The Australian Climate Change Science Programme (ACCSP):

A review of the value, impact and lessons learned

FINAL REPORT 11 November 2016

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Executive Summary

The Australian Climate Change Science Programme (ACCSP) was the Australian Government's longest standing climate change science programme, having run continuously from 1989 to 2016.

Key objectives of this ACCSP review were to: 1. assess the value and impact of the ACCSP specifically during the last three years and more broadly the overall life of the programme; and 2. identify key learnings for informing future climate change science research in Australia.

The reviewers contacted 71 stakeholders, with a 66% response rate: mainly Australian research organisations and universities, as well as representatives from the water industry, communication, NGOs, US research, local, state, federal and UK government. Also reviewed were annual reports; quarterly reports; Greenhouse conference summaries; findings of the final ACCSP workshop; a database of 660 peer-reviewed and other publications by ACCSP staff from 2010 to 2015; and past ACCSP reviews by Solomon/Steffen and Green/McCrea.

The review noted a number of science highlights, including the development of the Australian Community Climate and Earth-System Simulator (ACCESS), the production and dissemination of climate projections, tracking the global carbon budget and sea-level rise, monitoring the southern hemisphere's atmosphere, land and oceans, and providing far greater understanding of the drivers of Australian climate variability and change. The ACCSP delivered, or assisted in the delivery of:

- policy-relevant and practical outputs according to stated objectives and government-identified priorities, evolving with new science capability and new challenges;
- science of quality and efficiency;
- seed-funding for the upgrade to critical core climate modelling capability for Australia, undertaken by the Bureau of Meteorology and CSIRO (ACCESS);
- climate change projections for Australia, used in a wide range of applications, disseminated via a website (http://www.climatechangeinaustralia.gov.au) in collaboration with Natural Resource Management (NRM);
- Australian-relevant climate information that would not have been otherwise available;
- basic underpinning programme funding that enabled greater continuity than could have been achieved through short-term grants alone (e.g. ARC grants);
- national climate change research coordination that assisted Australia to address its research challenges, and to leverage off and contribute to international science;
- Australian climate science capability supporting our national interest in the region, locally (e.g. the South Eastern Australian Climate Initiative (SEACI) and the Indian Ocean Climate Initiative (IOCI)), and internationally (e.g., the Pacific-Australia Climate Change Science and Adaptation Planning (PACCSAP) programme);

- new understanding of the Earth system, the Southern Hemisphere climate, and the drivers of Australian climate variability and change;
- some targeted support to new and continued long-term climate data archives and records, particularly globally critical, continuous, long-term greenhouse gas monitoring records and ice core records;
- important strategic capability and credibility in international collaborations, such as the Intergovernmental Panel on Climate Change (IPCC); and
- communication activities, such as GREENHOUSE conferences linking researchers with stakeholder groups and the wider community.

However, some impediments to impact were identified, including:

- limited funding through short funding cycles (especially in the final years);
- the ACCSP was viewed by some as being difficult to participate in, with funding available to only limited research areas;
- limited focus on end users and stakeholder engagement;
- lack of public profile;
- climate science understanding and climate risks did not adequately inform funding decisions; and
- reductions in funding during the latter years, which have been exacerbated by further recent cuts to climate research funding, jeopardising Australia's core climate science capability.

The review team identified the following lessons:

- need for a world-class, well-funded, nationally co-ordinated Australian research and outreach effort in climate science;
- the ACCSP laid a solid foundation on which the NESP ESCC Hub and other programmes can build, but only if they are adequately resourced;
- tackling the highest priority climate science questions for Australia, and maintaining an appropriate overall national effort, must continue to be well-planned and appropriately resourced;
- future research needs to be centred around climate-related risk and around outstanding questions regarding Australian climate;
- outreach activities need support to effectively service national and stakeholder information needs; and
- the continuity, ongoing government support across many political cycles, and (mostly) stable funding contributed to the obvious scientific successes of ACCSP. It is noted that such funding continuity is essential to address a scientific problem with the complexity of climate change, compared with other single-solution-type problems.

In order to gain benefit from the ACCSP that the Australian community is reasonably entitled to expect from their investment in ACCSP, and to continue the research and outreach effort, this review identified the following important recommendations for ongoing needs, which are explained in more detail in the body of the report:

- an integrated research programme that continues to build on ACCSP and responds to evolving needs;

- ongoing data security and integrity (including preservation, quality control and a strengthened national data management policy);
- support for international engagement, as previous reviews also strongly emphasised (including to avoid the risk of reduced strategic negotiating capability);
- continue and broaden support to community information need, including a user-services framework for a community climate model;
- underpin Australia's research strength by maintaining a core national research capability; and
- ensure benefit to the broad community from ACCSP research outputs (as well as ensuring the community benefit continues as NESP delivers new/improved information) by, inter alia, developing a fully integrated, operational, climate services capability for Australia.

Overall, the ACCSP has left a legacy of improved understanding of the climate system and future climate. It has provided Australia's core climate change science capability over many years and has facilitated increased awareness of climate change, and provided information to reduce the costs of climate change impacts.

Analysis

Australia's variable climate and plans for growth require capability to provide an understanding of future climate change. Under the Australian Climate Change Science Programme (ACCSP), Australian climate scientists have developed expertise to provide high quality climate modelling, projections, monitoring and analysis relevant to the region, and the ability to deliver it to policymakers and other stakeholders using a combination of communication tools.

Australian Government funding specifically for research into climate change was allocated in 1989, leading to the ACCSP, a collaboration between the Australian Department of the Environment and Energy (and its predecessors), CSIRO and the Bureau of Meteorology (who provided co-investment from their appropriations budgets). The ACCSP, and the continuity it has provided, has underpinned Australia's climate research effort and improved the understanding of the causes, nature, timing and consequences of climate change.

Building on previous reviews of the ACCSP, this report finds the programme set in place observations and modelling capabilities, scientific strength, a management structure and other processes to deliver a successful science programme in support of the national interest. Over its 27 years, ACCSP produced research findings and output of national relevance and importance, with particular focus in recent years on key users.

Key achievements and deliverables

The programme has provided a number of science highlights, including the development of the weather, coupled-climate and Earth-system model known as the Australian Community Climate and Earth-System Simulator (ACCESS), the production and dissemination of climate projections, tracking the global carbon budget and sea-level rise, monitoring the southern hemisphere's atmosphere, land and oceans, and providing key understanding of the drivers of Australian climate variability and change. Specifically, the ACCSP delivered, or assisted in the delivery of:

- policy-relevant and practical outputs according to stated objectives and government-identified priorities, and evolving as science capability evolved and new challenges arose;
- science of a quality and efficiency standard comparable with other, similarly funded, developed nations;
- seed-funding for the upgrade to critical core climate modelling capability for Australia, undertaken by the Bureau of Meteorology and CSIRO (ACCESS);
- new climate change projections for Australia, which have been used in a wide range of applications, and disseminated via a comprehensive website (http://www.climatechangeinaustralia.gov.au) in collaboration with the Natural Resource Management community;
- Australian-relevant climate information that would not have been otherwise available;

- basic underpinning programme funding that enabled greater continuity than could have been achieved through short-term grants alone (such as ARC grants);
- national climate change research coordination and strategic planning that assisted Australia to address its particular research challenges, and to leverage off and contribute to international science;
- Australian climate science capability in the Southern Hemisphere continuing to support our national interest in the region, locally in support of the South Eastern Australian Climate Initiative (SEACI) and the Indian Ocean Climate Initiative (IOCI), and internationally in support of the Pacific-Australia Climate Change Science and Adaptation Planning (PACCSAP) programme;
- new understanding of the Earth system, the Southern Hemisphere climate, and the drivers of Australian climate variability and change;
- some targeted support to new and continued long-term climate data archives and records, particularly globally critical, continuous, long-term greenhouse gas monitoring records and ice cores that have increased scientific understanding of the changing climate;
- important strategic capability and credibility in international collaborations, such as the Intergovernmental Panel on Climate Change (IPCC); and
- communication activities, such as biennial Greenhouse conferences at different locations around Australia to discuss latest results and issues and to link researchers with stakeholder groups and the wider community.

Despite its many successes the extent of the programme was limited by the relatively modest level of funding. Reductions in funding during the latter years of the programme, which have been exacerbated by further recent cuts to climate research funding, is jeopardising Australia's core climate science capability. Unless restored, this will result in a severely diminished ability to deliver climate science in the national and international interest.

There were some impediments to impact, including limited funding through short funding cycles and (especially in the final years) not enough resources for communication of results to government, end-users, and the general public. It was commented on by stakeholders interviewed for this review that funding was available only to CSIRO and Bureau researchers. It should be noted that the university sector had access to funding (such as through ARC grants) not open to the agencies, and that ACCSP was not designed to meet the needs of all research communities, however the different funding mechanisms probably contributed to a lack of co-ordination across the Australian climate change science community.

Furthermore, the ACCSP was viewed by some as being difficult to participate in, with funding available to only limited research areas. However, limited funding necessarily limited the scope of research that could be undertaken within the programme. Also, it was sometimes unclear to the outside community what activities conducted by CSIRO and the Bureau were part of the ACCSP, and what were part of other operations and activities in these organisations. Until the advent of the Australian Research Council Centre of Excellence for Climate System Science

(ARCCSS) and the National Climate Change Adaptation Research Facility (NCCARF), collaboration with university researchers was also an area that could have been improved.

However, it is clear that the ACCSP made a significant contribution to climate science for the amount of annual funding it received. Furthermore, it provided leverage to enhance other climate research programmes such as SEACI, NCCARF and Cooperative Research Centres (CRCs). That is, the existing capability provided by ACCSP permitted large and complex climate change programmes, such as PACCSAP, to be rapidly spun up.

The ACCSP also provided the core climate change research capability for Australia, enabling extensive international collaboration, such as through the involvement of Australian scientists in key roles of the IPCC and on international panels and committees.

Overall the ACCSP has left a legacy of improved understanding of the climate system and future climate. It has provided Australia's core climate change science capability over many years and has facilitated increased awareness of climate change, and provided information to reduce the costs of climate change impacts.

> *ACCSP has been instrumental in the level of understanding of Australian climate change that currently exists. This is no mean feat. There are only a few other countries with a similar level of understanding of their own climate.*
> Susan Solomon, MIT

Key characteristics of success

A programme of this length, policy-relevance and obvious scientific successes provides some useful indicators of the key characteristics that underpin a successful programme of this kind. These include:

a. national coordination;
b. continuity and (mostly) stable funding – such funding continuity is essential to address a scientific problem with the complexity of climate change, compared with other single-solution-type problems;
c. building of core expertise, capability, and capacity and relationships within the research community;
d. responsiveness to national priorities;
e. periodic high quality reviews of the programme that were actively responded to;
f. global engagement;
g. focus on strategic research objectives;
h. leveraging and collaboration with other programmes and organisations; and
i. dedicated communication effort, including engagement with government and industry.

Additional features that could have improved the ACCSP and should be considered for future long-term national programs of this nature include:

j. a stronger process for peer review of funding proposals;
k. slightly greater programme flexibility and agility in response to scientific and policy developments;
l. capacity for long-term engagement with the academic sector; and
m. increased focus on the development of climate services for end-users, including those in industry, and policy-makers.

Recommendations

The following table identifies the most important needs, in order to gain benefit from the ACCSP that the Australian community are reasonably entitled to expect from their investment in ACCSP, and to continue the research and outreach effort.

Current and future research needs **(to maximise return-on-investment from ACCSP and continue research and outreach effort in climate science)** *(based on a 5-7 year timeframe)*	**Recommendation**
Research Needs	
An integrated, research programme that continues to build on ACCSP and responds to evolving needs	Continuation of research into the causes, nature and consequences of climate change in the Australian regions and Southern Hemisphere Ensure there is a balance between policy- and application-driven research and the fundamental science research that crucially underpins applications and impacts research Science components also need to strike a balance between observations and the construction and analysis of datasets, process studies and modelling Restore the overall national effort in climate change science, applications, impacts, adaptation and services to at least the level between 2005 and 2015 in real terms with annual Consumer Price Index adjustments
Ongoing data security and integrity needs	Preserve and quality control ACCSP-related climate observations and archives and continue the key monitoring programs that have underpinned ACCSP and wider applied and adaptation research. This requires a modest targeted funding increase for integrated atmosphere, water, oceans data sets and management
	Build on past clear calls for a strengthened national data management policy to ensure ongoing security of climate-related archives and data, and improve delineation of data management and services as an operational rather than

	research responsibility
Mechanisms to support the national interest	
	Strategic engagement of end-users to improve guidance of research direction, increase uptake of results, and improve impact
Support international engagement as previous reviews have strongly emphasised (including to avoid the risk of reduced strategic negotiating capability)	Improved cross community collaboration nationally, and enhanced engagement internationally, on collaborative research, IPCC and UNFCCC work As ACCSP is replaced with the National Environmental Science Programme (NESP) Earth Systems and Climate Change (ESCC) Hub, review/revise peak national coordination mechanisms, to maximise benefit from ACCSP/NESP, ARCCSS, NCCARF, State activities and involvement in WCRP, Future Earth and other key international research programs, as well as continuing our strategic R&D support in the Pacific region
Collaboration and Linkages.	
Continue and broaden support to community information need	Improve the mechanisms to make ACCESS a true community model for Australia, by developing a user-services framework for a community model. This is a key task for revitalised peak national leadership structure
Underpin Australia's research strength	Ensure there is a clear development path for early career scientists and incentives to retain world leading experts that are in high demand in a competitive global market, in order to maintain a core national research capability
Services, communications, outreach from the ACCSP, CSIRO, Bureau of Meteorology knowledge base	
Ensure benefit to broad community from ACCSP research outputs (as well as ensuring they continue as NESP delivers new/improved information)	Develop a funded, targeted, service oriented module for ACCESS community model support – help-desk and services website Work towards a fully integrated, operational, climate services capability for Australia.
	Operationalise the services associated with the Climate Change in Australia website, to relieve time pressures on top-level CSIRO research scientists, and enhance operational climate services. Fund a help desk and information services unit in an operational agency such as the Bureau of Meteorology.
	Upgrade resourcing of, and commitment to, communication for public awareness, government liaison, and industry advice, including continuation of the Greenhouse conferences

Australia's climate science needs

Australia's climate presents special opportunities and unique challenges for innovation and sustainability – including distance, droughts and flooding rains, the future of our coasts, environmental sustainability and protection of key ecological assets (e.g. the Great Barrier Reef), the potential for development of a food-bowl in northern Australia, realising the massive renewable energy potential, sourcing water

for agriculture-people-industry-environment, and liveable cities in challenging landscapes, as well as managing economic and energy-use transitions.

For example, Australia as a nation has a current goal of expanding its agricultural sector while making it sustainable in a continent of poor soils, variable climate and water scarcity. Australia needs to maintain and improve its scientific capabilities in climate and agriculture to manage the significant climate risks without incurring losses faced in the past (such as sheep and cattle losses, wool losses of up to one quarter of a billion dollars in today's terms, as well as huge dust storms during droughts). Understanding the Australian climate system and being able to supply Australian-relevant climate information to advise these opportunities and challenges are key requirements of public-interest science in this area.

According to Geosciences Australia, Australia has the third largest maritime jurisdiction in the world. The science of projecting sea-level rise, along with the accompanying changes in coastal waves, coastal swell and coastal storm surges has developed substantially over past two to three decades, but is ongoing. The implications for coastal communities, business continuity and companies with long supply chains influenced by climate and weather are substantial, and risks need to be updated on a regular basis.

Australia has a diversity of landscapes, oceans, climate zones and food production regions as well as important infrastructure located in tropical cyclone regions and coastal zones. It can be argued that Australian businesses want government services that deliver ongoing improvements in disaster management, urban planning and security, in support of economic activity. This requires continuation of the nation's ability to provide weather forecasts and extreme weather alerts, and also our ability to understand future extreme events and how they are likely to change. Because the ACCESS climate modelling system employs essentially the same atmosphere component for both climate prediction and weather forecasting, improvements made in this component of the climate model, particularly in 'fast' physical processes, immediately benefits our weather forecasting capability and seasonal prediction efforts, with the aim to provide a 'seamless' system of weather forecasting, seasonal prediction and climate projection for the Earth system.

Users of climate information often need to understand the nature, trend and variability (including crucial decadal variability) of climate change, and what these mean for various community activities, business domains, biodiversity, and the environment. Under the ACCSP, Australian climate scientists developed expertise to assist users and provide information relevant to the local scene, and the ability to deliver it using a combination of web-based and explanatory services.

The June 2015 White Paper on developing Northern Australia (Our North, Our Future) highlighted agricultural opportunities, as well as the challenges associated with developing northern Australia such as unpredictable weather events. Massive rainfall variability must be managed to realise these ambitions, and this requires climate research and advice tailored for stakeholders. Much-needed information on

decade-to-decade variations in climate behaviour cannot yet be provided since key science issues remain to be solved. Specialised Southern Hemisphere information will almost certainly be needed and Australia is the only country placed to do that work. Seasonal and inter-annual forecasts and longer-term climate projections produced by Australian climate experts are needed to help fulfil the above requirements. Climate modelling capability, underpinned by improvements in understanding of the key drivers of Australian climate change, kept up-to-date and leading edge, and serving a wide variety of needs, is therefore a core Australian public good activity.

Introduction

The ACCSP

The Australian Climate Change Science Programme (ACCSP) grew in response to the major environmental challenges of climate change. In 1989, the Commonwealth Government provided CSIRO and the Bureau of Meteorology funding to establish the Climate Change Research Programme. Its name changed over the years to the National Greenhouse Science Programme, to the Australian Greenhouse Science Programme, and then the ACCSP.

The ACCSP was the Australian Government's largest and longest standing climate change science programme, having run continuously from 1989 until its wind up in June 2016.

It provided climate research aimed at improving understanding of the causes, nature, timing and consequences of climate change in the Australian region and beyond.

The ACCSP received funding through a collaboration between the Australian Department of the Environment and Energy (and its predecessors) and CSIRO and the Bureau of Meteorology (who each provided matching in-house support).

The programme has varied in its amount of funding and number of researchers. Since 2007-08, ACCSP funding has ranged between about $11 million up to $19 million (including Federal Government funding, and CSIRO and Bureau of Meteorology co-investment). As an example, in 2014-15 the ACCSP received funding of approximately $11 million, involved more than 100 scientists throughout Australia who undertook 22 projects, and published 90 peer-reviewed papers or articles in Australian and international scientific journals.

During the life of ACCSP, the effort of scientists and managers across many institutions have tackled diverse climate research challenges, facilitated by the support and outputs from the ACCSP. These institutions have included the Bureau of Meteorology (seasonal climate services and climate change research), CSIRO (climate change, impacts, agriculture and adaptation, intersection between climate variability and change), ARCCSS (academia), Australian Antarctic Division, Antarctic Climate and Ecosystems Cooperative Research Centre, NCCARF and others.

The ACCSP has underpinned Australia's climate change research effort. It has provided core capabilities (including observations of carbon dioxide and the Southern Hemisphere oceans, and modelling capability such as the development of ACCESS), without which much science and applications would not have been possible. As identified below by stakeholders interviewed for this review, it has also been a facilitator in the overall national climate change research effort beyond the size of its budget. It has:

- been a catalyst for a larger effort within the participating research organisations;
- been a facilitator of collaboration among scientists from a range of institutions and disciplines;
- fed back into planning for the research effort at the national level; and
- helped to respond to policy needs for up to date, evidence based information on climate matters.

Further details on each of these major areas of contribution are provided in the sections on science highlights, value and impacts in the body of this report.

Background to the review

The ACCSP Management Committee (Rob Colman from the Bureau of Meteorology, and Helen Cleugh, Geoff Gooley and Mandy Hopkins from CSIRO) and the Department of the Environment and Energy agreed that an evaluation of the ACCSP would be beneficial in both ensuring that its value is assessed and documented, and thereby its legacy recognised. In this context, the evaluation also provides informative and timely insight for the establishment of the National Environmental Science Programme (NESP) Earth Systems and Climate Change (ESCC) Hub, which commenced in 2015 with most research projects starting in July 2016.

The purpose of the evaluation is to undertake a broad assessment of the programme, from the quality of the science delivered, to the programme's value and impact on the status of Australian climate change science, and the extent to which the ACCSP has enhanced scientific understanding and knowledge of Australian and Southern Hemisphere climate drivers and Australia's past and future climate.

Emphasis for the evaluation is on the cumulative value, impacts and learning realised more broadly over the entire 27 years of research delivered through the ACCSP and its predecessors, with a focus on the last few years. Hence the key objectives of this evaluation are to:

1. assess the value and impact of the ACCSP specifically during both the last three years and more broadly the overall life of the programme; and
2. identify key learnings for informing future climate change science research in Australia.

Over the past 27 years, our understanding of Australia's past and future climate has improved radically through the work of the ACCSP. The research is world-class and underpinned by high quality peer-reviewed literature.
Kevin Hennessy, CSIRO Oceans and Atmosphere

Methodology of the review

The ACCSP Review Oversight Committee (Rob Colman from the Bureau of Meteorology, and Helen Cleugh, Geoff Gooley and Mandy Hopkins from CSIRO, and

Dave Johnson and Sonia Bluhm from the Department of the Environment and Energy) commissioned appropriately qualified consultants on a short-term contract basis to complete the review guided by the scope, coordination and feedback of the ACCSP Programme Management Team. The consulting team was Simon Torok (Scientell Pty Ltd), David Griggs (Monash University) and Mary Voice (Cumulus Consulting).

The consulting team compiled a list of 71 stakeholders to interview, including mainly external personnel (research collaborators, end-users, and others) but also some internal staff (CSIRO, Bureau, Department). Email contact and follow up resulted in 56 replies, including 30 detailed responses to questions by email, 10 phone/skype interviews, and seven responses providing brief insight into the lack of awareness of the ACCSP. (There were eight replies declining to participate for various reasons, and 15 people did not reply.) Of the 40 detailed replies and interviews, sectors represented included mainly Australian research organisations and universities, as well as water industry representatives, consultants, communication, NGOs, US research, and local, state, federal and UK government. It is recognised that such sector representation (and, in particular, the areas of research covered) would influence the choice of topics raised by respondents, with a bias towards the opinions of those closely involved in climate research, and hence the order of reported popularity below.

In addition, the consulting team reviewed relevant documentation, including:

- past annual reports;
- quarterly traffic light reports from the past 2 years;
- past reviews of the ACCSP by Solomon/Steffen and Green/McCrea;
- Greenhouse conference summary reports;
- other documents (e.g. a PowerPoint presentation summarising the programme for the 20th celebrations)
- a report summarising the findings of the final ACCSP workshop in May 2016, which identified internal views on highlights, shortcomings, and legacies; and
- a database of 660 peer-reviewed and other publications by ACCSP staff over the 5-year annual report period from 2010/11 to 2014/15.

This 2016 review builds on two prior reviews (by Susan Solomon and Will Steffen in 2006, and Roy Green and Don McCrea in 2003), adding a focus on recent years when funding had decreased and the programme's goals and objectives were strongly driven by the 2009 *Australian Climate Change Science: A National Framework* (the National Framework) and the 2012 *A Plan for Implementing Climate Change Science in Australia* (the Implementation Plan). The focus on recent years was practical, due to a possible bias in the interview/survey responses where people naturally recall highlights of recent years more so than earlier years. However, such memories – while focussed on recent years – are likely to integrate significant highlights over the life of the programme. Furthermore, the review team focussed on documentation over recent years, with more material available electronically over the period since the 2006 review. With limited time and resources for completion of the review, the consulting team aimed to provide the Oversight Committee an overview of identified

science highlights and insights into the perceived value and impact of the programme with some recommendations for ongoing research management in the NESP ESCC Hub, rather than a detailed evaluation of the programme.

Planning, evolution, reviews and resulting progress and outputs from ACCSP

Appendix 1 explores the evolution and resulting progress of ACCSP as a result of the planning, reviews and regular reporting, including in relation to the ACCSP programme elements, or components. It summarises recommendations from past reviews, the extent to which they were adopted and/or assisted with the growth and development of ACCSP and how the work quality evolved.

It should be noted that the ACCSP's planning process was thorough and extensive (as past documentation shows, including the National Framework and Implementation Plan documents). Appendix 1 clearly shows that the planning and review process led to:

(i) a logical progression of the science programme over the lifetime of ACCSP, in response to growing science capability, evolving national need and uptake of the recommendations from the reviews (to the extent that resources allowed); and

(ii) an even stronger programme of outputs and results over the recent ten years of ACCSP, following on from both that growing science capability in Australia and from the reviews.

Australia is much better equipped than it would have been otherwise to respond appropriately to the challenge of climate change.
Penny Whetton, Honorary Research Fellow, CSIRO Oceans and Atmosphere

Two previous programme progress reviews (Green and McCrae, 2003, and Solomon and Steffen, 2006) both made relevant recommendations regarding aspects of ACCSP.

It is our judgement that a combination of internal programme expertise and the external reviews resulted in a logical progression of the research components of the ACCSP (for details see Table 1A and Table 1D).

Both reviews made recommendations for appropriate national frameworks for strategic planning and enhanced collaboration. The Australian climate science community responded to these recommendations with the National Framework, which (for reasons outside the scope of this review) has not been fully implemented. Whilst the ACCSP in effect covered a significant part of the scope laid out in the National Framework, the subsequent establishment of ARCCSS, NCCARF and more recently the NESP ESCC Hub, has reinforced the need for national coordination. It is a strong recommendation of this review that the needs laid out in the National Framework still exist but the National Framework (and the subsequent

Implementation Plan) requires updating as institutional arrangements change (as they are changing at the time of writing). See Table 1B for further detail.

Strong global scientific engagement was seen by both past reviews as essential for Australia (see Table 1B). The Australian science community, and those working for ACCSP have brought clear benefits to Australia from continuing this engagement, as seen by many of the collaborations and research outputs identified in this review and in the stakeholder interviews (see "Science Highlights", Table 1D, and elsewhere below). Large funding reductions in the move from ACCSP to the NESP ESCC Hub combined with large changes (reductions) foreshadowed in CSIRO place this engagement at risk. It is our judgement that a high degree of continuity in global engagement is sensible, and requires recognition across both academia and government that ongoing support should be provided.

It should also be noted that as funding decreased over the final few years of the programme, reporting requirements apparently stayed high. Stakeholder interviews and the internal workshop (see below) suggested that many ACCSP participants recently felt an excessive burden from the reporting requirements.

The right hand two columns of Table 1D in Appendix 1 highlights some of the key science progress that had been made under ACCSP by the end of its funding period. More information is available under "Science highlights" and "Value and impact" below. Many of the outputs are now available (in principle) for use by the Australian community, policy-makers and decision-makers. Many of the outputs require interpretation and delivery (an ongoing service task) and maintenance and improvement (an ongoing research task).

It is notable that previous ACCSP reviews recommended increases in funding to the programme in order for it to fully meet its mandate. While this initially occurred, funding had reduced in real terms over the last 8 years of the programme, apart from a one-off specific amount for additional extremes work. The new NESP ESCC Hub, which has addressed one of the weaknesses of the ACCSP by better integrating university research into the overall programme, has lower levels of funding, occurring at around the same time as foreshadowed large cuts to CSIRO's climate research effort. This leaves Australia's climate research funding at a seriously low level, even compared to the modest funding provided to the ACCSP programme, which in itself was deemed too low by the two previous independent reviews.

Timeline of atmosphere and oceans research and development in Australia

Decade	Australian research, Australian contribution, Australian services, where collaboration between agencies has been a significant factor/benefit	State of climate science/climate change science at the time	ACCSP evolution
1940s	Bureau-CSIRO collaboration on establishment and operation of the Australian ozone monitoring network (Dobson instruments).	Important early data	
1950s	1957 – National and international collaboration for the International Geophysical Year (IGY) (especially on the Antarctic meteorological programme through ANARE). 1959 – Establishment of the International Antarctic Analysis Centre (IAAC), collaboration of the Bureau with the Australian Academy of Science.		
1960s	1966 – World Weather Watch World Meteorological Centre (WMC), Melbourne, Bureau of Meteorology – international collaboration.		

	1967 – Wangara field experiments, led by CSIRO, collaboration with the Bureau and others.		1969 – CMRC (Commonwealth Meteorology Research Centre) established as a joint venture between the Bureau and CSIRO.
1970s	1971/72 – Australia considered its contribution to the Background Air Pollution Monitoring Network (BAPMoN) programme, potentially important for the whole Southern Hemisphere (Heads of CSIRO Atmospheric Physics and the Bureau collaborated on early ideas), leading to establishment of Cape Grim station. Early 1970s – Bureau-CSIRO-Navy collaboration on establishment of a sea temperature monitoring network around Australia. 1970s – Cold Fronts Research Project. 1974 – Koorin Field Project at Daly Waters (mostly CSIRO and the Bureau). 1976 – observations of background atmospheric composition commenced at Cape Grim. 1976 – International collaboration – Turnaround Ranging Station (TARS) for Japanese satellite installed in Orroral Valley (later transferred to HMAS Cerberus and	1970s: Important early gas observations 1970s: Important new observations of the oceans 1970s: New understandings of meteorological (including	1974 – CMRC changed into Australian Numerical Meteorology Research Centre (ANMRC) (1974 - 1984) CSIRO-Bureau collaboration 1975 – major symposium held at CSIRO Aspendale on geophysical monitoring for climatic change

	subsequently (1994) to Crib Point) where it was combined with Chinese TARS installed in 1991 (to help stabilise the orbit of the satellites, etc.) 1978 – Australia commenced launchings of 47 ocean buoys as part contribution to the Global Weather Experiment (collaborative efforts again) 1979 – Major collaborative Australian participation (Bureau, CSIRO, universities) in the Global Weather Experiment (GWE) also called FGGE.	climate) systems of the Southern Hemisphere, but capability to understand climate change only as global phenomenon	
1980s	Early 1980s – AMEX (Australian Monsoon Experiment) with large Australian and international [including US (NOAA, NASA and NCAR) and Chinese] participation. Early 1980s – Bureau-CSIRO (Cloud Physics) collaboration in international PEP (Precipitation Enhancement Project) studies (following earlier rainmaking experiments in the Snowy, Tasmania etc.) 1980s to early 1990s – Australia (the Bureau, CSIRO and others) contributed to international Tropical Oceans Global Atmosphere (TOGA) programme, including hosting TOGA-COARE experiment in northern	1980s: Recognition of climate change as a problem for Australia and the Southern Hemisphere	Early 1980s –ANMRC develops a two-level global atmospheric model to enabling long climatic simulations. This original two-level model evolved into a four-level model, and was brought to CSIRO in 1985 after ANMRC was disbanded in 1984. 1985 – Established BMRC within the Bureau of Meteorology 1987 – CSIRO and Australian Government's Commission for

	Australia Late 1980s/early 1990s – Australian Bureau of Meteorology commences an operational seasonal outlook service (3-months ahead guidance system) – based on models/methods developed during previous collaborations		the Future hold first Greenhouse meeting: GREENHOUSE87 1989 – Climate Change Research Programme begins
1990s	1990 – First Assessment Report by IPCC 1995 – Second Assessment Report by IPCC 1997 – Establishment of joint Bureau-CSIRO High Performance Computing and Communications Centre (HPCCC) 1990s – MCV Managing Climate Variability Programme of the rural R&D corporations, spurred some collaboration on seasonal forecasting methods, with emphasis on rural/agricultural needs	1990s – State climate change projections prepared under contract	1990 – Establishment in Aspendale of GASLAB/ICELAB 1990 –Australian contributions to the First Assessment Report of the IPCC provided by CSIRO, the Bureau and others. Contributions by ACCSP researchers continued for subsequent IPCC assessments, recognised by joint awarding to IPCC of 2007 Nobel Peace Prize. 1992 – ACCSP researchers prepared and released first suite of national climate change projections 1993 – 2000 Cooperative Research Centre for Southern Hemisphere Meteorology

			1994 – GREENHOUSE 94 held in Wellington; organised in collaboration with NIWA Mid-90s – Programme renamed National Greenhouse Science Program 1996 – ACCSP researchers prepared and released second suite of national climate change projections 1997 – Indian Ocean Climate Initiative (IOCI) commences 1998 – Release of Australia's Greenhouse Science Advisory Committee Plan for 1999-2005 1999 – Programme renamed Australian Greenhouse Science Program 1999 – 2006 Cooperative Research Centre for Greenhouse Accounting
2000s	2001 – Third Assessment Report by IPCC Late-2000s - POAMA (Predictive Ocean-Atmosphere Model for Australia), seasonal to inter-annual forecast system (based on a coupled model of the ocean and		2001 – ACCSP researchers prepared and released third suite of national climate change projections 2004 – Programme renamed

	atmosphere) for Australia and the south Pacific. 2000s – various collaborations on researching ENSO, the Indian Ocean Dipole (IOD), the Madden-Julian Oscillation (MJO), the Southern Annular Mode (SAM) and the Interdecadal Pacific Oscillation (IPO), all important drivers of inter-seasonal and seasonal climate variability in Australia 2007– Fourth Assessment Report by IPCC 2007 – Centre for Australian Weather and Climate Research (CAWCR) – collaboration between the Bureau and CSIRO		Australian Climate Change Science Programme 2005 – GREENHOUSE 2005, Melbourne 2005 – decision made by the Bureau and CSIRO to jointly develop the Australian Community Climate and Earth-System Simulator (ACCESS), with the key aim to provide world-class weather prediction and climate modelling capabilities to Australian users. 2005 – South East Australia Climate Initiative (SEACI) was established in 2005 to improve understanding of the nature and causes of climate variability and change in south-eastern Australia in order to better manage climate impacts. 2006 – Solomon and Steffen review. 'The current programme has been remarkably successful' 2007 – BMRC was disbanded to merge into the joint Centre for Australian Weather and Climate

			Research with CSIRO. ACCESS development was a central activity. 2007 – ACCSP researchers prepared and released fourth suite of national climate change projections 2007 – GREENHOUSE 2007, Sydney 2009 – GREENHOUSE 2009, Perth 2009 – Pacific Climate Change Science Programme (PCCSP) commences
2010s	2010 – Operational implementation of the ACCESS Numerical Weather Prediction systems in the Bureau 2010 – Australian Academy of Science publishes "The science of climate change: questions and answers" (scientific input by many individuals and organisations) 2011 – The ARC Centre of Excellence for Climate System Science is established, an international research consortium of five Australian universities and a suite of national and international Partner Organisations.		2011 – GREENHOUSE 2011, Cairns 2011 – Pacific-Australia Climate Change Science and Adaptation Planning programme (PACCSAP) commences 2011 – Specific extremes funding from the Department 2012 – Regional NRM Planning for Climate Change programme commenced, with funding allocated to CSIRO and the

	2007-2015 – Development of national information website for climate change: http://www.climatechangeinaustralia.gov.au. Collaboration between CSIRO, the Bureau, Department of the Environment. Other collaborations of recent decades include the CRC for Southern Hemisphere Meteorology, IOCI, BlueLink (Bureau-CSIRO-Navy) 2013 – Fifth Assessment Report by IPCC 2015 – Australian Academy of Science publishes an update to 2010 "The science of climate change: questions and answers" document 2015/16 – Cape Grim BAPS collaborative partners and researchers include: UQ, ANSTO, Stockholm, Bureau, AAD, Uni Nth Carolina, MIT, NOAA and others 2016 – Some collaborations potentially at risk from proposed changes at CSIRO.		Bureau to develop the next suite of climate change projections' Funding reductions commence from 2012. 2013 – GREENHOUSE 2013, Adelaide 2014 – Launch of RV *Investigator* 2014 – CAWCR evolves from a centre to a collaboration following a Bureau of Meteorology internal review and a re-structure at CSIRO. ACCESS development and climate change research remained part of a joint portfolio of projects between Bureau and CSIRO. 2014 – CSIRO, Bureau of Meteorology and five Universities successfully win a competitive bid to deliver the new NESP Earth Systems Hub. 2015 – Fifth suite of climate change projections for Australia produced by CSIRO and the Bureau (funded from 2012).

			Communicated via climatechangeinaustralia.gov.au 2015 – GREENHOUSE 2015, Hobart June 2016 – ACCSP concludes July 2016 – NESP ESCC Hub commences operation

ACCSP has been the premier climate change research programme in Australia for the last quarter of a century.
Peter May, Bureau of Meteorology

Science Highlights

Document review

This report builds on the two previous reviews, which have been summarised and analysed above and in Appendix 1. Appendix 1 also shows how many of the science achievements culminating at the end of the ACCSP evolved over a long period of time, partly or largely as a result of the continuity of the programme.

