**NASA DEVELOP National Program**

**2018 Summer Project Proposal**

**Virginia – Wise**

**Fremont River Basin Water Resources II**

*Water Availability Assessment from Annual Snow Cover in the Fremont River Basin Based on NASA Earth Observations and In Situ Data*

**Project Overview**

***Project Synopsis*:** Utah’s Fremont River relies on water from annual snowpack to provide year-round irrigation for agricultural areas in Rabbit Valley. Currently, 16,000 acres within the watershed are irrigated for agricultural purposes. The river also runs through the Capitol Reef National Park (NP), which depends on the river for historic land management. As part of a two term project, the second term will focus on assessing irrigation water diversions upstream of Capitol Reef NP, plus efforts to predict changes in snowmelt and irrigation demands. Using the SNOW-M tool completed during the first term snowmelt runoff predictions will be improved upon by updating key input variables and by using data from the Suomi satellite’s VIIRS sensor for snow cover and surface temperature data. This tool will also be transformed from MATLAB to R for increasing end-user model accessibility.

***Community Concern:*** The forecasted river flow based on snowpack data and the observed Fremont River flow through Capitol Reef NP do not agree, but sufficient observational data are lacking to explain these differences. River flows have diminished despite several years of higher than average snowpack in the Dirty Devil River watershed. Consequently, reductions in irrigation water from the Fremont River have been requested by the Utah Division of Water Resources. The requests have become more common in recent years, although the acreage under irrigation has remained constant. Capitol Reef NP manages historic orchards and pastures in the Dirty Devil River watershed that rely on irrigation water from the Fremont River. Currently, the National Resources Conservation Service (NRCS) creates forecasts for the Dirty Devil River downstream of Capitol Reef, but it does not partition outflows for the Fremont River. The objective of this project is to produce snow mapping products that could be used with modeling to help improve assessments of streamflow trends in the Fremont River basin.

***Source of Project Idea:*** This idea originated from the project partners Rebecca Weissinger of the Northern Colorado Plateau Network, and Terry Fisk, Chief of Resource Management and Science, at Capitol Reef National Park.

***National Application Areas Addressed:*** Water Resources, Agriculture & Food Security

***Study Location:*** Fremont River Basin, UT

***Study Period:*** 2000 – 2018 (September – March)

***Advisors:*** Joseph Spruce (Science Systems & Applications, Inc.), Dr. L. DeWayne Cecil (NOAA National Center for Environmental Information, Global Science & Technology, Inc.), Bob VanGundy (The University of Virginia’s College at Wise)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **National Park Service, Northern Colorado Plateau Network** | Rebecca Weissinger, Ecologist | End User | No |
| **National Park Service, Capitol Reef National Park** | Terry Fisk, Chief of Resource Management and Science | End User | No |

***End-User Overview***

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

Currently, remote sensing is not incorporated into the National Park Service’s decision-making process in assessing their water allotment from the Fremont River basin. The existing management practices are provided via state and federal agencies, such as the Utah Division of Water Rights and the USDA, which are involved in water management. Irrigation reduction is currently the only decision made to help conserve water. More specifically, The Utah Division of Water Resources has directed a reduction in water use, even when the snowpack is above average providing more usable water than usual.

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

*National Park Service, Northern Colorado Plateau Network* – The Northern Colorado Plateau Network is familiar with NASA Earth observations as they incorporate Landsat and MODIS vegetation indices into their monitoring practices. This project would introduce the partners to the use of remote sensing monitoring and assessing water resources, expanding the role NASA Earth observations play in the Northern Colorado Plateau Networks’ water management activities.

*National Park Service, Capitol Reef National Park* – The Capitol Reef NP has previously used NASA Earth observations for vegetation indices to aid some daily operations. This project would introduce the partners to the use of remote sensing to monitor snow cover, expanding the role NASA Earth observations in the Capitol Reef NP’s daily operations.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The team will communicate project progress and issues with Terry Fisk and Rebecca Weissinger of the National Park Service via bi-weekly teleconferences or as deemed necessary or feasible. The main DEVELOP POC will be the Project Lead at the Virginia – Wise node.

***Transition Plan*:** The project hand off will be conducted either via teleconference or Google Hangout with shared screen. The tools produced by this project will be used by the partners to identify areas where snowmelt is impacting the water supply to the Dirty Devil River and Capitol Reef National Park.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **SRTM** | Digital Elevation Model | SRTM elevation values will be incorporated into models for water resources. |
| **Terra MODIS** | Snow Indices, Total Column Water Vapor | Incorporation of Terra MODIS data will allow for a more accurate spatio-temporal representation of snowpack, water loss due to natural processes, and for tracking sublimation from snowpack. |
| **Aqua MODIS** | Snow Indices | Incorporation of Aqua MODIS data will allow for a more accurate representation of snowpack. |
| **TRMM PR** | Rainfall Averages | TRMM data will be used to monitor rainfall averages in the SNowmelt Observational Watershed Model (SNOW-M). |
| **PERSIANN-CDR** | Precipitation | PERSIANN-CDR data will be utilized to monitor precipitation averages for SNOW-M. |
| **GPM DPR** | Precipitation | GPM data will be utilized to monitor precipitation averages for SNOW-M. |
| **Suomi NPP VIIRS** | Snow Indices | This will be used to compare Suomi NPP VIIRS snow maps to those from Aqua and Terra MODIS Normalized Difference Snow Indices (NDSI). |

***Ancillary Datasets:***

USGS National Hydrography Dataset– defining the hydrologic units for the Watersheds

USGS National Hydrography Dataset Plus – defining the hydrologic units for the Watersheds at a high resolution

