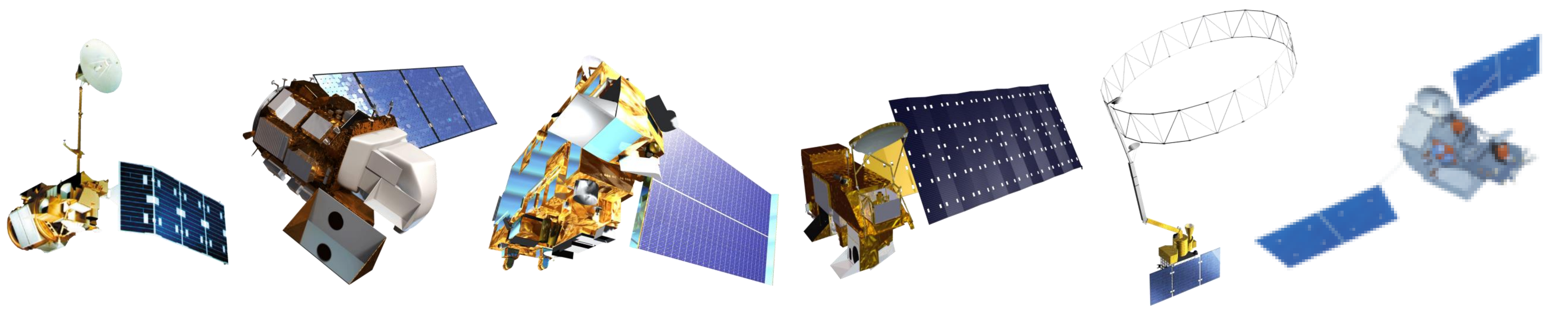
Estimating Glacier Trends in Chile's Aconcagua Watershed from NASA Earth Observation Imagery and Integrating Analysis into Google Earth Engine

Abstract

The Aconcagua basin in Central Chile, located 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 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* discharge 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.

Earth Observations



Landsat 4/5 TM | Landsat 8 OLI | Terra MODIS | Aqua AMSR-E | SMAP Radiometer | TRMM PR, TMI, VIRS

Methodology

Preprocessing

Acquired Earth observation imagery, performed atmospheric correction, mosaicked scenes together for study area coverage

Analysis

1) Supervised Classification
2) NDSI Trend Analysis
3) Correlated *in situ* and remotely sensed variables

Results

Google Earth Engine tools for near-real time glacial extent monitoring, NDSI trend analysis, and discharge correlations

Results

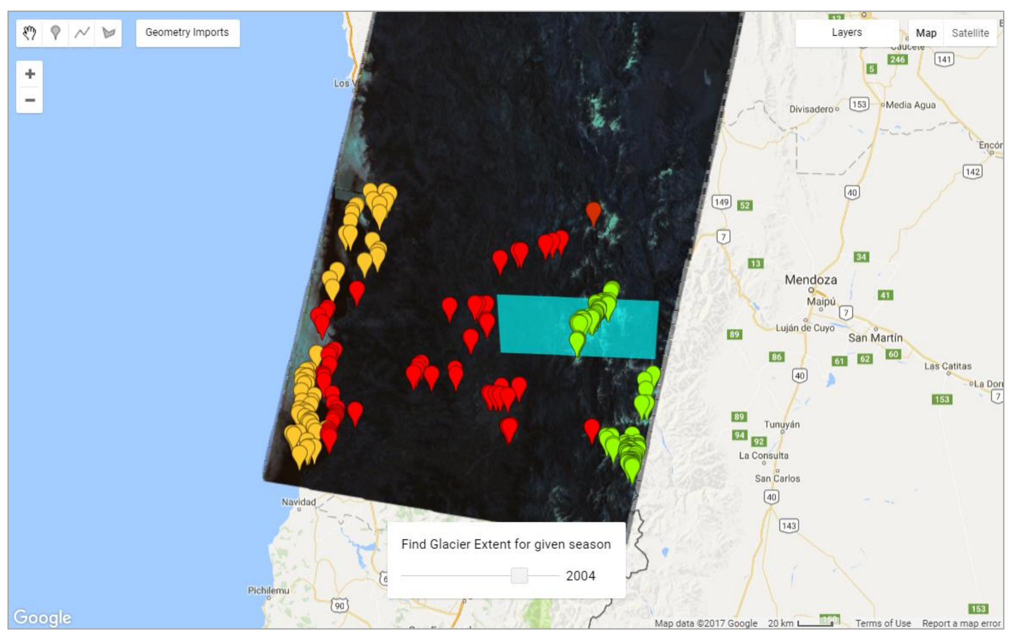


Figure 1. Supervised hard classification of glaciated area in 2004. Spectral signatures from Landsat imagery are used to differentiate ice from non-ice. The classification and area of glacial can be applied to any year of Landsat coverage. The glaciated area within the blue bounding box is 376.95 km².

