# Submission

## 2016 National Research Infrastructure Roadmap Capability Issues Paper

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The Australian Energy and Water Exchanges (OzEWEX) initiative is a research community organisation with wide reach in the climate and water domain. A brief summary of our organisation and activities is provided at the end of this letter under 'Other Comments'.

We welcome the opportunity to provide a submission in response the release of the National Research Infrastructure Capability Issues Paper. This submission is the result of feedback from our working group membership followed by an exposure period to allow for comment by the wider community.

### The importance of climate and water research

Australia's water and climate are a billion dollar business that supports many thousands of jobs. More than most countries, our economy and society is regularly buffeted by extreme weather events and related natural hazards (e.g. fire) and water supply shortages. Every day, weather and water forecasts inform economic activity in a wide range of sectors: in construction, mining, agriculture, tourism, transport, defence, to name but a few. Climate and water are an integral aspect of economic decision making and its aggregate value is not easily assessed in separation. However a few numbers illustrate its economic importance: An estimated 5% of Australia's GDP – or $65 billion annually - is highly responsive to annual climate and water variations. Irrigated agriculture contributed $14.6 billion per year to Australia's economy in 2013-14 while the water supply industry generated $16.1 billion. Climate and water related disasters currently cost Australia about $6.3 billion annually, projected to increase to $23 billion per year by 2050. The costs of the 2010/2011 Queensland floods were estimated to exceed $30 billion. The viability of a coal seam gas industry worth ~$50 billion and tens of thousands of jobs is dependent on successfully containing land and water impacts.

Australia urgently needs to find ways to adjust to changing extreme climate events and water availability, to mitigate risks and to take advantage of the new opportunities that these changes will also bring. A leap in our ability to understand, predict and manage Australia's climate and water resources will be worth billions to the economy in avoided damages and realised opportunities. Fortunately, the Australian climate and water research community is poised to achieve just such a leap.

***Question 2: Are these governance characteristics appropriate and are there other factors that should be considered for optimal governance for national research infrastructure.***

We support the identified characteristics. As a community organisation OzEWEX particularly endorses the importance of 'collaboration and networking'. They are critical to achieve the coordination needed to maximise the efficiency and effectiveness of research: providing the right framing of research efforts, avoiding duplication and wasted effort, and propagating scientific advances into practical benefits through industry partnerships. OzEWEX plays a role in this infrastructure component through information sharing (e.g., *www.ozewex.org*), workshops and events, our summer institute, and project-based activities such as collaborative data collation and literature syntheses (details at the end of this submission).

***Question 6: How can national research infrastructure assist in training and skills development?***

We see room for innovative approaches. For example, OzEWEX coordinates a consortium of government and academic partner organisations in organising the Australian Climate and Water Summer Institute (*link*), a prestigious six-week intensive project opportunity for only the most talented students from across Australia. One of the key objectives of this event is to provide this select group with hands-on training in using national data and model infrastructure components. Our partners, which include NCRIS facilities and operational agencies, directly involve their data and technology experts to deliver this training. The Summer Institute helps identify the best approach to provide training and skills development for this type of user and creates additional value in this way.

***Question 8: What principles should be applied for access to national research infrastructure, and are there situations when these should not apply?***

OzEWEX strongly advocates for free merit-based access to research infrastructure for research purposes where its development or provision are already funded from the public purse. We acknowledge that providing access is not always without cost.

In such cases investment to remove or lower the cost of providing access would be appropriate.

## Environment and Natural Resource Management

***Question 18: Are the identified emerging directions and research infrastructure capabilities for Environment and Natural Resource Management right? Are there any missing or additional needed?***

Recent years has seen considerable investments in Australia's computing and data collection infrastructure and in ecosystem science. Some of these investments have also much benefited the water and climate research community. Individual agencies have also made progress in connecting outward and overall our research infrastructure is now in a promising shape.

At the same time, the revolution in observation, data processing and prediction technology underfoot is rapidly creating dramatic new opportunities to forecast natural resources and hazards. While the overall capability of federal agencies to undertake climate and water research has generally been stabilised, the opportunities created by new technology are growing exponentially. With the increasing impact of climate extremes and pressure on our natural resources, the importance of environmental prediction will only grow further. To achieve national-scale excellence and economic benefits, the innovation capacity of the entire research sector must be unleashed and focused – not only that in government agencies, but also in the academic and private sectors. This will require a whole new level of data sharing, collaboration and coordination.

