Semi-Annual Report

July 2003

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Task objectives

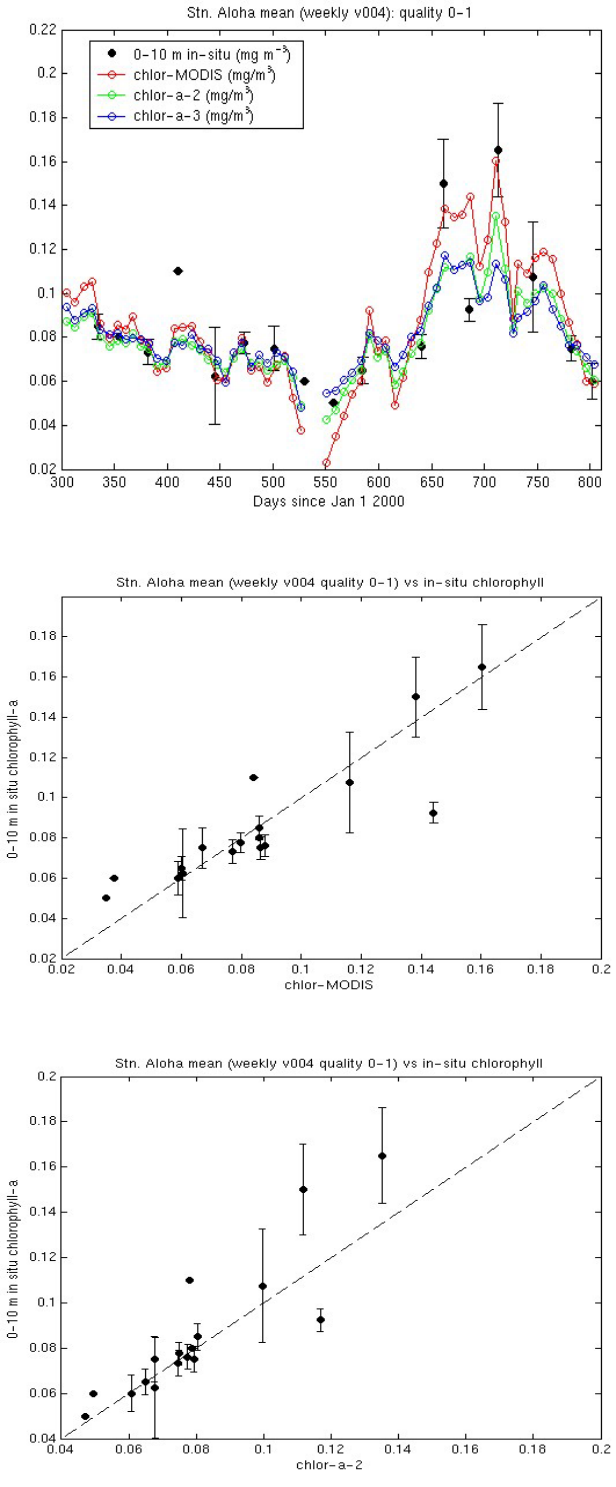
- Continue analysis of data from MODIS validation cruises
- Continue evaluation of MODIS imagery from several regions of the world ocean
- Continue development of software for MODIS Direct Broadcast facility for cruise support
- Continue to develop and expand browser-based information system for in-situ bio-optical data and MODIS imagery

Work Accomplished

MODIS Validation Cruises and Evaluation of MODIS Imagery

We conducted our first winter cruise off the Oregon coast during February 2003 to study the impacts of downwelling on coastal ecosystem dynamics. In addition, we participated in a Gulf of Alaska GLOBEC cruise during May 2003. During both cruises we collected bio-optical measurements using a Tethered Spectral Radiometer Buoy (TSRB) and underway remote sensing reflectance using a Satlantic MicroSAS. Fast Repetition Rate fluorometry (FRRf) data were collected using a flow-through system in order to compare the sun-stimulated chlorophyll fluorescence with the physiological state of algal assemblages in surface waters. Algal pigment distribution and particle absorption spectra were determined in discrete samples.

We continue collecting a similar set of bio-optical measurements as part of the Hawaii Ocean Time-series (HOT) program, and we participated in a cruise between Hawaii and Alaska earlier this year in which we collected FRRf data as well as Remote Sensing Reflectance. These datasets are aimed to better characterize the bio-optics and algal physiology in oligotrophic environments. Results from these cruises have been used to validate MODIS chlorophyll algorithms in these environments. The comparison between in situ and MODIS derived chlorophyll concentrations in the North Pacific subtropical gyre show excellent agreement.



