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On temporal resolution of performance indicators of water resources systems

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The spatiotemporal variation of water resources and growing global requirements for freshwater necessitates planning and construction of water resource infrastructure to enable the management of a variable and potentially scarce resource. Large-scale water infrastructure serves multiple purposes including provisioning of freshwater, protection from floods, navigation, hydroelectricity, etc. At present, more than 16.7 million reservoirs with an area greater than 100 m^2 exist, a majority of which serve multiple water sectors. Decision analysis for reservoir systems relies heavily on optimization techniques that identify optimal operational strategies for a dynamic systems model. All optimization frameworks require the analyst to define performance indicators, more formally, objective functions, that aggregate performance across multiple time periods in a planning horizon. A question thus arises: does the manner in which objective functions are aggregated have a substantial impact on resultant optimal operational strategy? For complex reservoir systems such as inter-basin water transfers, which require coordinating operations across multiple reservoirs, the temporal scale of operations likely impacts the system's performance. Here, we assess the impact of temporal aggregation of the objective function on resultant operational strategies for a proposed inter-basin water transfer in Southern India. We optimize monthly water transfer decisions using a multi-objective evolutionary algorithm that optimizes for the reliability of demand satisfaction at multiple temporal resolutions (annual, seasonal, fortnightly). We then re-evaluate the performance of all resultant strategies at fortnightly resolution. We find strategies obtained by optimizing reliability at an annual resolution that release water based on annual demands outperform the other two resolutions. This improvement in performance requires the presence of additional storage structures like lakes, ponds, check dams, etc. in the reservoir system, which is true in our study region. We further quantify the dependency between decision variables across these formulations to better understand the convergence dynamics of the optimization algorithm.