**NASA DEVELOP National Program**

**2017 Spring Project Proposal**

**Mobile County Health Department**

**Southeastern Arizona Water Resources II**

*Using NASA Earth Observations to Assist the National Park Service in Assessing Snow Cover Distribution and Persistence Changes in the Sky Islands*

**Project Overview**

***Project Synopsis*:** This project is partnering with the National Park Service (NPS) in order to assess snow cover persistence and extent in the sky island region of southeastern Arizona. Currently, the NPS does not have a record of snow cover in the area due to its remote locations and high elevations. Aqua and Terra MODIS will be used to assess snow cover during the MODIS era. When cloud free data is available, Landsat 5 TM, Landsat 7 ETM+, Landsat 8 OLI, and Sentinel-2 MSI data will be used to supply higher resolution data to supplement MODIS data. The previous term of this project provided preliminary analyses of snow cover area within one watershed located in the Rincon Mountains. The second term will provide snow cover maps and a snow cover map time series of the entire Rincon Mountain area in order to produce a detailed account of snowpack change using NASA Earth observations. Snow and other land cover data from the project will provide vital information that the NPS is currently missing when making park management decisions.

***Community Concern:*** Southeastern Arizona is home to unique mountain ranges known as the sky islands. The sky islands are hotspots of biodiversity and rely on the slow melting snowpack to sustain these diverse ecosystems during the dry periods. Currently the NPS monitors water presence in springs and other small pools of water, or tinajas, as well as in flowing water with stream gauges; however, a record of snow cover does not exist. Increasing temperatures in the region result in precipitation to fall as rain rather than snow, leading to a growing concern that snow cover will decrease to levels that cannot sustain aquatic ecosystems through the dry seasons. Decreasing water resources pose a threat to the aquatic habitats home to unique species as well as to backcountry visitors to the park who rely on streams and pools as their main source of hydration.

***Source of Project Idea:*** This project was requested by Colleen Filippone, a hydrologist with the NPS, after hearing a DEVELOP presentation in the spring of 2016. In doing so, Ms. Filippone drafted a project idea that would help enhance the NPS’s decision making in Saguaro National Park, which led to this project proposal being created.

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

***Study Location:*** Southeastern AZ and Northern Sonora, Mexico

***Study Period:*** October 1985 to January 2017

***Advisors:*** Joe Spruce (SSAI, NASA Langley Research Center), Dr. Kenton Ross (NASA Langley Research Center)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| National Park Service, Intermountain Region | Colleen Filippone, Intermountain Region Hydrologist | End-User | No |
| National Park Service, Saguaro National Park | Don Swann, Biologist | End-User | No |

***End-User Overview***

***End-User’s Current Decision-Making Process:***The NPS currently does not use remote sensing to assess snow cover in Saguaro National Park and the surrounding sky islands. Assessment of snow cover water resources is done through visual analysis of conditions at lower elevations in the study area, along with general assessment of local weather station data. In particular, park managers currently use weather data, stream gauge data, and annual to semi-annual observations of water presence in tinajas to manage water resources. This resulting information is then used to manage resources for aquatic wildlife (such as leopard frogs), backpackers and hikers, and water rights cases. The amount, extent, and impact of snow occurrence are important variables to their decision-making process that they are unable to accurately assess due to the high elevation and remoteness of the mountain ecosystems.

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

*National Park Service, Intermountain Region –* The NPS is familiar with NASA Earth observations but has not used such data to assess snow cover in the region. The project’s partners at the NPS are familiar with other remote sensing technologies and data, such as from LiDAR, but have not used these methods to further understand spatio-temporal trends in snow cover in the region. This project will help to build the capacity and understanding of the capabilities of NASA Earth observations as well as enhanced decision making.

*National Park Service, Saguaro National Park –* The Saguaro National Park managers do not currently use NASA Earth observations to assess snow cover but are familiar with these kinds of data. This project will help to build the experience in using and the capacity of NASA Earth observations for inclusion in future park management decisions.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The team will communicate with the partners at the NPS through a weekly telecon. Colleen Filippone, Intermountain Region Hydrologist is the main POC with Don Swann, Saguaro National Park Biologist, joining telecons and assisting as needed.

