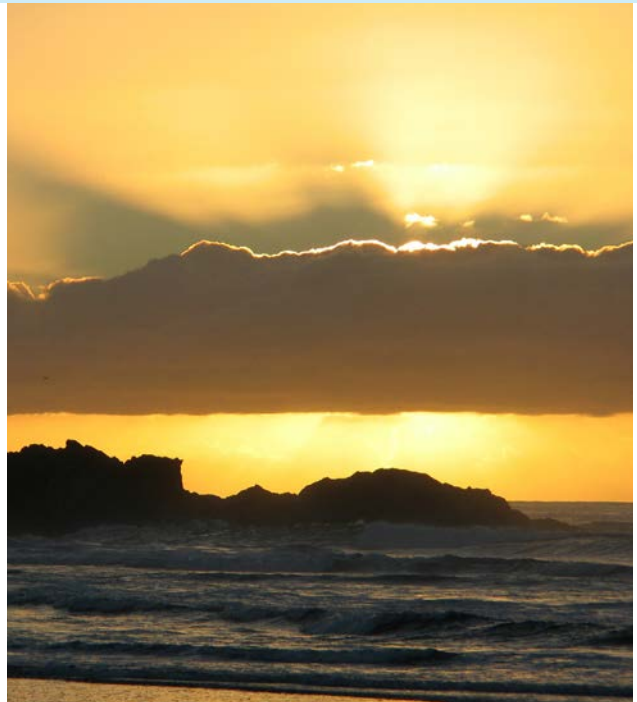
Australian Government
Bureau of Meteorology

The Centre for Australian Weather and Climate Research

A partnership between CSIRO and the Bureau of Meteorology

CSIRO

Highlights 2012–13



The Centre for Australian Weather and Climate Research (CAWCR)
Highlights 2012–13

Contents

Overview

The Centre 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 brings together the Commonwealth Scientific and Industrial Research Organisation's (CSIRO) Division of Marine and Atmospheric Research (CMAR) and the Bureau of Meteorology (the Bureau) in a joint research venture covering the fields of meteorology, climate, and Earth system science.

The vision of CAWCR is to be recognised for scientific excellence and innovation by providing in-depth research capability and scientific vision that positions it in a national leadership role.

CAWCR research informs government policy and decision-making in the physical domains of weather; ocean; Earth system modelling; observations; understanding the drivers, impacts and adaptation to climate variability and climate change; studies of regional and global carbon and water budgets; climate projections science; and science underpinning national response to hazards.

The primary outputs of CAWCR are publications in scientific literature, new technology and systems, modelling infrastructure, research services, support for operational services reports to clients, and coordination of scientific advice to both government and industry which are delivered through the output portfolios of both CMAR and the Bureau.

CAWCR maintains a joint management structure combining CSIRO research culture and the research-to-operations ethos of the Bureau.

This brochure highlights some of CAWCR's research achievements from 2012–13.

CAWCR renewed for a second five-year term

CAWCR was reviewed in 2011 to assess the quality of CAWCR science capability, the competitive position of CAWCR nationally and internationally, efficiencies offered by CAWCR, and the degree to which CAWCR is able to enhance the performance of our partners. This overwhelmingly positive review has guided the development of a new five-year phase of CAWCR with CSIRO and the Bureau committing in 2013 to continue the CAWCR relationship for another five years to meet the future research needs of our partners and the nation.

Objectives and operations

CAWCR's overall objectives are to lead the scientific community in Earth system simulation, develop an Australian Earth system observatory and advance knowledge of water in the Earth system.

- **Atmosphere–Land Observation and Assessment:** To develop the techniques and knowledge to monitor, observe and understand atmospheric and land processes, their interaction, and the roles they play in Australia's environment.
- **Climate Variability and Change:** To deliver new knowledge and applications for decision-making in climate sensitive industries, and to understand and project climate variability and change and its impacts to improve adaptive responses and to inform policy and decision-making. Research in the CVC programme covers timescales from weeks to decades, and includes multi-week prediction, seasonal prediction, and climate change projections.
- **Earth System Modelling:** To lead development of a world-competitive coupled climate and Earth system simulation and modelling system for the Australian community.
- **Ocean Observation, Assessment and Prediction:** To observe, monitor and understand the key processes that drive variability and change in Australia's regional ocean waters, and apply that understanding to model and predict the behaviour of oceans in the Australian region, and their role in regional and global climate.
- **Weather and Environmental Prediction:** To improve our understanding of atmospheric processes, develop and apply numerical weather prediction systems for advanced weather forecasting and related environmental services, including prediction and monitoring of severe weather and air pollution hazards and generation of climate projections.

Atmosphere – Land Observation and Assessment

ALOA

Climate Variability and Change

CVC

Earth System Modelling

ESM

Ocean Observation, Assessment and Prediction

OOAP

Weather and Environmental Prediction

WEP

Earth System Modelling

Australia is vulnerable to weather and climate extremes, and faces serious risks from human-induced climate change. To inform government, the community and affected sectors, predictive and simulation tools are necessary to underpin mitigation and adaptation responses. The Australian Community Climate and Earth System Simulator (ACCESS) is a coupled climate and Earth system simulator being developed to meet such challenges. CAWCR is taking the lead role in this development with support from the Department of Climate Change and Energy and the university community in Australia. Making optimum use of our national and international partnerships is necessary to tackle these complex problems facing our nation. Significant progress has been made over the 2012–13 period.

