lifetime of the Hub, as explained in the C&KB Strategy.

Table 4: Hub Collaborations and Partnerships (all acronyms are defined in the glossary at Appendix 5). The Hub has had face-to-face contact with all partners and stakeholders listed below in 2017.

Partner	Relationship to ESCC Hub	Role (institution, program, individual)	Expertise	Alignment to Hub goals
Programs or agencies who are non-funded partners providing research capability and/or represent key next and end users				
IMOS	Director is a member of HSAG (this may change during implementation of RPV4)	Program: Provides critical research infrastructure to NESP ESCC research	Ocean observing infrastructure	Critical to ocean observations; which underpin several outcomes and research priorities
NCI	Member of ACCESS Advisory Group (Bureau, CSIRO, Universities are part of this)	Program: Provides critical research infrastructure to NESP ESCC 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
ARCCSS and ARC Centre of Excellence in Climate Extremes (ARCCLEX)	Director of ARC Centre of Excellence in Climate Extremes is member of HSC. CIs are involved in Hub research projects	ARC-funded centre providing underpinning climate system science to Hub research	Climate systems science, climate extremes	Aligned to some research priorities
ACE CRC and AAD	ACE CRC CEO was a member of the HSC; AAD Senior researcher (van Ommen) is a member on HSAG	Program: CRC and AAD potentially both users, and providers, of research	Antarctic and Southern Ocean – cryosphere processes	Aligned to some research priorities; complementary research goals
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
Reef Traditional Owners and Reef Catchments NRM	Stakeholders and collaborator on Indigenous Engagement	Program: 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.

Partner	Relationship to ESCC Hub	Role (institution, program, individual)	Expertise	Alignment to Hub goals
Goyder Institute	Potential partners for a case study on water	Program: Provides research needed to inform decisions, resource management and policies in South Australia	Water resources, hydrology, coastal; mitigation and adaptation	Strong interest in Hub's research into water, fire, and NRM and extremes outcome areas
Kimberley Land Council and Seed	Potential co-leaders of a proposed workshop with Indigenous leaders on climate change	Agency: Seed is an Indigenous group within the Australian Youth Climate Coalition	Traditional owners and Indigenous knowledge; climate change; natural resource management	Aligned to Hub's Indigenous engagement goals and objectives.
Lucsan, Climate Policy Research and NAB	Potential case study partner(s)	Individual and institutional	Providing private sector perspective on managing climate risk and valuation of risk capital	Proposed case study
National Farmers Federation	HSAG membership (this may change during implementation of RPV4)	Individual	Agriculture sector; Water & energy policy;	Stakeholder engagement support
Government collaborators, with whom the Hub has established links in 2015/16 – 2016/17 (Qld and NT pending)				
State & Local Government Departments and Agencies	<p>States and territories:</p> <ul style="list-style-type: none"> • SA Dept of Environment, Water & Natural Resources • Tas Dept of Primary Industries, Parks, Water & Environment • Vic Dept of Environment, Land, Water & Planning; and Dept of Economic Development, Jobs, Transport & Resources • ACT Climate Change Policy Group • WA Depart of Water Resources • NSW Office of Environment & Heritage <p>Other:</p> <ul style="list-style-type: none"> • City of Greater Geelong • Torres Strait Regional Authority • World Heritage Areas: Gondwana Rainforests World Heritage Areas (and Australian World Heritage Areas) <p>Commonwealth:</p> <ul style="list-style-type: none"> • Department of Agriculture and Water Resources (DAWR) • Murray Darling Basin Authority (MDBA) 			

NESP Hubs

<ul style="list-style-type: none"> • Clean Air & Urban Landscapes (CAUL) • Marine Biodiversity • Threatened Species Recovery • Northern Australia Environmental Resources (NAER) • Tropical Water Quality 	<p>Collaborators on specific areas of research; Indigenous engagement; and users of climate knowledge and information. At the Cross-Hub Workshop run by the Hub in 2016, we identified a several research areas of mutual interests, and a set of actions to build the collaboration and path-to-impact for our Hub.</p> <p>New cross-Hub collaborative case studies are proposed with TWQ and TSR Hubs as part of RPV4</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 (NA)</p>	<p>Aligned to some research priorities</p>
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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 strategies.

To avoid any confusion, 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) 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).
- b) 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.
- 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.

Given that a single forum cannot practically represent the interests of all these stakeholders, the Hub has developed a two-tiered approach to engaging with our external stakeholders comprising the HSRN and HSAG. Both the HSRN and HSAG are described under Hub Governance (Section 2).

The task of identifying the Hub's key internal and external stakeholders and their respective needs was a focus of RPV2 and RPV3, and our ongoing implementation of the Hub's C&KB Strategy, Indigenous Engagement Strategy, and by association, the Hub's EPF.

External stakeholders

The External Stakeholder Engagement Plan identifies over 200 external institutions, agencies and individuals who *have an interest in, or use for, the best available Earth system and climate change science*. As described above, these stakeholders encompass all levels of government, NGOs, Indigenous communities, peak bodies and private companies; many relevant sectors (including emergency services, environment, agriculture, fisheries, forestry, water, health, energy, defence, transport, infrastructure, finance, insurance, foreign affairs and trade, tourism, resources); research agencies and broader research communities, including other NESP Hubs. The latter include agencies and programs that invest in infrastructure upon which the Hub's research depends (for example, the National Computational Infrastructure [NCI] led

by ANU and the Integrated Marine Observing System [IMOS]); and research providers/programs outside the Hub but with strong allied interests (for example, NCCARF, Antarctic Climate and Ecosystems Cooperative Research Centre [ACE CRC]).

HSRN details are managed within a dedicated database that summarises relevant engagement activities and outcomes, actions arising and associated contact details etc. The HSRN database is categorised in a manner to facilitate prioritised and customised engagement activities as part of the Hub's projects and associated case studies along the following lines:

- Minister for the Environment and Energy/Department of the Environment and Energy (as the relevant NESP Program Manager and sponsor).
- Those stakeholders for which the Hub has an agreed and tangible direct link to one or more designated projects in RPV2, RPV3 and RPV4.
- All other HSRN registered stakeholders (typically who have a general interest in the Hub's projects but not necessarily a direct link to any one project)

The Hub recognises that the broader Australian community are also stakeholders, 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 very nature of Earth system and climate research means that there is often no one-to-one relationship between a specific research project and end-user needs. For example, end-users may want credible, tailored estimates of future temperatures for an Australian region; producing this requires development of an internationally-benchmarked model that performs well for Australia and has been tested and parameterised using Earth system observations and data. These simulations then need to be combined with other global climate model simulations to produce an ensemble of simulations. The model outputs are then evaluated and refined to a finer spatial resolution; and the results need to be packaged and delivered in a way that is useful for end-users (which may require an iterative process of engagement and co-design).

Internal stakeholders

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) and in the universities (e.g. the Monash Sustainability Institute).

As explained in our C&KB Strategy, 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 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 Strategy.

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 to now to build strong, trusted partnerships with our Indigenous stakeholders and explore ways that Traditional Knowledge can play in informing the Hub's research. These partnerships will form the foundation for ongoing collaboration and mutual benefit.

The Hub will do this through participatory approaches, primarily in collaboration with existing Hubs and other programs/initiatives, 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 case studies and engagement with key groups such as 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. 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.

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.

As part of RPV4 implementation during 2018, the Hub will finalise two of three activities implemented in RPV3 that collectively draw on the research expertise of Hub Central and the relevant research projects and activities/case studies undertaken throughout 2017. These are described below in Attachment A. The Hub has also been invited to an internal CSIRO Workshop, which is part of the **Indigenous Futures** science initiative that aims to contribute scientific expertise to the key national challenge of Closing the Gap. The initiative aims to work with Indigenous Australians to build on existing foundations of capability and excellence, in order to provide methods for new industries, services, economic participation and other objectives prioritised by Indigenous people, and an evidence-base for effective policy and

² <http://aiatsis.gov.au/>

program delivery. This will enable the Hub and its researchers to have more connections with Aboriginal and Torres Strait Islander people and communities.

We will continue to send our project team members to appropriate cultural awareness programs. This training program equips the Hub’s leadership team with the awareness and understanding needed to enable them to work with Indigenous staff, groups and communities in an effective and meaningful way; and increases the capacity of individuals and teams to communicate with Indigenous stakeholder groups and contribute to more effective engagement generally with Indigenous people and communities.

