

Getting a better picture of Australia's water resources

By Albert van Dijk, Luigi Renzullo and CSIRO, Canberra

Prolonged drought in eastern Australia has exposed the lack of water balance information required for timely response and adaptive water resources management. The Australian Bureau of Meteorology has recently been delegated a legislative mandate and resources to develop a range of water information services and the statutory power to request water observations from all relevant sources.

Services will include annual national water accounts, scheduled and occasional water resources assessments that interpret current and future water availability and trends in a historical context, and forecasts of water availability over days to decades.

A five-year water information research and development alliance between CSIRO's Water for a Healthy Country Flagship and the Bureau of Meteorology will develop the science, technology and



Albert van Dijk.

capability required to underpin national water balance observation and modelling.

A major challenge is to achieve the nation-wide coverage, currency, accuracy, consistency and interpretation of water

balance data that is required to support policy and management at national as well as local scale.

It requires a new generation of integrated observation and modelling systems that can incorporate all relevant observations. The measurement network is generally sparse in Australia and therefore remote sensing plays a crucial rule alongside on-ground observations.

First assessment system

A first, proof-of-concept version of an Australian Water Resources Assessment system has been developed. It includes features of land surface schemes but expands this with additional observations and processes (such as lateral flows) derived from modelling systems suitable for river and groundwater resource management, as well as some novel eco-hydrological modelling theory.

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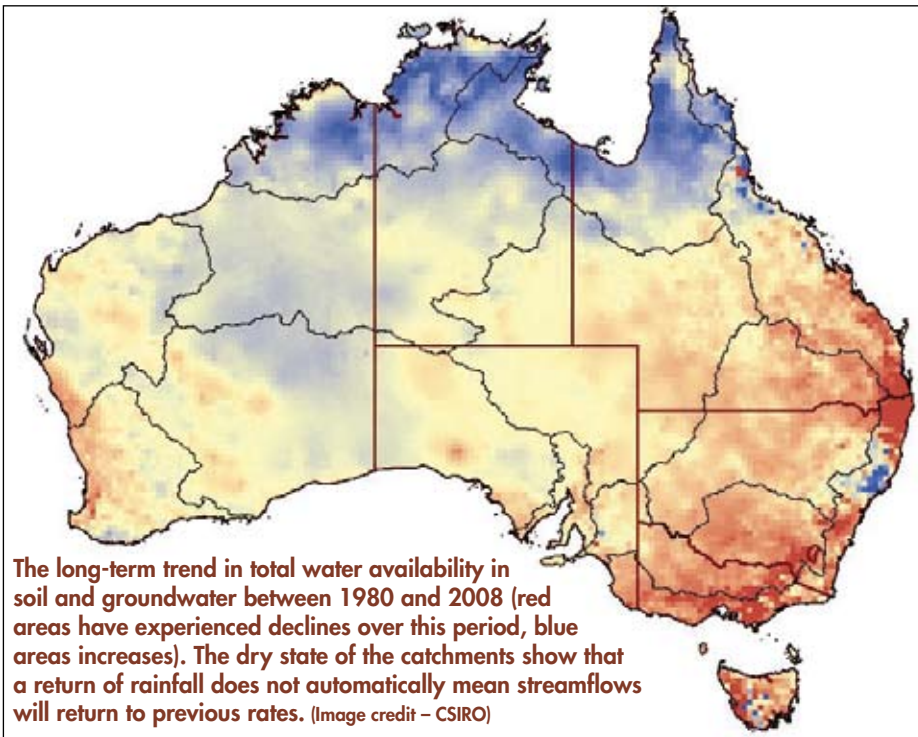
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The long-term trend in total water availability in soil and groundwater between 1980 and 2008 (red areas have experienced declines over this period, blue areas increases). The dry state of the catchments show that a return of rainfall does not automatically mean streamflows will return to previous rates. (Image credit – CSIRO)

WATER SCARCITY STARTED 15 YEARS AGO

New analysis shows that the water scarcity being experienced in southeast Australia started up to 15 years ago.

While the results from the work by senior CSIRO researcher, Dr Albert van Dijk, may not surprise many people, it provides scientific evidence of the shift.

The finding follows the first ever national and comprehensive analysis of 30 years of on-ground and satellite observations of Australia's water resources.

Dr Albert van Dijk told the Sixth International Scientific Conference on the Global Energy and Water Cycle in Melbourne in August that the analysis provides a valuable, new insight into the country's water balance.

"The data shows the first signs of diminishing water availability in Australia appeared somewhere between 1993 and 1996 when the rate of water resource capture and use started to exceed the rate of streamflow supply," Albert said.

Albert's work is part of the water information research and development alliance between the CSIRO's Water for a Healthy Country Flagship and Bureau of Meteorology in which scientists are building an observation and modelling system that will provide water balance estimates across Australia.

