**NASA DEVELOP National Program**

**2019 Summer Project Proposal**

**Virginia – Langley**

**Dominican Republic Disasters**

*Utilizing NASA Earth Observations to Map Landslide Occurrence, Susceptibility and Vulnerability in the Dominican Republic*

**Project Overview**

***Project Synopsis*:** This project will use NASA Earth observations to map landslide occurrence, susceptibility, and vulnerability in the Dominican Republic. Primary end users for this project are the Dominican Republic’s Servicio Geológico Nacional (SGN) and Oficina Nacional de Meteorología (ONAMET). This project is intended for the broader benefit of Sistema de la Integración Centroamericana (SICA), or the Central American Integration System in English. Earth observations will include TMPA rainfall from TRMM, IMERG rainfall from GPM, SRTM DEM, and Landsat and Sentinel-2 for landslide detection. The project intends to generate susceptibility maps of the Dominican Republic based on variables such as slope, geology, tectonic activity, presence of roads, and forest loss which can be input to the the Landslide Hazard Assessment for Situational Awareness (LHASA) model (Kirschbaum & Stanley, 2018), along with precipitation data, to provide near real-time landslide susceptibility monitoring, . A secondary goal of the project is to port LHASA from Python to Google Earth Engine (GEE) for ease of use and scalability.

***Community Concern:*** In the Dominican Republic, as in other Central American and Caribbean countries, there are many areas at intense risk for rainfall-triggered landslides and a high proportion of vulnerable communities. This is due to a combination of factors such as abrupt relief and weakness of lithologic materials, tropical rainfall of high intensity, high population density, and fragile infrastructure, such as informal settlements. The presence of informal population settlements may result in higher casualty and displacement, as a result of poverty and marginalization. The Dominican Republic would benefit from improved landslide susceptibility information to support early warning and alert protocols.

***Source of Project Idea:*** The original source of this project was a project request from Ricardo Quiroga, AmeriGEO Disasters Coordinator for the NASA Applied Sciences Program (ASP). Mr. Quiroga was responding to a call within the Applied Sciences Program for DEVELOP projects supporting SICA. This project is supporting the NASA-SICA Joint Statement for Activities in Applied Science Research and Earth Observations for Societal Benefit.

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

***Study Location:*** Dominican Republic

***Study Period:*** November1997 – May 2019

***Advisor:*** Dalia Kirschbaum (NASA Goddard Space Flight Center), Kenton Ross (NASA Langley Research Center)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Servicio Geológico Nacional (Dominican Republic)** | Dr. Santiago Munoz, Director | End User | No |
| **Oficina Nacional de Meteorología (Dominican Republic)** | Dr. Andres Campusano, Sub-Director | End User | No |
| **Sistema de la Integración Centroamericana, [SECRETARIAT] Centro de Coordinación para la Prevención de los Desastres Naturales en América Central** | Claudia Herrera, Executive Secretary [Tentative, Must Check] | Collaborator | No |
| **BGC Engineering, Inc.**  | TBD | Collaborator | No |

***End-User Overview***

***End User’s Current Decision-Making Process:***SGN and ONAMET are the government entities in the Dominican Republic responsible for making the public aware of landslide risks due to topography and lithography (SGN) and due to weather and soil water content (ONAMET). Their shared objective is the protection of life and property. Currently, the agencies maintain an inventory of landslides across the country and issue alerts regarding landslide risk at the provincial level.

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

***Servicio Geológico Nacional (Dominican Republic)*** – This partner is somewhat familiar with Earth observations. They use aerial and satellite imagery for mapping and cartography. They have GIS expertise and are familiar with various types of geospatial data.

***Oficina Nacional de Meteorología (Dominican Republic)*** – This partner is somewhat familiar with Earth observations. They use in-country in situ measurements and ground-based radar observations. They ingest meteorological observations and model outputs from US and European sources.

***Collaborator & Boundary Organization Overview***

***Collaborator Support:***

***Sistema de la Integración Centroamericana*** – The appropriate SICA secretariat(s) will be involved to assess the extensibility of the work to other SICA member states.

*BGC Engineering, Inc.*– BGC, a Canadian engineering company, has years of engagement in the Dominican Republic with engineering projects, is well-acquainted with stakeholders, and has potentially relevant data for landslides in the area. BGC is willing to support the project through its philanthropic outreach arm called “BGC Squared.”

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** During the term, the team will have biweekly teleconferences with partners to provide updates on project methodologies and analyses. The Project Lead will be the primary point of contact for in-term communications with project partners. One team member is a fluent Spanish speaker but translation services may be required for some partner communication.

