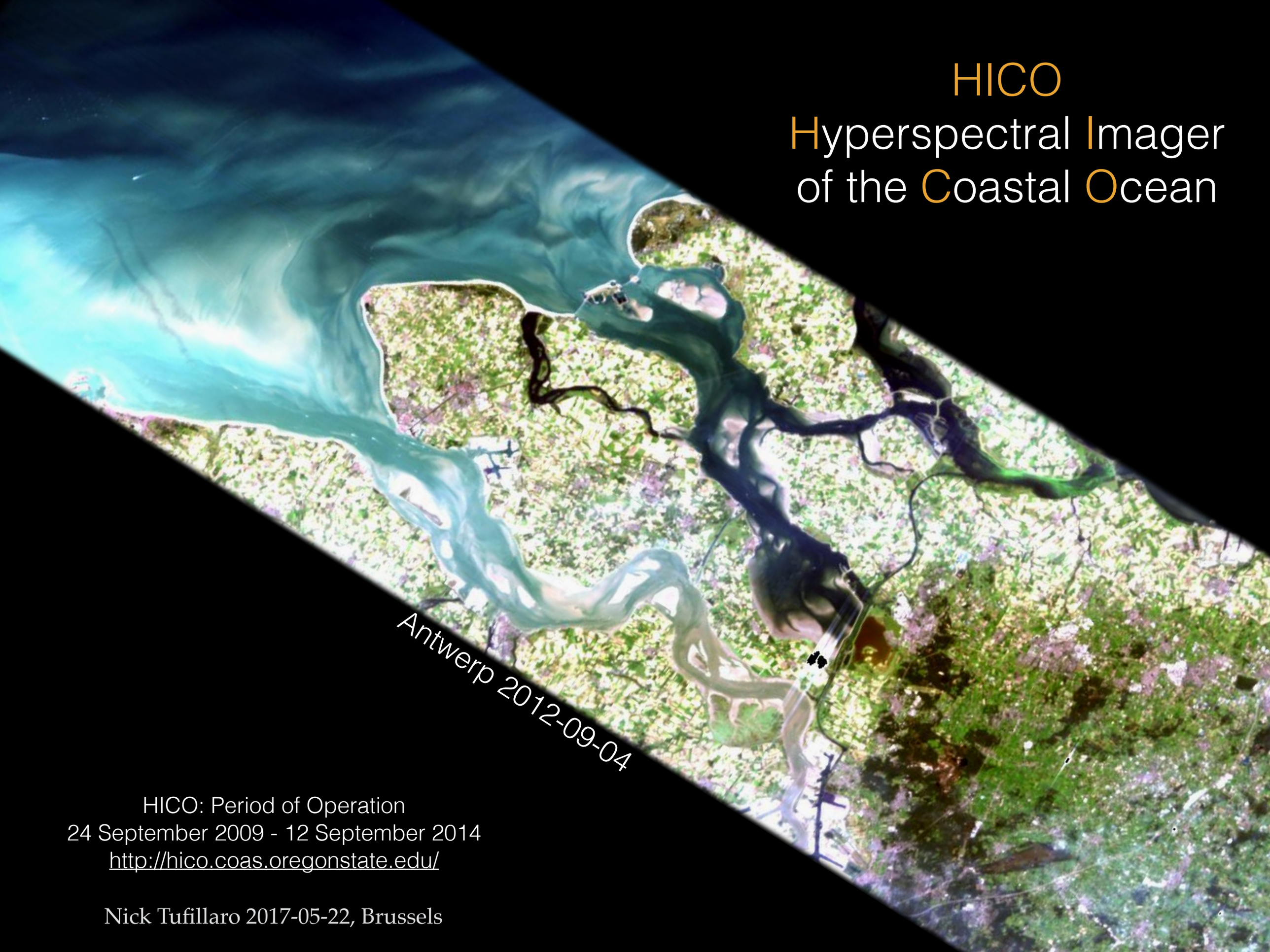
# HICO
# Hyperspectral Imager of the Coastal Ocean




HICO: Period of Operation
24 September 2009 - 12 September 2014
http://hico.coas.oregonstate.edu/

Nick Tufillaro 2017-05-22, Brussels

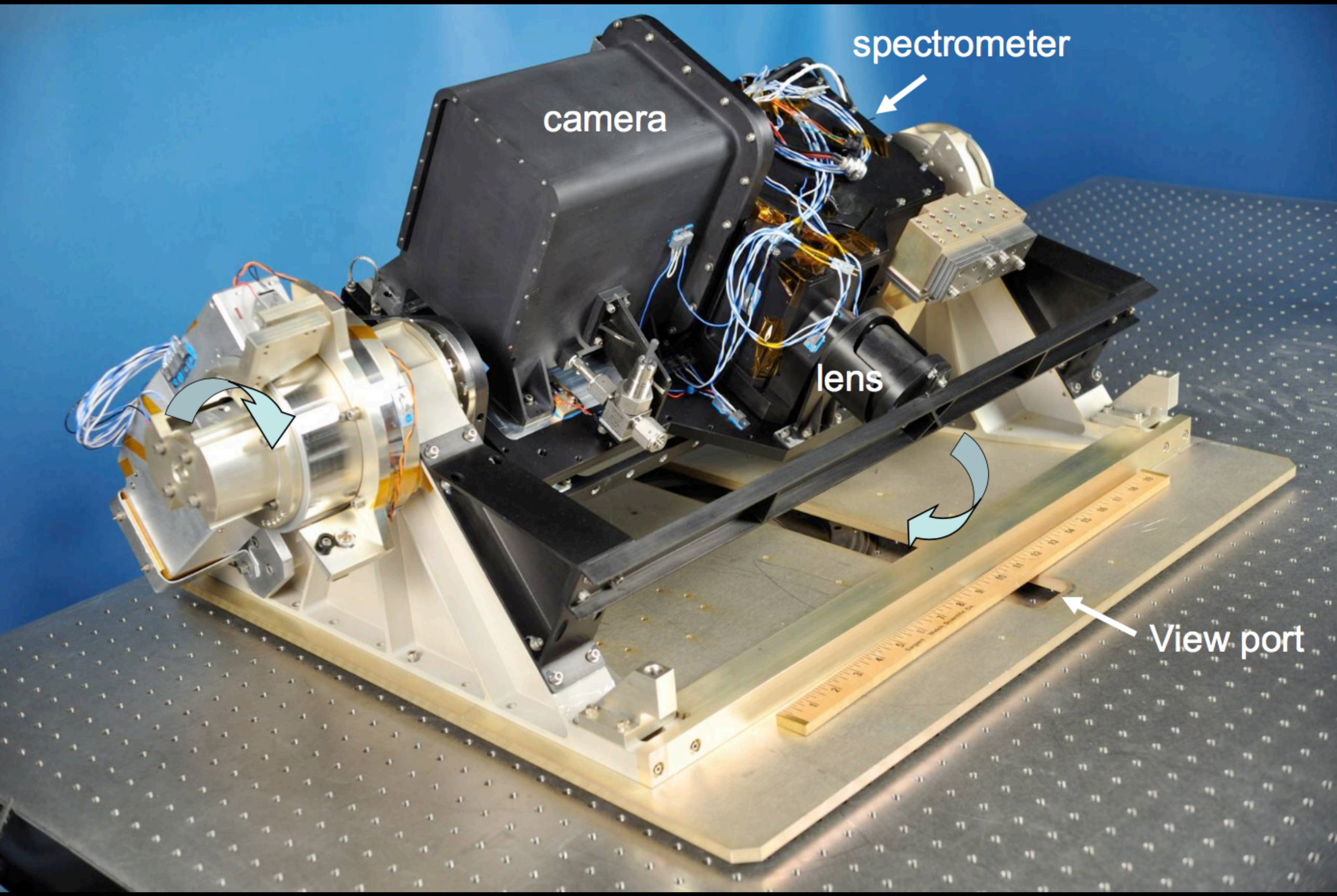
# HICO

## Instrument and Data

## Processing

## Example Products / Science

Bathymetry
Edge-Detection
— Dredging
Specific Pigments and Species
Mesodinium Rubrum, Phycocyanin
— Monitoring health of coastal and Inland waters
Hyperspectral IOP’s