Weather prediction

A new ACCESS-based numerical weather prediction (NWP) system, covering the Australian region became operational within the Bureau in April 2013. The new system features advanced model and data-assimilation components, together with assimilation of a wider range of satellite data, and delivers significantly improved forecast accuracy. The high-resolution ACCESS 'city' weather prediction models, which provide forecasts for Australia's major cities were also upgraded to ensure compatibility with the system and are ready for Bureau operational implementation in early 2013–14.

Predicting high-impact weather[1]

The development of very short-term (0–12 hours) weather prediction systems that make effective use of radar data has been a priority for CAWCR. This is required for forecasting of high-impact weather. A trial ACCESS system was successfully completed and has demonstrated an improved ability to forecast

heavy rain on a 6 to 12-hour lead time. A major forecast demonstration project is being planned for summer 2014–15 to exhibit these new capabilities to forecasters and users of forecast information.

ACCESS high-resolution (400–1200 m) simulations of nine Australian extreme bushfire events were completed as part of collaboration with the Bushfire Cooperative Research Centre. These simulations vividly show detailed atmospheric fluid flows

[1] Weather that has a major impact on one or more segment(s) of society.

when viewed as animations, contributing to a better understanding of atmospheric processes under extreme conditions. Further understanding was gained through fire plume behaviour simulations using the United Kingdom Met Office large eddy model. The fire weather simulations are being used to drive fire spread models.

Climate modelling delivered to the international Coupled Model Intercomparison Project Phase 5 (CMIP5)

Additional model runs using two versions of the ACCESS coupled climate model were delivered to CMIP5. ACCESS climate model versions were found to be comparable in accuracy (as judged by historical simulations over the Australian region) to the world's leading climate models, and hence provide a valuable new resource for Australian climate projection studies. This contribution also significantly increases the potential impact of the ACCESS model in the extensive number of climate studies being undertaken internationally. ACCESS model results have so far been used in about 70 papers. In addition, ten papers by CAWCR staff on the ACCESS CMIP5 model versions have been published in a special issue of the Australian Meteorological and Oceanographic Journal.

Making ACCESS available to the research community

CAWCR made progress in transitioning all of its computational large-scale research and development from the Bureau to the supercomputers at the National Computational Infrastructure (NCI) National Facility. This will enable Bureau supercomputing to focus on operational and pre-operational systems. The increased computing capacity at NCI allows CAWCR to demonstrate next-generation NWP systems, undertake complex seasonal prediction development and further enhance coupled climate and Earth system simulations. The transition to NCI is particularly important for ACCESS, as NCI is a shared computing

resource that will bring CAWCR, the university sector, the private sector and associated computer specialists for ACCESS research under a common computing environment. This will greatly enhancing collaboration and the use of ACCESS.

Climate Variability and Change

CAWCR scientists examined the essential processes that influence Australian climate on all spatial scales, its natural variability on all timescales, the potential for medium and long-range prediction and climate change detection and attribution. Many of the scientists are associated with the Intergovernmental Panel on Climate Change as Convening Lead Authors, Lead Authors, or Expert Reviewers and played key roles in the IPCC Special Report on Extremes (SREX) and the Fifth Assessment Report.

Climate change and Australian flooding

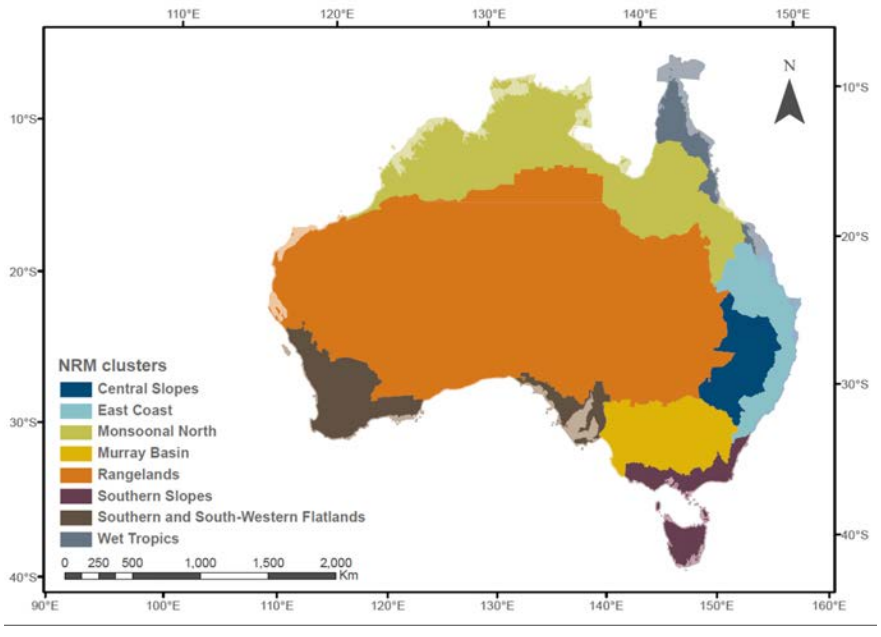
CAWCR scientists have started to elucidate the three-way interactions, or relationships, between the large-scale global atmosphere and ocean circulations, modes of climate variability and weather systems that impact on the Australian flooding especially for two of the most extreme flooding periods during January 1974 and January 2011.

