SeaDAS Training Manual

Ocean Biology Processing Group

October 29, 2007

Chapter 1

An Introduction to the OBPG

Introduction

This chapter introduces the NASA Ocean Biology Processing Group (OBPG) and the software used in conjunction with data distributed by the group, the SeaWiFS Data Analysis System (SeaDAS).

1.1 What is the OBPG?

The goal of the Ocean Biology Processing Group is to make available the highest quality **ocean color and SST data** to the broadest user community in the most timely and efficient manner possible. More specifically the OBGP is the:

- Designated NASA team responsible for the **processing and distribution** of ocean color and SST data from various spaceborne instruments:
  - **Ocean Color**: MODIS/Aqua, MODIS/Terra, SeaWiFS, OCTS, CZCS
  - **SST**: MODIS/Aqua, MODIS/Terra
- Product Evaluation and Test Element (PEATE) for OC and SST on NPP/VIIRS
- Science Team Lead for OC on NPP/VIIRS.
- Designated as the software development, processing, and distribution element for Sea Surface Salinity measurements from Aquarius.

1.2 What Services does the OBPG Provide?

The primary service provided by the OBPG is data distribution, the details of which are covered in the next chapter. Main features of the data distribution system are:

- **Instant access**: entire archive of Level-1A through Level-3 data for all missions is stored online
- **Minimal latency**: MODIS L0/L1A/GEO/L1B/L2 data available 2-5 hours after satellite observation
- **Web-based browser**: simple viewing/order/download tool for the entire multi-mission data set
- **Full ftp access**: data may be downloaded via ftp

- **Data subscriptions**: automatic staging of new data products to user-specific ftp accounts

The other main service provided by the OBPG is user support for accessing, understanding, processing, and working with the data. A great deal of this support takes place on the Ocean Color Forum (http://oceancolor.gsfc.nasa.gov/forum/oceancolor/forum_show.pl) and through documentation available on the Ocean Color Web (http://oceancolor.gsfc.nasa.gov/).

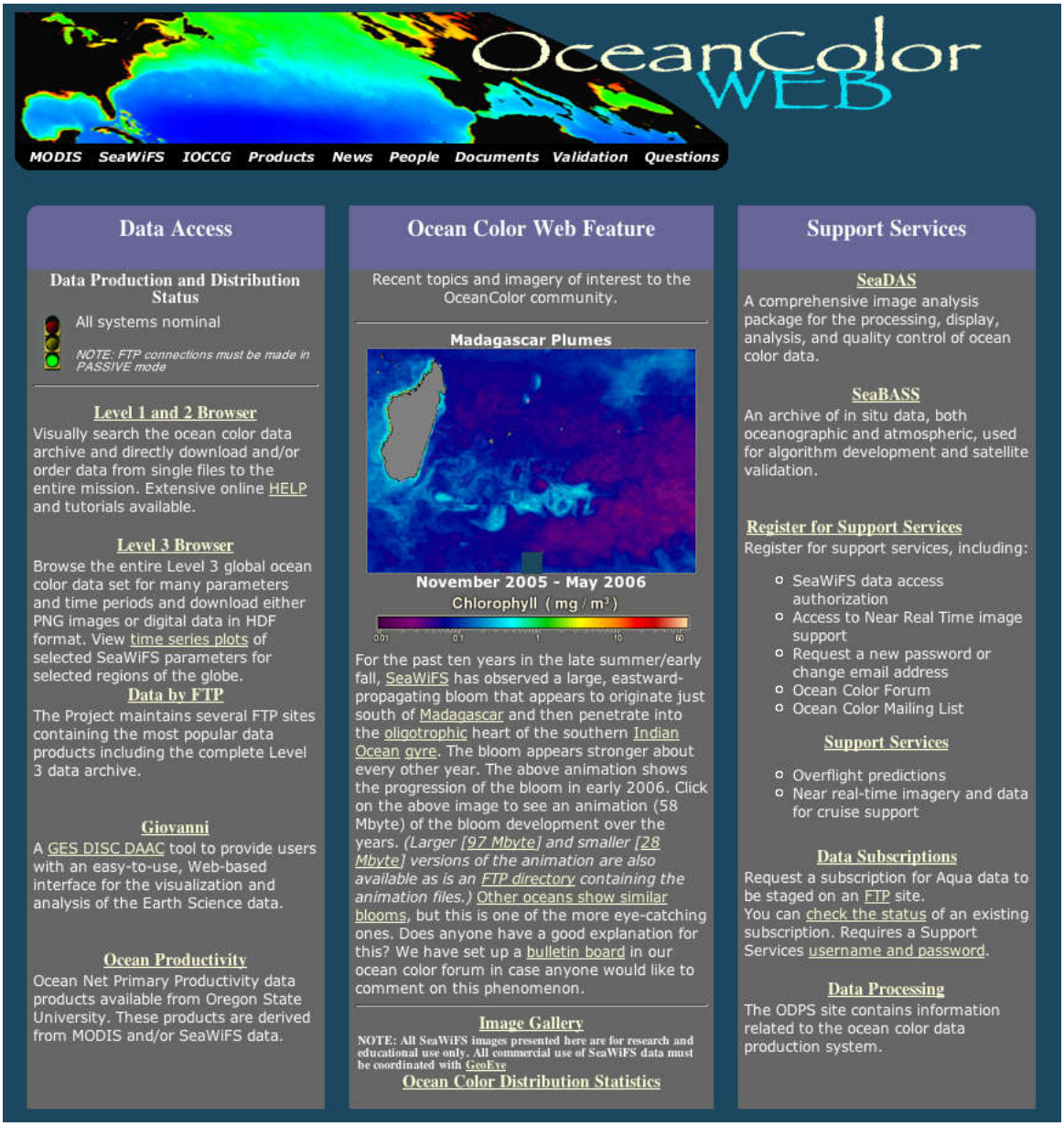

Figure 1.1: The Ocean Color Web

1.3 What Data does the OBPG Provide?

As mentioned, the OBPG provides ocean color data from the MODIS/Aqua, MODIS/Terra, SeaWiFS, OCTS, and CZCS sensors, and SST data from MODIS/Aqua and MODIS/Terra. Data levels range from Level-0 or Level-1A up to Level-3 Binned and mapped products. The Level-2 and Level-3 data contain geophysical products, some of which are listed below. (Hundreds of predefined products and unlimited custom products can be created using the SeaDAS software package.)

- **Standard Ocean Color Products (all sensors, daytime only)**
  - Normalized water-leaving radiances, $nLw(\lambda)$
  - Chlorophyll, C_a
  - Diffuse attenuation, $K_d(490)$
  - Aerosol type and concentration
  - Optical thickness, τ_a
  - Ångström exponent
  - Atmospheric epsilon
  - Processing flags
  - Cloud, land, glint, atmfail, atmwarn, chlfail, chlwarn, etc.
- **Standard Ocean Temperature Products (MODIS only)**
  - Long-wave SST (11-12 μm) (daytime and nighttime)
  - Short-wave SST (3.9 - 4.0 μm) (nighttime only)
  - SST quality level (0-4)
- **Non-standard Ocean Color Products (all sensors, daytime only)**
  - Alternate C_a and K_d algorithms
  - Chlorophyll fluorescence, FLH
  - Particulate inorganic carbon, Calcite
  - Inherent optical properties (various bio-optical models)
  - absorption (total, phaeophytin, dissolved matter)
  - backscatter (total, particulate)
  - Photosynthetically active radiation, iPAR, PAR
  - Euphotic depth (Z_{eu}, Z_{sd})
  - Subsurface PAR at 1st optical depth, K_d(PAR)
  - Intermediate atmospheric correction products
  - ..and many others
- **Non-standard Ocean Temperature Products (MODIS only)**
  - Brightness temperatures (daytime and nighttime)

1.4 What is SeaDAS?

SeaDAS is a comprehensive image analysis package for the processing, display, analysis, and quality control of ocean color data. SeaDAS is intended for use with all of the OBPG supported sensors: MODIS/Aqua, MODIS/Terra, SeaWiFS, OCTS, CZCS. SeaDAS can also be very useful as a general scientific imagery/data analysis package. SeaDAS features include:

- Visualize and manipulate all data distributed by the OBPG
- Visualize and manipulate non-OBPG data (e.g. general HDF 4, AVHRR Pathfinder)
- Process all data from L0 or L1A through to L3 and SMI (complete source code included)
- Reproduce products identical to the OBPG standard ocean color and SST products
- NPP/VIIRS will be supported in the future
- Runs on **UNIX-like systems only**: Linux, Macintosh OS X, Sun Solaris, SGI IRIX
- Direct user support and extremely active user support forums