Summary

The matrix below captures the level of proposed Indigenous community engagement by RPV4 projects:

- High – the project will work closely with Hub Central in all Indigenous engagement activities proposed for RPV4.
- Medium – the project will have some engagement, either in an activity specifically being developed for that project and/or with some of the Indigenous engagement activities planned for RPV4.

Low – Hub Central will draw on project’s science and capability to develop information products for the activities proposed in RPV4 but the project itself is less likely to be directly involved.

Short project name	High	Medium	Low
2.1: ACCESS and CMIP5			
2.2: Climate variability			
2.3: Decadal prediction system and marine extremes			
2.4: Changing oceans			
2.5: Improving ACCESS			
2.6: Regional climate projections science, information and services			
2.7: Water futures			
2.8: Weather extremes			
2.9: Carbon risks			
2.10: Coastal hazards			
2.11: NCCC			

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.

The table below describes the funding from the NESP available to the ESCC Hub over the life of the agreement which ceases on 30 June 2021.

Expenditure for 2015 and 2016 lists the actual funds spent. The budgets for 2017, 2018 and 2019 incorporate the variances in 2015 and 2016 between funds received and actual expenditure incurred therefore there is no balance item for years 2015 through to June 2019.

The Budget Flexibility Allocations for 2019 and 2020 reflect funds to be planned under RPV5 from 1 July 2019.

	2015 Actual ¹	2016 Actual ¹	2017 Budget	2018 Budget	2019 Budget	2020 Budget	2021 Budget	Total
	\$	\$	\$	\$	\$	\$	\$	\$
NESP Funding²	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 amongst three main items of expenditure (Research, General Communication and Administration). The funding must be expressed, in the table below, 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.

Research	81%
General communication	10%
Administration	9%

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 management and mitigation

The Hub's Risk Register, which is divided into (a) Hub level risks and (b) risks that have been identified and categorised from the individual research project proposals that will be managed and treated at a whole-of-Hub level – primarily via implementation of the Hub's governance arrangements and Hub-level Monitoring and Evaluation Plan. The Hub's Risk Register for RPV4 has been updated to reflect any change in details relating to existing (RPV3) risks, noting that there are no new and emerging risks for RPV4.

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).
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. 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 is able to 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 (RPV2) 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 case study 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 (2.1–2.11). The annual case studies 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' (<\$10-50K) tailored products and services for target stakeholders as an adjunct to the existing research projects. There are also uncommitted NESP research funds available from 2018–21 for investment. 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 held back 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 case studies 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 coinvestment opportunities to leverage core Hub funding (detailed in our C&KB Strategy). Examples to date include recent developments in the 'water' project area and outcome domain, which has seen direct additional coinvestment from CSIRO of \$200K and indirect coinvestment via SA Government/Goyder for proposed case studies.

Appendix 1. Guidelines for Hub Leadership and Programme Management Teams



Guidelines for Hub Leadership and Programme Management Teams

A. Hub Leadership and Programme Management Team: Duties and Behaviours

1. Hub Leadership Team (HLT)

This comprises the Hub Leader, the Hub Programme Manager as the HLT Deputy Leader, and three Partner Representatives (CSIRO, Bureau of Meteorology and the universities). The HLT (and Hub Programme Management Team, below) are nominated and chosen for their long term commitment to the role.

1.1. *Hub Leader*

The Hub Leader is nominated by the Lead Agency, but also needs to be acceptable to all partners and the Department of the Environment and Energy (the Department). Once the Hub is formed, the task of replacing the Hub Leader (if this is needed) would be overseen by the Chair of the Hub Steering Committee (HSC).

The Hub Leader's key accountabilities and responsibilities include:

- a) Successful development and delivery of the Hub's research portfolio and stakeholder engagement as envisaged by the relevant plan/strategy.
- b) Effective and meaningful Hub communication and knowledge brokering.
- c) Acquittal of all project and financial reporting for the Hub.
- d) Delegating Hub operations. Governance and project implementation to appropriate nominees, including the Partner Representative, Programme Management Team and Lead Chief Investigators.
- e) Be the lead spokesperson and liaison for all Hub activities.
- f) Ensuring that the Hub achieves its goals and objectives, within the budget provided by the Department and the Partner agencies.

1.2. *Partner Representatives*

The Partner Representatives are nominated and agreed between the Hub Leadership Team and the Partners. Their key responsibilities include:

- a) Deputise for the Leader when needed.
- b) Represent Partners on the Hub Leadership team, specifically:
 - Communicating Hub and Partner issues between the Hub Leadership (especially the Hub leader) and the Partners.

- Providing the linkage between Hub Central and the Partners in administrative and financial matters such as sub-contracts, finance reports and acquittal, budget information.
- Providing advice to project staff in their respective partner agencies on Hub matters.
- c) Strategic advice to the Hub leadership on science direction, research priorities – reflecting both scientific expertise and Partner interests.
- d) Lead Working Groups/Task Groups as needed and appropriate (see 2 below).
- e) Participating in external and internal communication, knowledge brokering, stakeholder engagement, risk management and associated monitoring and evaluation activities on behalf of the HLT as needed and appropriate.
- f) Provide feedback and input to operational decisions being made by Hub Leader.

2. Hub Programme Management Team (HPMT)

This comprises the Programme Manager, Knowledge Broker, Programme Support Officer and Communication Advisor, with key duties and responsibilities as follows:

- a) Hub-level programme management and coordination; and strategic policy advice – primarily to Hub Leader but also to Partner Representatives. Note 'programme management' includes:
 - Hub-level risk management
 - Coordination of Hub-relevant contract and sub-contract, financial and HR management between relevant support functions in Lead Agency (CSIRO) and the Hub leadership
 - Evaluation planning/monitoring and evaluation
 - Stakeholder engagement coordination and management
 - Communication and knowledge brokering coordination and management
- b) Coordinate and, as appropriate and under direction from the Hub Leader, lead Indigenous engagement and facilitate associated communication and knowledge brokering activities.
- c) Liaise with the Department, CSIRO and Partner administrative functions to ensure all reporting and other administrative requirements are met.
- d) Secretariat for Hub Steering Committee, and other Hub-level governance committees as needed.
- e) Provide Hub-level administrative support as appropriate.

3. HLT and HPMT behaviours

- a) Honest, open and consultative.
- b) Provide objective and balanced advice and views, with the goals and success of the Hub as the priority.
- c) Treat each other with respect, and listen to their perspectives.
- d) Act with integrity.
- e) Present a united/consistent Hub voice to our researchers and stakeholders.
- f) Work collegiately across the broader climate science community.

- g) Decisions will be made by consensus. If this is not possible, then the Hub Leader will take all points of view on board and make a decision. The HSC will review and endorse major strategic and budget decisions.
- h) Best endeavour to honour commitments and meet deadlines.

4. Temporary substitution arrangements

The Hub Programme Manager is the default replacement for the Hub Leader, otherwise the Partner Reps' or other suitable replacement as agreed with the host agency (CSIRO).

Section B provides guidance on the procedures for replacing the Hub Leader or Partner Representatives.

B. Process for Replacing Members of the Hub Leadership Team

1. Preamble

The Funding Agreement between CSIRO and the Department includes specific clauses and requirements regarding changes to Specified Personnel in the Agreement.

This means that changes to any of the Hub Leadership and Specified Personnel requires formal agreement by the Department; approval from the relevant Partner Agency and the Hub Leadership; and endorsement from the HSC.

For changes to the HLT, the standard operating procedures are as described below.

For changes to Specified Personnel, the standard operating procedure is for the HLT to be advised; they will ensure that the Department, HSC and Partners are informed and approve any changes required. The Department will require assurance that the NESP funds will continue to be matched by the Partner agency; and that the projects can still be delivered as per the approved project plan. The Department will need to formally approve these changes.

Any changes to project staffing should be updated in the annual Research Plan update.

Any unresolved issues should be directed to the HSC and/or the Department as appropriate for resolution.

2. Hub Leader

The Hub Leader needs to have the appropriate leadership and scientific experience to perform the role; and they need to be agreeable to the other Partners and the Department.

As the Hub Leader was a key part of the success of the open competitive process for the Hub's selection and funding under NESP, any changes need to be approved by the Department. They will take this historic perspective into account and also in consult with the relevant Minister. The level of engagement/approval by the Minister is something that would be discussed with the Minister at the time.

Where the Hub Leader leaves the role, for whatever reason, then the Lead Agency (CSIRO) should in the first instance discuss with the HSC Chair, and thence the Partners and the Department, what is the best approach to filling the role from within the Lead Agency.

