**NASA DEVELOP National Program**

**2017 Fall Project Proposal**

**California – JPL**

**San Francisco Bay-Delta Water Resources II**

*Water Quality Monitoring and Management in the San Francisco Bay-Delta Utilizing NASA Earth Observations*

**Project Overview**

***Project Synopsis*:** The goal of this project is to evaluate and increase understanding of water quality in the San Francisco Bay-Delta through the use of remote sensing, in partnership with the Metropolitan Water District of Southern California (MWD). Water quality, specifically turbidity and water temperature, are extremely important within this region as a result of the Delta smelt (*Hypomesus transpacificus*). Studies have shown that Delta smelt require turbid waters for successful feeding and can be impacted by changes in water temperature. This study will use a combination of multispectral, thermal, and hyperspectral data from PRISM, MASTER, and AVIRIS/AVIRIS-NG airborne instruments from April 2013 to the present to produce turbidity and temperature maps across the Bay-Delta and assess trends in the spatio-temporal dynamics of turbidity and temperature in the Bay-Delta. This analysis will enable inferences of how the environmental conditions that impact smelt habitat are evolving throughout the Delta. The results of this analysis can be used to support future monitoring of water quality parameters and pumping facility management in the Bay-Delta in association with the endangered Delta smelt.

***Community Concern:*** The MWD is responsible for supplying reliable and safe water to over 19 million people in Southern California. Seventy percent of California’s water originates in the northern part of the state, such as the San Francisco Bay-Delta, with the south accounting for over seventy percent of the demand. The Delta smelt is a rare and endemic fish species listed as threatened under both the California and U.S. Endangered Species Act. The Delta smelt spawn and feed in the San Francisco Bay-Delta and like to feed in cloudy turbid waters to help them hide from predators because the smelt have translucent bodies. As a result the Delta smelt largely control water operations in California. This is especially true during winter storm events, wherein turbid river inflows create a favorable environment for Delta smelt, leading to strict pumping restrictions, periodic closure, or high Delta smelt salvage at pumping facilities in the southern Bay-Delta.

***Source of Project Idea:*** Project advisors, Christine Lee and Michelle Gierach, have existing relationships with the MWD. This project is built on an existing joint activity between the MWD and NASA Jet Propulsion Laboratory to enhance the use of remote sensing data for water management in the Bay-Delta.

***National Application Area Addressed:*** Water Resources

***Study Location:*** San Francisco Bay-Delta, CA

***Study Period:*** April 2013 – August 2017

***Advisors:*** Michelle Gierach (NASA Jet propulsion Laboratory, California Institute of Technology), Christine Lee (NASA Jet Propulsion Laboratory, California Institute of Technology), Glynn Hulley (NASA Jet Propulsion Laboratory, California Institute of Technology), David Thompson (Jet Propulsion Laboratory, California Institute of Technology), Erin Hestir (UC Merced)

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| Metropolitan Water District of Southern California | Dr. David Fullerton, Principal Resource SpecialistDr. Shawn Acuna, Environmental Scientist | End User | Yes |
| California Department of Water Resources, State Water Project | Bryant Giorgi, Export Management Sections Chief | End User | No |

***End-User Overview***

***End User’s Current Decision-Making Process:***The MWD and the California Department of Water Resources (CDWR) use *in situ* data at fixed locations and sediment transport models to monitor and inform management of the Bay-Delta, supporting water managers and other agencies to balance requirements between ecological benefits and water resources. The MWD works with the CDWR to protect this endangered species from entrainment in water export infrastructure and other impacts from habitat alterations. During the wet season, the CDWR and the MWD closely monitor the evolution of turbidity plumes, with turbidity being used as an indicator for the presence of smelt. When the CDWR sees an exceedance in turbidity threshold over three days, they are required to respond (e.g., pumps needs to be shut off). During summer months, the primary variable of interest is temperature, which also triggers a response related to pumping operations. The MWD and the CDWR work together to ensure that the environmental conditions within the Delta remain favorable to smelt.

***End User’s Capacity to Use NASA Earth Observations:***

*Metropolitan Water District of Southern California* – The MWD has limited experience with using remote sensing and is not familiar with NASA or ESA Earth observations.

*California Department of Water Resources, State Water Project* – The CDWR has very limited experience and familiarity with NASA or ESA Earth observations.

***Dissemination by Boundary Organizations*:**

*Metropolitan Water District of Southern California* – Results from the project will be presented at the end user meeting, such as the San Francisco State of the Estuary Conference in October 2017. The project team will also work with MWD to package results with their feedback, to facilitate their dissemination and presentation of results with other regional stakeholders.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The team will talk to the partners as needed throughout the term, aiming for biweekly communication via email or telecon. The main POCs at the MWD are Dr. David Fullerton and Dr. Shawn Acuna and the Project Lead will be the main POCs between the partners and the team.

***Transition Plan*:** The team will provide the MWD with a technical report and turbidity maps from April 2013 to present and as available. The team will schedule a last meeting with the MWD near the end of the term to discuss final results through WebEx. The MWD can use this information to better inform their managers and stakeholders. Software release is not planned at this time.