Fig, 1: Comparison between in situ and MODIS derived chlorophyll concentrations at Station ALOHA (22°45'N, 158°W).

We continue developing a chlorophyll algorithm for case II waters, based on sun-stimulated fluorescence. Using in situ chlorophyll samples collected off the Oregon Coast and MODIS EOS Direct Broadcast images, we have developed an empirical relationship between sea surface chlorophyll and MODIS derived Fluorescence Line Height (FLH). This empirical relationship has been used successfully by Ken Carder when sampling harmful algal blooms. Furthermore, it is consistent with a theoretical derivation proposed by Yannick Huot and John Cullen at Dalhousie University. However, more research is needed to evaluate the robustness of the algorithm.

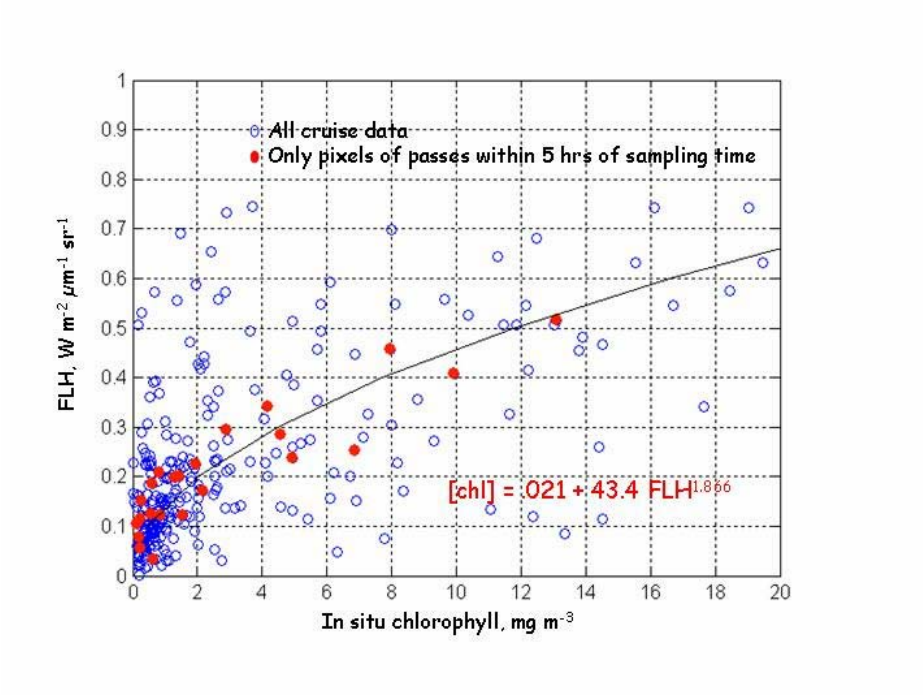


Figure 2: Comparison between in situ chlorophyll off the Oregon Coast and MODIS FLH

