Interpretation of satellite measurements over the ocean

REU/HIRES project summer 2016

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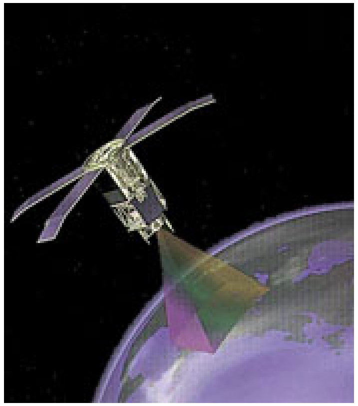
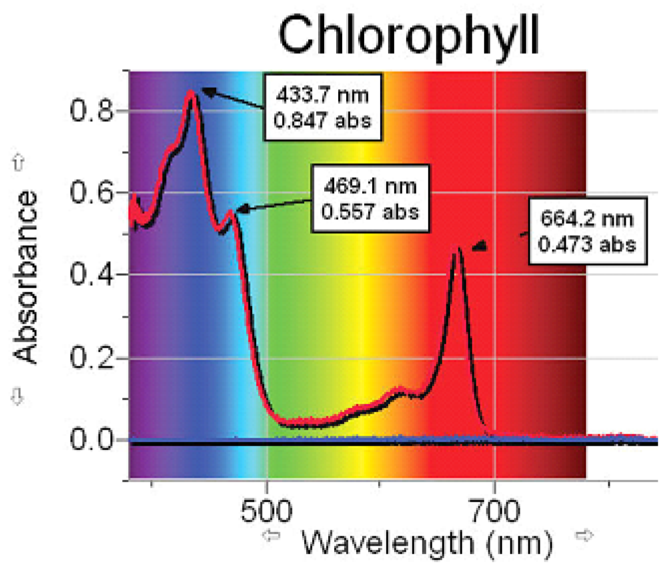
Remote Sensing of Water Regions



RS of water areas provides an efficient way of monitoring water quality, biomass in the ocean, sediment plumes, spatial and temporal scales of the water structures, sea surface temperature, etc.



Phytoplankton are a very important part of ocean life:

- Phytoplankton are the first link in the food chain.
- Phytoplankton convert nutrients into plant material by using sunlight through photosynthesis and convert carbon dioxide from sea water into organic carbon and oxygen as a by-product and thus affect carbon balance.

Amount of phytoplankton in the ocean can be traced by the concentration of the optically active pigment chlorophyll [Chl]

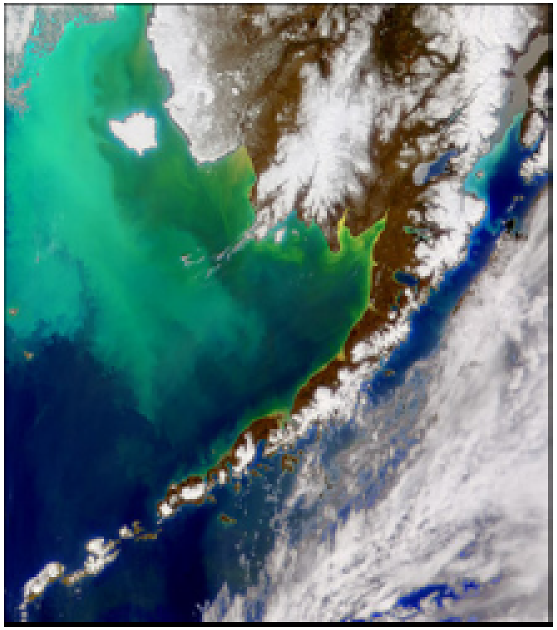
Water Clarity

Water in the open ocean, far from land, is nearly as transparent as glass, a deep navy blue when viewed over the side of a ship. Closer to shore, water becomes turbid for a variety of reasons. Ocean color remote sensing algorithms is to distinguish different types of water and the constituents that determine a particular color, and calculate the concentration of suspended particulates in the muddy water, and the concentration of chlorophyll in both turbid and clear water.

Louisiana coastal plume, March 15, 1999

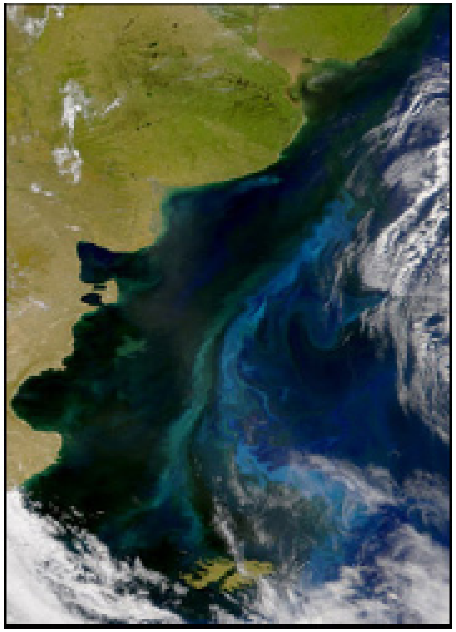
The dynamic coastal region showing the suspended sediments, organic matter and phytoplankton.