It would be appropriate for the HSC, especially the Chair, the Department and the Partner representatives, to take a lead role in facilitating the approach and indeed the final decision for a replacement.

Options for a replacement to be canvassed would include:

- a) The current CSIRO Deputy Hub Leader – certainly as an interim but possibly as a permanent replacement.
- b) Advertising the Hub Leader role across the Lead Agency, or externally.

Any unresolved issues should be referred to the HSC and/or the Department for advice and resolution. If appropriate, the incumbent Hub Leader may provide advice regarding a replacement, however the decision will be made as described above.

3. Partner Representatives

- a) Relevant Partner Agency to advise Hub Leader that a new Partner Representative is needed, and the reasons why the current Representative is no longer able to fulfil the role. Note that in the case of the Universities, the same approach will apply.
- b) Hub Leader:
 - Confirms with the current Representative that they understand that this request has been received and agrees for the Hub leader to initiate a replacement.
 - Requests the Partner Agency to propose a replacement Representative; and confirms that he/she agrees and is willing to become a Partner Representative.
 - Has an in-confidence discussion with other members of the Hub Leadership team - especially the other Partner Representative – as to the suitability of any proposed replacement.
- c) Hub Leader discusses the recommendation with, and secures endorsement from, both the Department and the HSC Chair.
- d) Hub Leader confirms and advises all stakeholders of change.

4. Staff from Hub Central and/or projects moving between Partner Agencies

In the circumstance where a member of the HPMT/HLT, or a project, moves employment to another of the Partner agencies; the Hub Leadership will:

- a) Where applicable, discuss within the HLT whether the individual can continue their role from another agency (this will depend very much on which member of the HLT/HPMT).
- b) Ensure that both the 'receiving' (new) Partner agency and the former agency agree on the individual continuing to play a role on the HLT/HPMT, or contribute to the project.

- c) Ensure that the Department is advised, including any changes or implications to the budget and other financial arrangements (especially coinvestment), and reassured that these changes will not negatively affect the Hub performance.
- d) Advise the HSC – including the Partner representatives and the Lead Agency – and seek their endorsement of the new arrangement.
- e) Capture changes in relevant (next) Research Plan.

5. Staff from Hub Central and/or projects leaving the Hub

Where applicable, discuss within the HLT the selection criteria for a suitable replacement; and discuss with the Partner Agency the process for replacing the staff, and the Hub's expectations around selection criteria.

6. Movement of staff between Partners

As with other staffing changes; approval is needed by both Partner agencies, the Department along with endorsement from the HSC. The overriding considerations will be, firstly, whether both Partners agree with the move and the staff member continuing to work in the NESP; and secondly assurance from the new Partner that they will provide the matching funds.

Revised 15 November 2017

Appendix 2. Steering Committee Terms of Reference and Membership



TERMS OF REFERENCE AND MEMBERSHIP

Hub Steering Committee

Purpose

The Hub Steering Committee (HSC) provides strategic direction and oversight of Hub governance, including processes for managing partnerships, setting research priorities, approval and acquittal of finances, allocation of funding and resources, and performance monitoring and assessment of Hub impacts.

The HSC is not a decision-making body, rather is a high-level review and advisory forum designed to facilitate outcomes as an independent source of reference and oversight on behalf of the Hub and the Department of the Environment and Energy (the Department) relating to:

- strategic decisions made by the Hub Leader/Leadership team and partners (both supporting and associate)
- strategic advice and directions provided to the Hub by the Department.

Membership

The HSC will comprise the following members and representation:

Role	Nominee	Status
1. Independent chair	Dr Wendy Craik	Accepted
Partner representatives:		
2. CSIRO	Dr Helen Cleugh, Director, Climate Science Centre, CSIRO Oceans & Atmosphere	Accepted
3. Bureau of Meteorology	Dr Peter May, Head of Research, Science to Services	Accepted
4. Universities	Vacant	
5. Department of the Environment and Energy	Mr Chris Johnston, Assistant Secretary, Heritage Branch, Department of the Environment and Energy	Accepted
	Ms Beth Brunoro, Assistant Secretary, Domestic Emissions Reduction Division, Department of the Environment and Energy	Accepted
6. Hub Stakeholder Advisory Group (HSAG)	Dr Nick Wood, Director, Climate Policy Research	Accepted

7.	Director of ARC Centre of Excellence in Climate System Science (<i>ex officio</i>)	Dr Andy Pitman, UNSW	Accepted
8.	Up to two independent members with expertise in Earth systems science and its application to government policy, industry and broader end-user needs	Ms Jo Mummery, University of Canberra Vacant	Accepted
9.	Hub Leader (<i>ex officio</i>)	Dr Geoff Gooley, CSIRO (interim Hub Leader)	Accepted
Other invitees from time to time as appropriate (observer status), including other key personnel representing the ESCC Hub, other NESP Hubs, the Department, other government portfolio agencies, the HSAG and other key end-users and stakeholders			

Specific HSC roles and responsibilities

Given their purpose, the specific functions and associated roles and responsibilities of the HSC will be to:

1. Provide a structured forum for engagement between the Hub Leadership with:
 - The Minister and Department of the Environment and Energy (NESP management)
 - The Hub Stakeholder Advisory Group
 - Other NESP Hubs and external stakeholders.
2. Provide strategic guidance to the Hub on research directions, priorities, delivery and outputs, communication and engagement, to ensure alignment of research activities to policy needs of the Department and other target end-users and key stakeholders.
3. Oversee, review and endorse or approve as appropriate:
 - Research Plan development, implementation and resource allocation
 - Amendments to the Hub organisational arrangements, Research Plan and associated allocation of resources that may constitute a variation to formal agreements between the Hub and the Department
 - Development and delivery of annual progress, financial, monitoring and evaluation and final reporting to ensure:
 - i) compliance with agreed performance and associated quality standards
 - ii) strategic alignment with agreed NESP priorities and expected outcomes.
4. Identify and communicate high-level issues and opportunities, including new and emerging research gaps and needs of target end-users, to facilitate linkages to broader research and government initiatives across government and other stakeholders.
5. Provide a forum for members to share information relevant to core business of the Hub and the NESP more generally, including providing specific advice to the Hub in

relation to communicating outcomes to external stakeholders within government, industry and the general community.

Decisions made by the HSC will be by consensus.

Role of the independent chair

The independent chair will be appointed in agreement with the Department, and will work closely with Hub Leader to:

1. Preside over HSC meetings and ensure the HSC is well organised, functions effectively, and meets its obligations and responsibilities.
2. Act as a conduit between Hub leadership, the Steering Committee members and the Department as appropriate.
3. Ensure the Hub leadership is reporting well to the HSC and the functionality and responsibilities of the relationships between the two groups is well managed
4. Ensure all HSC members are meeting the roles and responsibilities as detailed in these Terms of Reference.

Terms of appointment

Appointments will be made by formal invitation from the Hub Leader. Members will be appointed for a term of three years. After this time they will be eligible for re-appointment. If a member wishes to resign his or her appointment, they must provide the Hub Leader and Chair with a written resignation. The appointment of a Steering Committee member may be terminated, on the advice from the Hub Leader to the Chair, if they fail to meet the HSC Terms of Reference or failure to attend three consecutive Steering Committee meetings.

Meeting frequency

The HSC will meet quarterly during the term of the Hub; meetings will be scheduled 12 months in advance (from 2016). HSC meetings will be scheduled to align with the delivery of key milestones that require HSC approval due in April (Annual progress reports) and October (Research Plans) of each year.

Operational matters

The HSC secretariat support will be provided by the Hub Programme Management Team, who will be responsible for the preparation and circulation of agendas, minutes and actions arising, and of supporting documentation, papers and reports on behalf of the HSC.

A draft agenda and relevant background documentation will be circulated to all members for comment a minimum of 10 working days prior to scheduled meetings.

All meetings will be minuted, with draft minutes and associated actions circulated to members for comment a maximum of 10 working days after scheduled meetings, and final minutes circulated to members after a maximum of 10 further days.

Remuneration

All HSC operating costs including out-of-pocket costs for HSC members will be covered by the Hub Leadership & Management component of the Hub budget.

The Hub reserves the right to provide a modest honorarium to the HSC Chair if needed, funded from the Hub budget.

Conflict of interest

Steering committee members must declare any conflicts of interest at the start of each meeting or before discussion of the relevant agenda item or topic. Details of any conflicts of interest should be appropriately minuted. Where members of the HSC are deemed to have a real or perceived conflict of interest, it may be appropriate that they are excused from Committee discussions and/or deliberations on the issue. The Chair will be responsible for assessing declared conflicts of interest and how these will be managed for the meeting and/or particular agenda items.