Coordination is already improving in the climate research sector, with a number of new initiatives in recent years and others under consideration. On the other hand, the end of water-related CRCs has affected coordination in the water research community and industry. Beyond climate and water research, OzEWEX activities have also demonstrated strong overlap between the interests of these with other communities in earth observation, environmental informatics, ecosystem science and public policy, among others. OzEWEX has been playing a role in coordination across the different communities but as a voluntary organisation its capacity is naturally limited. Australia is in a unique position to better integrate these mentioned research domains and create greatly enhanced outcomes through environmental prediction and sustainable management of natural resources and the climate-water-energy nexus.

Addressing three critical remaining bottlenecks in the research network, data and model infrastructure would go a long way to 'turbo charge' the existing infrastructure and create achieve global research excellence, and through this, generate optimal economic and social outcomes for Australia. These three bottlenecks relate to

*collaboration* infrastructure, *data* infrastructure and *modelling* infrastructure. They are elaborated on below.

**Priority 1) Strengthening national collaboration infrastructure**

The Issues Paper identifies the need for a "*more explicit emphasis on people and networks/collaboration; integration across (…) people, networks and infrastructure*". We wholeheartedly agree with this recommendation. For climate and water research it is an absolute priority. Experience within OzEWEX shows that elements of a highly productive national collaborative research network would likely include:

(i) A community-targeted IT infrastructure to share information and data and to enable deep collaboration (also see Priorities #2 and #3 below);
(ii) training and education-related measures targeting students and early-career researchers (e.g. intensive training courses and workshops); and
(iii) collaboration and networking events that connect academic research, government functions and private industry.

These human infrastructure components are necessary to achieve full benefit from the two technical priorities described below.

**Priority 2) Maintaining and improving critical data infrastructure**

In recent years, there has been substantial progress in improving the collection, maintenance and delivery of several data assets that are critical to climate and water research. For example, the National Computational Infrastructure and the RSD/RSDI have been major catalysts in the bringing together some essential data collections, and in connecting these data assets to high performance computation systems. The Terrestrial Ecosystem Research Network (TERN) has also improved access, discoverability, and useability of some key national ecosystem datasets. Already, the site water, energy and carbon flux data collected and provided by TERN OzFlux play an eminent role in climate and water research. Other data sets produced through the TERN Ecosystem Modelling and Scaling Infrastructure Facility (e-MAST), Remote Sensing Data Facility (AusCover) and the Soil and Landscape Grid of Australia are set to find widespread uptake once residual data continuity and accessibility challenges are dealt with. The mentioned NCRIS facilities have made a very important contribution to innovation in the climate and water domain and we advocate their continuation and expansion.

There are some additional access challenges with other highly significant research data assets that have obvious potential to greatly enhance climate and water research, and provide a shared foundation for future research across the community. Many of these data assets are in the custody of government organisations such as Geoscience Australia, CSIRO, the Australian Bureau of Meteorology and a small

number of other organisations. Given budgetary constraints and competing priorities, the custodian organisations have made a commendable effort to make these data more discoverable and accessible. However, to differing degrees, the broader research community still faces challenges in make effective use of these data assets. Some examples are listed in the Issues Paper. A non-exhaustive list includes:

- satellite data assets, such as the Australian Geoscience Data Cube, Water Observations from Space, Dynamic Land Cover Data;
- topographical/elevation data, such as the National Elevation Data, Australian Hydrological Geospatial Fabric, and lidar data collections;
- gridded climate and water balance data;
- weather and seasonal climate forecasts;
- hydrological measurements collections (e.g., streamflow, groundwater and reservoir storage water data); and
- spatial soils, shallow geology and aquifer data.

There are varying reasons for this limited accessibility: e.g., the data may not be widely accessible due to license or commercial constraints; the data may be formally but not practically accessible because of challenges in discovery, download, documentation or user assistance; or tools or networked infrastructure are lacking to use the data productively (e.g. for analytics, data drilling, transformation or data integration in a high performance environment).

