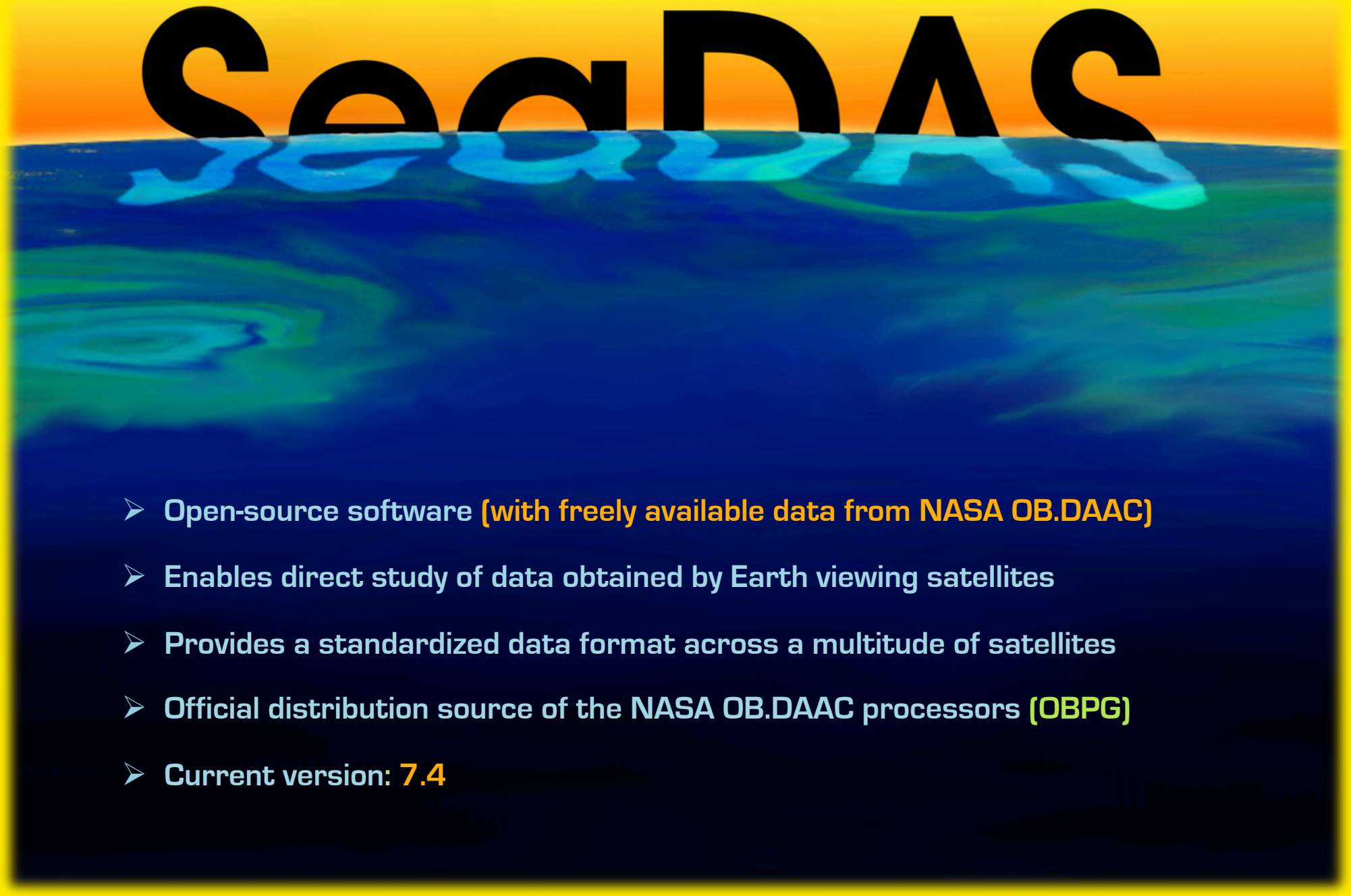
SeaDAS Introduction

Prepared for IOCS 2017

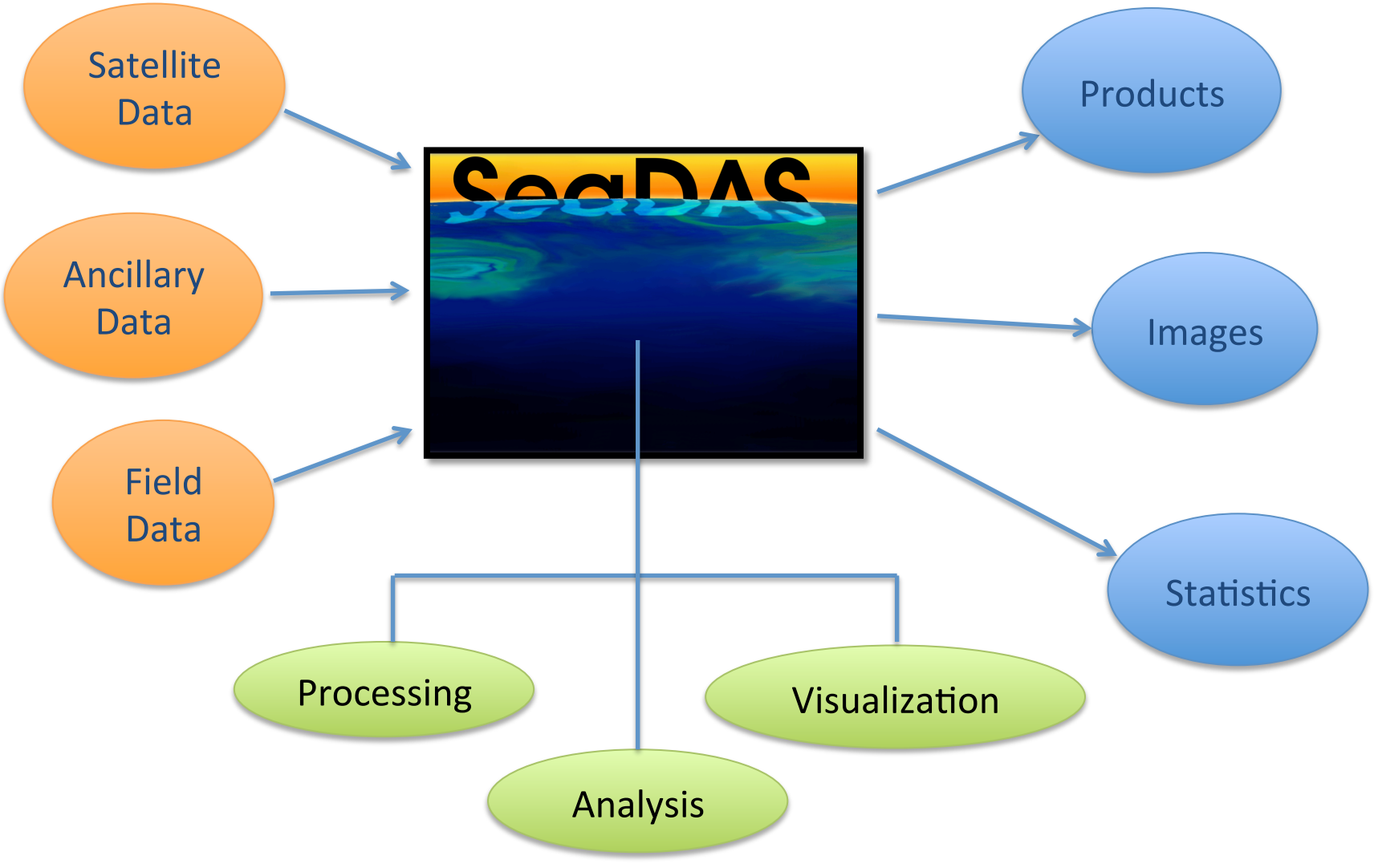
May, 2017

Ocean Biology Distributed Active Archive Center (OB.DAAC)
NASA - Goddard Space Flight Center
www.seadas.gsfc.nasa.gov

SeaDAS: The Official NASA (OB.DAAC) Processing Software

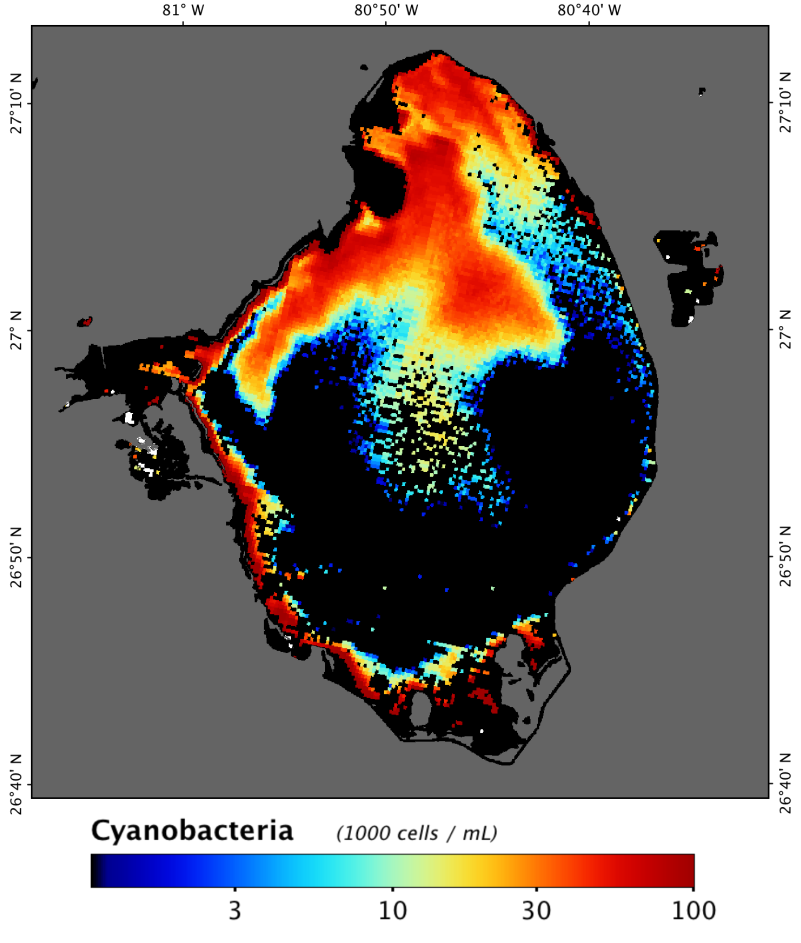


- Open-source software (with freely available data from NASA OB.DAAC)
- Enables direct study of data obtained by Earth viewing satellites
- Provides a standardized data format across a multitude of satellites
- Official distribution source of the NASA OB.DAAC processors (OBPG)
- Current version: 7.4

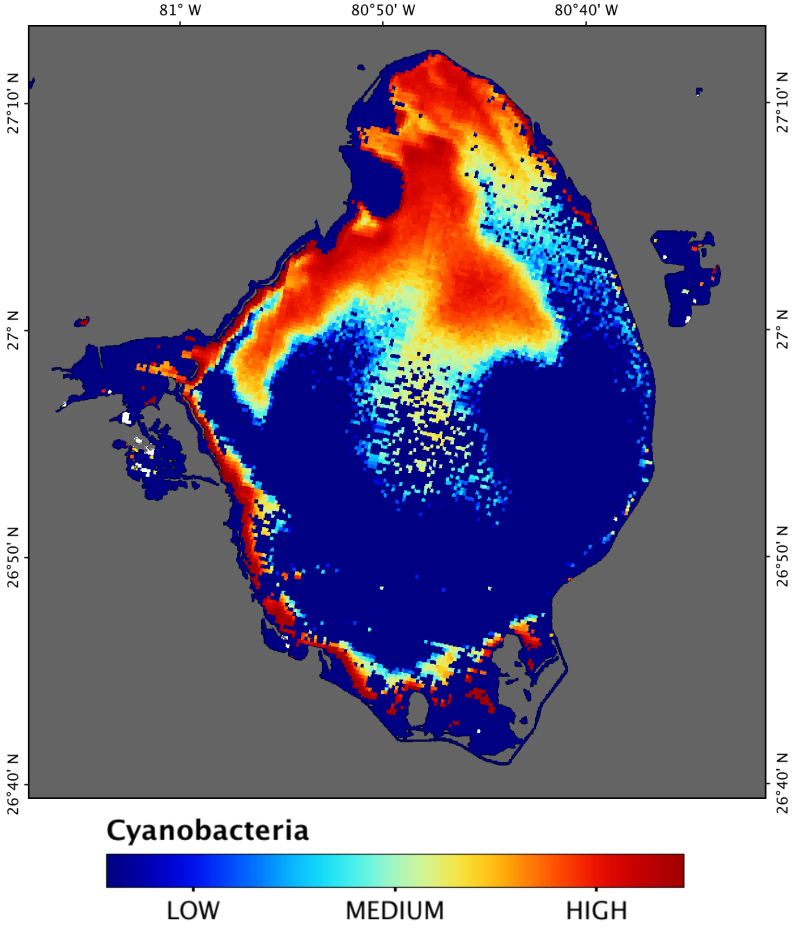

Satellite Data
Ancillary Data
Field Data
SeaDAS
Products
Images
Statistics
Processing
Analysis
Visualization

SeaDAS Sample Imagery

Cyanobacteria Concentration in Lake Okeechobee Satellite Derived Imagery (MERIS - June 22, 2011)



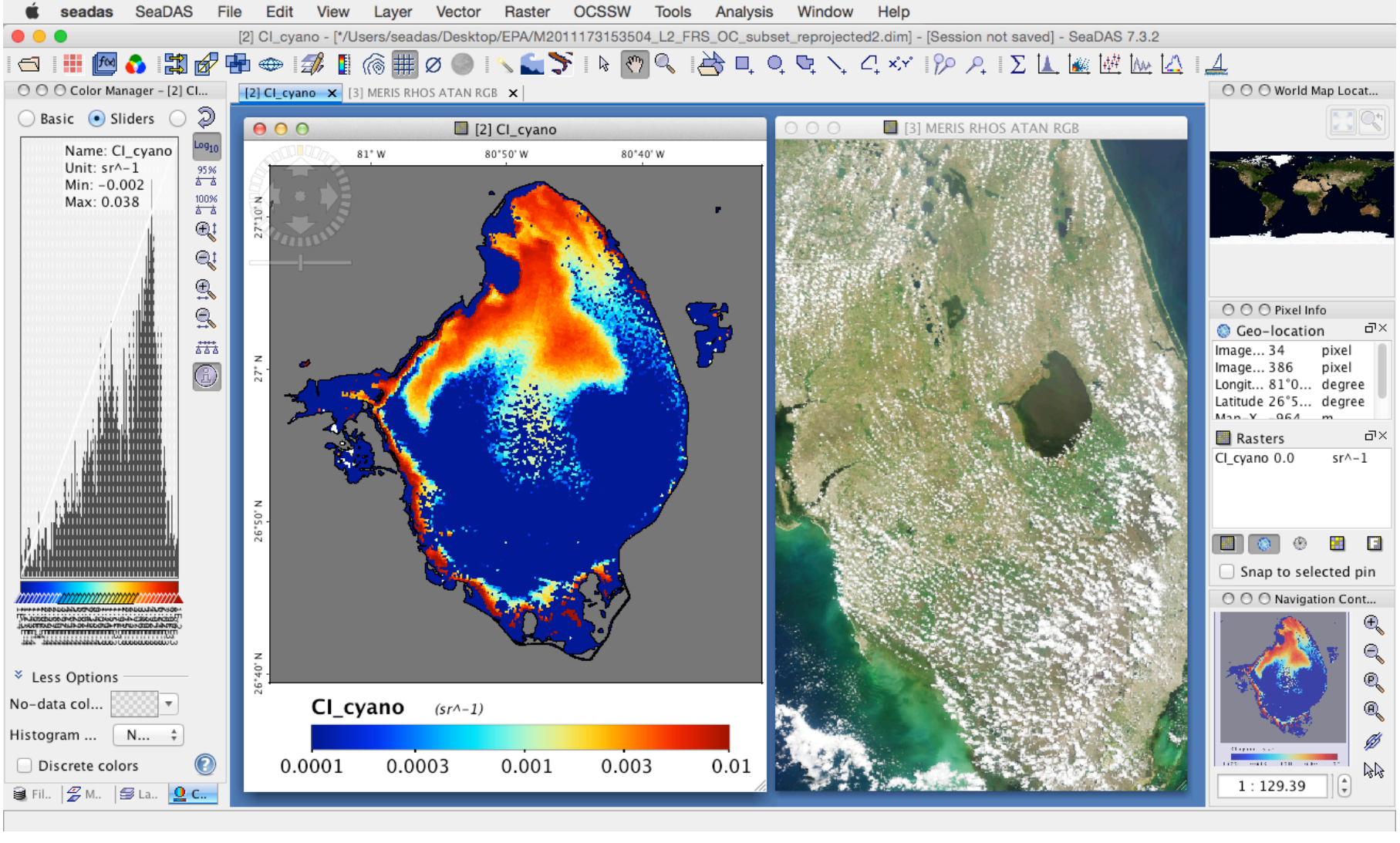
"Universal" color palette
Modified with black low end



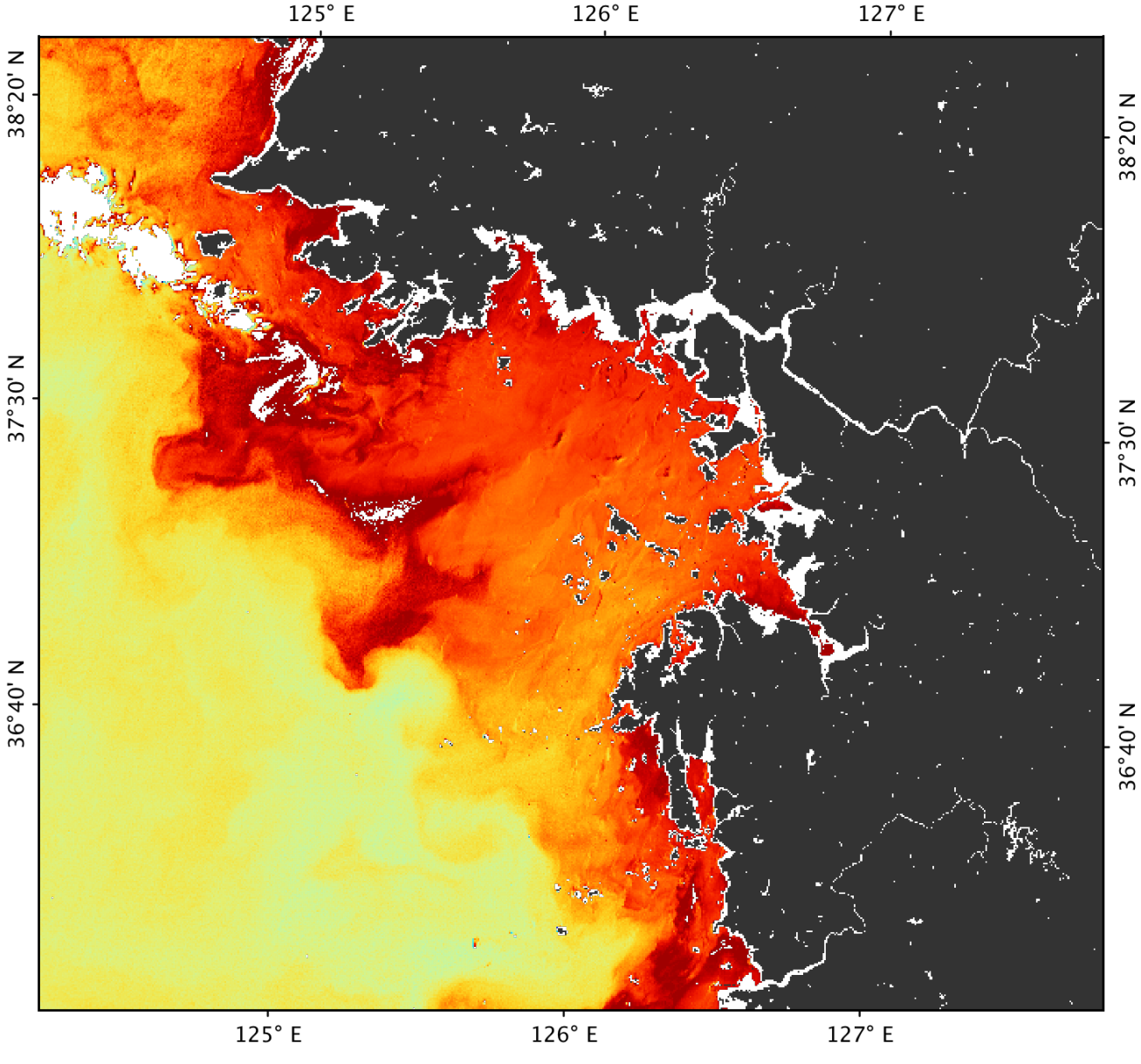
"Universal" color palette
Word label

Source data: MERIS satellite file M2011173153504

Cyanobacteria Concentration in Lake Okeechobee Satellite Derived Imagery (MERIS - June 22, 2011)



