Modeling, Monitoring, & Messaging Wildfire Smoke for Air Quality and Public Health

Sim Larkin, U.S. Forest Service AirFire Research Team

- with many others -



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Smoke and Fire

- On average, over 7,000,000 acres of wildfire per year (U.S.)
- Doesn't count 12,000,000+ acres of prescribed burning
- Wildfires are the single biggest source of high-level air quality impacts (in U.S.)
- Single fires have been known to cause significant impacts to millions
- But multiple regional fires are common and can collectively impact large areas of the country
- Fires differentially impact rural communities
- Also those with respiratory issues (1 in 3 households)
 - E.g. children with asthma, Chronic Obstructive Pulmonary Disease (COPD), emphysema
- Wildfire response efforts have expanded beyond physical property and safety, now includes air impacts



Smoke can be a problem:



How to respond?

(in real-time)

Need:

- Rubric
- Data
- Models
- Tools
- Messaging
- Coordination



- Interagency Wildland Fire Air Quality Response Program
- Data, Models, Tools, Research
- •Some Lessons Learned



Interagency Wildland Fire Air Quality Response Program

- Interagency response (2011-Present)
- Operationally addressing wildfire smoke
- Four components:
 - Modeling
 - Monitoring
 - Messaging / Communication
 - Active Coordinated Response
- Integration / coordination
 - EPA, NOAA, NASA, States, and beyond
- Signed into law in March (S.47)



Public Health



Firefighter Safety / Health



Transportation Safety

Air Resource Advisors

Smoke specialists deployed as part of an Incident Management Team (TSHP in ICS)

Enables:

- Enables smoke information within Incident decisions
- Allows incident decision information to be made available for modeling, etc.
- Develops outlooks and other documents for communications
- Works with local agencies and communities

Air Resource Advisor (ARA) Deployments over Time Annual ARA Deployments

Monitoring

- 40+ monitors in US Forest Service (USFS) national cache deployed to most impacted communities
- Monitor deployments affect underserved communities directly
- Web tool (USFS AirFire) aggregates and displays data across all sources
- Used by impacted communities
- Used by smoke forecasters, public health agencies, the public, others

2018 Smoke Outlooks

- ~1000 Smoke Outlooks Issued
- Done in collaboration with local agencies

Smoke Outlook for 6/14 - 6/15 SW Colorado 416 and Burro Fires Issued at: 2018-06-14 14:35 UTC

Outlook for SW Colorado

Fire

416 Fire is at about 32,000 acres, 15% containment. Burro Fire is about 3,000 acres at 0% containment. Predicted thunderstorms may bring strong outflow winds and increase the potential for extreme fire behavior.

Smoke

Durango and Bondad should get a reprieve from smoke today. Hermosa will see smoke impacts at varying levels throughout today. Silverton and Lake City will see greater smoke impacts today and tomorrow. Vallecito may see smoke drifting in late this afternoon as well tomorrow morning. Dolores and Aztec should not see much smoke impacts today.

One way to reduce smoke exposure

Consider using a HEPA air filtration unit to help keep a room in your home less smoky. For more information see: https://www.missoulaclimate.org/hepa-air-filtration.html

Daily AQI Forecast for Jun 14, 2018

	Y	′ester	day	Wed	Forecast	Thu	Fri
Station		hourl	У	6/13	Comment for Today Thu, Jun 14	6/14	6/15
	6a	noon	6p				
Bondad					Generally clear today, smoke returning tomorrow morning before clearing around noon.		•
Dolores					Generally clear today		
Hermosa					Heavy smoke drift mid-afternoon, some clearing tonight, returning at heavy levels early tomorrow morning, persisting to noon.		
Durango					Generally clear today with heavy smoke returning early tomorrow morning before clearing late morning.		•
Silverton					Smoke drifting in late this morning, persisting overnight with heaviest concentrations after midnight and clearing late tomorrow morning.		•
Vallecito					Smoke drifting in late this afternoon, clearing tonight. Smoke returning tomorrow morning, clearing before noon.		•
Aztec					Generally clear today		

Issued 2018-06-14 14:35 UTC by Andrea Holland, Julie Hunter (t)

Air Quality Index (AQI)		Actions to Protect Yourself		
	Good	None		
0	Moderate	Unusually sensitive individuals should consider limiting prolonged or heavy exertion.		
	USG	People within Sensitive Groups* should reduce prolonged or heavy outdoor exertion.		
	Unhealthy	People within Sensitive Groups* should avoid all physical outdoor activity.		
	Very Unhealthy	Everyone should avoid prolonged or heavy exertion.		
	Hazardous	Everyone should avoid any outdoor activity.		

