NASA DEVELOP National Program
2023 Summer Project Workplan

North Carolina – NCEI
Pacific Northwest Health & Air Quality
Monitoring Trends in Air Quality during a Drought Case Study to Improve Public Health Response to Drought Threats

Project Overview

Project Synopsis: In partnership with the University of Nebraska Medical Center (UNMC)'s Water, Climate, and Health Program, NOAA National Integrated Drought Information System (NIDIS), Oregon Health Authority (OHA), and Washington State Department of Health (DOH), this project will examine changes in air quality during recent drought conditions in the Pacific Northwest. The project team will measure trends in air quality indicators including Aqua and Terra MODIS aerosol optical depth (AOD) and Suomi NPP VIIRS aerosol optical thickness (AOT) alongside *in situ* monitoring information from EPA Air Quality System (AQS). Using data from the U.S. Drought Monitor (USDM) and Standardized Precipitation Evapotranspiration Index (SPEI), the team will evaluate these trends during the evolution of drought conditions and construct maps depicting areas in Oregon and Washington vulnerable to changes in air quality across the study period.

Study Location: OR, WA
Study Period: January 2000 – May 2023; Case Study Focus: January 2015 – December 2022

Advisor(s): Dr. Jesse Berman berma186@umn.edu, Dr. Babak Fard (University of Nebraska Medical Center's Water, Climate, and Health Program) babak.jfard@unmc.edu, Ronald Leeper (NOAA National Centers for Environmental Information, North Carolina Institute for Climate Studies) ronald.leeper@noaa.gov, Jared Rennie (NOAA National Centers for Environmental Information) jared.rennie@noaa.gov, Molly Woloszyn (NOAA National Integrated Drought Information System) molly.woloszyn@noaa.gov

Partner Overview

Partner Organizations:

Organization	Contact (Name, Position/Title)	Partner Type	Sector
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	End User	State Government

	Health Program), Sarah Worthington, Climate and Health Program Coordinator (Crook, Deschutes and Jefferson Counties)		
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	State Government
NOAA National Integrated Drought Information System	Britt Parker, Regional Drought Information Coordinator Pacific Northwest Region	Collaborator	Federal Government
University of Nebraska Medical Center, Water, Climate, and Health Program	Dr. Jesse E. Bell, Director; Rachel E. Lookadoo, Director of Public Health Policy	Collaborator	Academic

End User Overview

End User's Current Decision-Making Process & Capacity to use Earth Observations: UNMC's Water, Climate, and Health Program addresses public health concerns related to climate and water resources through research, education, community engagement, and the facilitation of policy development. The Water, Climate, and Health Program currently uses NASA Earth observations to study human health impacts of drought with associated reductions in air quality at the national level; they are interested in engaging in a case study of drought in partnership with a local health department to improve public health responses to drought and support human health outcomes at a regional level. NIDIS was created to develop a national drought early warning system and disseminate information and resources in support of community preparation for, response to, and mitigation of drought effects. NIDIS is interested in expanding efforts to address public health risks posed by droughts across the United States by supporting health departments to understand patterns in regional drought health impacts and reduce adverse health outcomes from drought in local communities. To support the health of Oregon residents, OHA improves quality of and access to health care across the state. Currently, OHA uses 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. The OHA is interested in examining health impacts related to drought to support hospital systems to prepare for impending drought events and expanding real-time reports, which currently focus on wildfire smoke conditions, to incorporate signals of air quality. The Washington State Department of Health (DOH) works alongside state, federal, and private organizations to support public health across Washington state. Like OHA, the DOH intends to incorporate CyAN into their work. With the creation of the Climate Commitment Act (CCA), the DOH is interested in assessing where potential vulnerabilities due to climate change and drought events occur in Washington to guide policy decisions on region-scale intervention priorities.

Earth Observations Overview

Earth Observations:

Platform & Sensor	Parameter(s)	Use
Aqua MODIS	AOD	Trends in AOD—a measure of aerosol column concentration based on extinction of optical beam power as it passes through the atmosphere—will be used as a proxy of particulate matter concentration to indicate air quality across the

		entire study period. The MCD19A2 Version 6.1 data product is a gridded Level 2 product produced daily at 1 kilometer (km) pixel resolution.
Terra MODIS	AOD	Trends in AOD—a measure of aerosol column concentration based on extinction of optical beam power as it passes through the atmosphere—will be used as a proxy of particulate matter concentration to indicate air quality across the entire study period. The MCD19A2 Version 6.1 data product is a gridded Level 2 product produced daily at 1 kilometer (km) pixel resolution.
Suomi NPP VIIRS	AOT	Trends in AOT—a measure of the scattering and absorption of visible light by particles in a vertical column of the atmosphere—will be used as a proxy of particulate matter concentration in the atmosphere as higher values of AOT correspond to higher concentrations of particles in the atmosphere. AOT, which is analogous to AOD collected by MODIS, will be measured across the drought case study from January 2015–December 2022.