This report reinforces that the early phases of the programme set in place a framework, including observations and modelling capability, scientific strength and a management structure that has allowed, during the recent programme phase, for expanded scientific thinking and a much broader assessment of Australian climate variability and change and its impacts. Following on from the foundation laid by earlier programme phases, in recent years the ACCSP has produced research findings and output more directly useful to the nation and key users than previously possible (see also Appendix 1). It has also delivered more accessible information through the Climate Change in Australia web site (in association with the Regional NRM Planning for Climate Change Fund). In addition, it has also met all its research objectives and targets in an exemplary fashion. These successes owe much to the dedication of the scientists and managers involved. Thus the value of ACCSP is clear, its stakeholders recognise the value, as does the international community and our regional Pacific neighbours (e.g. through the PACCSAP programme).

Whilst the ACCSP's scientific strength and value has been aided by the programme's organisation and management, and the coordination provided across the participating agencies and responsiveness to policy needs, stakeholders identified scope for greater translation into impact through improvement in end-user engagement, and translating research results into useable information for planning and other purposes. However, the reviewers note that the ACCSP's primary focus was the underpinning climate science, required to advance our understanding of the drivers of Australian climate and how they are changing; the modelling and methodologies for evaluating models and for making climate change projections. Communication was only one component of the program. Now that ACCSP funding has ceased, these stakeholder comments demonstrate a stakeholder need to use ACCSP outputs in their work, and an ongoing need in the user community for climate change information, professional advice and services.

A review of documentation (including annual reports, past reviews, and publication records) confirms that over its lifetime, the ACCSP, while a relatively modest programme, has been an important underpinning contributor to the national effort, and an important catalyst to building new capability and creating national and international collaborations. It is clear from the survey responses and documentation that other programmes and individual scientists would not have been able to function as effectively without the ACCSP.

Publication rates in the peer reviewed literature (as evidenced by annual reports and the ACCSP reference database compiled by Stephanie Baldwin from ACCSP Annual Reports 2010/11 to 2014/15) were certainly at a level commensurate with the size of the programme, with a relatively high proportion in high impact journals such as *Nature*.

Science highlight: Greenhouse gas monitoring and understanding
Australian scientists have been monitoring greenhouse gases in the atmosphere since the early 1970s, but the advent of the ACCSP saw more funding directed to monitoring programmes and facilities, including monitoring at the Cape Grim Baseline Air Pollution Station in Tasmania and the establishment of CSIRO's world-class GASLAB/ICELAB facility in Melbourne.

Over the past 25 years the ACCSP has:
• improved our understanding of the role of the Southern Ocean in the uptake of carbon dioxide and its effect on the global carbon budget.
• taken high-precision measurements of both concentrations and isotopic ratios of atmospheric carbon dioxide over the Earth that have improved our understanding of atmospheric and oceanic transport processes.
• developed methods to calculate gas exchange at the Earth's surface that have provided a better understanding of how the atmosphere, land surface and oceans interact.

From the 2013/14 ACCSP Annual Report

Interviews and survey responses

Of 71 stakeholders contacted, the review team received 56 replies, including 30 detailed responses to questions by email, 10 phone/skype interviews, and seven responses providing brief insight into the lack of awareness of the ACCSP. The 40 detailed responses to questions are included in Appendix 2.

Overall, of the 40 replies, 70 per cent (28) were very positive, 25 per cent (10) were positive, and 5 per cent (2) were somewhat negative.

Stakeholders were asked to explicitly note the top scientific and other achievements that come to mind in relation to the ACCSP. This generated an impressive list of scientific achievements, augmented by references to other science highlights that survey respondents noted in response to other questions, such as research advances that would not have been possible without the ACCSP, and respondents' overall impression of the ACCSP. Areas of science that stood out to respondents as highlights of the programme, in order of popularity, were as follows.

These highlights identified by survey respondents are listed to provide context for further discussion of scientific highlights and value of the programme in other sections of the report.

1. The ACCSP's contribution to climate change modelling and the development of Global Climate Models was raised as a top scientific achievement by more than half (60 per cent, or 24 respondents) of the survey respondents. In particular, ACCESS was highlighted as a scientific achievement that would not have been possible without the funding, collaboration, and management structures provided through the ACCSP. Advances in understanding of the climate system resulting from the development and use of ACCESS, including impacts of climate change and how to prepare for them, have been critical for Australia. Furthermore, respondents highlighted the international role and engagement that this modelling expertise enabled Australia to benefit from (see detailed point under 'Value and Impact', below).

"What are the top scientific achievements? ACCESS, ACCESS, ACCESS."
Mark Gibbs, Queensland University of Technology

Science highlight: ACCESS
The ACCSP has supported the collection of climate data, investigation of climate processes and the development of improved climate models for Australia. The ACCSP has enabled Australia's global climate models be benchmarked internationally. ACCESS's participation in the international modelling project, CMIP5, showed it to be one of the top performing models across a range of metrics, including those of greatest relevance to climate in the Australasian region.

The culmination of the years of model improvement supported by the ACCSP has been development of the Australian Community Climate Earth-System Simulator (ACCESS), our national climate model.

ACCESS delivers climate change simulations to the Australian and international science community. International model comparisons rate ACCESS highly, particularly for its capacity to simulate Australian climate. The contributions made via ACCESS to international engagement are recouped many times over through the wealth of tools, data and knowledge obtained for the national benefit.
Modified from the 2013/14 ACCSP Annual Report

2. The climate change projections for Australia were just as notable as modelling, with this work being raised as a scientific highlight by 58 per cent (23) of the respondents. Discussion particularly noted the development over the life of the ACCSP in the detail and scientific rigour behind the projections, the improved efforts to communicate them using user-focussed tools (such as the Climate Change in Australia website, which has attracted more than 100,000 users), and the benefits to decision-making.

The 2015 report was a step change in effectiveness.
Will Steffen, Councillor, Climate Council

The 2015 climate change projections, as well as earlier ACCSP projections in 1990, 1992, 2007, have allowed for improved understanding of climate impacts, and outreach to stakeholders who need the information for decision making.
David Karoly, University of Melbourne

3. Australia's important role in monitoring the Southern Hemisphere's oceans, atmosphere, land and climate was raised by 48 per cent (19) respondents. In particular, although not all funded by ACCSP, survey respondents highlighted the role of observations of greenhouse gases at the Cape Grim Baseline Air Pollution Station and the related analyses at CSIRO's GASLAB in Aspendale, the contribution to the Argo programme of ocean observations, and the land-based measurements from OzFlux.

These were profoundly enabling programs – the basic infrastructure around observations and modelling are irreplaceable and important contributions from the ACCSP.
Andy Pitman, ARC Centre of Excellence for Climate System Science

4. The contribution to sea-level rise research was raised by 40 per cent (16) of the survey respondents as a scientific highlight of the programme. Respondents discussed the important contribution of observations of sea-level rise, projections, and understanding of the measurements and mechanisms of sea-level rise, and relative contributions from warming that put Australian science funded by the ACCSP on the world stage.

Science highlight: Understanding oceans
Prior to the ACCSP Australia did not carry out any research on the role of oceans in the climate.

Researchers have made substantial progress in understanding the behaviour of the oceans surrounding our continent and their role in the climate system. These advances have come from extensive observations from ships, moorings, drifting robotic floats and satellites, and from our ability to simulate the interactions between the atmosphere, ocean, sea ice and biogeochemistry.

Australia has also been a leader in international efforts to rigorously assess the extent to which sea level will change as the Earth warms.

From the 2013/14 ACCSP Annual Report

5. Building on point 3 (Southern Hemisphere monitoring) and point 4 (sea-level rise) above, 38 per cent (15) of the respondents also highlighted the role of ACCSP-funded research in understanding the Southern Ocean.

6. Another scientific highlight raised by 38 per cent (15) of the survey respondents was the contribution to global understanding of the carbon cycle. The leadership of

the Global Carbon Project was a particularly noteworthy aspect of the ACCSP's programme support.

7. Similar to point 3 (Southern Hemisphere monitoring) above, the contribution of the ACCSP to a Southern Hemisphere perspective on understanding climate change was raised as a scientific highlight. Eleven survey respondents (28 per cent) pointed to the importance of researchers in Australia leading the global research community in understanding how climate is and will change in the Southern Hemisphere, and the importance of these changes to the global Earth system.

The importance of providing a Southern Hemisphere perspective should not be undervalued given the likely distribution of impacts.
Lynne Turner, University of Southern Queensland

8. While the focus of ACCSP-funded research was on climate change, 28 per cent (11) of the survey respondents noted the benefits to Australia of the research in better understanding shorter-term climate fluctuations. In particular, an improved understanding of the drivers of Australian climate variability and their causes was noted as a science highlight.

[The ACCSP] was the best thing that ever happened for improving our understanding of Australian climate.
Harry Hendon, Bureau of Meteorology

Other areas raised by survey respondents as significant scientific highlights included, in order of popularity:

9. Understanding of changes in extreme weather events, including drought, and their causes: 15 per cent (6 respondents);
10. Assessment of climate change impacts: 13 per cent (5 respondents);
11. Land-atmosphere interactions, including the Community Atmosphere Land Exchange (CABLE) model: 10 per cent (4 respondents);
12. Greenhouse gas records from ice cores: 10 per cent (4 respondents);
13. Understanding of aerosols and their impact on climate: 8 per cent (3 respondents);
14. Tropical meteorology: 5 per cent (2 respondents);
15. Complex systems science: 3 per cent (1 respondent);
16. Hydro-climatology: 3 per cent (1 respondent);
17. Climate sensitivity: 3 per cent (1 respondent).

Science highlight identified by survey respondents: Understanding Australian climate drivers
ACCSP research delivered better understanding of short-term climate fluctuations, in particular the drivers of Australian climate variability and their causes. Research performed as part of the ACCSP involved the discovery (and naming) of a mode of variability – the Interdecadal Pacific Oscillation (IPO). There was also ground-breaking work on the El Nino Southern Oscillation (ENSO), Indian Ocean Dipole (IOD), Southern Annular Mode (SAM), and other aspects that influence Australian climate. Our understanding of these modes and their possible changes has been transformed thanks to ACCSP research.

Science highlight: Global Carbon Project
The Global Carbon Project (GCP) is an international collaboration to improve scientific understanding of the carbon cycle to support policy development and action on climate change.

The GCP is working towards building a complete picture of the global carbon cycle, including interactions and feedbacks between human, biological and physical dimensions. The ACCSP supports the GCP to provide information on annual changes to global carbon flows and stocks, and a complete carbon balance for the Australian continent.

From the 2013/14 ACCSP Annual Report

Internal workshop

In May 2016, representatives from CSIRO, the Bureau of Meteorology and the Department of the Environment and Energy met to review the past year and overall legacy of the ACCSP. The workshop provided an opportunity to draw on the experiences of ACCSP-related staff to identify highlights of relevance to this review.

The workshop involved about 40 personnel who could be considered 'internal' to the ACCSP, as a contrast to the (coincidentally) 40 mainly external stakeholders interviewed for this review. However, there wasn't proportional representation at the workshop of all ACCSP research, so some fields, such as oceanic research, may have rated lower than they would have if more oceans scientists had attended the workshop.

Workshop participants gathered in small groups, each containing participants representing different research areas and agencies, to consider questions about highlights from the ACCSP over the past 27 years (although of course most participants were only part of the ACCSP over a much shorter period). They then participated in a process to rank these highlights: each workshop participant had five votes to allocate to research areas in any manner they desired, including awarding more than one vote to a topic.

Many of the scientific highlights identified by external stakeholders are reflected in the highlights as seen by those working as part of the ACCSP. Scientific highlights including ACCESS, the climate projections, Southern Hemisphere monitoring, understanding the drivers of Australian climate, and research of the carbon cycle (including the Global Carbon Project) were rated highly by both groups. The table below lists the scientific highlights raised by the internal workshop, in order of popularity. The score refers to the number of votes accorded to the topic.

ACCSP research topic	Score
Australian climate change projections, from simple to a full suite of tools, science information supporting policy, extremes, climate feedbacks and understanding of uncertainty	23
ACCESS, including CMIP5 contributions, and Earth system model development – carbon cycle and global chemistry	22
Understanding drivers of Australian climate, including Southern Hemisphere focus and causes of the South-western Western Australia rainfall decline	15
Climate change impacts in Australia – temperature, pressure, storms, extremes (observations and projections), ozone interactions, connection of ozone and Southern Hemisphere surface climate, detection and attribution of extremes	14
Global Carbon Project – tracking emissions along most intense scenarios; land and ocean sink growth and efficiency; science information in support of policy, including the Carbon Atlas	10
Collection and analysis of data – ozone fluctuations, ocean observations, dust, ice core record and Cape Grim observations	9
Increased understanding of rainfall responses to ENSO in a warmer climate, including drought intensity, and floods and fires	7
Science information policy support, including GREENHOUSE conferences, and provision of information to the community	7
Ocean data, observations and understanding of role in climate	5
International engagement, including leverage and importance to Australia, including IPCC	5
Sea-level rise – closure of budget, past observation record, projections, attribution of different components and emergence of rise from signals, policy support.	5
Integration across disciplines from process studies, to projections and impacts	3
Connecting climate models with observations	3
Tropical cyclone science – much improved understanding of tropical cyclone climatology under climate change scenarios	2
Foundation for many programmes and future improvements	1
Aerosol impact on climate	1
Closing the gap between ‘top down’ (from atmospheric measurements) and ‘bottom up’ (from emissions data) approaches of greenhouse gas quantification	1

Science highlight: Climate projections

The ACCSP's investment in the development of improved climate models for Australia has allowed the generation of projections of Australia's future climate that are used by governments, industry and communities to plan for and adapt to our changing climate.

Through the ACCSP, researchers in CSIRO's climate impact group developed the first climate change scenarios for Australia in 1992, with updated scenarios released in 1996, 2001, and 2007.

In 2015 CSIRO and the Bureau of Meteorology released an updated assessment, drawing on improvements in climate models and our understanding of climate processes. The new projections were funded through the Regional Natural Resource Management (NRM) Planning for Climate Change Fund and include more climate variables and greater regional information. Extensive projections data is available to support impact studies and adaptation planning.

Modified from the 2013/14 ACCSP Annual Report

Value and impact

Interviews and survey responses

Stakeholders were asked about the contribution and value of the ACCSP to Australia and global climate science. There were clear messages that emerged about the value and impact of the programme from this question, in addition to the topics covered in the section on scientific highlights above. Furthermore, there were other questions relating to non-scientific highlights and overall impressions of the ACCSP that identified themes relating to value and impact reported here.

Topics relating to value and impact that stood out to respondents, in order of popularity, were as follows.

1. The most striking highlight identified by most (73 per cent, or 29 of 40) respondents was the international collaboration enabled by ACCSP funding, and the global reputation of Australian science and scientists that resulted. In particular, Australia's role in writing chapters of the IPCC reports in several assessments was noted. Also mentioned was Australia's contribution to the Coupled Model Intercomparison Project (CMIP) of the World Climate Research Programme: participation in this international programme conducted in several phases meant that Australia was able to be an informed user and reviewer of modelling outputs produced by teams around the world.

> *The knowledge that Australian scientists and government funding contribute to global science makes us proud. It would be an embarrassment if that ongoing contribution isn't there. We're part of the world team.*
> Geoff Withycombe, Sydney Coastal Councils Group Inc.

Value and impact: International collaboration and IPCC

ACCSP researchers have made profound contributions to the Intergovernmental Panel on Climate Change (IPCC) as authors of assessment reports and through dozens of cited publications. In the Fifth Assessment Report, ACCSP research is cited extensively in the Working Group I and II reports. Seven Programme researchers contributed as either coordinating lead authors or lead authors, and many other ACCSP researchers contributed to the report's content and review.

ACCSP researchers play leading roles in international bodies such as the World Climate Research Programme, the International Geosphere-Biosphere Programme and the Global Carbon Project. The ACCSP also supports Australia's participation in global observation programs such as the International Argo Project and the global flux network and database (FluxNet).

From the 2013/14 ACCSP Annual Report

2. The role that the ACCSP had in 'kick-starting' or supporting other programs, such as SEACI was listed as a valuable outcome of the ACCSP by 30 per cent (12) of the respondents. The leverage ACCSP funding provided for CSIRO and the Bureau of Meteorology to conduct climate research beyond that directly funded by the ACCSP was also mentioned. The positive influence (including provision of research results and collaborative research opportunities) on other bodies such as the Antarctic Climate and Ecosystems Cooperative Research Centre (ACE CRC) and NCCARF was referred to by some respondents.

While it is important to note that in dollar terms, the contribution of ACCSP was a relatively small component of the total expenditure in this area of research, it significantly leveraged support from CSIRO and the Bureau of Meteorology.
Graeme Pearman, Graeme Pearman Consulting and former Chief of CSIRO Atmospheric Research

Value and impact: Paving the way
The ACCSP paved the way for a host of regional programmes that have increased our understanding of climate change, including:

- South-Eastern Australian Climate Initiative (SEACI): investigated climate change and climate variability in the Murray-Darling Basin, Victoria and southern South Australia, paying particular attention to rainfall and run-off.
- Indian Ocean Climate Initiative (IOCI): examined the causes of the rainfall decline in Western Australia, and developed climate projections to inform policy.
- South-East Queensland Climate Adaptation Research Initiative (SEQ-CARI): the first comprehensive regional study of climate change adaptation in Australia, examining south-east Queensland's vulnerability to climate change and developing adaptation options.
- Goyder Institute for Water Research: providing scientific support for South Australian water management, including assessing changes in water availability as a result of climate change.
- Pacific Climate Change Science Program (PCCSP) and Pacific-Australia Climate Change Science and Adaptation Planning (PACCSAP): examining past climate trends and variability and providing regional and national climate projections for Pacific island countries and East Timor

From the 2013/14 ACCSP Annual Report

3. Nine survey respondents (23 per cent) observed the importance of social capital and spirit of collaboration in the Australian climate research community that the ACCSP enabled. The programme facilitated conversations on the climate system, climate change science and regional adaptation, building a strong climate research community over many years.

What the ACCSP did, in my view, was to build a community and resource a research backbone that actively fostered cross-linkages that made the whole much greater than a sum of parts.
Tas van Ommen, Australian Antarctic Division

4. 23 per cent (9) of the respondents identified the communication of climate change, particularly through products such as the State of the Climate biennial reports, as an outcome that highlighted the value of the ACCSP. Respondents noted that scientists and others associated with the ACCSP increased public awareness of climate change, and raised the profile of climate science in government circles.

However, communication was also noted by some respondents as a shortcoming of the ACCSP (see Impediments to Impact, below). This difference of opinion between respondents does not diminish the recognition (particularly by researchers close to the ACCSP) of the excellent outreach products and communication efforts by many ACCSP staff. However, as discussed below, more investment in communication relative to the size of the research investment would have improved the programme's impact on respondents who are less familiar with the ACCSP.

The demand from external stakeholders for more information identifies a strong need in the community for ongoing research and outreach. The Green/McCrae review in 2003 recommended a rigorous appraisal of how climate science communication and media activities are delivered, noting this was not strictly an internal ACCSP task. It is likely that communication activities subsequently increased between the Green/McCrae review in 2003 and the cuts to funding (including to communication) in recent years.

From a policy perspective, bringing together all of these threads of information and being able to communicate it to politicians, managers and the community has been its greatest achievement.
Antonio Mozqueira, ACT Government Environment and Planning Directorate

5. 23 per cent (9) of the respondents noted that for the relatively modest amount of annual funding, the ACCSP provided a significant contribution to climate science. The programme had funding of approximately $7 million per year from the Federal Department of the Environment (averaged over the past 10 years – see Figure 1), combined with equivalent in-kind contribution from CSIRO and the Bureau. This large contribution relative to funding was noted by nine survey respondents. However, the lack of funding was also noted as an impediment (see Impediments to Impact, below) and one respondent noted that 'it was like the ACCSP funded the development of a Ford Fiesta – certainly a functional car, but not a Lamborghini'.

ACCSP has made a major contribution to global climate science. One that is disproportionately larger compared to Australia's relative population and economy size compared to many developed countries of the world.
James Duggie, WA Department of Environment Regulation

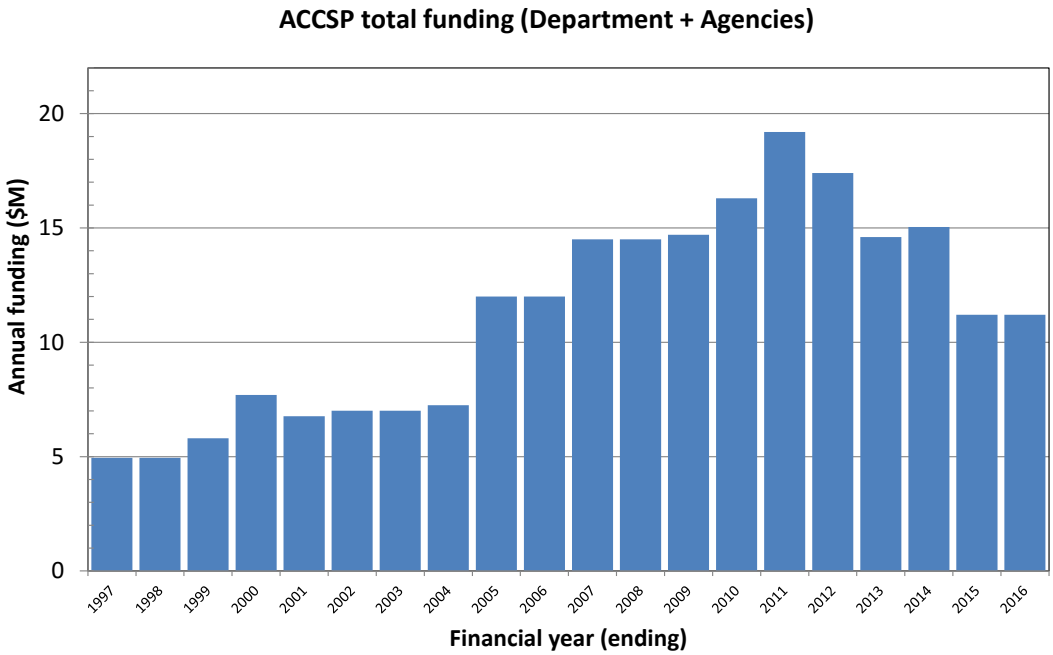


Figure 1: Annual funding totals for the ACCSP from 1997 to 2016. Note that the peak funding in 2011 included funding for extremes research.

6. Similar to the building of a research community noted above by nine respondents, 18 per cent (7) of the respondents noted that the ACCSP helped build a capacity and capability in climate research in Australia.

While it was noted that such capability development in areas such as climate modelling is difficult to quantify in terms of dollars, comments from one respondent (a former consultant) highlighted the economic value to Australia of the public good science of ACCSP in supporting the Australian economy. He explained that as a result of his consulting company's partnership with CSIRO on infrastructure impacts, and by using climate advice from the ACCSP, they were able to do $70 million of work globally – much of it in Australia. He said the work stemming from the CSIRO partnership provided significant jobs and prestige, positioning the company globally. Thanks to the foundation work with CSIRO, the company obtained a number of $5 million contracts globally associated with resilience to climate change, employing 50 to 100 people, and the work is ongoing, generating $10 million a year and operating globally. The former consultant explained that this benefit to industry is likely to have been repeated by other consulting companies, so extrapolating there would be 1000-1500 jobs in the climate adaptation and resilience consulting field that have been generated and supported out of the science conducted under the ACCSP.

Furthermore, the training of students and provision of a local path for career development was also highlighted, enabling graduate students to contribute to increasing Australian research capability.

Without the ACCSP Australia's climate science capability would still be small, patchy, potentially duplicative, and with no clear direction.
Sonia Bluhm, Australian Department of the Environment

There would be 1000-1500 jobs in the climate adaptation and resilience consulting field that have been generated and supported out of the science CSIRO has done.
Michael Nolan, RMIT University

7. A similar number (18 per cent) of respondents noted the success of the GREENHOUSE conference series in bringing scientists together with stakeholders from government and industry. Over the past decade, ACCSP initiated (and CSIRO organised) GREENHOUSE conferences in 2005, 2007, 2009, 2011, 2013 and 2015 in Melbourne, Sydney, Perth, Cairns, Adelaide and Hobart, respectively. These followed earlier GREENHOUSE conferences in 1987 in Melbourne, and in 1994 in Wellington, New Zealand.

It is important for Australia's climate science community and climate change public policy that these biennial events to review the science in some detail continue.
Lynne Turner, University of Southern Queensland

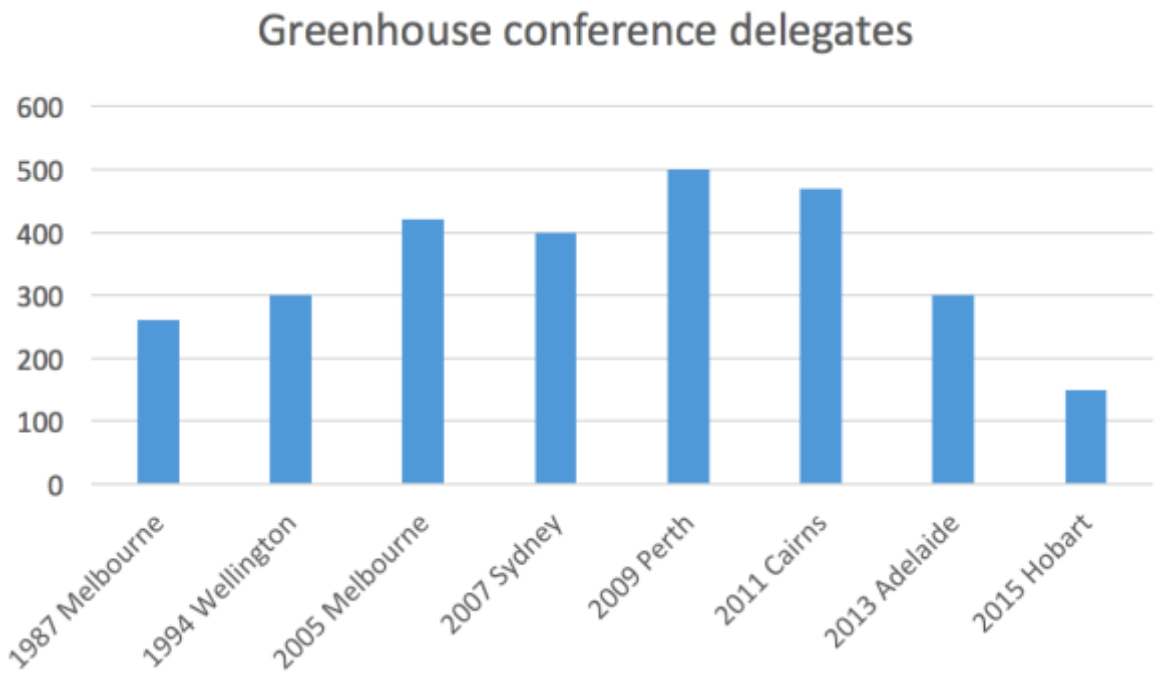


Figure 2: Number of participants at the GREENHOUSE series of conferences.

Value and impact: Greenhouse conferences
The GREENHOUSE conferences included plenary and parallel presentations on a wide range of themes relating predominantly to climate change science. There are also many posters and an exhibition featuring displays from numerous organisations involved in research and application.

The conferences typically attract up to 500 delegates and communicate the latest national and international climate change science. They bring together researchers, students, and government and industry representatives.

Dr Graeme Pearman from CSIRO initiated and convened the first meeting, with GREENHOUSE 87 attracting some 260 participants. It was a five-day event held at Monash University in Clayton, Victoria, from 30 November to 4 December, 1987. Greenhouse: Planning for Climate Change was a publication containing conference papers.

GREENHOUSE 94 in Wellington, New Zealand followed, organised jointly by CSIRO and the National Institute of Water and Atmospheric Research (NIWA).
The new century saw GREENHOUSE 2005, back in Melbourne. The theme was action on climate change. Subsequent conferences were held in Sydney (2007), Perth (2009), Cairns (2011), Adelaide (2013) and Hobart (2015).

From the 2013/14 ACCSP Annual Report

8. 18 per cent (7) of the survey respondents noted the significant value that ACCSP research had in reducing costs of climate impacts by advising adaptation activities. The ACCSP helped to prompt and then advise climate change adaptation activity in Australia. Examples include adaptation planning based on climate change risk and vulnerability assessments, associated adaptation measures such as engineering designs based on changes in extreme weather events, and work with councils on coastal planning based on high resolution sea-level rise data. It was seen that the programme reduced the current costs of climate change impacts, as well as providing future savings from avoided climate change impacts.

Projections of changes in frequency of extreme weather events for emergency preparedness, the conduct of planning schemes for coastal development and the delivery of community services for aged residents with heightened vulnerability to heat stress are just some of the issues for which there is the need for the best possible data upon which to base responses.
Greg Hunt, South East Councils Climate Change Alliance

9. 18 per cent (7) of the respondents noted the value of interactions between scientists and government enabled by the ACCSP. The sharing of knowledge about Australia's potential exposure to climate change and the strong relationships built up over time between scientists and Department staff provided decision-makers with accurate information straight from the source, an awareness of climate change, and practical advice to underpin risk assessment.

Without the ACCSP I believe Australia today would not have a strong enough understanding of our climate system to be able to inform climate change policies and decisions. This would result in even more risks to our industries, businesses, governments and environment than already exists. It is important for decision makers and scientists to build direct relationships.
Sonia Bluhm, Australian Department of the Environment

Other areas of value and impact raised by survey respondents, in order of popularity, were:

10. the leverage provided by ACCSP for PACCSAP and other international programs: 15 per cent (6 respondents);
11. an improvement in the Bureau of Meteorology's operations: 5 per cent (2 respondents);
12. delivery of research that advices reductions in greenhouse gas emissions: 5 per cent (2 respondents); and
13. the contribution to peer reviewed literature about climate change: 3 per cent (1 respondent). Note: although this was not raised by a high number of survey respondents, it reflects the more practical focus of the external user community, with many such respondents presumably taking publications in the peer-reviewed literature as a 'given' for the ACCSP. The review of documentation (above) identified the ACCSP's high publication output and the international reputation of many papers, and publication in peer reviewed literature was a key part of the scope of the programme.

Impediments to impact

Document review

A review of relevant documentation (including annual reports, past reviews, and publication records), when combined with survey responses, suggest additional impact was inhibited in a number of ways:

1. The limited funding to provide ACCESS support in such a way that it could be used extensively by the academic community was highlighted by some respondents of the survey. Universities explained that they have consistently struggled to gain the access and support needed to use ACCESS effectively in their research. This may have resulted from the fact that this was not a direct responsibility of the ACCSP programme, and ACCESS development was guided by a separate oversight committee that included broad representation from the Bureau, CSIRO, universities and the Department. Furthermore, much ACCESS development lay outside ACCSP. Nevertheless, as a key player within the Australian climate science community ACCSP was aware of the issue and played a role within the community (within funding constraints) by providing direction to ACCSP-funded ACCESS-related projects. CWSLab (Climate + Weather Science Laboratory – see http://cwslab.nci.org.au/) was another project that aimed to address this concern. It is clear that a climate simulation system of this complexity requires ongoing maintenance, IT support, user documentation and outreach functionality to enable a range of model-literate users across Australia to use ACCESS to maximum advantage. This has been missing and has partly limited the impact of this national resource.

2. Furthermore, universities were not able to receive funding and hence participate fully in the programme or to get their science included, for example in ACCESS. This engagement with universities is being addressed by the NESP ESCC Hub, although it is hampered by the reduction in funding. It should be noted that the ACCSP was not set up to include universities, but collaboration was always encouraged, especially after the National Framework was released in 2009 and the High level Coordination Group was established.

3. The budget allocation for management and communication was around 4 per cent in recent years (with extra funding through the Regional NRM Planning for Climate Change Fund to deliver the Climate Change in Australia projections and website). While recognising the tightly constrained funding envelope of the past few years, these funds were inadequate to provide extensive advice services, engage fully with the wider academic community (e.g. around ACCESS, see point 1) and communicate with the general public (these additional services appeared to be in increasing demand). This does reflect the design of the ACCSP as primarily about research and delivering this to next-users rather than end-users. The reviewers note that a dedicated communication officer was employed between 2005 and 2014 to communicate research delivered by the ACCSP, and the ACCSP produced a number of outreach products (including annual reports, policy-relevant booklets

summarising aspects of climate science, fact sheets, and other materials); however, the communication activities did not always meet the needs of stakeholders or government and could have been better integrated with the communication activities of the Department, Bureau, and CSIRO to increase impact. While not diminishing the value of the research and capability derived from the ACCSP investment; this greater focus on communication and knowledge brokering that was identified by the reviewers is an important lesson learnt for future research programs.

4. The rapidly reducing funding envelope in recent years, coupled with increasing need for underpinning climate science, growing demand for policy-driven research and a rapidly expanding number and range of stakeholders wishing to use the research products means that the programme was faced with an impossible task to accommodate all these demands. Hence, it was extremely difficult to obtain an effective balance between targeted research serving policy needs and wider enquiry-driven research needed for the effective use of resources. During the life of ACCSP, the balance favoured policy-focussed research a little too much, so ongoing attention to the balance is important into the future.

Interviews and survey responses

Survey participants were asked to note impediments, if any, to the impact of ACCSP research and application of the programme's results, and to identify any shortcomings of the ACCSP.

Impediments to impact identified by respondents, in order of importance, were as follows.

1. A lack of funding was raised by 13 respondents, with many of these plus another 5 (a total of 45 per cent) of the respondents adding that there is a need for continued support to maintain the ACCSP's legacy. As noted above, the amount of annual funding was modest, averaged at about $15 million a year (which includes Government, CSIRO and Bureau funding) over the past 10 years (see Figure 1). For an area of science that is recognised as a national priority and international challenge, the amount of financial support is noticeably lacking. In addition to underfunding such a significant programme of research, the further impediment of the short funding cycle of the ACCSP was raised by some of the 13 respondents, where planning long-term science projects was difficult on short-term (even annual) budget cycles.

It is very important for the future prosperity, productivity, competitiveness and resilience of the Australian economy, its communities and the natural environment, that the Federal Government continue to invest in, and indeed expand its investment in, climate science.
James Duggie, WA Department of Environment Regulation

2. Almost half (43 per cent, or 17) of the survey respondents identified the programme's lack of focus on end users. In addition, there were comments related to the lack of stakeholder engagement, resulting in research results having less impact. Some respondents didn't have a sense that the programme emphasised adding value to completed research (e.g. through additional outreach and communication products), resulting in reduced input to policy and decisions. However, the reviewers note the ACCSP's scope was for underpinning research more than end-user engagement. Respondents suggested researchers need to bridge the gap between the language and focus of scientists, and the needs and 'packaging' of research results required by less technically qualified end users. The reviewers note a balance between targeted research serving the policy needs of one specific group of end-users (as noted in point 4 above) and wider enquiry-driven research is needed. Also, there has been a shift in the ACCSP's focus over the years, with the requirement of end-user focus not so strong in the early years of the ACCSP compared with today.

3. The ACCSP's lack of public profile was noted by 10 respondents, plus another 5 stakeholders who did not answer the survey due to reasons relating to a lack of knowledge of the programme (a total of 38 per cent). Respondents were generally aware of the research in CSIRO and the Bureau, but may not have been familiar with the ACCSP name, so in reality the lack of awareness of ACCSP research was small. Some respondents understood the ACCSP to be nothing more than a source of funding rather than a research programme, while others attributed broader CSIRO and Bureau of Meteorology research to the ACCSP. However, it was recognised that the strength of the CSIRO and Bureau brands did not warrant strong branding for the ACCSP. In addition, the need for collaborative science and joint investment means that having several brands of research partners rather than a strong programme brand may be preferable.

What was part of the ACCSP or not part of ACCSP was never clear . . . transparency of the programme to people outside was not there, and what climate science is included in the ACCSP is not clear to outsiders.
Andy Pitman, ARC Centre of Excellence for Climate System Science

4. The politicisation of climate science was seen as an impediment to impact by 28 per cent (11) respondents. Because the ACCSP produced results that warranted action on climate change, the political climate of the day in relation to climate change action influenced the discussion and acceptance of the science. However, there was some recognition that political scepticism about climate change has been reduced due to the science that was completed and communicated by the ACCSP and others, leading to more political support for action and a willingness to respond to climate change.

