

Assimilation of OC-CCI data for parameter estimation in the coupled ocean biogeochemical model MITgcm-REcoM

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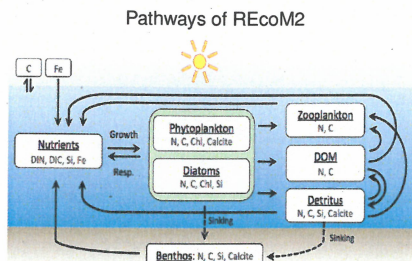
Introduction

MITgcm-REcoM is used to simulate biogeochemistry in a global ocean configuration. The Regulated Ecosystem Model REcoM simulates biogeochemical processes using two phytoplankton groups (small phytoplanktons and diatoms) in a quota-formulation using separate variables for carbon and chlorophyll.

The model has been shown to produce realistic phytoplankton carbon concentrations with spatially constant parameters controlling the processes. To further improve the model representation we plan to estimate spatially varying parameters so that the biogeochemical processes can adapt to regional environmental conditions.

The parameter estimation will be performed by assimilating ocean color data from OC-CCI using an ensemble filter provided by the Parallel Data Assimilation Framework (PDAF). We discuss the performance of the global model configuration with fixed parameters as well as data assimilation component and plans for the parameter estimation.

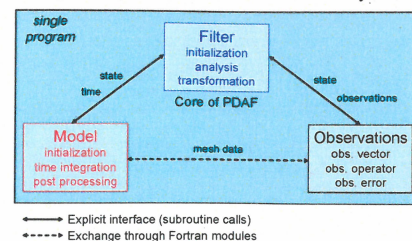
Biogeochemical Model REcoM2



REcoM2 has been coupled to MITgcm [1] for large-scale simulations with focus on the Southern Ocean [2]. It belongs to a class of quota models. The internal stoichiometry of the cells depends on light, temperature, and nutrients. The uptake of nutrients is based on internal concentrations rather than the Redfield-ratio and external nutrient concentrations.

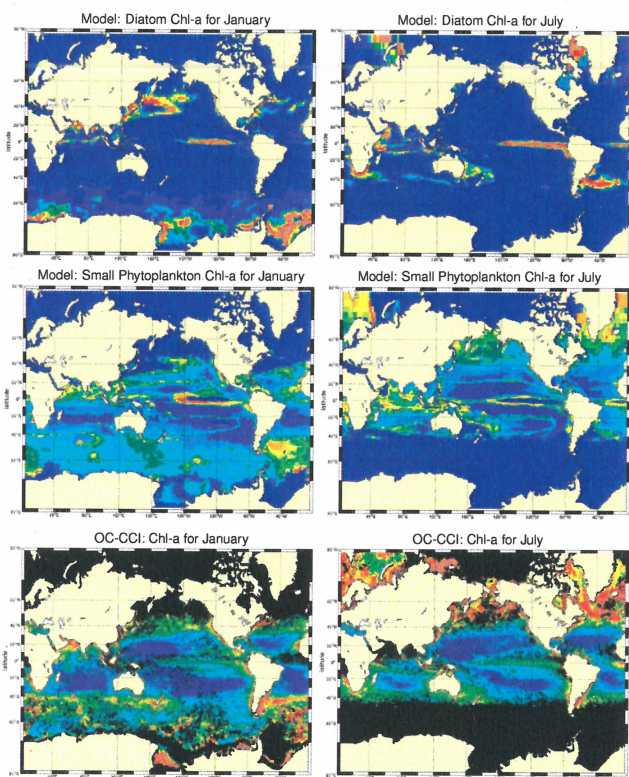
Ensemble Data Assimilation

Logical separation of the assimilation system



The data assimilation system can be separated into three components: Model, filter algorithm, and observations. The filter algorithms are model-independent, while the model and subroutines to handle observations are provided by the user. The routines are either directly called in the program code or share information, e.g., through Fortran modules.

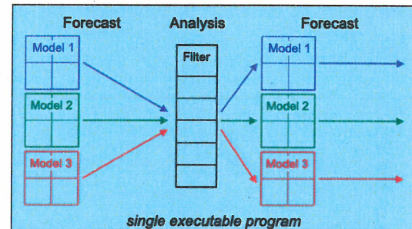
Model Fields and Observations



The model fields are shown after a 4-year spin up. Both groups show a clear seasonality. The sum of chlorophyll-a from both model phytoplankton groups yields total Chl-a as provided by OC-CCI. As shown, the chlorophyll-a from this model configuration shows some correspondence with the Chl-a satellite product from OC-CCI in January and July. However, concentrations are too low in the Southern Ocean. At the equator regions with too high concentrations appear.

The chlorophyll-a fields of the model are very sensitive with respect to the chlorophyll degradation rate constants of the phytoplankton groups. They were previously tuned manually to a value of 0.3 d^{-1} .

2-level parallelization of the assimilation system

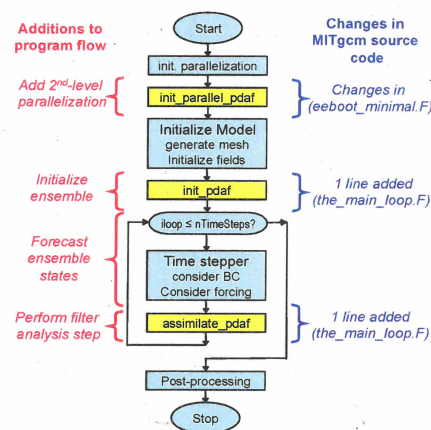


Ensemble-data assimilation can be performed using a 2-level parallelization:

1. Each model integration can be parallelized.
2. All model tasks are executed concurrently.

Thus, ensemble integrations can be performed fully parallel. In addition, the filter analysis step uses parallelization.

Extending the model for data assimilation



Legend: Model (blue box), Extension for data assimilation (yellow box)

MITgcm is coupled with PDAF [3] by adding three subroutine calls the model source code and utilizing parallelization. Operations specific to the model and the observations are performed in user-supplied call-back routines that are called through PDAF.

Outlook

- As a first step, we will assimilate the OC-CCI Chl-a data to estimate the degradation rate constants and will allow these parameters to vary spatially.
- Further parameter estimations are planned for the parameters controlling the photophysiology of the model. This should result in better representation of Chl-a in particular in the Southern Ocean.
- The assimilation will use the local ESTKF (Error subspace Transform Kalman Filter) filter [4] or a particle filter method.
- PDAF is coded in Fortran with MPI parallelization. It is available as free software. Further information and the source code of PDAF are available on the web site: <http://pdaf.awi.de>

References

- [1] Losch M., Schröter M., Hohn S. and Voelker C. (2008). High-resolution modelling of phytoplankton distribution and adaptation. *NIC Symposium 2008*, 289–296
- [2] Hauck J., Voelker C., Wang T., Hoppema M., Losch M., Wolf-Gladrow Dieter A. (2013). Seasonally different carbon flux changes in the Southern Ocean in response to the southern annular mode. *Global Biogeochemical Cycles*, 27(4): 1236–1245
- [3] Nerger, L. and W. Hiller (2013). Software for Ensemble-based Data Assimilation Systems – Implementation Strategies and Scalability. *Computers & Geosciences*, 55: 110–118
- [4] Nerger, L., T. Janjić, J. Schröter, J., and W. Hiller (2012). A unification of ensemble square root Kalman filters. *Mon. Wea. Rev.* 140: 2335–2345