Alison York, coordinator

Thanks to Randi Jandt, Martin Stuefer, and Stacey Cooper for content

April 18 ACCAP webinar at accap.uaf.edu/Wildfire_Smoke
June 22, 2015

MODIS. NASA Earth Observatory image by Jesse Allen, using data from the Land Atmosphere Near real-time Capability for EOS (LANCE).
Today’s outline:
Alaska wildfire trends with climate change
Smoke prediction tools
Health effects and protection
April 18 webinar at accap.uaf.edu/Wildfire_Smoke
Warming climate effects on wildfire in Alaska

Randi Jandt, Fire Ecologist, UAF
Changes in the environment . . .

- Temperature
- Rainfall
- Ignitions
- Season Length
- Fire Behavior

Photo credit: Tom McCabe
Twice as many large fire seasons now

Alaska acres burned/yr

1950-1989: 27,148,432
1990-2015: 36,687,882

Photo: Trevor Kaufman, AK-DOF, Card Street Fire 2015
Alaska warming 2x as fast as the rest of the US

Average year-around temperature 1949-2016
https://www.ncdc.noaa.gov/
Fairbanks (UAF Exp Station), Alaska
Average Annual Temperature, 1912-2016

© 2017 Rick Thoman

Data source: NOAA/NCEI & NWS
More heat = drier fuels = more combustion
Moss duff -- 2-4x more biomass than trees!

- Live Moss
- Dead Moss
- Upper Duff
- Lower Duff
- Mineral Soil

Forest floor moss “duff”
2015 Fire Season

- 295 fires ignited in 1 week
- 5.1 million acres burned
- Smoke all the way to east coast!

Figure by Rick Thoman, NWS Alaska Climate Center

Alaska Wildfire Cumulative Acreage
2004 vs. 2015

Acreage as reported on the morning AICC Situation Report
Climate models tell us to expect more rainfall, but . . .

Not much change since 1949 in central Interior Alaska

↑T° leads to more “Effective” Drying: need **15% more rain** to offset 1.8° F increase in T°

http://www.ncdc.noaa.gov/cag/
Research predicts increased lightning: 
~12% per C° of warming

Romps et al. 2014, Science

2015: one day in June had 15,000 strikes; week of 6/19 saw 61,000 strikes!
Longer Fire Seasons

Interior Alaska has more snow-free days.
Break-up ~ 1-2 days earlier/decade & snow cover ~2-5 days later/decade.

April 17th, 2016—Fire jumped on Knik R near Palmer.
Photo Amy Breen, Researcher, UAF

October 18th, 2016
Interior Alaska has more snow-free days.
Break-up ~ 1-2 days earlier/decade & snow cover ~2-5 days later/decade.

Photo Amy Breen, Researcher, UAF
Fairbanks: Daily average Temp 70°F or warmer in:

“1971-2000” 2031-2060 2071-2100

Summer Days > 70 deg

Future Temperature?

Data courtesy: John Walsh, UAF
Future: How much burning?

- Yue, et al. 2015: Equations predict a 2.5x increase in burn area in Boreal Interior & 4.8x increase in Boreal Cordillera in Alaska.
- Young, et al. 2016: Most of Alaska will see 2X increase in 30-yr burn probability, with some areas increased 4X or more.

Excerpt from Fig. 7, Young et al. 2016. Climatic thresholds shape northern high-latitude fire regimes and imply vulnerability to future climate change. Ecography 39: 1-12.
PM2.5 of 1,000µg/ml

Smoke & Health Impacts
Most of Alaska will experience at least a **doubling** (light green) of fine particulate smoke (PM 2.5) exposure with climate-induced wildfires by 2050 (relative to 2000).
Any evidence for increased smoke impacts?

Fairbanks International Airport
Days with Visibility 65M or less in Smoke

©Rick Thoman, National Weather Service Alaska Region
Can I find out what my air quality is right now?

