

NEW DEVELOPMENTS

The Australian Bureau of Meteorology is one of the world's leading national meteorological and hydrological services. The Bureau has a highly efficient integrated infrastructure and places emphasis on continually improving systems and services leading to the delivery of new and improved products to all Australians. The Bureau seeks to make the most of the Government's investment in meteorology and hydrology by continuing research into Australia's weather, climate and water resources developing and adopting new technologies to observe, model and predict weather, climate and water, and consulting with the community to further enhance its services to meet national needs.

It is the ongoing task of the Bureau to improve the scientific understanding of the atmosphere and oceans, develop new tools to create better products and services, incorporate new data sources to increase accuracy, achieve efficiencies in routine operations, get information to clients more quickly and effectively, and respond to emerging community needs.

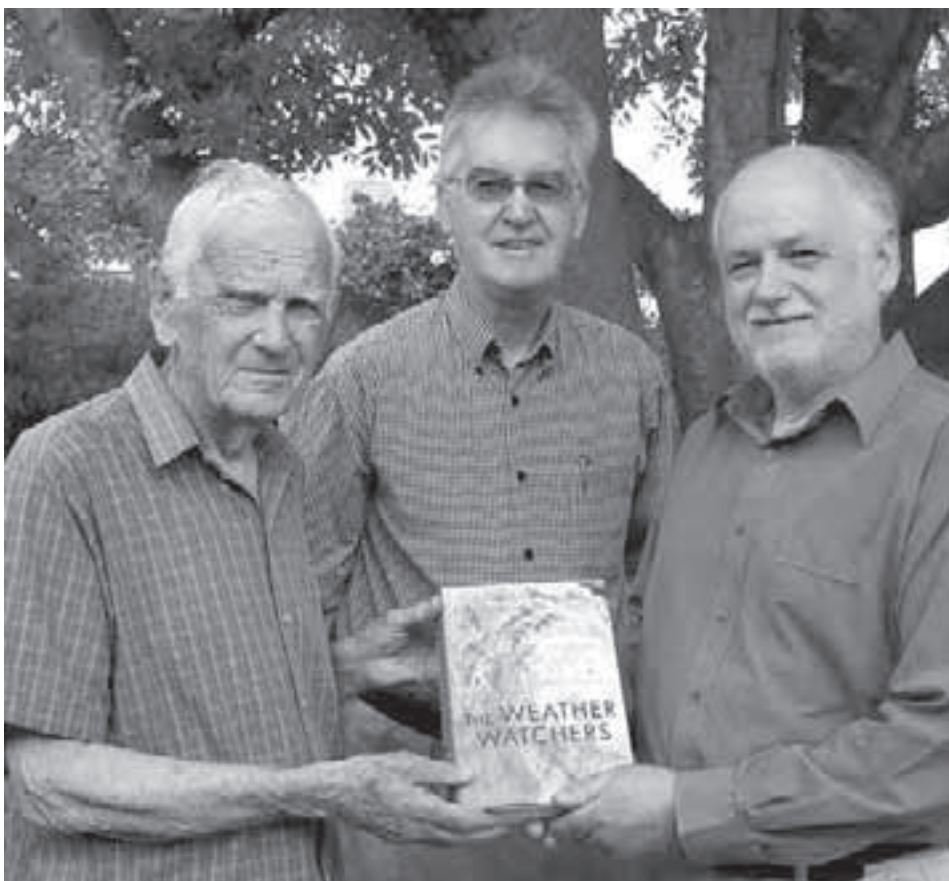
The Bureau also participates in international forums and agreements that advance meteorological and related disciplines worldwide. Australia benefits greatly from this activity in terms of the exchange of scientific knowledge, information and resources, and has been able to assist other countries in similar ways. For example, the Bureau is able to pass some of its expertise to developing nations through collaborations with the Australian Agency for International Development (AusAID).



A CENTURY OF SCIENCE AND SERVICE

The Bureau of Meteorology completed '100 years of science and service' on 1 January. Although the establishment of a national meteorological bureau was foreshadowed by the colonies in the discussions leading up to Federation, it was not until 1907 that Henry Hunt was appointed as the first Commonwealth Meteorologist, and on 1 January 1908 the Bureau of Meteorology commenced operations. From that beginning, the Bureau has developed into an internationally significant science organisation that produces a wide variety of services and is helping Australians to better understand the challenges they face with regard to weather, climate and water.

