**NASA DEVELOP National Program**

****NASA Goddard Space Flight Center

**Fall 2015**

**Short Title: Himalaya Disasters III**

**Subtitle:** Utilizing a Landslide Identification Product and a Real-time Rainfall Detection Tool for Enhanced Landslide Detection in Nepal

**VPS Title:** SLIP: An Automated Tool for Enhanced Detection of Rainfall-Induced Landslides

**Project Team & Partners**

**Project Team:**

Amanda Rumsey (Project Lead), Amanda.c.rumsey@nasa.gov

Jordan Scheffler

Jessica Fayne

**Advisors & Mentors:**

Dr. Dalia B. Kirschbaum (NASA GSFC)

Dr. John D. Bolten (NASA GSFC)

Thomas A. Stanley (NASA GSFC)

Sebastian Wesselman (ICIMOD)

**Past or Other Contributors:**

Justin Roberts-Pierel

Aakash Ahamed

Jamie Shiplet

**Partner Organizations:**

International Centre for Integrated Mountain Development (ICIMOD), Collaborator and End-User, POC: Sebastian Wesselman and Deo Raj Gurung

**Project Details**

**Applied Sciences National Applications Addressed:** Disasters

**Study Area:** Nepal

**Study Period:** Feb 2000 - Nov 2015

**Earth Observations & Parameters:**

TRMM, TMPA – rainfall measurements

GPM, IMERG – rainfall measurements

SRTM, 1 arc-second global topography

ASTER, global DEM topography

Terra, MODIS – land cover, permanent water, and Leaf Area Index (LAI)

Landsat 8, OLI – landslide identification

**Ancillary Datasets Utilized:**

* Dr. Dalia Kirschbaum’s Global Landslide Catalog– landslide locations
* ICIMOD’s Landslide Dataset 1992-2010 - visually assessed manually digitized landslides
* ICIMOD’s Lithology Dataset - geology
* USGS Landscan 2011 - population
* USGS HydroSHEDS - rivers
* OpenStreetMap - roads
* ISRIC SoilGrids 1km - soil properties
* Polar Geospatial Center and the Byrd Polar and Climate Research Center--Nepal SETSM 20 and 2 meter DEMs-- topography

**Models Utilized:**

* NASA Landslide Hazard Assessment Model
* NASA Susceptibility Model

**Software Utilized:**

Python - automation of landslide detection, real-time precipitation monitoring

R - statistical analysis of Landsat imagery and precipitation trends

ArcGIS - raster manipulation/analysis, image enhancement & map creation

MATLAB - TRMM/GPM processing

**Project Overview**

**80-100 Word Objectives Overview:**

Through previous DEVELOP research, a Sudden Landside Identification Product known as SLIP and a Detecting Real-time Increased Precipitation product known as DRIP were developed to locate and predict rainfall-induced landslide event information. The objective of this study was to validate the results of SLIP and DRIP and to assess their global prediction capabilities. The other objective of this study was to develop a web-based data portal that can host SLIP and DRIP and will allow our end-users to collect and download landslide event and rainfall event information.

**Abstract:**

Nepal is a hotspot for landslide activity due to its mountainous topography, complex terrain, and monsoon rains. Previous related studies combined NASA Earth observation data from Landsat 8, Shuttle Radar Topography Mission (SRTM), Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), Tropical Rainfall Measuring Mission (TRMM) and the Global Precipitation Measurement Mission (GPM) with various ancillary datasets to create two products for use in the region: the Sudden Landslide Identification Product (SLIP), and Detecting Real-time Increased Precipitation (DRIP). SLIP will help identify landslides in near real-time using Landsat 8 and elevation products, as well as provide damage assessments by mapping landslides automatically after a disaster such as the Gorkha earthquake in May 2015. DRIP will monitor precipitation levels extracted from the GPM-IMERG 30-minute product to create alerts when current rainfall levels exceed calculated threshold values. SLIP and DRIP were also integrated to provide a more comprehensive landslide notification system for the region. The objective of this study was to validate the results of SLIP and DRIP and to assess their global prediction capabilities, and to develop a web-based data portal that can host SLIP and DRIP and will allow end-users to collect and download landslide event and rainfall event information.

The DRIP-SLIP model combination will be used by the International Centre for Integrated Mountain Development (ICIMOD) to: a) protect and manage ecosystems and villages in Nepal, b) prevent future loss of life and infrastructure due to landslides, and, c) reduce poverty through integrated natural resource management and regional cooperation.

**Community Concerns:**

* Landslides cause hundreds of fatalities and millions of dollars in losses in the Nepal and Himalaya region annually.
* In August 2014, heavy rains caused several landslides in 18 districts throughout Nepal. A total of 29,680 people were displaced, and a total of 53 people were confirmed dead.
* Landslides are a significant induced hazard arising from the 2015 M7.8 Gorkha earthquake, and increase in frequency and severity during the summer monsoon.
* The number of landslides occurring in Nepal are currently underestimated due to the association of landslides with other disaster events and occurrence of landslides in unpopulated areas.

