**NASA DEVELOP National Program**

**Fall 2016 Project Proposal**

**NASA Goddard Space Flight Center**

**North Carolina Water Resources**

Utilizing NASA Earth Observations and Hydrological Modeling to Monitor Nutrient Levels in Jordan Lake, North Carolina for Improved Water Quality Management

**Project Overview**

***Objective:*** This project will develop a GIS-based tool for monitoring and mapping Nitrogen (N) and Phosphorus (P) levels in Jordan Lake, North Carolina – a major resource for drinking water and wastewater management for the Town of Cary, North Carolina, to help the Town of Cary water utility in planning water treatment activities.

***Community Concern:*** It is well-known that excessive amounts of N and P in rivers and lakes affect water quality and cause health problems to humans and aquatic ecosystems. Jordan Lake, located in the Haw River Basin in North Carolina, provides drinking water for roughly 250,000 people in Cary and several other cities and municipalities. A major concern about Jordan Lake is the water pollution due to excessive N and P from wastewater treatment plants, and from suburban developments and farms. A few water samples taken within the lake show N and P levels frequently exceed the water quality standards, potentially increasing harmful cyanobacteria in drinking water. Currently, there are only a few sampling stations in Jordan Lake where water quality parameters are observed, and the temporal sampling is non-uniform ranging from several weeks to a month.

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

***Study Location:*** Jordan Lake watershed, Haw River Basin, North Carolina

***Study Period:*** March 2014 to September 2015 (to be extended based on the availability of in situ data).

***Advisor:*** Amita Mehta, NASA GSFC-UMBC/Joint Center for Earth Systems Technology (JCET)

***Source of Project Idea:*** The idea for the project emerged from an ongoing NASA Applied Sciences Program (ASP) project in which Amita Mehta (GSFC) and Josh Weiss (Hazen & Sawyer – H&S) are involved in developing a Decision Support System (DSS) to predict water quality parameters such as Natural Organic Matter (NOM) and turbidity based on remote sensing observations for the Town of Cary Utilities. The proposed project is independent of the NASA ASP project and the project outcome (i.e. N and P amount in the Lake) and dissemination to the Town of Cary does not depend in any way on the ASP project. The NASA ASP project focuses purely on statistical technique development and implementation for monitoring NOM and turbidity whereas the proposed project will focus on physically-based watershed modeling by using the Soil and Water Assessment Tool (SWAT) to provide N and P loading in the Jordan Lake. In addition, the DSS developed by the ASP project will be utilized to provide these additional water quality parameters offering the Utility with an integrated platform to access multiple water quality parameters necessary for decision making about water intake and purification strategy.

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| Town of Cary Public Utilities | Jeff Adkins, Water Resources Manager at Town of Cary | End-User | No |
| Hazen and Sawyer P.C. | Dr. Josh Weiss, Water Resources Engineer | End-User | Yes |
| University of Guelph | Dr. Prasad Daggupati, Postdoctoral Research Associate | Collaborator | No |

***End-User Overview***

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

Currently the Town of Cary Public Utilities Department uses *in situ* measurements to aid water treatment and management decisions. There are several locations in Jordan Lake where *in situ* measurements of water quality parameters are collected by the utility company and the USGS. These measurements are infrequent (approximately once a month) and samples are limited to the lake. The proposed project will build capacity in using NASA remote sensing data to run SWAT to specifically assess N and P levels in the Jordan Lake that will be used by H&S and the Town of Cary Utility.

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

Currently the end-user organization (Town of Cary) does not use any remote sensing observations in decision support for water treatment. The aim of this project is to develop a semi-automatic tool that acquires and inputs the required remote sensing observations from NASA DAAC to SWAT, and to provide a web-based visual and tabulated information about N and P. The end-user organization H&S is familiar with MODIS vegetation indices data and has used them in the past for projects modeling surface hydrology, but have yet to incorporate other Earth observations (EO) into their work.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

Texas A&M University – Dr. Daggupati (recently joined University of Guelph, Ontario, Canada) is an expert in setting, calibrating, and running SWAT in ArcGIS. He will guide the project team in the installation and running of SWAT for the Jordan Lake watershed. Dr. Daggupati will also help in transitioning the SWAT set-up to the DSS that Hazen & Sawyer is developing for the end-user organization.

***Boundary Organization Dissemination:***

Hazen & Sawyer (H&S), an engineering company working on helping clients provide safe drinking water to their customers, has a presence in several US cities and towns, including Cary, NC and Baltimore, MD. H&S works closely with the Town of Cary Public Utilities Department in water management activities and is currently developing a DSS for water treatment planning for them. H&S (POC: Josh Weiss) will participate in this project as a boundary organization by helping to communicate the Town of Cary’s Public Utilities Department’s needs and requirements, and disseminating outcomes of this project via the DSS they are developing for the Town of Cary Public Utilities Department.

***Project Communication & Transition Overview***

***In-Term Communication Plan:***

At the onset of the project, a clear timeline and list of goals will be designed, and progress will be reviewed on a weekly basis. A teleconference/web-meeting will be held with incoming DEVELOP participants, Dr. Amita Mehta, Dr. Prasad Daggupati, Josh Weiss (H&S), and Jeff Adkins in the first week of the project term. The project partners and DEVELOP team will have frequent web-meetings via Google hangout, as well as weekly emails to facilitate communication.