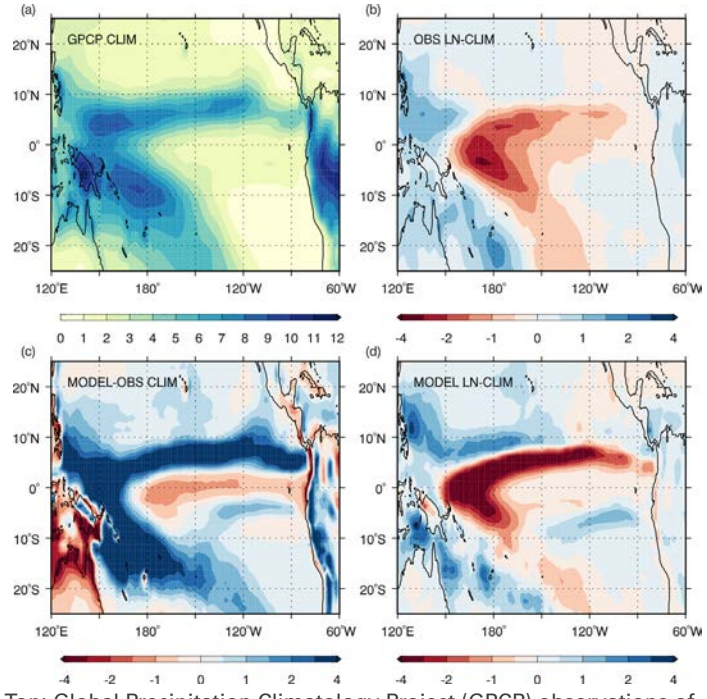
Climate change projections for natural resource management

Established in 2012 as part of the Federal Government's regional Natural Resource Management (NRM) Planning for Climate Change Fund (NRM Fund), this project will deliver regional climate change projections for the whole of Australia based on the most recent set of climate models (CMIP5) by mid-2014. The projections will focus on the elements of climate change of highest priority to Australia as a whole, as well as more specific needs, within regional NRM organisations. Together with a set of reports—eight regional and one main report—and other communication products, the main delivery tool will be a new website (www.climatechangeinaustralia.gov.au) that will host not only the climate change projections but also deliver application-ready datasets for impact studies.

Analysis of the CMIP datasets

The collected global climate model datasets from CMIP have been analysed to show that as a La Niña strengthens the precipitation responds in three ways: the Intertropical Convergence Zone (ITCZ) dries and moves poleward, the maximum precipitation along the equator moves west (towards Australia), and the South Pacific Convergence Zone (SPCZ) becomes more diagonal and shifts southward. Precipitation responds nonlinearly to sea-surface temperature (SST) anomalies, though not as strongly as in the El Niño case.



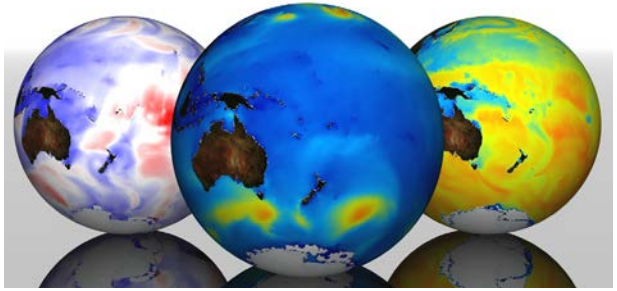


Top: Global Precipitation Climatology Project (GPCP) observations of Nov–Apr rainfall over the tropics (1979–2009): (a) climatology, and (b) precipitation anomaly averaged over all La Niña years. Bottom: AGCM simulated Nov–Apr rainfall: (c) difference in simulated and observed climatology, and (d) modelled precipitation anomaly response to composite La Niña SST pattern. Units are mm/day.

Understanding and predicting the ocean

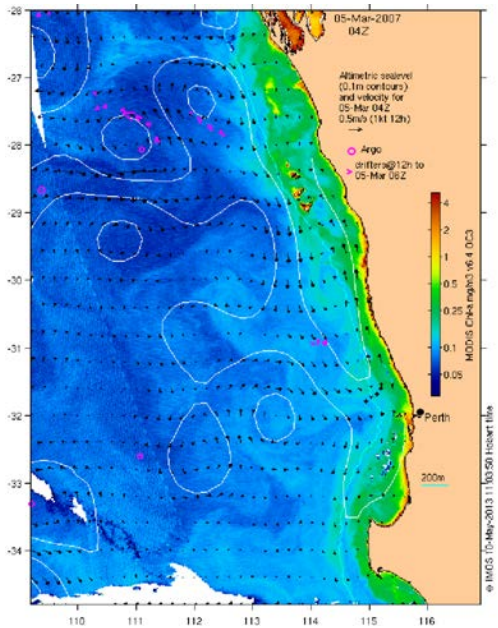
A 35-year wave hindcast

Knowledge of historical wave conditions is necessary for many activities, such as offshore structure design, shipping, coastal-hazard assessment and renewable-energy feasibility studies. CAWCR has recently completed a high-resolution wave hindcast, covering 1979 to mid-2013, providing hourly wave data over the globe at 0.4° spatial resolution, far exceeding that of previous hindcasts. The study was funded by AusAID and the Department of Climate Change and Energy Efficiency, and the data are now publicly available.



