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Optimization approach for water resources long term planning and management

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Integration of short-term operation and long-term planning is one of the challenges of development and management of water resources systems. This research is interested in an optimization algorithm consisting of a short-term time step dynamic programming (DP) formulation, coupled with a long-term time step expectation of the future benefit function of flows scenarios. The method takes into account the short-term variability or seasonality of the flow regime as well as long-term uncertainty of flows, which is actuated by either climate change or global climate variability associated with phases of oceanic and atmospheric phenomena. The DP is used to determine an optimum operating policy of flows scenarios for the short-term time step. The use of flows scenarios in optimization problem represents the stochastic aspect of flows, and transition between scenarios is done at long-term time step. This method could be used for water resources planning in the context of future hydrologic regime uncertainties or to evaluate climate change impacts on existing water resources systems.

The algorithm was tested for optimum hydropower production of Manicouagan water resources system, Québec, Canada, with two hydropower plants with reservoir and three run-of-river plants, for a period of 90 years, from 2010 to 2099. Future climate weekly time step operating policy was produced with two time steps: annual time step for management of water resources in non-stational climate and a weekly time step for flow seasonality. Annual flows have been used to compute transition probabilities between flow scenarios. Results show that there will be an increase of hydropower production in the future climate thanks to the increase of seasonal and annual flows. However, climate change will reduce the efficiency of the existing hydropower system, with more unproductive spills. The algorithm permitted to evaluate the impact of climate change on water resources without taking any assumptions other than the climate change scenarios and it was able to adapt the operating policy to the climate seasonality and climate change uncertainties in the optimization problem.

Key words: water resources, optimization, non-stational climate, flow regime, dynamic programming