NASA DEVELOP National Program

Alabama – Marshall

Fall 2021 Project Summary

Central America Disasters

Using Earth Observations to Map Flooding for Disaster Monitoring, Inform Potential Risk, and Prepare for Possible Response

Project Team

Project Team: Caroline Williams (Project Lead) Lauren Carey Maria De Los Santos Deanna Fanelli Payton Ireland

Advisors & Mentors:

Kel Markert (NASA SERVIR Science Coordination Office) Eric Anderson (NASA SERVIR Science Coordination Office) Betzy Hernández (NASA SERVIR Science Coordination Office) Dr. Emil Cherrington (NASA SERVIR Science Coordination Office) Vanesa Martin (NASA SERVIR Science Coordination Office) Ronan Lucey (NASA Applied Sciences Disasters Program) Dr. Robert Griffin (University of Alabama Huntsville) Dr. Jeffrey Luvall (NASA Marshall Space Flight Center)

Team POC: Caroline Williams, cawilliams719@gmail.com Partner POC: Berta Olmedo Vernaza, bolmedo@recursoshidricos.org Marcelo Oyuela, moyuela@cepredenac.org Jorge Cabrera, jcabrera@sica.int

Project Overview

Project Synopsis:

Central America regularly experiences hydrometeorological events and faces flood-related hazards. Focusing on sites in Guatemala, Honduras, Nicaragua, El Salvador, Belize, western Panama, and eastern Costa Rica, this project used NASA SERVIR's Hydrologic Remote Sensing Analysis for Floods (HYDRAFloods) tool and Google Earth Engine (GEE) to create surface water maps, analyze the flood effects of Hurricanes Eta and Iota, examine precipitation trends during the case study, and design a code tutorial for partner organizations. The results provided both information and a learning resource to help monitor surface water, prepare for flood events, and inform risk management.

Abstract:

In November 2020, Hurricanes Eta and Iota hit Central America within weeks of each other, causing severe flooding, landslides, and widespread damage. NASA DEVELOP partnered with Comité Regional de Recursos Hidráulicos (CRRH), Centro de Coordinación para la Prevención de los Desastres en América Central y República Dominicana (CEPREDENAC), and Sistema de la Integración Centroamericana (SICA) to better understand how flooding throughout Central America has impacted and will continue to affect communities, focusing on sites in Guatemala, Honduras, El Salvador, Belize, Nicaragua, western Panama, and eastern Costa Rica from January 2015 to September 2021. The team utilized surface reflectance data from Landsat 7 Enhanced Thematic Mapper Plus (ETM+), Landsat 8 Operational Land Imager (OLI), Sentinel-2 MultiSpectral Instrument (MSI), Suomi National Polar-orbiting Partnership Visible Infrared Imaging Radiometer Suite (NPP VIIRS), and Terra Moderate Resolution Imaging Spectroradiometer (MODIS). This project also utilized backscatter data from Sentinel-1 C-band Synthetic Aperture Radar (C-SAR) and elevation

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data from the Shuttle Radar Topography Mission (SRTM). Incorporating these Earth observations in NASA SERVIR's Hydrologic Remote Sensing Analysis for Floods (HYDRAFloods) tool run on Google Earth Engine (GEE), the team produced historical surface water maps, a case study analysis of the two hurricanes, and a code tutorial. These results indicated that surface water increased in priority sites from 2015 to 2021, optical and SAR imagery detected similar flood patterns and extent after the hurricanes, and rainfall was concentrated on the east coast of the region. These products allow partners to make informed decisions around flooding preparation and disaster mitigation.

Key Terms: Central America, Hurricane Eta, Hurricane Iota, HYDRAFloods, flood mapping, disaster management, tropical cyclones

National Application Areas Addressed: Disasters, Water Resources

Study Location: Selected sites in Guatemala, Honduras, Nicaragua, El Salvador, Belize, western Panama, and eastern Costa Rica

Study Period: January 2015 – September 2021

Community Concerns:

- In November 2020, Hurricane Eta and Iota brought catastrophic winds and rain of unprecedented strength to Central America. These storms caused 189 deaths and an estimated \$738 million in damages to homes and infrastructure.
- Hurricane Eta and Iota are the most severe natural disasters to affect Honduras in more than 20 years. Several major roads were inundated or destroyed, isolating more than 180,000 people from humanitarian access.
- Several Central American nations had to resort to unofficial emergency shelters to accommodate an
 estimated 351,300 of the 5.2 million people affected by the storms. In Honduras and Guatemala,
 many of the unofficial shelters were schools.
- As climate change threatens to increase the frequency and intensity of these storms, it is crucial to understand how flooding has affected communities in Central America in an effort to prepare for future events.

Project Objectives:

- Produce historical surface water maps utilizing Earth observations to compare with resources and infrastructure data and identify areas vulnerable to flood events
- Conduct a case study analysis on Hurricane Eta and Iota in Central America using the HYDRAFloods tool
- Provide a code tutorial on the HYDRAFloods tool to improve near real-time flood monitoring for the partners and serve as capacity building training
- Examine precipitation trends during Hurricanes Eta and Iota to facilitate the incorporation of
 precipitation data into the workflows of the Comité Regional de Recursos Hidráulicos (CRRH)

Partner Overview

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Organization	POC (Name, Position/Title)	Partner Type	Boundary Org?			
Comité Regional de Recursos	Berta Olmedo Vernaza, Executive	End User	Yes			
Hidráulicos (CRRH)	Secretary					
Centro de Coordinación para la	Marcelo Oyuela, GIS & Remote	End User	Yes			
Prevención de los Desastres en	Sensing Specialist					
América Central y República						
Dominicana (CEPREDENAC)						

Sistema de la Integración	Jorge Cabrera, Executive Secretary	End User	No
Centroamericana (SICA)			

