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Investigating Antarctic PFTs based on satellite observation and modeling

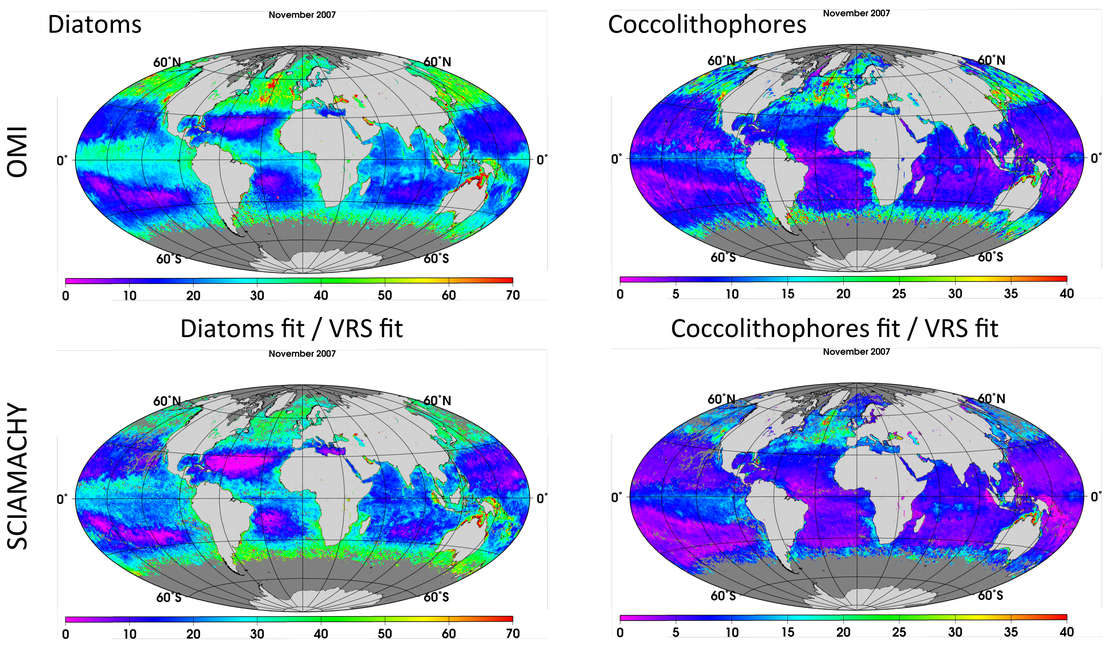
Abstract

We investigate the role of natural phenomena and anthropogenic activity on biogeochemical cycling and ecosystem dynamics in the Southern Ocean over the last decades. The study relies on model simulations of various phytoplankton functional types (PFTs) based on a version of the Darwin ocean biogeochemical model (Follows et al., 2007, Dutkiewicz et al., 2015) coupled to the MITgcm general circulation model with a configuration based on a cubed-sphere grid (Menemenlis et al. 2008). The biogeochemical model configuration in use considers 6 PFTs among other tracers. The results are complemented and evaluated with information on phytoplankton compositions retrieved with PhytoDOAS (Bracher et al. 2009, Sadeghi et al. 2012) from available hyper-spectral optical satellite measurements (SCIAMACHY and OMI), which are synergistically combined via an optimal interpolation technique with multi-spectral optical satellite data (OC-CCI). When assessing the model performance and satellite data retrievals, in situ HPLC based observations are used as an additional independent information on PFTs.

