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Opportunities and challenges of Ensemble Forecast and Cross-Validation for MOEA optimisation in water resources management

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The acceleration in the hydrological cycle and increased frequency and intensity of extreme events prompt a shift towards adaptive control strategies in water reservoir management. In this study, we explore the potential of improved hydro-meteorological forecast products, particularly those extending to longer time scales and incorporating uncertainty information through Ensemble Forecast (EF), to facilitate this transition.

In particular, we consider the problem of managing Lake Como, a regulated system with diverse objectives, including flood prevention, low-level avoidance, and meeting downstream agricultural and hydroelectric generation demands. The lake operation can be informed using short-term, locally calibrated deterministic forecasts as well as sub-seasonal/seasonal large-scale ensemble forecasts from the European Flood Awareness System (EFAS), a part of the Copernicus Emergency Management Service.

The lake regulation is determined by operating policies derived using the Evolutionary Multi-Objective Direct Policy Search method, resulting in Pareto optimal policies capable of integrating various forecasts as inputs. This approach is seamlessly integrated with our newly developed algorithm, PECAN (Parallel Ensemble foreCAst coNtrol), designed to harness uncertainty information within EF. Validation of these policies is crucial for determining their generalisation capabilities, and it is performed through Blocked K-Fold Cross-Validation.

In this study, we demonstrate the presence of overfitting during the optimisation process and present an early stopping rule designed to save computation time while learning robust policies. Additionally, we introduce a second rule to dynamically determine epsilon parameters for the ε-approximate Pareto front, particularly useful in the presence of diverse multi-year climatic conditions. Through the application of these rules, we show the importance of cross-validation, highlight the greater generalisation capabilities of PECAN, and present how PECAN enables EF at longer time ranges to be competitive against locally calibrated deterministic forecasts at shorter intervals.