**NASA DEVELOP National Program**

**2020 Spring Project Proposal**

**Alabama – Marshall**

**Washington Health & Air Quality**

*Quantifying Air Quality and Air Pollution Sources Impacting the Health of Puget Sound Residents Through the Use of NASA and ESA Earth Observations*

**Project Overview**

***Project Synopsis*:** The Puget Sound region of northwest Washington is home to 4.2 million and a bustling economy in the greater Seattle metropolitan area. Due to diesel exhaust from marine transport vessels in the Puget Sound and wood smoke from wildfires, the outdoor air quality of the region is at risk. In 2018, the state of Washington experienced 1,743 wildfires that burned nearly half a million acres. In collaboration with the Puget Sound Clean Air Agency (PSCAA), this project aims to quantify air quality and examine the dispersion of air pollutants including nitrogen dioxide, carbon dioxide and particulate matter using Sentinel-5P TROPOMI and CALIPSO CALIOP. Through a wildfire risk detection product and index, vegetative stress will be identified and measured using imagery from Suomi NPP VIIRS and Aqua/Terra MODIS. These products will provide the PSCAA with supplementary data to inform their decision-making and strengthen their community outreach initiatives.

***Community Concern:*** According to the PSCAA, over 1,100 people die each year from air pollution related illnesses in the Puget Sound Region. In this area, the toxics posing the highest risks are particle pollution and smog. Much of the smog in this area stems from diesel exhaust from marine cargo vessels, and particle pollution emanates from the smoke of nearby wildfires. According to the American Lung Association, even short-term exposure to particle pollution can result in cardiovascular disease, severe respiratory inflammation, exacerbated asthma attacks, and increased mortality rates in infants, young children, and adults with pre-existed cardiovascular and respiratory illnesses. While the exhaust originating from marine vessels can be predicted, the wildfire smoke is largely unpredictable from year to year. With increasingly warmer and drier summers forecasted, smog pollution is expected to increase.

***Source of Project Idea:*** This project emerged from a discussion between Alabama – Marshall node leadership and mentors who hoped to build upon methodologies from a recent project (Alaska Disasters) while incorporating underused sensors for air quality application.

***National Application Areas Addressed:*** Health & Air Quality, Disasters

***Study Location:*** WA

***Study Period:*** January 2010 – December 2019

***Advisors:*** Dr. Jeffrey Luvall (NASA Marshall Space Flight Center), Dr. Robert Griffin (The University of Alabama in Huntsville), Dr. Mike Newchurch (The University of Alabama in Huntsville), Dr. Mohammad Al-Hamdan (NASA Marshall Space Flight Center)

**Partner Overview**

***Partner Organizations:***

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

***End User Overview***

***End User’s Current Decision-Making Process:***The PSCAA was chartered by state law in 1967 under the Washington Clean Air Act and works to protect the public health of four counties (King, Kitsap, Piece, and Snohomish). Its goal to improve air quality and reduce the area’s contribution to climate change is achieved by monitoring air pollution, enforcing air quality regulations mandated by the federal Clean Air Act and the Washington Clean Air Act, and educating the public about available clean-air and climate-friendly alternatives. The agency currently provides a suite of interactive air quality monitoring products to the public via its website. These products include an Air Quality Network Map that indicates up-to-date air quality measurements for each of the agency’s 16 stations, while also provided a localized air quality forecast of the region. The agency does not currently employ remote sensing in their research.

***End User’s Capacity to Use NASA Earth Observations:***

*Puget Sound Clean Air Agency* – The PSCAA is familiar with NASA Earth observations, but has not leveraged remotely sensed data in its decision-making practices. This project will create a replicable methodology to develop and expand its capacities to use NASA products.

