ALASKA FIRE SCIENCE CONSORTIUM

akfireconsortium.uaf.edu

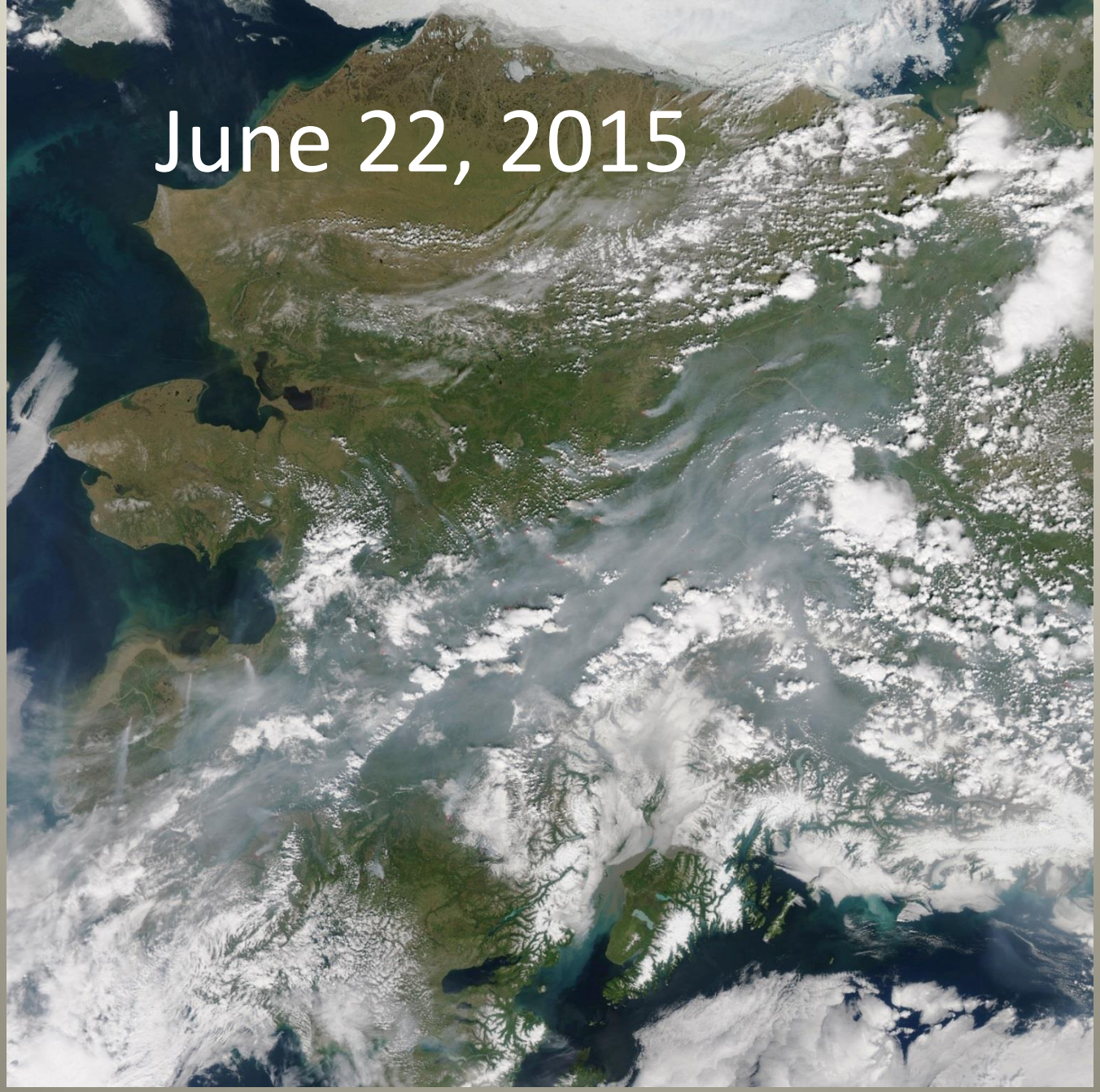
Alison York, coordinator

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

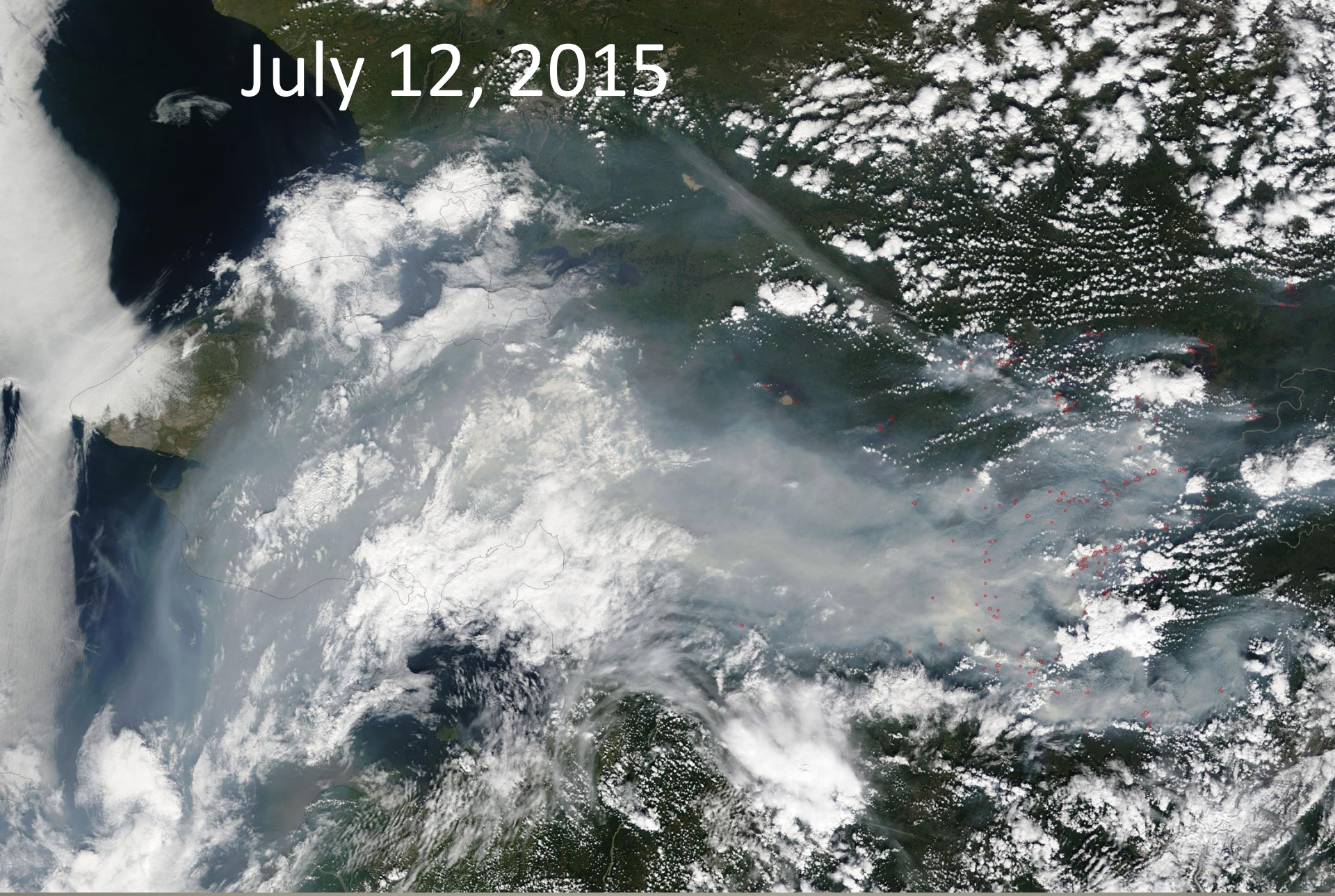
April 18 ACCAP webinar at accap.uaf.edu/Wildfire_Smoke

International Arctic Research Center IARC University of Alaska Fairbanks

UAF UNIVERSITY OF ALASKA FAIRBANKS



MODIS. NASA Earth Observatory image by Jesse Allen, using data from the Land Atmosphere Near real-time Capability for EOS (LANCE).



MODIS. NASA image by Jeff Schmaltz, LANCE/EOSDIS Rapid Response

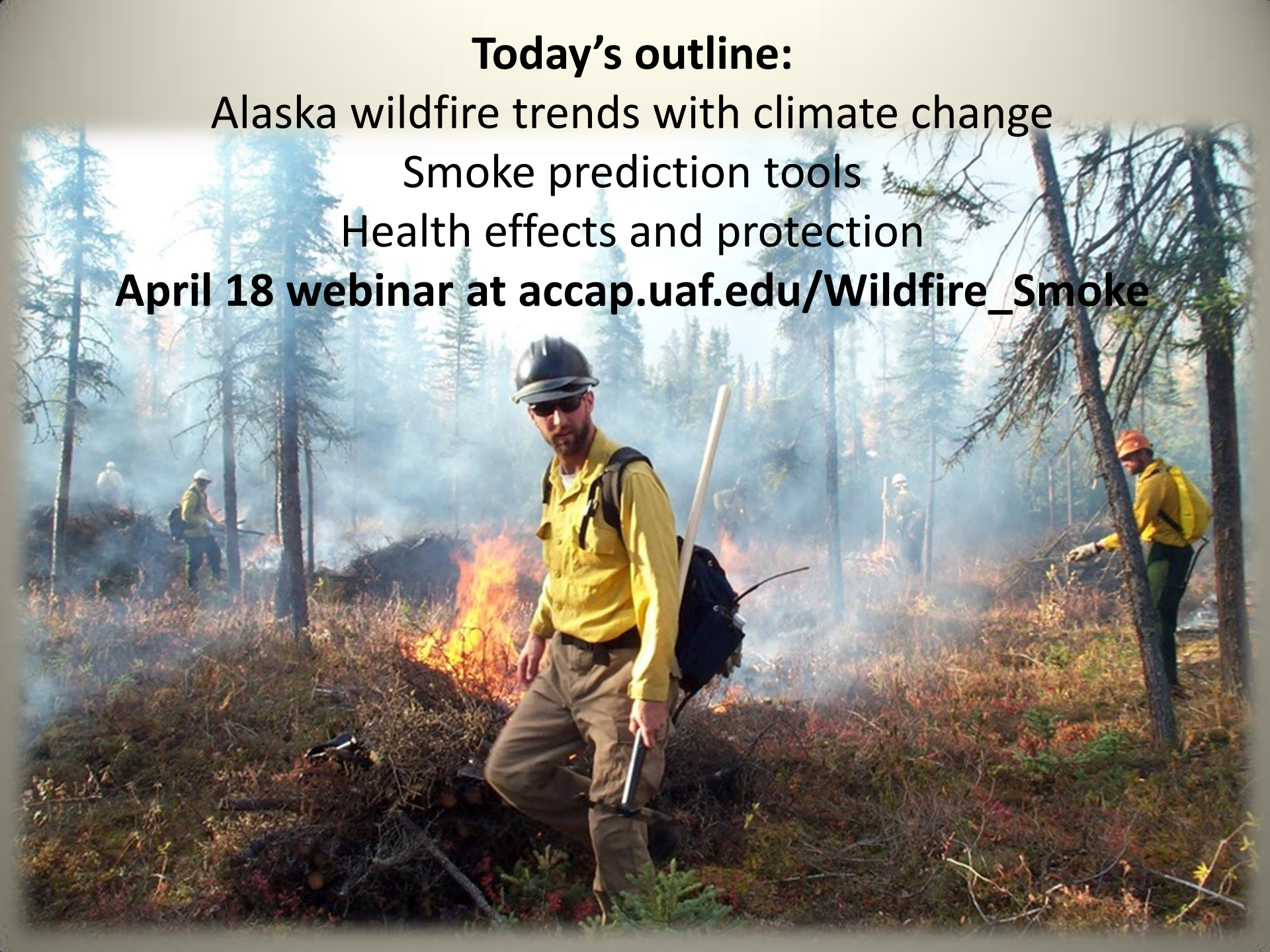
Today's outline:

Alaska wildfire trends with climate change

Smoke prediction tools

Health effects and protection

April 18 webinar at accap.uaf.edu/Wildfire_Smoke



http://akfireconsortium.uaf.edu

ALASKA FIRE SCIENCE CONSORTIUM

Mission: *Better collaboration between fire science and fire management*

JOINT FIRE SCIENCE PROGRAM

Photo by Rob Allen

Warming climate effects on wildfire in Alaska

Randi Jandt, Fire Ecologist, UAF

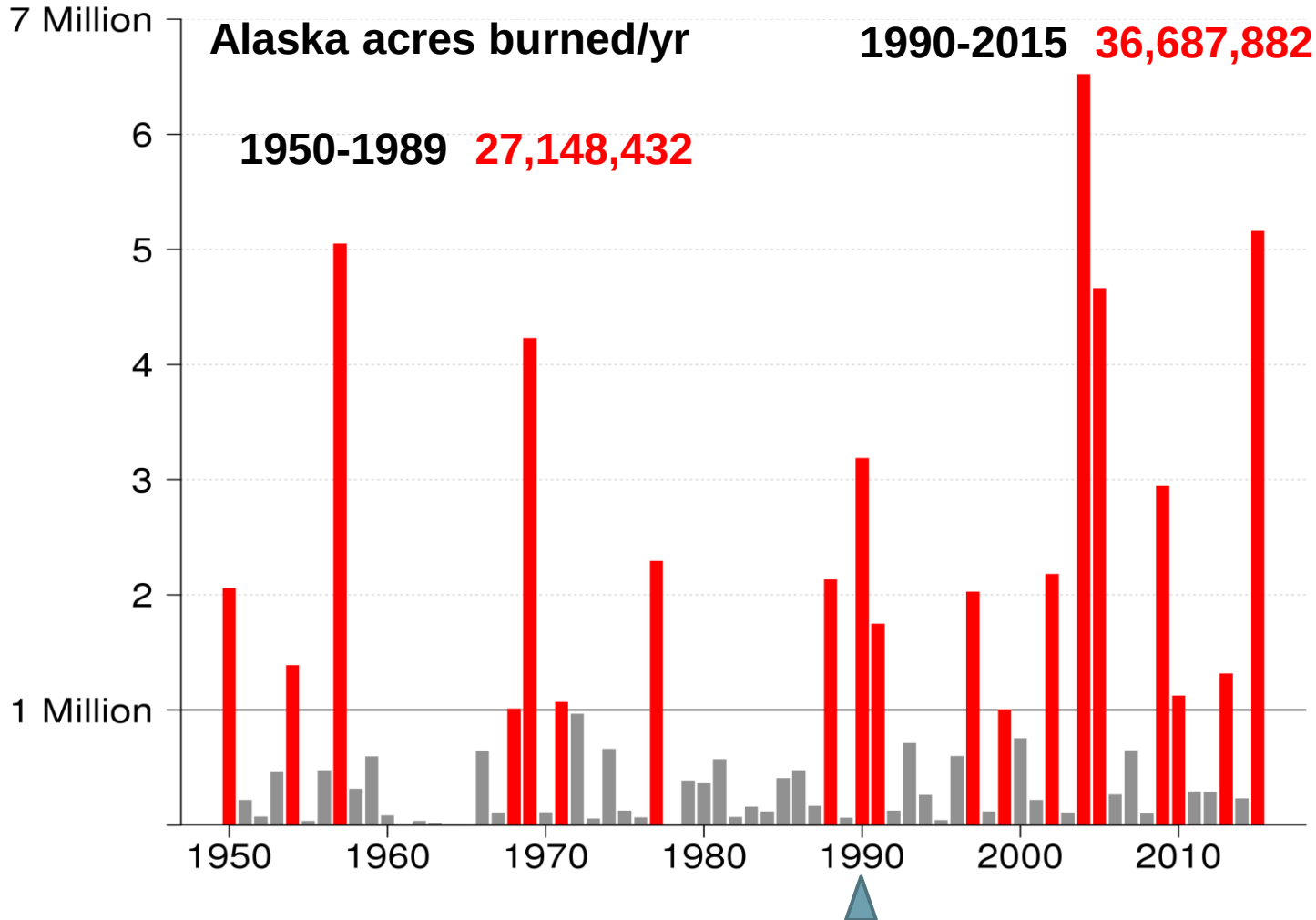
Changes in the environment . . .

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

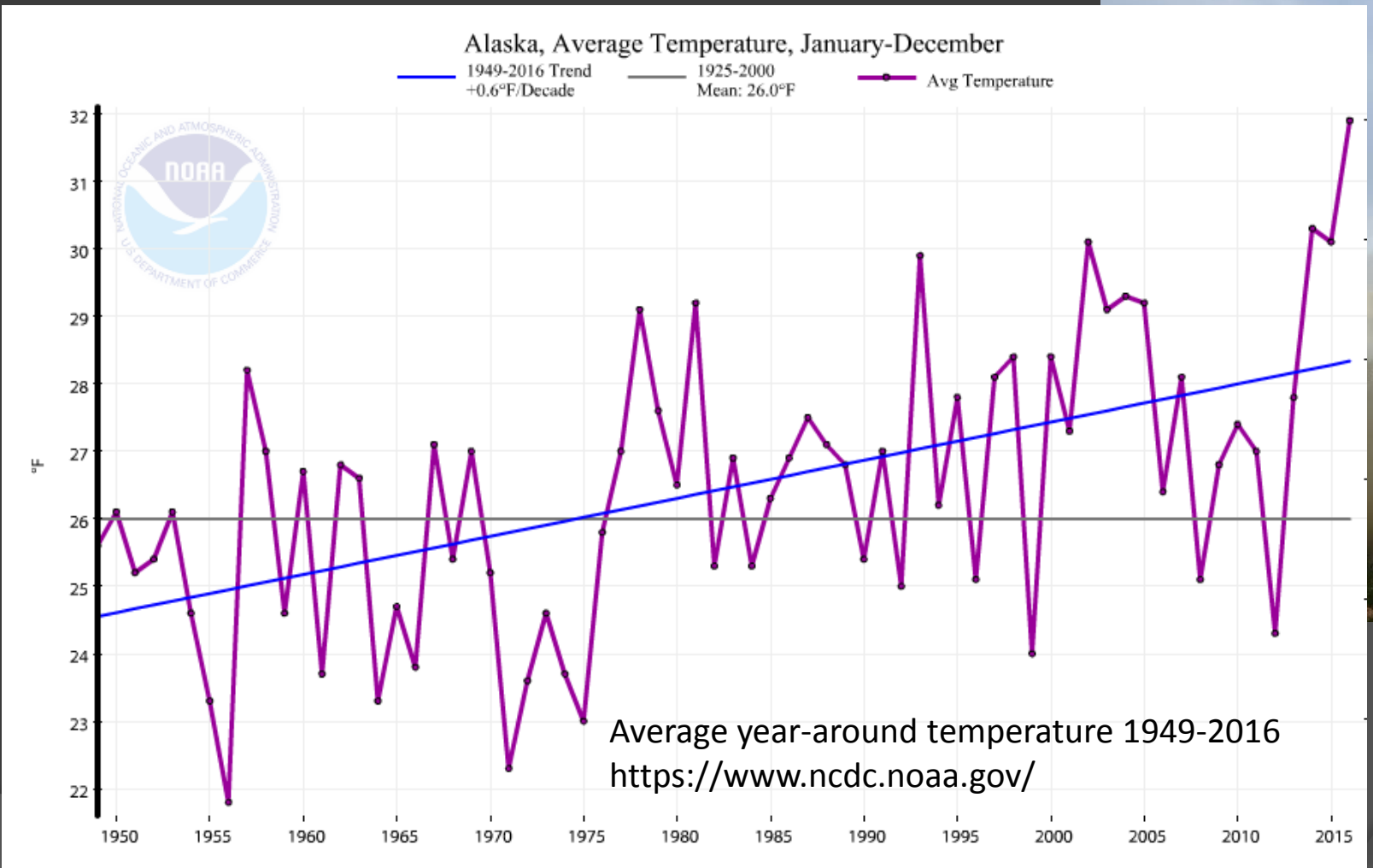
Photo credit: Tom McCabe

Twice as many large fire seasons now

Photo: Trevor Kauffman, 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/

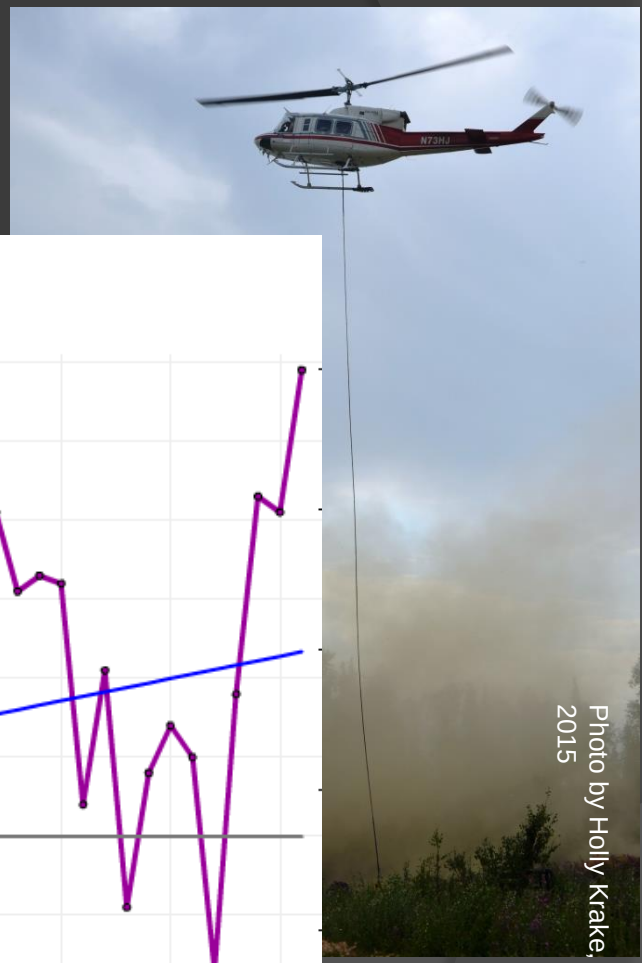
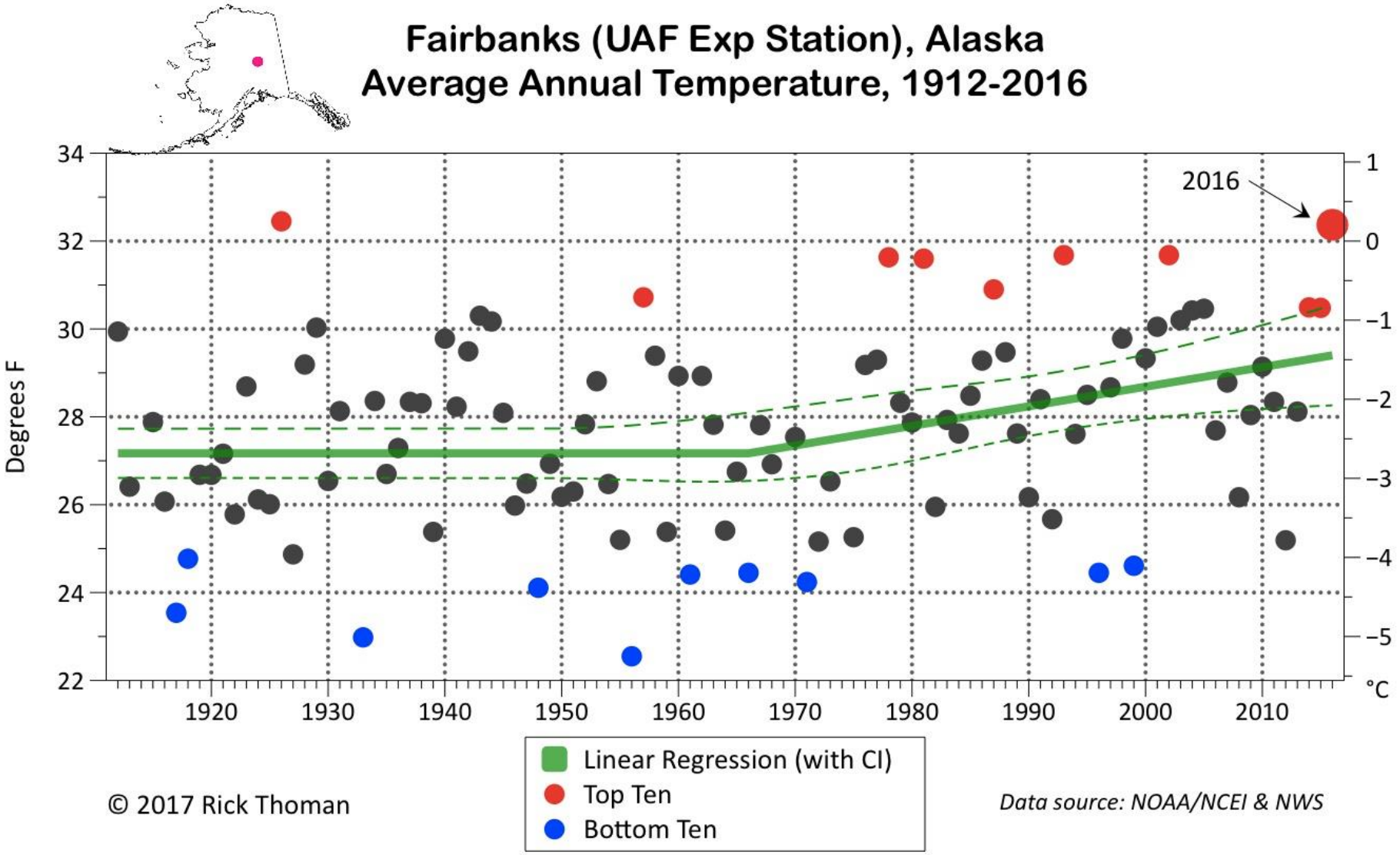


Photo by Holly Krake, 2015


Fairbanks (UAF Exp Station), Alaska
Average Annual Temperature, 1912-2016
Degrees F
34
32
30
28
26
24
22
1
0
−1
−2
−3
−4
−5
°C
2016
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Linear Regression (with CI)
Top Ten
Bottom Ten
© 2017 Rick Thoman
Data source: NOAA/NCEI & NWS

More heat = drier fuels = more combustion

May 2016 Ft. McMurray Fire
Photo by Jonathen Hayward, The Canadian Press

Moss duff -- 2-4x more biomass than trees!