This milestone was recognised in a wide variety of ways across Australia, including by the publication in December of *The Weather Watchers*, written by noted biographer and historian David Day. This 530-page history of the Bureau, described as 'part institutional history, part drama and part natural history', was especially commissioned for the Centenary.



David Day (right), the author of The Weather Watchers, a history of the Bureau, with his father Alan (left), who worked for some years as a Bureau weather observer, and Dr Bill Downey (centre), then Deputy Director (Corporate Activities) of the Bureau, whose Bureau service spanned almost a half century.

WATER INFORMATION SERVICES

Australia's water information is currently collected and stored by more than 250 different organisations across Australia, making it difficult to assess the quantity and quality of water in dams, aquifers, rivers, lakes and other storages. The resulting lack of comprehensive water information impedes both the effective management of Australia's water resources and action to reform the way Australia manages, measures, plans for, prices, and trades water (water reform).

Under the Government's \$450 million Improving Water Information Program, the Bureau of Meteorology has been tasked and resourced to provide leadership in solving this problem. The initiative now being undertaken by the Bureau, in cooperation with water information managers in all States and Territories, has the potential to transform Australia into a best-practice water information provider, using state-of-the-art technology. The stakes are high in this endeavour; without a highly-developed and accurate understanding of Australia's water availability at the national level, water users and governments will not be properly equipped to address the urgent problem of water scarcity that has emerged in Australia through over-allocation of water resources and climate change.

At the beginning of the year a new Water Division of the Bureau was created, headed by a new Deputy Director (Water). The Hydrological Services Major Output now integrates the longstanding hydrological functions of the organisation with its new water-related responsibilities and comprises three individual outputs: the Water Data Service; the Water Monitoring Service; and the Water Prediction Services.

Under the *Water Act 2007*, the Bureau's water information role has been extended to include:

- collecting, holding, managing, interpreting and disseminating Australia's water information;
- providing regular reports on the status of Australia's water resources and patterns of usage of those resources;
- providing regular forecasts on the future availability of Australia's water resources;
- compiling and maintaining water accounts for Australia, including a set of water accounts to be known as the National Water Account;
- issuing national Water Information Standards;
- giving advice on matters relating to water information; and
- undertaking and commissioning investigations to enhance understanding of Australia's water resources.

The first step in mapping national water resources is to collate data from the many organisations in all States and Territories of Australia that currently measure and store such data. The authority to do so is provided to the Bureau through the *Water Act 2007* and the *Water Act Regulations*, which commenced on 30 June.

The primary data provided by the States and Territories will provide the raw ingredients for the Bureau to develop a range of innovative water information products (e.g. an Australian Dam Level Index), which will be freely available to the public. A state-of-the-art Australian Water Resources Information System, the development of which commenced during 2007-08, will house this collection of nationwide water data and enable the Bureau to produce and deliver its new water information products.



Representatives from New South Wales and Tasmania at the inaugural meeting of the Jurisdictional Reference Group on Water Information (JRGWI) held in the Bureau's Head Office on 31 January and 1 February. The JRGWI plays a key role in bringing together the national water information activities of the Bureau with the regional water information activities undertaken by the States and Territories.

THE CENTRE FOR AUSTRALIAN WEATHER AND CLIMATE RESEARCH: A PARTNERSHIP BETWEEN CSIRO AND THE BUREAU OF METEOROLOGY

In September a new science team was formed to take a leading role in Australia's climate change and weather research. The Centre for Australian Weather and Climate Research (CAWCR) is a partnership between two of Australia's leading atmospheric and climate research agencies - the Bureau of Meteorology and CSIRO.

The CAWCR, which came into operation in September but was formally launched at the National Museum of Australia in Canberra in December, was established to facilitate the climate, weather and oceans research that will help Australia meet the severe weather and climatic challenges that continue to confront the nation. The Bureau and CSIRO have established an initial five-year collaboration that links scientists based in Melbourne, Hobart, Canberra and Perth, and, with total staffing approaching 250, will deliver a number of advantages including access to a wider range of research skills, more efficient use of resources, and increased potential to develop effective research relationships with government, industry and other research providers.

