Seasonal and ENSO Variability in Global Ocean Phytoplankton Chlorophyll Derived from Four Years of SeaWiFS Measurements.

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The purpose of this study is to use the 4-year (1998-2001) time series of SeaWiFS chlorophyll imagery to: (1) quantify the major seasonal (as well as the 1998 ENSO) signals in phytoplankton biomass; (2) determine interannual variability; and (3) find relations in the basin-scale patterns in the global ocean.
**What we found....**

- 6-month phase shift in peak Chl $a$ conc. between subtropical and subpolar waters;
- greater seasonal range at high latitudes in the Atlantic than in the Pacific;
- interesting phasing between spring and fall biomass peaks at high latitudes in both hemispheres;
- effects of the 1998 ENSO in the tropics, including Equatorial and off-Equatorial impacts; and
- first 6 (of 184) modes account for 68% of variability, with Mode 1 accounting for 41%.

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**Methods**

- Started with 9-km and 8-day SeaWiFS imagery.
- Averaged on a 0.25º X 0.25º grid and then smoothed using a 1º X 1º median filter.
- Subsampled to a 1º X 1º grid covering the global ocean from 50º N to 50º S and from 1998-2001.
- Log-transformed, and then used a 3-point (24 day) running mean to smooth in time.
- Filled in another ca. 20% of missing points.
- Final x,y and time cube has 184, 8-day “maps” each consisting of 25,551 grid points representing 91% ocean coverage [submitted to U.S. JGOFS data archive].
**Methods - Analyses**

- For EOFs, we used singular value decomposition (SVD) method to calculate temporal amplitudes, spatial eigenfunctions and corresponding eigenvalues.
- Focused interpretation on the first 6 (of 184) modes, i.e. those modes not degenerate.
- Also prepared a similar data set and used similar analyses for summer months (26 “weeks”/year) at high latitudes.

Mean CZCS (a) and mean (b), maximum (c) and minimum (d) SeaWiFS pixel values.
Mode 1 Spatial Pattern and Amplitude Time Series

Mode 2 Spatial Pattern and Amplitude Time Series
Mode 3 Spatial Function and Amplitude Time Series

EOF 3: 6.1%

Amplitudes for Mode 3

Modes 4 and 6 Spatial Pattern and Amplitude Time Series

EOF 4: 6.2%

Amplitudes for Mode 4

EOF 6: 2.7%

Amplitudes for Mode 6
Mode 5 Spatial Pattern and Amplitude Time Series

- **First 3 modes explain 66% of variance.**
- **Mode 1** (49% for NH and 46% for SH) is the same as for previous analyses.
- **Mode 2** enhances spring, and lowers winter, concentrations at latitudes > 40°.
- **SH Mode 2** is dominated by frontal features.

**Summer High Latitude Analyses**
(and summer is defined as a 26 “week” period centered on solstice; 3-year time series)

- First 3 modes explain 66% of variance.
- Mode 1 (49% for NH and 46% for SH) is the same as for previous analyses.
- Mode 2 enhances spring, and lowers winter, concentrations at latitudes > 40°.
- SH Mode 2 is dominated by frontal features.
Conclusions

- Little inter-annual variability at mid to high latitudes.
- Seasonal variations globally account for substantially (ca. 7X) more variability than did 1998 ENSO effects in the first 6 (non-degenerate) EOF modes.
- Mean global spatial pattern is very stable, i.e. one sees the basic pattern of high vs. low Chl a in 4-year mean, max and minimum fields.