spectrometer
camera
lens
View port

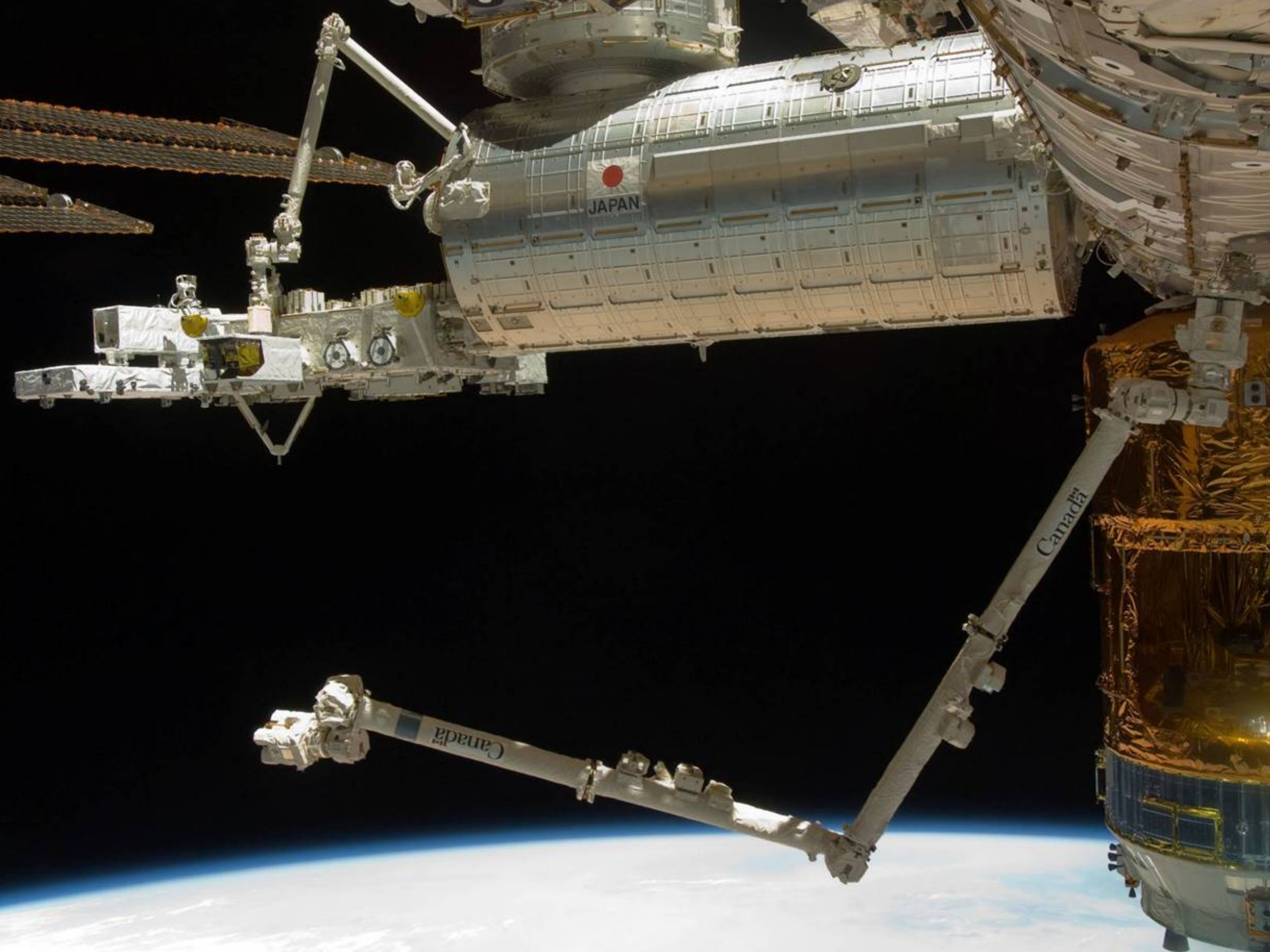

JAPAN
Canada
Canada

Image Coastal Ocean Zones
Along ISS Ground Track,
Swath Length 200 km

ISS Orbit
Altitude: 375 km (nominal)
Inclination: 51.6 deg

Ground Swath Width: 45 km

Cross-Track Field of Regard:
Left + Right Total 600 km
(+45°/-30° off-nadir)


Christchurch, NZ


AAOT Venice

## HICO Specifications

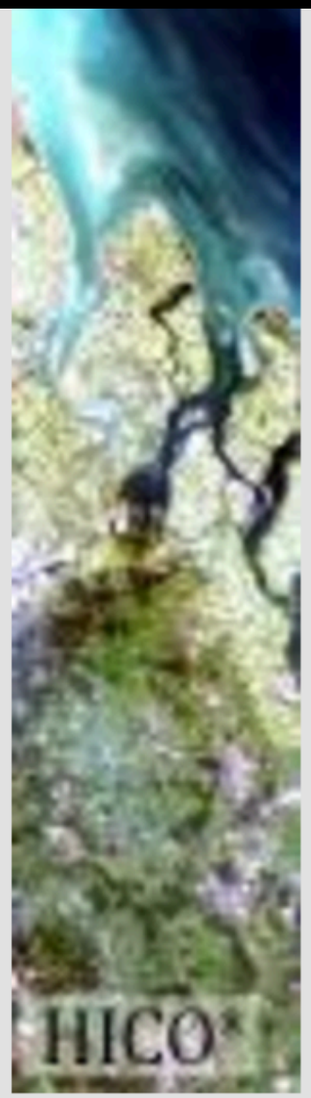
**General properties**

| | |
|---|---|
| platform | International Space Station (ISS) |
| HICO launch | September 10, 2009 |
| HICO installed on ISS | September 24, 2009 |
| first image date | September 25, 2009 |
| last image date | September 13, 2014 |
| HICO end of operations | September 13, 2014 |
| on-orbit lifetime | one year minimum |
| orbit | near circular (see the Orbit page) |
| inclination | 51.6° |
| altitude | 343 km (varies) |
| ISS orientation | +XVV (standard forward orientation)<br>-XVV (reverse orientation - infrequent) |
| orbit repeat time | 3 days (approximate) |
| orbit lighting cycle | 63 days |
| orbit period | 90 minutes |
| scenes per orbit | 1 maximum |
| scenes per day | 15 maximum |
| cross-track pointing | varies from -45 to +30 degrees<br>-45: 45 degrees port (north if +XVV orientation)<br>+30: 30 degrees starboard (south if +XVV orientation) |
| swath orientation | varies depending on the orbit path:<br>NW to SE (descending)<br>SW to NE (ascending) |
| ground sample distance (GSD) | 90 m (varies with altitude and angle) |
| scene size (km) | 42 x 192 km (varies with altitude and angle) |
| scene size (pixels) | 500 x 2000 pixels (width x length) (details below)<br>(512 x 2000 pixels uncropped) |
| sensor field of view (FOV) | 6.92° (i.e. +/- 3.46° from the center)<br>covering 512 cross-track pixels |
| wavebands | 87 bands (details below)<br>(128 bands uncropped) |
| wavelengths | 400 - 900 nm (details below)<br>(353 - 1080 nm uncropped) |
| RGB bands | R : 638.9 nm (band 42)<br>G : 553.0 nm (band 27)<br>B : 461.4 nm (band 11) |
| spectral resolution | 5.7 nm (details below) |
| spectral FWHM | 10 nm (400 - 745 nm)<br>20 nm (746 - 900 nm)<br>(details below) |
| signal-to-noise ratio (SNR) | > 200:1 for water-penetrating wavelengths and assuming 5% albedo |
| polarization sensitivity | < 5% (430 - 1000 nm) |
| data format | *from this website*: binary BIL and BSQ (ENVI™ compatible[1])<br>*from NASA*: HDF5 |
| disk space required per scene | L1B: 120 MB (varies) / 230 MB (uncompressed)<br>L2A: 400 MB (varies) / 696 MB (uncompressed) |

*For more information, see*: Lucke, R.L. et al. (2011), "Hyperspectral Imager for the Coastal Ocean: instrument description and first images", Appl. Opt. v 50(11), 1501-1516.

http://hico.coas.oregonstate.edu/

Oregon State On-line L2 processing




BEL_Antwerp
Belgium
2012-09-04 12:59:05
Scene ID : 11299
L1B
full resolution image

ENVI data

HDF5 data

process to L2

# HICO Atmospheric Correction

The atmospheric correction algorithm used is tafkaa_6s from NRL, developed by Marcos Montes, Bo-Cai Gao, and Curtiss Davis. Further details are available in the Tafkaa User's Guide.