Prior to this joint initiative, the Bureau and CSIRO had worked closely together for many years in a range of partnerships with State and Federal Government agencies and the private sector, and both have excellent records in research, including science publication. Achievements of this partnership include the BLUElink ocean forecasting service launched in August.

The CAWCR research capabilities cover the sciences associated with:

- ACCESS;
- Climate Change;
- Seasonal and Inter-annual Prediction;
- Ocean Observation and Assessment;
- Weather and Environmental Prediction;
- Ocean Prediction; and
- Atmosphere and Land Observation and Assessment.

The core modelling and data assimilation capability supporting these activities is itself a new initiative in Australian climate science. The Australian Community Climate and Earth System Simulator (ACCESS) is an initiative led by the Bureau of Meteorology and CSIRO and built on a foundation of strong research partnerships, with the United Kingdom Met Office's Hadley Climate Centre among other international organisations as well as with Australian universities, government research agencies and the Department of Climate Change. ACCESS has already demonstrated that the new system can produce significant improvement in the performance of global and regional models of the atmosphere.

The CAWCR aims for high levels of both innovation and scientific excellence, and to be a world leader in the field of earth system modelling, building on collaboration based on both an Australian regional focus and linkages to more distant partners.



The Director of Meteorology, Dr Geoff Love, addresses participants at the official launch of the CAWCR on 5 December.

IONOSPHERIC PREDICTION SERVICE JOINS THE BUREAU

The Ionospheric Prediction Service (IPS) moved from the former Department of Industry, Tourism and Resources to join the Bureau of Meteorology in December this year, thereby adding space weather to the Bureau's existing range of services.

Space weather refers to the variations in the sun's magnetic field, the solar wind, and high energy phenomena such as solar flares which can have a major effect on the earth and its nearby environment. The most visible impact of space weather is the aurora, which is seen mainly near the poles but occasionally from Tasmania and, very rarely, during a major solar storm, as far north as Brisbane. The invisible space weather effects are ever present, affecting an increasing number of technological systems. Sixty years ago, the main impact of space weather was evident in the spasmodic reduced effectiveness and changing nature of High Frequency (HF) radio. More recently, in addition to HF radio and radar effects, a wide range of additional problems have been recognised, from damage to

satellites (including destruction in extreme cases), damage to power distribution networks and long pipelines, interference to aeromagnetic surveys, and the occasional loss of Global Positioning System services. Through the IPS, the Bureau now offers a range of observations, services and advice to help planners anticipate the worst effects of space weather as well as to negotiate the daily fluctuations it imposes on their systems.

A monitoring network spanning the region of interest to Australia provides real-time information on the nearby manifestations of space weather, the ionosphere, and the current state of the earth's magnetic field. Solar observations are made at the Culgoora and Learmonth solar observatories using a range of radio receivers and optical telescopes.

During 2007-08 there was little of interest to be seen on the sun as its activity had reached the minimum of its 11-year cycle. No sunspots are currently visible and the effects of space weather are at their minimum level. However, within the next 18 months solar activity is expected to increase once again as a new solar cycle commences. More sunspots will be seen and more solar storms will occur; aurorae will occasionally be seen from Australia and, most importantly, a range of services will be provided by the Bureau to help mitigate the effects of solar weather on our technological systems.



Learmonth Solar Observatory comprises three parabolic antennae, operating from sunrise to sunset every day of the year, capable of detecting solar radio signals at 8 discrete frequencies between 245 MHz and 15.4 GHz. The different frequencies give an indication of the different processes occurring in the solar atmosphere and these radio signatures are used to determine the solar events likely to cause significant space weather in the vicinity of Earth. The solar radio observations equipment at Learmonth has been provided by the US Air Force (USAF) for joint USAF/IPS use.

BLUELINK

On 2 August the initial implementation of the BLUElink project, aimed at developing a world-class operational ocean forecast system for Australia, was marked with an official launch in the Royal Australian Navy Heritage Centre at the Garden Island Naval Base in Sydney. The launch was conducted jointly by the BLUElink partners - the Bureau of Meteorology, the CSIRO Wealth from Oceans Flagship and the Royal Australian Navy (RAN).

