Validation of VIIRS Ocean Color Products for the West Coast

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To evaluate VIIRS Ocean color products we compare them with *in situ* data and other satellite data. Examples using data from the Ocean Color AERONET site `Platform Eureka,' in the Southern California Bight, and cruises as part of the Hawaiian Ocean Time Series (HOT).

Data Sources:

VIIRS data sources:

- NASA VIIRS
- NOAA STAR VIIRS (MSL12)
- NOAA CLASS

In situ

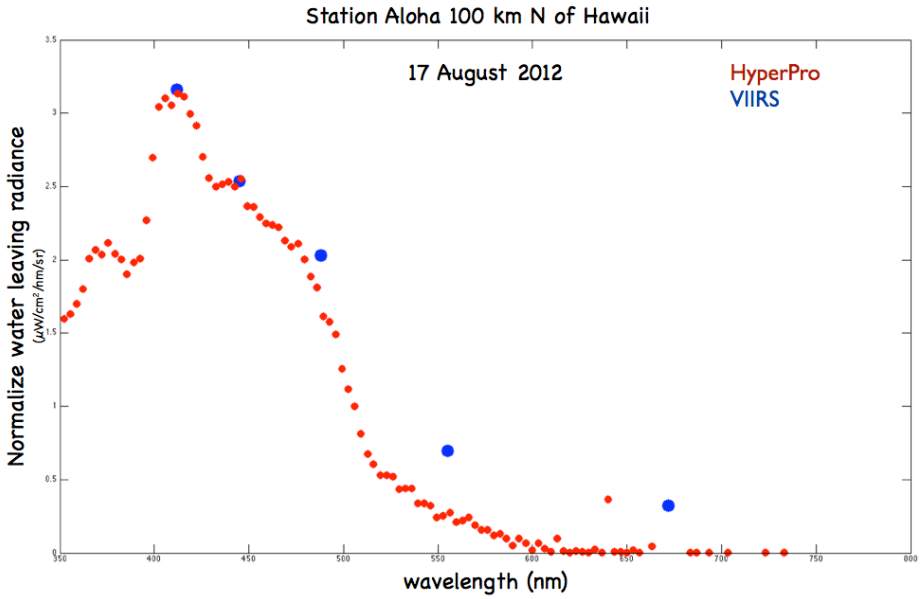
- HyperPRO (Hawaii from OSU)
- SeaPRISM (Platform Eureka from NASA Ocean Color AERONET)
- HyperPRO and above water Rrs with Spectral Evolution PSR-1100

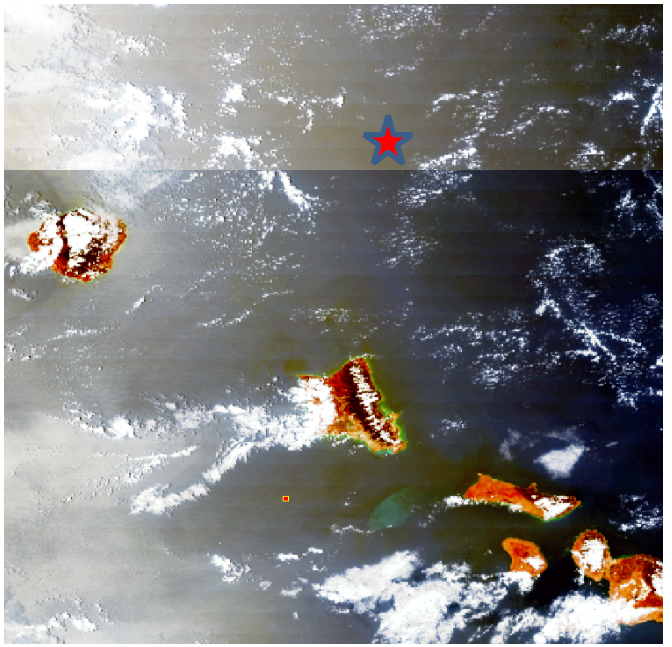
Satellite

- MODIS-AQUA (from NASA Ocean Color Website)
- Landsat-8

VIIRS and HOT data

Above and in-water light field measurements are routinely made at Station ALOHA, 100 km north of Oahu, Hawaii (22.75 ^{o}N, -158.00 ^{o}E) as part of the Hawaiian Ocean Time Series (HOT) program.
Spectral matches at Station ALOHA of VIIRS data with HyperPRO cruise data collected one minute apart (23:43 and 23:44 GMT).

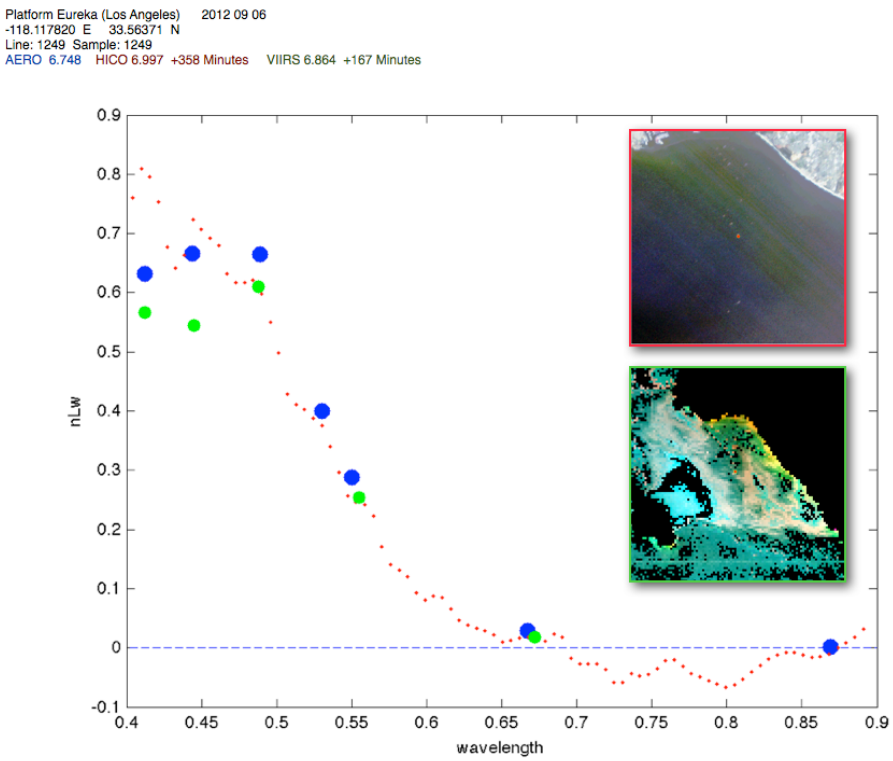


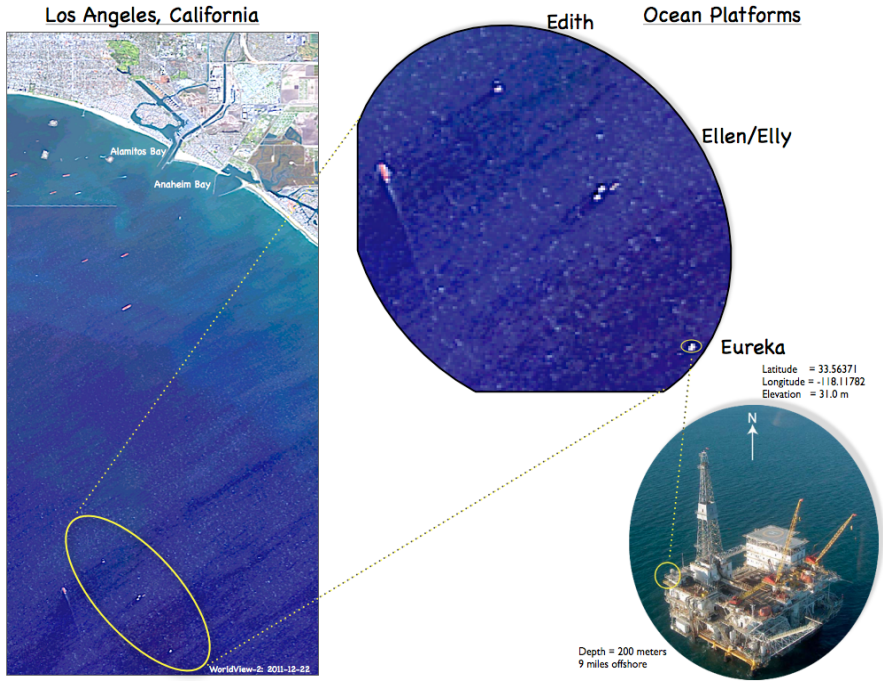


VIIRS image over Hawaii from 17 August 2012 (23:43 GMT). The star marks Station ALOHA.

Platform Eureka SeaPRISM

Use of the SeaPRISM hourly optical data at the Ocean Color AERONET site 'Platform Eureka' aboard an oil platform in the Southern California Bight.



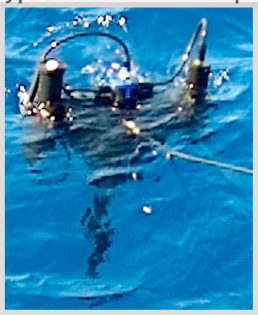


Spectral matchups at Platform Eureka between the in situ data (blue), HICO hyperspectral measurements (red), and VIIRS measurements (green). Data are from September 6, 2012.

Above and in water validations
Cruise October 2014



Satlantic HyperPRO in water Spectrometer



Spectral Evolution above water Spectral Reflectance with fiber optic.