Appendix 3. Stakeholder Advisory Group Terms of Reference and Membership



TERMS OF REFERENCE AND PRELIMINARY MEMBERSHIP

Hub Stakeholder Advisory Group

Purpose

The purpose of the Hub Stakeholder Advisory Group (HSAG) is to ensure that relevant external stakeholder engagement activities are undertaken in an effective and efficient manner, consistent with meeting the Hub’s broader strategic objectives. These arrangements should also provide appropriate assurance to the Steering Committee, which has oversight of all aspects of the Hub’s operations and performance, that such activities are based on appropriate governance in terms of meeting the expectations of stakeholders and adding value where appropriate.

The HSAG consists of up to 10 individuals who would be nominated/selected because of their acknowledged expertise in those research domains of relevance to the Hub – especially the Hub’s outcome areas. It is envisaged that the HSAG would act collectively as an agent/advocate dealing with the Hub on behalf of and in the best interests of the Hub Stakeholder Reference Network (HSRN). Most importantly, they would be enthusiastic and committed to the role that climate science plays in informing decision-making in Australia. The HSAG will facilitate the Hub’s engagement with the broader stakeholder community; using the HSRN as its ‘eyes and ears’ into stakeholder needs and views. Specifically, the HSAG would provide:

- a structured and transparent mechanism to ensure that stakeholder engagement over the Hub’s lifetime is consistent with the Hub’s goals, and
- oversight of the implementation of the Hub’s stakeholder engagement activities - on behalf of the broader stakeholder network and the Hub Steering Committee (HSC).

Membership

The HSAG will comprise the following members and representation:

Role	Nominee	Status
1. Independent chair	Dr Nick Wood, Director, Climate Policy Research	Accepted
2. Member	Prof Jean Palutikof, Director, National Climate Change Adaptation Research Facility	Accepted
	Mr Michael Nolan, Chair, United Nations Global Compact-Cities Program, RMIT University	Accepted

Role	Nominee	Status
	Dr Tas van Ommen, Program Leader, Climate Research, Australian Antarctic Division	Accepted
	Dr Tim Moltmann, Director, Integrated Marine Observing System, University of Tasmania	Accepted
	Dr Karl Braganza, Head of Climate Monitoring, Environment and Research Division, Bureau of Meteorology	Accepted
	Ms Stella Whittaker, Principal Sustainability & Climate Change, Ramboll Environ Australia Pty Ltd	Accepted
	Ms Kate Mackenzie, Director, Policy, Finance & Decision Metrics, Climate-KIC Australia Ltd	Accepted
3. Observer (<i>ex officio</i>)	Dr Geoff Gooley, CSIRO, Hub Program Manager	Accepted
Other invitees from time to time as appropriate (member and observer status), including other key personnel representing the ESCC Hub, other NESP Hubs, Department of the Environment and Energy, other government portfolio agencies, the HSC and other key end-users and stakeholders		

Specific HSAG roles and responsibilities

Given the stated purpose, the specific functions and associated roles and responsibilities of the HSAG will be to:

- Advise the Hub Leadership, and HSC more broadly, in relation to the governance around the Hub's external stakeholder engagement arrangements in order to meet expectations of the HSRN, specifically in terms of balance (fairness and equity) and quality control (completeness, accuracy and timeliness), and add value to stakeholder outcomes and impacts.
- Facilitate active engagement with the Hub Leadership/Programme Management and Project Teams on all matters to do with interests of the HSRN.
- Advise the Hub Leadership about relevant (external) next and end-user information gaps and needs, including emerging issues and new opportunities.
- Advise the Hub Leadership about important external stakeholder engagement fora, activities and scope; including potential business development and communication opportunities.
- Provide input to, and feedback on, the Hub's Research Plan(s), Evaluation Planning Framework, and Communication and Knowledge Brokering Strategy – from a HSRN perspective.
- Provide feedback on the Hub's overall performance in relation to its alignment with external user needs and priorities, including relevance, effectiveness and

efficiency in addressing program objectives, realising outcomes and delivering impact.

Role of the independent chair

The independent chair will be appointed in agreement with the Hub Leader, and will work closely with Hub Leader and/or Programme Manager to:

1. Preside over HSAG meetings and ensure the HSAG is well organised, functions effectively, and meets its obligations and responsibilities.
2. Act as a conduit between Hub leadership, the HSAG members and the HSC on behalf of the broader Hub stakeholder network
3. Ensure all HSAG members are meeting the roles and responsibilities as detailed in these Terms of Reference.

Terms of appointment

Appointments will be made by formal invitation from the Hub Leader. Members will be appointed for a term of one year initially. After this time, they will be eligible for re-appointment. If a member wishes to resign his or her appointment, they must provide the Hub Leader and Chair with a written resignation. The appointment of a HSAG member may be terminated, on the advice from the Hub Leader to the Chair, if members fail to meet the agreed Terms of Reference or failure to attend three consecutive HSAG meetings.

Meeting frequency

The HSAG will meet quarterly during the term of the Hub; meetings will be scheduled 12 months in advance (from 2016) to align with scheduled HSC meetings.

Operational matters

The HSAG secretariat support will be provided by the Hub Programme Management Team, who will be responsible for the preparation and circulation of agendas, minutes and actions arising, and of supporting documentation, papers and reports on behalf of the HSAG.

A draft agenda and relevant background documentation will be circulated to all members for comment a minimum of ten working days prior to scheduled meetings.

All meetings will be minuted, with draft minutes and associated actions circulated to members for comment a maximum of ten working days after scheduled meetings, and final minutes circulated to members after a maximum of ten further days.

Remuneration

All HSAG operating costs including out-of-pocket costs for HSAG members will be covered by the Hub Leadership & Management component of the Hub budget.

Conflict of interest

HSAG members must declare any conflicts of interest at the start of each meeting or before discussion of the relevant agenda item or topic. Details of any conflicts of interest should be appropriately minuted. Where members of the HSAG are deemed to have a real or perceived conflict of interest, it may be appropriate that they are excused from Group discussions and/or deliberations on the issue. The Chair will be responsible for assessing declared conflicts of interest and how these will be managed for the meeting and/or particular agenda items.

Appendix 4. Earth Systems and Climate Change Hub: Program logic (V1.12)

Attachment A: NESP Earth Systems & Climate Change Hub - Programme Logic (V1.12)

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	Water Futures	Global Warming & the Carbon Cycle	Climate Extremes & DRM	Coasts & 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 Objective(s)	Through world class research and development, to: <ul style="list-style-type: none"> • lead further development of the nation's modeling capability and capacity for weather and climate prediction and projections • achieve greater 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 end-users and the general public 					
Practice change	ES science more targeted at end-users through clearer path-to-impact and outcomes focus	ES science more effectively & efficiently integrated within Australian environmental research	End-users routinely access best available ES science capability and knowledge to inform policy and management decisions	Stakeholders actively engage with the Hub; seek to understand ES science; and provide positive feedback and support to Hub		
Stakeholders and Next/end-users	Australian Government Minister/Department of the Environment	Other NESP Hubs	Federal, State & Local Government Sectors	Australian industry - business, finance and insurance groups	Indigenous communities and general community	Australian and international Earth system science and climate research community
ESCC Hub Governance	Programme Management: Administration; Progress Reporting; Performance, Financial and Risk Management; Monitoring & Evaluation Communication, Knowledge Brokering and Outreach: Steering Committee and Stakeholder Engagement; Data & Information Management; Coordination and Management					
ESCC Hub Research Outputs	Science & Technical: Enhanced models (multi-year and higher spatial resolution); data/information management systems; analyses, forecasts & projections; data access and analysis tools; journal papers, technical reports and other information products Communications, knowledge brokering, outreach and capacity development: knowledge management systems, websites and content, non-technical summaries, multi-media content and training, postgraduate and professional development, professional and public forums (training workshops, seminars, conferences 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	Communications, knowledge brokering, data/Information management & outreach/end-user engagement					
	Climate variability & extremes	Past, present & future climate		Future coasts & regions		
	Earth Systems & Climate Change Science integration & capacity building					
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 5. Glossary for Research Plan V4 and project/case study summaries in Attachment A

