This submission has been prepared jointly by the ARC Centre of Excellence for Climate Extremes and the ARC Centre of Excellence for the Weather of the 21st Century. Both Centres address key challenges in the areas of climate system science and prediction. ARC Centres of Excellence constitute major cross-institutional collaborations with both Centres comprising more than 20 national and international partners. This submission is the result of consultation with Centre staff and has been compiled by the two Centre Directors.

1. The draft priorities intend to identify specific challenges facing the country that will require multidisciplinary and multisector efforts to address. Do they achieve this objective? How can we improve them?

The four priorities and their objectives capture the challenges ahead very well and there is a welcome focus and emphasis on climate change throughout. The priorities also make it clear that we need to better understand and predict future climate conditions. We note that there should be stronger emphasis on the interrelatedness of climate prediction, mitigation, and adaptation, as they are strongly linked. For example, we will need improved predictions with earth system models to inform the utility of carbon sinks and renewable energy in our unique environment. How will drought & fires impact our management of forests and agriculture in the future, how can we enhance carbon sinks while also reversing declines in biodiversity, how will weather variability and change impact renewable electricity resources?

We note that there are several scientific and technological innovations that underpin all four priorities that are currently not explicitly drawn out. We highlight one here. To succeed in all priority areas requires a significant uplift in our ability to predict the future of our climate, including changes in the weather that will power our net-zero economy, as well as its extremes, that will strongly impact communities. Achieving this uplift not only relies on scientific advances but requires a significant enhancement of the research infrastructure that is critical to delivering the science and predictions. This includes enhancing the nation's High-Performance Computing and Data (HPCD) systems to improve our prediction capabilities, enhancing our development and support for the software systems that provide the predictions (climate models), as well as machine learning and AI driven information systems that turn the predictions into information for societal applications. Given the fundamental role research infrastructure plays in delivering both science and information in all priority areas, we suggest to explicitly include a paragraph/section in the document that emphasises its role.

2. Feedback stressed the need to work in partnership with First Nations people to embed First Nations knowledge and knowledge systems in the way we address national challenges. How might governments and the science and research sector best work with First Nations people to achieve this objective?

The National Environmental Science Program has developed strong and genuine strategies to engage First Nations people in elements of climate impacts and climate adaptation. We would view this Federal Government led program as an exemplar in creating a trusted and effective partnership. We note that all engagement needs to be culturally sensitive, effective, and on-going, making it more effective to be pursued in longer term programs, such as the National Environmental Science Program, rather than shorter term research grants (although there will obviously be exceptions). These more strategic programs are likely able to achieve long-term benefits from engaging with First Nations peoples in ways that other Australian research programs could not.

3. The draft priorities provide a range of critical research paths. How could we refine these research paths, for example, to address immediate challenges?

Following from our comment above, we note that many of the critical research areas in the report, simply assume and assert the availability of the necessary information about the future of our climate, that is critical for their delivery. Examples are:

- Future climate conditions in Australia … (Priority 1, page 8)
- Social and environmental drivers of ill health … (Priority 2, page 10)
- Understanding the impacts of climate change on Australia's future productivity and our key markets. (Priority 3, page 12)
- Food safety and security for future Australian conditions and markets. (Priority 4, page 13)
- Housing and built environments that support climate resilience (Priority 4, page 13)

All the above require major advances in climate prediction systems and climate system science, underpinned by the HPCD and software infrastructure necessary to deliver them. This will require significant and continuous investments that are in the national interest and that are collaborative, instead of investments spread across many individual organisations. It will also require a systematic approach to cross-institutional collaboration, setting of research directions, undergraduate and postgraduate training, and long-term funding.

It is worth noting that the scale of research and infrastructure required to address the science and societal needs ahead is beyond individual institutions and, increasingly, beyond individual nations. This calls for the recognition in the report that international science and technology partnerships are likely a critical path forward and need to be developed with some urgency.

We see two options for more explicitly bringing out the need of the underpinning capabilities in climate prediction.

Option 1, which is our preference, is to add an additional bullet point under 'Critical Research' in Priority 1 as:

- Improved models and predictions of the earth system, underpinned by cutting edge systems and practices in supercomputing, software engineering and AI.

Option 2 would be to explicitly mention the need for future climate information in all Research Priorities. We give illustrative examples here:

Additional point in Priority 2: Understanding how the future climate may affect well-being, health, and the environment, supported by data and models that describe the earth system and human activities with increasing complexity.

Additional point in Priority 3: Techniques to quantify and plan for the role of the changing climate in shaping future industries and the future energy supply, underpinned by modelling and data.

4. How would you implement the priorities in your organisation or setting? What mechanisms would support implementation?

We note that the scientific and technological problems in all four priorities are of a scale that is unlikely to be addressed by individual organisations. As a result, more focus needs to be given to national and international collaboration, including the potential establishment of coordinating organisations that bring together expertise and infrastructure in a more holistic way.

5. The National Science Statement will explain the role our science systems will play in delivering the priorities and maximising the benefits from science for Australia. How can the following best support the priorities:

a. Science agencies

b. Science infrastructure

We note the scale of investment in national HPCD infrastructure in many other countries far exceeds that of Australia and that Australia is in danger of falling behind in delivering the HPCD infrastructure required for climate system science and prediction. The solution is the provision of strategic and continuous support to a national HPCD facility that is, at least in part, dedicated to climate system science and prediction.

Fundamental infrastructure for observations is currently provided by NCRIS. We strongly endorse NCRIS's prioritisation of marine observations via IMOS and terrestrial observations via TERN. We note, however, that the software infrastructure required to create a seamless and effective flow of observations through to understanding and into modelling infrastructure is not well supported. The investment by NCRIS in the ACCESS NRI is a very welcome step, and we suggest that it is the kind of software infrastructure that many other research communities will require in the near future.

c. Australian government science programs

d. Domestic and international science relationships.

Our climate is global, so is the science and infrastructure that supports its prediction. As outlined above, domestically a national approach to climate system science and prediction is required bringing together the effort currently spread across different institutions. This effort

will have to be embedded in international science, such as the World Climate Research Programme. As noted above, the infrastructure required to provide the predictions and information needed in all four priority areas is quickly outgrowing the capacity of individual nations (and certainly individual institutions), calling for a regional international approach. For example, one could envisage the establishment of an Indo-Pacific HPCD facility for research on Australian soil, powered by renewable energy resources.

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