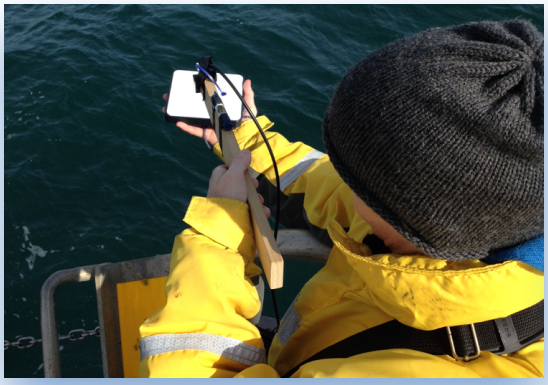
SKY Measurement



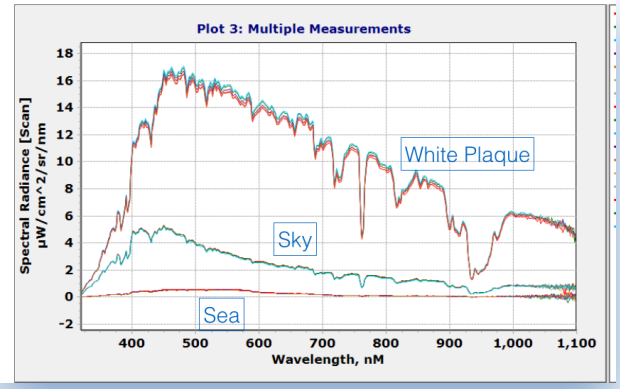
WATER Measurement



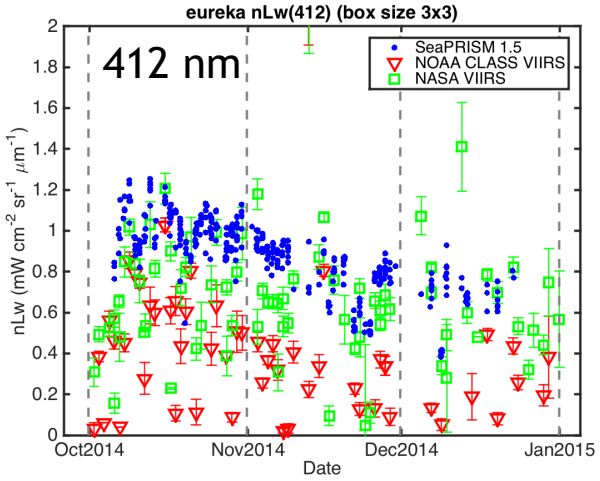
Reflectance REFERENCE Measurement

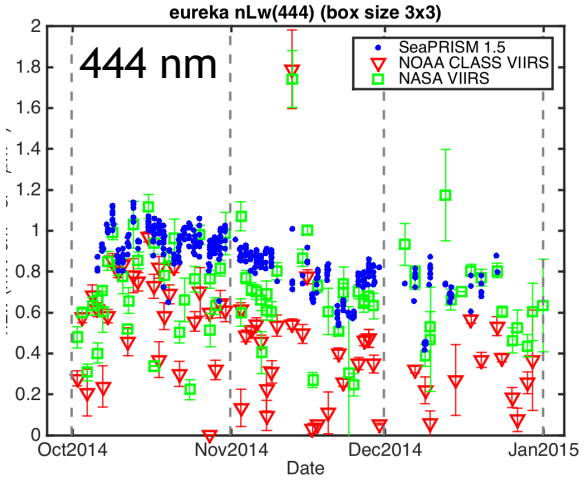


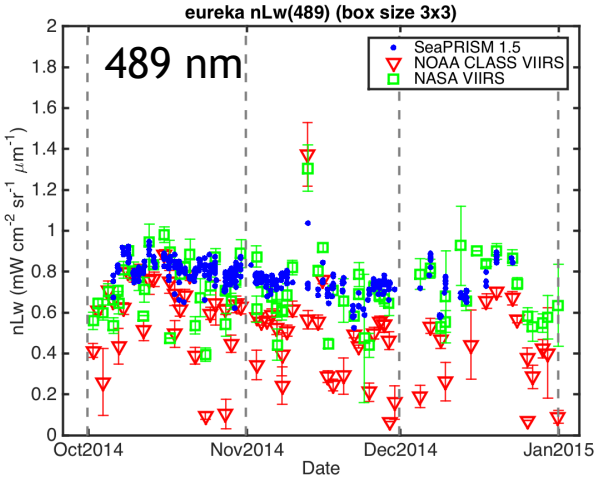
Example SPECTRA



Platform Eureka: October-December 2014
October 7, 2014 Cruise Match Example

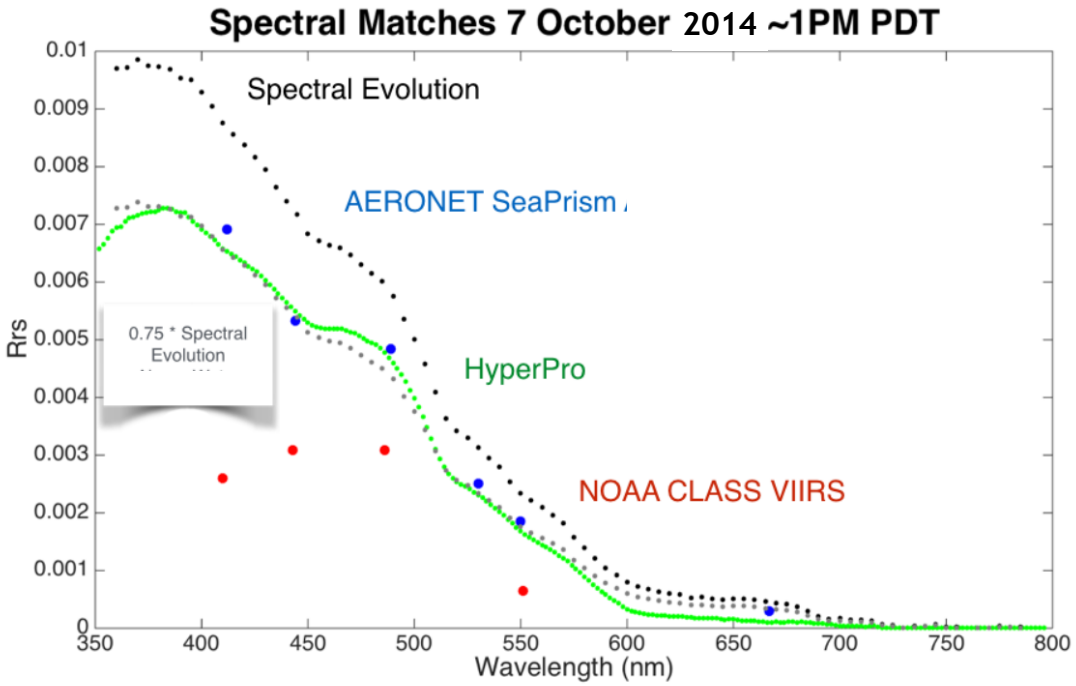




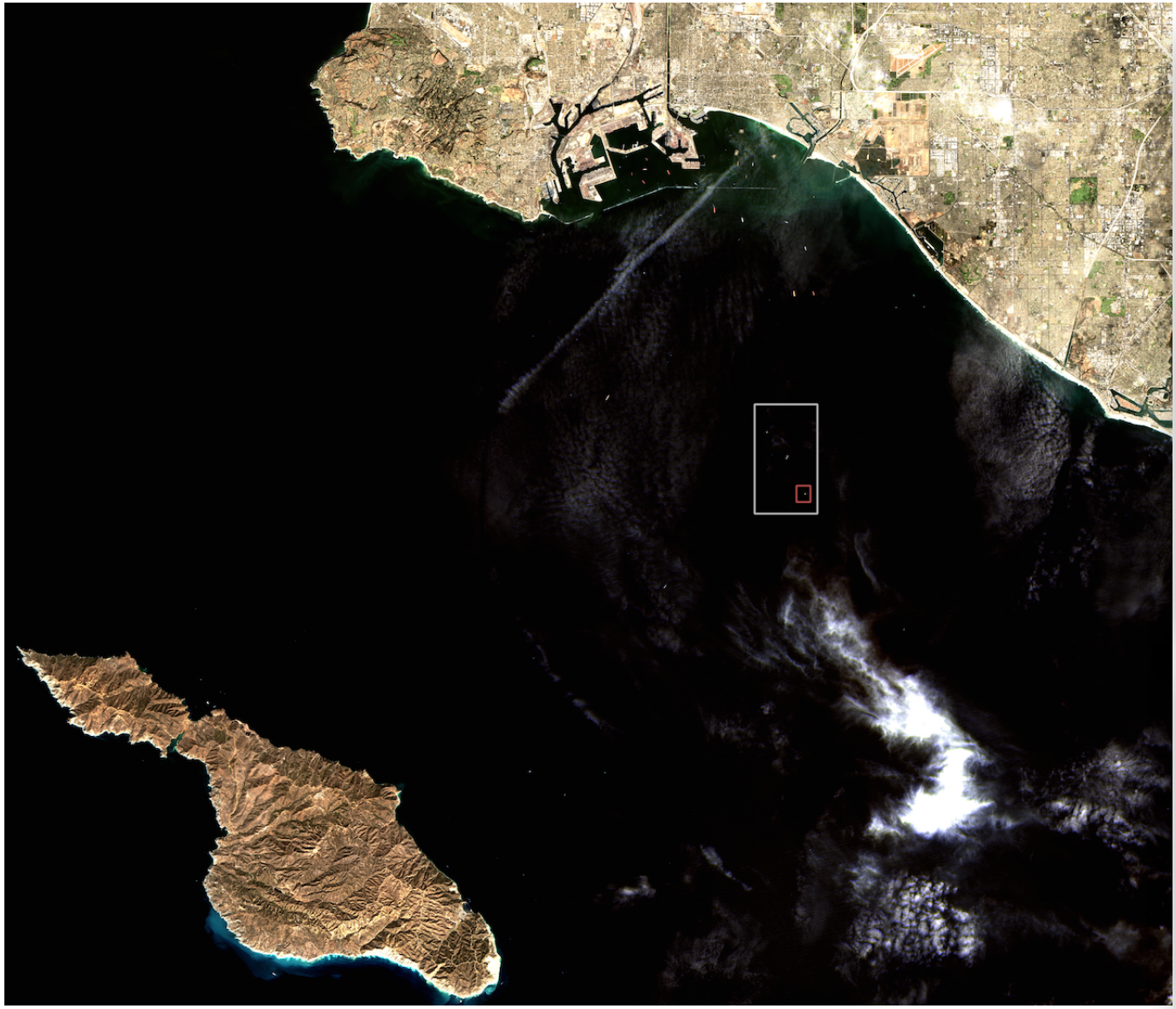