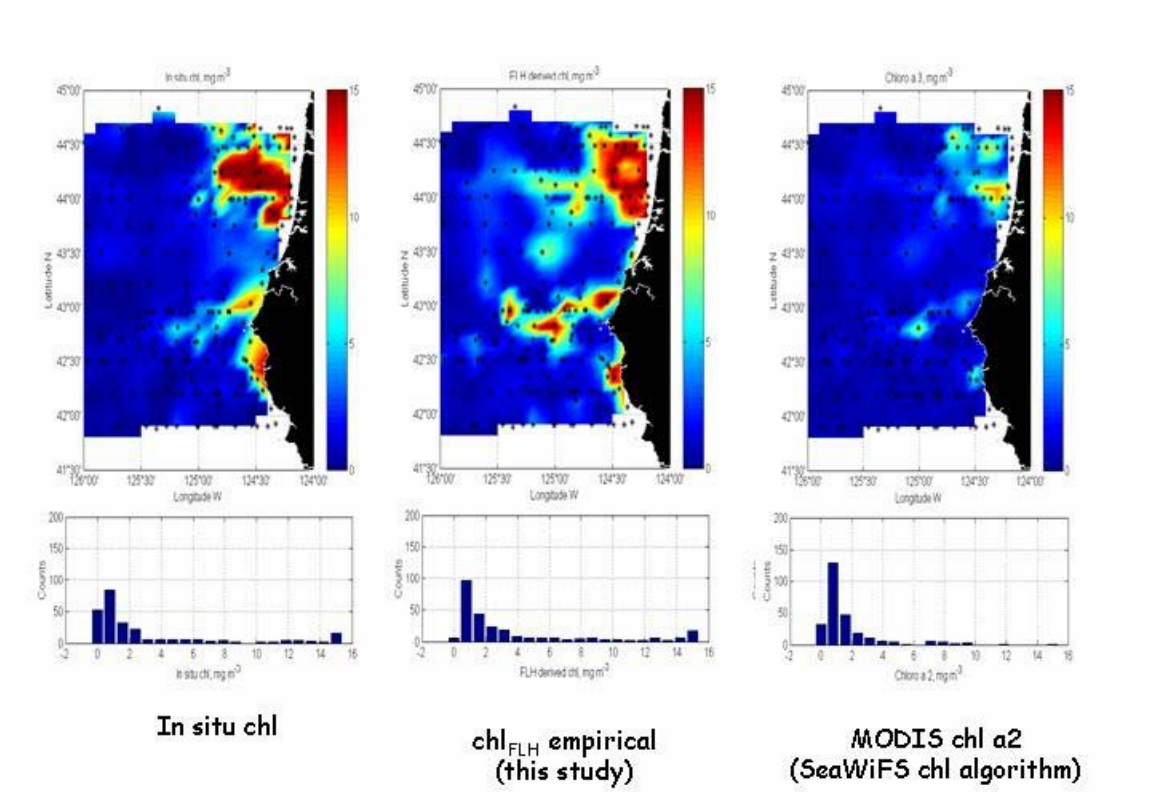


Figure 3: Spatial distribution of chlorophyll concentration off the Oregon coast derived from in situ measurements, using the empirical relation between chlorophyll and MODIS FLH, and MODIS chl a2.

Evaluation of MODIS imagery

Three distinct oceanic regions have been selected to study the distribution of MODIS Chlorophyll Fluorescence products using 4.9 km weekly level 3 data collected between November 1st, 2000 and March 19th, 2002. These regions are: 1) the oligotrophic North Pacific subtropical gyre around Station ALOHA (22.25-23.25 N, 157.5-158.5 W), 2) The Southern Ocean (59.5-60.5 S, 169.5-170.5 W), and 3) The upwelling region off the Oregon coast (41-45 N, 123-127 W). These regions display significant differences in the distribution of chlorophyll concentrations and FLH. The Chlorophyll Fluorescence Efficiency (CFE) displays its narrowest distribution in the oligotrophic North Pacific and its broadest in the upwelling region off the Oregon coast. This is consistent with the variability in nutrient distributions observed in these environments.

