# Changes in Southern Ocean phytoplankton biomass linked to climate variability

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Understanding the response of Southern Ocean phytoplankton to climate change is crucial to predict future biogeochemical cycles that mediate global climate. Phytoplankton biomass is controlled by several environmental factors such as temperature, light, and nutrients, which are also regulated by sea ice dynamics, wind-induced mixing, and so on. Previous studies have reported that tropical climate variability, such as El Niño/La Niña and the Indian Ocean Dipole (IOD), likely contributed to the Antarctic sea ice expansion via the Southern Annular Mode (SAM). However, the knowledge we have on the effect of these climate variability on phytoplankton in the Southern Ocean is limited. Here we investigated relationships between several climate variability and phytoplankton biomass using dataset of a long-term in situ chlorophyll *a* (chl-*a*) observations (1965-2020) and satellite-derived products (1996-2020). In the region between 40˚-60˚S during austral summer, higher chl-*a* concentrations were detected after the 1990s more frequently than before the 1970s, and an increasing trend along 110˚ E was correlated with SAM index positively. Our model experiments with wind forcing in 1960s and 2010s suggested that iron supply associated with enhanced westerly winds contribute decadal increasing of phytoplankton biomass in this region. On interannual time scale, variability of chl-*a* concentrations in the subantarctic zone is positively correlated with IOD index in September (i.e., IOD peak) but not Oceanic Nino Index (ONI) and SAM index. Composite analysis was performed on satellite-derived chl-*a* concentrations for the periods of only positive IOD (pIOD), only negative IOD (nIOD) without El Niño/La Niña events. During the austral summer (December–February), chl-*a* during pIOD events was higher than during nIOD in the east area of Kerguelen Islands and in the marginal ice zone of the Australian sector. The spatial pattern of JRA55 sea level pressure (SLP) was also different during each IOD event. Our results suggest that changes in phytoplankton biomass in the Southern Ocean could be affected by the IOD as well as the SAM on interannual to decadal time scales.

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