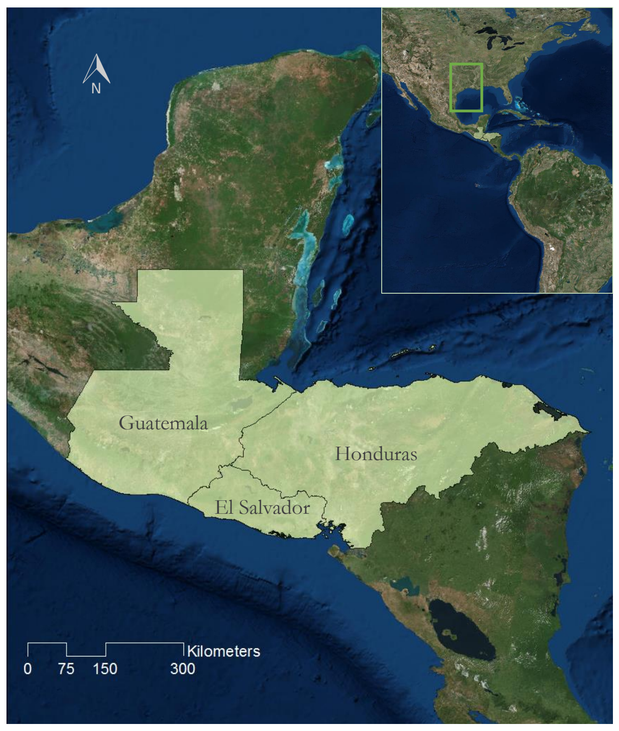
Utilizing NASA Earth Observations and NOAA Climate Data Records to Monitor Drought and Precipitation Patterns for Coffee Agriculture Management in Guatemala, Honduras, and El Salvador

Abstract

In November of 2017, Guatemala, Honduras, and El Salvador produced over 12 million kg of coffee combined, accounting for half of Central America's total output. However, in the last 20 years Central America has experienced crop declines between 50% and 90%, due largely to drought and irregular rainfall. These irregularities in the weather patterns have increased coffee crop vulnerability to diseases, such as coffee rust, as well as significantly decreased the productivity and overall quality of coffee crops. In particular, the 2015-2016 El Niño spurred a drought lasting for two years, the most severe drought in Central America in recent history. This project partnered with the United States Agency for International Development (USAID) Feed the Future Alliance for Resilient Coffee, International Center for Tropical Agriculture, and Conservation International to produce detailed analyses of precipitation anomalies for next generation coffee farmers, co-ops, and regional planners. The team created an atlas of El Niño-Southern Oscillation (ENSO) phases using the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS), and a time-series analysis of the frequency and intensity of historical drought periods using the Scaled Drought Condition Index (SDCI). Analyses will be used to assist partners in early warning detection by observing anticipated rainfall conditions aiding in determining adaptive management options.

Study Area



Objectives

- **Produce** a 37-year atlas detailing precipitation anomalies associated with moderate-strong, neutral, and weak ENSO phases through use of remotely-sensed precipitation data
- **Compute** a Scaled Drought Condition Index based on remotely-sensed precipitation, Normalized Difference Vegetation Index, and land surface temperature data to provide a historical context on spatial and time series drought trends
- **Enhance** the ability of agriculture extension workers and other coffee industry stakeholders to make farm management decisions based on remotely-sensed climate data

Project Partners

- **USAID**, Feed the Future Alliance for Resilient Coffee
- **International Center for Tropical Agriculture** (CIAT)
- **Conservation International**

Methodology

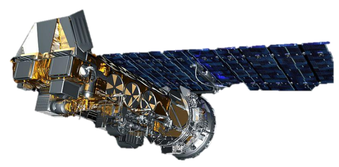
ENSO Precipitation Anomaly Analysis

- **Data Acquisition (1981 – 2017)**
  - **Precipitation** from CHIRPS
- **Seasonal Climatology Processing**
  - 3 mo. seasonal means (Jan-Mar, Feb-Apr, Mar-May, etc.)
- **ENSO Phase Categorization**
  - **La Niña** | **Neutral** | **El Niño**
- **ENSO Phase Anomaly Measurement**
  - Year of onset (**Year 0**) | Year after onset (**Year +1**)