Acronym	Definition
AAS	Australian Academy of Science
ACCESS	Australian Community Climate and Earth System Simulator
ACCSP	Australian Climate Change Science Programme
ACE CRC	Antarctic Climate and Ecosystems Cooperative Research Centre
ANDS	Australian National Data Service
ARC	Australian Research Council
ARCCSS	Australian Research Council's Centre of Excellence for Climate System Science - Australian Research Council Centre for Climate System Science: collaboration of key universities and PRFAs on climate modelling and extremes
ARCCLEX	Australian Research Council's Centre of Excellence for Climate Extremes (to start in 2018)
Argo	A global array of profiling floats operated by over 25 nations under the auspices of the United Nations' World Meteorological Organisation and the International Oceans Commission. Argo Australia is major contributor funded partially by the Integrated Marine Observing System and partner programs such as the Australia Climate Change Science Program, the ACE CRC, Bureau of Meteorology and CSIRO. www.argo.net ; www.imos.org.au
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 GO-SHIP program and also helps compile high-quality calibration datasets used to quality control Argo profiles for climate applications.
CFT	Climate Futures for Tasmania
CLI	Chief lead Investigator
CORDEX	COordinated Regional Downscaling EXperiment
CMIP5 and CMIP6	Coupled Model Intercomparison Project 5 and 6
CMOR	Climate Model Output Rewriter

Acronym	Definition
CSIRO DAP	CSIRO's Data Access Portal – access to publically 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
EPF	Evaluation Planning Framework
ECL	East coast low
ENSO	El Niño–Southern Oscillation
ESCC	Earth Systems and Climate Change
ESGF	Earth System Grid Federation
ESM	Earth System Model
ET-CCDI	Expert Team on Climate Change Detection & Indices
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
IMOS	Integrated Marine Observing System - 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.
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
NERP	National Environmental Research Program
NESP	National Environmental Science Program

Acronym	Definition
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 & Adaptation Planning Program
PEGS	Process Evaluation Groups
POP	Population Orders 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	Research Plan Versions 1, 2, 3 and 4
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
WCRP	World Climate Research Program

Attachment A – ESCC Hub Research Projects and Case Studies

Research projects

Project 2.1: Preparing ACCESS for CMIP6

Project overview

Project details				
Length	Start date	End date	Approval date	Status
3 years	01/07/2016	30/06/2019	12/2015	In progress
Lead research organisations		Project leader		
CSIRO		Simon Marsland simon.marsland@csiro.au (03 9239 4548)		

The World Climate Research Programme’s Climate Model Intercomparison Project (CMIP) makes simulations from climate models around the world publicly available in a standardised format. These simulations are used by researchers around the world. Simulations from CMIP5, the fifth phase of this project, underpinned the Intergovernmental Panel on Climate Change’s fifth assessment report. The next phase of this project, CMIP6, features new scenarios and revised experiments to keep pace with advances in climate modelling and our understanding of the climate system.

We’re updating Australia’s national climate model, the Australian Community Climate and Earth System Simulator (ACCESS), so it can participate in CMIP6. When the updates are complete, we will submit our climate simulations to the global CMIP database.

The ACCESS simulations will be benchmarked against simulations from other global climate models allowing us to rate ACCESS’s capability on a global scale. Through the CMIP6 database, the simulations will be used by researchers worldwide to produce peer-reviewed publications. These publications will inform the Intergovernmental Panel on Climate Change’s sixth assessment report, which will provide governments around the world with objective, scientific information on climate change, it’s likely impacts and mitigation strategies.

Expected outcomes

CMIP6 participation:

1. focuses ACCESS model development on the highest priority and most significant climate research questions, ensuring our investment in research is well targeted, and effective.
2. ensures that Australian global climate simulations are included in IPCC AR6, giving Australia profile, status and credibility among the international community, and raises the credibility and profile of ACCESS within the Australian community
3. ensures that ACCESS – and therefore Australian climate simulations – are well integrated into CMIP6 data, which will be used to develop periodic climate change assessments for the Australian region that effort.

The capability and model improvements generated in this project are directly transferable to the other modelling projects within the ESCC Hub, and the improvements in model performance are of direct benefit to the other ESCC science projects that exploit ACCESS model results.

Project 2.2: Enhancing Australia's capacity to manage climate variability and climate extremes in a changing climate

Project overview

Project details				
Length	Start date	End date	Approval date	Status
3 years	01/07/2016	30/06/2019	12/2015	In progress
Lead research organisations		Project leader		
Bureau of Meteorology		Pandora Hope pandora.hope@bom.gov.au (03 9669 4774)		

Climate extremes such as heatwaves, floods and droughts have huge impacts on Australia's communities and their natural and economic resources. These events are influenced by large-scale climate features, such as the El Niño–Southern Oscillation, and by changes in the climate due to human activities. Explaining the drivers of past extremes, variability and trends is crucial in providing confident projections of future climate changes and frequency of extreme events.

We're analysing past climate variability and extremes to enhance our understanding of the underpinning climate drivers. Our focus is on climate variability driven from the oceans (including El Niño, La Niña and the Indian Ocean Dipole), and longer timescale extremes such as extended heatwaves, floods and droughts. We'll use climate models to examine how these factors change as the global climate changes.

This analysis will provide greater clarity on what causes extreme events, identify trends and variation in large-scale climate features and extreme events and to what extent these events are caused by human activities. This information will be integrated into Australia's climate change projections, enabling us to better plan for and respond to drought, heatwaves and floods.

Expected outcomes

The research in this project will provide greater clarity on the role of climate variability and climate extremes (drought, heavy rainfall, extreme temperatures and severe winds) in past and future climate.

This will help decision makers (e.g. local, state and federal government representatives, water managers, NRM groups, Indigenous groups, infrastructure planning, public health and coastal planners) to more clearly understand the risks and opportunities that climate change poses, and so will contribute to:

- reducing environmental damage and loss of productive ecosystems and land-uses
- supporting sustainable reconstruction and asset maintenance
- supporting improved design and operation of infrastructure
- enhancing resilience to climate change and specifically the ability of Australians to prevent, prepare for, and respond to extreme events and multi-year and decadal changes in Australian climate.

Project 2.3: Towards an ACCESS decadal prediction system

Project overview

Project details				
Length	Start date	End date	Approval date	Status
3 years	01/07/2016	30/06/2019	12/2015	In progress
Lead research organisations		Project leader		
CSIRO		Terence O'Kane terence.o'kane@csiro.au (03 6232 5066)		

Ocean temperature extremes can have devastating consequences for marine life, fisheries, and aquaculture, making them environmentally and economically significant events. Tracking and predicting changes in marine extremes are key to managing and reducing their impacts in these sectors.

We're improving understanding of the predictability of ocean temperature extremes over multi-year to decadal timescales. We're also examining past marine heatwave events to determine if they were the result of natural climate variability or climate change due to human activities.

Data from this project will feed into ACCESS, Australia's global climate model. The projections developed through this research will better inform marine and coastal planning decisions, as well as fisheries and aquaculture.

Expected outcomes

A decadal prediction system will routinely inform policies and adaptive management strategies in the marine and land sectors at an economically relevant timescale. This project will begin to close the critical forecast gap between seasonal climate prediction and longer-term (multi-decadal) climate projections, and give us better insight into the feasibility of decadal predictions.

The ocean temperature extremes component of this project will improve our understanding of the time scales over which these events are predictable and will enable improved marine and coastal planning and response decisions informed by knowledge of changing ocean temperature extremes on 1–10-year time scales.

Project 2.4: Changing oceans and Australia's future climate

Project overview

Project details				
Length	Start date	End date	Approval date	Status
3 years	01/03/2016	30/06/2019	12/2015	In progress
Lead research organisations		Project leader		
CSIRO		Steve Rintoul steve.rintoul@csiro.au (03 6232 5393)		

Ocean heat uptake is one of the primary rate-setters of global warming. Over 93% of the extra heat stored by the Earth over the past 50 years is found in the ocean. This has not been well integrated into Australia's climate models. To interpret past changes, and better simulate changes in the climate we need to understand how the ocean takes up heat, and how ocean heat uptake may change as the planet warms.

We're using data collected from ocean monitoring (historical archives, Argo floats and research vessels) to improve understanding of past changes in ocean temperature and salinity. We're using this data to identify sources of bias in ocean heat update efficiency in climate models, as well as to examine the connection between ocean salinity changes and water balance over Australia.

This research will result in better representation of ocean processes in climate models, which will improve projections of future warming, sea-level rise and water availability for Australia. This work will also inform ocean-related climate change policy.

Expected outcomes

This project will deliver new information on how and why the oceans are changing and on the consequences of ocean change for terrestrial climate and marine ecosystems. Decision-makers will be able to use this information to develop more robust strategies for marine conservation, biodiversity and natural resource management.