EPA AirNow homepage: https://www.airnow.gov/
Also air quality alerts statewide
Tips on mitigating exposure risk
Smoke Reports on Local Environmental Observers Network

https://www.leonetwork.org/en/
OUTLINE

- Background
- Resources to Date – Weather Research Forecast Model (WRF) with Chemistry (WRF-CHEM) and the implementation of biomass burn emissions
- Weather Feedback
- Airborne Validation and Operational Tool Development Status
BACKGROUND

AEROSOL TYPES
May - September 2004: Average Visibility measured at the 2 locations Fairbanks and Nenana
Analysis by the Alaska Climate Research Center, University of Alaska Fairbanks
Summer 2004:
⇒ 41 days unhealthy to hazardous in Fairbanks
⇒ 16 (of the 41) days clearly hazardous

Department of Environmental Conservation Presentation to Alaska Climate Impact Assessment Commission
January 24, 2007: ‘Fire smoke pollution must be actively managed for health protection; integrated with fire fighting agencies.’
- Weather Research and Forecasting (WRF) model coupled with Chemistry (WRF-CHEM)
- Gridded hourly fire emissions vertically distributed with the plume rise model as source for WRF/Chem.
HYBRID FIRE PRODUCTS AS WILDFIRE SOURCE – SATELLITE REMOTE SENSING

Fire source data from the Alaska Interagency Coordination Center (AICC). In synergy we use VIIRS thermal anomalies and MODIS fire hotspots. Satellite products are compared to AICC data and optionally serve as direct input to the smoke model system.

- MODIS and VIIRS thermal anomalies.
- Additional Landsat Thematic Mapper (TM) sensor data, which include a middle infrared channel (2.08-2.35 μm).
  => 30 m high spatial resolution sensor, which permits active fires to be detected. A 700 K fire that occupies 20% of the 30 m pixel will saturate the middle infrared TM channel.
  => A single Landsat TM scenes covers typically areas of about 150 times 150 miles.
  => Airborne FLIR data

Landsat TM from July 7, 2009 showing fires south of Galena.

Fires detected by VIIRS
Emitted tracer mass $E$ for a certain fire species $i$ from biomass burning is estimated according to:

$$E_i = a \times b \times CE \times e_i$$

- $a$: burning area
- $b$: fuel loading
- $CE$: combustion efficiency (above-ground biomass available for burning)
- $e_i$: emission factor

- Andrae and Merlet's (2001) comprised necessary emission factors in order to relate various fuel-load types involved in **biomass burning to emissions**.
Emission data generator package; developed by Saulo Freitas and Karla Longo, Brazil Center for Weather Forecasting and Climate Studies, implemented into WRF/Chem

Gridded emission fluxes (kg/m²).

**Biomass burning / wildfire emissions**
- **Brazilian Biomass Burning Emission Model** (Freitas et al. 2005; Longo et al., 2007)
- Emission Factors from Andrae and Merlet, 2001, 110 chemical species, 6 types of biomass
- **GFEDv2**: Global Fire Emissions Database (van der Werf et al., 2006): 8 days/monthly – 1°x1°

**Anthropogenic sources**
- **RETR**O: REanalysis of the TROpospheric chemical composition over the past 40 years, global, 0.5° x 0.5°, monthly
- **EDGAR**: Emission Database for Global Atmospheric Research, global, 1° x 1°, annually

**Biogenic sources**
- **GEIA**: Global Emissions Inventory Activity, 1° x 1°

**GOCART**: Goddard Chemistry Aerosol Radiation and Transport model, 1° x 1.25°, monthly, anthropogenic and natural sources
ALASKA DAILY SMOKE FORECASTS

UAFSMOKE  Wildfire Smoke Prediction for Alaska

List of current fires
Last updated: 17 Apr 2017, 14:50. Data from the Alaska Interagency Coordination Center, which is currently tracking 6 fires in Alaska (active, smoldering or in the process of being demobilized). Circles represent the size, but not the shape, of the fire.