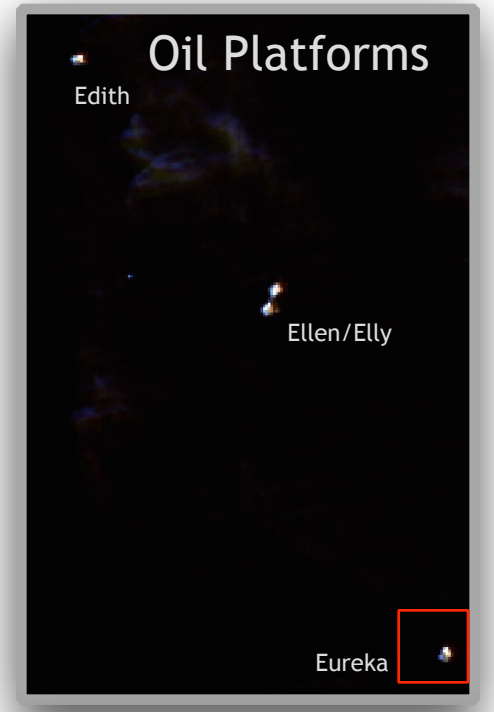
Spectral Evolution PSR-1100
Using 'empirical' correction (0.75) to get matches for new instrument

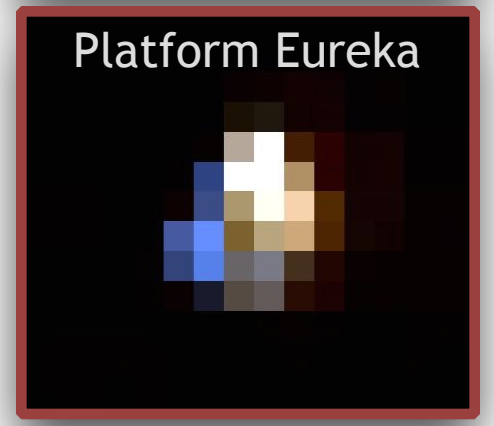
Current Processing with HyperPro showing good correlations.



Landsat-8 OLI. Panchromatic Enhanced ~15 m.
7 November 2014, 18:28 GMT (11:28 PDT)

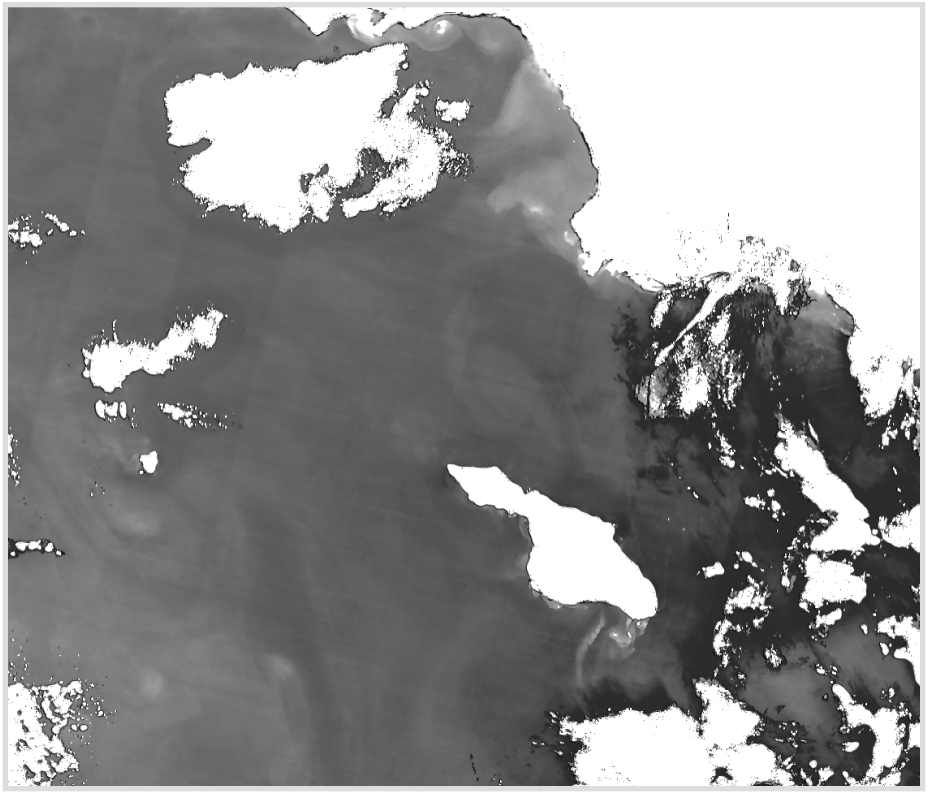




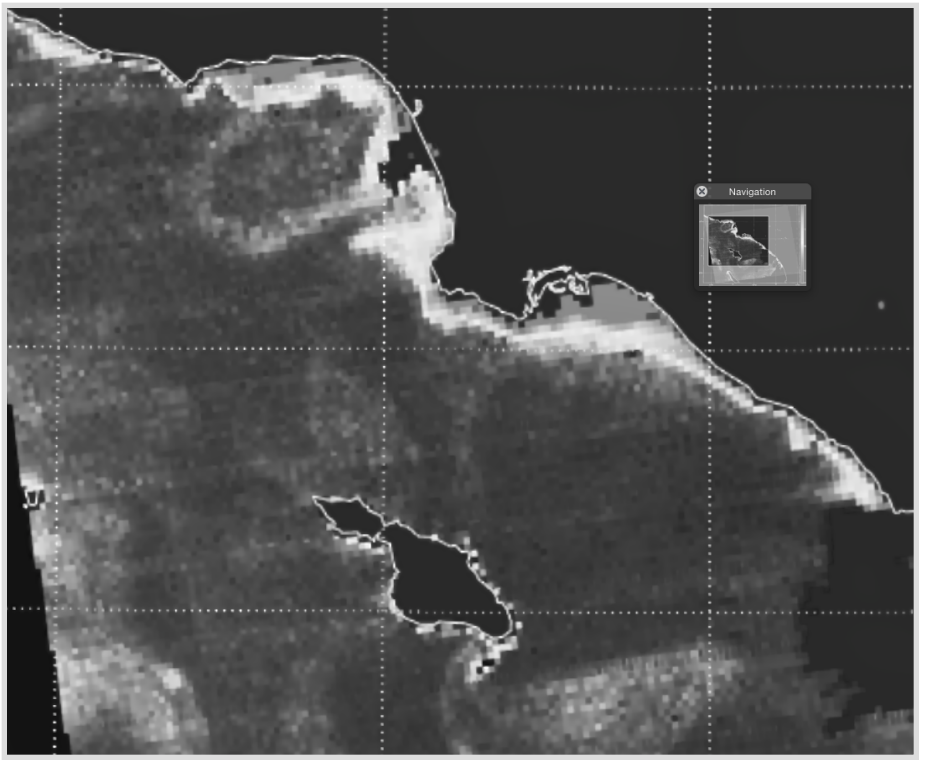


Landsat and VIIRS OC3 on 7 October 2014

Landsat OC3: 18:28 GMT (11:28 PDT)

