



National Environmental Science Programme



Research Plan

VERSION 5

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Australian Government



National
**Environmental
Science**
Programme

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Introduction

The National Environmental Science Program

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

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

The NESP is delivered through multi-disciplinary research hubs or consortia, hosted by Australian research institutions. The NESP seeks to achieve its objective by supporting research that:

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

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

The intended outcomes of the NESP are:

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

The Earth Systems and Climate Change Hub

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

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

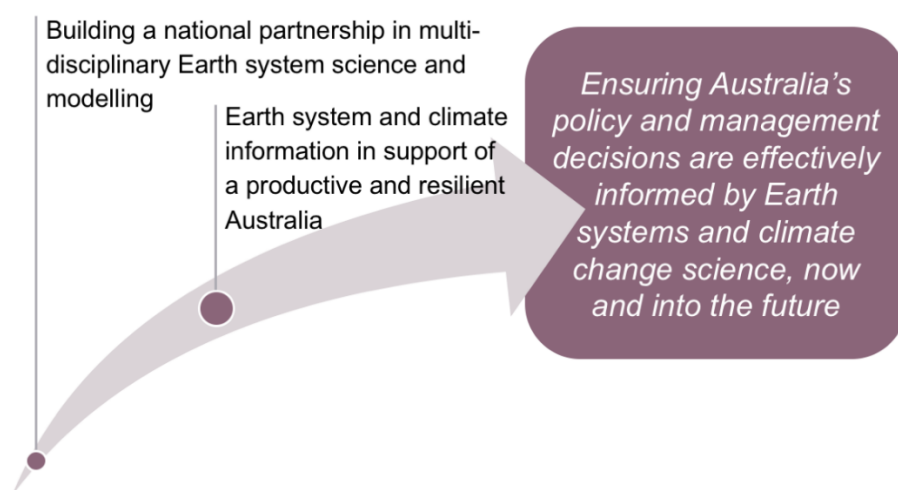


Figure 1. Earth Systems and Climate Change Hub goal

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

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

- lead the further development of a world-competitive, national Earth system and climate modelling capability (the Australian Community Climate and Earth System Simulator, ACCESS) to deliver weather and climate predictions and projections for the Australian community
- 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.

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

History of Australian Earth systems and climate research

The NESP is an amalgamation of the NERP and the ACCSP.

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

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

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

- 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.

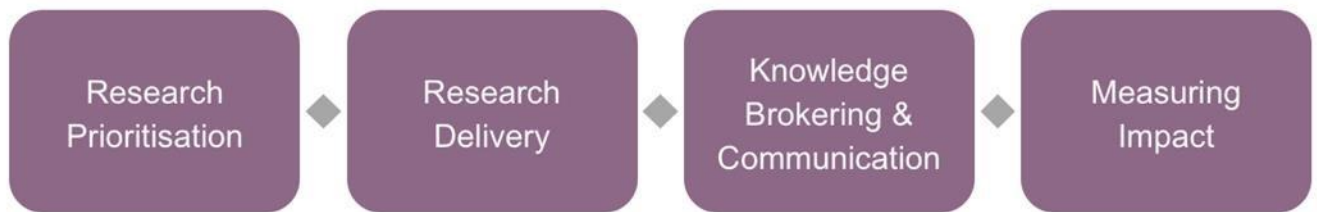
Purpose of the Research Plan

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

The purpose of the Research Plan is to outline:

- the research priorities the Hub is funded to investigate
- the research projects that will address these priorities
- how the output of the research will be communicated and brokered to key stakeholders

- how the impact of the research will be measured
- how the Hub will work collaboratively within and across hubs.



This Research Plan includes details on two rounds of research projects: those approved under RPV2 for three years (July 2016 – June 2019) and new 18-month projects approved under this plan (July 2019 – December 2020). Project details are in [Attachment A](#).

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

Hub administration and governance

Hub leadership and governance

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

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

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

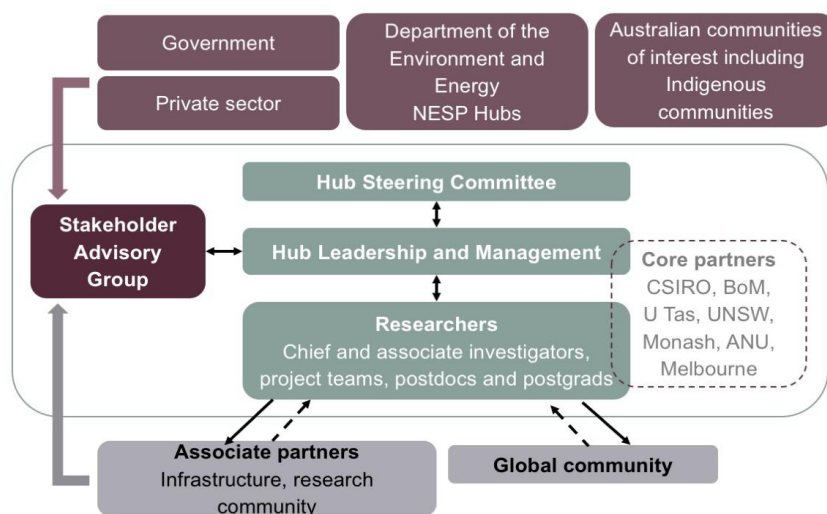


Figure 2: Earth Systems and Climate Change Hub governance

Hub Leadership and Program Management Teams

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

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

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

Hub Steering Committee

The Hub Steering Committee (HSC) meets on a regular basis and provides strategic oversight of the Hub's performance against its objectives. The roles, responsibilities and membership of the HSC 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, they have been prioritised and organised under six Target User Groups in RPV5: federal government, state government, local government, government authority agencies, the financial services sector and Indigenous communities. These user groups represent the key stakeholder groups with which the Hub currently engages closely and through which the Hub can most effectively deliver impact across its five climate challenge (outcome) areas. The Hub primarily engages with these six Target User Groups at a Hub level through case studies, knowledge exchange and stakeholder engagement activities and Indigenous activities. The Hub also engages with these user groups at the level of the science capability projects, with Hub-level coordination and oversight.

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

The 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, equitable consistent and timely.

The Department of the Environment and Energy

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

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

The Minister

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

Research priorities

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

This research prioritisation is a rolling process and key milestones in each activity year, like the Annual Progress Report and submission of the next Research Plan, will inform the process. This constant consideration and evaluation of research output and impact builds confidence in the performance of the Hub and the effectiveness of the program. It also provides the basis for the flexibility needed in the ESCC Hub to engage in new themes of research in an adaptive manner and ensures that the Hub's focus is fixed on the delivery of relevant and practical research.



The research priorities for the ESCC Hub are:

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

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

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

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

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

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

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

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

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

Progress towards addressing research priorities

The Hub has made significant progress in 2018 towards addressing its research priorities through its science capability projects and associated case studies. A summary of key achievements, activities and outputs can be found in the highlights publication 'Meeting Australia's climate challenges' (<http://nеспclimate.com.au/wp-content/uploads/2016/03/Meeting-Australias-climate-challenges-Nov18.pdf>).

A list of completed research projects and outputs funded under the ESCC Hub is available on the Hub's website, www.nеспclimate.com.au.

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

Hub outputs and outcomes

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

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

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

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

Through this process, the Hub has identified the top five climate challenges facing Australia as the Hub's outcomes (Figure 3). The Hub's portfolio of research projects is designed to address these outcomes at a sectoral level and thereby deliver impact and benefit for Australia. Additional and important climate challenges, in the health, heritage, infrastructure, and national security/defence sectors, are also acknowledged and will be indirectly addressed by the Hub's research to varying degrees.

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.

CLIMATE CHALLENGES FOR AUSTRALIA






| | |
|--|---|
|  | Future hydroclimate and water resources More effective water resources planning, management, infrastructure and investment |
|  | Food security, ecosystems and natural resource management More effective decision making and planning through better climate information at multi-annual to multi-decadal timescales |
|  | Carbon cycle and Australia's future warming Australia's emissions mitigation policy responses are informed by tracking past, and predicting future, changes in greenhouse gases |
|  | Changes in coastal climate Coastal planning and development decisions are informed by nationally coordinated data and information on changing sea levels and climate in coastal regions |
|  | Extremes and disaster risk reduction Greater resilience to extreme weather and climate events through improved knowledge and better quality, relevance and delivery of targeted information |

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 of Australian capability in Earth system and climate science; deeply engaged with global climate research activities that deliver benefit to Australia.

Target User Group outcomes and impacts

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

A suite of tailored outputs will be produced by the Hub to address the priority data and information needs of these user groups, which in turn is expected to realise multiple impacts over the short-to-medium term (within the life of the Hub) and also the medium-to-longer term (beyond the life of the Hub). The outputs are specifically designed to align with and be informed (if not produced directly) by the science capability projects, and will also be facilitated by one or more customised case studies undertaken in collaboration/active participation with the user groups.