Long-term on-ground records and 30 years of satellite observations are combined with models that integrate and analyse the data within a powerful computer system that provides comprehensive, detailed and reliable information about the nation's water resources.

"If this technology had been available to us in the mid-1990s, the onset of dry conditions could have been detected earlier," Albert said.

"The results of the study underscore the importance of good water information for water resource planning."

The data also reveals that the impact of the drought on Australia's current water resources is broadly consistent with both the historical trend and climate change predictions.

"Parts of Australia have had record low rainfall the last several years, but our records aren't very long and the drought may still be within natural limits.

"What makes the situation appear so much worse is that the sixties and seventies were quite wet. That's also when we started capturing river flows in large reservoirs for our growing cities and irrigated agriculture. In retrospect it appears we have become over-reliant on what is now looking like 'bonus' rainfall during that time," Albert said.

The observation system that is developed will assist the Bureau in conducting regular water resource assessments and produce national water accounts.

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The system has been designed with an emphasis on flexibility (for example, modularity and variable spatial resolution) and optimal model complexity. The latter was achieved by selecting, simplifying or removing model components and degrees of freedom in existing process models through formal statistical assessment of their ability to explain observations. Stream flow gauging and flux tower evapotranspiration data as well as satellite observations of greenness were used in model development, parameter estimation and cross-validation.

On-ground metering of water use, active and passive microwave satellite observations of soil moisture and gravity measurements by the GRACE instrument were used for system evaluation and generally showed very satisfactory agreement. These and other underutilised observations are guiding further system development and are considered for future assimilation.

Forcing data for the current system include gridded daily rainfall and near-surface meteorology (both derived by blending station data and satellite observations) and vegetation mapping (derived from Landsat classification).

Vegetation vigour is a telling measure of water availability in Australia's mostly water-limited conditions, and is simulated by the model in forward mode, whereas satellite observations of greenness can be assimilated sequentially in analysis mode.

Testing of the system has demonstrated that additional satellite observations can help improve evapotranspiration estimation. The quality of rainfall estimation imposes a basic limit on the accuracy of water balance estimation.

Water availability 1980–2008

An example of system evaluation and analyses over the period 1980–2008 is presented in the chart on this page.

This period has seen reduced water availability in southeast Australia and increases in northern Australia. Patterns of water balance (and land cover) changes in space and time can be attributed to climate variability and trends and their drivers, such as the El Niño Southern Oscillation and Indian Ocean Dipole.

Comparison of analyses and independent observations identify additional processes that have a more localised effect on the water cycle, including human and natural disturbance events such as land clearing and bush fires.

The model-observation system offers



Scientists are developing a modelling system to better estimate Australia's water balances.

new opportunities to analyse land surface-climate feedback processes and investigate scaling issues in global land surface models. Current development priorities include:

- Greater accuracy in rainfall estimation by blending in additional data (a greater fraction of the gauge network, rainfall radar, satellite observations and climate reanalysis products);
- Increased resolution and process detail in areas of strategic water resource importance (such as river routing and regulation, regional groundwater system hydrology, incorporation of on-ground metering and high resolution remote sensing); and,
- Strategies to efficiently assimilate additional observations (including those relating to the surface energy balance).

The longer-term aim is to extend the modelling system to the global scale so it can be integrated within the Australian Climate Community Earth System Simulator, which will require coupling of water and carbon cycle process models and observations.

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HIGH COURT QUESTIONS WATER ENTITLEMENTS

High Court judges have recently questioned claims by the nation's largest private agribusiness that ground-water entitlements allowed it to 'take and use' bore water as if it was private property.

ICM Agriculture says the 2005 funding deal between the commonwealth and NSW, which cuts its allocation by about 70 per cent, is unconstitutional because it allows NSW to acquire the entitlements on other than just terms.

Former federal attorney-general Bob Ellicott QC, for ICM, told the court there was a historic right to "water percolating beneath the land" and that it "was a proprietary right".

"If you sell the land, the next owner or the tenant has that right, the right to take and use."

But several judges said this right had been affected by legislation designed to tackle the problem of water scarcity.

Judge Susan Kiefel noted the government "could direct the licensees of the bore not to pump at all".

Judge Susan Crennan added: "It is not as though (the government said) 'it would be a good idea not to use the water' – orders can be put in place."

Judge Bill Gummow also suggested the worth of Mr Ellicott's submission "depends on what the word right involves".

Mr Ellicott conceded there were "conditions and limitation" but said the rights conferred by the licence were "sufficiently stable" to be considered property and thus to be subject to acquisition on just terms.

Experts say the week-long case has the potential to dramatically increase the costs to governments of reallocating or restricting water use. Either way, it will generate a large legal bill, with Victoria, Queensland, South Australia and Western Australian intervening to support the commonwealth and NSW.

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