Re-evaluating the controls on springtime initiation of temperate phytoplankton blooms

Seasonal time series of net community production have been constructed by combining wind observations from the IMOS Southern Ocean Flux Study meteorological mooring with hourly subsurface oxygen and total gas tension observations from the Pulse biogeochemical mooring. It shows unexpected phytoplankton production ahead of stratification in late winter, while the ocean is still cooling, possibly due to sporadic variations in the intensity of surface mixing. The results may help to resolve why no global carbon cycle models are able to simulate both mean annual amplitude and seasonal cycles in Southern Ocean carbon uptake.



Advancing environmental prediction

Smarter forecast process

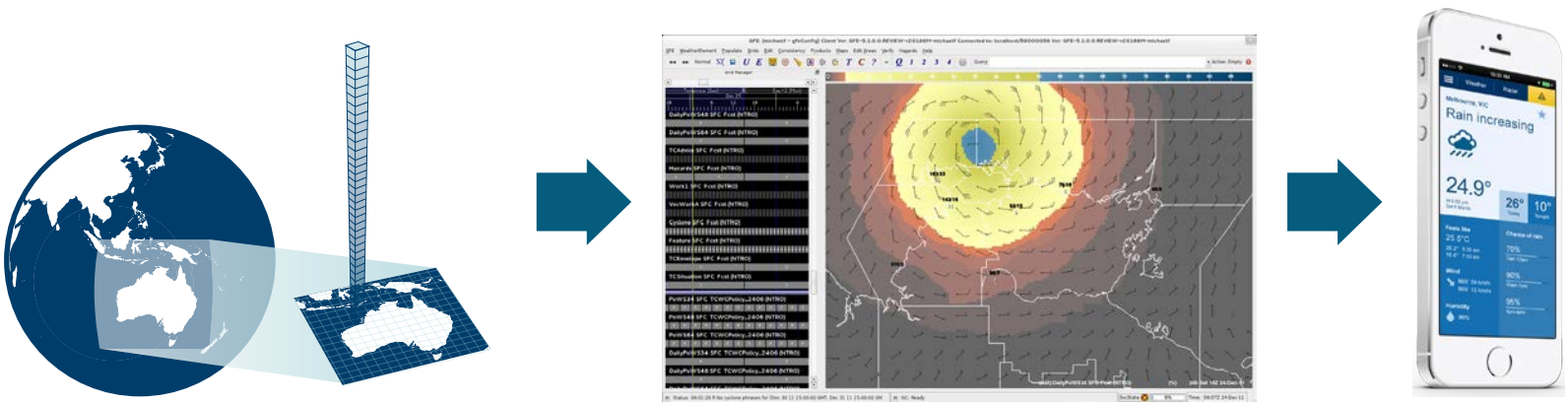
Smart tools and text formatters (which convert gridded information to natural language), including new functionality to support tropical cyclone prediction, were delivered to support the successful rollout of the Bureau's Next Generation Forecast and Warning System to Western Australia. This has enabled the Bureau to provide far more complete forecast services to the public and other stakeholders in Western Australia.

Better use of model guidance

Major improvements were made to the Gridded Operational Consensus Forecasts system that combines data from the ACCESS model with international forecast model output to improve forecast accuracy. In particular, the spatial and temporal resolution increased to 0.25 degrees latitude/longitude and hourly, respectively, and the probability of precipitation calibration was refined to vary according to regime.

Rainfall forecasts for hydrological use

Substantial progress was made on the development of a rainfall portal to provide ensemble rainfall forecasts on timescales of ten minutes to ten days. ACCESS precipitation forecasts are downscaled using the Short Term Ensemble Prediction System (STEPS) to have similar spatial and temporal structure as observed by radar. These rainfall forecasts will provide input to ensemble predictions of streamflow.



The NexGen system provides forecasts and warnings—derived from weather prediction models—where and when you need them.

Sailing to success

Sailing was one of Australia's most successful sports at the 2012 Olympic Games. While the skill of the sailors played an obvious role in winning their medals, they had a little extra help from detailed forecasts of wind conditions on the sailing course. The Dynamical Downscaling Team set up an ensemble CCAM weather forecasts on a 220 m forecast grid to provide wind forecasts for the race boats.

High-resolution climate projections for southeast Asia

CAWCR continued its important assistance to neighbouring nations in southeast Asia to generate updated scenarios for climate and sea level rise. Scientists from Vietnam, Indonesia, and the Philippines received access and training on use of the Cubic Conformal Atmospheric Model (CCAM) to dynamically downscale global climate model output to a regional level. The high-resolution climate projections are being extensively analysed to better understand the impacts of climate change on local weather and to underpin adaptation planning and prioritise investment.

