**Oklahoma Health & Air Quality**

*Mapping Air Quality Using NASA Earth Observations to Investigate Recent Increases in Ozone Concentrations*

**Project Team**

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**Project Overview**

***Project Synopsis:***

During the summer of 2018, the Oklahoma Department of Environmental Quality (DEQ) reported anomalous spikes in ozone in Seiling, Oklahoma. These spikes were notable given the rural nature of Seiling, a city with only 875 inhabitants as of 2019. This project utilizes remotely sensed atmospheric data along with ground measurements of ozone and its precursors to determine the causes of these anomalies. This investigation will support DEQ efforts to better identify and address contributors to emissions, fill gaps in the ground monitoring network, and implement regulations to improve air quality in Oklahoma.

***Abstract:***

Tropospheric ozone (O3) is formed by anthropogenic pollutants interacting with sunlight and is considered harmful to human health in high concentrations. In the summer of 2018, the Oklahoma Department of Environmental Quality (DEQ) measured unexpected spikes in O3 in Seiling, Oklahoma, with concentrations exceeding those measured in bustling Oklahoma City and Tulsa. The DEQ tracks air quality using ground monitors and does not utilize Earth observation data in its monitoring or analysis. This project used remotely sensed data to investigate these 2018 air quality anomalies, identifying possible causes. We analyzed atmospheric data from Terra and Aqua Moderate Resolution Imaging Spectroradiometer (MODIS), and Sentinel-5P Tropospheric Ozone Monitoring Instrument (TROPOMI) in conjunction with ground-based measurements of tropospheric ozone (O3), nitrogen dioxide (NO2), methane (CH4), carbon monoxide (CO), formaldehyde (HCHO) and aerosol optical depth (AOD). We compared Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model simulations and Earth observation visualizations to pinpoint ozone spike causes. We also generated models to identify contributing factors to variations in ground ozone concentrations in our study area. The results point to a variety of ozone spike causes, primarily from outside of the state, and support the placement of additional NO2, O3, and CO monitors to the southeast of Seiling. These analyses can help guide the placement of future monitors in the ground monitoring network and inform air quality regulations in Oklahoma.

***Key Terms:***

HYSPLIT, MODIS, TROPOMI, back-trajectory analysis, emissions transport, atmospheric pollutants

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

***Study Location:*** Oklahoma

***Study Period:*** May 10 to August 10, 2018

***Community Concerns:***

* In 2018, ozone concentrations in Seiling, Oklahoma surpassed the EPA’s limit for healthy air. Officials were concerned by the size of these spikes, and were unable to determine the cause.
* Ozone poses potential individual and community health concerns. In high concentrations, it is associated with increased rates of lung cancer, asthma, and other lung-related diseases, as well as impaired cognitive function.
* Ozone can damage vegetation via oxidation through the plant's leaf openings during the respiration process. Therefore, elevated ozone concentrations also present a concern for agricultural activities in Oklahoma, particularly in Seiling where these activities predominate.
* There are considerable spatial gaps in Oklahoma’s air quality monitoring network, making it difficult to pinpoint causes for air quality anomalies, such as those seen in Seiling.

***Project Objectives:***

* Identify potential causes for ozone spikes in Seiling, Oklahoma in the summer of 2018
* Compare and link *in-situ* and satellite-based air quality monitoring approaches
* Determine pollutant hotspots across Oklahoma and pinpoint gaps in the state’s ground monitoring network

**Partner Overview**

***Partner Organization:***

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| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Oklahoma Department of Environmental Quality (DEQ), Air Quality Division** | Carrie Schroeder, Emissions Inventory Section Manager; Grant Loney, Emissions Inventory Section, Environmental Programs Specialist; Thomas Richardson, Rules & Planning Section, Professional Engineer; Cecelia Kleman, Technical Resources & Projects Section, Environmental Programs Specialist; Camas Frey, Enforcement Section Manager; Daniel Ross, Monitoring Section West, Environmental Programs Specialist | End User | No |

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

Current decision-making practices by the Oklahoma DEQ generally depend on data collected by ground monitors located throughout the state. Additionally, some emission data utilized by the agency are reported by corporations and other privately-owned businesses within the state. The Oklahoma DEQ collects this data, and then determines if levels comply with the National Ambient Air Quality Standards (NAAQS). NAAQS are federal air quality standards set by the Environmental Protection Agency (EPA) and implemented by states through the Clean Air Act. Currently, the Oklahoma DEQ does not utilize or have experience with NASA Earth observation data, software, or analysis tools to support their ozone monitoring.