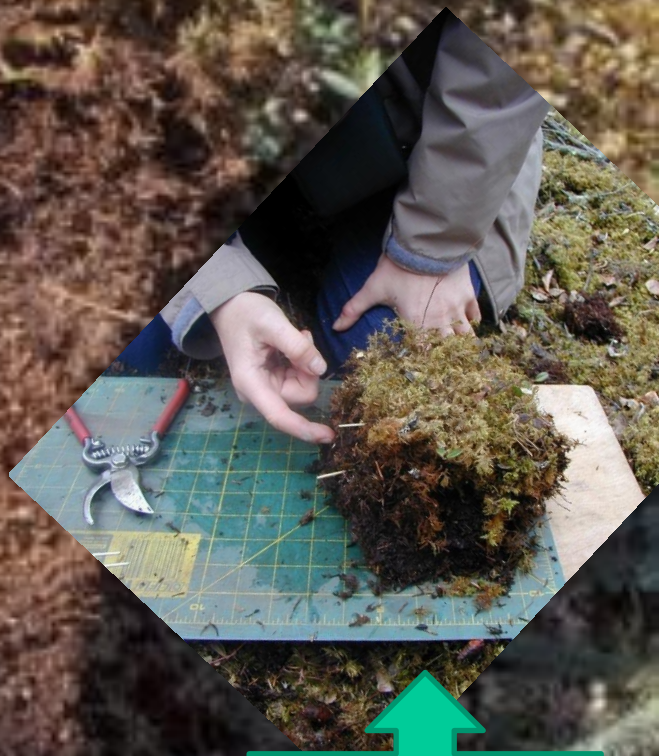
Live Moss

Dead Moss

Upper Duff

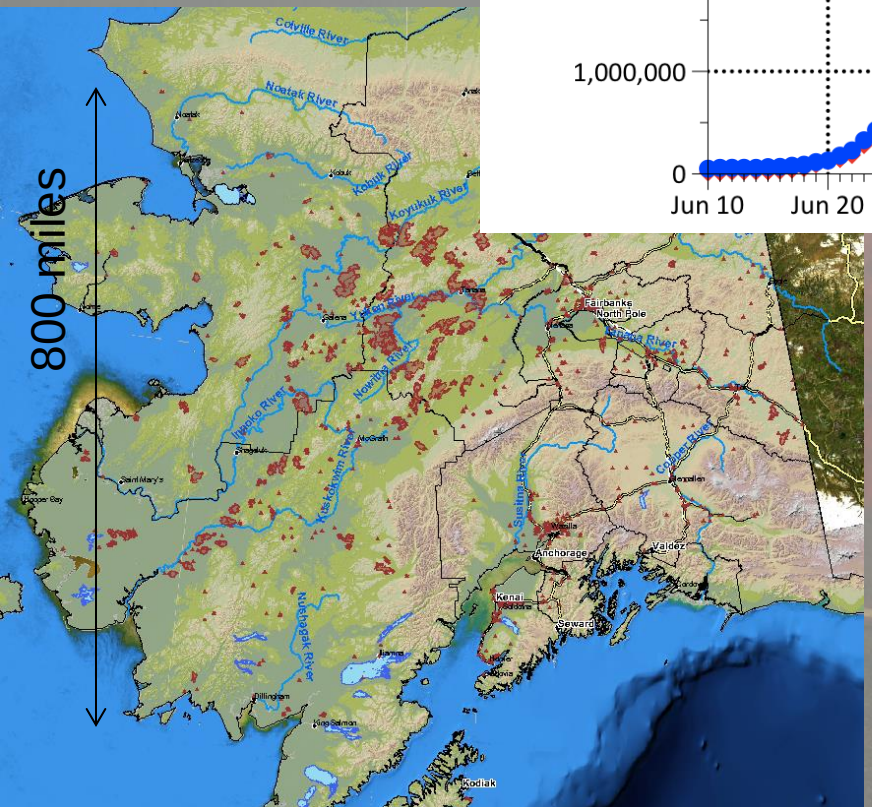
Lower Duff

Mineral Soil



Forest floor moss “duff”

2015 Fire Season



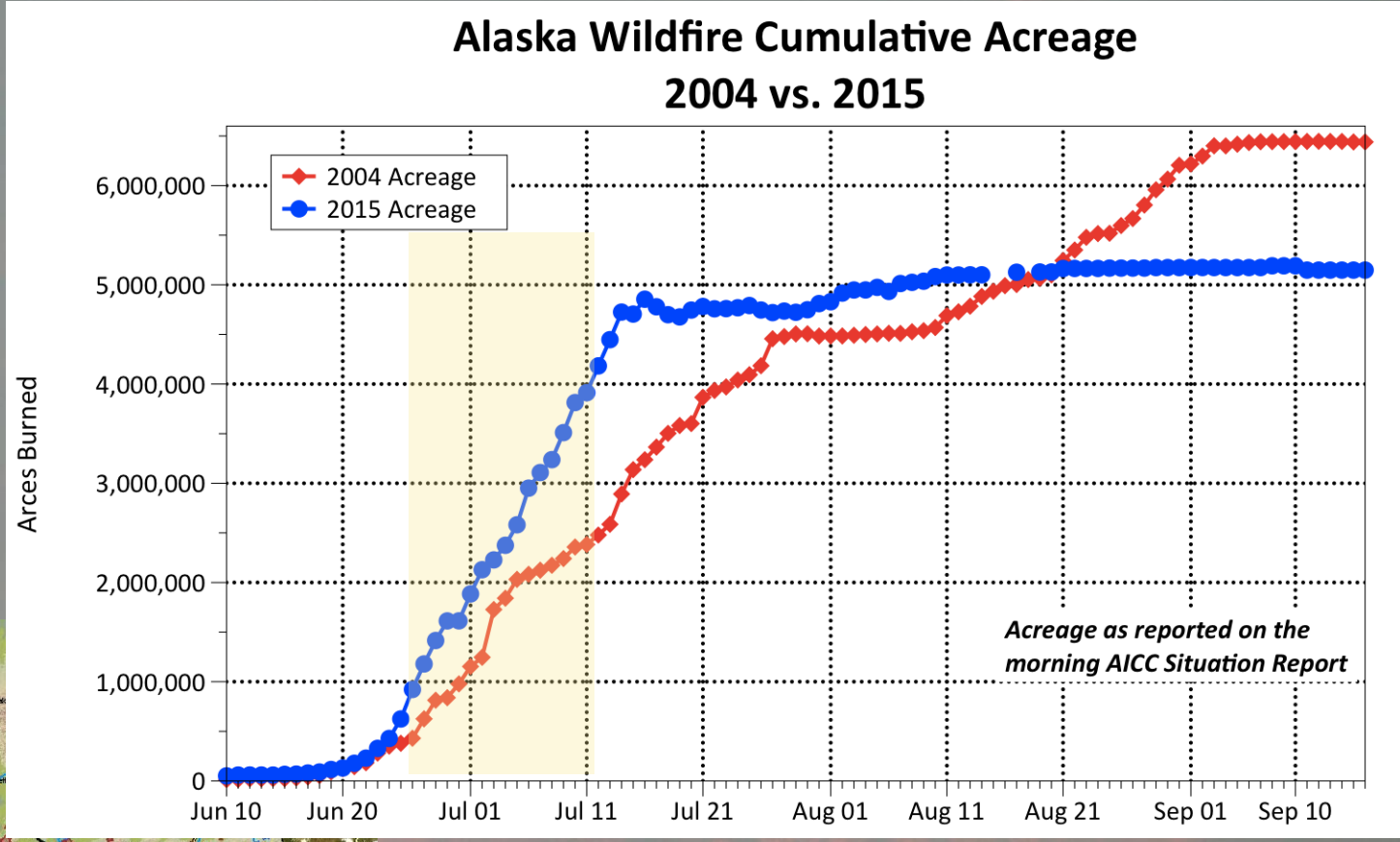


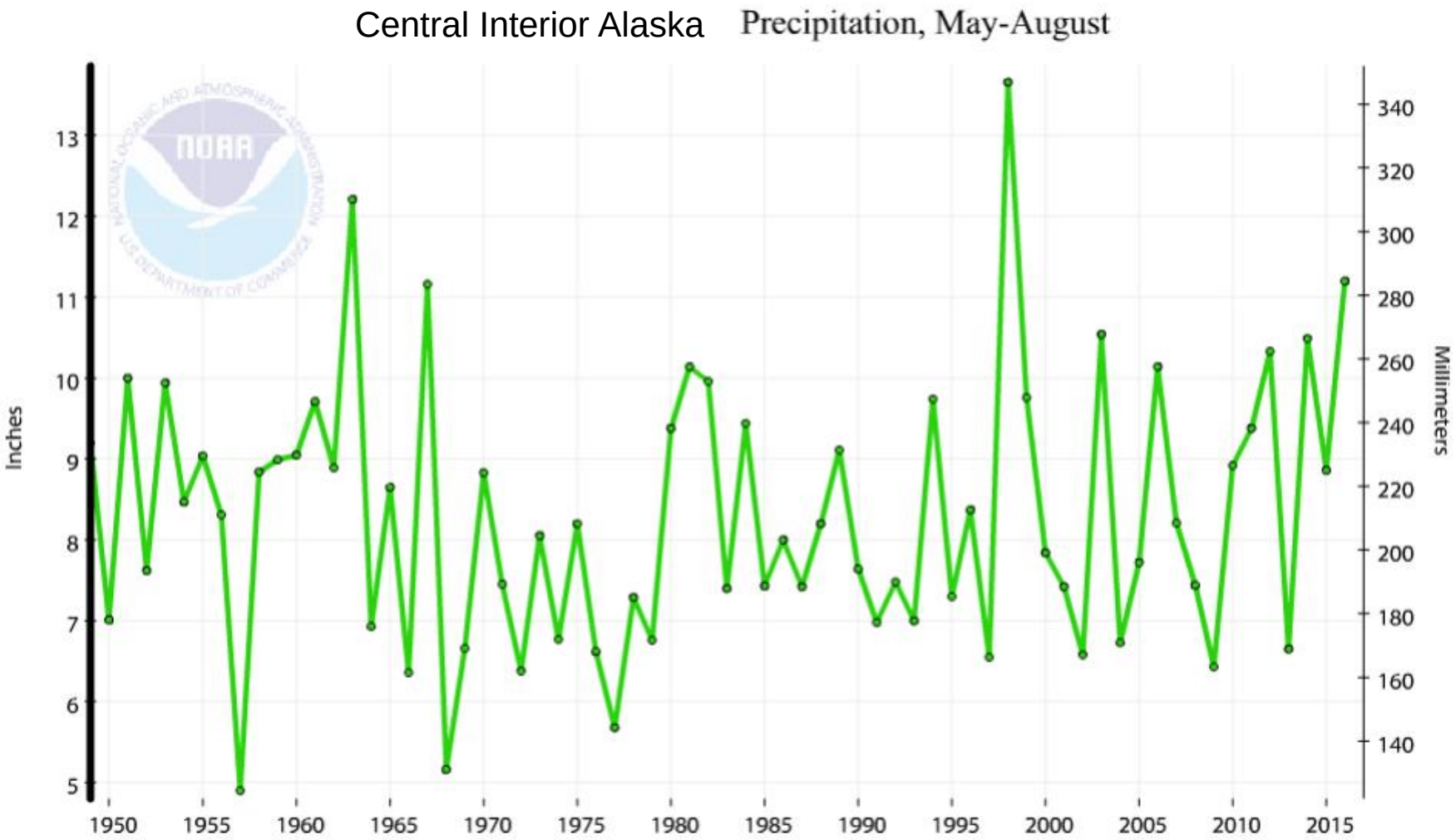
Figure by Rick Thoman, NWS Alaska Climate Center

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

Climate models tell us to expect more rainfall, but . . .

Not much change since 1949 in central Interior

↑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

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

Longer Fire Seasons

October 18th, 2016

April 17th 2016—Fire jumped on Knik R near Palmer.