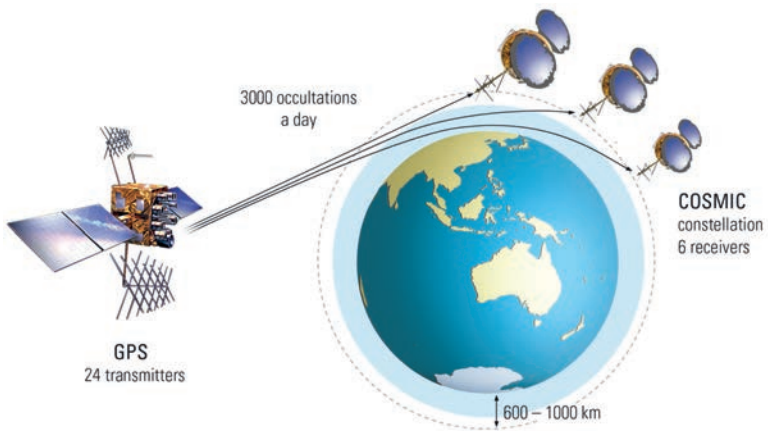
Observing the Environment

State-of-the-art carbon dioxide and methane data collected at the Cape Grim Baseline Air Pollution Station (CGBAPS) in Tasmania by the Bureau and CSIRO have contributed to two papers in *Nature Climate Change* in 2013. The Cape Grim and other global data provide so-called 'top-down' estimates of global carbon dioxide and methane emissions, calculated from measured gas concentrations. These are used to refine 'bottom-up' estimates which use global emissions models. The carbon dioxide paper resulted in Cape Grim being highlighted on the front cover of the May issue of *Nature Climate Change*.

GPS spin-off benefits weather forecasting

An unusual spin-off of GPS (Global Positioning System) technology is having a significant positive impact on weather forecasting and climate analysis. Half a century ago, planetary and atmospheric scientists in the USA developed a technique called radio occultation, which calculates a refractive index from the bending of radio waves as they pass close by a planet.

The technique has been applied to meteorological applications using six special satellites (the COSMIC constellation) to record data from about 3000 occultations daily when transmissions from the 24 GPS satellites pass through the atmosphere close to earth. This yields global data on atmospheric temperature and moisture, an important addition to geographically restricted data from land-based weather balloon stations in the southern hemisphere. The uses of this data have now been introduced into the Bureau's operational numerical weather prediction system (ACCESS) and has been shown to improve the skill of forecasts.



A schematic of GPS occultation. The bending of radio waves transmitted between satellites near the earth is able to be measured. The amount of bending can be used to calculate the temperature.

National and international science leadership

World-leading science

Our scientists continue to be engaged in key national and international leadership roles providing policy-informing documents and science summaries for government. Four CAWCR scientists are involved as coordinating or lead authors within IPCC, contributing to an objective and impartial analysis of the latest climate information including the special report on extremes.

Climate change

The Australian Climate Change Science Programme (ACCSP) has continued to study the influence of terrestrial, ocean and atmospheric processes and their impact upon climate change, climate variability, and extremes.

Regional collaboration and projections

The Pacific Climate Change Science Program (PCCSP) examined the impact of climate change upon the highly vulnerable Pacific zone and published a major two volume report titled *Climate Change in the Pacific: Scientific Assessment and New Research*.
The report included 15 country-specific chapters describing past and future climate change. As part of the project, projections from six CMIP3 global coupled models for current and future climate were analysed to estimate changes in climate means and extremes, including tropical cyclones.

Climate projections and impacts

Development of analysis methods for the upcoming CMIP5 climate model results using the climate futures approach is being undertaken in preparation for the next round of national climate change projections.

Major CAWCR workshops

Indian Ocean Rim Association for Regional Cooperation (IOR-ARC) Ocean Forecasting Workshop to build capacity to progress, validate and apply Indian Ocean forecasting systems

CAWCR led an AusAID-funded workshop in Perth in May 2013 to further cooperation and understanding on international ocean-forecasting capabilities and needs in the Indian Ocean. Oceanographers and scientists from member countries of the Indian Ocean Rim Association for Regional Cooperation (IOR-ARC) participated along with IOR-ARC dialogue partner countries and technical experts, with the programme including training in BLUElink products. The next meeting of IOR-ARC countries will seek endorsement for ongoing capacity-building activities in ocean-forecasting in the Indian Ocean.

Attendees at the Indian Ocean Rim Association workshop

Annual CAWCR Workshop: Understanding and Prediction of Monsoon Weather and Climate

The topic for the 6th Annual CAWCR Workshop was Understanding and Prediction of Monsoon Weather and Climate. Key themes included the observed monsoon variability from weather to climate timescale; physical processes important in the monsoon; short-term monsoon prediction; intra-seasonal/seasonal prediction of the monsoon; monsoon decadal prediction and the impact of climate change.

The CAWCR workshop attracted 120 participants with eight invited international speakers. It was supported by the Bureau, CSIRO, the Australian Climate Change Science Programme, the Pacific-Australia Climate Change Science and Adaptation Planning Program, INTEL, Oracle and the ARC Centre of Excellence for Climate System Science.