SeaDAS Sample Imagery

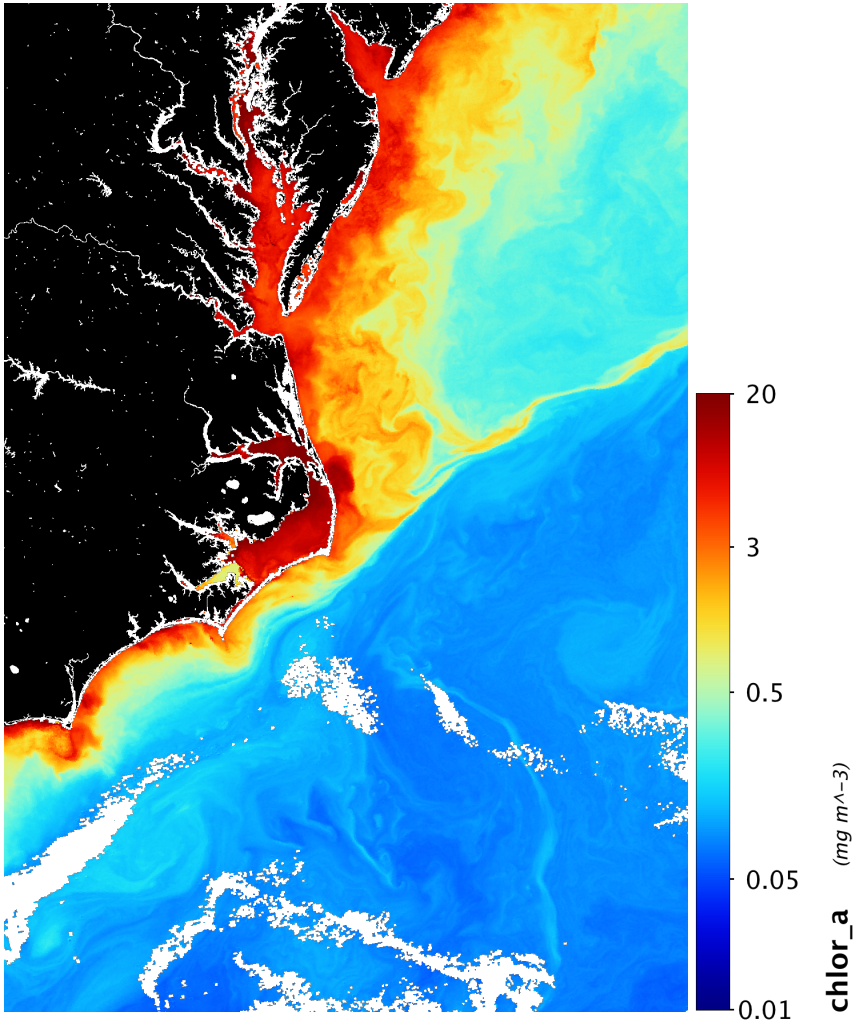


Chlor_a with land mask

The NASA OB.DAAC Product

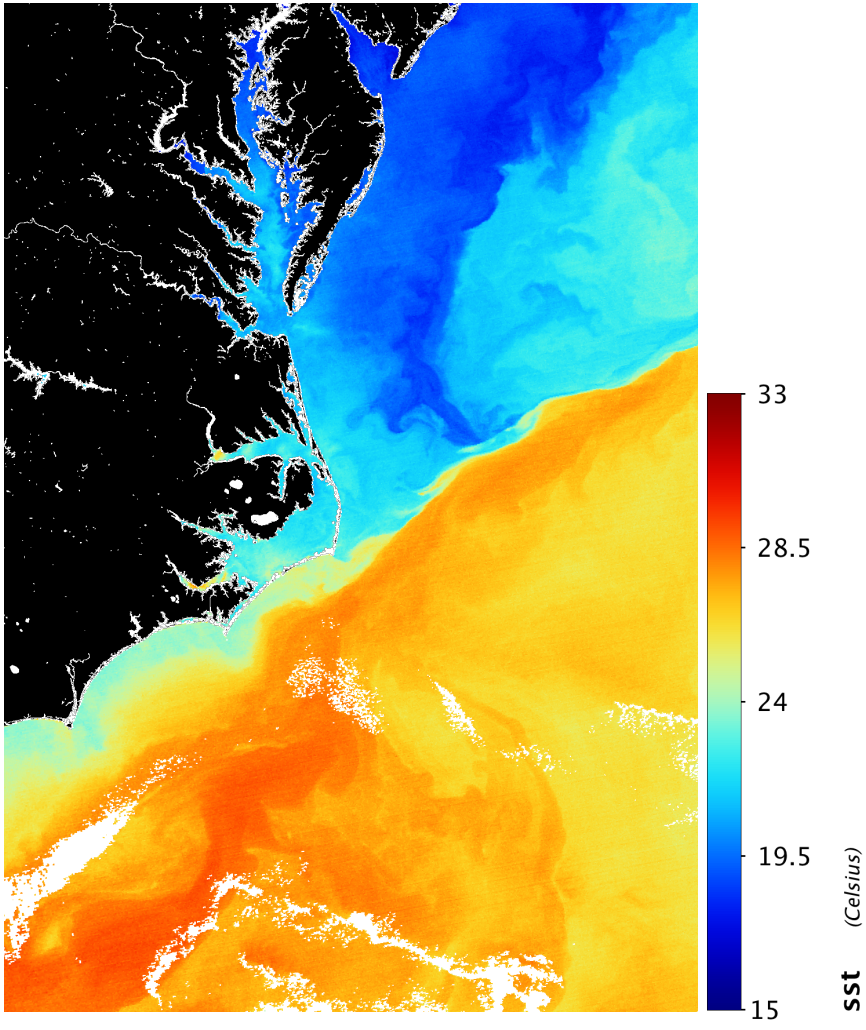
Chlorophyll (chlor_a)

Satellite-based measurement of the near-surface concentration of the photosynthetic pigment chlorophyll-a



Sea Surface Temperature (sst)

Satellite-based measurement of the water skin surface temperature



Standard Product Suites

- OC
  - aot — Aerosol Optical Thickness
  - angstrom — Aerosol Angstrom Exponent
  - Rrs — Remote Sensing Reflectance
  - chlor_a — Chlorophyll Concentration
  - chl_ocx — Chlorophyll Concentration (uses historic oc3 algorithm)
  - Kd_490 — Diffuse Attenuation Coefficient
  - pic — Particulate Inorganic Carbon
  - poc — Particulate Organic Carbon
  - ipar — Instantaneous Photosynthetically Available Radiation
  - nflh — Normalized Fluorescence Line Height
  - par — Photosynthetically Available Radiation
- SST
  - sst — Sea Surface Temperature (if available in mission - usually 11 µm)
- IOP
  - a — Total Absorption
  - bb — Total Backscattering
  - aph — Absorption due to Phytoplankton
  - adg — Absorption due to gelbstoff and detrital matter
  - bbp — Particulate Backscattering
  - rrsdiff — Fractional Mean Rrs Difference

A sampling of other Products

- Lt — Top of Atmosphere Radiance
- Lw — Water Leaving Radiance
- nLw — Normalized Water Leaving Radiance
- rhot — Top of Atmosphere Reflectance
- rhos — Surface Reflectance
- ndvi — Normalized Difference Vegetation Index
- Zeu — Euphotic Depth
- sena — Sensor Azimuth Angle
- senz — Sensor Zenith Angle
- sola — Solar Azimuth Angle
- solz — Solar Zenith Angle
- ozone — Ozone Concentration
- pressure — Surface Pressure
- water_vapor — Water Vapor Concentration
- windspeed — Wind Speed
- windangle — Wind Direction
- cloud_albedo — Cloud Albedo
- epsilon — Single-Scattering Aerosol Epsilon
- lat — Latitude
- lon — Longitude
- elev — Elevation Above Sea Level
- CI_cyano — Cyanobacteria Index

Atmospheric Correction

✧ **SeaDAS uses atmospheric correction algorithms to effectively remove the atmospheric components from the at-sensor signal in order to determine L_w.**

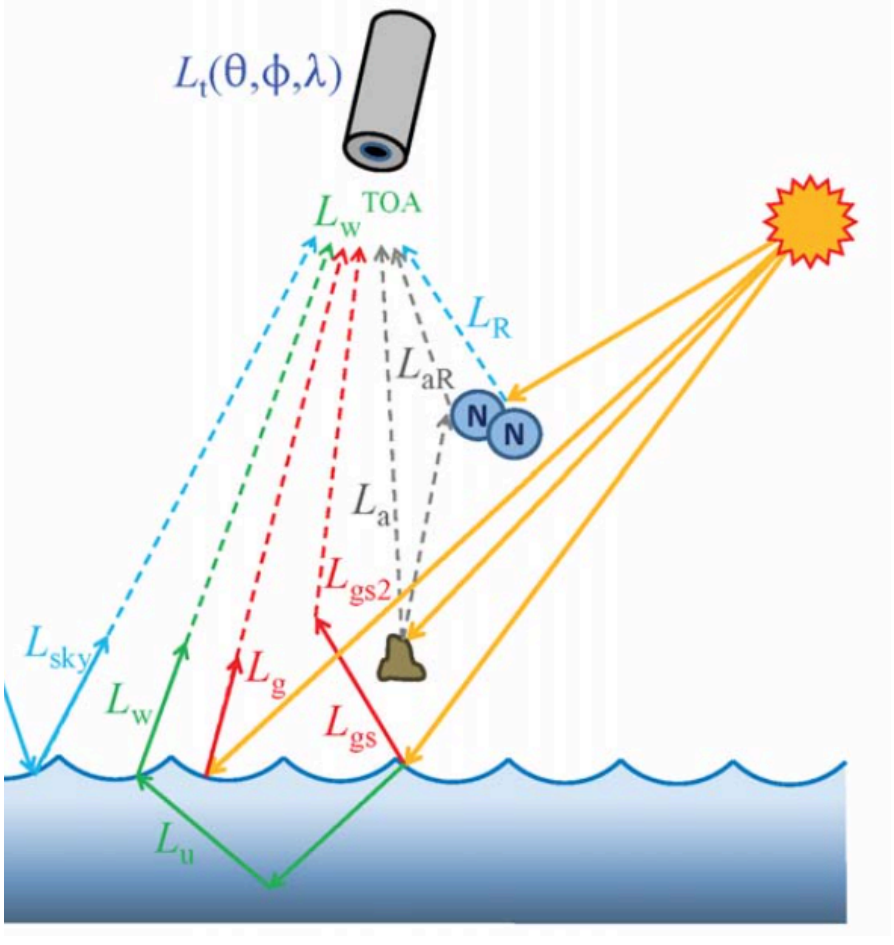
Primary at-sensor radiance contributions

- Scattering from gases (L_R)
- Scattering from aerosols (L_a)
- Direct scattering from the water surface (L_g)
- Diffuse scattering from the water surface (L_{sky})
- Water leaving radiance (L_w)

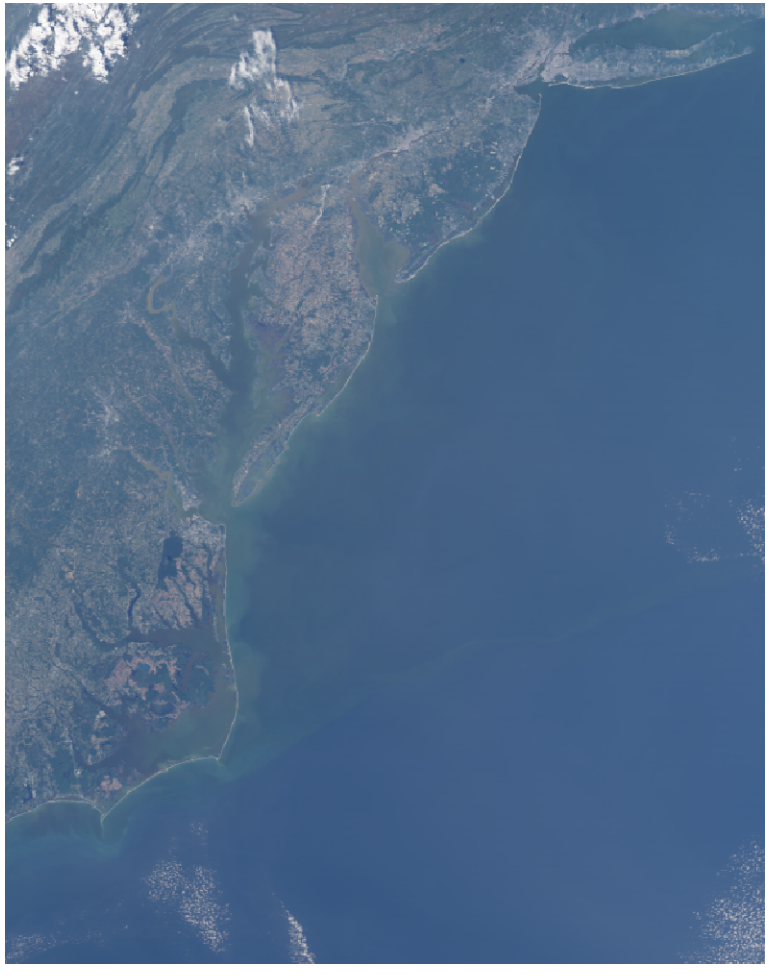
Primary contemporaneous data used in atmospheric correction algorithms

- wind speed
- surface pressure
- ozone and NO_2 concentrations
- water vapor concentration
- relative humidity
- on-board near-infrared measurements

Satellite-borne sensors measure the top of atmosphere at-sensor radiance



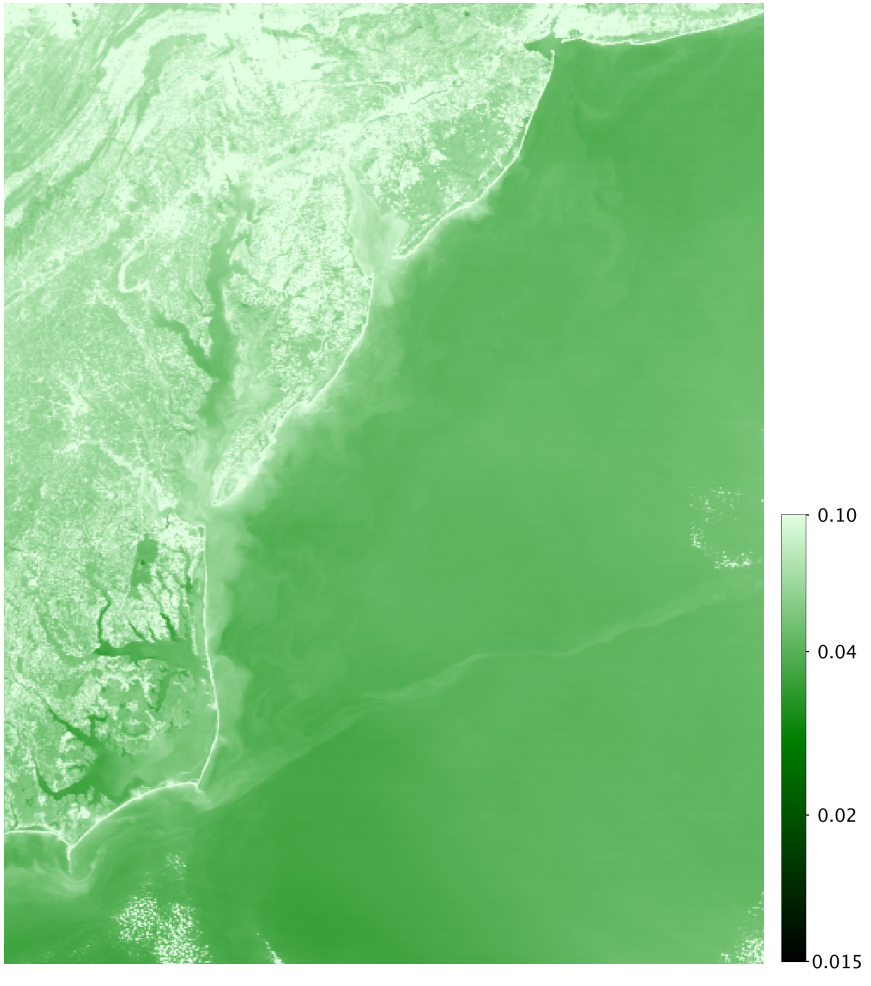
Atmospheric Correction



True Color

No Atmospheric Correction Applied

MODIS Aqua RGB (rhot_469, rhot_555, rhot_645)



Reflectance at top of atmosphere (555nm)

No Atmospheric Correction Applied

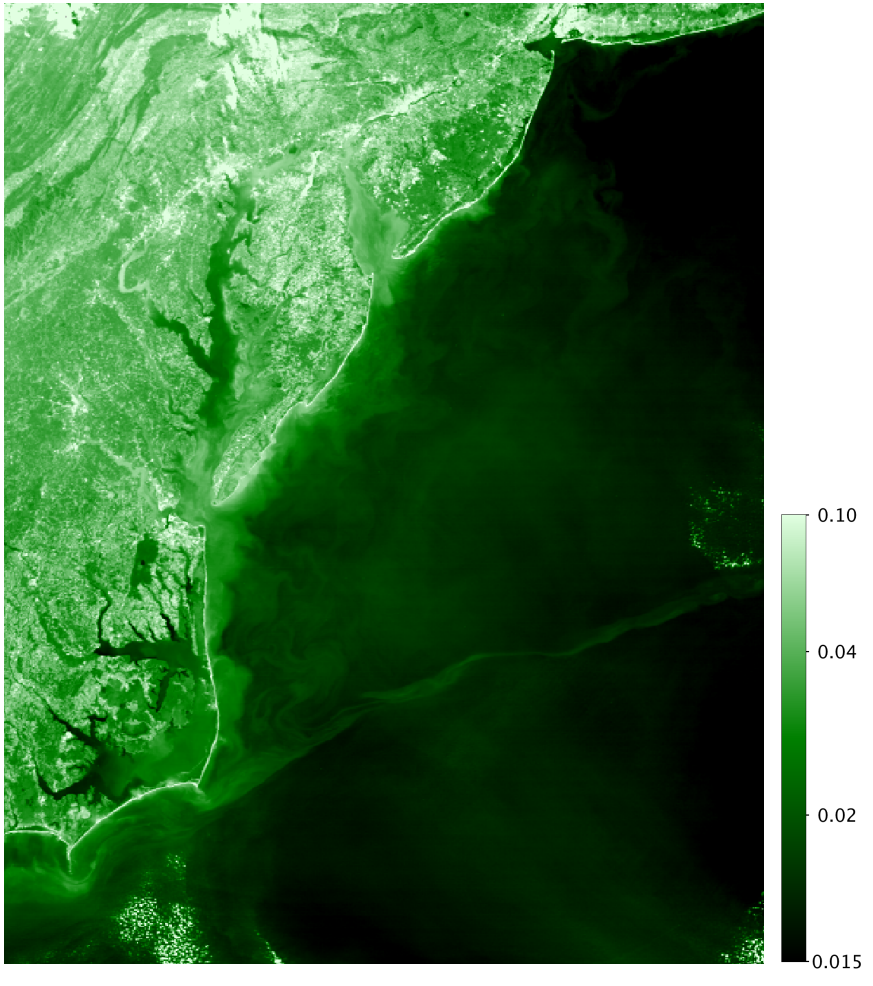
MODIS Aqua rhot_555

Atmospheric Correction

True Color

With Atmospheric Correction Applied

MODIS Aqua RGB (rhos_469, rhos_555, rhos_645)



Reflectance at the planet surface (555nm)

With Atmospheric Correction Applied

MODIS Aqua rhos_555

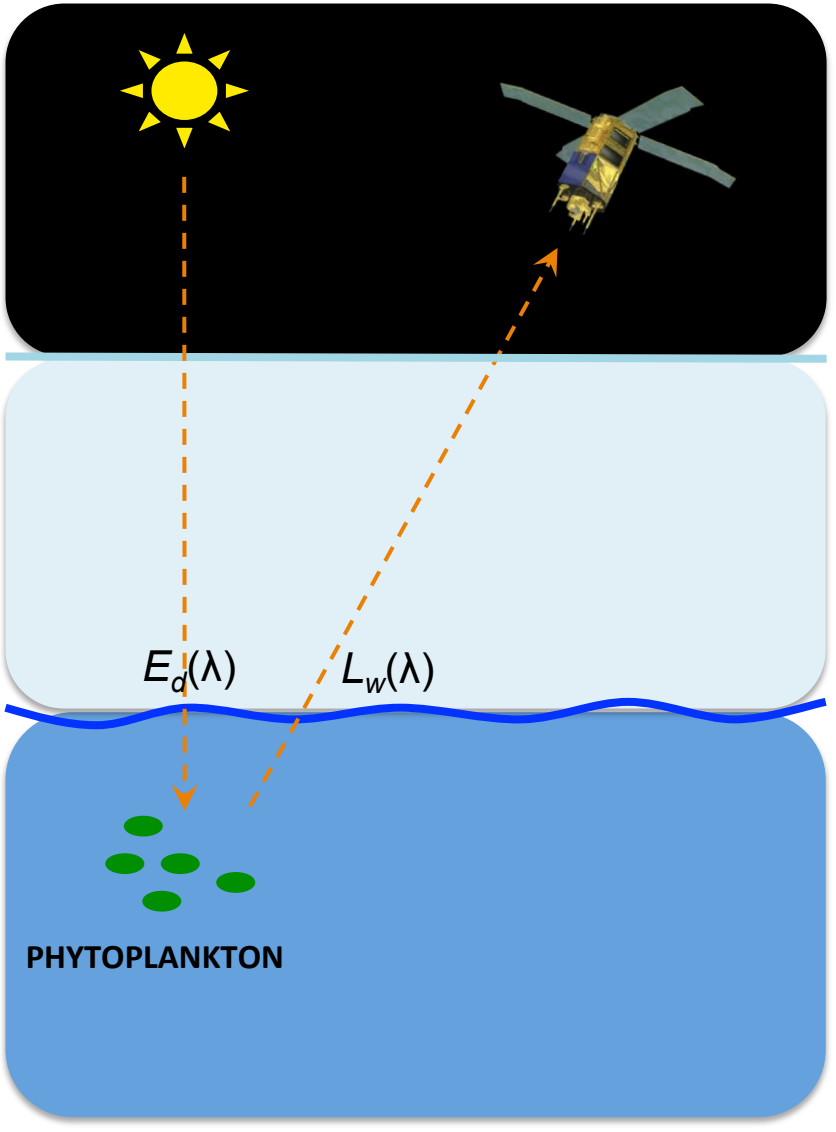
Remote Sensing Reflectance and Ocean Color Products

