A decade-long drought followed by downpours and floods: Australia is a continent of climate extremes. The challenges that come with a highly variable climate, together with increasing demand for water and emerging pressure from climate change, emphasise how important it is to manage our nation’s water resources well.

In 2008 the Bureau of Meteorology and CSIRO joined forces to develop innovative, next generation tools and technologies to deliver national water information and services. In its first four years the Water Information Research and Development Alliance (WIRADA) has delivered significant achievements in improving Australia’s water information systems, water accounting, and water forecasting, with national and global impacts.

Key achievements:

- Australia’s first seasonal streamflow forecasting service and increased accuracy and reliability of flood and short-term streamflow forecasting.
- Dramatically improving our understanding of Australia’s landscape and water resources through a high-resolution digital elevation model.
- A national water resources modelling system to underpin national water accounts and water resource assessments.
- Enabling the capture, analysis and sharing of the huge amount of water data collected by many different agencies through a common format and international water data standard.

Our vision is to improve the management of Australia’s water resources by delivering world-class water information products based on a comprehensive, innovative and robust national water resources information system.
The Bureau of Meteorology is the lead agency for providing Australia’s flood forecasting and warning services. To improve the Bureau’s water forecasting, WIRADA researchers developed science and technology to better predict short-term river flow and floods, and seasonal inflows to river systems across Australia. More accurate forecasts will help inform decisions by water managers, lead to economic benefits through more efficient irrigation allocations, help meet environmental flow objectives, and improve information for recreational water users.

Providing continuous streamflow forecasts

To expand the Bureau’s forecasting services, WIRADA researchers developed the Short-term Water Information and Forecasting Tools (SWIFT), which generate continuous short-term streamflow forecasts, seven to ten days ahead. SWIFT uses daily updated rainfall forecasts to produce an ‘ensemble’ of forecasts, spanning the range of possible streamflows and indicating the most likely flow. Short-term streamflow forecasting using SWIFT was successfully piloted at three sites in the Ovens Valley, Victoria. The service will soon be expanded to ten additional catchments. New forecasts will target key water management locations and water control infrastructure, rather than just flood-prone areas. This will assist managers of water reservoirs and environmental water reserves to assess when and how much water to release from storage. SWIFT can also be used to provide longer warning lead times for flooding, providing community and emergency service agencies with more preparation time.

Seasonal predictions of water availability

WIRADA researchers helped create the Seasonal Streamflow Forecasting Service, launched by the Bureau in 2010. The seasonal forecasts predict how much water is expected to flow into rivers and water storage systems. Forecasts are available at 50 sites across Australia and the service will expand to become national. Forecasts are updated each month. The service uses relationships between climate indicators, past catchment conditions and site-specific historical rainfall and streamflow to forecast future streamflows. A new dynamic modelling approach being developed applies climate predictions from global climate models to hydrologic models to forecast future streamflows. The service gave crucial guidance to water managers in the southeast Murray–Darling during the very wet conditions of 2010–11. The forecast results during this period were significantly better than using historical or climatology based forecasts.

The Bureau’s streamflow forecasts are improving the ability of water managers to respond to challenges presented by climate variability.

Stewart Chapman, Senior Manager Water,
Environment and Sustainable Development Directorate, ACT
Streamflow forecasting: information from days to seasons

Australia’s streamflows are among the most variable in the world, but nevertheless are relied on by a range of water managers and users, including irrigators, urban and rural water supply authorities, environmental managers and hydroelectricity generators.

In short-term forecasting, the next seven to ten days of streamflow at a particular river location depends on how much water from previous rainfall in the catchment ‘runs off’ in that period, as well as flow generated by possible future rainfall.

The ability to forecast streamflow requires modelling how much rainfall runs off the ground into streams, soaks into the soil or is lost through evaporation, and modelling of groundwater discharge.

One of the major challenges in forecasting seasonal streamflows is obtaining accurate and reliable forecasts of seasonal rainfall. Improving these forecasts is essential for helping water operators and environmental water holders to plan operations for months ahead.

Better information about future natural streamflows helps to prevent unnecessary water releases and provides opportunities to extract water during local flow peaks. Reliable streamflow forecasts for weeks to several months ahead can influence important decisions such as water allocations, cropping strategies, water market planning, environmental watering, restricting water supply and managing drought.

