Smoke: The Next Frontier
Wildfire and prescribed burning impacts on air quality in the U.S.

Susan O’Neill, USDA Forest Service, Pacific Northwest Research Station
Dan Jaffe, University of Washington

Teepee Springs Wildfire, August 2015
Eastern Oregon
Incident Management Team (IMT) Basecamp
Photo – Greg Johnson, Air Resource Advisor
Fire Hot Spot Detections by Season
MODIS 2017

Jaffe et al., 2020
Satellite Information for Smoke

- NASA Worldview
  https://worldview.earthdata.nasa.gov/
  - VIIRS, MODIS, OMI, MOPITT
  - Visible smoke imagery, AOD, Fire Detections, Aerosol Index
  - LOTS more
- NOAA Hazard Mapping System (HMS)
  https://www.ospo.noaa.gov/Products/land/hms.html
  - Fire Detections, Plume Analysis
- NOAA AerosolWatch
  https://www.star.nesdis.noaa.gov/smcd/spb/ag/AerosolWatch/
  - GOES-16/17, VIIRS
  - AOD, Fire Detections, Surface Monitors
- JPSS JSTAR Mapper
  https://www.star.nesdis.noaa.gov/jpss/mapper
  - Suomi NPP, NOAA-20
  - Sentinel 5P (CO, NO2)
Remote-Sensing: Plume Top, Vertical Plume Extent

Cloud-Aerosol LiDAR with Orthogonal Polarization (CALIOP)

> 80% of wildland fire plumes are under the PBL (Sofiev et al., 2009, 2012; Val Martin et al., 2010; Paugam et al., 2016)

Multi- Angle Implementation of Atmospheric Correction (MAIAC) MODIS Collection 6

Mohammad Al-Hamden, NASA

Mika Tosca, NASA
Real-time PM2.5 Monitoring Data for Wildfires

- Permanent Monitors (Circles)
- Temporary Monitors (Triangles)
- Temporary monitors hit more small communities (Larkin et al. 2019)
- R Package PWFSLSmoke (Mazama Science)

https://tools.airfire.org/monitoring/v4/
Low Cost Sensors

• Example, Purple Air, > 6000 sensors
• Reports 2-min average data. Can set averaging time on the map.
• EPA conducting evaluation of performance
  • 50 sensors at 39 unique sites across 16 states
  • Compare to FRM and FEM
  • 6 Wildfire cases
  • Finding: Purple Air over-reports PM2.5 concentrations by 30-50%
• Correction Equation
Modeling Smoke Transport
Component: Natural Variability and Uncertainty

- Fuels Variability
  - Order of Magnitude
  - (10 - 100 tons/acre)

- Emission Factor Variability
  - Factor of 2-5

- Wind Direction
  - Mean Error
  - 40 degrees Day
  - 80 degrees Night

Miller et al. 2019

Urbanski 2014
Prichard et al. 2020
FEPS
Hardy et al. 2001
Modeling Smoke Transport

- Combustion Models (WFDS, FIRETEC)
- Coupled Fire Behavior (WRF-Sfire, CAWFE)
- Dispersion (Complex terrain, Superfog)
- Atmospheric Chemistry (CMAQ, CAMx)
- Coupled Fire Atmosphere (WRF-Chem, GEOS-5)
- Data Fusion Techniques
Large uncertainties and natural variability exist with each component. Each component is an area of research.
Health Hazards of Smoke

• Respiratory Issues
  • One in three households has someone with an existing respiratory issue.
  • Smoke exposure exacerbates asthma and chronic obstructive pulmonary disease (COPD)
  • Bronchitis, pneumonia, and upper respiratory infections several days following
  • Out-of-hospital setting – increased usage of medication, ER visits and outpatient clinics

• Cardiovascular health: increased risk of congestive heart failure, ischemic heart disease, hypertension, acute myocardial infarction, cardiac arrest and apnea.

• Hospitalizations: US, 2008–2012 Annually,
  • 3900–6300 respiratory hospitalizations
  • 1700–2800 cardiovascular hospitalizations
  • due to short-term smoke exposures (Fann et al., 2018)

• Mortality
  • Respiratory mortality increased by 9%
  • COPD mortality increased by 14%
  • Respiratory mortality for adults 45-64 increased by 35%
Health Hazards of Smoke

• Maternal exposure: Evidence of pre-term birth and low birth weight.
• Infant exposure: Ex. Unintentional cohort primate study. Reduced lung function.
• Socio-economics, Stress, Wildlife
• Workplace exposure (e.g. Fire Fighters, Outdoor Field Workers)

Annual health costs of wildland fire episodes from 2008 to 2012 were estimated at $11 billion to $130 billion (Fann et al., 2018). Cost of hospitalizations and mortality.
Regulatory Considerations

• National Ambient Air Quality Standards (NAAQS)
  • Fine Particulates (PM2.5), 35 µg/m³ 24-hr Average
  • Ozone, 0.070 ppm, 8-hr Average
  • Carbon Monoxide
    • 9 ppm, 8-hr Average
    • 35 ppm, 1-hr Average
  • NO₂
  • SO₂
  • Lead

• Smoke Management Programs
• Basic Smoke Management Practices
• Cal OSHA

Exceptional Events Rule
• Exceptional events are unusual or naturally occurring events that can affect air quality but are not reasonably controllable. Exceptional events may include wildfires, high wind dust events, prescribed fires, stratospheric ozone intrusions, and volcanic and seismic activities.
• Demonstration Process to remove the data point(s) from regulatory consideration (SIP process)
  • Resource intensive undertaking for States
• Example of the Challenge (western states):
  • 2018 (high wildfire year)
    • > 2000 monitor-days of PM2.5 concentrations over 35 µg/m³
  • 2016 (low wildfire year)
    • 730 monitor-days of PM2.5 concentrations over 35 µg/m³
Interagency Wildland Fire Air Quality Response Program (IWFAQRP)

- Deployment of Air Resource Advisors (ARA) with Incident Management Teams (IMT) or Geographic Area Coordination Centers (GACC)
- Provide: Modeling, Monitoring, Messaging

Marsha and Larkin, 2019.

https://wildlandfiresmoke.net
Smoke Ready Communities

NEW: EPA and Partners Fire and Smoke Map (airnow.gov)

https://www.epa.gov/smoke-ready-toolbox-wildfires

Wildfire Smoke and COVID-19
Frequently Asked Questions

• Smoke and COVID19 Fact Sheet – USDA, CDC
  • Why do people need to consider COVID-19 along with wildfire smoke?
  • Who is most at risk from wildfire smoke?
  • How are symptoms from wildfire smoke exposure different from symptoms of COVID-19?
  • What actions can I take to minimize potential health impacts from wildfire smoke?

https://drive.google.com/file/d/1Lfc1l_PMZFAWZack2cqtUIBmBXlpve0Q/view