**BEL_Antwerp** **11299** **2012-09-04 12:59:05 GMT**

output parameter: rrs (remote-sensing reflectance)

**MAJOR** *The parameters in the section below have a significant effect on the magnitude of the output.*

aerosol model: maritime

aerosol optical depth (tau_550): 0.2

elevation: 0 km

offset removal: remove positive offset over water

**MINOR** *The parameters in the section below make only minor changes to the spectrum; the default values are recommended.*

atmospheric model: automatic

ozone: -1 ppm

atmospheric gases: $H_2O$ $O_3$ $NO_2$ $O_2$

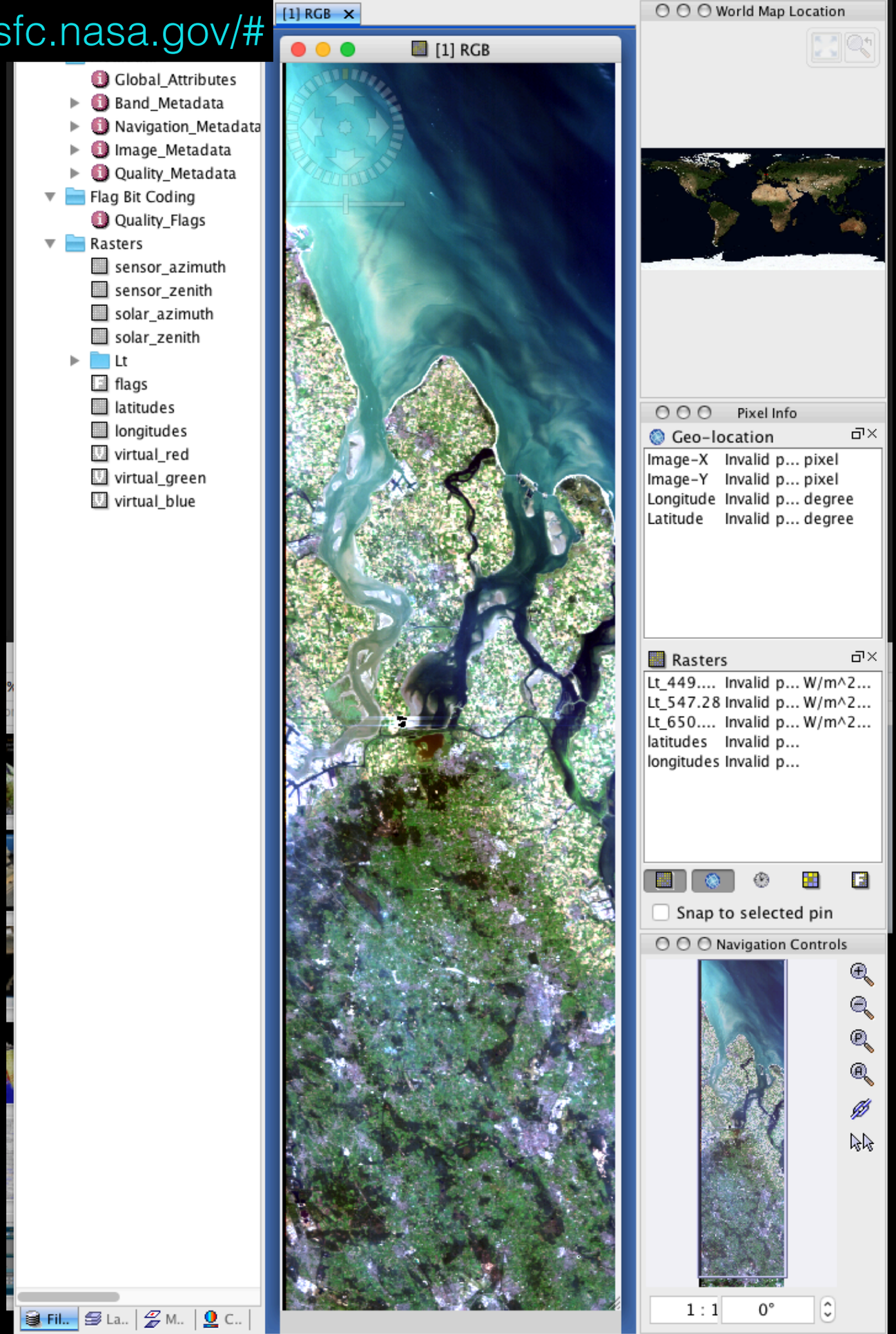
water vapor lines

| | adjacent window | $H_2O$ band center | adjacent window |
|---|---|---|---|
| Set 1: | 0.705 µm 3 | 0.725 µm 5 | 0.745 µm 3 |
| Set 2: | 0.805 µm 3 | 0.825 µm 5 | 0.845 µm 3 |