These case studies and associated knowledge exchange and communication activities will be coordinated for the most part by Hub Central in partnership with designated ‘Science Leaders’ involved in the delivery of the science capability projects and with designated HSAG stakeholder ‘sponsors’ to ensure compliance with stakeholder expectations.

The expected impact will be the primary (but not only) unit of measurement for the Hub’s impact evaluation which will be implemented according to the updated (RPV5) version of the Hub’s Evaluation Planning Framework and associated action plan.

ESCC Hub program logic

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

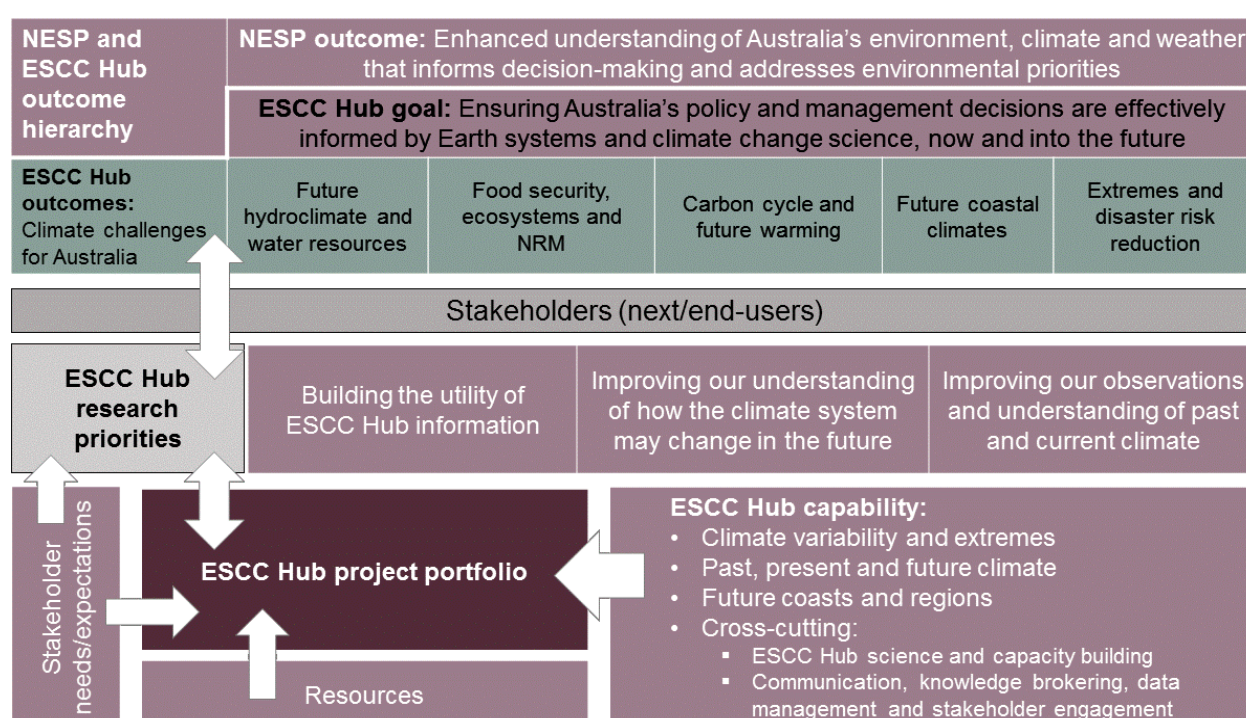


Figure 4: Summary schematic of NESP Earth Systems and Climate Change Hub program logic

The program logic also describes the core capability within the Hub, which is critical to delivering the outcomes and providing flexibility. The project research areas are all strategically important priorities for the partner agencies, meaning that the Hub 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 capability research projects proposed in RPV5.

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

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

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

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

Table 1 describes the generic types of research outputs that will be delivered, either through the research projects and/or via the Hub communication and knowledge exchange activities (and the Hub's Communication and Knowledge Brokering and Indigenous Engagement and Collaboration strategies, available at <http://www.nespcclimate.com.au/publications/>)

Output types 1–4 primarily address the specific scientific and technical needs of next/end-users, while output types 4–7 primarily address the more general communication, knowledge brokering and outreach needs of next/end-users.

Table 1: Earth System and Climate Change Hub outputs

| Type of output | Purpose | Comments |
|--|---|---|
| 1. Research publications <ul style="list-style-type: none"> a) Journal papers b) Conference papers c) Technical/summary reports | <ul style="list-style-type: none"> • Peer review – establish quality and credibility of Hub research • Communication and exchange of knowledge | <ul style="list-style-type: none"> • Publicly available, via links available on ESCC website |
| 2. Data <ul style="list-style-type: none"> a) Model data – hindcasts, current assessments and future projections as digital datasets, maps and similar visualisation products b) Observed data – past and current c) Application-ready datasets d) Information products | <ul style="list-style-type: none"> • Peer review – establish quality and credibility of data and information products • Deliver credible, peer-reviewed information for scientific assessments, impact assessment, adaptation planning and mitigation responses • Data available for other users | <ul style="list-style-type: none"> • Publicly available, via links on ESCC 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 <ul style="list-style-type: none"> a) Enhanced or new model versions and/or systems b) Enhanced or new submodels, 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, including submission of ACCESS simulations to the CMIP6 coupled climate model intercomparison. |
| 4. Communication and knowledge products <ul style="list-style-type: none"> a) Targeted information products b) Brochures c) Case studies d) Newsletters (including The Chirp) e) Tailored products to support Indigenous engagement, capacity building and research, as appropriate and consistent with the Hub's Indigenous Engagement and Collaboration Strategy | <ul style="list-style-type: none"> • Communication and knowledge exchange • Building knowledge and understanding • Deliver credible, peer-reviewed information for impact assessment, adaptation planning and mitigation responses | <ul style="list-style-type: none"> • Products will be made available via the ESCC (and other appropriate) website and stakeholder networks. • Social media will be used to promote products and stakeholder engagement activities. • Products will be derived from Research Project materials as appropriate. |
| Type of output | Purpose | Comments |
| 5. Communication and engagement activities <ul style="list-style-type: none"> a) Regular engagement with stakeholder networks. b) Workshops and conferences c) Seminars and forums d) Regular 'science informing policy' event | <ul style="list-style-type: none"> • A more active way to share and exchange knowledge and information – either to a general or specific audience – that facilitates co-production, feedback, problem-solving and value-adding. | <p>The Hub is holding:</p> <ul style="list-style-type: none"> • annual, targeted workshops • briefings to the government, states, business sector and other key stakeholders • regular engagement with key stakeholders to either exchange knowledge or to co- |

| | | |
|---|---|--|
| <p>e) Briefings</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> | | <p>produce knowledge and information.</p> |
| <p>7. Training</p> | <ul style="list-style-type: none"> • Building the capacity of our next-users, end-users, general public and Indigenous communities to: <ul style="list-style-type: none"> ○ understand the current state of climate change science ○ effectively utilise the information provided by our Hub and other knowledge providers • effectively use Hub models, data and other products | <ul style="list-style-type: none"> • For postgraduates: training activities will 'piggy-back' on the world-class training activities that the ARC CLEX already provide. • For stakeholders: training activities will be provided through our stakeholder networks as appropriate and affordable. |

Communication and knowledge brokering

Integral to the success of the NESP in influencing decision-making is the clear and effective communication and brokerage of research outputs to key stakeholders from the Hub's science capability projects, Target User Group activities and case studies. The Hub has developed and maintains a Communication and Knowledge Brokering (C&KB) Strategy that is available on the Hub's website at <http://nespclimate.com.au/publications/>, and is underpinned by an internal action plan which describes detailed activities and products in more detail.

The strategy:

- strongly aligns with this Research Plan
- describes how the Hub will facilitate knowledge sharing between researchers and end-users
- includes activities that bring researchers, policy-makers and environmental managers together to facilitate evidence-based decision-making
- details the research products and communication material to be developed by the Hub.

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

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

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

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

- develop and manage key stakeholder relationships and where appropriate collaborative partnerships to ensure that communication and knowledge brokering activities are strategically targeted to facilitate adoption and realisation of specified ESCC Hub outcomes and impacts [**stakeholder engagement**].

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

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

RPV5 knowledge exchange, co-production and communication activities

The proposed knowledge exchange, co-production and communication activities and associated deliverables for RPV5 will be focussed around addressing the needs of the six Target User Groups through the lens of the Hub's five designated national climate challenges (outcomes). This will ensure that the specific outputs of the underpinning science capability projects will be focussed, centrally coordinated, operationally consolidated and ultimately optimised to address the key needs of the Target User Groups (Figure 5). These activities will also serve as an important adjunct to the Hub's proposed impact evaluation. More specifically, the reaction of the Target User Groups to these activities will form the basis of the unit of management for evaluating Hub level impacts.