Ancillary Datasets:

- EPA Air Quality System (AQS) – Measure ozone, PM2.5, and PM10 as additional air quality indicators across the study period.
- National Drought Mitigation Center, USDA, and NOAA U.S. Drought Monitor (USDM) Drought Severity and Coverage Index (DSCI) – Calculate a single continuous, aggregated, weighted value of the proportion of an area in each drought category at the county level on a weekly timstep based on intensity, coverage, and drought duration accumulated over case study period.
- Vicente-Serrano et al., 2010 Standardized Precipitation Evapotranspiration Index (SPEI) – SPEI will be used to measure drought severity according to intensity and duration to explore how air quality changes between drought onset, main, and amelioration phases (Fig. 1).

Decision Support Tool & End Product Overview

End Products:

End Product	Partner Use	Datasets & Analyses
Time Series Trend Analyses of Air Quality and Drought Conditions	Time series of aerosols and atmospheric gasses will be used to evaluate trends in air quality indicators across recent drought conditions. These trends will support partners to assess which air quality metrics were associated with changing drought conditions, which can support partners to identify potential health risks regional droughts pose to local populations.	The team will utilize data gathered by Terra MODIS and Suomi NPP VIIRS along with the EPA Air Quality System (AQS) dataset to analyze trends in time series of air quality trends at each phase of the drought event (onset, middle, and amelioration phases).

Air Quality and Drought Hazard Maps	Air quality and drought conditions will be depicted through Air Quality and Drought Hazard Maps across the study area from 2015–2022. These maps will support partners to assess locations in Oregon and Washington that experienced potential vulnerabilities to changing air quality during recent drought conditions and may inform region-scale intervention priorities to mitigate impacts of future droughts in the region.	Observations from Terra MODIS and Suomi NPP VIIRS as well as *in situ* air quality monitoring data from the EPA Air Quality System (AQS) will be averaged across the study area along with drought monitoring data to depict drought severity and air quality variation across the study area.
Creative Communications Deliverable (TBD)	The Creative Communications deliverable will support communication about drought impacts on human health to local health departments and the public by utilizing time series trends across Oregon and Washington as a case study of environmental variation during recent drought conditions in the Pacific Northwest. This end product will support partners' understanding of potential health risks that regional droughts pose to local communities based on trends in air quality.	The Creative Communications deliverable will display the results of air quality trend analyses and hazard maps across drought conditions in the Pacific Northwest and describe human health risks associated with changes in air quality during the progression of drought events.

Project Timeline & Previous Related Work

Project Timeline: 1 Term: 2023 Summer

Similar Past DEVELOP Projects:

- Summer 2016 (LaRC & WC) – Appalachian Trail Health & Air Quality (https://develop.larc.nasa.gov/2016/summer/AppalachianTrailHealthAQ.html): https://www.devpedia.developexchange.com/dp/index.php?title=Appalachian_Trail_Health_%26_Air_Quality_LaRC_%26_WC_Summer_2016
- Fall 2019 (LaRC) – Central America Health & Air Quality (https://develop.larc.nasa.gov/2019/fall/CentralAmericaHAQ.html: https://www.devpedia.developexchange.com/dp/index.php?title=Central_America_Health_%26_Air_Quality_LaRC_Fall_2019
- Spring 2020 (MSFC) – Washington Health & Air Quality (https://develop.larc.nasa.gov/2020/spring/WashingtonHAQ.html): https://www.devpedia.developexchange.com/dp/index.php?title=Washington_Health_%26_Air_Quality_MSFC_Spring_2020
- Summer 2020 (ARC) – Pacific Northwest Health & Air Quality (https://develop.larc.nasa.gov/2020/summer/PacificNorthwestHAQ.html): https://www.devpedia.developexchange.com/dp/index.php?title=Pacific_Northwest_Health_%26_Air_Quality_ARC_Summer_2020
- Fall 2021 (LaRC) – Southeast Michigan Health & Air Quality (https://appliedsciences.nasa.gov/what-we-do/projects/identifying-trends-ground-level-ozone-precursors-southeast-michigan-and):

https://www.devpedia.developexchange.com/dp/index.php?title=Southeast_Michigan_Health_%26_Air_Quality_LaRC_Fall_2021

- Spring 2023 (VEJ) – Great Salt Lake Health & Air Quality (https://appliedsciences.nasa.gov/what-we-do/projects/monitoring-lakebed-exposure-and-its-impact-air-quality-and-environmental): https://www.devpedia.developexchange.com/dp/index.php?title=Great_Salt_Lake_Health_%26_Air_Quality_VEJ_Spring_2023

Related to other NASA work?

The University of Nebraska Medical Center is currently conducting a NASA-funded project using NASA air quality and drought monitoring data products to evaluate health outcomes associated with drought events. This project was created to inform the development of public health tools and resources to support public health departments' preparation for and response to drought and associated human health impacts. By supporting decision-making activities, this project aims to mitigate negative health outcomes associated with drought.

