

# Remote Sensing of Suspended Particulate Matter and Algal Blooms in San Francisco Bay and Estuary Using Landsat 8 OLI and Sentinel 2

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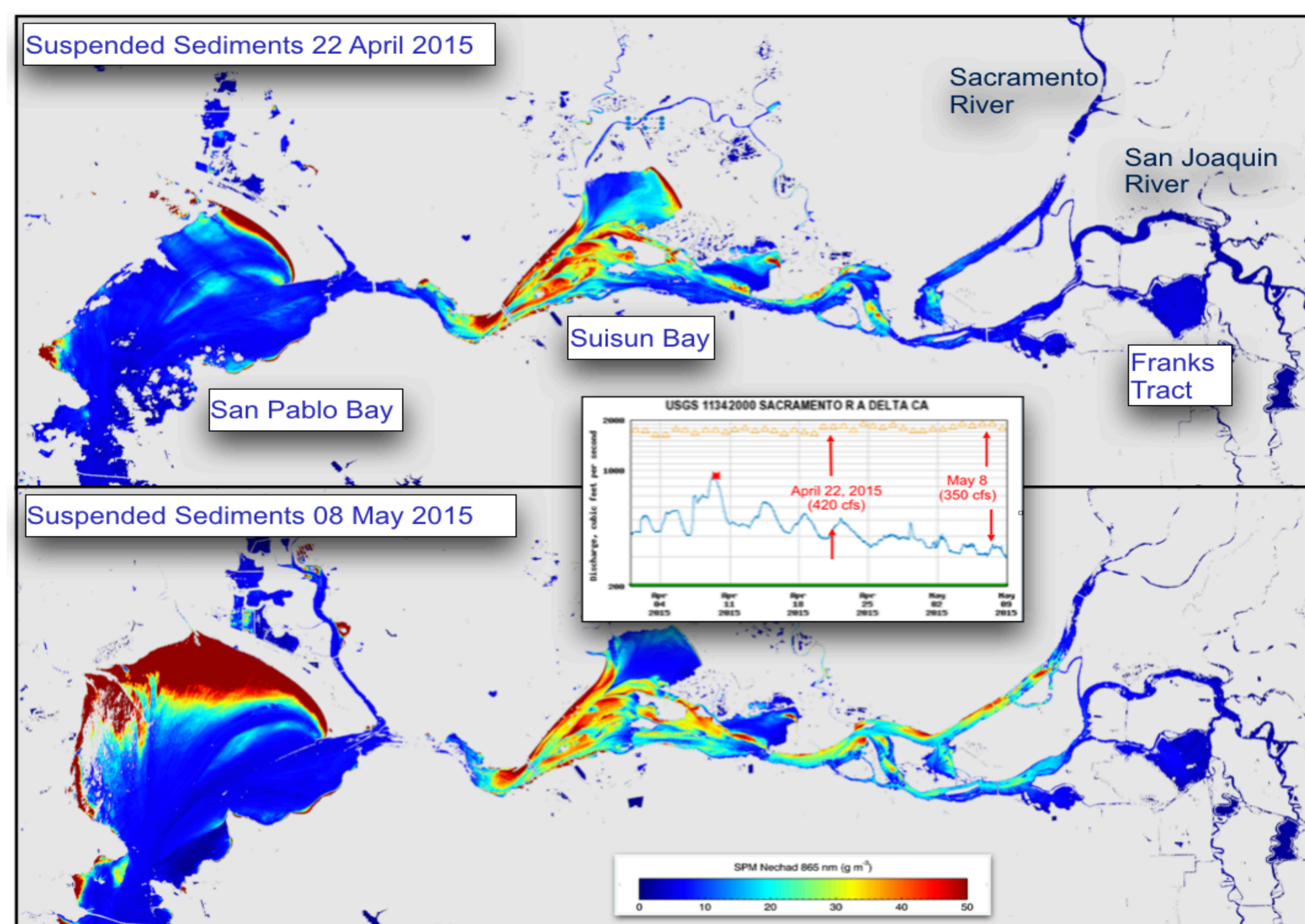
## ABSTRACT:

Landsat-8 Operational Land Imager (OLI) has high spatial resolution (~30 m nominal), improved signal-to-noise ratio (SNR) and expanded band set which opens up new applications for coastal and in-land waters. We use a newly developed ocean color processor for Landsat-8 to examine changes in the Northern San Francisco Bay, in particular looking for possible changes due to the on-going California drought. Product maps using panchromatic enhancement (~15 m resolution) and scene based atmospheric correction allow a detailed synoptic look every 16 days. We have developed a similar product for Sentinel 2 data and when there are two of them on orbit the coverage will be once every 5 days. This work is part of a larger NASA funded project aimed at improving the modeling and predictive capabilities of the biogeochemical state for the San Francisco Bay. In particular in situ measurements of suspended sediments, phytoplankton and inherent optical properties are used to validate the suspended particulate matter algorithm.