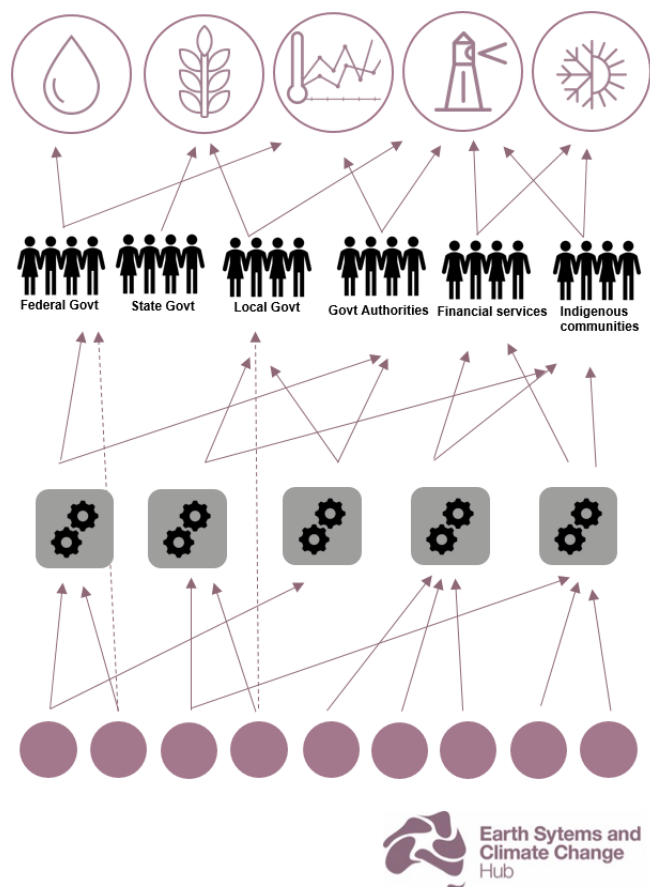
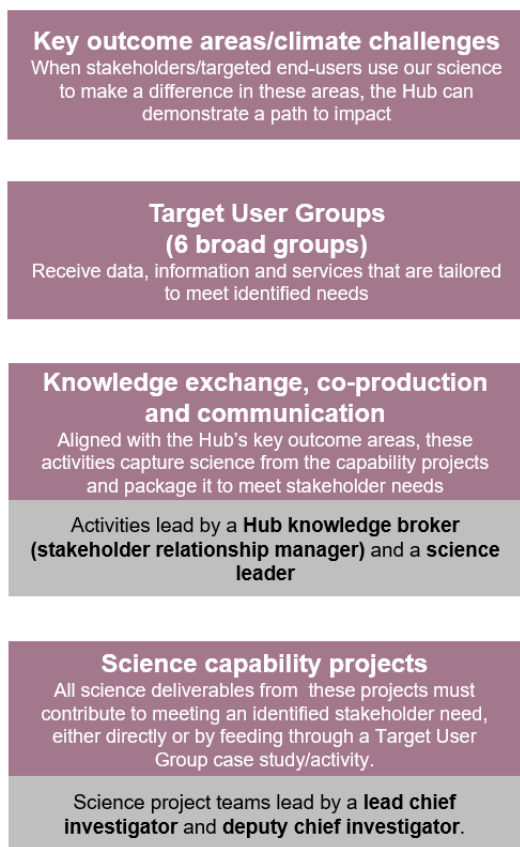


Figure 5: Schematic of ESCC Hub path-to-impact via its six Target User Groups

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

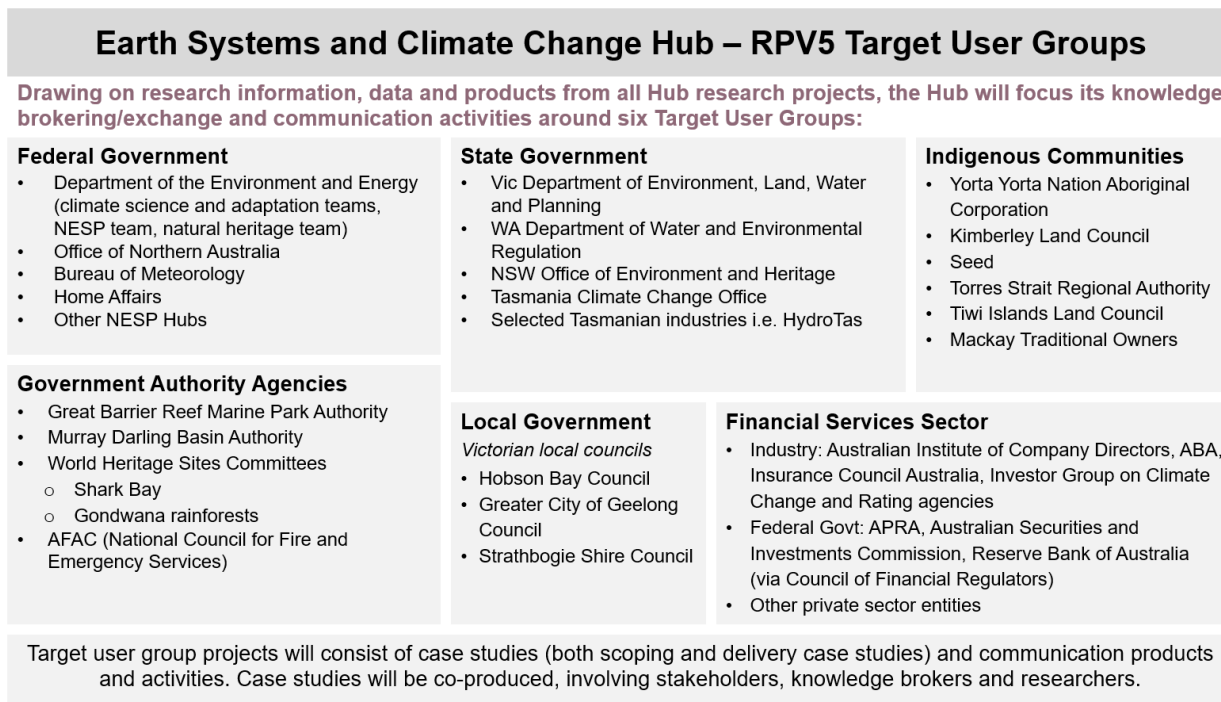


Figure 6: ESCC Hub Target User Groups

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

Case studies

Since 2017 (RPV3) a suite of Hub and project-level case studies and activities have been implemented on an annual basis as an adjunct to the existing science capability projects.

The purpose of the case studies is to develop (in partnership with stakeholders) additional outputs (i.e. products and services) that are tailored to the specific needs of target stakeholders to facilitate path-to-impact for the Hub's existing portfolio of research projects. In practice, the case studies are operationally linked to one or more research projects and are typically low-cost activities and outputs (\$10–50K) funded on a discretionary basis by Hub Central from knowledge brokering and communication funds to facilitate outreach (communication and knowledge exchange) 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 and Target User Groups. 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.

Under RPV5, these case studies (knowledge exchange, co-production and communication activities) will now be structured around the six identified Target User Groups. These activities and case studies have been identified through stakeholder engagement and discussions with key stakeholders both at the Hub and research project level.

Data accessibility

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

The Hub's approach to data and information management is covered in its Data Management Plan, available on the Hub's website at <http://nespclimate.com.au/publications/>.

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

partner agencies to ensure consistency with relevant agency-specific data and information management arrangements.

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

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

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

Monitoring and evaluation

NESP monitoring and evaluation plan

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

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



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

Project and financial reporting

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

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

NESP evaluations

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

Performance measures

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

ESCC Hub Evaluation Planning Framework

The Hub's Evaluation Planning Framework (EPF) sits within the Hub but otherwise is designed to complement the overarching NESP 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 measurable impact.

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

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

The EPF, through design and implementation of a specific Hub-level M&E action plan, also provides 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 and Collaboration Strategy, all of which inform the implementation of the Hub's annual Research Plan. As for the C&KB Strategy, the Hub's EPF also underpins the Hub's flexibility and responsiveness (e.g. through the operational development and implementation of annual 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. 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 a part of this, all RPV5 projects will be required to submit annual work plans describing their objectives, tasks and outputs. Operationally, these work plans will feed into the Hub's internal quarterly progress reports and annual reporting to the Department. They also enable the Hub to monitor resourcing, and track progress in a measurable way.

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 and Collaboration strategies throughout the life of the Hub, at both a Hub and project level.

Collaboration and partnerships

NESP encourages a collaborative, multi-disciplinary approach to environmental research. Key to the success of the Hub will be the capacity to foster partnerships across hubs and with a wide range of relevant research stakeholders. Table 2 identifies those partners and stakeholders with whom the Hub has previously or currently engaged. This list has grown and matured throughout the life of the Hub and will continue to be refined.

