**NASA DEVELOP National Program**

**2020 Spring Project Proposal**

**Virginia – Langley**

**Lambayeque Water Resources**

*Assessing Precipitation, Vegetation Health, and Groundwater Storage to Prioritize Land Management Resources in Peru’s Coastal Mesquite Forests*

**Project Overview**

***Project Synopsis*:** *Prosopis* spp*.* (mesquite) forests are a vital ecosystem of coastal Peru, providing critical habitat to support the region’s rich biodiversity and playing an important role in nearby communities who rely on subsistence agriculture. Forest decline and high rates of tree mortality in the Lambayeque region threaten this unique habitat. Land managers from the regional government in Lambayeque, Peru are interested in using remote sensing to better understand the relationship between regional hydrologic trends and forest decline. This project will generate a time series of precipitation from GPM IMERG and TRMM TMPA, estimated ground water flux from GRACE and GRACE-FO, and soil moisture from SMAP to get a picture of the entire water cycle in Lambayeque. These data will be paired with vegetation health indices from MODIS and ECOSTRESS to give a holistic general assessment of hydrologic trends in the region, which will help land managers address the forces behind current rates of forest decline.

***Community Concern:*** Mesquite is a critical keystone species in coastal Peru that underpins the region’s high biodiversity. Such forest ecosystems have provided food, fuel, and resources to local inhabitants for thousands of years. The Lambayeque Regional Government is interested in understanding the relationship between tree mortality and hydrologic cycles to inform their management and policy decisions pertaining to the forests and other lands they manage. Government officials hope to incorporate the results of this project alongside their other ongoing research efforts to help design strategies that mitigate forest decline in the Lambayeque region.

***Source of Project Idea:*** The previous LaRC Center Lead met the project collaborator, Dr. Deborah Woodcock, at the 2018 American Geophysical Union annual meeting in Washington, DC. This proposal emerged out of conversations between Dr. Woodcock, her Peruvian colleagues, and the LaRC Center Lead and succeeding Fellow.

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

***Study Location:*** Lambayeque, Peru

***Study Period:*** January 2002 – December 2019

***Advisors:*** Dr. Kenton Ross (NASA Langley Research Center), Dr. Venkataraman Lakshmi (University of Virginia)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Gobierno Regional de Lambayeque, Gerencia Regional de Recursos Naturales y Gestion Ambiental, Gerencia Regional de Agricultura** | Juan Chapoñan Sanchez; Gerente Regional de Agricultura, Regional Manager of Agriculture | End User | No |
| **Universidad Nacional Pedro Ruiz Gallo** | Professor Eleazar Rufasto, Professor of Agronomy | End User | Yes |
| **Clark University, George Perkins Marsh Institute** | Dr. Deborah Woodcock, Research Fellow | Collaborator | Yes |
| **Clark Labs** | James Toledano, Executive Director | Collaborator | No |

***End User Overview***

***End User’s Current Decision-Making Process:***Land managers from the Lambayeque government currently prioritize their management of mesquiteforests based on limited information from *in situ* assessments of soils and forest health. They recently collaborated with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ; The German Society for International Cooperation) to study forest health, soils, and land cover within the Huacrupe la Calera Reserve Zone, an approximately 7000 ha nature reserve. They lack such comprehensive information for other lands that they manage and do not currently utilize remotely sensed data, which could provide a landscape-scale view of hydrologic processes or changes in land cover. They do utilize a limited number of ground-based precipitation measurements, but no aspect of their current decision making process allows for assessment of landscape-scale spatiotemporal trends in precipitation, groundwater, soil moisture, or evapotranspiration.

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

*Gobierno Regional de Lambayeque, Gerencia Regional de Recursos Naturales y Gestion Ambiental, Gerencia Regional de Agricultura*  – Officials from the Lambayeque Regional Government are familiar with the use of a variety of geospatial data and have in-house GIS staff, but they do not currently use NASA Earth observations in their monitoring or management procedures. Their staff primarily use GIS for urban planning and zoning purposes.