Satellite Observations

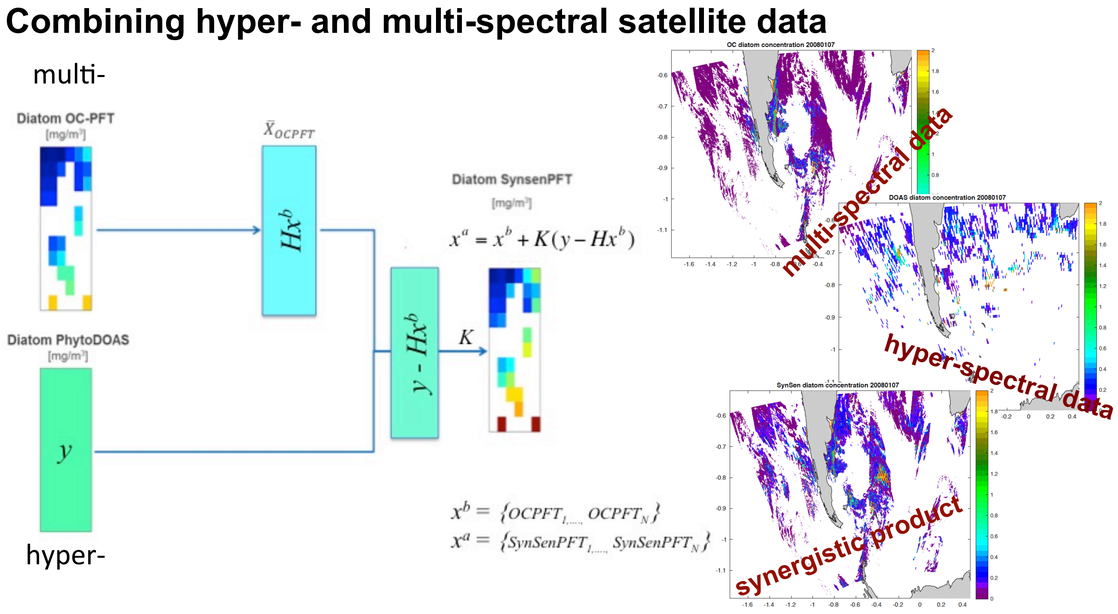
The biomass of important phytoplankton groups in the Southern Ocean are extracted using differential optical absorption spectroscopy (PhytoDOAS) on hyperspectral satellite data. Combining the PFT products from two hyper-spectral sensors provides better spatial sampling of the Southern Ocean and extension of observed time period (2002 until present). Current status of PFT products from the still operating OMI sensor is presented.

Global Biomass of Phytoplankton Groups: Comparison of two different hyperspectral sensors



Synergistic Product:

Combining hyper- and multi-spectral satellite data



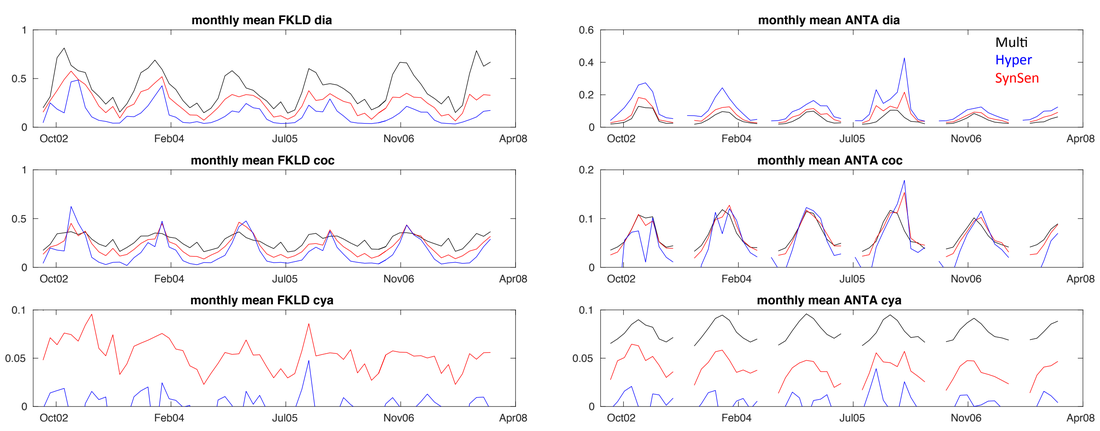
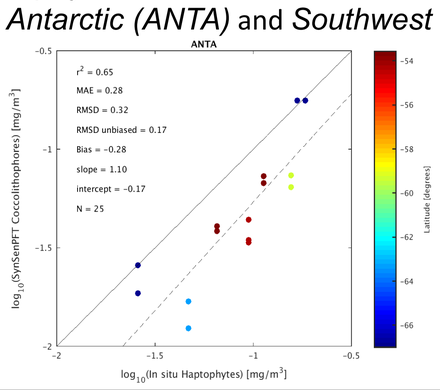


