**NASA DEVELOP National Program**

****NASA Ames Research Center

*Summer 2017*

**Short Title: Chile Water Resources II**

**Subtitle:** Remote Monitoring of Glacier Dynamics and Water Availability in Chile’s Aconcagua Watershed Using NASA Earth Observations in Google Earth Engine

**VPS Title:** Agua in Aconcagua: Integrating NASA Earth Observations into Chile’s Water Management Practices

**Project Team**

**Project Team:**

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**Advisors & Mentors:**

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**Past or Other Contributors:**

Garrett McGurk

Jenna Williams

**Project Overview**

**80-100 Word Objectives Overview:**

This project provided an enhanced understanding of water availability for agricultural purposes within the Aconcagua basin in Central Chile. The research team used Landsat-derived glacial extents via the Normalized Snow Difference Index (NDSI) to detect significant glacial changes from 1988 to 2017. Furthermore, the team utilized Google Earth Engine to analyze the correlation between glacial variation, river discharge, surface temperature, and precipitation. This project demonstrated the applicability of NASA Earth observations in the Google Earth Engine platform for the production of actionable hydrologic climate information for the Chilean Ministry of Agriculture.

**Abstract:**

The Aconcagua basin of Central Chile, just north of the capital city of Santiago, is an arid region dominated by the Andes Mountains and heavily dependent on glaciers and seasonal meltwater for its water reserves. Due to the orographic nature of precipitation on the basin, rain events occur sporadically in the late autumn and winter months of the year, accounting for 80% of total annual precipitation, while drought conditions prevail in the austral spring and summers. The Mediterranean-type climate supports agricultural practices such as fruit and vegetable farming, which account for 70% of regional water usage. Around the globe, weather intensification and the rising zero-degree isotherm are poised to threaten glacial retreat or complete wastage during the upcoming decades. The Aconcagua basin is especially vulnerable to these changes as a result of its large population, increasing water demands, and reliance on meltwater during the summer months. In response to the concerns articulated by the Chilean Ministry of Agriculture, the research team created a time series of seasonal NDSI from 1988 to 2017 to quantify glacier change using TerrSet software. The team replicated the time series analysis in near-real time with server-side processing using Google Earth Engine and compared the results of the parallel analyses. Google Earth Engine was also used to build a tool that combines NASA Earth observations with *in situ* hydrologic data for a comprehensive overview of regional factors affecting agriculture. The analysis tools created provide an enhanced understanding of glacial meltwater and agricultural water usage and can be used to supplement the Chilean Ministry of Agriculture’s water resource management decision-making.

**Keywords:**

Glacial Extent, NDSI, Discharge, TerrSet, Google Earth Engine, Landsat, MODIS, TRMM

**Partner Organizations:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| Ministerio de Agricultura (Chile) | Antonio Yasik, Manager of Agricultural Emergencies | End User | Yes |
| Oficina Agrícola de la Embajada de Chile en los Estados Unidos de América (Chile) | Javier Chaud, Agriculture Specialist | Collaborator | No |

**Community Concerns:**

* Agricultural practices in the Aconcagua water basin in Central Chile, which account for 70% of regional water consumption, rely primarily on glacial meltwater runoff for irrigation
* The expansion of Chile’s agricultural economy has resulted in consumption of greater volumes of water, stressing already strained water resources
* Anomalous climate dynamics, including the elevation of the zero-degree isotherm and periods of extended drought, have threatened the stability of water resources and present a need for an improved understanding of climate-hydrology interactions

**Current Decision-Making Practices & Policies**:

The Chilean Ministry of Agriculture currently uses the Climate Data Library (CDL), a data repository and analysis tool, for the dissemination of climate data relating to agricultural applications. The CDL’s Drought Monitor visualizes historic, current, and forecasted climate data. Datasets available include precipitation, discharge, snow depth, reservoir levels, temperature, soil moisture, and the Combined Drought Index (CDI). This information is freely available on the web and is integrated into water resource management decisions.