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

| Programs or agencies who are non-funded partners providing research capability and/or represent key next- and end-users | | | | |
|---|--|---|---|--|
| Partner | Relationship to ESCC Hub | Role (institution, program, individual) | Expertise | Alignment to Hub goals |
| Integrated Marine Observing System (IMOS) | Director is a member of the Hub Steering Committee (HSC) | Program: Provides critical research infrastructure to Hub research | Ocean observing infrastructure | Critical to ocean observations; which underpin several outcomes and research priorities |
| National Computational Infrastructure (NCI) | Member of ACCESS Advisory Group (Bureau, CSIRO, Universities are part of this) | Program: Provides critical research infrastructure to Hub research | High Performance Computing for ACCESS modelling; CMIP model and observed data storage | Critical to ACCESS development and use; CMIP6 participation; and delivery of climate information |
| ARC Centre of Excellence for Climate Extremes | Director of Centre is a member of Hub Steering Committee (HSC); CIs are involved in Hub projects | ARC-funded centre providing underpinning climate system science to Hub research | Climate systems science, climate extremes | Aligned to some research priorities |
| Antarctic Climate & Ecosystems Cooperative Research Centre (ACE CRC) and the Australian Antarctic Division (AAD) | ACE CRC CEO was a member of the HSC; AAD senior researcher is a member on HSAG | Program: CRC and AAD potentially both users and providers of Hub research | Antarctic and Southern Ocean – cryosphere processes | Aligned to some research priorities; complementary research goals |
| National Climate Change Adaptation Research Facility (NCCARF) | Director is a member of HSAG | Program: Both a next- and end-user of Hub research. NCCARF also connects the Hub's research to broader end-user communities | Adaptation to climate change, with a focus on the coastal zone, especially sea-level rise impacts | Aligned to some research priorities; complementary research goals |
| Kimberley Land Council and Seed | 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 |

| Partner | Relationship to ESCC Hub | Role (institution, program, individual) | Expertise | Alignment to Hub goals |
|--|--|--|--|---|
| Yorta Yorta Nation Aboriginal Corporation | Co-leaders of a proposed workshop with Indigenous leaders on climate change | Agency: Stakeholder group with whom the Hub is developing Indigenous activities | Traditional owners and Indigenous knowledge; natural resource management | Aligned to Hub's Indigenous engagement goals and objectives. |
| Mackay Traditional Owners | Stakeholders and collaborators on Indigenous engagement | 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. |
| Climate Policy Research | Director of this company (Nick Wood) is a chair of the HSAG and member of the HSC | Individual and institutional | Providing private sector perspective on managing climate risk and valuation of risk capital | Proposed case study and associated knowledge exchange activities and communications |
| Financial services sector: <ul style="list-style-type: none"> • Australian Institute of Company Directors • Australian Banking Association • Insurance Council Australia • Investor Group on Climate Change • APRA • Australian Securities and Investments Commission • Reserve Bank of Australia | The Hub has interacted with these stakeholder groups and/or associated focal points via Hub Central, HSAG and some LCIs to determine needs and potential collaborative opportunities | Potential end-users of Hub outputs | Financial services, specifically retail banks, insurance companies/actuaries and super fund managers | Proposed case studies and associated knowledge exchange activities and communications |

| NESP hubs | | | | |
|--|---|---|--|--|
| Partner | Relationship to ESCC Hub | | Expertise | Alignment to Hub goals |
| <ul style="list-style-type: none">• Clean Air & Urban Landscapes (CAUL)• Marine Biodiversity• Threatened Species Recovery (TSR)• Northern Australia Environmental Resources (NAER)• Tropical Water Quality (TWQ) | <p>Collaborators on specific areas of research, Indigenous engagement and users of climate knowledge and information.</p> <p>The Hub has organised a variety of cross-hub collaborations in 2018, such as cross-hub business breakfast events at national conferences to showcase the science of the NESP.</p> <p>The Hub organised a cross-hub workshop in 2016 where several research areas of mutual interests were identified, and a set of actions were determined to build the collaboration and path-to-impact for our Hub.</p> <p>Cross-hub collaborative case studies were conducted as part of RPV4 and will be conducted under RPV5.</p> | | Primarily urban greenhouse gas emissions and climate change (CAUL); threatened species ecology (TSR); mangrove and coral reef ecology (TWQ); climate impacts (all); and Indigenous engagement (NAER) | Aligned to some research priorities |
| Government collaborators, with whom the Hub has established links | | | | |
| Federal, state and local government departments; government authority agencies | Federal: <ul style="list-style-type: none">- Department of the Environment and Energy- Department of Agriculture and Water Resources (DAWR)- Office of Northern Australia- Bureau of Meteorology, Climate Services Group- Home Affairs, National Resilience Taskforce | States and territories: <ul style="list-style-type: none">- Tas Dept of Primary Industries, Parks, Water & Environment- Vic Dept of Environment, Land, Water & Planning- ACT Climate Change Policy Group- WA Depart of Water and Environmental Regulation- NSW Office of Environment and Heritage- SA Dept of Environment, Water & Natural Resources | Local councils: <ul style="list-style-type: none">- City of Greater Geelong- Hobson Bay Council- Strathbogie Shire Council | Government authority agencies: <ul style="list-style-type: none">- Murray Darling Basin Authority (MDBA)- AFAC- GBRMPA- Torres Strait Regional Authority- World Heritage Committees: Gondwana Rainforests, Shark Bay |

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.

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

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

The task of identifying and refining the Hub's key internal and external stakeholders and their respective needs has been a focus under each of the Hub's research plans and our ongoing implementation and update of the Hub's C&KB Strategy, Indigenous Engagement and Collaboration Strategy, and EPF.

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

Indigenous engagement

The ESCC Hub is committed to meaningful Indigenous engagement and collaboration during all phases of the delivery of the NESP. Where relevant, due consideration will be given to actively involving key Indigenous stakeholders in research prioritisation, research delivery and, especially, the communication of research output. The Hub's approach to Indigenous engagement is detailed in its Indigenous Engagement and Collaboration Strategy, found on the Hub's website at nespclimate.com.au/publications/.

The vulnerability of some Indigenous communities to climate-related risks, and the potential for adaptation, is well-understood by the Hub. The Hub also understands that Indigenous communities are custodians of a wealth of knowledge about Australia's weather and climate – knowledge that can complement and benefit the Hub's research and impact. In turn the Hub, through its Bureau of Meteorology, CSIRO and university partners, can build upon earlier work with Pacific Island nations and communities, and the Bureau's Indigenous Weather Knowledge (<http://www.bom.gov.au/iwk/>) to ensure effective Indigenous engagement that benefits Australia and Indigenous communities.

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

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

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

The Hub will focus on developing targeted partnerships, expertise and products to meet the needs of Indigenous stakeholders through case studies and engagement. Our aim is to provide instructive examples of success that provide the building blocks for future engagement and delivery.

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

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

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

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

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

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

Activities under the Indigenous Communities Target User Group will be informed by past and current collaborations with Hub Indigenous stakeholders. For example, in partnership with CSIRO Land and Water's Collaborative and Indigenous Science team, Kimberley Land Council (KLC), Yorta Yorta Nation Aboriginal Corporation and Seed (the Indigenous branch of the Australian Youth Climate Coalition, and Australia's first Indigenous youth-led climate network), the Hub has been working to identify Indigenous priorities for climate-change-focussed information, capacity building and forms of engagement. The National Dialogue on Climate Change workshop is planned for November 2018 and will bring together key Indigenous stakeholders and selected Hub researchers and management staff to discuss information needs and priorities and how the Hub can continue to work with Indigenous communities to co-produce relevant and accessible information and products, as well as continue a meaningful two-way exchange of information and knowledge. The outcomes of the workshop, and previous engagements will contribute to future plans to meet the Hub's Indigenous engagement goal. Previous engagement activities which continue to inform the Hub's Indigenous engagement activities include:

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

Funding

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

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

Table 3. ESCC Hub funding summary

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

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

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

Hub approach to risk mitigation and management

The Hub's Risk Register is divided into (a) Hub-level risks and (b) risks that have been identified and categorised from the individual research project proposals. These risks will be managed and treated at a whole-of-Hub level – primarily via implementation of the Hub's governance arrangements and Hub-level Monitoring and Evaluation Plan. The Hub Risk Register is reviewed and updated at least annually to reflect any change in details relating to existing risks. There are no new and emerging risks for RPV5.

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 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. The 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' tailored products and services for target stakeholders.
4. **Communication and knowledge brokering:** The Hub has some discretionary resources that are available to be committed to activities (including products and services) that emerge from yet-to-be determined next/end-user needs. These typically include case studies, but where appropriate can also include other discretionary activities proposed and commissioned out-of-session throughout the year.
5. **Business development and stakeholder engagement:** The Hub is also undertaking a strategic and systematic approach to business development as an integral part of our stakeholder engagement strategy. The purpose is to facilitate new co-investment opportunities to leverage core Hub funding. In practice the Hub has limited capacity beyond the existing commitment of resources from partner agencies. Therefore, it is appropriate that new projects and associated co-investment opportunities leveraged off the Hub's existing research projects and stakeholder engagement activities will be addressed by one or more of the Hub's partner agencies subject to the specific nature of the opportunity and the requisite domain knowledge and associated capability. The Hub has therefore recognised a new class of 'adjunct' project for which the Hub has been instrumental in facilitating in a manner consistent with the Hub's broad objectives, but for which administratively and operational the implementation is to be the responsibility of the partner agencies. It also follows however that the Hub will seek to realise evidence of path-to-impact as appropriate in association with the relevant partner agencies.