Notes & References:

Notes: Earth Trends Monitor in TerrSet is a potential platform for generating time series analyses due to the variety of tools available to study trends in time series through this program. However, time series could be generated through other software programs along with time change maps. Many of the air quality and environmental datasets are currently available through Google Earth Engine (GEE), and previous DEVELOP projects have constructed tools to visualize using air quality indices in GEE based on those datasets.

Project technical ranking: 3.25/4

References:

Abadi, A. M., Gwon, Y., Gribble, M. O., Berman, J. D., Bilotta, R., Hobbins, M., & Bell, J. E. (2022). Drought and all-cause mortality in Nebraska from 1980 to 2014: Time-series analyses by age, sex, race, urbanicity and drought severity. *Science of the Total Environment*, *840*, Article [156660]. https:// https://doi.org/10.1016/j.scitotenv.2022.156660

Fard, B. J., Puvvula, J., & Bell, J. E. (2022). Evaluating changes in health risk from drought over the contiguous United States. *International Journal of Environmental Research and Public Health*, *19*(8), Article [4628]. https://doi.org/10.3390/ijerph19084628

Lynch, K. M., Lyles, R. H., Waller, L. A., Abadi, A. M., Bell, J. E., & Gribble, M. O. (2020). Drought severity and all-cause mortality rates among adults in the United States: 1968–2014. *Environmental Health*, *19*, Article [52]. https:// https://doi.org/10.1186/s12940-020-00597-8

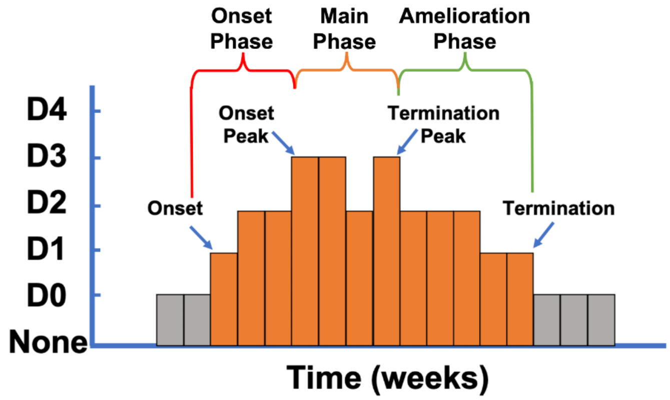


Figure 1. Overview of drought evolution, courtesy of Ronald Leeper.

2023 Summer Project Work Plan

Objectives and Priorities

1. **Air quality trend analysis** using satellite observations and *in situ* data
    - MODIS/VIIRS aerosol optical depth and aerosol optical thickness
        - Aggregate satellite air quality data around ground-based EPA Air Quality System monitoring locations
    - EPA Air Quality System
2. **Drought analysis**
    - Correlating drought conditions with changes in air quality using SPEI and USDM DSCI data
3. **Air quality and drought mapping**
    - Map air quality and drought severity across the study area

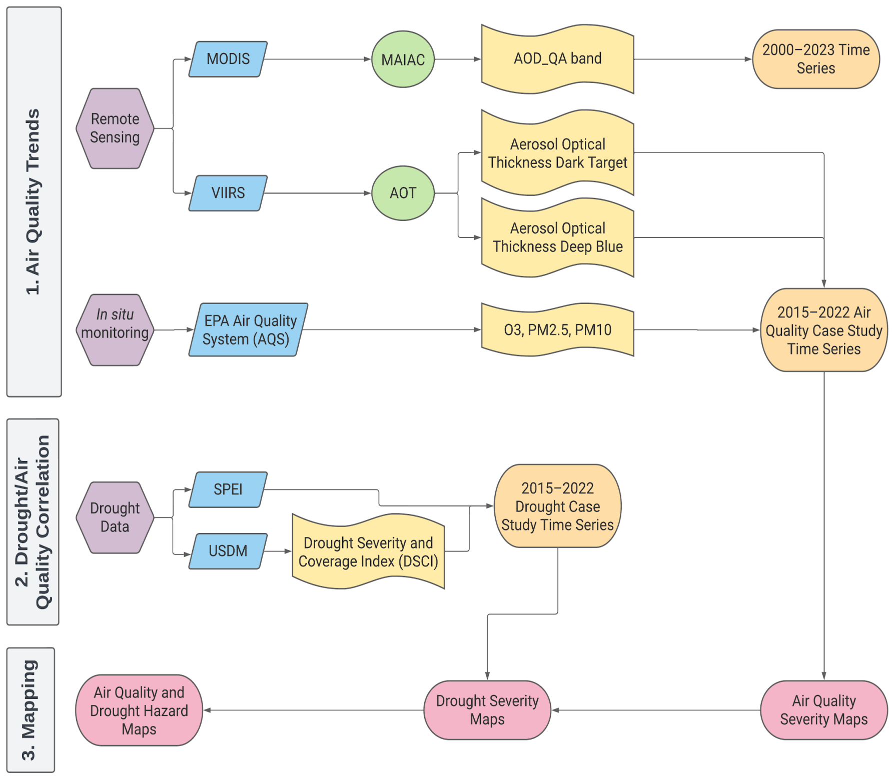
Decision Support Tool & End Product Overview