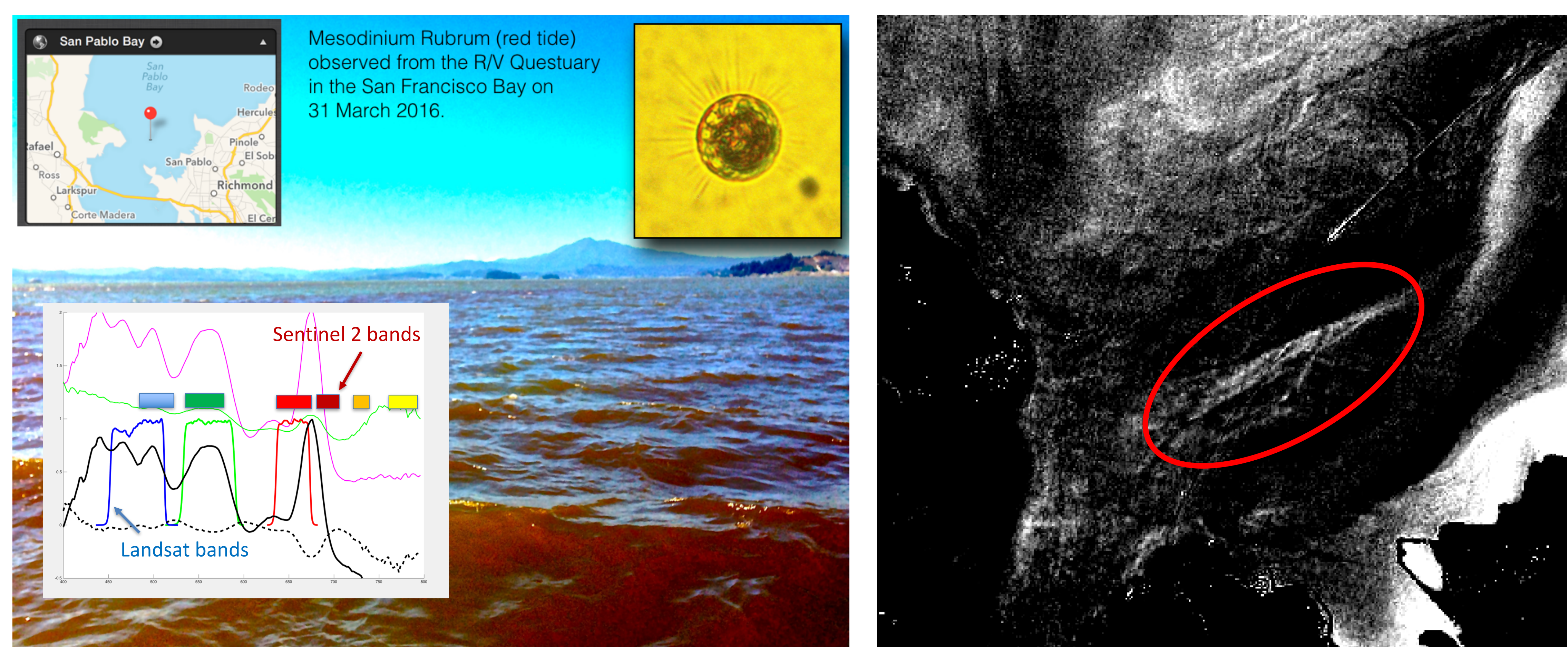
## LANDSAT 8 OLI and SENTINEL 2 PROCESSING METHODS:

Landsat-8 OLI and Sentinel 2 San Francisco Bay Atmospheric correction uses an iterative SWIR method optimized for highly turbid waters (Vanhellemont & Ruddick 2014) using the 'Acolite' processor created by Vanhellemont and coworkers. Total Suspended Sediment (TSS) maps (Nechad, Ruddick, and Park 2010) typically show an increase of turbidity in the lower Sacramento River and North San Pablo Bay. The product maps are 'regionally tuned' using in situ observations.

Landsat OLI Bands	Wavelength (micrometers)	Resolution (meters)	Sentinel 2 Bands	Center Wavelength (micrometers)	Resolution (meters)
Band 1 - Coastal Aerosol	0.43 - 0.45	30	Band 1 - Coastal Aerosol	0.443	60
Band 2 - Blue	0.45 - 0.51	30	Band 2 - blue	0.490	10
Band 3 - Green	0.53 - 0.59	30	Band 3 - Green	0.560	10
Band 4 - Red	0.64 - 0.67	30	Band 4 - Red	0.665	10
			Band 5 - Vegetation red edge	0.705	20
			Band 6 - Vegetation red edge	0.740	20
			Band 7 - Vegetation red edge	0.783	20
Band 5 - Near Infrared (NIR)	0.85 - 0.88	30	Band 8 NIR	0.842	10
			Band 8A Vegetation red edge	0.865	20
			Band 9 - Water Vapor	0.945	60
Band 6 - SWIR 1	1.57 - 1.65	30	Band 11 - SWIR	1.610	20
Band 7 - SWIR 2	2.11 - 2.29	30	Band 12 - SWIR	2.190	20
Band 8 - Panchromatic	0.50 - 0.68	15			
Band 9 - Cirrus	1.36 - 1.38	30	Band 10 - Cirrus	1.375	60



Landsat-8 suspended sediment maps for the Northern Bays and Delta during the spring of 2015. As shown in the inset graph of the USGS gauging station at Sacramento, the historical norm for flow is ~2000 cfs. During the drought, a flow of ~400 cfs was typical. These low flows allowed intrusion of salt water into the Delta possibly destroying sensitive habitat in regions such as the Franks Tract section toward the right and a temporary rock dam was put in place in 2015 to limit these salt water intrusions.



Left, Mesodinium bloom from the ship and Rrs spectra (black). Right Gower, et al. MSI Sentinel 2 product from showing bloom.

## CONCLUSIONS:

Landsat 8 OLI data provides a valuable new tool for remote sensing of rivers and estuaries. It is the first Landsat data to have sufficient SNR and additional blue band for coastal ocean remote sensing. Products from Acolite algorithms are being validated with RIO-SFE in situ data. Sentinel 2 data provides similar high resolution data with additional channels for tracking phytoplankton blooms. The time series of Landsat and Sentinel 2 data combined with in situ data from the RIO-SFE Project provides a unique new view of upper San Francisco Bay and Estuary. Landsat 8 and Sentinel 2a and b can provide 5 day repeat coverage to study the dynamics of SFE and other important estuaries.

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