Alaska Bering Sea, SeaWiFS Image, April 25, 1998



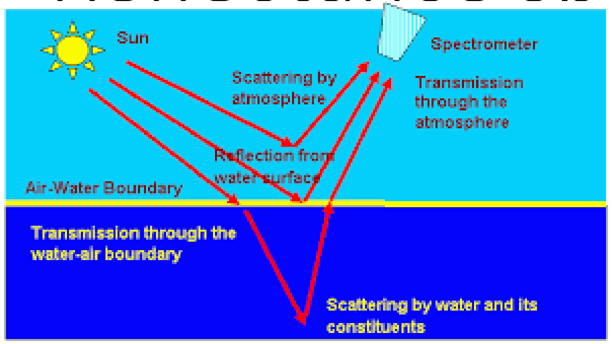
The bright aquamarine water is caused by the huge numbers of coccolithophores (type of phytoplankton). This bloom was present in 1997 and 1998, and re-occurred in 1999.

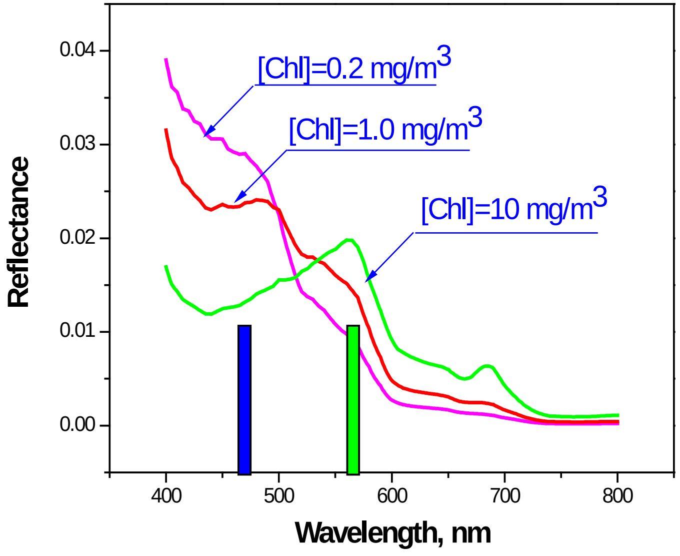
Brazil Warm Current & Colder Malvinas/Falkland Current, SeaWiFS Image



The distinct populations of phytoplankton in these two currents perceived as different ocean colors.