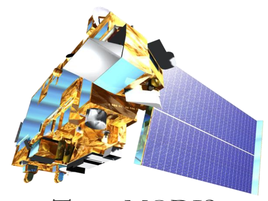
SDCI Analysis

- **Input Data Acquisition (2000 – 2017)**
  - **NDVI** from AVHRR | Precipitation (**PR**) from CHIRPS | **LST** from MODIS
- **Scaled Input Processing**
  - $(X_{max} - X) / (X_{max} - X_{min})$ | *regional maxima/minima scaled from 0 to 1
- **SDCI Calculation:** 0 (driest) to 1 (wettest)
  - (.25) scaled **NDVI** + (.5) scaled **PR** + (.25) scaled **LST**

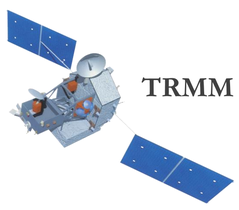
Earth Observations



NOAA-18 AVHRR



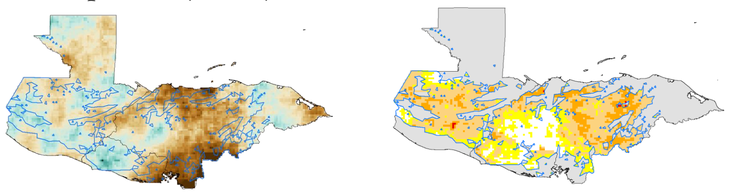
Terra MODIS



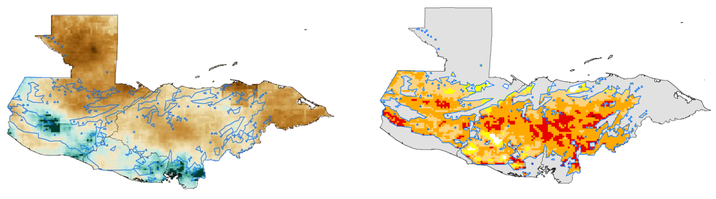
TRMM TMI

Results

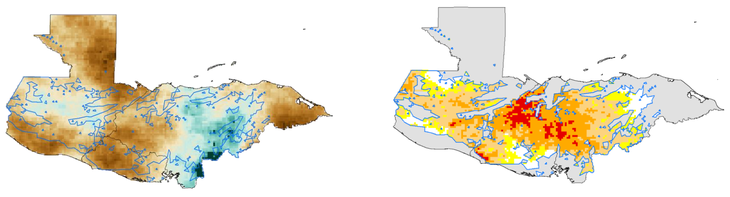
Moderate/Strong El Niño Sept-Nov (Year 0) ⟷ **SDCI Oct 2015**



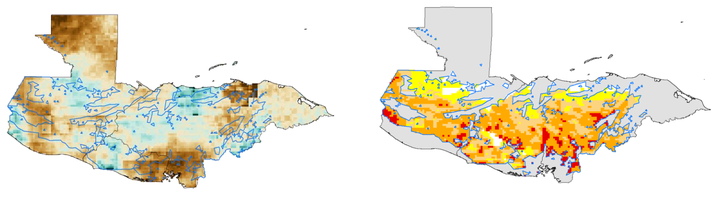
Moderate/Strong El Niño Jan-Mar (Year +1) ⟷ **SDCI Feb 2016**



Moderate/Strong La Niña Sept-Nov (Year 0) ⟷ **SDCI Oct 2010**



Moderate/Strong La Niña Jan-Mar (Year +1) ⟷ **SDCI Feb 2011**



ENSO Precipitation Anomaly (%)

-100 -80 -60 -40 -20 -5 +5 +20 +40 +60 +80 +100

SDCI Severity

Exceptional Drought — No Drought

Coffee Suitability Regions

Conclusions

- With ENSO outlook reports, ENSO anomaly maps can be used as an early warning system for anticipated precipitation changes.
- Scaled Drought Condition Index exhibits strong seasonality influenced by wet vs. dry season precipitation cycles and do not display expected drought patterns associated with ENSO phase.
- El Niño and La Niña phases exhibit mirrored precipitation anomalies, especially in areas experiencing greatest wet vs. dry season cycles in the Dry Corridor along the Pacific coast.
- Coffee industry stakeholders will be able to replicate ENSO anomaly and SDCI analyses within varying periods of record, seasons, and coffee growing locations across the globe.
- Future work should examine the weight of SDCI inputs in tropical areas like Central America to improve its applicability in regions with wet and dry season cycles, large elevation ranges, and year-round vegetation greenness.

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