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Improving continental scale hydrological model performance and stability under variable climate conditions in order to improve the assessment of future water resources

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Ensuring future water security in a changing climate is becoming a top priority for Australia, which is already dealing with the ongoing socio-economic and environmental impacts from record-breaking bushfires, infrastructure damage from recent flash flooding events, and the prospect of continuing compromised water sources in both regional towns and large cities into the future. In response to these significant impacts the Australian Bureau of Meteorology is providing a hydrological projections service, using their national operational hydrological model (The Australian Water Resources Assessment model: AWRA-L, www.bom.gov.au/water/landscape), to project future hydrological fluxes and states using downscaled meteorological inputs from an ensemble of curated global climate models and emissions scenarios at a resolution of 5km out to the end of this century.

Continental model calibration using a long record of Australian observational data has been employed across components of the water balance, to tune the model parameters to Australia's varied hydro-climate, thereby reducing uncertainty associated with inputs and hydrological model structure. This approach has been shown to improve the accuracy of simulated hydrological fields, and the skill of short term and seasonal forecasts. However, in order to improve model performance and stability for use in hydrological projections, it is desirable to choose a model parameterization which produces reasonable hydrological responses under conditions of climate variability as well as under historical conditions. To this end we have developed a two-stage approach: Firstly, a variance based sensitivity analysis for water balance components (e.g. ephemeral flow, average to high flow, recharge, soil moisture and evapotranspiration) is performed, to rank the most influential parameters affecting water balance components. Parameters which are insensitive across components are then fixed to a previously optimized value, decreasing the number of calibratable parameters in order to decrease dimensionality and uncertainty in the calibration process. Secondly, a model configured with reduced calibratable parameters is put through a multi-objective evolutionary algorithm (Borg MOEA, www.borgmoea.org), to capture the tradeoffs between the water balance component performance objectives under climate variable conditions (e.g. wet, dry and historical) and across climate regions derived from the natural resource management model

(https://nrmregionsaustralia.com.au/).

The decreased dimensionality is shown to improve the stability and robustness of the existing calibration routine (shuffled complex evolution) as well as the multi-objective routine. Upon examination of the tradeoffs between the water balance component objective functions and in-situ validation data under historical, wet and dry periods and across different Australian climate regions, we show there is no one size fits all parameter set continentally, and thus some concessions need to be made in choosing a suitable model parameterization. However, future work could include developing a set of parameters which suit specific regions or climate conditions in Australia. The approach outlined in this study could be employed to improve confidence in any hydrological model used to simulate the future impacts of climate change.