*Universidad Nacional Pedro Ruiz Gallo* – The Pedro Ruiz Gallo National University in Lambayeque works closely with the regional government to provide academic and research expertise. Agronomy professor Eleazar Rufasto has ongoing research related to mesquiteforests but relies heavily on *in situ* data collection and does not regularly use NASA Earth observations. The university staff helps the regional government make decisions about management strategy and prioritization.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

*Clark University, George Perkins Marsh Institute* – Dr. Deborah Woodcock is an experienced researcher who has previously collaborated with both the Lambayeque government and the Universidad Nacional Pedro Ruiz Gallo. She is able to leverage the considerable geospatial resources and expertise available at Clark University to assist both the project team during project execution and the Peruvian end users following project completion. She is also bilingual and has thus far been the primary translator in all communications with the Peruvian partners. In July of 2019, Dr. Woodcock traveled to the Huacrupe la Calera Reserve Zone, approximately 75 km north of Lambayeque, with a research group from the Universidad Nacional Pedro Ruiz Gallo.

*Clark Labs* – Researchers at Clark Labs will provide guidance and support to the team throughout the term in the form of advising and expert knowledge on the methods the team may pursue. James Toledano, the Executive Director of Clark Labs, has expressed an interest in the project and is willing to provide guidance during the term and discuss the potential for further research.

***Dissemination by Boundary Organizations*:**

*Universidad Nacional Pedro Ruiz Gallo* – The Pedro Ruiz Gallo National University in Lambayeque is closely associated with the regional government, but officials there also regularly interact with researchers from other areas of Peru. They recently participated in a partnership between the Lambayeque Regional Government and GIZ. They will share project results with their German partners and other academics. They plan to incorporate the DEVELOP project into their larger research efforts.

*Clark University, George Perkins Marsh Institute* – Officials from George Perkins Marsh Institute will work closely with the project team during the DEVELOP term and will continue to partner with the Lambayeque Regional Government on their larger research efforts after the term is complete. Dr. Woodcock will disseminate the results of this project amongst her other collaborators, both in Peru and in the US. She will also be able to share the results with others at Clark University, who may be interested in utilizing similar methodologies.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The team will communicate with project partners in Peru on a bi-weekly basis via the NASA DEVELOP international teleconference line. The LaRC Fellow and Project Lead will coordinate with bilingual DEVELOP contacts for translation assistance. The LaRC Fellow may also seek assistance from the NASA SERVIR Amazonia team for translation and project guidance. The primary POC in Peru will be Professor Rufasto, who works closely with the Lambayeque government officials. Juan Chapoñan Sanchez, Regional Manager of Agriculture for the Lambayeque government, will relay all information to the appropriate officials within the government offices.

***Transition Plan*:** All maps, data files, descriptions of project methodology, and written reports will be transferred to each of the project end users and collaborators using NASA Large File Transfer. The Project Lead will organize an end-of-term handoff presentation via either the NASA DEVELOP international teleconference line or WebEx so that there is an opportunity to relay all information directly to all end users and collaborators.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **GPM IMERG** | Precipitation | GPM IMERG data will be used to derive a precipitation time series. |
| **TRMM TMPA** | Precipitation | This is the IMERG equivalent for dates prior to the launch of GPM and will be used to help derive the precipitation time series. |
| **SMAP L-Band Radiometer** | Soil Moisture | SMAP data will be used to generate a time series of soil moisture values from 2015 – 2019. |
| **GRACE Tellus** | Monthly Mass Grids – Land | GRACE Mass Grids will be used to estimate periodic groundwater fluxes and assemble an estimated time series of groundwater state from 2002 to 2019. |
| **GRACE-FO Tellus** | Monthly Mass Grids – Land | GRACE-FO Mass Grids will be used to estimate periodic groundwater fluxes and assemble an estimated time series of groundwater state in 2019. |
| **Terra MODIS** | Evapotranspiration (ET) | MODIS data will be used to estimate trends in evapotranspiration and will be compared with ECOSTRESS products. |
| **Aqua MODIS** | ET | MODIS data will be used to estimate trends in evapotranspiration and will be compared with ECOSTRESS products. |
| **ECOSTRESS** | ET, Evaporative Stress Index, Water Use Efficiency | ECOSTRESS data will be used to estimate trends in evapotranspiration, understand how mesquite forests are responding to stressors, and determine how efficiently the forests are able to utilize available water resources. |