- local: <10 acres (0.04 km²)
- moderate: 10 to 250 acres (0.04-1 km²)
- large: 250 to 2500 acres (1-10 km²)
- very large: >2500 acres (10 km²)

Sawmill Island fire
Discovered: 07 Mar 2017, 04:51
Last updated: 29 Mar 2017, 02:51
0.1 acres
A contractor in the area east of Totchak Slough located a smoldering fire. Information was relayed to the FMO and it will be monitored.

⇒ 72 hour Smoke WX
⇒ GFS meteorological initial and boundary conditions
⇒ daily during the fire season
⇒ Forecast graphics at

⇒ Chemistry: GOCART simple aerosol scheme, no O3
⇒ WSM 5-class scheme microphysics
⇒ RRTM longwave
⇒ Dudhia shortwave
⇒ YSU boundary layer scheme

HTTP://SMOKE.ARSC.EDU/
NEAR REAL-TIME FORECASTS

http://smoke.arsc.edu/

Example Black Carbon
NEAR REAL-TIME FORECASTS

http://smoke.arsc.edu/

Example PM 2.5
SMOKE IMPACTS WEATHER? => PRECIPITATION

Without Fires 0000UTC, July 4, 2004 With Fires

Grell et al., 2011, Atmos. Chem. Phys., 11, 5289–5303
Impacts Weather? => Temperature and Water Vapor

Temperature difference (°C)

Water vapor difference (g/kg)

Cross section: July 4, 2004

Grell et al., 2011, Atmos. Chem. Phys., 11, 5289–5303
Data:

- with ground based reference data: PM measurement data from State and Local Air Monitoring Stations (SLAMS) and Special Purpose Monitoring Stations (SPM) are available.
- LIDAR
- Sun photometer and aerosol measurement data from the US Department of Energy - Atmospheric Radiation Measurement (ARM) program.
- Multiangle imaging spectroradiometer (MISR) data & additional satellite sensing data are available for model comparison.

- UAS measurements in future

- PUBLIC FEEDBACK
2009: FORECAST COMPARISON FOR PARTICULATE MATTER (PM2.5)

Measurement Source: Fairbanks North Star Borough

Wood River Fire size updated by 15735 acres
VERIFICATION - DRY CREEK FIRE 2012

OBSERVED
Particulate Matter 10 (μg m³)

WRF-CHEM -- MADE/SORGAM
Particulate Matter 10 (μg m³)

Simulation with different aerosol modules

WRF-CHEM -- GOCART
Particulate Matter 10 (μg m³)
VERIFICATION

- Airborne optical particle counter (Grimm Particle Spectrometer)
- FLIR IR Imaging
- Hyperspectral Fire Data
• HySpex VNIR-1800 and SWIR-384 cameras
• integrated with an IMAR iTrace RT-F400 IMU/GPS (Inertial Measurement Unit / Global Positioning System)
• passive vibration dampening

Focus on fire source: a main challenge for near real time air-quality modeling.

Airborne low-cost observations available.

GOES-R Products: Aerosol (detection, optical depth, particle size), cloud and visibility Products.

New: We are working on the development of ‘VOLC-WRF’ in synergy to UAFSmoke. VOLC-WRF implements volcanic eruptions into the WRF/Chem forecast system.