Awards

Bureau Excellence Awards

Dr Diana Greenslade

This award acknowledges Diana for her excellence in scientific research leadership, especially her work in supporting the Bureau's tsunami and ocean wave forecasting capabilities, and her willingness to adapt to new scientific challenges. Because of Diana's dedication to excellence, the Bureau is now in a leading position for ocean and marine forecasting. Diana had a leading role in the tsunami research component and was instrumental in generating the tsunami model database that underpins the Bureau's operational tsunami warning system.

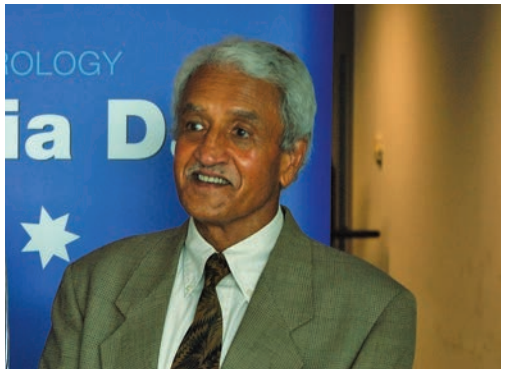
Dr Michael Foley

Michael is recognised for his vision, innovation, dedication and commitment in providing one of the leading contributions to the implementation of the Next Generation Forecasting and Warning System (NexGenFWS). Michael's skill and commitment have ensured all regional NexGenFWS implementations were delivered on time. He has been the chief designer and lead contributor to about 120 smart tools that encapsulate the process that transforms gridded model guidance into weather services.

Dr Phil Purdam

Phil is recognised for his vision and innovation in driving the design and leading the development and ongoing support for the Bureau's state-of-the-art radar visualisation system, RAPIC. RAPIC provides the Bureau with an unparalleled ability to use and interpret radar data, helping to deliver a range of forecast and warning services. Phil's very high-level technical expertise and meteorological nous, and his eagerness to work closely with forecasters and other users, have been crucial to the success of RAPIC.

The Bureau Excellence Awards recognise outstanding contributions from individuals or groups in support of the Bureau's role and objectives.



Dr Kamal Puri

Australia Day Achievement Medallion

Dr Kamal Puri

Kamal has been one of the foremost figures in numerical weather prediction (NWP) modelling and earth system modelling for the past four decades. Since the early 1980s he has been one of the key scientific and intellectual leaders in the Bureau's NWP research. He is highly respected internationally and is a member of key international panels on Earth system modelling.

Australia Day Achievement Medallions were instituted in 1984 by the Australia Day Council and provide government departments and agencies with an opportunity to acknowledge the contribution of their staff. The award relates to outstanding performance in delivering special projects or in the performance of core duties.

Australian Antarctic Medal

Dr Neil Adams

Meteorologist and scientist Neil Adams has been awarded a posthumous Australian Antarctic Medal. Dr Adams was the manager of the Bureau's Antarctic Meteorological Section and spent two decades supporting Australia's Antarctic programme. Dr Adams' exceptional abilities as a forecaster contributed immensely to the achievement of scientific programmes across many years. Dr Adams passed away in March 2012.

Dr Steve Rintoul

Dr Steve Rintoul

Steve Rintoul was awarded the Australian Antarctic Medal for his leadership and outstanding contribution to science and Australia's Antarctic programme. His work has improved the world's understanding of the workings of the Southern Ocean and its significance in the global climate system.

The Antarctic Medal was established in 1987 and is an award in the Meritorious Service Awards category of the Australian Honours System. It is awarded for outstanding service to the Australian Antarctic programme.

