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Quarterly Report for January - March, 1994
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a) Objectives:

The algorithm-development activities at USF continue. We continue to refine our version 1 ATBDs(Algorithm Theoretical Basis Document) and will submit them to major journals for publishing. We will also participate on cruises planned for data collection.

b) Task Accomplished:

1. An R/V SUNCOASTER cruise was made from Tampa Bay to the Cape San Blas area along the Florida west coast between March 13 and 21, 1994. Tasks included partitioning of the absorption coefficients of water samples, taking CDT and chlorophyll fluorescence profiles, and collecting remote sensing reflectance data for this cruise. Pigment and in-water optical measurements were made by cruise collaborators.

2. A remote-sensing reflectance model by Lee et al. (1994) has been accepted for publication by Applied Optics. An additional 9 papers have been presented at National meetings or submitted for publication.

3. Three version 1 ATBDs were completed and submitted to the EOS Project Science Office:

3-1. Determining chlorophyll a concentration and gelbstoff of absorption coefficient for radiance data.

3-2. Calculating surface PAR(photosynthetically available radiation and IPAR(instantaneous PAR).

3-3. Calculating clear-water epsilons.

Based on a semi-analytical model of remote-sensing reflectance (Rrs), Lee et Al. (1994), a preliminary algorithm for chlorophyll a and gelbstoff parameterized for the Gulf of Mexico has been developed and tested. This bio-optical algorithm utilizing the SeaWiFS wavebands centered at 412, 443, 490, 555, and 670 nm is used to estimate chlorophyll a concentration ([Chl a]) and gelbstoff concentration, represented by its absorption coefficient at 400 nm (ag(400)).

The Rrs model has numerous parameters that cannot be fixed and applied to the entire globe; i.e., they maybe somewhat site- and season-specific. Extensive field data sets are needed to allow seamless modification of the model parameters with time and space. The changes required will be due mostly to changes in the dominant plankton groups present and the subsequent effects on bio-optical parameters such as pigment packaging. Additional cruises to the Indian Ocean and South China Sea planned for the coming year to evaluate changes to these parameterizations for low latitudes. High-latitude data from 60o N in the Atlantic will be used in the model modification for higher latitudes.

Photosynthetically available radiation, PAR, is a measure of the photon flux of quanta available in the wavelength range (350 - 700 nm) where light-harvesting pigments of plants are capable of absorbing and utilizing light. Instantaneous PAR or IPAR is a measure of this variable just below the sea-surface as MODIS passes over. Since skylight has a different radiance distribution than sunlight, its effective penetration angle below the sea surface differs from that of sunlight. It averages about 32o while sunlight penetrates at angles from 0^{o} to the critical angle (48.5^{o}), depending upon time of the day, latitude, and season. Since skylight differs markedly in color from sunlight, and travels a different slanted path length to depth, and since light attenuation with depth is spectrally dependent, each must be separately designated at the surface in order for models to accurately calculate PAR(z) at depth from their sum. For this reason Surface IPAR should be designated spectrally for each of its sky and solar components. The ATBD submitted for this task has been largely based upon Gree and Carder (1990) with modifications based upon variables provided by MODIS data products.

In the oligotrophic ocean (found typically between 35o N and S), where chlorophyll a concentrations are less than 0.25 mg m-1, the remote-sensing reflectance, Rrs, and normalized water-leaving radiance, Lwn, can be predicted with only a small error for wavelengths longer than about 500 nm (Gordon and Clark, 1981). Under these conditions the aerosol radiance for wavelengths longer than 500 nm can be determined. For large, iron-rich desert dust particles, the ratio of aerosol reflectances at 550 nm and 670 nm, n(550,670), has been found using CZCS data to decrease to 0.9 and below, as opposed to more typical values of 1.0-1.5 for small, non-iron-bearing aerosols. n(550,670) has strong dependence on the iron content of aerosols. Thus, the primary purpose of this algorithm is to use a measured clear-water epsilon value for the MODIS wavelengths 531 nm and 667 nm, n(531,667), over clear waters to estimate aerosol iron content. In addition, for regions where n(531,667) < 1.0, chances are the standard MODIS Lw(~) values at shorter wavelengths will be suspect due to the blue-absorbing aerosols. A second purpose of this algorithm is to recalculate such suspect Lw(~) values using the clear-water epsilon technique. Lastly, since these effects probably won't be discernable from Angstrom exponents derived using ratios of longer wavelengths (e.g. 670, 750, 870nm), n(531,667) can also provide a check on the Angstrom exponent derived using only red and infra-red wavelengths.

The method for obtaining clear-water epsilon values have been thoroughly documented in the CZCS literature, and no significant alterations to this earlier approach have been applied. We did modify the values of the normalized water-leaving radiance at 520, 550, and 670 nm for CZCS to the slightly different MODIS bands by means of the water absorption curve (note that low-chlorophyll waters, water is the dominate absorber).

