**NASA DEVELOP National Program**

**Fall 2016 Project Proposal**

**USGS at Colorado State University**

**Ethiopia Disasters**

Utilizing Landsat, MODIS, TRMM, GPM, and SMAP to Assess Agricultural Drought Severity in Ethiopia and Provide a Tool for Monitoring Drought at the Regional Level

**Project Overview**

***Objective:*** Agricultural drought severity in Ethiopia will be analyzed and mapped using land surface temperature, evapotranspiration, precipitation, soil moisture, and vegetation conditions to identify vulnerable hot spots and improve humanitarian aid resource allocation.

***Community Concern:*** The ongoing drought in Ethiopia is a result of extreme El Niño weather patterns in 2015 that created the worst drought in half a century. Massive crop failures, primarily in the central and eastern portions of the country, have left over 10 million people currently in need of emergency food assistance, and La Nina in 2016 could further suppress rainfall in the latter half of the year. Timely information is needed to identify which locations are being most affected in an effort to direct response efforts and allocate humanitarian aid.

***National Application Area Addressed:*** Disasters

***Study Location:*** Ethiopia

***Study Period:*** August 2006 to August 2016

***Advisor(s):***

Dr. Paul Evangelista (Natural Resource Ecology Laboratory)

Dr. Amanda West (Natural Resource Ecology Laboratory)

Ryan Anderson (Natural Resource Ecology Laboratory)

***Source of Project Idea:*** In recent communication between the Institute of Geo-Information and Earth Observation Sciences (I-GEOS) in Mekelle, Ethiopia, and Dr. Evangelista, I-GEOS staff expressed concern about the ongoing drought as well as the organization’s ability to communicate drought severity to residents and the local government. After extensive communication on partner needs, this project idea was formed.

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| US Department of State Office of Space and Advanced Technology (OES/SAT) and Humanitarian Information Unit (HIU) | Dr. Melinda Laituri, Director of Secondary Cities Project | End-User | Yes |
| Institute of Geo-Information and Earth Observation Sciences (I-GEOS)  Mekelle University | Dr. Daniel Teka, Director | End-User | No |
| USGS North Central Climate Science Center | Dr. Gabriel Senay, Research Physical Scientist | Collaborator | No |

***End-User Overview***

***End-User’s Current Decision Making Process:***

Locations impacted by drought and humanitarian aid allocation are often determined using administrative boundaries, which may be too generalized and do not represent actual environmental conditions. Satellite data provides important tools for monitoring and comparing soil moisture conditions over time at the regional scale. To date, I-GEOS has not implemented remote sensing techniques in drought monitoring, however they are establishing an Earth Observation Center (EOC) that will be focused in the use of remotely sensed data for earth observations. The EOC is in the process of securing hardware and software resources, however the competitive bidding process has taken over a year since the first request. Timely information concerning drought and flooding is needed in the region, and this has been emphasized by the US Department of State OES/SAT and HIU. The OES/SAT and HIU frequently incorporate satellite imagery in their decision making processes, including the Famine Early Warning Systems Network (FEWS NET).

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

Institute of Geo-Information and Earth Observation Sciences – This organization has utilized some NASA Earth observations in past research projects, but never for drought assessment. This project will build this organization’s capacity in two ways: 1) it will enable the organization to carry out future assessments of drought severity through implementation of similar methodologies, and 2) the organization will share the project results and methods with their graduate students in an effort to train them to use NASA Earth observations in applied research settings.

US Department of State Office of Space and Advanced Technology (OES/SAT) and Humanitarian Information Unit (HIU)- This organization frequently incorporates products derived from NASA Earth Observations in their decision making process. One example of this is data from FEWS NET, which monitors food security in developing countries.

***Project Communication & Transition Overview***

***In-Term Communication Plan:***

The team will communicate with the partners frequently throughout the term. Collaborator Dr. Gabriel Senay is in the NCCSS office on a regular basis and can provide expert knowledge to the team. While the project is international, Dr. Evangelista and Dr. Amanda West have a regular working relationship with the US Department of State HIU and I-GEOS, and can facilitate team and partner communication via e-mail and web conferences.

***Transition Approach:***

At the end of the term, the team will disseminate project results and hand off decision support tools via a web conference. Products from this project will be disseminated by US Department of State OES/SAT and HIU. The end-users plan to begin using these products as soon as they are available for drought monitoring, and tutorials produced in this project will be incorporated in coursework at I-GEOS.

