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Model reduction of process-based hydro-ecological models: a comparison between projection- and selection-based methods

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Complex process-based hydro-ecological models are often used to describe the water quality processes in lakes, rivers and other water resources systems. However, the computational requirements typically associated to these models often prevent their use in computationally intensive applications, such as optimal planning and management. For this reason, the purpose of model reduction is to identify reduced-order models (or emulators) that can adequately replace complex hydro-ecological models in such applications.

Projection-based model reduction is one of the most popular approaches used for the identification of emulators. It is based on the idea of sampling from the original model various values, or snapshots, of the state variables, and then using these snapshots in a projection scheme to find a lower-dimensional subspace that captures the majority of the variation of the original model. The model is then projected onto this subspace and solved, yielding a computationally efficient emulator. Yet, this approach may unnecessarily increase the complexity of the emulator, especially when only a few state variables of the original model are relevant with respect to the output of interest. On the other hand, selection-based model reduction uses the information contained in the snapshots to select the state variables of the original model that are relevant with respect to the emulator's output, thus allowing for model reduction. This provides a better trade-off between fidelity and model complexity, since the irrelevant and redundant state variables are excluded from the model reduction process.

In this work we address these issues by presenting an exhaustive experimental comparison between two popular projection- and selection-based methods, namely Proper Orthogonal Decomposition (POD) and Dynamic Emulation Modelling (DEMo). The comparison is performed on the reduction of DYRESM-CAEDYM, a 1D hydro-ecological model used to describe the in-reservoir water quality conditions of Tono Dam, an artificial reservoir located in western Japan. Experiments on one of the model output variables (i.e. release water temperature) show that DEMo allows obtaining the same fidelity as POD while reducing the number of state variables in the emulator.