



Washington Health & Air Quality

Quantifying Air Quality Parameters and Validating Air Pollution Sources Impacting the Health of Puget Sound Residents Through the Use of NASA and ESA Remote Sensing Data

VPS Title: NO_x Your SO_x Off with Atmospheric Remote Sensing

Project Team

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Project Overview

Project Synopsis: This project focuses on pollutant distribution in the Puget Sound in Washington State. Anthropogenic aerosols enter the atmosphere through the burning of fossil fuels, especially from transportation. High concentrations of aerosols put vulnerable populations at risk and may cause individuals to develop critical health conditions. The project's main objective was to provide a resource within Google Earth Engine that displays aerosol optical depth (AOD) for the state of Washington. The Puget Sound Clean Air Agency (PSCAA) will use this tool to support their decisions about when to issue burn bans and in outreach efforts to ensure the public is aware of air quality notices and alerts.

Abstract:

In the Puget Sound region of Washington, high levels of air pollutants put residents' health at risk by increasing their likelihood of developing critical respiratory conditions. This project used remotely-sensed data to investigate aerosol optical depth (AOD) from NASA satellite sensors including the Terra and Aqua MODerate resolution Imaging Spectroradiometer (MODIS) and European Space Agency Copernicus Sentinel-5 Precursor TROPOspheric Monitoring Instrument (TROPOMI). The team visualized the most recent data in Google Earth Engine (GEE) API to display air pollution trends from Northern California to British Columbia, which will support the Puget Sound Clean Air Agency's (PSCAA) decision-making processes. The team performed linear regressions using the Multi-Angle Implementation of Atmospheric Correction (MAIAC) algorithm to form a relationship between ground-level microscopic particles (PM_{2.5}) and AOD in the Puget Sound region, validating the relationship using concentration readings taken from Environmental Protection Agency (EPA) air quality monitors. The team utilized estimated PM_{2.5} and other satellite data to produce a web-based tool and to evaluate the effectiveness of using such a tool for near real-time air quality monitoring within a particular region. The team found that the tool provides useful supplementary data that fills in the gaps of the PSCAA's air monitoring network.

Keywords:

Public health, MODIS, MAIAC, Sentinel-5P TROPOMI, Google Earth Engine, CALIPSO CALIOP

National Application Area Addressed: Health & Air Quality

Study Location: Washington State

Study Period: 2018 to 2019 (June through September)

Community Concerns:

- According to the Puget Sound Clean Air Agency, 1,100 people die in Washington State each year from illnesses related to air pollution.
- The most impactful air pollutants around the Puget Sound are fine particulates from wood smoke, particularly from home fireplaces and wildfires, and air toxics from diesel exhaust. Both of these pollutants can cause respiratory and cardiovascular problems, such as asthma and heart attacks.
- Diesel exhaust in particular is responsible for 78% of cancer risk from all air toxics in the Puget Sound area.
- Pollution from wood smoke and diesel exhaust disproportionately affect children, the elderly, pregnant women, and people with sensitive immune systems.

Project Objectives:

- Identify sources and dispersion patterns of air pollutants that cause heightened health risks to vulnerable communities by creating a web-based tool that identifies current trends in spatial distribution of air pollutants
- Validate the data produced by the web-based tool using *in situ* data provided by the PSCAA’s ground sensors

Partner Overview

Partner Organization:

Organization	POC (Name, Position/Title)	Partner Type	Boundary Org?
Puget Sound Clean Air Agency	Erik Saganić, Technical Analysis Manager	End User	Yes

Decision-Making Practices & Policies:

The state of Washington established the PSCAA to protect the public health of King, Kitsap, Pierce, and Snohomish counties. The PSCAA monitors air pollution, enforces regulations set by the federal Clean Air Act and the Washington Clean Air Act, and educates the community about air pollution and climate-friendly alternatives with the aim to improve air quality. The PSCAA also declares and enforces burn bans and provides public notices for wildfires and hazardous air quality levels. Hazardous air quality levels are defined by the EPA as “a quantity and duration of air emissions that are known or suspected to cause serious health effects.” The PSCAA currently provides an Air Quality Network Map that shows data collected from 16 ground stations, while also providing air quality forecasts for the region. The PSCAA does not use remote sensing in their research.

