**Pacific Northwest Health & Air Quality**

*Utilizing NASA Earth Observations to Analyze Air Quality Impacts from Wildfires in the Pacific Northwest*

**Project Team**

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**Project Overview**

***Project Synopsis:***

Decades of fire suppression and historical land management practices across the Pacific Northwest have left large swaths of land vulnerable to wildfires. Wildfire smoke plumes release aerosols into the atmosphere that are associated with increased risk of respiratory and cardiovascular diseases. To assess impacts of wildfire smoke on the Pacific Northwest’s air quality from 2008 to 2020, this project partnered with The Nature Conservancy’s Washington Chapter and the Puget Sound Clean Air Agency. This project integrated Terra and Aqua Moderate Resolution Imaging Spectroradiometer (MODIS), Terra Multi-angle Imaging Spectroradiometer (MISR), and Sentinel-5P Tropospheric Monitoring Instrument (TROPOMI) to create a web-based tool and methodology to analyze wildfire smoke plumes and pollutants.

***Abstract:***

The Pacific Northwest region of the United States and Canada has become more vulnerable to intense wildfire regimes due to years of fire suppression and climatic changes. Smoke from fires exposes communities to hazardous aerosols and pollutants known to trigger asthma symptoms and exacerbate other respiratory and cardiovascular diseases. In partnership with The Nature Conservancy’s Washington Chapter and the Puget Sound Clean Air Agency, NASA DEVELOP investigated the impacts of wildfire smoke on air quality from 2008 to 2020 using NASA Earth observations. To explore the various dimensions of smoke and its relation to air quality, the team looked at the vertical extent of smoke plumes and the resulting changes in air quality. The team evaluated the potential relationship between plume height of wildfire smoke and fire radiative power (FRP) using data from the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard the Aqua and Terra satellites and data products retrieved from Terra’s Multi-angle Imaging SpectroRadiometer (MISR) using the MISR INteractive eXplorer (MINX). The team determined that there was no regional relationship between FRP and smoke plume height. To investigate changes in air quality resulting from wildfire smoke, the team utilized data from NASA’s Fire Information for Resource Management System, from the European Space Agency’s Sentinel-5P Tropospheric Monitoring Instrument (TROPOMI), and true color imagery from Landsat 8 Operational Land Imager (OLI). The team created a Google Earth Engine-based (GEE) web tool to visualize changes in atmospheric pollutants and aerosol optical depth. Results of case study fires showed varying increases in pollutant concentrations when compared to a baseline map. The end products provided the partners with tools to quantify plume height using MINX and to visualize recent air quality patterns relating to variations in wildfire extent and severity in the Pacific Northwest.

***Key Terms:***

remote sensing, Google Earth Engine, aerosol optical depth, smoke plume height, MINX, MISR, MODIS, TROPOMI

***National Application Area Addressed:*** Health & Air Quality

***Study Location:*** North American Pacific Northwest – Washington, Oregon, Southern British Columbia

***Study Period:*** July 2008 to July 2020

***Community Concerns:***

* Wildfires are increasing in scope and severity due to historic fire suppression and increased drought conditions.
* Wildfire smoke composition includes particulate matter and other air pollutants such as nitrogen oxides, ozone, and carbon monoxide that are hazardous to human health.
* Air quality stations are concentrated in urban areas, leaving rural communities east of the Cascade Mountains with limited access to air quality monitoring.

***Project Objectives:***

* Develop a methodology to quantify vertical smoke plume height and composition in MISR INteractive eXplorer (MINX)
* Evaluate how wildfire smoke impacts air quality in the Pacific Northwest
* Provide air quality information for locations with limited access to ground-based air quality sensors
* Create a web-based tool in Google Earth Engine (GEE) to visualize air quality impacts due to fire events

**Partner Overview**

***Partner Organizations:***

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| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **The Nature Conservancy, Washington Chapter** | Brian Straniti, Central Cascades Community Coordinator | End User | Yes |
| **Puget Sound Clean Air Agency** | Erik Saganić, Technical Analysis Manager | End User | Yes |

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

The Nature Conservancy, Washington Chapter (TNC-W) seeks science-based solutions that integrate multi-scale agencies and organizations to conserve land and natural resources, improve local communities, and protect wildlife. Under the Central Cascades Management Plan, TNC-W engages in forest restoration practices to reduce the risk of wildfire, such as pre-commercial and fire-wise thinning, prescribed burning, management of forest fuels, and planting species to diversify the forest. TNC-W also conducts outreach to engage community stakeholders to create a shared vision for the land. The Puget Sound Clean Air Agency (PSCAA) is a special-purpose regional government agency that works to improve air quality in counties around the Seattle metropolitan area. The PSCAA aims to reduce the area’s contribution to climate change by monitoring air pollution, educating the public on clean-air and climate-friendly choices, and enforcing air quality regulations mandated by both the federal Clean Air Act and the Washington Clean Air Act. The PSCAA works with the Washington State Department of Ecology to operate the Puget Sound region's monitoring network that is composed of meteorological and pollutant-specific equipment to identify and monitor air quality trends.