***Collaborator & Boundary Organization Overview***

***Dissemination by Boundary Organizations*:**

*Puget Sound Clean Air Agency* – The agency’s Strategic Plans call for public outreach to bring awareness of air quality issues and encourage air- and climate-friendly decisions. The PSCAA has established relationships throughout the community and provides presentations to service clubs, schools, and other local organizations. This project would provide data and visual tools to use in these outreach and education efforts across the PSCAA’s current and future networks.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The Fellow will schedule an initial meeting between the project partners and the team for the first week of the term. During this meeting, the partners and team will review the project expectations and determine if any initial changes are needed. Meetings will take place with the partners via teleconference every one or two weeks throughout the term with ad hoc updates provided through email.

***Transition Plan*:** At the end of the term, an in-depth handoff package will be disseminated to the project partners via Google Drive and explained through a Google Hangouts or WebEx conference. During this meeting, the team will give a presentation of the results and field any questions that the partners may have. This will be followed by a tutorial explaining how to use the end products. This project is not likely to require software release.

**Earth Observations Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Sentinel-5P TROPOMI** | NO2 and CO columns, NO2 and CO profiles,aerosol layer height  | Sentinel-5P TROPOMI’s NO2 profile data can provide insight into emissions linked to marine vessel and automotive exhaust. NO2 and CO were also defined by the end users as a possible surrogate for aerosol optical depth (AOD), which assists with vertical information of wildfire smoke. TROPOMI’s aerosol layer height data will be used to measure biomass burning aerosol and potentially volcanic ash plumes.  |
| **Aqua MODIS** | AOD, surface reflectance | Aqua MODIS AOD data will act as a proxy for an aerosol analysis column depth to obtain vertical information of wildfire smoke. Surface reflectance will also help assess vegetation and vegetation stress for fire risk assessments. |
| **Terra MODIS** | AOD, surface reflectance | Terra MODIS AOD data will act as a proxy for an aerosol analysis column depth to obtain vertical information of wildfire smoke. Surface reflectance will also help assess vegetation and vegetation stress for fire risk assessments. |
| **Suomi NPP VIIRS** | Aerosol particle size, aerosol optical thickness, surface reflectance | These data will allow users to map AOT trajectories by depth. This dataset has a wider swath coverage (3000 km vs. 2330 km) and more sensor bands for aerosols than Aqua and Terra MODIS. Surface reflectance data will help assess vegetation and vegetation stress for fire risk assessments. |
| **CALIPSO CALIOP** | Aerosol profile | These data can delineate at what altitude aerosols are found in the atmosphere, which can then inform users about the risk of the aerosols traveling long distances and potentially causing visibility and health issues over larger geographic areas. |

***Ancillary Datasets:***

* NASA Socioeconomic Data and Applications Center (SEDAC) Gridded Population of the World (GPW) – socioeconomic data to observe the vulnerability of the communities to pollution concentrations
* NASA SPoRT Atmosphere-Land Exchange Inverse (ALEXI) Evaporative Stress Index (ESI) – Determine areas experiencing vegetation water stress
* Puget Sound Clean Air Agency Air Quality Data – Validate remotely sensed air quality measurements like particulate matter and nitrogen dioxide in the Puget Sound region
* State of Washington, Department of Ecology Air Monitoring Network Data – Validate remotely sensed air quality measurements including particulate matter, ozone, sulfur dioxide, and nitrogen dioxide with state-wide *in situ* data
* US Census Bureau Population Dataset – Census data to observe the demographic characteristics in the Puget Sound region
* US Department of the Interior, LANDFIRE, Landscape Fire and Resource Management Planning Tool – Identify vegetation and fuel data

***Software & Scripting:***

* Esri ArcGIS 10.5 – Raster manipulation and analysis, imagery processing, and map production
* Google Earth Engine API – Data acquisition and manipulation, imagery processing