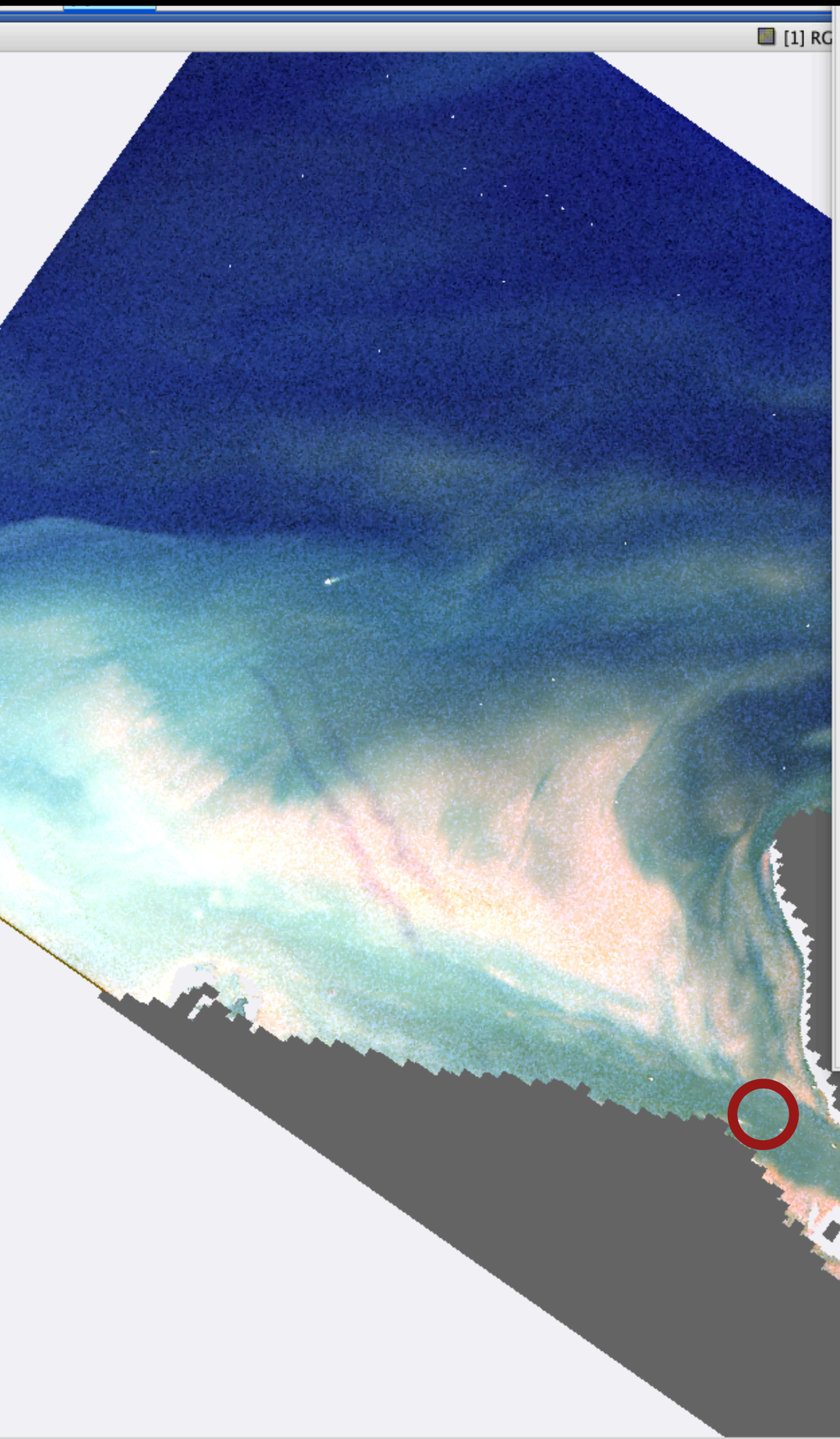
process to L2

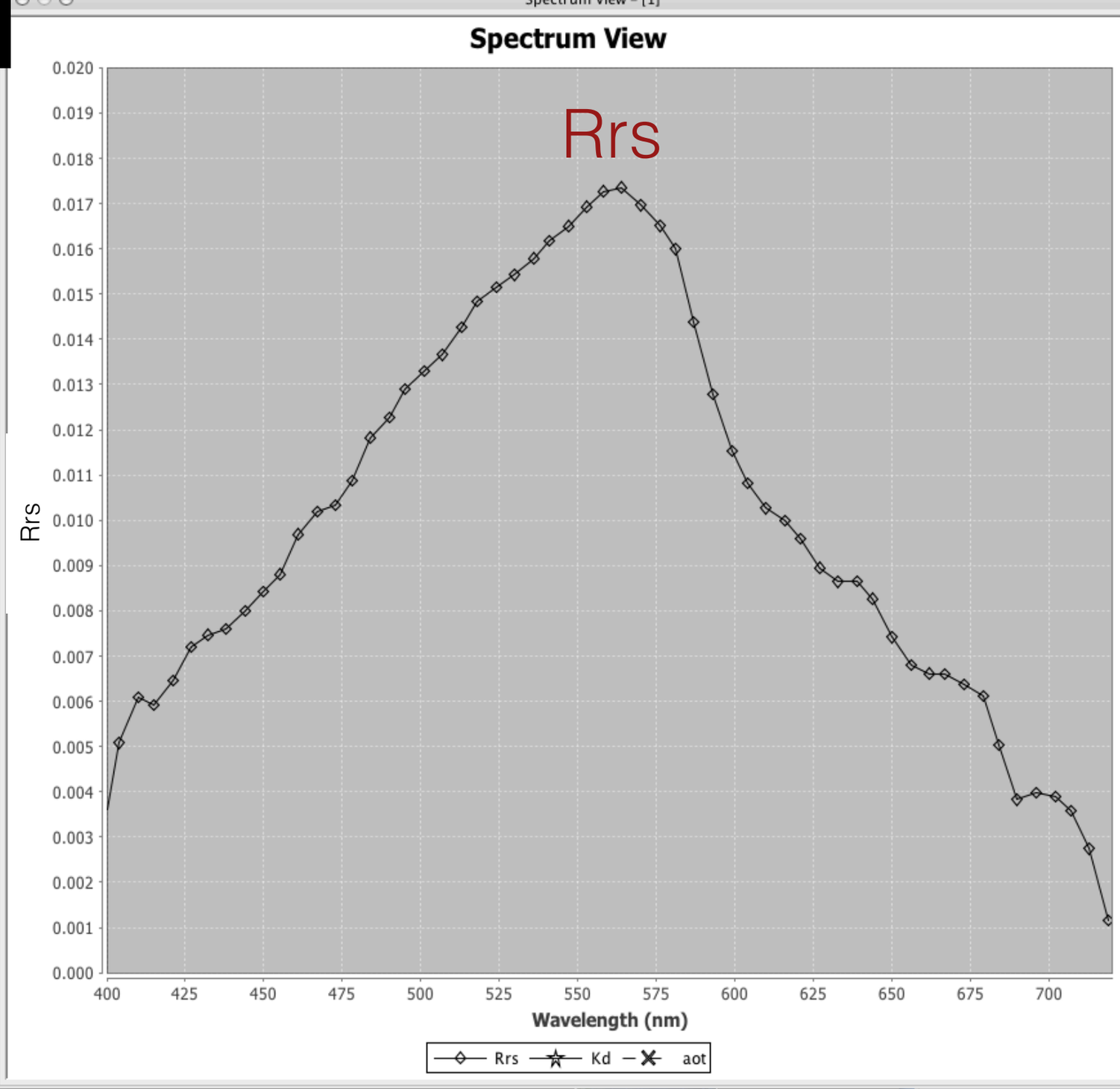
https://oceancolor.gsfc.nasa.gov/#

NASA SeaDAS L2 processing



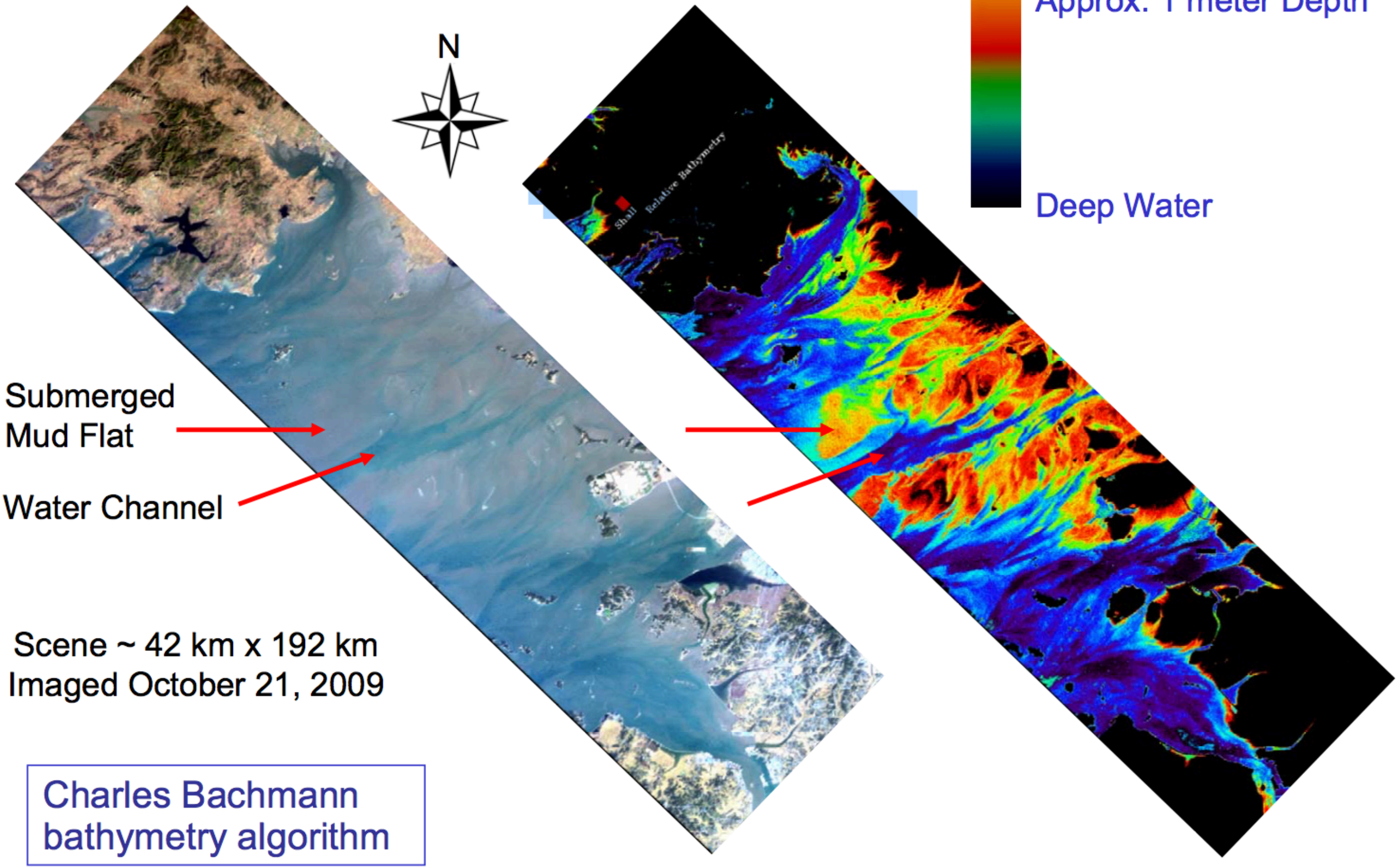
# NASA SeaDAS


[1] RG


Spectrum View
Rrs
Rrs
0.020
0.019
0.018
0.017
0.016
0.015
0.014
0.013
0.012
0.011
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
400
425
450
475
500
525
550
575
600
625
650
675
700
Wavelength (nm)
Rrs
Kd
aot