The output product in its simplest form will be n(531,667) maps that scientists can use to evaluate the iron content of aerosols over clear waters (mostly q35o latitude) and to flag potential problems with Lw values calculated using Angstrom-exponent-based extrapolations from the infra-red for aerosol radiance values in the visible. These would typically be used with La(667) to estimate total iron content/flux of aerosol clouds. While 4 km, spatially binned n(531,667) data would be sufficient for most science interests regarding iron flux, diagnosing potential problems with the Lw field may require full-resolution data.

4. In AGU, 1994 Ocean Sciences meeting in San Diego, Calif., Feb. 21-25, 8 presenations were presented by the individuals of our group. The list is provided in section d.

c) References cited:

Carder, K.L., S.K. Hawes, K.A. Baker, R.C. Smith, R.G. Steward, and B.G. Mitchell, Reflectance Model for Quantifying Chlorophyll a in the Presence of Productivity Degradation Products, J. Geophys. Res., 96(C11), 20,599-20,611, 1991.

Gordon, H.R., and D.K. Clark, 1981. Clear water radiances for atmospheric correction of coastal zone color scanner imagery, Appl. Opt. 20:4175-4180.

Gordon, H.R., and A.Y. Morel, Remote assessment of ocean color for interpretation of satellite visible imagery: A review, Springer, 1983.

Gregg, W.W. and K.L. Carder, 1990, A simple solar irradiance model for cloudless maritime atmospheres, Limnol. Oceanogr. 35(8): 1657-1675.

d) Published and submitted manuscripts and paper presentations:

1. Lee, Z., K. L. Carder, S. K. Hawes, R. Steward, T. Peacock and C. O. Davis, A model for Interpretation of Hyperspectral Remote-sensing Reflectance, accepted by Appl. Opt.

2. Carder, L. K., P. Reinersman, and R.F. Chen, AVIRIS Calibration Using the Cloud-Shadow Method, Proceeding of the 4th JPL AVIRIS Workshop, Oct., 1993.

3. Hou, W., D.K. Costello, K.L. Carder, and R. G. Steward, High Resolution Data from the Marine Aggregated Particles Profiling and Enumerating Rover(MAPPER), a new, In-situ, Optical Instrument, poster, O11A-7, AGU, 1994 Ocean Sciences Meeting, EOS Trans., AGU, 75(3):21, Jan., 1994.

4. Peacock T.G., K.L. Carder, P.G. Coble, Z.P. Lee, and S.K. Hawes, Long-Path Spectrometer for Measuring Gelbstoff Absorption in Clear Water, poster, O11A-14, AGU, 1994 Ocean Sciences Meeting, EOS Trans., AGU, 75(3):22, Jan., 1994.

5. Costello, D.K., K.L. Carder, and R.G. Steward, The Distribution and Optical Properties of Large Marine Particles: Data From Culture Tank and Field Experiments, O11J-04, AGU, 1994 Ocean Sciences Meeting, EOS Trans., AGU, 75(3):35, Jan., 1994.

6. Steward, R.G., K.L. Carder, and T.G. Peacock, High Resolution, in Water Optical Spectrometry Using the Submersible Upwelling and Downwelling Spectrometer (SUDS), O22O-03, AGU, 1994 Ocean Sciences Meeting, EOS Trans., AGU, 75(3):102, Jan., 1994.

7. Young, L.R., K.L. Carder, and P. Hallock, Hyperspectral Remotely Sensed Colored Dissolved Organic Matter as a

Photoprotective Agent Against Bleaching in Corals and Foraminifera, O22O-10, AGU, 1994 Ocean Sciences Meeting, EOS Trans., AGU, 75(3):103, Jan., 1994.

8. Reinersman, P., F. Chen, and K.L. Carder, Monte Carlo Simulation of Atmospheric Point Spread Function With Application to Coastal Image Processing, O22H-08, AGU, 1994 Ocean Sciences Meeting, EOS Trans., AGU, 75(3):136, Jan., 1994.

9. Hawes, S.K., K.L. Carder, L.P. Lee, and T.G. Peacock, A Case 1 and Case 2 Bio-optical Algorithm for SeaWiFS, O22H-09, AGU, 1994 Ocean Sciences Meeting, EOS Trans., AGU, 75(3):136, Jan., 1994.

10. Lee, Z.P., K.L. Carder, and T.G. Peacock, Hyperspectral Modeling of Remote Sensing Reflectance: From the Florida Shelf to the Mississippi River, poster, O51A-13, AGU, 1994 Ocean Sciences Meeting, EOS Trans., AGU, 75(3):193, Jan., 1994.