

# Monitoring the Bay and Estuary with Landsat-8 and Sentinel-2

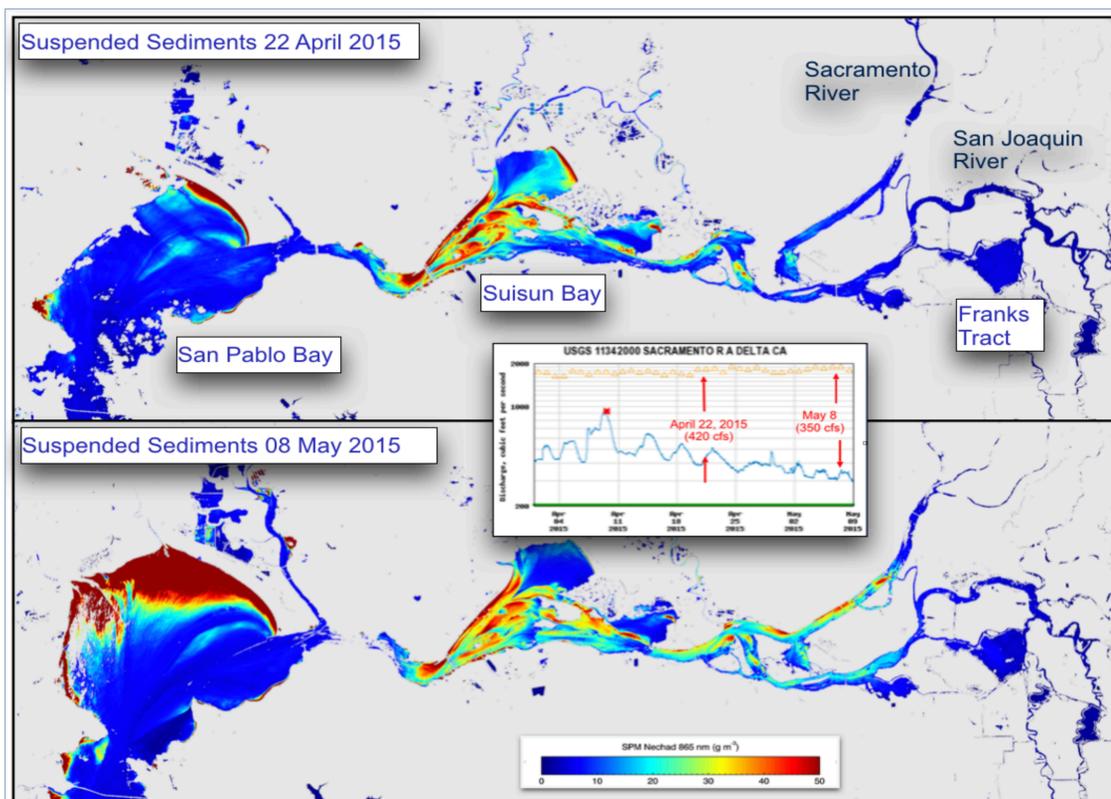
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**Abstract:** Landsat-8 and Sentinel-2 are high spatial resolution (15-30 m) satellites providing visible imagery which can be used to monitor water quality in the San Francisco Bay and Estuary. We provide examples of product imagery (Chlorophyll, ...) using these satellites, and discuss the processing chain, including *in situ* measurements, used to calibrate and validate the product imagery. In collaboration with JPL, USGS, and with the support of MWD, we are working to provide maps of water quality products in near-real-time for use by MWD, as well as, other state and federal agencies to assist in monitoring and managing Bay and Estuary waters.

