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Trends in marine plankton composition and export production in a CCSM-BEC hindcast (1960-2006)

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Climate-driven changes in marine plankton distribution are assumed to influence primary production, export production and export efficiency. We analyse trends in marine primary and particle export production and their relation to marine phytoplankton community composition using a hindcast simulation of the Biogeochemical Elemental Cycling Model (BEC) coupled to the Community Climate System Model over the period 1960-2006. The BEC models one generic zooplankton type and three phytoplankton types, diatoms, diazotrophs and small phytoplankton. In our simulation, small phytoplankton biomass, diatom biomass and zooplankton biomass decrease by 8%, 3% and 5%, respectively over the last 50 years. This decrease in plankton biomass is followed by a decrease in global primary and export production by 6% and 7%. Primary and export production decrease strongest in the Western Pacific (-18% and -23% respectively), where increased stratification leads to a decrease in total phytoplankton (-10%) and a decrease in diatom fraction (-12x%). The effect is a decrease in zooplankton biomass (-14%) and a lower export efficiency (-5%). Strong phytoplankton composition changes occur in the Southern Ocean and North Atlantic, where increased wind stress leads to stronger mixing, which reduces the biomass of small phytoplankton (-5% in the North Atlantic, -28% in the Southern Ocean), while diatoms profit from higher nutrient inputs and lower grazing pressure (+40% in the North Atlantic, + 22% in the Southern Ocean). The export efficiency and the relative fraction of diatoms are positively correlated (r=0.8) in most areas except the Northern Pacific and Antarctic Circumpolar Current, where the correlation is negative (r=-0.5). In areas where the correlation between diatom fraction and export efficiency is negative, small phytoplankton are simulated to consist of a high fraction of calcifiers, which are parameterized to produce faster sinking particles than diatoms in our model.While interannual variability in export efficiency is mostly driven by changes in the relative diatom fraction, long-term trends in global export efficiency are driven by decreases in small phytoplankton which lead to less efficient particle production in our model and consequent decreases in calcifier biomass.