HICO Image off
Korean Peninsula

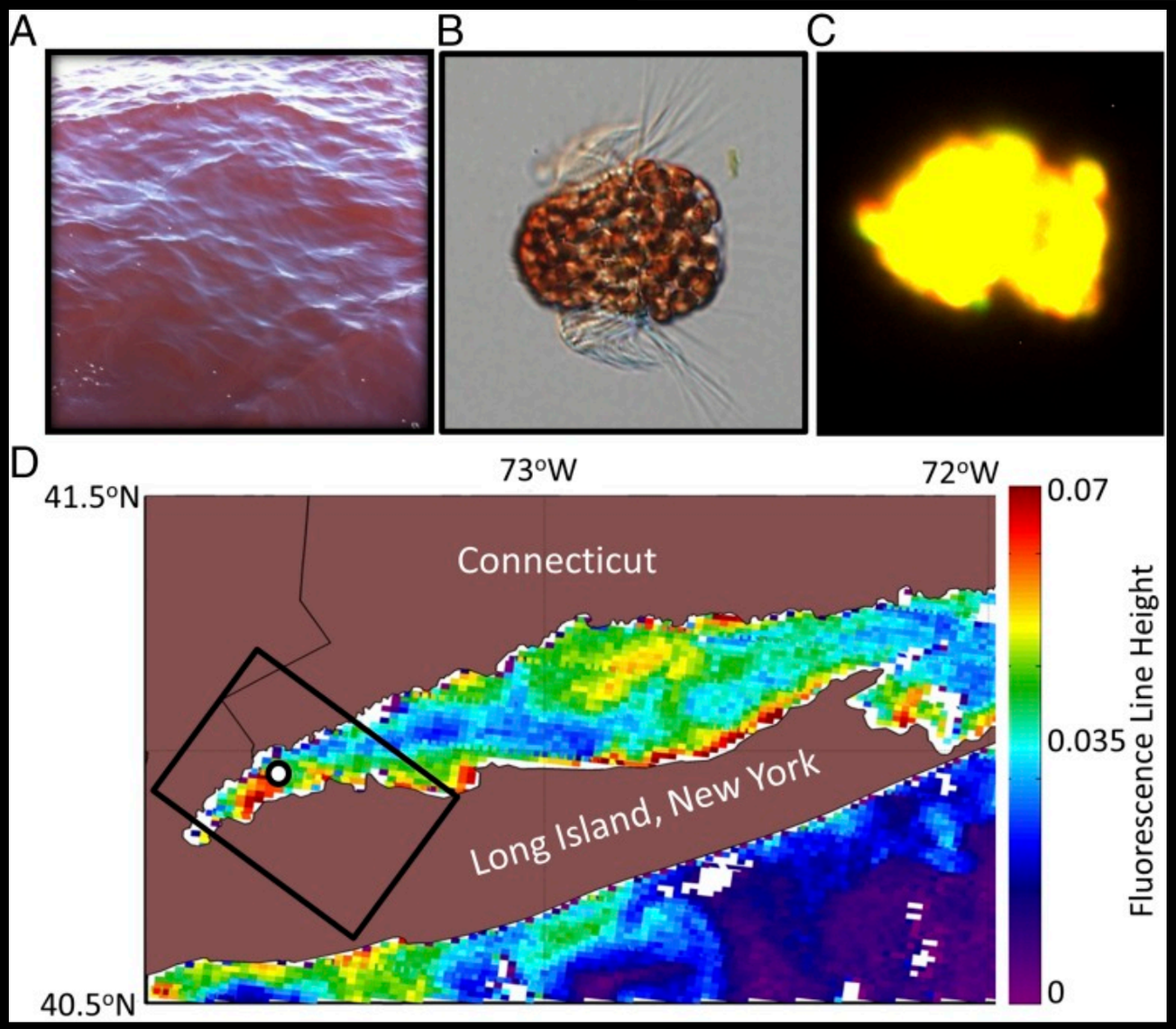
Relative Bathymetry Map
Retrieved from HICO Image

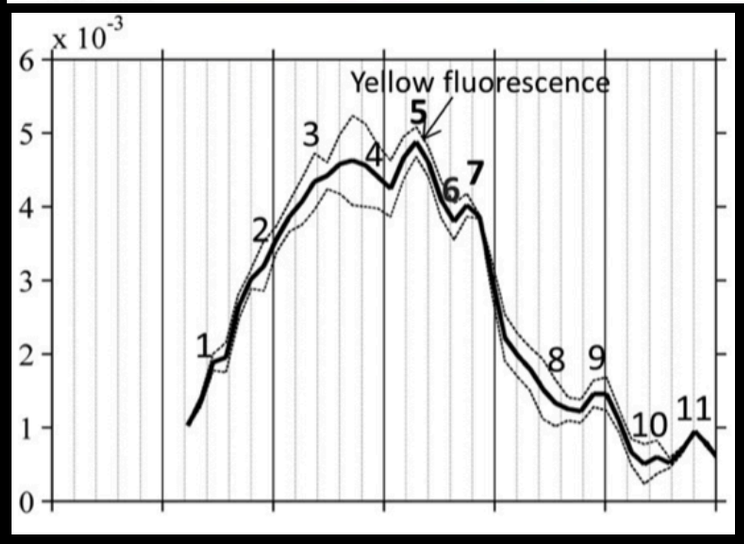


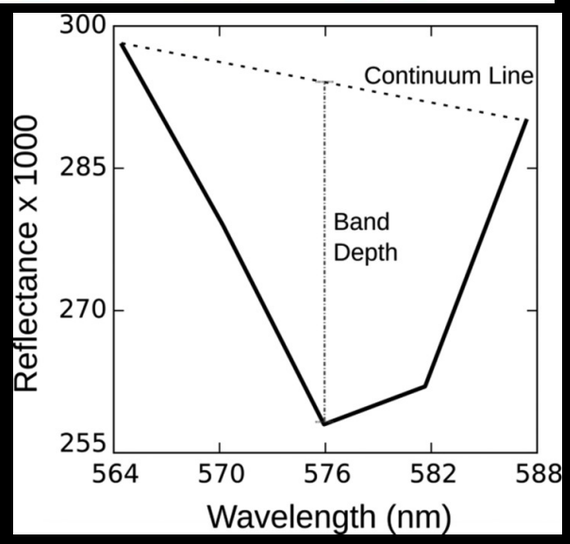
Proc Natl Acad Sci U S A. 2015 Dec 1; 112(48): 14783–14787.
Published online 2015 Nov 16. doi: 10.1073/pnas.1512538112
PMCID: PMC4672822
Environmental Sciences, Environmental Sciences

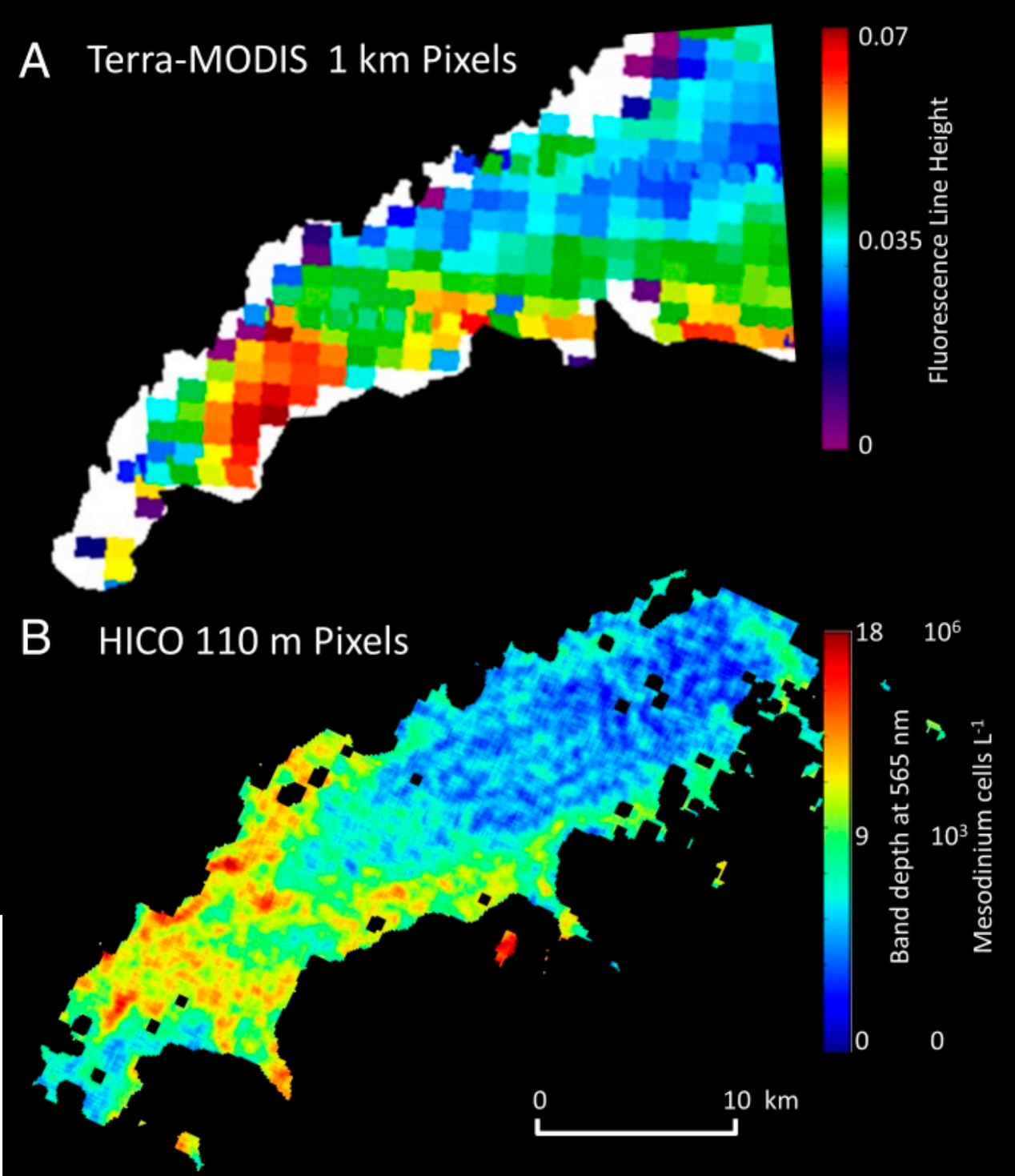
# Space station image captures a red tide ciliate bloom at high spectral and spatial resolution

