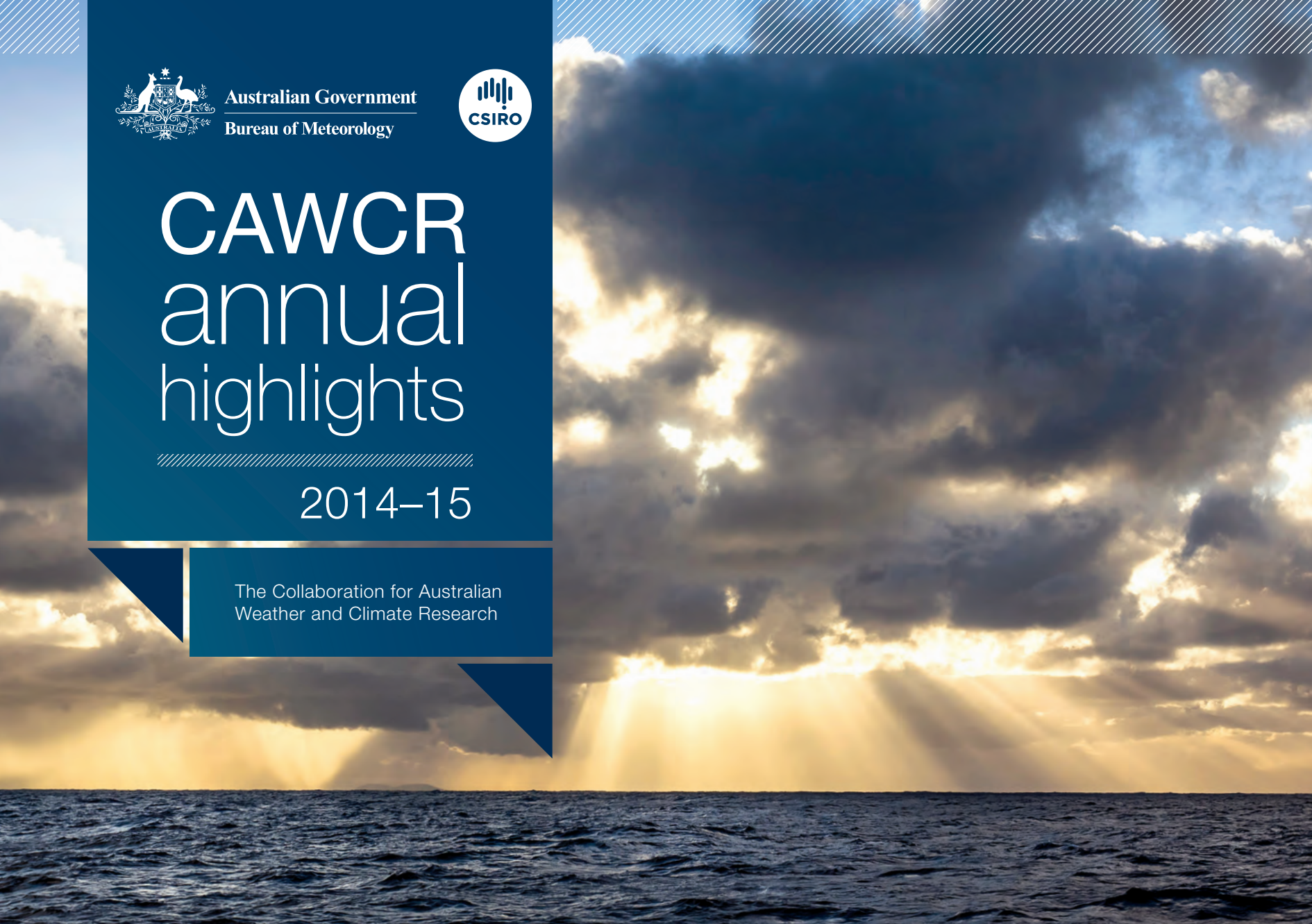


Australian Government
Bureau of Meteorology

CSIRO

CAWCR annual highlights

2014–15

The Collaboration for Australian Weather and Climate Research

CAWCR highlights 2014–15

Contents

Cover photograph: Ken Ridgway

CAWCR annual highlights

2014–15

The Collaboration for Australian Weather and Climate Research (CAWCR) was established in 2007 to build Australian capability in the areas of weather, climate and Earth-system science.

