Modelling oceanic CO₂ uptake: the relevance of zooplankton grazing

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Plankton and CO₂ uptake
Understanding plankton dynamics is crucial to modelling ocean CO₂ uptake. Biogeochemical models are developed for simulating the plankton dynamics of one oceanic region. Yet many models perform poorly when applied to a fundamentally different oceanic region. Constructing a globally valid model to assess CO₂ uptake poses a challenge.

1. how much?

Objective
The objective is finding a model setup that fits available time-series data from stations across the globe.

2. high impact

Stations (see fig. 1)
For three fundamentally different stations, the data are sufficient to allow for model-data-comparisons:
1. BATS (Bermuda Atlantic Time-Series Station); nutrient-poor
2. PAPA (Ocean Station P); nutrient-rich, little phytoplankton due to heavy grazing
3. NABE (Station of North Atlantic Bloom Experiment); nutrient-rich, supporting annual phytoplankton blooms

Fig. 1: Stations used for model validation

The Biological Pump:
Marine phytoplankton, via photosynthesis and sinking, stimulates oceanic uptake of atmospheric CO₂:

CO₂

surface ocean

phytoplankton

detritus

organic carbon

depth ocean

CO₂

Model performance
Biogeochemical models are highly sensitive to the grazing function.

Five different grazing functions were implemented, one of which allows for a model setup that fits all three stations (Peters’ grazing function), see fig. 2).

The grazing function most widely used (Holling III) is not compatible with optimal phytoplankton growth.

Characteristics: steep beginning, then levelling off. Strong grazing pressure at low food concentrations, weaker at higher ones.

Fig. 2: Peters’ function

Results
Predicted (red) and observed (crosses) annual nitrogen cycles. The annual cycle of dissolved inorganic nitrogen is reproduced at all stations.

Conclusion
Choosing a suitable grazing function is crucial for model behaviour and enables fitting fundamentally different regions.

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Literature cited