Photo Amy Breen, Researcher, UAF

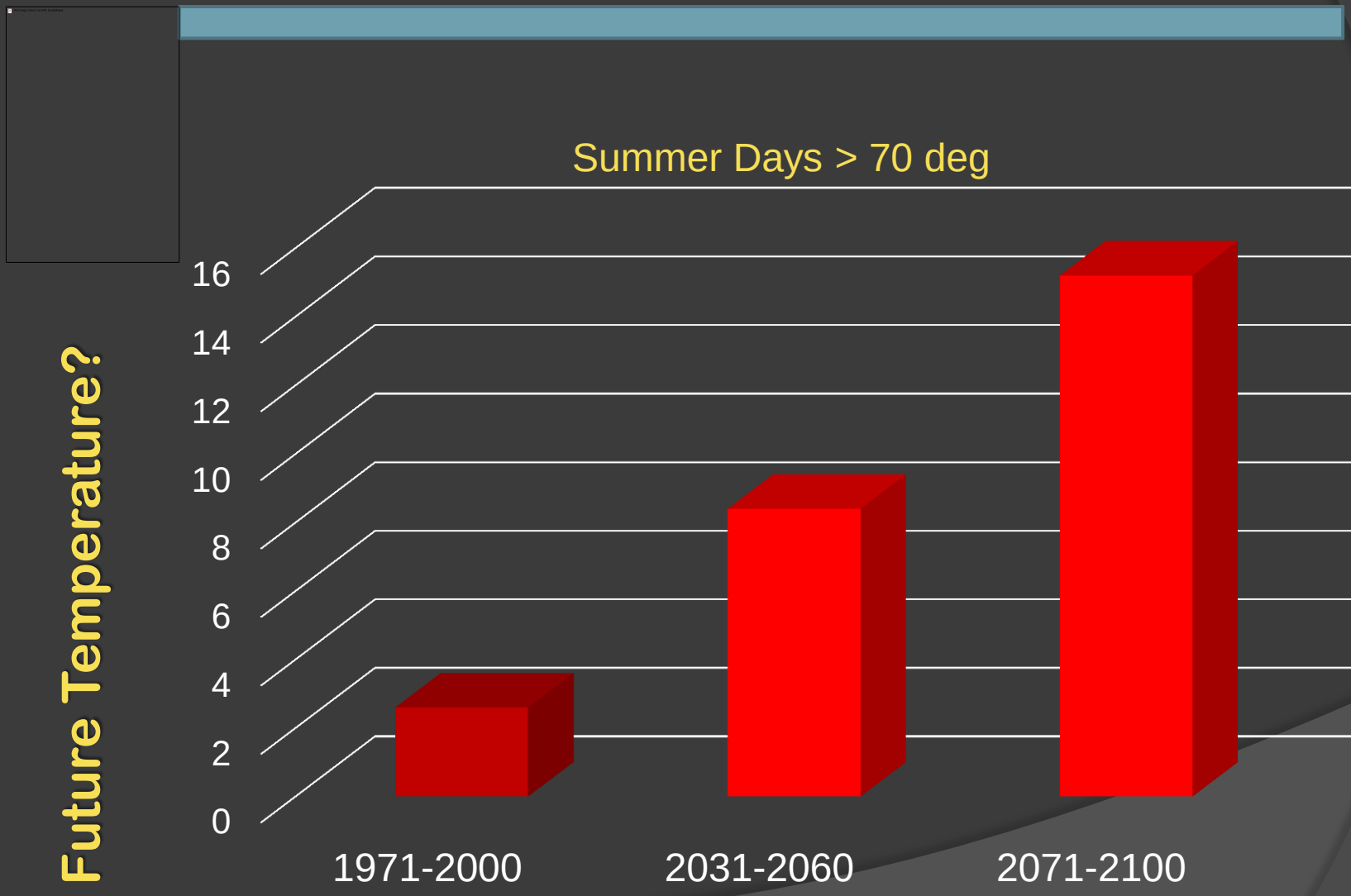
Interior Alaska has more snow-free days.

Break-up ~ 1-2 days earlier/decade

& snow cover ~2-5 days later/decade.

Fairbanks: Daily *average* Temp 70°F or warmer in:

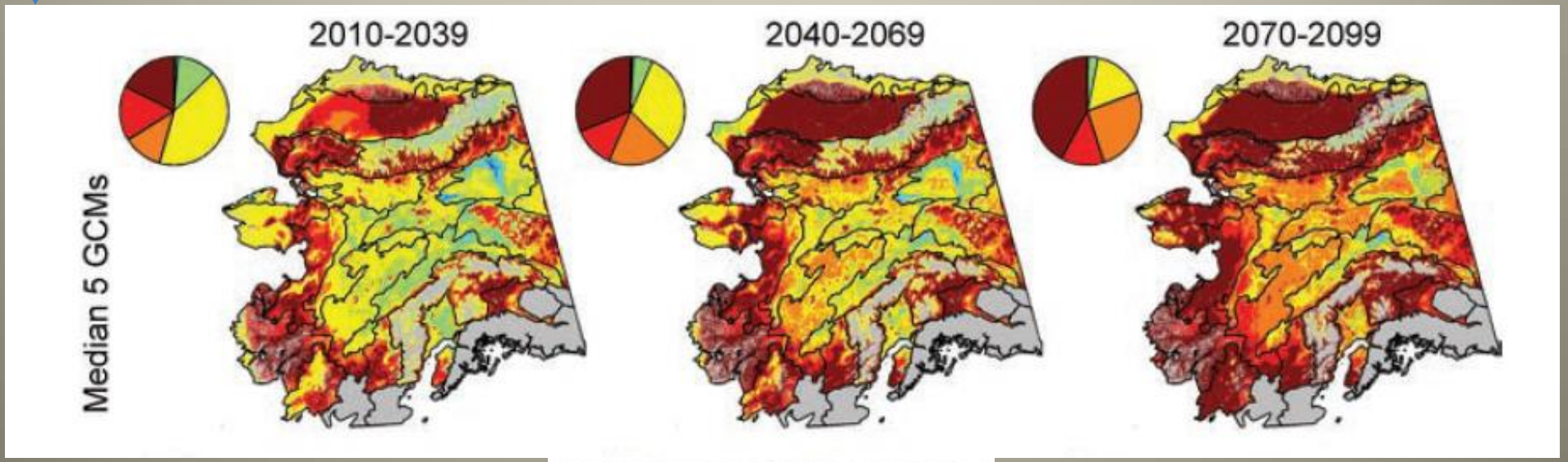
"1971-2000" 2031-2060 2071-2100



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.

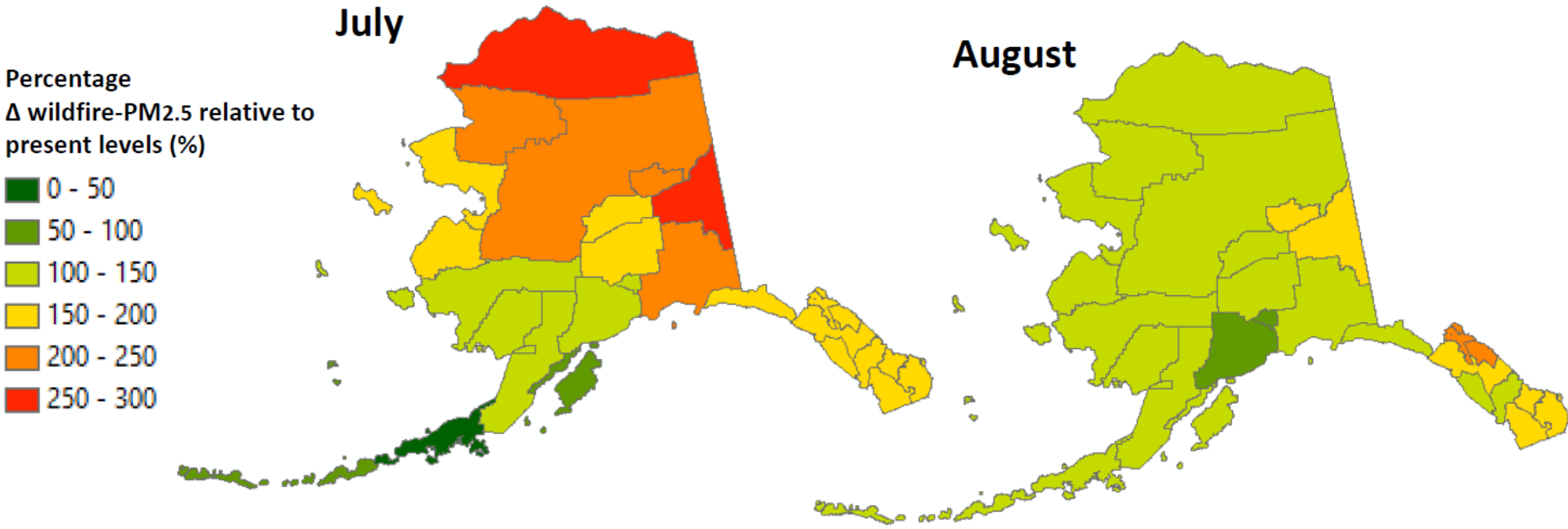

PM2.5 of 1,000µg/ml
Smoke & Health Impacts
WELCOME TO FAIRBANKS
TIME 8:17 AM

Air Quality Impacts?

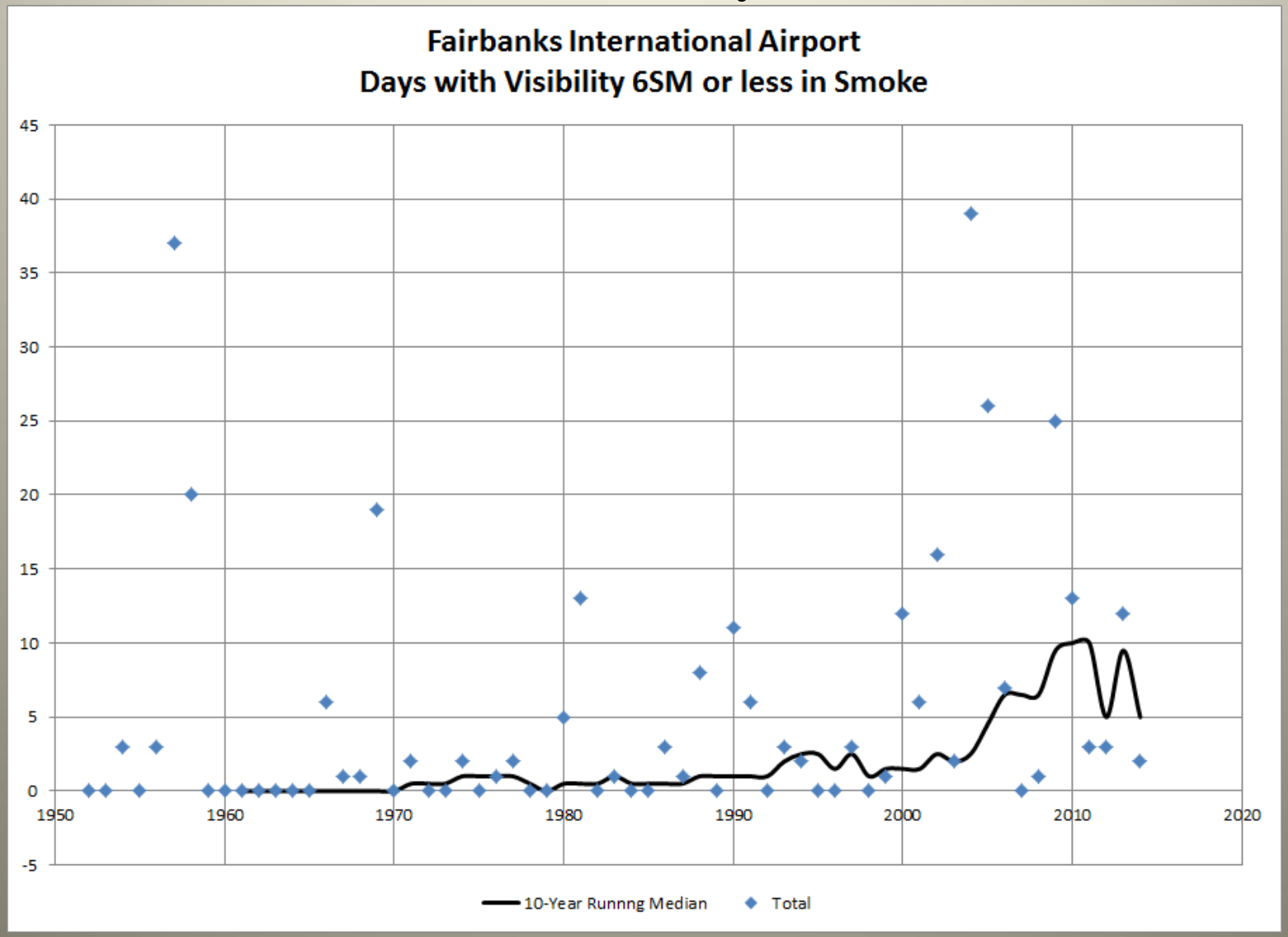
SEUNG HYUN LUCIA WOO
YALE SCHOOL OF FORESTRY & ENVIRONMENTAL STUDIES
IARPC WILDFIRES TEAM MEETING, 12 MAY 2016