**Earth Observations & End Products Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Sentinel-5P Tropospheric Ozone Monitoring Instrument (TROPOMI)** | Tropospheric NO2, Total Column Ozone, Tropospheric Formaldehyde column, Total Column Methane, Total Column Carbon monoxide | Sentinel-5P TROPOMI NO2, ozone, and formaldehyde data provided insight into emissions compared to ground measurements. Methane and carbon monoxide data gave insight into potential drivers as proxies for oil and gas activity and wildfires, respectively. |
| **Terra Moderate Resolution Imaging Spectroradiometer (MODIS)** | Aerosol Optical Depth (AOD) | The team implemented Terra MODIS AOD to study the spatial distribution of PM2.5. |
| **Aqua MODIS** | Aerosol Optical Depth (AOD) | The team implemented Aqua MODIS AOD to study the spatial distribution of PM2.5. |
| **Global Land Data Assimilation System (GLDAS)** | Air Temperature, Air Temperature Humidity, Wind Speed, Surface Pressure, Precipitation Rate | GLDAS meteorological Data elucidated modelling ground ozone variation across the study area, and helped determine which weather conditions are significant in predicting ground ozone. |
| **Landsat Earth Observing System (EOS)** | National Land Cover Database (NLCD) | NLCD Dominant land cover type was used as a predictor variable in the model. |
| **Sentinel 2 Multispectral Instrument (MSI)** | Normalized Difference Vegetation Index (NDVI) | NDVI data was used to capture seasonal vegetation changes in the Seiling model. |
| **Shuttle Radar Topography Mission (SRTM)** | Elevation | SRTM elevation data for each 1km radius surrounding ground stations was used to create datasets for the ozone prediction models. |

***Ancillary Datasets:***

* EPA Air Quality System (AQS) data – Assess ground-based air quality trends, and current monitoring capabilities and coverage of Oklahoma DEQ
* U.S. Energy Information Administration Layer Information for Interactive Maps – Calculate air quality monitor proximities to natural gas plant, power plant, and oil refinery locations.

***Modeling:***

* NOAA Hybrid Single-Particle Lagrangian Integrated Trajectory model (POC: Le Kuai, le.kuai@jpl.nasa.gov) – Back trajectory analysis of air pollutants

***Software & Scripting:***

* Python 3.9.7 – Perform a statistical investigation to identify the most significant predictors for ground level ozone and quantify their impacts on influencing ozone variance.
* QGIS 3.16 Hannover – Overlay visualizations to assess EO pollutant data
* QGIS 3.22.2 – Generate visualizations for end products

***End Products:***

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| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Air Pollutant Concentration Maps** | Sentinel-5 TROPOMI, Terra MODIS, Aqua MODIS | Daily trend maps will be used to assess spatial and temporal trends in pollutant concentrations in and around Seiling. The maps will help determine locations for new monitoring stations. | I |
| ***In-situ* Comparison Graphs** | Sentinel-5 TROPOMI | The graphs compare time series EO pollutant concentrations with the *in-situ* data at the Seiling monitoring station, and will help evaluate lags and differences between ground and satellite monitoring approaches. | I |
| **TROPOMI Visualization and Comparison Tool** | Sentinel-5 TROPOMI | This tool will support the creation of still graphics and animations of timeseries TROPOMI pollutant concentrations, allowing the DEQ to qualitatively assess the spatiotemporal distributions of atmospheric ozone and ozone precursors. | IV |
| **Emission Transport Graphics** | GLDAS | These animations will help the DEQ identify potential emission source locations and trajectories leading to ozone anomalies in Seiling during summer 2018. | I |

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

Air pollutant concentration maps and emissions transport analysis results will allow the Oklahoma DEQ to identify potential regions contributing to recent ozone anomalies in Seiling. Pinpointing these locations will inform locations for new monitors, which in the future will enable the Oklahoma DEQ to better target emissions regulations and therefore ensure cleaner air in Seiling and other hotspots across Oklahoma. Should it be found that ozone spikes are resulting primarily from wildfires, the Oklahoma DEQ can still identify new monitoring locations and perhaps identify a need for future investigation of how to predict air quality surges in the state after nearby wildfire activity. Additionally, the TROVISCO tool will allow the Oklahoma DEQ to use EO data to analyze air quality in areas where ground monitor data are not available, as well as to recreate pollutant maps and transport graphics in the future.

**References**

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