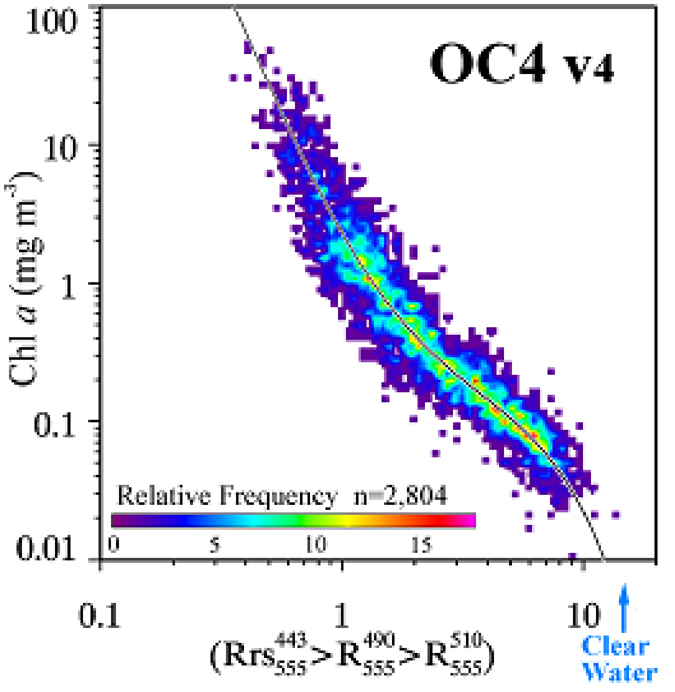
Reflectance spectra for the open ocean





[Chl] can be well characterized by blue-green ratio

With increasing [Chl] water changes its color from blue to green

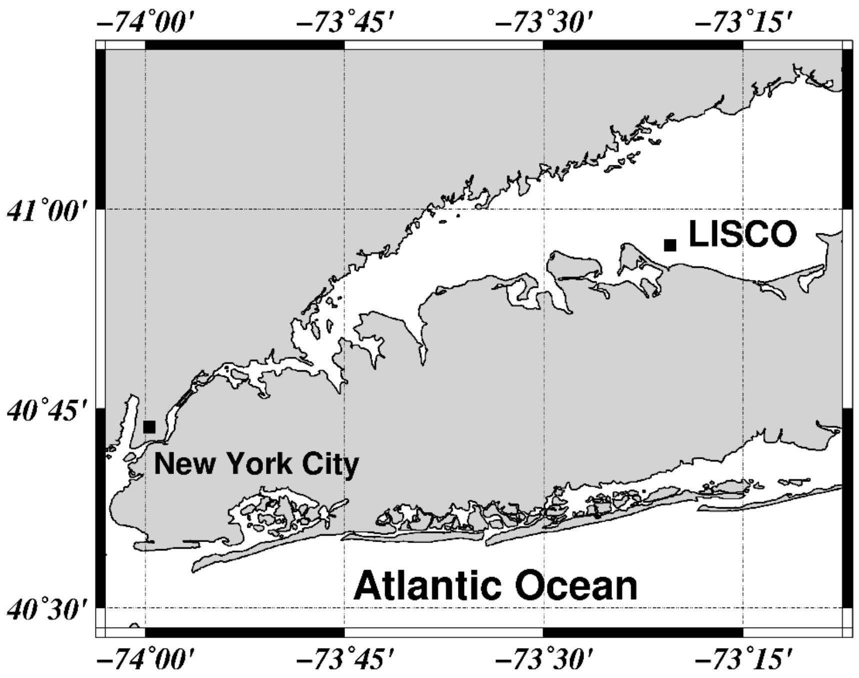


SeaWiFS Blue-Green Ratio Algorithm

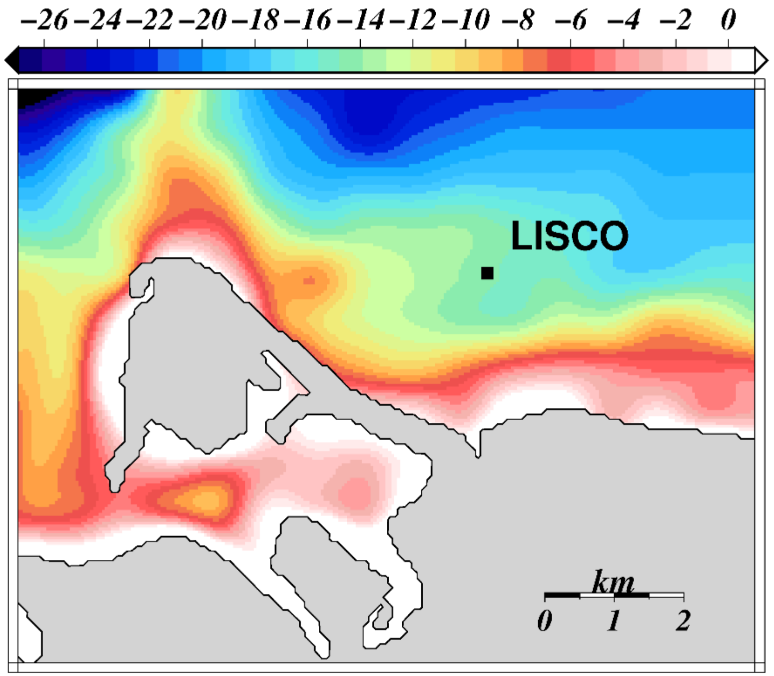
From K. Carder, et al. ,2003

LISCO Site Characteristics

Location and Bathymetry



Depth in meters (GEBCO data)



Water type: Moderately turbid and very productive (Aurin et al. 2010)