Project Benefit to End User:

The GEE Air Pollutant Identification Tool (AirPIT) will give the PSCAA the ability to assess air quality levels based on individual air pollutant concentrations as well as identify vulnerable populations. AirPIT will help the PSCAA assess levels of individual air pollutants and identify the location of vulnerable populations. AirPIT will also provide the PSCAA with the opportunity to understand how Earth observations can be used in combination with its established 16 ground sensors to support a larger in-depth analysis of various air quality parameters.

Earth Observations & End Products Overview

Earth Observations:

Platform & Sensor	Parameters	Use
Sentinel-5P TROPOMI	NO _x , CO, SO ₂ , Ozone, Methane, Formaldehyde columns	Sentinel-5P TROPOMI NO ₂ provided further insight into diesel emissions compared to ground measurements.
Terra MODIS	AOD	The team used Terra MODIS AOD to study the spatial distribution of PM _{2.5} .
Aqua MODIS	AOD	The team used Aqua MODIS AOD to study the spatial distribution of PM _{2.5} .
CALIPSO CALIOP	Averaged aerosol profile data	The team provided instructions for the PSCAA to include this data in the tool to supplement its knowledge on aerosol vertical profiling.

Ancillary Datasets:

- Puget Sound Clean Air Agency Air Quality Data – validate remotely sensed air quality measurements, such as particulate matter and nitrogen dioxide, in the Puget Sound region
- EPA AirNow Program Data – validate remotely sensed air quality measurements including particulate matter, ozone, sulfur dioxide, and nitrogen dioxide using Federal Reference Method (FRM) *in situ* data

Software & Scripting:

- Google Earth Engine API – data acquisition and manipulation, imagery processing
- Esri ArcGIS 10.5 – raster manipulation and analysis, image processing, and map production
- ArcGIS StoryMap – create technical tutorial
- Microsoft Excel 3D Map 2016 – create ground sensor map
- Microsoft Excel 2016 – data organization and linear regression performance
- LibreOffice Calc – data organization and linear regression performance

End Products:

End Products	Earth Observations Used	Partner Benefit & Use	Software Release Category
Air Pollutant Identification Tool (AirPIT)	Terra MODIS, Aqua MODIS, Sentinel-5P TROPOMI, CALIPSO CALIOP	The PSCAA will be able to use this tool to identify locations of air pollutants in Washington state during poor air quality events.	IV
Technical Story Map: NO_x Your SO_x Off	Terra MODIS, Aqua MODIS, Sentinel-5P TROPOMI	The PSCAA will be able to reference this product internally to understand how to use AirPIT and its limitations.	N/A
Validation Maps	Terra MODIS, Aqua MODIS, Sentinel-5P TROPOMI	These maps will provide a visual aid to better understand the effectiveness and limitations of AirPIT.	N/A

Project Handoff Package

Transition Plan: The team held a videoconference to hand off end products to the PSCAA. They made the end products available to the PSCAA through Google Drive. The team conducted a brief explanation of how to use AirPIT by walking the PSCAA through the technical StoryMap tutorial so that once the software release is finalized, the PSCAA can easily use the tool on its own.

Software Release Plan: The team discussed the delayed availability of the final version of AirPIT during the first partner call, and the partner was willing to wait to be able to use the tool. The team will remain in contact with the Fellow at the Alabama – Marshall node in order to stay up-to-date about the status of the software release. The team will provide a readme file along with the final code.

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Partner POC: Erik Saganić, eriks@pscleanair.gov

Handoff Package:

- Google Earth Engine Air Pollutant Identification Tool (following software release)
- Technical Paper
- Technical Story Map
- Validation Maps
- Project Poster
- Project Presentation

References

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