**Earth Observations & End Products Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
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| **Aqua MODIS** |

 | Aerosol Optical Depth (AOD), Thermal Anomalies/Fire, Fire Radiative Power (FRP)  | AOD data were used in the GEE web tool as an air quality indicator. MODIS MOD14/MYD14 Thermal Anomalies-derived Fire Information for Resource Management System (FIRMS) dataset was used for locating fire events and measuring FRP.  |
| **Terra MODIS** | AOD, Thermal Anomalies/Fire, FRP | AOD data were used in the GEE web tool as an air quality indicator. MODIS MOD14/MYD14 Thermal Anomalies-derived FIRMS dataset was used for locating fire events and measuring FRP. |
| **Terra MISR** | AOD, Plume Height | The MISR AOD data were used as an air quality indicator. MISR plume measurements were used to visualize and quantify smoke plume heights. |
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| **Sentinel-5P TROPOMI** |

 | Carbon Monoxide Column Number Density, Formaldehyde Tropospheric Column Number Density, Nitrogen Dioxide Column Number Density  | Pollutant measurements for the troposphere and total atmospheric column were employed in the GEE web tool for visualization and indication of air quality. |
| **Landsat 8 OLI** | True Color Imagery | True color imagery was incorporated into the GEE tool to view actual images of wildfire smoke plumes for the user-selected date or fire event. |

***Ancillary Datasets:***

* NASA Land, Atmosphere Near real-time Capability for EOS (LANCE) Fire Information for Resource Management System (FIRMS) - Identify fire locations and hot spots for further analysis of smoke impact on air quality
* Oregon Spatial Data Library Oregon State Boundaries – Oregon Shapefile for study area map
* Washington Department of Natural Resource GIS Open Data WA State Boundary – Washington Shapefile for study area map
* British Columbia Data Catalogue Health Authority Boundaries – British Columbia Shapefile for study area map
* US Census Bureau Tigerline 2019 – States Shapefile Layer for United States Shapefiles for study area map
* ESRI Data and Maps – Canada Shapefile for study area map

***Software & Scripting:***

* Google Earth Engine API – Data acquisition and manipulation; creation of web-based air quality tool showing smoke and pollutants for the study area
* R Version 3.6.1 – MISR data download; creation of internal code to visualize MISR and plume height data
* MINX (MISR INteractive eXplorer) Version 4.1 – MISR data analysis; manual digitization of plumes and calculation of smoke plume heights
* ArcGIS Pro Version 2.5.1 – MISR data graphics, creation of study area shapefile and map

***End Products:***

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| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **Google Earth Engine Plume Hazards and Observations of Emissions by Navigating an Interactive eXplorer** (**PHOENIX) Tool** | Aqua MODISTerra MODISSentinel-5P TROPOMI  | PHOENIX provided the partners with a user-friendly way to assess wildfire smoke impacts across different temporal and spatial resolutions. This tool also provided supplemental air quality information for areas where air monitoring stations are geographically sparse.  | III |
| **MINX Methodology**  | Terra MISRTerra MODISAqua MODIS | This document is aimed at helping a user with novice-level understanding of MISR to use the MINX software.  | N/A |
| **MINX Methodology Video Walkthrough** | Terra MISRTerra MODISAqua MODIS | This recording will walk users through how to digitize a smoke plume in MINX and acts as a supplement to the MINX Methodology.  | N/A |
| **Science Communication Infographics** | N/A | Educational infographics designed with the results from PHOENIX and the MINX Methodology to provide public-facing communications for the project partners to disseminate.  | N/A |

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

TNC-W and PSCAA traditionally use information collected from ground-based sensors and occasionally use satellite imagery for standalone visuals and smoke model inputs. The end products from this project will provide TNC-W and PSCAA with additional methods to identify the distribution of smoke plumes and their impacts on public health. The end products will allow both partners to monitor air quality in areas that do not currently have ground monitoring stations. Providing partners with these tools and methodologies will assist them in learning about past smoke events and establish a framework to analyze future wildfires.

**References**

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