***Transition Plan*:** The decision support tools will be handed off via email to the team’s partners at the NPS. The NPS will also be briefed on the outcome of the project. Following the hand off, the NPS will have access to snow presence information that was previously unknown allowing the partners to add this information into conceptual models and analyses of *in situ* data to inform decisions regarding water resources in the region. The partner will be able to identify areas disproportionately affected by decreasing snow cover and take action in these locations.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **Aqua and Terra MODIS** | Standard Snow Cover Products (e.g., MOD10A1) | Standard Aqua and Terra MODIS data will be used to detect snow presence in the sky islands during the MODIS era. Analysis of this data will be used to detect trends and changes that varying snow cover has on the region’s water resources, enhancing park management’s decision-making |
| **Aqua and Terra MODIS** | Value-added Snow Cover Products | In addition to standard snow products, value added snow products from Snow Data System at NASA JPL will also be considered. |
| **Landsat 5 TM** | Historic Snow Cover | Landsat 5 TM data will be used for providing a higher resolution alternative to MODIS if/when cloud-free data exists during times with snow cover. |
| **Landsat 7 ETM+** | Historic Snow Cover | Landsat 7 ETM+ data will be used for providing a higher resolution alternative to MODIS if/when cloud-free data exists during times with snow cover. |
| **Landsat 8 OLI** | Current Snow Cover | Landsat 8 OLI data will be used for providing a higher spatial alternative to MODIS if/when cloud-free data exists during times with snow cover. |
| **Sentinel-2 MSI** | Current Snow Cover | Sentinel-2 data will be used for providing a higher spatial alternative to MODIS if/when cloud-free data exists during times with snow cover. |

***Ancillary Datasets:***

NPS – Historical water presence data – to understand how snow cover and snow depth impact water resources in the park

USGS – Stream gauge data – to understand the effect of snowmelt on streamflow in certain regions of the park

***Software & Scripting:***

ESRI ArcGIS – raster manipulation and the production of maps

ERDAS Imagine – image data analysis, assuming availability of such software

Google Earth Engine – processing of MODIS and Landsat time series data

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| Historical Snow Cover Maps | The NPS does not currently have data for snow presence or extent in the study region. These maps will be used by the partner to enhance their understanding of the region’s water resources and fill a data gap in their decision-making tools. | Aqua and Terra MODIS daily snow cover data products and Landsat data products will be the input for these maps. A trend analysis will be conducted to assess patterns and changes that may be occurring in the region. | N/A |
| Snow Cover Map Time Series | These maps will inform the NPS of areas that have seen long term changes in snow cover. This data will be used with analyses from other datasets to inform their decision-making and highlight specific areas within the park which may need heightened intervention. | The snow cover map time series provide historical data of snow cover change in the region. This data will be analyzed with historical stream gauge data to correlate snowmelt and streamflow. | N/A |

***End-User Benefit*:** Currently the NPS does not have a spatio-temporal, synoptic record of snow cover in the sky islands. Many of the areas with snow cover are inaccessible, leaving park managers without a method to regularly and accurately assess snow presence or its extent in the region. Historical maps of snow cover will allow the park to analyze historical impact of snow cover on water resources. The snow cover map time series will allow the NPS to correlate streamflow with snow cover as well as analyze the characteristics of different watersheds and the variation in stream flow in relation to the amount of observed snow cover. Overall, information from the project will be used by the NPS to help make more informed decisions regarding water resources and prescribed fire management efforts.

**Project Timeline & Previous Related Work**

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

***Multi-Term Objectives:***

* **Term 1:** 2016 Fall (MCHD) – Southeastern Arizona Water Resources
  + The first term of the project was used to create an overall assessment of snow cover in the Upper Rincon Creek Watershed using both MODIS and Landsat products. The first term was able to accomplish and create preliminary analyses of snow cover in this watershed. A methodology was established for the following term as well as data acquisition and processing. Additionally, the team began looking into various image fusion techniques in order to provide an end-product with both increased spatial and temporal resolutions, helping to mitigate for atmospheric interference in the study area. Partner interaction during the first term included weekly telecons and the exchange of data between the partner and team.
* **Term 2 (Proposed Term):** 2017 Spring (MCHD) – Southeastern Arizona Water Resources II
  + The second term of the project will continue to refine methodology for analyses of individual watersheds in the sky island region. The team will build on the methodology developed in the first term in order to create a historic assessment of snow cover area for Saguaro National Park. The team will incorporate temperature and precipitation data from local weather stations in order to better understand the relationship between these factors and snow cover. Additionally the team will continue to use MODIS in order to observe snow cover on a daily time scale. Continued efforts will be made to use image-fusion techniques for the MODIS data as a way to refine the spatial scale of the data. Partner involvement will increase as the team refines methodology and end-products for the partner’s use. A telecon presentation and mailing of the results are expected for the partner handoff. Efforts will be made to outreach project results at one or more professional meetings.

***Related DEVELOP Work:***

2013 Fall (LaRC) - Chile Water Resources: Assessing Potential Water Availability from Andean Snowpack for Agricultural Uses in the Coquimbo Region of Chile

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

2013 Summer (ARC) - Sierra Nevada Water Resources: Sierra Nevada Climate Change and Its Impact on Snow Water Equivalent In Relation to Wildfire

2015 Summer (ARC) - Sierra Nevada Water Resources II: Sierra Nevada Climate Change and Its Impact on Snow Water Equivalent in Relation to Wildfire

2016 Fall (WC) - Utilizing NASA Earth Observations to Detect Changes in Annual Snowpack Coverage in Intermountain National Parks