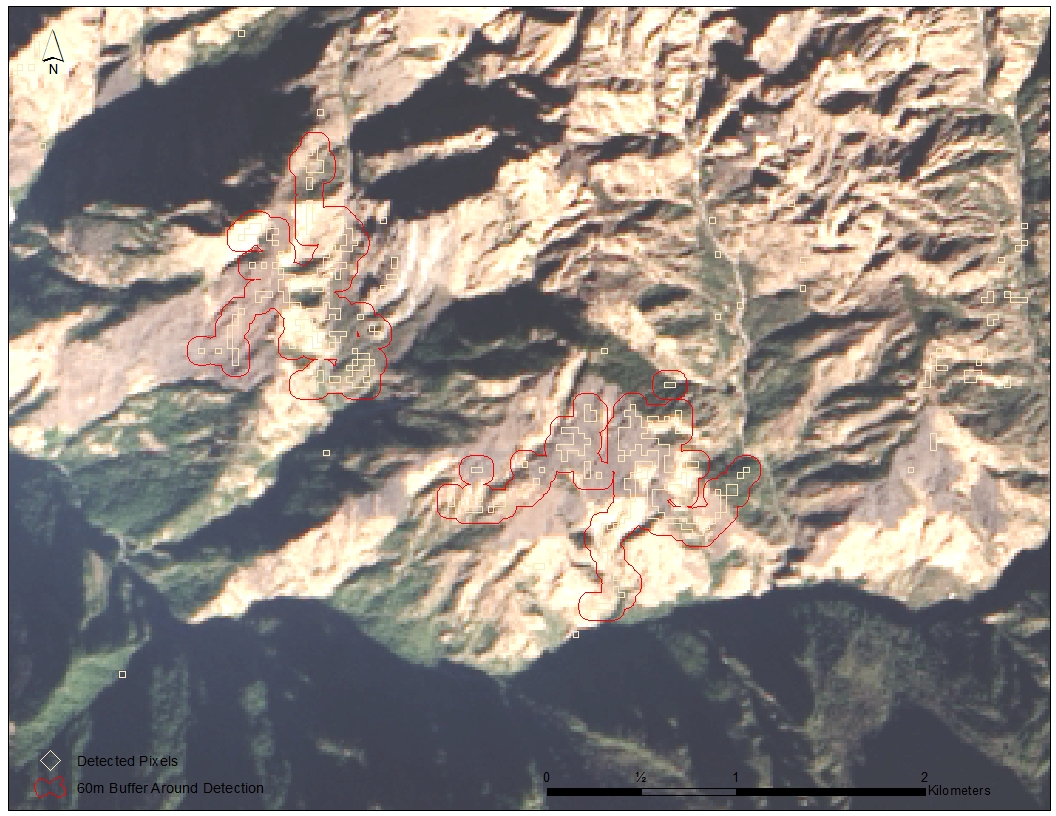
**Current Management Practices & Policies**:

The International Centre for Integrated Mountain Development (ICIMOD) is an intergovernmental organization that serves eight regional entities located within the Hindu Kush Himalayan region, including: Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan. Through partnerships with regional institutions, ICIMOD is able to serve as a regional knowledge hub that provides its end-users with insight on how climate change and globalization impacts the fragile mountainous ecosystems. ICIMOD oversees a variety of programs that were constructed to generate innovative forecasting products. While ICIMOD has a variety of resources and projects, few efforts have been made to use remotely sensed information to document precise landslide locations and estimate potential landslide conditions in the region. Many existing models rely on reporting which can reduce the spatial accuracy as well as introduce underreporting biases.

**Decision Support Tools & Benefits:**

|  |  |  |
| --- | --- | --- |
| **End-Product** | **Earth Observations Used** | **Benefit & Impact** |
| Sudden Landslide Identification Product | Landsat 8 OLI | SLIP detects areas that have potentially experienced landslides from one Landsat scene to the next. Events are catalogued and added to a landslide database for the Nepal and Himalaya region. Cataloging landslide events will help ICIMOD better classify landslide susceptibility. |
| Detecting Real-time Increased Precipitation (DRIP) | GPM GMI, TRMM TMI | DRIP detects areas that have experienced anomalously high precipitation accumulation. DRIP will help ICIMOD better prepare for landslide events by issuing landslide warning in near real-time. |
| Landslide Hazard Assessment Web Portal | Landsat 8 OLI, GPM GMI, and TRMM TMI | The landslide hazard assessment web portal will provide ICIMOD with a GUI interface to download landslide and rainfall event data in near real-time and historical capacities. |

**Project Imagery**



**Caption:** The red regions represent landslide event delineated through SLIP Image Credit: Himalaya Disasters Team

**Image:** SLIP Landslides

**Software Release Requirements**

What category do the tools your project is creating fall within? Category IV

If your decision support tools fall within Category IV, fill out this section:

**Software Title:** DEVELOP SLIP and DRIP Landslide Detection Package

**Software Abbreviation:** DRIP-SLIP.py

**Technical Point of Contact:**

Justin Roberts-Pierel, justin.roberts-pierel@nasa.gov, Goddard Space Flight Center, employed through CRESST/UMBC

Amanda Rumsey, [arumsey@bu.edu](mailto:arumsey@bu.edu), Goddard Space Flight Center, employed SSAI

Jessica Fayne, [jfayne2@gmu.edu](mailto:jfayne@gmu.edu), Goddard Space Flight Center, employed through SSAI

**Brief Description of the Software:** The DRIP-SLIP package will be used to functionalize common programming tasks regarding landslide and rainfall anomaly detection through the use of NASA data products. It will include functions for processing satellite data and will assist in rainfall induced landslide analysis. DRIP-SLIP will output two images. The first image will display a 24-hour rainfall total, and the second image will display landslide event information derived from SLIP.

**Type of Code:** *Source Code*

**Will the software include any embedded computer databases?** *Yes*

**Does the software use or call any open software or libraries?** *Open Source*

**List the software or libraries used, under what license they were obtained, and the URL for the license in the table below:**

|  |  |  |
| --- | --- | --- |
| **Name** | **License** | **License URL** |
| Python 3.4 | Open source license | https://www.python.org/download/releases/3.4.0/license/ |
| R version 3.0.2(2013-09-25)- “Frisbee Sailing” | Open source license | https://www.r-project.org/Licenses/GPL-3 |

**Full Software Description and Plan**

**Introduction/Objective:**

A landslide is a type of mass wasting event that occurs when down-slope forces exceed the strength of the slope materials. Changes in slope stability can occur due to natural forcings including intense rainfall, rapid snowmelt, and seismicity, as well as anthropogenic factors like deforestation and land use change. Nepal is highly susceptible to landslides due to its complex mountainous topography, active seismicity, monsoon rain, and underdeveloped infrastructure.

Previous research efforts have utilized landslide event data and heuristic, statistical, and deterministic models to create landslide susceptibility maps for Nepal. These susceptibility maps depict “hot spot” areas that have an increased risk of experiencing a landslide event. These maps aim to prevent loss of life and economic damages caused by landslides but are limited in accuracy due to the availability and inherent biases present in most landslide event datasets.

Currently landslide event databases are limited in scope and size due to non-reporting biases associated with the lack of knowledge of landslide events in under-populated areas and with the grouping of landslide events with their primary triggering hazards. The DRIP-SLIP software addresses the inaccuracy issues associated with conventional collection methods, by leveraging spectral red band properties to develop an automated Sudden Landslide Identification Product (SLIP), and uses Global Precipitation Measurement Mission (GPM) data to develop a real-time rainfall measurement tool known as Detecting Real-time Increased Precipitation (DRIP). Together SLIP and DRIP can be used to form a real-time landslide hazard assessment model for Nepal.

**Applications and Scope:**

The DRIP and SLIP Landslide Detection Package, developed by the Himalaya Disasters Team at Goddard Space Flight Center, was created to identify landslide events in Nepal in a near real-time capacity. This product will be used to develop accurate landslide prediction models, and will be used for future disaster management.

**Capabilities:**

While most landslide detection studies are conducted using expensive software and high-resolution imagery with considerable human training of classification datasets, this software automatically analyzes red band spectral information and soil moisture information derived from Landsat 8 and ASTER and SRTM data, at a fine to moderate resolutions, to determine areas that might be new landslides. This is important to help increase the temporal latency for landslide products that emergency managers, planners, and scientists are able to use in their work.

**Interfaces:**

The python script is currently hosted on an ftp server called Open Science Data Cloud run by the Open Science Data Consortium. The package is called by typing the name of the file ‘DRIP-SLIP.py’. The user also has the option to manipulate the script in order to find the exact path/row of the Landsat scenes and dates they require.

**Assumptions, limitations, & Errors:**

The scripts will only work as well as their underlying algorithms. While the DRIP and SLIP algorithms are fully functional, they will likely be undergoing editing as future verification and validation trains the algorithms’ improvements. The script is python-based, and runs from the command line--it would be beneficial to have the script invoked from the website where the DRIP-SLIP outputs will be hosted. This will help users get and visualize information more quickly, as well as provide those with limited programming experience more accessibility to the models. The script currently detects landslide events for Nepal and will have to be modified by the end-user for global landslide event detection.

**Testing:**

The software was manually tested by the software developers on a regular basis. As different elements were added to the product, the software developers added print statements, and analyzed end products to ensure product accuracy. The product was validated by comparting the results of SLIP to actual known landslide events conveyed in Landsat 8 and World-View 2 images. An accuracy assessment was completed, and errors of commission and omission were provided.