Overview of smoke forecast map

This smoke forecast tool provides a 24-hour and 48-hour prediction of the amount of smoke that can be expected in each area, from wildfires and other sources. Forecasts can be used to plan outdoor activities, and reduce exposure to air pollution. There may be areas within each zone that experience higher or lower smoke concentrations throughout the day due to various reasons. Health warnings linked to each air quality category can be found here.

This map shows expected daily average air quality conditions in different areas based on:
- Forecasts issued by local clean air agencies
- Projections by a smoke forecast model run by Washington State University
- Ecology forecasters' best professional judgement
- Note: No forecasts are made for areas without nearby monitors, or when monitoring data were unavailable.

The forecast zones shown on the map are built around Ecology's statewide network of air quality monitors, and the air quality management regions of some local air agencies. Ecology analyzed past measured and modeled data to estimate smoke levels for a zone around each monitor, based on terrain, weather patterns and other information.

The WSU forecast model uses the previous day's levels of particulate pollution, along with forecast weather conditions from a University of Washington computer model, to predict smoke for the next two days.

For more information
Appendix A and Appendix B on the following pages provide technical descriptions of these procedures.

Still have questions?
Please email Ranil Dhammapala (ranil.dhammapala@ecy.wa.gov) or call him at 360-407-6807.

Appendix A: Technical description of smoke forecast tool development

Author: Ranil Dhammapala (ranil.dhammapala@ecy.wa.gov); 360-407-6807.

Local air agency (LAA) forecasts

Four of the seven LAAs in Washington submit daily forecasts to EPA's AirNow system. Daily forecasts are not issued in areas within the jurisdiction of Ecology and the other three LAAs. Further, AirNow simply interpolates all available point forecasts using inverse distance weighting. This technique does not respect natural airshed boundaries or differing pollutant emissions in areas without forecasts.

LAA- issued point forecasts are retrieved several times a day from AirNow. PSCAA and SRCAA provided Ecology with maps (see Figure A.1) and shapefiles of their air quality management zones, so their forecasts are assigned to these areas. Where the LAA boundaries intersect the polygons described in Appendix B (hereafter referred to as "ECY polygons"), best professional judgement was used to smooth out discrepancies and preserve the LAA boundaries. The Bremerton monitor is thought to represent an additional area in Mason County across Hood Canal, which is outside PSCAA's jurisdiction. The monitor on Monroe St in Spokane lies within SRCAA's smoke control zone but also represents a large swathe further west. ORCAA and NWCAA have not yet developed such maps, and requested Ecology to assign their forecasts to ECY polygons.

WSU Machine Learning Forecasts (More detailed documentation forthcoming)

Following the successful implementation of a Machine Learning model to forecast ozone in the Tri Cities, the same approach was pursued to build a more reliable forecast product for all $PM_{2.5}$ and ozone monitoring sites in Washington, Oregon and Idaho. Site- specific O_3 and $PM_{2.5}$ vs meteorology relationships were developed using 4km WRF forecasts archived since 2017. These learned relationships describe the how the airshed's $PM_{2.5}$ (or ozone) levels have responded in recent years under different meteorological conditions. The relationships are then applied to the forecast ensemble mean meteorological parameters from UW, to construct a two day forecast. No forecasts can be made if the monitor didn't report data the previous day. More details can be found here.

The ECY polygons outside the LAA polygons in Figure A.1 are used to map these $PM_{2.5}$ forecasts.