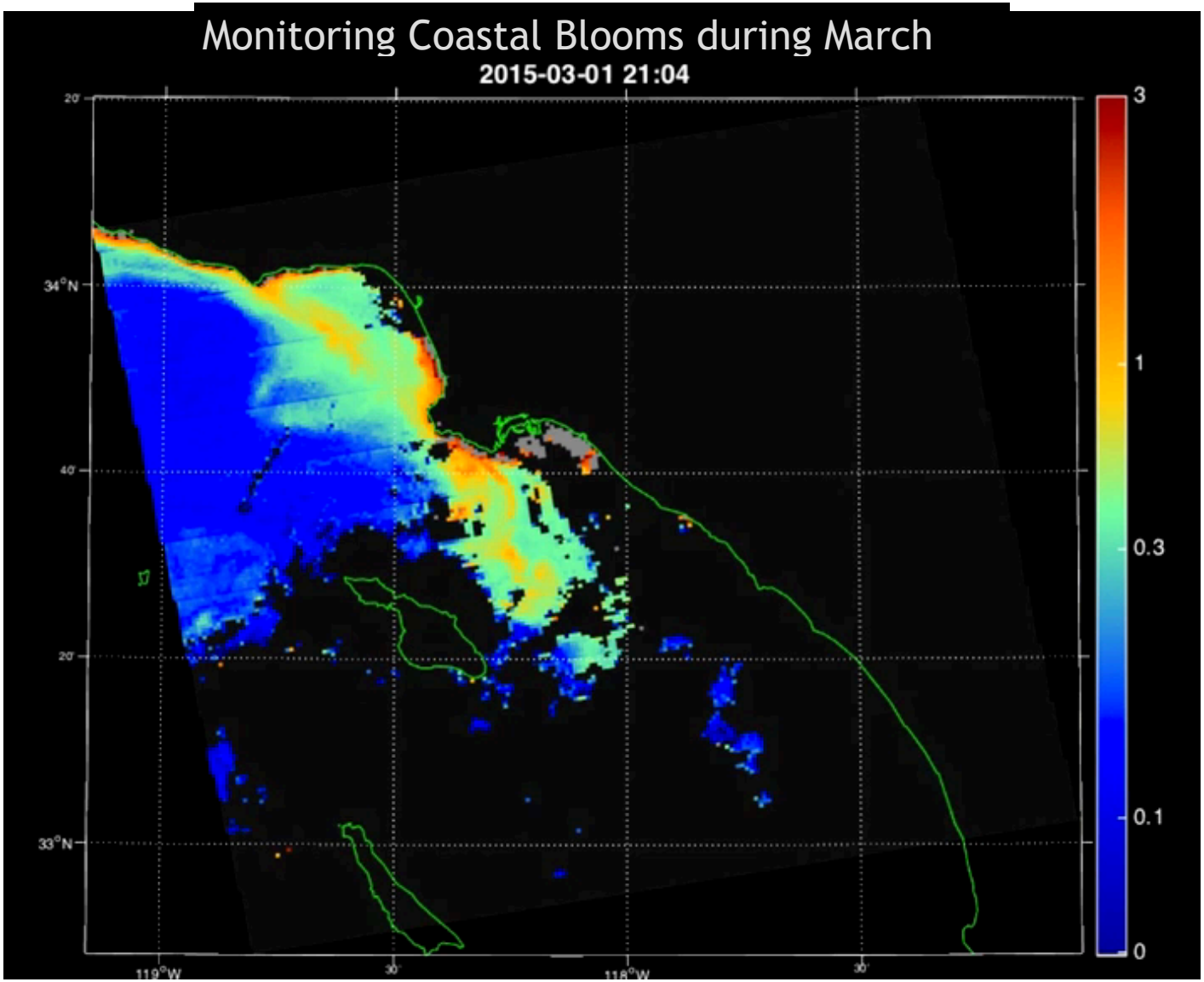


VIIRS OC3: 21:26 GMT (01:26 PDT);
Landsat +2HRs



Linear Scale from 0 - 3 mg/L. Each image, though, has been individually contrasted adjusted to try to highlight features. Water was very clear this day.

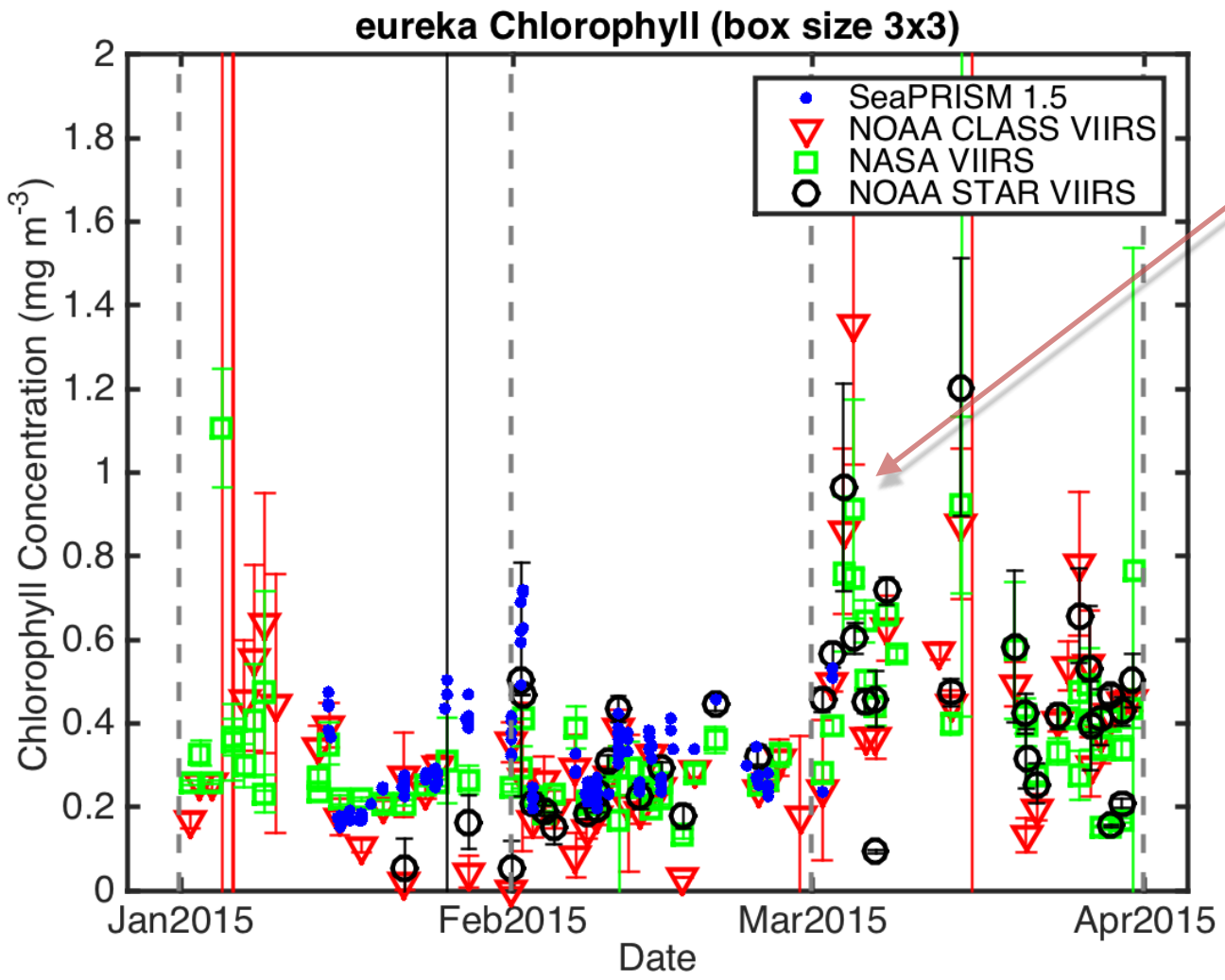
Monitoring coastal ‘Mesoscale’ events

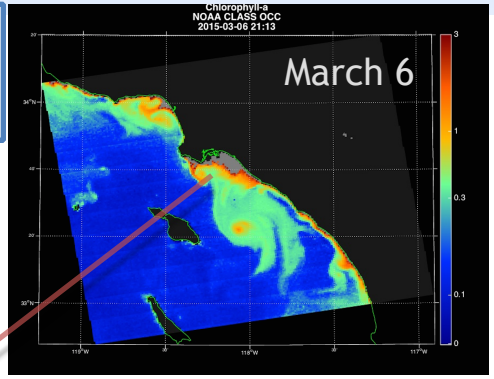


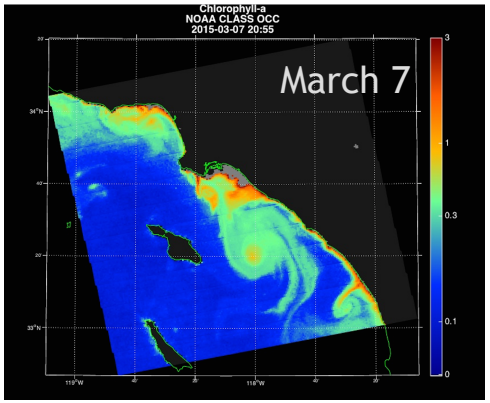
movie: click to play

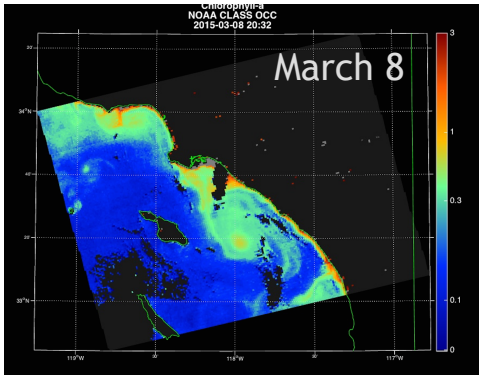
Platform Eureka time series

Time series of chlorophyll-a data from VIIRS shows Bloom/ Eddie passing by Platform Eureka during March 6-8, 2015.

