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Surrogate-based optimization of parameters in a marine ecosystem model

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We present a computationally efficient methodology for the optimization of climate model parameters, here applied to the example of a one-dimensional marine ecosystem model. We use a response correction technique to create a reasonably accurate "coarse" or "surrogate" model. We show that replacing the direct parameter optimization of the original ecosystem model by iteratively updating and optimizing the surrogate leads to a satisfactory solution while yielding a significant reduction in the total optimization effort. The model, developed by Oschlies and Garcon \cite{OscGar99}, is of NPZD type and simulates the distribution of nitrogen, phytoplankton, zooplankton and detritus in a water column, and is driven by ocean circulation data. A key issue is to optimize model parameters in order to minimize the misfit between the model output and given observational data. Reduction in the optimization cost, which becomes particularly important for more complex 3D-models, is highly desirable. We use a coarser time discretization for obtaining a suitable physically-based coarse model. This coarse model is then aligned by a multiplicative response correction technique to create a surrogate. The correction term is obtained through point-wise dividing the fine model by the coarse model output, which turns out to be the most suitable approach in this case, taking into account the character of the misalignment between the coarse and the fine model. We illustrate that the surrogate provides a reasonable approximation of the fine model. We furthermore verify our approach by using synthetic target data as well as real data and by comparing the results to those obtained from direct fine and coarse model optimization. We finally show that, by using the surrogate, remarkably good results can be obtained at a very low computational cost. The cost savings compared to an original fine model optimization are significant. The method can be generalized to three space dimensions.