Manual forecasts by Ecology

This option is used to override the WSU ML forecast only if a compelling reason exists, such as a large new fire that isn't handled well by the forecast model. No changes to LAA forecasts are envisaged.
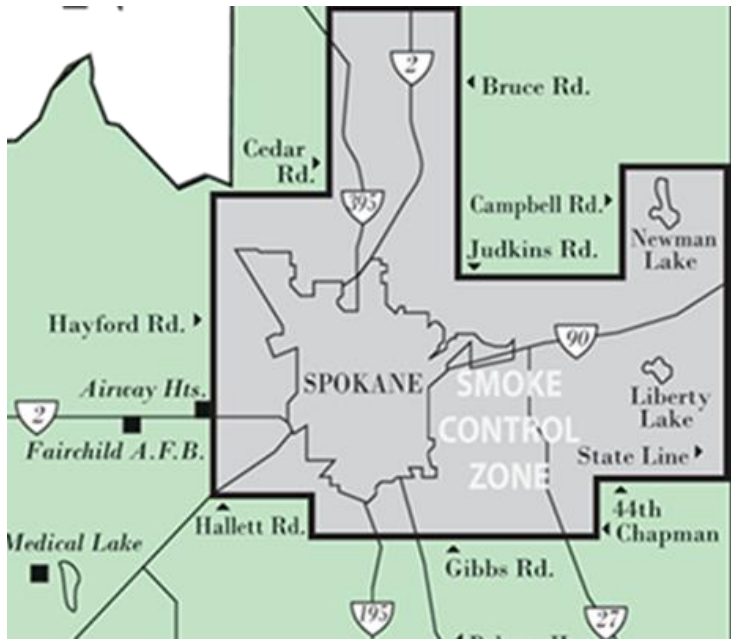
Figure A.1: PSCAA (top) and SRCAA (bottom) air quality management zones.

Appendix B: Populations Attributed to Monitors (Summer PM$_{2.5}$)

Last Update 4/3/2019

Questions? Contact Jill Schulte, WA Ecology Air Quality Program, jils461@ecy.wa.gov, 360-407-6877

The populations attributed to each monitor are those that meet two criteria: their estimated summer mean PM$_{2.5}$ concentration is within 2 μg/m^3 of that monitor's summer mean, and that monitor is one of the three closest monitors to their location active in that year. The closest site is selected first, and the 2nd or 3rd closest are selected in order if the closer site does not meet the 2 μg/m^3 criteria or is missing data on that day. Represented populations are only counted once, and a small fraction of Washington's population is not represented by a monitor.

Process overview:

1. Interpolate summer mean PM$_{2.5}$ concentrations at 4km grid cells by combining AIRPACT modeled concentrations and monitored PM$_{2.5}$ data with Empirical Bayesian Kriging (EBK).
2. Assign grid cells to monitoring sites when that grid cell's interpolated summer mean PM$_{2.5}$ is within 2 μg/m^3 of the monitor's mean summer concentration and the monitor is one of its three closest.
3. Assign census block group populations to 4km grid cells.

Input datasets:

1. 2010 U.S. census block group land-only polygons with annual WA OFM population estimates from 2006:2017
2. Summer (June – Sept) mean PM$_{2.5}$ at monitoring sites censored for extreme wildfire data from July 2014 - June 2017
3. Summer (June – Sept) mean modeled PM$_{2.5}$ at 4km grid cells from AIRPACT-4 from July 2014 – June 2017
4. Daily summer (June – Sept) PM$_{2.5}$ concentrations and meteorological variables at monitoring sites from 2006 – 2017

Assumptions:

1. Populations are evenly distributed throughout census block groups.
2. Empirical Bayesian Kriging of monitor/model ratio produces accurate estimates of summer mean concentrations at unmonitored locations.
3. The cutoff of 2 μg/m^3 in summer mean PM$_{2.5}$ difference is appropriate to distinguish airsheds represented by a monitor.
4. The July 2014 – June 2017 time frame represents typical summer air quality conditions.

Detailed steps:

ArcGIS process

1. Intersect 4km grid cells and census block group polygons.
2. Calculate the percent of each block group polygon within each grid cell and multiply by that grid cell's population for each year in 2006:2017.
3. Sum the total population within each grid cell in each year 2006:2017.
4. Join each monitoring site to its nearest 4km grid cell.
5. Calculate the ratio between the monitor's mean summer PM$_{2.5}$ and the grid cell's modeled mean summer PM$_{2.5}$.

6. Interpolate the ratio across the domain using Empirical Bayesian Kriging with the following inputs: 2000m cell size, logempirical transformation, max 100 local points, overlap factor of 1, 100 semivariograms, standard circular search neighborhood, minimum of 10 neighbors.
7. Extract EBK results to grid cells.
8. Multiply EBK raster value by modeled summer mean $PM_{2.5}$. The resulting value is the interpolated summer mean $PM_{2.5}$ concentration (called "EBK $PM_{2.5}$" below).