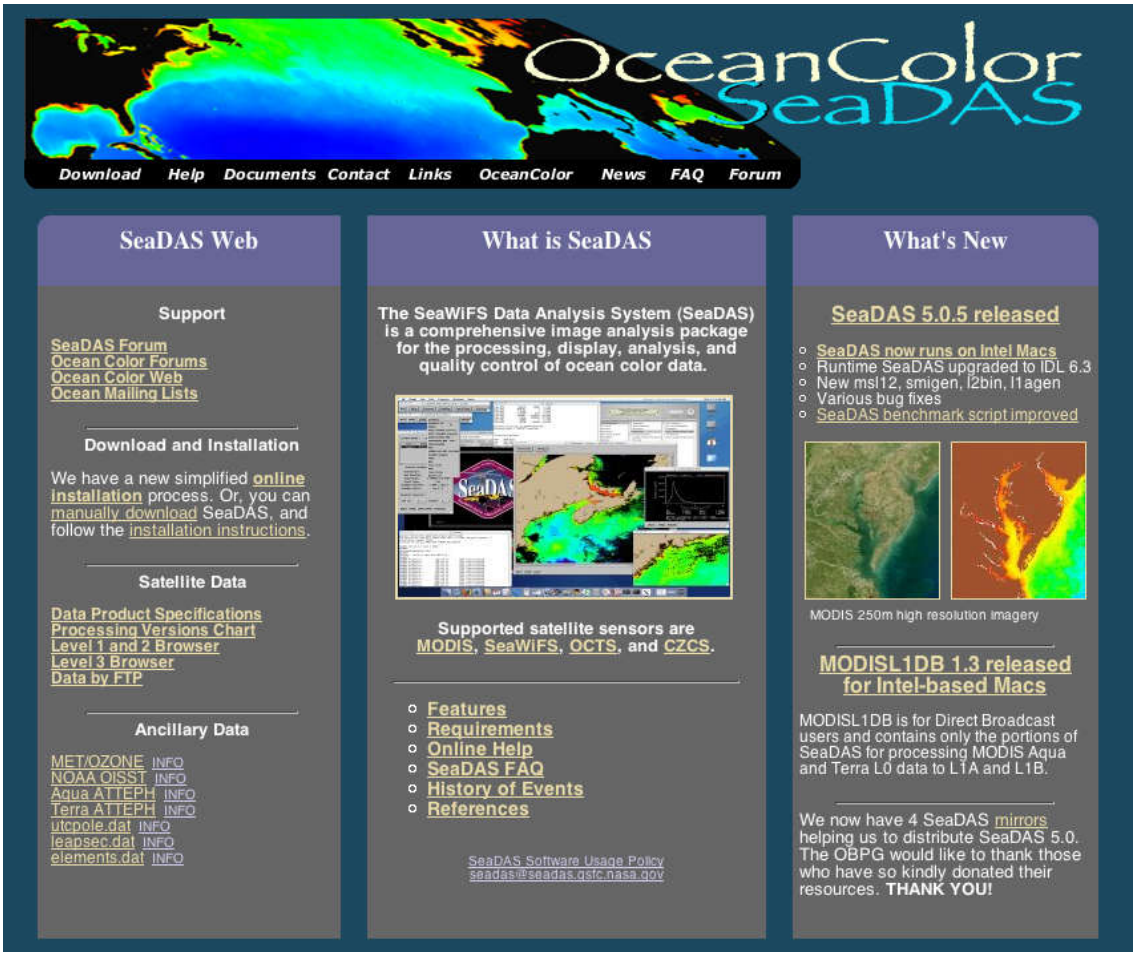

Figure 1.2: The SeaDAS Home Page

The SeaDAS GUI and most data visualization/manipulation functions are written in the Interactive Data Language (IDL), made by ITT Visual Information Solutions (ITT VIS). IDL is a scientific programming language and scientific environment similar in many ways to Matlab. It is not necessary to purchase IDL in order to have access to full SeaDAS functionality.

Figure 1.3: The Main SeaDAS GUI Window

1.4.1 SeaDAS Modes of Operation

SeaDAS functionality can be accessed in a variety of ways:

- **Using the Graphical User Interface (GUI)**
  - Virtually all SeaDAS functionalities are accessible via the GUI. The GUI is often a good way to learn about the capabilities of SeaDAS and to work with single data files. Once a user determines his or her goal and accomplishes a task using the GUI, it is often more efficient to automate the steps by using a command-line approach.
- **Using the SeaDAS command-line**
  - The SeaDAS command-line is available to those who have purchased a full IDL license from ITT. The SeaDAS command-line is actually an IDL command-line that provides access to both SeaDAS and IDL commands. Almost all SeaDAS processing, display, visualization, and manipulation functions can be accessed on the SeaDAS command-line in concert with IDL commands.
- **Using the UNIX command-line**
  - All SeaDAS **processing** capabilities are also accessible via the UNIX command-line. This includes L0 to L3 processing (including automatic ancillary data determination and retrieval), as well as functions for subscening data files and generating true-color mapped image products. None of SeaDAS' graphics capabilities are available on the UNIX command-line.
- **Automating SeaDAS using IDL scripts and/or UNIX shell scripts**
  - Virtually any series of SeaDAS processing and graphics operations can be automated by writing IDL scripts. These scripts can combine both SeaDAS and IDL commands (and optionally spawn UNIX commands) to perform complex data operations. **This feature does not require the purchase of IDL.**
  - For data processing, UNIX shell scripts can be used to easily automate the subscening and processing of multiple data files from L0 through to L3. IDL scripts can also be called from such UNIX shell scripts to access SeaDAS display, visualization, and manipulation functions.

1.4.2 Components of the SeaDAS Distribution

The SeaDAS distribution package is primarily made up of IDL code, C binaries and libraries, and UNIX shell scripts. The SeaDAS GUI is written in IDL code as are various image and data manipulation functions. Binaries (executable files created by compiling C and Fortran code) are used for data processing (e.g. the msl12 binary used for L1 to L2 processing). SeaDAS also makes use of HDF binaries and libraries. Shell scripts (executable text files containing various UNIX and shell commands) are mainly used as wrappers for data processing (e.g. modis_L1A_to_L1B.csh). Other shell scripts exist as stand-alone utility scripts (e.g. the ms_met.csh script for meteorological ancillary data determination and retrieval).

1.4.3 SeaDAS Support

As mentioned direct user support and extremely active user support forums are available for SeaDAS users. Direct support can be obtain via email (seadas@seadas.gsfc.nasa.gov) or by phone. However, most support occurs in the Ocean Color Forum (http://oceancolor.gsfc.nasa.gov/forum/oceancolor/forum_show.pl), where announcements are made and both technical and scientific questions and discussions take place. SeaDAS-specific technical questions are asked on the 'SeaDAS: General Questions' board, data access questions on the 'Satellite Data Access' board, and scientific queries on the 'Satellite Data Products & Algorithms' board.

TIP SeaDAS GUI windows have a *Help* button that will spawn that window's local help webpage. All SeaDAS-specific help documents are also available online: http://oceancolor.gsfc.nasa.gov/seadas/help.html

