Response to the review of our approach to developing climate risk data

We commissioned a group of independent experts to assess our approach to climate risk when developing regional water strategies. This document describes key the outcomes of this assessment and our response to the group's recommendations.

Our valuable and essential water resources are under pressure across NSW. There are challenges coming from a changing and more variable climate, industry changes and growing populations. To address these challenges, the NSW Government is developing regional water strategies that will help us balance the various demands on our vital water resources.

These regional water strategies were developed using the best available climate evidence and a range of analytical tools, including sophisticated water models for each region.

Our approach to developing the strategies considered climate variability so that the uncertainty in plausible climate futures was well represented. The method was developed collaboratively with researchers and combined knowledge of climate drivers, paleoclimate information and historical climate observations in a stochastic framework and modelled climate projections.

In order to build confidence in this approach and to continue to improve the methods, we commissioned a group of independent experts to assess our methodology.

The independent expert panel

We engaged 4 leading researchers and practitioners with diverse expertise in climate science, water management and statistics to review our methodology. The panel members were Professor Bryson Bates, Emeritus Professor George Kuczera, Professor Andy Pitman and Dr Scott Power. These experts were convened as a panel chaired by Dr Chris Armstrong PSM, the then Deputy Chief Scientist and Engineer from the NSW Government Office of the Chief Scientist and Engineer.

The panel met with officers from the water modelling and regional water strategies teams in September 2019 to understand the approach we had taken, as set out in a recently published report. A second meeting held in March 2020 allowed the panel to discuss with us its draft findings and recommendations. The panel presented its final report to the NSW Government in April 2020.

Report findings and recommendations

Key findings from the report were that:

> 'Overall, the [the department's] methodology to use observational and paleoclimate data informed by an understanding of climate drivers to select, calibrate and test stochastic models and the factoring of NARCliM projections is consistent with best-practice approaches to climate risk management'

and:

> 'the use of stochastic models represents an important advance compared with the use of historical data and climate models alone…[allowing]…the practitioner to understand the joint impact of climate variability and climate change.'

We greatly appreciate the considerations and effort of the independent experts. Their input has allowed us to continue to implement this important work across NSW.

The panel also identified several areas where the methodology could and should be improved. These were described in 15 recommendations along with the rationale, relative importance and recommended timelines. We respect the intent of these recommendations for continual improvement and overwhelmingly support them.

We are working through the recommendations. Several have been fully addressed through the implementation of the climate data method. The remaining are either in progress or in planning.

Table 1 provides a summary of the recommendations and their statuses. The sections following set out the recommendations and our responses in detail.

Table 1. Summary of the independent expert panel recommendations and the status of our response

No.	Summary of recommendation	Status	Date
1	Detailed documentation	In progress	Oct 2023
2	Document reasons for choice of data source and quality assurance of observations	Completed	-
3.1	Clarify references to ET and PET	Completed	-
3.2	Consider replacing current PET approaches with physically based models	In progress	Dec 2023
4	Collaborate to improve paleo records	In progress	Dec 2023
5	Collaboratively develop diagnostic principles for stochastic model performance	Completed	-
6.1	Further explanation in methods report	Completed	-
6.2	Further development of approaches to develop data where unclear of dominant driver	In-progress	Ongoing

No.	Summary of recommendation	Status	Date
6.3	Examine if future climate drivers' behaviours will remain consistent with past behaviours	Completed	-
7	Investigate stationarity to ensure that models do not underestimate climate risk	Completed	-
8	Investigate impacts of parameter uncertainty in stochastic models on system yield	In planning	Ongoing
9.1	Incorporate NARCliM 1.5 into work	Completed	-
9.2	Monitor approaches to ensure NSW methods remain at international standard	In progress	Ongoing
9.3	Explore incorporation of NARCliM 2.0	In planning	June 2024
10	Convene a state level community of practice	In progress	Ongoing

Detailed recommendations and responses

The following sections provides the detailed recommendations from the independent expert panel's report and gives our responses to individual recommendations.

Recommendation 1 – supported

'[The department] to prepare a single document outlining the methodologies described in each of the background papers. Currently, the description of the methodology is distributed through the draft Methods Paper, but the level of detail described in the relevant sub-project documents is not reflected in the Methods Paper. The Methods Paper should explain the various subprojects, including the commonalities and differences and the reasoning behind the method and choices made by the modelling experts. A useful example, in terms of the level of detail, was prepared for the Queensland Water Modelling Network, Critical review of climate change and water modelling in Queensland (Alluvium, 2019).'