***Ancillary Datasets:***

* GIZ; Estudio De Suelos Proyecto: Recuperación Del Bosque Del ACR Huacrupe - La Calera, Distrito de Olmos, Provincia y Region Lambayeque (soil study and forest report) – Provide context from field survey and *in situ* measurements, comparison to areas defined in the report as potential forest remediation sites

***Software & Scripting:***

* R – data manipulation, statistics, time series analysis
* Esri ArcGIS – visualization and map creation

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **2002 – 2019 Estimated Aggregated Hydrologic Flux Charts & Time Series** | Estimating hydrologic conditions on a monthly basis over multiple years will help quantify conditions and enhance decisions concerning sustainable management strategies. | Data from SMAP, GPM, TRMM, MODIS, GRACE, GRACE-FO, and ECOSTRESS will be integrated to produce the time series and flux charts. | N/A |
| **Standard Operating Procedure (SOP) Tutorial and Guide Document** | The partners will use the description of project methodology in the SOP document to continue their use of NASA Earth observations. | This document will include a description of the download and use of all datasets, including SMAP, GPM, TRMM, MODIS, GRACE, GRACE-FO, and ECOSTRESS. | N/A |

***End User Benefit*:** The products generated through this project will help end users in Peru better understand spatiotemporal trends in various hydrologic parameters throughout the water cycle, including soil moisture, precipitation, groundwater, and evapotranspiration. These data will be paired with literature about how these parameters relate to mesquite forest health to connect this research with solutions on the ground. This research will help the regional government continue to assess the hydrodynamics of the lands they manage and aid in the prioritization of forest restoration projects. The end users hope to understand which forested landscapes may be most susceptible to further forest decline based on these hydrologic relationships and prioritize their actions accordingly. These data could be paired with future land cover analysis, either from remotely sensed or ground-based assessments, to give a landscape scale view of forest health and distribution.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2020 Spring

***Related DEVELOP Work:***

2017 Summer (GSFC) – Niger Water Resources: Implementing a Global Toll for Mercy Corps Based on Spatially Continuous Precipitation Analysis for Resiliency Monitoring and Measuring at the Community-Scale

2018 Summer (ID) – Idaho Water Resources: Estimating Soil Moisture in Semiarid Sagebrush Steppe Utilizing NASA Satellite Imagery

**Notes & References:**

***Notes*:** Another data option is the SMAP/Sentinel-1 L2 Radiometer/Radar 30-Second Scene 3 km EASE-Grid Soil Moisture V002 product. This product combines SMAP and Sentinel-1 data to generate a product similar to the 3 km SMAP product that is only available for 2015 (because of the SMAP radar failure). This project will require the use of a variety of different data products, each of which has different benefits. Those listed here are not an exhaustive list, and he project team should feel free to explore other options. The goal will be to find products that could be useful to aid the partners in understanding forest health and demonstrate how they can be used in future work.

***References:***

Goddard Space Flight Center. (December 2003). *Studying the Earth’s Gravity From Space: The Gravity Recovery and Climate Experiment (GRACE).* Retrieved from <https://grace.jpl.nasa.gov/mission/grace/>

Kim, S., J. Van Zyl, R. S. Dunbar, E. G. Njoku, J. T. Johnson, M. Moghaddam, and L. Tsang. 2016. SMAP L3 Radar Global Daily 3 km EASE-Grid Soil Moisture, Version 3. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. doi: <https://doi.org/10.5067/IGQNPB6183ZX>. [2019-02-20].

Landerer F.W. and S. C. Swenson, 2012: Accuracy of scaled GRACE terrestrial water storage estimates. *Water Resources Research*, *48*, W04531, 11 PP, doi:10.1029/2011WR011453.

Swenson, S.C., 2012. GRACE Monthly Land Water Mass Grids Geotiff Release 5.0 Ver. 5.0 PO.DAAC, CA, USA. Dataset accessed [2019-02-20] at <http://dx.doi.org/10.5067/TELND-GO005>.