

Overview of smoke forecast map

The smoke forecast map provides a prediction of fine particulate matter, shown as a PM_{2.5} Air Quality Index (AQI) category. Health warnings linked to each air quality category are available in [What Is AQI](#).¹ Forecasts can be used to plan outdoor activities and reduce exposure to air pollution.

A 5-day forecast is issued from June through October, when wildfire smoke is of concern, while a 2-day forecast is issued the rest of the year. The forecast map is broken into many zones, based on Ecology's network of air quality monitors and some local clean air agency management regions. The size of the zones is smaller in the cold months because smoke impacts are localized.

The smoke forecast is based on forecasts:

- Issued by local clean air agencies and Ecology, based on professional judgment
- Produced by the Idaho Department of Environmental Quality (DEQ) Machine Learning model (an update to the WSU version formerly used)
- Produced by the Ecology HYSPLIT model (wildfire season only)

Forecasts issued by local clean air agencies are retrieved from AirNow and assigned to the appropriate zones on the map. All forecasts issued by a local clean air agency or Ecology are shown unaltered on the map.

The Idaho DEQ Machine Learning model uses previously-monitored PM_{2.5} and the University of Washington Weather Research and Forecasting (WRF) model to produce a 2-day forecast. The average of Ecology's eight HYSPLIT forecast simulations is used to produce a 5-day forecast. The automated forecast shown on the map uses the Idaho DEQ Machine Learning model for days 1-2 and Ecology's HYSPLIT ensemble average for days 3-5 or when the machine learning forecast is unavailable.

Two-day forecasts from Idaho DEQ Machine Learning model

WSU developed site-specific PM_{2.5} versus meteorology relationships using 4-kilometer UW WRF forecasts archived since 2017. These relationships show how PM_{2.5} has changed in recent years during different meteorological conditions. The relationships are used in combination with the UW WRF ensemble forecast average to construct a 2-day forecast. More information is provided in [Fan, et al., 2023](#).² Idaho DEQ updated the machine learning model to include bias correction and site characteristic inputs to capture regional effects. Idaho DEQ also retrains the model with recent monitoring data every year.

Five-day forecasts from Ecology HYSPLIT ensemble model

Eight simulations of wildfire smoke are performed using the NOAA [HYSPLIT](#)³ model as implemented by Ecology. Each scenario has a unique method for calculating emissions, as listed in the table (next page). Meteorology is obtained from the UW WRF 12km extended forecast. Anthropogenic sources, boundary conditions, initial conditions, chemical reactions, and deposition are not included. Fire locations are from NOAA's Hazard Mapping System (HMS). Daily processes include:

1. Download NOAA HMS file for recent fire locations and remove duplicate locations.
2. Assign 194 acres to each location and merge clusters (sum acres; max FRP).
3. Apply FRP modification formula (scenario-specific) for emissions. Keep original FRP for heat.
4. Assign daily emissions basis (66.1 Kg PM_{2.5}/MW).
5. Apply fire potential (U.S.) and fire danger (Canada) and vegetation factors.
6. Apply hourly diurnal profile for heat and emissions (scenario-specific).
7. Create HYSPLIT input files (hourly emissions with heat and area for plume rise) sounds.
8. Run all 8 HYSPLIT scenarios and report the average PM_{2.5} within each zone on the forecast map.

