Submesoscale Anisotropic Marine Biological Variability near Bermuda: Ocean Color and SST

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Introduction

Submesoscale and mesoscale physical variability strongly modulate the structure, biomass, and rates of marine ecosystems and their functioning in the ocean. Characteristic time and space scales of key ocean physical-biological phenomena range from the submesoscale (0.3-10 km, day-week) to mesoscale (10-300 km, week-few months). In Doney et al. (2003), we characterized for the first time the geographical patterns of the magnitude and spatial-scales of mesoscale ocean biological variability globally for a single year. Now, we present interim results characterizing the submesoscale component of ocean color variability using variogram techniques applied to high spatial resolution (1 km), regional satellite data near Bermuda. In the previous work, using SeaWiFS standard mapped level 3 products, we were unable to resolve between a true geophysical signal in the submesoscale versus instrument and environmental noise; here, we show that the submesoscale (<10 km) accounts for approximately 50% of the total resolved variance, the remainder found at mesoscales. We can extend this analysis to remotely sensed, physical variables and introduce here geostatistical analyses of the spatial variability found in sea surface temperature (SST). On submesoscales, we present variograms of chlorophyll and SST data collected at near-coincident times and compare the results. The distribution of submesoscale variability among biological and physical variables provides important insights into the mechanisms of interaction between biological ecosystems and their physical environment. Quantification of anisotropic submesoscale variability is an essential first step in deriving physical-biological parameterizations that may deviate significantly from purely physical, conservative tracers.

Data

Matched data image pairs (SeaWiFS: Chl a and AVHRR:SST) 8 Jan 1998

AVHRR and SeaWiFS

matched data image pairs (SeaWiFS: Chl a and AVHRR:SST) 8 Jan 1998

Original Data

Low-Pass Filtered Data

Low-Pass Filtered Residuals

Methods

The semivariogram or structure function \( \gamma (r) \) measures the local spatial variation of geophysical data \( Z(x) \), describing how samples are related with vector distance \( r \) (Chiles and Delﬁner, 1999). The semivariogram is closely related to the covariance function. In general, two neighboring points are more likely to have similar values than sample pairs farther apart. Thus the semivariogram (covariance) function will have low (high) values at small (large) spatial lags, increasing (decreasing) with distance. Beyond some distance, the data points can often be assumed to be uncorrelated or independent, in which case the semivariogram approaches a uniform variance while the covariance function goes to zero.

Geostatistics

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Results

The panels above show the distribution and magnitude of the total, resolved and unresolved variability in SeaWiFS ocean color and AVHRR SST data and the angular distribution of the vectors. Although the level of vari of AVHRR data is considerably lower than variability SeaWiFS data, the pattern we observed in our mesoscale study (Doney et al., 2003) is repeated for AVHRR-derived SST than for SeaWiFS-derived chlorophyll, but

References