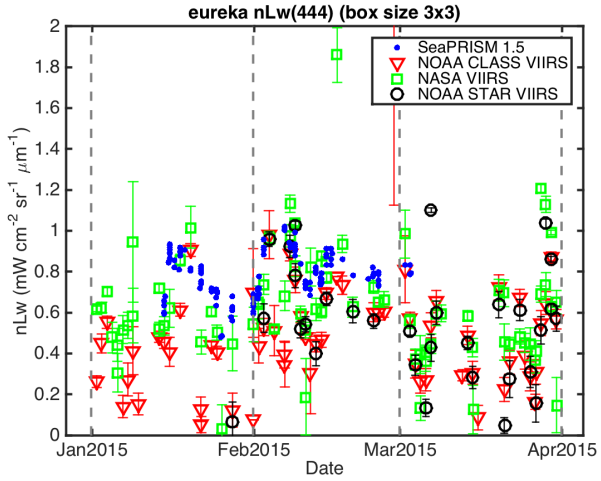


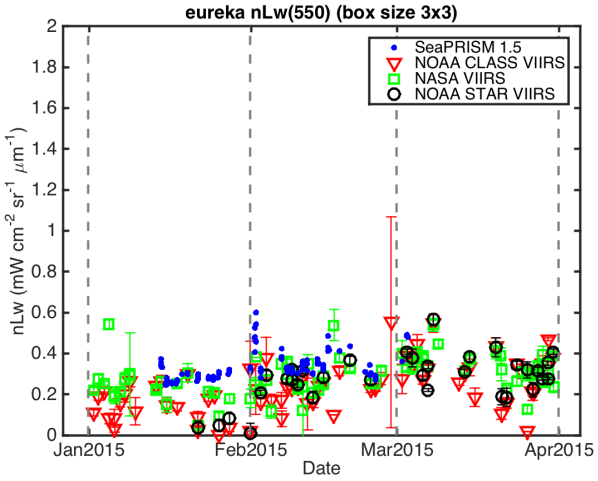


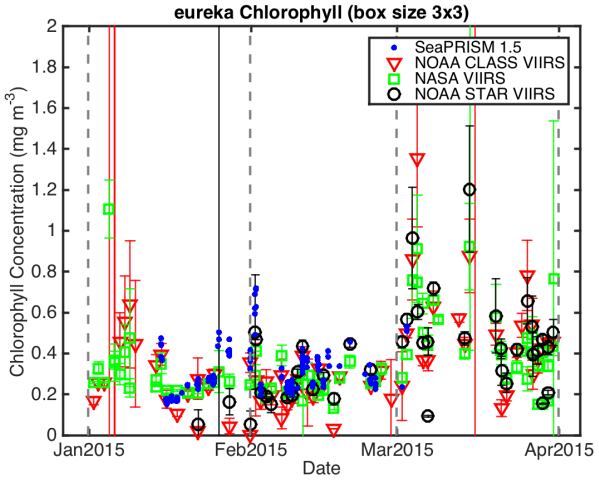


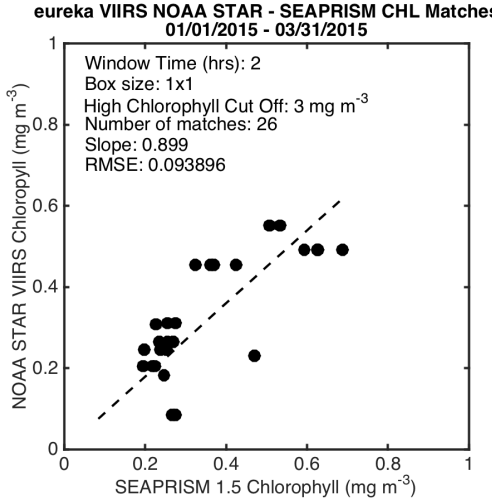


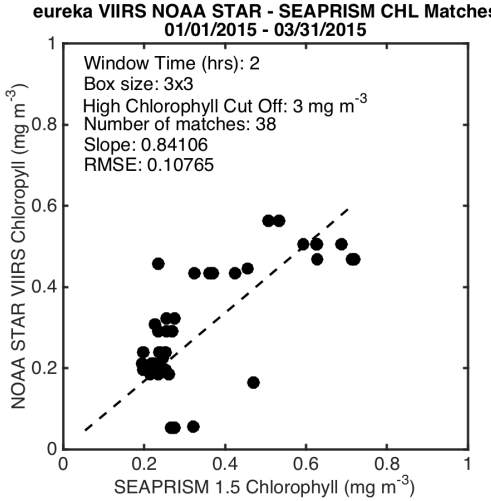
Example Time Series and Regressions: Jan-March 2015

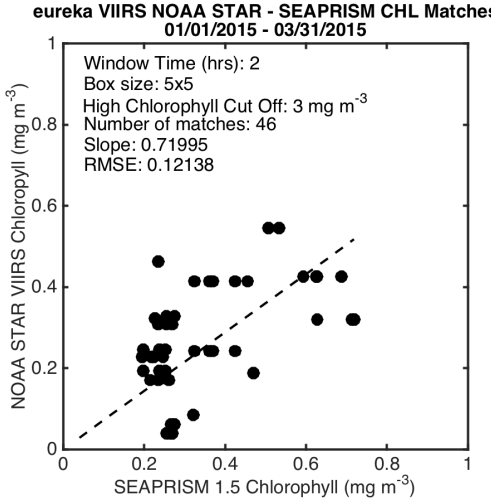




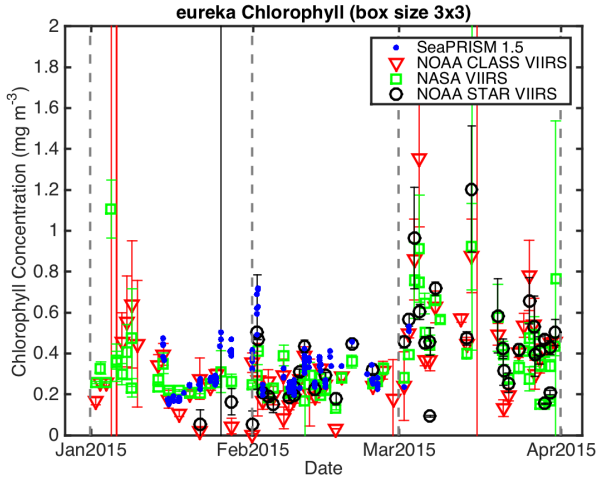


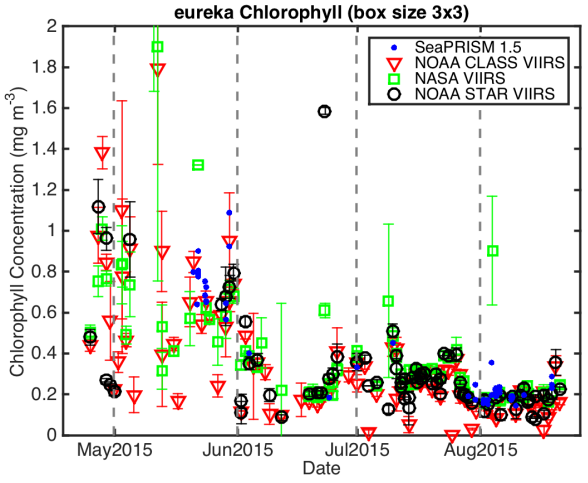


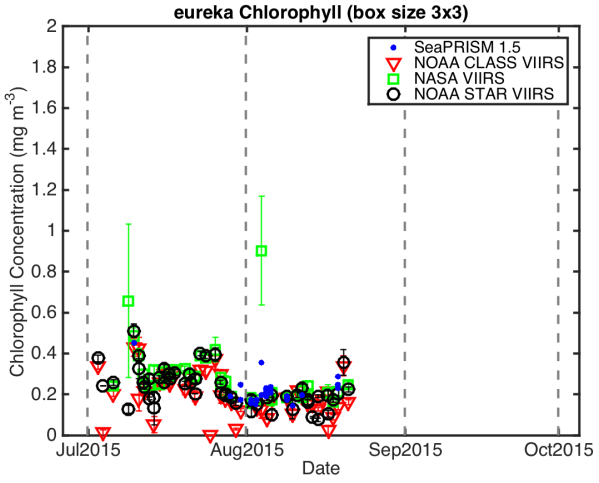


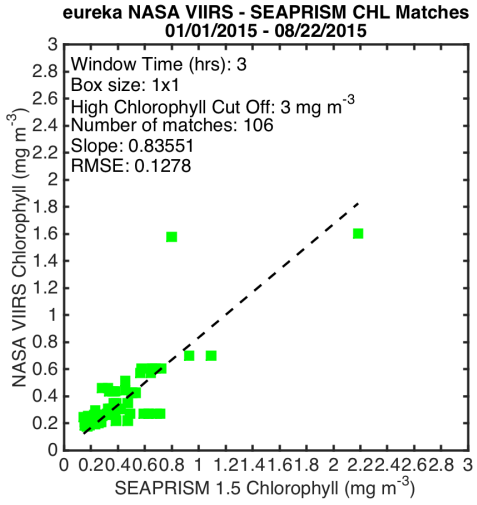


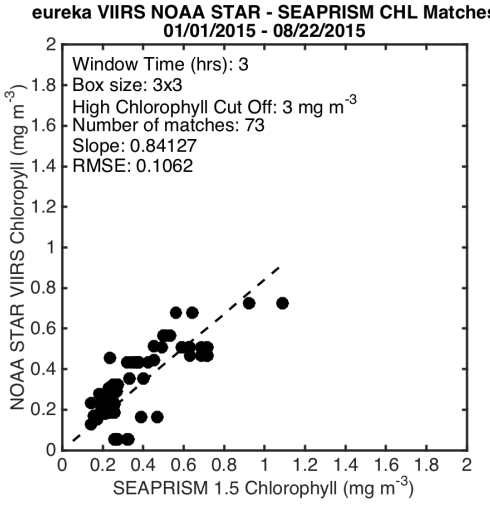
Chlorophyll Time Series 2015 at Platform Eureka

