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Quarterly Report for July - September
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a) Near-term Objective:

The near-term task of the algorithm-development activities at USF involve modeling coastal Case II waters and deriving algorithms based upon those models. Since SeaWiFS will be used as a surrogate for MODIS-N, SeaWiFS algorithm development is our first objective, and an algorithm for chlorophyll a concentration [Chl a] is the first algorithm being developed. This requires field data, which are being acquired.

Background:

Models of the radiance leaving the ocean are directly dependent upon the back-scattering coefficient and inversely dependent upon the absorption coefficient for seawater. Of these, the absorption coefficient is far more important for determinations of [Chl a]. The absorption coefficient can be partitioned into the sum of parts due to water molecules, phytoplankton, detritus (includes bacteria), and colored dissolved organic matter (CDOM). Since the absorption coefficient due to phytoplankton (am) is dependent upon [Chl a] in a non-linear manner due to the pigment-packaging or self-shading effect of phytoplankton, large, highly pigmented cells are less efficient absorbers per unit chlorophyll than are small, slightly pigmented ones (Morel and Bricaud, 1981). We proposed (Carder et al., 1991) that because smaller cells are found in warm, oligotrophic waters and larger cells are found in cold, eutrophic waters, the package effect should vary with season, location, and [Chl a]. One of our primary objectives since then has been to gather data widely to test this concept and others.

b) Task Progress:

Model results were presented at the SPIE meeting in San Diego (Lee et al., 1992) for a complicated coastal environment on the west Florida shelf that included radiance contributions from bottom reflectance, CDOM fluorescence, and water Raman. The results closely matched measured curves of remote sensing reflectance Rrs(~) from a field spectroradiometer and from the Airborne Visible/InfraRed Imaging Spectrometer (AVIRIS). A second paper was presented at SPIE (Hawes et al., 1992) which provided the fluorescence efficiency curves needed to model CDOM fluorescence.

Additional data were collected on an R/V Thompson II cruise from Seattle to Honolulu from 20 July to 2 August, covering eutropic to oligotrophic waters. Measurements of aCDOM, am, and ad were obtained along with Rrs(~) and pigment concentrations. Similar measurements from Monterey Bay were obtained 4 September when an

AVIRIS flight was scheduled. Cloudy weather and a faulty navigation system precluded AVIRIS coverage of the cruise, however.

Data from the Tambax II cruise from 11-13 May on the west Florida shelf have been worked up to test the pigment package model algorithm presented in Carder et al. (1991). The model algorithm, "tuned" to the field data, well represented the spring data for this subtropical environment, with only an 11.3% error (see Fig. 1) for the pigment range encountered (0.08< [Chl a] <1.0 mg/m2). As species succession changes cell size over the year, and light and nutrient stress play roles affecting intracellular pigment concentration and composition, this curve is expected to change. How well we can eventually predict or monitor these changes will determine the limiting accuracy of SeaWiFS and MODIS-N [Chl a] data. As of now, satellite-derived accuracies significantly better than 15% are unlikely since the satellite effectively is measuring absorption, not [Chl a], and algorithms such as in Fig. 1 with this order of error are required to convert phytoplankton absorption coefficients into [Chl a].

c) Anticipated Activities:

Next quarter we will participate on a cruise of the Florida Department of Natural Resources making measurements over the entire west Florida shelf. In addition to the measurements mentioned above, bottom albedos and sediment pigment concentrations will be measured to evaluate correction methodologies of satellite imagery for bottom reflection. Significant portions of the west Florida shelf are shallower than 30 m, where bottom-reflected radiance values will significantly augment total radiance values near 500 nm (Lee et al., 1992).

An AVIRIS overflight of damage by Hurricane Andrew may provide an opportunity to obtain hyperspectral offshore and coastal imagery from 400 nm to 1000 nm. Field data from a blue-water calibration site will be obtained to help with calibration and atmospheric correction of AVIRIS imagery (Carder et al., 1992). Pixel-binning will be used to increase the signal-to-noise ratio and to permit 1 km2 pixels consistent with SeaWiFS and MODIS-N imagery.

d) Problems/Corrective Actions:

None to report.

e) Publications:

1. Lee, Z., K.L. Carder, S.K. Hawes, R.G. Steward, T.G. Peacock, and C. O. Davis, 1992, "An interpretation of high spectral resolution remote sensing reflectance," SPIE 92 (to be submitted to Applied Optics).

2. Hawes, S.K., K.L. Carder, G.R. Harvey, 1992, "Quantum fluorescence efficiencies of fulvic and humic acids: effects on

ocean color and fluorometric detection," SPIE 92 (to be submitted to Limnology & Oceanography).

f) References:

1. Carder, K. L., S.K. Hawes, K.A. Baker, R.C. Smith, R.G. Steward, and B.G. Mitchell, 1991, "Reflectance model for quantifying chlorophyll a in the presence of productivity degradation products," JGR, 96(C11), 20599-20611.

2. Carder, K.L., P. Reinersman, R.F. Chen, F. Muller-Karger, C.O. Davis, and M. Hamilton, 1992, "AVIRIS calibration and application in coastal oceanic environments," G. Vane, ed., Remote sensing of Environments, special issue on imaging spectrometry, in press.

3. Hawes, S.K., K.L. Carder, G.R. Harvey, "Quantum fluorescence efficiencies of fulvic and humic acids: effects on ocean color and fluorometric detection," SPIE 92 (to be submitted to Limnology & Oceanography).

4. Lee, Z., K.L. Carder, S.K. Hawes, R.G. Steward, T.G. Peacock, and C. O. Davis, "An interpretation of high spectral resolution remote sensing reflectance," SPIE 92 (to be submitted to Applied Optics).

5. Morel, A., and A. Bricaud, 1981, "Theoretical results concerning light absorption in a discrete medium, and application to specific absorption of phytoplankton," DSR, 28A(11), 1375-1393.