**NASA DEVELOP National Program**

**2017 Summer Project Proposal**

**NASA Jet Propulsion Laboratory**

**San Francisco Bay-Delta Water Resources**

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

**Project Overview**

***Project Synopsis*:** To evaluate and understand 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, is extremely important within this region as a result of the Delta smelt, a rare and endemic species listed as threatened under both the California and U.S. Endangered Species Act. Studies have shown that Delta smelt require turbid waters for successful feeding. This study will use Landsat 8 from April 2013 to May 2017 and Sentinel-2 from November 2016 to May 2017 to (1) produce turbidity maps across the Bay-Delta in ranges considered optimal for the endangered Delta smelt, and 2) assess trends in the spatio-temporal dynamics of turbidity in the Bay-Delta, enabling inferences of how the smelt habitat is evolving throughout the Delta. The results of this analysis can be used to support future monitoring of turbidity and pumping facility management in the Bay-Delta in association with the endangered Delta smelt. We aim to increase accessibility to and use of remote sensing data by MWD.

***Community Concern:***

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 spawn and feed in the San Francisco Bay-Delta, and 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 (higher populations in turbid waters) leading to strict pumping restrictions, periodic closure, or high Delta smelt salvage at pumping facilities in the southern Bay-Delta. Therefore, knowledge of turbidity distribution in the Bay-Delta is extremely important for California water management. Currently, turbidity measurements in the Bay-Delta are made at fixed locations that are difficult to extrapolate over the broad and heterogeneous habitats of the estuary. Remote sensing can alleviate this issue, providing uniform, high density maps of turbidity. This study proposes to use Landsat 8 (655/865nm bands) and Sentinel 2A (664/865nm bands) to produce turbidity maps (Dogliotti et al., 2015) across the Bay-Delta to improve monitoring of turbidity and pumping facility management in the Bay-Delta in association with the endangered Delta smelt.

***Source of Project Idea:***

Project advisors, Christine Lee and Michelle Gierach, have existing relationships with MWD. This project is built on an existing joint activity between 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)

**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 |

***End-User Overview***

***End-User’s Current Decision-Making Process:***

MWD uses *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 relies heavily on understanding the distribution of turbidity before making decisions on water management (e.g., pumping restrictions, periodic closure, or Delta smelt salvage at pumping facilities) in the Bay-Delta. The MWD has also been involved in science efforts in understanding the habitat conditions for the endangered Delta smelt and the environmental conditions of turbidity using technologies such as GPS tagging and drones.

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

*Metropolitan Water District of Southern California* – The MWD has no experience with using remote sensing and is not familiar with NASA Earth observations.

***Collaborator & Boundary Organization Overview***

***Dissemination by Boundary Organizations*:**MWD will report the findings to the US Fish and Wildlife Services who manage the Delta smelt. Findings include turbidity maps across the Bay-Delta in ranges considered optimal for the endangered Delta smelt and trends in the spatio-temporal dynamics of turbidity in the Bay-Delta, enabling inferences of how the smelt habitat is evolving throughout the region.

***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 and/or telecom. The main MWD POCs are Dr. David Fullerton and Dr. Shawn Acuna.

***Transition Plan*:** The team will provide MWD with a technical report and turbidity maps from April 2013 to May 2017. The MWD can use this information to better inform their managers and stakeholders.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Landsat 8 OLI** | Remote sensing reflectance (Rrs, sr-1); Turbidity (FNU) | Landsat 8 OLI Rrs (30m spatial resolution) will be used to derive turbidity maps in the Bay-Delta from April 2013 to May 2017 using ACOLITE software. |
| **Sentinel-2 MSI** | Remote sensing reflectance (Rrs, sr-1); Turbidity (FNU) | Sentinel-2 MSI Rrs (10m spatial resolution) will be used to derive turbidity maps in the Bay-Delta from November 2016 to May 2017 using ACOLITE software. |

***Ancillary Datasets:***

USGS/California Department of Water Resources (CDWR) turbidity monitoring stations – Publically available *in situ* turbidity data throughout the Bay-Delta to validate turbidity maps derived from Landsat 8 and Sentinel-2.

***Software & Scripting:***

ACOLITE – derive turbidity from Landsat 8 OLI and Sentinel-2 MSI Rrs

MATLAB – analysis and image generation for presentations and reports

ArcGIS – create quality maps for presentations and reports

**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. | Landsat 8 OLI and Sentinel-2 MSI Rrs will be used to derive turbidity in the ACOLITE software, and validated with *in situ* turbidity data. | N/A |

***End-User Benefit*:**

Turbidity maps from this project will improve MWD’s understanding of drivers and spatial variability of turbidity. The resulting maps can be incorporated in their future research in improving Delta smelt habitat and turbidity forecasting. 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 (Start) to 2018 Spring (Completion)

***Multi-Term Objectives:***

* **Term 1 (Proposed Term):** 2017 Summer (JPL) – San Francisco Bay-Delta Water Resources
	+ To evaluate and understand water quality in the San Francisco Bay-Delta through the use of multispectral remote sensing in partnership with MWD. This study will use Landsat 8 from April 2013 to May 2017 and Sentinel 2A from November 2016 to May 2017 to produce turbidity maps across the Bay-Delta.
* **Term 2:** 2017 Fall (JPL) – Bay-Delta Water Resources II
	+ To evaluate and understand water quality in the San Francisco Bay-Delta through the use of hyperspectral remote sensing in partnership with MWD. This study will use limited existing NASA JPL airborne imaging spectrometer (e.g., AVIRIS and PRISM) and in situ data to derive a regional turbidity algorithm to generate turbidity maps across the Bay-Delta.
* **Term 3:** 2018 Spring (JPL) – Bay-Delta Water Resources III
	+ To evaluate the benefits of hyperspectral vs. multispectral for water quality monitoring in the San Francisco Bay-Delta using Term 1 and Term 2 results. Provide MWD with a report that summarizes the findings, as well as the software and algorithms used such that MWD could build up this capability within their own agency or continue collaboration with NASA. Preparation and submission of a journal article by the end of the term.

***Related DEVELOP Work:***

2016 Spring (NASA Jet Propulsion Laboratory) – Los Angeles Oceans: Remote Sensing Detection of Wastewater Plumes to Assess Public Water Quality in Los Angeles County

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

2014 Summer (NASA Jet Propulsion Laboratory) – Los Angeles Oceans: Remote Sensing Detection of Wastewater Plumes to Assess Public Water Quality in Los Angeles County

***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.