It is a formal collaboration between CSIRO Oceans and Atmosphere and the Bureau of Meteorology (the Bureau), designed to achieve maximum impact and benefit for Australia from the research of the two agencies. Their commitment to collaboration was reinforced in April 2015 with the signing of a new CAWCR Agreement.

This report highlights the achievements of a selection of CAWCR's research projects during 2014–15. It focuses on practical outcomes of the projects, rather than their scientific outputs. A full list of CAWCR projects and publications can be found on the CAWCR website.

The second part of the report describes the impacts over years of some of the longer-running CAWCR programs and projects. This is followed by a description of awards won by CAWCR staff during the year.

The first RV *Investigator* research voyage to the Southern Ocean

The Southern Ocean is the source of storms that carry much-needed rain to Australia. Despite this, not much is known about rain and clouds over the Southern Ocean because, until now, weather observations of suitable accuracy have not been available.

From 20–29 March 2015, scientists and engineers from the Bureau and CSIRO, as part of CAWCR, collected the first collocated measurements of cloud, aerosol properties, precipitation, and surface radiation down to 50 °S latitude, using state-of-the-art instrumentation on the RV *Investigator*. During this voyage, researchers also deployed three automated buoys to measure heat and carbon-dioxide exchanges between the atmosphere and the ocean.

The measurements are now being analysed jointly by CSIRO and Bureau scientists. The team is also working on models to predict the clouds and rain more accurately. Ultimately, more observations will be needed to refine predictions. Long-term measurements to be collected at Macquarie Island (54 °S) from March 2016, in collaboration with the Australian Antarctic Division, and future research voyages with the RV Investigator will continue to extend our knowledge of Southern Ocean meteorology.

Image: Marine National Facility, CSIRO

Improving bushfire and smoke prediction

Bushfire is an ever-present danger throughout Australia. In addition to the risk of fire damage to life and property, smoke causes problems for people with asthma and other breathing difficulties. State fire agencies are kept busy throughout the year with fuel-reduction burns in the cooler months and firefighting during the warmer months.

In 2013, in response to a request from the Victorian Government, CAWCR began a three-year $1.5 million project to improve forecasts for the amount and location of bushfire smoke. The project team is building a modelling system that uses information on fuel availability and burning efficiency to estimate how much smoke will be produced, and predicts where the smoke will go and how long it will be in the air. Fire agencies will be able to use the model to check whether a planned fuel-reduction burn or existing fire could send smoke over populated areas.

In late 2014 a Forecast Demonstration Project was held in Sydney to explore how the Bureau's forecasters could best use new high-resolution (1.5 km) hourly updates from the Australian Community Climate and Earth System Simulator (ACCESS) model. CAWCR used this opportunity to demonstrate its emerging high-resolution weather and smoke prediction capability to the Office of Environment and Heritage NSW, and the NSW Rural Fire Service. Multiple ten-day forecasts (known as 'ensembles') of fire weather were also trialled, to provide information on the range of fire weather conditions which may occur over the forecast period. These proved immensely popular with fire-behaviour analysts. The experimental smoke-modelling system has been running daily in New South Wales since October 2014.

Image: CSIRO

Victorian Climate Initiative

The Victorian Climate Initiative (VicCI) is a three-year program of research to inform the management of water supplies across Victoria. The program is a partnership between the Victorian Department of Environment, Land, Water and Planning (DELWP), the Bureau and CSIRO.

The science in VicCI is aimed at improving a) seasonal climate prediction for Victoria, b) understanding of past climate variability and change in Victoria, and c) understanding of future climate and the associated risks to water resources in Victoria in the decades ahead. An impetus for VicCI was the severity of the 'Millennium Drought' experienced across Victoria from 1997 to 2009, when streamflows dropped by as much as 80 per cent in water catchments across the State.

