**Pacific Northwest Health & Air Quality**

*Monitoring Trends in Air Quality During a Drought Case Study to Improve Public Health Response to Drought Threats*

**Project Team**

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**Project Overview**

***Project Synopsis:***

The Pacific Northwest Health & Air Quality project examined trends between air quality and drought from 2015 to 2022 using remotely sensed and ground-based datasets. In collaboration with Washington and Oregon-based state and local health authorities, the team utilized NASA aerosol optical depth (AOD) Earth Observations, *in-situ* particulate matter (PM) data, and gridMET Standardized Precipitation Evapotranspiration Index (SPEI) data, to develop visualizations of drought and air quality over time. The results of this project supplemented partners’ research into the implications of drought on human health for public health and policy recommendations.

***Abstract:***

Recent studies have documented a correlation between air quality and drought in the United States, which has been linked with increased aerosols including airborne particulate matter (PM) during drought conditions. This study partnered with local health departments to evaluate trends in air quality in the Pacific Northwest during the evolution of drought conditions using aerosol optical depth (AOD) observations collected by NASA’s Moderate Resolution Imaging Spectroradiometer (MODIS) sensor aboard the Terra and Aqua satellites. These satellite data were analyzed in conjunction with ground-based PM2.5 and PM10 data sourced from the Environmental Protection Agency (EPA)’s network of ground-based monitors and the Standardized Precipitation Evapotranspiration Index (SPEI) drought index. Based on recommendations by local health departments, this study examined air quality trends between 2015 and 2022 in 12 counties within Oregon and Washington that reflected diversity in population density, drought exposure, rural and urban status, and data availability from EPA monitors. Overall, results indicated variation in relationships among drought, satellite, and ground-based air quality data across the study area. This study did not control for the impact of wildfire events on air quality and also did not investigate shorter SPEI aggregation periods, both of which are avenues for future research. This project supplemented research into links between drought and human health and provided health departments with an objective foundation from which they can communicate public health risks to local communities.

***Key Terms:*** Pacific Northwest, air quality, drought, MODIS, aerosol optical depth, SPEI, remote sensing, particulate matter

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

***Study Location:*** Pacific Northwest (PNW) - WA & OR

***Community Concerns:***

* Due to the observed and projected increase in hazards under a changing climate, extreme drought is an area of distinct concern in the PNW.
* Particulate air pollutants have been found to accompany extremely dry conditions. Severe drought, as well as its secondary impacts, such as wildland fires and dust storms, have been demonstrated to elevate concentrations of airborne particulate matter in the atmosphere.
* Above-normal concentrations of atmospheric PM have been shown to directly impact the physical health of the study area’s population of over 12 million people; specifically, the respiratory, cardiovascular, metabolic, renal, neurologic, and reproductive systems.
* Certain populations, including communities of color, individuals of low socioeconomic status, the elderly, and individuals with pre-existing health conditions, are particularly vulnerable to the damaging effects of substandard air quality in terms of high PM concentrations.
* Drought and wildfire events have even been shown to exacerbate mortality rates by contributing to heightened concentrations of airborne PM, increasing the demand for air quality monitoring.

***Project Objectives:***

* Integrate satellite observations with ground-based monitoring
* Generate time series of PNW air quality and drought conditions
* Map air quality and drought severity using bivariate choropleth maps

**Partner Overview**

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

|  |  |  |
| --- | --- | --- |
| **Organization(s)** | **Contact (Name, Position/Title)** | **Partner Type** |
| **Oregon Health Authority, Public Health Division** | Amber Blanchard, Emergency Preparedness Coordinator for Crook County Public Health; Victoria Clemons, CSTE Epidemiology Fellow (Environmental Public Health Tracking); Curtis Cude, Healthy Waters Program Coordinator (Environmental Public Health); Dr. Carol Trenga, Epidemiologist (Environmental Public Health Tracking, Occupational Public Health Program), Sarah Worthington, Climate and Health Program Coordinator (Crook, Deschutes and Jefferson Counties) | End User |
| **Washington State Department of Health** | Marnie Boardman, MPH, Climate & Health Coordinator (Office of Environmental Public Health Sciences); Annie Doubleday, Ambient Air Quality Epidemiologist;  Julie Fox, Environmental Epidemiologist | End User |
| **NOAA National Integrated Drought Information System** | Britt Parker, Regional Drought Information Coordinator Pacific Northwest Region | Collaborator |
| **University of Nebraska Medical Center, Water, Climate, and Health Program** | Dr. Jesse E. Bell, Director; Rachel E. Lookadoo, Director of Public Health Policy | Collaborator |

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

The Washington State Department of Health (DOH) and the Oregon Health Authority (OHA) are state government agencies that work to protect and improve the health of their citizens. Both agencies have identified air quality as a health risk associated with drought and conduct research in order to guide policy decisions and improve public health. Currently, both agencies utilize the Cyanobacteria Assessment Network (CyAN), which is created by the EPA, NASA, and NOAA using satellite data, to monitor for algal blooms in Oregon freshwater systems, but other use of remote sensing is limited. The University of Nebraska Medical Center (UNMC)’s Water Climate and Health Program leads interdisciplinary research, education, and solutions to public health challenges associated with water and climate globally. The NOAA National Integrated Information System (NIDIS) aims to improve national capacity to manage drought-related risks with resources to assess, prepare, mitigate, and respond to drought. As part of its mission to engage in case studies of drought and air quality with local health authorities, UNMC’s Water, Climate, and Health Program also facilitated collaboration between NASA DEVELOP, NIDIS, and our project end users, the Washington State DOH and OHA. NIDIS collaborated on this study to expand its efforts to address public health risks posed by drought and support other end-user organizations who aim to understand patterns in health impacts caused by regional drought.

