**NASA DEVELOP National Program**

**Spring 2016 Project Proposal**

**NASA Jet Propulsion Laboratory**

**Los Angeles Oceans II**

Remote Sensing Detection of Wastewater Plumes to Assess Public Water Quality in Los Angeles County

**Project Overview**

***Objective:*** To develop a report to provide to the City of Los Angeles Hyperion Treatment Plant (HTP) regarding the analysis of satellite data collected during the wastewater diversion that occurred during September to November 2015. The report will focus on the detection of the thermal signatures, surface movement, and ecosystem response to wastewater plumes using various satellite products, in combination with in situ data that was also collected.

***Community Concern:*** Treatment plants must undergo maintenance or upgrades to the infrastructure of the outfall pipes that routinely carry treated wastewater into deep, offshore coastal waters. During discharge pipes upgrades, the treated wastewater is diverted to shorter outfall pipes that may only extend into shallow coastal zones, where buoyant, freshwater plumes containing possible contaminants may reach the surface. The concern is to identify the surfacing plumes and where they are transported to by coastal winds and currents, to determine the environmental impact of the nutrient-rich treated waters on the coastal ecosystem, and to identify possible excursions to nearby beaches and surf zones where public health may be affected

***National Application Area Addressed:*** Oceans

***Study Location:*** Santa Monica Bay, CA

***Study Period:*** September to November 2015

***Advisors:*** Benjamin Holt, Michelle Gierach, Ocean Circulation Group, JPL

***Source of Project Idea:***

JPL was a full participant in the 2006 HTP and 2012 Orange County Sanitation District diversions and was contacted by the City of Los Angeles to develop a satellite plan and to participate in the Fall 2015 HTP diversion. Because of the earlier work and analysis provided by the previous DEVELOP projects, this is a natural follow-on for a follow-on DEVELOP project to provide satellite analysis in near-real time that could be used by HTP to guide their in situ sampling strategy and to provide a broader scale assessment of the ecological impact on the 2015 diversion.

**Partner Overview**

***Partner Organizations:***

City of Los Angeles Hyperion Treatment Plant (End-User POC: Curtis Cash, Water Biologist III, Ashley Booth, Water Biologist I, and Mas Dojiri: Division Manager, Environmental Monitoring Division)

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

The overriding concern of these agencies during required diversion events is to identify the wastewater plume, where the plume goes, and how the plume might impact water quality and public health, related to potential nutrient enrichment and beach bacterial contamination, respectively. Extensive *in situ* sampling programs was undertaken on a daily basis during the recent diversion to determine water quality, concentration and spread of effluent-indicator components (e.g. fecal indicator bacteria and nutrients), and environmental ocean conditions. Satellite data provided a synoptic capability for plume detection, which was used for guiding adaptive *in situ* sampling strategies. During the diversion period, the DEVELOP team obtained and processed imagery and provided these products routinely to the City partners with analysis.

***NASA Earth Observations Capacity:***

The City of Los Angeles has no expertise in satellite observations. The partners have expressed interest in the value and capability of satellite sensors to detect wastewater plumes and to determine the possible impact on water quality and coastal biology, based on prior analysis performed by DEVELOP teams at JPL.

***Collaborators:***

The City of Los Angeles will be undergoing daily sampling of water quality during the diversion period, as required. The City has also enlisted the support of researchers from the University of Southern California, University of California Santa Barbara, and Scripps Institute of Oceanography to provide additional *in situ* sampling related to biological impact, ocean currents, and physical parameters. A project web site was established for the diversion participants to see daily results. Satellite data and in situ was provided to this web portal during the diversion to aid with *in situ* sampling strategies and to detect the general plume extent.

***Communication Plan & Transition Approach:***

The City requests a final report to be submitted by Spring 2016 through JPL/DEVELOP participation. This will include a combined analysis of satellite with in situ data, which was not done during the diversion, to confirm and validate the satellite observations of the environmental and ecological impacts to the region.

***End-User Benefit:***

JPL will provide a final report regarding the satellite observations of plume signatures to the City of Los Angeles that will help determine the location and extent of the plume as well as the impact on water quality during the course of the diversion.

**Letters of Support:**

Request by the City of Los Angeles to participate in the 2015 diversion program.

**Earth Observations Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform** | **Sensor** | **Geophysical Parameter** |
| **Terra** | ASTER | Sea surface temperature (SST) |
| **Aqua** | MODIS | SST, chlorophyll-a, water leaving radiance |
| **Landsat 8** | Optical, TIR | SST, surface roughness from sun-glint, ocean color derivations |
| **Sentinel-1, ALOS-2** | SAR | Surface roughness, slick detection |

***NASA Earth Observations Use:***

The thermal signature of the surfacing effluent plume will be detected by MODIS, Landsat 8, and ASTER thermal IR data, using 1 km resolution data obtained by MODIS and 90 m thermal IR data from Landsat8 and ASTER. Changes related to ocean color, including the potential phytoplankton response to nutrient enhancement (using chlorophyll-a as a proxy) will be assessed using MODIS. The ASTER data are available from NASA’s Land Processes Distributed Active Data Center (DAAC) while MODIS data are available from the Ocean Biology Processing Group at NASA GSFC. SAR data are sensitive to changes in ocean surface roughness, including those related to marine slicks.

SAR imagery will detect the plume by surface turbulence from the rising plume, as well as a slick caused by the presence of oils, which are not completely removed during treatment. Limited Sentinel-1 SAR data was obtained during the diversion from European Space Agency, which now has an open data policy. Also ALOS-2 SAR imagery was obtained from the Japanese Space Agency (JAXA) through an approved data proposal investigation with Holt as PI.