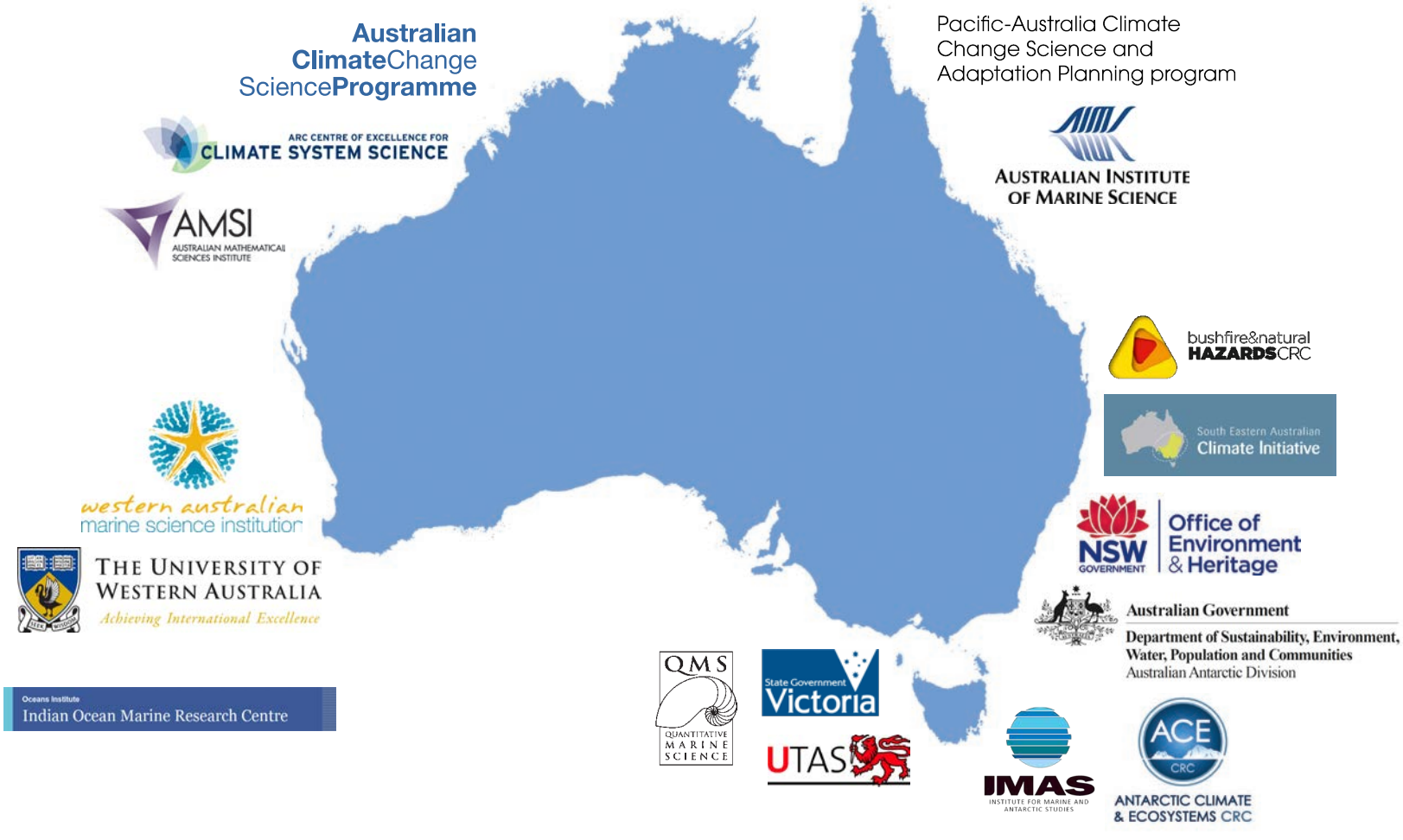
Martha T. Muse Prize

Dr. Steve Rintoul

Dr Stephen Rintoul has been awarded the prestigious 2012 Martha T. Muse Prize for Science and Policy in Antarctica for his outstanding research on the Southern Ocean.

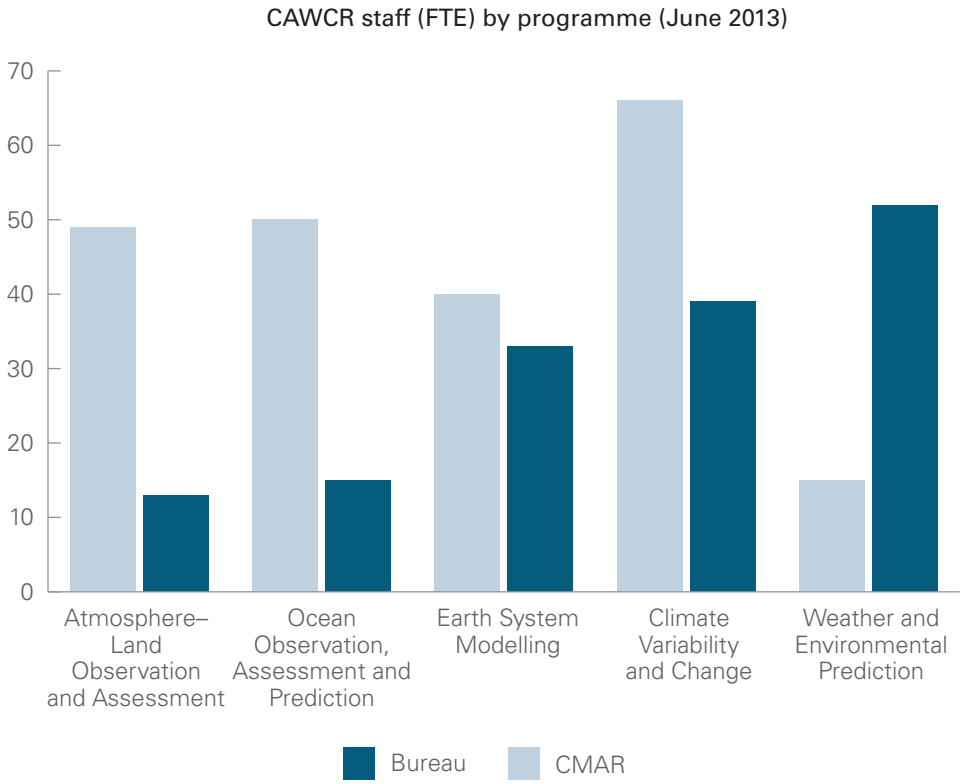
The Muse Prize is awarded to an individual in the fields of Antarctic science or policy who has demonstrated potential for sustained and significant contributions that will enhance the understanding and/or preservation of Antarctica.