**Earth Observations & End Products Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Aqua MODIS** | AOD | Data were used as a proxy of particulate matter concentration to indicate air quality across the entire study period. The MCD19A2 Version 6.1 data product, equipped with the Multi-Angle Implementation for Atmospheric Correction (MAIAC) algorithm, is a gridded Level 2 product produced daily at 1 kilometer (km) pixel resolution. |
| **Terra MODIS** | AOD | Data were used as a proxy of particulate matter concentration to indicate air quality across the entire study period. The MCD19A2 Version 6.1 data product, equipped with the Multi-Angle Implementation for Atmospheric Correction (MAIAC) algorithm, is a gridded Level 2 product produced daily at 1 kilometer (km) pixel resolution. |

***Ancillary Datasets:***

* EPA Air Quality System (AQS) – Measure PM2.5 (particulate matter sized less than 2.5 microns in diameter), and PM10 (sized less than 10 microns in diameter) as additional air quality indicators across the study period.
* gridMET Standardized Precipitation Evapotranspiration Index (SPEI) – Measure drought severity according to intensity and duration to explore how air quality changes between drought onset, main, and amelioration phases.

***Software & Scripting:***

* Google Earth Engine Application Programming Interface (API) - Processing of MODIS satellite imagery and gridMET SPEI data
* R 4.2.0 – Data manipulation, plotting, and statistical analyses
* ArcGIS Pro 3.0.0 - Data visualization, interaction
* ArcGIS Pro 3.1.2 - Data visualization, interaction

***End Products:***

|  |  |  |
| --- | --- | --- |
| **End Products** | **Earth Observations Used** | **Partner Benefit & Use** |
| **Time Series Trend Analyses of Air Quality and Drought Conditions** | Terra & Aqua MODIS | This visualization will be used to evaluate trends in air quality indicators across drought conditions during the case study. It will support partners to assess which air quality metrics are associated with changing drought conditions, supporting their identification of potential health risks regional droughts pose to local populations. |
| **Bivariate Choropleth Air Quality and Drought Hazard Maps** | Terra & Aqua MODIS | These maps will allow partners to visualize air quality and drought data, supporting them to assess locations that saw trends over the study period, and locate areas of interest to better understand the relationship between conditions. The methodology will increase potential for incorporating remote sensing methods into future air quality monitoring. |
| **One-Page Informational Flyer** | Terra & Aqua MODIS | This one-pager will support communication about trends in air quality during drought conditions throughout the case study, supplementing partners’ efforts to share research pertaining public health to local communities. |

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

The end results of this project will provide the partners with a comprehensive collection of datasets, methodology, and products to highlight air quality trends during drought conditions in Oregon and Washington between 2015–2022. The time series trend analysis will help end users better understand changes in air quality associated with drought at the regional level, along with influence, timing, magnitude, and extent. The air quality and drought hazard maps will help visualize data to assess locations that experienced trends over the study period. The one-page informational flyer will support communication about the project and place an emphasis on the viability of NASA Earth observations for future air quality indication. End products will supplement research into the implications of drought on human health by state and local health authorities and provide partners with an objective foundation from which they can make public health recommendations. This project also has the capacity to increase understanding of remote sensing methods for air quality and increase potential for incorporating remote sensing methods into air quality monitoring in the future.

**References**

Berman, J. D., Ebisu, K., Peng, R. D., Dominici, F., & Bell, M. L. (2017). Drought and the risk of hospital admissions and mortality in older adults in Western USA from 2000 to 2013: A retrospective study. *The Lancet Planetary Health*, *1*(1). <https://doi.org/10.1016/s2542-5196(17)30002-5>

Liu, Y., Austin, E., Xiang, J., Gould, T., Larson, T., & Seto, E. (2021). Health Impact Assessment of the 2020 Washington State Wildfire Smoke Episode: Excess Health Burden Attributable to Increased PM2.5 Exposures and Potential Exposure Reductions. *GeoHealth*, *5*(5). <https://doi.org/10.1029/2020gh000359>

McClure, C. D., & Jaffe, D. A. (2018). US particulate matter air quality improves except in wildfire-prone areas. *Proceedings of the National Academy of Sciences*, *115*(31), 7901–7906. <https://doi.org/10.1073/pnas.1804353115>

Sharratt, B. S., & Lauer, D. (2006). Particulate matter concentration and air quality affected by windblown dust in the Columbia Plateau. *Journal of Environmental Quality*, *35*(6), 2011–2016. <https://doi.org/10.2134/jeq2006.0212>

Simon, S. D. (2022). Census bureau (U.S.). *Encyclopedia of Big Data*, 155–158. https://doi.org/10.1007/978-3-319-32010-6\_257