**San Joaquin Valley Health & Air Quality II**

*Assessing Urban Heat Island Distribution and its Intersections with Air Quality to Understand Converging Vulnerabilities*

**Project Team**

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2023 Summer (VEJ) – San Joaquin Valley Health & Air Quality

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**Project Overview**

***Project Synopsis:***

The Spring 2024 NASA DEVELOP San Joaquin Valley (SJV) Health and Air Quality II team utilized Landsat 8 Thermal Infrared Sensor (TIRS), Landsat 8 Operational Land Imager (OLI), and Sentinel-5P TROPOMI Earth observations coupled with sociodemographic data to map the converging effects of land surface temperature (LST) and nitrogen dioxide (NO2) from vehicle emissions and identify areas with dense urban development and limited tree canopy cover in the city of Stockton, CA. The team partnered with Little Manila Rising (LMR), a social and environmental justice advocacy non-profit that works towards developing equitable solutions to institutionalized racism, community outreach, and urban tree planting. This project focused on identifying areas within the SJV that experience the compounding effects of low canopy cover, high air pollutants, and high land surface temperature.

***Abstract:***

The city of Stockton, California, located within the San Joaquin Valley (SJV), is a major hub for agricultural production and has endured the continuous threat to community health from nitrogen dioxide (NO2) and increasing temperatures. The convergence of these issues occurs within historically segregated communities that are disproportionately facing health risks related to heat and air quality. Little Manila Rising (LMR), a social and environmental justice (EJ) advocacy non-profit, partnered with NASA DEVELOP for a second term project to evaluate county wide urban heat islands, sociodemographic vulnerability, landcover classification, and the convergence of these variables. We utilized Landsat 8 Thermal Infrared Sensor (TIRS) and Operational Land Imager (OLI) data to produce a land surface temperature (LST) and Normalized Difference Vegetation Index (NDVI) map. They added Centers for Disease Control (CDC) socioeconomic data from 2020 to identify which communities in Stockton were more susceptible to these environmental factors. Additionally, we used imagery from National Agriculture Imagery Program (NAIP) to create a landcover map differentiating developed infrastructure from tree canopy cover. We discovered that south Stockton, where LMR resides, had the worst convergence of urban heat, air pollution, low canopy coverage and sociodemographic vulnerability compared to northern and rural parts of the city. This was further substantiated by statistical analysis showing a strong positive relationship between areas of high LST and low vegetation. The results provided LMR with compelling evidence to support in their EJ advocacy, and in their efforts to inform state officials of the discriminatory issues they face.

***Key Terms:***

Urban heat islands, environmental justice, air pollution, sociodemographic vulnerability, land surface temperature, nitrogen dioxide

***Application Area:*** Health and Air Quality

***Study Location:*** Stockton & San Joaquin County, CA

***Study Period:*** 2012 – 2023 (July – August)

***Community Concerns:***

* Due to increased urban development, there are now extensive impervious surfaces and limited vegetation throughout Stockton, causing the city to experience abnormally high temperatures and climate anomalies.
* Stockton and the SJV experience some of the worst air quality in the state. Neighborhoods in Stockton that are closer to freeways and major roads are frequently exposed to NO2, a pollutant created by vehicle emissions.
* Southern Stockton has faced racist polices such as redlining that perpetuate segregated race-based and low-income communities into areas that disproportionately face health risks from environmental issues.

***Project Objectives:***

* Produce a social vulnerability index (SVI) based on sociodemographic variables
* Identify areas of extreme heat within San Joaquin Valley and map them against the socially vulnerable regions
* Locate neighborhoods experiencing increased concentrations of NO2, taking note of overlap with our SVI
* Create a brochure with visualizations and descriptions to help inform the impacted community

**Partner Overview**

***Partner Organization(s):***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization(s)** | **Contact (Name, Position/Title)** | **Partner Type** | **Sector** |
| **Little Manila Rising** | Gloria Alonso Cruz, Environmental Justice Advocacy Coordinator | End User | Non-profit |