Comments

We developed a stakeholders' communications strategy in the short term focusing on plain language guides to the method and presentations at conferences. We will publish the reports developed during the design of the approach after some minor editing. We are preparing more detailed methods documents incorporating information in consultant's reports and how this has been used in our modelling. We are also planning to develop a peer-reviewed scientific journal paper explaining the overarching methodology and referring to detailed elements that have already been published.

Action

This is in progress. The detailed methods report is scheduled for October 2023.

Recommendation 2 – supported

'[The department] to investigate the difference between the SILO and AWAP data sets and justification for use of one over the other should be provided, including efforts to quality control the data. This should be clearly documented by [the department].'

Comments

SILO[1] and AWAP[2] (Australian Water Availability Project) are 2 proprietary models that provide patched point and/or gridded rainfall and evaporation datasets across Australia. There are

---

[1] https://www.longpaddock.qld.gov.au/silo/

[2] http://www.bom.gov.au/metadata/catalogue/19115/ANZCW0503900567

differences between the 2 datasets. The expert panel recommended that we undertake further work to determine the best source of this data.

There are practical reasons why we have relied on SILO to date. The SILO data set has a longer period of record compared to the AWAP data set, capturing statistically important wet and dry periods at the end of the 19th century. Also, we use a patched point data set in preference to gridded data because it is temporally more homogenous and includes information on missing observed data required to undertake quality control before using it in climate modelling and water modelling.

We also assessed the quality of the data sets some time ago, relying on studies comparing AWAP and SILO spatially interpolated daily rainfall datasets. The studies concluded that overall error statistics are similar for both methods, with the SILO method producing slightly lower error statistics overall for the 2001 to 2007 period. On this basis, we see no need to move away from using SILO in the short term.

AWAP has since been superseded by AGCD (Australian Gridded Climate Data). We believe that investigating the merits of SILO versus AGCD data is something that should be considered by the broader user community of practice referred to in recommendation 10.

Action

This has been completed.

Recommendation 3.1 – supported

'The language in the Methods Paper and the corresponding background documents relating to ET and PET should be clear and anywhere that PET is used needs to be carefully evaluated for the biases it might introduce.'

Comments

We confirmed to the expert panel that we use 3 different accepted methods of derived evapotranspiration (Penman-Monteith reference evapotranspiration for irrigation demand estimation, Morton's shallow lake evaporation for evaporation from water surfaces and Morton's wet environmental areal potential evapotranspiration for estimating catchment runoff). We will clarify our references to and use of ET and PET in the report referred in recommendation 1.

Action

This has been completed.

Recommendation 3.2 – supported

'[The department], in discussion with the community of practice, consider whether recommendation 3.1 could be notionally addressed by replacing the FAO56 and Mwet approaches with a physically based model.'

Comments

We engaged the University of New South Wales to investigate the feasibility of integrating a physically based method to estimate actual evapotranspiration into our conceptual rainfall-runoff model framework. This work is in progress. We will consider actions to replace current methods after the completion of this work and further discussion with a community of practice.

Action

This is in progress. The research project is scheduled to be finish in December 2023.

Recommendation 4 – supported

'[The department] engages external expertise to explore options to improve proxy records by, for example, obtaining and incorporating local proxy records. This may go some way toward improving the situation where current proxy records are derived from distant locations with different climate influences. Efforts to improve both the quality and quantity of proxy records could improve our understanding of climate variability. Moreover, the (possibly interactive) climatic variables that affect the proxies need to be clearly identified by experts.'

Comments

We, along with other NSW water management agencies, have engaged the University of Newcastle to investigate additional regional palaeo-climate records. Field work in Barrington Tops was completed in late 2020 and the results have been analysed. Further work in the Blue Mountains to provide a proxy for the Sydney region is underway. We are also aware of recent and ongoing research in other palaeo data sets. We will include an update of emerging regional and local palaeo data sets in additional reporting by July 2023, with further reporting from our research partners ready by December 2023.

Action

This is in progress. We expect to report by December 2023.

