**Chile Wildfires**

*Utilizing NASA and NOAA Earth Observations to Determine Lightning-induced Wildfire Risks in Central Chile*

**Project Team**

***Project Team:***

Chris Matechik (Project Lead)

Reuben Alter

Jennifer Ruiz

Stephen Sene

***Advisors & Mentors:***

Dr. Kenton Ross (NASA Langley Research Center)

Lauren Childs-Gleason (NASA Langley Research Center)

Kristopher Bedka (NASA Langley Research Center)

***Team Contact:*** Chris Matechik, matechik4@gmail.com

***Partner Contact:*** Fernando Vázquez, [fernando.vasquez@minagri.gob.cl](mailto:fernando.vasquez@minagri.gob.cl); Jorge Saavedra Saldías, jorge.saavedra@conaf.cl

**Project Overview**

***Project Synopsis:***

Wildfires have been increasing in frequency in central Chile, and with conditions becoming warmer and drier this trend is expected to continue. Chile’s Corporación Nacional Forestal (CONAF), believes that lightning strikes could be causing many of these wildfires because the fires are occurring in areas inaccessible to humans. This project aims to create a fire risk map using lightning frequency data, fuel presence, land surface temperature, and fuel moisture content in order to aid CONAF with preventative fire risk management.

***Abstract:***

In recent years, Central Chile has experienced wildfires of increasing frequency and intensity which threaten natural resources and communities. The Corporación Nacional Forestal (CONAF) is charged with planning for, detecting, and responding to wildfires caused by a variety of ignitions. Lightning is one ignition source for wildfires, but the rate of lightning-induced wildfire ignitions is unknown. In collaboration with CONAF and the Embassy of Chile, Agricultural Office, the team used Earth observations to visually assess potential relationships between lightning strikes and wildfire ignitions and then created a wildfire risk map for Central Chile. The Active Fire Product of Suomi NPP Visible Infrared Imaging Radiometer Suite (VIIRS) provided footprints of fires, which the team compared to lightning events detected by GOES-16’s Geostationary Lightning Mapper (GLM) to determine the relationship between lightning strikes and wildfire ignitions. Next, the team aggregated and mapped lightning strikes from February 2018 through December 2021 across Central Chile. Finally, the team calculated and mapped a relative estimate of lightning-ignited wildfire vulnerability by aggregating the following ranked factors: lightning frequency, land surface temperature, and vegetation moisture content. The team was unable to establish a relationship between lightning strikes and wildfires hitherto, due to a confounding effect from fires started by other sources. However, the team successfully created wildfire risk maps for central Chile.

***Key Terms:***

lightning, remote sensing, risk map, NDMI, fuel moisture, vegetation moisture content

***National Application Areas Addressed:*** Wildfires, Disasters

***Study Location:*** Central Chile

***Study Period:*** March 1, 2019 – February 28, 2022

***Community Concerns:***

* Wildfires in central Chile have been occurring more frequently and burning with greater intensity.
* Wildfires cause economic damage by destroying tree plantations.
* Natural ecosystems are significantly disrupted by wildfires.
* Wildfires negatively impact farming and crop production, livestock health, natural resources for local cities and communities, and health and well-being of human populations.
* Wildfires, specifically in the regions wildland-urban interface (WUI) areas, have caused numerous deaths of local populations and destroyed personal property.
* In areas with steep slopes, wildfires pollute reservoirs and decrease water quality.
* Some areas are more susceptible than others, so it is critical to identify areas of greatest risk.
* Damage sustained through wildfire disasters has historically been extensive and costly, and an increase in wildfire activity provides greater potential for future wildfire occurrences.

***Project Objectives:***

* Map past lightning strikes and historic lightning-induced wildfires to visually determine the relationship between lightning strikes and wildfire ignition
* Calculate and map NDMI across fuel-laden parts of the study area as a proxy for fuel moisture content
* Map LST across fuel laden parts of the study area
* Calculate and map relative lightning-ignited wildfire risk as a function of lightning frequency, land surface temperature, fuel moisture content, and percent fuel cover

**Partner Overview**

***Partner Organizations:***

|  |  |  |
| --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** |
| **Corporación Nacional Forestal (CONAF)** | Jordi Brull Badia, Forest Engineer; Pablo Lobos, Forest Fire Manager; Tatiana Lumy Osses Acuña, Forest Engineer; Jorge Saavedra Saldías, Forest Engineer | End User |
| **Embassy of Chile, Agricultural Office** | Andres Rodríguez, Agricultural Attaché; Fernando Vásquez, Information Officer | Collaborator |

