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Improving the robustness of a multi-reservoir system to climate change using multi-objective optimization

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Current climate circulation models simulate a climate change induced increase of temperatures and a decreasing amount of precipitation in the region of Saxony (Germany) in summer. Consequently, the operation of reservoirs has to consider decreasing inflows, more severe drought periods as well as increasing demands for water. New management strategies for the reservoirs are required to adapt to these new pressuring conditions and to meet the future demands of all water sectors and simultaneously providing flood protection.
This study combines multi-objective optimization and Monte Carlo simulation for finding effective management strategies for multi-purpose reservoirs and multi-reservoir systems. To achieve robust operating strategies (rule curves and diversions) a new framework is developed which comprises (i) the physically based rainfall-runoff model WaSiM-ETH (ii) a time series model for the generation of a large number of synthetic inflow time series, (iii) a comprehensive reservoir model, (iv) an adapted multi-objective optimization algorithm and advanced visualization methods for a compact presentation of the results for the decision maker. In a real case application the new framework is used to find operating strategies to potential impacts of the projected climate change for the multi-purpose multi-reservoir system Klingenberg – Lehnmühle – Rauschenbach in the Ore Mountains (Saxony, Germany).
The automatically calibrated model WaSiM-ETH is applied to different climatic conditions of the time periods of the WETTREG-2010 climate model and the IPCC CO_2 emission scenarios A1B, B1 and A2 for generating reservoir inflows. In addition to the climate change scenarios different scenarios describing increased demands or enlarged flood protection zones are considered. The overall robustness of the multi-reservoir system operation is quantified and possible intensifications of trade-offs between management goals or reservoir utilizations are shown.