Recommendation 5 – supported

'[The department] to work with experts to develop a statement of general principles about the use of diagnostics to aid in the evaluation of competing stochastic models and to enable water resource modellers to determine which models are fit for purpose. As part of this, the stochastic models should be subject to holdout validation so that their reliability can be more accurately assessed.'

Comments

We have collaboratively developed diagnostics with researchers we have worked with to assess and improve the performance of stochastic models used to develop the stochastic climate data for our water models. We will describe the methods used to assess the suitability of stochastically generated data in our detailed methods report by July 2023. The broader application of this work would need additional industry involvement. This could be pursued in the community of practice referred to in recommendation 10.

Action

This has been completed.

Recommendation 6.1 – supported

'The Methods Paper would benefit from further articulation of the role (or not) that the climate drivers play specifically in the development of the stochastic data sets and how uncertainty about their future behaviour may be manifested into the scenarios.'

Comments

The methods adopted and presented to the independent expert panel describe our current approach to how climate drivers contribute to stochastic data generation. Future behaviour of east coast lows was addressed explicitly as a change in frequency. However, future climate for regions where the IPO signal dominates has not been addressed as part of stochastic modelling. Instead, future climate conditions are based on NARCliM outputs and it is unclear whether the climate models used have identified a change in behaviour of the IPO. We will address the evidence for change and how this might be considered in our response to Recommendation 6.3.

Action

This has been completed.

Recommendation 6.2 – supported

'[The department], in collaboration with experts in climate science and statistics, to explore alternative approaches to generating randomised samples as part of the future research program, particularly for regions where it is not clear what the dominant driver is or where there are multiple dominant drivers.'

Comments

In most NSW regions, the dominant driver has been identified. However, the discussion in our detailed methods report includes what is known of the contribution of other known drivers. We are keen to continue working with experts to identify the need for this and to provided targeted support

to develop the science around some of the areas of uncertainty noted in the report. However, the actual work would need to be undertaken as part of a national community of practice (see recommendation 10).

Action

See recommendation 6.3

Recommendation 6.3 – supported

'[The department] to work with colleagues, such as the community of practice, to examine whether the future behaviour of climate drivers (e.g. IOD, IPO, ECL, ENSO, and SAM) will remain statistically consistent with the past. Climate science can provide guidance on how these may change, and a review of the latest literature every few years would be prudent.'

Comments

We support working with communities of practice at a state and national level to examine possible changes in future behaviour of climate drivers. The latest Independent Panel on Climate Change Assessment Report provides a review of the contemporary climate change science literature and notes varying degrees of uncertainty about how the frequency, duration, magnitude and location of climate drivers such as IOD, ENSO, IPO, ECLs and SAM could change in the future.

We commissioned a focused literature review to examine the importance of different climate drivers in an NSW context and how these may change based on climate models and related science. A summary of this will be included in our detailed methods report.

Action

This has been completed.

Recommendation 7 – supported

'[The department] engages external expertise to undertake a two-step approach to investigate stationarity over the historical record to ensure the risk that models do not underestimate current and hence future climate risk. The objective is to capture the current climate risk and a baseline that reflects this.'

Comments

Recommendation 7 also included a detailed suggestion about how this 2-step approach may be applied. We note that the issue of stationarity is common to any stochastic data method and has been the subject of extensive studies over many years.

We began this investigation with researchers from the University of Adelaide to analyse available data separately for the northern Murray Darling Basin and the southern Murray Darling Basin. The

analysis indicated non-stationarity in the southern Murray Darling Basin. The researchers presented a range of options and a recommended approach to deal with non-stationarity. We also engaged the University of Newcastle to provide advice on a method for accounting for non-stationarity in the Sydney Basin, to inform urban water security studies.

We re-engaged the expert panel to review and provide advice on the suitability of these recommended methods.

The expert panel found that there is no definitive method for accounting for non-stationarity and recommended that both methods were suitable. Data has now been prepared for the Sydney Basin, and for the southern Murray Darling Basin.

Action

This has been completed.

Recommendation 8 – in-principle support

'[The department], through consultation with external experts and the community of practice, to look at possible sources of parameter uncertainty in various stochastic models and continue efforts to identify and document this uncertainty, including using statistical methods to quantify the uncertainty and mechanisms to incorporate this knowledge into decision making.'