PRELIMINARY

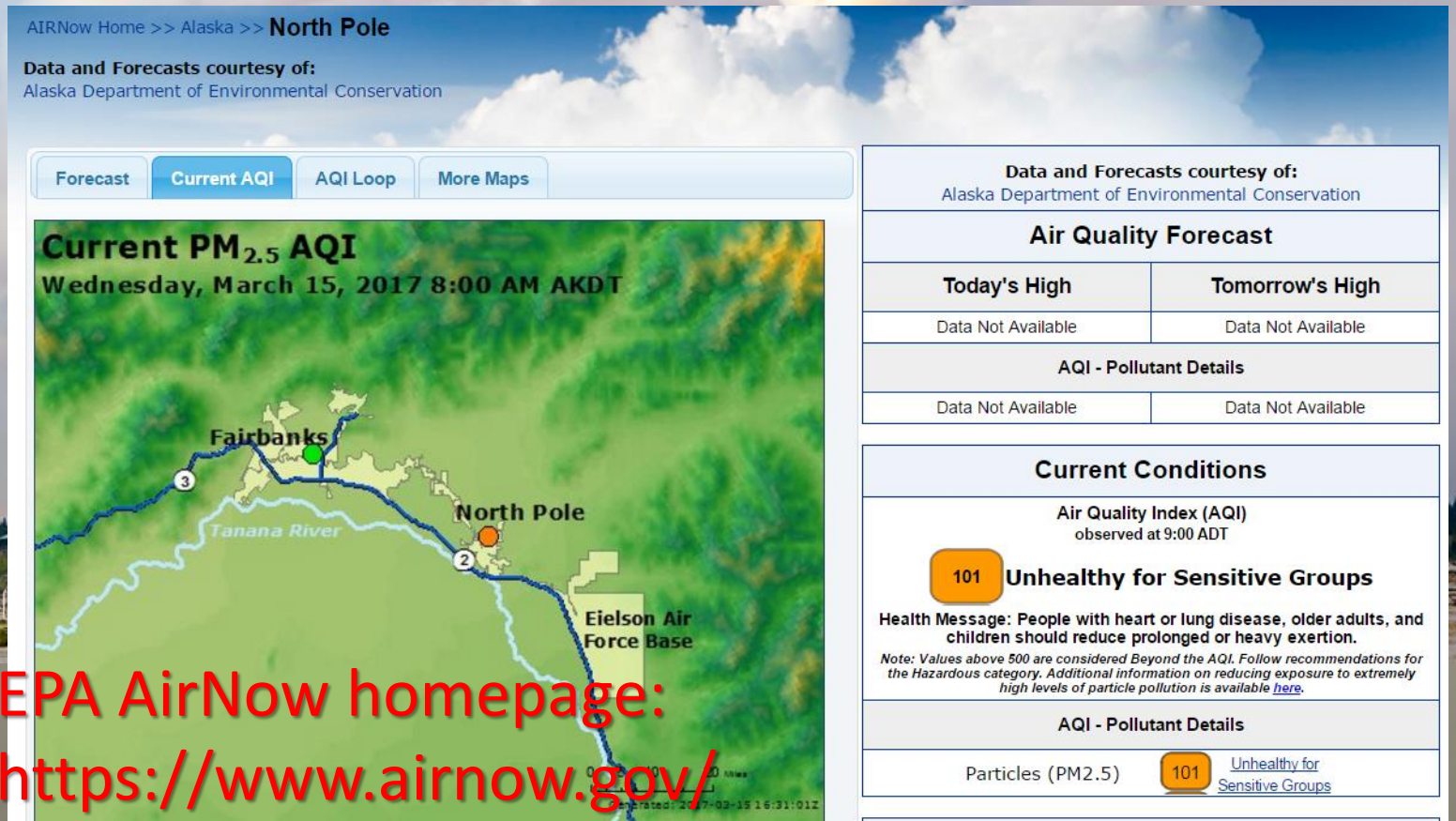
Most of Alaska will experience at least a **doubling** (light green) of fine particulate smoke (PM 2.5) exposure with climate-induced wildfires by 2050 (relative to 2000).



Any evidence for increased smoke impacts?



Can I find out what my air quality is right now?



EPA AirNow homepage: https://www.airnow.gov/

State of Alaska myAlaska My Government Resident

Alaska Department of Environmental Conservation

Division of Air Quality

State of Alaska > DEC > Air Quality > AOS > Air Quality Summary > Air Quality Detail

Air Quality for FNSB NCORE

Predominant Pollutant (4/13/2017 10:23 AM)

42.5 $PM_{10}(\mu g/m^3)$

0 55 155 255 355

GOOD MOD UNHEALTHY

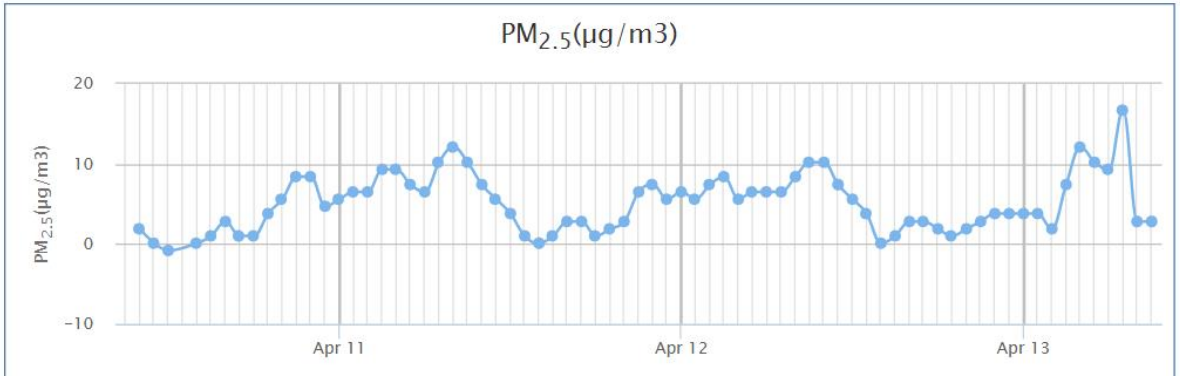
Serving Area

Click for Station Detail

Health Effect Categories

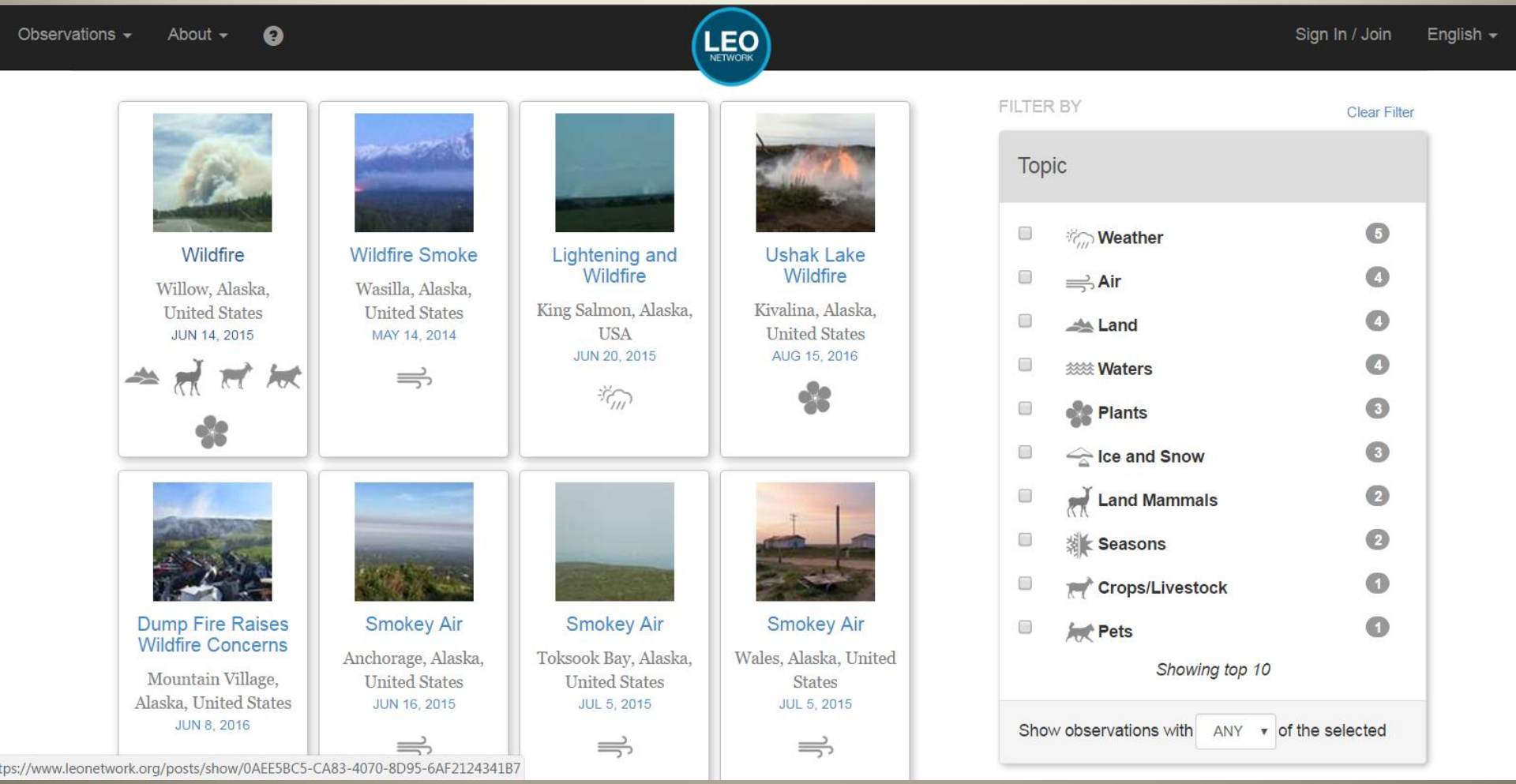
- Hazardous
- Very Unhealthy
- Unhealthy
- Unhealthy for Sensitive Groups
- Moderate
- Good
- No Data