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

| | | | | | | | |
|---|--|---|---|--|---|--|--|
| NESP Goal & ESCC Specific Outcome | To improve our understanding of Australia’s environment through collaborative research that delivers accessible results and informs decision-making Improved climate and weather information for Australia through a greater understanding of the drivers of Australia’s climate. | | | | | | |
| ESCC Hub National Challenges | Water Futures | Global Warming and the Carbon Cycle | | Climate Extremes and Disaster Risk Management | | Coasts | Food Security and 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: • lead further development of the nation’s modelling 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 and 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 and Energy | Other NESP Hubs | Federal, State and 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 | Program 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 | <u>Science & Technical</u> : 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 <u>Communications, knowledge brokering, outreach and capacity development</u> : 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 Improving our understanding of how the Improving our observations and information climate system may change in the future understanding of past and current climate | | | | | | |
| ESCC Hub Thematic Research Areas | Communications, knowledge brokering, data/Information management and outreach/end-user engagement Climate variability and extremes Past, present and future climate Future coasts and regions Earth Systems and Climate Change Science integration and 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 2. Glossary for Research Plan V5

| Acronym | Definition |
|---------------|--|
| AAS | Australian Academy of Science |
| ABA | Australian Banking Association |
| ACCESS | Australian Community Climate and Earth System Simulator |
| ACCSP | Australian Climate Change Science Programme |
| ACE CRC | Antarctic Climate and Ecosystems Cooperative Research Centre |
| AICD | Australian Institute of Company Directors |
| ANDS | Australian National Data Service |
| APRA | Australian Prudential Regulation Authority |
| ARC | Australian Research Council |
| ARCCSS | Australian Research Council's Centre of Excellence for Climate System Science (closed in 2018) |
| ARC CLEX | Australian Research Council's Centre of Excellence for Climate Extreme |
| Argo | A global array of profiling floats operated by over 25 nations under the United Nations' World Meteorological Organisation and the International Oceans Commission. Argo Australia is a major contributor, funded partially by the Integrated Marine Observing System and partner programs such as the ACE CRC, Bureau of Meteorology and CSIRO. www.argo.net ; www.imos.org.au |
| ASIC | Australian Securities and Investments Commission |
| AWRA | Australian Water Resources Assessment (model) |
| BIOS | Fine-spatial-resolution (0.05 degree) offline modelling environment for Australia, in which predictions of CABLE are constrained by multiple observation types |
| BoM | Bureau of Meteorology |
| CABLE | Community Atmosphere Biosphere Land Exchange model |
| CAPRICORN | Clouds, Aerosols, Precipitation Radiation & Atmospheric Composition over the Southern Ocean |
| C&KB Strategy | Communication and Knowledge Brokering Strategy |
| CAUL | Clean Air and Urban Landscapes Hub |
| CCiA | Climate Change in Australia website (climatechangeinaustralia.gov.au) |
| CCAM | Cubic Conformal Atmospheric Model (a CSIRO global model that can 'zoom' to high resolution over regions of interest – used to generate downscaled climate projections) |
| CCHDO | CLIVAR and Carbon Hydrographic Data Office – funded by the US National Science Foundation and operated by the Scripps Institution of Oceanography. CCHDO is the data curator, repository and distribution point for the global GOSHIP program. |
| CFT | Climate Futures for Tasmania |
| CLI | Chief Lead Investigator |
| CORDEX | CO-ordinated Regional Downscaling EXperiment |
| CMIP5, CMIP6 | Coupled Model Intercomparison Project 5 and 6 |
| CMOR | Climate Model Output Rewriter |

| | |
|-----------|--|
| CSIRO DAP | CSIRO's Data Access Portal – access to publically available, catalogued and DO I'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 |
| ICA | Insurance Council of Australia |
| IGCC | Investor Group on Climate Change |
| IMOS | Integrated Marine Observing System – funded by Australia's National Collaborative Research Infrastructure Strategy. IMOS provides partial support for key climate ocean observing systems such as Argo, moored series, some carbon measurements. |
| IPCC | Intergovernmental Panel on Climate Change |
| LSAVs | large-scale atmospheric variables |
| M&E | monitoring and evaluation |
| MCV | Managing Climate Variability research and development program |
| MDBA | Murray Darling Basin Authority |
| MHW | marine heat waves |
| MOM | Modular Ocean Model (MOM), developed by NOAA GFDL (see below) and is part of the ACCESS system. |
| 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 (closed) |
| NESP | National Environmental Science Program |
| NOAA | US National Oceans and Atmosphere Administration. NOAA spans operational forecasting and research services across fisheries, weather, oceans and climate. |

| | |
|------------------------------------|---|
| | NOAA's many laboratories and arms operate substantial parts of the global climate and ocean observing system and modelling centres. |
| NOAA GFDL | NOAA Geophysical Fluid Dynamics Laboratory – a key partner in ACCESS as the developer of the ocean model used, the Modular Ocean Model (MOM). |
| NRM | natural resources management |
| OTE | ocean temperature extremes |
| PACCSAP | Pacific-Australia Climate Change Science and Adaptation Planning Program |
| PEGS | process evaluation groups |
| POP | Populations Order Physiology (a stand-alone tree demography and landscape structure module for Earth system models) |
| PCCSP | Pacific Climate Change Science Program |
| RCP | representative concentration pathways |
| RPV1, RPV2, RPV3, RPV4, RPV5 | Research Plan Versions 1, 2, 3, 4 and 5 |
| SAM | Southern Annular Mode |
| SCU | Southern Cross University |
| SEACI | South Eastern Australia Climate Initiative |
| SOCRATES | Southern Ocean Clouds Radiation Aerosol Transport Experimental Study |
| TC | tropical cyclones |
| TERN | Terrestrial Ecosystem Research Network |
| TRMM | Tropical Rainfall Measurement Mission |
| UM | Unified Model |
| UoM | University of Melbourne |
| UNFCCC | United Nations Framework Convention on Climate Change |
| WCRP | World Climate Research Program |

Attachment A: Research projects under RPV5

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 for used by national and international researchers. Simulations from CMIP5, the fifth phase of this project, underpinned the Intergovernmental Panel on Climate Change's fifth assessment report. Ensuring Australian global climate simulations are included in IPCC assessment reports gives Australian research and modelling profile and credibility among the international research community. The next phase of CMIP, CMIP6, features new scenarios and revised experiments to keep pace with advances in climate modelling and our understanding of the climate system.

Given its importance to Australia's climate preparedness and resilience, Australia's national model, the Australian Community Climate and Earth System Simulator (ACCESS) needs to be an internationally benchmarked, world-class climate modelling capability that is more accurate than other global climate models for the Australasian and Southern Hemisphere region.

This project is updating 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 (AR6), which will provide governments around the world with objective, scientific information on climate change, its likely impacts and mitigation strategies.

Expected outputs and outcomes

Participation in CMIP6:

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 the IPCC AR6, giving Australia profile, status and credibility among the international community, and raising 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.

The capability and model improvements generated in this project are directly transferable to 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, ENSO) 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.

This project is 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. Climate models will be used to examine how these factors change as the global climate changes.

This analysis will provide greater clarity on what causes extreme events, it will identify trends and variation in large-scale climate features and extreme events and determine 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 outputs and 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 information will help decision makers (e.g. local, state and federal governments, water managers, NRM groups, Indigenous groups, infrastructure planning, public health and coastal planners etc.) 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 | | Neil Holbrook, neil.holbrook@utas.edu.au (03 6226 2027) | | |

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.

The marine, agriculture, energy and water sectors have expressed a growing need for multi-year to decadal climate forecasts that enable strategic planning over this time frame to account for climate variability and extremes. However forecasts over this timescale is a current research gap in Australia. Research under this project will improve understanding of the predictability of ocean temperature extremes over multi-year to decadal timescale. It will also examine 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 outputs and 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.

This project uses 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 outputs and 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. As an outcome of this project, 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.

Although ACCESS has been identified as one of the best models in international Intercomparison projects (i.e. CMIP5), pervasive and well-identified issues shared by all climate models remain. These issues and uncertainties reduce the confidence that can be placed on predictions and projections derived from model results.

This project is 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 more accurate multi-year to multi-decadal projections, as well as enabling better forecasting on daily through to seasonal time scales. The project will focus on improving the utilisation of ACCESS for three key aspects of relevance to Australian climate:

- biases in cloud and precipitation in the tropical Indo-Pacific region
- biases in cloud, surface radiation and ocean surface temperature over the Southern Ocean
- uncertainty in the ‘climate sensitivity’ – the surface temperature response per unit of increase in atmospheric carbon dioxide

Expected outputs and 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. A key outcome from this project is a national preparedness that enables Australia to better manage weather and climate impacts, including future risks and opportunities; saving lives, resources and money.