Heidi Dierssen,[a,1] George B. McManus,[a] Adam Chlus,[a] Dajun Qiu,[a,b] Bo-Cai Gao,[c] and Senjie Lin[a]



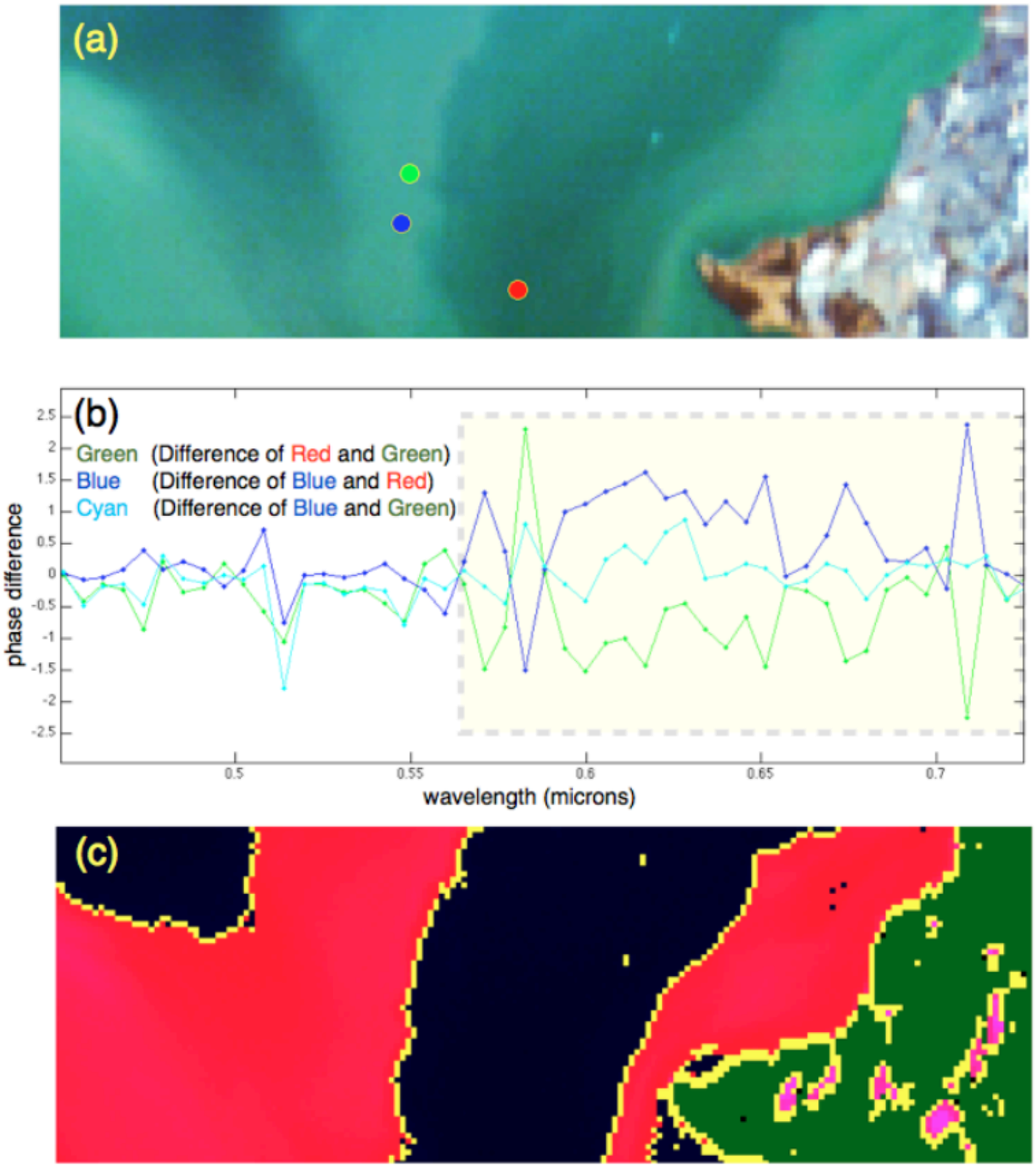



Fig. 12. HICO image of San Pablo Bay off of Pinole Point Park (a) 28 September 2011. (b) The phase difference computed from the 'winding number' of the spectra indicated by the colored dots in (a). (c) Edge detection is computed from phase difference between $0.575\ \mu m < \lambda < 0.75\ \mu m$. The edge detection identifies the San Pablo Strait.

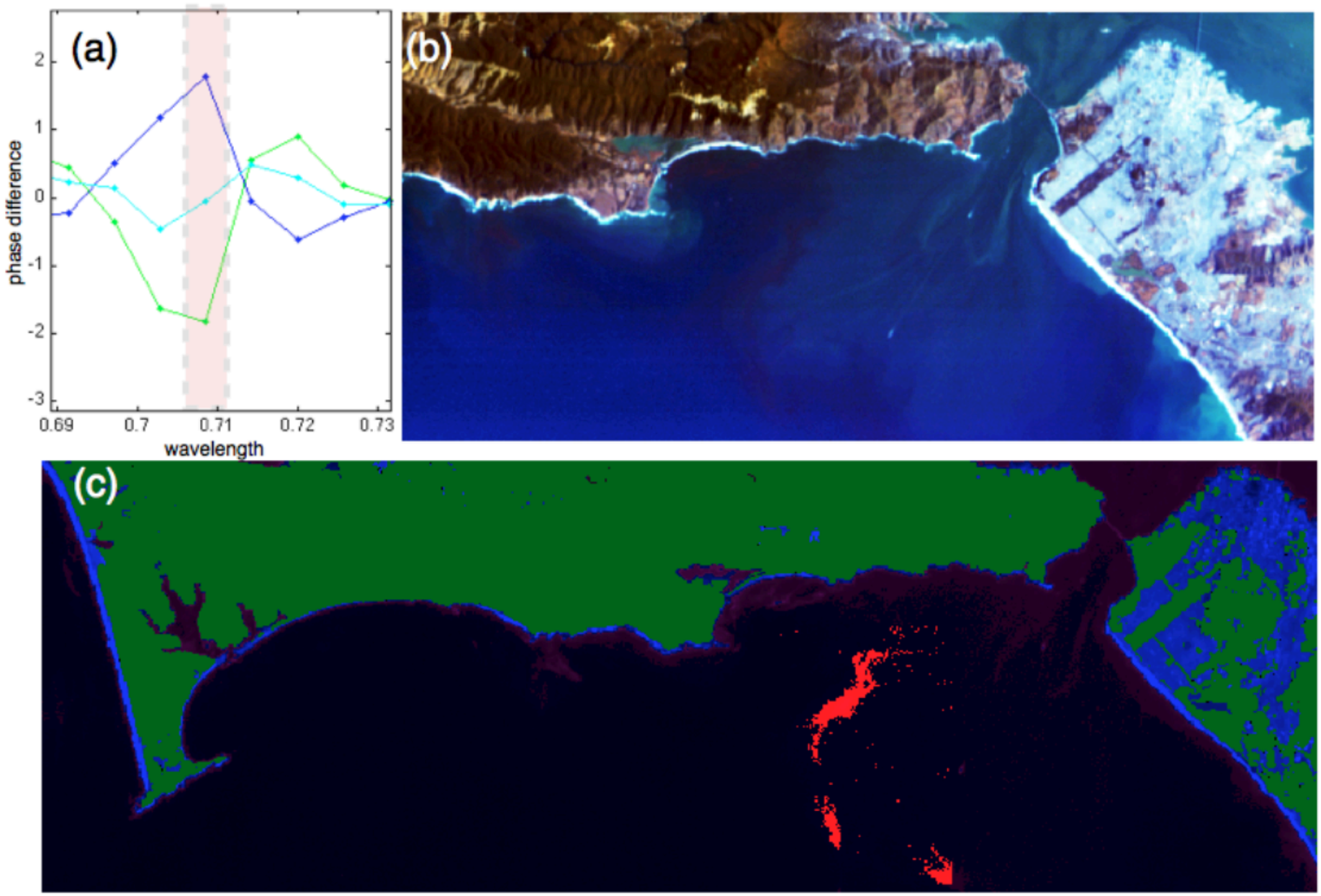



Fig. 14. (a) The phase difference function for spectra at the mouth of the San Francisco Bay showing that the 709 nm HICO channel can be used to indicate chlorophyll rich water. (b) HICO image of the mouth of San Francisco Bay, 28 September 2011. (c) Indicator function for high chlorophyll levels which appear to show a high concentration of chlorophyll at the interface of bay water and sea water.

