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Biogeochemical dynamics on the East Australian Current System

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Nutrient and light availability are the two main conditions for phytoplankton growth. Because of this, the movement and mixing of water masses creates spatial and temporal heterogeneity in marine biogeochemical processes. Mixed layer depth variability is one of the major drivers of this heterogeneity through two main counteracting effects: a deeper mixed layer may increase phytoplankton production by supplying nutrients from depth, but it may also inhibit it by mixing phytoplankton cells deeper, where there is less light. Here, we explore this paradigm for the East Australian Current (EAC) System by coupling a biogeochemical model emulating the pelagic nitrogen cycle to a 10-year high-resolution (2.5 - 5 km horizontal) three-dimensional ocean model that extends from 25.25^{o} S to 41.55^{o} S and nearly 1000 km offshore. We find that nutrient replenishment to the euphotic zone caused by the winter deepening of the mixed layer is especially high in the southern region of the domain. The seasonal increase in nitrate supply during the austral winter sets the conditions for phytoplankton blooms to occur during the winter-spring transition, when stratification starts to re-establish and short-wave radiation increases. Results show that offshore phytoplankton blooms are strongly modulated by the poleward propagation of nutrient-depleted EAC waters, the front established between these and Tasman Sea waters, and the presence of EAC-derived submesoscale and mesoscale eddies. This study improves our understanding of phytoplankton bloom drivers, which play an integral role in the marine food chain and marine biogeochemical cycling. Amidst the physically-driven background variability, seemingly small changes in regional phytoplankton dynamics may have significant impact in global biogeochemistry and the global carbon budget.