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Addressing the impact of environmental uncertainty in plankton model calibration with a dedicated software system: the Marine Model Optimization Testbed (MarMOT 1.1 alpha)

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Abstract. A wide variety of different plankton system models have been coupled with ocean circulation models, with the aim of understanding and predicting aspects of environmental change. However, an ability to make reliable inferences about real-world processes from the model behaviour demands a quantitative understanding of model error that remains elusive. Assessment of coupled model output is inhibited by relatively limited observing system coverage of biogeochemical components. Any direct assessment of the plankton model is further inhibited by uncertainty in the physical state. Furthermore, comparative evaluation of plankton models on the basis of their design is inhibited by the sensitivity of their dynamics to many adjustable parameters. Parameter uncertainty has been widely addressed by calibrating models at data-rich ocean sites. However, relatively little attention has been given to quantifying uncertainty in the physical fields required by the plankton models at these sites, and tendencies in the biogeochemical properties due to the effects of horizontal processes are often neglected.

Here we use model twin experiments, in which synthetic data are assimilated to estimate a system's known "true" parameters, to investigate the impact of error in a plankton model's environmental input data. The experiments are supported by a new software tool, the Marine Model Optimization Testbed, designed for rigorous analysis of plankton models in a multi-site 1-D framework. Simulated errors are derived from statistical characterizations of the mixed layer depth, the horizontal flux divergence tendencies of the biogeochemical tracers and the initial state. Plausible patterns of uncertainty in these data are shown to produce strong temporal and spatial variability in the expected simulation error variance over an annual cycle, indicating variation in the significance attributable to individual model-data differences. An inverse scheme using ensemble-based estimates of the simulation error variance to allow for this environment error performs well compared with weighting schemes used in previous calibration studies, giving improved estimates of the known parameters. The efficacy of the new scheme in real-world applications will depend on the quality of statistical characterizations of the input data. Practical approaches towards developing reliable characterizations are discussed.

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