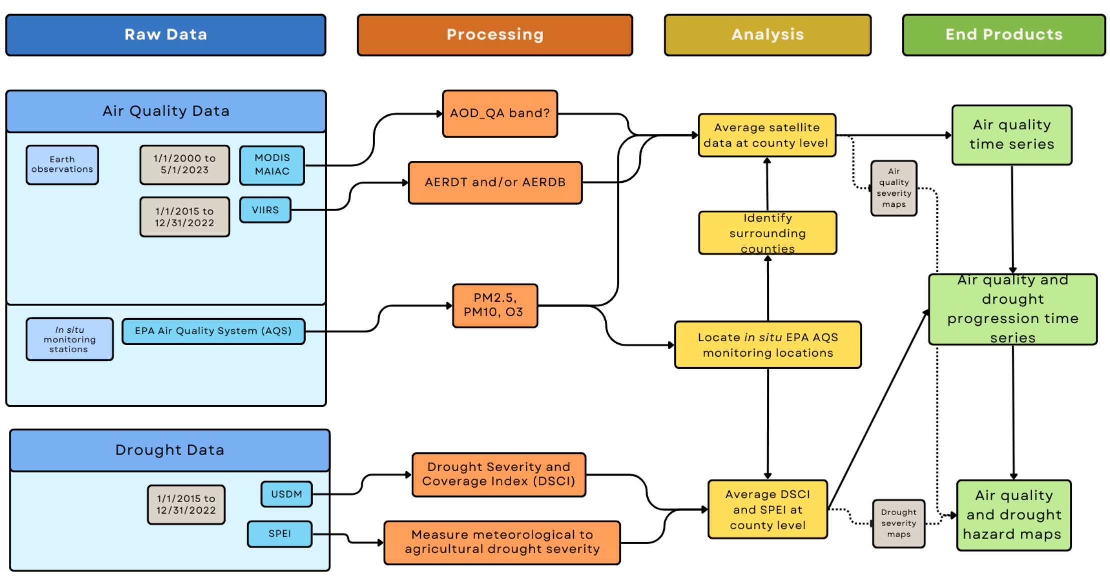
- Air quality and drought time series analysis
- Air quality and drought hazard map
- Communications tool

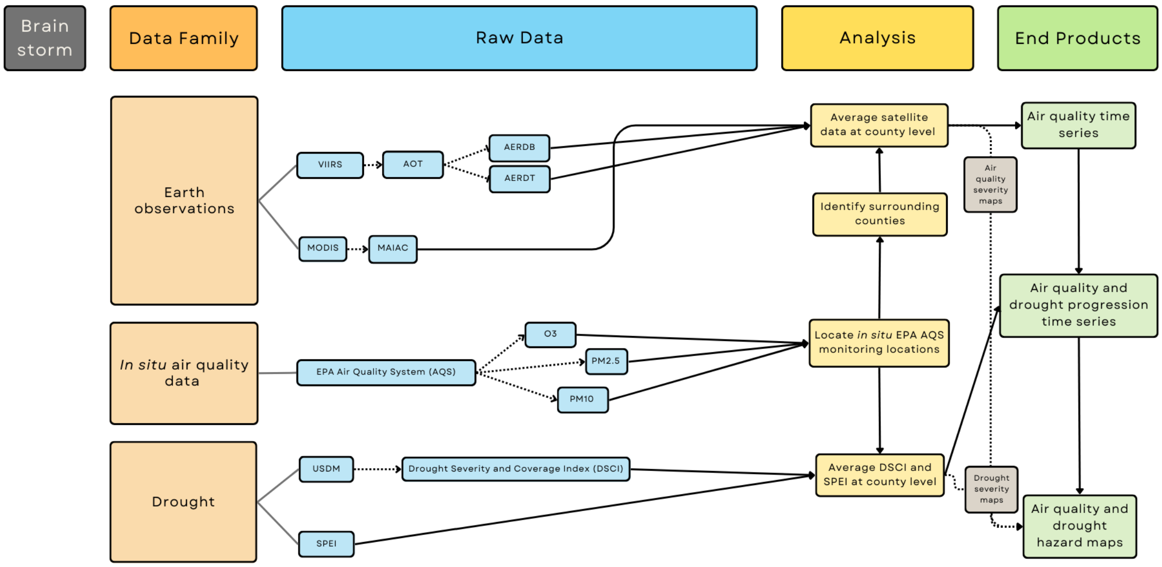
Potential Workflow

Editable methodology flowchart links:

- LucidChart priorities
- Canva
- Canva intro presentation


1. Air Quality Trends
2. Drought/Air Quality Correlation
3. Mapping
Remote Sensing
MODIS
VIIRS
MAIAC
AOT
AOD_QA band
Aerosol Optical Thickness Dark Target
Aerosol Optical Thickness Deep Blue
2000–2023 Time Series
In situ monitoring
EPA Air Quality System (AQS)
O3, PM2.5, PM10
2015–2022 Air Quality Case Study Time Series
Drought Data
SPEI
USDM
Drought Severity and Coverage Index (DSCI)
2015–2022 Drought Case Study Time Series
Air Quality and Drought Hazard Maps
Drought Severity Maps
Air Quality Severity Maps


Raw Data
Processing
Analysis
End Products
Air Quality Data
Earth observations
1/1/2000 to 5/1/2023
MODIS MAIAC
1/1/2015 to 12/31/2022
VIIRS
In situ monitoring stations
EPA Air Quality System (AQS)
Drought Data
1/1/2015 to 12/31/2022
USDM
SPEI
AOD_QA band?
AERDT and/or AERDB
PM2.5, PM10, O3
Drought Severity and Coverage Index (DSCI)
Measure meteorological to agricultural drought severity
Average satellite data at county level
Identify surrounding counties
Locate in situ EPA AQS monitoring locations
Average DSCI and SPEI at county level
Air quality severity maps
Drought severity maps
Air quality time series
Air quality and drought progression time series
Air quality and drought hazard maps



Earth Observations Overview

MODIS:

- MAIAC Aerosol Optical Depth (AOD)
  - Dataset in Google Earth Engine

VIIRS:

- With MODIS sunsetting in the coming years, we will also be pointing project partners to VIIRS data, which will be continuing the MODIS Climate Data Record (CDR).
  - There are two potential sources of VIIRS data for this project:
    1. VIIRS MAIAC Aerosol Optical Thickness (AOT)
       - MAIAC description from VIIRS Land
       - Dr. Alexei Lyapustin, the PI for the VIIRS MAIAC product, said that re-processing of VIIRS will start this summer and may continue for several months. I have requested that they share data from OR and WA between January 2015 and December 2022, but these data may not become available in time to incorporate into the project.
    2. If the VIIRS MAIAC product is not available, there are two other options for analyzing VIIRS data. Either or both of these can be incorporated based on your capacity for analysis and your literature review on which would be more appropriate:
       - VIIRS Dark Target Aerosol Optical Thickness (AERDT)
         - If we are unable to incorporate VIIRS MAIAC data into the project, we will look to the VIIRS Dark Target product to analyze AOT:
         - SNPP VIIRS, L2 Swath, 6-Minute, Dark Target Aerosol Optical Thickness (AERDT_L2_VIIRS_SNPP)

- VIIRS Deep Blue Aerosol Optical Thickness (AERDB)
    - SNPP VIIRS, L2 Swath, 6-Minute, Deep Blue Aerosol Optical Thickness ([AERDB_L2_VIIRS_SNPP]())

Ancillary Datasets

EPA Air Quality System:

- O3, PM2.5, PM10 [data download]()

In situ *Air Quality Data:*

- Here are maps of the coverage of different air quality monitoring networks across Oregon and Washington. In this project, we plan to aggregate satellite-based measures of air quality around ground-based monitoring locations to validate those satellite measurements. If necessary, we can bring in other sources of *in situ* air quality data for additional validation.