We have allowed those with power to exercise their ignorance to further vested interest rather than the response an issue of this magnitude requires. The vitriol, bullying and harassment that climate scientists as messengers have been subjected to is just wrong.

Lynne Turner, University of Southern Queensland

The failure of science into policy is political rather than due to any scientific or communication failing.
Tony Press, University of Tasmania.

5. 23 per cent (9) of the respondents commented that ACCSP funding was only available to a small subset of CSIRO and Bureau of Meteorology areas. Furthermore, there was a perception among some that the programme was "closed" to many researchers. Comments also were raised about the review process to decide funding allocations, and that the funding process was inward looking. On the other hand, the reviewers recognised the need to provide funding for critical ongoing and long-term tasks and capabilities such as the support of modelling, and investment in monitoring of the oceans, land surface, and carbon. This reduced the ability of the programme to fund new science, particularly with flat or reducing budgets – although there are many examples of new areas of science requiring research, such as attribution of extremes, paleo modelling, and research into bushfires and tropical cyclones.

If you weren't in the loop, you could never get in . . . just wasn't clear there was any interest in new or different directions from outside the loop.
Harry Hendon, Bureau of Meteorology

6. 23 per cent (9) of the respondents noted that a lack of public communication was a shortcoming of the programme. While other respondents had noted the advances in public understanding and awareness of climate science due to the ACCSP, the lack of communication (particularly to address the anti-climate science statements and sentiment of sceptics – although the responsibility for this includes the wider research community and others) was raised as an impediment to impact.

With hindsight there should have been better storytelling to the public, to the political class and to sections of the media to counter the trenchant attacks on climate science in sections of all three that ultimately have affected the politics, perception of and actions this country has taken on anthropogenic climate change.
Greg Ayers, Former Chief, CSIRO Marine and Atmospheric Research and former CEO, Bureau of Meteorology

Other topics identified as a shortcoming of the programme by a small number of respondents were:

Impediment	**No. respondents**
Lack of public awareness or support for climate science	3 (8 per cent)
Lack of regional products and needs, such as in SW WA	3 (8 per cent)
Lack of Government engagement	3 (8 per cent)
Lack of University engagement	3 (8 per cent)
Poor communication of complexities	3 (8 per cent)
Reporting requirements and bureaucracy	3 (8 per cent)

The failure to target specific research using limited funds	3 (8 per cent)
Lack of raw data and accessible results for non-researchers	2 (5 per cent)
Competing organisations	2 (5 per cent)
Lack of a monitoring and evaluation framework	2 (5 per cent)
Problems with the CSIRO-Bureau relationship	2 (5 per cent)
Adaptation barriers	1 (3 per cent)
Communicating climate change in terms of risk management	1 (3 per cent)
Interaction between researchers in climate and water domains	1 (3 per cent)
Social science and communication research	1 (3 per cent)
Links to adaptation	1 (3 per cent)
Managing the transition from research to services	1 (3 per cent)
A disconnect between long-term climate change research and seasonal prediction research	1 (3 per cent)

Internal workshop

As with the scientific highlights, there was much commonality between the areas identified by representatives from the internal ACCSP workshop in May 2016 that the programme could have managed better, and the impediments to impact identified by external stakeholders.

For example, just as funding and related issues were identified as a key impediment above, the internal workshop noted that the ACCSP was under resourced in some areas, including administration, and that periods of 3-year and sometimes single-year funding allocations were challenging. Furthermore, staff allocations to multiple projects and small allocations of staff to individual projects was identified to have precluded sufficient time being allocated to research. This was exacerbated by increased administrative workloads on scientists in the ACCSP (a trend likely experienced beyond the programme). Furthermore, it was noted that 'increased bureaucracy over the years diminished intellectual freedom'.

The internal workshop identified 'limited take up of findings' by users as an impediment to impact, reflecting the lack of user-focus identified above. Internal workshop participants also raised communication as something the programme could have managed better, especially in the latter years, with too little emphasis on communication to the public and targeting of key stakeholders.

Greater interactions between researchers and the Department would have improved the programme's links to policy-making.

The internal workshop participants recognised the perceptions that ACCSP funding had been provided only to limited areas of research, including the perception (at universities, as well as from inside CSIRO and the Bureau) that the programme was difficult, if not impossible, to obtain funding from. Participants also noted the need for improved review of research proposals, perhaps using a broader review panel to address the negative perceptions.

Future research

Interviews and survey responses

Although the main focus of this review was on the past activities of the ACCSP, it also sought to identify the assessment by programme participants and stakeholders of the top areas of climate change research required now and in the near future. The key areas identified by the 40 survey respondents, in order of popularity, were as follows.

Research area	No. respondents
Extremes	17 (43 per cent)
Model development	17 (43 per cent)
Adaptation research and advice	13 (33 per cent)
Regular update of projections as improvements become possible	12 (30 per cent)
Ongoing observations of the land, ocean and atmosphere, integrated with climate models	10 (25 per cent)
Impacts, including freshwater ecosystems, water, terrestrial, marine and built environment	10 (25 per cent)
Influence of climate change on climate variability, such as El Nino	9 (23 per cent)
Sea-level rise	9 (23 per cent)
Seasonal and multi-year predictability	8(20 per cent)
Antarctica, Greenland, cryosphere	7 (18 per cent)
Model downscaling	7 (18 per cent)
Greenhouse gas and carbon budgets	5 (13 per cent)
Tipping points, positive feedbacks	5 (13 per cent)
Renewables, mitigation	5 (13 per cent)
Clouds, radiative forcing	4 (10 per cent)
Climate change detection and attribution	4 (10 per cent)
Circulation change	3 (8 per cent)
Quantifying projections of rainfall, and other parameters	3 (8 per cent)
Ocean acidification	3 (8 per cent)
Oceans	3 (8 per cent)
Climate sensitivity	3 (8 per cent)
Social science	2 (5 per cent)
Paleo records	2 (5 per cent)
Hydrology	2 (5 per cent)
Tropical atmospheric dynamics	2 (5 per cent)
Historical and prehistorical data	2 (5 per cent)
Policy-science integration	1 (3 per cent)

Carbon sinks	1 (3 per cent)
Communication	1 (3 per cent)
Geoengineering	1 (3 per cent)
Climate change and cities	1 (3 per cent)

Internal workshop

CSIRO, the Bureau of Meteorology and the Department of the Environment and Energy personnel attending the May 2016 workshop considered areas that either were not addressed by the ACCSP or could have been investigated more comprehensively. Consolidated responses are presented below in alphabetical order, although note that there was not proportional representation at the workshop of all research ACCSP areas, so some fields may not be represented here. Areas that were not addressed by the ACCSP or could have been investigated more comprehensively identified by the internal workshop were:

- ACCESS development and use, including:
    - improvements in modelling (such as the atmosphere component, convection, low clouds and cloud feedbacks, and ENSO – including atmospheric and ocean aspects);
    - data assimilation;
    - regional modelling;
    - boundary-layer modelling; and
    - applications for research (answering important Australian questions);
- Aerosol monitoring and modelling;
- Climate mitigation science;
- Climate surprises and tipping points, including stability of Antarctic ice sheet;
- Downscaling research, including quantification and reduction in uncertainties;
- Extreme events and their attribution;
- Geoengineering and its impacts; geoengineering assessments;
- Greenhouse gas ongoing measurements and links to carbon and chemistry;
- Multi-year and decadal predictions;
- Oceans and ice:
    - Ocean acidification;
    - Ice sheets and their impact on sea level;
    - Involvement in the deep Argo monitoring programme;
- Palaeoclimate research;
- Water cycle modelling and understanding, including hydrological research.

Legacy

From interviews with stakeholders and responses to the survey, the legacy of the ACCSP is clear and positive. The programme has provided a vastly improved understanding of the climate system and projections of climate change. It has enhanced Australia's capability in Earth system science, including building social capital and a national spirit of collaboration that extends to colleagues internationally. It has facilitated an awareness of climate change among government, the general public, and other groups, providing benefits to industry through reduced costs of exposure to climate change impacts.

Furthermore, the May 2016 workshop delegates listed the following enduring achievements (listed alphabetically):

- An Australian climate model, ACCESS, that is recognised internationally;
- Better knowledge of climate change risk;
- Capability, professional development and job satisfaction;
- Climate change projections;
- Continuity and scale of investment enabled the programme to deeply investigate important science, including topics of strategic national and international importance;
- Extensive contributions to international climate change science, including IPCC;
- Contributions to national climate change science programs, such as NRM projections development, SEACI and IOCI;
- Contributions to ocean science;
- GREENHOUSE climate change science conferences;
- Linking climate models with measurements;
- Monitoring environmental changes, including greenhouse gases through the air archive and Cape Grim data, and information on changes to the atmosphere;
- Multidisciplinary work that grew over the lifetime of the programme;
- Policy support for government;
- Southern Hemisphere issues incorporated into the IPCC, international collaborations, and others;
- Strong collaboration between CSIRO and the Bureau of Meteorology, providing the basis for strong links between climate change researchers;
- Strong relationships between the research community and government and a multiplicity of stakeholders.

The legacy will be ... the dawning on the world during this period that the changing climate can be 100% attributed to man. This legacy has been a 30-year journey.
Nathan Bindoff, University of Tasmania

In some ways the Earth System and Climate Change Hub of the NESP is a legacy of the ACCSP. The Hub represents a more community-based research programme, including five Australian universities as well as CSIRO and the Bureau.
Sonia Bluhm, Australian Department of the Environment

Lessons learned

Recommendations

The overarching lesson learned from the review is that the need for a world-class, well-funded, nationally co-ordinated Australian research and outreach effort in climate science is now, if anything, stronger than ever.

Knowledge of Australian climate variability and change in ever increasing detail and accuracy is being demanded by a wide range of stakeholders. The economic and social costs of climate maladaptation, the lack of preparedness for extreme events and other applications vastly outweigh investment in climate science. The ACCSP laid a solid foundation on which the NESP ESCC Hub and other programmes can build, but only if they are adequately resourced. Recent severe reductions in funding and additional cuts to the CSIRO climate programme and a reduction in the Bureau's climate change research capability will put Australia's climate science capability in severe jeopardy unless alternative funding sources can be identified. Reversal of these cuts or the provision of new funding sources will enable continued resourcing of key research areas identified in this review, including model development, projections, observations, and improved understanding of key drivers of global and regional climate change.

To meet ongoing and new challenges/demands, the nationally coordinating model of ACCSP, which has by and large served the nation well, needs to be recognised for its strengths and adapted to new needs as the NESP ESCC Hub evolves and major research agencies such as CSIRO and the Bureau of Meteorology review their activities. Tackling the highest priority climate science questions for Australia, and maintaining an appropriate overall national effort, must continue to be well-planned and appropriately resourced.

The 2003 Green and McCrae review noted: "One particularly concerning aspect resulting from this evaluation was the apparent lack of a clear policy and stable support arrangements for the ongoing collection of essential data sets." Thirteen years along, the community is still struggling with this issue, as evidenced by challenges in maintaining the CSIRO GASLAB, carbon budgets, etc. (sometimes considered to be a maintenance task in a research oriented organisation). This situation reflects a weakness and challenge in national policy continuity – and perhaps lack of clear enunciation of statutory responsibility. While support for such activities may not necessarily be part of programmes such as the ACCSP that have a focus on research, observations are important and must be ongoing. The relevant recommendation from Green and McCrae needs to be revisited.

Future research needs to be centred around climate-related risk and around outstanding questions regarding Australian climate. In order to optimise use of and benefits from ACCSP research outputs, outreach activities need support to effectively service national and stakeholder information needs. While these needs

have evolved over the life of ACCSP, both researchers and stakeholders have identified that an evolution of a research and outreach programme is needed rather than any radical change.

Climate change science is not a short term research field that can be readily switched off and then on again. The skills and precision ...require a long-term perspective.
Jo Mummery, Griffith University

Appendix 1. Planning, evolution, review and resulting progress and outputs from ACCSP

This section explores the evolution and resulting progress of ACCSP as a result of the planning, reviews and regular reporting. This includes changes to, and highlights from, the various programme Components. It summarises recommendations from past reviews, the extent to which they were adopted and assisted with the growth and development of ACCSP and how they led to a firm programme of outputs and results over the recent ten years of ACCSP.

Firstly, it should be noted that the planning process was thorough and extensive (as past documentation shows, including the National Framework and Implementation Plan documents).

Two previous reviews were undertaken, Green and McCrae in 2003 and Solomon and Steffen in 2006. Both made relevant recommendations regarding aspects of ACCSP.

The following table 1A summarises the suggested new components for the programme proposed in the Green and McCrae review in2003, and the impact on subsequent ACCSP evolution.

TABLE 1A

Suggested Component	**ACCSP programme evolution in response to Green/McCrae review**
1. Impacts, Vulnerability, and Adaptation	Stronger focus on impacts and vulnerability in ACCSP Establishment of NCCARF. Some linkages between the two programs have occurred.
2. Climate Change Detection and Attribution	Recommendation acted on, resulting in stronger focus on modes of variability, etc.
3. Climate Change and Extreme Climate Events	Significant effort in extreme events research
4. The Effect of Climate Change on Climate Variability	New efforts in ENSO response under climate change, etc. Nevertheless, still an area in need of new research undertaken
5. The Ocean's Role in Regional Climate Change and Variability	Important new work undertaken
6. The Effect of Climate Change on the Carbon Cycle	Important new work undertaken
7. International Climate Change Assessments	Continued important Australian contributions in this area
8. Coordination	Continuation of sound coordination

The following table 1B summarises the policy and governance suggestions made by Green and McCrae, and Solomon and Steffen and the impact on subsequent ACCSP evolution. Note that recommendations outside the scope of ACCSP itself, or this review, are not included in the table below.

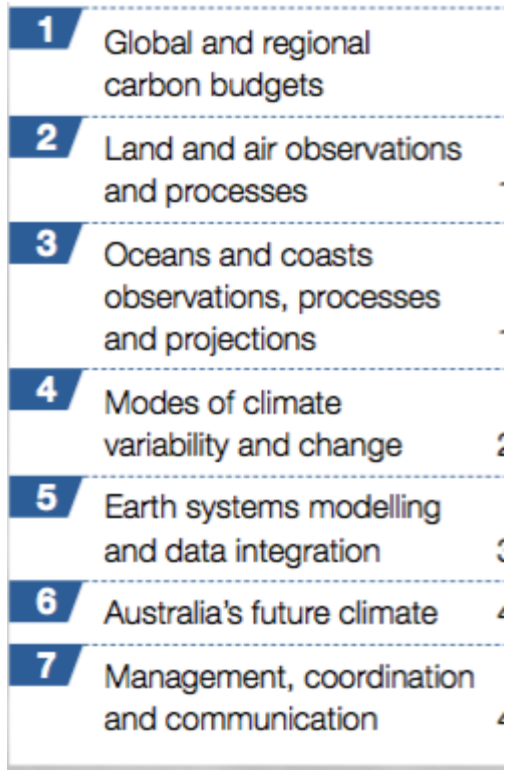
TABLE 1B

Recommendation	**Result (noting that these have generally been considered in a budget-constrained environment)**	**Implications**
Green and McRae (2003)		
Recommendation 2: That Australia invests in Impacts and Adaptation science and technology in concert with the existing Greenhouse and Climate Change science. Such an investment might use an 'integrated assessment' framework to develop goals, objectives and milestones	NCCARF established. The integrated assessment framework (from climate research results to impacts to adaptation and mitigation) partly implemented as a result.	Improved capability to use the research outputs of ACCSP.
Recommendation 4: That an advisory body be established with members drawn from both key user-stakeholders and senior scientists, to advise the AGO on the content and priorities of the greenhouse science programme, in the context of the total Australian effort and the special funds provided by the Government.	Helped lead to the development of the Australian Climate Change Science: A National Framework, and A Plan for Implementing Climate Change Science in Australia, and the establishment of the High Level Coordination group for Climate Change Science	The ongoing planning and review process has proved useful in identifying national priorities
Recommendation 5: That funding for the AGSP should be increased to enhance the current programme and to support additional activities in clearly identified priority areas, with commensurate increases in AGO staff resources to ensure responsive and responsible management and administration.	This recommendation was initially successful, but unfortunately was not maintained.	Stresses in the ACCSP developed in recent years, as the increases were reversed
Recommendation 6: That the AGSP and its components should be formulated to reflect purposes rather than processes, and that this should be emphasised in the structure of and descriptors used for the Programme and its components.	Future annual reports and milestone documents reflected this emphasis	Helped in the understanding of the Programme rationale
Recommendation 7: That a rigorous appraisal is conducted of the means of delivering greenhouse science communication and media activities.	Not strictly an internal ACCSP task, but ongoing effort was made in this area	The current review indicates some effort still needed in this area
Recommendation 9: That in planning the future programme for greenhouse science, the manner by which the ongoing collection of essential data sets is supported be determined.	Poorly followed up at a national level as evidenced by current concern over key datasets under the CSIRO cuts	While not necessarily responsibility of ACCSP principals, the effects of the lack of follow-up are now being felt in cuts to areas that hold data sets and archives
Recommendation 10: That Australian support for the International Geosphere-Biosphere Programme and the World Climate Research Programme be continued.	Clearly recognised, and generally supported	Reduced funding puts stress on this national need
General statement: The future structure of the programme should address: "Filling (**data** and **research**) gaps (that) will provide significant returns on the investment: in climate prediction at regional as well as global scales; in achieving sustainable solutions to the interdependent problems of climate change, water deficit, and land degradation; and in developing solid mitigation and adaptation programs. (emphasis added)	This is very much what the next phase of the programme targeted and largely/partly achieved.	
Solomon and Steffen (2006) The following elements are essential for a strengthened and more effective national approach, building on the established role and mode of working of the Australian Climate Change Science Programme:		

1. A national framework for strategic planning and enhanced collaboration. Based on complementarity and synergy, the framework should provide the structure for collaboration and integration across institutions. The centrepiece of the framework should be a national-level core programme around a set of high priority science questions of importance for Australia.	Whilst ACCSP provided a large part of the National Framework, the subsequent establishment of ARCCSS and NCCARF showed the continued benefit and need for the National Framework	The national framework need still exists and needs updating as institutional arrangements change
2. An increased and more flexible funding base. A measured ramp-up of funding for fundamental biophysical climate science over the next five years to a new, higher level is required to implement the framework. Removing some constraints on the use of existing funding sources can add flexibility to and increase the effectiveness of the framework.	Establishment of ARCCSS and NCCARF contributed to increased flexibility	Funding to ACCSP, while initially increased, is now at or below levels of ten years ago, in real terms
3. Next generation scientists and renewed infrastructure. Opportunities are needed for young scientists to build stable, long-term career paths and for the most talented investigators to undertake "blue sky" research. Core infrastructure such as supercomputing for global climate modelling urgently needs renewal.	This analysis assisted the improvements to computing infrastructure, while establishment of ARCCSS assisted with professional development of young scientists	
4. Global scientific engagement to address a global policy problem. A globally networked and effective scientific enterprise is essential to support the global policy process on climate change. Fostering Australia's unique scientific strengths will benefit the pursuit of sound national and international policy.	Our international involvement continued to national advantage	

The following tables explain and summarise the science highlights of recent years that have been built on the early legacy of AGSP/ACCSP and the 2003 and 2006 reviews. The first, table 1C, shows how the programme Components evolved following the reviews.

TABLE 1C

2005-06 Programme Components	**2014-15 Programme Components**
Understanding the key drivers of climate change in Australia (maps closest to 3 and 4 in opposite column) Oceanic processes – the role of the ocean in climate (maps to 3) Global and regional sea level rise (maps to 3) Atmospheric research - aerosol and cloud feedbacks (maps to 2) Terrestrial carbon cycle – a focus on the Australian biosphere (maps to 1) Detection and attribution of climate change (maps to 4?) An Australian climate modelling system (maps closest to 5) Climate change, climate variability and extreme events. (3.2 Maps to 4) Regional climate change projections (maps to 6) International research collaboration (has been dropped as a separate component) Coordination and communication (Maps to 7)	

In the following table 1D, the progress of ACCSP over the past ten years is summarised by comparing Key Outputs from 2005-06 to 2014-15.

Note that some mapping between the programme objectives during the two periods has been done, but recognising that the programme expanded and developed its focus over time, so that new work/new objectives occurred in 2014-15.

TABLE 1D

Highlights and key development work from 2005-06	**Progress and advancement of the science evident in 2014-15, as well as new outputs of relevance to stakeholders and the broad Australian community**	**Conclusions/ assessments**
Component 1: Understanding the key drivers of climate change in Australia *This component at that time, covered what could be described as early identification of some of the key Australian climate-linked changes, robust and more relevant implementation of carbon fluxes research and carbon budget estimates.* There was an emerging and important focus on Australia's oceans and particularly those between Australia and Antarctica. Some of Australia's high quality data sets were being enhanced via ACCSP funding.	**Component 2: Land and air observations and processes** A focus on response of Australian ecosystems to a changing climate, and the impact of aerosols on climate and regional weather patterns. New tools for ecosystem response to climate variability - installed a world- first remote sensing system at the Bago State Forest research site near Tumbarumba in south-east New South Wales. Pollution aerosols shown to be problematic for Australian tropical temperature and rainfall projections. Climate forcing by aerosols has been refined but still needs work. ACCSP researchers have recently made significant contributions to the assessment of climate feedbacks, as part of the international CMIP5 assessments. ---------- **Component 4: Modes of climate variability and change** Significant focus on ocean-induced climates, attribution, projection and mechanisms of climatic extremes and change, modes of variability and regional weather systems. -- particularly new ENSO research, important to many stakeholders, e.g., Climate change signal detected in Australian rainfall variability, e.g.	Wider range of climate questions tackled A very useful advance in understanding climate sensitivity – significant progress over ten years ago. ------ Much greater

Highlights and key development work from 2005-06	Progress and advancement of the science evident in 2014-15, as well as new outputs of relevance to stakeholders and the broad Australian community	Conclusions/ assessments
	Pacific warming has emerged from background variability and is due to greenhouse gases Relative influence of ozone depletion and Greenhouse gases on the Southern Annular Mode (SAM) teased out. --- **Component 1: Global and regional carbon budgets** New quantification of century-long sources and sinks, emissions from agriculture and changes during the Little Ice Age. New Australian results on the role of vegetation dynamics: including sensitivity to temperature change of respiration and photosynthesis of vegetation.	understanding of relative influence of modes of variability and change Processes and details of carbon flows substantially improved over past decade
Component 2: An Australian climate modelling system New parameterisations were being implemented into the ACCESS system, including land surface models. The modelling system was being used for new studies of Antarctic ozone depletion impact in the broad Australian region, and the then challenging question of Asian anthropogenic aerosols impact on climatic trends over Australia in the second half of the 20th century.	**Component 5: Earth Systems modelling and data integration** ACCESS has been, and continues to be, a major collaborative undertaking, bringing together the climate observations, research and modelling capability of the Bureau of Meteorology and CSIRO, with involvement of some Australian universities and international researchers. ACCESS model improvements included: a high horizontal resolution ocean component, improved cloud-process representation and improved representation of clouds and precipitation, and global climate-chemistry-aerosol modelling. The inclusion of new processes in the ACCESS land carbon module (called CABLE) has been a recent achievement (these represent significant improvements over a decade ago) And enabled, e.g.: Successful simulation of the carbon cycle response to increasing atmospheric carbon dioxide	Improved capacity to model Southern Hemisphere climate features and refine climate projections. The early work in ACCSP provided a basis for a quality Earth Systems modelling suite. Universities ability to be involved in and use ACCESS has been less than planned.

Highlights and key development work from 2005-06	Progress and advancement of the science evident in 2014-15, as well as new outputs of relevance to stakeholders and the broad Australian community	Conclusions/ assessments
	Improved representation of Australian climate drivers in ACCESS- CM2 makes the model more useful in support of natural resource management and climate related infrastructure planning, and also in the analysis of carbon cycle/climate feedbacks so as to inform mitigation policy. ACCSP and ACCESS enabled participation in the World Climate Research Program's (WCRP) Grand Challenges of Climate Science (http://www.wcrp- climate.org/grand-challenges)	Resources needed to provide ongoing maintenance, associated data management and enabling wider academic community use, need to be recognised and developed.
Component 3: Climate change, climate variability and extreme events New studies of the impact of global warming on tropical cyclone-like vortices, severe storms and hail, and the Southern Oscillation Index (SOI) and Australian rainfall. New downscaling studies were underway. The first preliminary indications of the potential for decadal predictability of surface temperature in some geographic locations in the Southern Hemisphere. ---------- **Component 4: Regional climate change projections** A new approach for assessing model performance was developed (automated), along with graphical methodologies for downscaled future climate change projections – both important for accessibility and quality control of future research within Australia.	**Component 6: Australia's Future Climate** Strong focus on regional projections science, extreme events, and likely impacts of relevance to stakeholders, e.g., the impact of climate change on the ignition of bushfires and the Australian carbon budget. Climate change projections for Australia were released in January 2015, supported by the *Regional NRM Planning for Climate Change Fund* and co-investment from CSIRO and the Bureau of Meteorology. This work was partly underpinned by contributions from the ACCSP. *Climate Change in Australia: Projections for Australia's NRM Regions* are available at www. climatechangeinaustralia.gov.au, and supported by opportunity to consult with climate scientists. An important improvement is the supply of a confidence rating system for all the projections. The website is now widely used by many stakeholders and across sectors.	The new projections and website are an important upgrade in the capacity of the science to inform decision-making. It is particularly unclear how the climate scientist consultation service can be maintained in the face of funding and staffing cuts. – and yet this is crucial for getting the benefit of the past investment. Consideration needed on whether this is now a

Highlights and key development work from 2005-06	Progress and advancement of the science evident in 2014-15, as well as new outputs of relevance to stakeholders and the broad Australian community	Conclusions/ assessments
Modelling work showed likelihood of reduction of frost occurrences across the Murray-Darling Basin and further reduction of early winter (May to July) rainfall in south-west Western Australia with magnitude dependent on the emission scenarios employed.		service priority rather than a research activity and resourced as such.
In 2004-05, *an emerging and important focus on Australia's oceans was one part of the then Component 1.*	**Component 3: Oceans and Coasts observations processes and projections** Since then, a stronger oceans and coasts focus has led to more climate-quality ocean data, and improved global and regional analyses of sea level changes and trends, as well as better understanding of storm surges and extreme events around the Australian coastline, via key research: -- Maintenance of Argo observing array; -- Work on quality-control of bathythermograph observations -- Extended Australian ocean climate record shows continued global warming and sea level rise -- Ocean drivers of climate variability -- Longer-term ocean trends and ENSO -- Refining regional oceans information and likely trends -- Improved understanding of the Southern Ocean carbon dioxide uptake	Important and relevant expansion of the effort in oceans and coastal processes
Component 5: International collaboration Collaboration on the study of biospheric carbon pools was underway and priorities for carbon cycle research were being workshopped. ACCSP scientists were also participating actively in international inter-comparison projects such as "The Cloud Feedback Model Intercomparison Project" (CFMIP)	International collaboration of benefit to Australia made possible by ACCESS, e.g. the World Climate Research Program's (WCRP) Grand Challenges of Climate Science (http://www.wcrp- climate.org/grand-challenges) Support to consideration of CMIP Phase 6 and an IPCC 6th Assessment Report also made possible. The Coordinated Ocean Wave Climate Project (COWCLIP) is an	International collaboration continued at a high level of benefit to the Australian science, to Australian standing and to flow-on information to the Australian community.

Highlights and key development work from 2005-06	Progress and advancement of the science evident in 2014-15, as well as new outputs of relevance to stakeholders and the broad Australian community	Conclusions/ assessments
	international working group coordinating efforts to understand wave climate change and variability. ACCSP researchers have had large involvement in COWCLIP planning.	
Component 6: Coordination and communication Annual reports showed that research milestones were being well met. Collaborations between CSIRO, the Bureau of Meteorology and the Australian Greenhouse Office were facilitating the implementation of the Australian Climate Change Science Programme.	**Component 7: Management, coordination and communication** Regular Greenhouse conferences have been a key communication tool throughout ACCSP. However, 2015 saw the release of the most comprehensive national climate projections to date through the *Climate Change in Australia: Projections for Australia's NRM Regions* initiative. These projections, available at **www. climatechangeinaustralia.gov.au**, were underpinned by ACCSP science. A range of products, including technical reports, summary material and online tools, is available - more accessible and more comprehensive information source than previously available.	Substantial upgrade to communication and accessibility for stakeholders and public generally.

It is clear from the above table that the early investment in ACCSP and the resulting early research effort has produced a return-on-investment in terms of the subsequent research quality and quality of outputs.

Appendix 2: Interviews and survey responses

Note: responses sorted by question, in alphabetical order of respondents' surnames.

Name	Organisation
Rob Allan	Met Office Hadley Centre
Andrew Ash	CSIRO
Greg Ayers	
Bryson Bates	CSIRO
Nathan Bindoff	University of Tasmania
Sonia Bluhm	Department of the Environment and Energy
John Church	CSIRO
James Duggie	WA Department of Environment
Mark Gibbs	Queensland University of Technology
Harry Hendon	Bureau of Meteorology
Kevin Hennessy	CSIRO
Robert Henson	The Weather Company
Lesley Hughes,	Macquarie University
Greg Hunt	South East Councils Climate Change Alliance
David Karoly	University of Melbourne
Peter May	Bureau of Meteorology
Chris Mitchell	Seafarms Group Ltd
Antonio Mozqueira	ACT Government
Josephine Mummery	University of Canberra
Neville Nicholls	Monash University
Michael Nolan	RMIT University
Jean Palutikof	NCCARF
Graeme Pearman	Graeme Pearman Consulting
Jon Petch	UK Met Office
Neil Plummer	Bureau of Meteorology
Andy Pitman	ARC CoE for Climate System Science
Tony Press	University of Tasmania
Bruce Rhodes and KS Tan	Melbourne Water
Steven Sherwood	Climate Change Research Centre, Uniy of NSW
Will Steffen	Climate Council
Susan Solomon	MIT
Lynne Turner	University of Southern Queensland
Tas van Ommen	ACE CRC
Penny Whetton	Melbourne University
Kate Wilson, Matthew Riley and David Hanslow	NSW Office of Environment and Heritage
Geoff Withycombe	Sydney Coastal Councils Group
Tony Worby	ACE CRC
Anonymous	Water – Government
Anonymous	

1. Please confirm your name, position, organisation, and sector (e.g. research, industry, government, agriculture, water, infrastructure, etc.)

Rob Allan,
International ACRE Project Manager, Climate Monitoring and Attribution Group, Met Office Hadley Centre.
Editor-in-Chief, Geoscience Data Journal
Member of the WMO Commission for Climatology Expert Team on Data Rescue
Adjunct Professor, International Centre for Applied Climate Sciences, University of Southern Queensland.
Research

Andrew Ash
CSIRO
Agriculture

Greg Ayers
Former Chief, CSIRO Atmospheric Research (2002-2005), Chief CSIRO Marine and Atmospheric Research (2005-2009), and Director of Meteorology and CEO, Bureau of Meteorology (2009-2012). I do not represent any organisation – this is a private submission.

Bryson Bates
Chief Research Scientist, CSIRO Oceans and Atmosphere
Research

Nathan Bindoff
University of Tasmania
Research

Sonia Bluhm
Climate Change Science Officer, Department of the Environment and Energy (Government)

John Church
CSIRO
Research

James Duggie
Principal Policy Officer – Adaptation, Department of Environment Regulation
Sector: government (state)

Mark Gibbs
Director: Knowledge to Innovation, Queensland University of Technology
Research

Harry Hendon

Senior principal research scientist, Climate processes team leader, climate change and variability program (seasonal prediction)
BoM
Sector: Research

Kevin Hennessy
Principal Research Scientist
Leader of the Climate Variability, Extreme Weather and Adaptation Group
CSIRO Oceans and Atmosphere

Robert Henson
Meteorologist and blogger, Weather Underground
The Weather Company, an IBM Business
Sector: private

Lesley Hughes
Macquarie University, Wentworth Group of Concerned Scientists, Councillor with Climate Council of Australia, Director, WWF-Australia, Director of Biodiversity Node, NSW Adaptation Research Hub, former IPCC lead Author, 4th and 5th Assessment Reports, Working Group II. My personal research area is the impacts of climate change on Australian biodiversity but I spend a lot of time doing climate change communication.

Greg Hunt
Executive Officer, South East Councils Climate Change Alliance, an incorporated association of 8 local governments on whose behalf we conduct climate change response projects in both mitigation and adaptation

David Karoly
Professor of Atmospheric Science, University of Melbourne
Research Sector

Peter May
Head of Research, Bureau of Meteorology, research, Govt.)

Chris Mitchell
Executive Director Seafarms Group Ltd

Antonio Mozqueira
Manager Climate Change Policy, Environment and Planning Directorate, ACT Government.

Josephine Mummery
Currently at the University of Canberra (PhD candidate), Griffith University (Senior Research Fellow), the Open Digital Earth Foundation (General Manager), and the Earth Systems and Climate Change Hub Steering Committee (independent member)

for the National Environmental Science Programme, Department of the Environment.

Neville Nicholls
School of Earth, Atmosphere & Environment, Monash University

Michael Nolan
Chair, UN Global Compact - Cities Programme, RMIT University
Research (Cities) sector

Jean Palutikof
Director, NCCARF
Research

Graeme Pearman
Director, Graeme Pearman Consulting; Adjunct Senior Research Fellow; Monash University; Professorial Fellow, Melbourne University.
Scientific research related to climate change and energy futures.

Jon Petch
Head of Science Partnerships, UK Met Office
UK Government.

Neil Plummer
Assistant Director Climate Information Services, Bureau of Meteorology
government (science and services)

Andy Pitman
Director of the ARC Centre of Excellence for Climate System Science
(Research sector)

AJ (Tony) Press
Adjunct Professor, Antarctic Climate and Ecosystems Cooperative Research Centre, and the Institute for Marine and Antarctic Studies, University of Tasmania.
Sector: Research

KS Tan, Senior Water Resources Engineer, Melbourne Water
Bruce Rhodes, Manager Water Resources Management
Melbourne Water
Sector: urban water corporation

Steven Sherwood
ARC Laureate Fellow
Director, Climate Change Research Centre, University of New South Wales

Will Steffen
Councillor, Climate Council

NGO

Susan Solomon
Ellen Swallow Richards Professor of Atmospheric Chemistry and Climate Science at MIT, Cambridge, MA USA

Lynne Turner
International Centre for Applied Climate Science (Research), University of Southern Queensland

Tas van Ommen
AAD, Senior Principal Research Scientist, Program Leader: Antarctica and the Global System.
ACE-CRC Co Program Leader: Cryosphere and Oceans
Chair, Australian Academy of Science, National Committee for Earth System Science Research

Penny Whetton
Honorary Research Fellow, CSIRO Oceans and Atmosphere; Honorary Fellow, School of Earth Sciences, Melbourne University.
Climate research.

Matthew Riley, Director Climate and Atmospheric Science
David Hanslow, Senior Team Leader Coastal and Marine Science
Kate Wilson, Executive Director Science
NSW Office of Environment and Heritage
Australian state government

Geoff Withycombe
Executive Officer
Sydney Coastal Councils Group Inc.
Local Government

Tony Worby
Chief Executive, Antarctic Climate & Ecosystems CRC
Research

Anonymous, Water - Government

Anonymous

2. What is your relationship to the ACCSP programme?

During the 1990s I worked in the Climate Impact Group at the then CSIRO Division of Atmospheric Research at Aspendale in Victoria, holding the following positions:
1999-2000: **Principal Research Scientist:** Climate Impact Group, CSIRO Atmospheric Research (CAR), Mordialloc, Victoria, Australia.
1994-1998: **Senior Research Scientist**: Climate Impact Group, CSIRO Atmospheric Research (CAR), Mordialloc, Victoria, Australia.
1990-1993: **Research Scientist:** Climate Impact Group, CSIRO Division of Atmospheric Research (DAR), Mordialloc, Victoria, Australia.
--

Formerly, I was the CSIRO Climate Adaptation Flagship Director, which housed the climate impacts work and climate projections work in CSIRO. For both of these work areas we required outputs from climate models, including ACCESS.
--

Between 2002 and 2012 I had responsibility for CSIRO's or the Bureau's participation in and their scientists' very wide variety of contributions to the ACCSP programme.
--

Principal CSIRO investigator for ACCSP project joint with BoM.
--

I am employee of the University of Tasmania and ACE CRC. My position is joint with CSIRO. The ACCSP has never funded my research activities or salary.
--

I have been the Department's ACCSP manager/administrator for the last 5-6 years (with one year off in 2014).

