Idaho Wildfire Smoke Portal: interactive decision support for air quality forecasting

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Outline

- Origin and history
- Objectives
- Structure of website
- Demonstration
- Future development

Origin and history

- 2012:
  - intense wildfire season, DEQ created wildfire response processes
  - regional forecasters repeatedly asked by public, "Where is the smoke coming from and how long will it last?"
  - started as a daily emailed Powerpoint containing MODIS imagery, fire detects, and narrative interpretation
- 2016-2017:
  - changed to ESRI StoryMap platform
  - data feeds becoming increasingly automated
  - data covers all of North America (and some worldwide)
- Available to all, not just Idaho-centric
- Annual updates accomplished by start of NW wildfire season (mid-late July)
- AQ forecasters use site in conjunction with IDEQ meteorology forecasts and smoke outlook reports

Objectives

- Provide an aggregation of relevant satellite data and website links to facilitate ease of forecasting process (but provide value-added through integration with GIS)

- Build technical support infrastructure for AQ forecasters similar to what met forecasters have (this site does not contain met data)

- Document and describe, with satellite data, the fire locations and smoke movement that affect air quality

- Provide insight into smoke behavior as it interacts with the underlying terrain and regional weather

- Support the efforts of air quality forecasters by supplying technical data in the form of imagery, aerosol and trace gas detection, monitoring, and smoke forecast models

Section 1: Situational Awareness

Current Fires Dashboard
- provides an interface to explore *fire locations*, *fire perimeters*, *satellite thermal detections*, and *monitor sites* in a geographical framework. Map feature attributes, including fire name, acres burned, and percent contained, are exposed in lists and indicators. Fire Radiative Power values from satellite detections are plotted in bar charts.

Satellite Imagery
- MODIS
  - MODIS *true color imagery* displays the recent fire, smoke, and weather situation. During typical summertime high pressure weather conditions, the morning image from the Terra satellite shows visible smoke in morning inversion conditions, providing indications of smoke interaction with terrain, decoupled from transport winds. The afternoon image from the Aqua satellite provides insight into smoke behavior after the daily inversion break, displaying plume-driven fire behavior subject to local and regional fire weather. 250 m resolution imagery.
- GOES
  - GOES-16 and 17 are geostationary satellites that provide high temporal resolution imagery in 5 minute increments. The spatial resolution is lower than MODIS, however. GOES-16/East has a spatial resolution of 3-8 km for northwest states. GOES-17/West provides a 2 km spatial resolution for NW states.

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Section 2: Satellite Fire Emissions

AOD
- Aerosol Optical Depth (AOD) is an indexed value that represents the amount of aerosol loading in the atmosphere.
- MODIS instrument, Terra/Aqua satellites, 2x daily at 10:30 am/1:30 pm, 3 km spatial resolution

Aerosol Index (AI)
- Aerosol Index (AI) is another way to quantify the aerosol loading in the atmospheric column. Also known as the Absorbing Aerosol Index (AAI), the algorithm identifies the presence of UV-absorbing aerosols, like smoke. The difference between an AI and an AOD retrieval is that AI can be calculated in the presence of clouds, whereas AOD cannot. AI therefore can achieve greater data coverage in cloudy conditions.
- TROPOMI instrument, Sentinal-5P satellite, 2x daily at 1:30 am/pm, total column concentrations, 5.6 km x 3.5 km spatial resolution.

CO
- Carbon Monoxide (CO) is a trace gas directly emitted during the smoldering phase of wildfires. CO lifetime in the atmosphere is several weeks to months which makes it a good tracer of long-range smoke transport.
- TROPOMI instrument, Sentinal-5P satellite, 2x daily at 1:30 am/pm, total column concentrations, 5.5 km x 5.5 km spatial resolution.

NO_2
- Nitrogen Oxides ($NO_x = NO + NO_2$) are directly emitted during the flaming phase of wildfires. Nitrogen oxides are also a precursor for the formation of ozone (O_3).
- TROPOMI instrument, Sentinal-5P satellite, 2x daily at 1:30 am/pm, total column concentrations, 5.6 km x 3.5 km spatial resolution.

NOTE: All maps show previous day's retrieval. All data are NRT.

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Section 3: Air Quality Monitors

AirFire PM$_{2.5}$ Monitoring

- This is a handy site provided by the Airfire team at the USFS. It pulls in current data from EPA's AirNow state monitoring networks, the Western Regional Climate Center (WRCC), and AIRSIS (Interagency Real Time Smoke Monitoring, USFS), which includes emergency smoke monitors. The site provides multiple useful charts for analysis and access to data download.

EPA AirNow

- EPA AirNow provides maps and values for individual monitors in the EPA's monitor network. Current and forecast Air Quality Index (AQI) levels are available in addition to many other air quality resources.

Idaho DEQ Air Quality Monitoring

- This site supplies real-time air monitoring data from Idaho DEQ's monitor network. Concentration and AQI measurements are available for all criteria pollutants measured.

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Section 4: Models

Bluesky
- Bluesky is a Lagrangian Particle dispersion model running Hysplit v. 4.9, produced by the USFS AirFire team.
- Domains range from 1.33 km to 12 km
- Forecasts surface concentrations of $PM_{2.5}$ for hourly, 3-hour running average, daily maximum, and daily average products
- Forecast periods range from 36 to 84 hours

IDEA
- The Infusing satellite Data into Environmental Applications (IDEA) model is a forward air parcel trajectory forecast. The model initiates on areas of high MODIS AOD and OMI AI and calculates forward trajectories from these origins.
- Forecasts trajectory movement at 3-hour increments. The trajectories are colored by height (or pressure), with white indicating the air parcels will be lofted above the boundary layer and pink indicating that the air stays on the surface. This is a useful model to investigate the predicted movement of leftover smoke.

HRRR-Smoke
- High-Resolution Rapid Refresh (HRRR) model runs the WRF-Chem coupled Eulerian grid/chemical model
- Forecasts hourly $PM_{2.5}$ concentrations from smoke
- 48 hour forecast reinitializes every 6 hours, recycling smoke from previous runs
- VIIRS satellite fire detections and MODIS FRP are assimilated in model

AIRPACT-5
- AIRPACT-5 runs the CMAQ Eulerian grid model
- Model resolution is 4 km and the forecast period is 48 hours
- Products include hourly and daily $PM_{2.5}$ concentrations and hourly and 8-hour average O_3 concentrations

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Demonstration

https://storymaps.arcgis.com/stories/f681a2398cf24f26ae0542abe0ff6b60

Future Development

- Spaghetti chart of model outputs at monitor sites
- Outputs from IDEA model run by Wei
- Map the ARA forecasts
- Add PurpleAir monitoring link
- Keep up with satellite developments: GOES bands and composites, VIIRS/TROPOMI Aerosol Index, aerosol layer height, TEMPO, …
- Update and share satellite matrix

Thank you

Please contact me at
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with any comments,
questions, suggestions, or
if you'd like to be added to
the mailing list.