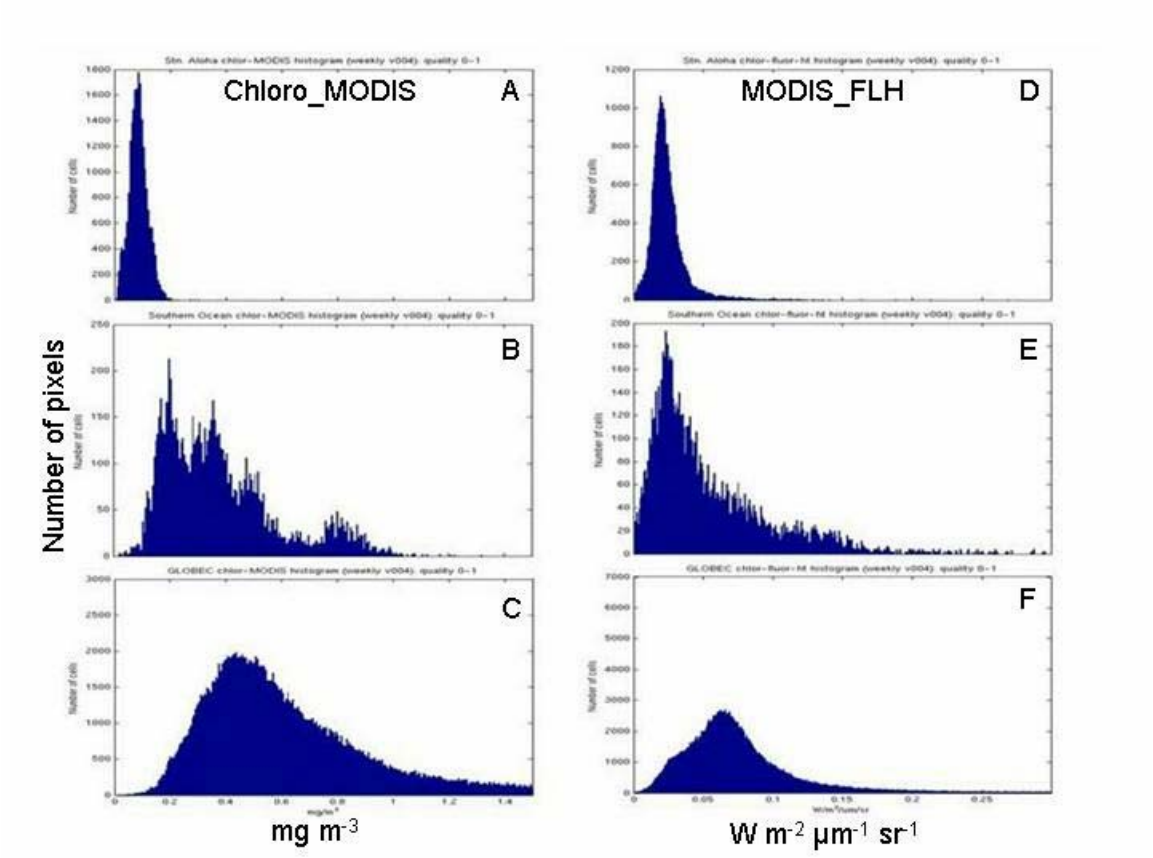


Figure 4: Frequency distributions of chl_MODIS and FLH for three ocean regions. the top row is the N. Pacific Subtropical Gyre, the second row is from the Southern Ocean, and the third row is off Oregon.

Chemostat Experiments

We have performed studies comparing Walz PAM fluorometry with FRRf and sun-stimulated fluorescence. The Walz systems has allowed us to generate quasi-instantaneous Productivity versus Irradiance (P vs E) curves that are being compared to CFE data.

Direct Broadcast

Our EOS Direct Broadcast facility (http://picasso.oce.orst.edu/ORSOO/MODIS/DB) continues to operate. We are now ingesting MODIS DB data collected at the University of Hawai'i, thus providing a nearly complete view of the NE Pacific Ocean. The data are immediately available for public use from our website:

http://picasso.coas.oregonstate.edu/ORSOO/MODIS/DB/

This site provides access to the data in a number of ways: 1) quick views of the most recent data collected, 2) search and order archived data, 3) subscribe to real-time data as it is collected, 4) interactively create figures of the most recent

data, and 5) view interesting past images in a gallery. This site also provides information on upcoming TERRA and AQUA passes to help with cruise planning. All data are also available via anonymous FTP on request.

A web-service view to our MODIS DB data is being constructed to enable the development of end-user applications that transparently "consume" the data and services provided by COAS. This consists of a layer that resides on a web-server and provides building-block type services. These services enable processing of the data on the server, such as the extraction of a subset of pixels or extracting data that corresponds to a scientific feature. Once the building-block type services have been implemented, we plan to combine them in meaningful ways to solve more complex problems.

Both the development and run-time environments will be .NET, with client and server components developed using Visual Studio .NET and applications running on top of the .NET Common Language Run-time. New services are described in the table below.

	Service	Description
*	readMODISdata inputs: path, filename, [parameter name] OR [ref number] outputs: data matrix	reads a given MODIS data file and outputs the chosen data as an ASCII matrix
*	getMODISfilenames inputs: [date range] OR [date vector], lat/lon range, file type, satellite, level, parameter, spatial resolution, temporal resolution, source, processing date range, file status, lat/lon required outputs: list of paths and filenames	queries our database to return a list of all available MODIS filenames that match the given criteria
	getMODISattributes inputs: path, filename outputs: date sampled, lat/lon corners, satellite, parameter, spatial resolution, temporal resolution, image path, source, level, met file path, processing date, thumbnail path, browse image path, file status	queries our database to return a list of attributes for a given MODIS filename
	subsetdata inputs: data matrix, [lat matrix, lon matrix, lat/lon range] OR [line/pixel range] outputs: data subset matrix, [lat subset matrix, lon subset matrix] OR [line/pixel subset vectors]	takes matrix data and outputs the chosen subset region (based on either lat/lon values or line/pixel values)
*	extractpixels inputs: data matrix, [lat matrix, lon matrix, lat/lon	extracts pixels for given lat/lon values or line/pixel values