## 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.

## Product Map Examples:



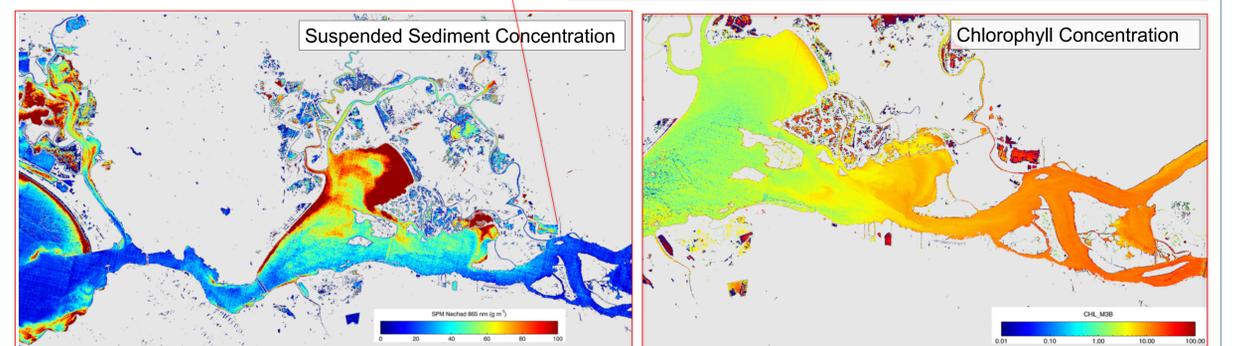
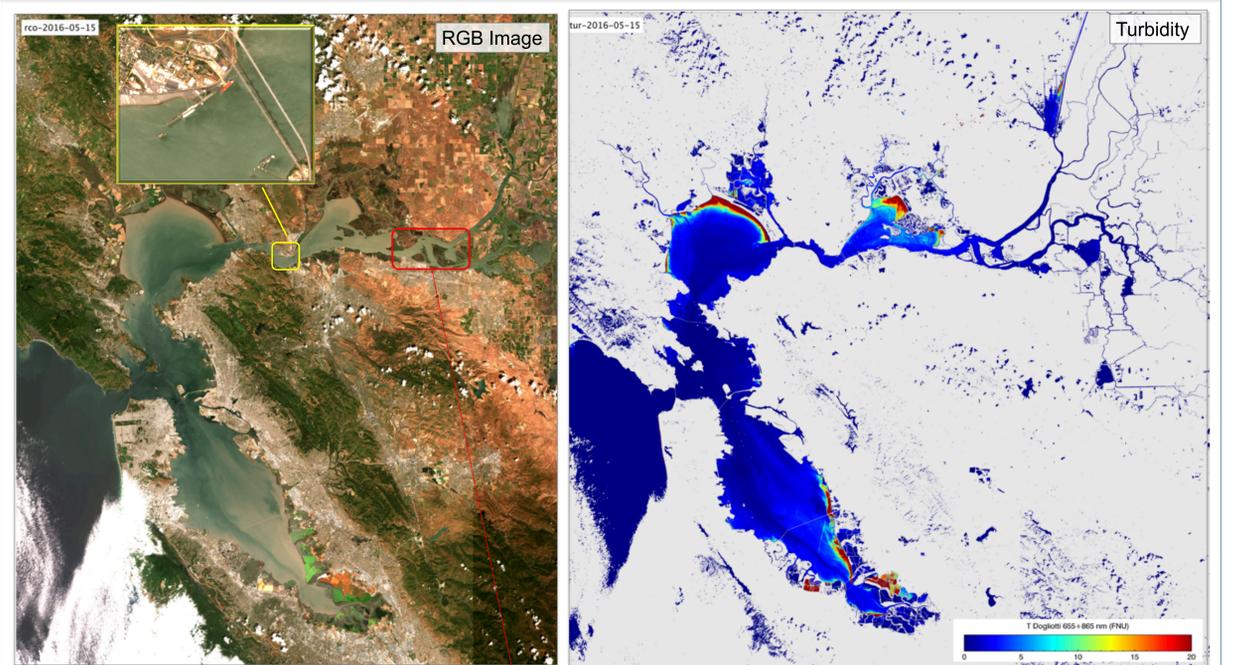
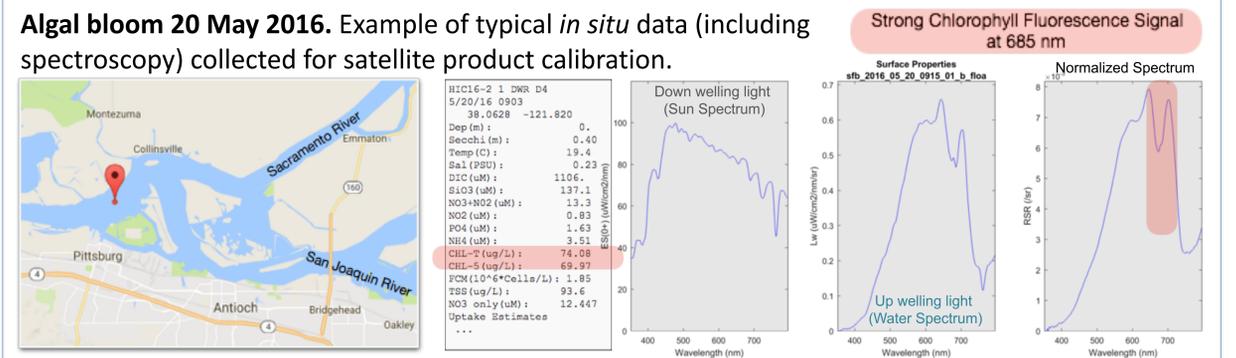
**Landsat-8 Suspended Sediment Maps** for the Northern Bays and Delta during the spring of 2015. As shown in the inset graph of the USGS gauging station at Sacramento, the historical norm for flow is ~2000 cfs. During the drought, a flow of ~400 cfs was typical. These low flows allowed intrusion of salt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



## Conclusions

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

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**Large Algal Bloom in Broad Slough 15 May 2016.** Sentinel-2 product maps from 15 May 2016 indicating a large algal bloom in Broad Slough. The top left image is a RGB of the 'Rayleigh corrected' radiance with an inset showing the 'Golden Bear' docked at Cal Maritime to illustrate the spatial resolution of the sensor. The top right is a Turbidity Map for the entire region. The bottom left shows an estimate of the Suspended Sediment Concentration, while the bottom right shows the coincident Chlorophyll Concentration product map. At least at these high Chlorophyll Levels (> 10 ug/L), the use of the SWIR bands for atmospheric correction, along with the 'red edge' product algorithms, allows us to deconvolve the sediment signal from the chlorophyll pigment signal.