- Remote sensing reflectance (R_{rs}) can be derived from the water leaving radiance L_w. This quantity effectively normalizes the signal to remove dependency on solar and viewing angles.

$$R_{rs}(\lambda) = \frac{L_w(\lambda)}{E_d(\lambda)}$$

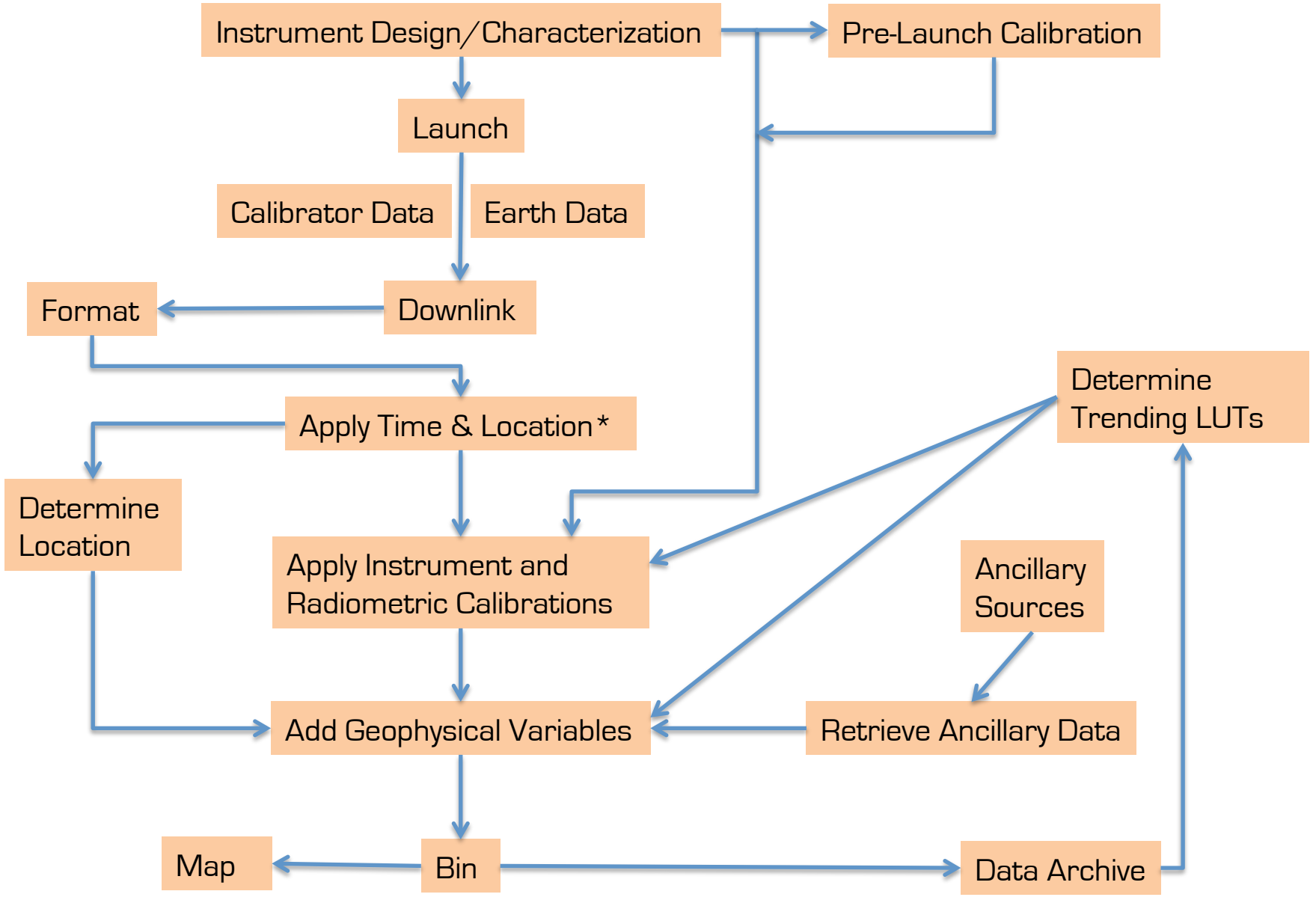
- R_{rs} is dependent on the types and relative concentrations of optically-active constituent matter present in the water column. From R_{rs}, higher order products, such as Chlorophyll concentration, can be empirically derived.

$$\log_{10}(chlor\_a) = a_0 + \sum_{i=0}^{4} a_i \log_{10}\left(\frac{R_{rs}(\lambda_{blue})}{R_{rs}(\lambda_{green})}\right)^i$$

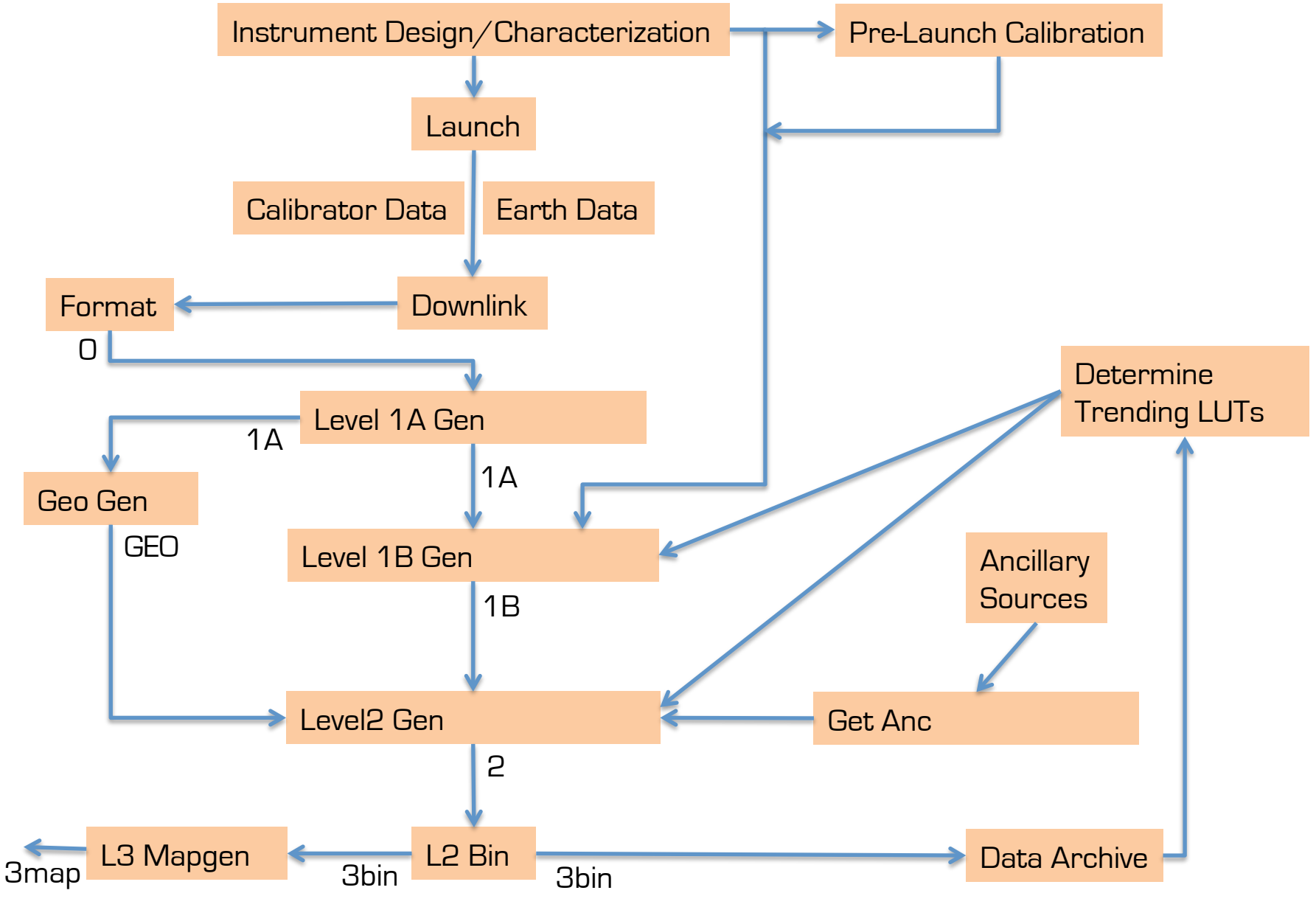


The NASA OB.DAAC Data Levels

Data Levels & Flow



Data Levels & Flow



Data Access

The NASA OB.DAAC Data Levels

- Level 0 data
  unprocessed "raw" instrument data (at native resolution)
  - ✓ Available only for some supported missions

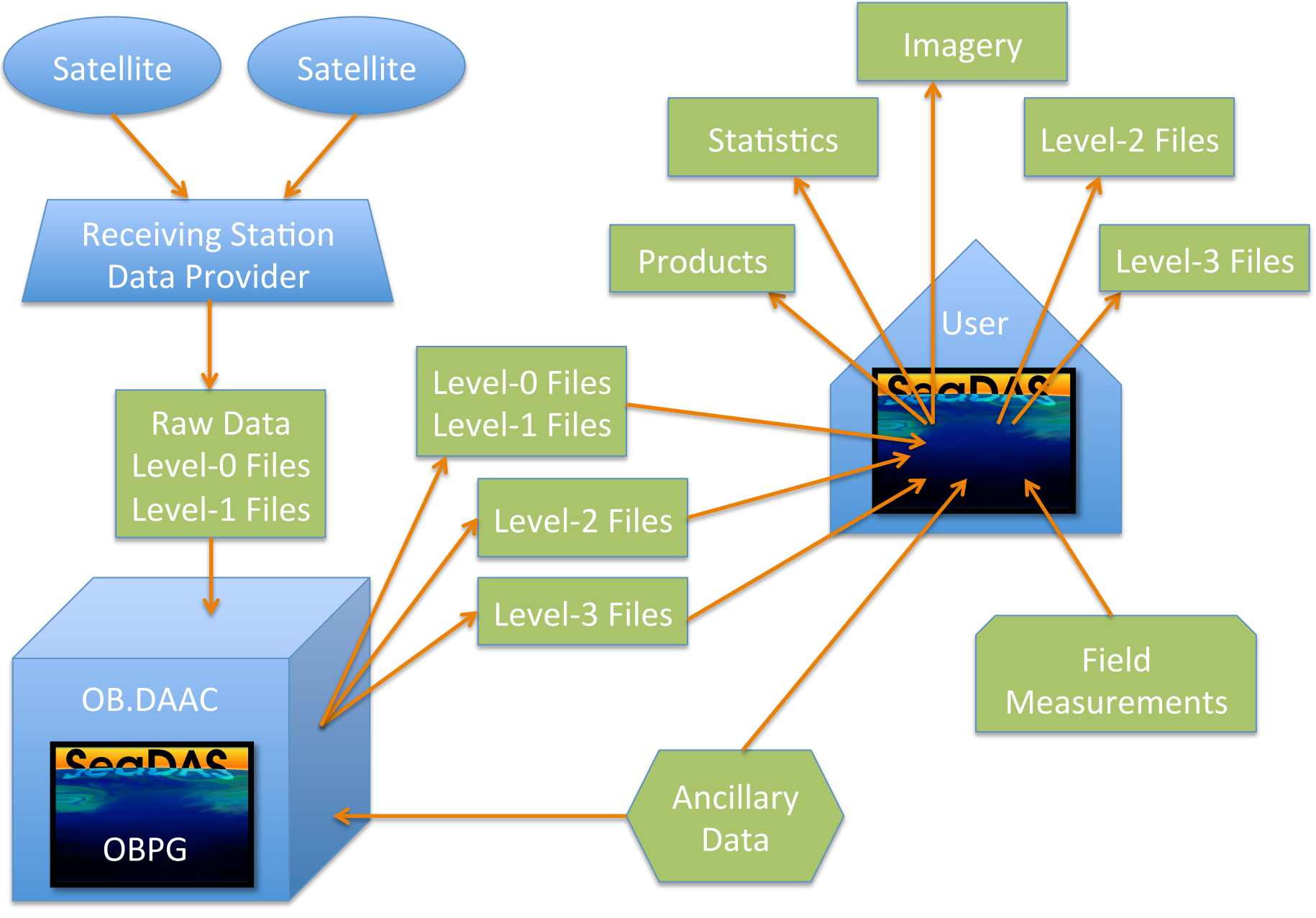
- Level 1A data
  time and location information applied (at native resolution)
  - ✓ Available for most supported missions

- Level 1B data
  instrument and radiometric calibrations applied (at native resolution)
  - ✓ Available for some supported missions, but can be generated from L1A data

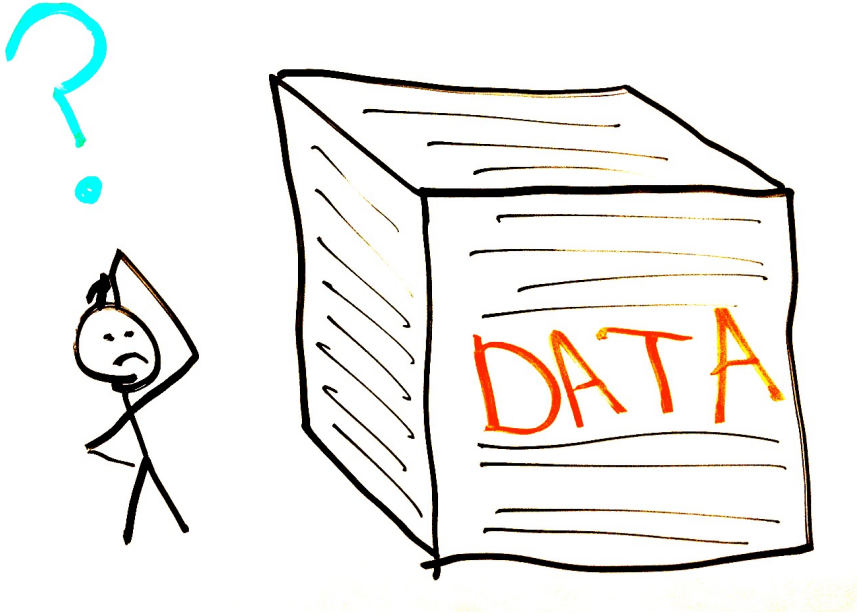
- Level 2 data
  geophysical variables added (at native resolution)
  - ✓ Available for most supported missions

- Level 3 binned data
  merged and mapped
  - Binned (Sinusoidal nearly equal-area grid)
    - ✓ Available for most supported mission (4km & 9km)
  - Mapped (Plate Carrée pixel-registered grid)
    - ✓ Available for most supported missions (4km & 9km)

The Big Picture



- https://oceancolor.gsfc.nasa.gov (OB.DAAC)
  - SeaWiFS
  - MODIS Aqua
  - MODIS Terra
  - MERIS (RR and FRS)
  - VIIRS
  - OCTS
  - HICO
  - GOCI
  - CZCS
  - OLCI



- https://earthexplorer.usgs.gov
  - Landsat 8 OLI

- ENVISAT MERIS
  - MERIS (Medium Resolution Imaging Spectrometer) is the sensor
    - spatial resolution = 300m
    - operational dates = 2002 to 2012
    - ✓ NASA OB.DAAC data available
  - ENVISAT-1 is the satellite platform on which MERIS is mounted

- SENTINEL-3 OLCI
  - OLCI (Ocean and Land Colour Instrument) is the sensor
    - spatial resolution = 300m
    - operational dates = 2016 to present
    - NASA OB.DAAC data will be available (date TBD)
    - ✓ ESA data available
  - SENTINEL-3 is the satellite platform on which OLCI is mounted

Level 2 Browser

SeaWiFS	MODIS	MERIS	Select
☐ GAC	☑ Aqua	☐ RR	☑ Day
☐ MLAC	☐ Terra	☐ FRS	☐ Night

☐ VIIRS (Suomi-NPP)	☐ OCTS (ADEOS)	☐ HICO (ISS)	☐ GOCI (COMS)	☐ CZCS (Nimbus-7)

Radius (*km*) about map click or about typed-in location:

◉	72
○	400
○	800
○	1200
○	1500

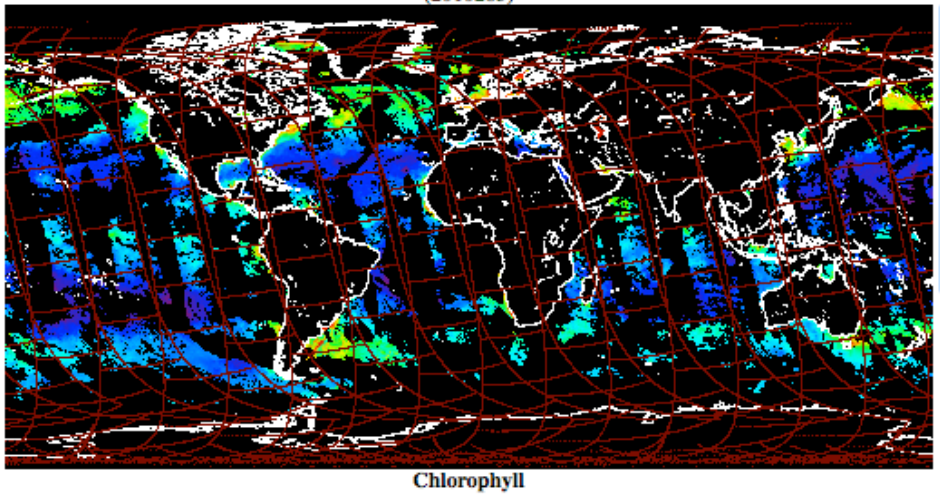
Select swaths containing *(at least)*:

◉	any part
○	25 %
○	50 %
○	75 %
○	all

of the area of interest.

