**NASA DEVELOP National Program**

**Fall 2015 Project Proposal**

NASA Jet Propulsion Laboratory

**Los Angeles Oceans**

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

**Objective:**

To participate in the planned wastewater diversion to be undertaken at the City of Los Angeles (City) Hyperion Treatment Plant (HTP) during September to October 2015 by providing concurrent analysis of satellite data that will detect the thermal signature, surface movement, and ecosystem response to wastewater plumes.

**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. The treated wastewater is diverted to shorter outfall pipes that may only extend into shallow coastal zones, where buoyant, freshwater plumes containing possible containments may reach the surface. The concern of these municipal agencies is to identify the surfacing plumes and where they are transported by coastal winds and currents, to determine the environmental impact of the nutrient-rich treated waters to the coastal ecosystem, and to identify possible excursions to nearby beaches and surf zones where public health may be affected. 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). This project will provide 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.

**Partners/Collaborators:**

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)

JPL was a full participant in the 2006 HTP diversion and in the fall 2012 Orange County Sanitation District diversion. JPL was contacted by the City to develop a satellite plan and to participate in the 2015 HTP diversion, planned for September 8 through October 13. 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. Prior to the diversion, the DEVELOP project will provide a list of planned coverage from the non-daily sensors like Landsat 8 and ASTER, including nighttime TIR-only requested coverage, and SAR data including from ALOS-2 and Sentinel-1 from the diversion after it starts. We anticipate full participation in planned telecons as they are scheduled and delivery of analyzed satellite products on a timely basis. After the diversion ends, a final report with data listings and analyzed examples will be provided by the project to the City, and plans will be made for further analysis and a planned future publication, which will be more feasible at a later time once *in-situ* data have been completely processed and made available to the City and larger research team. Also during the term, there will be opportunities for DEVELOP interns to participate in *in-situ* sampling on the HTP research vessel.

**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 will be undertaken on a daily basis during each diversion to determine water quality, concentration and spread of effluent-indicator components (e.g. fecal indicator bacteria, nutrients), and environmental ocean conditions. Satellite data will provide a synoptic capability for plume detection, which will also be used for guiding adaptive *in-situ* sampling. During the diversion period, the DEVELOP team will obtain and process imagery and provide these routinely to the City partners with analysis. The City has invited JPL (consisting of DEVELOP interns) to participate to provide satellite expertise and analysis in order to help guide the sampling program and assess any impact on water quality.

**Earth Observations:**

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

**NASA Earth Observations to be Highlighted:**

Plume thermal signatures will be detected by MODIS, Landsat 8, and ASTER SST data, making use of the 90 m resolution available in the Thermal IR band with the latter two sensors. 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 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 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. Sentinel-1 SAR data are expected to be available at the time of the diversion from the ASF DAAC or, if not, then from ESA, which now has an open data policy. Also ALOS-2 SAR imagery will be available via JAXA through an approved data proposal investigation.

**Ancillary Datasets:**

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

**Decision Support & Analyses:**

|  |  |  |
| --- | --- | --- |
| **Proposed End Products** | **Decision Impacting** | **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 possible impact on water quality. Impaired water quality may impact human health, knowing where the plume location travels could lead to public notice of poor water quality along beaches.

*Water Quality and Biological Response* – A final data report will be submitted to the City before the end of the term. At a later time, when the *in-situ* data become finalized and made available, we anticipate a publication to be submitted to a special issue on the fall 2015 HTP diversion to a journal that has not yet been determined.

**Project Details:**

**National Application Areas Addressed:** Oceans

**Source of Project Idea:** Participation in previous diversion monitoring efforts.

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

**Period being Studied:** September-October 2015

**Advisors:** Benjamin Holt, Michelle Gierach, Oceans-Ice Group, JPL

**Participants Requested:** 2

**Project Timeline:** 1-2 Terms: 1) Fall 2015, and 2) TBD term to complete analysis and submit journal paper.

**Multi-Term Objectives:**

* **Term 1 (Proposed Term)** – Provide analyzed satellite data in support of the fall 2015 HTP diversion including a final data report to the partner.
* **Term 2** – Finalize results and conclusions. Focused on creation and submission of the journal paper.

**Previous Related DEVELOP Work:**

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

**Software & Scripting Requested:**

ENVI, ArcGIS, SeaDAS, Matlab, NEST

**Reference:**

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.

**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 terminates 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.