The modelling approaches and tools developed by WIRADA have extended the lead time for forecasts, allowed forecasts of high and low water conditions, greatly increased accuracy of both short-term and seasonal streamflow forecasts, and produced verification tools to support forecast improvements. They can also calculate how uncertain each forecast is, and communicate this level of uncertainty to users of the forecasts.

Forecasts are available from the Bureau’s website <www.bom.gov.au/water>.

Streamflow forecasting research is targeted to allow accurate and reliable forecasts, from hours to months in advance, to inform water planning decisions.
To sustainably manage and share our limited water resources, it is essential that we accurately account for how much water is available and how water is used. As information and observations are collected by numerous public and private organisations that manage water across Australia, and these data are fed into the Bureau of Meteorology’s new and improved information systems. One use of this information is analysis and publication in regular national water resource assessments and national water accounts.

WIRADA researchers have developed cutting-edge methods and technologies to help the Bureau provide integrated surface water and groundwater resource assessments, water accounts, and water resource outlooks.

Modelling water resources from catchment to continent

WIRADA researchers developed an integrated system for detailed water balance assessment from sub-catchment to continental scale, capturing water in the landscape, river systems and in groundwater. The state-of-the-art Australian Water Resources Assessment modelling system is able to tell us how much water has been produced, how much water is used by the environment or through irrigation, how much water we have left, how this compares with the past, and whether extractions, land use, farm dams or bushfires are having an impact on water security and the environment. It draws on a wide range of on-ground and remote sensing data, to provide unprecedented accuracy, coverage and insights into Australia’s water resources system. This information underpins the Bureau’s annual National Water Account and regular water resources assessments, providing valuable and timely information to water management practitioners and policy makers. The scale of this endeavour requires ongoing innovation in model development, calibration, data assimilation and remote sensing.

Average water balance for Australia during the period 2000–08, produced by combining precipitation and satellite evapotranspiration products. In blue areas, precipitation exceeds water use; in red areas, evapotranspiration exceeds precipitation (e.g. irrigation areas, floodplains, wetlands).

Accurate estimates of evapotranspiration across the continent

Accounting for how much water evaporates or is transpired by plants into the atmosphere (evapotranspiration) is an important element of calculating the terrestrial water balance. WIRADA researchers found a more effective approach for the Bureau to use in estimating daily actual evapotranspiration across the continent. They evaluated different products and data from 585 catchments and found that products based on water balance analysis work well in areas of Australia where evapotranspiration is limited by rainfall. However, in areas that have significant lateral flow, such as flood plains and irrigation districts, estimates are improved by using a remote-sensing based method. The Bureau used this research to deliver a combined actual evapotranspiration product to contribute to water assessments across Australia.

The Australian Water Resources Assessment modelling system enabled us to paint a much richer picture of changes in Australia’s water resources.

Dr Rob Vertessy, Director of Meteorology
Digital Elevation Model: mapping the continent in fine detail

To support its water forecasting, assessment and accounting, the Bureau of Meteorology needs high-resolution elevation (topographic) data for the entire continent.

WIRADA researchers produced a high-resolution, Australia-wide digital elevation model based on one-second (~30 m resolution) shuttle radar topographic mission data, significantly improving the detail available for the Bureau to use in hydrological applications.

The one-second digital elevation model provides a map of Australia's terrain in unprecedented detail, and increases our understanding of how the shape of Australia's land surface influences the volume and distribution of water resources.

The new model is helping the Bureau provide more accurate and credible assessments of national water resources and annual water accounts. Three-dimensional visualisations of the landscape will contribute to improved understanding of potential flood extents and impacts.

The techniques and methods used by WIRADA to improve the quality and usability of the global shuttle radar topographic mission data are expected to have significant international impact. The technology developed is being considered for adoption by several international agencies, including NASA's Jet Propulsion Laboratory, the United Nations Environment Program and the World Bank.

Other partners in the project include Geoscience Australia, the Defence Imagery and Geospatial Organisation and The Australian National University.

The model is publicly available from Geoscience Australia <www.ga.gov.au>.

Part of the Murrumbidgee River shown at nine-second (left) and the new one-second (right) digital elevation model resolution, showing the much greater detail provided by the new model.
In its new expanded role of providing accessible and comprehensive water resources information, the Bureau of Meteorology is required to collate, manage and publish a broad range of water information.