The climate of Victoria is influenced by large-scale climate phenomena, especially El Niño–Southern Oscillation in the Pacific Ocean, the Indian Ocean Dipole, and the Southern Annular Mode, which controls the passing of weather systems south of Australia. More locally, the positioning of large high-pressure cells over Australia has a strong impact on Victoria's rainfall. Investigations thus far have clarified not only the influence of each phenomenon on Victoria's climate, but also the interactions between them. The research is expected to lead to improvements in seasonal rainfall prediction, which will in turn improve the Bureau's forecasting system for seasonal streamflow. These forecasts assist in the sustainable management of water supplies.

Image: Plant Industry, CSIRO

Climate and Weather Science Laboratory

The Climate and Weather Science Laboratory (CWSLab) is a set of software tools that gives scientists access to the very large climate databases stored on the National Computational Infrastructure (NCI) and the ACCESS models. CWSLab is a virtual (i.e. computer-based) laboratory that reduces programming duplication, and encourages efficiency and collaboration in Australian climate and weather research.

Developed by the Bureau, CSIRO and NCI, CWSLab offers Australian researchers interfaces to climate and weather modelling software; an extensive data library; new research, analysis and visualisation tools; and computer storage space for sharing climate and weather model experiments and results.

Studies supported by this virtual lab include investigations of weather prediction, extreme weather events, atmosphere–ocean–land–ice interactions, climate variability, climate change, greenhouse gas dynamics, water cycles, and carbon cycles. Importantly, CWSLab will grow with use. Users can add new software to the existing set of tools, thereby upgrading the capacity of the whole climate research community.

Image: Aurel Moise

Natural Resource Management Climate Projections

Natural Resource Management (NRM) organisations are updating their existing regional plans to incorporate climate change and adaptation.

In this way, they intend to enhance the resilience of the communities that depend on their resources. In a four-year (2012-13 to 2015-16), $8.3 million project, CSIRO and the Bureau, together with the Department of the Environment, are delivering climate products and services to assist with NRM planning.

New climate projections were released in 2015 through regional brochures, regional reports and a technical report. An updated website was also launched to provide access to a wider range of reports, including a data delivery report and a selected cities report. An extensive selection of downloadable data, guidance material, web tools and online training is also available on the website.

In addition, 11 Australian Government departments were briefed face-to-face in December 2014, and the Minister for the Environment and the Parliamentary Secretary for Agriculture were briefed in February 2015. State departments and agencies were updated in webinars in February and March 2015.

The information covers four greenhouse gas emission scenarios (low, medium, medium–high, high), four 20-year periods (centred on 2030, 2050, 2070 and 2090), and 21 climate variables (including temperature, rainfall, wind, evaporation, humidity, soil moisture, cyclones, fire weather and sea level). The dataset has been designed to meet a wide range of NRM needs.

Image: Gregory Heath, CSIRO

Australian Community Climate and Earth System Simulator

The Australian Community Climate and Earth System Simulator (ACCESS) is a suite of computer models developed in CAWCR to provide the Bureau's weather and seasonal prediction systems, and Australia's climate projections.

The suite consists of separate models for the atmosphere, ocean, land surface and sea ice which are run together, exchanging information between them. The models are able to 'assimilate' data: that is, to take in observations, mostly from satellites, to improve their accuracy. Many CAWCR projects contribute to the development of, or make use of the results from, ACCESS.

Here is a selection of ACCESS highlights from 2014–15:

WEATHER PREDICTION: In late 2014, a 70-day Forecast Demonstration Project was conducted in Sydney by researchers and forecasters. For this exercise, ACCESS was set up to resolve down to 1.5 km horizontally, and to incorporate radar data. The forecasts showed their superiority, particularly on the two major events of the period: near record temperatures on 29 September and extreme (87-knot) winds on 14 October.

Image: NASA/Goddard Space Flight Center Scientific Visualization Studio

SEASONAL PREDICTION: In 2015, the Bureau began moving its multi-week to seasonal forecasting to an ACCESS-based system. The models have been implemented and will be tested and refined through 2016 for anticipated operational release in early 2017.