***Transition Plan*:** A formal handoff will take place at the end of the project term in the form of one to two webinar trainings via Skype. Project end users will receive access to the Google Earth Engine app, including access to datasets and code after software release is approved. End products and deliverables will be sent to partners via NASA Large File Transfer (LFT) or similar file transfer tool within two weeks after the project ends. Any new code generated by this project must be released NASA Software Release process which can be expected to take six to twelve months following project completion.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter** | **Use** |
| **GPM IMERG** | Rainfall | Rainfall is one of the primary inputs to LHASA for estimation of landslide susceptibility. GPM IMERG rainfall will provide more recent precipitation estimates. |
| **TRMM TMPA** | Rainfall | Rainfall is one of the primary inputs to LHASA for estimation of landslide susceptibility. TRMM TMPA rainfall will provide historical precipitation estimates. |
| **SRTM** | Elevation | SRTM will provide a reference DEM used to derive slope for input into LHASA. |
| **Landsat 5 TM** | Surface Reflectance | Surface reflectance data will be used to identify landslide occurrence. |
| **Landsat 8 OLI** | Surface Reflectance | Surface reflectance data will be used to identify landslide occurrence. |
| **Sentinel-2 MSI** | Surface Reflectance | Surface reflectance data will be used to identify landslide occurrence. |

***Ancillary Datasets:***

OpenStreetMap: Road Vectors – road vectors as an open resource to identify the presence of roads as an input to LHASA to estimate landslide susceptibility

University of Maryland Department of Geography Global Forest Change Project: Forest Loss – raster maps of estimated forest loss as an input to LHASA to estimate landslide susceptibility

NASA Global Landslide Catalog: Landslide Locations – identify landslide sites for reference

SGN: Landslide Inventory – identify landslide sites for reference

SGN: Faults and Geological Information – create a distance to fault LHASA input as a proxy for tectonic activity

Center for International Earth Science Information Network: Gridded Population of the World, Version 4.11 – population and demographic spatial estimates for potential vulnerability analysis

***Modeling:***

Landslide Hazard Assessment for Situational Awareness (LHASA) (POC: Dalia Kirschbaum, NASA Goddard Space Flight Center)

***Software & Scripting:***

Python 3.7 – Run the existing LHASA model

Google Earth Engine API – Data acquisition, image processing and potential porting of LHASA model to GEE JavaScript

ESRI ArcGIS 10.x and or ArcGIS Pro – Offline dataset pre-processing and post-processing mapping products

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Landslide Susceptibility Maps** | Gridded landslide susceptibility maps will allow the partners to identify landslide potential at a finer spatial resolution than current provincial alerts.  | These maps output from LHASA are primarily based on precipitation (from GPM or TRMM) and slope (from SRTM, but involve all inputs to LHASA. | N/A |
| **Landslide Vulnerability Maps** | Gridded landslide vulnerability maps will allow the partners to identify highlight landslide risk for vulnerable populations. | These maps will cross reference the Landslide Susceptibility Maps with population data. | N/A |
| **LHASA GEE (Dominican Republic Version)** | This potential tool would allow partners to produce landslide susceptibility and other products via Google Earth Engine. This would facilitate complete archival and near-real time product access and would ease scalability to other SICA member states. | This tool will use the same inputs as the existing version of LHASA (SRTM elevation, GPM IMERG & TRMM TMPA precipitation, etc) and would produce similar outputs. | IV |

***End-User Benefit*:** The primary benefit of this project to SGN and ONAMET will be the evaluation of the efficacy of higher granularity estimates of landslide susceptibility. A potential secondary benefit would be a GEE-based LHASA tool that could increase usability and scalability of the LHASA model for SGN and ONAMET.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2019 Summer

***Related DEVELOP Work:***

2015 Spring (GSFC) – Himalaya Disasters I: Evaluating Landslide Hazards in Nepal through Remotely Sensed Data, Event Nowcasting and Crowdsourcing

2015 Summer (GSFC) – Himalaya Disasters II: Expanding Upon Landslide Identification Product and Hazard Assessment Model Capabilities for Enhanced Landslide Detection in the Koshi River Basin

2015 Fall (GSFC) – Himalaya Disasters III: Utilizing a Landslide Identification Product and a Real-Time Rainfall Detection Tool for Enhanced Landslide Detection in Nepal

2015 Summer (MSFC) – East Africa Disasters I: Assessing Landslide Characteristics and Developing a Landslide Hazard Map and a Landslide Susceptibility Map in Rwanda and Uganda Using NASA Earth Observations

2016 Summer (MSFC) – East Africa Disasters II: Assessing Landslide Characteristics and Developing Susceptibility and Exposure Maps in Malawi

**Notes & References:**

***Notes*:**

1. Given evolving partner requirements, this project has an even chance to need a second term, but initial planning is for a single term.
2. Although a partner requirement for landslide susceptibility products has been established, the need for vulnerability products has not been confirmed.
3. Partner preferences for analysis platform (i.e. desktop GIS, offline code, or online API such as GEE) have not been confirmed.
4. Partners have expressed interest in a case study of rainfall-triggered landslides associated with consecutive tropical storms Noelle and Olga in 2007.
5. Project is likely to require special reporting to SICA stakeholders.
6. LHASA code on github: <https://github.com/nasa/LHASA>

***References:***

Kirschbaum, D., & Stanley, T. (2018). Satellite-Based Assessment of Rainfall-Triggered Landslide Hazard for Situational Awareness. *Earth’s Future*, *6*, 505–523. <https://doi.org/10.1002/2017EF000715>