New information about the influence of the Indian Ocean on Australian climate, in particular changes in the hydrological cycle and water availability, will inform more effective water resources planning, management and infrastructure investment.

Assessments of change in ocean heat storage will guide the development of national and international climate policies, contribute to verification of their efficacy, and provide a means of tracking mitigation impacts on the rate of climate change.

This project will enhance Australia's resilience to climate variability, climate change, and their impacts by improving the national capacity to anticipate, interpret and respond to climate events and trends. Outcomes of the project will include:

Nationally coordinated data and information on changing sea levels and climate in coastal regions will inform coastal planning and development decisions.

Project 2.5: Improving Australia's climate model (ACCESS)

Project overview

Project details				
Length	Start date	End date	Approval date	Status
3 years	01/07/2016	30/06/2019	12/2015	In progress
Lead research organisations		Project leader		
CSIRO		Harun Rashid Harun.rashid@csiro.au (03 9239 4532)		

The Australian Community Climate and Earth System Simulator (ACCESS) equips Australia with a global climate modelling capability that is uniquely concerned with the weather and climate of the Australasian and Southern Hemisphere region.

We're improving ACCESS's simulation of important climate processes in the Australasian region, focusing on rainfall and weather extremes, as well as climate variability and change. This will allow for multi-year to multi-decadal projections, as well as enabling better forecasting on daily through to seasonal time scales.

The key outcome is a national preparedness that enables Australia to better manage weather and climate impacts, including future risks and opportunities; saving lives, resources and money. As a result, policy makers and researchers will have access to better climate information.

Expected outcomes

All sectors of Australia's economy that require information about climate for management and policy decisions will benefit from the enhanced capability of ACCESS resulting from this project.

Better model predictions underpin better decision making for our environment. Improvements in the skill of the predictions of key weather and climate phenomena over Australia, from heatwaves to floods, will lead to improved management of our natural and human resources, enhanced resilience and productivity, and reduced costs associated with climate-related damage.

Australian researchers broadly can access and use the ACCESS model system, diagnostic tools and experimental frameworks developed under this and related projects. The consequence is that Australian climate research is more coordinated and efficient through use of common models, tools and methodologies. Next-user researchers, particularly projects in projections development, detection/attribution and carbon-cycle change, will benefit from the development undertaken in this project.

Project 2.6: Regional climate projection science, information and services

Project overview

Project details				
Length	Start date	End date	Approval date	Status
3 years	01/07/2016	30/06/2019	12/2015	In progress
Lead research organisations		Project leader		
CSIRO		Michael Grose michael.grose@csiro.au (03 6232 5345)		

Our understanding of the climate system and our ability to simulate it in climate models are constantly evolving. At the same time, the needs of those using climate projections are increasing and becoming more sophisticated. This means there is an ongoing need to update and improve climate projection products and services with new data and lessons learned.

We're improving confidence in projections, particularly rainfall projections, as a result of improved understanding of climate feedbacks and key climate processes. We're also running targeted workshops, presentations and training to better identify user needs and help stakeholders access climate change information that is already available.

This will produce more targeted projection products for stakeholders to improve the usability and uptake of climate change information for adaptation and related activities. One such product is the development of a 'Climate Change in Australia' mobile app which will provide seasonal climate projection data across Australia up until 2090.

Expected outcomes

Work undertaken in this project will ensure:

- targeted stakeholders understand and have access to relevant information, products and services to support uptake and utility of existing (and future) projections.
- stakeholders have better understanding of the sources of confidence and uncertainty in projections, so risk management will be better informed.
- preparation for the next set of projections is based on strategic planning, well in advance, including progress towards development of new methodologies and approaches and co-ordinated preparation for new data sources.

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.

Easy access to credible, relevant and legitimate information and guidance about climate change will:

- reduce environmental damage and loss of productive ecosystems and land-uses
- support sustainable reconstruction and asset maintenance
- support improved design and operation of infrastructure
- enhance resilience to climate change
- facilitate better-informed use of various sources of climate projections and reduce the potential for conflicting messages in impacts and adaptation work.

Project 2.7: Refining Australia's water futures

Project overview

Project details				
Length	Start date	End date	Approval date	Status
3 years	01/07/2016	30/06/2019	12/2015	In progress
Lead research organisations		Project leader		
CSIRO		Dewi Kirono dewi.kirono@csiro.au (03 9239 4651)		

Information about, and analyses of, future water availability are critical for water resources planning and investment decisions; however consistent projections for a range of hydroclimate variables (e.g. rainfall, surface run off, lateral water flow, soil moisture) and drought metrics are not currently available.

We're working with state and federal government and water managers to identify gaps in hydroclimate metrics and improve climate-water modelling. Building on existing science will develop methods to deliver next generation projections of future water availability and hydrologic variables or metrics important to the water and related sectors.

This will improve Australia's ability to assess the impact of climate change on Australia's hydroclimates and water resources, and inform planning and climate change adaptation in the water and related sectors.

Expected outcomes

In the long-term, this project will contribute to more sustainable water management practice, with water managers being able to routinely access and use best available hydroclimate projections to inform water resources planning, management and investment.

Science from this project has the potential to enhance management and policy in natural resources adaptation to climate change. The availability and utility of consistently derived and interpreted hydroclimate metrics will allow integrated assessments and adaptation planning in many different and connected applications and sectors, including agriculture, industry, mining and environment.

For example, the projections developed from this project will fill the knowledge gaps around northern Australia future surface water and hence have significant potential to contribute to the Government Plan for Information Support Development described in the White Paper on Developing Northern Australia.

Outputs from this project also have significant potential to contribute to improve information for on-farm decision making as part of the government plan to support framers to prepare for drought and other risks³.

The Bureau of Meteorology is a likely key end-user for these future assessments of water resources.

³ Strengthening our approach to drought and risk management, Chapter 3 of the Agricultural Competitiveness White Paper.

Project 2.8: Extreme weather projections

Project overview

Project details				
Length	Start date	End date	Approval date	Status
3 years	01/07/2016	30/06/2019	12/2015	In progress
Lead research organisations		Project leader		
Bureau of Meteorology and CSIRO		Andrew Dowdy andrew.dowdy@bom.gov.au (03 9669 4722)		

Extreme weather events, such as tropical cyclones, bushfires, east coast lows and thunderstorms, incur significant economic, environmental and human costs. These events, and the costs associated with their impacts, are likely to change in a changing climate. Robust scientific information about the influence of climate change on these extreme events is essential for planning to improve the resilience and wellbeing of communities in the future.

We're using observation data to examine historical extreme events and their causes, so we can better understand how, when and where extreme weather events occur. We're also assessing the ability of climate models to simulate extreme weather events, and investigating the causes of projected future changes in extremes.

This will result in projections of extreme weather events that will allow us to develop information and tools to enhance disaster risk reduction, emergency response, infrastructure design and operation, planning and policy making, and sustainable development.

Expected outcomes

By refining estimates of the effect of climate variability and change on extreme weather events, and improving the quality and delivery of this information, this project will enable better prevention, preparedness, response and recovery to extreme weather and climate events in Australia.

Our science will be available to inform:

- Design standards for infrastructure and planning (e.g. wind speed and storm surge events).
- National and state guideline documents (e.g. bushfire risk management and bushfire-prone area maps; and mitigation of the adverse impacts of future storms on coastal communities and the environment).
- Planning and policy documents (e.g. land planning in coastal areas; and bushfire management plans that set out informed long-term management strategies for fire hazards and risks within a bushfire-prone area).

The work undertaken in this project will also address key knowledge gaps for tropical cyclones, east coast lows, thunderstorms and extreme fire weather, thereby underpinning ongoing research within and outside of the ESCC Hub. For example, extreme rainfall and winds are produced by tropical cyclones, east coast lows and thunderstorms, all of which are poorly represented by current global climate models. Improved knowledge about how these systems might change in the future will help inform other projects in relation to interpretation of climate model output for various regions of Australia.

Project 2.9: Risk assessment of future carbon sources and sinks

Project overview

Project details				
Length	Start date	End date	Approval date	Status
3 years	01/07/2016	30/06/2019	12/2015	In progress
Lead research organisation		Project leader		
CSIRO		Pep Canadell pep.canadell@csiro.au		

Policy makers need information on carbon and greenhouse gases so they can develop successful national policies and international engagement to achieve climate mitigation targets. They also need robust evidence to help identify effective carbon mitigation options. Revegetation is a potentially low-cost option, but we don't know how climate change will affect uptake and availability of nutrients and water, and how this will affect plant growth (and so potential to store carbon).