Milestones being celebrated were the completion of Phase I of BLUElink research and the commencement of Phase II, along with the commencement of public provision of operational ocean analyses and forecasts delivered from the BLUElink system, which were made available for the first time via the Bureau's website.

The website was launched by Senator Concetta Fierravanti-Wells, representing the Minister for Defence, and addressed by Deputy Fleet Commander, Commodore Ray Griggs, RAN, Dr Neville Smith, then Chief Scientist of the Bureau of Meteorology, and Mr John Gunn, then acting Director of the CSIRO's Wealth from Oceans Flagship. The launch received extensive coverage in the press, via online electronic media, and on radio and television throughout Australia. The launch was accompanied by a workshop for students and potential users, with technical presentations from the BLUElink science team on the various system components.

Phase I of the BLUElink operational system provides, twice weekly, an analysis and seven-day forecast of full-depth ocean temperature, salinity, currents and surface height anomaly (the difference from the climatological mean of sea level), and provides the core of an extended oceanographic service for Australia and surrounding ocean areas. Graphical representations of the forecast variables at the sea surface are available on the Bureau's website, and the underlying three-dimensional data-sets required by specialised users are also available via an internet connection. Phase II research will focus on a range of enhancements to the basic forecast model, including increased resolution, and the development of a near-shore wave model and a fully coupled ocean-atmosphere tropical cyclone model.

The BLUElink system puts Australia at the forefront of ocean modelling and forecasting capability. In addition to directly supporting operations of the Australian Defence Force, potential benefits of the system include better operational weather forecasting leading to improved safety at sea, enhanced understanding of, and capability in, environmental management and protection, a range of applications to coastal and off-shore commerce and industry, and enhanced ocean climatologies.



Participants at the formal launch of BLUElink, Garden Island Maritime Heritage Centre, Sydney on 2 August.

IMPROVING ONLINE ACCESS TO CLIMATE INFORMATION

The National Climate Centre of the Bureau of Meteorology has been undertaking substantial work to increase the range of climate data and information freely available on the internet. During 2007-08 a major development of the Climate Data Online system was completed, and the Bureau commenced providing free online access to extended historical rainfall data-sets. This new data access tool enables the community to directly access all available years of monthly rainfall data from more than 10,000 Bureau rainfall stations across Australia. The data retrieval product also provides a dynamic graphing capability.

The utility of the Bureau's Water and the Land web pages for the purposes of primary industry and natural resource management has been further improved through the merging of weather forecast and climate information into one coherent package. External funding from agencies such as Land and Water Australia's Managing Climate Variability program assisted the development of new products to improve the communication of seasonal outlooks. These include better ways of communicating information on probabilities, describing the key drivers of Australian climate (Figure 5), and providing scenarios of future rainfall.

More online information on climate change was also provided. The Department of Climate Change helped fund work to identify trends in synoptic weather systems which can be viewed on the Bureau's climate change web pages, and the CSIRO and the Bureau collaborated in developing the Climate Change in Australia website, which includes results from the latest projections of future change over Australia.

SUPERCOMPUTING COLLABORATIONS

The weather forecast services that the Bureau of Meteorology provides today would be impossible without numerical weather prediction models – complex simulations of the earth's environment. Each of the Bureau's eleven numerical weather prediction model suites is run at least every 12 hours, on each occasion involving trillions of calculations performed on huge volumes of data, with the resulting output being required according to a strict schedule.

The Bureau has used large computers to perform routine weather prediction simulations since 1971, and more recently to provide computational services for related sciences including climate change, air quality prediction, and oceanography. The complexity of numerical models and the volume of data being processed are continually increasing, requiring regular upgrades to computing infrastructure. The need to continue this process has led to a new collaborative arrangement with the Australian National University (ANU), which hosts the National Computational Infrastructure (NCI) peak supercomputer facility for Australia. During the first half of 2008 the Bureau and ANU issued a joint request for tender to acquire interoperable supercomputers. The outcome will be upgraded supercomputing equipment at both the Bureau's Head Office in Melbourne, and at the ANU/NCI. The infrastructure will facilitate the development of advanced simulation models, simplify the transfer of research models into operational use, and provide computational resources for CAWCR investigations into environmental sciences such as climate change research.