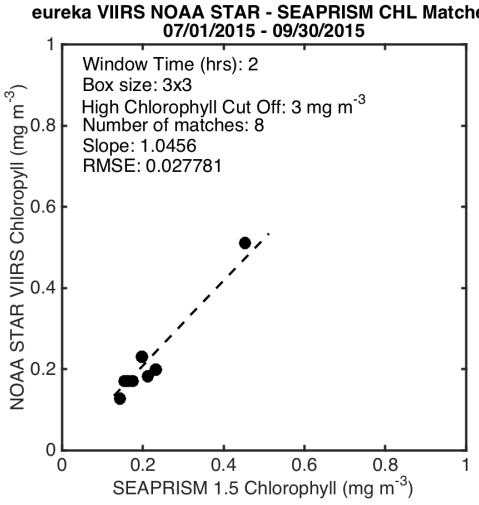








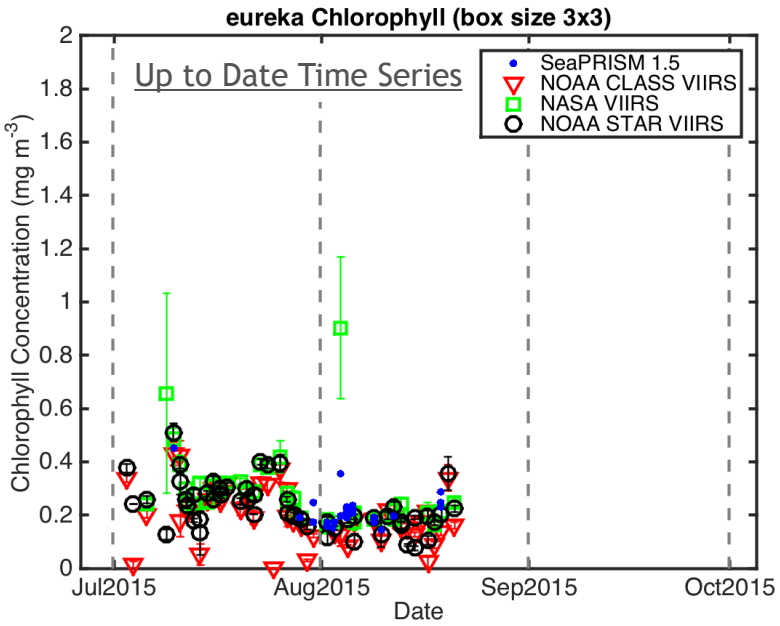




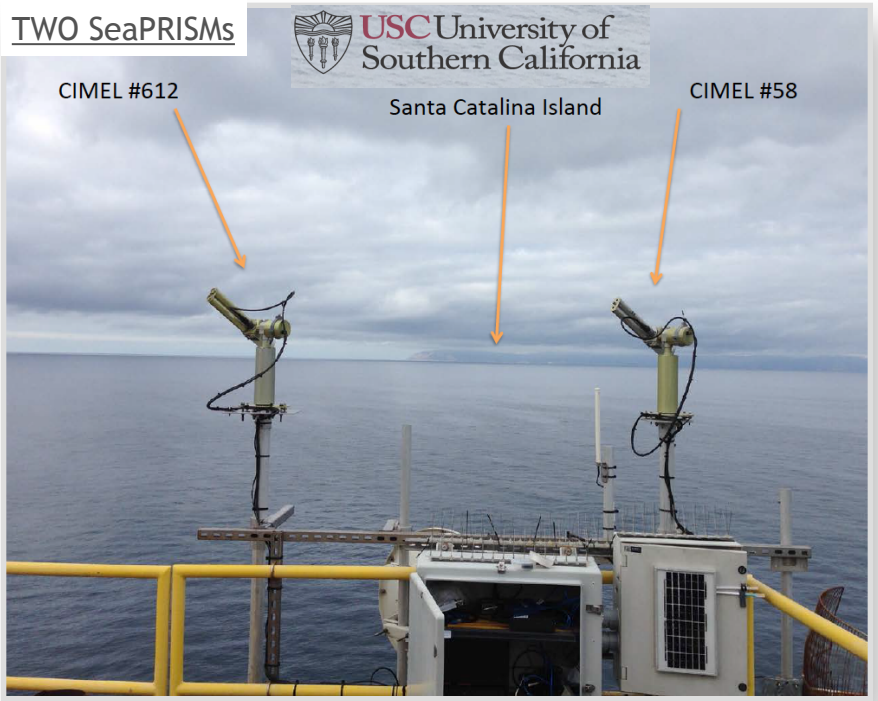
Platform Eureka Data Collection
Challenges

Platform Eureka SeaPRISM site is excellent and data is key for our work, however:

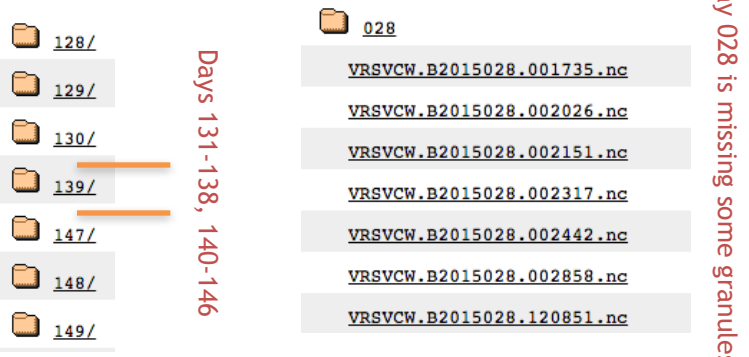
- Data flow has been intermittent; *New radio system installed.*
- Calibration issues: *Installed TWO SeaPRIMSs to cross-check.*
- Some NOAA STAR (MSL12) swaths not processed: *Will be picked up on reprocessing.*
- Protocols/Processing for New Spectrometer



TWO SeaPRISMs



Example Data Gaps in MSL12: Year 2013



NOAA STAR (MSL12) Data Catalog
http://www.star.nesdis.noaa.gov/thredds/catalog/swathNPPVIIRSL2WW00/2015/catalog.html

Experimental Products

Research and development using ‘optical flow’ to interpolate and (short time) extrapolation of product fields — helps us to track ‘mesoscale’ events.

Steps:

1. *Destriping* building on NOAA’s* variational methods
   - — added optimization over spectra and time
   - — automating optimization (does not require user to pick threshold)
   - — ‘in-painting’ experiments to handle lost data due to cloud cover

2. Image sequence ‘*equalization*’
   - — this is integrated into the destriping step

3. ‘*Optical flow*’: variational functional is used to estimate vector fields between images
   - —integration providing a dynamic model of the product fields evolution

Collaborators:
Erik Bollt and Ranil Basnayake, Clarkson University
Theory/numerics is part of NGA funded project to Clarkson University:
NGA 2013-15: *Impacts of Remote Multi-Attribute Spatiotemporal Dynamical Systems Analysis*, Erik Bollt, Clarkson University, PI.

* Destriping References

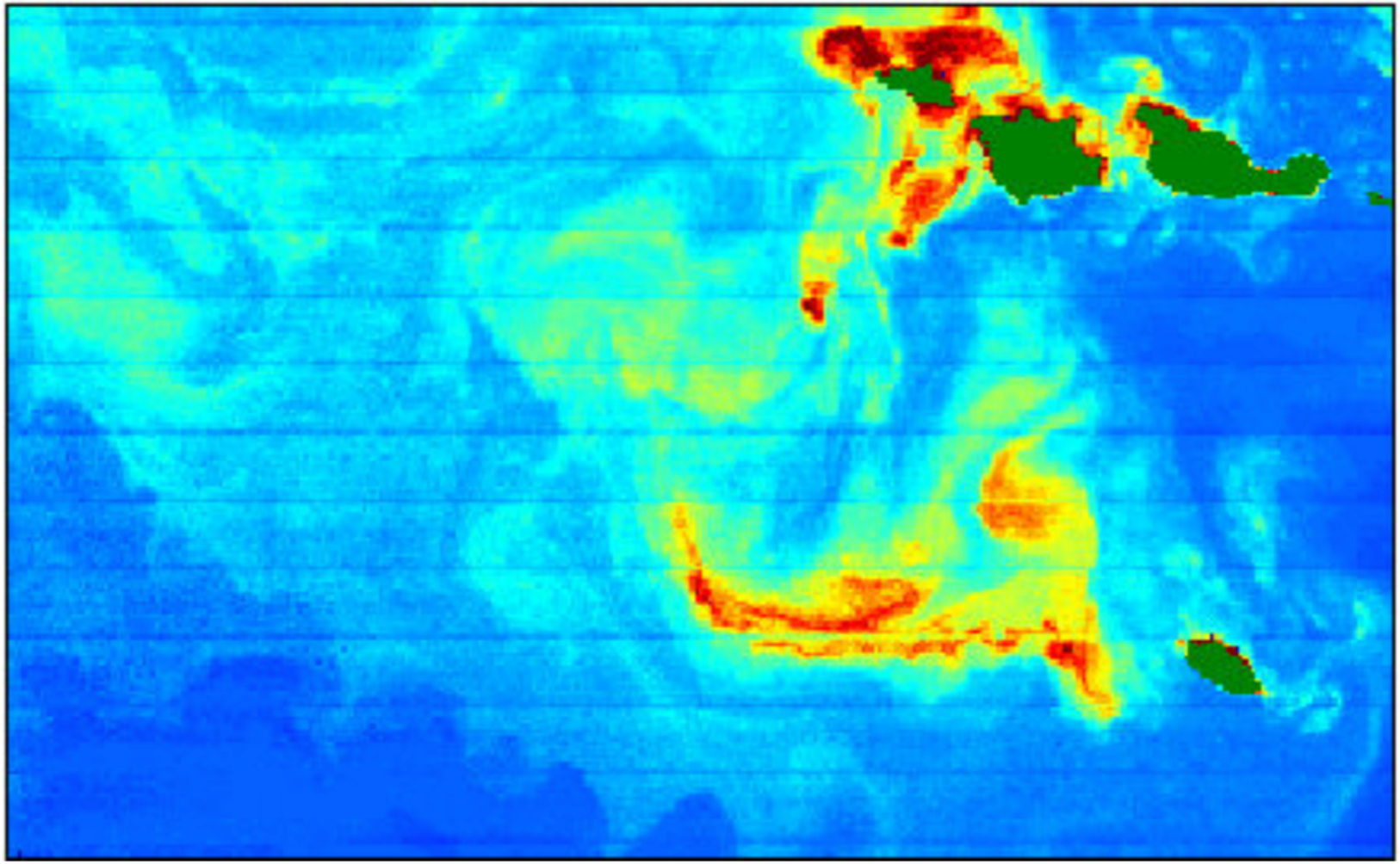
Karlis Mikelsons, Alexander Ignatov, Marouan Bouali, and Yury Kihai. A fast and robust implementation of the adaptive destriping algorithm for snpp viirs and terra/aqua modis sst. volume 9459 of *Proc. SPIE*, pages 94590R–94590R–13, 2015.

