Overview of the RIO-SFE Program and Remote Sensing with Landsat 8

Curtiss Davis, Oregon State University, cdavis@coas.oregonstate.edu
Nicholas Tufillaro, Oregon State University, nbt@coas.oregonstate.edu

We are conducting a three year NASA Interdisciplinary Science project on San Francisco Bay and Delta Ecosystem (RIO-SFE) developing data sets and a modeling framework for an ecosystem approach to the stewardship of the SFE including freshwater and marine resources within the SFE. Our SFE project combines four components: (1) satellite observations, (MERIS, HICO on the International Space Station, Landsat 8-OLI); (2) field observations (nutrients, phytoplankton, suspended sediments, CDOM and optical properties); (3) the CoSiNE ecological model integrated the SCHISM hydrological model of SFE, and (4) Coordination with Stakeholders. In this talk we give an overview of the remote sensing work and particularly highlight the use of Landsat-8 OLI data which has been particularly useful for work in the Delta. We use a newly developed ocean color processor for Landsat-8 to examine changes in the Northern San Francisco Bay. Product maps using panchromatic enhancement (~15 m resolution) and scene based atmospheric correction allow a detailed synoptic look every 16 days. We discuss how this and other satellite data is used together with in situ data to validate models and advance our understanding of the ecology of San Francisco Bay and help with the management of this complex system.

Keywords: Landsat-8, remote sensing, ecosystem modeling, RIO-SFE, ecosystem
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In situ Measurements of Optical Properties and Lower Trophic Level Dynamics in the San Francisco Estuary, Made during Drought and El Niño Conditions (RIO-SFE Study)

Frances Wilkerson, Romberg Tiburon Center, San Francisco State University, fwilkers@sfsu.edu
Richard Dugdale, Romberg Tiburon Center, San Francisco State University, rdugdale@sfsu.edu
Curtiss Davis, Oregon State University, cdavis@coas.oregonstate.edu
Nick Tufillaro, Oregon State University, nbt@coas.oregonstate.edu
Sarah Blaser, Romberg Tiburon Center, San Francisco State University, sarahbaser@gmail.com
Edmund Antell, Romberg Tiburon Center, San Francisco State University, edmund.antell@gmail.com
Jamie Lee, Romberg Tiburon Center, San Francisco State University, jamielee00@gmail.com

The San Francisco Estuary/Delta (SFE) region experienced extreme drought conditions in 2014 and 2015 followed by heavy precipitation during spring 2016 as a consequence of an El Nino. In situ measurements were made in 2014 (May, October), 2015 (March, May, October) and 2016 (March, May) to compare the effects of the different flow and climate conditions as part of a three-year NASA Interdisciplinary Science project on the SFE Ecosystem (RIO-SFE). The goals were to a) measure remote sensing reflectance and inherent optical properties and the pigment (chlorophyll-a) and suspended sediment concentrations that determine optical regimes within the system and b) measure nutrient concentrations, phytoplankton productivity and community composition. Our hypothesis was that there will be elevated nutrients accompanying the drought as a result of less dilution, with elevated chlorophyll and spring phytoplankton blooms enabled by longer residence times. The converse - lower nutrient concentrations and less chlorophyll with elevated turbidity and TSS might be expected with the high flow conditions. These data from the northern SFE, South Bay and the Sacramento River are compared with past more "normal" conditions for spring to test these hypotheses. Surprisingly in March 2016 there was elevated chlorophyll (> 10 ug/L) in the river accompanied by the lowest spring values of ammonium that we have observed, and extremely high chlorophyll of 80 ug/L measured near the confluence in May 2016. These types of data will become increasingly important to inform adaptive management of pelagic species of concern and water quality for ecosystem sustainability in a future changing estuary.

Keywords: phytoplankton, bloom, nutrients. primary productivity, water quality, El Nino
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Development, Implementation, and Validation of a Modeling and Forecast System for the San Francisco Bay

Yi Chao, Remote Sensing Solutions, ychao001@gmail.com
John Farrara, Remote Sensing Solutions, farraraj@yahoo.com
Carrie Zhang, UCLA, zhc216@gmail.com
Fei Chai, University of Maine, fchai@maine.edu
Curt Davis, Oregon State University, cdavis@coas.oregonstate.edu
Richard Dugdale, San Francisco State University, rdugdale@sfsu.edu
Frances Wilkerson, San Francisco State University, fwilkers@sfsu.edu
Joseph Zhang, VIMS, yjzhang@vims.edu
Eli Ateljevich, Department of Water Resources, Eli.Ateljevich@water.ca.gov