***Ancillary Datasets:***

Collaborating groups and HTP collected *in situ* data during the monitoring program that included temperature, salinity, dissolved oxygen, pH, conductivity, transmissivity, CDOM, turbidity, phytoplankton species, effluent-indicator discrete samples and chlorophyll-a fluorescence, HF radar for surface currents, and GPS-equipped drogue surface drifters,. These are to be utilized for satellite analysis when they become available after final processing.

**Decision Support Tool & End-Product Overview**

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| --- | --- | --- |
| **Proposed End Products** | **Decision to be Impacted** | **Current Partner Tool/Method** |
| Thermal Plume Detection | *In situ* sampling planning, Impact on water quality | *In situ* sampling |
| Water Quality and Biological Response | *In situ* sampling planning, impact on water quality | *In situ* sampling |

*Thermal Plume Detection* – Analysis of satellite data that identifies wastewater plume location, shown on a map, and the possible impact on water quality.

*Water Quality and Biological Response* – Analysis of satellite-derived ocean color products, combined with in situ sampling for.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 2 Terms: 2015 Fall to 2016 Spring

* **Term 1** – To participate in the 2015 HTP diversion during September to November 2015, providing satellite data to the City to assist in guiding their in situ sampling program and to identify the potential areas of altered water quality and impacts to public health in nearshore environments.
* **Term 2 (Spring 2016)** – Finalize processing of satellite data and combine these results with in situ data for verification, which was not done during the diversion, and provide analysis and conclusions in a final report to the project partner HTP. This work will also lead to the preparation and submission of a journal article by the end of the term.

***Previous Related DEVELOP Work:***

This is a follow-on effort to two recent related DEVELOP efforts, specifically from the Summer 2014 and Fall 2012 terms, which produced a satellite sampling strategy and methods based on observations from the 2006 and 2012 diversions (Gierach et al., 2015). The first term project in Fall 2015 provided concurrent satellite analysis for 2015 HTP diversion directly to the City to assist in guiding their in situ sampling program, to identify the potential areas of altered water quality and impacts to public health in nearshore environments.

The second term project in Spring 2016 will provide further analysis of the acquired satellite data, together with in situ data collected by other investigators in the diversion program. This combined analysis will be provided in a report to the HTP. This effort will work towards the submittal of a journal article by the end of the term.

Fall 2012 (JPL) - Southern California Water Resources: Remote sensing detection of storms and wastewater plumes to assess public health and water quality in Los Angeles and Orange Counties

Summer 2014 (JPL) - Southern California Water Resources: Remote sensing detection of storms and wastewater plumes to assess public health and water quality in Los Angeles and Orange Counties

Fall 2015 (JPL) – Los Angeles Oceans I: (Remote Sensing Detection of Wastewater Plumes to

Assess Public Water Quality in Los Angeles County

**Project Needs/Requests**

***Participants Requested:*** 2

***Software & Scripting:***

ENVI, ArcGIS, SeaDAS, Matlab, NEST

**Notes & References:**

***Notes:***

Two wastewater diversions have previously taken place, one at the City of Los Angeles Hyperion Treatment Plant in Playa del Rey, CA, in November 2006, and the other in September-October 2012 at the Orange County Sanitation District in Huntington Beach, CA. In both cases, the treated wastewater was diverted from nominal 5 mile long pipes that terminate at approximately 60 m depth, to shorter 1 mile pipes that end at about 20 m depths. The concerns during each diversion were: Where did the plume go and what was the impact related to nutrient-rich waters entering into the shallow euphotic zone? JPL participated in both monitoring programs by providing both daily and limited coverage satellite datasets intended to detect the plume location and movement. There was also extensive *in situ* sampling conducted by the respective agencies and additional monitoring partners during each diversion. JPL was a participant in the 2006 HTP diversion that lasted 50 hours, with the collection of SAR and MODIS imagery. Participation in the approximately month-long 2012 diversion was a component of the Fall 2012 JPL DEVELOP Southern California Water Resources Project, utilizing both MODIS and ASTER imagery. During the Summer 2014 DEVELOP term, all satellite datasets collected during 2006 and 2012 diversions processed and examined in comparison with *in situ* data collections, with processing methods developed for all data sets. The DEVELOP participants are the main people conducting the satellite analysis for the city.

Gierach et al. (2015) described the results from the Summer 2014 DEVELOP project assessing the capability of multi-satellite datasets to detect the wastewater diversion plume and its impact on water quality and biological productivity. In the 2006 diversion, SAR imagery was able to identify and track the surfacing wastewater plume and MODIS Aqua showed a decreased sea surface temperature (SST) response. In the 2012 diversion, key results were obtained for chlorophyll-a (chl-a) and SST using MODIS Aqua and ASTER imagery (no SAR data were available). In this case, chl-a showed a reduction in the phytoplankton response (low chl-a) compared to surrounding waters in association with enhanced chlorination of the discharged wastewater that suppressed the phytoplankton response. Both MODIS and ASTER showed decreased SSTs. A Landsat 8 image taken in a later year after the diversion for a similar time of year as the HTP 2015 diversion was processed to illustrate that sensor’s capability for SST.

***References:***

Gierach, M. M., B. Holt, R. Trinh, B. Pan, and C. Rains (2015). Satellite detection of wastewater diversion plumes in Southern California, Estuarine, Coastal, and Shelf Science, under revision.