This has involved contract development and management, Government financial management and reporting, assessing project proposals for policy relevance to the Department, attending ACCSP Oversight Committee meetings and Annual Review Meetings, reviewing communication products and reports, and general day to day involvement in the programme, primarily through the ACCSP Management Team (CSIRO).

Also, another part of my role is to provide climate change science advice to the Department and Minister. This requires the regularly use of ACCSP research outcomes for input into:

- Ministerial briefings
- Policy papers or reports
- Briefs to departmental executive
- Correspondence with other Ministers and the public, and
- International briefing packs for Australian delegates attending relevant international scientific and policy fora.

--

Participant
--

Currently no formal relationship.

I'm a state government end user of the program's research and advisor to other climate change adaptation practitioners who may use climate change science research results.

The Indian Ocean Climate Initiative was climate science research collaboration between the Western Australian Government and CSIRO and BoM. For the full period of the Indian Ocean Climate Initiative Stage 3 program (2008 – 2012) I was a colleague, in the same Climate Change Unit, of the 'Technical Specialist' that managed the IOCI Stage 3 program on behalf of the Western Australian State Government. My Director was on the IOCI Board for this program. I attended every Workshop or stakeholder meeting that the IOCI Stage 3 program held.

Since 2009 I have been a jurisdictional representative for WA on national climate change adaptation fora (e.g. currently I'm a member of the National Climate Change Adaptation Research Facility's Project Review Committee, and of Adaptation Working Group that reports to the Meeting of Environment Ministers).
--

From a previous role, as Deputy Chief CSIRO Division of Marine and Atmospheric Research/Deputy Director, CAWCR
--

Had a one-year project in 2014 (with Ming Feng) on ocean processes, otherwise not involved, just an interested bystander.
--

CSIRO researcher partly supported by the ACCSP from 1989-2015
--

Science writer who occasionally calls on ACCSP literature (esp. the annual reports)
--

I use the outputs of the program on a regular basis, to provide context for research, and as a basis for many of the outputs produced by the Climate Council. The researchers funded by the biodiversity node all rely on the ACCSP outputs, as did the authors of Australia-related IPCC chapters.
--

SECCCA is a user of the knowledge generated through ACCSP.
--

First involved in parallel program in the 1990s through the Australian Greenhouse Office and Federal Government Dept's National Greenhouse Advisory Committee research grant. The ACCSP arose at a similar time as the NGAC funding and expanded when the NGAC funding stopped as the funding was directed to CSIRO/BoM rather than universities.

Hasn't had any formal involvement with ACCSP in terms of specific joint research projects or jointly funded activities.

But has had a lot of collaboration with CSIRO and BoM scientists funded by ACCSP, and has been used by ACCSP and Govt Department on associated communication activities around IPCC, climate change projections, etc.
--

Oversee the Bureau contributions, sign off on proposals, member of the proposal assessment committee.
--

I was previously employed by CSIRO and coordinated the Program and was the formal account manger/liaison with the government departments responsible for the program (1990-2001 approx.). Subsequently was CSIRO Theme Leader for the Theme with the largest footprint within the ACCSP and the established the Centre for Australian Weather and Climate Research (2004-2008).
--

Previously when employed by the then Department of Climate Change, I was in-charge of administration of the ACCSP on behalf of the Department.

In my current role as Manager Climate Change Policy for the ACT Government, I am a second-tier user of data and advice generated by the ACCSP informing our mitigation and adaptation policy development.

Information is also used to engage with the broader community and regional stakeholders.
--

Previous senior executive manager with responsibility for the ACCSP in the Australian Greenhouse Office, and the Departments of Climate Change, Industry and the Environment.
--

I coordinated the Bureau of Meteorology involvement in ACCSP for the period 2000-2005. My own personal research received little or no funding from the ACCSP in this period or before or after. I have not been involved at all since the end of 2005.
--

Throughout my career, I have worked with ACCSP research and teams as a consultant and advisor to governments and private sector.
--

None, knows the program and informally interacts with staff in ACCSP. But no actual interaction at the program level.
--

I was one of the authors of the original Department of Arts, Science, Sports, Environment and Territories climate change research program 27 years ago; for five years Assistant Chief of the CSIRO Division of Atmospheric Research (1987-1991) followed by 10 years (1992-2002) as Chief of that Division and thus responsible for the Divisional support of the ACCSP Program. For several years I acted as Director of the CSIRO Climate program which at one stage entailed 14 Divisions of CSIRO contributing to climate change research across a wide spectrum of areas. Much of this activity was underpinned by central ACCSP funding. Following retirement from CSIRO I acted, for a short period, as Chairman of an oversight committee for the Program.
--

We are a partner of BoM and CSIRO as members of the Unified Modelling partnership.
--

Largely as a client of the research and deliverables from the ACCSP.
--

None: No ACCSP funding went to universities, so no relationship. Was never asked for advice or had any other interaction so far as I recall. Has been on high level climate change coordination group and other committees, but unclear if these interactions were linked to the ACCSP.

This questionnaire is the first time he has been consulted on ACCSP. Universities were expressly excluded.

What was part of the ACCSP or not part of ACCSP was never clear. The universities were not part of ACCSP, but transparency of the programme to people outside was not there, and what climate science is included in the ACCSP is not clear to outsiders.

Questions about what science was enabled by the ACCSP could be turned around to ask how enabling was the ACCSP, what outcomes existed that couldn't otherwise be achieved? The ACCSP was one of the foundations in Australian climate science, and so outcomes of it should be seen in the context of other programs.
--

I was on one of its science advisory committees; some ACCSP funds were allocated to the Antarctic Climate and Ecosystems Cooperative Research Centre (ACE CRC) and to the Australian Antarctic division.
--

Water industry stakeholder (user of ACCSP products and information, and industry partners in research e.g. ARC linkage projects)
--

I have been an external collaborator on one proposal, I think 2012 or so.
--

Reviewed the programme in 2006 (with Susan Solomon).

Had a longer relationship with the ACCSP, from 2004 to 2007 was an advisor to the Federal Environment Dept (and its predecessors, including the AGO), so had an ongoing interest in ASSCP activities.

Has connections with researchers individually and the programme generally, particularly around the formulation and establishment of the ARC climate change Centre of Excellence (in his role as Director of ANU climate change institute), working with Andy Pitman, David Karoly and others. The 2006 Review had found that the BoM and CSIRO were collaborating well, but Unis were fragmented and not involved in the ACCSP. So as funding was limited, the Review recommended that the Unis get their act together through the ARC system. ARC had strong relationships with the ACCSP written into its plan. This helped build a more integrated climate change science capability across BoM, CSIRO and the Unis, which was a major achievement of the programme.

This legacy of how ACCSP developed is important to this day, and goes well beyond the programme's lifetime. Thanks to the ACCSP we have built a climate change science capability in Australia that draws on relevant expertise across the CSIRO, BoM and Unis. The role of the ACCSP is still an ongoing factor in discussions about the future of climate research in CSIRO, due to its role in building and maintaining this capability: the ACCSP was the major attempt to bring collaboration across all institutions working in climate change.
--

I have worked with many scientists involved in ACCSP as part of the IPCC reports on climate change and the WMO/UNEP stratospheric ozone assessments. I believe that I also served on a review team for the ACCSP program about 10 years ago.
--

- Collaborator (2007-2010) – QCCCE/CSIRO collaboration running CSIRO3.6 experiments to contribute to CMIP 5. Used outputs to inform ClimateQ – Queensland's Climate Change Adaptation policy

- End user (2015-2016) – Central Slopes Cluster NRM Stream 2 investment – used the projections and the Climate Futures framework to incorporate projections into a range of modelling tools and applications.

--

Through AAD and ACE-CRC I have worked closely with researchers in ACCSP and also through connections in the Department of the Environment have been involved in the ACCSP more officially, in minor ways.

--

My research activities and those of my group were in part supported by ACCSP for many years. I was the leader of a project on 'Climate Projections Science' for many years.

--

As a state government agency, we are primarily consumers of ACCSP research outputs. Sought advice from ACCSP scientists on our science and research programs. We have directly accessed advice on sea level rise through collaboration and through commissioning advice (John Church and Neil White).

We liaised extensively with the regional climate modelling group (Penny Whetton) while both ACCSP team and our group (OEH in collaboration with UNSW) were undertaking regional climate projections.

--

Has had long-term relationship for more than 12 years with CSIRO on climate science, and with the BoM. But a bit confused about what the ACCSP is in terms of the program, so there is a branding issue around what ACCSP is.

--

When at AAD/ACE CRC was aware of program, but didn't have access to funding. When at CSIRO, knew that scientists relied on ACCSP funding but wasn't close to process
Primary involvement has been the way the ACCSP and ACE CRC have leveraged each other. This has been an excellent outcome for both programs.

--

No direct relationship. Knowledge from ACCSP-funded research informs MDBA policy discussions and decisions.

--

Manager from 2003 to 2014.

--

3. What level of awareness do you have of (a) the ACCSP and (b) its research results?

Directly, only from when I worked at the CSIRO Division of Atmospheric Research in the 1990s.
--

I am familiar with the overall goals of the ACCSP and its history, including the long-term partnership with the BoM and the more recent involvement of key universities. I have not been close to the program for the last three years so I am less aware of recent achievements. Research results have had a significant impact on Australia being able to effectively contribute to the IPCC process and, in particular, Working Group 1.
--

Good historical awareness.
--

I have been involved with the ACCSP and its predecessors since 1991, but not on a continuous basis. Therefore, my knowledge of the ACCSP and its achievements is fragmented to say the least.
--

I have modest awareness of the ACCSP program. I am aware of the scientists and the broad outcomes and if I can attribute their work to ACCSP then my knowledge of the ACCSP and its research results is clear.
--

High for both a) and b) due to both roles described above in Question 2 - awareness of ACCSP through management of the programme on behalf of the Department, and awareness of research results due to my climate science advice role within the Department.
--

Relatively detailed
--

I have been active in the climate change adaptation policy field for eight years, so I am reasonably aware of some elements of the ACCSP of the last eight years. I am somewhat aware of the program from before then. I don't have a comprehensive knowledge of all elements of the ACCSP.
--

Reasonable
--

Broad level of awareness. Not the detail of what went on, especially in areas of ocean, carbon cycle, but broadly aware of scope and longevity of the programme.

In some areas much more aware than others, especially in the climate variability area, implications for ENSO.
--

(a) I'm deeply aware of the ACCSP because I've been involved since 1989
(b) I'm very familiar with results from Component 6 "Regional projections" and reasonably familiar with results from the other Components
--

Some familiarity with major products, meetings, etc. Some familiarity with particular research results.
--

The Climate Council research staff and Councillors keep as up-to-date as possible with new data produced by the ACCSP to use in our publications. We do this via personal contacts with ACCSP staff and via their publications and web material.
--

I do not have a broad awareness of ACCSP, I know of the items that have been of direct use to my organisation.
--

Generally aware of what's been done, and the massive advances in climate modelling capability and its application, from very familiar with the series of CSIRO GCMs (Mark 1, 2, 3 etc.), the BoM's modelling activities, ACCESS, BMRC, CAWCR.

Also involved in oversight through membership of the High Level Coordinating Group on Climate Change Science established by the Dept to develop a national climate change science framework, to provide recommendations, strategy and plan for the Australian climate change science, including ACCSP.
--

High in both – it has been a core research program for the Bureau
--

High until about seven (7) years ago
--

I am well aware of the role and functions of the ACCSP from my prior positions with both Commonwealth and ACT governments.

I am aware of the research results of the ACCSP, in a broader sense, as in my current role I mainly consider outputs in climate science, especially projections and impacts.
--

My level of awareness is lower than it should be, given the role of ACCSP. Partly this is because apart from the period 2000-2005 when I coordinated Bureau involvement in the ACCSP, I was not directly involved in the ACCSP, or in direct collaboration with scientists funded through the ACCSP. My research was largely funded through mechanisms separate to the ACCSP.
--

a) high and b) high
--

Was on the government's High Level Coordinating Group on Climate Change Science that provided ACCSP guidance. Involved in the ARC CC CoE at UNSW – some overlap with ACCSP assumed.

Knows to obtain information required from Climate Change in Australia (CCIA) website, although it is unclear if this is ACCSP.

Aware of climate change research in Australia, but there is a branding issue for program, as it is not clear what research results are tied to the ACCSP. But it doesn't matter if the results are ACCSP or not, as long as they are accessible.
--

The ACCSP activities covered broad aspects of climate change research, and thus it was difficult to stay abreast of all of its programmatic work. This has even been more difficult after retirement from CSIRO. But I have remained interested in much of the activities, particularly through the published works of the Program, but also through personal ongoing connections with some of the research scientists.

With these restrictions I have remained reasonably familiar with the research results of the Program, particularly as I have used these results in many presentations of climate science to the wide private sector, public sector and community audiences. For the period 2002 to 2012 this numbered over 500 presentations. The aim was for me to remain, as far possible, familiar with the latest research, the only rationale for contractors to seek my input, and in some areas to support my own research particularly related to the theoretical limits to the use of bio-fuels.
--

Very little but good awareness of the aims of CAWCR while it existed. We have jointly developed our modelling capabilities which are referred to as the Unified Modelling system in the Met Office and ACCESS in CAWCR. We have collaboration around related science beyond simple modelling development such as attribution work etc. through Peter Stott and his colleagues.
--

High level of awareness as one of the key clients.
--

(a) Reasonable awareness of the ACCSP, commonly from conference presentations and posters, and acknowledgements to ACCSP in papers.

Knows Federal Government valued it very highly, as seen from ongoing funding to the BoM and CSIRO.

Some areas important in his view were resourced. But he isn't aware of what the priorities were annually, or who was or wasn't funded by ACCSP.

(b) Has the profound feeling that the quality of the science wasn't commensurate with the level of funding. This is because when money came in, CSIRO and the Bureau had to fund people they had on staff to do the work. So a lot of the work was fine, some was of high quality such as by Wenju Cai, Ying Ping Wang, and others, but the money in general did not build capacity that is sustainable in an effective way, Universities can invest in young capability, but Bureau and CSIRO does not have this capacity to bring on new talent. However, noted that funding universities would not have been a positive result as the alternative unless formal structures were created to enable Universities to deliver. The NESP might be an example.

ACCSP did have some impressive outcomes, but these were disproportionate to the money involved. The resulting research capability scaffolding and results not as impressive as you would have expected from the level of funding.
--

I have a good level of awareness of the program and its science outputs.
--

(a) the ACCSP – moderately high
(b) its research results – moderately high
--

I am roughly aware of how it works but do not know broadly what it funded.
--

Very high
--

The work conducted by Australian scientists, including that under ACCSP is well known to scientists worldwide. ACCSP has fostered outstanding science in the past, and I am aware of many key research results that were carried out under ACCSP. I have studied a number of key papers, heard scientific presentations, and examined the findings relative to others on many occasions over the years through scientific assessments under IPCC and UNEP/WMO, so I am fairly familiar. Like many others, I am aware of the attempts by the bureaucracy to cut it, and am deeply concerned about this since I feel it would be a huge loss to world science. While I am aware of a number of ACCSP's leading accomplishments, I'm sure I don't know about

everything they have done. I may also not know in detail of every study what climate research may fall officially under ACCSP and what may be done under different auspices in Australia.
--

- Low in terms of the ocean and atmospheric monitoring and modelling (have seen presentations of the results at greenhouse conferences) – however obviously understanding what is happening in terms of circulations, temps and acidification important – just not relevant to my current role.
- High in terms of the Australian Climate Futures framework (was on the end-user panel) and the regional projections.
- Medium in terms of aerosols and process modelling.
- Low in terms of the emissions of high CO2eq substances such as SF_6 and others - however I do feel this is an area requiring far more investment and communication – think has lots of potential in terms of mitigation policy (e.g. can we really justify tin foil in kitchens and hair salons if that's the footprint?? Same is true for around 70 other substances – really need better info on these their greenhouse intensity and the service they provide to society to inform the policy response).

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a) Fairly high generally and detailed for aspects. b) Fairly high generally and detailed for aspects.
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Reasonably high awareness, although I am less in touch with its achievements in its last year.
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a) High level of awareness across multiple research areas (GHGs, carbon budgets, climate modelling, observations, oceans, etc.)

b) Lots to list here: development of ACCESS, Cape Grim baseline monitoring, paleo-climatology and Law Dome ice cores, Global Carbon Project and its website and RF from different carbon sources, Climate projections for Australia and its website, climate futures tool, regional climate modelling, climate extremes, global chemical transport modelling and the role of aerosols in rainfall and global cooling, sea level rise.
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(a) As in q. 2, limited awareness about the program itself.

(b) Great awareness of the research at CSIRO and the BoM, from obtaining climate information, to directly working collaboratively with many parts of CSIRO across Oceans and Atmosphere, Land and Water, and those in the social science area. Sydney Coastal Councils Group (SCCG) has worked on collaborative projects with

CSIRO worth in excess of 2-3 million dollars in grant funding, on work including that that led to a 2009 Eureka award for climate research.
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Very aware of it being around for a long time, it became known in a generic sense as a brand for funding climate science from Federal Govt. High level of awareness of the programme, but not aware of the granularity of exactly what it was funding.

For most of the ACCSP life, Tony was at the AAD so while aware of the program there was always an understanding that this was funding for CSIRO and the Bureau, not others.

Then at CSIRO there was the feeling that it was funding that just went to a small part of the CSIRO and BoM.

So level of awareness high, but also an understanding that it was a closed shop. But that's not to say it didn't achieve a lot.
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a) The level of awareness of the ACCSP in the MDBA is low. Our perspective on this is that ACCSP seems largely to be a funding body and for whatever reasons has not promoted a significant public profile.
b) Much of the ACCSP research is not directly relevant to the work of the MDBA and in these cases, level of awareness is low. Where ACCSP-funded research results are of direct relevance to the MDBA (i.e. South Eastern Australia Climate Initiative – SEACI), awareness is high. The more recent work that ACCSP has funded on climate projections (i.e. Climate Change in Australia portal) is also likely to support MDBA action on climate change.
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Strong.
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4. What are your overall impressions of the ACCSP?
I'm not best placed to comment about recent times, although I know that the whole CSIRO situation has been made most precarious by several waves of cuts since I left in 2000. This has put its role in providing vital monitoring, analyses and research on Southern Hemisphere weather and climate in a difficult position. The international ACRE initiative that I lead does have a small project with a CMAR colleague and a Melbourne University academic, and we would like to do more with bodies like CSIRO if situations arise.
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The ACCSP has had a long history of continuing support (until recently). This has allowed it to tackle science challenges requiring longer time horizons e.g. observations and monitoring, development of climate change models.
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A well-targeted, highly productive, internationally benchmarked national climate science program that has served the national interest extremely well. Not expensive, given the plethora of high quality outputs and the formation of a national collaborative capability able to underpin multiple downstream outcomes, such as policy advice and climate risk assessment for a diversity of industry, commerce and societal sectors.
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It was an invaluable and irreplaceable science-based initiative that has delivered a great body of knowledge about our climate system in a highly cost-effective manner.
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Over the past 27 years, the ACCSP has been Australia's longest running and 'core' climate change science research programme – providing a long term and relatively stable platform for both climate scientists within CSIRO and the Bureau and the Federal Government Department responsible for climate change policy development.

The ACCSP has continued to expand its influence both nationally and globally through the development of a strong national and international reputation for the delivery of quality climate science research and for supporting world leading climate experts.

The programme has contributed hugely to national and international knowledge on the global and Australian climate system, not only through the provision of high quality scientific results, but also through the many interactions, collaborations and engagements with many national and international research projects, programmes, organisations, initiatives and assessments.

The science performed under the ACCSP has been world leading, and has generally been focused on priority research areas identified by all three partners (CSIRO, Bureau and the Department) and, more recently, the broader Australian climate

change science research community. This has resulted in the ACCSP developing a level of flexibility in its objectives and areas of research focus, allowing it to shift and change to reflect changing Government and climate change science information needs. This has been instrumental in ensuring the programme outputs have remained useful and relevant to stakeholders.

The ACCSP has enabled the development of close and long lasting relationships between the CSIRO, the Bureau and the Department. This has been so important in the successful delivery of the programme over the last 27 years and has, and will continue to, play a large role in the success of the Earth System and Climate Change Hub within the National Environmental Science Programme (NESP).
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A huge success, although one can always make constructive criticisms
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ACCSP has been a highly successful, very valuable and influential science research program. It has provided some of the core climate change science research needs for federal, state, and local governments and other business and community sector stakeholders. It has played a central role in the advancement of understanding of climate patterns in the Southern Hemisphere, the effect of climate change on those patterns – a better understanding of the physical processes of how climate change is effecting climate in Australia and the oceans of the southern hemisphere.

ACCSP has also been an important contributor to a range of international climate science collaborations, including the International Panel on Climate Change.
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Fantastic- one of the most significant and longest running research programs ever delivered in Australia
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Main impression was that it was a fantastic program because it was driven by the science, rather than being focussed on practical outcomes and deliverables. There was a long term commitment and investment in basic understanding of the science, with no prior expectation of the direction the science was going – the direction jointly guided by scientists and the Department.
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Over the past 27 years, our understanding of Australia's past and future climate has improved radically through the work of the ACCSP. The research is world-class and underpinned by high quality peer-reviewed literature. Other projects such as SEACI, IOCI, VicCI, PCCSP, PACCSAP, NRM and NESP ESCC leveraged the ACCSP and added value. However, there was limited uptake of the science outputs by next/end-users, so outcomes and impacts are hard to measure. Insufficient resources were invested in management, communication and knowledge-brokering.
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A sound, useful, and important enterprise.
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The ACCSP is an incredibly valuable program and as a climate change scientist I rely heavily on the credibility and expertise provided.
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A program such as ACCSP is of fundamental importance to users of knowledge. Making practical, evidence-based responses to the many climate change impacts with which local government has to deal is not an optional extra in service delivery. Projections of changes in frequency of extreme weather events for emergency preparedness, the conduct of planning schemes for coastal development and the delivery of community services for aged residents with heightened vulnerability to heat stress are just some of the issues for which there is the need for the best possible data upon which to base responses.
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Overall, the ACCSP was very successful in leading a broad-ranging and focussed activity on climate monitoring, observations, modelling, impacts research in atmosphere, oceans, and lots of other areas. It has been a very successful programme.

But can't say what the boundaries are between ACCSP, BoM, CSIRO, SEACI, IOCI and other research programmes – those boundaries were sometimes fuzzy. That's okay to have fuzzy boundaries – joint investment in these activities is really important. Co-investment is important, and having brands from various partners involved is fine. Hope that the powers that be don't require single and unique branding, as that would not enable multiple organisations to be involved in research. Important in partnerships to share branding.
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This has been a long standing flagship project that has delivered vital science in informing public debate and government policy as well as providing leading edge science. Adaptation work has been reliant on this basic research.
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The ACCSP was critical for building and then maintaining core scientific capability in relation the the science underpinning climate change, but also climate process understanding, inter-annual climate variability and outlooks of climate variability on seasonal timescales. The program also delivered the scientific knowledge and understand for others within the science community and elsewhere to explore and understand the potential impacts of climate change (unmitigated), the impacts of climate change under various mitigation scenarios and requirements in relation to adapting to climate change.

In terms of biogeochemistry the Program supported key science in relation to greenhouse gases: emissions, sources and sinks; the carbon cycle; non-CO2 greenhouse gases.
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I have always been impressed with the calibre of the researchers, the institutions they work in and the results they produce. The ACCSP is a significant asset to the country and makes an invaluable contribution to the understanding of global climate science. The Southern Ocean and Antarctica are key drivers of global climate and Australian research centred in these vast areas of the world is a major input to global efforts.
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The ACCSP has been a small and catalytic climate change science program that consistently delivered world-class research and model development, in a complex area of national interest, with very modest funding relative to the scale of the research challenge. The quality of the program and its research outcomes have been recognised in previous independent reviews, for example:

“The ACCSP has produced an impressive body of work that has clearly been state-of-the-art and world class: i.e., of the highest impact on climate change science, on par with the best achievement obtained by the top research groups internationally.” (from Solomon, S and Steffen, W. (2006). Australian Climate Change Research: Perspectives on Successes, Challenges, and Future Directions. Prepared as part of a review of the Australian Climate Change Science Programme, p.4)

A key function of the ACCSP has been its role in driving the national coordination capability that underpins delivery of the top science priorities identified in the National Framework. The stability of the core funding of the ACCSP, and the high quality of its research outputs, enabled establishment of collaborative approaches, including between CSIRO and the Bureau of Meteorology, leading university researchers and international science organisations. This collaboration delivered world-class research, efficiencies and a critical mass in science capability.

Climate change science is not a short term research field that can be readily switched off and then on again. The skills and precision required to identify climate change from high variability on long-term records, to develop complex GCMs tailored to regional climate, and build on a substantial multi-disciplinary body of research across large parts of the Southern Hemisphere to determine likely changes for Australia, require a long-term perspective. The stability of the program since 1989 enabled delivery of fundamental science and the building of research capacity which cannot be achieved through short term ARC grants.

The implications of climate change for society and the complexity of international negotiations to reduce greenhouse gas emissions have also demanded a climate change science program aligned with policy priorities. As noted by Solomon and Steffen, “the ability to identify and focus scientific activity on issues that are of the

highest priority to inform policy … make the ACCSP unique in the Australian climate change science management system … and a hallmark of, and essential to, the excellent performance of the programme to date."

Much of the research delivered by the ACCSP is not being supported by other research programs. Australia has the lead climate science capability in the Southern Hemisphere, and the bulk of global research is focussed on the Northern Hemisphere. The differences between the Hemispheres in ocean, terrestrial and cryosphere environments mean that research findings from the north cannot be assumed to be relevant to the south.

Finally, funding for the ACCSP has had a real term decline since 2004, resulting in reduced capacity to deliver at a time when demand for information and support in accessing and understanding climate science was increasing.
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Much of the work undertaken through ACCSP funding would have been conducted anyway, but at a much lower level and would have been less productive and useful without ACCSP funding.
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World leading research and well respected. Very strong experience in Australia, Pacific and Asia. High confidence in research results. Considered peak body for climate projections and related impacts research.
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As in 2 and 3 above, not really aware of what science is actually part of the ACCSP.

Commented on the persistent trend towards an expectation by governments for the same amount of research for less and less money. That simply doesn't work, so we are moving into a bad situation for Australia, with impacts globally, due to the importance of work on Southern Hemisphere climate processes, El Nino and Antarctic research – if Australia isn't doing this type of research, there are global implications as well as national ones.
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ACCSP has been a cornerstone of Australia's scientific research on aspects of climate change. While it is important to note that in dollar terms, the contribution of ACCSP were a relatively small component of the total expenditure in this area of research, it significantly leveraged support from CSIRO and the Bureau of Meteorology.

It is difficult to quantify just how significant this research has been in terms of developing both public awareness, and private and public sector policy development. The role of ACCSP, through both its publications and the wider community communication of scientific results should not be underestimated. At one time, during the early stages of the ACCSP and related research activities, Australia was regarded by the UN as having one of the most well-informed

communities globally on the issue of climate change. This only happened by having a well-informed, internationally respected and communicative research community.

The program, particularly in its early days, produced fundamental results related to the global carbon cycle, oceanic circulation, the physics of radiation penetration of the atmosphere, and so on. It also supported the ongoing development of a national climate modelling capacity that at one stage was assessed to be within the top three models in the world.

The impact of this knowledge in terms of assessments of Australia's potential exposure to climate change has been an exemplar of the way such a program and its results can lead to practical, nationwide, advice to underpin risk assessment by specific companies, by sectoral leadership, and by governments at all three levels.

The science generated by the ACCSP and related research activities has, as one might expect, varied in its quality, related both to the capabilities of individual scientists, and the difficulty of the work encountered. But overall, there is no question, that the quality of the research, and therefore the return on investment from that particular point of view, has been extremely high. The publication record of work coming out of ACCSP has been excellent and this has contributed to the respect of the individual scientists internationally and to the program itself.
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It is a brand I was not aware of although we considered CAWCR a key partner for our weather and climate research.
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An excellent scientific programme that has provided substantial public good and helped maintain Australia as an international leader in climate science.
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Broadly positive. It was an important program. The consequences of not having the program are clear: as seen by CSIRO imploding now due to the loss of the ACCSP and associated funding. ACCSP provided a foundation for CSIRO activity that when lost turned the foundation into a bed of sand.

Best illustrated with an analogy: It was like the ACCSP funded the development of a Ford Fiesta – certainly a functional car but not a Lamborghini. It runs reliably, all is fine, but it lacks flair. A lot of ACCSP work lacked flair. Perhaps its aim was to deliver against objectives, rather than being about discovery and world-leading science; if this was the aim then it did deliver. If the aim was world class science then it delivered to some degree.
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I believe that in the time that I was engaged with the ACCSP (from mid-2000s) the funds were generally well targeted to priority climate change science.
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A successful national science programme that facilitates and supports peer-reviewed research in climate change science both nationally and internationally. In particular, the ACCSP contributes to the science used/reviewed by the Intergovernmental Panel on Climate Change (IPCC).
--

The process seems to have involved superficial proposals for (sometimes) relatively small amounts of money and short durations. I think this may have fragmented the research and led to many researchers in the agencies splitting their time between multiple projects, and/or frequently switching projects. I am also not sure how carefully proposals were vetted, as it was a closed process with no involvement from (for example) experts outside the agencies.
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High quality.

There was a tension between what the Government wants (more immediate, consultancy-type results), and what science and scientists need to do to be world class (with publications in the top journals, etc.). In the end the Department was pleased with the science outcomes. From 2005 to 2010, with climate change being more prominent as a political issue, the ACCSP played a role in responding to what the Dept wanted for input to the IPCC, adaptation, and more. The ACCSP managed to get the mix right between new science and more immediate material of use to Govt in policy briefs. Furthermore, the ACCSP enhanced the interaction with Govt without detracting from the quality of the science.
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My overall impressions are extremely positive. ACCSP has been one of a handful of programs in countries worldwide that have been leading players in bringing forward key scientific advances.
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High quality fundamental research in an area of high impact in terms of public good and policy.
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The ACCSP has been a very successful long-term initiative that placed Australia at the forefront of global climate science. The building blocks and individual ingredients for this prominence already existed and no doubt some of the successes would have emerged without ACCSP itself. What the ACCSP did, in my view, was to build community and resource a research backbone that actively fostered cross-linkages that made the whole much greater than a sum of parts. The fact that the ACCSP was, for much of the time, somewhat inward focussed in its structures was an impediment to those of us in the wider climate community gaining fuller engagement – and this was probably the only serious shortcoming. Despite this, the conference series and the strength of the backbone provided by ACCSP, together

with an increasing outward focus in the later years were a significant improvement and a gave a promising trajectory by the end of the program.
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ACCSP enabled a large body of research to be undertaken that was essential for Australia to respond appropriately to the problem of climate change. It supported long term world class observational and modelling programs that would have been unlikely to be funded any other way in Australia. It provided the necessary foundation (such as in the projections area) for more applied research supported by other agencies.
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ACCSP was a large and comprehensive program that enhanced Australia's reputation in delivering global climate science
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The branding issue aside, very impressed with the science; it is very accessible, world-leading, and relevant to management applications at SCCG.
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A behind-the-scenes funding body for a range of scientists, research agencies and special projects (e.g. SEACI).
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A world leading program that undertook outstanding and highly relevant research. The program achieved great results; far more than one would expect from the level of funding. It significantly advanced national and international climate science. The program also supported a range of policy initiatives at state and federal level and spawned a number of Australian regional environmental programs, including SEACI and IOCI.
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5. What are the top (a) scientific and (b) other achievements that come to mind in relation to the ACCSP?

Basically in climate change scenarios, baseline monitoring and research in the Southern Hemisphere and engagement with various Australian State Governments in the 1990s on climate change issues.
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(a)

- Monitoring of greenhouse gases at Cape Grim and its contribution to global monitoring of GHG
- Ocean process understanding, especially related to the Southern Ocean through research voyages and associated modelling
- Ocean observations of temperature, salinity, acidification, especially in the Indian ocean and equatorial regions of the Indo region
- Sea level rise observations, satellite monitoring
- Better understanding of extreme weather events e.g. tropical cyclones and how they might change with increased GHG
- Development of the ACCESS model and its contributions to both weather (BoM) and climate change (CMIP 5)
- Climate change projections for Australia

(b) Organisation of the Greenhouse conferences which not only informed a wider audience about the ACCSP but also provided a forum for industry, government and science to come together to discuss climate science, mitigation and adaptation.
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Too many to mention. The Annual Reports provide comprehensive lists of the key science outputs updated on an annual basis. The “other achievements” are also numerous, with particular value produced in what I'll call downstream reports where the basic science underpinned projections of a wide range of likely future climate change risks and impacts, on things like sea level rise, coastal erosion, temperature extremes, precipitation changes, water resources, marine habitat and marine ecology changes, agricultural impacts (e.g. wine and grapes), ski resort snow levels, natural disaster risk and insurance to name just a few.
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- Greater understanding of the role of the Southern Ocean in the global climate system.
- The creation of and ongoing enhancement of ACCESS

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(a) ACCSP has created a very influential set of science capabilities that have informed the third, fourth and fifth assessment reports of the IPCC.
a. These capabilities have included CMIP3 and CMIP5 simulations that have performed very well in the international arena. Indeed the ACCESS CMIP5

simulations were by some objective measures the best simulations of all the contributions from all participating nations.

b. The CCAM model, for which I have enormous respect for, being used in the Climate Futures of Tasmania and Climate Futures of Australia simulations, and indeed its continuous refining grid (the cubic conformal grid) has an enormous appeal. The combination of the ACCESS and CCAM gave CSIRO an advantage in its ability to take global simulations at coarse resolution to fine-scale, relevant to adaptation and impacts study in the climate area.

c. The cape grim facilities, the gas lab, and monitoring of the composition of the atmosphere is a critical element of understanding climate the drivers of climate change. The concept of the gas lab is that it has allowed the retrospective examination of past composition of the atmosphere. The cape grim is one of the few high quality monitoring stations in the Southern Hemisphere. We continue to monitor the changing amount of uptake in the atmosphere and oceans (e.g. recent papers of declining uptake, and now increased uptake, most recent including Bronte Tilbrook) and the atmospheric measurements including CO2 are part of this.

d. The global carbon project is another ACCSP project that has played an important role in the discussion of the global budget (Pep Candadell). The annual releases of the carbon budget by the international consortium has played a key role in keeping the scientific and global community abreast of the changing carbon budgets for the earth.

e. Australia's contribution to the ARGO program, and CSIRO's contribution to understanding the evolving heat budget of the earth. ACCSP has played a leading role in the global oceans monitoring, on XBT corrections and on understanding of heat content changes, including recent papers on the increasing role of the southern hemispheres in recent times, and work on the climate hiatus.

f. Sea-level research and the contributions of the various components in the earth systems. Its attribution to human influence.

g. The contributions by CSIRO scientists to IPCC to second, third, fourth and fifth assessments. This includes the big names and the smaller names within CSIRO.

h. The projects like PACCSAP, NRM (all part of the ACCSP) have provided invaluable climate information to the Australian community and Pacific Island nations.

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a) Scientific achievements (primarily over the past 3-5 years) – obviously there have been many specific achievements over the life of the programme, but a few higher level achievements from my point of few include:

- Oceans – development of ocean monitoring networks/programmes to measure such variables as salinity, ocean heat etc. and to track changes in these variables, i.e. measurements by ships, moorings, satellites and Argo floats.
- Atmospheric greenhouse emissions and carbon budgets – Monitoring and research of greenhouse gases – i.e. long term monitoring through the Cape Grim facility. ACCSP researchers have played a leading role in the development and delivery of the Global Carbon Project and have developed a complete carbon balance for Australia.