With the goal of monitoring and predicting environmental conditions in the Bay, a three-dimensional modeling system for the San Francisco Bay (SFB) has been developed and implemented. The system is based on the Semi-implicit Cross-scale Hydroscience Integrated System Model (SCHISM), an open-source community-supported modeling code with unstructured grids. SCHISM is coupled to a ROMS-based regional coastal ocean model and forced by output from a regional atmospheric model. The importance of monitoring and prediction efforts in the Bay has been underscored recently by the unprecedented warming in the region during 2014-2015.

We will present a documentation of the SFB SCHISM model configuration and its performance during a multi-year (April 2004 - April 2015) hindcast. Validation against tide gauges sea surface heights demonstrates that the system can accurately reproduce the major tidal components observed in the Bay. Validation of the annual mean and mean seasonal cycle using USGS observations of temperature and salinity reveals very good agreement between the model and observations, especially for the Central Bay region. An analysis of the heat and salt budgets for the Central Bay aimed at determining the major forcing terms driving the annual and seasonal changes will be presented. Lastly, a discussion of the modeled interannual variability, including the 2014-15 warming, will be given.

Keywords: modeling, unstructured grid, circulation, heat & freshwater flux, river discharge
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Modeling the San Francisco Bay Ecosystem Dynamics

Qianqian Liu, School of Marine Sciences, University of Maine, liuqianqian0622@gmail.com
Fei Chai, School of Marine Sciences, University of Maine, fchai@maine.edu
Richard Dugdale, Romberg Tiburon Center, San Francisco State University, rdugdale@sfsu.edu
Frances Wilkerson, Romberg Tiburon Center, San Francisco State University, fwilkers@sfsu.edu
Yi Chao, Remote Sensing Solutions, ychao001@gmail.com
Hongchun Zhang, Remote Sensing Solutions, zhc216@gmail.com

A coupled physical-biogeochemical model is used to study the nutrient and biomass cycles in San Francisco Bay. The hydrodynamical processes are simulated by Semi-implicit Cross-scale Hydroscience Integrated System Model (SCHISM), and the biogeochemical processes use the Carbon, Silicate, Nitrogen Ecosystem Model (CoSiNE). As a measure of light attenuation and a key ecological parameter, turbidity is highly correlated with the biomass production in San Francisco Bay and has been incorporated into the CoSiNE model in the form of Suspended Particulate Matter (SPM). Measurements of chlorophyll and nutrients (Dugdale and Wilkerson), and turbidity (Tufillaro and Davis) are used to assess the model accuracy. This study investigates the ecosystem of San Francisco Bay and its response to different hydrological conditions in 2011 and 2012 by a series of process-oriented experiments.

Keywords: Ecosystem, Numerical Simulation, Turbidity, Chlorophyll, Nutrients, Wet and Dry Years
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Delta Dash: Bay-Delta SCHISM Operational Modeling

Eli Ateljevich, DWR, Eli.Ateljevich@water.ca.gov
Kijin Nam, DWR, Kijin.Nam@water.ca.gov

We describe prototype work on a 3D model of hydrodynamics, temperature and water quality for short and medium term operational decisions. The combination of higher fidelity modeling and data assimilation provides a more accurate picture of real-time conditions within the Delta than has previously been possible, and the injection of observations has allowed researchers to constrain complex biogeochemical systems sufficiently to study individual components. Data assimilation also yields an improvement in accuracy on simpler dynamics and here we focus on how these improvements tally with the requirements of operational decision support and water quality compliance. The 5-7 day horizon emerges an important time scale, characterizing the prediction window of synoptic events offshore and the routing time from Orville and Shasta reservoirs. As expected, longer-than-fortnight improvement persists for tracer transport and this improvement is particularly important for low export scenarios with longer residence times. As the prediction window is extended to months, we compare uncertainty from atmospheric, consumptive use and ocean forcing assumptions to the uncertainty associated with Delta operational response. The work described in this talk comes from a prototype for an always-running operational and emergency response modeling tool (Delta Dash), encompassing contributions from DWR and other authors in the session. Our conclusions concerning operational time scales are pertinent to the definition of outflow and salinity standards.

Keywords: Hydrodynamic Modeling, Real-time Decision Support, Data Assimilation, Water Quality Management
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