# Using Hyperspectral Ocean Color Sensors for Monitoring Cyanobacterial Blooms in Lakes and Reservoirs.

**Nicholas B. Tufillaro[1,*], Connie S. Bozarth[2], Jonathan W. Shepardson[2], Jennifer L. Graham[3],**

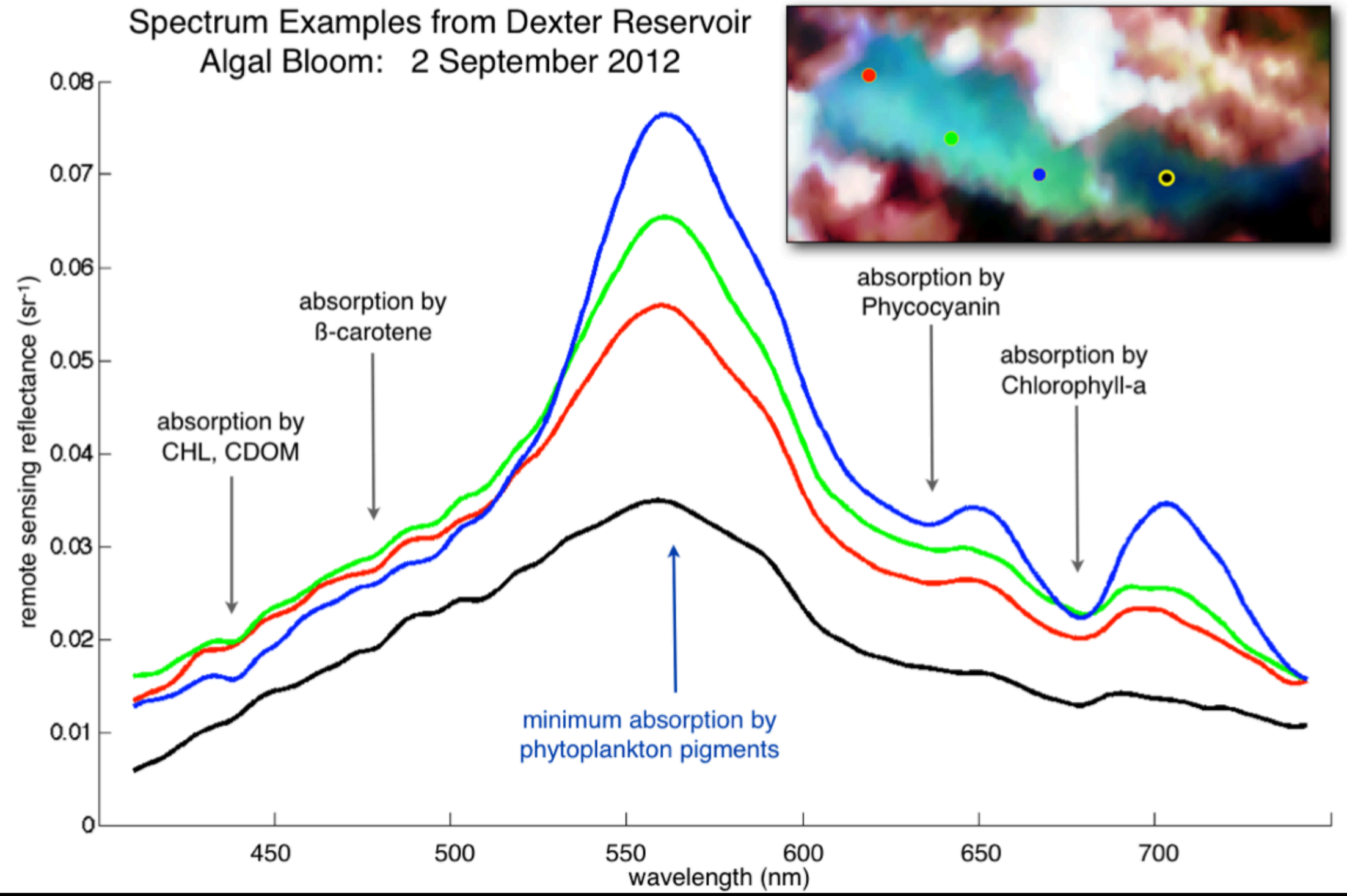
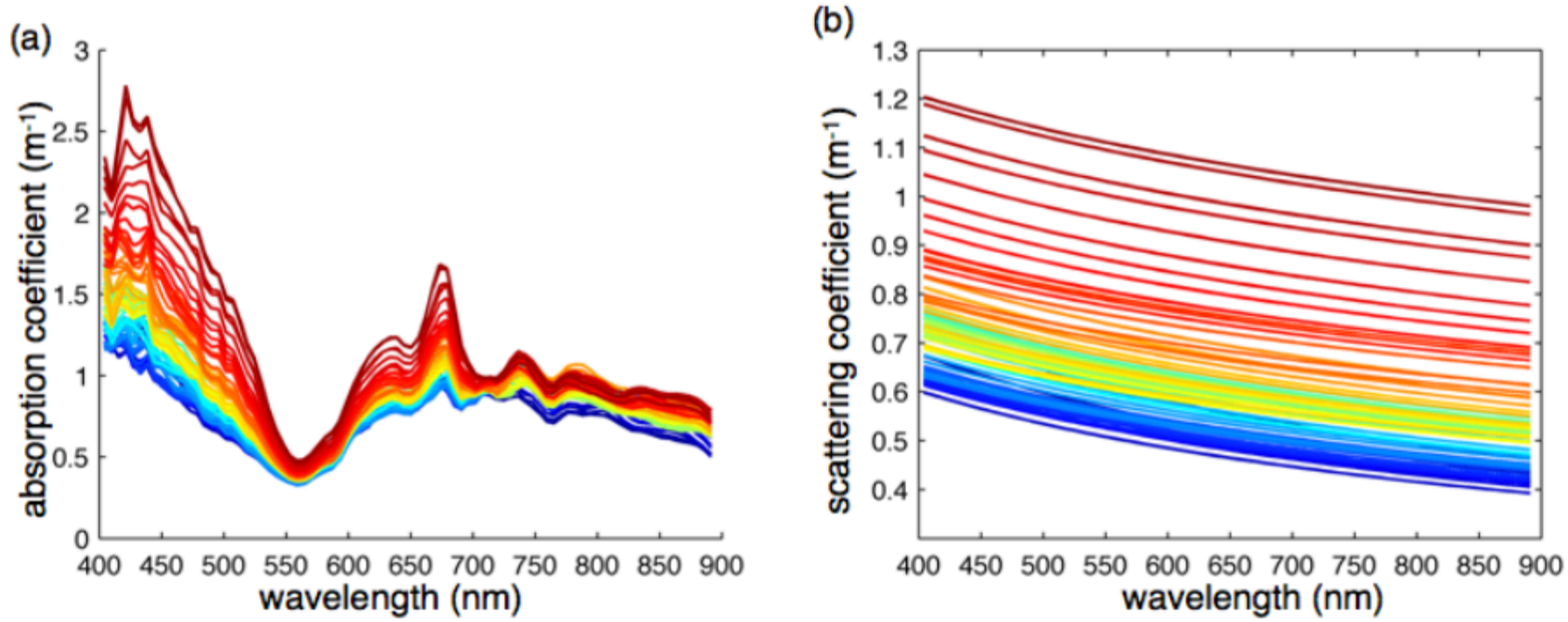


**Figure 7.** (a) Absorbance and (b) scattering calculated using QAA along (c) a transect along a middle section of Dexter reservoir for 4 September 2012. The color indicating the site location changes from blue to red from the northwest to the southeast corners




(c)

**Figure 8.** Peak Finding (using nonlinear optimization for fitting Gaussians) locates two peaks with nearly the same centers in absorbance along the whole transect which are proportional to Phycocyanin and Chlorophyll-a concentrations.