- Modelling – ACCSP has supported huge advances in Australia's modelling capability, resulting in the development of ACCESS and the ability to contribute to international modelling programmes (i.e. CMIP's).
- Projections – ACCSP investment in better modelling has enabled the development of climate projections for Australia. The latest version, released in 2015, represents the most comprehensive, regional and detailed projections produced to date. They have been taken up extensively by researchers, industries and governments.
- Extremes – ACCSP research into extreme events has increased understanding and attribution of extreme events in Australia. This has included observations and projections, with particularly confidence in projected increases in extreme heat and heat waves across most of Australia, and attribution of recent record warm periods (i.e. 2013 spring).

b) Other achievements (primarily over the past 3-5 years) include:

- The ACCSP has punched above its weight in terms of the number of ACCSP scientists involved in the development of IPCC Assessment Reports.
- Engagement with the broader Australian climate research community, including collaboration with such national organisations as the ACE CRC, IMOS, AAD, AIMS, NCI, Goyder Institute, ARC Centre of Excellence for Climate System Science, other Australian Universities etc.
- Similarly, ACCSP's collaboration and involvement in various international research programmes and initiatives, such as the IPCC, WCRP, IGBP, CMIP's, ARGO etc., and engagement with international research organisations within Japan, America, UK, China, France, Germany, Sweden, NZ, etc.
- Production of over 100 peer reviewed scientific papers every year.
- Development of strong and lasting relationships between the CSIRO, Bureau and Department.
- The key role ACCSP played in encouraging a more cohesive Australian climate research community, including participation in the development of policy relevant papers by the Government, (i.e. the Framework and Implementation Plan for Climate Change Science in Australia). These policy papers led to a clearer and articulated national climate science research agenda for Australia.
- Delivery of GREENHOUSE climate change science conference series to communicate the latest climate science research to policy makers, researchers and industry.

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a. Building of a climate change science team, Observational programs of the ocean and other components of the climate system, Incorporation of parameterisations to represent ocean eddies in the climate model, regional climate change projections for Australia, major progress in understanding and projection regional sea level rise

b. Awareness of climate change in the Australian community; regional climate change projections

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(a) The Indian Ocean Climate Initiative investigations into climate variability and possible climate change in South West Western Australian, particularly in IOCI Stages 1 and 2 helped establish that the changes in climate and in particular rainfall in the that regions could be in part attributed to human induced climate change. This was concluded at a time when it was one of the first places in the world such attribution could be made.

The development of global climate models, and of climate change projections from these have been a crucial contribution to climate science understanding.

(b) ACCSP program has played a very important role in increasing the awareness of the most up-to-date climate change science in Australian among government, business and community sector organisations. The climate change projections that have been prepared through the ACCSP have been used in many Western Australian local government and some state agency climate change risk and vulnerability assessments. The ACCSP program has therefore played an important role in triggering, and then supporting climate change adaptation activity in Australia. This climate change adaptation activity, including the adaptation planning based on climate change risk and vulnerability assessments and the subsequent associated implementation of adaptation measures will have reduced the current costs of the impacts of climate change, and will no doubt be significant contributor to future savings from avoided climate change impact costs (as climate change proceeds and causes larger impacts and costs).
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ACCESS, ACCESS, ACCESS
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Advancement of modelling capability, i.e. ACCESS
CO2 monitoring, ice core work
Comprehensive understanding of how Australian climate works in the context of global climate.
Understanding how El Nino impacts may change in a future climate
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(a) The 1992, 1996, 2001, 2007 and 2015 national climate projections (the 2007 and 2015 projections were partly supported by ACCSP) were used in many impact assessments. The Global Carbon Program (GCP) improved our understanding of global carbon sources and sinks. Development of the ACCESS climate model, it's use in CMIP3 and CMIP5, and its incorporation in national projections highlighted the importance of having this national modelling capability. Improved understanding of Southern Ocean processes fed into the GCP, ACCESS, national projections and a range of other applications.
(b) The ACCSP developed and established strong partnerships:

i. between CSIRO and BoM. Having joint projects and workshops enabled these partnerships to flourish. Media releases associated with key publications raised the public profile of CSIRO and BoM, who became trusted advisors on climate science. ACCSP research underpinned the popular BoM-CSIRO State of the Climate reports in 2010, 2012 and 2014.
ii. between the research agencies and the government funding agency (AGO/DCC/DCCEE/DIICCSRTE/DotE). This grew through a sustained and strategic engagement process led by the ACCSP Management team. It was critical for governance, milestone delivery, issues management, contract negotiations and ongoing funding. This partnership also had benefits for government funding of research projects outside the ACCSP, such as $1.4 m for research on climate extremes and $5.1 m for climate projections through the NRM planning for climate change fund.

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Wide range of peer-reviewed research
Awareness-raising on topics such as ocean acidification and drought
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I don't have any specific achievements in mind – rather, I value the consistency and credibility of the expertise provided.
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The localising of climate change impacts to the regional scale that is of real relevance to our councils is the most immediate beneficial achievement that comes to mind. At a general level, research into the major drivers for weather systems from the ACCSP gives us a lens through which understand and communicate the changes that we all are experiencing.
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The most important achievement has been the continued development of climate modelling capability from CSIRO Mark 1 through Mark 2, 3 and to ACCESS, and the shared modelling capability across timescales in the climate and weather research communities.

Science achievements:

- improved understanding of what's happening in the Southern Ocean, monitoring of the southern ocean's temperatures, CO2 and oxygen profiles. These have been very important for Australia.

- Improved understanding and modelling of El Niño, how it changes, and its impacts on Australia.

- Higher resolution regional scale modelling, and downscaling modelling to understand regional impacts.

- Also models' contribution to CMIP, and contributions to international science.

Most important outcomes are the climate change projections – 2015 also badged with NRM – as well as earlier ACCSP projections in 1990, 1992, 2007. These have allowed for improved understanding of climate impacts, and outreach to stakeholders who need the information for decision making.

Interactions with universities, and capability that CSIRO and BoM had through ACCSP, was key to enabling graduate students at universities to learn how to use research outputs. Support of ACCSP researchers was important in training university researchers, up until the formation of the ARC CC CoE.

Also important is the capability for Australia to be involved in the IPCC assessment process; providing lead authors with strong science reputations to be involved in these roles. Australia had a greater representation relative to its population than any other country, partly thanks to support from ACCSP.

These achievements show the importance of underpinning and continuing funding that ACCSP provided.
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National projections data such as NRM.
Instrumental in the development of a world class Earth System Modelling capability
Understanding of key drivers of variability including ENSO, IOD and SAM
Pioneering work on carbon budgets and GHG budgets.
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(a) Scientific achievements: - Too many to mention *in globo*

- Heat budget of the Southern Ocean
- Contribution to the global Argo program
- Estimates of sea-level rise (both historic and future)
- High resolution paleo-records of atmospheric constituents derived from ice cores – particularly methane
- Development of a climate modelling capability
- Development of scenarios of climate change
- Risk-based methods for assessing potential future impacts.

(b) The program was also instrumental in the development of young scientists who via a variety of pathways became internationally or nationally significant scientists. Professor Matthew England (for example) undertook a post-doc within the ASSCP

The ACCSP also assisted in institutional changes such as much improved collaboration within CSIRO (the Climate Change Research program was the first successful multi-divisional research program within CSIRO and this was established

off the back of the initial ACCSP) and between institutions: notably the Bureau of Meteorology, but also between CSIRO and universities and CRCs.
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There are a range of programs that have served to build up the knowledge base and expertise contained within the ACCSP. Equally, the linking of the ACCSP with international efforts has ensured that Australia is at the forefront of knowledge.

From a policy perspective, bringing together all of these treads of information and being able to communicate it to politicians, managers and the community has been its greatest achievement. Communication and extension work must continue to be delivered if the program is to be truly effective.
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There are numerous areas where ACCSP scientists have delivered outstanding and world class research outcomes. These span fundamental and applied science, and model development, and include:

- The development of the Australian Community Climate and Earth System Simulator, ACCESS, supported and facilitated by the ACCSP, has demonstrated Australian capability to perform with the world's best model development agencies in a short period of time. Since commencement in 2005, ACCESS has delivered model runs for the Intergovernmental Panel on Climate Change (IPCC) *Fifth Assessment Report*. The model inter-comparison project found that ACCESS performed better than virtually all other global models in simulating the Australian climate – an outstanding achievement in a very short period of time.

- Australia is surrounded by vast ocean bodies which have a major influence on our climate as well as the global climate, and are changing in response to anthropogenic greenhouse gas emissions. This research has always been a core part of the ACCSP, and there have been numerous world-class contributions to our understanding of oceans and sea level rise, including:

    - The role of the Southern Ocean as the world's largest carbon sink, the extent to which it is changing and the implications of such change for the speed of climate change and the global carbon budget
    - The importance of relative drivers of sea level rise, and regional projections of sea level rise that recognise the variability around the Australian coastline
    - Breakthroughs in understanding the role of the Southern Ocean and Antarctica in the global thermohaline circulation, which prior to the ACCSP had been poorly understood
    - Major new insights into the links between oceans and terrestrial rainfall patterns, particularly across southern Australia.

- The Global Carbon Project, an international collaboration supported by the ACCSP and led by Australian scientists, has delivered a robust scientific framework to understand the extent and magnitude of the emission mitigation challenge to avoid dangerous climate change. To be effective greenhouse gas emissions mitigation initiatives need to have a measurable and significant impact on the atmosphere and its concentrations of greenhouse gases (and not just be assessed against policy targets and claimed potential outcomes of measures).

- As noted previously, the ACCSP delivered science that was policy relevant. Climate science underpins climate mitigation, adaptation, and international negotiation policy objectives. More broadly, climate change science is directly relevant to human health and well-being, terrestrial and oceanic productivity, and the resilience of natural ecosystems (including their capacity to deliver ecosystem services) as well as the built environment.

    - The ACCSP delivered new understanding of the capacity of Australia's soils and vegetation to be carbon sinks. As noted in the ACCSP 2012-13 Annual Report – "on a unit-area basis, the Australian terrestrial carbon sink operates at only 40 per cent of the strength of the global average terrestrial sink" (p. 18). This finding, as well as the research outcomes from the Tumbarumba flux station on the high variability in carbon uptake of Australia's forests, illustrate that it is not possible to draw on global average research findings in the design and implementation of policy settings and measures in Australia.
    - Australia is a country that frequently experiences extreme weather such as drought, fire and flood, and the intensity and impact of such events directly links to a wide range of policies related to such matters as building codes, engineering standards for transport infrastructure, natural disaster management and emergency evacuation planning, insurance premiums, and coastal management. The ACCSP has provided a core focus and leadership in understanding how such weather extremes will change with climate change, in addition to projected mean changes in climate.

- Accurate and long-term records are critical to enabling the detection of change, and Australia as a leading science capacity in the Southern Hemisphere makes globally important contributions to the climate record. The samples of pristine air from Cape Grim since the 1970s for example play a vital role in a global network that enables scientists to precisely measure changes of atmospheric composition over time.

- As noted in the response to question 4, a strength of the ACCSP has been its leadership in effective national research coordination and strategic science planning. This has enabled Australia to address its own unique research challenges, and to leverage off and contribute to regional and global science.

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Development of Australian climate modelling capability; production of climate change scenarios; Australian involvement in IPCC; Australian involvement in aspects of climate change science such as estimation of climate sensitivity; increased studies of the nature and causes of natural and anthropogenic climate variations (to a lesser degree than the other achievements on this list).
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Climate futures NRM projections
Australian climate change projections and effects technical report
Pacific climate change projections
Multiple coastal climate change impact assessments considering storm surge, sea level rise and erosion
Multiple research projects on climate change risk to infrastructure and assets related research
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Contribution to IPCC and CMIP modelling activities is the only one that stands out. Hope they can participate in the upcoming IPCC 6AR.
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Difficult question to respond to given the many achievements from the ACCSP. I think I would identify the following:

- The contribution to the understanding of the global carbon cycle, fundamental to anticipating future climate change related to hypothesised future emissions;
- The construction of a world-class climate model specifically designed to study of climate change and thus identify risk;
- The development of an understanding of the Southern Ocean and entirely ocean circulation is through unique observations and dynamical studies;
- The linking of climate change science to the very specific needs of sectors such as viticulture, alpine tourism, stone fruit industries, et cetera;
- The periodic production of assessments of Australia's exposure to climate change rendering the most up to date science in a practical way for the community.

The program has impacted on the operation of the CSIRO GasLab program which has had broader implications for both the international regulation of emissions of chlorofluorocarbons and ongoing relevance to the monitoring of other gases identified as being potentially important.
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From our key relationship as a modelling partner, the key achievement was the delivery of CMIP submissions with a modelling system utilising components of the Unified model.
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(a) Using model simulations to understand the likely changes and their impacts, and represent an Australian contribution to the IPCC Fifth Assessment Report (AR5).

(b) The contribution of Australian climate science to improving understanding of climate change globally.
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The most important thing seen was the delivery of CMIP5 and ACCESS related science: building of that infrastructure. But he is very worried about the longevity of those programs now. ACCESS was a bloody miracle. But nothing about it has longevity, it is not operationalised and there is no system in place, it is software in place for now that is threatened without ongoing funding. But a huge achievement nonetheless.

Also the accumulation of observations of ocean and air, IMOS and Ozflux

These were profoundly enabling programs – the basic infrastructure around observations and modelling are irreplaceable and important contributions from the ACCSP.

In terms of other science discoveries: the work as reported in papers by Ying Ping and Cai were achievements, and assumed ACCSP funded. There will be many others but determining which were / were not ACCSP is problematic.
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(a) scientific achievements

Better understanding of the drivers of Australian climate

Better ability to predict climate outcomes (water/ drought etc.)

Better projections of Australian climate futures

Better understanding of ocean processes

The development of the ACCESS model and the linking of research communities

The development of the Centre for Australian Weather and Climate Research (CAWCR).

(b) other achievements that come to mind in relation to the ACCSP?

Improved Australian contributions to international initiatives such as the Intergovernmental Panel on Climate Change; and to national and international policies to combat climate change.
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(a) Work with the Bureau of Meteorology and CSIRO to initiate/invest in the Australia's weather and climate forecasting system.
(b) Promote and support climate change forums e.g. the Greenhouse conference series
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Much nice work has come out of CSIRO and BoM but I do not know what was funded by ACCSP and what not.
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(a) SEACI is a highlight, given the importance of the water cycle for communities, the economy and environment. Excellent science coming out of this area in terms of changes in variability, circulation patterns, etc. (although a failing was not including Uni research as much as could have been, prior to the formation of the ARC CC CoE). Would have been very hard to do this work without the ACCSP and related social capital that it built.

Climate projections, having them done at a national level. The 2015 report was a step change in effectiveness.

(b) The social capital of a community of researchers, bringing together those who previously hadn't collaborated well, and bringing together user groups and Govt groups and improving their understanding of what science can and can't do.
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Among other scientific accomplishments, some of the ones that come to mind immediately are:

- the global carbon project and its extraordinary accomplishments in understanding carbon emissions, their changes with time, their relationship to fossil fuel use and the economy
- ACCSP scientists have provided frontier findings on understanding changes in a wide range of ozone-depleting and climate forcing agents including chlorofluorocarbons, atmospheric aerosols, nitrous oxide, carbon dioxide, perfluorocarbons, hydrochlorfluorocarbons, and hydrofluorocarbons.
- Definitive studies of weather patterns in Australia and elsewhere in the region depend not only on the ENSO but also on the sea surface temperatures of the Indian ocean, and the southern annular mode (SAM). Our knowledge of climate and its links to modes of variability in this area owes much to leadership work in ACCSP
- Seminal studies of drought, which have established that drought is becoming more severe even for the same amount of rainfall, due to global warming.
- Major advances in understanding sea level rise, particularly its driving factors including thermal expansion and ice loss

Among other achievements related to the science:

- the monitoring record of the Cape Grim observatory, which are one of a very limited number of stations worldwide essential for understanding changes in greenhouse gases, ozone-depleting substances, and aerosols. If this record did not exist or if it were to be lost, there would be a huge hole in our knowledge that cannot otherwise be filled.
- leading contributions to the ARGO ocean measurement system, which is unique in the world and has substantially enhanced our understanding of how heat is taken up in the ocean, as well as sea level rise and ocean circulation, since its inception.
- leading measurements of ocean acidification and the documentation of change in ecosystems including the Great Barrier Reef
- outstanding contributions by individual scientists as authors and leaders in IPCC and UNEP/WMO science assessments, which have been instrumental for global policy.

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BOM has had an operations based culture. I think the opportunity to engage at a research level has improved their operational skill as well as providing them with better tools, approaches and understanding that they would not have been able to achieve without this partnership. The greenhouse conferences have been a valuable opportunity to discuss the science in detail – niche opportunity that you don't get at NCCARF or other climate change conferences. Think it is important for Australia's climate science community and climate change public policy that these biennial events to review the science in some detail continue.

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There have been a slew of major science achievements across the program that make choosing "top" ones somewhat unhelpful. From my perspective the underpinning science achievements provided by ACCESS are pivotal and while I would call this an "other" achievement because it extends beyond the mere science, it is central to so much of the science that it rates at the top. The strengthened observational science is a major achievement and the oceanographic work has been a great achievement. I think the work on Southern Ocean change has been particularly valuable for Australia to pursue from a national-importance and globally significance perspective. This is work that we should be driving. The other strand of achievement that has been necessary and timely has been the building of climate science tailored to Australian needs: this includes the projections for Australia and the improved understanding of processes controlling Australia's climate and weather.

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I will probably not be able to remember ones I should remember but the scientific ones that come to mind are the ACCESS model development and our much improved knowledge of Southern Ocean climate – both of which would not have been achieved without ACCSP funding. Without the foundation provided by the ACCSP, Australia would not have been as well served as it has been by the provision of world-class climate change projections.

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a) Scientific achievements:

- Global carbon budget – particularly partitioning radiative forcing impacts from different carbon pools
- The Ozflux network, e.g. Tumbarumba and improved understanding of carbon fluxes from land surface processes
- Addition to paleoclimatology record from work in Antarctica
- Southern Ocean science – acidification, circulation changes, Southern annular mode, sea level rise
- Improved understanding of tropical meteorology
- Indian ocean dipole understanding plus interactions with El Nino – and El Nino influences on Australian climate variability

b) Other

- Driving the development and implementation of ACCESS – bringing multiple researchers from multiple institutions together
- Keeping climate science front and centre in policy discussions
- State of the climate reports were of particular assistance
- The ACCSP really enhanced the scientific reputation of Australia as a whole
- It delivered a concerted and integrated program of climate science that was clearly recognised

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(a) SCCG and CSIRO winning the Eureka award in 2009 was a highlight. This research and recognition provided the momentum that led to SCCG doing 8 years of climate research and activity, obtaining almost $10 million in external funding. The achievements range from pure science to applied research and then the flow of this into management.

(b) Providing essential benchmarking and pure science activities – with the physical monitoring of the environment one of the biggest achievements. The research also leads to Australia being on the world stage, which makes us all proud of the contribution to science globally. The relevance of outputs, and how they are customised for specific regions and stakeholders, is an achievement. The program has maintained support for climate science and ensured its and relevance across Australian society.

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(a) From his perspective, main awareness is through the work of Steve Rintoul (physical oceanography) and the carbon work, all leveraged with ACE CRC funding. For most of the past 20 years the ACE CRC and ACCSP worked together to deliver outstanding results in understanding the Southern Ocean and long-term change, dynamics of the Southern Ocean and Antarctic circumpolar current, the uptake of carbon, ocean acidification, etc. These were among the top results coming from the programme.

Importantly, the CSIRO staff funded by ACCSP couldn't have delivered what they did without the resources from the ACE CRC and support of field observations at sea. The leverage between the two programs helped deliver a whole that was greater than the sum of its parts.

(b) Leveraging as mentioned above. Didn't get a sense that there was a lot of emphasis on adding value after the research, to engage with end users and feed into policy. If it was there, wasn't visible.
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Ongoing monitoring of the atmosphere and oceans, regular production and communication of national climate change projections, a world class climate modelling system, insights into national and international emissions and uptake of greenhouse gases, insights into the role of the Pacific and Indian Oceans on Australia's climate. The ACCSP was undoubtedly the foremost programme of its kind in the southern hemisphere. There were important advances in aerosol and cloud science, and in understanding of extreme climate events.
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6. What is your assessment of the quality of the scientists in the programme and their international standing?

Most are of very high quality, but are having to increasingly work under a regime of reduced staffing and budgets with continually lowering morale. Staff attrition and cuts in the latter part of my time with CSIRO, and especially since I moved to the UK, have left even the combined CMAR staff very vulnerable. This is especially in the face of the vagaries of politics, and especially climate change sceptics and deniers in and underlying successive conservative governments.
--

The quality of the scientists and their international reputation is very high. Both the observational and modelling work makes invaluable contributions to global research on climate change with considerable influence and impact in the IPCC process. This level of reputation is evident both in journal publications and requests to participate in international meetings. The proposed reductions to climate science in CSIRO has drawn considerable international interest, largely because of how highly valued the ACCSP science is globally.
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Top notch. Many of the individuals involved have been internationally recognised as experts in their fields. Their publications records and lists of invitations to international meetings and representation on international programme committees or other scientific and policy bodies attest to the high esteem in which a large number of Australian climate scientists from the ACCSP have been held.
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Outstanding. This demonstrated by the awards given to and benchmark papers written by ACCSP scientists.
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ACCSP scientists cover a spectrum, from ordinary to world class scientists with a truly outstanding reputation. However, I believe it is the program that has built CSIRO's reputation in climate science and the program that has been greater than the individual, and this is why the collective program has such high reputation…. Perhaps a case where the sum of individuals has had greater impact than any single individual.
--

ACCSP scientists represent some of Australia's leading climate researchers, many of which are also world leading scientists in their field.

The high quality of the programme's scientists can be seen in the large number of peer-reviewed journal articles they produce each year (many in high impact journals), the number of ACCSP scientists who have been involved in the development of IPCC Assessment Reports, and the number of programme scientists involved in and/or holding leading roles in international programmes and initiatives

(i.e. Global Carbon Project, ARGO etc.). These roles in international programmes and involvement in IPCC reports are also indicators of how highly regarded ACCSP scientists are within the global climate research community.

A number of ACCSP scientists have also be awarded various awards recognising their expertise, including being made fellow's of the Australian Academy of Science, nominated for the Eureka Science Prize etc.
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The program contained a number of international leading climate scientists, and some others of world standing. Overall though, the program lagged behind major international activities because of the limited scale of resources.
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The quality of the scientists in the ACCSP program has been of very high international standard. For the elements of the ACCSP program I have been exposed to the scientists have been of a consistently high standard.
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Most good to exceptional, but patchy in places
--

Seems high quality, involving top people.
Key people were big players internationally (Scott Power, Cai, Paul Fraser), all important internationally
--

The Program has encouraged recruitment and retention of talented scientists, many of whom are now highly regarded internationally. The number of papers in high impact international journals such as *Nature, Science* and *PNAS* is a testament to the quality of the research and the level of international collaboration. Many of the ACCSP scientists have been invited to be lead authors or reviewers of the IPCC assessment reports, members of international committees/panels, and keynote speakers at conferences. Some of the ACCSP scientists are considered domain experts nationally and internationally, and are key points of contact for stakeholders and the media.
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I have a very positive impression of ACCSP scientists.
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I think that Australia is blessed with outstanding climate scientists and am extremely distress at the gutting of this expertise due to the CSIRO staff cuts. This is reprehensible.
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Steffen, Pittman, Karoly, Braganza and Griggs are some of the scientists associated with ACCSP with whom I have had contact. They are outstanding and well-regarded professionals who bring great credit to the STEM in Australia.
--

Scientific standing of those involved in IPCC outstanding. Not everyone can be a world leader, and probably don't want everyone to be a world leader, as teams need some people who are important as support scientists and people developing their careers. But there have been some outstanding international scientists. You can see the development over time, like succession planning, of people who started in support roles in the ACCSP who developed into internationally recognised scientists.
--

Overall very high. Many are internationally recognised with some world leaders in their fields
--

With any reasonable-size program conducted over many years the quality of the scientists varied from genuinely outstanding to competent. It would be unrealistic to expect that every scientist was outstanding. Many have/had genuine international reputations and from all benchmarks were considered to be world-leading.
--

The capability of Australian scientists is reflected in their contribution to the Intergovernmental Panel on Climate Change assessment reports, and to international science programs. A number of the ACCSP climate scientists are outstanding and well-recognised for excellence.
--

First class. The international standing of Australian climate science has been strongly enhanced through the work conducted under the ACCSP.
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The quality of research is very high. At the present time, the international standing is high, but in light of CSIRO cuts there is a partial misunderstanding that national policy around climate science and CSIRO policy are the same – in Australia you would make a distinction between the two, but internationally the view is that the quality of science is high but this standing is under threat due to national policy.
--

Both CSIRO and Bureau of Meteorology have strict criteria for the employment of staff, so that the quality of the scientists is second to none. Of course other factors, not identifiable at the time of appointment of scientists, can influence their subsequent performance. This is to say nothing of the fact, that all scientists, from time to time, will be confronted with trying to resolve hypotheses that turn out to be unresolvable. But by far the majority of scientists employed by these organisations

associated with the ACCSP have been of excellent quality and have attracted significant international standing.

The latter is demonstrated by a combination of citation rates, invitations to conferences, and invitations to be key players in the International Program on Climate Change, as Leading Authors or Authors of particular chapters. As an employer of many of those scientists, I have no regrets about appointments made.
--

There are many strong scientists within the BoM and CSIRO who contribute to model development and weather and climate science.
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Very high quality and the ACCSP has assisted in highlighting this internationally.
--

Brutally, a large fraction of BoM and CSIRO scientists are not internationally outstanding, but there are obviously some that are. It may well be this lack of world-leading capability is a result of how BoM and CSIRO scientists are required to work – against operational needs or short-term contracts. Neither lead naturally to breakthroughs.

Assessing this is difficult because there are different metrics between ACCSP organisations and others.

ACCSP scientists would have been more people competitive on the global stage a decade ago, but now staff are driven by short-term contracts so can't provide vision of big, long term scientific achievements over next 5 years. This is due to nature of the organisation.

Some of the world's best scientists in this area have historically been in CSIRO and the Bureau, but rejuvenation of capability and bringing in the next generation has not been a focus, so it is now shocking that CSIRO is getting rid of the next generation of talent in much of the current cuts.

Simon Marlsand, Ying Ping, Richard Matear, Tony Hirst and others were involved in CoE re-bid because of their outstanding in science and/or capability. Others may be outstanding against CSIRO metrics, but may not be against metrics used elsewhere.
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In the main, excellent. Australia's international standing in climate science (as reflected in Australia's participation in the Intergovernmental Panel on Climate Change) was greatly enhanced by the funds and focus of the ACCSP.
--

Highly regarded internationally. However my impression is that majority of the scientists in ACCSP are drawn from the CSIRO, Bureau of Meteorology (and their CAWCR partnership) and major universities in Australia.
--

Well it is mixed of course — there are some very highly renowned scientists and some less so
--

Can assess this well from his involvement in international science (IGBP) and working closely with WCRP: when looking at individual WCRP and IGBP project steering committees, requiring someone from southern hemisphere, the representative would invariably be Australian, and it stood out how many of the representatives from the southern hemisphere were CSIRO people. So the presence was strong, and highly respected.

You see that international awareness and respect of ACCSP scientists playing out today following the CSIRO cuts – there have been unprecedented protests by people around the world due to the long history of international, high level engagement.

Areas of research such as the carbon cycle, complex system science, sea level research are world leading, and have come out of the CSIRO system.
--

There are many leading scientists in the ACCSP program whose contributions are well recognised as world-class.
--

Mixed. I think that it is important to acknowledge the capacity building nature of the programme though as well. Someone needs to grow the skills and talent, we all need to start somewhere – the programme did have a good mix of youthful energy and experience and maturity.
--

First rate.
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There is a remarkable number of climate scientists of world class level. This demonstrated in part by the significant role ACCSP scientists have played in the IPCC.
--

World-class scientists (in multiple fields) and recognised as such by the international scientific community
--

Very high, SCCG has worked with some of the leading climate scientists at CSIRO, which has been a privilege. ACCSP researchers have great international standing, as

seen from Geoff's travels around the world, where practitioners internationally always know of the research, and his presentation of collaborative work, which is always well-received.
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Of the ones he knows, they are world class, top of their field, and have excellent international standing.
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We only feel qualified to answer this question in relation to the SEACI program. The scientists involved in SEACI were leaders in their field and we believe were highly regarded in the research community.
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Internationally leading, as demonstrated via publications, citations, conference invitations and presentations, stakeholder briefing requests. My assessment is supported by those of external reviews. And there was that Nobel Prize.
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7. What is your opinion on the contribution and value of the ACCSP to (1) Australia and (2) global climate science?

Vital for both (1) and (2), especially when it comes to programs monitoring and analysing regional to Southern Hemisphere weather and climate
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Have answered the international component in Q6. In terms of Australia, the work on projections (part funded out of the ACCSP) has been invaluable in underpinning work on impacts and adaptation. Most recently that has been through the NRM project which provided the vehicle for development of new projections for Australia. These outputs have been used in a wide range of sectors from agriculture and NRM to urban and coastal planning.
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Profoundly important in both cases. The annual reports again provide the detail, the many specific scientific outputs. Independent evidence that the Australian climate science outputs were internationally valued is clear in the furore internationally over CSIRO's decision to exit climate change science. The 3000+ signatures and numerous public pronouncements by the international leaders in climate change science condemning CSIRO's action and seeking its reversal is cogent, powerful evidence of the universal view that Australia's' contribution to global and local understanding of climate science is at the highest level. ACCSP has been the central organising process harnessing Australia's world-standard climate science to deliver to the global, as well as local communities.
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The contribution to global climate science can be gauged by the number of international awards and prizes given to ACCSP scientists, and the recent international furore over cuts to CSIRO's capability in climate science.
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I judge the ACCSP as an extra-ordinary contribution.
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1) The contribution and value of the ACCSP over the past 27 years to Australia, in my opinion, has been large. ACCSP has been the 'core' research capability within Australia, from which other organisations and agencies have been able to build upon and progress our understanding of the climate system. Without the ACCSP I believe Australia today would not have a strong enough understanding of our climate system to be able to inform climate change policies and decisions. This would result in even more risks to our industries, businesses, governments and environment than already exists.

Without the ACCSP Australia's climate science capability would still be small, patchy, potentially duplicative, and with no clear direction.

2) The ACCSP has provided valuable and high quality Southern Hemisphere climate information to assist in the development of truly global climate assessments, such as the IPCC. Therefore I believe that ACCSP has played a valuable role in global climate science, increasing the global understanding of the Earth's climate system. In addition, Australia has assisted developing countries within our region (primarily the Pacific) to increase their climate science capability too – helping to ensure that those most vulnerable to climate change in our region are better prepared for the impacts of climate change than they otherwise would have been.
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i. Enormous contribution, that would not have been possible without the ACCSP.
ii. Important contributions in some specific areas.
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(1) Answered under other questions.
(2) ACCSP has made a major contribution to global climate science. One that is disproportionately larger compared to Australia's relative population and economy size compared to many developed countries of the world. Australia's location in the Southern Hemisphere has further added to the relative importance of the observation programs and climate science research results, given the very few advance climate science programs in other Southern Hemisphere countries.
--

Substantial contributions in specific areas. My personal view is that the hydro-climatology and tropical atmospheric research were the standouts.
--

ACCSP enabled more understanding of fundamental aspects of the Australian climate that we wouldn't have otherwise known. It was the best thing that ever happened for improving our understanding of Australian climate.

Enabled Australian science to play prominent roles in global science, such as IPCC.
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(1) The ACCSP has made a significant contribution to our understanding of Australia's past climate variability, the associated causes, and projections for the 21st century. For example, in 1987, CSIRO produced a 4-page monochrome statement about Australian climate projections by 2030, with short (mostly qualitative) statements about seven climate variables. By 2001, the ACCSP produced a 2-page and 8-page colour brochure about Australian climate projections in 2030 and 2070 for nine variables, plus a 2-page and 8-page colour brochure about Australian climate impacts. The value of this information has been high according to some key stakeholders (e.g. AGO/DCCEE/DotE and State governments) and it has certainly raised public awareness about climate science, but uptake in decision-making is hard to quantify because there has not been a monitoring and evaluation framework.

(2) The ACCSP has made significant contributions to global climate science, especially through (i) measurement and analysis of greenhouse gases in the Cape Grim / GasLab / IceLab / GCP activities, (ii) ocean measurements and analysis, (iii) global sea level rise research, (iv) ocean acidification research, (v) Indo-Pacific Ocean variability research and (vi) Southern Ocean process research. The value of this information has been high in academic circles (e.g. high impact journal papers, invited presentations at conferences), and through involvement in the IPCC process, and membership of various committees contributing to the WCRP, IGBP, GOOS, etc. Uptake in decision-making is hard to quantify because there has not been a monitoring and evaluation framework.

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I believe ACCSP and similar national programs (e.g., USCCRP) are invaluable mechanisms for bringing resources and attention to bear on climate change as a multifaceted, long-term issue. I can't speak to (1), as I'm not based in Australia.

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As above, outstanding contributions

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ACCSP scientists have made major contributions to the IPCC's assessment reports, representing Australia's interests to great advantage and in turn contributing the wealth of research from Australia to the international understanding of this greatest of challenges. In partnership with NCCARF and the program of communication of research generated by our scientists, the Australian community is much better informed on these issues than would have been the case.

At the local government level, councils have been able to use the understanding generated by our scientists to frame effective responses for community care and protection.

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The value is very high – but can't quantify it in terms of dollars or return on investment, as that would underestimate the value. A lot is not quantifiable in terms of dollars – such as the establishment of climate modelling capability, the value of projections and their value to various sectors to plan for climate change impacts, the training of students and career development, and the science needed to plan for mitigation of climate change in Australia and globally, as well as planning in Australia for impacts of climate change and of El Niño. All these contributions are unquantifiable.

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The program has provided very good value in underpinning science and the development and maintenance of national capability in climate modelling and observations as well as the interpretation of climate data. Much of this has contributed at the international level e.g. CMIP, sea level monitoring, GHG

measurement, carbon budgets. I could continue this for many pages if you want detail, but the key message here has been the influential and critical contribution of ACCSP to the basic understanding of Australian climate, its variability and climate change at both the global and continental scale.
--

One of the major contributions to Australia, was that much of the research resulted in the development of scenarios and then projections of climate change for use by Australians for decision-making, planning, risk management, policy analysis and other purposes. These scenarios were contentious at the outset, were a product that was refined over the years and yet were critical in framing decision-making in a wide variety of contexts. They have been used in State of Environment reports, many government policy documents that were used to frame the need for policy and action and so on. Later generis outputs were specialised that enabled scientists to explore the potential impact of climate change on questions of interest.

Beyond science outputs the ACCSP enabled Australia to claim some scientific sovereignty in relation to climate change science ensuring that the view of climate change was not solely a northern hemisphere one. This was a key argument used to maintain support for the program from governments.
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The value of the ACCSP as a lead program that drives coordination and collaboration and delivers cost-effective research that aligns with national priorities, is extremely high to Australia and globally important. As noted in the response to question 4, we cannot assume that research in the Northern Hemisphere will be relevant to the Australian climate. This will become even more evident in coming decades as the impacts of climate change, which can be of high economic, social and environmental cost, affect more communities. Australia is highly vulnerable to the effects of climate change, and a robust and tailored knowledge base to understand and support management of these effects is critical.

With leadership roles in many areas of Southern Hemisphere oceanic and terrestrial sink research, Antarctic research, and research into tropical systems, the ACCSP has made many contributions to an improved understanding of global climate, how it is changing, and the capacity of the global science community to simulate that change.
--

Without the ACCSP Australian climate science would have made only small contributions to global climate science, in the areas the ACCSP focussed on (especially modelling). In other areas, e.g. documentation of changes in Australian climate, some trace gases measurement and analysis, Australian contributions to global climate science might still have been strong without the ACCSP. The major contributions to Australia from the ACCSP would be the higher international regard for Australian climate science, the availability of better projections of Australian climate change, and the improved capability for climate modelling.
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1. Huge impact and enabled significant climate adaptation industry and government action and progress.

2. Significant contribution globally to scientific methodology and communication to enabling adaptation
--

The global-level contribution has mainly been through IPCC and representation on other international bodies.

NCCARF relies heavily on climate change science data for adaptation research based on changing climate and related impacts. They need information and expert guidance on on climate change – could do it within NCCARF, but it is better coming from authoritative source.