Disclaimer: Forecasts may be wrong; use at own risk. Use caution as conditions can change quickly. See your health professional as needed. Smoke sensitive groups should take appropriate precautions.

Issued by USFS Wildland Fire Air Quality Response Program – www.wildlandfiresmoke.net SW Colorado Updates – tools.airfire.org/production-outlooks/SWColorado Smoke and Health Info – www.airnow.gov/index.cfm?action= smoke.index Smoke plume crashes 911 system Albuquerque, NM 2011

Bringing smoke science into incident support

•Forecasts

•Tools

•Development of specialist Air Resource Advisors •New models

•Advanced data fusion

Model verification and validation

PM2.5 Monitoring gated ground monitoring information More info

BlueSky Daily Run Viewer Visualize daily smoke forecasts More info

Customized emissions and dispersion modeling Mor

USFS AirFire and Partners' work within the Interagency Wildland Fire Air Quality Response Program

Data and Tools Online

<u>https://wildlandfiresmoke.net/tools</u>

Wildland Fire / Air Quality Tools

This page provides links to the most recent versions of tools produced by the U.S. Forest Service PNW Research Station's Pacific Wildland Fire Sciences Laboratory in support of wildland fire operations.

REAL TIME SMOKE TOOLS

PM2.5 Monitoring Aggregated ground monitoring information More info

BlueSky Daily Run Viewer Visualize daily smoke forecasts More info

BlueSky Playground Customized emissions and dispersion modeling More info

Monitoring V4 Site quick access, tailored analysis / diagrams

(also available: R packages for analysis)

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(also available: R packages for analysis)

Other Outputs Available from Monitoring v4

Data as CSV

parameter	blank	lon_138.858.
monitoriD		lon_198.858
kongitude		
latitude		
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timezone		America/Den
countryCode		us.
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telemetry/UnitSD		
sesses PM2.5 hourly data (NOT NowCast) begins below here		
UTC Time	UTC Time (no Local Time because > 1 monitor timecone)	lon_198.858
2018-11-28 00:00:00 UTC	2018-11-28 00:00 UTC	
2018-11-26 01:00:00 UTC	2018-11-28 01:00:00 UTC	
2018-11-28 02:00:00 UTC	2018-11-28 02:00:00 UEC	
2018-11-28 03:00:00 UTC	2018-11-28 03:00:00 UTC	
2018-11-26 04:00:00 UTC	2018-11-28 04:00:00 UTC	
2018-11-26 05:00:00 UTC	2018-11-28-05:00:00 UTC	
2018-11-26 06:00:00 UTC	2018-11-26 06:00:00 UTC	
2018-11-26 07:00:00 UTC	2018-11-28 07:00:00 UTC	
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2018-11-26 10:00:00 UTC	2018-11-28 10:00:00 UTC	
2018-11-28 11:00:00 UTC	2018-11-28 11:00:00 UTC	
2018-11-28 12:00:00 UTC	2018-11-28 12:00:00 UTC	
2018-11-26 13:00:00 UTC	2018-11-26 13:00:00 UTC	
2018-11-25 14:00:00 UTC	2018-11-26 14:00:00 UEC	
2018-11-26 15:00:00 L/TC	2018-11-28 15:00:00 UTC	
2018-11-26 18:00:00 UTC	2018-11-28 16:00:00 UTC	
2018-11-26 17:00:00 UTC	2018-11-26 17:00:00 UTC	
2018-11-26 18:00:00 UTC	2018-11-26 18:00:00 UTC	
2018-11-26 19:00:00 UTC	2018-11-26 18:00:00 URC	
9046-41-98 9940-00 L/TC	9048-44-26 00:00:00 UBC	
9046-41-00 P1-00-00 LTV	9748-44-98-94-90-98-LIEP	
2010-01-20-20-00-010	1778-17-28-27-06-07-07-0	
	2018 11 28 23 40 40 UPC	
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	2018-01-22 000000 000	
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2010-11-29-02:00:00 UTC	2018-11-29 02:00:00 UTC	
2018-11-29 03:00:00 UTC	2018-11-29 03:00:00 UTC	
2018-11-29 64:00:00 UTC	2018-11-29 04:00:00 URC	
2018-11-29 05:00:00 UTC	2018-11-29 05:00:00 UBC	
2018-11-29 06:00:00 UTC	2018-11-29 06:00:00 UBC	
2018-11-29 07:00:00 UTC	2018-11-29 07:00:00 UEC	