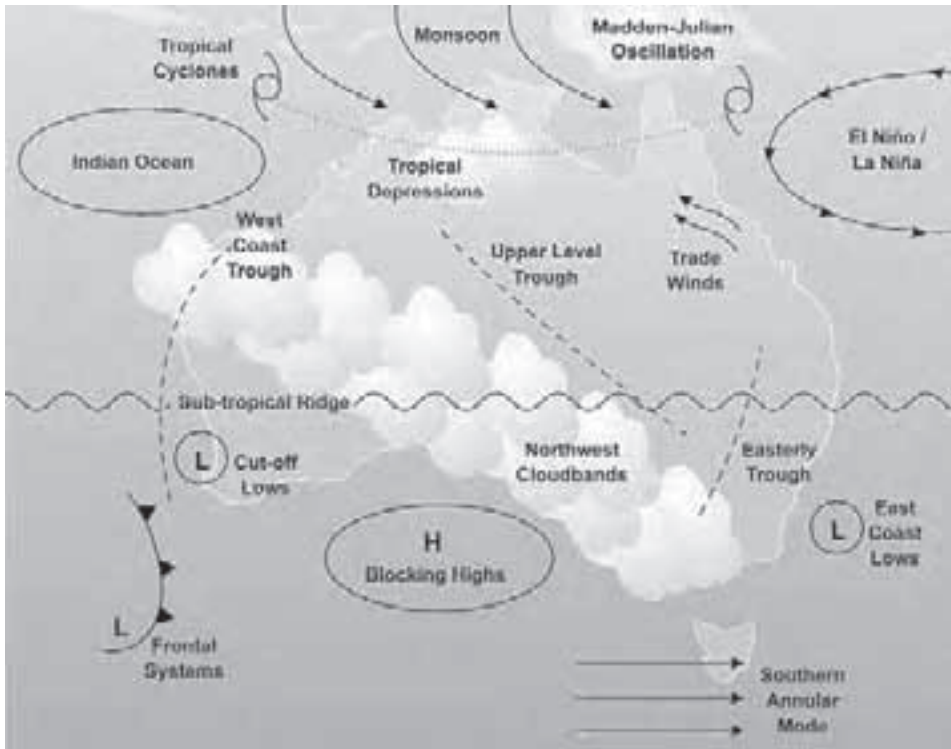


Figure 5. A diagram from the new pages of the Water and the Land section of the Bureau's website illustrating influences on Australia's climate. These new pages were developed as part of a project funded by the Managing Climate Variability program to improve communication of seasonal outlooks.

MAJOR RADAR NETWORK UPGRADE

The weather radar upgrade initiative, which commenced in 2003-04 supported by \$62.2 million provided over five years by the Australian Government, moved into its final stages during 2007-08. As a result of this project and the Bureau's routine asset replacement program, during the year a total of five obsolete radars were replaced with modern state-of-the-art weather surveillance radar with, where appropriate, digital and Doppler signal processing capability.

The Melbourne radar, located at Laverton, was replaced by a high resolution Doppler radar, and the Yarrowonga radar was upgraded with Doppler capability during the year. The Melbourne radar images available to the public via the internet are now updated every six minutes, rather than at the ten-minute intervals that applied previously, providing a new level of detail about the weather. Available images include 64 km, 128 km and 256 km range views, as well as Doppler-derived wind velocities for the 128 km range view. Doppler wind images are also available from the Adelaide, Brisbane and Yarrowonga radars.

The weather radar at East Sale (Victoria), which had been used for both weather balloon tracking (for the purpose of upper air wind monitoring) and weather surveillance, was replaced

by a full-time Gippsland weather surveillance radar at Bairnsdale in May, and the Gympie (Queensland) weather radar was replaced by a modern higher resolution weather radar in September.

The Gove (Northern Territory) upper air winds monitoring and weather surveillance radar was replaced as part of the Bureau's routine asset replacement program. Planning also progressed on the replacement of upper air wind monitoring radars at Brisbane, Adelaide, Darwin and Perth Airports, and for weather surveillance radars at Perth, the high-resolution Doppler radar at Sydney, and the new Doppler radar at Tamworth in northeastern New South Wales.