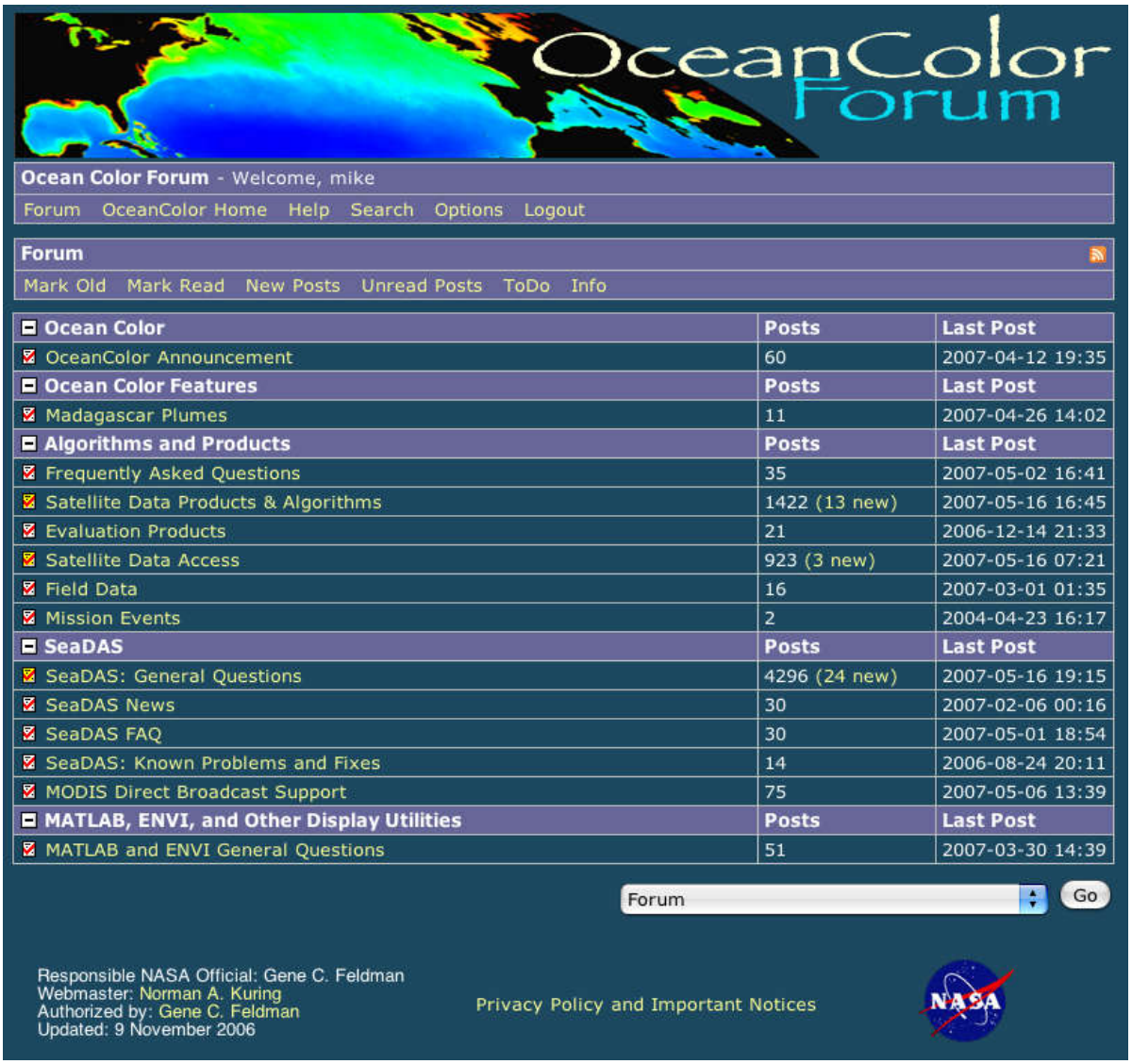

Figure 1.4: The Ocean Color Forum

Chapter 2

An Overview of Ocean Data Levels

Introduction

As mentioned, the OBPG is the designated NASA team responsible for the processing and distribution of ocean color and SST data acquired from the MODIS/Aqua, MODIS/Terra, SeaWiFS, OCTS, and CZCS sensors. This chapter discusses the standard NASA data levels used for storing ocean color satellite data. These data levels are distributed by the OBPG and/or are producible by the SeaDAS software package.

Goal

This chapter gives an introduction to the HDF file format and briefly describes the following standard OBPG satellite ocean data levels:

- Level-0
- Level-1A
- MODIS GEO
- Level-1B
- Level-2
- Level-3 Binned
- Level-3 Standard Mapped Images

2.1 HDF and HDF-EOS Data Formats

OBPG Level-1A to Level-3 data files are stored in the HDF file format. HDF can be thought of as a 'container' that can store a variety of data types and meta data in a single file (see Figure 2.1). From the NASA Atmospheric Science Data Center:

`Hierarchical Data Format (HDF) is a data file format designed by the National Center for Supercomputing Applications (NCSA) to assist users in the storage and manipulation of scientific data across diverse operating systems and machines. NCSA developed a library of callable routines and a set of utility programs and tools for creating and using HDF files. This work is now performed by The HDF Group (THG).`

OBPG files are actually stored in the HDF-EOS format, a specialized form of HDF created by NASA in 1993 as a standard format for all data generated by instruments on the Earth Observing System (EOS) satellites.

TIP SeaDAS is fully compatible with all OBPG HDF-EOS data files.

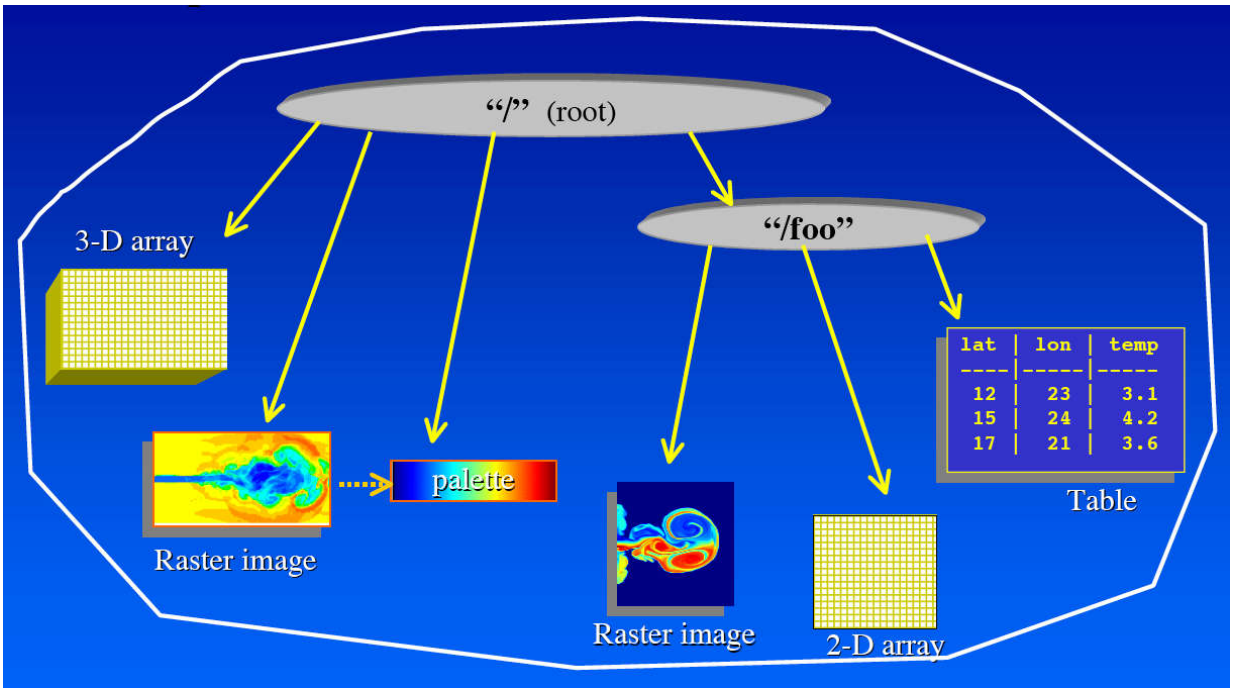

Figure 2.1: HDF File Example (Curtesy of The HDF Group)

2.2 Level-0 Data

Level-0 (L0) data files contain the raw radiance counts (digital numbers) and this is the lowest and most raw level of data normally available to end-users. **L0 data is rarely utilized by end-users since the Level-1A (L1A) data is usually a simple re-organization of the L0 data into the more friendly/standardized HDF-EOS format.** However, L0 data from MODIS Aqua and Terra may be desired because unlike MODIS L1A data (which has been ocean-band-subsetted), MODIS L0 data contains all 36 MODIS bands including the 7 high resolution bands, some of which may be useful for oceanic processing. As of July 2007, all MODIS L0 data is available from the single file selection page of the OBPG Level 1 and 2 Browser. A rolling 60-day archive of L0 MODIS Aqua and Terra data is also available via ftp://oceans.gsfc.nasa.gov/.

TIP SeaDAS has the ability to process L0 data to L1A for only the MODIS and SeaWiFS sensors, and can display only L0 SeaWiFS data.

2.3 Level-1A Data

L1A data files contain the sensor raw radiance counts (digital numbers) as well as spacecraft and instrument telemetry and calibration data. Navigation data is also included except for MODIS, in which case the geolocation data is contained in a separate file.

All L1A filenames use the SeaWiFS-like convention, which indicates sensor (e.g. S for SeaWiFS, A for MODIS-Aqua, T for MODIS-Terra), sampling rate (e.g. LAC for full 1-km sampling), and time of the first scan in the file (e.g. AYYYYDDDHHMMSS.L1A_LAC).