	array of pixels] OR [line/pixel array of pixels] outputs: data vector	
*	plotXYscatter inputs: X matrix/vector, Y matrix/vector, X label, Y label, X range, Y range, JPEG x size, JPEG y size outputs: JPEG	creates a JPEG of an X vs. Y scatterplot
*	makeimage inputs: data matrix, data range, [lat matrix, lon matrix, lat/lon range] OR [line/pixel range], mask color, JPEG x size, JPEG y size outputs: JPEG	creates a JPEG of matrix data
*	imageoverlay inputs: data matrix, data range, lat matrix, lon matrix, lat/lon range, track lat vector, track lon vector, coastlines, mask color, JPEG x size, JPEG y size outputs: JPEG	creates a JPEG of matrix data with tracks and/or coastlines
	getdrifterIDs inputs: date range, lat/lon range, parameter(s) outputs: list of drifter IDs	queries the database and returns a list of drifter IDs
	readdrifterdata inputs: drifter ID, parameter outputs: lat vector, lon vector, parameter data vector	extracts chosen drifter data from the database
	readdrifterattributes inputs: drifter ID outputs: lat/lon range, parameters, date range	queries the database and returns a list of attributes for the chosen drifter ID
	makemovie inputs: list of jpeg paths and filenames outputs: movie	combines a series of JPEGS into a movie
	makeimagegrid inputs: list of jpeg paths and filenames, JPEG x size, JPEG y size outputs: JPEG	combines a number of JPEGS into a grid of thumbnails in a single JPEG
	maskdata inputs: data matrix, mask matrix, mask value range outputs: masked data matrix	applies a mask to a data matrix

	extractdatarange inputs: data matrix/vector, data range outputs: extracted data vector, row indices, column indices	extracts data values from a matrix within a chosen range
	matchdata inputs: data matrix/vector containing values to be found, data matrix/vector containing values to be searched, acceptable range outputs: retrieved data matrix/vector, row indices, column indices	find values that match between 2 matrices within a given range

These services can be combined into “chains” to provide more sophisticated services, reducing the level of detailed knowledge needed on the part of the user to develop complicated web-based tools. Some examples are shown in the following table.

waterfall plot of a given line or pixel number within a series of MODIS images inputs: date range, lat/lon range, MODIS file type, satellite, MODIS level, MODIS parameter, MODIS spatial resolution, MODIS temporal resolution, MODIS source, MODIS processing date range, MODIS file status, line or pixel number outputs: JPEG getMODISfilenames readMODISdata (parameter, lat, lon) [LOOP] extractpixels (pixel or line) [LOOP] makeimage
animation of ship track over a sequence of MODIS images inputs: ship dates, ship lat/lon, MODIS file type, satellite, MODIS level, MODIS parameter, MODIS spatial resolution, MODIS temporal resolution, MODIS source, MODIS processing date range, MODIS file status outputs: movie getMODISfilenames readMODISdata (parameter, lat, lon) [LOOP] getMODISattributes (date sampled) [LOOP] matchdata (ship dates, date sampled) extractdatarange (ship lat, lon) [LOOP] imageoverlay [LOOP] makemovie
plot of extracted MODIS data values along drifter track as a function of date inputs: date range, lat/lon range, MODIS file type, satellite, level, MODIS parameter, MODIS spatial resolution, MODIS temporal resolution, MODIS source, MODIS processing date range,

MODIS file status outputs: JPEG getdrifterIDs readdrifterdata (date) [LOOP] getMODISfilenames readMODISdata (parameter, lat, lon) [LOOP] getMODISattributes (date sampled) [LOOP] extractdatarange (drifter date) [LOOP] matchdata (drifter dates, date sampled) extractMODISpixels [LOOP] plotXYscatter (MODIS data vs. date sampled)
grid of thumbnails of MODIS subset images inputs: date range, lat/lon range, MODIS file type, satellite, MODIS level, MODIS parameter, MODIS spatial resolution, MODIS temporal resolution, MODIS source, MODIS processing date range, MODIS file status, [line/pixel range] outputs: JPEG getMODISfilenames readMODISdata (parameter, lat, lon) [LOOP] subsetdata [LOOP] makeimage [LOOP] makeimagegrid
highlight/mask pixels within a data range inputs: date range, lat/lon range, MODIS file type, satellite, MODIS level, MODIS parameter, MODIS spatial resolution, MODIS temporal resolution, MODIS source, MODIS processing date range, MODIS file status, [line/pixel range], mask range, mask color outputs: JPEGs getMODISfilenames readMODISdata (parameter, lat, lon) [LOOP] maskdata [LOOP] makeimage [LOOP]

In September 2003 we will host a MODIS-oceans product workshop for scientists interested in using MODIS DAAC resources, as well as our EOS direct broadcast archives.