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Drivers of the Chl:C ratio in global model runs with dynamic photoacclimation and its impact on modeled primary production

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Chlorophyll a is used as a proxy to estimate marine phytoplankton biomass because it is easily measured both in situ and remotely. The Chl:C ratio which is used to convert from chlorophyll to biomass, is, however, not constant in phytoplankton but regulated by the cells, presumably to maximize the growth rate under limiting environmental conditions. This acclimation increases the chlorophyll content under low light and decreases it under nutrient limitation. Global biogeochemical models increasingly take into account varying Chl:C ratios, often based on a steady-state assumption, i.e. on balanced growth. However, the ratios are seldomly validated and their effect on net primary production (NPP) estimations from chlorophyll data is still highly uncertain.
Here we analyze a number of simulations with the global biogeochemical model REcoM2 that is based on the photoacclimation model by Geider et al. (Limnology and Oceanography 1998, 43, 679-694). REcoM is special in that it can handle unbalanced growth conditions. We show that the spatio-temporal distribution of the Chl:C ratio in these model runs is quite sensitive to the chlorophyll degradation rate, without affecting the agreement with satellite Chl values much. Observed phytoplankton Chl:C ratios therefore are an independent strong constraint on model parameters. An analysis of the relative increase rates of Chl, phytoplankton N and phytoplankton C in our model shows that the cells in our model results are often not in balanced growth where the relative increase rates are equal, but that diatoms are more often in balanced growth than nanophytoplankton. We speculate about how the modelled Chl:C ratio in the Southern Ocean depends on the way that iron limitation is implemented in our model and what the effects of Chl:C ratios on NPP and biogeochemical cycles are.