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Evaluation of Marine Biogeochemistry in the CMIP5 Earth System Models

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We evaluate the ability of 10 of the IPCC AR5 Earth System models (CMIP5 models) to simulate marine biogeochemical observations of recent past conditions, and assess simulated changes since preindustrial conditions, with a focus on marine primary production (NPP) and ocean surface chlorophyll.
In order to assess the performance of the models over the reference period 1986-2005, metrics are computed (correlation coefficient, standard deviation and bias) for averaged seasonal cycles of chlorophyll-a, NPP, export production, SST, MLD and nutrients compared with available observations. These metrics are evaluated for the current generation (CMIP5) and older generation (OCMIP5) models to assess recent model improvements. We find that in general the models show no improvement in ability to simulate global NPP from OCMIP5 to CMIP5.
Spatial analysis of seasonal patterns in the models is performed by comparing month and magnitude of the maximum chlorophyll bloom with SeaWiFS estimates at the grid scale. We show that the models are generally consistent with observations but are out of phase by up to six months in the Southern Ocean.
It has been shown that changes in global NPP are driven by changes in upper ocean temperature and stratification in the low latitudes (Behrenfeld et al., 2006). The co-variability of chlorophyll and SST over the period 1986-2005 and 1850- 2005 in the CMIP5 models is evaluated by calculating the correlation between modeled chlorophyll-a anomalies and changes in Nino region 3.4 SST. We show that some of the models show a strong anti-correlation in the equatorial pacific, similar to observational based estimates, however several of the models do not capture this important signal.
We show that the CMIP5 models do not agree on whether global NPP has increased or decreased since pre-industrial times, and that none of the models show a correlation of greater than 0.5 to observational based estimates of global NPP. This raises concern about the predictive skill of these models.