Karlis Mikelsons, Menghua Wang, Lide Jiang, and Marouan Bouali. Destriping algorithm for improved satellite-derived ocean color product imagery. *Optics express*, 22(23):28058–28070, 2014.

Marouan Bouali and Alexander Ignatov. Adaptive reduction of striping for improved sea surface temperature imagery from suomi national polar-orbiting partnership (s-npp) visible infrared imaging radiometer suite (viirs). *Journal of Atmospheric and Oceanic Technology*, 31(1):150–163, 2015/06/25 2013.

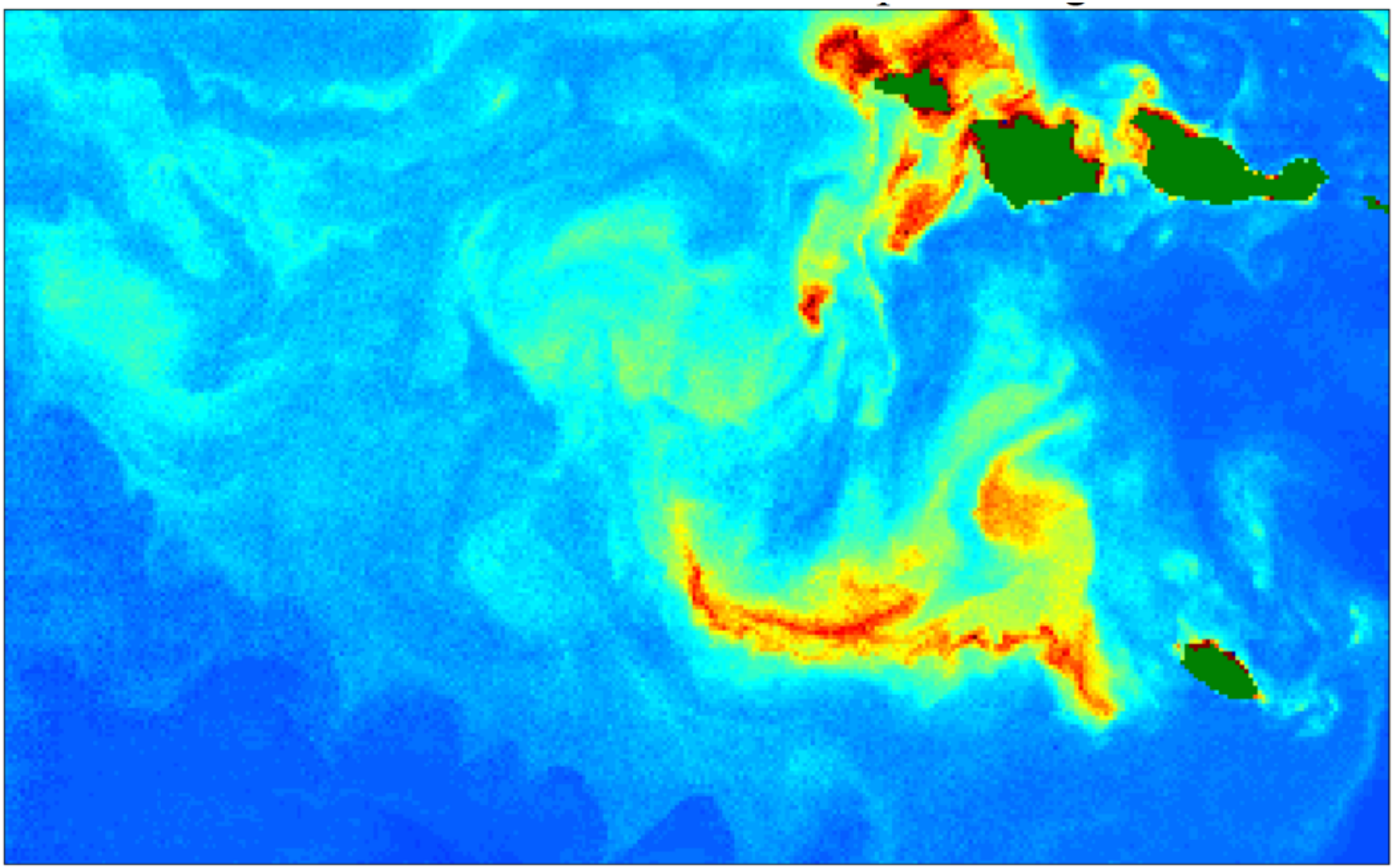
Example of Striping in VIIRS Image

- Subsampled image near the Santa Monica region in Southern California on November 6th



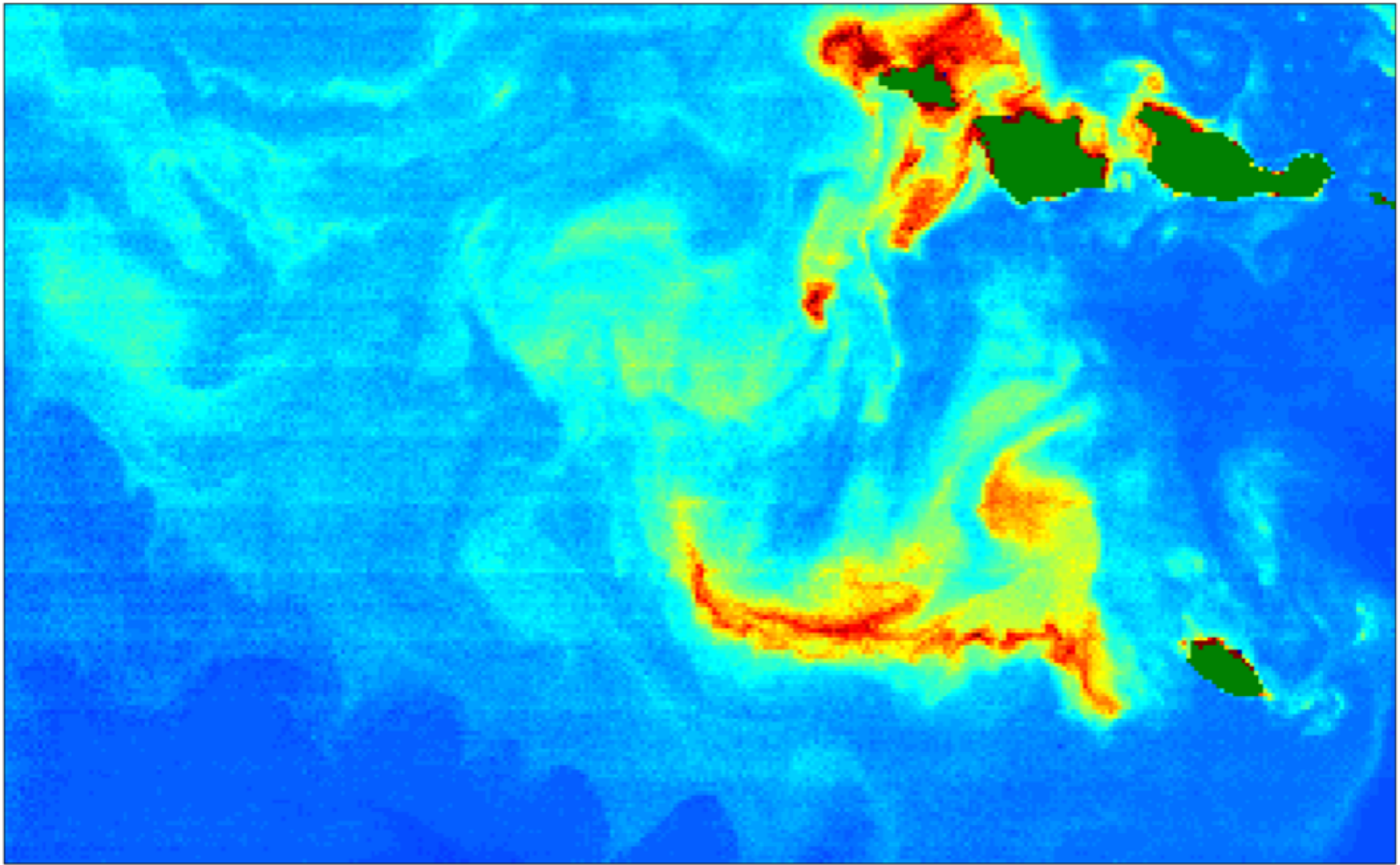
Example of destriping in VIIRS Image

- Subsampled image near the Santa Monica region in Southern California on November 6th

