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Exploring Structural Sensitivity in a Marine Biogeochemical Model

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The dynamics of the biogeochemical models are determined by the mathematical structure of the models. Earlier studies have shown that a slight change in model structure and parameterisation may lead to a major change in system dynamics, a property known as ‘structural sensitivity’. We assessed the impact of structural sensitivity of an intermediately complex biogeochemical model (MEDUSA) on its model output, particularly the chlorophyll concentration, at five different oceanographic stations in three different regions: oligotrophic, coastal, and abyssal plain. We used phytoplankton phenology (initiation, bloom time, peak height, duration, and termination of phytoplankton bloom) and other ecological indicators as the metrics for quantifying the impact of structural sensitivity. An ensemble of 1-d MEDUSA made by perturbing the model structure, was devised in order to investigate the uncertainty in the model output. Each ensemble member was embedded with a combination of equivalent functional forms, which described the key biogeochemical processes, such as nutrient uptake, zooplankton grazing, and plankton mortalities. The simulation was run from 1998 to 2007. We found that the effect of structural sensitivity varies across different regions. Surface chlorophyll means showed that in the oligotrophic region, the ensemble range is smaller (0.14) than those in the coastal (6.10) or abyssal station (0.64). The phenological metrics, such as the timing of phytoplankton bloom, based on in situ measurement were mostly between ensemble ranges. This suggests that our ensemble-based results would be useful for providing meaningful ranges for forecasting phytoplankton blooms.