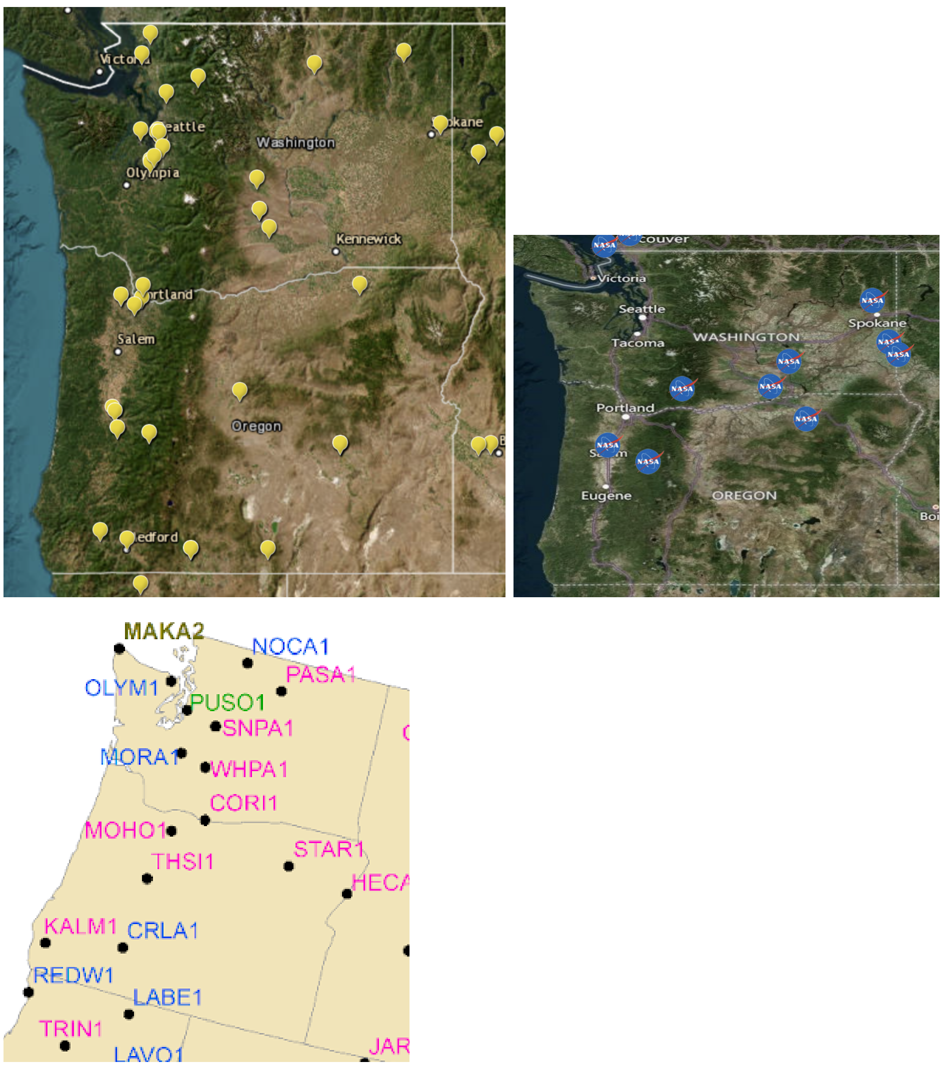


Figure 2. Air quality monitoring networks mapped from right to left: EPA Air Quality System, NASA AErosol RObotic NETwork (AERONET), and Interagency Monitoring of Protected Visual Environments (IMPROVE).

US Drought Monitor (USDM):

- Data download from the USDM website
- With air quality variables monitored continuously rather than in discrete categories like the USDM (none–D4), the science advisors are interested in incorporating continuous measures of drought in this project. We will use the Drought Severity and Coverage Index (DSCI) to convert drought levels from the U.S. Drought Monitor map to single values.
    - From Babak Fard: [DSCI] numbers do not have any physical interpretation by themselves. Similar to vulnerability scores that can be used to compare and rank different locations. Compared to D0 to D4 categories, the use cases can be other. As I remember, when a category (e.g. D4) is assigned to a county, it means that at least one of its considered areas is in D4, all others in a lower severity level. Therefore, that can be used for crisis management and planning since that shows the maximum within each county. Whereas DSCI considers all areas and their related category in its calculation, a weighted average. Therefore, the pick points of drought might vanish on that average. At the same time, it gives a better understanding of the general situation, and I think it can be used for long-term, usual condition planning.
    - From Johnson et al. (2020) *Building an Improved Drought Climatology Using Updated Drought Tools: A New Mexico Food-Energy-Water (FEW) Systems Focus*: "DSCI was developed as a method for converting categorical USDM drought levels to a single continuous aggregated value for a specified area. To compute the DSCI using a weighted average, a weight of 1 through 5 is given to each USDM category (D0–D4), and this weight is then multiplied by the categorical percent area for the drought category, and these totals are summed together (Equation 1). This results in a DSCI value that has a continuous scale of 0–500."
    - From Smith et al. (2020) *Calibrating Human Attention as Indicator Monitoring #drought in the Twittersphere*: "The DSCI is a weighted sum of the proportion of an area in each category of drought. It converts the weekly U.S. Drought Monitor categories of intensity into a single value that takes areal coverage and magnitude of the drought into account for an area (county, climate division, climate region, National Weather Service Regions, River Forecast Center Regions, urban areas, as well as USDA Climate Hub regions). These weekly values can be accumulated throughout a drought period for a given location for comparison with other drought periods. This index, containing not only drought intensity and coverage but also the duration when accumulated over a period of time, can provide a single summary statistic representative of an entire drought."
    - Link to a UDSM page about DSCI
    - Map link including documentation