We're developing models that we will use to assess the potential of revegetation and conservation activities in Australia to remove carbon from the atmosphere. We're also looking at how vulnerable the mitigation potential is to climate change.

This research will help determine the potential for land-based mitigation options in Australia, which will inform both Australia's climate change and greenhouse gas policies, and growing carbon markets. This work will also produce national and global carbon budget data products that show how carbon dioxide and methane levels are tracking on the pathways needed for global climate stabilisation by the end of the 21st century.

Expected outcomes

Research in this project will improve our national capability to track, understand and predict future changes in greenhouse gases, and the biogenic (produced by living organisms) carbon budget for Australia. This will support and inform Australia's policy responses, and play a key role in ensuring the effectiveness of global actions to mitigate emissions.

Our assessment of the potential of land-based carbon sequestration and its vulnerability under future climates will lead to more effective carbon sequestration activities. It will also inform decisions on how much and where to invest in carbon sequestration and protect existing carbon sinks, establishing more successful and long-term sustainable deployment of mitigation capacity.

For example, enhanced government abatement policies that take full advantage of the carbon mitigation potential from revegetation and carbon stocks conservation will directly enhance the robustness of policies to achieve Australia's 2030 emissions reduction target and inform about the potential for carbon sequestration in Northern Australia that that could lead to new development policies

Our work tracking Australian and global carbon budgets, and monitoring carbon budgets against agreed global targets, will support the Australian Government in achieving its mitigation targets.

Project 2.10: Coastal hazards in a variable and changing climate

Project overview

Project details				
Length	Start date	End date	Approval date	Status
3 years	01/07/2016	30/06/2019	12/2015	In progress
Lead research organisation		Project leader		
CSIRO		Kathleen McInnes kathleen.mcinnnes@csiro.au (03 9239 4569)		

As sea levels rise, coastal areas are likely to experience increased erosion and inundation, which poses a threat to communities, infrastructure and coastal ecosystems. The effect of storm surges and waves will amplify these impacts, which vary from place to place. Planning and preparing for current and future coastal erosion and flooding depends on the availability of regional data linking coastal extreme events to their impacts, but these datasets are not readily available.

We're improving our understanding of past sea level, storm surges and waves to develop projections for the future, so we can determine the physical impact these changes might have. Our research is examining these stressors individually and in combination. We're drawing on recent observations and climate models, as well as historical tide charts and records that we're digitising to allow their analysis.

This research will result in new information about how extreme sea levels are changing and improved regional sea-level projections for the 21st century, as well as projections for coastal extremes. The datasets developed in this project will support national coastal planning, protection of the coastal environment, and investment and development decisions in coastal areas.

Expected outcomes

Our sea-level projections, analysis of extreme events and changes in wave conditions will be critical inputs to improved coastal planning guidelines. This improved knowledge base will inform planning and management decisions by councils, state planning and conservation authorities and coastal developers, and help deliver appropriate responses to environmental and social developments.

More robust and demonstrable knowledge of coastal impacts will result in more cooperative (win-win) strategies being adopted in the coastal zone, and reduce conflict and costly litigation between councils and developers. These strategies will be more directly linked to local needs but, at the same time, be based on nationally and globally consistent scenarios.

Our science will also inform the Australian Government on the impacts of coastal change, assisting both the government and our near neighbours to better deal with coastal change and be well informed in international negotiations related to climate change.

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

Project overview

Project details				
Length	Start date	End date	Approval date	Status
3 years	01/05/2016	01/05/2019	15/04/2016	In progress
Lead research organisation		Project leader		
University of Melbourne		Stephen Swearer s.swearer@unimelb.edu.au (03 8344 6253)		

Despite considerable knowledge about climate change and its impacts on marine and terrestrial habitats in coastal ecosystems, there has been very little change in the way coasts are governed in Australia. The local governments responsible for coastal management do not always get the science-based information at the scales they require.

We've established the National Centre for Coasts and Climate (NCCC) at the University of Melbourne to work with stakeholders to identify the best ways of addressing climate change impacts in Australian coastal ecosystems. Through the NCCC we're investigating how coastal vegetated habitats store carbon, and how climate change is likely to impact on coastal erosion. We'll use this knowledge to develop ecological engineering solutions to enhance the capacity of coastal ecosystems to adapt to climate change.

Phase 1 of the NCCC is developing methods to evaluate sensitivity and impacts of climate change and trialling solutions for coastal and marine environmental management challenges in Victoria. Phase 2 will expand these activities to other locations in Australia. Ultimately this work will assist in the development of nationally coordinated policies and approaches for adapting Australia's coast to climate change.

Expected outcomes

The creation of NCCC will provide increased capability in delivering practical science to identify feasible solutions for addressing climate change impacts in coastal ecosystems.

Our work on blue carbon (carbon stored in marine and coastal habitats) will improve our understanding of the variability and underlying drivers of carbon accumulation rates in coastal vegetated habitats.

Our research will improve understanding of the drivers of coastal erosion and of coastal erosion processes at higher resolution time and space scales. This will allow for better predictions of how different types of coastlines are likely to respond to future climate change.

Through our examination of ecological engineering solutions and how to implement them, local government will have a greater awareness of the value and feasibility of these solutions, and be better informed on their implementation.

This research will also:

- Assist in the development of nationally coordinated policies and approaches for adapting Australia's coast to climate change.
- Assist Government in meeting Australia's post-2020 emissions reduction targets.
- Generate methods for reducing the production of greenhouse gas emissions as part of Government's Emissions Reduction strategy.

Indigenous engagement activities and ESCC case studies

Commencing in 2017 as part of RPV3, a suite of new Hub and project level case studies have been implemented on an annual basis as an adjunct to the existing/approved research projects (2.1–2.11).

The purpose of the case studies is to develop additional outputs (i.e. products and services) as required, 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 case studies are operationally linked directly to one or more research projects and are typically low-cost activities and outputs (\$10–50K) funded on a discretionary basis by Hub Central to facilitate outreach (communication and knowledge brokering) to key stakeholders and associated path-to-impact.

Like the research projects, the individual case studies are not intended to deliver impact in isolation, rather they contribute to the overall (cumulative) path-to-impact at Hub level via the several designated research projects. On this basis, the case studies 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 latter as determined by direct engagement by the Hub and/or via input from the HSAG). Given this context, the case studies are not defined as 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 existing approved research projects and the Hub more generally.

Activity 3.2: Meeting Indigenous priorities for climate change information, capacity building and engagement

In partnership with CSIRO Land and Water's Collaborative and Indigenous Science team, Kimberley Land Council (KLC) and Seed (the Indigenous branch of the Australian Youth Climate Coalition, and Australia's first Indigenous youth-led climate network), the Hub will identify Indigenous priorities for climate-change focussed information, capacity building and forms of engagement. This will contribute to future plans to meet the Hub's Indigenous engagement goal.

This activity will build on previous work with Indigenous communities to reach common understanding about priority needs, including: (1) the 2012 workshop run by Monash University and the Yorta Yorta National Aboriginal Corporation (YYNAC) as part of an NCCARF-funded activity; (2) NCCARF's current initiatives in peer-learning events⁴ with Indigenous peoples to underpin further development of their Indigenous Adaptation Research Plan; and (3) other relevant initiatives identified through the project.

The activity will co-design a workshop bringing together Hub researchers and interested respected and trusted members of the Indigenous and research community (outside the ESCC Hub). A primary objective of the workshop is to continue the dialogue about climate change with Indigenous leaders, with a focus on one of the key findings from the 2012 NCCARF Workshop: the need to ensure that climate data and information are provided in a useful and meaningful way to Indigenous communities; and that there is consideration given to what are the most important variables that are relevant to Indigenous communities.

⁴ This was the event held in Adelaide around the time of the NCCARF Conference in July 2016.

A key goal for this workshop is to provide recommendations regarding what climate change information, capacity building, and form of engagement would be of greatest value to Indigenous communities. A product that we are very keen to propose, and explore in terms of its utility and impact, is a narrative about climate change that captures Indigenous knowledge and insights, for example a *Seeing through both eyes* version of the State of the Climate, which is produced biennially between CSIRO and the Bureau of Meteorology

CS 3.3: Climate change impacts on inshore aquatic ecosystems and coastal communities in the Torres Strait Islands

The Torres Strait Regional Authority (TSRA) and Australian Fisheries Management Authority (AFMA) want information on interdependencies between climate change and impacts on inshore fisheries, marine habitat (coral reefs, seagrass beds, mangroves) and coastal communities. Such knowledge would be drawn from Projects 2.2, 2.3, 2.4, 2.6 and 2.10.