The entire mission archive of L1A ocean data for all sensors is maintained online, and all higher-level products are derived from this archive. **Due to the ever-changing nature of L1B calibration coefficients for active missions, it is recommended that researchers who intend to generate their own L2 products begin their processing using the L1A data (and an up-to-date version of SeaDAS).**

OBPG MODIS L0 to L1A processing is performed using the standard code developed by the MODIS Science Data Support Team (SDST) and all MODIS L0 and L1A files distributed by the OBPG are 5-minute granules. For file size and bandwidth reasons, MODIS L1A files are reduced (band-subsetted) by removing excess bands and data that are not utilized for oceanic processing. A standard MODIS L1A file is ~575MB (~220MB compressed), while a band-subsetted L1A file is ~215MB (~50MB compressed). The reduced Ocean L1A file format retains the bands shown in Figure 2.2).

MODIS Band	Wavelength (nm)	MODIS Band	Wavelength (um)
8	412	20	3.7
9	443	22	3.9
10	488	23	4.0
11	531	24	4.5
12	551	26	1.3
13lo	667	27	6.7
13hi	667	28	7.3
14lo	678	29	8.5
14hi	678	31	11
15	748	32	12
16	869		

Figure 2.2: MODIS Ocean Subset Band List

2.4 MODIS GEO Data

For the MODIS sensor only, a separate geolocation (GEO) file must be generated from an L1A file, and contains the navigation for that granule. L1B and L2 processing then requires the GEO file as an input. The naming convention for GEO files is similar to that of the L1A files, e.g. AYYYYDDDHHMMSS.GEO.

GEO files are not maintained in the long-term OBPG archive since they can be regenerated as needed using SeaDAS, so only a short-term rolling archive is made available for distribution by the OBPG. For the OBPG distribution's NRT stream, predicted attitude and ephemeris files are used to produce Quick-Look GEO files. Several days later, in the Refined processing stream, the definitive attitude and ephemeris files are used to create the final GEO version and refined data products.

2.5 Level-1B Data

Level-1B data files contain the calibrated at-aperture (top-of-atmosphere) radiances derived from L1A sensor counts by applying the sensor calibration. L1B files are named similarly to L1A files, e.g. AYYYYDDDHHMMSS.L1B_LAC or simply AYYYYDDDHHMMSS.L1B.

For non-MODIS sensors the end-user will rarely make use of L1B files since the processing software produces a L2 file directly from an L1A input. However, for MODIS processing, generating the L1B file is a required separate step. If the input MODIS L1A file is not band-subsetted, separate high resolution L1B files will also be produced, e.g. AYYYYDDDHHMMSS.L1B_HKM, AYYYYDDDHHMMSS.L1B_QKM.

There are differences between the MODIS L1B files produced by the OBPG and those from the MODIS Calibration Support Team (MCST). First, since ocean pixels are generally much darker than land and cloud pixels, a higher level of precision is required for ocean processing. Therefore the OBGP fine-tunes the MCST calibration coefficients for ocean data and so the ocean radiances will be slightly different (and hopefully improved). Second, the OBPG uses the ocean subsetted L1A files as input to the L1B processing so OBPG L1B files will contain only the bands listed in Figure 2.2. However, if SeaDAS is used to process

a non-subsetted L1A file, all the non-high-resolution MODIS bands will be present in the L1B file (the high-resolution bands will exist in separate L1B HKM ad QKM files).

2.6 Level-2 Data

Level-2 data files contain calculated geophysical values for each pixel (e.g. nLw's, Chlorophyll-a, SST) derived from the L1B radiances by applying atmospheric corrections and bio-optical algorithms. L2 data files also contain geolocation data. Each L2 product corresponds exactly in geographical coverage (scan-line and pixel extent) to its parent L1A product and is stored in one physical HDF file. As with previous levels, the data has not been mapped and so is in "satellite view".

L2 filenames have the form AYYYYDDDHHMMSS.L2_LAC. MODIS SST products require different processing parameters than other ocean products, therefore MODIS SST L2 files are generated in a separate processing run and are named AYYYYDDDHHMMSS.L2_LAC_SST or TYYYYDDDHHMMSS.L2_LAC_SST.

The L2 files distributed by the OBPG contain a standard suite of products including water-leaving radiances, chlorophyll *a* concentration, the diffuse attenuation coefficient at 490nm, and a few other products. In addition, thirty-two flags are associated with each pixel indicating if any algorithm failures or warning conditions occurred for that pixel. These flags exist in the 'l2_flags' product. The separate standard MODIS SST files contain the 11μ and 4μ (nighttime only) SST products. Five quality levels are associated with these SST products and are stored in the 'qual_sst' and 'qual_sst4' products. Using SeaDAS, L2 files can be creating that contain hundreds of pre-defined products and/or custom products.

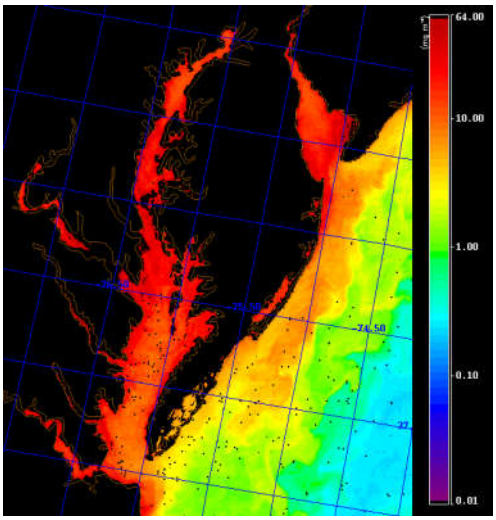

Figure 2.3: Level-2 Chlorophyll-a Product

Level-2 processing is performed using the Multi-Sensor Level-1 to Level-2 (`msl12`) code, which is developed and maintained by the OBPG. `msl12` is used for the standard processing of all ocean products distributed through the OBPG web browsers and ftp sites. This software is capable of retrieving oceanic optical properties and a multitude of derived products from the observed top-of-atmosphere (TOA) radiances. For non-MODIS sensors the L1A file is input to `msl12`, and for MODIS the L1B and GEO files are used as input. Full documentation, source code, and output product descriptions can be found at http://oceancolor.gsfc.nasa.gov/DOCS/MSL12/.

2.7 Level-3 Binned Data

Level-3 Binned (L3b) data files contain spatially and temporally binned L2 data products. In other words, an L3b data file consists of the accumulated L2 data statistics for the specified instrument, product(s), spatial resolution, and time period. Bins can be thought of as square grid elements or grid cells. (Prior to L3b, geophysical variables are derived only for individual satellite pixels.)

The statistical data provided in L3b files allow for the calculation of the mean, standard deviation, median, and mode for each L2 variable, and for certain other variables (e.g. primary productivity) which are functions of the L2 variables. The L3b data are stored in a representation of a global, sinusoidal equal-area grid (see Figure 2.4), and the standard OBPG-distributed bin resolutions are either 4.6km or 9.2km (certain regional products are 1km resolution). Only those bins containing data values are present in the L3b file; land bins and bins with no data are not stored. To create L3b files, the L2 files are spatially averaged into L3 Daily

binned files using the `l2bin` program, and the Daily files are further composited into Weekly, Monthly, Annual, Seasonal, and Climatological time periods using the `l3bin` program.

TIP SeaDAS can be used to create an L3b composite for an arbitrary time period, and the available SeaDAS binning resolutions are 0.5, 1, 2, 4, 9, and 36 kilometers.

