**NASA DEVELOP National Program**

NASA Marshall Space Flight Center

**Summer 2014**

**Andes Mountains Disasters**

*Utilizing NASA Earth Observations to Model Volcanic Hazard Risk Levels in Areas Surrounding the Copahue Volcano in the Andes Mountains*

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**Applied Sciences National Application Addressed:**

Disasters

**Study Area:** Copahue Volcano, Andes Mountains, Chile-Argentina Border, South America

**Study Period:** January 2003 - June 2014

**Partners/Collaborators**

NASA SERVIR: Eric Anderson, Science and Technology Integration Lead

**80-100 Word Blurb**

Copahue is a stratovolcano, located along the Chile-Argentina border, whose recent eruptions have released volcanic ash causing the cancellation of hundreds of flights and the evacuation of thousands of people living in proximity. Areas surrounding the volcano are likely to be affected in the event of an eruption, but its isolated location has left it poorly monitored and in need of new methods to prioritize evacuation measures. The objective of this project was to address the volcanic hazard risk at the Copahue Volcano and the surrounding communities through mapping historic volcanic deposits and developing a volcanic hazard risk map.

**Community Concerns**

* Copahue is an active volcano that is poorly monitored, endangering the surrounding communities, primarily Caviahue and Banos Copahue.
* Recent eruptions have released volcanic ash, causing the cancellation of hundreds of flights and the evacuation of thousands of people in surrounding regions.
* Identification of areas at greatest risk of being affected by hazards produced by small to moderate-sized eruptions are needed for emergency planning to help better prioritize aid and evacuation measures.

**Current Management Practices & Policies**

Currently, Chile and Argentina utilize sparse seismic ground stations, visual confirmation, and satellite imagery to monitor the volcano. These observations aid in the alerts and evacuation orders that are issued during small eruptions. Satellite imagery, in particular, is used to divert air traffic and to create an evacuation plan for a radius of 15-25 km around the volcano. SERNAGEOMIN (Servicio Nacional de Geología y Minería) currently issues a volcano report on their government webpage with a brief description of eruption events. While this information may be easy to obtain, there may be concern that the people of smaller communities may not have reliable access to that data. SERNAGEOMIN and ONEMI (Oficina Nacional de Emergencia del Ministerio del Interior) are in charge of determining areas that should be evacuated and when; however, current techniques are not very accurate at pinpointing populations at greatest risk of volcanic hazards needed to prioritize evacuation.

**Abstract**

Copahue is a stratovolcano located along the rim of the Caviahue Caldera near the Chile-Argentina border in the Andes Mountain Range, and is estimated to have been active for the last 2 million years. There are several small towns located in proximity of the volcano with the two largest being Banos Copahue and Caviahue, located 4-9 km from the volcano. During its eruptive history, it has produced numerous lava flows, pyroclastic flows, ash deposits, and lahars. This isolated region has steep topography and little vegetation, rendering it poorly monitored. The need to model volcanic hazard risk has been reinforced by recent volcanic activity that intermittently released several ash plumes from December 2012 through May 2013. Ash emitted during these eruptions canceled hundreds of flights and forced the evacuations of thousands of people from their homes. Exposure to volcanic ash is currently the main threat for the surrounding populations as the volcano becomes more active. The goal of this project was to study Copahue and determine areas that have the highest potential of being affected in the event of an eruption. Remote sensing techniques were used to examine and identify volcanic activity and areas vulnerable to experiencing volcanic hazards including volcanic ash, SO2 gas, lava flow, pyroclastic density currents and lahars. Landsat 7 Enhanced Thematic Mapper Plus (ETM+), Landsat 8 Operational Land Imager (OLI), EO-1 Advanced Land Imager (ALI), Terra Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), Shuttle Radar Topography Mission (SRTM), ISS ISERV Pathfinder, and Aura Ozone Monitoring Instrument (OMI) products were processed using ArcGIS 10.2.1 and ENVI 5.0, and used to analyze volcanic hazards. These datasets were used to create a historic lava flow map of the Copahue volcano by identifying historic lava flows, tephra, and lahars both visually and spectrally. Additionally, a volcanic risk and hazard map for the surrounding area was created by modeling the possible extent of ash fallout, lahars, lava flow, and pyroclastic density currents (PDC) for future eruptions. These model results were then used to identify areas that should be prioritized for disaster relief and evacuation orders.

**Decision Support Tools**

* Historic Volcanic Deposits Map - a map of historic volcanic deposits denoting where ash, lavas, lahars, and pyroclastic flows have occurred as well as previous SO2 emission concentrations; this will highlight areas that have been affected during previous eruptions
* Volcanic Risk and Hazard Map - a map that depicts areas near the Copahue volcanic system that are most likely to be affected during eruptions; the map will be based on the Historic Volcanic Deposits Map as well as current elevation, land cover, and current SO2 emissions
* Data and Methodology – this information will allow end-users to recreate the techniques used to develop the final historic and hazard vulnerability maps

**Benefit to End-User:**

* Stronger understanding of the Copahue volcano hazards and risks for the surrounding communities
* Aid in the development of more defined evacuation warnings for locations identified to be at greatest risk of volcanic hazards
* Better monitoring methodology for volcanoes in developing countries that will help identify hazard and risk areas
* The ability to monitor volcanoes in remote locations

**Earth Observations & Parameters**

Aura, OMI – SO2 Monitoring

EO-1, ALI – Historic lava flow and tephra spectral signatures

ISS, ISERV Pathfinder – Land Cover

Landsat 7, ETM+ – Land Cover, spectral signatures

Landsat 8, OLI – Land Cover, spectral signatures

SRTM - Global Digital Elevation Model (DEM)

Terra, ASTER - Global Digital Elevation Model (DEM)

**Future Applicable NASA Missions**

DESDynI - InSAR

ICESat-2 - Topography, vegetation

**Models Utilized**

Consejo Superior de Investigaciones Cientificas (CSIC) Volcanic Risk Information System (VORIS 2.0.1)

Laboratoire et Volcans VolcFlow: Simulation of Volcanic Flows

USGS LAHARZ: GIS programs for automated mapping of lahar inundation hazard zones

**Ancillary Datasets Utilized**

Global Volcanism Program (GVP) - Historic Eruption Data

**Software Utilized**

ArcGIS 10.2.1 - Raster Manipulation/Analysis, Image Enhancement & Map Creation of Landsat OLI, Terra ASTER, Aura OMI, ISS ISERV, and EO-1 ALI

ENVI Classic, 5.0- Raster Manipulation/Analysis, Image Enhancement of Landsat OLI, SRTM, Terra ASTER, Aura OMI, ISS ISERV, and EO-1 ALI

MATLAB- Modeling pyroclastic density currents, running VolcFlow