Explanation of Categories



- ✓ Also air quality alerts statewide
- ✓ Tips on mitigating exposure risk

Smoke Reports on Local Environmental Observers Network

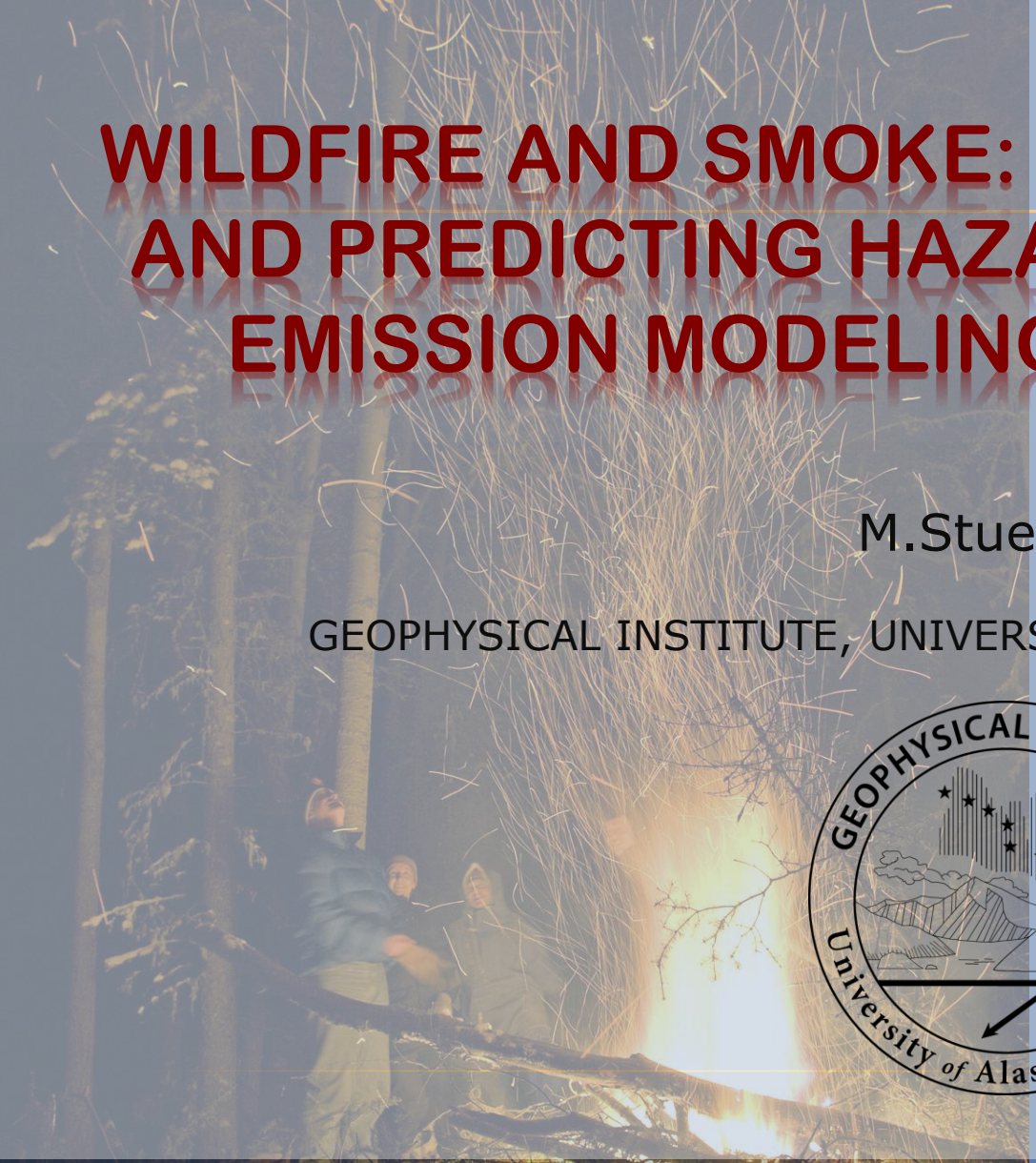


https://www.leonetwork.org/en/

WILDFIRE AND SMOKE: UNDERSTANDING AND PREDICTING HAZARDS IN ALASKA: EMISSION MODELING WITH WRF-CHEM

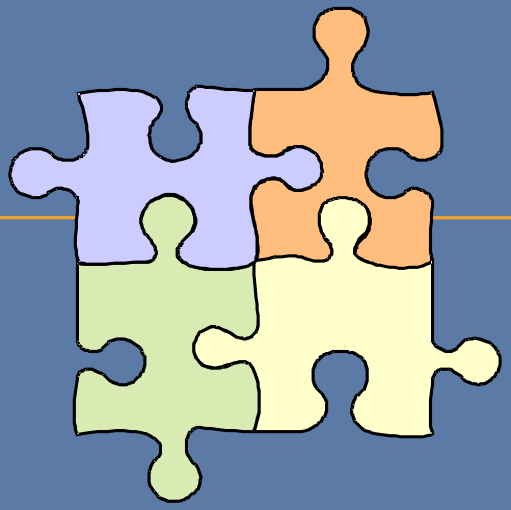
M.Stuefer, C. Waigl

GEOPHYSICAL INSTITUTE, UNIVERSITY OF ALASKA FAIRBANKS

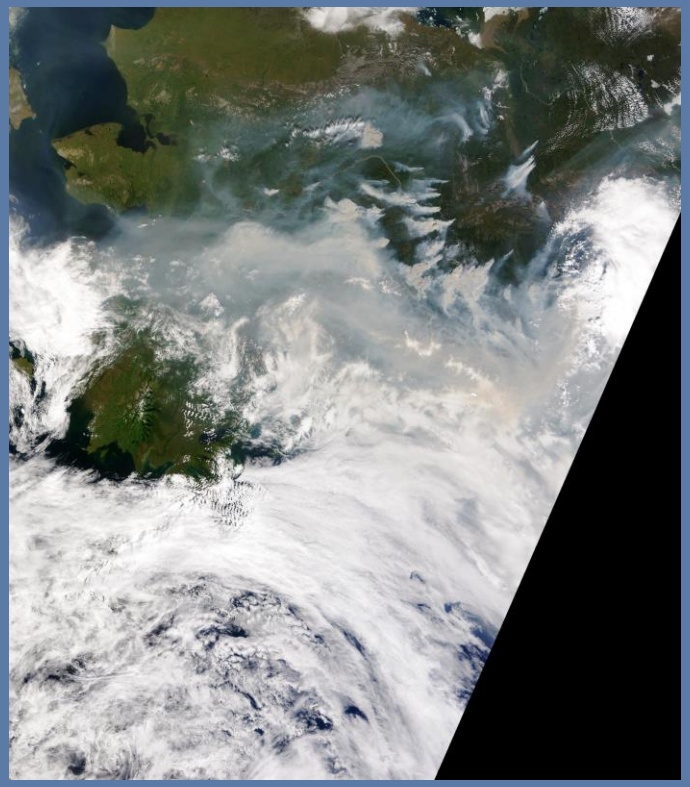


ACCAP/AFSC WEBINAR, 18 April 2017

OUTLINE

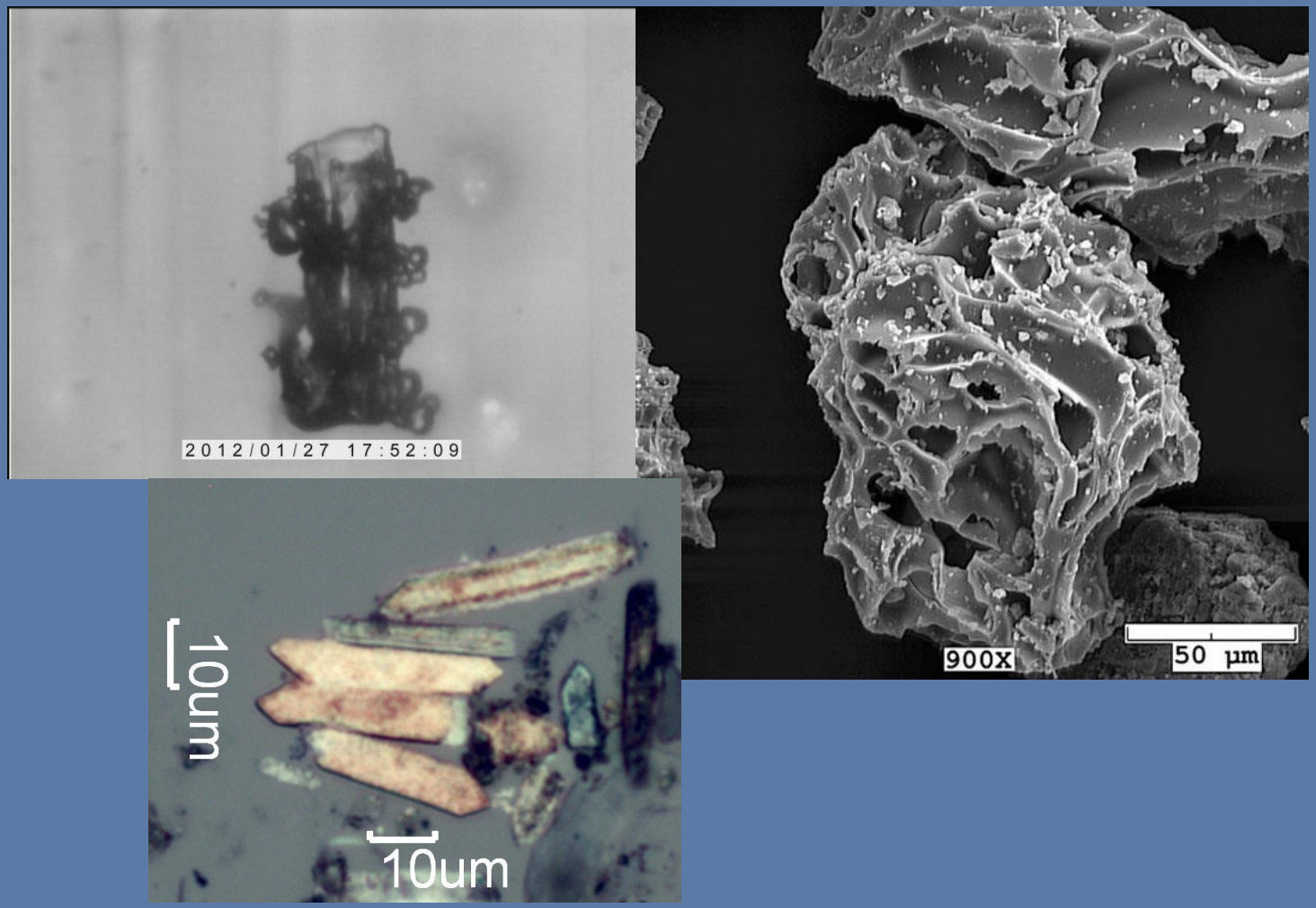


- Background
- Resources to Date – Weather Research Forecast Model (WRF) with Chemistry (WRF-CHEM) and the implementation of biomass burn emissions
- Weather Feedback
- Airborne Validation and Operational Tool Development Status

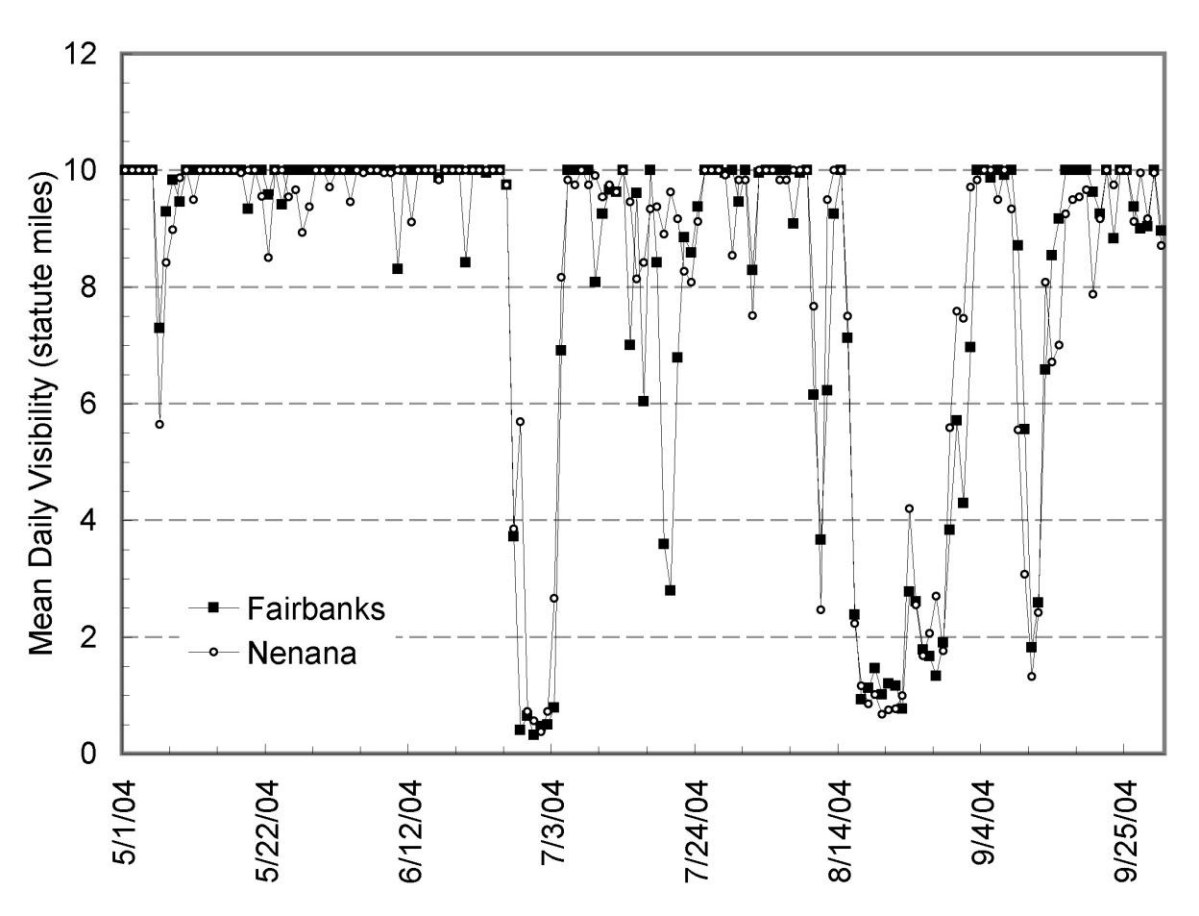


BACKGROUND

AEROSOL TYPES

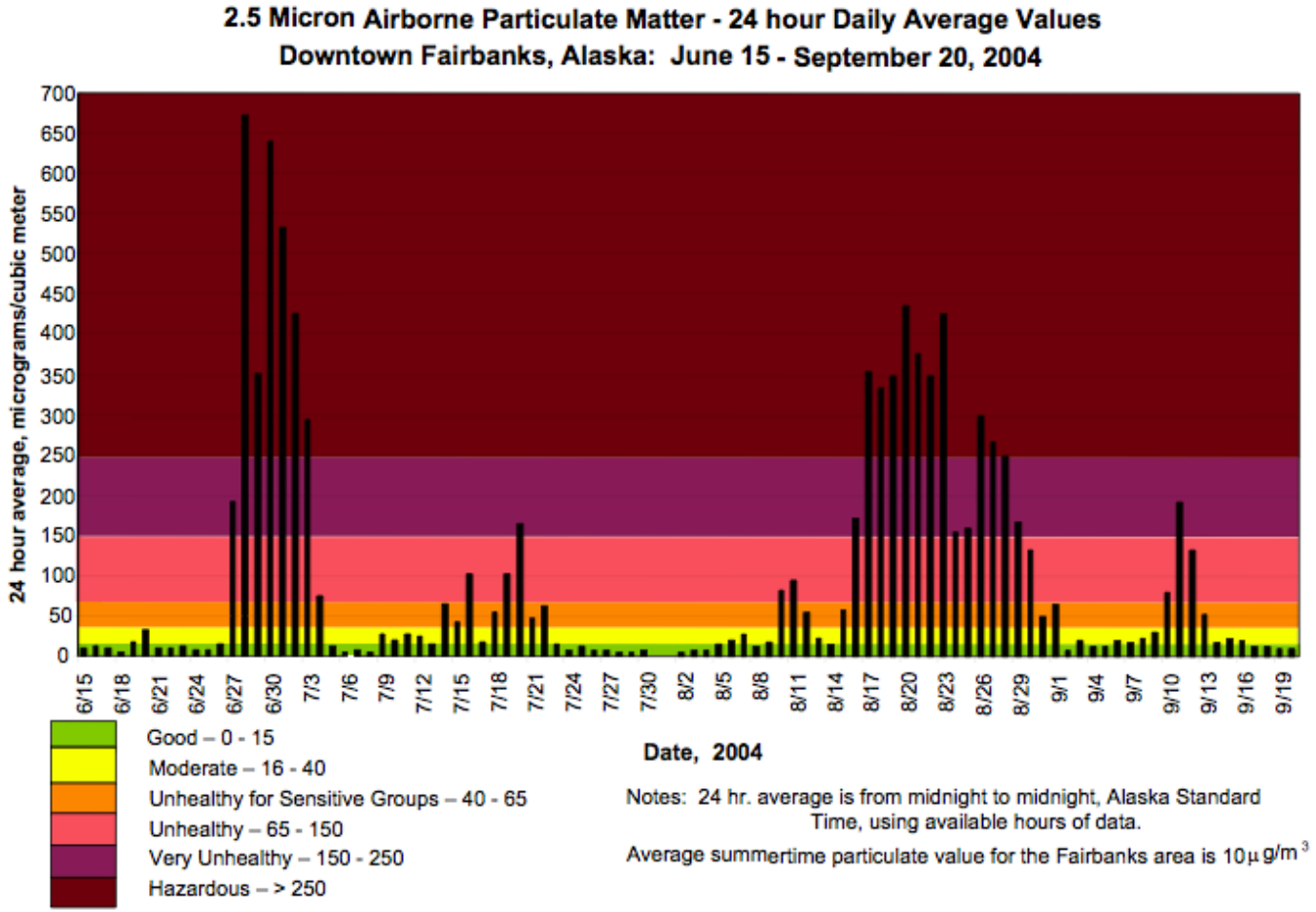


BACKGROUND



May - September 2004: Average Visibility measured at the 2 locations Fairbanks and Nenana
Analysis by the Alaska Climate Research Center, University of Alaska Fairbanks

AIR QUALITY AND SMOKE



Prepared by the DEC Division of Air Quality
http://www.dec.state.ak.us/air/

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'.