¹ <https://enviwa.ecology.wa.gov/Documents/WhatIsAQI.pdf>

² <https://www.frontiersin.org/articles/10.3389/fdata.2023.1124148/pdf>

³ <https://www.ready.noaa.gov/HYSPLIT.php>

HYSPLIT Emissions Scenarios

| | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 |
|---------------------------------------|--|---|---|---|---|---|---|---|
| First Hour Kept from HMS | Noon (-1 Day) | Noon (-1 Day) | 2 a.m. (-1 Day) | 2 a.m. (-1 Day) | Noon (-1 Day) | Noon (-1 Day) | Midnight (-3 Days) | Midnight (-3 Days) |
| Duplicate Dist. | 10m | 10m | 10m | 10m | 10m | 10m | 50m | 50m |
| FRP Modification Formula | FRP max = 100 min = 0.3 | 1.25 FRP max = 100 min = 0.3 | 2 sqrt FRP max = N/A min = 0.3 | 2 sqrt FRP max = N/A min = 0.3 | 4 sqrt FRP max = N/A min = 0.3 | 4 sqrt FRP max = N/A min = 0.3 | 2 sqrt FRP max = N/A min = 0.3 | 3 sqrt FRP max = N/A min = 0.3 |
| Area per Detect | 194 Acres (r = 500m) | 194 Acres (r = 500m) | 194 Acres (r = 500m) | 194 Acres (r = 500m) | 194 Acres (r = 500m) | 194 Acres (r = 500m) | 194 Acres (r = 500m) | 194 Acres (r = 500m) |
| Merge Aggregation | FRP = Max Area = Sum | FRP = Max Area = Sum | FRP = Max Area = Sum | FRP = Max Area = Sum | FRP = Max Area = Sum | FRP = Max Area = Sum | FRP = Max Area = Sum | FRP = Max Area = Sum |
| Merge Distance | 1000m | 1000m | 1000m | 1000m | 1000m | 1000m | 1000m | 1000m |
| USA Fire Potential Factors | None | Moist = 0.25 Dry = 1.00 Lightning = 1.00 Very Dry = 1.25 Hot = 1.25 Burn Env. = 1.25 Windy = 1.25 Hot & Dry = 1.50 | Moist = 0.25 Dry = 1.00 Lightning = 1.00 Very Dry = 1.25 Hot = 1.25 Burn Env. = 1.25 Windy = 1.25 Hot & Dry = 1.50 | Moist = 0.25 Dry = 1.00 Lightning = 1.00 Very Dry = 1.25 Hot = 1.25 Burn Env. = 1.25 Windy = 1.25 Hot & Dry = 1.50 | Moist = 0.25 Dry = 1.00 Lightning = 1.00 Very Dry = 1.25 Hot = 1.25 Burn Env. = 1.25 Windy = 1.25 Hot & Dry = 1.50 | Moist = 0.25 Dry = 1.00 Lightning = 1.00 Very Dry = 1.25 Hot = 1.25 Burn Env. = 1.25 Windy = 1.25 Hot & Dry = 1.50 | Moist = 0.25 Dry = 1.00 Lightning = 1.00 Very Dry = 1.25 Hot = 1.25 Burn Env. = 1.25 Windy = 1.25 Hot & Dry = 1.50 | Moist = 0.25 Dry = 1.00 Lightning = 1.00 Very Dry = 1.25 Hot = 1.25 Burn Env. = 1.25 Windy = 1.25 Hot & Dry = 1.50 |
| CAN Fire Danger Rating Factors | None | Low = 0.25 Moderate = 0.50 High = 0.75 Very High = 1.00 Extreme = 1.25 | Low = 0.25 Moderate = 0.50 High = 0.75 Very High = 1.00 Extreme = 1.25 | Low = 0.25 Moderate = 0.50 High = 0.75 Very High = 1.00 Extreme = 1.25 | Low = 0.25 Moderate = 0.50 High = 0.75 Very High = 1.00 Extreme = 1.25 | Low = 0.25 Moderate = 0.50 High = 0.75 Very High = 1.00 Extreme = 1.25 | Low = 0.25 Moderate = 0.50 High = 0.75 Very High = 1.00 Extreme = 1.25 | Low = 0.25 Moderate = 0.50 High = 0.75 Very High = 1.00 Extreme = 1.25 |
| Vegetation Factors | Barren = 0.01 Scrub = 0.40 Forest = 1.00 Crops = 0.20 | Barren = 0.01 Scrub = 0.40 Forest = 1.00 Crops = 0.20 | Barren = 0.01 Scrub = 0.40 Forest = 1.00 Crops = 0.20 | Barren = 0.01 Scrub = 0.40 Forest = 1.00 Crops = 0.20 | Barren = 0.01 Scrub = 0.40 Forest = 1.00 Crops = 0.20 | Barren = 0.01 Scrub = 0.40 Forest = 1.00 Crops = 0.20 | Barren = 0.01 Scrub = 0.40 Forest = 1.00 Crops = 0.20 | Barren = 0.01 Scrub = 0.40 Forest = 1.00 Crops = 0.20 |
| Diurnal Profile | Legacy | Legacy | Legacy | WRF-CHEM | BlueSky | WRF-CHEM | BlueSky | Legacy |

Diurnal Profile Hourly Factors

| Hour (PST) | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
|-------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-------|-------|-------|-------|------|------|------|------|------|------|
| Emis. (Legacy) | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.3 | 0.6 | 1 | 1.5 | 1.9 | 2.3 | 2.4 | 1.7 | 1 | 0.6 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| Heat (Legacy) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.5 | 1 | 1 | 10 | 20 | 20 | 20 | 10 | 1 | 0.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Emis. (BlueSky) | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.28 | 0.55 | 0.97 | 1.39 | 1.80 | 2.22 | 2.36 | 1.66 | 0.97 | 0.55 | 0.14 | 0.14 | 0.14 | 0.14 |
| Heat (BlueSky) | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.29 | 0.65 | 2.04 | 5.52 | 8.95 | 12.21 | 15.43 | 16.47 | 11.13 | 5.52 | 2.04 | 0.29 | 0.29 | 0.29 | 0.29 |
| Emis. (WRF-CHEM) | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.3 | 0.4 | 0.6 | 0.8 | 1 | 1.2 | 1.5 | 1.7 | 1.5 | 1.2 | 1 | 0.8 | 0.5 | 0.2 | 0.2 | 0.2 | 0.2 |
| Heat (WRF-CHEM) | 0.66 | 0.66 | 0.66 | 0.66 | 0.66 | 0.66 | 0.66 | 0.75 | 0.83 | 1.41 | 2.91 | 5.65 | 8.81 | 12.3 | 13.46 | 12.13 | 8.81 | 5.65 | 2.74 | 1.25 | 0.66 | 0.66 | 0.66 | 0.66 |