CCIA website addresses some, but in no way all, their needs. For example, sea-level rise information used in Coast Adapt required extra funding to get the specifics on sea-level rise at a national level. Couldn't have got this data into the tool without extra NCCARF funding. Scientists haven't discussed with users what their needs are – there's a tendency for scientists to say what practitioners need. But users need to say what they need, then sit down with scientists to work out what to research and deliver. Need a one-to-one dialogue and pay to get what you want.

NESP has less capacity to do fundamental research than ACCSP. The whole funding package is thinner than what was available in the past. The collaboration between CSIRO and the BoM is hence threatened. Scientists can't keep doing more, or even the same, with less.
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The ACCSP has directly, and via its leveraged research, contributed enormously to Australia by the:

- Provision of access to the wider world of collective climate-change research;
- Conducting of both physical and dynamical research to underpin climate modelling specifically to provide projections of climate change for Australia, independent of potential bias associated with the use of northern hemisphere modelling;
- Spin-offs in term of the input to weather forecasting;
- Periodic collection together the best knowledge into updated assessments made widely available to the user community;
- Direct interaction between the scientists and selected economic sectors, to provide advice on potential risk and risk assessment;
- General communication of the science in the accessible way by the media and the Internet the public and in particular to teachers and students.

Australia generally contributes to about 2% of global scientific research. In the case of climate-change research it far exceeds this ratio, even though an exact percentage

is difficult to assess. This is demonstrated by the significant in-balance between the number of Australian/ACCSP scientists contributing to the IPCC Assessments compared with those from other countries including highly developed countries such as the US and UK. Key areas of specific contribution to the international science have been:

- The production of a highly competitive climate modelling capacity;
- Contribution of observations of greenhouse gases in the atmosphere that, when combined with international measurements, provide clear indications of the biogeochemical cycling of those gases;
- High latitude observations and modelling of ocean circulation;
- Analysis of air trapped in ice cores from Antarctica contributing to both the development of the analysis technologies and a long history of the gases in the atmosphere;
- And in specific areas such as the role of aerosols in the radiation budget of the planet.

--

Through their contributions to the CMIP process and through having a good quality climate model that is tested on weather timescales, ACCSP add value to climate science both nationally and internationally.
--

(1) Very strong contribution and very high value through synergies from a programmatic approach coordinated across many organisations.
(2) Strong contribution and high value, especially through e.g. IPCC 5AR, Global Carbon Project.
--

Mixed: If funding stopped today, and assessed the value in 5 years' time, the answer would be potentially nothing. If ongoing funding provided to build on the work done, the answer would be significant, particularly in ocean science. But if funding stops then ACCESS won't be around in 5 years' time.

He doesn't believe there was evidence of priority for ACCSP to be globally cutting edge. Published papers don't mean you are internationally outstanding. ACCESS is internationally outstanding, but it needs ongoing funding for longevity.

In that context, the ACCSP didn't create things that are hardened to a loss of funding.
--

See the answer to 5. Some of very significant research (e.g. Church; Trull; Rintoul) was facilitated by the ACCSP. ACCSP science fed directly into the deliberations in the IPCC and other international initiatives.
--

(1) Australia – high

(2) global climate science – high
--

ACCSP was the principal mechanism for funding core science relevant to climate (and to some extent, weather or short-term climate prediction). So clearly it was very valuable.
--

(1) SEACI, and other big process studies are coming to fruition in things like the 2015 climate projections report. You can now get valuable, practical information thanks to the integration of fundamental science through to adaptation information required by managers and decision makers. This comes from 20 years of building up capability.

(2) Unclear what is ACCSP and what is CSIRO more generally. But CSIRO scientists are the main players in understanding Southern Ocean processes, which is globally important.
--

I have already answered this in the above. It's clear that knowledge of drought for example is essential to Australia, and ACCSP scientists have brought forward information that is important and unique. ACCSP's value to global climate science is remarkable for a relatively small country, and has had a very large influence.
--

High. The importance of providing a southern hemisphere perspective should not be undervalued given the likely distribution of impacts. Participation means that Australia not only had its own climate modelling expertise but was also in a position to be an informed user and reviewer of the modelling outputs produced by others. The need to be able to enhance the models in terms of their ability to account for longer cycles of "natural" drivers of variability as well as various policy interventions remains. The sea-level rise information did make a critical impact on public policy – it provided a credible cover to have the discussions about 1.1m and what that looks like instead of 20-30cm.
Ongoing responsibilities in the Pacific will ensure continued demand for Australian contributions in this area beyond our domestic requirements.
--

This is touched upon in Q5 above. ACCSP has been a primary contributor to climate science that is relevant to Australia. Looking more globally, the science has been of top international standing, relevant and significant. Australian scientists, both ACCSP participants and collaborators, have been prominent in IPCC contributions, reflecting the global significance of the work. As noted above, the critical global importance of southern high latitude climate science and Australia's strong interests have made our contributions highly significant.
--

ACCSP is has been critical in developing the excellent scientific knowledge base we have in Australia for mitigation and adaptation planning, which is of enormous value to the nation. Global climate science has benefited, in particular, from the observational programs supported by the ACCSP. Without the Australian contribution supported by the ACCSP, global understanding of the southern Hemisphere's role in the climate system would be much impoverished.
--

a) See above.
b) ACCSP made substantial contributions to advancing global climate science. Many ACCSP scientists are recognised as leaders in their fields.
--

As above there is a marketing problem about what the ACCSP is/does. Clear from the concern raised in Australia and internationally about the cuts to climate research that there will be impact of ceasing the work.

The knowledge that Australian scientists and government funding contribute to global science makes us proud. It would be an embarrassment if that ongoing contribution isn't there. We're part of the world team.
--

Of the parts he is familiar with, the programme made a very significant contribution to global climate science. The research was published in work that formed the basis for the IPCC reports, so a major contribution there. By extension, a lot of value was delivered to Australia; for example, sea-level research. In terms of science outcomes, it made an excellent contribution.

But translation of research and delivery to end users was not a core part of the programme. This was possibly because there are other vehicles such as the ACE CRC to do that. But there was not much emphasis on delivery to user, so value could have been greater.
--

Huge, far in excess of the level of financial support. The programme also 'leveraged' all sorts of international support and information that we would not have received without the ACCSP.
--

8. What research advances would not have been possible without the ACCSP?

Coordinated climate change modelling, monitoring and research into both climatic variability and climate change would not have been put in place without the ACCSP.
--

We wouldn't have an Australian climate model without the ACCSP and that has ramifications for not just climate change research but also domestic weather prediction given the ACCESS atmospheric model underpins both weather prediction from the BoM and climate change outputs. Observational data and process understanding of the Southern Ocean wouldn't be nearly as advanced without the ACCSP. Our understanding of the terrestrial component of the carbon cycle and fluxes that feeds into climate models would not have advanced far without the ACCSP. Climate projection work may have still proceeded but it wouldn't be as advanced as it is today.
--

Every one of the six or so highlighted areas in the past half-decade of annual reports (e.g. in 2011 it was: Global and regional carbon budgets, Land and air (observations and processes), Oceans and coasts, Modes of climate variability and change, Earth system modelling and data integration, Predicting Australia's future climate and its extremes; slightly different titles in later years) would have been impoverished in multiple ways or impossible to significantly progress without the many years of ACCSP effort.
--

While there are many research advances that would not have been possible without the research performed under the ACCSP over the past 27 years, the top for me include:

- Sophisticated Earth system modelling for Australia and the Southern Hemisphere
- Climate projections for Australia
- Long term ocean and atmospheric observations, monitoring and process understanding. Plus the inclusion of Australian observations ocean and atmospheric data into international programmes and global assessments.
- Development of a carbon budget for Australia

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The network of ocean observations
--

Additional research has not been the focus of my work. It has been more in applying ACCSP research.
--

ACCESS, ACCESS, ACCESS
--

Development of ACCESS
Basic and broad understanding of how El Nino operates and how it will be affected in future, and what it means for Australian climate.
CO2 monitoring, ice core work, and trace gas work with world-leading capability.
--

Without the ACCSP, Australia would not have:

- Solid evidence about changes in greenhouse gas emissions and concentrations over the past 800,000 years, and the human contribution to increases in greenhouse gases since the Industrial Revolution (1750)
- Robust information about past and future Australian climate variability and change, showing that the warming and drying over much of Australia since 1950 is likely to continue in future, with more extreme weather events. The range of projection uncertainty has been reduced, e.g. the warming range by 2030 was 2-4^{o}C (CSIRO, 1987), then 0.4-2.0^{o}C (CSIRO 2001), then 0.5-1.2^{o}C (CSIRO and BoM 2007), and now 0.6-1.3^{o}C (CSIRO and BoM 2015)
- Key insights into the key role played by the Southern Ocean in the Australian region and the global climate system
- Used ocean observations and process studies to constrain sea level rise projections. For example, by 2100, sea level rise was estimated to be 15-125 cm (CSIRO 1992), then 9-88 cm (CSIRO 2001), then 18-79 cm (CSIRO & BoM 2007) and now 26-82 cm (by 2090, CSIRO & BoM, 2015).
- A global climate modelling capability, ranked in the top 10, which allows Australia to explore a range of foresighting scenarios
- Discovered possible links between increases rainfall in northern Australia since 1950 and increases in Asian aerosols
- Discovered a likely increase in extreme El Niños and La Niñas in future due to global warming
- Closed the global carbon budget and understood the critical role played by the oceans and terrestrial biosphere.

--

I won't comment on one or two specifically, rather I re-emphasise that the overall quality of the people and program is invaluable.
--

The downscaling of climate data to the regional level as a basis for framing effective responses to climate change impacts would not have occurred without ACCSP involvement. This has enabled us to explain the need for responses with the authority of the evidence base behind us.
--

Hard to say, but clear that in Australia there would still have been some limited climate change research and university-based research. But it would have been done using, for example, models available through the US and Europe – not models specifically designed and developed with a focus on simulations over Australia. One

example of that is CABLE – this has specifically developed vegetation types suited for eucalyptus forests, whereas all other systems don't have specific eucalyptus vegetation. So tailoring of modelling and observations for Australia is important.

Without the support of graduate students, and the provision of research for them to use, students would have gone overseas.
--

Australia would not have a national projections data base, nor a world class modelling capability. Our understanding of ENSO and other modes of variability would be significantly compromised.
--

Always impossible to construct a counter-factual such as this. The reason is that the question asks us to imagine a world in which Australia did not have a meaningful climate change science program between about 1990 and 2015. This is unrealistic because the science being undertaken around the world demanded that Australia invest in the science underpinning our understanding of anthropogenic climate change. A program such as the ASSCP was actually required. How the gap would have been filled in the absence of the ACCSP is impossible to gauge – program such as the CRC program may have been more fully deployed although two CRCs (Antarctic CRC, and the Greenhouse Accounting CRC) had relationships back to the ACCSP.
--

Australia (and climate research and knowledge around the world) would be severely hampered if it did not have the observations base, research and analysis provided by the ACCSP.
--

Little climate model development would have been possible without ACCSP, and Australian involvement in IPCC and other assessments of climate change would have been weaker. In most other areas there would have been some development without the ACCSP, but progress would have been much slower.
--

The application of climate change science to multiple sectors across Australia and Pacific such as agriculture, water management, energy generation and transmission, transport infrastructure and building development.
--

Not clear due to branding issues identified above. But the modelling work through CMIP and the sea-level rise information mentioned above wouldn't have been available without the ACCSP.
--

This is a difficult question to answer given the highly integrated nature of the ACCSP research with the wider commitments of both CSIRO and Bureau of Meteorology. From one perspective, the enormously significant reach that the ACCSP captured from these organisations might be interpreted as, all advances by these joint programs and being made possible by the existence of the ACCSP. But specifically I think that some advances that would have unlikely occurred are:

- The early development of the GasLab program;
- Significant contributions from the Climate Change Adaptation research within CSIRO;
- Components of the climate modelling program;
- Components of the Southern Ocean-Antarctica research could be argued to have at least been significantly dependent on the existence of the ACCSP, if not entirely a result of the existence of the ACCSP.

In my own view, as a manager of climate change research over many years within CSIRO, it is hard to imagine that the enormous progress and advances made by that Organisation could have occurred without the existence of the ACCSP.

Indeed the closure of the ACCSP at this time, is especially critical given that it's nonexistence is likely to be a significant factor in the loss of the leverage of other CSIRO resources in climate-change research.
--

Several, but most notably

- Improved understanding of Australian continental carbon balance
- Knowledge of sea level changes in the Australian region
- ACCESS coupled climate model development
- Regional climate projections science

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If research advances are defined as publications, a lot, as many papers published.

But if advances are things that can then be maintained, then they are quite limited. Excellent work done in ocean sciences, but not sure how much is sustainable. For an advance to not be followed by a catastrophic defeat, you need ongoing funding.

So what did ACCSP achieve that will withstand funding cuts? Don’t know, as unclear what has sufficient, hardened systems to withstand the funding cuts. Some advances will be picked up, but unclear what. The Government is undermining the legacy of ACCSP.

Data collated through oceans and land, these wouldn’t have been taken without ACCSP. These will always be valuable and have a legacy.
--

At least the following areas of research would not have been as advances as they are today:

Understanding ocean processes
The drivers of regional and global sea-level rise
Better models to predict/project climate and climate change
The ACCESS model
--

Develop projections, synthesis and communication of climate change science – Climate Change in Australia report, website and information.
ACCSP also supported the Bureau of Meteorology and CSIRO in improving Australia's weather and climate forecasting system.
--

Again, I do not know exactly what results were funded by ACCSP but important work on the carbon cycle, ocean acidification, the Haitus and El Nino, and other topics over the last few years has presumably been funded by ACCSP. ACCSP has also funded research activities to improve the ACCESS forecast model.
--

- The projections report couldn't have been possible
- Less would be known about changes to water cycle, particularly across southern part of the continent
- Knowledge of the Southern Ocean
- Land-atmosphere interactions would be a big gap. The climate model draws heavily on ACCSP capability through CABLE.
- We wouldn't have had the engagement between Govt and scientists that we had, as the ACCSP was central in that interaction.

--

I already enumerated this under item 5. I doubt if this work would have occurred without the resources of ACCSP, so it would not have been possible.
--

I think the enhanced understanding around aerosols is significant and would not have happened without this investment. To my mind though the most significant benefit to Australia from this programme is a social outcome. It facilitated nation wide, local scale conversations on the climate system, science and regional adaptation through the release of credible and consistent regional projections of climate change. It is disappointing that this has been undermined somewhat by the NarClim release in NSW – now there are two sets of stuff out there and it has been left to individual groups to try to explain their choice and the differences such as discrepancies in projected changes to autumn rainfall. By providing a common baseline and language for these conversations, the project helped to elevate the discussion to the values and priorities level instead of defaulting to the data / belief discussion.
--

The field of Southern Ocean physical oceanography would not have advanced to nearly the degree it did, nor would the national climate modelling capability. Each of these have driven advances across the climate space domestically and internationally.
--

We would not have developed an Australian world class climate model. National climate projections for Australia would not have been possible. Global understanding of the Southern Ocean would be much less advanced. There would be very little understanding of Australia's carbon budget.
--

Not sure what this question means. Probably addressed by answer to question 5, noting that it is not possible to know what would have happened. There was a climate science program before ACCSP and the University sector has considerably strengthened its climate research, including through the ARC centre of Excellence.
--

Don't know details of program to be able to comment.
--

See above – if funding was not there through ACCSP or other mechanisms, the science wouldn't have been done.
--

See all those I listed in Q5. Were it not for the ACCSP, we might have had atmospheric monitoring and some limited ocean monitoring and modelling and that would have been about it.
--

9. (Please skip question 9 if you are ACCSP staff). How much have you consulted ACCSP (BoM, CSIRO) scientists on climate science/climate change matters, and if so was it useful?

The international ACRE initiative that I lead has always looked to involve and invite ACCSP scientists to work with it on data rescue issues. There has been CSIRO involvement, support and staff participation in a number of annual ACRE Workshops and a small joint project initiated between us.
--

Over the years, I have regularly interacted with ACCSP scientists both from specific research areas of interest in my area of application (agriculture, northern Australia) and in my role as CAF Director.
--

This has varied over the years. My earlier work involved collaboration with CSIRO scientists at Aspendale. Over the last three years this has broadened to include BoM scientists as well. The collaborations have been very useful in terms of the provision of climate model output and meteorological expertise.
--

We have consulted at length with ACCSP scientists in the explicit use of their time for the delivery of joint contracts that we held during together in ACE CRC and UTAS. We have written papers together.
--

While there have been occasions when I have consulted directly with ACCSP scientists, this is an area I think could have been improved over the life of the programme.

While many request for information from the Department where handled through the ACCSP Management Team (which always resulted in timely advice from ACCSP scientists being delivered to the Department in an accessible and well written manner), I feel that at times this led to a disconnect between policy makers/Departmental staff and the actual scientists of ACCSP.

I think it is important for decision makers and scientists to build direct relationships. Not only does this allow decision makers to get accurate information straight from the source, but it also enables the formation of lasting relationships, increased communication on climate change issues and an increase in trust between policy makers and scientists. In best case scenario's this a) allows researchers insights into the policy development process, how things work in Government, and how information should be delivered to best enable uptake into policy, and b) enables decision makers to better understand the science, thereby increasing their confidence in using scientific information and findings in policy papers, and manages the expectations of the decision makers by enabling them to understand what products/information can and cannot actually be delivered by researchers.

These relationships build up trust between decision makers and scientists and ultimately lead to greater up take of scientific information into policies and decisions – one of the goals of the ACCSP. I think greater communication between researchers and relevant departmental staff should be strongly encouraged in the roll out of the ESCC Hub.

However, when ACCSP researchers were directly consulted on climate change science, the information was provided willingly, clearly and timely. The information was useful for Departmental use in advisory briefs or policy documents.
--

I have liaised with ACCSP scientists on numerous occasions. I have also heard them give presentations on various aspects of climate science; probably at least 80 or so presentations over the last 8 years. All these interactions and presentations have played a fundamental and crucial role in my current understanding of climate science and climate change, that informs my climate change adaptation work, and the policy and program design advice that I provide.
--

Extensively since leaving CSIRO, especially in the domain of hydro-climatology, and climate models/projections
--

Yes, main area was work on El Nino, work on extremes. Turned to them (especially Scott, Cai) to understand anything about what will happen to El Nino in a future climate. Useful, received the information required.
--

I've occasionally consulted BoM and CSIRO staff on climate change processes and impacts relative to Australia. Not sure which of those scientists/projects were ACCSP-related.
--

The Climate Council regularly consults scientists at BoM and CSIRO re updates on climate trends. Councillor Will Steffen also regularly attends BoM briefings. The BoM and CSIRO staff have also regularly reviewed our reports to ensure they are accurate and up-to-date.
--

I have communicated with, consulted and arranged events where BoM and CSIRO scientists have spoken with audiences of councils and their communities. Steffen, Karoly and Braganza are three that quickly come to mind. Their knowledge and willingness to share it is particularly valued and so extremely useful.
--

Co-authored papers with them, used output from CSIRO Mark 2, 3, and ACCESS, jointly supervised students with CSIRO/BoM scientists, so a lot of interactions since the 1990s.
--

I have in past, and in my current role, sought advice from ACCSP. It is invaluable to be able to reach out and discuss aspects of climate change directly with researchers. Their input is essential in my work going forward.
--

I have frequently interacted with ACCSP on climate science and climate change matters and the interactions have always been extremely useful in terms of my research and the impacts of the science from the ACCSP scientists.
--

In past 12 years, I have consulted with ACCSP at least 6 times a year on average. The engagement has always been useful.
--

Sea-level rise science (see above)

Strong collaboration at the moment (and ongoing) with BoM, very helpful with stakeholder consultation, especially participating in stakeholder engagement meetings and making positive contributions to put discussions in the context of climate change science. Also a general willingness to address concerns, help NCCARF to do the best job that they can.

Consultation became more difficult when the CSIRO Climate Adaptation Flagship (CAF) disappeared, as that provided a clear point of contact. Post-CAF NCCARF has had less to do with CSIRO, and interactions are now based on one-one relationships and knowledge of individuals' work (e.g. sea-level rise).
--

My current research on the theoretical limits to biofuels I have had frequent connections with ACCSP/CSIRO scientists concerning greenhouse gas emissions and budgets.
--

We develop joint programmes with CAWCR around climate model evaluation and development and take part in various joint workshops annually.
--

High level of consultation and almost always useful.
--

Assuming BoM/CSIRO people were ACCSP, collaborated with many – 2 dozen, on everything from potential vorticity in cyclonic behaviour to soil moisture – across the entire spectrum of climate research.
--

Regularly; and most useful.
--

We do consult quite regularly with BoM & CSIRO scientists on issues, progress and challenges on the science of climate change and variability and its impact on water resources management.

Also through our involvement (directly or indirectly) in research projects e.g. ARC linkage projects, SEACI and VicCI so it was very useful. However, it is unclear to me if most or all BoM & CSIRO scientists are also affiliated with ACCSP.
10a. What activities in your area, if any, relied on outputs of the ACCSP?
10b. To what extent were activities/outcomes in your area improved due to ACCSP research results?
--

I have not consulted per se but I am a basic researcher at a university. I am working with staff at the BoM who receive ACCSP funding.
--

A lot, particularly with the Climate Commission/Council, which ensures that the science is accurate in their reports and communication, so we have consulted ACCSP scientists a lot. The input from the ACCSP ensured everything in their reports was correct. People such as John Church, Helen Cleugh and others enabled the engagement of scientists to ensure the Climate Council's products were 100% accurate. Having the relationship with CSIRO scientists has been fantastic.

Importantly, it takes a long time, decades, to build up the effective capability, and seeing deliverables such as the projections report shows what can be achieved with the social capital of researchers working together. The build-up takes a long time, but it can be killed overnight.

So you can evaluate the ACCSP based on the science. But it is the social capital that really is important, as you need teams to work on climate change, and it takes time to build up these teams effectively.
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While I worked on IPCC and WMO/UNEP assessments, I have frequently worked with and consulted ACCSP scientists from BOM and CSIRO over many years, dating back to 1994 but most intensely from 2002-2008 when I co-chaired IPCC WG1. BOM and CSIRO scientists were key members of IPCC and being able to consult with them led to a much better report, not only for the coverage of Australia but also globally.
--

Like most things it is individual specific and if you find someone helpful and useful you punish them by asking them for more! My go to folks were exceptional and generous – Leanne Webb, John Church, Ian Walker, Leon Rotstayn, John Clarke, Mandy Hopkins, Paul Holper and Penny Whetton.
--

As a researcher I have had regular contact and strong collaborative links with many ACCSP staff over the years.
--

a) Consulted often with ACCCSP scientists on a range of issues including:
- regional climate modelling
- climate extremes
- sea level rise
Interactions were mostly very useful, and staff very helpful
--

SCCG has consulted a lot, and at all levels: from scoping research activity (e.g. 12 years ago SCCG identified that CSIRO wasn't doing much work on Sydney coasts, which led to research in this area), to working on project ideas and development that has led to funding, through to working collaboratively on projects and research implementation.

Also have contacted ACCSP scientists for advice and general knowledge transfer, and seeking collaborative arrangements with other research organisations through the ACCSP's contacts and network.

He has always found them accessible, professional, timely and supportive.
--

In terms of science collaboration, there were formal and informal interactions between ACCSP and non-ACCSP scientists, with lots of collaborative work in the ACE CRC. ACCSP scientists were open for collaboration with non-ACCSP scientists.
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MDBA has had significant interaction with CSIRO climate scientists, firstly with the collaborative work under SEACI, and secondly in providing advice and data on appropriate climate change scenarios that could be used in hydrological modelling.
--

As a consultant, I have successfully received invaluable information and data on climate change projections, which I have applied on behalf of two state governments.
--

10a. What activities in your area, if any, relied on outputs of the ACCSP?
10b. To what extent were activities/outcomes in your area improved due to ACCSP research results?

a. The above small project relied on a combination of ACCSP (CSIRO, BoM and Melbourne University) partners and interactions.
b. As above - they were an integral common
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Climate projections work has been essential for a range of projects I have been involved in over the years relating to the pastoral industry in northern Australia and mixed crop-livestock systems. For the work across the Climate Adaptation Flagship we needed to draw on outputs from the ACCSP for sectoral work in marine impacts and adaptation, agriculture, fisheries, urban and coasts, health, down-scaled climate projections,
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CSIRO's and the Bureau's climate-related advice, products and services to Australian governments and other community sectors have relied heavily on the outputs from the ACCSP. The quality and quantity of climate change risk assessments, future projections, mitigation and adaptation responses and strategies across Australia has been underpinned centrally by the ACCSP.
--

(a)

- Downscaling global climate model simulations
- Modelling the spatial and temporal characteristics of weather and climate extremes

(b) My work would not have been possible without the support of the ACCSP owing to funding pressures over the last 20 years. Also, the level and depth of expertise available via the ACCSP was unparalleled in Australia and many other developed countries.
--

We have relied the CCAM models, and the CMIP3 and CMIP5 model outputs from the ACCSP programs. Also the ARGO float arrays and support on the calibration of our own floats.
--

a) The inclusion of climate science information into policies and briefings relied on the outputs of the ACCSP. Without the ACCSP, there would not have been the same level of clear and accurate information on the past, current and future changes to our climate for use in developing climate polices, as well as informing other climate-related policies (i.e. national food pan, international ocean policies etc.).
b) The development of climate change science policy papers (such as the Framework, Implementation Plan and resulting policy work) were also greatly improved due to the ACCSP, including both its research and role within the broader

community. The 'core' role of the ACCSP within the Australian climate research community was instrumental in drawing the community together, providing high level conclusions on the state of climate science research in Australia, and in developing key policy questions and their research deliverables.
--

(a) Analysis of ocean thermal expansion and understanding the sea level budget, and projections of future sea level change
(b) Significantly so
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a. In Western Australia ACCSP work has informed environmental impact assessments regarding potential climate change impacts on biodiversity and on development proposals. It has informed climate change risk assessments: on human health impacts, impacts on freshwater fisheries in South West Western Australia, impacts on the mining sector in Western Australia, impacts on the tourism industry in the Margaret River region in South West Western; on Natural Resource Management Strategies and their objectives for the NRM Regions within Western Australia; on Main Roads infrastructure located close to the coast; and on a wide range of local government climate change risk and vulnerability assessments undertaken over the last nine years.
b. Without an appreciation of the potential future climate changes that are possible, and the ones that have now been observed, there is little motivation for organisations to undertake climate change risk and/or vulnerability assessments and other climate change adaptation activities. ACCSP program has been important in helping build awareness in Western Australia, as in elsewhere in Australia, of the phenomena of climate change, the fact it is already starting to be observed, how it is occurring and why. Importantly program has been at the forefront of informing governments and stakeholders about the potential future climate changes that may occur and the possible risks, impacts and opportunities that they represent.
--

a. All climate adaptation studies to some extent rely on projections. The authoritative source of projections in Australia is CSIRO/BoM.
b. Improved projections and clime science knowledge in general leads to better adaption recommendations; therefore the Australian adaption community has greatly benefitted.
--

a. Work didn't reply on the projections or other products so much as tapped into the expertise of ACCSP researchers on El Nino, annular mode on Australian climate, for development and enhanced understanding of predictability, understanding the underlying mechanisms, to enable better seasonal predictions – now and in a future climate.
b. Certainly having ACCESS developed has fundamentally changed the Bureau's work in seasonal prediction, and ACCESS probably wouldn't have happened without ACCSP.

--

a. In the climate projections area, we relied on the ACCSP for

- climate simulations from the BMRC, CSIRO4, CSIRO9, CSIROmk2, CSIROmk3, CSIROmk3.5, CSIROmk3.6 and ACCESS models
- development of methods for analysing climate model data
- analysis and presentation of atmospheric and oceanic data
- development of the OzClim software
- national climate projections in 1990, 1992, 1996, 2001, 2007 and 2015[1]
- the services of a Climate Projections Liaison Officer
- documentation of results in peer-reviewed literature
- participation in the IPCC process.

b. Climate projection activities and outcomes were improved by ACCSP research results because:

- CSIRO and BoM have high credibility and trusted advisor status
- Collaboration between CSIRO and BoM created fertile ground for innovation. Many methods and results were at the cutting edge. We "punched above our weight".
- International collaboration was supported, thereby allowing Australian scientists to accelerate shared learning, develop world-class research ideas, publish multi-institutional papers, and participate in international activities such as IPCC and various conferences.
- Most ACCSP projects were multi-year, allowing the development of strong collaboration and deep analysis of big issues, such as uncertainty in regional rainfall projections and the value of downscaling
- The ACCSP facilitated learning by doing over 27 years, as demonstrated by the evolution of the national climate projections published in 1990, 1992, 1996, 2001, 2007 and 2015[1]
- ACCSP support for the fundamental climate science allowed the projections team to develop value-added products for other clients (e.g. state governments, private sector) who had specific needs.

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As above, the credibility of Climate Council reports relies extremely heavily on output form the ACCSP.

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SECCCA was involved in the recent Western Port Local Hazard Assessment, in which coastal processes and their interactions with coastal geomorphology were investigated. Climate projections, involving storm behaviour, wave setup and runup were necessary components of the assessment. Projections developed by ACCSP were important for this.

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a. Co supervision of graduate students
Use of climate model data to analyse climate variability and climate change
Use of observational data from Cape Grim

Collaboration on many papers – in fact, it would be interesting how many ACCSP papers have collaboration with non-ACCSP funded people, to see if researchers were inward looking, or if partnered with other research organisations and universities, and also with international researchers. Even a sample over a small period would illustrate whether the ACCSP valued partnerships.
b. A lot of what he has used is climate model output, so ACCESS and the other climate models have been critically important. Work on coupled ocean-atmosphere chemistry modelling, including an interactive ozone chemistry, would not have been possible without ACCESS, which would not have been possible without ACCSP. That is, the CRC for Southern Hemisphere Meteorology set up a coupled atmosphere chemistry model. But it was stopped at the end of the CRC, and not continued by the Bureau or CSIRO. Then ACCESS made it possible again, and has been used, linked to the UK chemistry and atmosphere model (UKCA), to enable capability to look at ozone depletion. This would not have been possible without ACCESS. It is important as summer seasonal climate variations in southeast Australia are dependent on ozone variations as much as El Niño – stratospheric circulation and chemistry explains as much of the climate variance as El Niño.
--

a. ACCSP has provided the underpinning science for key advice to Government as well as the public. ACCSP work has made critical contributions to our understanding of climate variability in Australia as well as climate change. Change can only be understood in the context of variability. This is especially the case when considering extremes, which is an area we need an increasing focus on.
b. Significant contributions to our advice to government and to the community through improved understanding of climate variability and change. This has also underpinned efforts funded by DFAT on regional climate and capacity building in the Pacific.
--

a. Directly in projections of climate change and development of scenarios on which I can base policy option development in both mitigation and adaptation.
b. Ultimately, the ability to test, observe and confirm projections of climate change in Australia (as opposed to somewhere else in the world) by Australian scientists has been essential in engaging with the community and raising awareness that action must be taken. Without the ability to provide assurances to the community that climate change is real, and confirmed by our scientists, it would be much harder to justify action that will represent a cost to the community.
--

Understanding the impacts of human activity on climate in the Australian region has relied on outputs from the ACCSP, and the outcomes in this area certainly were improved because of ACCSP.
--

a. Climate risk assessments, climate adaptation plans and climate resilient designs for Councils, state government agencies, Australian Government

Departments, corporates from mining, oil & gas, tourism, retail, transport, manufacturing, power and water sectors.
b. The results of our projects were credible because we used CSIRO projections and related research.
--

Sea-level rise information and BoM stakeholder engagement (see above).

CCIA is useful, even if a bit complicated to use.

Without the ACCSP, NCCARF could always do things, but the quality would be much worse without the input of ACCSP research, CCIA outputs.

Without the program, the people, and the results, it would be the difference between having the international standing of climate adaptation work in NCCARF, and being a mediocre camp follower. Without ACCSP, they couldn't do the work they want to do, and staff would leave to work elsewhere.
--

a. My work relies on ACCSP/CSIRO research on greenhouse-gas biogeochemical. My contract work, particularly with private sector organisations, depends on ACCSP/CSIRO outputs regarding projections of Australia's future climate and exposures.
b. My science presentations to particularly private and public sector organisations, incorporate significant outputs from the ACCSP program.
--

a. Our joint model development programme relies on evaluation from scientists in CAWCR.
b. Model development has benefited from contributions from all UM partners including CSIRO and BoM. This cuts across weather and climate timescales so it is hard for me to separate out specific climate input.
--

a. Our climate change services were improved from (1) regional climate projections, (2) a better understanding of sea-level rise, and (3) attribution (to increasing greenhouse gases) studies. Our 'seasonal' forecasting services were improved by (4) having a better understanding of ocean changes and their influence on global and Australian climate.
b. From above: (1) high; (2) high; (3) moderate; (4) moderate.
--

a. His group routinely used a range of ocean and land based observations
CABLE is the community model now used daily.
ACCESS used daily
Ocean modelling system MOM used often

Not relied on, but deeply collaborated on a number of capabilities that exist as a result of ACCSP.
If ACCSP didn't submit results to CMIP 5, people would have used other CMIP 5 models. But the ACCESS contribution made the difference between being a user of and having an understanding of CMIP results. That is, you can take ACCESS and run bespoke experiments with CMIP data, and examine phenomenon seen in CMIP 5 models, and see why models behave the way they do. Huge scientific use. You need a climate model in Australia.
b. Collaborate with a number of BoM and CSIRO scientist as they have specific capabilities and understanding. Some individuals are world-class and contribute superb knowledge, and he uses those results routinely. A lot of the ARC CoE's research is collaborative, as the collaboration adds considerable value.
There are jewels in the ACCSP, but overall framework of ACCSP is the problem in terms of how University researchers can properly sustain collaboration.
--

a. Sea-level rise research;
Climate Futures (for Tasmania) research
Southern Ocean processes.
b. The scientific funding support, and well as the interactions with other ACCSP projects and funded staff were fundamental to the success of the science carried out by the Antarctic Climate and Ecosystems Cooperative Research Centre.
--

a. Understanding of drivers of climate change and variability; climate change projections
b. Improved greatly. Without ACCSP there will be less investment and effort in climate science and research which is crucial for understanding and projecting impacts on water resources management, e.g. changes in pattern and increased risk of future droughts, floods, heatwaves, bushfires, sea level rise, etc.
--

a. See previous responses
b. The one project I was involved with was a valiant attempt but did not happen to lead to important results. That is basic research...
--

See question 9 in terms of accuracy and review of Climate Council products.
In addition, doing work on planetary boundaries, tipping points, and dangerous limits. Understanding these relies on Southern Hemisphere results on circulation, sea-level rise, etc., with CSIRO science often coming up as input to these.
--

It is not clear what is meant by 'area' here. I will interpret it as my research area. IPCC certainly relied heavily on the outputs of ACCSP for each of its climate science reports. ACCSP contributions to WMO/UNEP ozone assessments were also extremely important. Not only did the scientists provide leading results and

contributions but the Cape Grim observatory is the foremost one in midlatitudes of the southern hemisphere.
--

a. There are a range of modelling and assessment tools that are used to inform various sectors (Ag, NRM, Infrastructure and Health) that are now able to ingest climate data as a result of this work and extension support. Focus of advice should be to ensure the full range of the model ensemble is represented – including unrealistic emissions scenarios for applications modelling is a waste of computational resources. Needs to be clearer advice on SRES A1FI / RCP 8.5. Would also assist in integrating / comparing consistent output.
b. Moderate extent – its about incremental improvement CMIP3 and associated downscaling good, CMIP5 and regional data better – further downscaling and refinements would be better again. Definitely need clearer signals around rainfall and extreme events / rainfall intensity – good work but the job is not finished.
--

a and b) The ocean science within the Australian Antarctic Program and the ice core gas analysis were heavily reliant on ACCSP research. To a very high extent, outcomes in these areas were the result of ACCSP. Other research from the ACCSP that supported improved observations and modelling outputs are used pervasively by the wider community.
--

a. The development of climate change projection science obtained critical direct support from ACCSP. For example, the Climate Futures concept was developed with ACCSP support (although the development of the related software was supported by other, more applied projects). The ongoing support that ACCSP provided to climate projections methods development made it possible to capitalise on external funding opportunities (when they arose) to provide climate projections. Also the projection work benefited from climate modelling, downscaling, detection and attribution work supported elsewhere in ACCSP.
b. Greatly improved. Hard to imagine how we would have done much at all without ACCSP.
--

a)
- Sea level rise understanding and projection
- Data from Cape Grim used to support climate change policy discussions
- Bluelink modelling

b) Hard to answer. We generally received very good and engaged support from ACCSP scientists – see above.
--

Having a more evidence-based approach for supporting policy and management practice has been the biggest way the ACCSP has improved the SCCG, which includes 15 councils representing 1.4 million people.