Select only scenes having in situ matchups. ☐

Sunday, 10 October 2010
(2010283)



Chlorophyll

Display results 10 at a time. Reconfigure page

Select one or more regions:

Brazil
BrazilCoast
CanaryIslands
CapeVerdeIslands
Caribbean
CaspianSea
ChagosArchipelago
ChesapeakeBay
ChukchiSea
CrozetIslands
Cuba

or specify boundary coordinates or a single location:

N: W: :E S:

Find swaths

Mission	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2002	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2005	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2006	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2007	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2009	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2011	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2012	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2013	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2014	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

September 2010

S	M	T	W	T	F	S
			1 xxx	2 xxx	3 xxx	4 xxx
5 xxx	6 ^^^	7 ^^^	8 ^^^	9 ^^^	10 ^^^	11 ^^^
12 ^^^	13 ^^^	14 ooo	15 ooo	16 ooo	17 ooo	18 ooo
19 ooo	20 ooo	21 ooo	22 ***	23 ***	24 ***	25 ***
26 ***	27 ***	28 ***	29 ***	30 xxx		

October 2010

S	M	T	W	T	F	S
					1 xxx	2 xxx
3 xxx	4 xxx	5 xxx	6 xxx	7 xxx	8 ^^^	9 ^^^
10 ^^^	11 ^^^	12 ^^^	13 ^^^	14 ^^^	15 ^^^	16 ooo
17 ooo	18 ooo	19 ooo	20 ooo	21 ooo	22 ooo	23 ooo
24 ***	25 ***	26 ***	27 ***	28 ***	29 ***	30 ***
31 ***						

November 2010

S	M	T	W	T	F	S
	1 xxx	2 xxx	3 xxx	4 xxx	5 xxx	6 xxx
7 xxx	8 xxx	9 ^^^	10 ^^^	11 ^^^	12 ^^^	13 ^^^
14 ^^^	15 ^^^	16 ^^^	17 ooo	18 ooo	19 ooo	20 ooo
21 ooo	22 ooo	23 ooo	24 ooo	25 ***	26 ***	27 ***
28 ***	29 ***	30 ***				

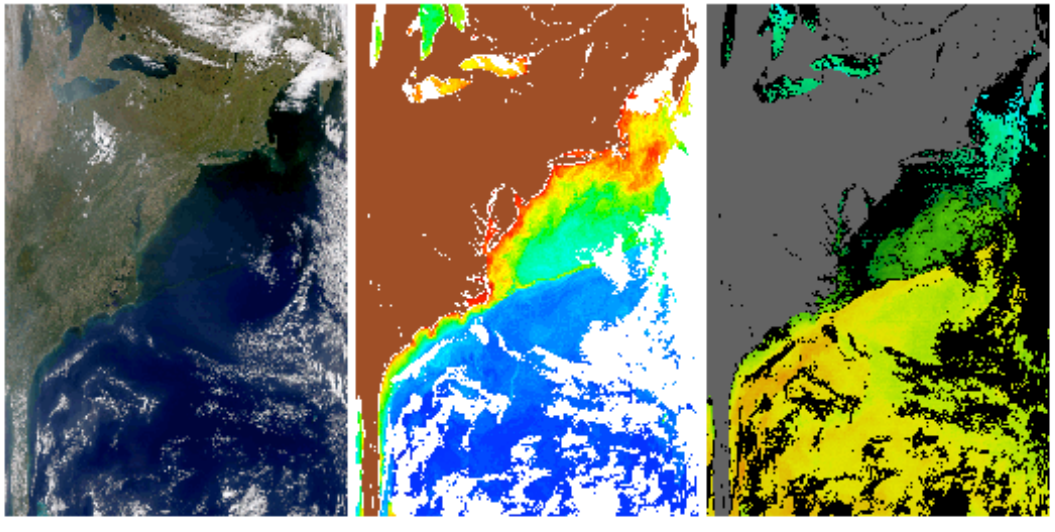
Level 2 Browser

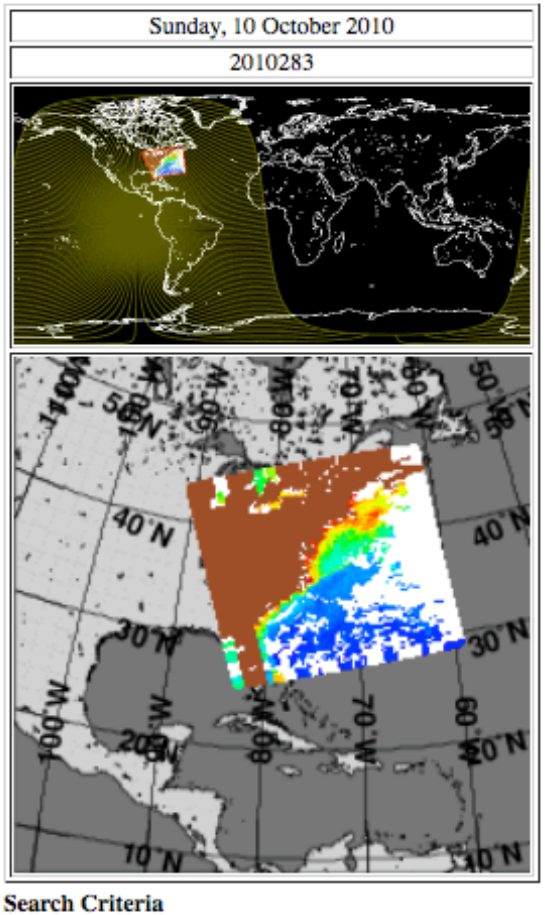
A2010283180500.L0_LAC	276,269,160 bytes
A2010283180500.L1A_LAC	192,112,712 bytes
A2010283180500.L2_LAC_OC.nc	62,336,386 bytes
A2010283180500.L2_LAC_IOP.nc	66,428,368 bytes
A2010283180500.L2_LAC_SST.nc	22,376,305 bytes

(The above hyperlinks point to compressed files.
Documentation on these products can be found HERE.)

Select this scene

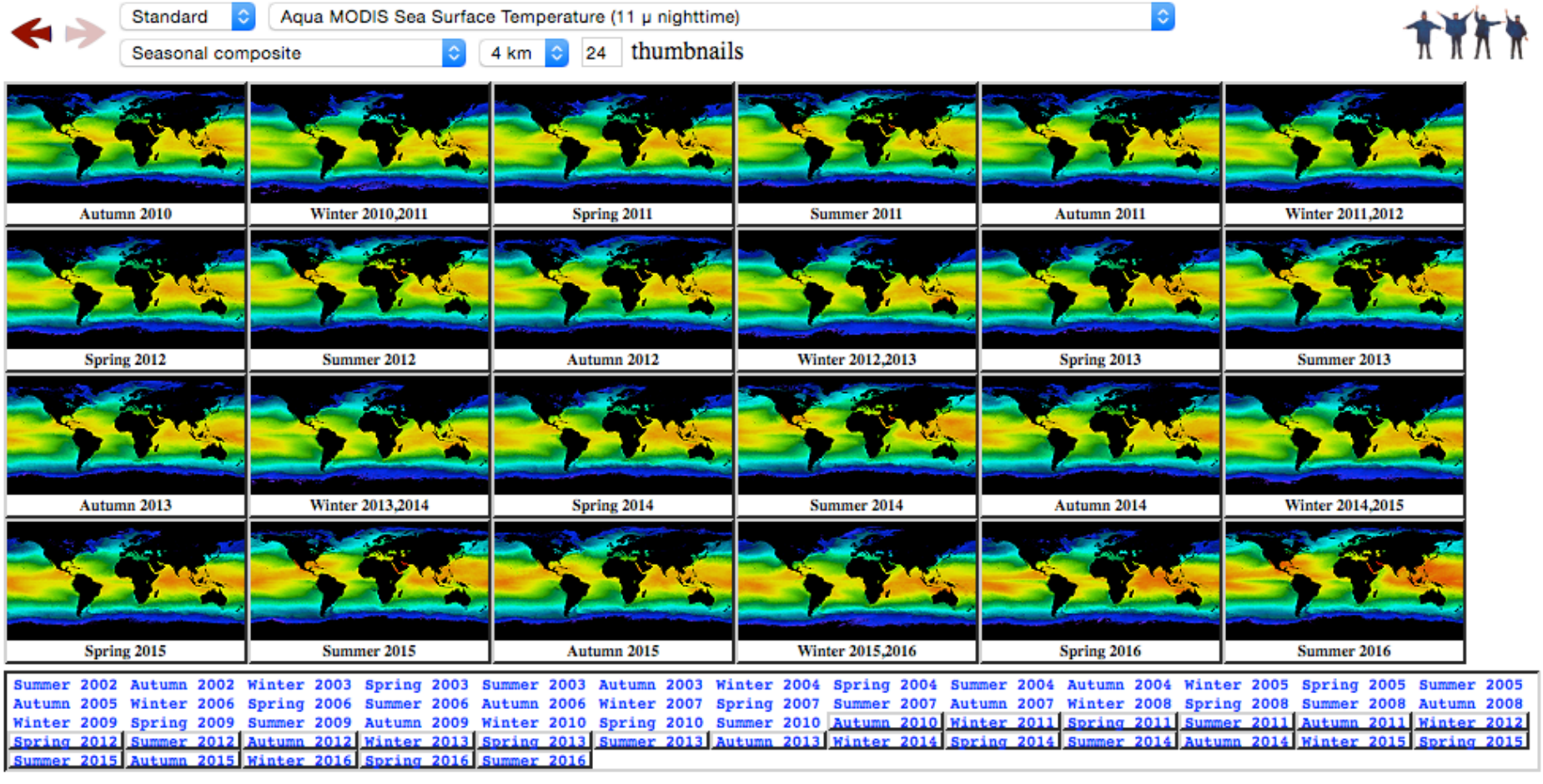
Quasi True Color | **Chlorophyll** | **Sea Surface Temperature (11 μ)**





Search Criteria
Time Period: Sunday, 10 October 2010 (daytime)
Sensors: Aqua
Area of Interest: ChesapeakeBay

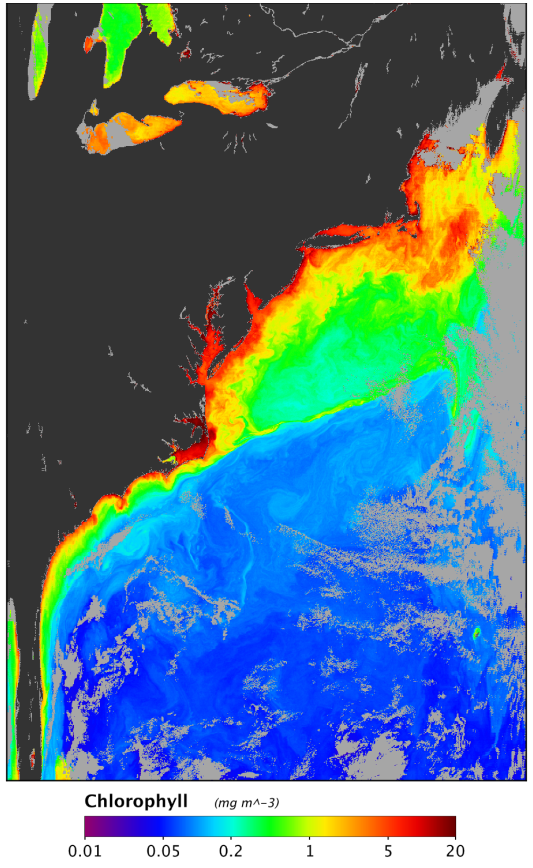
Level 3 Browser



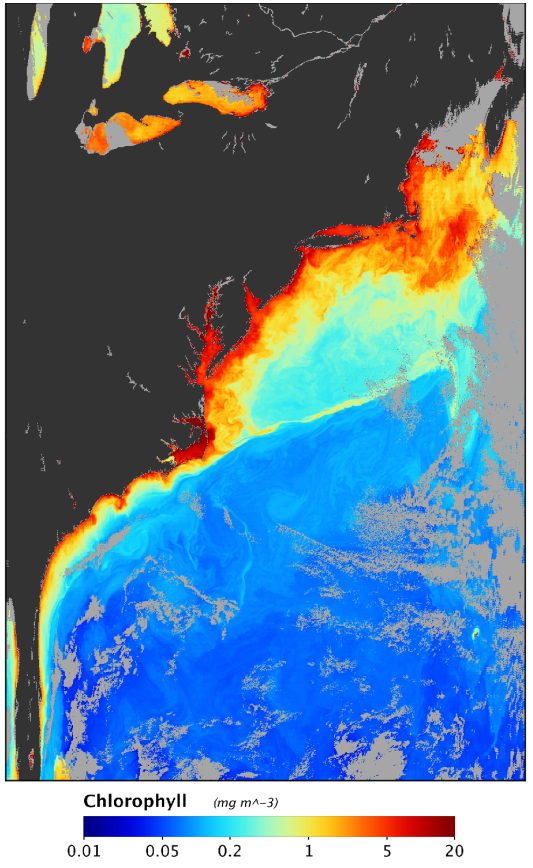
SeaDAS

Color Palettes

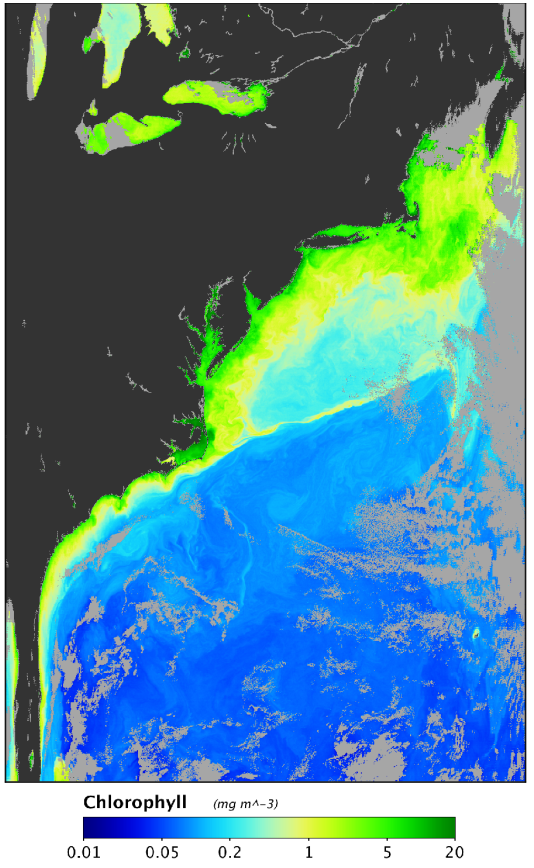
- **SeaDAS has many choices of color palettes. These may be selected or loaded by default for configured products.**



"Rainbow" Palette
No-Data (gray)
Land (dark gray)
CAUTION: not color-blind compliant

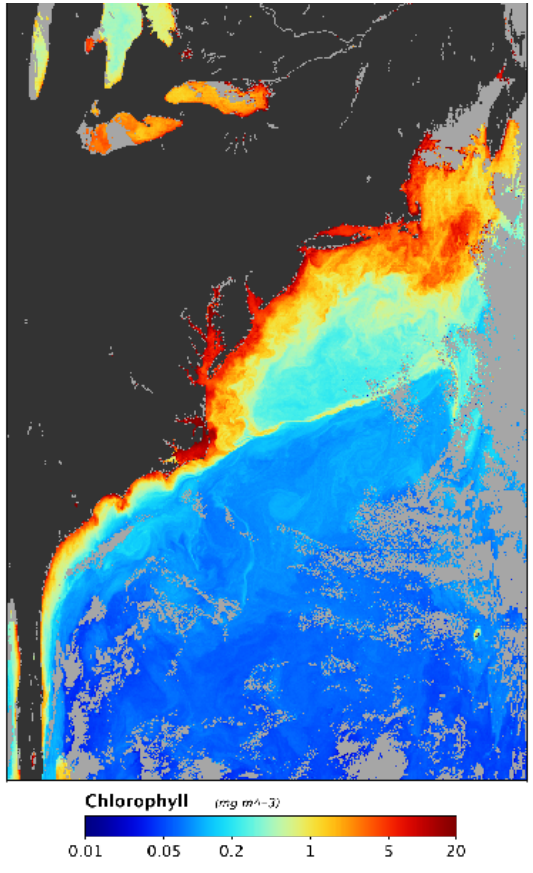


"Universal_BlueRed" Palette
No-Data (gray)
Land (dark gray)
✓ fully color-blind compliant

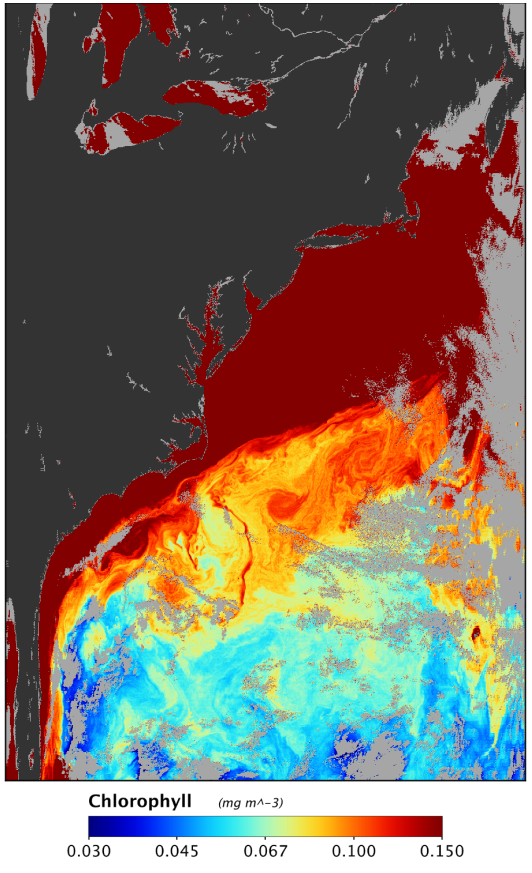


"Universal_BlueGreen" Palette
No-Data (gray)
Land (dark gray)
✧ mostly color-blind compliant

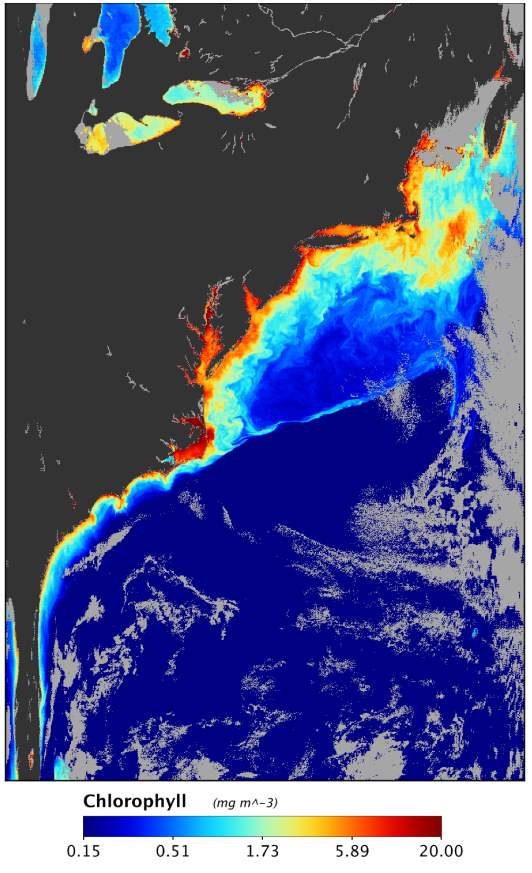
- **SeaDAS enables simple adjustments to the dynamic range of a color palette which can bring out desired features of interest**



"Universal" Palette
standard scale range



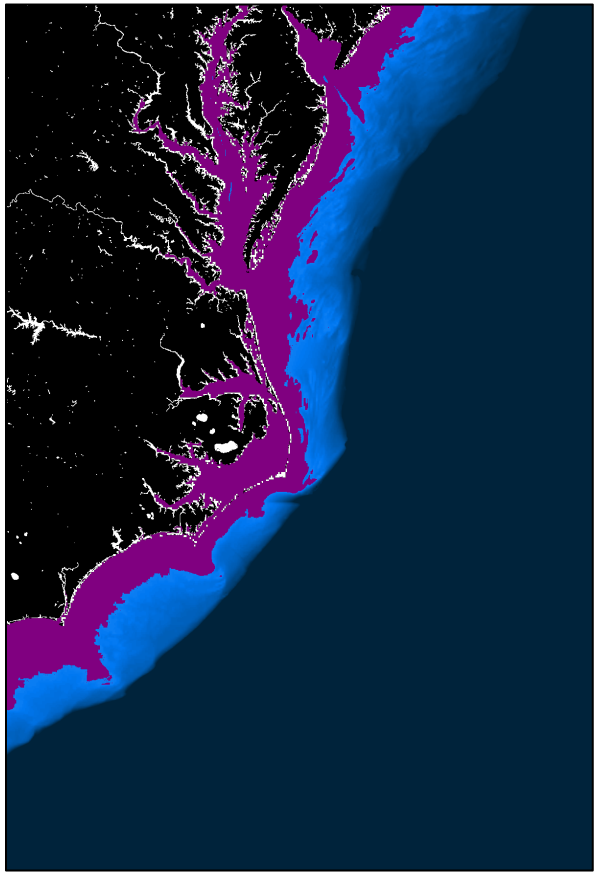
"Universal" Palette
low scale range



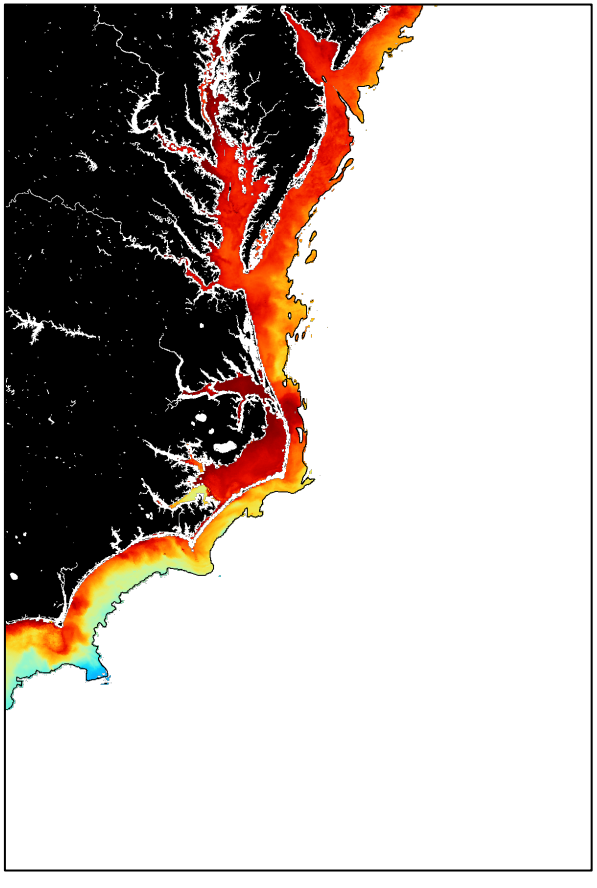
"Universal" Palette
high scale range

Masking

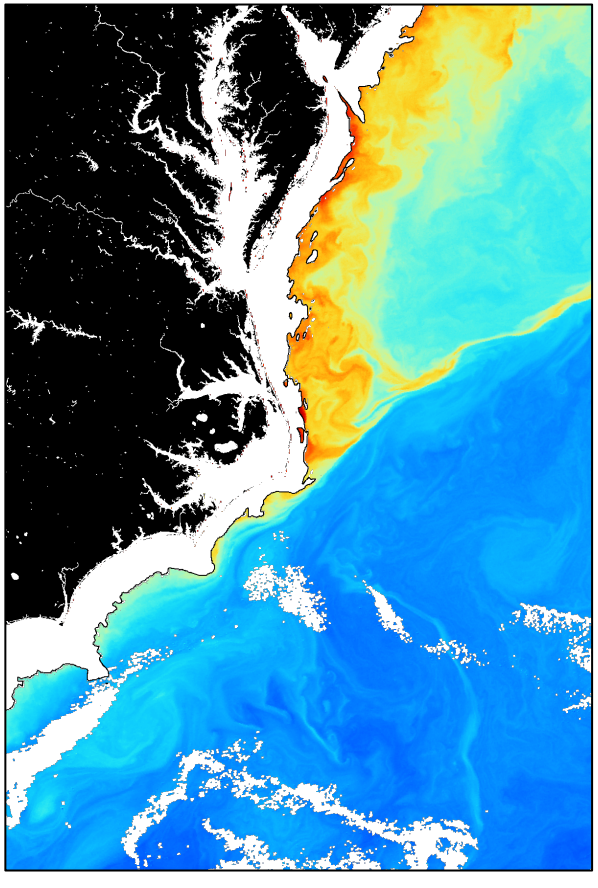
- **SeaDAS contain tools for using the level-2 flags for masking as well as creating custom masks based on any available band data**



