

## Seasonal and ENSO variability in global ocean phytoplankton chlorophyll derived from four years of SeaWiFS measurements

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Seasonal changes in phytoplankton biomass and productivity are very important components of the total variability associated with ocean biological and biogeochemical processes. Seasonal changes in phytoplankton biomass and productivity are generally related to incident solar irradiance, upper ocean mixing and stratification and other processes that affect the ocean's light and nutrient environment. SeaWiFS and other satellite ocean color sensors now provide data sets to assess seasonal and other sources of phytoplankton variability on global scales. We used empirical orthogonal function (EOF) analysis on a 4-year time series of global SeaWiFS chlorophyll a measurements to quantify the major seasonal (as well as the 1998 ENSO) signals in phytoplankton biomass between 50° S and 50° N, and then a second analysis to quantify summer patterns at higher latitudes. Among the important effects we resolved are a 6-month phase shift in maximum chlorophyll a concentrations between subtropical (winter peaks) and subpolar (spring-summer peaks) waters, greater seasonal range at high latitudes in the Atlantic compared to the Pacific, spring and fall biomass peaks at high latitudes in both hemispheres, and the effects of the 1998 ENSO cycle in the tropics. Our EOF results show that dominant seasonal and ENSO effects are captured in the first 6 of a possible 182 modes. These first six modes explain 67% of the total temporal variability associated with the global mean phytoplankton chlorophyll pattern in our smoothed data set. The results also show that the time (seasonal) /space (zonal) patterns between the ocean basins and between the hemispheres are similar, albeit with some key differences. Finally, the dominant global patterns are consistent with the results of ocean models of seasonal dynamics based on seasonal changes to the heating and cooling (stratification/de-stratification) cycles of the upper ocean.

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