Previously, more than 200 organisations across Australia used a range of collection and reporting methods for water data, making it very difficult to compare the data with any reliability. WIRADA scientists focused on creating robust systems for water information management, including developing a national standard for the transfer of water information, and making sure the data could be used to improve the management of our water resources.

Revolutionising management of water data

To take a national approach to water information for the first time, WIRADA researchers developed the Water Data Transfer Format, a common format for the transfer of water information such as surface water and groundwater observations, transfers of water between storages, water quality and water trading information. Since its official launch in March 2010, most large water agencies have adopted the format, as have vendors of water information system software used in Australia. The format helps water providers to efficiently deliver four million files of water observation data to the Bureau each year. The Bureau uses this data to provide reports and updates on the state of Australian water resources.

A global standard for water information sharing

WIRADA researchers led efforts to develop an international water information exchange standard: WaterML2.0. The international standards body, Open Geospatial Consortium (OGC), adopted the standard in August 2012. Lack of data standardisation has greatly limited efficient data exchange between water management authorities around the world. This is set to change once major software vendors and government agencies that manage water information adopt WaterML2.0, making it possible for governments to manage water resources that cross country borders. WaterML2.0 is being incorporated in Australian Water Data Transfer Format development and has already been adopted by a number of organisations, including the United States Geological Survey, KISTERS, Deltares and GeoConnections - Natural Resources Canada.

Tools to consistently manage information models

Models underpinning the information systems used in the water sector are often inconsistent and documented differently, because each agency uses information systems that suit their particular circumstances. To overcome the problems with linking these different information systems, WIRADA researchers developed Solid Ground: a suite of tools for creating and managing information models in a consistent way. Solid Ground has been delivered to the Bureau and other organisations to support cooperation between different water information systems. In Australia, this work has been used in developing the Geofabric.

WaterML2.0 is the first public, open source, global standard for the exchange of water information through the Internet. It is critical for linking local, regional, national and global water information sources into connected water information networks throughout the earth.

Dr David Maidment, Center for Research in Water Resources, University of Texas at Austin

WIRADA is transforming the way we measure and analyse water information.
Geofabric: an information system for Australia’s land and water

The Australian Hydrological Geospatial Fabric (Geofabric) is a specialised geographical information system that shows the links between important features of Australia’s water system such as rivers, aquifers and dams. By detailing the spatial dimensions of these features and how they are connected, we are able to see how water is stored, transported and used through the landscape.

The Geofabric contains a number of data sets and layers, such as stream networks, connections, aquifers, key measurement points, and boundaries of reporting regions and catchments.

A sophisticated information model, developed by WIRADA researchers, underpins the Geofabric. The model captures the complex connections between the features of our water system and, significantly, allows the Geofabric to be applied at many scales for many uses such as water resource management, disaster prevention and response, and water cycle modelling.

The Geofabric has been updated a number of times since its launch in 2010, its conceptual architecture makes it easier to maintain and improve as new data becomes available. The next step is to further boost the level of resolution with one-second digital elevation data developed by WIRADA researchers.

WIRADA researchers also helped develop documentation to help Geofabric users. The Geofabric data sets are available free of charge from the Bureau’s website <www.bom.gov.au/water>.

Other partners in the Geofabric project are Geoscience Australia and The Australian National University.
To celebrate early achievements and discuss future challenges, more than 200 scientists from around the world attended the WIRADA Science Symposium in Melbourne on 1–5 August 2011. The Symposium gave researchers the opportunity to showcase their science and have peers review the impressive body of work from the first three years of WIRADA research. The Symposium covered the breadth of WIRADA research and development across the broad disciplines of water information systems, foundation data, water accounting and assessment, and water forecasting and prediction. The Science Symposium Proceedings are available from <www.csiro.au/WIRADA-Science-Symposium>.

WIRADA communicates its research via a suite of activities, including workshops, journal articles, reports, brochures, media and the web.

In some areas of the research program we are only starting to scratch the surface and there remains much to be done. Nevertheless, the core message from the Symposium is that the research and development emerging from WIRADA is world class.

Dr Rob Vertessy, Director of Meteorology

CSIRO deeply values its strategic relationship with the Bureau of Meteorology, of which an important feature is the Water Information Research and Development Alliance. The Alliance is a clear example of the impact that results when policy and operations are supported by excellent science and technology.

Dr Andrew Johnson, CSIRO Group Executive, Environment