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

Little Manila Rising (LMR) aims to assist marginalized communities by developing solutions to harmful public policy and institutionalized racism through community development, environmental justice, health equity programs, urban forestry, and air quality sensing initiatives. LMR was first introduced to Earth observation data for fire sensing and air quality applications through the summer 2023 DEVELOP team. Although some members of the organization have GIS experience, they otherwise have not had much direct experience with remote sensing. Hoping to expand their capabilities to integrate Earth observations in their work, LMR partnered with DEVELOP for a second time., LMR will incorporate the project results about urban heat and its convergences with air quality to improve decision-making related to their Urban Forestry program, community members, and stakeholders.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Landsat 8 OLI** | Normalized Difference Vegetation Index (NDVI) | We used Landsat 8 OLI to measure NDVI over space and time. |
| **Landsat 8 TIRS** | Land Surface Temperature | We used Landsat 8 TIRS to measure land surface temperatures over space and time. |
| **Sentinel 5 TROPOMI** | Atmospheric Gases | We used Sentinel 5 TROPOMI to measure Nitrogen Dioxide over space and time. |

***Ancillary Datasets:***

* EPA EJScreen: Environmental Justice Screening and Mapping Tool – CSV file that provides population in poverty, percentage people of color, percentage less than high school education, percent low income, percentage less than the age of 5, and percentage greater than the age of 64 data used to calculate our Social Vulnerability Index
* US Census Bureau TIGER dataset – Used to provide zonal statistics of land surface temperature and NO2 by census tract. Also used as shapefile for county and city limit boundaries.
* NAIP land cover classification – Used to classify surface land cover of SJC and Stockton at high resolution

***Software & Coding Languages:***

ESRI ArcGIS Pro - vector-based analysis, raster manipulation, and map creation

R – data analysis, data set cleaning, standardization, graphing, manipulation

Python - data analysis, data set cleaning, standardization, graphing, principal component analysis

Google Earth Engine – raster manipulation, data filtering, vector-based analysis, map creation

QGIS – data set analysis, data set cleaning, zonal statistics

Microsoft Excel – census data set analysis, data set cleaning, data set standardization, SVI creation

***End Product(s):***

|  |  |  |
| --- | --- | --- |
| **End Product(s)** | **Earth Observations Used** | **Partner Benefit & Use** |
| **Social Vulnerability Map** | N/A | This map layer contains our social vulnerability index and the variables it is derived from. The map displays the social vulnerability of census tracts within SJC at various intensities. High social vulnerability index scores show increased vulnerability within census tracts and vice versa. LMR may use this map to identify areas that are vulnerable to harmful conditions including LST and NO2. |
| **Urban Heat Exposure Map** | Landsat 8 TIRS | This map layer contains average and maximum land surface temperatures for SJC for the years 2012 – 2023 and displays it on the census tract level. LMR may use this map to visualize the intensity of land surface temperatures across SJC. |
| **NDVI Map** | Landsat 8 OLI | This end product analyzed areas of highest vegetation concentration within the SJC. |
| **Land Cover Classification Map** | NAIP | This map layer divides our Stockton city limits shapefile into 7 different classes: water, developed, barren, canopy, grass, agriculture, and wetlands. LMR may use this map to visualize what the predominant land cover types are. For example, their Urban Forestry Program may benefit from this map because they can identify areas that are lacking tree canopy and decide what to do about it. |
| **Urban Heat and Air Quality Analysis Package** | Landsat 8 TIRS  Sentinel 5 TROPOMI | This map layer combines data from the Social Vulnerability Map, Urban Heat Exposure Map, and Air Quality Exposure Map to display census tracts that are vulnerable to both urban heat and NO2. Urban heat and air quality are combined into a singular weighted index with urban heat comprising 66% of the index and air quality comprising 33%. LMR may use this map to identify converging vulnerabilities in SJC and Stockton. |
| **Air Quality Exposure Map** | Sentinel 5 TROPOMI | This map layer contains average NO2 of SJC for the years 2019, 2021, and 2022 at the census tract level. LMR may use this map to identify areas that are more exposed to NO2 than others. |
| **Creative Communication Deliverable** | Landsat 8 OLI  Landsat 8 TIRS  Sentinel 5 TROPOMI | Our brochure will outline the fundamental concepts of Urban Heat Islands and its relationship with air quality in Stockton. Our brochure will be in both English and Spanish to ensure that it reaches a larger audience. We hope that the brochure will help LMR inform their community of the risks that come with increased land surface temperature and decreasing air quality. |

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

By providing our partners with visualizations of which communities experience the worst convergence of poor air quality, high temperatures, and low canopy coverage, specific treatments can be planned for future planting projects. These products can also help guide legislation to provide cooling centers throughout Stockton. All analyses conducted will provide the ability to visualize each variable along with values that quantify the high correlation and lack of randomness between them. Our partners can then use this as evidence to combat environmental injustices and racist policies.

**References**

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