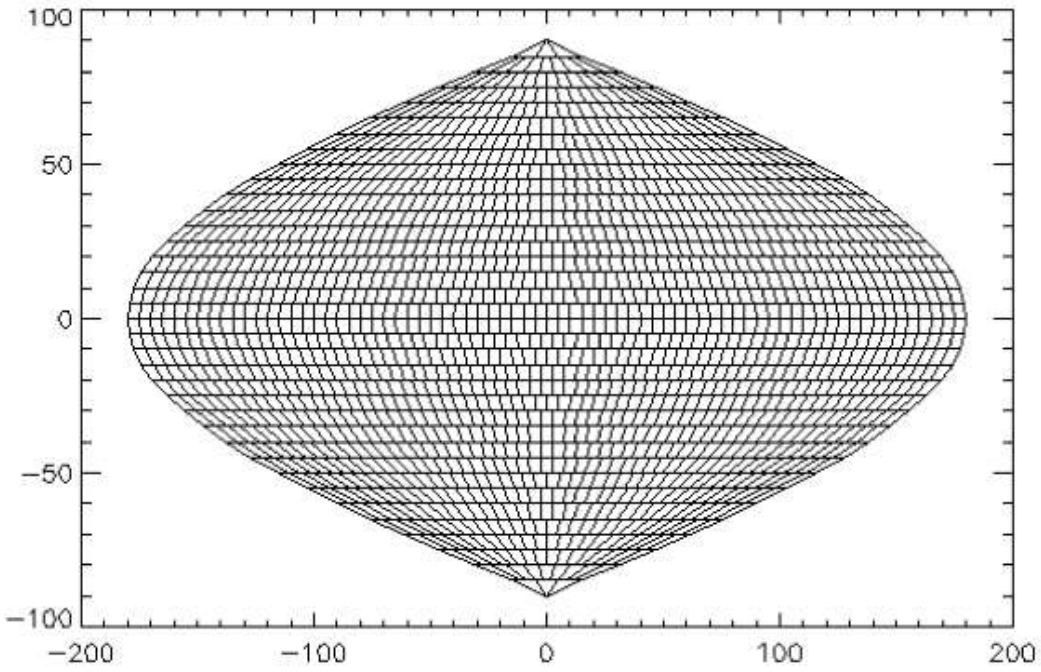

Figure 2.4: Square Bins Defined by a Sinusoidal Equal-Area Projection

The full suite of L2 ocean color parameters as well as three sea surface temperature parameters are available as standard temporal composites from the OBGP. Each product contains only data that has met data quality standards as indicated by a selected standard set of L2 flags and masks. SST products can contain data of varying data quality levels, but each bin will only contain the best quality data available for the time period.

L3b products are stored either in a single, self-contained file, or else in separate data files known as subordinates (for bandwidth and disk space considerations). Single-file L3b products have filenames of the form IYYYYDDDYYYYDDD.L3b_TTT, where I is the instrument identifier, YYYYDDDYYYYDDD are the concatenated digits for the GMT year and day of the start and end days of the binning period, and TTT is a code for the binning period length (DAY, 8D, MO, YR, etc.). For daily products, only the year and day of the data are used.

For the multi-file L3b products a 'main' file exists, containing all product-level metadata and other data common to all the binned geophysical parameters, along with the multiple subordinate files, each of which contains the data of one binned geophysical parameter. An example of the filenames used for a multi-file SeaWiFS L3b Daily product is:

S1998001.L3b_DAY.main
S1998001.L3b_DAY.x00
S1998001.L3b_DAY.x01
...
S1998001.L3b_DAY.x10

Although it is not necessary to know which subordinate file stores which product (SeaDAS automatically

handles this), each extension number (x00, x11, etc.) is permanently assigned to a certain geophysical product. For example, the extension numbers for SeaWiFS are assigned as follows:

x00 ⟶ nLw_412
x00 ⟶ nLw_412
x01 ⟶ nLw_443
x02 ⟶ nLw_490
x03 ⟶ nLw_510
x04 ⟶ nLw_555
x05 ⟶ nLw_670
x06 ⟶ angstrom_510
x07 ⟶ chlor_a
x08 ⟶ K_490
x09 ⟶ eps_78
x10 ⟶ tau_865

TIP L3 Binned data products are stored as VDATA HDF objects within the data files, so any HDF utility such as *vshow* can be used to obtain information about the contents of the data files.

More L3b documentation including algorithms used for spatial and temporal binning are listed in the OBPG *Algorithms and Products* FAQ: http://oceancolor.gsfc.nasa.gov/forum/oceancolor/topic_show.pl?tid=1959

2.8 Level-3 Standard Mapped Images

A Level-3 Standard Mapped Image (SMI) is an equidistant cylindrical projection of the arithmetic means derived from the statistical data of one Level-3 Binned geophysical product. (The equidistant cylindrical projection is also called the equirectangular projection or geographic projection.) Therefore SMI products are image representations of binned data products over the period covered by the parent product.

The OBPG distributes global SMI maps at 4.6km (4320×2160) and 9.2km (8640×4320) resolution to match the L3b standard resolutions. Grid points for the entire globe are present in the data files, including an assigned fill value for land and missing data points. SMI files are distributed both as HDF files and as PNG (Portable Network Graphics) image files. The SMI HDF product files are created using the `smigen` program.

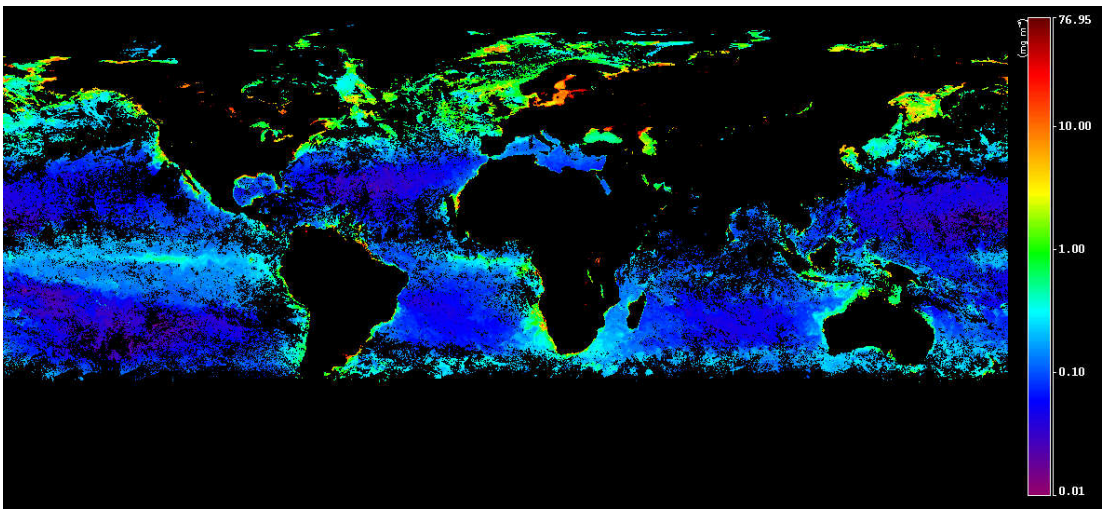

Figure 2.5: 8-Day Level-3 Standard Mapped Image (MODIS Aqua Chlorophyll-*a*, June 2007)

All of the OBPG-distributed SMI products are stored as 16-bit integers (scaled down from the 32-bit floating-point L3b products).

Due to scaling of the L3b data values and problems that may arise from mapping, researchers should fully understand the issues involved with the SMI format before using these maps for scientific purposes. Often using the L3 Binned data directly instead of mapping the bins may be the best approach.

TIP SeaDAS has the flexibilty to create SMI maps as 8-bit integer data, 16-bit integer data, or 32-bit floating-point data at 1, 2, 4, 4.6, 9, 9.2, or 36 kilometer resolutions.

Chapter 3

Obtaining Ocean Data

Introduction

As mentioned, the OBPG is the designated NASA team responsible for the distribution of ocean color and SST data acquired from the MODIS/Aqua, MODIS/Terra, SeaWiFS, OCTS, and CZCS sensors (this role had been previously shared by the NASA Goddard DAAC). The OBPG offers complete historical archives for each sensor, as well as near real-time (NRT) data for active missions. The access point for all OBPG data sets is the main OBPG webpage, the Ocean Color Web (http://oceancolor.gsfc.nasa.gov/).

Goal

This chapter outlines the various data access methods available via the Ocean Color Web. Each method for data access will be briefly discussed:

- Historical Data Access
  - SeaWiFS Data Access
  - The Level 1 and 2 Browser
  - The Level 3 Browser
  - Data by FTP
- Near Real-Time Data Access
  - Data Subscriptions for NRT Data
  - NRT Extracts and Maps
  - Data by FTP
- Citing Data Products Obtained from the Ocean Color Web

3.1 Historical Data Access

Complete historical data archives for all sensors are available for immediate download from the OBPG servers, with the exception of certain SeaWiFS data restrictions (see below). Data from active missions are made available as soon as the processing system can ingest and process it (MODIS/Aqua and MODIS/Terra data is normally available within 2-5 hours of capture).

3.1.1 SeaWiFS Data Access

The only OBPG-distributed sensor data with access restrictions is SeaWiFS data, which is currently under a two week embargo from date of collection (per the contractual agreement with GeoEye). Therefore SeaWiFS files less than two weeks old are unavailable.

All SeaWiFS data greater than five years old is publicly available, but data less than five years old is not available to the general public unless they become a SeaWiFS Authorized User. To become an authorized user one must make a (brief) request to the OBGP specifying the scientific rationale for the request along with some other information (see http://oceancolor.gsfc.nasa.gov/cgi/apply.pl?page=du). Authorized users can then use the 'SeaWiFS User Login' button in the data browser to gain access to all the SeaWiFS data.