Figure: Observed temporal evolution of PFTs chlorophyll concentrations for 2 biogeochemical provinces (Longhurst, 1998): the Antarctic (ANTA) and *Southwest Atlantic Shelves Province (FKLD)*

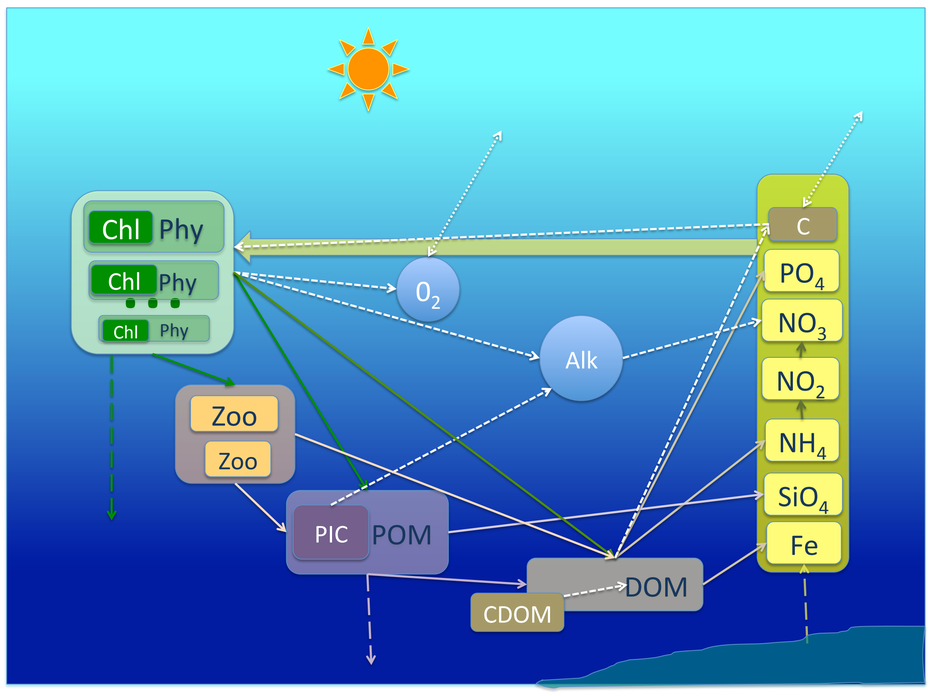
In-situ Validation Data

HPLC pigment data + ac-s spectro-photometer continuous absorption and Attenuation measurements of sea water.



Modeling

A version of the Darwin ocean biogeochemical model coupled to the MITgcm general circulation model is used to simulate the dynamics of 6 various phytoplankton functional types: Analogues of diatoms, other large eukaryotes, picophytoplankton *Synechococcus,* other picoplankton *Prochlorococcus,* nitrogen fixing *Trichodesmium*, and coccolithophores.



Following Taylor et al. (2013) we use the circulation model configuration based on a cubed-sphere grid (Menemenlis et al. 2008) with mean horizontal spacing of ~18 km and 50 vertical levels with the resolution ranging from 10 m near the surface to ~450 m in the deep ocean. The model is forced by 6-houly atmospheric conditions from the NCEP Climate Forecast System Reanalysis (CFSR).