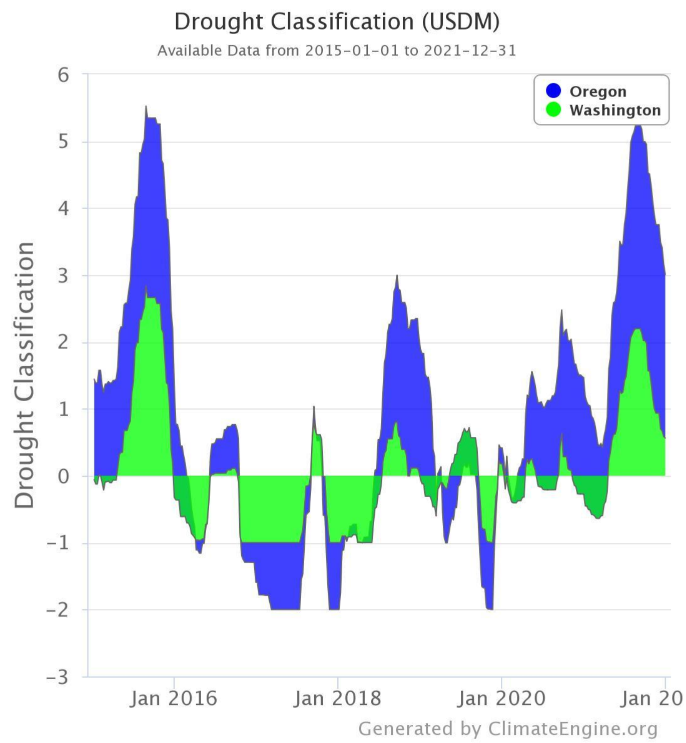


Figure 3. Drought classification across the study area and case study period generated using USDM data in Climate Engine.

Standardized Precipitation Evapotranspiration Index (SPEI):

- SPEI from GRIDMET is available in [Google Earth Engine]
- SPEI from nClimGrid-Monthly in NetCDF is available from [NOAA/NIDIS/NCEI]
    - Python Drought Indices [open-source package]

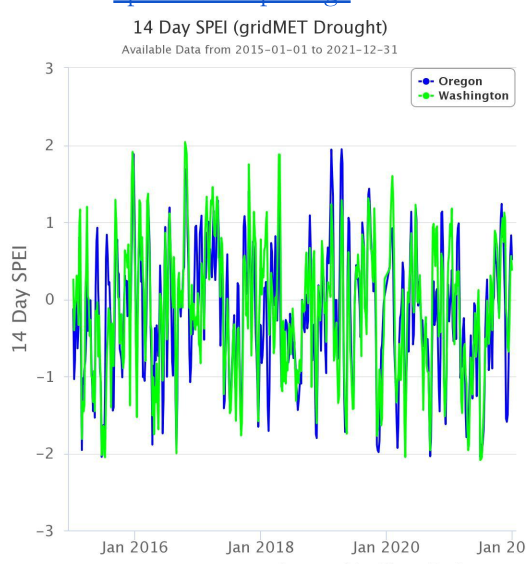


Figure 4. SPEI across the study area and case study period generated using gridMET drought data in Climate Engine.

Potential Platforms

- Google Earth Engine will be used to analyze MODIS MAIAC and TROPOMI data
- Climate Engine (link to the research app) is a great starting point for looking into datasets, including SPEI and USDM. We'll be meeting with Steve Ansari - NOAA Federal to go over some of the functionalities of this tool.
    - Tutorials
    - Data Search Spreadsheet
    - Support site
    - API
    - API Cloud Run
- Earth Trends Monitor in TerrSet is a potential platform for generating time series analyses
- Discussing which platforms to use to analyze EPA AQS and VIIRS AOT data would be a great question to ask during the first science advising meeting. Ronnie is most familiar with RStudio and Jared might be more familiar with Python.

Subject Matter Exploring

Please note that trainings are optional, and project work should be prioritized before taking trainings.

ARSET Trainings:

Listed in order of relevance.

1. Introduction to Satellite Remote Sensing for Air Quality Applications (introductory, five 1 hour sessions) link
    - NASA ARSET: Overview of Webinar Series and an Introduction to Satellite Remote …
    - NASA ARSET: Fundamentals of Remote Sensing Imagery and Tools to Access, Part …
    - NASA ARSET: NASA Aerosol Products for Particulate Matter Air Quality, Part 3/5
    - NASA ARSET: NASA Trace Gas Products, Part 4/5
    - NASA ARSET: Future Satellite Capabilities for Air Quality Monitoring and Review, P…
2. Fundamentals of Remote Sensing link
    - NASA ARSET: Satellites, Sensors, Data and Tools for Land Management and Wildfir…
3. MODIS to VIIRS Transition for Air Quality Applications link (advanced, one 90-minute session)
    - NASA ARSET: MODIS to VIIRS Transition for Air Quality Applications, Part 1/1
4. Data Analysis Tools for High Resolution Air Quality Satellite Datasets link (advanced, one 1-hour session and two 2-hour sessions)
    - NASA ARSET: Introduction to Datasets, Part 1/3
    - NASA ARSET: Read, Map, and Analyze Level 2 MODIS AOD Data, Part 2/3
    - NASA ARSET: Read, Map, and Analyze OMI NO2 and SO2 Data, Part 3/3
6. An Inside Look at How NASA Measures Air Pollution link
    - NASA ARSET: How NASA Measures Nitrogen Dioxide (NO2), Part 1/2
    - NASA ARSET: How NASA Measures Particulate Matter (Aerosols), Part 2/2
7. Remote Sensing of Drought (advanced, two 1 hour sessions) link

