Moored Time Series Measurements of the Vertical Structure of Optical Properties in the Coastal Ocean

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LONG-TERM GOAL

The overall goal of our work is to establish and quantify physical and particle relationships via optical properties as part of the ONR Coastal Mixing and Optics (CMO) program. Specific goals of our research are: 1) to better understand the problem of vertical mixing and transport of particles, 2) to obtain new observations which will enable us to examine and model important processes (both periodic and episodic) that affect the distributions of optical properties and particle concentrations, and 3) to improve the interpretation and facilitate the utilization of emerging optical measurements taken in coastal waters.

OBJECTIVES

The overall objective of our research is to determine how particles and optical properties respond to physical forcing under various oceanic conditions on a broad continental shelf off the east coast of the U.S. Specific objectives are:

1) To quantify the variability of optical and physical properties at time scales as short as a few minutes. Our data sets allow us to compute: power spectra, coherence, and phase functions of time series of spectral beam attenuation coefficient, spectral scattering coefficient, and spectral absorption coefficient, estimated particle concentration, chlorophyll fluorescence, temperature, salinity, and horizontal currents. The physical and optical data are being integrated with those of other groups for joint analyses directed toward physical aspects,
2) To relate physical processes (e.g., wind forced waves, mixing activity, internal and inertial waves, solitary waves, tides, advection, etc.) to observed optical variability,
3) To make general distinctions among particle types and to partition their origin (e.g., biogenic from euphotic layer versus resuspended sediment),
4) To relate optical and particle variability near the ocean bottom to physical processes affecting sediment resuspension, and
5) To provide time series (at several depths) of physical and optical properties to complement vertical microstructure measurements (optical and physical) to set the context for these observations and model development.

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APPROACH

We simultaneously collected time series of optical and physical data from several depths using a variety of newly developed optical (e.g., spectral capability) and physical instruments placed on a mooring at a mid-shelf location (Mid-Atlantic Bight, roughly 40.5N, 70.5W). Our choice of optical parameters enables the interpretation of the data in terms of different optically important components of seawater (biogenic particles and non-biogenic particles). We deployed 3 moored instrument packages (approximately 14, 37, and 52m depths) on a mid-shelf mooring (water depth of roughly 70m) and a fourth on a bottom tripod (within about 2m of the bottom). A total of 4 deployments were conducted between July 8, 1996 and June 11, 1997 with temporal resolution of a few minutes to one hour.

WORK COMPLETED

All four deployments of the mooring, data analyses, and data reports have been completed. Two papers have been published (Geophysical Research Letters and Applied Optics) and five other papers are in review for the Journal of Geophysical Research. Grace Chang's thesis (Chang, 1999), which is based on CMO data, is completed and will be defended by the end of 1999. Highlight data may be viewed on our web site (http://www.opl.ucsb.edu/cmo.html).

RESULTS

A remarkable data set with a very high percentage of data return was collected (Dickey et al., 1998a,b, Chang and Dickey, 1999a,b). The eye of Hurricane passed within roughly 110km of our mooring (site is on 70m isobath) on September 1-2, 1996 and soon after Hurricane Hortense passed within roughly 350km of our mooring on September 14, 1996 (Dickey et al., 1998a). With the passage of Edouard, the mixed layer deepened very rapidly with temperature differences from the top to bottom (68m) decreasing from 12degC to about 2 degC. Sediment resuspension was dramatic as well and is easily seen in all optical data, including the ac-9 data. The resuspension event is evident from 68m up to the 37m depth. Surprisingly, Hortense's passage resulted in significant sediment resuspension despite its relatively great distance from the mooring site (Chang et al., 1999). Souza et al. (1999) have reported modeling results for sediment resuspension. Internal solitary waves (ISWs) were ubiquitous during our observations (Chang and Dickey, 1998a; 1999b). Some ISW packets show a strong correspondence in chlorophyll fluorescence and/or beam attenuation, while others do not. In addition, partitioning of spectral absorption between phytoplankton, detrital, and dissolved components has been accomplished using a hybrid model (Chang and Dickey, 1998a). Other areas of study include the complete seasonal cycle of bio-optical and physical variability (Chang and Dickey, 1999b) and the occurrence of fronts and intrusions and their relations to optical property distributions (Boss et al., 1999; Pegau et al., 1999). Please see web site http://www.icess.ucsb.edu/opl/cmo.htm1.

IMPACT/APPLICATION

It is evident that the data collected during the two hurricanes are very unique and will be most valuable for understanding major episodic perturbation of the optical properties of the coastal ocean. Sediment resuspension, modification of biomass constituents, and productivity will all be topics of intense study and modeling using this rich data set along with complementary data collected by CMO/PRIMER colleagues. The roles of ISWs and fronts and intrusions in affecting optical signatures are other important aspects of the work, which will have high impacts we believe.

TRANSITIONS

The results of our work (see impacts above) should be of interest to several levels of Navy interest.

RELATED PROJECTS

Our study is highly complementary to other CMO/PRIMER activities. Several other moorings and another bottom tripod sampled in the vicinity of our mooring. A variety of shipboard (profile and SeaSoar) and satellite observations also complement our measurements. Our high resolution time series will be beneficial for the vertical and horizontal mixing efforts along with remote sensing activities and vice versa.

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