A decision support system will collate/synthesise new scientific and existing traditional knowledge to prioritise community values around ecosystem services. A stakeholder workshop convened by the Hub, TSRA and AFMA is proposed to facilitate outreach of existing knowledge, identify key information gaps and needs, generate tailored communication products, and identify strategic 'way forward' options.

The focus is on engaging with regional and Indigenous stakeholders in the Torres Strait who are both next and end-users of the Hub's climate science. Path-to-impact at Hub level will be achieved by ensuring key next/end-users have enhanced knowledge and the Hub is better informed for future project design and delivery.

CS 4.1: Test case for datasets and information for managing climate risk in the Australian banking and finance sector

The recent release of the FSB Taskforce on Climate-related Financial Disclosures report has significantly raised the awareness of corporate Australia in relation to climate change risk and the need for new and novel management approaches. Climate change projections, particularly with regards to weather extremes, provide essential information for climate risk assessments. With regulators and investors increasingly acknowledging the potential economic repercussions of climate-related risk on assets and operations, the banking and finance sector is developing a renewed interest in climate risk assessment.

This case study is a scoping study which seeks to test the utility of climate change projections for this sector, with a view to demonstrating how climate change projections information can be readily applied to decision-making in the banking and finance sector – demonstrating the path to impact of science from Projects 2.6 and 2.8.

The first step in developing effective information products and services for this sector is the preliminary identification of data and information gaps and needs, allowing for the development and testing of prototype products and generating feedback to inform further development.

This case study will examine the potential to adapt current projections data and information and present it in innovative ways tailored to the needs of target users and will provide a starting point for a process of partnering and delivering information for this growing need going forward, including potential alignment with:

1. Hub engagement of the UNEP-FI consortium of global banks recently facilitated by the HSAG

2. the newly announced Lucsan/NAB/Climate Policy Research consortium initiative to develop a science-based climate risk analytical tool for the Australian agriculture sector
3. engagement with APRA (or appropriate delegate(s)) on physical risks from storms and fires in a changing climate.

CS 4.2: Potential for carbon abatement by revegetation and conservation in Australia – stakeholder engagement and status report

This case study will identify existing vegetation/carbon information and tools available to policy makers, and identify gaps/needs that will inform future research direction. The case study will leverage primarily off activities and outputs (key data and information) being delivered through Project 2.9.

Revegetation and conservation in Australia may have great potential to contribute to achieving the mitigation targets of the Paris Agreement. Current estimates of this potential are limited to a few studies, none of which have been able to adequately address the opportunities and limitations of the biophysical and socio-economic worlds.

We will define key policy needs, information gaps and available assessment tools on the role of vegetation in carbon abatement in Australia through a stakeholder engagement workshop with policy-makers and practitioners at the federal and state/territory level with the scientific community.

More effective carbon sequestration activities are expected in the longer term as a result of this type of information being used to inform decision-making; in particular decision-making informed by a dynamic and spatially explicit continental assessment of the potential for revegetation and vulnerability of existing stocks to future climate change.

CS4.3: Communicating projected changes in hydroclimate affecting water supply in South-West Western Australia (SWWA)

Project 2.7 is focused on supporting the sustainability of Australia’s future water resources. This case study seeks to develop useful communication products for the Western Australian water sector to facilitate the application of science to water management, and thus demonstrate the impact of Project 2.7.

A series of engagements in 2016–17 between the water sector and other key stakeholders in WA and the ESCC Hub identified 14 recommendations relevant to climate data gaps and needs. Some might be met within existing ESCC resources (e.g. Projects 2.6 and 2.7) while others would require additional investment (see also findings in Case Study 3.5 Workshop Report). This case study intends to address two of the priority needs:

- Demonstration of ‘science to management’ as an exemplar of the use of existing climate science to inform WA water resource planning and management, and
- Communication products for key stakeholders on climate variability, extremes and reliability of water supply in a changing climate

Communication products on projected hydroclimate relevant to water supply availability will be developed. This will complement and build on RPV3 Case Study 3.5 (Climate Change Variability in WA), including addressing lessons learnt in engaging stakeholders to establish the type of communication products to meet their needs.

By demonstrating the application of science to management, this case study will show the benefits of climate science-based decision making, and will ensure decisions about future water supply are informed by science that is robust, useful and relevant – demonstrating the impact of science undertaken in Project 2.7. Outputs from this case study may inform the development of frameworks or prototypes for planning in other states, and for broader strategic water planning nationally.

CS4.4: Climate change impacts on threatened species and ecosystems – preliminary review and scoping

One of the activities in Project 2.6 is improving understanding of climate feedbacks and key climate processes, including clouds. This case study will demonstrate how the application of the Hub's work in this area particularly can be used to assess climate change impacts on threatened species and ecosystems, and will meet a stakeholder driven need as the Hub was approached to carry out this work by World Heritage Australia.

There is a growing body of work on the impact of climate change on threatened species and ecosystems/ecosystem services, but the ecological analysis and the weather and climate research are often not well connected due to the lack of (1) robust and functional systems modelling interface methods, and (2) relevant compatible, spatially and temporally explicit databases.

A partnership between the ESCC Hub, TSR Hub and key agencies (e.g. Queensland Herbarium) will bring together complementary skills in climate change, micro- and meso-scale meteorology, land surface feedbacks and ecology to address information gaps and needs in two specific areas of interest to key stakeholders:

- Climatic change and cloud caps and cloud forest ecosystems affecting threatened plant communities in the Lamington National Park World Heritage Area of SE Queensland, and
- Climatic change and the conditions impacting distribution and abundance and critical habitat for the Greater Glider in South Eastern Australia

Outputs from this case study are expected to raise awareness around the importance of factoring in climate change as a key environmental stressor for threatened species, and potentially to inform decision-making and enhance longer-term outcomes related to management of the target species and associated ecosystems in Australia.

CS4.5: Framework for determining the net socio-economic benefits of Earth systems and climate change science and services

The ESCC Hub supports a diverse portfolio of scientific research and service delivery to address stakeholder needs and to realise outcomes relevant to Australia's national interest. For the most part, 'path-to-impact' for ESCC Hub science requires the science to be delivered as products and services tailored to the needs of target end-users (see also *WMO Global Framework for Climate Services*). To validate tangible path-to-impact from this science it is necessary to estimate socio-economic 'return on investment' in the form of standardised metrics as part of a broader approach to climate change science and services impact evaluation and reporting.

This case study will develop a preliminary/conceptual cost-benefit framework designed to measure the short to long-term value of the Hub's research outputs to the Australian economy and society more generally. It will also demonstrate the practical application of this framework

as part of a virtual analysis designed to quantify the net social and economic value of the investment into selected areas of ESCC Hub science of direct relevance to selected key stakeholders. It will also propose a strategic process for further developing and implementing the framework over the life of the Hub as part of the overarching Evaluation Planning Framework for the Hub.

In showing the value of the science, this analysis will inform future research planning and government planning. Identified benefits will also demonstrate the value of the Government's investment in climate change science.

CS 4.6: Multi-disciplinary approach to understanding climate change impacts and exploring climate sensitive management solutions for the Great Barrier Reef

Project 2.9 is focused on assessing carbon sources and sinks, examining the carbon cycle. Carbon dioxide taken into the oceans is driving ocean acidification, which poses a threat to marine ecosystems, particularly reefs. Better regional data on the likely impacts of climate change on the Great Barrier Reef will be important for management and decision making and can be applied to the management of other Ramsar areas.

Climate change is a major threat to the long-term health of the Great Barrier Reef (GBR); however, the regional scale impacts are yet to be well quantified in the context of the global scale carbon cycle and associated atmospheric and oceanic climate drivers.

To address this knowledge gap, the goal of this case study is to undertake a multi-disciplinary approach to build consensus amongst stakeholders on how we can move from near-term understanding of climate impacts to exploring the projected GBR climate future under different emissions pathways, and how this information should be made available to stakeholders.

It is anticipated that this information will enhance awareness of stakeholders in relation to the relative significance of climate change impacts on the reef, and facilitate enhanced decision-making for policy development and adaptation planning purposes. This will lead to more informed, climate sensitive risk management by stakeholders in the process of improving the resilience and health of the GBR into the future. Future R&D opportunities will be explored and priorities will also be identified subject to stakeholder feedback.