UAFSMOKE SYSTEM HTTP://SMOKE.ARSC.EDU/

FIRE EMISSIONS

Static Fuel Data
Emission Factors

BACKGROUND EMISSIONS

WRF-CHEM WITH INLINE PLUME

WRF-Chem netCDF

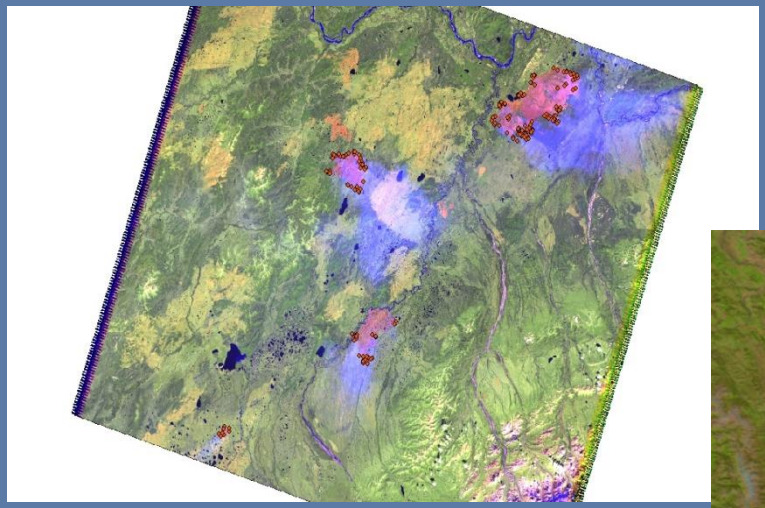
POSTPROCESSING

- 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.

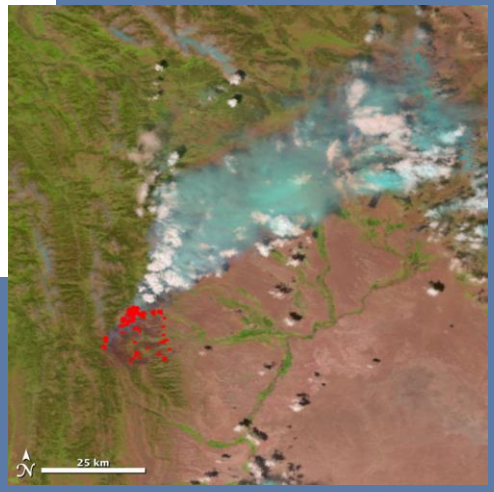
HYBRID FIRE PRODUCTS AS WILDFIRE SOURCE – SATELLITE REMOTE SENSING

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

FIRE EMISSIONS => 'FIXED EMISSION FACTORS'

Emitted tracer mass *E* for a certain fire species *i* from biomass burning is estimated according to:

$$E_i = a * b * CE * e_i$$

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

- Fuel load factors published by Wiedinmyer et al. 2006.
- Andrae and Merlet's (2001) comprised necessary emission factors in order to relate various fuel-load types involved in **biomass burning to emissions**.

PREP_CHEM_SOURCES

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/m^2).

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 – 1ºx1º

Anthropogenic sources

RETRO: REanalysis of the **TRO**pospheric chemical composition over the past 40 years, global, 0.5º x 0.5º, monthly
EDGAR: Emission Database for Global Atmospheric Research, global, 1º x 1º, annually

Biogenic sources

GEIA: Global Emissions Inventory Activity, 1º x 1º

GOCART: Goddard Chemistry Aerosol Radiation and Transport model, 1º x 1.25º, monthly, anthropogenic and natural sources

ALASKA DAILY SMOKE FORECASTS

UAFSMOKE

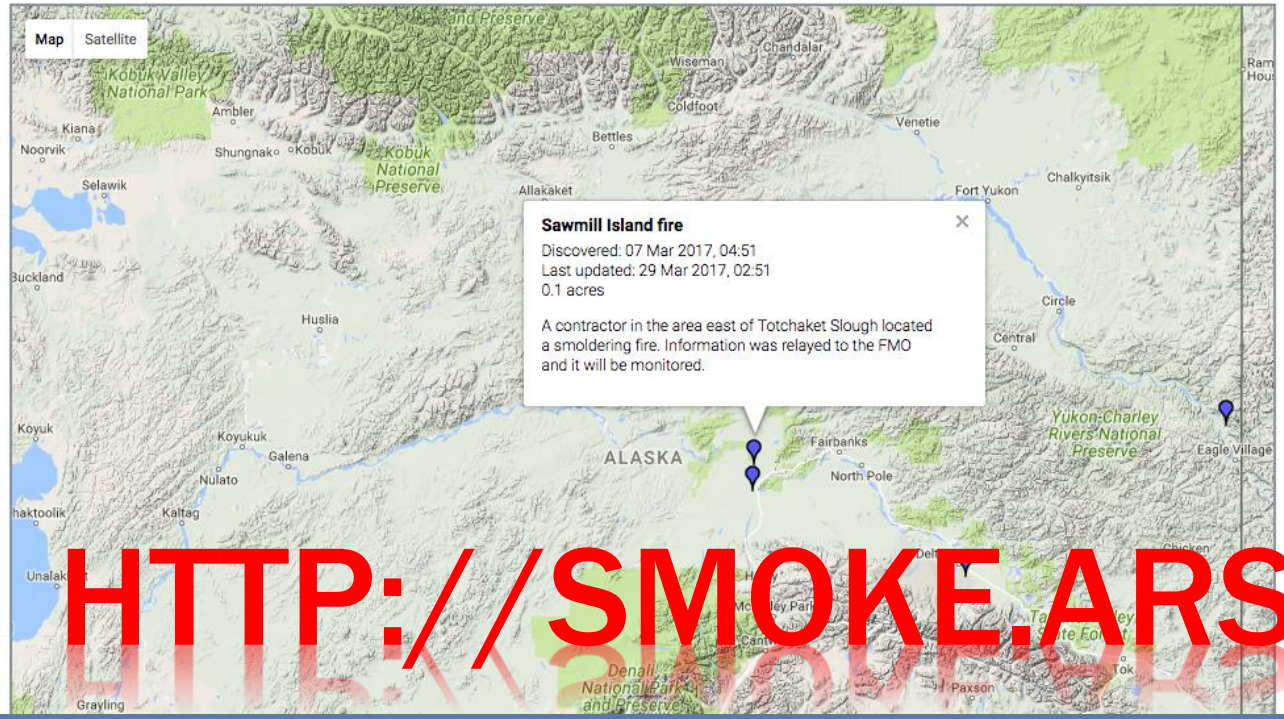
Wildfire Smoke Prediction for Alaska

Home
Forecasts
Current Fires
Documentation
About

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)



