Improving Remote Sensing of the San Francisco Estuary Using Ground-based Data

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Over the week of March 23 2018, members of the USGS Biogeochemistry Group participated in a project with a team of scientists from NASA, JPL, Oregon State University, UC Merced, CA Department of Water Resources, Metropolitan Water District of Southern California, Romberg Tiburon Center, and others to improve operational use of remote sensing data for evaluating water quality in the San Francisco Estuary and reservoirs. We conducted high-speed transects of water quality, nutrients, and “optical properties.” The “optical property” measurements are to characterize the spectral properties of the light signal received by the satellite, while the other measurements are to relate those spectral properties with actual water quality conditions. In this case, we coordinated the fieldwork to align with overpasses of the Landsat-8 and Sentinel-2 satellites, both of which collect high spatial resolution (15-30 m), multispectral image data. The goal is to improve characterization of chlorophyll-α, suspended sediment, and dissolved organic material. While calibration of satellite imagery has been more common in the open ocean, it has not been completed at this spatial resolution in estuaries. For the purpose of instrument development, redundant measurements of constituents were collected with a variety of bio-optical tools.

We used high-speed boat mapping (Downing et al., 2016) combined with data from our high-frequency (15 min) monitoring network data (Downing et al, 2017, Bergamaschi et al., 2017 and Kraus et al., 2017, 2017) to characterize conditions in the water through direct measurement. With Dr. Nick Tufillaro of Oregon State University, we also collected surface backscattering, surface absorption and attenuation data, while Nick collected above water radiometry, hyper spectral attenuation and absorption, and surface reflectance. Nick then constructed preliminary models to relate the two types of data based on statistical relationships between optical properties and constituent concentration measured in the study areas.

The purpose of the March 2018 transects was to capture the gradient in turbidity that occurred after recent storms to calibrate and validate models for suspended sediment concentration. Overall, Grizzly and Honker Bays had the highest turbidity values (Fig. 1) and mapping results over the sampling period aligned well with images from Sentinel-2a (Fig. 2) and Landsat-8. Turbidity mapping results also agreed with fixed-station measurements at Decker Island, Jersey Point, Confluence, and Grizzly with lowest turbidity values on the San Joaquin River and Sacramento River relative to the Estuary. Chlorophyll-α fluorescence values during mapping and at fixed-stations were low throughout the system (<3 µg/L) with the highest values measured near Grizzly Bay. Discrete samples were also collected at stations identified in Figure 2.

Remote sensing for water quality has the ability to provide periodic wide-area water quality maps for state and federal agencies monitoring and managing water. Funding for this project was provided by NASA/JPL. This project is a multi-agency effort and requires extensive field, laboratory, and technical support from abovementioned agencies.
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Figure 1. Turbidity measurements collected on Tuesday March 27, 2018 using a YSI EXO v2 attached to a boat-based, flow-through system.

Figure 2. Sentinel 2a image courtesy of Nick Tufillaro. Circles indicate locations of discrete samples and fixed-station measurements.