Having the diversity of scientists across the physical and biological areas, social science, economics, system planners etc. coming together with the SCCG leads to the research being applied. The work is not just about measurement, it is about using that information to extrapolate to what is needed on the ground at local and regional ways in a global city.

Also, collaboration with ACCSP led to many other research programs with others, it created the momentum to go forward, created the engagement with practitioners.
--

a. A lot of the field work was only achievable through co-investment of the ACCSP and ACE CRC. A lot of the external engagement with end users done by the ACE CRC (e.g. position analyses for policy advice) has relied on ACCSP outputs.
b. Substantially improved, for example outputs such as the CRC policy papers were enhanced by ACSP work.
--

a. No activities relied directly on the outputs of the ACCSP. SEACI outputs have however, along with other lines of evidence, informed policy positions on climate change which are reflected in the Basin Plan.
b. The work with SEACI provided valuable insights into the drivers of climate variability and change in the Murray-Darling Basin, and subsequent work in hydrological modelling provided predictions about the scale of changes in rainfall and runoff under different climate change scenarios.
--

See Q9. I have also used extensively communication material arising from the ACCSP.
--

11. Can you identify any programs that would not have been possible or would have been more difficult to deliver without the ACCSP; that is, did the ACCSP provide leverage or inspiration to conduct other research? If yes, to what extent did this happen?

I'm sure that it did in many cases, but not directly with the ACRE initiative that I lead.
--

Programs reliant on ACCSP have been identified above. Some outputs from ACCSP research drove new work which we wouldn't have otherwise commenced e.g. engineering designs based on changes in severity of tropical cyclones and extreme weather events, high resolution sea level rise data and work with councils on coastal planning.
--

See answer to Q.8. To which I'd add that current NCCARF activities, historical federal, state and local government climate risk assessments, the IOCI and SEACI programs and many other specific projects for industry and commerce were all synergistic with the ACCSP and would have been far more difficult to deliver without that synergy and the extensive scientific progress achieved by the ACCSP.
--

The ACCSP provided leverage, inspiration and core expertise for a number of regional climate initiatives such as the Indian Ocean Climate Initiative (1998-2012) and the South Eastern Australia Climate Initiative (2005-2012).
--

All of our work that depended on CCAM or on the ACCSP climate model runs could not have been done in the way that they were undertaken, and consequently may never been undertaken at all, as they would have been considered non-viable. Climate Futures projects (Tasmania and Alps work for example).
--

ACCSP paved the way for a number of regional climate and adaptation research programmes over the past 27 years. These include the Indian Ocean Climate Initiative (IOCI), the South-Eastern Australian Climate Initiative (SEACI), and the South-East Queensland Climate Adaptation Research Initiative (SEQ-CARI). ACCSP researchers and management staff have contributed or been involved in these programmes, and the scientific understanding and expertise developed through ACCSP has been vital in supporting and informing the development and research undertaken by these regional programmes. Other initiatives that have also depended on ACCSP research or expertise include the Victorian Climate Initiative (ViCi) and the Climate Futures for Tasmania.

The ACCSP has been vital in the development and delivery of the Pacific Climate Change Science Program (PCCSP) and the Pacific-Australia Climate Change Science and Adaptation Planning (PACCSAP) programme, and in providing the underlying

science and expertise for the development of the climate projections delivered under the Regional NRM Planning for Climate Change Fund. I believe that these programmes would not have been possible without the ACCSP.

In addition, I think it is important to note ACCSP's role in the development of CAWCR (not a research programme, but an important research partnership). Relationships and collaborations developed through the ACCSP have, I believe, been a large catalyst for the recognised need for a more formal collaboration between CSIRO and the Bureau. This resulted in the formation of CAWCR, which allowed the development of multi-agency research teams and resource sharing between the two organisations.
--

All of the observational activities. The ACE CRC.
--

The Indian Ocean Climate Initiative collaboration between the Western Australian Government and CSIRO and BoM would not have been possible, for the same cost and timeframe, if not for the ACCSP program and the expertise it allowed CSIRO and BoM to establish.
--

SEACI was completely dependent on the foundation and outputs of ACCSP. Then
VicCI continued thanks to ACCSP
WAMSI also
IOCI presumably depended on ACCSP
--

The NESP ESCC Hub would not have been possible without leveraging the ACCSP investment. The Hub partnership between CSIRO, BoM and 5 universities builds upon the ACCSP foundation, with a stronger client/outcome focus.

Other multi-million dollar programs leveraged the fundamental research undertaken by the ACCSP, such as the

- South-east Australian Climate Initiative (SEACI)
- Indian Ocean Climate Initiative (IOCI)
- Climate Futures for Tasmania
- Goyder Institute for Water Research
- South-east Queensland Climate Adaptation Research Initiative (SEQCARI)
- Victorian Climate Initiative (VicCI)
- Pacific Climate Change Science Program (PCCSP)
- Pacific-Australia Climate Change Science and Adaptation Planning (PACCSAP) program
- Natural Resource Management (NRM) Planning for Climate Change fund.

Smaller climate projection projects for a number of State governments also leveraged the ACCSP from 1989 to 2008, e.g.

- Hennessy, K., Whetton, P., Walsh, K., Smith, I., Bathols, J., Hutchinson, M. and Sharples, J. (2008). Climate change effects on snow conditions in mainland Australia and adaptation at ski resorts through snowmaking. *Climate Research,* DOI 10.3354/cr00706: 255-270.
- Hennessy, K.J., Page, C.M., McInnes, K.L., Walsh, K.J.E., Pittock, A.B., Bathols, J.M. and Suppiah, R. (2004). *Climate change in the Northern Territory*. CSIRO Atmospheric Research consultancy report for the Northern Territory Department of Infrastructure, Planning and Environment. 64 pp.
- McInnes, K.L., Suppiah, R., Whetton, P.H., Hennessy, K.J. and Jones, R.N. (2002). *Climate change in South Australia: report on assessment of climate change, impacts and possible adaptation strategies relevant to South Australia*. CSIRO Atmospheric Research, Aspendale, Vic. 61 pp.
- Pittock, A. and Whetton, P., Eds. (1990). R*egional impact of the enhanced greenhouse effect on Victoria.* Annual Research Report for the Government of Victoria. Melbourne, CSIRO.
- Pittock, A.B. and Hennessy, K.J. (1989). *Regional impact of the greenhouse effect on Victoria.* Report for Victorian Environment Protection Authority. CSIRO Division of Atmospheric Research. **1**4 pp.
- Suppiah, R. and co-authors (1998). *Climate change under enhanced greenhouse conditions in northern Australia: final report 1994-1997*. CSIRO Division of Atmospheric Research, Aspendale, Vic. iv: **5**0 pp.
- Suppiah, R., Pittock, A.B., Evans, J.L. and Mitchell, C.D. (1992). *Regional impact of the enhanced greenhouse effect on the Northern Territory, annual report, 1991-92*, research undertaken for the Northern Territory Government. CSIRO Division of Atmospheric Research, Aspendale, Vic. **7**1 pp.
- Walsh, K.J.E., Cai, W.J., Hennessy, K.J., Jones, R.N., McInnes, K.L., Nguyen, K.C., Page, C.M. and Whetton, P.H. (2002). *Climate change in Queensland under enhanced greenhouse conditions: final report, 2002*. CSIRO Atmospheric Research. vi: **8**4 pp.
- Walsh, K.J.E., Hennessy, K.J., Jones, R.N., Pittock, A.B., Rotstayn, L.D., Suppiah, R. and Whetton, P.H. (2000). *Climate change in Queensland under enhanced greenhouse conditions: second annual report, 1998-1999*. CSIRO Atmospheric Research. vii: **1**30 pp.
- Whetton, P.H. (1995). *Climate change under enhanced greenhouse conditions in northern Australia: first annual report 1994-1995*. R. J. Allan, K. J. Hennessy, A. B. Pittock et al, Climate Impact Group, CSIRO Division of Atmospheric Research. **3**3 pp
- Whetton, P.H., Fowler, A.M., Mitchell, C.D. and Pittock, A.B. (1992). *Regional impact of the enhanced greenhouse effect on New South Wales, annual report, 1990-91*, research undertaken for the New South Wales Government funded by the State Pollution Control Commission. Allan, R. J., Drury, S., Evans, J. L., Haylock, M. R., Hennessy, K. J., McInnes, K. L., Wang, Y. P., Beer, T., and Galbally, I. E. (contributors). C*SIRO report for N.S.W. State Pollution Control Commission.:* **6**9 pp.
- Whetton, P.H., Hennessy, K.J. and Allan, R.J. (1994). Regional climate change. T*he greenhouse effect: regional implications for Western Australia: final*

report, 1992-93. C. D. Mitchell, K. J. Hennessy and A. B. Pittock, CSIRO report for W.A. Department of Environmental Protection. **p**. 28-39.

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As above, virtually all Climate Council reports use BoM/CSIRO data and outputs.

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Work 10 years earlier through the national program of integrated assessment projects has been fundamental to setting up for SECCCA a coherent set of projects to assist our council members. Following the *Impacts of Climate Change on Settlements in the Western Port Region*, SECCCA conducted a project *Heatwave Strategies for Western Port* to assist member councils in providing community care to vulnerable residents using consultants who relied on BoM data and CSIRO projections. A further project (*Deciding for the Coast; a guide to effective decision* making conducted within the Coastal Adaptation Decision Pathways program) to develop a decision making guide for coastal planning relied on projections of climate change impacts by BoM and CSIRO.

--

Stratospheric ozone work would not have been possible without ACCSP.
Regional climate modelling and climate impacts research are based on having output from climate projections. ACCSP provided underpinning framework and infrastructure to do climate change research. Climate change research would have been held back significantly in Australia without the ACCSP.

--

There is along list of Bureau projects that have been informed by or informed ACCSP including IOCI, VicCI, SEACI, PCCSP, PACCSAP, as well as other national programs such as NRM, various state initiatives such as NARCLIM, and Australia's climate adaptation programs such as NCARFF. It also influenced programs such as MCV.

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I am aware of:
a) Cooperative Research Centres (Antarctic and Greenhouse Accounting)
b) A number of State Government programs including in the early years 'impacts' programs especially designed to lever off the so-called 'core' research. This work was not only done in CSIRO but also undertaken by State government departments and universities
c) ARC Centres of Excellence
d) the ACCESS work was intended to leverage widely across relevant capabilities in CSIRO, BoM and universities
e) Wide collaborations across universities – much ARC funded research benefitted from the focussed effort
f) Work at GBRMPA and the Antarctic Division.

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The ACT Government is currently identified as a world leader in its legislated emission reduction and renewable energy targets. As stated above, progress in these areas would have been negligible had there not been a trusted scientific Australian voice to confirm the need for action.
--

ACCSP research has directly and indirectly informed a wide variety of policies, programs, initiatives and decisions across Australia. These include:

- Recognition of the importance of supercomputing capacity and decisions on national computing infrastructure
- A range of key critical infrastructure decisions and investments, from investment in desalination infrastructure in WA to improve water security in the state, to informed planning of upgrades to storm-water infrastructure in Sydney; effective management of the risks from sea level rise in the design of the new runway at Brisbane airport; and more broadly the incorporation of climate change science in guidelines for engineers for coastal infrastructure and management, and to enable infrastructure to withstand changing patterns and intensities of rainfall and runoff
- Adaptation programs supported by national, state and local governments, including tool development such as the Coastal Risk Australia sea inundation tool, and sea level rise projections in the CoastAdapt tool being delivered by the National Climate Change Adaptation Research Facility. The delivery of regional projections has been immensely valuable to adaptation planning and initiatives, including by key sectors such as water resource management
- A growing understanding in the insurance sector of the implications of climate change for actuarial models, the setting of premiums, and the capacity to offer services in areas highly exposed to climate hazards
- Local Government planning and decision making in several areas, including coastal management and the location of coastal development, heatwave planning for example by Victorian and South Australian Councils, and emergency evacuation planning
- Significant insights into ocean circulation that contribute to operational forecasting capability of direct relevance to the Royal Australian Navy
- Contributions to strategies for biodiversity conservation and for the management of Australia's unique natural world heritage properties

ACCSP research also directly contributed to a number of reports to the Australian Government identifying the need for national reform and action to prepare for the impacts of climate change. These reports include:

- PWC, 2011. *Protecting human health and safety during extreme heat events: A national framework*. Price Waterhouse Coopers, August 2011.
- Department of the Environment and Heritage, and the Australian Greenhouse Office, 2005. *Climate Change Risk and Vulnerability: Promoting an efficient adaptation response in Australia*. Report by The Allen Consulting Group.

- Department of Climate Change, 2009. *Climate Change Risks to Australia's Coast: A First Pass National Assessment*, Commonwealth of Australia.
- Department of Climate Change and Energy Efficiency, 2011. *The Role of Regulation in Facilitating or Constraining Adaptation to Climate Change for Australian Infrastructure: Report for the Department of Climate Change and Energy Efficiency*, by Maddocks.
- Climate Commission, 2011. The Critical Decade: climate science, risks and responses, Climate Commission secretariat (Department of Climate Change and Energy Efficiency), Commonwealth of Australia.

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Australian climate model development and the production of climate change projections would have been very difficult without the ACCSP.
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Majority of my team's consulting work on climate risk, adaptation and resilient design would not have been possible without ACCSP.
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Need national programs to overcome the tendency to reduce research to the lowest common detonator. Without the ACCSP, we would otherwise rely on smaller scale programs, which would put Australia in trouble (and threaten our international contribution). The ACCSP has provided guidance and leadership to activities at State and Territory level.

CAWCR was a mechanism for collaboration between CSIRO and the Bureau – hope collaboration continues through NESP, but interactions will also need to rely on individual commitment and relationships.
--

As pointed out above, it is my view that without the ACCSP resources, it is difficult to see that large parts of the CSIRO commitment to climate change research would have proceeded. But whether this would have been a case is difficult, in retrospect to assess. As a manager of the CSIRO work for some years, I was very aware of the leverage that ACCSP funding had on our commitments of CSIRO resources. Specific areas of where programs may not have proceeded are indicated in Point 8 above.
--

I suspect the efforts on IPCC 5AR and possibly the Global Carbon Project would have been much more difficult, if not impossible, to deliver.

A large number of climate adaptation projects would be leveraging ACCSP outputs and would have been of reduced quality without the ACCSP.
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Most of the datasets and the modelling wouldn't have happened without ACCSP investment. Employment of CSIRO people a tremendous legacy of ACCSP, collaborated with them as many are are good scientists.

The basic capability of modelling and observations would not have been possible.
--

We believe without ACCSP, initiatives such as the Australia's weather and climate forecasting system & Climate Change in Australia may have been more difficult to deliver.
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- SEACI, and spin offs on rainfall change understanding, wouldn't have been possible.
- Adaptation work (CSIRO Climate Adaptation Flagship, also NCCCARF) would not have been as effective without ACCSP.
- Unis would have done what they've done, but their research wouldn't have contributed to the broader and deeper understanding of how the climate system is changing that the ACCSP generated.

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Yes. The program gave state governments the confidence to plan for climate change and incorporate climate risk into their decision making processes.
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The Southern Ocean oceanography, as noted above would have not existed in anything like the present form without the ACCSP.
--

In recent years the highly successful pacific research programmes (PCCSP and PACCSAP) as well as the NRM projections project would not have been possible without ACCSP. The research capability (people and methods) that was able to be applied in those projects would not have been available without the ACCSP. The 2007 projections release was similarly highly dependent on the ACCSP.
--

a) There are no programs that would not have been possible. However the sea level rise advice has been important in the current reform of coastal legislation in NSW.
--

Most of the SCCG's climate change activities would have been more difficult without the ACCSP. In 2004/5 when the engagement started, no one was doing this stuff. The work enabled them to get on the front foot and lead some of this activity, and share that research with many other regions around the country and around the world, showing off the CSIRO logo in many countries.
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Massively. SEACI and IOCI would probably not have happened were it not for the ACCSP. ACCESS enabled international modelling interactions and procurement that probably wouldn't have happened otherwise.
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12. What are the top (up to 5) key areas for climate change research?

Long-term historical data rescue, monitoring, analyses and reanalyses
Modelling of both climatic variability and climate change
Downscaling of model and reanalyses outputs
Applications and advice on future scenarios using a synthesis of all of the above
--

(a) Better understanding of tropical influences on climate for more definitive climate projections in the tropics
(b) greater understanding of the effects of climate change on seasonal and inter-annual variability and extreme weather events
(c) Narrowing the uncertainty in models for nearer term time horizons (decadal)
--

Refine our understanding of equilibrium climate sensitivity to better constrain projections.
Clarify the role of clouds and aerosols as modulating climate feedbacks.
Improve understanding of the interaction between GHG warming and natural modes of climate variability – ENSO, AMO etc.
Improve our ability to model and project spatial and temporal changes not only in temperature but also in other environmentally important parameters, such as precipitation, water availability, stream flow, and evaporation, extremes of all sorts, sea level rise and more.
Improve knowledge of climate change effects on the cryosphere (sea ice change, glacial melting etc.)
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Some of the following points have been taken from
http://www.nap.edu/read/12782/chapter/7

- Climate forcings, feedbacks, responses, and thresholds (or tipping points) in Earth's climate system
- Integrated climate observing systems
- Placing climate change projections into the context of climate variability over a range of temporal scales
- Weather and climate extremes (for many sectors, the extremes matter more than the means)
- Improved projections, analyses and assessments at regional to local scales

--

The vulnerability of Greenland and Antarctic to climate change.
Sea-level.
Predictability on short time scales but much longer than a week and less than a year.
The areas of research that deserved further work, have high uncertainties and impacts, e.g. methane release, destruction of Antarctic a
--

In my opinion, the top 5 areas for climate change research are:

- Earth system modelling
- Oceans, including changes to circulation, heat, acidity and sea level rise
- Climate projections
- Climate sensitivity
- Inclusion of climate information into adaptation and climate risk frameworks and impact assessments.

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Observations
Theoretical analysis
Model development and evaluation
Detection and attribution
projections

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1. Improving the accuracy and climate science underpinning of climate change projections, through refining global climate models and methods for developing climate change projections from them.
2. In particular, more accurate projections of what will happen with the full range of extreme weather events.
3. Ongoing climate observations to support and calibrate future global climate models, and climate change projections.
4. Climate change adaptation research to inform good adaptation practice.
5. Greenhouse gas emission reduction technologies, including energy efficiency and renewable energy technologies, and how these can be integrated into existing systems, and scaled up and deployed at scale and as fast as possible.

--

Atmospheric dynamics (especially tropical)
Land/sea/atmosphere interactions
Downscaling methods
Seasonal forecasting

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Seasonal prediction:

- what's the impact of El Nino predictability under future climate; most important, and we don't know this yet.
- how's intensity of El Nino going to change under future climate.

--

The National Climate Resilience and Adaptation Strategy (NCRAS, 2015) states "We ensure our decisions are sound by applying leading physical, economic and social science in decision making, but which do not defer adaptation planning or action because of a lack of perfect information about the future. We use risk management tools and approaches, and consider both the magnitude and likelihood of climate risks and capacity to respond to those risks. Continued investment in the science,

technology and innovation, adaptation information and skills, helps us to manage climate risks and find emerging opportunities".

Therefore, the key areas for climate change research are:

- Using physical science to reduce uncertainties in climate change projections, especially seasonal-average rainfall and risks associated with extreme weather events
- Using physical and social science to enhance the uptake of projections through better climate products and services
- Using physical, social and economic science to assess potential impacts
- Identifying and evaluating different adaptation options and pathways, including costs and benefits
- Identifying and evaluating different mitigation strategies, including costs and benefits.

--

Changes in global atmospheric circulation (variability, poleward shifts, etc.)
Sea level rise (regional variation in MSL trends, potential for rapid ice loss from Antarctica, etc.)
Relationship between warming temperatures and drought impacts (regardless of precipitation changes)
Evolution of global cloud cover and potential for negative or positive feedbacks from it
--

Monitoring climate trends and sea level; attribution of observed impacts; understanding predicted impacts; adaptation strategies and planning; mitigation strategies and planning
--

Local scale climate change impacts
Interactions between biophysical impacts and human consequences
Effective ways to communicate complex problems such as climate change
--

It is critically important to improve the multi-scale representation of climate variability and climate change involving the whole Earth system, including coupled atmospheric chemistry, coupled vegetation, coupled land surface, coupled ocean, coupled cryosphere, and coupled biogeochemistry. We need 5 km resolution globally, as only at that scale can you represent cloud processes and all the coupled process above. At present, Australian projections are not available at those scales, they don't take into account coupled land surface and vegetation interaction, effects of aerosols or ice and ocean variations at those scales. So in practise we have a broad idea of the larger scale climate change impacts for Australia, but we can't quantify the uncertainties. We won't reduce the uncertainties at the 5 km resolution, but we'll better understand the uncertainties to understand the climate response in Australia.

Current projections don't take into account the coupling between the land surface, vegetation, and climate. The uncertainty ranges in CMIP 5 projections don't take into account carbon cycle-atmosphere-climate interactions (IPCC chose to underrepresent the uncertainties in the high warming scenarios). Note that these aren't in the plan for NESP, which doesn't include the critical atmospheric chemistry-climate coupling.
--

Quantifying rainfall changes (noting the uncertainty in Temperature is dominated by emission scenarios beyond the next 20-30 years).
Extremes in a changing environment – heat, TC's, drought…
Multi year to decadal is a huge challenge yet to be met.
Coastal extremes in sea level change and ocean acidification
Carbon budgets
--

I am not particularly up-to-date however:
a) risks associated with positive feedback mechanisms as we force the system harder
b) risks associated with unexpected or rapid climate system discontinuities
c) better insight into the efficacy of mitigation in relation to forcings
d) developing clear insights into limits to adaptation
e) the reconciliation of observations and model outputs designed to provide better insights in to Australia's future climate – particularly extremes.
--

Extreme events
Climate change scenarios
Climate change impacts in the terrestrial environment (physical and biological)
Climate change impacts in the marine environment (physical and biological)
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As noted previously, Australian climate change research is critical for understanding and managing the social, economic and environmental risks of climate change. While substantial progress has been made in many areas, gaps remain in our ability to deliver the priority science identified in *A Plan for Implementing Climate Change Science in Australia*, 2012. Areas requiring further science investment include:

- ACCESS model development to develop capacity for next generation model code development, and address gaps including for a seamless prediction system, and for enhanced configured regional modelling to deliver regional projections
- Research to better understand the role and capacity for land and ocean sinks in our region to continue to sequester emissions, and how the sink capacity may change with climate change

- How modes of climate variability will change with climate change, and the implications for damaging extreme events. Such research needs to span ENSO, the subtropical ridge and the Indian Ocean Dipole
- While not solely an issue for the ACCSP, much remains unknown about the resilience of Antarctica to climate change and the rate of change in the sea and terrestrial ice. Significant change could result in high end impacts, which once triggered may not be readily reversible
- Understanding the differences in risk to societies of a 2 degree warming, versus a 3 or 4 degree warming, is needed to enable appreciation of dangerous climate change and to inform both mitigation and adaptation policies.

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Climate model development; projections of climate change; understanding the interaction between natural and anthropogenic climate change; documentation of historical and prehistorical climate variations; identification of the impacts of climate variations on human health, agriculture, and ecosystems.

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Primarily, being able to connect with discrete private sector groups (e.g. mining companies, oil & gas, agriculture, tourism and recreation) and quasi-government groups (e.g. transport, water, power, telecommunications) to shape the climate research at a detailed level, so it continues to (and better) interface with the users, as users become more sophisticated in knowing the need to apply climate change science to new infrastructure, investments, design and operations. Because climate changes are accelerating, the need for this will be greater. These groups would be willing to partner and pay for research that is bespoke to their organisation.

In addition, and in no particular order:

Stronger link between the science and impacts of sea-level rise, storm surge and coastal erosion (observed and projected) in terms of the costs and repercussions of certain levels of sea-level rise. There is great uncertainty about the rate of rise, so need to provide better information for coastal councils as they are planning for the minimum levels. They need to know different levels and implications of storm surge that is not tied to specific years. Need more information relating to tipping points in terms of the acceleration level for sea-level rise – going from 3mm a year to 1 cm a year, which provide triggers for policy and how people make decisions at different points around Australia.

Transfer of climate and temperature focus on max and min, and its implications on buildings. Need to take projections and create a weather file of hourly increments for a year that provides building and design industry standards for now, 2030, 2050, 2070, including ranges of uncertainty. Design now uses data from the past, using files produced in the 1980s. AECOMM/RMIT working with ERA (air conditioning and mechanical and electrical engineering groups that do the design for building

heating/cooling of buildings) about how to obtain this information – but need climate science underpinning this.

Implications for oceans in terms of acidity etc. in the Southern Hemisphere, and impacts on marine ecosystems, fisheries, and regional variations, and providing potential solutions.

Explore bespoke geoengineering responses at smaller scales with surgical approach and minimal impacts to gently intervene at local scale.
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Extreme events, particularly rainfall
El Nino in future, and increasing confidence levels in knowledge of future El Nino and what that means for regional rainfall distributions in Australia, and what it means in longer term for drought occurrence.
Sea-level rise, including contribution of melting ice, and whether projections are reliable in terms of lower or higher levels of sea-level rise.
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- Ocean circulation and sea-level rise
- Extreme weather events
- Biogeochemical cycling greenhouse gases, particularly the role of the terrestrial biosphere
- Climate modelling, particularly including downscaling regional levels
- Options for future energy sourcing and utilisation.

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- The development of high quality global physical coupled models that are fit for understanding and predicting climate and climate change.
- The maintenance and utilisation of high quality climate observing systems.
- Understanding the role of climate change and variability on local high impact weather and climate events.
- The development of full Earth system models that can inform longer tem climate and inform the impacts of various mitigation scenarios.
- The utilisation of global and convective scale modelling systems to inform climate adaptation policies at the local scale.

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Please note that this is a personal rather than Bureau of Meteorology perspective. I also add that my preference is to consider climate science priorities more generally (rather than climate change). Otherwise, we risk reducing priorities for climate matters that are very important for our stakeholders (e.g. forecasts, early warning systems). I've taken the broader view here with the following priorities:

- Improved understanding of key processes driving climate change and variability in the Australian region, including how ENSO will change
- Seamless prediction: from days to decades and with a focus on extremes

- Interfacing forecasts and projections to applications, e.g. for agriculture, water management, energy
- Improved multi-decadal climate projections
- Improved earth system models

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Improving the representation of processes in climate models
Improving regional rainfall projections
Assessment of climate change over cities
Linking climate projections with on the ground activities for impact – groups in CSIRO excellent, as good as anyone in world, in packaging climate information for stakeholders. Thanks to their quality of work and ongoing engagement, it has been seen this is a limited way to engage. You have to provide bespoke information directly based on needs of decision making. Need information to target their specific needs, not projections delivered to stakeholders. Building products for the users is useful but insufficient. Need to rebuild the projections delivery systems to provide what users need.
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(not in any particular order)
The strength and trajectory of climate change;
Climate change drivers and how these change with increased greenhouse gasses
Future projections of climate including agricultural weather projection; bushfires; sea level; extreme events.
Improved models for understanding climate change;
Palaeoclimate records (including the study of very old ice)
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1) Climate change impacts on extreme events e.g. extreme rainfall & bushfires events
2) Projecting the severity and duration of future drought events
3) Climate drivers and interactions – variability (wet/dry years) and climate change in Southeast Australia and Victoria
4) Climate baseline and methods to reduce uncertainties in climate change projections
5) Improve skill of seasonal to longer term rainfall and streamflow forecasting
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That is very hard to answer obviously, it depends on how you carve things up. A key factor for Australia is that you have to make the best use of the good people you have and do what you are good at. Right now I would say we are very strong in ocean and atmosphere modelling and the terrestrial carbon cycle and hydrology. Important areas we could strengthen are atmospheric model development
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Circulation change around the southern hemisphere, as this determines how habitable southern Australia will be and how much water is available. We

understand cool season rainfall changes in the south, but there is a lot of uncertainty around the rest of the continent and in other seasons.

Tipping points: at many scales, things are non-linear (e.g. impacts on the GBR recently, you get a flip in the system after prolonged warming and a step change in impact). So we need to understand tipping points like these and others, such as around ice sheets.

Paleo records: these provide insights and understanding of the higher ends of IPCC scenarios. Could collaborate with NZ expertise (e.g., Tim Naish) on this area. Need the immediate decadal framework about perturbations on systems we understand, but also need to look at stuff that the models can't predict, which is where paleo records and understanding can help.
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No research activity should assume that it can name the 'top' areas that are needed. By its nature, research has to be broad enough to ensure that surprises can be dealt with and unexpected areas will emerge. The Antarctic ozone hole is a prime example where a key area emerged that was wholly unanticipated. This is why maintaining a high quality research activity that has a broad remit is essential. That said, it is possible to identify some areas that are key. These include: predicting the changes in the location, nature and intensity of extreme events including but not limited to heat waves, heavy rainfall, storm surges, etc. ; biological and ecological impacts of climate change such as the spread of infectious disease, fire, impacts on agriculture, etc.; the influence of ocean acidification on life in the ocean; better predicting ice loss worldwide and its implications for sea level rise; and understanding how climate changes in the Arctic and Antarctic will affect the planet.
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- further work on greenhouse active substances, emission pathways and mitigation responses (beyond methane)
- change to "natural" / historical circulations as a result of climate change
- integrated mitigation and adaptation modelling (or at least a framework like there is for the economic modelling and forecasting) - localised projections, linked to forecasting and the ability to assess the adequacy of planning and policy responses
- tipping point (when the frog is gone regardless)
- better links with behavioural economics and anthropology to frame narrative choices that use climate change as an opportunity to live lighter and happier rather than being framed as a 'loss' – overcome the "wicked" nature of the problem.
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Sustained observations, particularly ocean and high latitude; Process studies in target areas, e.g. clouds, ice-ocean interaction; Model-intercomparison/development
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Climate projections and their application in mitigation and adaptation assessment

Climate modelling
Observations (climate, atmospheric chemistry, ocean state including sea level, ice).
Detection and attribution of climate change
Carbon budgets
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- continuing monitoring of the climate system
- improving our understanding of major regional climate drivers and how they interact
- improved understanding of physical processes underlying climate extremes, and their representation in models
- Coupling regional climate and ocean models
- Improved model resolution to enable local impact assessment

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- Physical science: modelling and monitoring, especially in this area of the globe;
- Ongoing issues around adaptation, especially focusing on infrastructure and vulnerable communities, planning, governance and economics;
- Research on biophysical environment – moving beyond people, infrastructure and money, and understanding climate impacts on biodiversity and ecology;
- Extreme events and the capacity to address emergency management requirements into the future;
- Cross-cutting systems thinking and management thinking across all areas of society.

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Stability of the Greenland and Antarctic ice caps and contribution to sea-level rise understanding is key
Interaction between ocean and ice shelves is critical
Understanding of sea ice in Antarctica
Deep ocean, maintaining Argo and extending observations to deep ocean
Better parameterisation of clouds and getting radiative forcing right in models
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1) Identifying particular global climate models and downscaled models that better predict the likely impacts of climate change on water availability in the Murray-Darling Basin.
2) Identifying how freshwater aquatic ecosystems may adapt under climate change.
3) Identifying the impact of climate change on different types of water entitlements in the Murray-Darling Basin.
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Projections
Atmospheric monitoring
Ocean monitoring

Extreme events
Climate modelling
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13. What impediments, if any, were there to research impact and application of results?

Funding and staffing issues for the ACCSP as time has gone on
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The program had its roots in the atmospheric and marine aspects of climate change and while over the years it attempted to link more closely to adaptation work it never really had the resources to do so effectively. As a consequence, I don't think we have taken full advantage of the research undertaken in the ACCSP.
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Mostly, lack of resources. In 2004 I visited climate change science groups in Europe, corresponded with groups in the US and Canada, and wrote a summary of resources devoted to climate change elsewhere that led me to conclude that we were significantly underweight. In turn that led to conversations with like-minded people heading CSIRO's marine Division and the Bureau which ultimately resulted in CAWCR, and a strong CSIRO-Bureau affirmation of the importance of partnership between these two Federal agencies and the progenitor to what subsequently became the Department of Climate Change. ACCSP was a central consideration in those conversations. We have always been underweight compared to Europe and the US, and will be more so in the future given CSIRO's exit from the area and the ending of the ACCSP and reduction in federal investment. That difficulty obtaining and maintaining world-standard critical mass was, is, and in future (more so) will be our major impediment. This is perhaps less of a problem with the Universities; it is the key problem for the Federal agencies that have the mandate for long-term, strategic climate research. The Australian universities will still provide world-standard investigator-led research on climate system science, but without a critical mass of federal mission-directed science into which to feed that shorter-term university science, we will struggle to yield downstream outcomes. The federal agencies have provided that path to impact, and they are increasingly underweight, indeed that will be exacerbated by CSIRO's exit from the field and the breakup of the historical collaborations that yielded the National Framework for Climate Change Science (2009) and its implementation plan (2011).
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Insufficient funding for external stakeholder engagement and knowledge brokering.
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One of the impediments was the difficulty in accessing results, and the explicit use of these results in quantitative models (since they are complicated) and then the lack of capability in the impacts and wider business community to use the results and turn them into knowledge at their business level. This is a difficult, but important task….
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I think the three main impediments to research impact and application of research findings from the ACCSP over the past 3-5 years were:

- A lack of understanding by researchers *and* policy makers of how to package climate science information so it can be easily assimilated into policy decisions, impact assessments etc.
- The lack of a process to ensure scientific results from the ACCSP were provided to the Department regularly (i.e. scientific research papers and summary provided to Department soon after paper is released). This made it harder for the Department to ensure the programme science was included into current policy development processes and decisions.
- The communication of research results to industry, business and state and local governments could have been improved to ensure better up-take and application of results into policies, decisions and land management planning. Of course, how best to communicate this information to enable this uptake of science into policies is still something that is being grappled with (as mentioned in the first dot point) - but better efforts could have been made. Communicating the economic benefits of research performed under the Programme may also have increased the research impact.

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Limited resources. Too strong a focus on CSIRO getting credit and too little on international leading science, support for the scientists and user needs

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Ensuring that the priority research topics for Western Australia were included in the ACCSP program has not always been easy from a Western Australia perspective. This is one of the motivations behind the development of the Indian Ocean Climate Initiative – to address climate science questions that were a priority for Western Australia. Thorough consultation with all state and territory governments during the design phase for future climate science programs would help ensure all possible priorities are considered and an appropriate balance of research questions are pursued.

Over the 27 years: The relative lack of awareness of the ACCSP and its findings by the significant proportions of the Australian public and of stakeholders who could potentially apply the results. This is not a criticism of the program, just an observation that if its results were even more widely known, controversies initiated by advocate of views that reject the climate science consensus, would have had less traction that they have had over the last two decades.

Lack of access to the raw data from climate change projections produced, and/or lack of ability to access research results for the specific geographic regions (of varying scales) that would be most useful for technically capable potential end-users. This has definitely improved in more recent years.

I think some of the early research from ACCSP could have been packaged in more accessible formats for end users. There is a wide range of capacities and expertise of end users who wish to use climate change science research. Other researchers from other research institutions can take advantage of normal academic publications.

However non-research organisations have staff who benefit from having information better interpreted. There is, for some potential end users, quite a gap between the academic research findings and the information packaged easily useable formats for the less technically qualified end users. Bridging this gap needs focussed attention and a mix of science research and communication expertise along with liaison with end users from target audiences. Future climate science programs would benefit from ensuring this communication component is allocated substantial resources.