***Decision-Making Practices & Policies:***

CONAF is funded by the Chilean Ministry of Agriculture, and is responsible for the sustainable management of Chile’s forests. CONAF works on anticipating, preventing, detecting, monitoring, and suppressing wildfires in Chile’s forested and protected areas. Their primary means of detecting and monitoring wildfires is real-time, *in-situ* ­observations, either by mobile ground crews or crews stationed in watch towers, which can be ineffective due to blind spots. Aerial detection efforts supplement ground detection, but can be costly. CONAF utilizes Earth observations to monitor the extent and movement of active wildfires. Additionally, CONAF uses Earth observations to forecast fire parameters such as land surface temperature (LST), precipitation, and fuel moisture content which are used to predict the behavior of active wildfires in real-time. With this information, they can identify areas in which fires are likely to ignite. The Embassy of Chile, Agricultural Office serves as the liaison between Chilean and United States government offices. The Embassy facilitates partnerships between NASA, the DEVELOP program, and Chilean government offices, with the goal of using remote sensing technology to benefit the Chilean people and their country’s natural resources.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **GOES-16 GLM** | Total Lightning | Total Lightning indicated where and when lightning events occurred. |
| **Suomi NPP VIIRS** | Land Surface Temperature (LST), Active Fire Product | LST was incorporated as a risk factor for wildfire in the risk assessment maps. The Active Fire product identified fires used for determining the relationship between lightning and wildfires. |
| **Landsat 8 OLI** | Normalized Moisture Difference Index (NDMI) | Surface reflectance was used to calculate NDMI, a proxy for fuel moisture content |

***Ancillary Datasets:***

* CONAF wildfire fuel mask – Allowed the team to filter data to fire prone areas which were included in lightning-induced wildfire risk maps.

***Software & Scripting:***

* Python 3.10.4 – extracted, queried, and analyzed GLM Data
* Google Earth Engine – filtered, masked, and downloaded Earth observation satellite data
* ArcGIS Pro 2.9.3 – Spatial analyses, created maps

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Lightning Strike Frequency Maps** | GOES-16 GLM | Visualize lighting strike densities within central Chile to inform wildfire preventative planning efforts. | N/A |
| **LST Maps** | Suomi NPP VIIRS | Visually highlight areas within central Chile that have higher land surface temperatures and are thus more prone to wildfires. | N/A |
| **NDMI Maps** | Landsat 8 OLI | Visually highlight areas within central Chile that have drier fuels and are thus more prone to wildfires. | N/A |
| **Lightning-Ignited Fire Risk Index Maps** | GOES-16 GLM, Suomi NPP VIIRS | Display where and under what conditions lightning-ignited fires occur in central Chile to inform planned responses to climatic conditions correlated with wildfires. | N/A |

***Product Benefit to End User:***

The project will inform CONAF wildfire management and protection planning efforts. The lightning strike frequency maps will visually assist CONAF with understanding where lightning strikes are most common. The NDMI and LST maps will serve as important parameters for CONAF when predicting fire intensity and behavior. Finally, the lightning-ignited fire risk maps will show CONAF which areas are at the greatest risk for lightning-ignited wildfires. CONAF will use these products to allocate fire detection, prevention, and suppression resources. The study is not intended for long-term forecasts due to changing climate and fuel patterns, but the methodology is well-documented and can be used by CONAF to produce short term forecasts as needed.

**References**

Corporación Nacional Forestal. (2022, June 22). *Forest Fire Detection.* https://www.conaf.cl/incendios-forestales/combate-de-incendios-forestales/deteccion-de-incendios-forestales/

Corporación Nacional Forestal. (2022, June 22). *Research.* https://www.conaf.cl/incendios-forestales/prevencion/investigacion/

Ringhausen, J., Bitzer, P., Koshak, W., & Mecikalski, J. (2021). Classification of GLM Flashes Using Random Forests. *Earth and Space Science (Hoboken, N.J.), 8*(11), n/a. 10.1029/2021EA001861

Úbeda X., & Sarricolea, P. (2016). Wildfires in Chile: A review. *Global and Planetary Change, 146*, 152-161. 10.1016/j.gloplacha.2016.10.004

Villacrés, J., Arevalo-Ramirez, T., Fuentes, A., Reszka, P., & Auat Cheein, F. (2019). Foliar Moisture Content from the Spectral Signature for Wildfire Risk Assessments in Valparaíso-Chile. *Sensors, 19*(24), 5475. 10.3390/s19245475