**Central America Dry Corridor Food Security & Agriculture**

*Assessing Vegetation Response to Remote Sensing Drought Indices within the Dry Corridor of Central America Using NASA Earth Observations*

**Project Team**

***Project Team:***

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**Project Overview**

***Project Synopsis:*** The Central American dry corridor faces significant crop losses during El Niño events. In prior El Niño occurrences, staple crops experienced significant impacts, including declines of as much of 60% of the maize crop and up to 80% of the bean crop. Using Global Precipitation Measurement (GPM) mission Integrated Multi-satellite Retrievals for GPM (IMERG) precipitation data, the team calculated the Standard Precipitation Index (SPI), a drought indicator used to identify the onset and severity of drought conditions. The team highlighted the lead-lag relationship between the SPI and the vegetation response measured with the Normalized Difference Vegetation Index (NDVI) from Terra Moderate Resolution Imaging Spectroradiometer (MODIS).

***Abstract:***

The dry corridor resides primarily in the pacific region of Central America, which experiences severe drought during the El Niño Southern Oscillation cycle. El Niño causes severe climate variances in Central America that impact agriculture, livelihoods, and hydrological cycles. The region is rich with cash crops, including bananas, plantains, corn, sugar, and coffee, that are at risk during El Niño events. The region is also home to many subsistence farmers who rely on rainfed agriculture. These climate anomalies can lead to loss of livelihood and regional food insecurity. The team used remote sensing data from Global Precipitation Measurement (GPM) mission Integrated Multi-satellite Retrievals for GPM (IMERG) and Terra Moderate Resolution Imaging Spectroradiometer (MODIS) to generate Normalized Difference Vegetation Index and Standard Precipitation Index data to identify regions that have been negatively impacted by past El Niño events in the dry corridor of Guatemala, Honduras, and Nicaragua. The project identified the historic areas of socioeconomic vulnerability during the onset of El Niño related drought. Team members worked with Universidad del Valle de Guatemala to provide information regarding regional drought to the Nicaragua Ministry of Agriculture and Forestry and the Honduran Ministry of Agriculture and Livestock. The project concluded that there is an increase in the area of severe and extreme drought during El Niño events in the Central American dry corridor, and the team provided time series maps that visually demonstrated the progression of drought in the region.

***Keywords:***

remote sensing, SPI, NDVI, GPM-IMERG, drought, Mesoamerica, Oceanic Niño Index

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

***Study Location:*** Nicaragua, Honduras, & Guatemala

***Study Period:*** June2000 to June 2019

***Community Concerns:***

* The Central American Dry Corridor is home to nearly half of the small producers of basic grain crops in the region.
* The Dry Corridor has experienced unprecedented drought events that have impacted the community and livelihoods of agricultural producers.
* The 2015/2016 drought, associated with a strong El Niño event, is considered the most severe in the region over that past 30 years and left over three million in conditions of acute food insecurity.

***Project Objectives:***

* Derive SPI from GPM-IMERG precipitation data to provide time series maps that show the progression of drought and highlight precipitation anomalies during El Niño seasons
* Show the lead-lag relationship concerning SPI and NDVI between rainfed planting seasons and growing season in the Dry Corridor agricultural cycle
* Calculate long-term precipitation and vegetation averages and create time series for El Niño to highlight precipitation and vegetation anomalies to the long term average
* Create a tutorial for partners to calculate SPI results in the future

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Nicaragua Ministry of Agriculture and Forestry** | Alejandro Pineda, Director of Follow-up and Monitoring of Production Cycles | End User | No |
| **Honduran Ministry of Agriculture and Livestock** | Enid Cuellar, Leader of INFOAGRO/SIMPAH | End User | No |
| **Universidad del Valle de Guatemala** | Gabriela Fuentes, Director of the Center for Environmental Studies | Collaborator | No |
| **Central American Agricultural Council** | Nathalie Villegas, Coordinator | Collaborator | Yes |