Bathymetry
Mask shown in purple
(depth <= 25m)



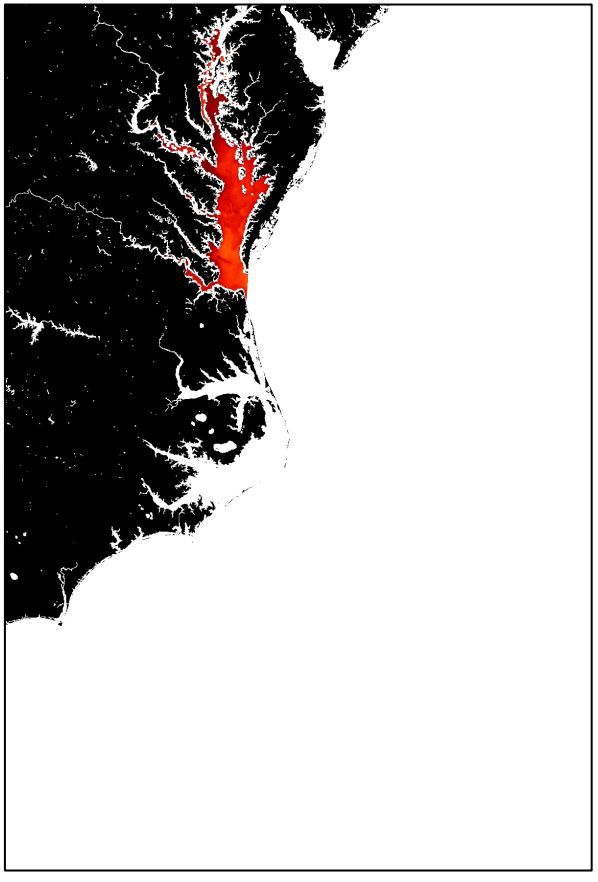
Chlorophyll
Region of interest (ROI) masked
(depth <= 25m)



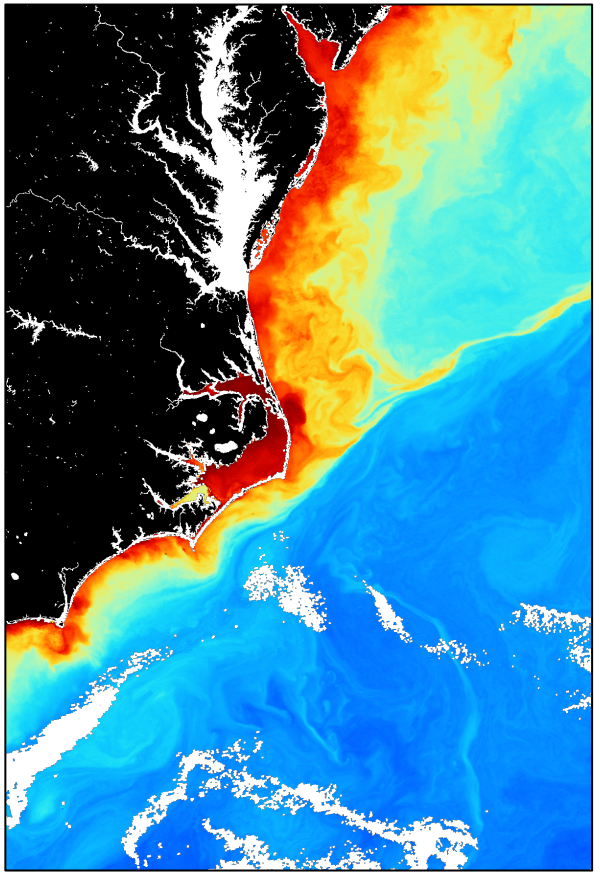
Chlorophyll
Exclusion masked
(depth > 25m)

- **SeaDAS creates, imports, and exports vector shapefiles which can be used for masking**

Geometric polygon mask
shown in purple



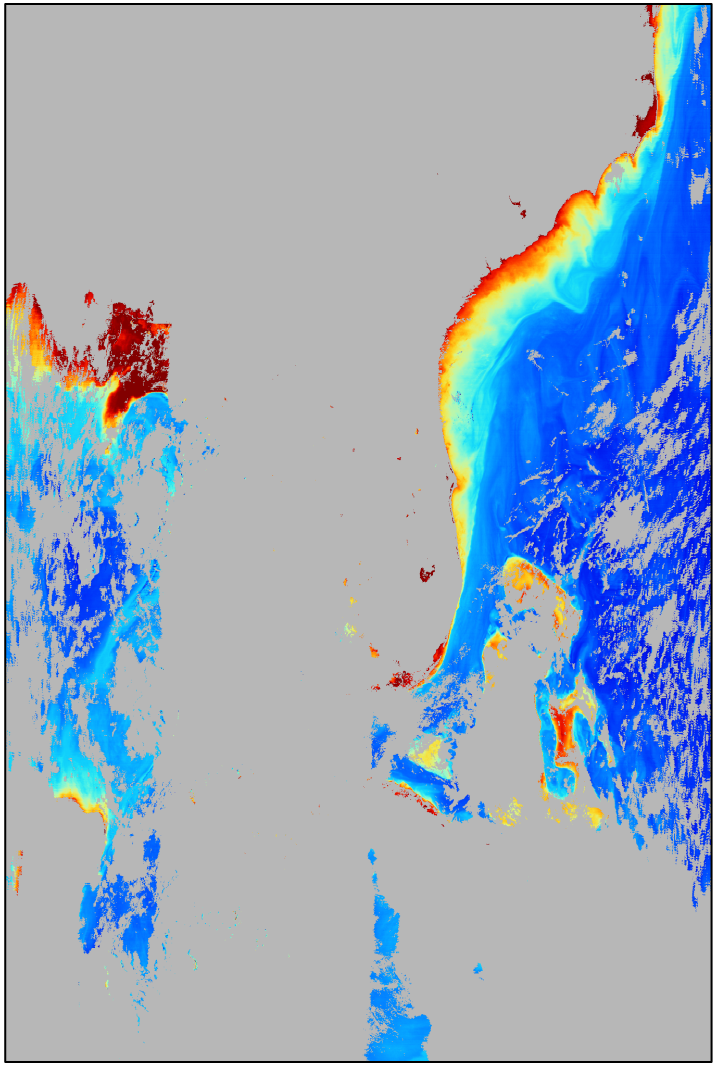
Chlorophyll
Region of interest (ROI) masked



Chlorophyll
Exclusion masked

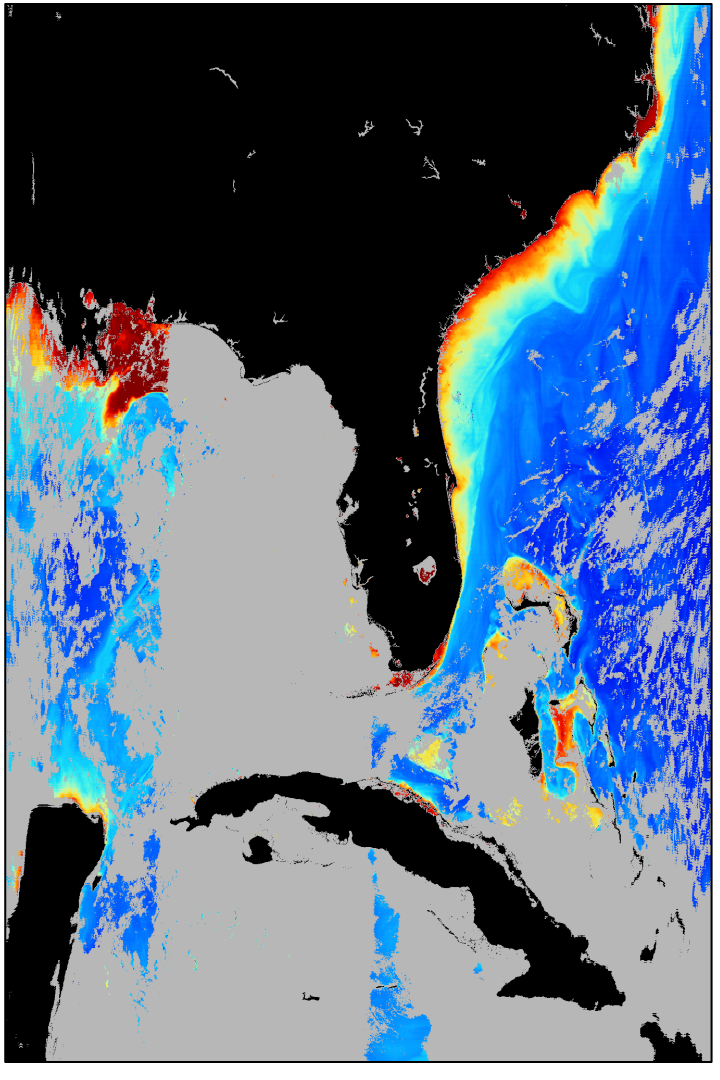
OCSSW Level 2 Flags

ATMFAIL	0	Atmospheric correction failure
LAND	0	Land
PRODWARN	0.5	One (or more) product algorithms generated a warning
HILT	0.2	High (or saturating) TOA radiance
HIGLINT	0	High glint determined
HISATZEN	0	Large satellite zenith angle
COASTZ	0.5	Shallow water (<30m)
STRAYLIGHT	0.2	Straylight determined
CLDICE	0	Cloud/Ice determined
COCCOLITH	0.5	Coccolithophores detected
TURBIDW	0.5	Turbid water determined
HISOLZEN	0.5	High solar zenith angle
LOWLW	0.5	Low Lw @ 555nm (possible cloud shadow)
CHLFAIL	0	Chlorophyll algorithm failure
NAVWARN	0.5	Navigation suspect
ABSAER	0.5	Absorbing Aerosols determined
MAXAERITER	0.5	Maximum iterations reached for NIR correction
MODGLINT	0	Moderate glint determined
CHLWARN	0.5	Chlorophyll out-of-bounds (<0.01 or >100 mg m^-3)
ATMWARN	0.5	Atmospheric correction warning; Epsilon out-of-bounds
SEAICE	0.5	Sea ice determined
NAVFAIL	0	Navigation failure
FILTER	0.5	Insufficient data for smoothing filter
BOWTIEDEL	0.1	Bowtie deleted pixel
HIPOL	0.5	High degree of polariztion determined
PRODFAIL	0.1	One (or more) product algorithms produced a failure



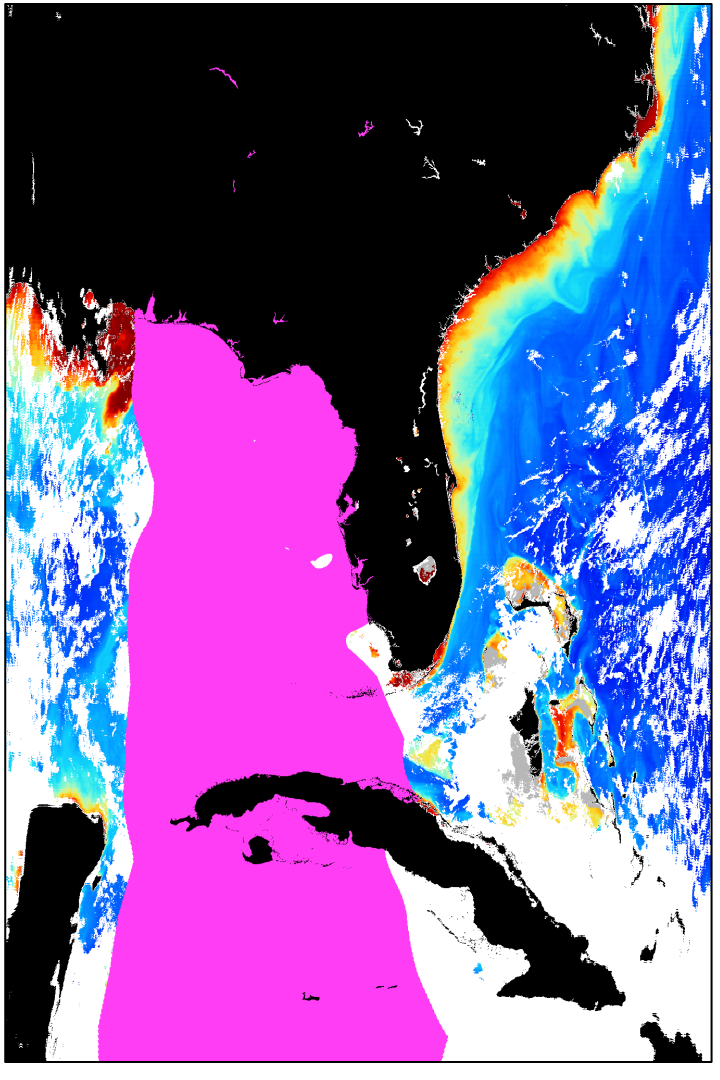
OCSSW Level 2 Flags

☐	ATMFAIL	0 Atmospheric correction failure
☑	LAND	0 Land
☐	PRODWARN	0.5 One (or more) product algorithms generated a warning
☐	HILT	0.2 High (or saturating) TOA radiance
☐	HIGLINT	0 High glint determined
☐	HISATZEN	0 Large satellite zenith angle
☐	COASTZ	0.5 Shallow water (<30m)
☐	STRAYLIGHT	0.2 Straylight determined
☐	CLDICE	0 Cloud/Ice determined
☐	COCCOLITH	0.5 Coccolithophores detected
☐	TURBIDW	0.5 Turbid water determined
☐	HISOLZEN	0.5 High solar zenith angle
☐	LOWLW	0.5 Low Lw @ 555nm (possible cloud shadow)
☐	CHLFAIL	0 Chlorophyll algorithm failure
☐	NAVWARN	0.5 Navigation suspect
☐	ABSAER	0.5 Absorbing Aerosols determined
☐	MAXAERITER	0.5 Maximum iterations reached for NIR correction
☐	MODGLINT	0 Moderate glint determined
☐	CHLWARN	0.5 Chlorophyll out-of-bounds (<0.01 or >100 mg m^-3)
☐	ATMWARN	0.5 Atmospheric correction warning; Epsilon out-of-bounds
☐	SEAICE	0.5 Sea ice determined
☐	NAVFAIL	0 Navigation failure
☐	FILTER	0.5 Insufficient data for smoothing filter
☐	BOWTIEDEL	0.1 Bowtie deleted pixel
☐	HIPOL	0.5 High degree of polariztion determined
☐	PRODFAIL	0.1 One (or more) product algorithms produced a failure



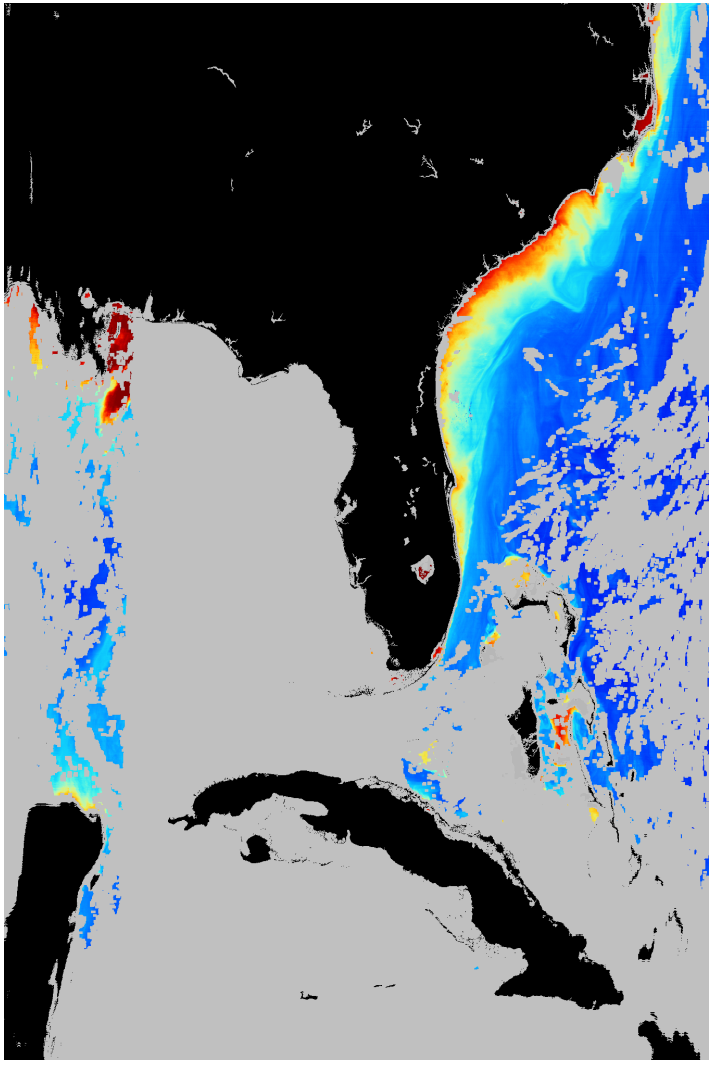
OCSSW Level 2 Flags

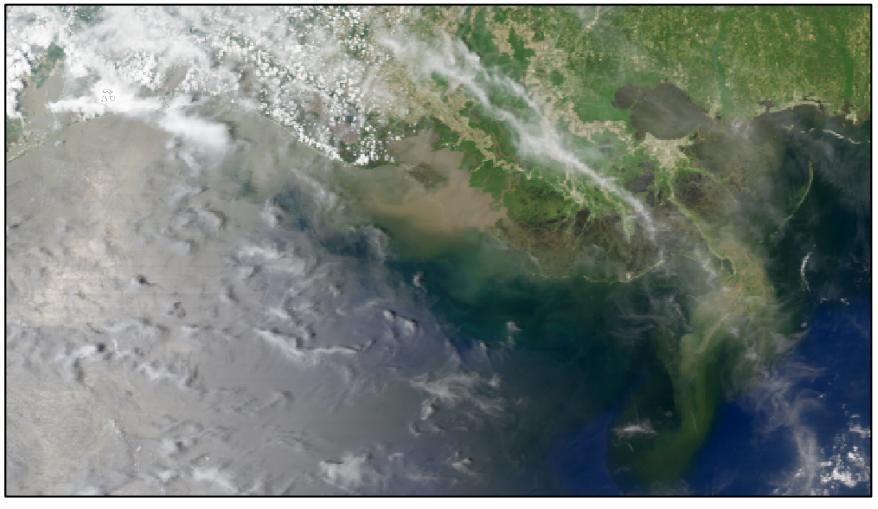
☐	ATMFAIL	0 Atmospheric correction failure
☑	LAND	0 Land
☐	PRODWARN	0.5 One (or more) product algorithms generated a warning
☐	HILT	0.2 High (or saturating) TOA radiance
☑	HIGLINT	0 High glint determined
☐	HISATZEN	0 Large satellite zenith angle
☐	COASTZ	0.5 Shallow water (<30m)
☐	STRAYLIGHT	0.2 Straylight determined
☑	CLDICE	0 Cloud/Ice determined
☐	COCCOLITH	0.5 Coccolithophores detected
☐	TURBIDW	0.5 Turbid water determined
☐	HISOLZEN	0.5 High solar zenith angle
☐	LOWLW	0.5 Low Lw @ 555nm (possible cloud shadow)
☐	CHLFAIL	0 Chlorophyll algorithm failure
☐	NAVWARN	0.5 Navigation suspect
☐	ABSAER	0.5 Absorbing Aerosols determined
☐	MAXAERITER	0.5 Maximum iterations reached for NIR correction
☐	MODGLINT	0 Moderate glint determined
☐	CHLWARN	0.5 Chlorophyll out-of-bounds (<0.01 or >100 mg m^-3)
☐	ATMWARN	0.5 Atmospheric correction warning; Epsilon out-of-bounds
☐	SEAICE	0.5 Sea ice determined
☐	NAVFAIL	0 Navigation failure
☐	FILTER	0.5 Insufficient data for smoothing filter
☐	BOWTIEDEL	0.1 Bowtie deleted pixel
☐	HIPOL	0.5 High degree of polariztion determined
☐	PRODFAIL	0.1 One (or more) product algorithms produced a failure

