**San Joaquin Valley Health & Air Quality**

*Evaluating the Overlap of Social Vulnerabilities and Air Quality in the San Joaquin Valley Air Pollution Control District*

**Project Team**

***Project Team:***

Jonathan Szeto (Project Lead)

Jasper Beardslee

Piper Christian

Bethany MacCarter

Alma Quintero

***Advisors & Mentors:***

Dr. Kenton Ross, NASA Langley Research Center (Science Advisor)

Dr. Travis Toth, NASA Langley Research Center (Science Advisor)

Dr. Liz Wiggins, NASA Langley Research Center (Science Advisor)

Lauren Childs-Gleason, NASA Langley Research Center (Science Advisor)

***Fellow:***

Julianne Liu (Virtual Environmental Justice)

***Team Contact:*** Jonathan Szeto, jonszeto2013@gmail.com

***Partner Contact:*** Jermaine Reece, jermaine@littlemanila.org

**Project Overview**

***Project Synopsis:***

Leveraging data from Terra and Aqua MODIS, Sentinel-5P TROPOMI, CALIPSO CALIOP, and Suomi NPP VIIRS alongside sociodemographic data, the team mapped the distribution of active fires, Nitrogen Dioxide (NO2), and Aerosol Optical Depth (AOD) across the San Joaquin Valley. The team found that AOD was slightly higher in agricultural regions, NO2 was higher along transportation corridors and urban areas, and South Stockton, a historically redlined community, had high vulnerability to both AOD and NO2. These findings will help the project partner, Little Manila Rising, in their air quality advocacy and grassroots environmental health interventions.

***Abstract:***

Little Manila Rising (LMR) is a nonprofit in Stockton, California that has been increasingly concerned by the air pollution in their city and the neighboring San Joaquin Valley (SJV). Geographical factors, climate conditions, and anthropogenic activities, such as agriculture burning and vehicle emissions, contribute to the high levels of air pollution in this region. To visualize the distribution of air pollution and social disparities across the SJV, LMR partnered with NASA DEVELOP. The DEVELOP team used Terra/Aqua MODIS, Sentinel-5P TROPOMI, and CALIPSO CALIOP to observe Aerosol Optical Depth (AOD), Nitrogen Dioxide (NO2), and the vertical distribution of pollutants at varying pollution levels, respectively. Additionally, Suomi-NPP VIIRS provided active fire data. By leveraging NASA Earth Observations along with sociodemographic and public health data, the DEVELOP team created maps identifying the areas experiencing the highest vulnerabilities and disparities in pollution exposure. The team found that AOD was slightly higher in agricultural regions, while NO2 was consistently higher along transportation corridors and urban areas. Wildfires dominated the type of detected active fires, and there was high correlation (R2 = 0.6924) between active fires and burn permits in agricultural tracts. Furthermore, the team identified both high AOD vulnerability and high NO2 vulnerability in census tracts in South Stockton, an area that has been historically redlined and disinvested in, and where LMR resides. There was also a high correlation between air quality reported from the satellites and in-situ ground monitors. These results will support LMR’s organizing strategies for stricter enforcement of air pollution regulations and increased public health equity for community members.

***Key Terms:***

Agricultural fires, air quality, CALIPSO, Environmental Justice, MODIS, San Joaquin Valley, Sentinel-2, VIIRS, aerosol optical depth, nitrogen dioxide

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

***Study Location:*** San Joaquin Valley, CA (San Joaquin, Stanislaus, Merced, Madera, Fresno, Kings, Tulare, and Kern counties)

***Study Period:*** January 2012 to December 2022

***Community Concerns:***

* SJV experiences some of the worst air quality in the nation and, for the past 25 years, has annually failed to meet federally established standards for both particulate matter (PM) 2.5 and ozone (Rodriguez-Delgado, 2022). Major sources of pollutant include agricultural crop burning and vehicle emissions, which are of primary concern to LMR (Hixson et al., 2012, Chen et al., 2014, Enayati Ahangar et al., 2022).
* Due to this heavy pollution burden, a 2020 health survey found that 19.5% of adolescents aged 1 – 17 were diagnosed with asthma, compared to the state rate of 11.9% for adolescents (California Health Interview Survey, 2020).

