

# NASA DEVELOP National Program

## Fall 2016 Project Proposal

### USGS at Colorado State University Rocky Mountain National Park Climate

Assessing the Feasibility of Monitoring Algal Productivity Using Landsat 8, Sentinel-2, and Worldview-2 to Inform Spatiotemporal Alpine Lake Dynamics in Rocky Mountain National Park

### Project Overview

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**Objective:** To assess the feasibility of monitoring algal productivity of alpine lakes in Rocky Mountain National Park (RMNP) using a suite of earth observations to support a remote monitoring program that will supplement our partner's regular in-situ data collection.

**Community Concern:** RMNP has over 140 lakes that provide critical habitat for native fish species as well as for recreational opportunities for park visitors. Despite park protection, alpine lakes, particularly those nearest to agriculture and urban areas, have received atmospheric nitrogen deposition from snow and rain since 1960. The nitrogen has fertilized the lakes east of the Continental Divide, altering their abiotic and biotic compositions, making them slightly more biologically productive. Since 2005, however, primary productivity appears to have greatly increased, causing the lakes to become murky and green. While the amount of nitrogen deposition has not changed, summer air and water temperatures have increased by 2-4 °C. If climate change is interacting with nutrients to increase lake algae, there are important implications for management. This project will give end-users an understanding of spatial and temporal trends in the lake's biochemical properties. This project will test the feasibility of monitoring these spatial and temporal trends in the lakes' biogeochemical properties.

**National Application Areas Addressed:** Climate, Water Resources

**Study Location:** Rocky Mountain National Park, CO

**Study Period:** June 2014 to September 2016

**Advisor:** Dr. Paul Evangelista (Colorado State University)

**Source of Project Idea:** The National Park Service established a long-term watershed study at RMNP in 1981 with the purpose of increasing understanding of natural and human-caused ecosystem variability and identifying the consequences of atmospheric deposition of pollutants as well as climate change. Continuous monitoring in Loch Vale, now performed by the US Geological Survey, has detected changes in lake conditions. It is critical to explore how widespread the observed lake eutrophication is within the park and thus, the USGS, along with RMNP, requested this project.

### Partner Overview

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#### Partner Organization(s):

Organization	POC (Name, Position/Title)	Partner Type	Boundary Org?
National Park Service, Rocky Mountain National Park	Dr. John Mack, Acting Chief of Resource Stewardship	End-User	No
United States Geological Survey, Fort Collins Science Center (FORT)	Dr. Jill Baron, Senior Scientist	End-User	No

### **End-User Overview**

#### **End-User's Current Decision Making Process:**

Intensive monitoring takes place in the Loch Vale watershed of RMNP on a weekly basis throughout the year to quantify the physical, chemical, meteorological, and biological characteristics over time. Additional intensive research takes place in two lakes during the open water season to determine light penetration, photosynthetically active radiation, temperature, chemistry, chlorophyll concentrations, and species composition. As a USGS FORT based project, the Central Rockies Western Mountain Initiative's objective is "to understand and predict the responses of Western mountain ecosystems to climatic variability and change, emphasizing sensitivities, thresholds, and resilience." Their research is then applied by the US Forest Service and National Park Service to craft climate adaptation management objectives for sites throughout the Rocky Mountains.

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

Rocky Mountain National Park – Although RMNP has used remote sensing in past research efforts, our specific point of contact does not currently have the capacity, funding, or staff to complete a project of this nature. This project will build RMNP's capacity to integrate remotely-sensed data into their future research efforts by displaying the value these end products can have on evaluating algal productivity in lakes located across the park.

USGS, Fort Collins Science Center – While this organization understands the value of the application of remotely-sensed data into algal productivity research, this particular research group within USGS has never used NASA Earth observations before, and are excited about the opportunity to partner with DEVELOP to build their capacity in remote sensing

### **Project Communication & Transition Overview**

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

The team will communicate with the partners biweekly. Meeting with the project partners will be convenient since they are based locally in Fort Collins or nearby in RMNP. The Center Lead and Team Lead of this project will be the primary points of contact with both partner organizations.