On December 24, 2004, the SeaWiFS project stopped receiving global data from HRPT stations (from which the MLAC data are produced). Since that time the OBPG contract with OrbIMAGE (now GeoEYE) is only for the global GAC dataset, and a new agreement has also provided the OBGP with the coastal U.S. 1km dataset. A request for recorded LAC data can also be made to the OBPG for cruise support, but NRT MODIS 1km data is now the preferred source. For non-coastal U.S. 1km data after Dec 24, 2004, data can be purchased directly from GeoEYE.

3.1.2 The Level 1 and 2 Browser

The 'Level 1 and 2 Browser' link on the Ocean Color Web homepage accesses the main browser interface for selecting, downloading, and ordering Level-1 and -2 data files (as well as MODIS L0 files). From this top-level interface, search criteria can be set and then searches launched for the matching Level-1 and -2 scenes (using the 'Find swaths' button or by clicking on the map).

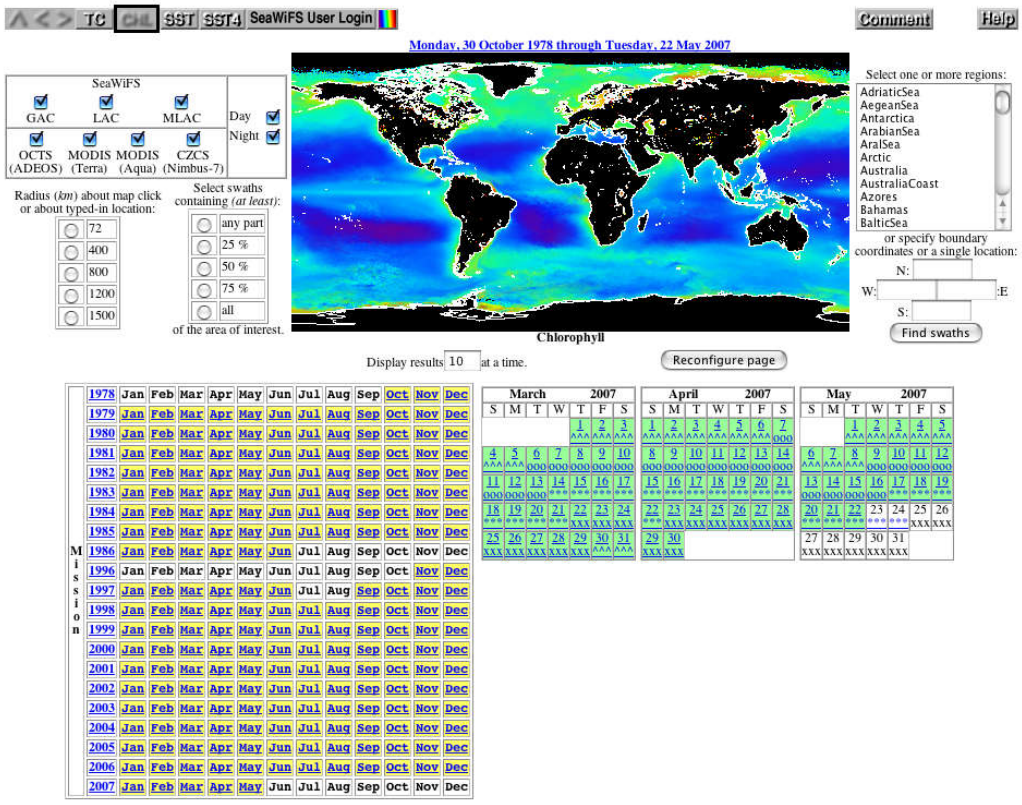

Figure 3.1: The Level 1 and 2 Browser

Search criteria of the data browser include:

- Sensor(s)
- Day and/or night scenes
- Geographic location defined by:
  - A predefined area of interest
  - User-specified area of interest (lat/lon box)
  - Scenes directly under mouse click on global map
  - Radius about mouse click on global map
  - Radius about specified lat/lon
  - Minimum percent of swath falling within area of interest
  - Date range (contiguous or non-contiguous)

When using the data browser, a 'Help' button is available in the upper-righthand corner of each different type of browser page to provide help topics for all the functionalities on that page. Since this help feature details all of the minute functions of the browser, these details will not be discussed here.

After a search has been launched using the 'Find swaths' button or by clicking a location on the global map, the search results will be displayed on a new browser page. If only one swath was found, then that swath's files will be listed as hyperlinks for immediate download along with thumbnail browse images of the data.

If more than one swath matches the search criteria, the results page will display multiple matching swath filenames and thumbnails (10 per page by default). An individual swath can be selected by clicking on its filename link, or a swath can be added to a user's 'shopping cart' by clicking the asterisks link ("****"). At any time clicking the 'ORDER DATA' button will take the user to the Scene Order Form page.

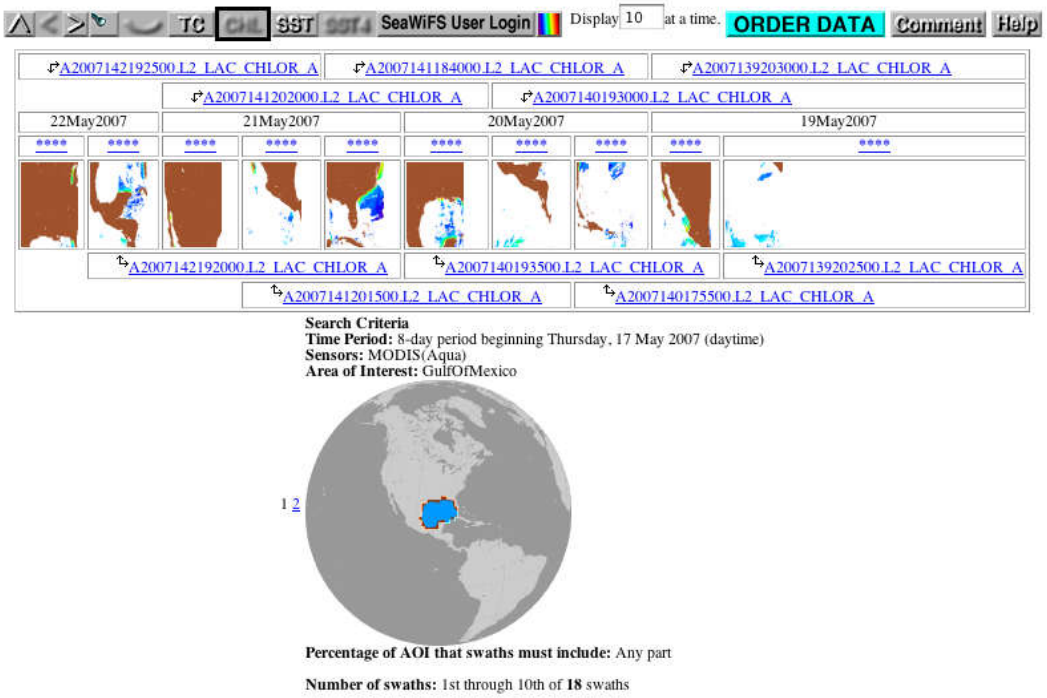

Figure 3.2: Level 1 and 2 Browser Search Results

On the Scene Order Form page the order can be viewed and the user must specify:

- An email address
- Whether or not to extract a specific region from the data files
- Data levels desired
- Level-2 Data products desired

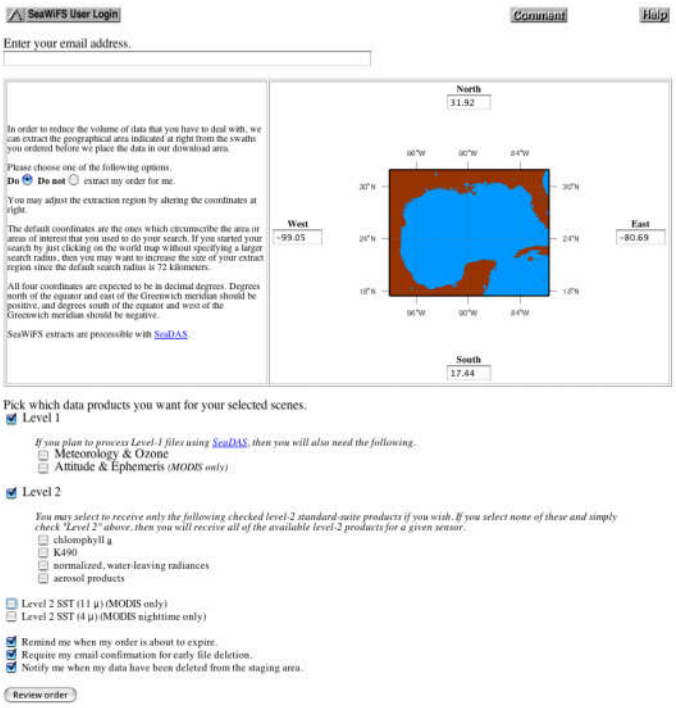

Figure 3.3: Level 1 and 2 Browser Order Form

Next, the 'Review order' button is clicked to continue to the Order Review page that will list all files to be staged. If the order looks correct, the user can then click the 'Submit Order' button to complete the Order.