Bathymetry : plateau at 13 m depth

SeaPRISM instrument installed on the tower

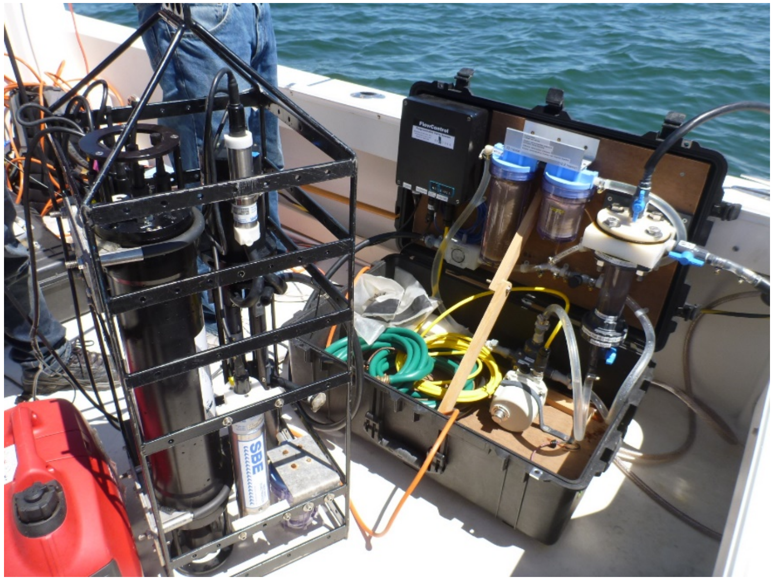
Tower with the instruments and solar panels on the platform in LIS

SeaPRISM data are transmitted through the satellite to NASA AERONET group. Processed data are posted on AERONET site

Field Measurements

Physical properties ↔ Optical properties ↔ Reflectance spectra ↔ Satellite sensor data

Underway measurements of water optical properties in Long Island Sound, June 2016



Measurements of reflectance spectra in Long Island Sound, June 2016

Instrumentation for Field Measurements

Water optical properties:

- WET Labs package: absorption, attenuation, scattering (82 channels 400-750 nm), backscattering (7 channels), Chl, CDOM fluorescence, temperature, salinity, depth

- CDOM absorption with 0.2 um filter on absorption tube

Reflectance measurements

GER spectroradiometer measures reflectance above and below water surface (512 channels between 300 and 1100 nm).
It is usually used to measure below surface reflectance in the fiber-optic mode

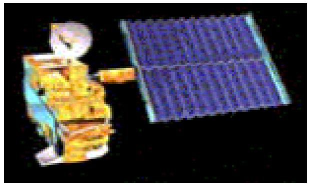
MODIS Spectral Bands for Ocean Color and Atmospheric Correction

MODIS Spectral Bands

(MODerate-resolution Imaging Spectroradiometer)

Primary Use	Band	Bandwidth (nm)	Spectral Radiance (W/m^2 -µm-sr)
Land/Cloud/Aerosols Boundaries	1	620 - 670	21.8
	2	841 - 876	24.7
Land/Cloud/Aerosols Properties	3	459 - 479	35.3
	4	545 - 565	29.0
	5	1230 - 1250	5.4
	6	1628 - 1652	7.3
	7	2105 - 2155	1.0
Ocean Color/ Phytoplankton/ Biogeochemistry	8	405 - 420	44.9
	9	438 - 448	41.9
	10	483 - 493	32.1
	11	526 - 536	27.9
	12	546 - 556	21.0
	13	662 - 672	9.5
	14	673 - 683	8.7
	15	743 - 753	10.2
	16	862 - 877	6.2
Atmospheric Water Vapor	17	890 - 920	10.0
	18	931 - 941	3.6
	19	915 - 965	15.0

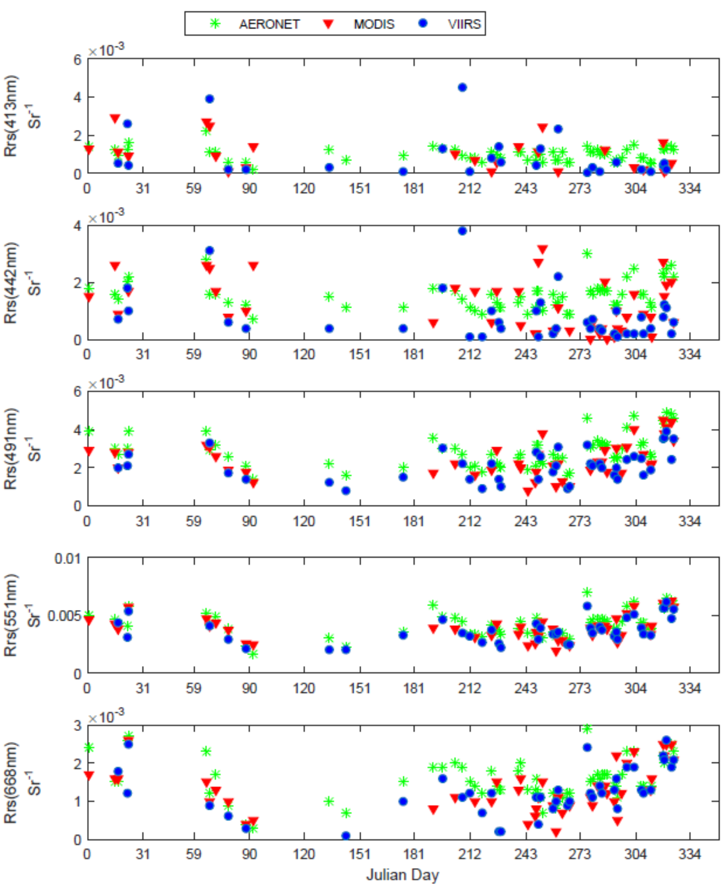
Aqua satellite (launched, May 2002)