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 developments 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. However there are a few areas where uncertainties exist, data are inadequate for impact assessments and update of projections information has been limited

This project is developing improved climate products and services for stakeholders, so they can readily access the information they need for adaptation and other climate related activities. 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 to access climate change information that is already available.

Expected outputs and 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.

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

The project will develop consistent, current state of science projections for an extended range of hydroclimate metrics and b) undertake activities to demonstrate how such information can be used to inform water resource planning and management, and to ensure that knowledge products developed are relevant and useable.

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 outputs and 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 the 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 farmers to prepare for drought and other risks³. The Bureau of Meteorology is also 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 | | 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.

This project is 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 outputs and 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 outputs 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 (02 6281 8238) | | |

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).

This project is 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 outputs and outcomes

Research under 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, 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.

Our work tracking Australian and global carbon budgets and monitoring carbon budgets against agreed global targets will provide vital information to support the Australian Government in developing policies and actions to achieve 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.

This project is 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 outputs and 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.

Under this project the National Centre for Coasts and Climate (NCCC) has been established at the University of Melbourne to work with stakeholders to identify the best ways of addressing climate change impacts in Australian coastal ecosystems. 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 trialing 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 outputs and outcomes

The creation of NCCC will provide increased capability in delivering practical science to identify feasible on-ground 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

Project 5.1 – ACCESS evaluation and application

Project overview

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

Australia's national climate model (ACCESS) has been developed to provide us with a global climate and Earth system modelling capability, uniquely focusing on Australia and the Southern Hemisphere. This is important because most other global climate models are developed by Northern Hemisphere countries with a main focus on their own regions. ACCESS can also be used for various climate applications, including estimating the individual and combined effects of different external forcings (i.e. changes in greenhouse gas concentrations and land use) on past, present and future climate variations.

In this project, different versions of ACCESS will be used to estimate the climate change signals associated with greenhouse gas and land use changes using ensemble simulations. The ACCESS simulations, combined with multi-decadal simulations from a higher-resolution ACCESS atmospheric model, will be used to perform additional CMIP6 scenario simulations and will directly support other Hub projects under RPV5 by providing means to reduce the effect of internal climate variability to improve climate change estimates.

Expected outputs and outcomes

Climate models are indispensable for understanding and predicting climate variability; they are also the only tools available for projecting any future climate changes in response to external forcings.

This project will deliver enhanced usability of ACCESS through model improvements and ensemble simulations by different versions of the model, which will underpin science activities across all Hub research areas through reduced uncertainties of Australia's climate variability and change, including land carbon budget in a warming world. ACCESS ensemble simulations produced under this project will underpin the research of other projects aiming to develop climate information and products for managers and policy makers.

Efforts to enhance the usability of ACCESS will contribute to:

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

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

Project overview

| Project details | | | | |
|-----------------------------|------------|---|---------------|----------|
| Length | Start date | End date | Approval date | Status |
| 18 months | 01/07/2019 | 31/12/2020 | 12/2018 | Approved |
| Lead research organisations | | Project leader | | |
| Bureau of Meteorology | | Pandora Hope, pandora.hope@bom.gov.au (03 9669 4774) | | |

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

The project will utilise the latest available observations and model outputs, as well as our own model simulations to better understand large-scale variability (such as temperature fluctuations in the Pacific and Indian Ocean) and their impacts on Australia (through, for example, droughts or flooding in various agricultural regions). The project will investigate processes occurring on global and regional Australian scales.

Australian scientists are leaders in research on event attribution science, in which climate models are used to determine the naturally occurring or human influence on climate processes leading to individual extreme events. Under this project, we will further extend the science of event attribution, including a near real-time attribution system, to better distinguish between natural variability and climate change signals relevant to extreme multi-day events.

Expected outputs and outcomes

The project will provide tailored data, information and associated technical advice relevant over multiple time and spatial scales to next and end users on the impacts of climate variability and change in Australia. It will:

- provide greater scientific understanding of the dynamics and impacts of Australia's climate drivers, leading to better informed guidance of near and long-term planning for managers of natural, agricultural and water resources, as well as adaptation planning and disaster risk management.
- provide updated information on the impact of global warming on both ENSO and ENSO's influence on Australian climate, using the latest generation of climate models, including ACCESS.
- develop enhanced understanding and applications of attribution science to help guide resource managers plan for short and long term changes.

Project 5.3 – Regional climate change projections science and delivery

Project overview

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

To make evidence-based decisions about climate change and to manage climate risks, Australia needs access to credible, up-to-date and relevant information on future climate change. This project will enhance the functionality of the current suite of national climate change projections (delivered through the *Climate Change in Australia* website) to improve the accessibility and scope of the projections for existing next- and end-users of climate projections in several key fields. The project will also allow new and emerging users (e.g. the finance sector) to better integrate climate projections into their area of interest through the provision of guidance, training and tailored information and datasets to meet their specific needs. In addition, the project will build the underpinning projection science and modelling to support and build towards the future major release of new national climate change projections (noting that no new high resolution projections will be produced under this project), setting up future and ongoing success in this arena.

Expected outputs and outcomes

Current and future decisions in sectors such as infrastructure, energy, water, food security, finance, insurance, national security and environmental management need information on future changes to our climate. Each sector will have specific needs, so it is not a case of 'one size fits all'. New products and services need to address these barriers, improve relevance for stakeholders and enable better decisions.

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

The three main anticipated outcomes are:

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

Project 5.4 – Water futures under climate change

Project overview

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

Robust projections of surface water are needed for impact assessment and developing adaptation options in the water and related sectors. Australian hydrology is different to other regions of the world, with a low runoff coefficient, high spatial and temporal variability, and strong ENSO teleconnections. This project will develop a framework that integrates climate and hydrological science and modelling to deliver the next generation of national projections of key surface water metrics. The project will also work with state government and federal authority agencies to demonstrate application of water projections to assess impact and adaptation options in water resources management. The project will build on outputs from ESCC Hub research and other hydroclimate initiatives in Australia and elsewhere.

Expected outputs and outcomes

Land and water resources influence people, agriculture, industry, mining, environment, and others. 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. 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 efforts to develop Northern Australia.

The project will engage with stakeholders and conduct outreach activities aimed at encouraging next-users to integrated hydroclimate projections capability and knowledge within related environmental research in Australia. In partnership with Project 5.3, this project will develop a framework that integrates climate and hydrological science and modelling to deliver the next generation water projections, as part of the broader next generation of the next suite of national climate change projections.

The project will enhance targeted stakeholders' understanding about hydroclimate projections science through direct partnerships with stakeholders (particularly the Murray Darling Basin Authority and the WA Department of Water and Environmental Regulation) to ensure the framework and the knowledge produced under this project are accessible, understood and directly adopted by the stakeholders. It is envisaged that over the long-term, this demonstration of how to apply climate change projections to assess impact and adaptation options in water resources management under a changing climate will contribute to a change of practice among relevant stakeholders.

Project 5.5 – Extreme weather hazards in a changing climate

Project overview

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

Many of the earliest and most significant effects of a changing climate are experienced through changes in hazardous weather events. However there are considerable scientific knowledge gaps around this, with a clear need for enhanced guidance and services to enable effective evidence-based planning. This project will deliver nationally significant knowledge products on natural hazards for the current climate as well as based on future climate projections. In particular, it will address identified needs around four key types of hazards: tropical cyclone hazards; bushfire hazards; east coast lows hazards; and thunderstorm hazards. To enable the translation of science into effective evidence-based policy, a range of targeted communication tools and research synthesis products will be developed through direct consultation with stakeholder networks.

Expected outputs and outcomes

The costs associated with extreme weather hazards and disasters are likely to change in the future. Building climate resilience and adaptation strategies, and also understanding the importance of mitigation, requires us to know more about how extreme weather hazards will change in the future. This requires improved knowledge of past changes, as well as better methods for projecting future changes. Key tools for assessing these events are observations, climate models and statistical approaches, however, these all have limitations. In addition, although considerable previous research exists on natural hazards, the key physical mechanisms and drivers are not well-understood in some cases. Consequently, research and subsequent science translation activities are needed to improve our understanding of the current climate and future changes in extreme weather hazards and disaster risk.

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

This project addresses the need for robust and informed science-based decision making in relation to the influence of climate change on extreme weather hazards. The knowledge products delivered by the project will address identified stakeholder needs around actionable intelligence for national and regional integrated risk assessments, as well as understanding disaster risk in a changing climate.