CONTACT: MSTUEFER@ALASKA.EDU
Health Effects of Wood Smoke

Stacey Cooper
Environmental Public Health Program
Alaska Section of Epidemiology
Sources of Wood Smoke

Outdoor
- Wildfires
- Outdoor wood boilers
- Your neighbor’s barbecue/fire pit

Indoor
- Fireplace
- Wood stove
- Coal or pellet stove
Particulate Matter (PM) Size

PM > 10 microns unlikely to make it past the head region when inhaled
Particulate Matter and Components Enter Lungs and Reach Other Body Parts

1. PM >10µm likely eliminated by coughing, sneezing, swallowing.
2. PM 5 - 10µm in trachea/pharynx region
3. PM < 5µm in lungs, PM< 2.5µm in alveoli

→ Lung and heart problems
Health Effects

**Short Term**
- Irritated eyes, nose, throat
- Exacerbate asthma
- Acute bronchitis
- Irregular heart beat
- Heart attack
- Headache
- Stroke

**Long Term**
- Reduced lung function
- Chronic bronchitis
- Lung cancer
- Heart disease
- Premature death
Sensitive Populations

• The risks of adverse health effects associated with exposure to fine particles varies through life.

• The likelihood of developing adverse health effects is
  o Higher in early childhood
  o Lower in adolescents and young adults
  o Increasing in middle- through old-age, as the incidence of heart and lung diseases increases
Sensitive Populations

• Children
  o Lungs are still developing
  o Spend more time outside
  o Engage in vigorous activities
  o Breathe more air per body weight

• Pregnant women
  o Potential harm to fetus
    • Some evidence of low birth rates when mothers were exposed to wildfire smoke
  o Increased respiratory rate
  o Increased blood and plasma volume

Holstius et al. 2012
Sensitive Populations

• Older adults
  o Are more likely to suffer from pre-existing heart or respiratory conditions
  o Decrease in defense mechanisms with age

• People with pre-existing respiratory conditions
  o Asthma
  o Chronic Obstructive Pulmonary Disease

• People with pre-existing cardiovascular conditions
  o Hypertension
  o Heart Failure
  o Coronary artery disease
  o Cerebrovascular conditions (atherosclerosis)
How to tell if you’re affected

Experiencing:
• Coughing
• Scratchy throat
• Irritated sinuses
• Shortness of breath
• Chest pain
• Headaches
• Stinging eyes
• Runny nose

Smoke may make pre-existing respiratory conditions worse

Source: http://burningissues.org/
How can I protect myself?

- Stay indoors if possible, close windows
- If too hot inside, shelter elsewhere (e.g. school, other community shelter)
- Reduce physical activity
- Minimize other sources of air pollution (e.g. smoking, wood stove, candles).
- Wear an N95 respirator mask
- Close windows in car if driving
- Use a portable air purifier (HEPA filter)
How can I protect myself?

Setting up a clean room in your house:

- Keep windows and doors closed
- Set up an appropriately sized air purifier (HEPA filter) for the room
- Don’t burn anything
- Don’t vacuum
- Keep the room clean
How can I protect myself?

- Monitor Air Quality Advisories issued by the state
- People can sign up for alerts or check the latest local air quality conditions on DEC’s website
  - [http://dec.alaska.gov/Applications/Air/airtoolsweb/Advisories](http://dec.alaska.gov/Applications/Air/airtoolsweb/Advisories)

<table>
<thead>
<tr>
<th>AQI Category (AQI Values)</th>
<th>Visibility (miles)</th>
<th>PM2.5 or PM10 (µg/m³)- 24 hr avg</th>
<th>Cautionary Statements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>≥11</td>
<td>0-12</td>
<td>None</td>
</tr>
<tr>
<td>Moderate</td>
<td>6-10</td>
<td>12.1-35.4</td>
<td>Unusually sensitive people should consider reducing prolonged or heavy exertion.</td>
</tr>
<tr>
<td>Unhealthy for Sensitive Groups</td>
<td>3-5</td>
<td>35.5-55.4</td>
<td>People with heart or lung disease, the elderly and children should reduce prolonged or heavy exertion.</td>
</tr>
<tr>
<td>Unhealthy</td>
<td>1.5-2.75</td>
<td>55.5-150.4</td>
<td>People with respiratory or heart disease, the elderly and children should avoid prolonged exertion; everyone else should limit prolonged exertion.</td>
</tr>
<tr>
<td>Very Unhealthy</td>
<td>1-1.25</td>
<td>150.5-250.4</td>
<td>People with respiratory or heart disease, the elderly and children should avoid any outdoor activity; everyone else should avoid prolonged exertion</td>
</tr>
<tr>
<td>Hazardous</td>
<td>&lt;1</td>
<td>&gt;250.5-500</td>
<td>Everyone should avoid any outdoor exertion; people with respiratory or heart disease, the elderly and children should remain indoor.</td>
</tr>
</tbody>
</table>
Resources

