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Southern Ocean coccolithophore biogeography – controlling factors and implications for global biogeochemical cycles

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Southern Ocean phytoplankton biogeography is important for the biogeochemical cycling of carbon, silicate, and the transport of macronutrients to lower latitudes. With the discovery of the "Great Calcite Belt" (GBC), revealing an unexpectedly high prevalence of calcifying phytoplankton in the subtropical frontal region between 40-55°S, the relative importance of Southern Ocean coccolithophores for phytoplankton biomass, net primary productivity and the carbon cycle need to be revisited.

Using a regional high-resolution model with an embedded ecosystem module (ROMS-BEC) for the Southern Ocean (24-78°S) that has been extended to include an explicit representation of coccolithophores, we assess the environmental drivers of Southern Ocean coccolithophore biogeography over the course of the growing season. We thereby focus on biotic interactions and the relative importance of top-down (grazing) versus bottom-up factors (light, nutrient, temperature) controlling growth and abundance.

In our simulation, coccolithophores are an important member of the Southern Ocean phytoplankton community, contributing $\sim$13% to annually integrated net primary productivity south of 30°S. We estimate the integrated annual calcification rate to account for $\sim$40% of the satellite derived global estimate.

Modeled coccolithophore biomass is highest in February and March in a latitudinal band between 40-55°S, when diatoms become heavily silicate limited. This region is characterized by a number of divergent fronts with a low Si:Fe ratio of waters supplied to the mixed layer, supporting an increased growth of coccolithophores at the expense of diatoms. We find top down controls to be the major control on the relative abundance of diatoms and coccolithophores in the Southern Ocean.

We perform iron and silicate fertilization experiments to assess the effects of changed nutrient availability on coccolithophore abundance in the GCB. We find that changes in nutrient stoichiometry significantly alter phytoplankton community composition, the relative contribution of particulate organic and inorganic carbon, as well as opal to export, and the supply of nutrients to lower latitudes. Consequently, when assessing potential future changes in Southern Ocean coccolithophore abundance and its implications for biogeochemical cycles, both physical (temperature, light, nutrient availability) and chemical (ocean acidification) changes, but also biotic interactions need to be considered.