The value of the Bureau's weather radar to the Australian community is evident from the regularly high usage of the radar products on the Bureau's public website. Upgrades to the web page radar viewer interface during 2007-08 introduced a number of new features, including user-selectable overlays (of rivers, lakes, catchments, major roads, railways, weather observations and forecast districts), a facility to navigate to nearby radars, and the introduction of a national mosaic of radar and satellite images.

Radar-derived rainfall accumulation products were made available for the Bureau's Doppler radars in Adelaide, Brisbane and Melbourne. These products are images which represent the estimated total rainfall over a particular duration (for the last six or ten minutes, for the last hour, for the last 24 hours, and since 9am). Public feedback indicates that these enhancements and new products were well received.

In September, the CP2 research radar, previously owned and operated by the US University

Corporation for Atmospheric Research, Earth Observing Laboratory, was installed west of Brisbane by the Bureau. The CP2 is a dual frequency Doppler/Polarimetric weather radar designed primarily to undertake weather research. As part of the Bureau's research and development program, it provides a facility for national and international research activities focussed on very short-range weather forecasting and the characteristics of clouds. It is enabling new developments in radar systems to be assessed for operational use in the Bureau, for example advanced signal processing techniques and the capability to use both horizontally and vertically polarised radar signals. These are expected to result in improved understanding of precipitation processes and improved quantitative rainfall estimates and forecasts.



Final stages of the installation of the new radar at Gove (Northern Territory).

AUSTRALIAN TSUNAMI WARNING SYSTEM

The \$69.8 million project to develop and implement the Australian Tsunami Warning System (ATWS) completed the third of its planned four years in 2007-08. The project, which will provide a comprehensive tsunami warning system for Australia and the surrounding region, is being undertaken by the Bureau in collaboration with Geoscience Australia and Emergency Management Australia, with assistance from the Department of Foreign Affairs and Trade and the Australian Agency for International Development (AusAID).

The Joint Australian Tsunami Warning Centre, operated by the Bureau and Geoscience Australia, commenced operation in July and its capability continued to be enhanced during the year. Model forecast guidance was formally introduced by the Bureau in December to provide more specific information on the tsunami threat along the Australian coast. Undersea earthquakes continue to occur approximately every two weeks in the Indian and Pacific Oceans, requiring an assessment of their potential to generate a tsunami. Low-level warnings and watches were distributed to the west and east coasts on two separate occasions. New reporting procedures have also been consolidated to ensure the prompt notification of Government Ministers during a tsunami event.

Two new deep ocean tsunami detection buoys were deployed, one in the Coral Sea and the other in the Tasman Sea. Australia became the first nation outside the US to use the full monitoring and data management capability of such buoys for direct input of information to its warning system. Negotiations with the Badan Pengkajian dan Penerapan Teknologi of Indonesia on an agreement covering joint deployment and maintenance of tsunami detection buoys to the northwest of Australia reached an advanced stage. New generation coastal sea level monitoring stations with radar sensors were also installed, at Point Murat (Western Australia) and Luganville (Vanuatu).

The Fifth Session of the Intergovernmental Coordination Group for the Indian Ocean



A deep ocean tsunami detection buoy shortly after its deployment in the Coral Sea.

Tsunami Warning and Mitigation System (IOTWS) was held in Malaysia in April. Australia, through the Bureau, took a leading role in the meeting and was instrumental in the development and acceptance of the implementation plan for tsunami warnings in the Indian Ocean. In line with government policy, Australia, together with India, Malaysia, Thailand, Indonesia, Iran and the Asian Disaster Preparedness centre in Bangkok, plans to contribute to the realisation of the IOTWS through contributions as a Regional Tsunami Watch Provider. Australian funding support continues for the Secretariat

Office of the Intergovernmental Coordination Group for the IOTWS, hosted by the Bureau's Regional Office in Perth.

The Bureau continues to lead a 'tsunami readiness' assessment project to assist Pacific Island Countries to develop their own warning systems and guide further donor support. This project is funded by AusAID and undertaken in collaboration with Emergency Management Australia and the Pacific Islands Applied Geoscience Commission. Assessment visits to Fiji, Vanuatu, Samoa, the Cook Islands and Niue were completed during 2007-08.