CLIMATE MODELLING: The Intergovernmental Panel on Climate Change (IPCC) released its Fifth Assessment report (AR5) in late 2014. AR6 is expected in the early 2020s, and will require several years of preparatory modelling. ACCESS is being set up and tested in readiness to contribute to the Sixth Climate Model Inter-comparison Project (CMIP6) that will form the basis for the AR6 projections.

EARTH-SYSTEM MODELS (ESMs): ESMs are climate models that contain representation of carbon dynamics, in addition to physics. The ACCESS ESM has been run during 2014–15 to simulate the time period from pre-industrial times through to the early 2000s, driven by known emissions of industrial gases. The ACCESS ESM will also contribute to CMIP6.

ATMOSPHERIC CHEMISTRY MODELLING: A global atmospheric chemistry model has been included in ACCESS, and test-run for 1920–2000. Active chemistry improves the performance of the climate simulations. A database of emissions of reactive gases and aerosols was developed to drive the model.

LAND-SURFACE MODELLING: The ACCESS land surface model, CABLE, is undergoing extensive development involving scientists from CSIRO, Bureau and the ARC Centre of Excellence for Climate System Science. CABLE is being used for stand-alone applications such as agriculture, and for coupling into the climate models. CABLE is now released under open-source licence, to enable wider use and uptake.

CLOUD MODELLING: Cloud dynamics are the most challenging aspect of atmospheric modelling. This year, CAWCR researchers showed that, by introducing co-existence of water and ice, and a concept called 'warm rain' in clouds, upper-air temperature and moisture levels were improved, as was the amount of heat reaching the Earth's surface. These results are indicative of the small, insightful steps along the path to better predictions.

ACCESS OPTIMISATION: NCI and Fujitsu have established a three-year Petascale Project, under which they are running an ACCESS Optimisation Project in collaboration with the Bureau, CSIRO and the UK Met Office. The Bureau is reporting a 40 per cent improvement in the runtime of its operational forecasting system as a result of this work, and the UK Met Office is reviewing the changes for inclusion in the next upgrade of its atmospheric model.

Image: John Coppi 1 January 1992

Past research in review:

the impact of completed and long-term collaborative programs

BLUElink

BLUElink was a research partnership between CSIRO, the Bureau and the Royal Australian Navy that ran from 2003 to 2014, with a budget of around $3.5 million per year. The project delivered a global ocean forecasting system (OceanMAPS), now run in the Bureau's National Operational Centre; a Navy-operated downscaling model (Relocatable Ocean–Atmosphere Model, or ROAM); and a prototype littoral-zone forecasting system. The systems were designed primarily to support the Navy's ambitions in anti-submarine warfare and littoral-zone rapid environmental assessment.

It is a mark of the success of the partnership that the Navy has entered into a ten-year contract for maintenance of the software systems through a Meteorological Services Agreement with the Bureau. CAWCR's primary liaison in the Navy, the Deputy Director, METOC Policy and Plans, described the key impact of BLUElink as 'situational awareness'. That is, as a result of BLUElink, surface and sub-surface vessel commanders have greater understanding and visualisation of the variability of the ocean surrounding them and, particularly, the implication of that variability for sonar performance for planning and operational purposes.

Image: ABIS Jayson Tufrey

Managing Climate Variability Program

The Managing Climate Variability Program (MCVP) aims to improve multi-week to seasonal forecasts and improve the uptake of the forecasts by the farming community. The program began under the Climate Variability in Agriculture Program in 1992. The three most recent phases have recently been reviewed for their impact (White et al, 2015: *Economic Impact Assessment: An Economic Analysis of Investment in the Managing Climate Variability Program [MCVP Phases II, III and IV]*). MCVP has been the strongest supporter of seasonal forecasting outside of the Australian Government.

MCVP is funded by a consortium of rural Research and Development Corporations, led by the Grains RDC. Funding peaked at $4.5 million in 2010/11 and, since 2008/9, has averaged around $1.5m per year from the program, with slightly less in co-funding from recipient agencies. The three recent phases of the MCVP supported 35 projects, of which around 20 involved research (the others being devoted to management and communication.) Eight of the research projects were led by the Bureau and four by CSIRO. One Bureau and one CSIRO project were still current in 2014–15.

