Estimating biological parameters of a size-dependent NPZD ecosystem model

S. Losa1, J. Schröter3, M. Wenzel1, I. Kriest2, A. Oschlies3

1AWI Bremerhaven, Germany; 2FIM-GEOMAR, Kiel, Germany;
3School of Ocean and Earth Science, University of Southampton, UK
sloza@awi-bremerhaven.de

Abstract

A new 1-dimensional 4-compartment biogeochemical model is developed by I. Kriest and A. Oschlies within the MERSEA project. Implicitly accounting for phytoplankton different size classes, the new model is one more attempt to describe the dynamics of phytoplankton P, zooplankton Z, nutrients N and detritus D under different physics given one (a unique) set of biophysical parameters. The model is calibrated with and validated against time series data collected at 6 locations of the World Ocean. Here we apply the Sequential Importance Resampling filter (Rubin, 1988) for the parameter optimization problem (Kriman, 2003). Several nonparametrical statistics criteria are presented and used for estimating "goodness" of the model to data fit.

1 Model

In the model, phytoplankton is presented by a spectrum of different sizes. Thus, some of the parameterized biogeochemical process, in particular, phytoplankton growth and exudation, are size-dependent. (We will refer to the model as SD NPZD).

2 Data

The model is constrained by monthly mean data of the Bermuda Atlantic Time-series Study (BATS) (2°N, 65°W), Ocean Weather station PAPA (50°N, 145°W), Equatorial Pacific Ocean (EIPac, 6°S, 140°W), the North Atlantic Bloom Experiments (NABE, 47°N, 20°W), the Arabian Sea C station (ASC-C, 21°N, 65°E), the Ross Sea (63°S, 170°W), particularly, by measurements of dissolved inorganic nitrogen and chlorophyll concentrations.

3 Model calibration and validation

Nonparametrical (distribution-free) rank statistics (based on "rank order") is used as criteria of "goodness" of model-to-data fit:

\[ r_p = 1 - 6 \sum_{i=1}^{d} \frac{i^2}{N(N+1)} \]

where are differences in statistical ranks of respective variables, \( N \) is the number of data, \( U = T - 0.5(N-N+1) \), \( T \) is a sum of negative (or positive) ranks,

\[ r_w = \frac{N^2 - (U - 0.5N^2)}{N^2 + 0.5N^2} \]

MW – Mann-Whitney U criterion tests whether all modes of data distribution (have same median value)

\[ r_m = \frac{1}{2} \sum_{i=1}^{d} \min\{Z_{1i},Z_{2i} \} \]

3.1 Optimized parameter values

Table 1. Agreement between model (simple and SD versions) and observed chlorophyll "a" concentrations. With respect to a certain criteria.

4 Results of simultaneous tuning the size dependent NPZD model for all the noted locations

Model forcing: solar radiation is calculated according to Brock (1981); mixing is assumed to be 2592 m\(^{-1}\) in the upper mixed layer (monthly mean upper mixed layer depths are extracted from Levitus, 1994), then decreasing within 10m to 2.592 m\(^{-2}\); nitrate concentrations at the upper boundary of the seasonal pycnocline are taken from Conkright et al (2002).

The statistics criteria values of yellow color indicate sufficient agreement between model and observed concentrations, with respect to a certain criterion.

5 Conclusions

Even with the slightly improved version of the biogeochemical model, it is still hardly, if ever, possible to reproduce the observed ecosystem dynamics under different environmental conditions given just one biophysical parameter set.

References


http://www.awi-bremerhaven.de/Modelling/INVERSE/

http://www.mersea.eu/