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Assessment of the impact of climate projection resolution on river system outcomes in the Murray-Darling Basin

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Abstract: Water resource planning in the Murray-Darling Basin (MDB) is typically undertaken at the valley scale, yet many ecological outcomes depend on flows influenced by basin-wide conditions. The Integrated River System Modelling Framework (IRSMF) connects existing valley-scale models to enable basin-scale assessments and has been used to investigate climate change impacts through inflow scaling. These scaling factors can be applied at varying spatial and temporal resolutions, but choices about their derivation—whether based on broad regional averages or individual GCMs—can influence model outcomes and the interpretation of climate change impacts.

This study used the IRSMF to compare two approaches for applying climate change scenarios in river system models: regional inflow scaling (for northern and southern MDB) versus valley-specific scaling derived from multiple GCM projections. The study assessed how these methods affect long-term water balance estimates and the achievement of site-specific flow indicators (SFIs). The findings highlight the trade-offs between computational efficiency and spatial precision, offering guidance for scenario selection in future climate impact assessments.

The analysis demonstrated that spatial scale matters when applying climate change scaling factors in river system models. Valley-scale approaches, which account for variations in climate and runoff responses at finer spatial resolution, produced different outcomes compared to those generated using broad regional scaling factors. This suggests that relying on regional averages may lead to systematic over- or under-estimation of climate change impacts, particularly for indicators that integrate hydrological responses over time and space. Despite both approaches being based on CMIP6 climate data and consistent rainfall-runoff modelling, their different spatial resolutions and assumptions influenced the outputs in meaningful ways.

While the simple regional scenarios offer a broad understanding of potential climate impacts, they may oversimplify complex spatial variations in climate and hydrology across the MDB. For instance, valley-scale scenarios better captured the distinct climate change signals and runoff responses across sub-regions, especially in headwater areas where rainfall patterns and changes can diverge significantly from lower elevations. Although not explored in detail in this study, alternative spatial boundaries that better align with climate and hydrological patterns could enhance the robustness of future modelling. However, care must be taken to avoid introducing false precision when defining such boundaries.

The study also highlighted methodological differences in how scenarios were constructed. Regional scenarios used percentile-based averages of climate forcing variables, assuming perfect correlations across regions and variables—an assumption not supported by GCM outputs. In contrast, valley-scale scenarios retained the internal coherence of each GCM, preserving more realistic inter-variable and spatial correlations. This led to a narrower and potentially more accurate range of projected outcomes. However, the study's reliance on simple inflow scaling is a limitation, as it does not capture flow-dependent changes in hydrology. More advanced methods, such as rainfall-runoff modelling, are needed to fully assess climate change impacts, and future studies will explore these approaches.

Keywords: *River system modelling, GCM projections, Uncertainty analysis*