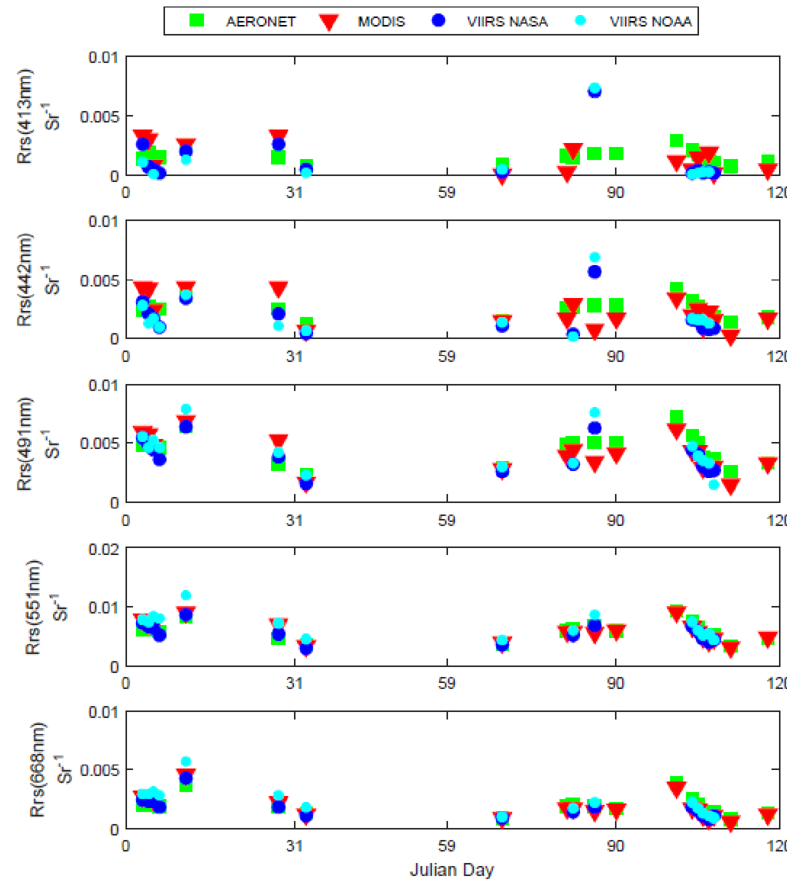
Primary Use	Band	Bandwidth (µm)	Spectral Radiance (W/m^2 -µm-sr)
Surface/Cloud Temperature	20	3.660 - 3.840	0.45
	21	3.929 - 3.989	2.38
	22	3.929 - 3.989	0.67
	23	4.020 - 4.080	0.79
Atmospheric Temperature	24	4.433 - 4.498	0.17
	25	4.482 - 4.549	0.59
Cirrus Clouds Water Vapor	26	1.360 - 1.390	6.00
	27	6.535 - 6.895	1.16
	28	7.175 - 7.475	2.18
Cloud Properties	29	8.400 - 8.700	9.58
Ozone	30	9.580 - 9.880	3.69
Surface/Cloud Temperature	31	10.780 - 11.280	9.55
	32	11.770 - 12.270	8.94
Cloud Top Altitude	33	13.185 - 13.485	4.52
	34	13.485 - 13.785	3.76
	35	13.785 - 14.085	3.11
	36	14.085 - 14.385	2.08

Comparison of satellite and in-situ data

All 2015



2016



Project involves:

- NASA MODIS and NASA/NOAA VIIRS satellite imagery download and visualization
- Satellite imagery quality control
- Data extraction from satellite granules
- Data modeling through computer simulations
- Introduction to geophysical data analysis tools (Matlab)

Students will participate in the selection and processing of suitable satellite imagery, and in the statistical analysis of radiances and derived ocean and atmospheric products at several world locations.