Environmental Public Health Program’s Webpage
http://dhss.alaska.gov/dph/Epi/eph/Pages/wildfire/default.aspx
Resources

Environmental Public Health Program’s Webpage

Fire and Smoke Health Concerns
Frequently Asked Questions

What is the health threat from fires and smoke?
Smoke from wildfires is a mixture of gases and fine particles from burning trees and vegetation. Smoke can hurt your eyes, irritate your respiratory system, and worsen chronic health conditions. If you are experiencing serious medical problems for any reason, seek medical treatment.

How can I tell if the smoke is affecting my family or me?
- Smoke can cause coughing, scratchy throat, irritated sinuses, sore throat, headaches, stinging eyes, and runny nose.
- If you have heart or lung disease, smoke might make your symptoms worse.
- People who have heart disease might experience chest pain, rapid heartbeat, and fatigue.

Smoke may worsen symptoms for people who have pre-existing respiratory allergies, asthma, and chronic obstructive pulmonary disease. Following ways:
- Inability to breathe normally
- Cough with or without mucus
- Chest discomfort
- Wheezing and shortness of breath
- When smoke levels are high enough, even healthy people may experience symptoms.

If you have asthma or another lung disease, follow your health care provider’s air management plan. Call your health care provider if your symptoms worsen or if you need medication. Call 911 if you are having a medical emergency.

Monitor Air Quality Advisories
July 13, 2015

Communities are advised to:
- Monitor state-issued air quality reports and stay alert to any news coverage or health warnings related to smoke.
- Find out if the Department of Environmental Conservation has an Air Quality Index (AQI) for their area community. The AQI, based on data from local air quality monitors or other data sources, informs you about the daily air quality in your area and about precautions that can be taken to protect your health. You are encouraged to sign up for alerts or check the latest air quality conditions here:
  http://dec.alaska.gov/Applications/Air/airtoolsweb/Advisories
- The following is an example of an AQI table:

<table>
<thead>
<tr>
<th>AQI Category (AQI Values)</th>
<th>Visibility - Arid Conditions (miles)</th>
<th>PM2.5 or PM10³ Levels (µg/m³) - 24 hour average</th>
<th>Cautionary Statements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good (0 to 50)</td>
<td>≥11</td>
<td>0-12</td>
<td>None</td>
</tr>
<tr>
<td>Moderate (51 to 100)</td>
<td>6-10</td>
<td>12.1-35.4</td>
<td>Unusually sensitive people should consider reducing prolonged or heavy exertion.</td>
</tr>
<tr>
<td>Unhealthy for Sensitive Groups (101 to 150)</td>
<td>3-5</td>
<td>35.5-55.4</td>
<td>People with heart or lung disease, the elderly and children should reduce prolonged or heavy exertion.</td>
</tr>
<tr>
<td>Unhealthy (151 to 200)</td>
<td>1.5-2.75</td>
<td>55.5-150.4</td>
<td>People with respiratory or heart disease, the elderly and children should avoid prolonged exertion; everyone else should limit prolonged exertion.</td>
</tr>
<tr>
<td>Very Unhealthy (201 to 300)</td>
<td>1-1.25</td>
<td>150.5-250.4</td>
<td>People with respiratory or heart disease, the elderly and children should avoid any outdoor activity; everyone else should avoid prolonged exertion.</td>
</tr>
<tr>
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