Comments

A single set of calibrated parameters was used to generate stochastic data for the regional water strategies. As with most models, calibrated parameters in stochastic models are subject to uncertainty. Many parameter combinations will result in a comparable model performance. Using different sets of key parameters to generate multiple sets of stochastic data results in increased uncertainty in model output, including more extreme conditions. This increased uncertainty may be important for certain water resources systems, such as those that principally supply populous urban areas where a yield of known security is an important design criterion. It is perhaps less important where water use responds adaptively to water availability, such as the large, regulated river systems in inland NSW.

A lot of work is required to fully explore the impacts of this parameter uncertainty and we would look for opportunities to do this analysis in systems supplying water principally for urban water use.

Action

By June 2024, we will identify if possible a regional urban water supply from headwater storage where this recommendation could be tested as a pilot and seek funding to engage research partners.

Recommendation 9.1 – supported

'[The department] works with the NARCliM developers and together begin the process of planning to incorporate NARCliM 1.5 into calculations.'

Comments

We have worked with University of Adelaide to analyse NARCLiM 1.5-modelled data and incorporate results of all 6 modelled realisations for 2 representative concentration pathways at 2 future climate windows into projections for the southern Murray Darling Basin.

Action

This has been completed.

Recommendation 9.2 – supported

'The community of practice monitor approaches used to quantify future climate risk elsewhere in Australia and internationally to ensure methods used in NSW remain at an international standard.'

Comments

A project-level community of practice exists at the department. The community of practice includes several of the department's water-related business units and other NSW government water agencies. There is also a program-level multi-jurisdictional community of practice convened by the Murray Darling Basin Authority that will assess approaches to implementation for Basin-scale water management.

Action

This is in progress. We will continue to operate at a project level and program level pending more formalised state-based and national-level arrangements (see recommendation 10).

Recommendation 9.3 – supported

'[The department] to work with the community of practice to explore incorporation of NARCliM 2.0.'

Comments

NARCliM 2.0 data has not yet been released. We will consider how to incorporate this data into future climate data sets as it becomes available. This will be informed by a hydrologically informed assessment of NARCliM 2.0-modelled outputs similar to those undertaken for the stochastically generated data.

Action

This has been planned. The assessment of data is scheduled for completion by June 2024.

Recommendation 10 – supported

[The department] to convene a Community of Practice on a defined and ongoing basis that includes at least relevant climate science and user groups within the department (including the broader departmental entities – Manly Hydraulics Laboratory, WaterNSW, Sydney Water, Hunter Water, Department of Primary Industries and the department's Water group and Environment, Energy and Science group) and possibly other agencies that have forecasting and response roles in NSW such as Rural Fire Services, Fire and Rescue NSW, NSW Health. In addition, experts from other entities, including universities, BOM and CSIRO should be invited to participate.

Some recommended focus areas include*:

> a) identifying best practice
> b) understanding uncertainty
> c) communicating and managing uncertainty
> d) adaptive management
> e) assessing new approaches
> f) contributing to technical improvements
> g) new approaches to ET
> h) observational networks and monitoring
> i) monitoring climate trends
> j) research
> k) national cooperation.

* Each of the focus areas (a)-(k) included detail that has been omitted in this document for brevity. The detail can be found in the independent expert panel report.

Comments

We strongly support the proposal that a community of practice be established. We have asked the Office of the NSW Chief Scientist and Engineer to help in this process, and 2 initial community of practice meetings were held. There are several other communities of practice, including a climate change community of practice hosted by the department's Environment and Heritage group and a hydrologic modelling community of practice hosted by the NSW Modelling and Monitoring Hub.

We need to do further work to determine how to best embed this community of practice, which sits at the junction of these groups. Full implementation of this will be a component of the department's NSW Water Climate Change Action Plan under development for 2023–28.

In addition to this state-based community of practice, we are involved an inter-jurisdictional working group with Murray–Darling Basin Authority. We are also aware of recommendations to the National Water Reform Committee to develop a 'coordinated national approach to addressing climate risk in water resource planning and management', which will provide an opportunity to represent this community of practice on a national scale. We will use the recommendation to develop draft terms of reference and draft membership.

Action

This is in progress. We will work with the NSW Modelling and Monitoring Hub to develop a state-based community of practice (September 2023) and engage with the national-level community of practice as it is mobilised.