National strategic alliances

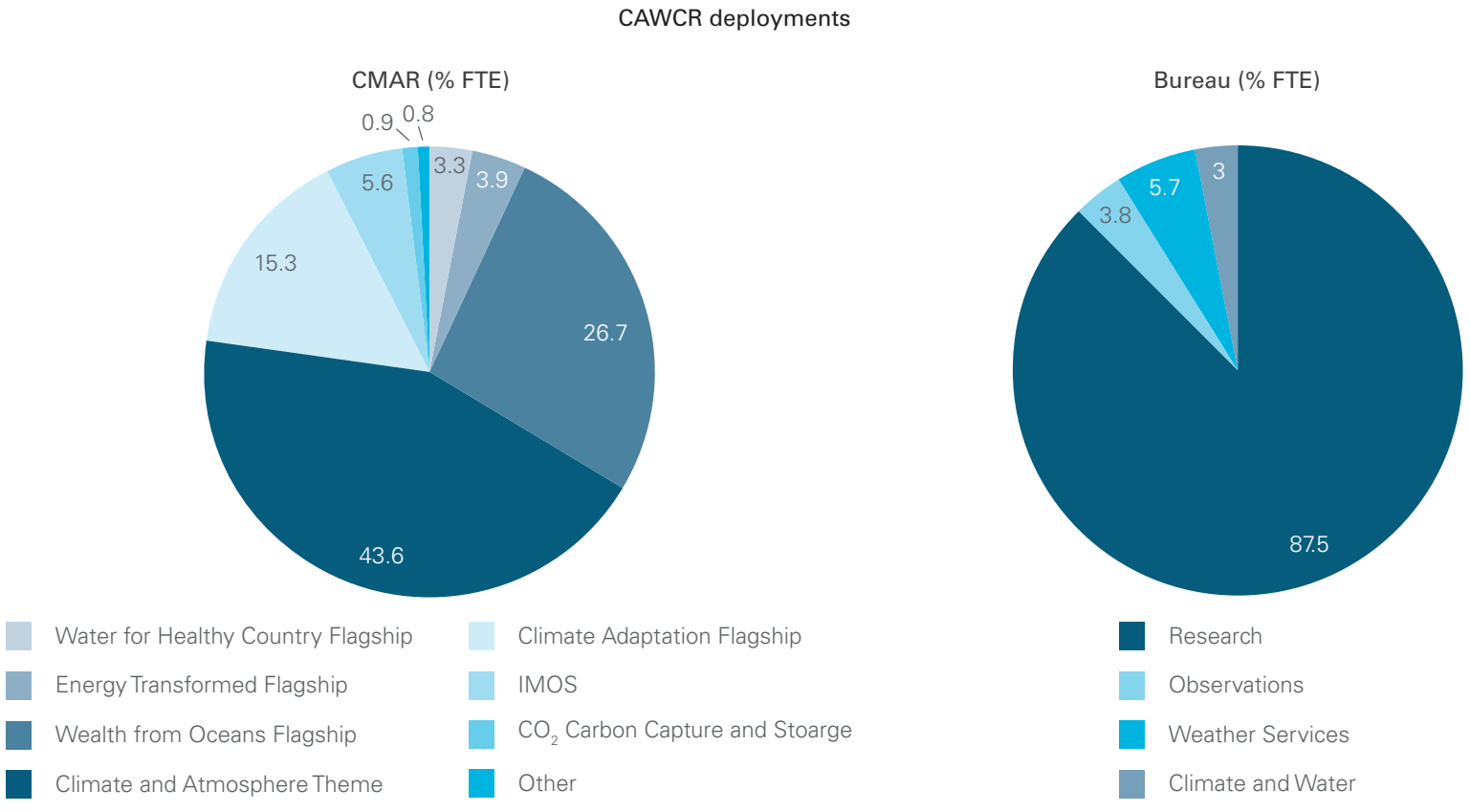


International links involving CAWCR

Deployment of CAWCR capability with



CSIRO and the Bureau



Photography credits

Front cover Left: Lake Bael Bael near Kerang, Victoria. Credit: Luke Shelley.
Middle: The sun rises behind clouds over the rocks at Sawtell beach, New South Wales. Credit: Andrew Treloar.
Right: Clouds, a windmill and water tank north of Melbourne, Victoria, early winter. Credit: Ian Forrest.

p. 6 The Goulburn River floods Shepparton, Victoria. Credit: Adrian Martins, North Central Catchment Management Authority.

p. 18 Haycocks Point near Pambula beach, New South Wales. Credit: Nigel Millett.

Back cover Left: Breaking ocean waves due to a storm crash over rocks at North Curl Curl beach, Sydney, New South Wales. Credit: John Grainger.
Middle:An unseasonal snow storm near Danglemah Road, Woolbrook, New South Wales. Credit: Ruth Watson.
Right: Sunset colours the clouds red over Merimbula Lake, New South Wales. Credit: Stephen Kemp.

Contact CAWCR

Director, Centre for Australian Weather and Climate Research (CAWCR)
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GPO Box 1289
Melbourne VIC 3001
Australia