Decision-Making Practices & Policies:

SICA is an intergovernmental body that coordinates the integration of policy and economy between seven Central American member states and the Dominican Republic. Decision-making is driven by consensus of the member states through several systems. CRRH and CEPREDENAC are both specialized institutions of SICA. Headquartered in Costa Rica, CRRH is a technical body that coordinates water resource projects of the region, from their design to identifying funding. Through these activities, it aims to strengthen water-related policies at the national scale. At the regional and global scales, CRRH seeks to strengthen Central American ties to meteorological surveillance, hydrological cycle, climate change, adaptation, and mitigation programs. Headquartered in Guatemala, CEPREDENAC focuses on natural disaster prevention, mitigation, and response by coordinating the international exchange of information and experiences, as well as technical and scientific assessment for the region. All end user organizations have used remote sensing techniques before and are familiar with some NASA Earth observations.

Earth Observations:				
Platform & Sensor	Parameter	Use		
Landsat 7 ETM+	Surface reflectance	Surface reflectance was acquired from the HYDRAFloods tool to monitor flooding characteristics of the region.		
Landsat 8 OLI	Surface reflectance	Surface reflectance was acquired from the HYDRAFloods tool to monitor flooding characteristics of the region.		
Sentinel-1 C-SAR	Backscatter	Backscatter data was utilized in the HYDRAFloods tool to examine surface water and flooding across the study area.		
Sentinel-2 MSI	Surface reflectance	Surface reflectance was acquired from the HYDRAFloods tool to monitor flooding characteristics of the region.		
Suomi NPP VIIRS	Surface reflectance	Surface reflectance was acquired from the HYDRAFloods tool to monitor flooding characteristics of the region.		
Terra MODIS	Surface reflectance	Surface reflectance was acquired from the HYDRAFloods tool to monitor flooding characteristics of the region.		
SRTM	Elevation data	Elevation was incorporated for terrain corrections and to mask shadows at high elevation that could be confused with surface water.		

Earth Observations & End Products Overview

Ancillary Datasets:

- Climate Hazards Center InfraRed Precipitation with Station data (CHIRPS) Precipitation case study analysis and supplementary to end products
- European Space Agency (ESA) World Cover 10m 2020 V100 Landcover for overlaying with flooded areas of interest in case study and generating a final landcover map
- La Comisión Centroamericana de Ambiente y Desarrollo (CCAD) Watersheds (2008) shapefile Conduct Zonal Statistics Analysis
- CEPREDENAC Priority Sites Polygons of areas of interest affected by Eta and Iota for case study
 analysis

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- Multi-Error-Removed Improved Terrain (MERIT) Hydro Hydrologically adjusted elevation (based on several products including SRTM) for satellite imagery preparation
- Environmental Systems Research Institute (ESRI) World Countries (Generalized) (January 2015) Polygons of world countries for raster clipping
- UNIGIS International Association UIA World Country Boundaries (Generalized) Polygon layer for study area shapefile
- European Coommission's Joint Research Centre (JRC) Yearly Water Classification History, v1.3 surface water location, distribution, and extent from 1984 to 2020 for comparison with historical surface water maps

Software & Scripting:

- Hydrologic Remote Sensing Analysis for Floods (HYDRAFloods) Flooding analysis and case study investigation
- Google Earth Engine (GEE) Python API Data retrieval and processing
- ArcGIS Pro 2.7 Map generation

End Products:

End Product	Earth Observations Used	Partner Benefit & Use	Software Release Category
Historical Surface Water Maps	Sentinel-1 C-SAR, SRTM	These maps will identify historically flood-prone areas and give partners the capacity to identify areas that are susceptible to flooding due to the infrastructure and resources of the study region.	N/A
Hurricane Eta and Iota Case Study Analysis	Landsat 7 ETM+, Landsat 8 OLI, Sentinel-1 C-SAR, Sentinel-2 MSI, Suomi NPP VIIRS, Terra MODIS, SRTM	This case study will provide partners with a detailed example of how HYDRAFloods can be utilized to study flood events in their area.	Ι
Precipitation Analysis	CHIRPS	This will give the partners an analysis of the rainfall that occurred during Hurricanes Eta and Iota and allow them to see which areas received the most rainfall.	Ι
Code Tutorial	N/A	The tutorial will give partner organizations an understanding of how to use the HYDRAFloods tool for flood visualization. They will be able to use this tool to monitor future flood-related events in near real-time.	I

Product Benefit to End User:

SICA, CRRH, and CEPREDENAC are crucial organizations in Central America for monitoring and responding to flood-related events. The results of this project will provide these partner organizations with surface water maps that highlight historically susceptible flooding areas, a case study of the devastating Hurricanes Eta and Iota, and a code tutorial that will enable them to utilize HYDRAFloods to observe future flood events using NASA Earth observations. Partners will be able to use this information to aid in flood monitoring and response as well as in the decision and policy-making processes.

References

- Centro de Coordinación para la Prevención de los Desastres en América Central y República Dominicana and United Nations Office for Disaster Risk Reduction. (2014). *Informe Regional del Estado de la Vulnerabilidad y Riesgos de Desastres en Centroamérica*. https://reliefweb.int/report/world/informeregional-del-estado-de-la-vulnerabilidad-y-riesgos-de-desastres-en-centroam
- Sistema de la Integración Centroamericana. (2021). *SICA Bodies and Institutions*. SICA Sistema de la Integración Centroamericana. https://www.sica.int/sica/instituciones_en.aspx
- United States Agency for International Development. (2021). Latin American-Storms Fact Sheet #4. https://www.usaid.gov/sites/default/files/documents/2020_11_27_USAID-BHA_Latin_America_Storms_Fact_Sheet_4.pdf