R process
9. Create long file with one row for each grid cell/date combination and the grid cell's EBK $PM_{2.5}$.
10. For each year in 2006:2017, create a subset of active monitors in that year (active monitors are defined as those with >50% data completeness in a given year).
11. From the active monitor subset in its matching year, assign each grid cell/date row its three nearest neighbors and their summer mean $PM_{2.5}$.
12. For each of the three assigned neighbors, subtract measured summer mean $PM_{2.5}$ from EBK $PM_{2.5}$.
13. For each grid cell/date row, remove neighbors where the absolute value of the $PM_{2.5}$ difference is greater than 2 $\mu g/m^3$.
14. For each grid cell/date row, select the "site assigned" from remaining neighbors using the hierarchy neighbor 1 → neighbor 2 → neighbor 3.
15. Match the daily $PM_{2.5}$ concentration and meteorological variables to each grid cell using the date and site assigned.
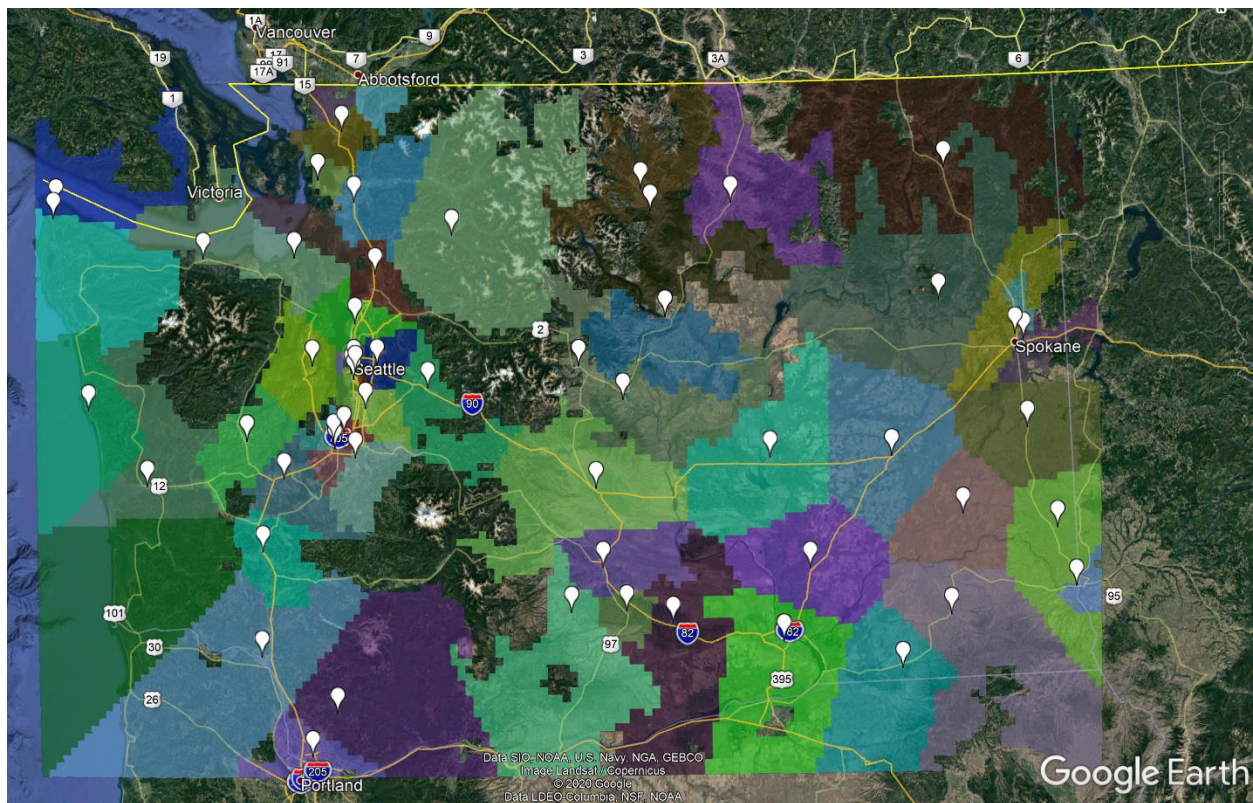

Figure B.1: Map of ECY polygons overlaid with $PM_{2.5}$ monitors (white balloons) used in this work.