Once an order is submitted the OBPG server will begin staging the requested files and send an email notification when the files are available for download. The entire ordering and staging process is completely automated so many orders will be available within minutes of submission.

3.1.3 The Level 3 Browser

The 'Level 3 Browser' link on the Ocean Color Web homepage accesses the interface for selecting and downloading the entire Level-3 global ocean color data set for many parameters and time periods. The Level-3 files in this browser have been converted from Level-3 Binned data files to Standard Mapped Images stored both as digital data in HDF formatted files and as PNG images. Both 4km and 9km data are available.

A variety of standard and evaluation products can be selected, and clicking on the timeline will set a start date for products to be displayed. Below the timeline is a table of thumbnail images depicting global projections of the selected product type during various time periods. Next to the thumbnails are hyperlinks to the 4km (4320x2160) and 9km (8640x4320) HDF and PNG files. Each column in the table is associated with time periods of a fixed length such as a year, a season, a month, or an eight-day 'weekly' period. Clicking on the

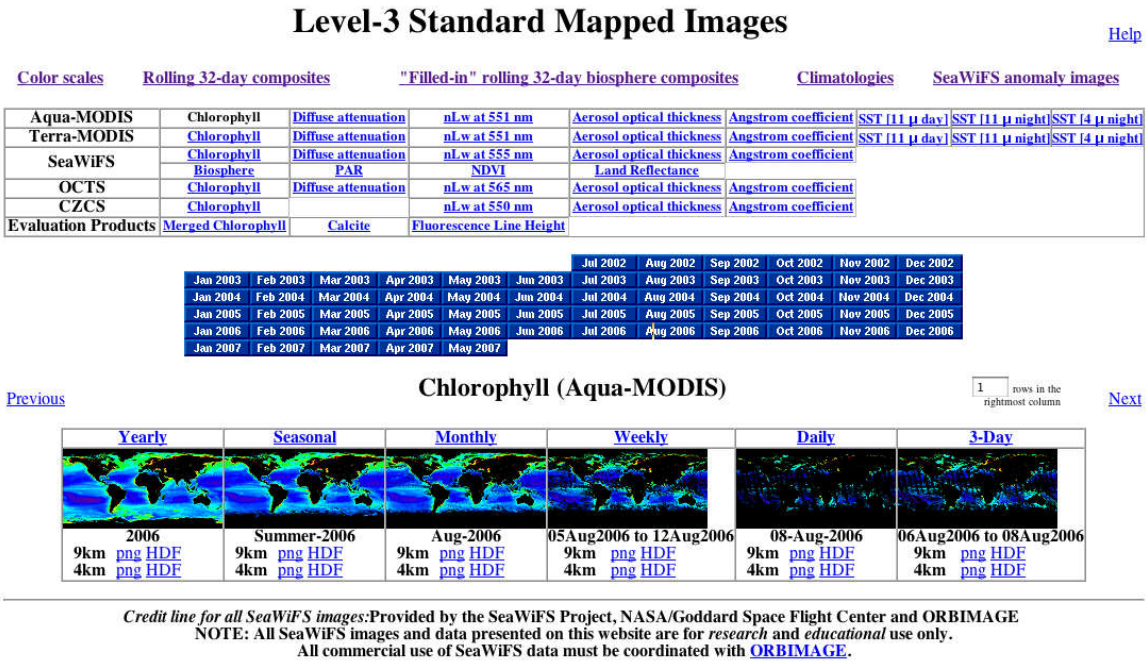

Figure 3.4: Level 3 Browser

heading of a column will toggle back and forth between displaying and not displaying the images in that column. The 'Help' link in the upper-righthand corner of the browser gives more detailed help instructions.

TIP The timeline is implemented as a client-side image map so as the pointer is moved along the timeline, changing dates can be viewed in the status line of a web browser.

3.1.4 Data by FTP

Along with web browser (html) access, the OBPG also hosts an anonymous ftp server, **oceans.gsfc.nasa.gov**. This ftp site contains the most popular data products including:

- A 60-day rolling archive of recent MODIS Aqua and Terra data (L0, L1, GEO, L2)
- The complete Level-3 Binned data archive for all sensors
- The complete Level-3 Standard Mapped Image archive for all sensors
- A merged Aqua/SeaWiFS 9km chlorophyll product
- Ancillary products (e.g. METOZ, OISST, ATTEPH, etc.)

3.2 Near Real-Time Data Access

As opposed to historical data access, the OBPG also offers services for data users interested in receiving NRT data from active missions. Currently, the primary NRT data source is from the MODIS Aqua and Terra sensors. Typical latency for MODIS data is 2-5 hours following satellite observation. **This minimal latency allows the OBPG servers to be used as a global MODIS virtual ground station.**

As mentioned, it is also possible to make a request for small amounts of NRT SeaWiFS recorded LAC data for cruise support.

3.2.1 Data Subscriptions for NRT Data

Data subscriptions can be used to automatically stage new Level-1 and Level-2 data products to user-specific ftp directories. Subscriptions are simple to create and consist of a defined region for which data are made available as they are processed. This option is intended for investigators who wish to receive all future data for a region. The subscription does not provide archived (historical) data to the user; for archived data the Level 1 and 2 Browser should be used. Data subscriptions can be created for limited geographic regions, allowing users to receive L1A, L1B, and L2 data extracts for their area(s) of interest within 2-5 hours of satellite observation. Once a subscription is set up along with automated downloads, this service can mimic an actual global ground station for each user.

Data types available through the subscription service are:

- Aqua Level-1 and Level-2
- Terra Level-1 and Level-2 (SST only)
- SeaWiFS Level-1 and Level-2
- Associated ancillary data (MET, OZONE, attitude and ephemeris files)

There is also an option to waiting until the refined processing has occurred (i.e. waiting until the data are processed with the optimal ancillary data), or receiving data in near real-time. Typically, refined processing occurs 3-5 days after the data are received. The status of an existing subscriptions can be checked via a web interface as well. If both refined and NRT data is desired, users can simply make two separate subscription requests. The same can be done to obtain both daytime and nighttime granules.

An end date can be entered for the subscription if your research interests are limited temporally (i.e. for the duration of a cruise). If no end date is specified, the subscription will continue for the life of the mission. Also, if a subscription has expired, it can be restarted again by simply entering an email address and clicking the 'Renew Subscription' button. This will retrieve a listing of all previous subscriptions made under the email address, and allowing selection of those to renew.

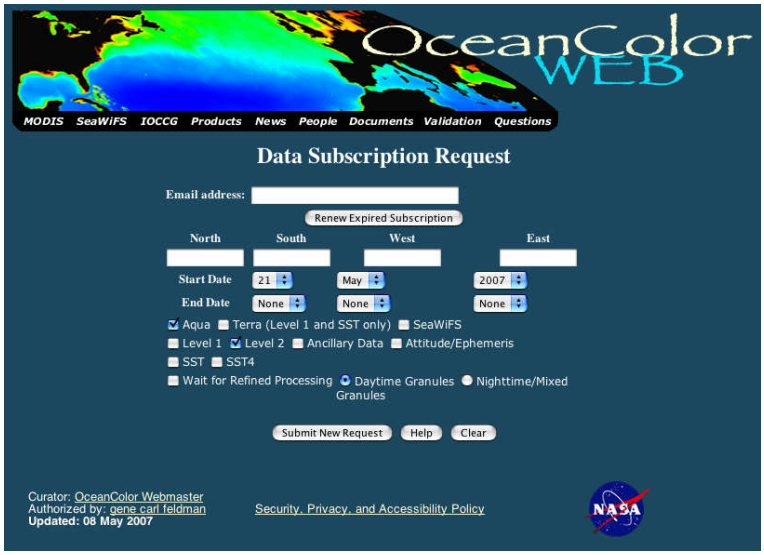

Figure 3.5: Data Subscription Form

3.2.2 NRT Extracts and Maps

The NRT map and extraction utility (see Figure 3.6) allows users to directly access the NRT image support system in order to create regions and requests for both maps (PNG and/or JPG formatted mapped products) and data extraction (HDF extracts).