#### **Transition Approach:**

At the end of the term, the team will host a seminar to disseminate project results and hand off decision support tools. The end-user plans to begin using these products as soon as they are available, so a training workshop on the use of the data and tutorial will follow the seminar.

**Letters of Support:** Rocky Mountain National Park, Dr. John Mack, Acting Chief of Resource Stewardship

### **Earth Observations Overview**

#### **Earth Observations:**

Platform & Sensor	Parameters	Use
<b>Landsat 8 OLI</b>	Surface reflectance	This dataset provides the temporal (16 days) and spatial (30 m <sup>2</sup> ) resolution needed for measuring algal productivity of alpine lakes.
<b>Sentinel-2 MSI</b>	Surface reflectance	This dataset provides the temporal (10 days) and spatial (10-20 m <sup>2</sup> ) resolution needed for measuring algal productivity of alpine lakes.
<b>Worldview-2</b>	Surface reflectance	This dataset, which will be provided by Rocky Mountain National Park, provides the spatial resolution (1.85m <sup>2</sup> ) needed for measuring algal productivity of alpine lakes in RMNP.

**Ancillary Datasets:**

USGS Fort Collins Science Center in situ data – Field measurements of Chlorophyll a, algal biomass, and reflectance by algae species – These measurements will be used in conjunction with Landsat data to create a “greenness” and/or Chlorophyll-a index for RMNP alpine lakes.

**Modeling:**

Random Forest Classification Model (POC: Catherine Jarnevich: USGS)

**Software & Scripting:**

ENVI – Landsat imagery calibration and pre-processing

ArcGIS – Landsat imagery processing (study area designation, clipping, etc.), derivation of indices, map creation

R – Statistical analyses for index derivation, imagery pre-processing

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

End Products	Partner Use	Datasets & Analyses	Software Release Category
Comparison of the Performance of Landsat 8, Sentinel-2a, and Worldview-2 for Use in Algae Monitoring Relative to In-Situ Measurements	Determining feasibility and recommendations for use of earth observations in future remote monitoring efforts	Landsat 8 OLI/TIRS, Sentinel-2a, Worldview-2 and recent (2015-16) on-site measurements provided by partners will be integrated to evaluate the relationship between in-situ measurements and earth observations	1
Tutorial	Apply methodology developed in this project to extend spatial and temporal extent of lake monitoring	The tutorial will teach our partners how to preprocess and analyze satellite images to detect lake algae	1
Algal Productivity Map of The Loch and Sky Pond: 2014-2016 and case study years	To augment partner knowledge of spatiotemporal trends in algal productivity	In-situ measurements, Landsat 8 OLI/TIRS, Sentinel-2a, and/or Worldview-2 will be applied to create an algal productivity map for 2014-2016 and partner-specified case study years.	1
Statistics summarizing within-lake heterogeneity of algal abundance	Knowledge of within-lake heterogeneity of algal abundance will inform our partner's future sampling design	Calculated from the Algal Productivity maps derived from Landsat 8 OLI/TIRS, Sentinel-2a, and/or Worldview-2	1

**End-User Benefit:**

RMNP rigorously manages the wilderness alpine lakes to protect their pristine quality and fisheries. The group's ground-based intensive research will determine if these lakes are changing

from warming or from warming plus atmospheric deposition of nutrients. Results from this project and the tutorial could augment field measurements by allowing for historical monitoring and monitoring of more alpine lakes. The end-user's findings will be used by RMNP to inform State and EPA policy for managing other human-caused disturbances, such as air pollution. The USGS will gain invaluable scientific knowledge of the extent of change from the interactions of climate change and atmospheric deposition.

### **Project Timeline & Previous Related Work**

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**Project Timeline:** 1 Term: Fall 2016

**Related DEVELOP Work:**

Summer 2014 (Langley Research Center) - New England Water Resources: Historical Tracking of Harmful Algal Blooms Utilizing Landsat Missions from 1999-2013