At the moment, these limitations are causing considerable overheads in research, as well as a lack of coordination, harmonisation and relevance in research framing, resulting in inefficiency and a drag on innovation. Fortunately this situation can be addressed through:

(i) improved collaboration network infrastructure (see Priority #1);
(ii) providing research users a voice in data service design;
(iii) more emphasis on data usability;
(iv) data standardisation protocols; and
(v) commitment to the public provision of tax-payer-funded data services.

**Priority 3) Community model infrastructure to catalyse innovation**

Atmospheric and hydrological modelling tools originally developed by CSIRO and Bureau of Meteorology form the core of current national-scale environmental predictions and the basis for future services. Examples include the ACCESS and CABLE models for climate and land surface modelling respectively, the AWRA modelling system for water balance modelling, and the flood to seasonal streamflow forecasting tools in operations by Bureau of Meteorology. These tools provide a vital role in preparing our society for imminent or developing climate and water related challenges.

To maintain Australia's capability in environmental prediction, the full breadth of our research community beyond these two agencies needs to be engaged. This means that these modelling tools and their enabling infrastructure should be considered a critical component of Australia's research infrastructure, and need to be widely available and used throughout the entire research community as a target for innovation. Already, there is progress towards establishing these tools as community models, along with improving access and useability. For example, much progress has been made in establishing CABLE as an Australian community land surface model and in making ACCESS more widely available. There are also plans to provide community access to the AWRA system.

These developments are much needed, but also expose an urgent need for supporting infrastructure and associated governance arrangements to achieve this inclusive transition.

The environmental prediction tools described require large scale computing and data hardware infrastructure that is readily accessible to the research community and that facilitates deep collaboration. To achieve this, we advocate for continued and targeted investment in high performance computing and data hardware at facilities such as the National Computational Infrastructure. This investment in large hardware is required, but not sufficient in isolation. Corresponding investment is required in the software platform on which these model tools are implemented. This infrastructure allows the models to make best use of the high performance computation and data infrastructure resources available. To realistically represent today’s complex operating conditions, the underpinning software infrastructure needs to be designed following modern software development paradigms, including a standardised testing environment, test-based development and continuous integration testing.

A critical component of a community modelling infrastructure is a standardised basis to evaluate model innovations - so-called benchmarking systems. Benchmarking systems dramatically reduce the large effort of model evaluation that is currently repeatedly duplicated among organisations and individuals. A well-maintained and dynamically evolving benchmarking system allow researchers to directly and consistently compare innovations and their impact of prediction skill at the push of a button in a manner that is relevant to operational applications. Benchmarking systems require (1) a high quality, standardised, and evolving data collection of relevant observations (see Priority #2), and (2) well-designed tools and automated processes by which alternative model simulations can be evaluated against the observations with rigorous transparency, reproducibility and provenance.

inally, a successful community model infrastructure cannot exist without user support, training and carefully considered governance that recognises the needs of stakeholder organisations but also those of individual researchers. Outside Australia, there are successful examples showing how data and model infrastructure can be maintained by a consortium of academic and government organisations.

Addressing the three priorities described above – collaboration networks, data and model infrastructure - would set up the climate and water research for international

excellence and consequently put Australia in an enviable position to prepare for future climate and water variability.

## Other comments

About OzEWEX

The Australian Energy and Water Exchanges initiative (OzEWEX) is a not-for-profit research community volunteer organisation. We have received funding from the Commonwealth Scientific and Industrial Research Organisation, Bureau of Meteorology, Geoscience Australia, Murray-Darling Basin Authority, National Computational Infrastructure, Bushfire and Natural Hazards CRC, ARC Centre of Excellence for Climate System Science, as well as several universities and some private donations.

Our purpose is to promote information and data sharing, collaboration and engagement between researchers, data providers, research users, resource managers and research managers, active in the climate and water domains. This includes academics, students and professionals in government operational and research agencies and in private industry.

We pursue our goals by:

- sharing information through our bi-monthly newsletter with more than 800 subscribers and our web site (*www.ozewex.org*);
- organisation of an annual workshop for more than 100 participants;
- coordination of working groups and their projects, with examples so far including joint synthesis projects, data collection projects and method inter-comparisons;
- facilitating establishment of priorities for data and model infrastructure, and advocating for these priorities; and
- organising an annual Australian Climate and Water Summer Institute (*link*), through a consortium of government and academic.