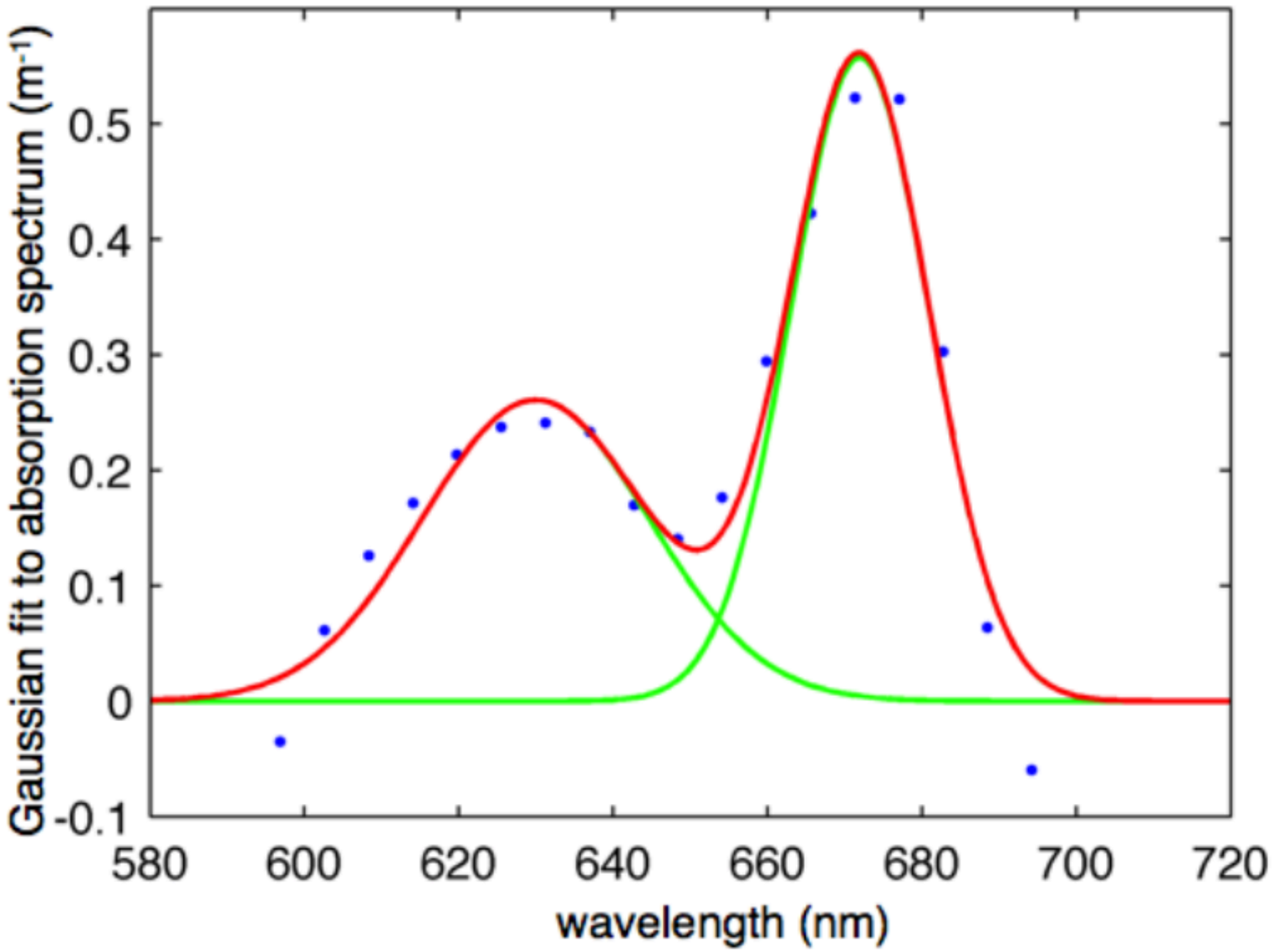
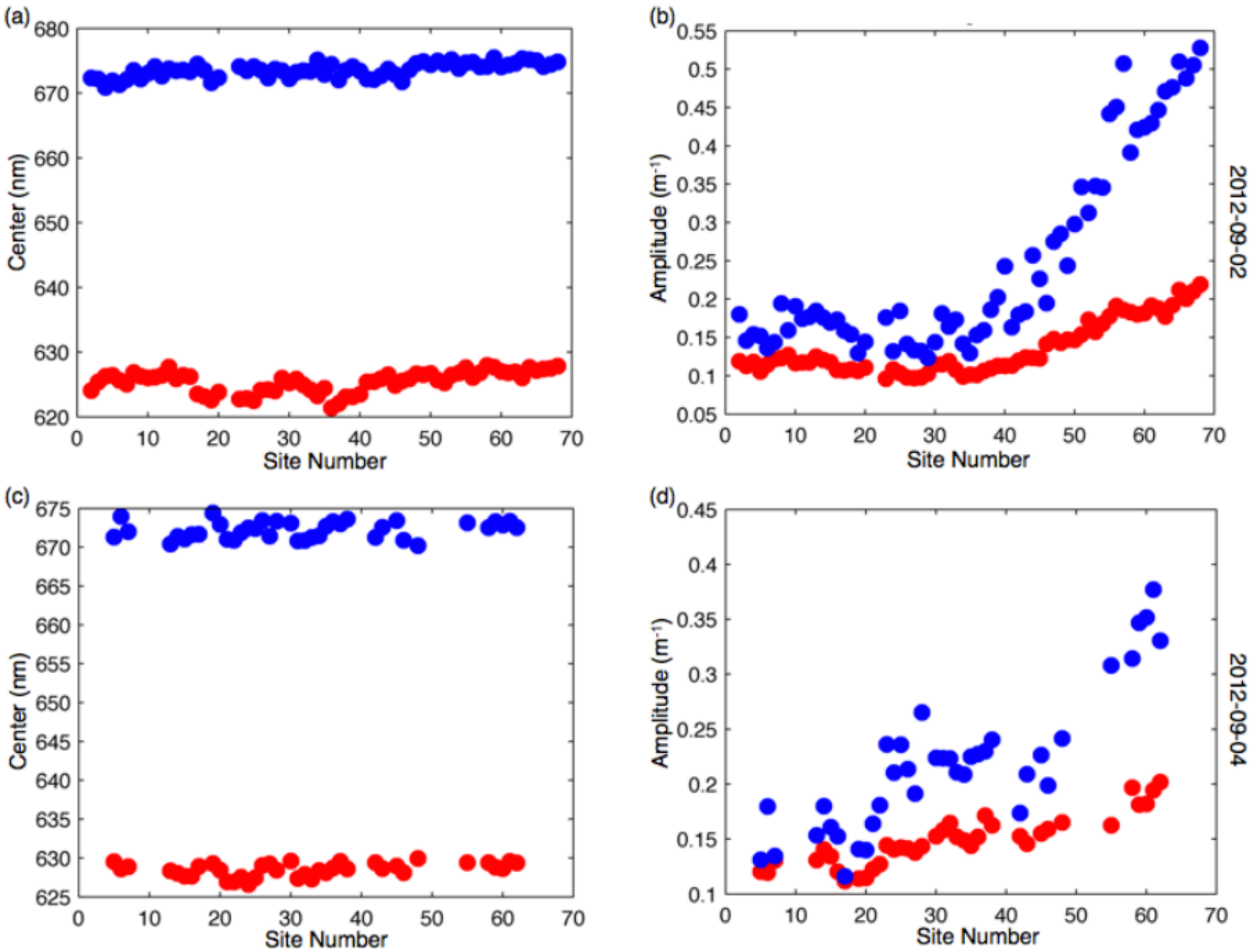


**Figure 9.** The Gaussian fits for absorption by Chlorophyll-a (blue) and Phycocyanin (red). The top row is data for a transect down the center of the reservoir from 2 September 2012 (a) center of Gaussians (means), (b) amplitudes of Gaussians. Data from 4 September 2012 (c) center of Gaussians (means), and (d) amplitudes of Gaussians. The site numbers run down the middle section as indicated in Fig. 7(c).



Questions?