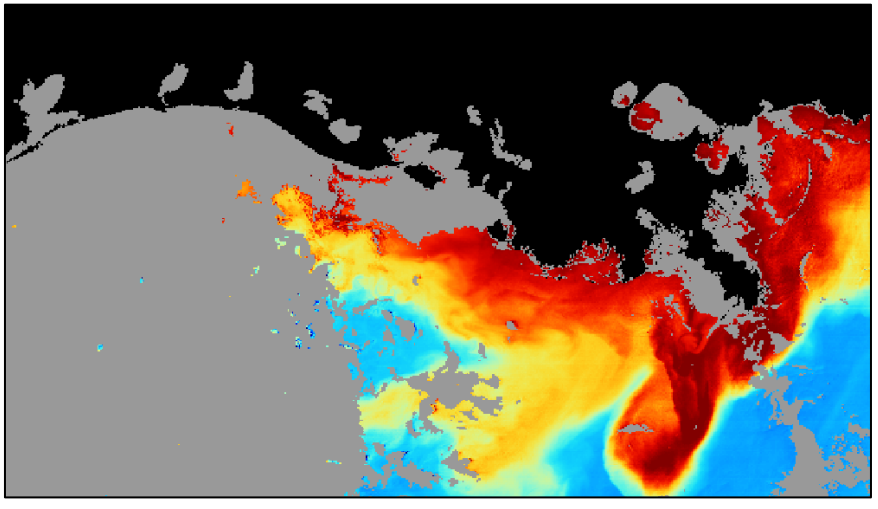


OCSSW Level 2 Flags

☐	ATMFAIL	0 Atmospheric correction failure
☑	LAND	0 Land
☐	PRODWARN	0.5 One (or more) product algorithms generated a warning
☐	HILT	0.2 High (or saturating) TOA radiance
☑	HIGLINT	0 High glint determined
☐	HISATZEN	0 Large satellite zenith angle
☐	COASTZ	0.5 Shallow water (<30m)
☑	STRAYLIGHT	0 Straylight determined
☑	CLDICE	0 Cloud/Ice determined
☐	COCCOLITH	0.5 Coccolithophores detected
☐	TURBIDW	0.5 Turbid water determined
☐	HISOLZEN	0.5 High solar zenith angle
☐	LOWLW	0.5 Low Lw @ 555nm (possible cloud shadow)
☐	CHLFAIL	0 Chlorophyll algorithm failure
☐	NAVWARN	0.5 Navigation suspect
☐	ABSAER	0.5 Absorbing Aerosols determined
☐	MAXAERITER	0.5 Maximum iterations reached for NIR correction
☐	MODGLINT	0 Moderate glint determined
☐	CHLWARN	0.5 Chlorophyll out-of-bounds (<0.01 or >100 mg m^-3)
☐	ATMWARN	0.5 Atmospheric correction warning; Epsilon out-of-bounds
☐	SEAICE	0.5 Sea ice determined
☐	NAVFAIL	0 Navigation failure
☐	FILTER	0.5 Insufficient data for smoothing filter
☐	BOWTIEDEL	0.1 Bowtie deleted pixel
☐	HIPOL	0.5 High degree of polariztion determined
☐	PRODFAIL	0.1 One (or more) product algorithms produced a failure

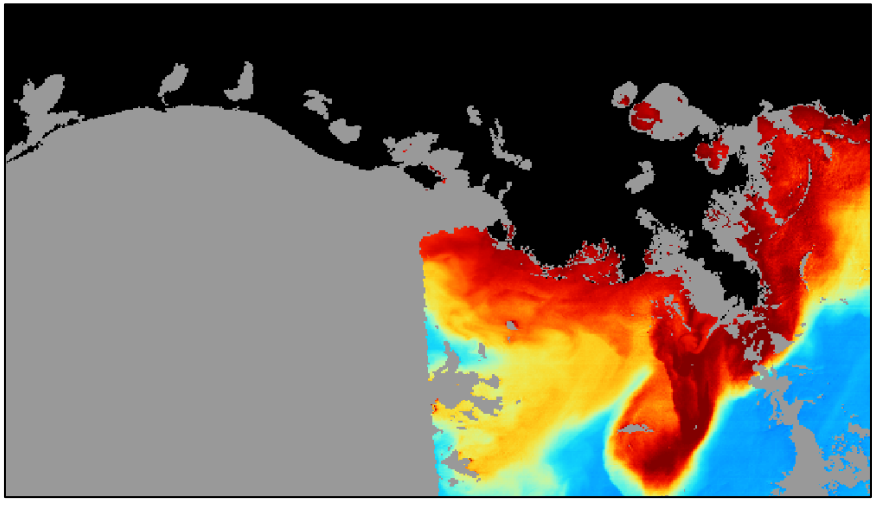


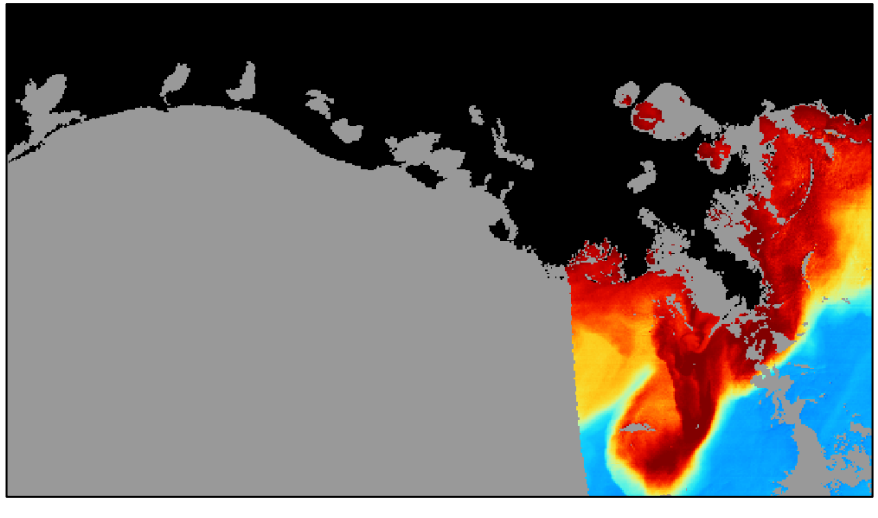




Glint Masking: MODIS Aqua Scene (Gulf of Mexico)

Above: True Color RGB (rhos_469, rhos_555, rhos_645)
Top Right: Chlorophyll (no glint masked out)
Right: Chlorophyll (HIGLINT masked out)
Bottom: Chlorophyll (HIGLINT and MODGLINT masked out)

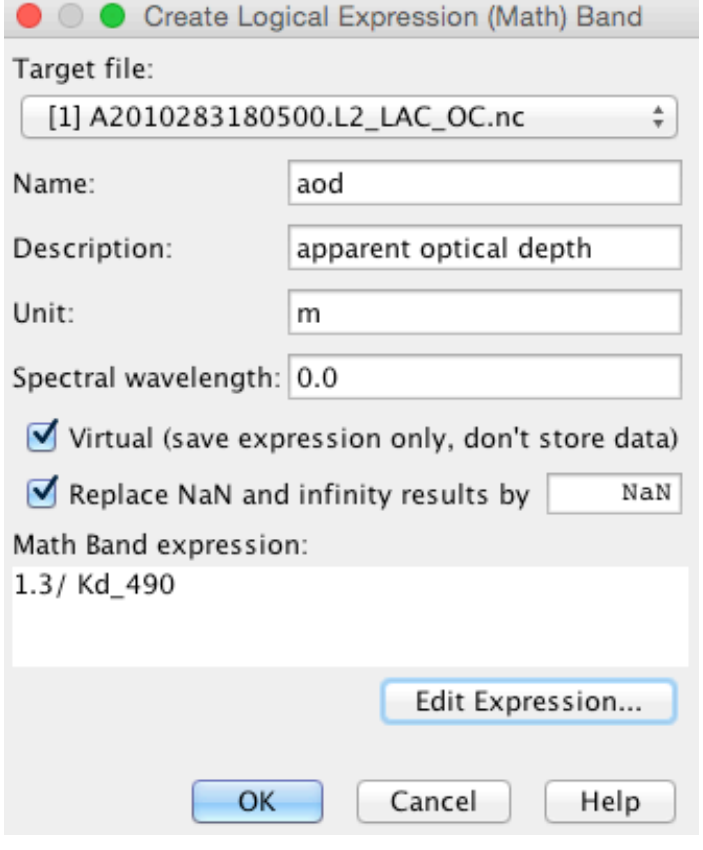


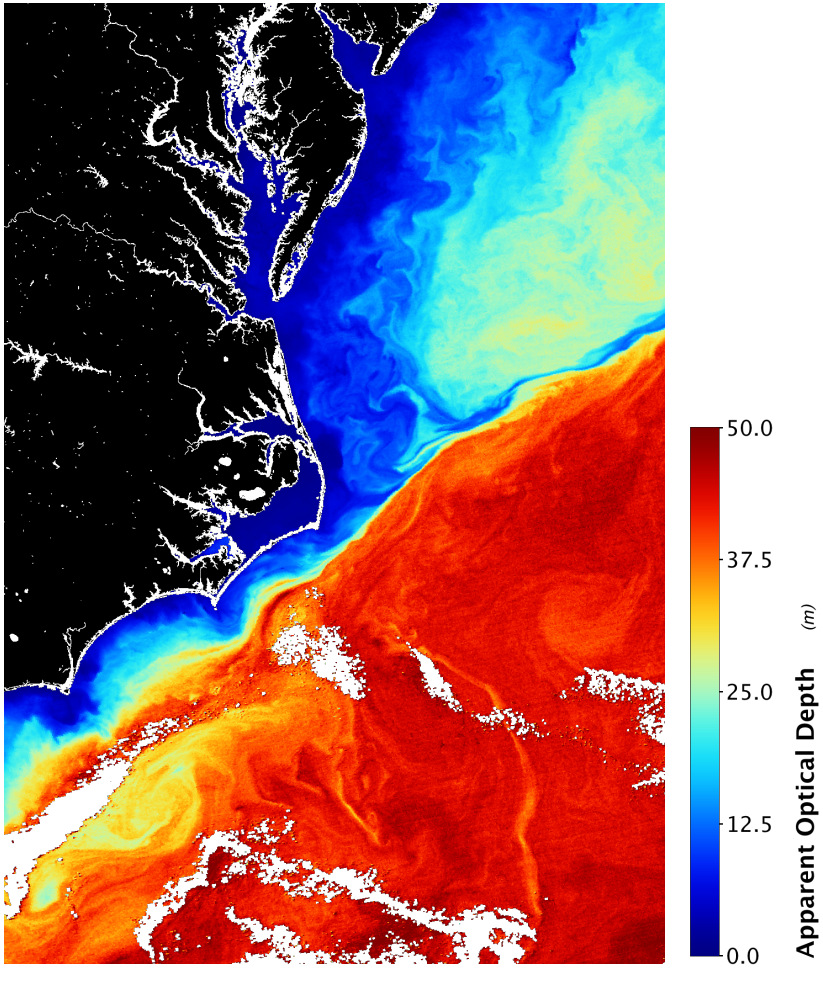


✧ An algorithm tool (Math Band) is available in SeaDAS to create custom products

- Note: an equivalent custom algorithm functionality in not available in OCSSW l2gen, however, the l2gen source code is readily available

- *EXAMPLE: Apparent Optical Depth band created from the the standard Kd_490*



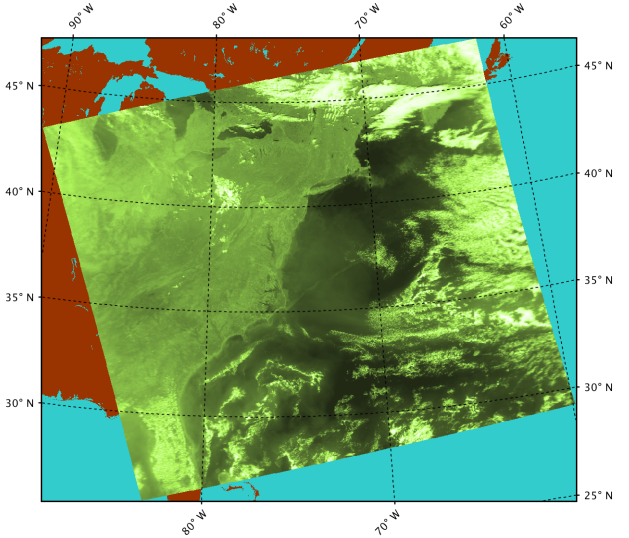


- **SeaDAS contains tools for reprojecting geolocated raster images to a desired map projection**

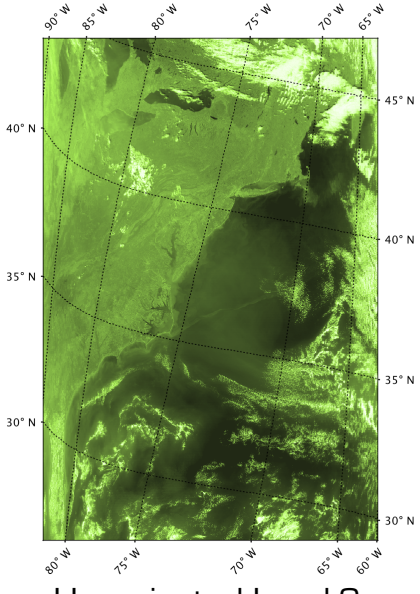
General criteria for choosing a map projection

- Scene Characteristics
  - size, shape and location
- Purpose
  - imagery or statistics

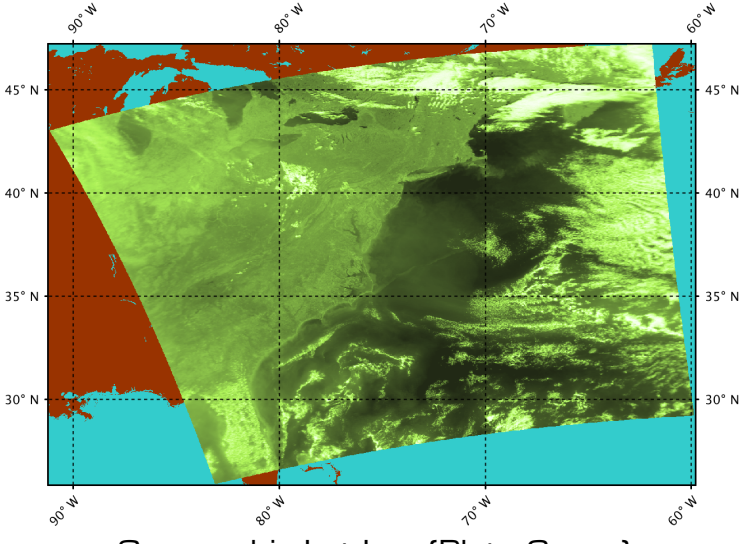
- *Example projections of a MODIS Aqua level-2 file*



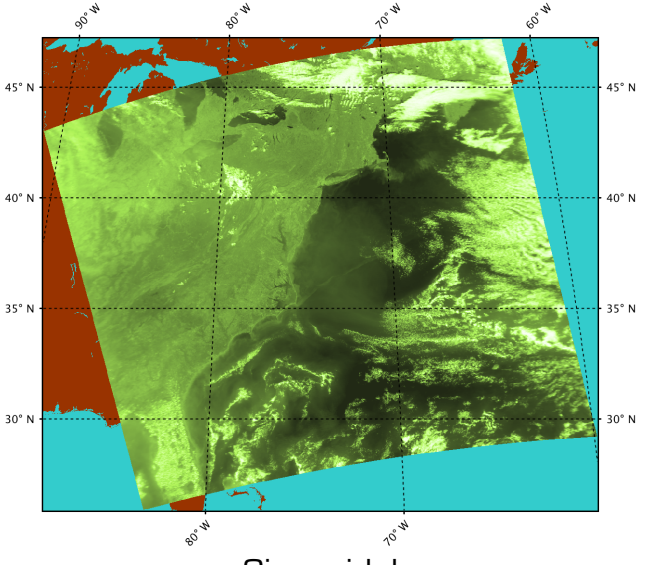
EPSG:2248 NAD83 Maryland



Unprojected Level-2



Geographic Lat Lon (Plate Caree)

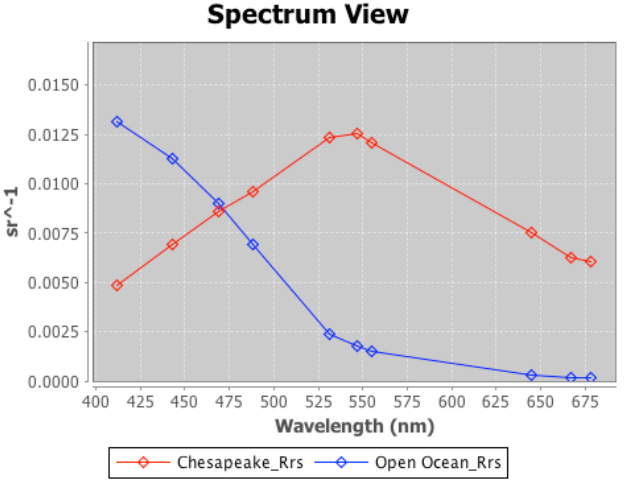


Sinusoidal

✧ **SeaDAS has a variety of file information tools and statistics can be generated both on scenes in their entirety, as well as on scenes restricted to any user-defined region of interest and quality flag settings.**

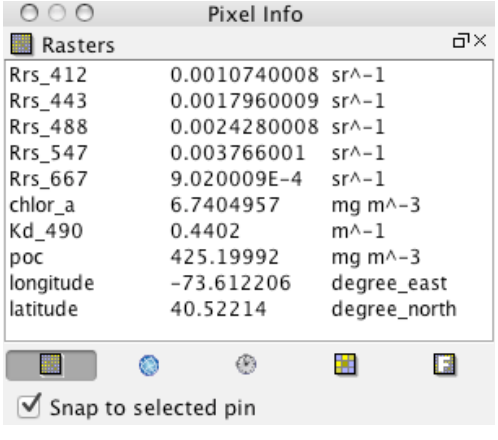
Statistics Tools

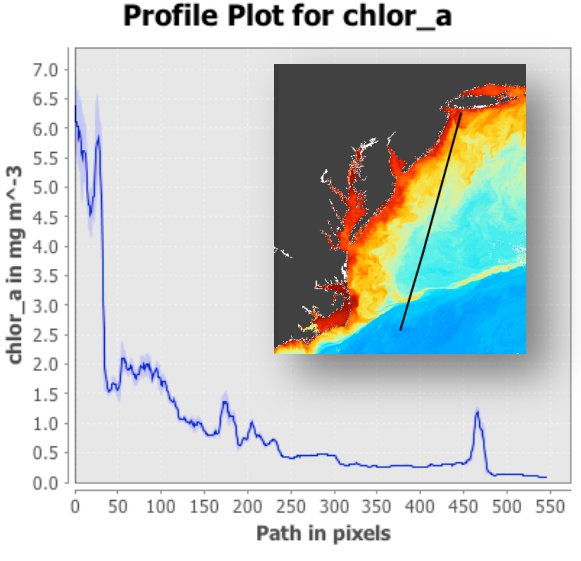
- General statistics (Minimum, Maximum, Mean, Sigma)
- Histogram plots
- Scatter plots
- Correlative plots
- Profile plots
- Spectra plots
- Cluster analysis tools (K-means, EM)



Information Tools

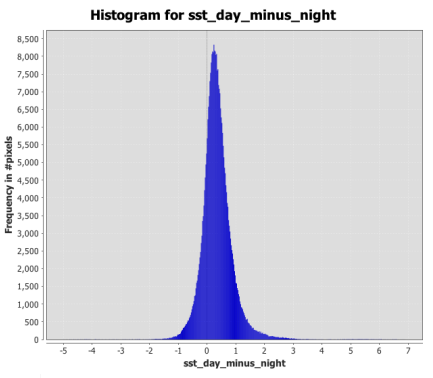
- File and band info
- Pixel info
- Geo-Coding info