- NASA ARSET: Remote Sensing-Based Drought Monitoring, Session 1/2
- NASA ARSET: Drought Monitoring Analysis and Application, Session 2/2

8. High Resolution NO2 Monitoring From Space with TROPOMI link
    - NASA ARSET: Remote Sensing of NO2 with OMI, Part 1/3
    - NASA ARSET: Introducing TROPOMI - High Resolution NO2 Observations from …
    - NASA ARSET: Python Tools for Analyzing NO2, Part 3/3
9. Satellite Remote Sensing of Particulate Matter Air Quality (in-person training, but online materials hosted here)
10. Applications of Satellite Observations for Air Quality and Health Exposure (in-person training, but online materials hosted here)
11. Satellite Remote Sensing of Dust, Fires, Smoke, and Air Quality (in-person training, but online materials hosted here)

MODIS and VIIRS:

- NSIDC MODIS to VIIRS: Building a time series
- LAADS DAAC MODIS/VIIRS Aerosols
- VIIRS Instruments Become More Essential As Terra and Aqua Drift from their Traditional Orbits
- MODIS
    - MAIAC
        - From MODIS Land: "MAIAC is a new advanced algorithm which uses time series (TMS) analysis and a combination of pixel- and image-based processing to improve accuracy of cloud detection, aerosol retrievals and atmospheric correction (Lyapustin et al., 2011a,b; 2012; 2018). TMS focuses on extensive characterization of the surface background in order to improve all stages of MAIAC processing. MAIAC starts by gridding MODIS L1B data to a fixed grid at 1km resolution (using area-weighted method, Wolfe et al., 1998) in order to observe the same grid cell over time and work with polar-orbiting observations as if they were geostationary.

          To enable the time series analysis, MAIAC implements the sliding window technique by storing from 4 (at poles) to 16 (at equator) days of past observations in operational memory. This helps to retrieve surface BRDF from accumulated multi-angle set of observations, and detect both seasonal (slow) and rapid surface changes. A detailed knowledge of the previous surface state also helps MAIAC's internal dynamic land-water-snow classification, including snow detection and characterization."
        - Information about the MAIAC product from Land Processes Distributed Active Archive Center (LP DAAC)
        - Tutorial: Aerosol Optical Depth from MODIS to PM2.5 using Google Earth…
        - R and Python tutorials
    - Aerosol Optical Depth global map
- VIIRS
    - The Fall 2019 LaRC Central America Health & Air Quality team used VIIRS AERDB (NOT AERBT) in their project

Wishlist Items

With 10 weeks to conduct our project, it is important to prioritize and there are a lot of additional analyses we could consider. First, focus on the objectives outlined in this proposal and if there is additional time, additional analyses could be pursued in these areas. Additionally, it is good practice to keep a running list of "future work" ideas—these will be great to mention in your presentation and technical report at the end of the term!

Wishlist item #1:

Earth Observations:

Platform & Sensor	Parameter(s)	Use
Sentinel-5P TROPOMI	Atmospheric gases	O_3 NO_2 —a proxy of NO_x—and HCHO will be measured at a 7 km x 3.5 km spatial resolution to assess air quality across the study period. CO and SO_2 will also be measured using TROPOMI data as additional air quality indicators.

TROPOMI:

- Carbon monoxide in Google Earth Engine
- Formaldehyde in Google Earth Engine
- Nitrogen dioxide in Google Earth Engine
- Ozone in Google Earth Engine
- Sulfur dioxide in Google Earth Engine

Wishlist item #2:

Project partners currently use AIRPACT in their work, so they are interested in incorporating it into his project:

- Washington State University Air Indicator Report for Public Awareness and Community Tracking (AIRPACT)
- Inquiring about how the partners might like to see this incorporated into the project would be a great discussion question for the first partner meeting. Julie Fox with the Washington DOH brought up the potential for integrating this into the project.

Additional MODIS Analyses:

- Carbon monoxide
- Aerosol size

Analyzing Aerosol Type:

- VIIRS Deep Blue Aerosol Type could categorize atmospheric aerosols (dust, smoke, high altitude smoke, pyrocumulonimbus clouds, non-smoke fine mode, mixed, background, fine dominated).

Incorporating Additional Remote Sensing Air Quality Datasets:

- Aura OMI
    - Aerosol indices: The aerosol index and ultraviolet (UV) aerosol index could measure the presence of UV-absorbing particles in the atmosphere as an indicator of air quality.