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

According toRamírez & Briones (2017) members of the Central American National Hydro Meteorological Services tend to have very different capacities. These agencies typically are the first to inform their nation that an El Niño southern oscillation is developing. Despite maintaining weather prediction organizations that have the capacity to detect Oceanic Niño Index events, governments tend to not respond or implement drought mitigation measures until after an El Niño event has been announced by the National Oceanic and Atmospheric Administration (NOAA). This impedes early response drought mitigation measures in Honduras. Honduras hopes to learn how to derive SPI from GPM-IMERG data to locate areas in the country most severely impacted by drought. Additionally, the country hopes to incorporate GPM-IMERG data into its climate change adaptation plan. Honduras uses the United States Department of Agriculture (USDA) Global Agriculture & Disaster Assessment System (GADAS) tool to view SPI and determine which locations are most impacted by drought. The Ministry of Agriculture and Livestock retains a force of trained individuals to educate farmers in the region on best practices to deal with drought and to inform farmers of drought-hardy and pest-resistant crop varieties. Nicaragua is attempting to draft a climate change adaptation plan. The country has seen an intensification of drought during El Niño events with the dry corridor often seeing the most disparate impacts. In its plan, Nicaragua hopes to build capacity to map drought in order to better develop policies in response to drought conditions. Currently, the country is experimenting with the introduction higher efficiency irrigation technologies and hardy crop varieties which can better withstand drought.

***Project Benefit to End User:***

The end products will demonstrate the use of spatially comprehensive climate and remote sensing data in the Dry Corridor of Nicaragua, Guatemala, and Honduras, where there are few publicly accessible weather stations. The partners will gain an enhanced understanding of how they can use measurements of SPI to anticipate a potential decline in vegetation in the study area. The project results will provide a retrospective view of El Niño. From the time series, the end-users will be able to deduce the regions in the country most heavily impacted by El Niño related drought. This can occur by either viewing precipitation related deficits from SPI measurements or declines in vegetation as measured by NDVI. This project will expand the drought monitoring and planning information available to the partners.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Terra MODIS** | NDVI | NDVI from Terra MODIS was used to measure historic vegetation health in the study area as the lag variable. |
| **GPM-IMERG** | Precipitation | The team demonstrated how to acquire precipitation data from GPM-IMERG and compute SPI for the tutorial product. |

***Ancillary Datasets:***

* NOAA Climate Prediction Center Oceanic Niño Index (ONI) – Indicates the oceanic water temperature to identify months classified as El Niño

***Software & Scripting:***

* Esri ArcMap 10.6 – Map generation, raster analysis, and land cover classification
* QGIS 3.8 – Raster analysis and raster processing
* R 3.4.0 – Data analysis and visualization

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Lead-lag Analysis of SPI and NDVI** | Terra MODIS  GPM-IMERG | The analysis showed which measures of SPI (e.g. 1-month, 2-month, etc.) relate to vegetation response and the time lags. This information will help the partners anticipate future vegetation decline based on current precipitation measurements. | N/A |
| **SPI User Guide** | GPM-IMERG | The partners will learn how to access precipitation data in near-real-time, compute SPI, and understand the relationship to NDVI for agricultural drought planning. | III |

**Project Handoff Package**

***Transition Plan:*** During the final partner phone call on November 14, 2019, the team discussed their finalized results and conclusions with the partners, as well as showcased data acquisition and the computation tutorial. The project results and tutorial were written into an atlas/user guide format, which was shared with the partner via Google Drive after the NASA Export Control process.

***Software Release Plan:***

The project partners have been briefed on the potential time frame of the Software Release Process. An in-depth tutorial will accompany the code handoff to assist in training the project partners. The code tutorial will not contain actual code and will be passed to the project partners during the handoff and training session. After receiving the code (after it is released) our project partners will be able to follow the previously distributed tutorial.

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***Handoff Package:***

* Poster
* Presentation
* Technical paper
* Lead-lag Analysis of SPI and NDVI
* SPI User Guide (pre-code release section)

**References**

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