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A practical approach to assessing climate change impacts on snow cover and streamflow in Southeast Australia

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Abstract: Globally, the impact of climate change on snow melt has become a growing concern. Snowfall is often a critical component of streamflow as it plays a crucial role in regulating seasonality and persistence. However, in Australia, snow cover is both intermittent and limited in space, with a lack of publicly available snow data records. As a result, snowfall is often neglected within streamflow analysis. This study presents a practical method to explicitly consider interactions with snow cover when examining risk to water supply and hydrology due to the impact of climate change. Although snow coverage in Australia is relatively small, the catchments affected are important for water supply. Previous studies have been limited in scope (e.g., focused on commercial outcomes such as changes to the ski season), and publicly available studies considering implications for water supply and hydrology are rare. The method presented here aims to be readily applicable in areas with limited data on snow fall and coverage, and within the context of broader regional water resource assessments.

We integrate a snow module into a monthly rainfall-runoff modelling framework using the southern Murray-Darling Basin as a case study. Challenges include that existing snow models can be complicated, requiring data inputs such as atmospheric fluxes that are not readily available for this region. To address this, we incorporate a simple temperature-dependent threshold to determine snow cover based on an existing widely used monthly-timestep snow module (Xu et al, 1996). Calibrated to a snow extent dataset based on remote sensing imagery over 2000-2014 (Thompson, 2015), we found the method can replicate snow dynamics across several climatically-distinct snow-covered areas in south-east Australia, increasing confidence in applicability under climate change.

The snow module was then added to an existing monthly rainfall runoff model (WAPABA, Wang et al, 2011). This process was applied to the Snowy Mountains (Australia's largest alpine region) to allow a "stress test" of climate change impacts on streamflow and snow cover. As expected, results suggest that both snow coverage and duration will likely significantly reduce in the future. Results suggest "low snow years" which occur 10% of the time historically will occur up to 80% of the time by 2080. Diminishing snowpack will reduce streamflow during spring, impacting seasonal flow regimes. This was seen to have an impact on the Snowy Mountains streamflow, with low annual streamflow (10% probability of historic occurrence), projected to occur up to 40% of the time by 2080.

In conclusion, this study showcases a highly effective approach for integrating snow into hydrology that is specifically well-suited to the data-sparse context of Australian snow. The snow modelling performed robustly under varied conditions and was seamlessly integrated into a broader hydrology framework. This innovation provides a simple method for investigating critical insights into catchments that are influenced by upstream snow in the face of climate change. As such, this study represents an important step towards informed decision-making and sustainable water management practices in snow-impacted regions within Australia.

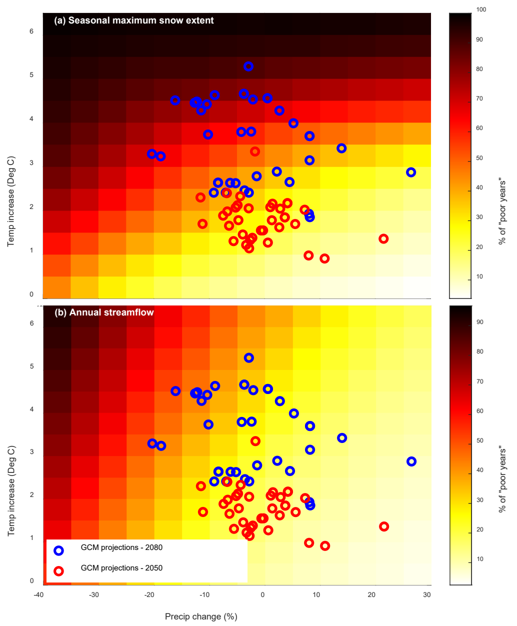

Figure 1. Stress test (precipitation and temperature) of (a) snow and (b) streamflow.

In both (a) and (b), the threshold for "poor" years is set so that only 1 in 10 years are "poor" in the baseline (historic) data. Projections for 2050 and 2080 from RCP8.5 GCMs shown with circles (red and blue respectively).

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