**Letters of Support:** Institute of Geo-Information and Earth Observation Sciences, Dr. Daniel Teka, Director and US Department of State, Dr. Melinda Laituri

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Aqua/Terra MODIS** | Evapotranspiration, NDVI, Scaled Drought Condition Index, Land Surface Temperature | Calculation of historical (2006 to 2014) parameter anomalies. Will be compared to monthly rainfall estimates and current anomalies (2014 to 2016). Spatial distribution of parameters will be used to refine study region/areas of focus. |
| **SRTM** | Elevation | Will be used to evaluate topographic heterogeneity in the landscape. |
| **Landsat 8 OLI/TIRS** | NDVI, Scaled Drought Condition Index, Land Surface Temperature | Calculation of drought severity in highly impacted areas identified from the MODIS analysis. Used both for validation and higher spatial resolution analysis and mapping. |
| **Landsat 7 ETM+** | NDVI, Scaled Drought Condition Index, Land Surface Temperature | Calculation of drought severity in highly impacted areas identified from the MODIS analysis. Used both for validation and higher spatial resolution analysis and mapping. |
| **Landsat 5 TM** | NDVI, Scaled Drought Condition Index, Land Surface Temperature | Calculation of drought severity in highly impacted areas identified from the MODIS analysis. Used both for validation and higher spatial resolution analysis and mapping. |
| **SMAP** | Land Surface Soil Moisture | Measurement of soil moisture difference will be used to validate MODIS and Landsat parameters and to augment regional drought severity maps. |
| **TRMM TMI** | Precipitation Data | Calculate average monthly rainfall and rainfall anomalies from 2006 to 2014. Will be included in Scaled Drought Condition Index. |
| **GPM IMERG** | Precipitation Data | Calculate average monthly rainfall and rainfall anomalies from 2014 to 2016. Will be included in Scaled Drought Condition Index. |

***Ancillary Datasets:***

Monthly Rainfall Estimates (RFE) from NOAA Climate Prediction Center – Used to analyze correlation with MODIS and Landsat Indices.

ISRIC World Soil Information – Soil Properties Dataset – Modeling Parameters

Climate Hazards Group InfraRed Precipitation with Stations (CHIRPS) – Historic Precipitation Dataset – Will be used to analyze trends over time and compare with RFE.

ESA 2009 Global Land Cover Map – Used to extract parameters based on land cover type; distinguish agricultural and non-agricultural land cover.

Central Statistical Agency of Ethiopia – Annual Agricultural Sample Survey Data – Crop yield data will be correlated with drought indices

***Modeling:***

R Statistical Software – Exploratory geospatial statistical analyses and regression analyses of satellite parameters (Ryan Anderson, Colorado State University)

***Software & Scripting:***

Exelis ENVI – Image correction

Python/Arcpy – Index calculation; Statistical comparisons

Rocky Mountain Research Station (RMRS) Raster Utility – Image normalization

ArcGIS – Raster manipulation/analysis; Map creation

**Decision Support Tool & End-Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| Evapotranspiration Anomaly Maps for Region | Support in identification of areas that are experiencing agricultural drought. Provides an indication of hardest hit locations where response efforts should be focused. | Using MODIS data, monthly evapotranspiration anomalies will be correlated with monthly precipitation data in regression analyses. Maps will be created to document areas of ongoing agricultural drought. | NA |
| Agricultural Drought Index Maps 2006 - 2016 | Assess historic and current drought severity based on a combination of changes in soil moisture and vegetation conditions and crop yield data. | Using MODIS, Landsat 5TM/7ETM+/8OLI/8TIRS data and TRMM/GPM data, moisture and precipitation monthly trends will be analyzed and incorporated into a drought index map. SMAP data will be used to validate map results. | NA |

***End-User Benefit:***

Effective response to the current drought in Ethiopia requires timely information related to impacted and vulnerable areas. This project will enable I-GEOS and the US Department of State OES/SAT and HIU to support future drought management efforts in Ethiopia and perform finer scale assessments of impacted areas. The organization plans to use tutorials created in this project to train staff and graduate students on the methodologies and NASA Earth observations necessary to monitor drought events.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: Fall 2016

***Related DEVELOP Work:***

Summer 2015 (Ames Research Center) – Navajo Nation Climate: A Drought Monitoring Decision Support Tool for Customized Calculation of a Standardized Precipitation Index Value in the Navajo Nation

Spring 2016 (NOAA NCEI) – Levant and Central America Climate: Monitoring Precipitation and Drought to Enhance U.S. Air Force Predictions and Decision-Making in the Levant and Central America

Spring 2016 (International Research Institute for Climate and Society – Palisades, New York) – Uruguay Agriculture: Deconstructing a Drought Severity Index Based on NASA Earth Observations into its Components for Better End-User Assessment of the Driving Factors Behind Local Scale Drought

Spring 2016 (NASA Langley Research Center) - Texas Water Resources II: Using NASA Earth Observations to Assess Soil Moisture in Texas for Wildfire Mitigation

Summer 2016 (NASA Jet Propulsion Laboratory) – California Water Resources: Quantifying the Impacts of the 2015-2016 El Nino Event On California’s Historic Drought to Improve Water Resource Management

**Notes & References:**

***References:***

Rhee J, Im J, and Carbone J (2010). Monitoring agricultural drought for arid and humid regions using multi-sensor remote sensing data. Remote Sensing of Environment 114(12): 2875-2887.

Tadesse, T., Senay, G. B., Berhan, G., Regassa, T., & Beyene, S. (2015). Evaluating a satellite-based seasonal evapotranspiration product and identifying its relationship with other satellite-derived products and crop yield: A case study for Ethiopia. International Journal of Applied Earth Observation and Geoinformation, 40: 39-54.