**Decision Support Tools & Benefits:**

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software**  **Release** |
| Hydrologic Anomaly Engine | This Google Earth Engine tool incorporates Landsat 5 and Landsat 8 data to calculate NDSI, as well as MODIS surface temperature and snow cover, TRMM precipitation observations, SMAP soil moisture, and AMSR-E snow water equivalent. After clipping all of our data layers to the study area, we will compare them using Pierson’s product-moment correlation coefficient. | This tool is used for functional glacial monitoring, offering current and historic analyses as well as a framework for future programmatic updates. Specifically, the user is able to perform statistical correlations on near-real time water resource indicator data. | IV (software release submitted in prior term, awaiting release at this time) |
| Mann-Kendall Statistical Maps of Seasonal Anomalies | The Landsat suite was used to generate NDSI for the study area. Statistical trend analysis was then conducted using TerrSet and Google Earth Engine. | This product provides a visualization of statistically significant areas of loss and gain within the glacial regions of the study area. Comparison to headwaters of rivers allowed for estimations of current and future water limitations. | I |

**Project Benefit to End User**:

The Hydrologic Anomaly decision support tool allows the Chilean Ministry of Agriculture a more robust decision-making process with regard to agricultural practices and water resource allocation. End users are able to rapidly analyze the relationships between near-real time hydrologic data. Furthermore, the graphic and tabular outputs of the time series analysis allow for an examination of current trends in glacial extent, and when conducted in Google Earth Engine, provide an accessible, dynamic resource for understanding glacial dynamics.

**Project Details**

**Applied Sciences National Applications Addressed:** Water, Agriculture, Climate

**Study Area:** Aconcagua basin, Central Chile

**Study Period:** 1988 – 2017 (January – March)

**Earth Observations & Parameters:**

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| Landsat 5 TM | Glacier Extent | Converted reflectance values were used to produce NDSI indices for the trend analysis. |
| Landsat 8 OLI | Glacier Extent | Converted reflectance values were used to produce NDSI indices for the trend analysis. |
| Terra MODIS | Surface Temperature & Snow Cover | Daily and monthly surface temperature along with daily snow cover was used to study climatic impact on water availability and glacier dynamics. |
| TRMM PR, TMI, VIRS | Precipitation | TRMM-derived precipitation was used to study climatic impact on water availability and glacier dynamics. |
| Soil Moisture Active Passive (SMAP), Radiometer | Soil Moisture Content | Soil moisture was used to study climatic impact on water availability and glacier dynamics. |
| Aqua, AMSR-E | Snow Water Equivalent (SWE) | SWE data was used to study climatic impact on water availability and glacier dynamics. |

**Ancillary Datasets Utilized:**

* Chilean Ministry of Agriculture – *in situ* discharge data

**Software Utilized:**

* Google Earth Engine API – data hosting, visualization, and analysis
* TerrSet – time series analysis, Earth Trends Modeler

**Project Handoff Package**

**Transition Plan:**

The transition will take place via virtual webinar. The partner organizations will receive both the final products as well as access to relevant datasets. A separate code handoff will occur when the software release process has been completed. The results will supplement the Google Earth Engine script from the first term of the project.

*Software Release Plan*: The project will be leveraging the software release for the Hydrologic Anomaly Engine, completed in the first term of the project, which is currently being processed.

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**Partner POC**: Javier Chaud, javier.chaud@minagri.gob.cl

**Handoff Package:**

* Google Earth Engine API Hydrologic Anomaly Engine (pending software release) including:
  + Tabular outputs of Mann-Kendall test as well as image differencing Z-scores for both TerrSet and Google Earth Engine Analysis
  + Glacial extent supervised classification tool for identifying glaciated area in near-real time
  + Discharge correlation tool for quantifying how NASA Earth observations datasets relate to water availability