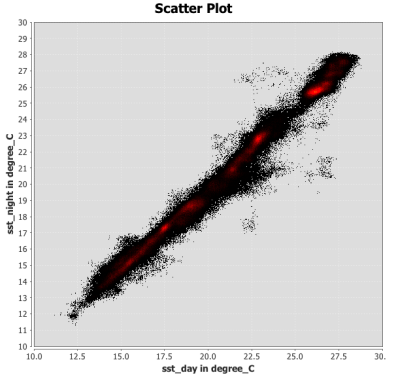




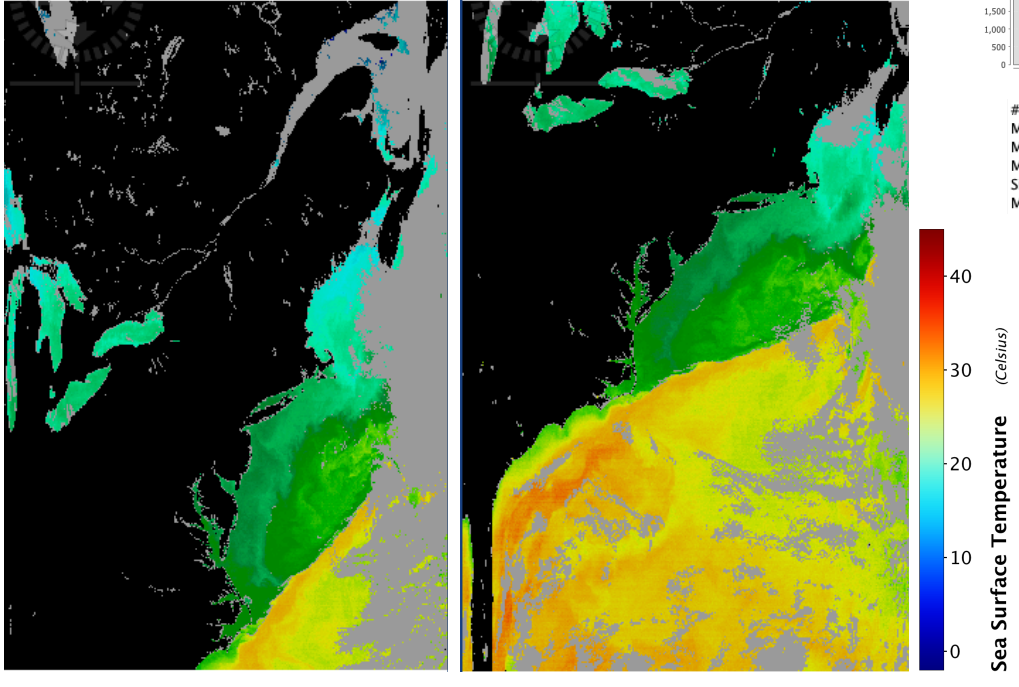
- **SeaDAS enables data which geographically overlaps to be projected into a single shared mapping file. The pixel aligned data can then be directly compared**

- *Example: A comparison of a nighttime and a daytime observation of Sea Surface Temperature for a single day* (Oct 10, 2010 MODIS Aqua)



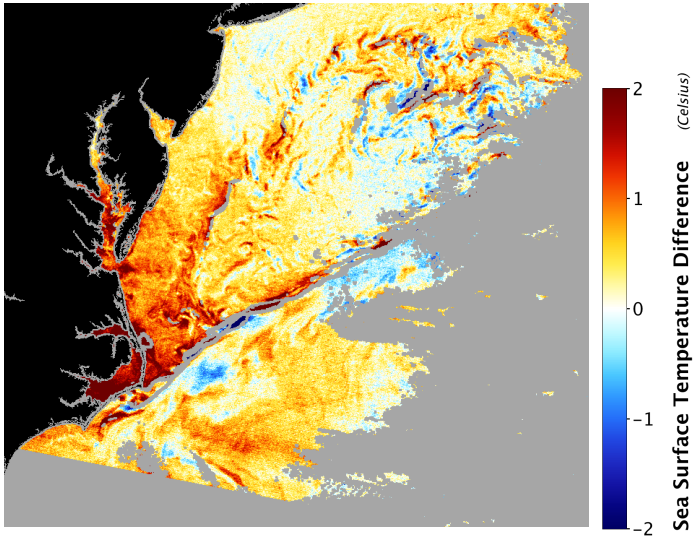


#Pixels tot... 333790
Minimum: -5.0061
Maximum: 6.8967
Mean: 0.3495
Sigma: 0.5395
Median: 0.2944



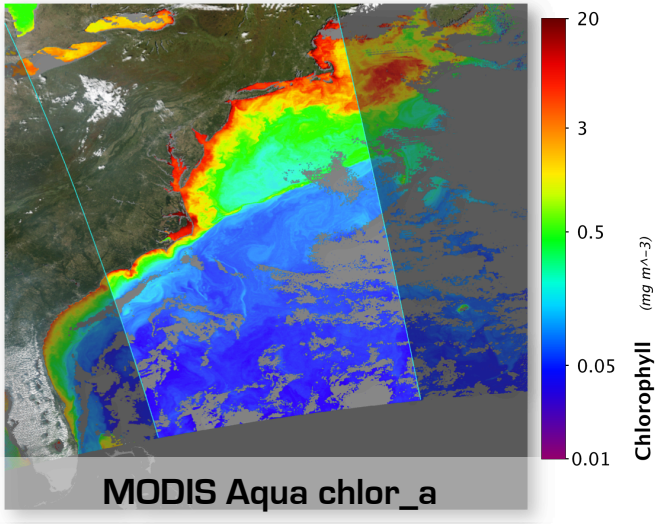
SST Night Level-2
(A2010283070000)

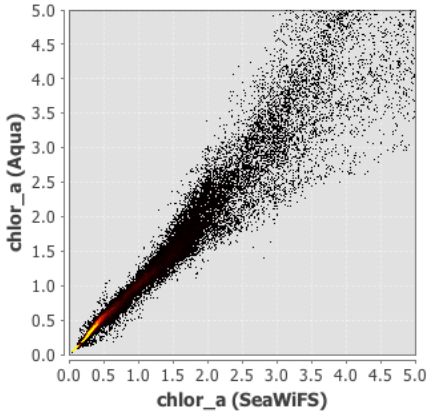
SST Day Level-2
(A2010283180500)

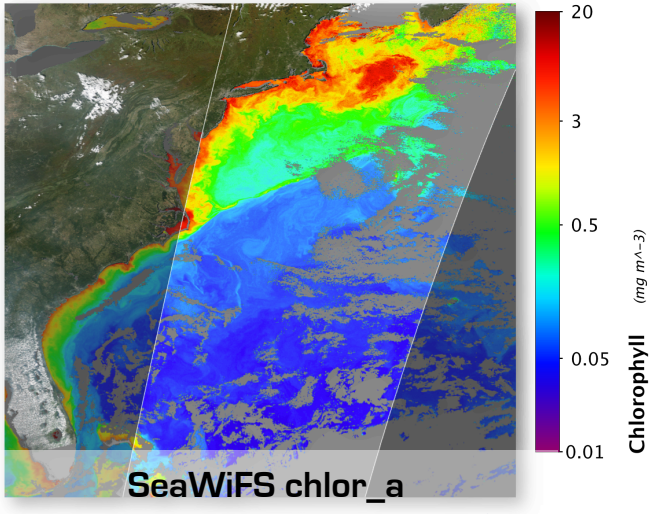


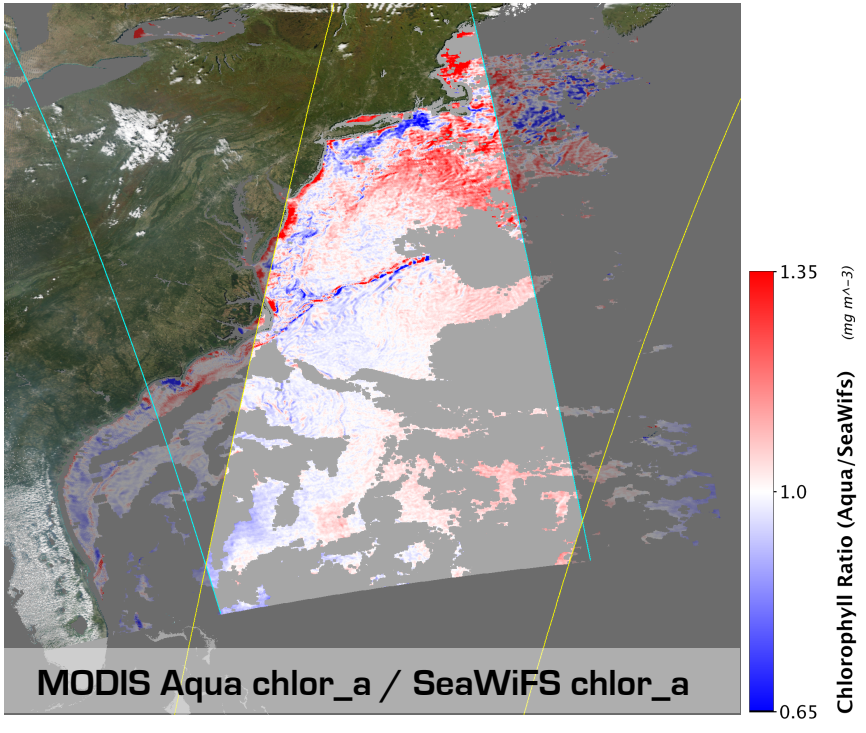
SST Difference (Day minus Night)

- *Example: A comparison of an Aqua (18:05 UTC) and a SeaWiFS (19:11 UTC) chlorophyll observation (Oct 10, 2010)*









- **SeaDAS can be used to produce time trend analysis across a large number of satellite files.**

- *Example: Time series trend on a set of monthly Chlorophyll concentration files.*
  (MODIS Aqua Level-3: Jan 2014 to July 2016)

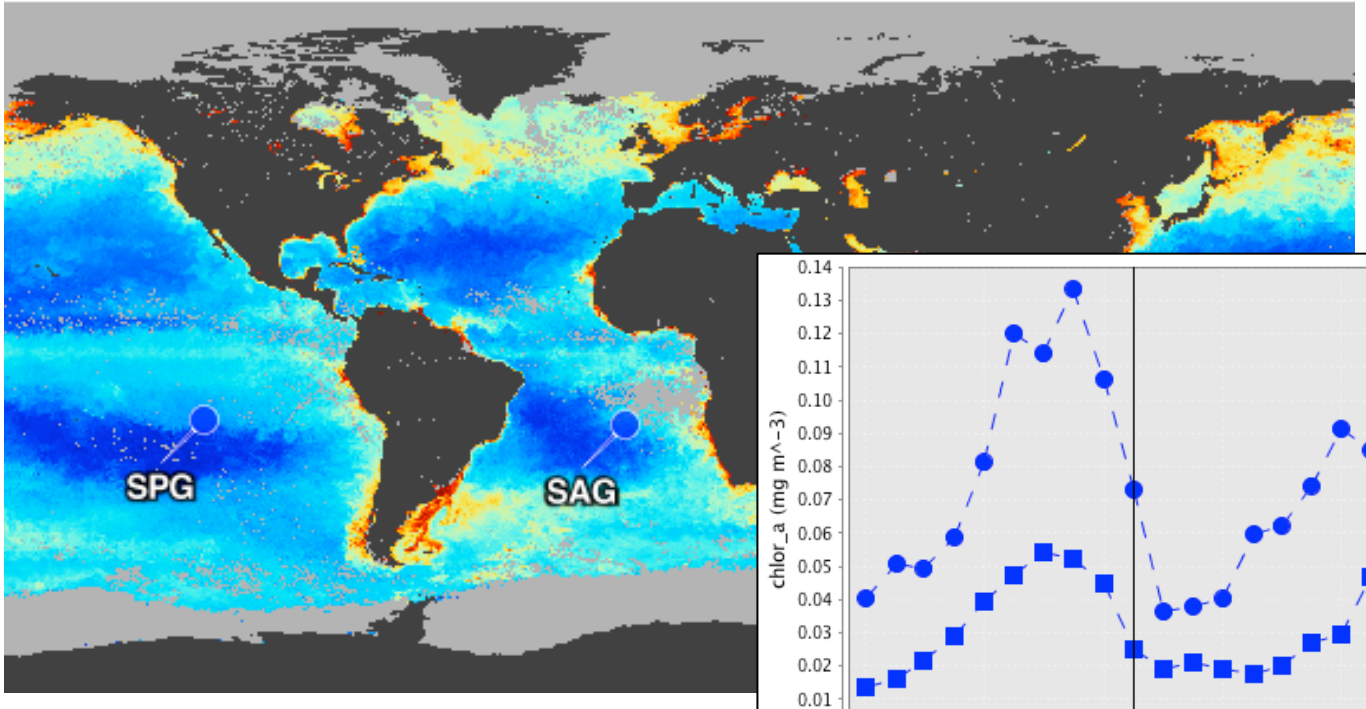
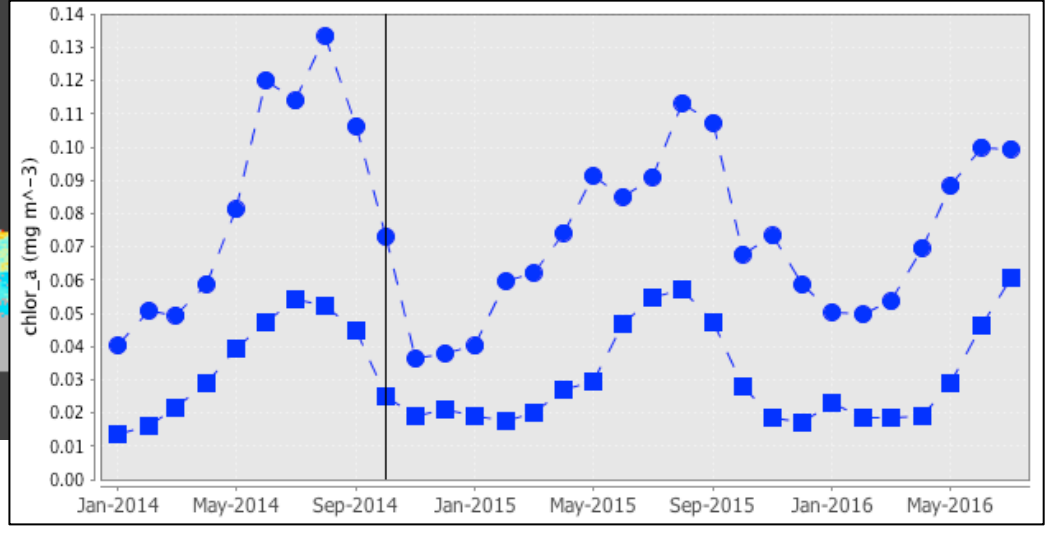
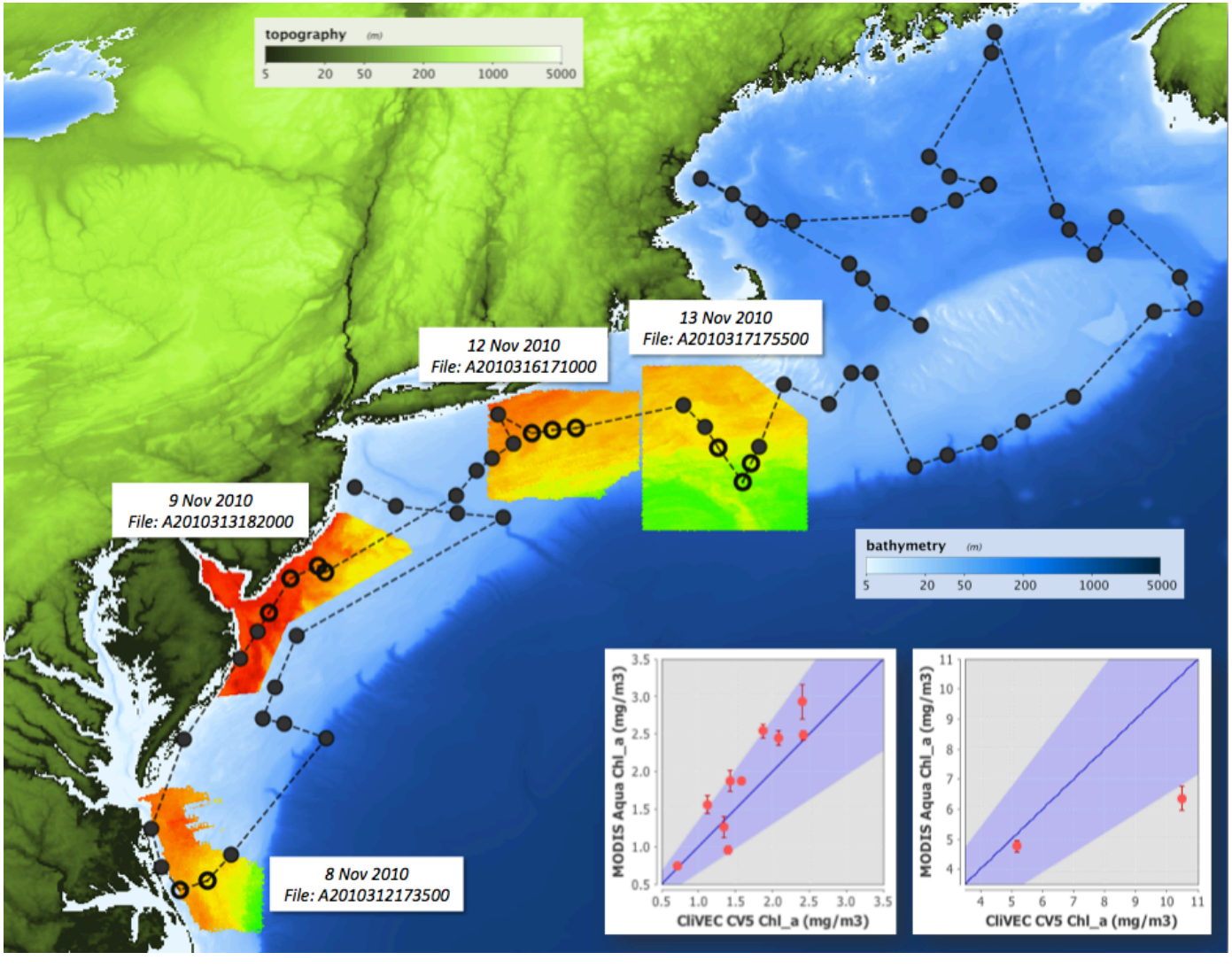


Image of Sept 2014 Chlorophyll Monthly
SPG: South Pacific Gyre
SAG: South Atlantic Gyre



Trend plot of MODIS Aqua Chlorophyll for a selected location within the South Pacific Gyre (blue squares) and South Atlantic Gyre (blue circles)

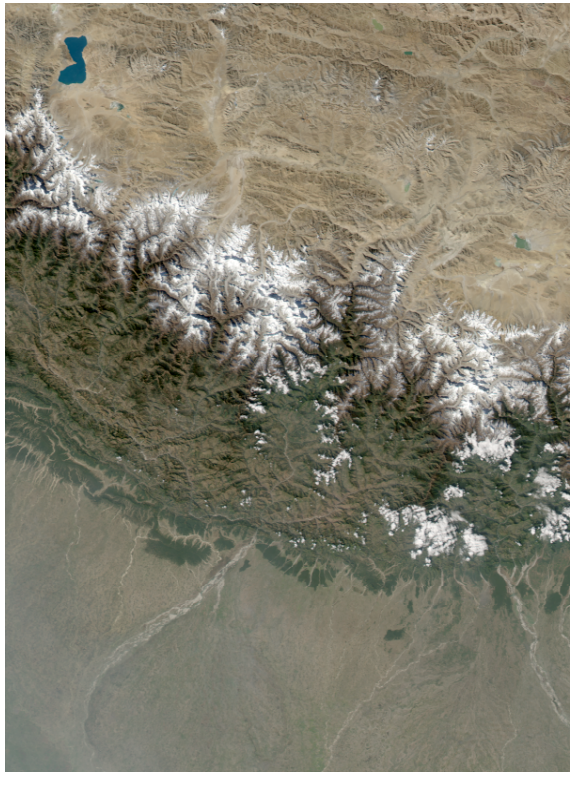
- **SeaDAS reads both satellite data and field measurement data (SeaBASS format) and enabling ship route image overlays and statistical comparison.**



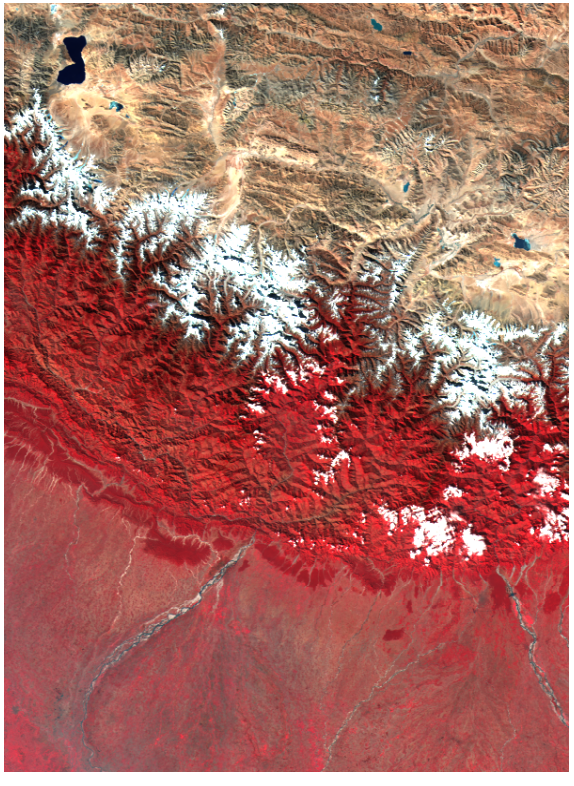
RGB / True Color Imagery

- **SeaDAS contains tools for creating RGB imagery based on any 3 selected bands. Commonly used for creating true color imagery.**