***Project Objectives:***

* Model air pollution distribution across the San Joaquin Valley
* Visualize disparities in air pollution impact based on social vulnerability
* Identify the overlap between poor air quality and regional burning
* Validate remotely sensed and ground-based air quality data

**Partner Overview**

***Partner Organization:***

|  |  |  |
| --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** |
| **Little Manila Rising** | Jermaine Reece, Operations and Air Quality Manager | End User |

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

With a strong emphasis on EJ and health equity, LMR strives to reduce exposure to environmental hazards, such as air and water pollution, to promote health and wellness regardless of socioeconomic background throughout the South Stockton community (Little Manila Rising, n.d.). LMR hosts a variety of environmental health programs, including Skywatch, an initiative to better understand pollution patterns by providing free air quality sensors to Citizen Scientists; DAWN (Decreasing Asthma Within Neighborhoods), a free asthma program for community members; and Youth Advocates, an effort to engage young people from Stockton in EJ advocacy. Among their policy initiatives, LMR advocates for the California Air Resource Board (CARB) to better regulate agricultural burning and is calling upon the City of Stockton to discontinue the Crosstown Freeway, a major polluter in the city. Our NASA DEVELOP end products will reinforce LMR's existing grassroots initiatives and advocacy efforts.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Aqua MODIS** | Aerosols | We used Terra and Aqua MODIS data to measure Aerosol Optical Depth (AOD) over space and time. |
| **Terra MODIS** | Aerosols | We used Terra and Aqua MODIS data to measure Aerosol Optical Depth (AOD) over space and time |
| **CALIPSOCALIOP** | Aerosols | We used CALIPSO CALIOP data to measure aerosol extinction profile (height in atmosphere and thickness of aerosols) and vertical feature mask (aerosol subtype). |
| **Sentinel-5P TROPOMI** | Atmospheric Gases | We used Sentinel-5P TROPOMI to measure Nitrogen Dioxide (NO2) over space and time. |
| **Suomi NPP VIIRS** | Fires | We used Suomi NPP VIIRS to locate the presence of active fires and compare them to the presence of burn permits. |

***Ancillary Datasets:***

* EPA EJScreen: Environmental Justice Screening and Mapping Tool – CSV text file providing total population, poverty population, minority status, percent low income, unemployment rates, less than high school education, age less than 5 years, age greater 65 years, and life expectancy data used for Social Vulnerability Index
* CDC Community Health Measures (PLACES) – CSV text file providing pulmonary disease rate, coronary heart disease rate, asthma rates, and health insurance rate data used for Social Vulnerability Index.
* NASA AERONET – In-situ AOD daily averages used for validation with Terra and Aqua MODIS
* Eat Crops Don’t Breathe Crops U.C. Berkeley San Joaquin Valley Burn Permitting Locations – Excel file of burn permit locations and dates used to compare with active fire data
* USDA Cropland Data Layer – Shapefile of cropland presence to determine relationship between land use type and pollution
* US Census Bureau TIGER dataset – Used for zonal statistics of pollution by census tract and shapefiles of county and state boundaries.
* Google Earth Engine 7.3.2.5776 - Processed AOD and NO2 satellite data for maps and time series analyses.

***Software & Scripting:***

* **Python 3.11.0** – Used to extract Vertical Feature Mask and extinction coefficient from CALIPSO CALIOP
* **ESRI ArcGIS** **3.1.2** – Used to generate raster and vector maps of distribution of AOD, NO2, fires, and land use type
* **R 4.3.1** – Used to conduct Principal Component Analysis of demographic data and validate satellite-derived pollution data with EPA and AERONET ground sensor data
* **Microsoft Excel** **Microsoft 365** – Used to plot time series data and graph/calculate regressions for validation data
* **QGIS** **3.32.1 'Lima'** – Utilized for tutorial for community partner to interact with data layers and present to stakeholders