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Air Pollution Hot Spot Maps** | Partners will quickly obtain a better understanding of the spatial distribution of the worst concentrations of air pollution to inform their decision making about health concerns to at-risk populations. | These hot spot maps will illustrate the spatial distribution and the degree of pollution concentration averages of indices from Sentinel-5P TROPOMI, Terra and Aqua MODIS, and Suomi NPP VIIRS over a period of 2 years. | I |
| **Puget Sound Air Quality Assessment** | The assessment will be similar to an Air Quality Index in that it will delineate levels of air pollution and associated potential health risks, but socioeconomic factors like income levels will also be considered with respect to the spatial distribution of air pollution. Partners can determine how socioeconomic factors might make a population more vulnerable to highly concentrated air pollution.  | This assessment will utilize the spatial dispersion of pollution from the Air Pollution Hot Spot Maps in conjunction with *in situ* data from the *In situ* data from the State of Washington’s Air Monitoring Network and the PCAA and socioeconomic data from NASA’s SEDAC GPW. | I |
| **Pollution Solution Google Earth Voyager Story** | In order to facilitate the communication of research findings to our partners and a wider non-technical audience, the team will produce an interactive Google Earth Voyager Story. | The Voyager Story will be created using Google Earth’s Voyager online platform and will include visualizations of the aforementioned deliverables. | I |
| **Washington Fire Risk Assessment** | Partners will use this risk assessment to inform their decision making regarding monitoring and/or evacuating high risk fire areas. They can also monitor these high risk fire areas for air pollution issues resulting from wildfires. | NASA SPoRT’s ALEXI ESI, the Department of Interior’s LANDFIRE tool, and surface reflectance data from Aqua and Terra MODIS will be used to classify areas as a low, medium, and high-risk of fire.  | I |

***End User Benefit*:** This project will provide the end user with supplementary methods to visualize and assess its Clean Air targets. The end products will enhance the agency’s understanding of how Earth observations can be used in conjunction with its established reporting mechanisms to provide a more robust analysis of various air quality parameters and if desired, can be a way to inform the agency and its partners of potential increases of pollution.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 2020 Spring

***Related DEVELOP Work:***

2019 Fall (LaRC) – Central America Health & Air Quality: Identifying Particulate matter and Aerosols in Central America Using NASA Remote Sensing Data

2019 Spring (MSFC) – Alaska Disasters: Evaluating the Atmosphere-Land Exchange Inverse Evaporative Stress Index to the Alaskan Environment to Determine Wildfire Likelihood

2018 Fall (LaRC) – Intermountain West Health & Air Quality: Monitoring Regional Air Quality to Address Air Pollution in National Parks Through the Application of NASA Earth Observations

2018 Spring (ARC) – California Health & Air Quality: Measuring California Air Quality through the Use of NASA Earth Observations to Identify Spatial, Temporal, and Social Disparities in Particulate Matter Pollution

**Notes & References:**

***Notes*:** The main focus of this project is the suite of air quality products, due to the direct benefit to the end-user. Should there be additional time after the completion of the air quality end products, the team can examine wildfire risk as defined in the Washington Fire Risk Assessment end product.

While SO2 may be measurable in areas with extreme circumstances (volcanic activity), it is not a parameter to pursue state-wide with high expectations. If there is volcanic activity contributing to air quality during the study period, it may be useful to incorporate (using Sentinel-5P).

There is a multitude of air quality data available from the state of Washington (none of which is remotely sensed). This would provide excellent opportunities for validation (<https://fortress.wa.gov/ecy/enviwa/>, <https://data.wa.gov/browse?q=air%20quality&sortBy=relevance>, <https://secure.pscleanair.org/windrose>).

The end-user is interested in potentially using satellite data to help verify its pre-existing models in better or new ways. The PSCAA works with other local governments to form AIRPACT, a CMAQ based model that attempts to capture all emissions in the Pacific Northwest (<http://lar.wsu.edu/airpact/gmap/ap5/ap5.html>). The PSCAA is working to expand its GIS/remote sensing staff but would appreciate web-based tools in the immediate future. The PSCAA also mentioned the new GOES17 data is helpful to them, so this could be incorporated, time permitting.

***References:***

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