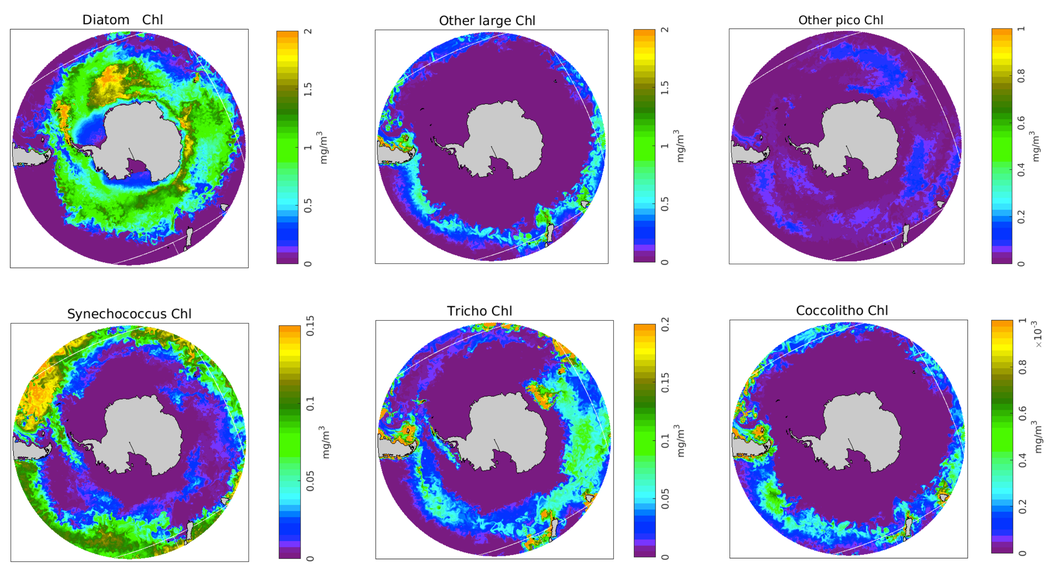
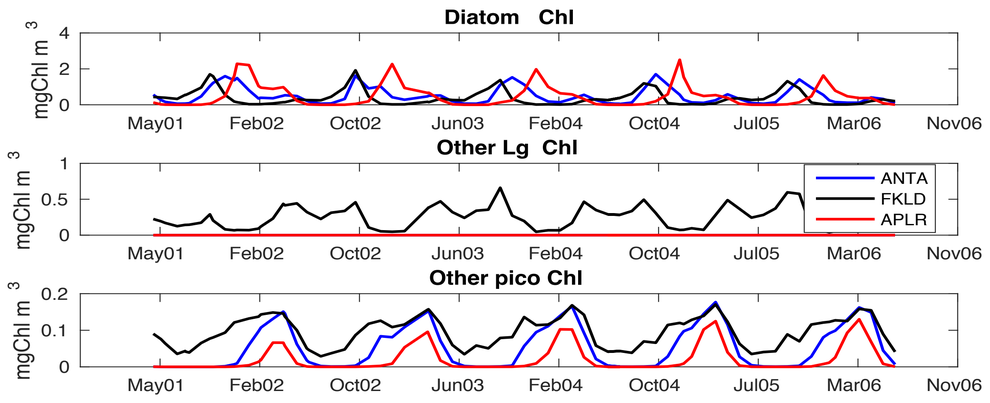


Figure: Spatial distribution of the model PFTs Chlorophyll "a" concentration for April 2004. The solution is sensitive to a large extend to the model parameters specified.

Figure: Model temporal evolution of PFTs chlorophyll "a" concentrations for 3 biogeochemical provinces (Longhurst, 1998): Antarctic Province (ANTA), Austral Polar Province (APLR) and Southwest Atlantic Shelves Province(FKLD)



Acknowledgement: The coupled model simulations were performed with resources provided by the North-German Supercomputing Alliance (HLRN)

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