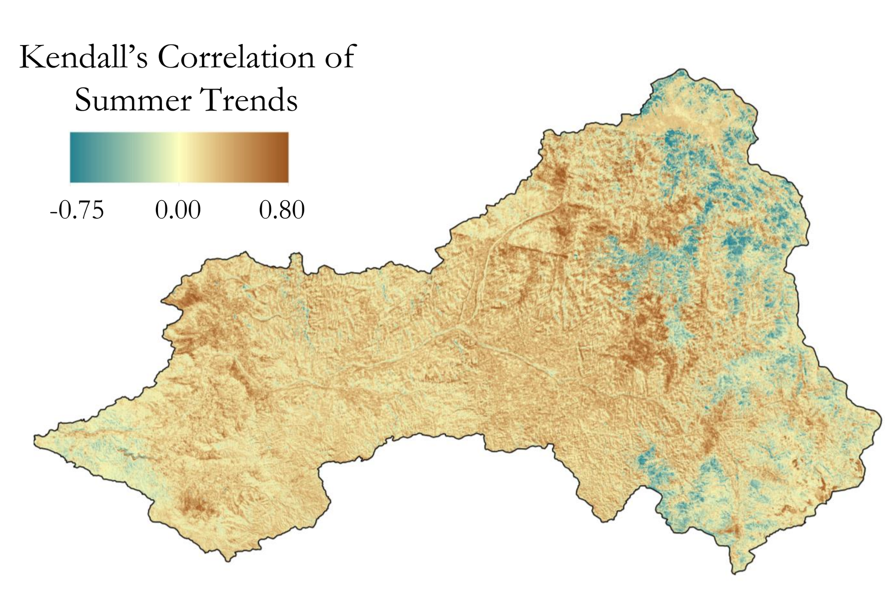


Figure 2. Kendall's Correlation conducted on detrended Normalized Difference Snow and Ice Index values from 2000 – 2016. Areas of drastic negative and positive trends lay within the zones of accumulation and ablation of perennial glaciers.

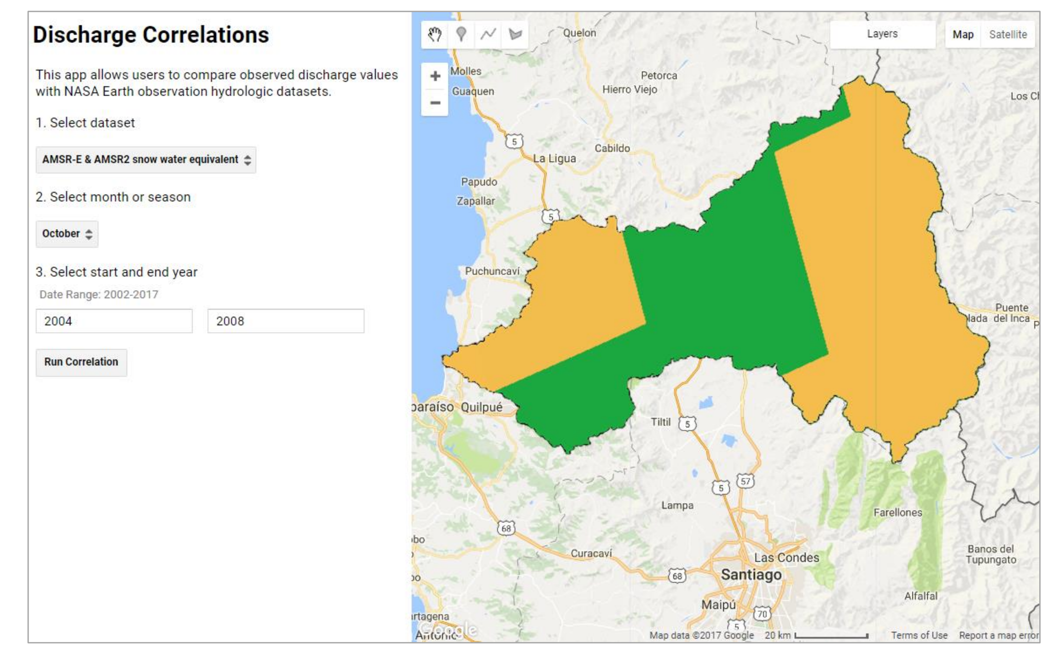


Figure 3. Preview of Pearon's Product-moment correlation coefficient tool relating *in situ* river discharge measurements (dependent) and important hydrologic indicator environmental variables derived from NASA sensors (independent).