***Transition Approach:***

This project is planned as a two-term (Fall 2016 and Spring 2017) project. At the end of the first term, i) SWAT calibrated for the Jordan Lake watershed, Haw River Basin, North Carolina, and ii) scripts to fetch necessary NASA data to run SWAT will be handed off to H&S in person, and via NASA LFT for them to start incorporating these tools in their DSS. This will take place after going through the requisite software release process. At the end of the second term, DEVELOP participants will visit the Town of Cary Utility Department to demonstrate the SWAT set-up using NASA data to monitor N and P in the Jordan Lake. At the same time, the DEVELOP team will hand over all the procedures to run SWAT model operationally for the Jordan Lake watershed to H&S. H&S will include SWAT-based N and P data output in the DSS they are developing for the Town or Cary Utility. In long term, H&S will be in charge of sustained training and support for Town of Cary Public Utilities Department in using DSS for planning their water treatment activities. The decision support tool will be implemented by H&S and the Town of Cary Utility within one year of receiving the products.

**Letters of Support:** This will be sent next week.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **GPM/IMERG** | Daily Precipitation | Will be used as input to the SWAT model used as a tool to calculate streamflow in the Jordan Lake Watershed |
| **Suomi NPP VIIRS** | Land Surface Temperature (LST) | Will be used as input to the SWAT model |
| **Landsat 8 OLI** | Land Cover | Land Cover Classification |
| **Sentinel-2 MSI** | Land Cover | Land Cover Classification |

***Ancillary Datasets:***

MERRA Reanalysis Model – Daily maximum and minimum air surface temperatures, winds and relative surface humidity, and net solar radiation – Calibrating SWAT model

USGS – *In situ* stream gauge data – Calibrating SWAT model

USGS – National Land Cover Database 2011 (NLCD 2011) – Calibrating SWAT model

USDA - Cropland Data Layer – Calibrating SWAT model

City Of Town of Cary Public Utilities Department – *In situ* N and P concentration – Validating SWAT model

***Modeling:***

Soil and Water Assessment Tool (SWAT) (POC: Dr. Prasad Daggupati, Texas A & M)

***Software & Scripting:***

ArcGIS – Satellite imagery processing, classification, raster manipulation/analysis, map creation, running SWAT

Python, R, IDL – Data extraction and statistical analysis

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

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| SWAT Model for Predicting *In Situ* Water Quality From Remotely Sensed Data for N and P | Provides Town or Cary Utility predicted *in situ* measurements used for future watershed monitoring with remote sensing data to forecast near term water quality conditions for N and P | Maps of precipitation, LST, and climatic data from MERRA will be used as inputs for the SWAT model | 1 |
| Tool/scripts to Download Imagery and to Visualize Maps and Time Series of the Jordan Lake Watershed Parameters (precipitation, streamflow) along with Tabular Values of N and P. (This will be shared through a web interface created and maintained by DSS, only after the tool has gone through the software release process) | Provides Town or Cary Utility ready access to NASA’s satellite remote sensing data, in a way that is easy for utility staff to analyze and summarize for use by decision-makers | Maps of precipitation, LST, and climatic data from MERRA will be used as inputs for the SWAT model | 4 |

***End-User Benefit:***

The SWAT-based N and P made available from this project via the H&S DSS will present the Town of Cary Utility department with a complete set of water quality parameters. This information will then be used for future watershed monitoring with remote sensing data to forecast near term water quality conditions. This will save the utility money and provide near-real time predictions of water quality impacting hundreds of thousands of people relying on the watershed for their drinking supply.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 2 Terms: Fall 2016 (Start) to Spring 2017 (Completion)

***Multi-Term Objectives:***

* **Term 1(Proposed term):** Fall 2016 (GSFC): North Carolina Water Resources
  + The first term of the project will be running and validating the SWAT model for predicting *in situ* water quality in the watershed. This will be executed through the advising of Dr. Prasad Daggupati and Dr. Josh Weiss. This will set the stage for a subsequent term when the model will be implemented in a near real time web-based platform for the Town of Cary Utility.
* **Term 2:** Spring 2017 (GSFC): North Carolina Water Resources II
  + The second term of the project will be integrating results of SWAT onto a web-based platform created and hosted by DSS, for the Town of Cary Utility to visualize maps of the watershed with tabular values of N and P. A second term is necessary as running and validating the SWAT model will take a lot of time. Communication will be maintained throughout the second term with all partners ensuring appropriate formatting and content is provided for hosting content on the web. Deliverables and tools will be handed off to project partners both in person (H&S) and via NASA LFT (Town of Cary Utility).

***Related DEVELOP Work:***

Summer 2016 (ARC) Elkhorn Slough Eco Forecasting: Detecting Eutrophication Sources, Hotspots, and Nutrient Levels in a Central California Estuary to Support Watershed Management Decisions

Summer 2015 (UGA) Costa Rica Water Resources: Utilizing NASA Earth Observations to Develop a Comprehensive Water Budget for the Arenal-Tempisque Irrigation District of Costa Rica

Spring 2015 (WC) Peru Disasters: Utilizing NASA Earth Observations to Develop the Tools for a Water Budget and Flood Risk Mitigation for the Asunción District and Gran Chimú Province of Peru