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

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

Project overview

| Project details | | | | |
|-----------------------------|------------|---|---------------|----------|
| Length | Start date | End date | Approval date | Status |
| 18 months | 01/07/2019 | 31/12/2020 | 12/2018 | Approved |
| Lead research organisations | | Project leader | | |
| CSIRO | | Pep Canadell, pep.canadell@csiro.au (02 6281 8238) | | |

The Paris Agreement requires the assessment and tracking towards achieving a balance 'between anthropogenic emissions by sources and removals by sinks of greenhouse gases', consistent with the well below 2°C target. While climate change policies seek to manage the net emissions of greenhouse gases, large uncertainties remain on how the full carbon budget can be best managed to reduce emissions, increase carbon sinks and protect existing carbon stock.

This project will estimate the net carbon balance (carbon budget) of Australia and support the development of an improved global carbon budget including both anthropogenic and natural carbon fluxes. The products developed under this project will support the policy call to better estimate and track the path towards zero net greenhouse gas emissions. The project will also provide projections of how Australia's carbon budget may change under a range of climate and land-use scenarios. The projections will be consistent with the Australian National Outlook integrated assessment modelling for Australia.

Expected outputs and outcomes

Both anthropogenic and natural fluxes in greenhouse gasses in the atmosphere impact our ability to limit global warming and head towards zero net emissions (or greenhouse gas neutrality). However there are no established global and national approaches on how to assess progress towards the requirement of greenhouse gas neutrality in light of changing climate, atmospheric composition and land use/cover.

To address this lack of information, the project will:

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

The information and products from this project will enable stakeholders to explore the most impactful mitigation policies to reduce emissions and enhance sinks, thereby improving mitigation outcomes. The new carbon budget assessment will also contribute to the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (Working Group I).

Project 5.7 – Tracking ocean change: ocean observations and models

Project overview

| Project details | | | | |
|-----------------------------|------------|--|---------------|----------|
| Length | Start date | End date | Approval date | Status |
| 18 months | 01/07/2019 | 31/12/2020 | 12/2018 | Approved |
| Lead research organisations | | Project leader | | |
| CSIRO | | Steve Rintoul, steve.rintoul@csiro.au (03 6232 5393) | | |

Changes in ocean heat and salinity affect the modes of climate variability that dominate Australia's climate and impact on the frequency and magnitude of extreme events. To assess how the oceans impact Australia's climate, we need to understand how and why the oceans are changing and how we can better project future changes.

This project will improve and deliver high quality ocean data which are vital for assessing ocean change. Ocean observations and model experiments will be used to track and understand ocean changes, and to identify the key mechanisms of ocean heat uptake. Insights gained will be used to improve the representation of heat uptake in ACCESS and other climate models, thereby improving climate change projections.

Expected outputs and outcomes

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

- increasing accessibility and quality control of ocean data streams for use by the Australian and international research community
- using analyses of ocean observations and model experiments to identify the key mechanisms regulating ocean uptake of heat and freshwater, thereby advancing scientific understanding of the ocean's role in the global energy and water budgets.
- enhancing performance of Australia's national climate model ACCESS and other climate models by improving the representation of ocean heat and freshwater uptake

This project provides critical underpinning science, and will deliver to a number of next user - high quality, accessible ocean data sets to be used by researchers around the world studying climate change and its impacts, and model improvements will be delivered to developers of ACCESS and international climate models. In turn, climate projections incorporating these improvements will be more reliable and relevant and therefore of more utility to decision-makers in government, industry and the community. Our research has the potential to help guide development of climate policy through assessments of ocean change (e.g. IPCC) and as a result of improved climate projections that better represent key ocean climate processes.

Project 5.8 – Marine and coastal climate services for extremes information

Project overview

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

Australia is a coastal nation. Changes in coastal climate, via sea-level, waves and coastal extremes (including marine heatwaves) have broad implications for a range of coastal stakeholders, such as marine and coastal industry, coastal infrastructure design and management, coastal environmental management and insurance.

This project will investigate and analyse a range of coastal and near-shore variables, such as sea level trends, current and future marine heat waves, extreme sea level, waves, estimates of ocean mass increases and the effects of wind, waves, sea level rise and storm surge on sediment compartments. The project will work closely with stakeholders to ensure this research is appropriately consolidated and delivered via a readily available, co-produced range of tools and data delivery mechanisms, to facilitate better understood and managed coastal climate risks in Australia.

Expected outputs and outcomes

Research carried out in the ESCC Hub to date has advanced our knowledge on both past and projected future changes of coastal hazards. While significant uncertainties remain, particularly at regional scales, we are now in a position where sufficient information is available to deliver improved coastal climate services. This project will provide readily-available extended knowledge of coastal climate stressors to Australia's coastal stakeholders to:

- advancing scientific understanding of coastal processes to inform the 'next generation' of coastal climate projections for Australia.
- developing a suite of science-based data and information services tailored to priority needs of coastal adaptation planning decision-makers and associated communities of interest.
- facilitating uptake and application by target users of nationally consistent science-based evidence to inform decision-making on extreme coastal events for Australia

The project outputs will bridge the gap between scientific knowledge and understanding and community perceptions of the magnitude of the coastal-climate change driven problem. The overall outcome of this project will be a better informed and aware coastal population, armed with the tools and knowledge base to assess risk and improve coastal planning and management by councils, state planning authorities, coastal developers and marine and coastal industries. Together these will result in more resilient management of Australia's marine and coastal assets.

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

Project overview

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

Living shorelines have the potential to play important roles in climate mitigation and adaptation because of their ability to sequester carbon and reduce the threats of coastal erosion and flooding. Unfortunately many of these habitats have been lost or degraded throughout Australia. While restoration is a clear national priority for biodiversity conservation, there are still key uncertainties regarding the value of natural habitats for coastal protection and carbon sequestration.

This project will synthesise the outcomes of several demonstration studies in blue carbon, coastal erosion and eco-engineering research into a roadmap that identifies the next steps towards developing national guidelines for coastal habitat restoration and eco-engineering for climate mitigation and adaptation.

Expected outputs and outcomes

This project aims to address key knowledge gaps in blue carbon, coastal erosion, and eco-engineering science to improve our understanding of the roles of vegetation in coastal protection and carbon sequestration. Outcomes include:

Blue Carbon

- better understanding of the proportion of the sediment carbon at a given project location that can be accounted for.
- national guidelines of how to measure and monitor blue carbon benefits from coastal ecosystem restoration, rehabilitation and soft engineering projects.
- improved methods to measure and monitor sediment carbon sequestration in blue carbon ecosystems.

Coastal Erosion

- better understanding of how vegetation change on the coast has altered shoreline vulnerability to coastal erosion.
- more practical management interventions that can promote shoreline resilience.
- greater awareness of what is the current 'active' beach zone which can identify when an erosion event is extreme and requires management interventions.

Ecological Engineering

- better understanding of hybrid living shoreline approaches for coastal restoration and defence.
- knowledge of potential barriers for implementing living shorelines and how this changes over time.
- guidelines for coastal managers on the application of living shorelines and the creation of a road map for living shoreline implementation.

Attachment B: Target User Groups: knowledge co-production and exchange, communication and impact evaluation activities

Overview

Drawing on research information, data and products from all Hub science capability projects, the Hub will focus its knowledge co-production and exchange, communication and impact evaluation activities around six Target User Groups. The co-production and implementation of these activities will involve stakeholders, knowledge brokers and researchers.

These user groups represent a broad cross section of stakeholders who are interested in engaging with the Hub to ensure climate change science data and information informs their activities, including policy development, planning and associated decision-making; particularly in relation to assessment of physical climate change risks. The reaction of these user groups in terms of their practical application of the Hub's data and information is the means by which the Hub can evaluate path-to-impact.

While it is recognised that there are many more stakeholders and organisations who would benefit from such engagement, the Hub is limited in its resources and capacity. However, the opportunity exists to use the knowledge co-production and exchange and communication activities, methodologies and products developed in conjunction with the six Target User Groups as pilots, which can be used by other stakeholders and organisations in the future; thereby enhancing the utility, value and reach of these activities and facilitating further impact delivery for the Hub.

The Hub will work with identified stakeholders across the Target User Groups to co-develop case studies and activities which meet the needs of the stakeholder and deliver to the user group deliverables and impacts outlined below.

Federal Government Target User Group: knowledge exchange, co-production and communication activities

Aim

The Hub will deliver information and training to Federal Government stakeholders to assist with the effective incorporation of climate change science and information into government policies and activities, including climate risk assessments.

Stakeholder/end-users

- Department of the Environment and Energy (the Department)
 - Climate Adaptation Team
 - Mitigation & Climate Science Team
 - Science Partnerships Section
 - Natural Heritage Section
- Office of Northern Australia
- Home Affairs
 - National Resilience Taskforce

- Bureau of Meteorology
 - Climate Services Group
- Other NESP Hubs – TSR, NAER, MB, TWQ and CAUL

Deliverables

- Training and other capability development to enhance understanding and application/use of climate change data and information.
- Guidance and guideline materials for using climate change information for risk assessment.
- Provision of timely climate science information and communication products for incorporation into government policies, briefings and activities.
- Advice and input into strategic climate change science and adaptation policy activities.
- Globally consistent scenarios (i.e. 1.5 and 2°C worlds, hotter and drier/hotter and wetter worlds) out to 2030/2050 to inform climate risk assessments.