The MCVP review concluded that: 'MCVP has produced significant outputs for improving the accuracy of forecast models and their ease of use for on-farm decision making'. All of the Bureau and CSIRO projects were assessed as having increased profits and/or reduced losses, seven were credited with leading to better natural resource management, and five with enhancing community preparedness and resilience. The review identified four 'particularly notable' consequences of MCVP 'which will make significant contributions to improved risk management by Australian farmers'. These are: the launch of the seasonal-prediction system POAMA-2 in 2013; 'ground-breaking forecasts of the two separate months ahead ... and of the wet-season onset'; the CliMate phone app for weather and climate information; and the ABC Landline seasonal climate and water updates by the Bureau.

Overall, the MCVP review concluded that the three phases have led to an increase in farm profits. It suggests that the total investment of $24.1 million over these phases has resulted in an annual return to Australia's farmers of $160.3 million, at a cost-benefit ratio of 6.6:1. Another study (2015, *Analysis of benefits of improved seasonal forecasting for agriculture*), commissioned by MCVP from the Centre for International Economics, concluded that the annual value of seasonal forecasts to Australia's agricultural sector is $1.5 billion, or 7.3 per cent of the industry value.

Australian Climate Change Science Program

The Australian Climate Change Science Program (ACCSP) is a partnership between CSIRO, the Bureau and the Australian Government Department of the Environment (DotE) that has been running continuously since 1989. For Australians, ACCSP has led to much of the explanation and documentation of climate change in our region. In 2014–15 alone, ACCSP had a budget of $11 million and resulted in 90 peer-reviewed publications.

As a consequence of ACCSP, Australia was a major contributor to the 2014 Fifth Assessment Report (AR5) from the IPCC that has shaped much of the Australian and international discussion on climate change. (See Fact Sheets on the DotE website.) CAWCR scientists were Convening Lead Authors (4), Lead Authors, and Expert Reviewers for AR5, and over 40 of their publications were referenced.

ACCSP was also the basis for the 2009 *Australian Climate Change Science – a National Framework* and the subsequent *2012 Plan for Implementing Climate Change Science in Australia* (current documents, available from the DotE website), and for the 2010, 2012 and 2014 State of the Climate reports (available from the Bureau website).

ACCSP has provided significant support for the ACCESS suite of models that perform Australia's climate projections, underpin Australia's climate research, and also double, through the Bureau, as Australia's weather-prediction package.

Image: Glenn Walker

Pacific–Australia Climate Change Science and Adaptation Planning Program

The Pacific–Australia Climate Change Science and Adaptation Planning (PACCSAP) program was a collaboration between the Bureau, CSIRO and the (now) Australian Government Department of the Environment (DotE), with funding provided by the Department of Foreign Affairs and Trade (DFAT; formerly AusAID). It built on earlier aid programs dating back to 2008. PACCSAP partners worked with 14 Pacific Island countries and Timor Leste (East Timor) to build awareness of, and ability to respond to, climate change. The program ran from 2011 to 2014, with a total budget of $32 million. An independent review of the program was commissioned by DFAT in 2013, and an assessment of the program's impacts is available through the DotE website.

PACCSAP significantly improved understanding of climate change in the Pacific. From the 2008 start of Pacific climate-change aid programs to the end of PACCSAP, around 100 peer-reviewed journal articles were written, together with less-technical reports and educational material aimed at the local communities. PACCSAP also led to computer-based climate tools, particularly a climate database called CliDE, and to specific support for local meteorological services.

According to the DotE, specific outcomes of PACCSAP include: studies of the impact of inundation on Kiribati's groundwater supply; economic analysis of options to enhance water security in Tuvalu; design standards for road and transport infrastructure in the Solomon Islands and Vanuatu; storm-surge modelling to guide upgrades to the 'iconic' Samoan Parliament House; assistance with a master plan for a new provincial capital in the Solomon Islands; a hazard analysis of the impacts of tropical cyclones on coastal erosion, inundation and groundwater for Tonga; and training to enable local government departments to run their own inundation modelling in Tonga, Papua New Guinea, Vanuatu and Samoa. PACCSAP also conducted regional assessments of the vulnerability of groundwater and coastlines to climate change.