Team Members

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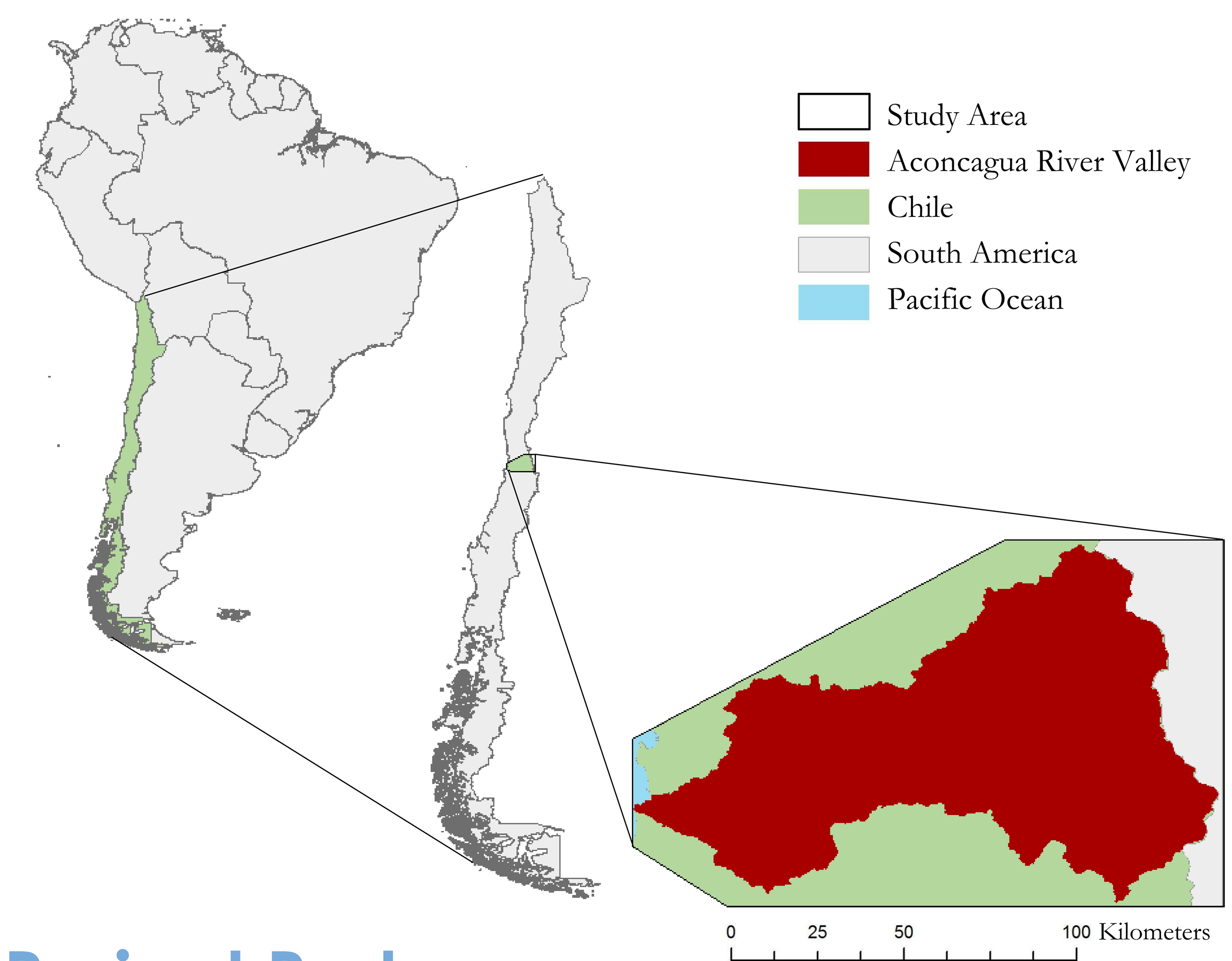
Objectives

- **Create** a time series of the study area from 1988 to 2017, highlighting statistically significant seasonal accumulation or ablation trends in local glaciers
- **Classify** Landsat Imagery using Google Earth Engine and quantify glacial extent on a pixel-to-pixel basis
- **Correlate** *in situ* river discharge stations in our study area with NASA Earth observations such as snow water equivalent, precipitation, and surface temperature

Study Area



Project Partners

- Chilean Ministry of Agriculture
- Agricultural Office of the Chilean Embassy

Acknowledgements

- Dr. Juan Torres-Pérez, Bay Area Research Institute
- Dr. Kenton Ross, NASA Langley Research Center
- Dr. Eduardo Bendek, NASA Ames Research Center
- Jenna Williams, NASA DEVELOP
- Garrett McGurk, previous team member
- Nick Clinton, Google Earth Engine Developer Advocate

Conclusions

- Adapting methodology and functionality from the TerrSet trend analysis provided useful adaptations for considering linearly detrended Kendall's Tau Google Earth Engine outputs.
- Interactive supervised hard classifications in Google Earth Engine give users a rapid and customizable means to visualize and quantify glacial extent in the study area.
- Correlation coefficients produced between *in situ* river discharge stations and each of the independent variables allows analysis of current hydrologic trends and implementation of future values of these inputs.

Chile Water Resources II

NASA Ames Research Center – Summer 2017

This material is based upon work supported by NASA through contract NNL16AA05C and cooperative agreement NNX14AB60A. Any mention of a commercial product, service, or activity in this material does not constitute NASA endorsement. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration and partner organizations.