**NASA DEVELOP National Program**

****Marshall Space Flight Center

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**Andes Mountains Disasters II**

*Using NASA Earth Observations to Develop a Monitoring Tool for the Copahue Volcano in the Andes Mountains*

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**Applied Sciences National Applications Addressed:**

Disasters

**Study Area:** Copahue Volcano, Andes Mountains, Chilean-Argentine Border, South America

**Study Period:** January 2012 - September 2014

**Partners/Collaborators**

NASA SERVIR: Eric Anderson, Research Associate

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**80-100 Word Blurb**

The Copahue volcano is a stratovolcano located on the Chilean-Argentine border in the Andes Mountains. In the past few years it has been quite active, the most recent eruption being on July 4th, 2014. According to the Google map, there are several towns and villages within 50km that could be affected by a large eruption from this particular volcano. The objective of this project was to generate a monitoring tool for the Copahue volcano. Daily inputs of thermal anomalies and air quality data could be used to estimate volcanic activity for more timely evacuation warnings.

**Community Concerns**

* The Copahue volcano is poorly monitored by both Chile and Argentina.
* Due to released volcanic ash by the Copahue volcano, flights were canceled and near-by towns were closed in association with the December 22nd, 2012 eruption.
* Volcanic activity can impact near-by settlements, in particular Caviahue and Baños Copahue, including the need to evacuate the settlements.
* The Grupo de Estudio y Seguimiento de Volcanes Activos (GESVA) researchers conducted fumarolic activity with the vapor and gas emissions during 2012 eruptions that caused irritated respiratory tracts and eyes.
* Monitoring thermal anomalies and SO2 levels around the volcano can help better forecast a severe eruption and aid these countries in adequate and timely evacuation warnings. According to BBC news, many civilians are hesitant to leave their homes and livestock; they choose to remain in the potential high risk zone due to the lack of understanding of volcanic activity consequences, the fear of losing their livelihood when they leave their livestock or crops, the economic impact of closing their businesses, or the expense of leaving. Many people are just trying to survive.

**Current Management Practices & Policies**

Chile and Argentina monitor the Copahue volcano due to seismic activity around the region, using sparse seismic ground stations, visual confirmation, and Earth-observing satellite imagery. A Chilean government agency, Servicio Nacional de Geología y Minería (SERNAGEOMIN), monitors the Bío Bío region and sends out alerts to the public. Currently, they continuously oversee the levels of alertness (green, yellow, red) using the measurements of the magnitude and frequency of earthquakes around the region. They also observe the volcano with several cameras around the basin, looking for activity such as constant smoke plumes, plume height and color, and the amount of ash venting out of the volcano.

**Abstract**

The Copahue volcano is located on the Andes Mountain chain, on the border between Chile and Argentina in South America. It is an active volcano and its last known eruption was on July 4th, 2014. Both Chile and Argentina have towns and villages in close proximity to the volcano, including economically vital resort areas. A paroxysmic eruption of this volcano may be devastating because of the potential volcanic ash, pyroclastic flows, lava flows, lahars, or deformation of the surface area. Both countries have issued evacuations when there have been eruptions in the past, though their citizens were hesitant to leave their property and livestock behind. Although there are towns in the vicinity of this volcano, it is located far enough from major urban areas that it is remote and hard to access for constant monitoring. The Chilean government has a Volcano Monitoring Branch (SERNAGEOMIN) which uses cameras set up on the base of the volcano to measure different forms of volcanic activity, such as the frequency of plume activity, plume height and color, and the amount of ash venting from the area. In addition to the physical observations, they track the frequency and strength of earthquakes in the area and gather some satellite imagery. SERNAGEOMIN has implemented a ranking alert system to indicate how active the volcano is becoming and when it would be wise to evacuate. Currently, Copahue is the only active volcano in the Southern Andes which has been indicated as a yellow, meaning that the volcano is on high alert and being monitored, while all other volcanoes in the region are classified as green. However, this monitoring method is in need of an enhanced methodology to monitor and identify areas at risk of volcanic activity. Remote sensing techniques can aid in the monitoring of other indicators of volcanic activity, such as thermal anomalies both on land surface area and water, SO2 emissions, and land cover. This project investigates remote-processing software options to aid in this monitoring. Data from Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS), Terra Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), Aqua Moderate Resolution Imaging Spectroradiometer (MODIS), and Aura Ozone Monitoring Instrument (OMI) were processed using ArcGIS and ENVI software to derive daily maps of land and water surface temperature variability, and sulfur dioxide emissions. By gathering this data and developing the methodology and techniques to monitor the volcano diurnal with NASA Earth observations, this project provided the end-users with novel decision-making and disaster preparation and recovery tools.

**Decision Support Tools**

* Thermal Anomalies Maps - maps showing daily land surface and water temperature differences, mainly focusing on the dates before, during and after the Copahue volcano eruptions, from the year 2012 to 2014; there was a comparison of ASTER, MODIS, and TIRS satellite products
* SO2 Emissions Maps - records of daily observations of SO2 emissions from the Copahue volcano using the period of time from 2012 to 2014
* Land Cover Maps - maps identifying the land cover classes (such as vegetation, water, bare soil, etc.); assessment of whether there is a change in land cover before and after predominant volcanic activity
* Monitoring Tool - a methodology that can be implemented into ArcGIS and used daily to estimate volcanic activity using NASA Earth observations and identify any changes in warning signs for volcanic activity

**Benefit to End-User:**

* Stronger understanding of thermal anomalies, air quality variations, and physical indications prior to eruptions
* Enhanced methodology to monitor and identify areas of thermal anomalies and SO2  emission increases
* Advantage in identifying future volcanic activity for the Copahue volcano

**Earth Observations & Parameters**

Aura, OMI - SO2 Monitoring

Aqua, MODIS - Thermal Anomalies

Terra, ASTER - Thermal Anomalies, SO2 Identification

Landsat 8, OLI & TIRS - Land Cover and Thermal Anomalies

**Future Applicable NASA Missions**

ICESat-2 - Topography, vegetation

HyspIRI – Volcanic activity

**Models Utilized**

None

**Ancillary Datasets Utilized**

UAVSAR - InSAR

**Software Utilized**

ArcGIS 10.2 - Raster Manipulation/Analysis, Image Enhancement & Map Creation of Landsat 8 OLI & TIRS, Terra ASTER, Aura OMI, and Aqua MODIS

ENVI - Land Cover Classifications of Landsat 8 OLI & TIRS