The impact of PACCSAP is expected to grow with time.

South-Eastern Australian Climate Initiative

The South-Eastern Australian Climate Initiative (SEACI) was a partnership between CSIRO, the Bureau, the (then) Victorian Department of Sustainability and Environment, the Murray–Darling Basin Authority and the (then) Commonwealth Department of Climate Change and Energy Efficiency. It ran (in two phases) from 2006 to 2012, with a total budget of $16.5 million. Its aim was 'to improve understanding of the nature and causes of climate variability and change in south-eastern Australia in order to better manage climate impacts'.

The program involved scientists from CSIRO's Land and Water, as well as those from CAWCR. It led to development of improved long-term projections of climate and water availability, and to upgraded seasonal forecasting systems for climate and streamflow at the Bureau.

The outputs from SEACI were used to inform actions and policy responses in the 2009 Northern Regional Sustainable Water Strategy, and the 2012 Gippsland and Western Sustainable Water Strategies. The seasonal water-availability forecasts now provided by the Bureau are used by Victorian water corporations to inform annual assessments of water security. In addition, the findings of SEACI are an important input to long-term supply planning undertaken by water corporations across Victoria, informing decisions about infrastructure development.

SEACI was followed by the VicCI partnership between the Bureau, CSIRO and the Victorian Department of Environment, Land, Water and Planning, which began in 2013 and continues until mid-2016.

Image: Brad Sherman 1 January 1996

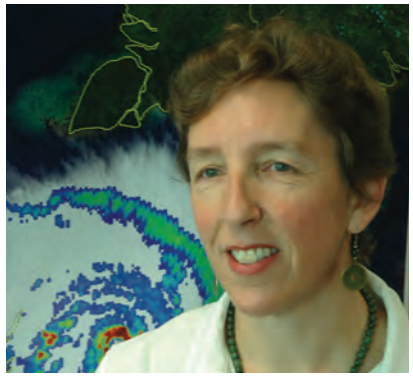
Awards

Dr John Church

American Meteorological Society Fellow

John was accepted as a Fellow for the American Meteorological Society. To be eligible for election, nominees must have made outstanding contributions to the atmospheric or related oceanic or hydrologic sciences or their applications over a substantial period of years.

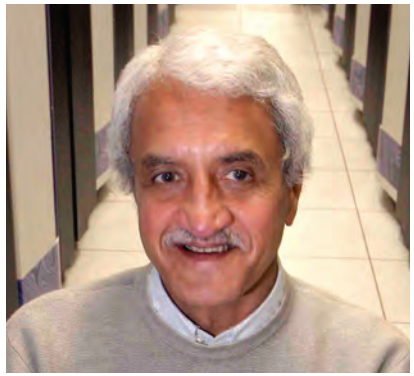
Dr Beth Ebert



RH Clarke Award

Beth was awarded the 2015 RH Clarke Award by the Science Committee for the Australian Meteorological and Oceanographic Society (AMOS) at their 2015 annual conference, in recognition of her scholarship and international standing.

Dr Kamal Puri



2015 Public Service Medal

Kamal was awarded a 2015 Public Service Medal for outstanding public service in meteorological science, particularly numerical weather prediction.

Dr Alan Seed

Bureau 2015 Excellence Awards

Alan received this award for his outstanding contribution and achievements in radar science and application, particularly in quantitative radar rainfall estimation and short-term rainfall forecasting.

Dr Fabienne Reisen and Dr Melita Keywood

Certificate of Recognition from the Clean Air Society of Australia and New Zealand

Dr Fabienne Reisen (left) and Dr Melita Keywood (right) photographed with Dr Mark Hibberd (centre), President of CASANZ: Fabienne and Melita received the Certificate of Recognition from the Clean Air Society of Australia and New Zealand for their significant contributions to the understanding of the air-quality impacts of a major emergency (the Hazelwood coal-mine fire) on the local community and environment.

A full list of other achievements by individual CAWCR scientists, including nominations to national and international committees and recognition for exceptional publications, can be found on the CAWCR website.

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