In the latter years of the ACCSP program these kind of weaknesses were being addressed, through the presentation of the 2015 version of the Climate Change in Australia website and documents to present this new generation of climate change projections and associated information.
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The interface between program scientists and the commercial consulting sector, that delivers most of the adaptation studies, was often poor. This is not a feature of the program, rather the culture of many of the researchers.
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On seasonal prediction, early on there was a disconnect between model development for climate change and its application for seasonal prediction. It has since changed, because seasonal prediction is using climate model directly from Met Office, rather than through ACCSP, so the disconnect is still there.
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The ACCSP did not have a Program Logic showing the links between impacts, outcomes, goals, objectives, outputs, activities, capabilities, stakeholders (next/end-users) and governance. It should have been underpinned by an independent survey of stakeholder needs (market pull) and research innovation (market push). Consequently, the ACCSP was output-focused rather than impact-focused. The key performance metrics were journal papers rather than application of results by next/end-users.

The ACCSP did not have a Monitoring and Evaluation (M&E) process to facilitate learning and assess impact. This made it difficult to measure the true value of the ACCSP.

Inadequate resources were allocated to management, communication and knowledge-brokering. About 20% of the $15m/year budget should have been allocated to these functions to facilitate better uptake of the research outputs and evaluation of the impacts. However, the Greenhouse Conferences in 1987, 1994, 2005, 2007, 2009, 2011, 2013 and 2015 were very successful communication events, and it is hoped that they will continue through the NESP ESCC Hub. The ACCSP website is also good.
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I can't identify specific impediments, other than to comment that the lack of a bipartisan approach to climate policy in Australia generally inhibits both the delivery of scientific understanding to the public and policy makers, as well as inhibits significant mitigation action.
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We NEED certainty that the long-term research that is needed will be supported for the time that it takes to complete and understand fully its implications. More research and hence more researchers are needed.
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Biggest was the constraints on the funding. More could have been done with more funding.

Over time, the lack of collaboration between CSIRO and BoM had impacts on joint versus separate nature of the research. There were a number of organisational changes to the collaborative nature of the research.

Some choices by ACCSP management to not fully use collaborative opportunities with universities was a handicap – more could have been achieved with collaboration with universities on specific topics. Even ACCSP funding of graduate students would have been a good way to engage with universities. This is a big difference between ACCSP and the NESP ESCC Hub. Universities also were more involved in PACCSAP, but not with ACCSP.
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Some of the science was inward looking and there was not enough incentive to look at direct impacts and communicate these risks. As a field, with the exception of SEACI and VicCi to some extent, the hydrological and climate communities have not been brought as close together as would be optimal.
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a) The political climate – the ACCSP frequently produced results that challenged the status quo in that they implied that action on climate change was desirable. This remains a major challenge.
b) Institutional arrangements – the dynamics between universities and CSIRO (in particular) were unhelpful. The program was originally set-up with a competitive funding component for universities (and others). The delivery from these original grants was deemed to be poor and therefore such funding began to be cut-back. Thus there continued to be a university vs CSIRO/BoM dynamic that was not always helpful, although this changed over time.
c) State of the science – there is an unanswerable challenge when science is unable to deliver knowledge in the form that users want. In particular, many uses want an accurate deterministic forecast of climate outcomes decades hence at fine (high) spatial scales. That this, given our current state of knowledge and the role of internal variability (including chaotic elements) is unlikely to be deliverable becomes highly problematic.

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It will always be a challenge to be able to disseminate research findings in a way that is accessible to managers and the broader community. The ACCSP has done a good job of it but more is required in the way of having a 'clearing house' of updated information in an accessible language and format.
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There are a wide range of impediments to the uptake and application of research results from climate change science, which this submission will not do justice to. Impediments include:

- A politicisation of mitigation policy that among other things led to a disconnect from the findings of global carbon budget research. There has been little analysis of this in Australia, but there is a growing body of social research and grey literature in this area globally.
- Challenges in the communication of climate science which is complex, spans long time-periods which are outside the frame of many day-to-day decisions, and utilises terminology such as uncertainty which can be easily misunderstood by the wider community.
- A range of factors that inhibit the uptake of adaptation measures. The Productivity Commission reported in 2013 on the barriers to effective climate change adaptation. Recent research in the social sciences is also pointing to the role of path dependency in policies or decision-making processes as an impediment to change, a number of psychological or cognitive barriers that constrain robust judgements on future risk, and the need for leadership including from governments.

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Because the ACCSP funding relied on political decisions for its continuation, the scientists in the program were always constrained in their ability to communicate their results. This meant that their results did not achieve the impact and application they deserved. And it also meant that scientists were employed on short-term contracts – this limited the ability to recruit the best scientists, at times.
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The position on climate change of the government of the day has been a significant impediment to the community of business and government officials using climate science to support decisions.

The co-development and co-creation between scientists and users to design and development research concepts. Some of the research is bespoke to particular industries or sectors and their needs. Building the research plan with users was attempted, but wasn't an imperative. There is still a great need for working with users in research planning. For example, working with agricultural investors in planning long-term crop development, timing and locations – which would lead to industry investment for bespoke research.
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Need to talk to users of research – but need to recognise how difficult this is to communicate with stakeholders and then fashion a research program taking into account user needs. It is difficult, and not done well now. Once the difficulty is recognised, can improve interactions with stakeholders. Important not to swing the other way to have too much target-driven research – as sometimes stakeholders are bad at identifying what they really need. So stakeholders need to be more humble, scientists need to be more consultative.

Funding is problem – can't get more for less and less. Government can't achieve that goal.

You can't always have clear deliverables, as science is science.
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Clearly the major impediment to research having an impact or being applied was response of a sceptic subset of the community. Some of these existed at extremely high levels of the Federal government, others existed within large and powerful companies and their sectoral organisations.

The scepticism derived from a number of sources including:

- A dependence on constructed world views;
- The dominance of neo-liberal economics;
- The denial of rationally inputs;
- The use a range of coping mechanisms such as denial;
- Clashes with vested interests.

But at the same time, despite extensive attempts at the publication/communication of climate change results, large sections of the private sector, particularly within the SMEs, remained and remain oblivious to the need for risk assessment related to their enterprises.
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The quality of the 'Climate Change in Australia' suite of products warranted higher profile stakeholder engagement and public release. (No criticism of the scientists here).
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ACCSP had a catastrophic model of collaboration. CSIRO/BoM no longer do blue sky or innovative science. For this you need postdocs, people working in fields outside climate science – real innovation comes from teams of young researchers, led by senior researchers, with a rapid turn over of talent. This isn't how the CSIRO/BoM works. You can't hammer young staff with administrative tasks, need to hammer them for innovative solutions to problems.

CSIRO/BoM can't collaborate with each other (e.g. CAWCR falling apart as 2 orgs have different ways of working, expectations and needs). Need the two government agencies to work together.

CSIRO BoM don't do strategy very well. Ask a group for key priority areas, you won't get 3 key ones, you will get 20 and CSIRO will try to fund all of them. Need to prioritise better to target the funding otherwise you're trying to have some capability in many broad areas. But success should be about having high quality depth of skills in subsets, and then working with others around world to bring in capability in other areas where you don't have the skills.

ACCSP had no need/requirement to collaborate with the Universities, which is where bright new talent resides. NESP ESCC Hub has learned from that.
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N/A
In phone follow up, I pushed on any lack of connection to policy. He would only say that under the previous government there was a clear link and process for science to feed into policy, but that has disappeared under the current government. So the failure of science into policy is political rather than due to any scientific or communication failing.
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Uncertainties in the climate change projections, and the difficulties/gaps in linking science/research to practical applications – more emphasis on engagement and forum so that researchers can better understand the needs of industry users/practitioners, and industry practitioners can have better understanding on the capabilities and limitations of science and modelling.
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There was the generic impediment of the influence of sceptics, the level of which influenced and was influenced by the atmosphere around the country relating to the Govt of the day. The sceptics' influence slows the uptake of the science, retards the science, and prevents engagement of some people.

There also should have been more engagement between Govt more broadly (beyond Dept of Environment) and scientists. This wasn't the scientists fault; rather it was due to interdepartmental jealousies and Govt silos that prevented engagement between the Commonwealth Environment Department and other departments. This rivalry within government between departments was one of the biggest impediments in getting the knowledge out.
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It is likely that the biggest impediments were funding limitations and lack of incentives and assistance from the organization for the staff to spend time on outreach.
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Politicisation. We have allowed those with power to exercise their ignorance to further vested interest rather than the response an issue of this magnitude requires. The vitriol, bullying and harassment that climate scientists as messengers have been subjected to is just wrong. Need to engage better to ensure aspirants are informed and will act – or better ways to marginalise them and work around them!
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Coordination and resources. Not a specific criticism of ACCSP, but the very breadth of the disciplines and physical areas to be covered makes coordination a challenge, and one that ACCSP increasingly appeared to do better over time. Resources will always be a limit, but ensuring that those available are targeted to the most serious bottlenecks is also a challenge.
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Within the restrictions provided by the funding envelop there were no significant impediments.
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- Some political scepticism about climate change – but this has advanced significantly due to the science being done and communicated, so now have more political support for action out of this sort of work; thanks to the science, people now are willing to do something about climate change;
- some limitations of funding/resourcing;
- competition in this space from different organisations;
- diffuseness of information, and the need to make information appropriate for practitioners (this impediment applies to whole area of science, not just this program).

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Not a block that could be removed, but there was no imperative in the establishment of the programme to take the extra step into end-user delivery. So that expectation wasn't established in the first place, which reduced the impact of research.
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Lack of funding, less than optimum expenditure on communication, a project selection process that may have been sub-optimal.
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14. Can you identify any shortcomings, or unexpected (positive or negative) outcomes, of the ACCSP?

Only those that have come about as a result of not having the staff or funds to undertake the research needed.
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No major shortcomings. Except that with hindsight there should have been better storytelling to the public, to the political class and to sections of the media to counter the trenchant attacks on climate science in sections of all three that ultimately have affected the politics, perception of and actions this country has taken on anthropogenic climate change. The science has played much less of a role in the public and political debate than is the case overseas and that is warranted by the quality of what was achieved and the scientific progress made in Australia's national interest by the ACCSP.
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- The lack of projections tailored to specific needs was a short coming, particularly with respect to assessments of future drought risk from a hydrologic perspective.
- To those within CSIRO but outside of the ACCSP it was often viewed as a club to which membership was either difficult or impossible.

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ACCSP was a wholly Bureau and CSIRO funded scheme, with no resources explicitly flowing to the wider research community and organisations. Therefore ACCSP had a privileged funding environment.
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Some short comings of ACCSP (over the past 3-5 years) include:

- The lack of a strong 'brand 'for ACCSP researchers and research findings. It often felt like the ACCSP brand got pushed aside in favour of organisational brands (i.e. Bureau and CSIRO) when research findings were reported on in the media and on websites. I think this resulted in the ACCSP not being as visible to the public as it could have been – especially as it was Australia's 'core' climate science research programme.
- The lack of independent monitoring and evaluation activities throughout the life of programme. Perhaps an independent M&E project for the programme would have assisted in capturing the value of the programme to Australia throughout the life of the programme, rather than waiting until the end of the programme to go back and capture the value and learnings. This may have assisted in communicating why investing in climate change science is important for Australian communities, businesses, industries and governments.
- The outcomes of ACCSP could have been better communicated – both to the Department and to the Australian public. For examples, research publications and articles were very rarely passed onto the Department in a timely manner

despite multiple requests from the Department to develop a process to enable this. This caused a barrier for getting the programme's science into policy. More innovative and creative ways of communicating the outcomes of the programme to the public and interested community groups, industries etc. could have been deployed – i.e. use of other organisations such as Climate Commission to advertise research findings, climate blogs, newsletters etc.

- The ACCSP was funded primarily through short funding rounds (mostly on a yearly basis). While this was out of the control of the programme management team (it was as a result of Government decisions), it is important to note that this short term funding process did not provide enough certainty, continuity, security or strategic planning ability for long term research projects or the programme as a whole.
- Unexpected outcomes of ACCSP:
- The ability of ACCSP to survive for 27 years throughout a number of government changes.
- The way the ACCSP has been a driver (over the past 3-5 years) in helping to bring the Australian climate science research community together to be more cohesive and collaborative.

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Inadequate review processes and overly generous assessment of CSIRO standing in international climate science. Despite these, an enormous success

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The Indian Ocean Climate Initiative collaboration between the Western Australian Government and CSIRO and BoM would not have been possible, for the same cost and timeframe, if not for the ACCSP program and the expertise it allowed CSIRO and BoM to establish.

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Only negative side of ACCSP was the perception of it being a closed shop/old boys network. If you weren't in the loop, you could never get in. He tried to get involved for a few years, but only had a project get up once, which is indicative of the track record. Just wasn't clear there was any interest in new or different directions from outside the loop.

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Due to the impediments list in item 13, the ACCSP did not realise its full potential. This made the ACCSP vulnerable to funding cuts in some years, with uncertainty about multi-year funding during some periods. When the ACCSP was terminated in June 2016, the research community was more concerned than the next/end-users. This highlights the lack of impact-focus.

An unexpected positive outcome has been the significant leveraging of the ACCSP research by other programs such as IOCI, SEACI, VicCI, PCCSP, PACCSAP and NRM. These programs added value and produced some notable outcomes, e.g. investment

in water security infrastructure such as pipes and desalination plants, inclusion of climate change in NRM Plans, and using research findings in Pacific Climate Actions Plans.
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No
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If there is a shortcoming, it is that the research is based in the STEM disciplines whereas the addition of social research and communication research might enable ACCSP to be even more effective.
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Graduate students and university collaboration were shortcomings.
Capability of using ACCESS as a coupled climate and chemistry model was unexpected – it was hoped for, but wasn't part of ACCSP plan to have this capability arise out of ACCSP.
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While ACCSP did a great job in the fundamental science, there was a gap in applications of the science. As an example, there was no great penetration into agriculture despite the obvious potential relevance. This was only partially picked up under other programs. The links to water availability and hydrology could have been stronger.
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Clearly this questionnaire exists in the background of CSIRO senior management wishing to make major changes to the organisation in relation to its climate research capability. I believe it is a serious error to diminish the national science capability in key areas such as earth systems modelling; understanding of greenhouse gas sources and sinks; oceanic process and climate processes. The remarks of CSIRO's current CEO to the Senate Committee have been fatuous. That said, there is a case for renewal reconsideration of science direction and determining whether existing science staff ought to be refreshed.

Thus, it may be that the ACCSP ultimately becomes a victim of its own success.

A general short-coming is that key elements of the ACCSP contributed to long term 'monitoring' research (e.g. Cape Grim, ocean observations program etc.). Again and institutional weakness is that Australia is very poor at committing to and supporting such research and thus ideally such research would not have been within the ACCSP but elsewhere.
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Bring back the Greenhouse Conferences!
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Shortcomings included the political and short-term nature of the funding of the ACCSP, the tendency to use the ACCSP to “top up” ongoing research which should have been funded in different ways, difficulties (at times) in the relationship between CSIRO and the BoM (at management levels), the competition between scientists to obtain funding for their research interests, the excessive requirements (at times) for reporting to the funding bodies.
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Benefits to the consulting industry, to the design industry, to a range of government agencies and organisations (e.g. transport) that use ACCSP info in major planning decisions.
Impact in supporting better decision-making.
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The earlier stages of the ACCSP, research funding tended to be in relatively large aliquots, with limited guidance from the Department with regard to research directions. In retrospect, I think this was very important, given that most of the questions about where research investments should go, at that stage, were and should be determined by the scientists. This is not to discount the role of the Department in transmitting to the research community guidance as to where the Government and its bureaucracy assess the needs lie.

In the latter stages of the ACCSP, however I believe this intervention in goal-setting, and the reduction in the size of specific allocations of funds to projects became counter-productive, tending to stifle scientific freedom and entrepreneurialism and increase the processes related to accountability and management. This is not to deny the fact that there will always be some disagreement of where this balance lies.
--

The ongoing sustainability of some components of the ACCSP would have been better satisfied through considering a transition path from research to services, e.g. ongoing structures for managing and (online) delivery of climate projections data.

There was also the positive benefit of allowing Australia to support Pacific climate change science and adaptation.
--

Positive outcomes: Australian capability around CMIP and ACCESS and some other key data. Can’t undersell how important that was.

Negative: Lack of collaboration between CSIRO/BoM/Universities weakened the research community but trying to resolve that.
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See #4. Because of these issues I am not sure everyone at the agencies has been used to their fullest potential.

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The silos as mentioned above in q. 13, and also at the start of the ACCSP the universities weren't engaged – prior to the ARC Climate Change CoE, there wasn't an institutional framework to properly have engagement.
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While it is clear that having data from many sites is valuable, I think the extent to which Cape Grim data have assisted global understanding of trace gases has been even better than one could have expected before it was undertaken. I don't see any substantive shortcomings in the work of the ACCSP given the funding limitations that it certainly worked under.
--

That the Australian community has been OK with the marginalisation of the climate science – their lack of passion to support the programme has provided elected officials with the opportunity and the means to withdraw support for the programme.
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None of note (aside from the comments at Q4 about the inclusion of external researchers in ACCSP work).
--

The one-year cycle for planning with operated in ACCSP in many of the latter years of the project was not ideal. It should have been longer. The strengthening of the components of ACCSP as a management unit, which was done in the latter years, was much needed and could have been done earlier and taken further.
--

As a regional decision maker it could be difficult to entice ACCSP scientists to look at regional climate change, and an impression that sometimes resulted was "we are more interested in tackling the global issues".
There was a gap between the global/national modelling efforts and our management needs for local/regional decision making hence the need for NARCLIM type projects. In the coast/estuary and marine space the National scale efforts e.g. Blue link are significant advancements but continued effort is required to get from the shelf scale to the coast/shoreline and eventually into estuaries.
--

Marketing: hadn't heard of the ACCSP even though the SCCG had worked with the scientists for years.
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Some wonderful scientific results from ACCSP.

Compared to current funding, the level of funding was substantial. The ability to leverage that funding enhanced the programme greatly. In a very leveraged world, the value of the investment paid dividends many times over due to leveraging.
--

Internal politics played too strong a role in selection of projects to be funded. A more dispassionate, disinterested approach would have been better. A stronger role in project selection from the Department may have seen an even greater impact from the programme.
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15. What do you see as the legacy of the ACCSP?
That will depend on what comes after it. In other words, this all needs to be continued and sustainable or their will be no legacy.
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Fundamental contributions to global research efforts in observations (atmosphere and marine, including sea level research), process understanding in oceans (Southern Ocean), carbon cycling in terrestrial landscapes, climate modelling, climate projections.
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First, a body of scientific work that has contributed very substantially to global understanding of climate change and particularly to local (Australian region/Southern Hemisphere) understanding. Second, a range of reports on specific topics provided to many users - sectoral groups across society and governments - built out of that science to provide balanced guidance for future action by industry sectors or policy makers on both mitigation and adaptation. ACCSP directly contributed to some reports, others were produced by consumers of the fundamental science, one such example being the the National Climate Change Adaptation Research Facility (NCCARF).
--

- The growth of a tightly-knit community which has experience with working together and progressing climate science for the benefit of Australia.

- Also, the large body of knowledge about climate system at the global and regional scales that has been accumulated during the last 27 years. This would not have been possible without a focused and strategic program like the ACCSP.

--

The legacy will be the following, the numerical simulations of future climate change (large and regional scales), the observations of climate during this period, the new and revolutionary change in the science around our changing environment, and the dawning on the world during this period that the changing climate can be 100% attributed to man. This legacy has been a 30-year journey.
--

The legacy of the ACCSP over the past 27 years includes:

- Amazing contribution to our understanding of Australia's, and the globe's, climate system.
- A climate science capacity in Australia which is larger, more collaborative and cohesive than it otherwise would have been – even with the funding cuts over the last few years.
- The high international reputation of climate research in Australia.
- The provision of Southern Hemisphere climate data into global assessments and initiatives, such as the IPCC and CMIP's.

- High quality, policy relevant regional climate projections for Australia.
- The development and maintenance of long term observation and monitoring of climate variables, notably ocean heat and salinity and atmospheric levels of the major greenhouse gases.
- Strong working relationships between CSIRO, the Bureau and the Department to ensure climate science continues to inform policy.
- In some ways the Earth System and Climate Change Hub of the NESP is a legacy of the ACCSP. The Hub represents a more community based research programme, including 5 Australian universities as well as CSIRO and the Bureau.

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A climate science community
Awareness of climate change in Australia
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The ACCSP has been a core input into of Australian governments, industry and business and other stakeholders to gain a better understanding of climate science, and the significance of climate change for the prosperity and sustainable future of Australia. It has played a vital role in providing the information base of climate change projections to support climate change risk assessment and adaptation planning specifically for Australia and Western Australia.
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ACCESS
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1. Investment in fundamental climate science that advanced the basic understanding on how Australian and global climate worked. A science program where understanding the science was the expected outcome. Doubt we'll ever see anything like this again — NESP is different, with an outcome, user-focus.
--

Over the past 27 years, our understanding of Australia's past and future climate has improved radically through the work of the ACCSP. The research is world-class and underpinned by high quality peer-reviewed literature. Other projects such as SEACI, IOCI, VicCI, PCCSP, PACCSAP, NRM and NESP ESCC leveraged the ACCSP and added value.

The ACCSP has made significant contributions to global climate science, especially through (i) measurement and analysis of greenhouse gases in the Cape Grim / GasLab / IceLab / GCP activities, (ii) ocean measurements and analysis, (iii) global sea level rise research, (iv) ocean acidification research, (v) Indo-Pacific Ocean variability research and (vi) Southern Ocean process research.

The ACCSP developed and established a strong partnership between CSIRO and BoM. Media releases associated with key publications raised the public profile of CSIRO and BoM, who became trusted advisors on climate science.

The ACCSP also developed a strong partnership between BoM, CSIRO and the federal government agency responsible for climate change. This was critical for ACCSP governance, milestone delivery, issues management, contract negotiations and ongoing funding. It also had benefits for government funding of research projects outside the ACCSP.

The Program has encouraged recruitment and retention of talented scientists, many of whom are considered domain experts nationally and internationally, and are key points of contact for stakeholders and the media.
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The body of work facilitated by ACCSP signifies that Australia takes climate change seriously and has contributed to both national and global knowledge on the issue.
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The ACCSP puts Australian science at the forefront of helping to understand climate change trends and impacts. This is a global contribution. This was made particular obvious during the compilation of the IPCC chapters I was involved in.
--

Legacy sounds as though ACCSP is time-limited. The legacy is that of a solid research and evidence base on which to base public policy. This might not be appreciated as widely as it should but we would be in deep trouble without it.
--

The people: Group of early, and mid-career and senior researchers to do the science. But now ACCSP is ending, CSIRO has chosen not to continue to fund them. The cutting of early and mid-career researchers is a threat to the legacy.

Modelling capability through ACCESS

Improved understanding of the science
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A huge legacy of science, e.g. the first understanding of regional sea level science, fantastic progress in understanding drivers of variability and their consequences, a national modelling capability, key input into international programs around carbon budgets, building work on extremes (there is a lot of work to be done in this area), national projection resources such as Climate Change in Australia. I could give a very long list. ACCSP has been the premier climate change research program in Australia for the last quarter of a century.
--

Before the ACCSP commenced whether anthropogenic forcing of climate: a) is real, b) is material (impactful and relevant), c) detectible and distinguishable from natural variability, were all considered open questions by many (if not most) reputable scientists working in a relevant field and by most of the public. The ACCSP has contributed to a science base in the Australian context which means that there is not only overwhelming scientific evidence to support the conclusion that anthropogenic forcings of the climate system are real, detectible distinguishable and potentially dangerous, but that most people are of the view that this is the case.
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I am confident that in spite of some sectors opposing action, the level and depth of awareness in the broader community on climate change impacts and the need to address them as a result of ACCSP's work will continue to be the determining factor in ongoing progress.
--

Far better Australian climate modelling capabilities than would have been possible in its absence, including high-quality climate change projections. Some improved understanding of natural climate variability and the details of anthropogenic climate change. A larger body of highly-qualified and experienced climate scientists in Australia than would have been the case without the ACCSP.
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As a result of this consulting company's partnership with CSIRO on infrastructure impacts, and by using climate advice from the ACCSP, they were able to do $70 million of work globally and mainly in Australia. The work stemming from the CSIRO partnership provided significant jobs and prestige, positioning the company globally. Initially the work was related to climate adaptation, then gave the company the credibility to step into disaster risk reduction and resilience, having the track record of doing climate adaptation work with the underpinning partnership with CSIRO. The company obtained a number of $5 million contracts globally in the resilience space, and was only able to do so due to the foundation work with CSIRO. This consulting work made a huge difference to the lives of 50 to 100 people who were able to be supported to do work in this area – and the work is still going, generating $10 million a year and operating globally. This benefit to industry is likely to have been repeated by other consulting companies, so extrapolating there would be 1000-1500 jobs in the climate adaptation and resilience consulting field that have been generated and supported out of the science CSIRO has done. From an analysis in the US, the climate adaptation market is estimated to be $1 billion globally.
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The main legacies are:

Australian science is recognised internationally in the climate area as being very high quality, especially in light of the country's small population. So we are punching above our weight in climate change, and this is especially important due to our geographic location: if Australia is not doing Southern Hemisphere research, who is?

The ACCSP enables organisations like NCCARF (which has limited resources) to also have high international standing on the back of what we know about climate change science due to program.
--

Despite the demise of the ACCSP and recent incredibly short-sighted attack on climate change research within CSIRO, the Australian community finds itself with a legacy of national interest and concern about the climate-change issue that in no small way is derived from an active and communicative research community supported by the ACCSP. The foundations in climate modelling set time of the existence of the ACCSP are now combined within the joint work of CSIRO and Bureau of Meteorology are in no small part a legacy of the ACCSP.
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The ACCESS climate model and the understanding gained from this.
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A program which greatly contributed to improving our understanding of Australian and global climate change science and that allowed Australia to play a very important international role.
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At this moment in time we have a competitive climate modelling system and a series of very important data sets (observations and modelling) that we wouldn't otherwise have.

But not clear whether that legacy would survive 5 years in the current funding environment.

A good legacy at severe risk.
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Strengthened understanding of climate change; improved modelling of climate change.
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An independent national science program that has contributed to our generation by advancing our understanding of the science and capability in projecting climate change and its impacts on our environment.
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I simply see the ACCSP as part of the model for distributing funds within the two agencies, so for me, it is not the ACCSP legacy that matters per se but that of the agencies. Some very high-profile and important research (e.g. papers in Nature) has come out so something is going well even though not every project is successful. Also, to the extent that ACCSP has been funding development and deployment of

the ACCESS model, this is a significant legacy, as this is one of the top models in the world and on some metrics outperforms both of its parent models (the UKMO atmosphere and GFDL ocean model).
--

The legacy – the social capital, building not only a group of scientists across many disciplines, but also a culture of working together – is being broken up quickly now. The ACCSP put in place the institutional structures that allowed scientists to work across disciplines and build a better knowledge base by working together. This is not replaceable if it is lost as a result of the current cuts to CSIRO.

For a couple of decades Australia had a growing capability to address the challenge of climate change. We have the knowledge base in products such as the projections report. But we need the capability to keep growing, and the social capital to be maintained, and sadly it is under threat.
--

ACCSP has been instrumental in the level of understanding of Australian climate change that currently exists. This is no mean feat. There are only a few other countries with a similar level of understanding of their own climate. ACCSP has also made a series of leadership contributions that have changed the way others understand climate science, identified in 5) above. ACCSP has provided research records that are unique and invaluable, including the Cape Grim measurements and the ARGO float records.
--

- enhanced understanding of projected climate change among the interested / captured regional communities
- consensus building as a gateway belief to enable the focus to be on “well if that’s the case where do we go from here….”
- enhanced capability – the talent developed through the programme will hopefully take that knowledge with them into their new roles and value add there
- enhanced forecasting and communication skill within BOM
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Good systems for providing national climate information that meets Australia’s needs and a much more capable national climate research community that is internationally competitive. This legacy is not durable and has declining value if not sustained.
--

There are many. I think the bottom line is that Australia is much better equipped than it would have been otherwise to respond appropriately to the challenge of climate change.
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Ground-breaking research leading to ongoing momentum in terms of application of research results – but ongoing effort is required to maintain the legacy.

The legacy includes the intangibles described in answers above (international reputation, momentum leading to other work, etc.), in addition to the tangible deliverables generally focussed on by politicians.
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The quality of the great research outcomes.
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A significant body of research which can be built upon as the effects of climate change become more apparent.
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Australia, and the world, being far better informed about the current and likely future impacts of climate change. A stronger commitment than would be the case otherwise to adaptation and mitigation.
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16. Do you have anything else to add?

Good Luck.
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It is a pity this national program has been terminated, leaving a significant void not just in Australian research but in global efforts.
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The ACCSP was crafted to address Australia's climate change science needs so as to underpin mitigation and adaptation in an orderly fashion: harnessing the best scientific capabilities from the two national agencies, CSIRO and the Bureau of Meteorology, to address national needs in an explicitly collaborative manner. There has always been strong outward-looking emphasis on collaboration - with a broad range of people and groups from the academic sector, as well as other federal and state agencies and other national groupings. All the way through it was acknowledged inside and outside the ACCSP that the scale of the scientific issues involved truly was, and still is of global proportions, hence the need to bulk up via truly national collaboration. No one or two agencies alone could do all the work Australia requires. A milestone was reached with the Federal government developing a National Framework for Climate Change Science during in 2008, and adopting it formally in 2009 (http://www.environment.gov.au/climate-change/publications/australian-climate-changescience-framework). The subsequent implementation plan (2011) (http://www.environment.gov.au/climate-change/publications/plan-implementing-climatechange-science) contains a list of the priority policy questions requiring attention under the National Framework, lists the climate science deliverables required to address those questions, and details which agencies or groups are best placed to produce those climate science deliverables. The work of the ACCSP is highlighted at points in the implementation plan, along with the comment that it alone was insufficiently resourced to generate the required outputs, outcomes and national benefits that the plan identifies, reinforcing a point made earlier that for a country with our vast area of continent and ocean, we are underweight in climate science capability. Without the ACCSP and CSIRO's involvement in it the difficulty of achieving the national interest benefits listed in the National Framework and its implementation plan can only increase.
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Need for an ongoing commitment. More scientific leadership and less bureaucratic management.
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Climate science research is a service with the characteristics that economists categorise as a public good. (That is it is a good that that is both non-excludable and non-rivalrous in that individuals cannot be effectively excluded from use and where use by one individual does not reduce availability to others.) Because of this, we know the private sector will always under-invest in climate science research compared to the level of research that is optimal from a broader interests of the

economy as a whole. Therefore investing in climate science research is a very important role for governments.

It is very important for the future prosperity, productivity, competitiveness and resilience of the Australian economy, its communities and the natural environment, that the Federal Government continue to invest in, and indeed expand its investment in, climate science.
It important that research into climate change adaptation and into greenhouse gas emission reduction technologies is expanded. But is also important that core our climate science, climate observations, and climate change projection research is continued and expanded.
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Great program, exceptionally well managed.
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Thanks for the opportunity to provide feedback. It is important to reflect on the achievements of a Program that has lasted 27 years. It is also valuable to assess what didn't work well so that lessons can be applied in ongoing research programs such as the NEPS ESCC Hub.
--

Australia is extremely vulnerable to the impacts of climate change – on our environment, economy, health, and society. Any diminution of the capacity of the ACCSP will amplify this existing vulnerability.
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Thank you for the opportunity to comment. In the complex field of climate research, there will never be a complete understanding across all the disciplines such that we can turn to adaptation. Thank you too to the scientists who provide the knowledge on which we all depend.
--

There is a significant national capability at risk in the coming years. We need to continue to develop capability on regional scales, links to hydrology and weather and climate extremes.
And communicate the huge risks associated with acidification of the ocean as well climate impacts.
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Thank you for the opportunity to comment.
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The ACCSP would have been more successful with a different management model. If a joint BoM and CSIRO body had been established, with BoM and CSIRO staff seconded to the body (and joined by some university seconded staff), with on-going funding guaranteed (and political and bureaucratic interference thereby avoided)

then the advances made under the ACCSP would have been far greater than were achieved with the politicised and bureaucratic arrangements that were employed. This alternative arrangement would have required CSIRO and BoM to identify what areas of climate research they would continue anyway (and keep these separate the new body and decline funding for these activities through the new body). The new body could then have focussed on the areas of climate science not "claimed" by CSIRO and the BoM. This would have simplified the funding of climate science research in Australia. Areas of research that were included in the new body would then not be pursued separately by CSIRO and the BoM using separate funding.
--

A number of foresighted individuals within the Federal bureaucracy were highly supportive of the development of the ACC SP in its early days, including people like Barry Jones, but also a number of staffers within DASSET. Their enthusiasm and willingness to work hand-in-hand with the scientists to establish the earlier program should not go unnoticed.

Climate change remains a, and perhaps the, most serious potential threat to Australia and other nations. It demands immediate and serious leadership and planning related to:

- Our Nation's contribution to the reduction of greenhouse-gas emissions;
- Our specific needs for projections to assess risk and identify modes of adaptation;
- Our obligation to play a part in the global attempt to assist less fortunate nations plan and adapt to climate change imposts largely created by other nations.

In all of these activities, climate-change science is needed to ensure that decisions are underpinned by rational assessments of risks and options. The loss of the ACCSP must be seen as serious at this critical time; as a turning back of the clock by 27 years.
--

The NESP ESCC Hub structure substantially addresses some of the problems identified here; it is a healthy, helpful model.

Any significant community in Australia that doesn't form a strong collaboration is screwed for the future, as seen by ecosystem science, and contrasted by how the astronomy community collaborates very well.

Pleased with how the NESP ESCC Hub has emerged, as it provides valuable, long term capability, but unsure if this can be realised due to funding situation that we now have.
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N/A
In phone follow up, added that looking at whole programme, it was successful. His view as a whole is it positioned Australia on the international stage – we wouldn't

have got there otherwise. Just look at number of scientists involved in IPCC discussions as chapter leaders, lead authors, convening lead authors etc. – proportionally Australia had more involvement than anywhere else in the world. Australians were represented in an extremely dis-proportionate way – and if you look at it, many were funded under the ASSCP program.
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Mitigating and adapting to the threat of human-induced climate change must be underpinned by the best science and research. We have just been made aware from your email that ACCSP is coming to an end this year, to be continued by the new National Environmental Science Programme (NESP) Earth Systems and Climate Change Hub, so we hope the new program will continue the legacy of ACCSP and even improve the program further.
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I do think many of the problems I note above have been addressed in the successor NESP program. Main problem with the latter is that the agency funding seems too small.
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Far more effective as a program that the adaptation flagships which has really been pretty light on achievement for the investment made. Arguably others may do a better job of meeting the adaptation job – no one else is really up to the basic climate science challenges – Universities operate on shorter timeframes and have different organisational cultures to a national science organisation that should be delivering public good outcomes and providing the evidence base for informed policy responses.
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Notwithstanding the role played by CAWCR, the ACCSP had a major role in building closer collaboration between CSIRO and BoM.
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The ACCSP struggled to translate its success on the global stage back to real world tangible outcomes or impacts for Australians. These leading scientists were unable to effectively leverage their knowledge towards assisting regional decision makers to tackle the impacts of climate change. This limited the political understanding of the importance of this research.

General comment: As end users we have only very rough knowledge of which projects may have been funded under ACCSP – to us it was a funding stream, not a concerted program. The programs we think about are variously CAWCR, IMOS, ACCESS etc. The space was a tangled one, and as I have not been directly involved for several years the memory of how the puzzle fitted together is hazy. This comment probably fits under general feedback, but also serves to explain why we may have nominated research that was not actually part of ACCSP.
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Noted the disappointment in cuts to CSIRO climate research, and confusion about why. Widely held view in SCCG that the cuts are disappointing, and they have made comment on this. Indeed, if this review of the ACCSP was done and publicised earlier, it may have raised the profile of the importance of climate funding and influenced cuts.
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Note his fairly narrow lens on key elements of the program means he doesn't have a broad view of the total remit of the program, so see the above answers in that context.
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While scientists funded by ACCSP have undertaken research of direct relevance to the MDBA, our awareness that ACCSP was involved has been low. SEACI is a case in point, and it was only by retrospectively viewing the 2010-11 ACCSP Annual Report that it became apparent ACCSP was one of the funding agencies.
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My answer to Q14 refers to an area that the new Hub will be well-served to address if it hasn't already. I note though that Hub funding for climate change is just a fraction of that we had with the ACCSP.
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