The first step in the map and extraction process is to select a region. Users may either choose from a pre-defined list of regions, or define a new region. Pre-defined regions are fixed, and cannot be edited by users and user-defined regions are only usable/editable by the user who created them.

Once a region is selected, a request for maps and/or data extraction must be defined. At this stage, the user chooses maps (PNG and/or JPG formatted mapped images) and/or L1/2 HDF data extracts.

The following options may be defined for each map request:

- Image Width
- Add a coastline
- Add a graticule frame
- Add lat/lon gridlines
- Add a colorbar
- Add a label to the image containing the parent filename
- Threshold for minimum percent of valid pixels (ocean retrievals)
- Product selection

Users may opt to have JPEG/PNG images, and/or digital data (HDF) extracts of Level-1 and Level-2 files created. Images can be sent to the user via email or placed on the OBPG anonymous FTP site for download. All HDF data will be place on the anonymous FTP site for download.

NRT images from SeaWiFS are available only to authorized SeaWiFS data users who have received permission to receive real-time image support.

3.2.3 Data by FTP

As mentioned earlier in this chapter NRT data is available from the OBPG ftp server **oceans.gsfc.nasa.gov**.

3.3 Citing Data Products Obtained from the Ocean Color Web

Data products retrieved from the OBPG should be cited as follows:

Feldman, G. C., C. R. McClain, Ocean Color Web, <SENSOR> Reprocessing <reprocessing #>, NASA Goddard Space Flight Center. Eds. Kuring, N., Bailey, S. W. <Access DATE>. http://oceancolor.gsfc.nasa.gov/

- replace <reprocessing #> with the appropriate reprocessing version (e.g. 5)
- replace <Access DATE> with the date of access
- replace <SENSOR> with the appropriate sensor (e.g. SeaWiFS)

Figure 3.6: NRT Extracts and Mapping Form

Chapter 4

The SeaDAS GUI

Introduction

Most SeaDAS functions are accessible via the SeaDAS Graphical User Interface (GUI). This chapter will overview the `SeaDAS Main Menu` window which gives access to all GUI functionality. Note that virtually every function available through the GUI also has a command-line equivalent.

Goal

The goal of this chapter is to introduce the primary functions of the `SeaDAS Main Menu`.

4.1 Starting the SeaDAS GUI

Starting SeaDAS on the UNIX command-line without any extra arguments will spawn the `SeaDAS Main Menu` (see Figure 4.1). This window is comprised of the *Display* button, the *Process*, *Utilities*, *Update*, *Help* menus, and the *Quit* button. Note that the SeaDAS GUI requires the terminal's display to be set to an X server.

Figure 4.1: `SeaDAS Main Menu` Window

The SeaDAS GUI and most of its display functionality use the Interactive Data Language (IDL), a general purpose computer language and data analysis environment distributed by ITT Visual Information Solutions (ITT VIS). However, it is not necessary to purchase IDL to use *runtime* SeaDAS, which uses a free IDL "embedded license". Running SeaDAS in this mode will take slightly longer to start up, but thereafter will run as fast as with a full IDL development license. All SeaDAS functions behave identically in runtime and non-runtime mode.

SeaDAS is started as follows (where % is a UNIX command-line prompt):

- If you have not purchased IDL, start SeaDAS in *runtime* mode:
  `% seadas -em`
- If you have purchased and installed IDL:
  `% seadas`

4.2 The *Display* Button

Clicking the *Display* button will spawn a file selection window to choose a file from which individual data products can be loaded and later displayed. SeaDAS will attempt to automatically detect the file-type, and if unsuccessful, will assume it to be a flat binary file. File-types supported are:

- MODIS L1A to L3
- SeaWiFS L0 to L3
- MOS, OCTS, CZCS L1A to L3
- AVHRR Pathfinder V4 and V5
- SeaDAS Mapped (HDF files containing projected products)
- HDF 4 (including navigation functionality if lat/lon SDs exist)
- PNG image files
- Flat binary data files

4.3 The *Process* Menu

The *Process* menu provides access to all of the SeaDAS processing functions. This menu is broken down by sensor, and Figure 4.2 shows the *MODIS* processing submenu. Note that each sensor submenu is organized from lower to higher data level processing operations.

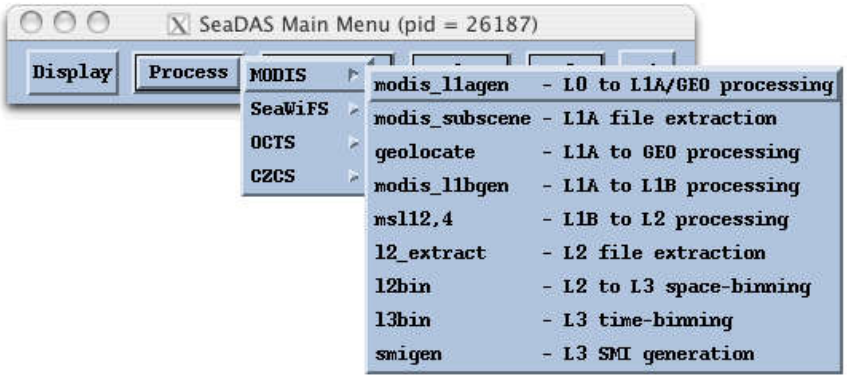

Figure 4.2: The *Process* Menu

4.4 The *Utilities* Menu

The *Utilities* menu provides access to a variety of SeaDAS utilities for loaded and/or displayed products. The *Data Visualization* and *Data Manipulation* submenus shown in Figure 4.3 access most of the analysis functions available in SeaDAS.

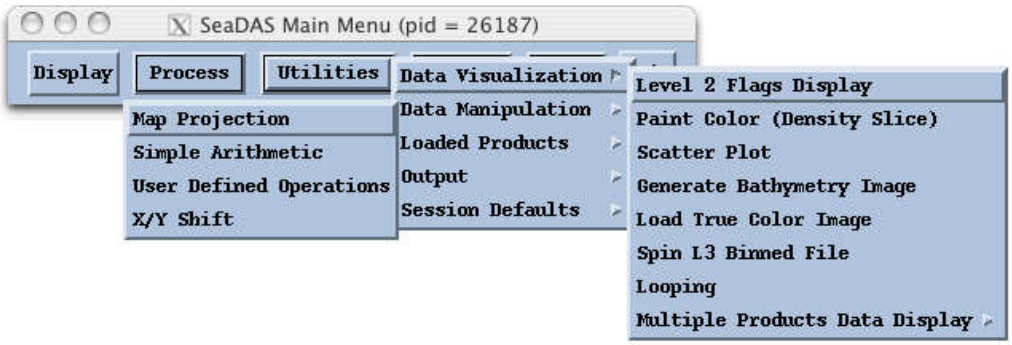

Figure 4.3: The *Utilities* Menu

4.5 The *Update* Menu

The *Update* menu provides functions for updating MODIS Aqua and Terra calibration LUTs used in L1A to L1B processing. (To fine tune calibration for ocean products the OBPG continuously modifies the standard MCST L1B LUTs to reduce detector striping artifacts and improve temporal extrapolation.) The *Update* menu can also update the utcpole.dat and leapsec.dat ancillary files, though the processing software itself will detect and update these files as well.

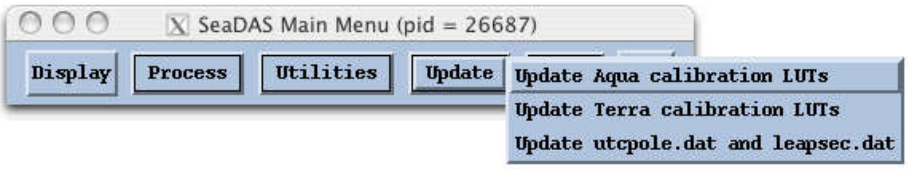

Figure 4.4: The *Update* Menu

4.6 The *Help* Menu

The *Help* menu provides access to the main SeaDAS help pages, tutorials, demos, and online help. Also note that clicking the *Help* button in any SeaDAS window will spawn a separate help page for that window in a web browser.

4.7 The *Quit* Button

Clicking the *Quit* button will immediately close all SeaDAS GUI windows and completely exit SeaDAS, returning the user to the UNIX command prompt.