**NASA DEVELOP National Program**

**2017 Summer Project Proposal**

**NASA Ames Research Center**

**Chile Water Resources II**

*Estimating Glacier Mass Balance from NASA Earth Observations and Quantifying its Relationship to Water Availability for Agriculture Production in Central Chile*

**Project Overview**

***Project Synopsis*:** The second term of the Chile Water Resources research project has two main objectives, the first of which is to validate the Google Earth Engine API decision support tool created during the previous term. The second objective is to determine glacier mass balance estimates from the glaciers surrounding the Aconcagua region of Chile. These glaciers provide a large amount of the water supply of agricultural lands. Meltwater availability estimates will be derived from these glacier-related calculations. Outcomes of this project aim to benefit the Ministry of Agriculture in Chile by enhancing their decision-making process and better inform agricultural practices, including irrigation recommendations. Satellites utilized will include Soil Moisture Active Passive (SMAP), Moderate Resolution Imaging Spectroradiometer (MODIS), GCOM-W1, STRM, and the Landsat record.

***Community Concern:*** With latitudes extending from 17 degrees to 56 degrees South, Chile’s stark geographic differences present a variety of hydrologic conditions throughout the country for the agriculture industry. Chile is also vulnerable to drought, and with sub-regions of Chile relying on distinct irrigation practices, balancing the management of supply and demand of water across the country proves a difficult task. Furthermore, historically agricultural regions are experiencing a changing climate and less precipitation overall. In particular, the highly productive agricultural region of Aconcagua in Chile relies year-round on nearby glaciers for irrigation. Water security for the region has become a concern as the glaciers have been melting at increasing rates. Informing governmental organizations such as Chile’s Ministry of Agriculture with NASA Earth observation derived hydrological data reduces vulnerability to drought and other agriculture-climate events by disseminating response information serving as early warning for decision-makers and stakeholders of the agriculture industry.

***Source of Project Idea:*** The idea for this project developed from the Navajo Nation Climate I & II projects (spring 2015 and summer 2015). Jamie Favors began a conversation with the Agricultural Office of the Chilean Embassy about how the Drought Severity Assessment Tool (DSAT) could be adapted to address similar concerns in Chile. Since learning of Chile’s Climate Data Library, the first term looked to assist in the implementation of soil moisture, snow cover, and snow water equivalent (SWE) data into the existing Chile Drought Observatory to enhance supporting hydrological and agricultural data. The second term will focus on the large agricultural region of Aconcagua and on improving the water resources decision support tool.

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

***Study Location:*** Chile

***Study Period:*** January 2001 **–** June 2017

***Advisors:*** Dr. Eduardo Bendek (NASA Ames Research Center), Dr. Juan Torres-Perez (Bay Area Environmental Research Institute)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| Ministerio de Agricultura | Sr. Antonio Yaksic, Sub-jefe Departamento de Información, Monitoreo y Prevención para la Gestión Integral de Riesgos (Deputy Chief Department) | End-User | Yes |
| Oficina Agrícola de la Embajada de Chile en los Estados Unidos de América | Sr. Javier Chaud, Especialista Agrícola (Agriculture specialist) | Collaborator | No |

***End-User Overview***

***End-User’s Current Decision-Making Process:***The Ministry of Agriculture in Chile utilizes an existing Climate Data Library (CDL) to serve as a drought observatory for the country and agricultural community. The Climate Data Library incorporates meteorological, hydrological, and agricultural data which help the department disseminate important information to farmers in the agricultural regions of Chile. With the information stated above, the Ministry informs farmers and stakeholders of best irrigation practices for their specific geographic regions. Some of the data provided are derived from remote sensing, and the Ministry seeks to enhance their dataset by incorporating soil moisture, snow cover, SWE, glacier monitoring, and water availability collected from NASA Earth observations (EO).

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

Ministerio de Agricultura – The Ministry of Agriculture in Chile is very familiar with NASA Earth observations and currently uses Landsat data through the CDL. The first term contributed soil moisture, snow cover, and SWE provided by NASA Earth observations to drought monitoring efforts in Chile.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

*Embajada de Chile en los Estados Unidos de América* – The Agricultural Office of the Chilean Embassy to the United States has been integral in the development of this project. Establishing contact with Sr. Javier Chaud, Agriculture Specialist, has allowed for direct communication with the Ministry of Agriculture in Chile and he will remain a vital collaboration throughout the project to act as a liaison between the DEVELOP program and Ministry of Agriculture.

***Dissemination by Boundary Organizations*:**

Results from this project will enable the Ministry of Agriculture in Chile to provide decision makers, farmers, and scientists with access to more NASA Earth observation derived data through GEE to complement the meteorological, hydrological, and agricultural conditions currently available in the CDL.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** During the research term, there will be bi-weekly teleconferences between the DEVELOP team and Sr. Yaksic’s team. The POC for communication will be Brittany Zajic, current Center Lead at NASA ARC.

***Transition Plan*:** The transition of the end products will take place via virtual webinar. Results will supplement the Google Earth Engine script from the first term, and will be integrated into Chile’s decision-making process as a case study for how to host CDL in the future. The official transition will take place several months following the end of the term due to software release requirements.