USGS Watershed Boundary Dataset (WBD) – defining the areal extent of surface water drainage to a point

USGS stream gauge data – investigation of relationships between snow and watersheds

USDA Snowpack Telemetry Snow Water Equivalent – measurements of snow depth, precipitation, and temperature for use in forecasting water supplies

USDA ForWarn – Aqua and Terra MODIS-based products used for snow cover analysis

North American Land Data Assimilation Systems (NLDAS) – Land and hydrology modeling data used for runoff modeling

***Modeling:***

Soil and Water Assessment Tool (SWAT) (Dr. Kenton Ross, NASA Langley Research Center)

Snowmelt-Runoff Model (WinSRM) (Dr. Kenton Ross, NASA Langley Research Center)

SNowmelt Observational Watershed Model (SNOW-M) (Margaret Mulhern, NASA DEVELOP)

***Software & Scripting:***

Google Earth Engine – Data processing and image classification

MATLAB - Data Processing, statistical analysis, and graphing

Esri ArcGIS – Data processing and analysis

ERDAS Imagine – Classification of Landsat imagery

R – Data processing, statistical analysis, graphing, and software development

QGIS – Data visualization, processing, and analysis

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Fremont River Snow Melt Statistical Analysis** | These statistics will reveal trends between snow cover and stream flow to increase understanding in water allocation for partners to help them plan current and future irrigation practices. | The water statistics will use Suomi VIIRS snow indices, SRTM elevation data, precipitation data from VIIRS, GPM, and TRMM, and *in situ* river gauge data, to monitor the snowmelt input into the Fremont River from SNOW-M. | II |
| **2000 – 2018 Snow Cover Time Series** | This time series will be used with the Fremont River Snow Melt Statistical Analysis to aid planning of future irrigation use. | This time series will date back to 2000 using Aqua and Terra MODIS indices. | II |
| **SNowmelt Observational Watershed Model (SNOW-M)** | This tool will allow the statistical analysis of snow dependent watersheds such as the Fremont River, and will allow our partner to continue to monitor and predict water availability with the given basin. | This code will use Suomi VIIRS snow indices and surface temperature, and precipitation data from multiple sources to continue the prediction of water availability with basins throughout Utah. | II |

***End-User Benefit*:** A down-scaled Fremont River forecasting model and time series of snow extent in the Fremont River watershed will enhance current methods of forecasting water resources throughout the Dirty Devil River watershed. Better planning for irrigation water use and better anticipation of calls for voluntary reductions in irrigation are some of the decisions that may be impacted by the results of this project.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 2 Terms: 2018 Spring to 2018 Summer

***Multi-Term Objectives:***

* **Term 1:** 2018 Spring (Virginia – Wise) – Fremont Water Resources
  + The first term investigated temperature and precipitation measurements from Terra and Aqua MODIS, Suomi NPP VIIRS, and GPM, and their effects on stream flow in the Fremont River. The project generated Terra and Aqua MODIS snow maps (from NDSI and Saito S3 snow indices) that will help monitor snow pack and snow melt during the snow season. These variables were analyzed using SNOW-M to compare the accuracy of predicted stream flow data and USGS stream gauge data.
* **Term 2 (Proposed Term):** 2018 Summer (Virginia – Wise) – Fremont Water Resources II
  + This term will expand the scope of the project to estimate water diversions for irrigations upstream of the park using SNOW-M. This will be done by updating key components of the existing code and using *in situ* data to validate the model. Work will include the use of SNOW-M to model future outputs and provide estimates of how future irrigation demands if agricultural land use remains static.

***Related DEVELOP Work:***

Spring 2017 (LaRC) – Glacier National Park Climate II: A Threshold-Based Decision Tree Approach to Mapping Landscape Disturbance in Glacier National Park

Spring 2014 (LaRC) – Chile Water Resources: Using NASA Earth Observation Data to Understand Snowmelt and Address Ongoing Drought in Central Northern Chile

Spring 2017 (MCHD) – Southeastern Arizona Water Resources: Using NASA Earth Observations to Assist the National Park Service in Assessing Snow Cover Distribution and Persistence Changes in the Sky Islands

Summer 2016 (WC) – Northern Great Plains Water Resources: Discovering Archaeological Sites by Utilizing NASA Earth Observations to Detect Changes in Snowpack Coverage in Intermountain National Parks

Fall 2016 (WC) – Northern Great Plains Water Resources II: Utilizing NASA Earth Observations to Detect Changes in Annual Snowpack Coverage in Intermountain National Parks

**Notes & References:**

***Notes*:**

* There are several SNOTEL sites in nearby mountains
* Interested in Google Earth Engine
  + Partners want a code they can continue to use in the future
* Partners have people with R coding experience

***References:***

Utah Department of Environmental Quality. (2002). *Fremont River Watershed Water Quality Management Plan.* Retrieved from <https://deq.utah.gov/ProgramsServices/programs/water/watersheds/docs/2006/09Sep/FREMONT_WQMP.pdf>

National Park Service U.S. Department of the Interior. (2004). Water resources management plan Capitol Reef National Park Utah. Retrieved from <https://www.nature.nps.gov/water/planning/management_plans/care_final_screen.pdf>

Asaoka, Y. & Kominami, Y. (2013). Incorporation of satellite-derived snow-cover area in spatial snowmelt modeling for a large area: determination of gridded degree-day factor. *Annals of Glaciology, 54*(62), 205-213.

U.S. Department of the Interior, Bureau of Land Management. (2005). Appendix 1-Wild and Scenic River Suitability Considerations. Richfield RPM. Retrieved from: <https://eplanning.blm.gov/epl-front-office/projects/lup/68293/86878/104135/Richfield_Appendices.pdf>