Distribution of phytoplankton functional types in high-nitrate low-chlorophyll waters in a new diagnostic ecological indicator model

Modeling and monitoring plankton functional types (PFTs) is challenged by insufficient amount of field measurements to ground-truth both plankton models and bio-optical algorithms. In this study, we combine remote sensing data and a dynamic plankton model to simulate an ecologically-sound spatial and temporal distribution of phyto-PFTs. We apply an innovative ecological indicator approach to modeling PFTs, and focus on resolving the question of diatom-coccolithophore co-existence in the subpolar high-nitrate and low-chlorophyll regions. We choose an artificial neural network as our modeling framework because it has the potential to interpret complex nonlinear interactions governing complex adaptive systems, of which marine ecosystems are a prime example. Using ecological indicators that fulfill the criteria of measurability, sensitivity and specificity, we demonstrate that our diagnostic model correctly interprets some basic ecological rules similar to ones emerging from dynamic models. Our time series highlight a dynamic phyto-PFT community composition in all high latitude areas, and indicate seasonal co-existence of diatoms and coccolithophores. This observation, though consistent with in situ and remote sensing measurements, was so far not captured by state-of-the-art dynamic models which struggle to resolve this "paradox of the plankton". We conclude that an ecological indicator approach is useful for ecological modeling of phytoplankton and potentially higher trophic levels. Finally, we speculate that it could serve as a powerful tool in advancing ecosystem-based management of marine resources.