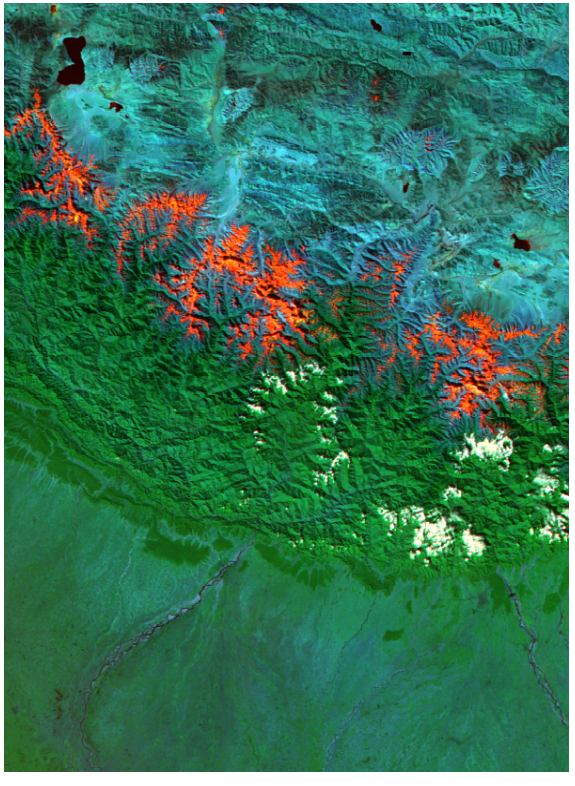
- *Example: Himalayas MODIS Aqua Dec 31 2011*



RGB bands: 645, 555, 469
Natural true color image
Landsat TM equivalent: 3,2,1
Landsat OLI equivalent: 4,3,2



RGB bands: 859, 645, 555
Distinguishes vegetation and soil
Landsat TM equivalent: 4,3,2
Landsat OLI equivalent: 5,4,3



RGB bands: 469, 1240, 2130
Distinguishes ice, snow, clouds
Landsat TM equivalent: 1,5,7
Landsat OLI equivalent: 2,6,7

Exporting Data Compatible with External Software

✧ **SeaDAS export satellite data in a variety of formats and hence can act as a useful gateway between the raw satellite data and the users preferred analysis software.**

Export formats

- GeoTIFF
- BigGeoTIFF
- NetCDF4-CF, NetCDF-CF
- NetCDF4-BEAM, NetCDF-BEAM
- CSV
- Shapefile *(vectors)*
- CPT *(color palettes)** – *(*Upcoming in SeaDAS 7.4 release)*

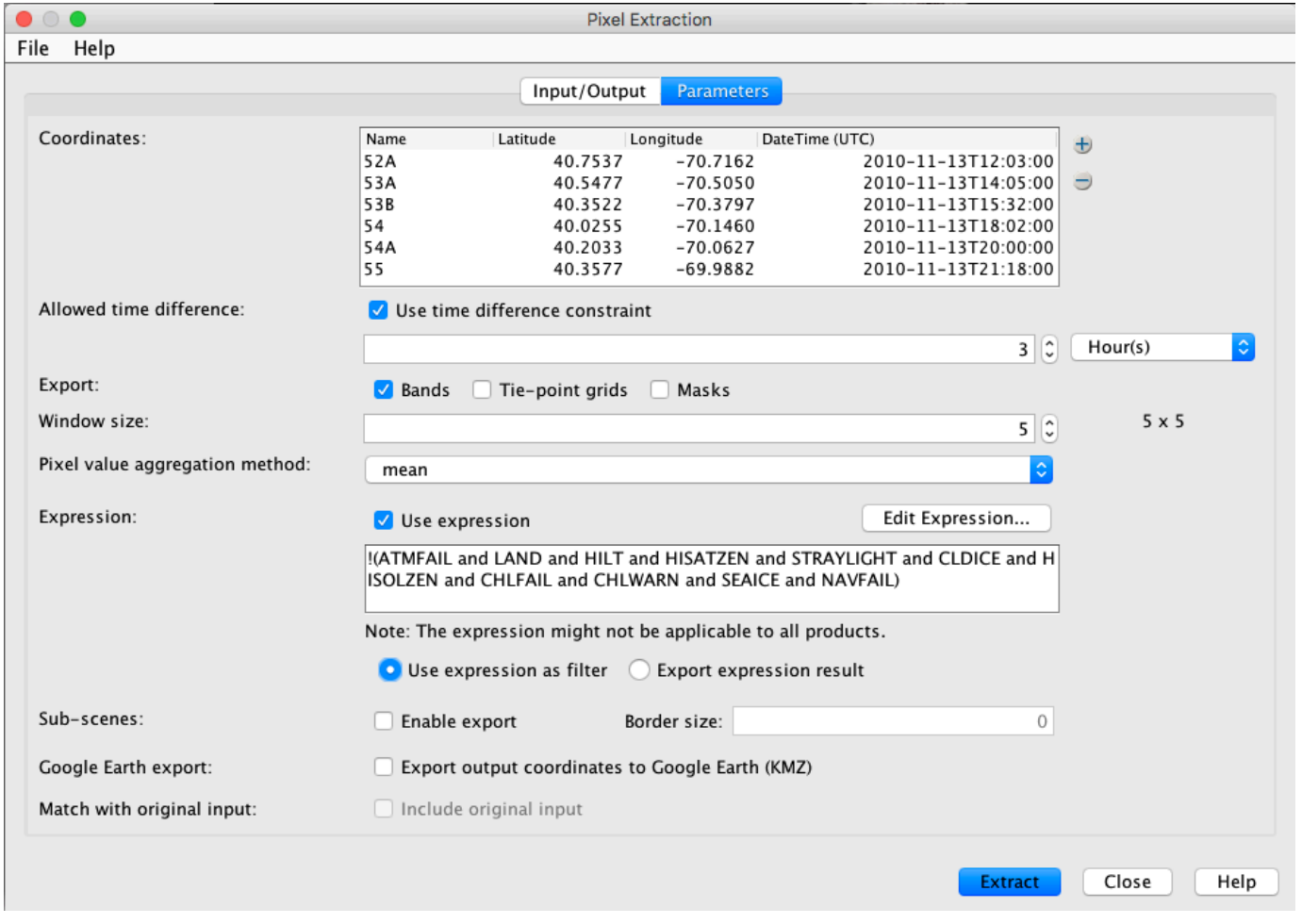
Some Commonly Used External Software

- ArcGIS
- BEAM (companion software)*
- C / C++
- ENVI
- ERDAS Imagine
- GMT (Generic Mapping Tools)
- IDL
- Giovanni (pre-processed only)*
- MATLAB
- Microsoft Excel
- Python
- QGIS
- R
- SNAP (companion software)*

Exporting Data Compatible with External Software

- **SeaDAS can extract satellite data pixel value(s) for user-specified geographic coordinates, time constraints, quality flag constraints and aggregation parameters into a readable text file (CSV)**

- *Example: SeaDAS Pixel Extraction Tool showing constraints applied to a loaded satellite file*



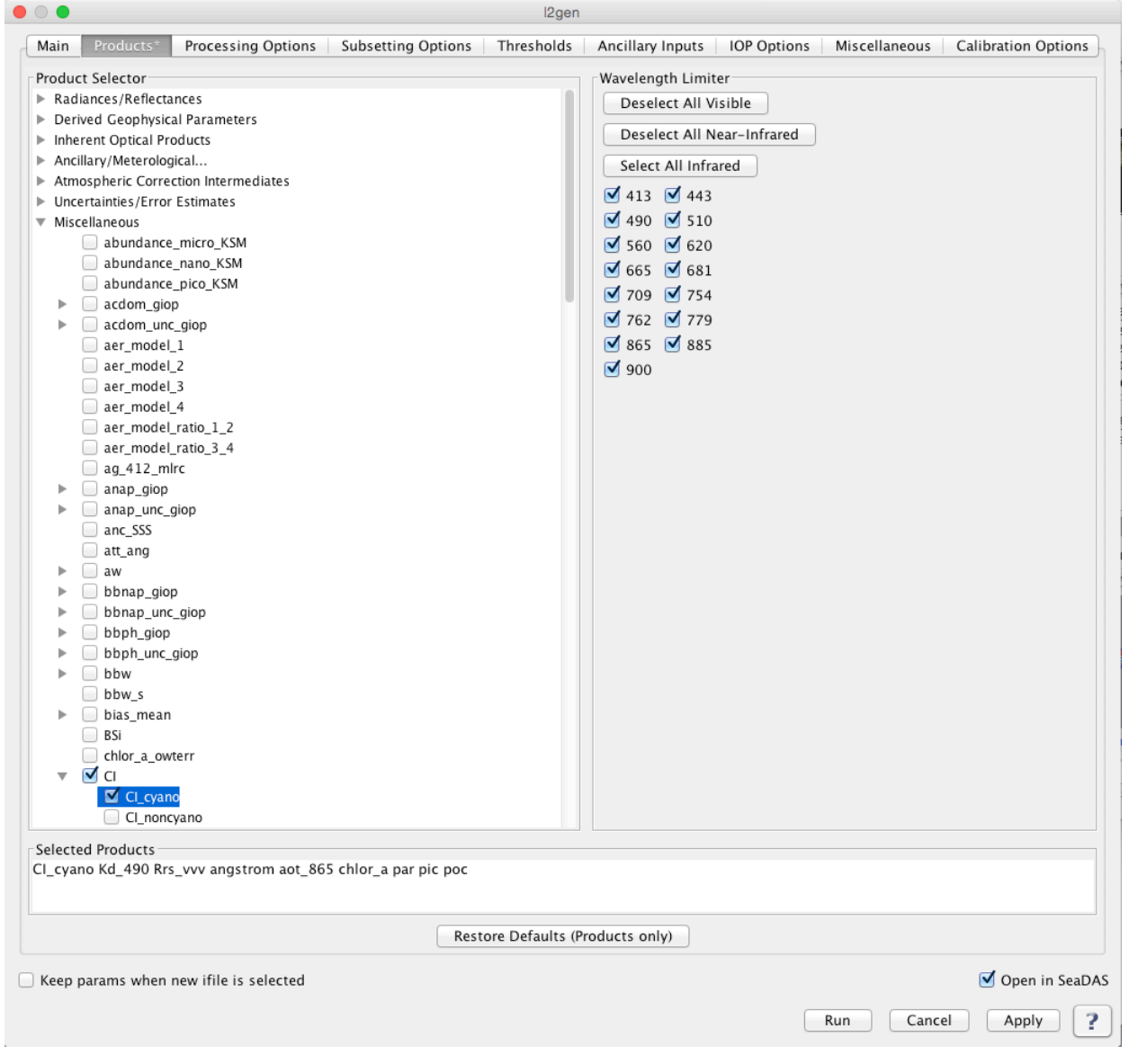
SeaDAS OCSSW Processors

✧ **SeaDAS produces OB.DAAC scientific products from supported pre-level 2 files**

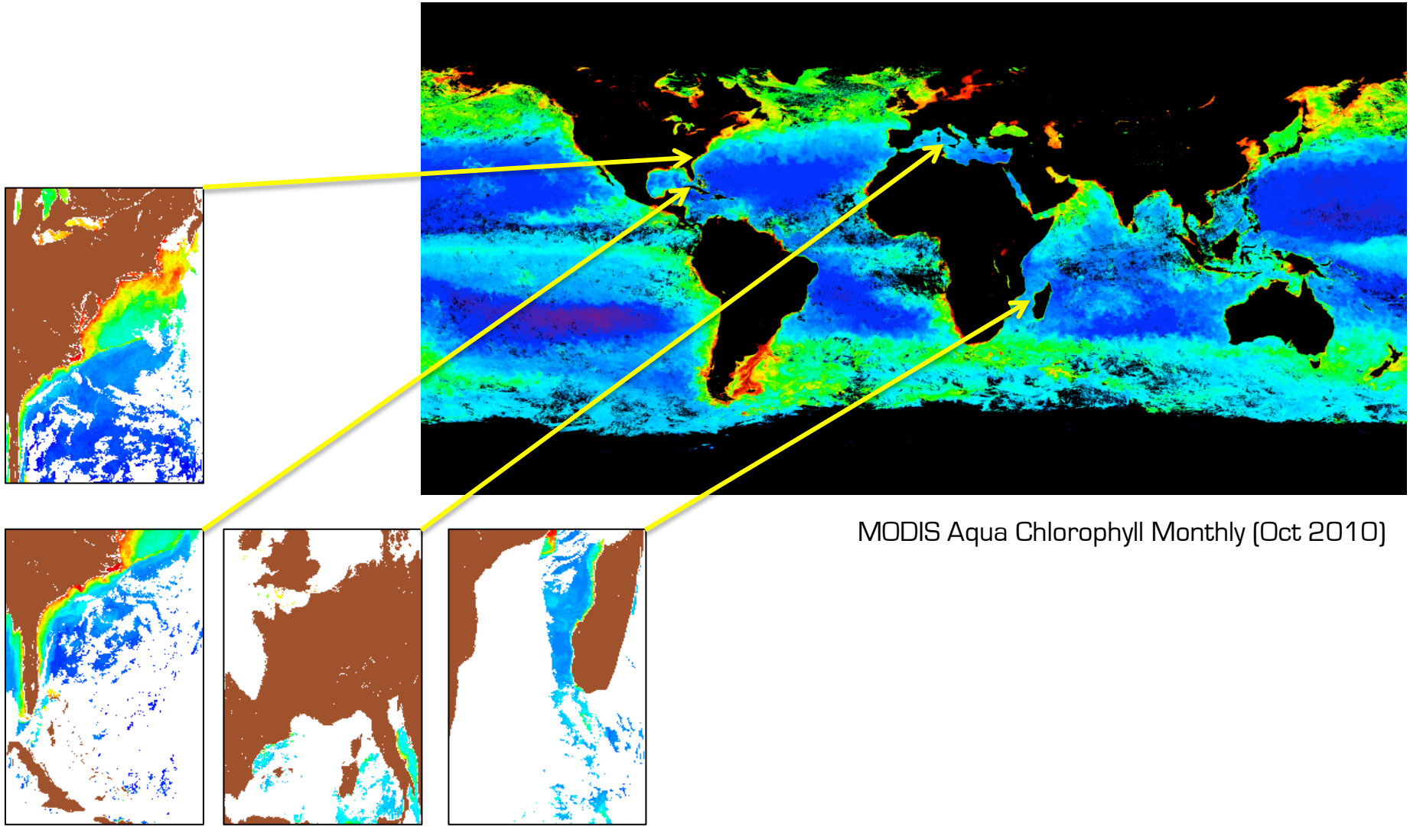
- Level 1B Gen - l1bgen (or modis_L1B.py)
  - ➢ input file
    - level 1A
  - ➢ output file
    - generates a level-1B file

- Level 2 Gen - l2gen
  - ➢ input files
    - level 1B file (for some missions level 1A file is used)
    - geolocation file (only for some missions)
    - ancillary or default climatology files
  - ➢ output file
    - generates a level 2 file
  - ✧ large selection of products
  - ✧ adjustable thresholds
  - ✧ cropping options
  - ✧ resolution options (for MODIS)

Level 2 Gen Interface



- **SeaDAS enables merging a large quantity of level-2 scenes into a single global image**



MODIS Aqua Chlorophyll Monthly (Oct 2010)

500+ MODIS Aqua Chlorophyll Level-2 Files (Oct 2010)

- Level 2 Bin – l2bin
  - input file
    - level 2
  - output file
    - generates a level 3 binned file

- Level 3 Map Gen – l3mapgen
  - input files
    - level 3 binned file
  - output file
    - generates a level 3 mapped file

- **SeaDAS incorporates relevant ancillary data into satellite scenes**
  - **For masking and image display**
  - **For atmospheric correction** *(where the satellite does not contain necessary measurements)*

Ancillary Data

Standard Tools

- Bathymetry, Topography, Elevation (2km resolution)
- Land (50m, 150m, 1km and 10km resolution)

OCSSW L2gen Processor and Products

- File=no2file *(from SCIAMACHY/GOME/OMI)*
  - NO_2 concentration (stratospheric and tropospheric)
- File=met1, met2, met3 (*from NCEP*)
  - wind speed
  - surface pressure
  - water vapor concentration
  - relative humidity
- File=ozone1, ozone2, ozone3 (*from OMI/TOMS*)
  - ozone concentration
- File=icefile
  - sea ice
- File=elevfile
  - elevation (with respect to sea level)
- File=land
  - land mask

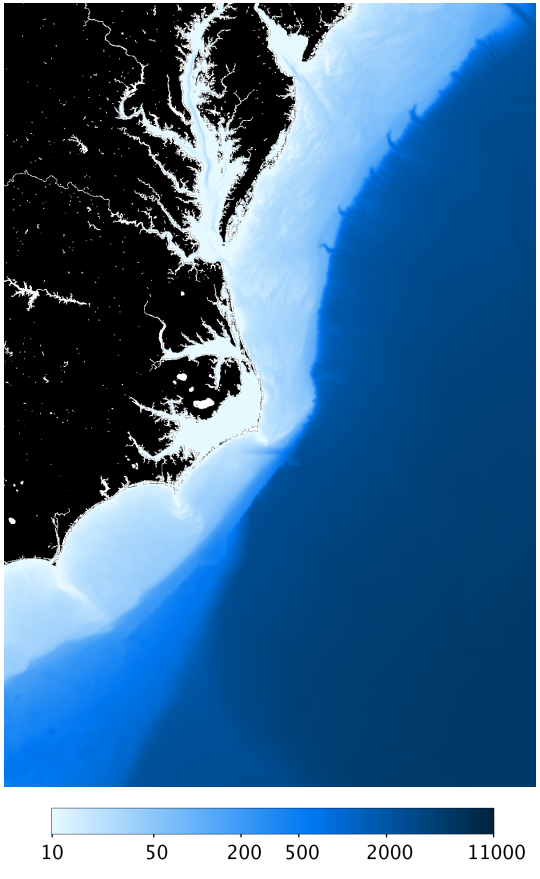
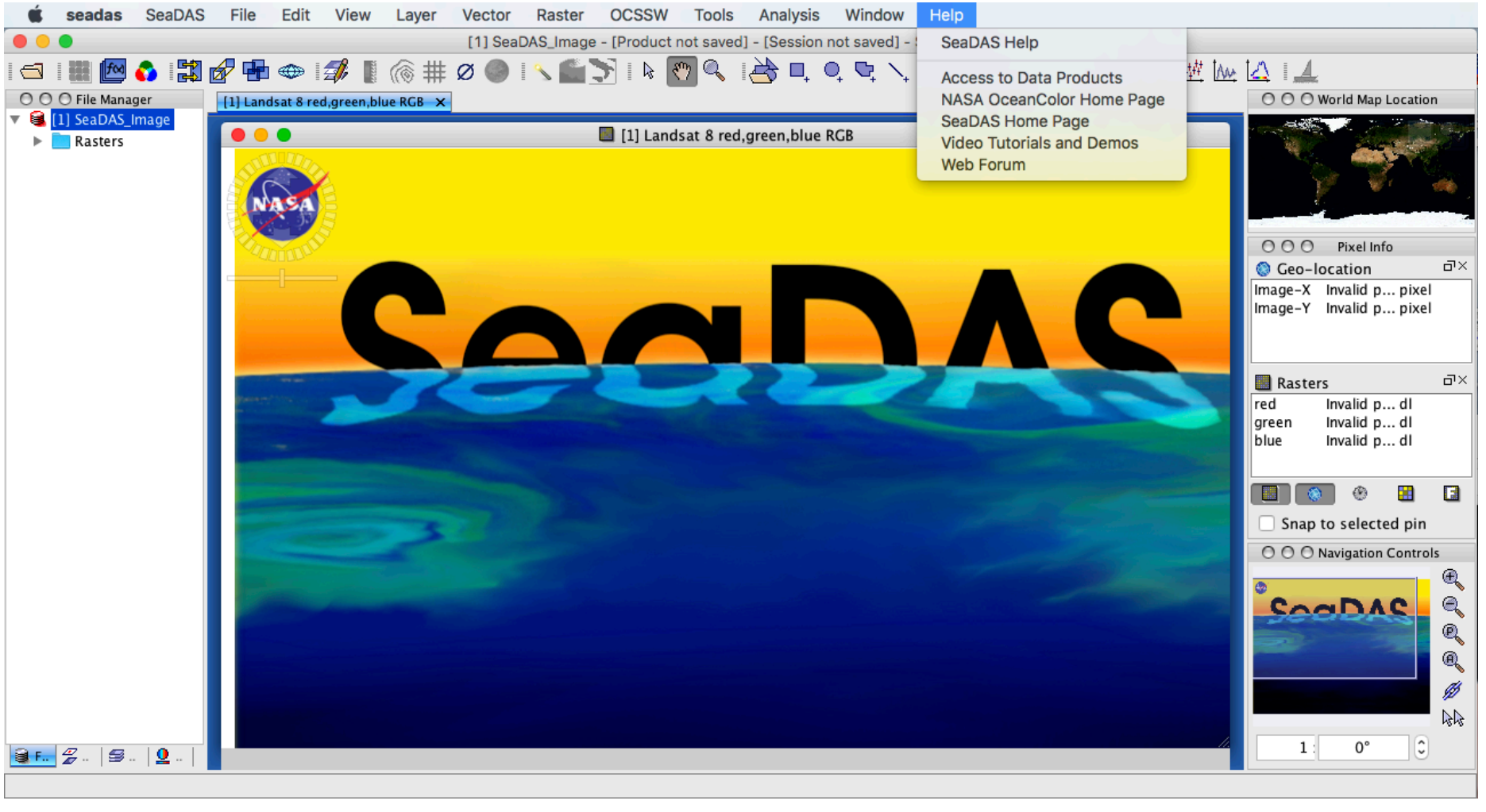


Image of land (masked in black) and bathymetry data for a satellite scene

User Support and Help

User Support and Help

- **SeaDAS has an active online forum, a strong tutorial presence on YouTube, and a regular presence at conferences and training sessions**



SeaDAS Sample Imagery