***Letters of Support*:** Letter of support for this project signed by Mr. Antonio Yaksic, Ministry of Agriculture – Sub Department of Information, Monitoring and Prevention for Integrated Risks Management IMP-IRM

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Soil Moisture Active Passive (SMAP), Radiometer** | Soil Moisture Content | Soil moisture estimates for across Chile will enhance agricultural data for the CDL. |
| **Terra, MODIS** | Snow Cover | The MODIS snow algorithm output will be used to estimate snow cover and enhance hydrological data to supplement the CDL. |
| **Aqua, AMSR-E** | Snow Water Equivalent (SWE) | Available from 2001 to 2011, AMSR-E will provide SWE data to enhance hydrological data to supplement the CDL. |
| **JAXA GCOM-W1 – AMSR2** | Snow Water Equivalent (SWE) | AMSR2 is processed and hosted by NASA Lance. This dataset serves as a continuation of AMSR-E for SWE hydrological data. |
| **Landsat 5, TM** | Glacier Extent | Input data for glacier delineation algorithm at a decadal time scale. |
| **Landsat 8, OLI** | Glacier Extent | Input data for glacier delineation algorithm at a seasonal and decadal time scale. |
| **ASTER, MODIS** | Glacier Mass Balance | Glacier thickness and volume estimations (glacier area, terminus position, transient snowlines, surface elevation). |
| **SRTM** | Digital Elevation Model (DEM) | To measure volumetric changes at the annual and decadal time scale. |

***Ancillary Datasets:***

Ministry of Agriculture – Snow Depth, Density and Water Equivalent at CDL – To validate snow cover.

Ministry of Agriculture – Soil Moisture percentage, Maximum Available Soil Moisture Content and Soil Moisture at Permanent Wilting Point set by INIA at CDL (by pixel, media value) – To validate soil moisture.

***Software & Scripting:***

Google Earth Engine API – data hosting, display and analysis

Python – data download and Google Earth Engine link using Python API

TerrSet – time series analysis, Earth Trends Modeler

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product(s)** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Validation Assessment of Google Earth Engine Decision Support Tool** | The importance of hosting NASA Earth observation data in the Google Earth Engine API was established in the first term of this project. The next critical component of actual implementation of this tool by the Ministry of Agriculture will be to validate the product of the first term in order to ensure the integrity of the decision support tool. | This tool incorporates data from SMAP, Aqua and Terra MODIS, and GCOM-W1 in Google Earth Engine. This tool will be validated using long term climate datasets across different regions of Chile collected from observatories. | III |
| **Quantitative Estimates of Water Availability in the Aconcagua Sub-region of Chile** | The ability to estimate water availability in agricultural regions of Chile with limited water resources presents a unique opportunity to expand upon the Ministry of Agriculture’s current knowledge of glacier mass balances of the region. A more comprehensive understanding of how glaciers are responding today will give more insight to future water resource forecasts as well. | The Landsat suite, ASTER, and DEMs will be the datasets used to compile the results of this end product. TerrSet Earth Trends Modeler will be utilized to model both historical and current glacier mass balances. | I |

***End-User Benefit*:**

Providing more remotely-sensed datasets encompassing indices of hydrological and agricultural observations increases temporal and spatial resolution capabilities regarding drought monitoring and water availability in Chile. More specifically, incorporating the Google Earth Engine Decision Support Tool and current water availability studies for a highly productive agricultural region of Chile into the Ministry of Agriculture’s drought monitoring will allow for more robust decision making for the agriculture industry as a result of these resolutions.

**Project Timeline & Previous Related Work**

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

***Multi-Term Objectives:***

* **Term 1:** 2017 (ARC) – Chile Climate I
  + The first term of this project will work closely with the Ministry of Agriculture to incorporate NASA Earth observation derived soil moisture, snow cover, and snow water equivalent (SWE) data into Chile’s drought monitoring and decision-making processes using the Google Earth Engine platform. The focus of the first term will be to complete the decision-making tool to enhance the Ministry of Agriculture’s access to applicable NASA Earth Observation hydrological data.
* **Term 2 (Proposed Term):** 2017 Summer (ARC) – Chile Climate II
  + The decision-making tool created in the first term will be validated in the second term using data found from the CDL and Ministry of Agriculture. The Ministry of Agriculture will support the second term’s efforts to apply the tool to a specific agriculture region of the country, the Aconcagua region. This agricultural region is highly dependent on the water from surrounding glaciers for irrigation, and water availability is a challenging measure to make from the ground. Remote sensing techniques using NASA Earth Observation data will be applied to this region to estimate glacier mass balances and quantify their relationship to water availability for agriculture.

***Related DEVELOP Work:***

2013 Fall (NASA Langley Research Center) – Chile Water Resources: Assessing Potential Water Availability from Andean Snowpack for Agricultural Uses in the Coquimbo Region of Chile

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

2015 Summer (NASA Ames Research Center) – Navajo Nation Climate II: Assessing Climate Change Impacts on Groundwater Availability and Drought Vulnerability in the Navajo Nation Using NASA Earth Observations

2016 Fall (Wise County Clerk of Circuit Court’s Office) – Northern Great Plains Water II: Discovering Archaeological sites by Utilizing NASA Earth Observations to Detect Changes in Snowpack Coverage in Intermountain National Parks

2017 Spring (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

**Notes & References:**

To note, we believe at this time that glacier mass balance calculations and how they relate to water availability will not be performed in the Google Earth Engine platform. The tool from the first term will likely remain as is with the exception of validation and accuracy assessments.

***References:***

Climate Data Library. (n.d.). Retrieved 2016, from <http://www.climatedatalibrary.cl/>

GLIMS Glacier Database. (n.d). Retrieved 2017, from <http://glims.org>

Observatorio Agroclimático. (n.d.). Retrieved 2016, from <http://www.climatedatalibrary.cl/>