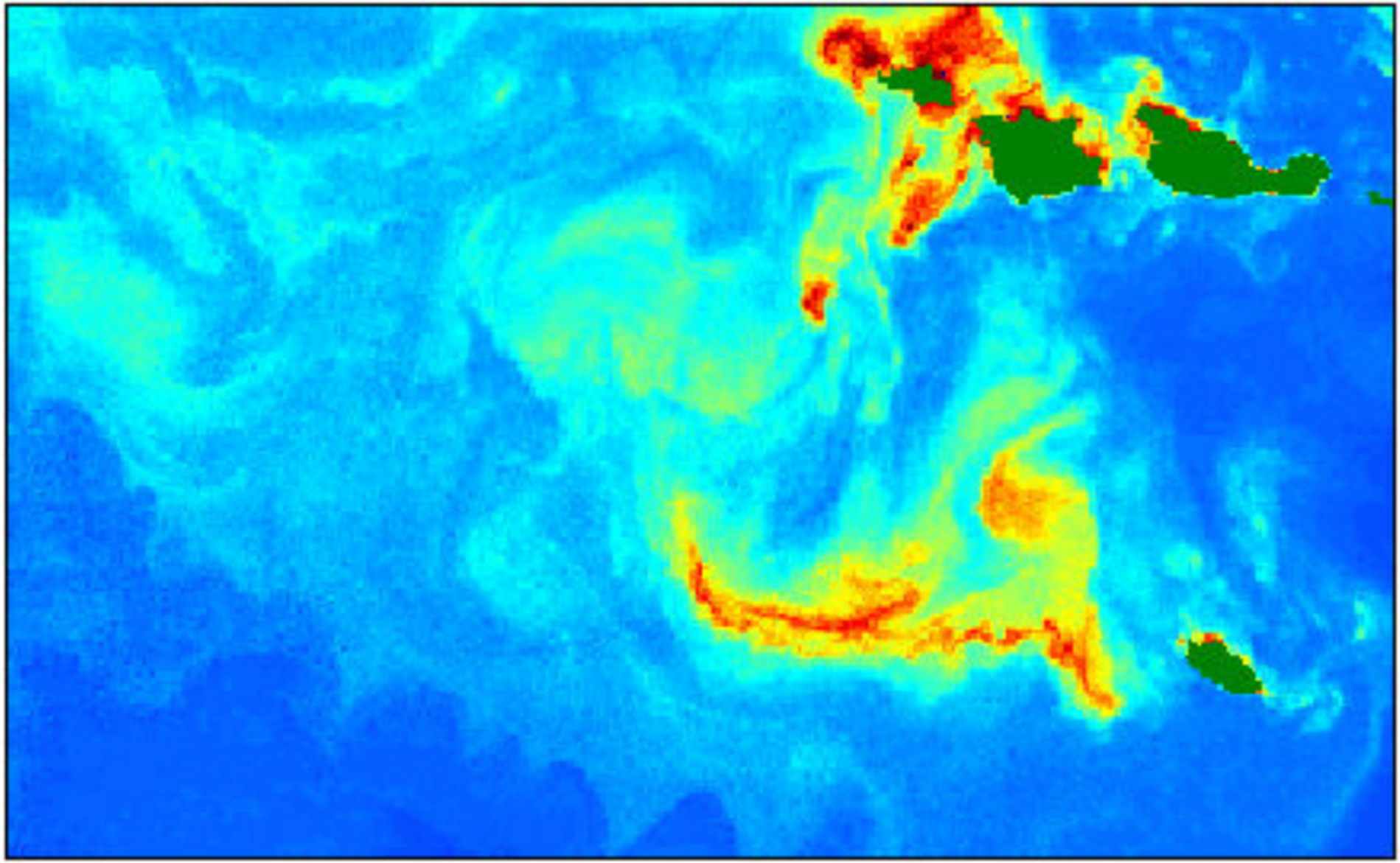


Example of a Destriped NASA image

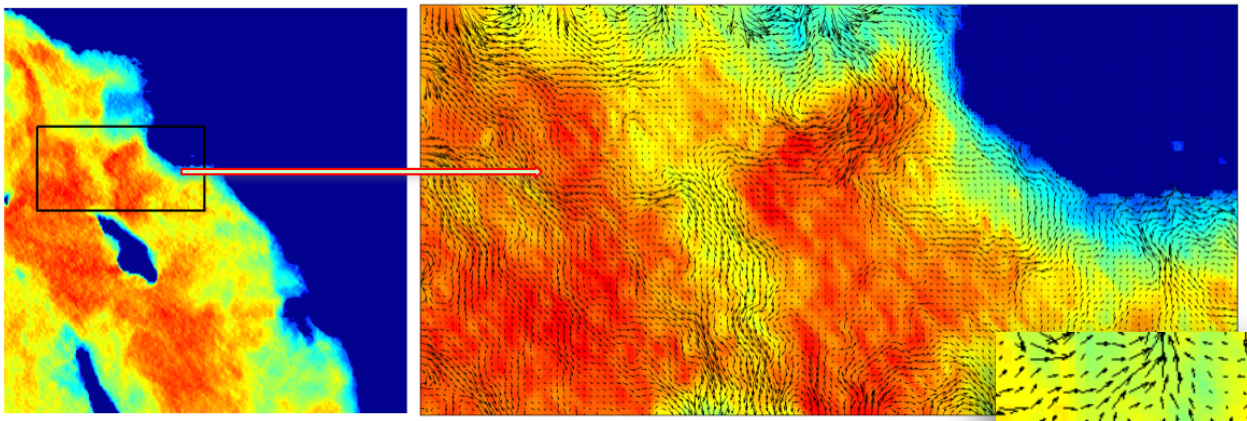
(*.nc from NASA Ocean Color Site; NASA uses a vicarious destriping method based on a historic image and calibration database for VIIRS)

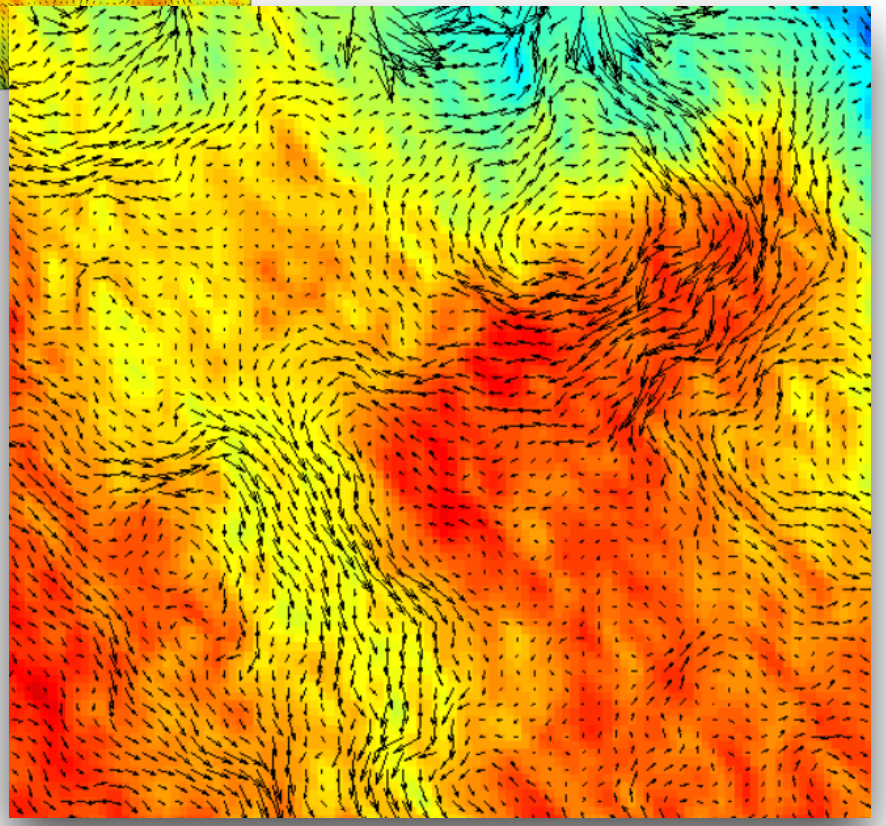


Example of a destriped image by applying two steps:
First, Vicarious destriping from NASA;
Second, a ‘Variational’ scene based destriping.



Optical Flow Example:
Chlorophyll flow map around Catalina and Platform Eureka, Work in progress





References:

E. Bollt, N. Tufillaro, R. Basnayake, J. Sin, and M. Gierach, Variational destriping on ocean color products with a simple numerical scheme, draft 2015.

A. Luttman, E. Bollt, R. Basnayake, S. Kramer, and N. Tufillaro, A framework for estimating Potential Fluid Flow form digital imagery, Chaos 23 (3), 2013.

Plans for July 2015-June 2016

- Participate in and present results at NOAA telecons and the NOAA STAR/JPSS Annual Meeting in August 2015.
- Participate in NOAA VIIRS science cruise for cross calibration of instruments and methods for:
  - Above Water Rrs
  - HyperPRO optical profiles
- Analysis of a two-year time series of NOAA STAR and NASA VIIRS data products at Platform Eureka.
- Publication on the Platform Eureka time series including comparisons with other SeaPRISM sites.
- Publication of statistical comparison of destriping methods on accuracy of final ocean color product fields.
- Research application of optical flow for dynamic ocean color product flow maps