**Earth Observations Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **PRISM** | Remote sensing reflectance (Rrs, sr-1), Turbidity (FNU) | PRISM Rrs (30 m spatial resolution) will be used to derive turbidity maps in the Bay-Delta from April 2013 to June 2016 using MATLAB software. |
| **AVIRIS/AVIRIS-NG** | Remote sensing reflectance (Rrs, sr-1), Turbidity (FNU) | AVIRIS/AVIRIS-NG Rrs (10 m spatial resolution) will be used to derive turbidity maps in the Bay-Delta, with datasets collected since April 2013 using MATLAB software. |
| **Landsat 8 OLI** | Remote sensing reflectance converted to turbidity | Landsat 8 Rrs will be used to derive turbidity maps in the Bay-Delta using freely available ACOLITE software. |
| **Sentinel-2 MSI** | Remote sensing reflectance converted to turbidity | Sentinel-2 Rrs will be used to derive turbidity maps in the Bay-Delta using freely available ACOLITE software. |
| **MASTER** | Remote sensing reflectances, land surface temperature and emissivity | MASTER LST and Rrs will be used to evaluate turbidity and water surface temperature, using MATLAB. |

***Ancillary Datasets:***

USGS/California Department of Water Resources California Data Exchange - Turbidity and temperature monitoring station data – publically available throughout the Bay-Delta for validation data

***Software & Scripting:***

MATLAB – Derive turbidity from PRISM and AVIRIS/AVIRIS-NG data following the approach of Fichot et al. (2015), and analysis and image generation for presentations and reports

Esri ArcGIS – Create quality maps for presentations and reports

Python - Statistical comparisons

R - Statistical comparisons

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| Turbidity Maps | Improved monitoring and management strategies for pumping facilities, such as pumping restrictions, periodic closure, or Delta smelt salvage at pumping facilities in the southern Bay-Delta, most applicable during winter months and wet season | PRISM, AVIRIS/AVIRIS-NG, Landsat 8, and Sentinel-2 Rrs will be used to derive turbidity using MATLAB software and ACOLITE, and validated with *in situ* turbidity data.  | N/A |
| Water Surface Temperature Maps | Improved monitoring and management strategies for pumping facilities, such as pumping restrictions, periodic closure, or Delta smelt salvage at pumping facilities in the southern Bay-Delta, most applicable during summer months and dry season | MASTER will be used to derive water surface temperature using MATLAB and validated with *in situ* temperature data | N/A |

***End-User Benefit*:** Turbidity and water temperature maps from this project will improve MWD’s understanding of how smelt may be impacted during winter and summer seasons. The resulting maps can be incorporated in their future research to improve Delta smelt habitat and turbidity forecasting, as well as improve monitoring of turbidity and pumping facility management in the Bay-Delta. Overall, the end product will increase the MWD’s accessibility to remote sensing data and allow them to utilize satellite information to improve future monitoring and management strategies.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 3 Terms: 2017 Summer to 2018 Spring

***Multi-Term Objectives:***

* **Term 1:** 2017 Summer (JPL) – San Francisco Bay-Delta Water Resources
	+ The first term of the project was used to evaluate and understand water quality in the San Francisco Bay-Delta through the use of multispectral remote sensing in partnership with MWD. The first term was able to use Landsat 8 from April 2013 to May 2017 and Sentinel-2 from November 2016 to May 2017 to produce turbidity maps across the Bay-Delta. This term also began deriving turbidity from Sentinel-3 but could not move forward in using this dataset until the SeaDAS update is available (most likely by Term 3).
* **Term 2 (Proposed Term):** 2017 Fall (JPL) – San Francisco Bay-Delta Water Resources II
	+ The second term of the project will evaluate and understand water quality in the San Francisco Bay-Delta through the use of airborne thermal and imaging spectroscopy remote sensing in partnership with the MWD. This study will use limited existing NASA JPL airborne thermal (MASTER) and imaging spectrometer (e.g., AVIRIS/AVIRIS-NG and PRISM) and *in situ* data to generate water surface temperature and turbidity maps across the Bay-Delta.
* **Term 3:** 2018 Spring (JPL) – San Francisco Bay-Delta Water Resources III
	+ The third term will focus on evaluating water quality in the San Francisco Bay-Delta utilizing a recently released, publicly available dataset from Planet Labs, which has much higher spatial (<4 m) and temporal (daily) resolution in the visible to near infared, and Sentinel-3 to produce turbidity maps. Team will also evaluate of the suitability of various remote sensing platforms, from analyses conducted over terms 1-3, for addressing pump operations responses to environmental changes and smelt distribution.

***Previous Terms:***

2017 Summer (JPL) – San Francisco Bay Delta Water Resources: Water Quality Monitoring and Management in the San Francisco Bay-Delta Utilizing NASA Earth Observations

***Related DEVELOP Work:***

2016 Spring (JPL) – Los Angeles Oceans: Validating Satellite Observations of Wastewater Plume Biological Impacts in Santa Monica Bay, California

2015 Fall (JPL) – Los Angeles Oceans: Remote Sensing Detection of Wastewater Plumes to Assess Public Water Quality in Los Angeles County

2014 Summer (JPL) – Southern California Oceans: Remote Sensing Detection of Wastewater Plumes to Assess Public Water Quality in Los Angeles and Orange Counties

**Notes & References:**

Dogliotti, A., Ruddick, K., Nechad, B., Doxaran, D., & Knaeps, E. (2015). A single algorithm to retrieve turbidity from remotely-sensed data in all coastal and estuarine waters. *Remote Sensing of Environment, 156*, 157–168.

Fichot, C. G., Downing, B., Bergamaschi, B., Windham-Myers, L., Marvin-DiPasquale, M., Thompson, D. R., & Gierach, M. M. (2015). High-resolution remote sensing of water quality in the San Francisco Bay-Delta Estuary. *Environmental Science and Technology, 50*(2), 573–583, doi:10.1021/acs.est.5b03518.