QA/QC "Engineering" Data

Additional Plot Types

Modeling

- BlueSky smoke modeling framework
- Focus on high resolution and customization
- Test-bed (new ideas, science)
- Customizable modeling (Playground + custom runs)

Partner with everyone we can: NOAA / NWS, Env. Canada, UBC

NASA

BlueSky Daily Run

Daily Model Runs

- Since 2003 (Now I feel old)
- HYSPLIT, CMAQ, WRF-CMAQ
- 30+ runs / day
- 36-hrs to 8 days runs
- Domains
 - 2-km CA/NV
 - 6-km Western US
 - 1.33-km WA/ID
 - 4-km PNW
 - 12-km CONUS
 - 12-km Alaska
 - 3-km CONUS
 - 1.8-km AZ/NM
 - 1.27-km FW (NWS moveable)
- Partnerships:
 - NOAA/NWS, UW, WSU, DRI, UofAK, UofAZ, UBC, Env. Canada, ...

HYSPLIT = Hybrid Single-Particle Lagrangian Integrated Trajectory model CMAQ = Community Multiscale Air Quality model WRF = Weather Research and Forecasting model CONUS = contiguous United States

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Retrospective Analyses

NASA HEALTH AND AIR QUALITY APPLIED SCIENCES TEAM

Connecting NASA Data and Tools with Health and Air Quality Stakeholders

HAQAST Team – 13 Principle Investigators •Tracey Holloway (Team Lead, UW-Madison) •Bryan Duncan (NASA GSFC) •Arlene Fiore (Columbia University) •Frank Freedman (San Jose State University) Daven Henze (University of Colorado, Boulder)
Jeremy Hess (University of Washington, Seattle)
Yang Liu (Emory University)
Jessica Neu (NASA Jet Propulsion Laboratory)
Susan O'Neill (USDA Forest Service)

•Ted Russell (Georgia Tech) •Daniel Tong (George Mason University) •Jason West (UNC-Chapel Hill) •Mark Zondlo (Princeton University)

USFS AirFire:

- Expand use of satellite data by Air Resource Advisors (ARAs), Incidents
- Tiger Team Lead Health Impacts of the 2017 Northern California Wildfires
- Online Training Introduction to Satellite Resources for Smoke and Fire

Santa Rosa San Francisco San losé Wildfires ignited Oct 8, 2017 resulted in approximately 7 million people across Northern California exposed to unhealthy and worse air quality conditions for a 9-day period.

Smoke Impacts are Under-Quantified

AirFire assembled dataset 5/1/18-12/5/18Monitor-Days with PM_{2.5} daily value >= USG

Note: Over 10x more Permanent Monitor-Days than Temporary Monitor-Days

USG = unhealthy for sensitive groups, air pollutant level at which people within Sensitive Groups* should reduce prolonged or heavy outdoor exertion

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Temporary Monitors were more likely to see a USG or worse day

For higher Air Quality Index (AQI) categories, this tendency increases

• E.g., in 2018, Temporary monitors 200x more likely to see a Hazardous day.

Smoke connects back to small scale complexities

Smoke connects back to small scale complexities (and they are important!)

Example: plume convective cores

Fire and smoke models are still rapidly evolving

Complex coupled fire-atmosphere-chemistry models with nested fire subdomains are coming. But they need more testing and development.

And to do that they need more observational data.

Courtesy: Mell

Fire and Smoke Model Evaluation Experiment (FASMEE)

USFS / DOI in coordination with efforts of NOAA, NASA, Department of Defense, EPA

Largest U.S. fire field campaign study in 30+ years.

Initial campaign: now!

Forecasting smoke is not like forecasting temperature

It is closer to forecasting precipitation.

But, smoke forecasting often lacks both data and the human element of weather forecasting

We need a common language to talk about smoke

- Must relate to more than just health (lifestyle, etc.)
- Smoke is highly spatially and temporally dependent
- Even fleeting impacts can be significant
- Models will necessarily be probabilistic

We have such a language for precipitation

• e.g. 30% chance of showers

Thank you!

More Information:

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Interagency Wildland Fire Air Quality Response Program https://wildlandfiresmoke.net

Tools: <u>https://wildlandfiresmoke.net/tools</u>

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