Impacts

- The Federal Government uses and incorporates relevant and credible climate change science and information in relevant policies, briefings and activities.
- Stakeholders are trained in the use of climate change tools and scenarios and are therefore able to provide advice across the Commonwealth on understanding, assessing and acting on climate risks.
- The Federal Government routinely factors climate change projections and associated scenarios into long-term strategic business planning in a manner consistent with the global emission targets of the Paris Agreement.
- Climate change risks and impacts are considered in the management of Australia's natural and world heritage sites.
- The Department uses the ESCC Hub as the first point of call for the provision of climate change science information and advice to ensure their activities are based on credible and accurate evidence.
- Climate change is considered as a cross-cutting issue across the National Environmental Science Program, and the ESCC Hub's climate science information and data is used by all Hubs.

State Government Target User Group: knowledge exchange, co-production and communication activities

Aim

The Hub will deliver information, guidance and training to state government stakeholders to enable the incorporation of climate change science into management policies and activities, including modelling and assessments.

Stakeholder/end-users

- Department of Environment, Land, Water and Planning (Vic)
- Department of Water and Environmental Regulation (WA)

- Tasmania Climate Change Office and selected Tasmanian industry agencies
- Office of the Environment and Heritage (NSW)

Deliverables

- Provision of climate science information and data for incorporation into state government policies, adaptation plans and activities.
- Training and other capability development to enhance understanding and application/use of climate change data and information.
- Guidance for using climate change information for risk assessment and adaptation planning.
- Globally consistent scenarios (i.e. 1.5 and 2C worlds, hotter and drier/hotter wetter worlds) out to 2030/2050 to inform assessments on various climate risk.

Impacts

- State governments use and incorporate relevant and credible climate change science and information in risk assessments and adaptation plans.
- State governments start to routinely factor climate change projections and associated scenarios into long-term strategic business planning.
- WA Government successfully incorporates climate change projections into hydrology models used to determine state water management practices and policies, and understand the impacts of climate change on farm dam and environmental flows.
- Victorian Government understands how to use dynamically downscaled data for land-use planning in local governments.
- Tasmanian Government and Tasmanian climate sensitive industries have a collective understanding of the risks posed by climate extremes, have assessed these risks and developed adaptation actions and/or strategies.
- The data, tools and guidance developed for identified state government stakeholders (Vic, WA, TAS, etc.) can be used by other state and local governments in the future, thereby extending the reach, benefit and value of these activities.

Local Government Target User Group: knowledge exchange, co-production and communication activities

Aim

The Hub will deliver local governments with relevant and useable climate change science information and data, and provide guidance and guidelines for incorporating this information into risk assessments and adaptation plans and strategies.

Stakeholders/end-users

- Hobson Bay Council
- Greater City of Geelong
- Strathbogie Shire Council

Deliverables

- Development and delivery of tools, guidelines and guidance for incorporating climate change information into risk assessments and adaptation plans and strategies.
- Training and other capability development to enhance understanding and application/use of climate change data and information.
- Provision of climate change science information and data for incorporation into policies, plans and activities.
- Globally consistent, landscape-scale scenarios out to 2030/2050 to inform climate risk assessments.

Impacts

- Local governments increase their awareness and understanding of climate change and their climate risks.
- Local governments understand how to use relevant climate change science information, data, tools and products, and have increased confidence in incorporating climate information into management and adaptation planning purposes.
- Local governments start to routinely factor climate change information, projections and scenarios into long-term strategic business planning.
- Coastal councils use the coastal hazard data platform to access and use information on projected coastal hazards and impacts for local planning.
- The data, tools and guidance developed for identified local councils can be used by other local councils in the future, thereby extending the reach, benefit and value of these activities to Australian local councils more broadly.

Government Authority Agencies Target User Group: knowledge exchange, co-production and communication activities

Aim

The Hub will deliver climate change science information and products to government authority agencies to assist with the effective incorporation of climate change science into management plans, risk assessments and operational activities.

Stakeholder/end-users

- Great Barrier Reef Marine Park Authority (GBRMPA)
- Murray–Darling Basin Authority (MDBA)
- World Heritage Sites Committees
 - Shark Bay
 - Gondwana rainforests
- AFAC (National Council for Fire and Emergency Services)

Deliverables

- Provision of timely climate change science information data and products for incorporation into management planning, policies and activities.
- Training and other capability development to enhance understanding and application/use of climate change data and information.
- Guidance for using climate change information and projections for risk assessment.
- Globally consistent scenarios (i.e. 1.5 and 2°C worlds, hotter and drier/hotter and wetter worlds) out to 2030/2050/2090 to inform assessments on various climate risks.

Impacts

- Government authority agencies and world heritage site managers use and incorporate credible climate change science and information in relevant policies, management plans and activities.
- Agencies understand the impacts a changing climate will have on their operations.
- Agencies routinely factor climate change projections and associated scenarios into long-term strategic business planning in a manner consistent with the global carbon emission targets of the Paris Agreement.
- Climate change risks and impacts are considered in the management of Australia's natural and world heritage sites.
- AFAC is provided with current and future climate change science information, data, maps and products relevant to their fire and emergency management policies, practices and industry guidance materials.

Financial Services Sector Target User Group: knowledge exchange, co-production and communication activities

Aim

The Hub will develop and deliver a preliminary suite of tailored, national level data and information products, including complementary management tools and capacity development support, for target end-users in the financial services sector to inform physical climate risk and associated decision-making.

Stakeholder/end users

- Industry: Australian Institute of Company Directors (AICD), Australian Banking Association (ABA), Insurance Council of Australia (ICA), Investor Group on Climate Change (IGCC) and ratings agencies
- Federal Government: Australian Prudential Regulation Authority (APRA), Australian Securities and Investments Commission (ASIC), Reserve Bank of Australia (RBA)
- Other private sector entities (TBA)

Deliverables

- Stakeholder needs analysis and initial framing of proposed methods and potential products (initiated in RPV4).

- Stock take of existing inventory and pending (Next Gen update) projections data and information, including ready-reckoner description of model evaluation characteristics, spatial and temporal limitations of data, and associated applications utility.
- Globally consistent, national-scale scenarios and associated multi-hazard projections data for both mean and extremes out to 2030/2050 to inform assessments of physical climate risk.
- Training and other capability development to enhance understanding and application/use of climate change data and information.
- Guidelines for using climate change information for risk assessment and documented case-study communications.

Impacts

- The financial services sector gains enhanced awareness of the availability and utility of science-based data and information, and enhanced capacity for operational applications of science-based climate change services for informing climate risk.
- The financial services sector begins to routinely access and apply science-based information as part of new/enhanced methods/frameworks to mainstream assessment and management of physical climate change risk in a transparent and rigorous manner consistent with requisite standards of corporate governance, regulatory obligations and best available science.
- The financial services sector begins to meet the expectations of government stakeholders by being seen to be pro-active in managing science-based climate change risk in a manner which is fiscally responsible and in the best interests of the Australian population and economy.
- The financial services sector actively engages with the Australian climate change science community in support of developing and applying new scientific knowledge to better inform decisions to mitigate new and emerging risks from a changing climate.
- The financial services sector starts to routinely factor climate change projections and associated scenarios into long-term strategic business planning in a manner consistent with the global emission targets of the Paris Agreement and associated science data and information.
- Other sectors of government and industry with related institutional exposure to physical climate impacts leverage off the learnings/experience of the financial services sector to enhance risk management-based governance arrangements (i.e. sectoral transferability/utility and scalability).

Indigenous Communities Target User Group: knowledge exchange, co-production and communication activities

Aim

The Hub will engage in a mutually beneficial two-way dialogue with Indigenous stakeholders to explore ways traditional knowledge can inform Hub research and determine what climate change information Indigenous communities need.

Stakeholder/end users

- Yorta Yorta Nation Aboriginal Corporation
- Kimberley Land Council
- Seed
- Torres Strait Regional Authority
- Tiwi Islands Land Council
- Mackay Traditional Owners

Deliverables

- Assessment of Indigenous climate change science information needs resulting from the RPV4 National Indigenous Workshop.
- Training and other capability development to enhance understanding and application/use of climate change data and information.
- Provision of relevant and accessible climate change science information.
- Two-way knowledge sharing.

Impacts

- Established ongoing relationships between the Indigenous communities and the Australian climate change science community and NESP program.
- Western and Indigenous science knowledge is combined to understand the climate risks relevant to Indigenous communities.
- Indigenous researchers and stakeholders are empowered to lead research and knowledge exchange activities and case studies relevant to their communities.
- Indigenous communities use tailored climate change information to train and inform their own communities about the changing climate and the potential impacts to their country and people.
- The Australian climate change science community values and incorporates traditional knowledge in climate change information and research.