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Using both top-down and bottom-up approaches to assess environmental outcomes under climate change – a case study

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Abstract: The Victorian Environmental Water Holder (VEWH) engaged a team led by HARC to assess the current and potential future reliability of environmental entitlements in Victoria, and identify the environmental watering objectives most at risk. The outcomes will inform the VEWH's strategies for adapting to climate change.

Assessments of the impact of climate change on water availability in Victoria typically use a top-down approach. This typically involves selecting future climate scenarios informed by climate model outputs, and scaling climate variables (e.g. rainfall, evaporation, inflows) based on the relative change factors between future and baseline conditions (DEECA, 2020). The timeseries of scaled inputs are then used in detailed water resource models to assess how the system is likely to respond under the chosen climate scenarios. However, top-down approaches have been criticised for restricting analysis to only a few scenarios, which may not represent a broad range of uncertainty in future climate conditions, nor properly observe non-linear system responses (Brown et al., 2012). Bottom-up approaches seek to address this, by using computationally efficient models to simulate the system response under a broad range of potential climate change (Fowler et al., 2024), with a key goal being identifying particular degrees of change that lead to undesirable outcomes. However, owing to exploration of a wider range of possible futures, the computational burden of bottom-up modelling can be much higher.

We used a top-down approach to assess potential changes in environmental water allocations and how often watering objectives are met in all Victorian catchments with significant environmental water holdings. The top-down results were then compared to outcomes from three different bottom-up methods, derived to overcome the computational challenge of running many hundreds of scenarios:

- Machine learning emulator models calibrated to water resource model outputs from the top-down scenarios for the Wimmera Catchment using methods from John et al (in review).
- The Stochastic Goulburn Environmental Flow Model (SGEFM), a simplified monthly model developed by the University of Melbourne (Horne et al, 2022; John et 2021).
- Statistical models developed by the University of Melbourne that use annual inflows to predict end-of-season allocations (Horne et al, in review).

The top-down and bottom-up results generally aligned, except for predictions about the relative vulnerability of two systems. The bottom-up modelling provided additional insights into how modelled environmental entitlement reliability and hydrological indicators behave outside of and in-between the climate conditions represented in the top-down scenarios.

There is value in both top-down and bottom-up approaches as they are designed to answer different questions and address different challenges. However, judging which approach is better for the task at hand or whether both should be used is not straightforward. This presentation uses a case study to explore questions such as:

- Would the outcomes have been the same if only the top-down approach had been used?
- What value did the bottom-up approaches add and how are these best communicated?
- How can insights from the top-down modelling be used to improve bottom-up approaches and vice-versa?

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