***End Products:***

|  |  |  |
| --- | --- | --- |
| **End Product(s)** | **Earth Observations Used** | **Partner Benefit & Use** |
| **Agricultural Burning Map Package**   * Active Fire Distribution Map * Agricultural Land Use Map * **Burn Permit Map** * Active Fire/AOD Bivariate Map. | USDA’s Cropland Data Layer  Suomi NPP VIIRS | These maps demonstrate that there is a higher AOD presence in agricultural areas and areas with active fires. Partners may use these maps in their advocacy for stricter agricultural burn regulations. |
| **Air Quality Indicator Map Package**   * AOD Concentration Map * NO2 Concentration Map * AOD Time Series * NO2 Time Series * Vertical Feature Mask * AOD Validation Graphs * NO2 Validation Graph | Terra and Aqua MODIS  Sentinel 5-P TROPOMI  AERONET  CALIPSO CALIOP  Suomi NPP VIIRS | AOD and NO2 concentration maps and time series will help partners understand the spatial and temporal distribution of pollutants in SJV. The Vertical Feature Mask helps partners understand the composition and location of aerosols in the atmosphere. AOD and NO2 validation ensures that our data is high quality and demonstrates how well our satellite measurements can act as proxies for ground-based pollution concentrations. |
| **Social Vulnerability Indicator Map Package**   * **San Joaquin Valley Social Vulnerability Index Map** * **San Joaquin County Social Vulnerability Index Map** | N/A | By demonstrating the distribution of certain sociodemographic indicators, partners can share our visualizations to demonstrate how pollution exposure compounds upon pre-existing disparities and injustices. |
| **Pollution Vulnerability Indicator Map Package**   * AOD Vulnerability Map * NO2 Vulnerability Map | Terra and Aqua MODIS  Sentinel 5-P TROPOMI | Partners will be able to identify regions and corridors where populations face greater risks when exposed to pollution, informing targeted interventions. |
| **Creative Communication Deliverable**   * Two-page flyer in Spanish and English which summarizes our findings | Terra and Aqua MODIS  Sentinel 5-P TROPOMI | Our two-page flyer communicates the relationship between land use type, NO2, and AOD to help LMR inform their community of risks and advocate for pollution interventions. |
| **QGIS Data Package and Tutorial** | Terra and Aqua MODIS  Sentinel 5-P TROPOMI  Suomi NPP VIIRS | This tutorial will build our partners’ capacity in GIS and allow them to display our findings in an interactive format for their advocacy work. |

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

Our maps and figures will provide strong visualizations that reinforce the observations and lived experiences of those with whom LMR works. Our maps and figures on cropland distribution, active fires, and AOD presence will help our partners show the relationship between agricultural burning and air pollution, aiding them in their advocacy for data-driven policy interventions. Our visualizations of elevated NO2 concentrations in urban areas and along transportation corridors may assist in their efforts to protect residents who live within those regions. Our bivariate choropleth maps on NO2 and AOD vulnerability support their assertions that the historically redlined South Stockton community is disproportionately impacted by air pollution and help them identify neighborhoods to prioritize with grassroots interventions. Our capacity-building support in working with remotely sensed air quality imagery will build upon their existing air quality sensing program so that they can utilize more tools to communicate air quality issues.

***Project Continuation Plan:***

In the Spring 2024 term, a NASA DEVELOP project will work with LMR to map urban heat island effect in the San Joaquin Valley and Stockton area, providing more data to support LMR’s various environmental justice initiatives. Additionally, the San Joaquin Valley Health and Air Quality team intends to pursue publication of their findings from this term to make their work more broadly accessible.

**References**

California Department of Public Health. (2020). *California breathing county asthma data tool*. California Breathing County Asthma Data Tool. https://www.cdph.ca.gov/Programs/CCDPHP/DEODC/EHIB/CPE/Pages/CaliforniaBreathingCountyAsthmaProfiles.aspx

Hixson, M., Mahmud, A., Hu, J., & Kleeman, M. J. (2012). Resolving the interactions between population density and air pollution emissions controls in the San Joaquin Valley, USA. *Journal of the Air & Waste Management Association*, *62*(5), 566–575.<https://doi.org/10.1080/10962247.2012.663325>

Little Manila Rising. (n.d.). *More than History*. Little Manila Rising. <https://littlemanila.org/more-than-history>

Rodriguez-Delgado, C. (2022, June 16). *California has some of the worst air quality in the country. The problem is rooted in the San Joaquin Valley*. PBS NewsHour. <https://www.pbs.org/newshour/nation/california-has-some-of-the-worst-air-quality-in-the-country-the-problem-is-rooted-in-the-san-joaquin-valley>