⇒ **72 hour** Smoke WX

⇒ GFS meteorological initial and boundary conditions

⇒ **daily** during the fire season

⇒ Forecast graphics at

=> Chemistry: GOCART simple aerosol scheme, no O_3

⇒ WSM 5-class scheme microphysics

⇒ RRTM longwave

⇒ Dudhia shortwave

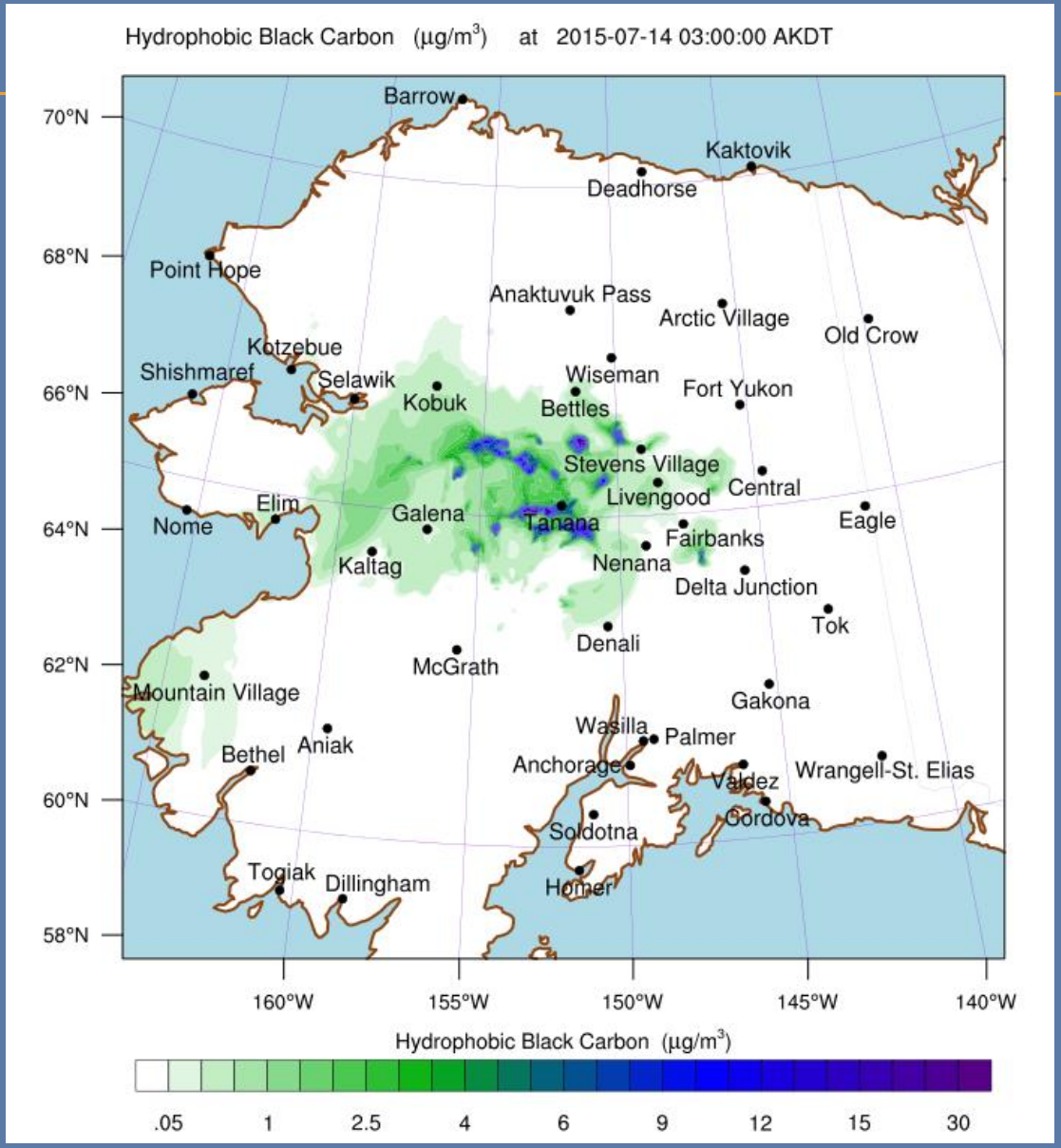
⇒ YSU boundary layer scheme

HTTP://SMOKE.ARSC.EDU/

NEAR REAL-TIME FORECASTS

http://smoke.arsc.edu/

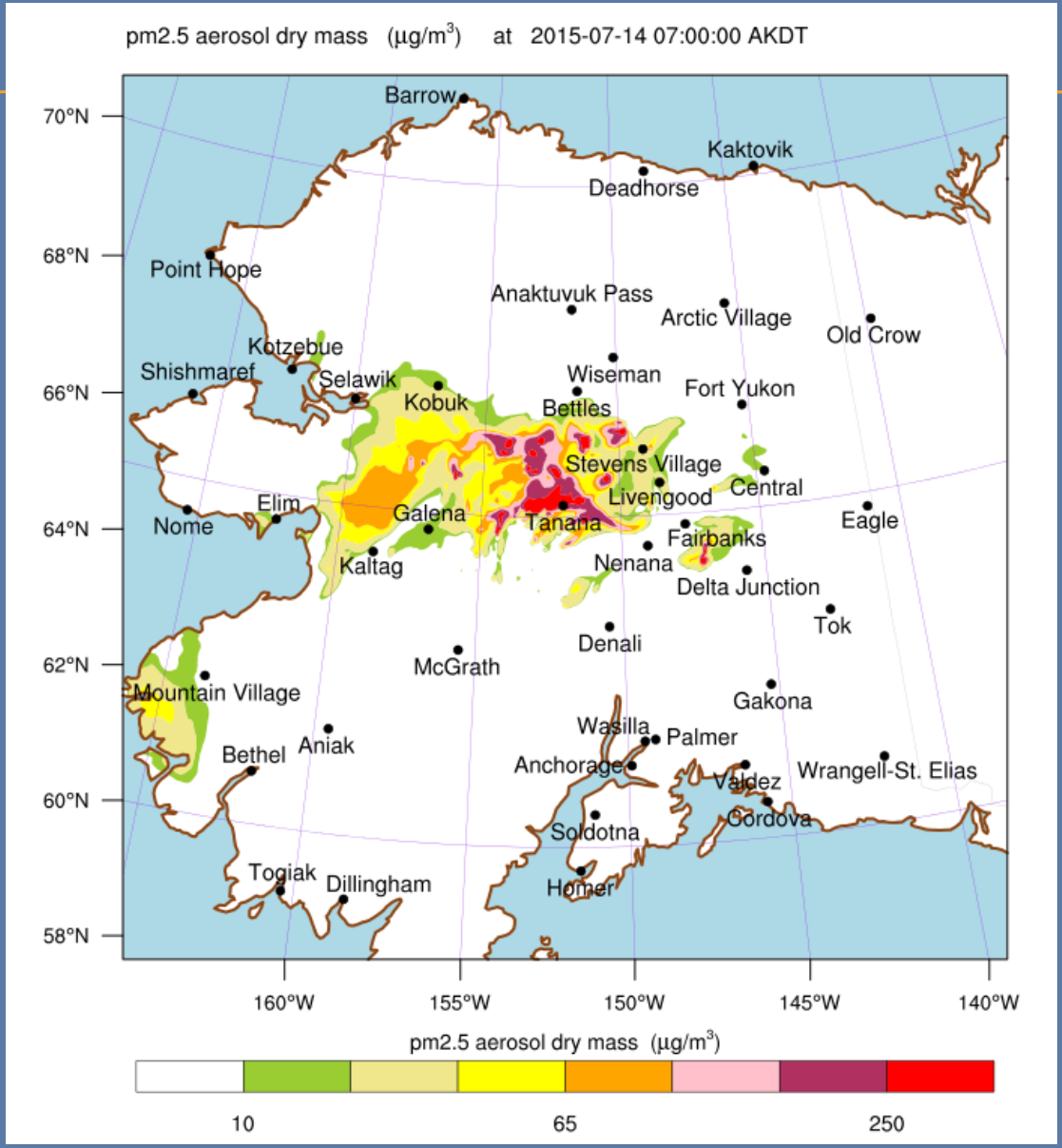
Example Black Carbon



NEAR REAL-TIME FORECASTS

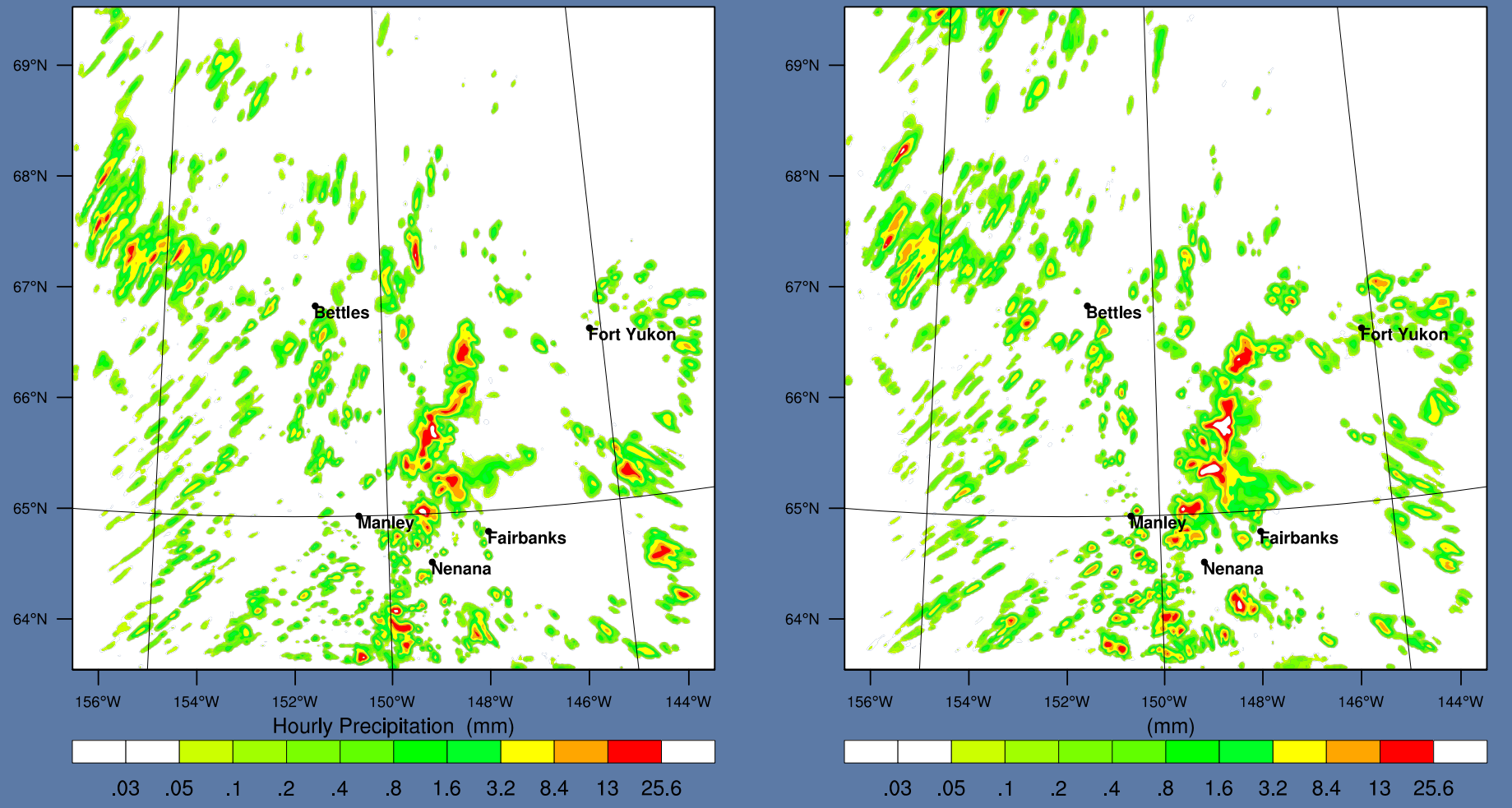
http://smoke.arsc.edu/

Example PM 2.5



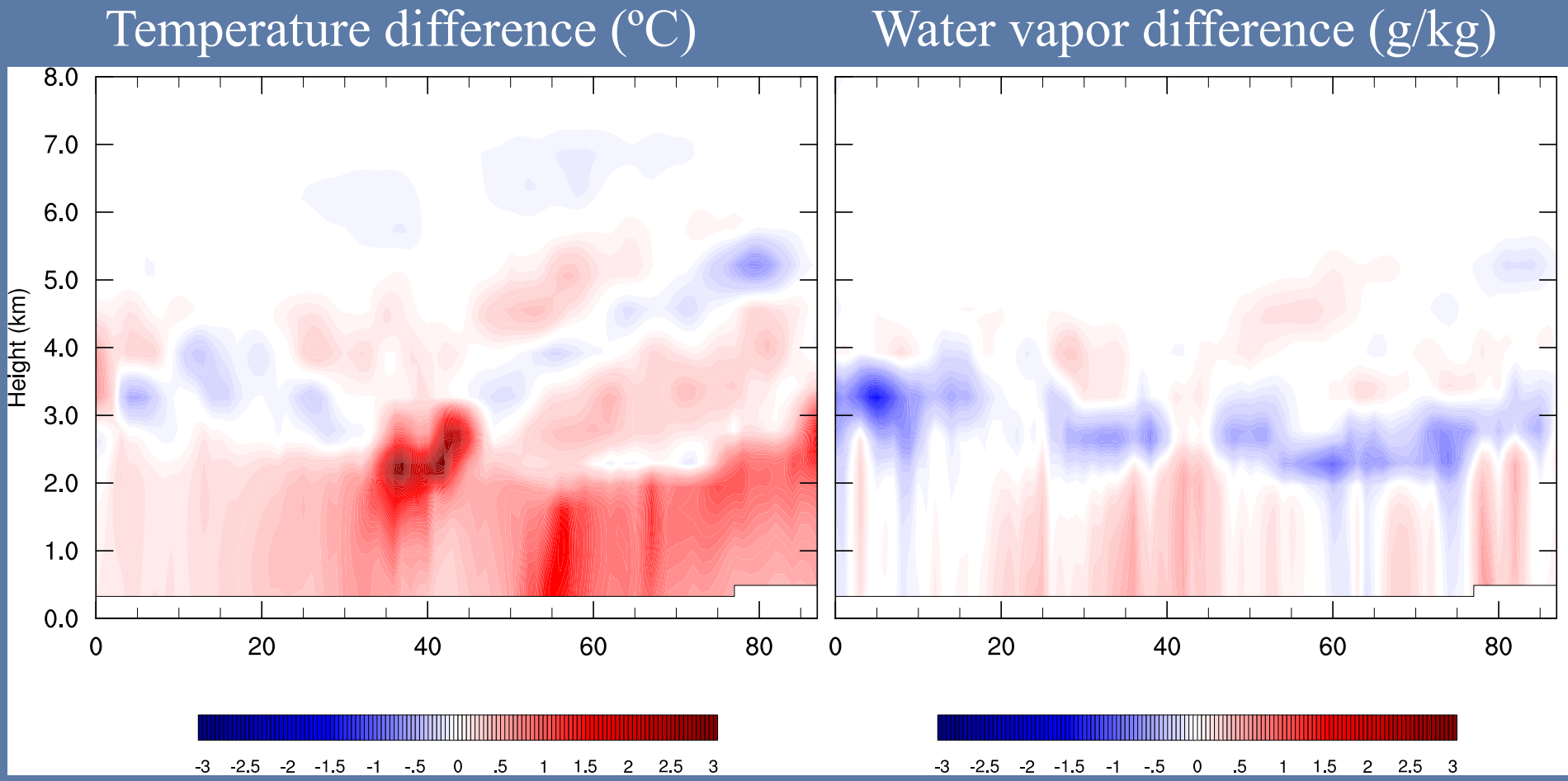
SMOKE IMPACTS WEATHER? => PRECIPITATION

Without Fires **0000UTC, July 4, 2004** With Fires



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

IMPACTS WEATHER? => TEMPERATURE AND WATER VAPOR



Cross section: July 4, 2004

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

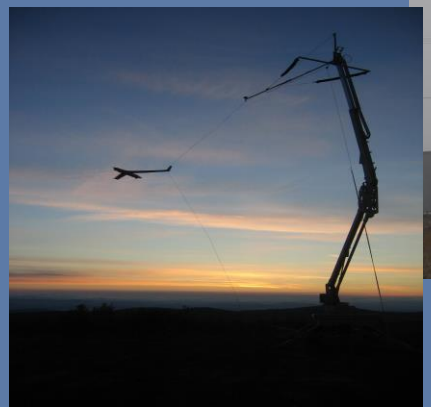
MODEL VERIFICATION

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.

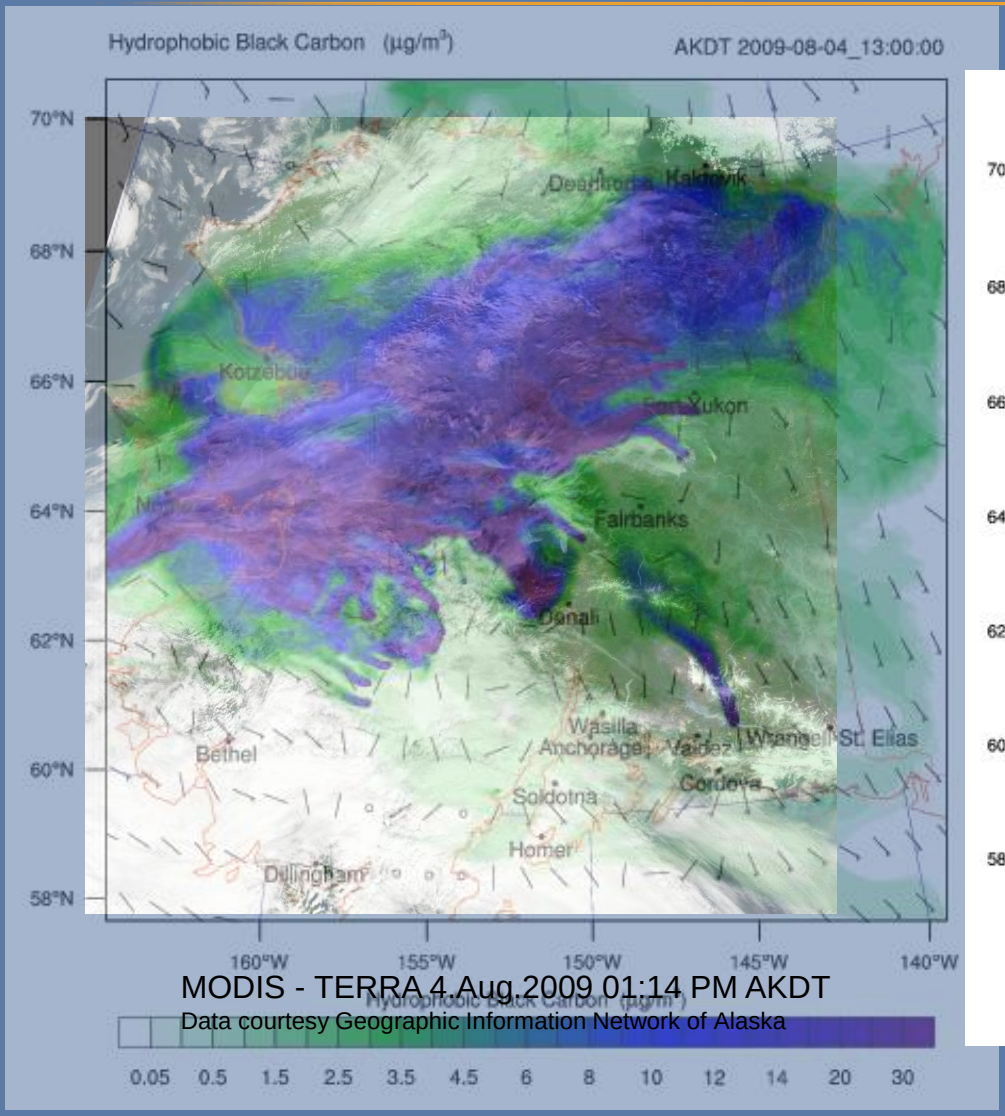
- UAS measurements in future
- PUBLIC FEEDBACK

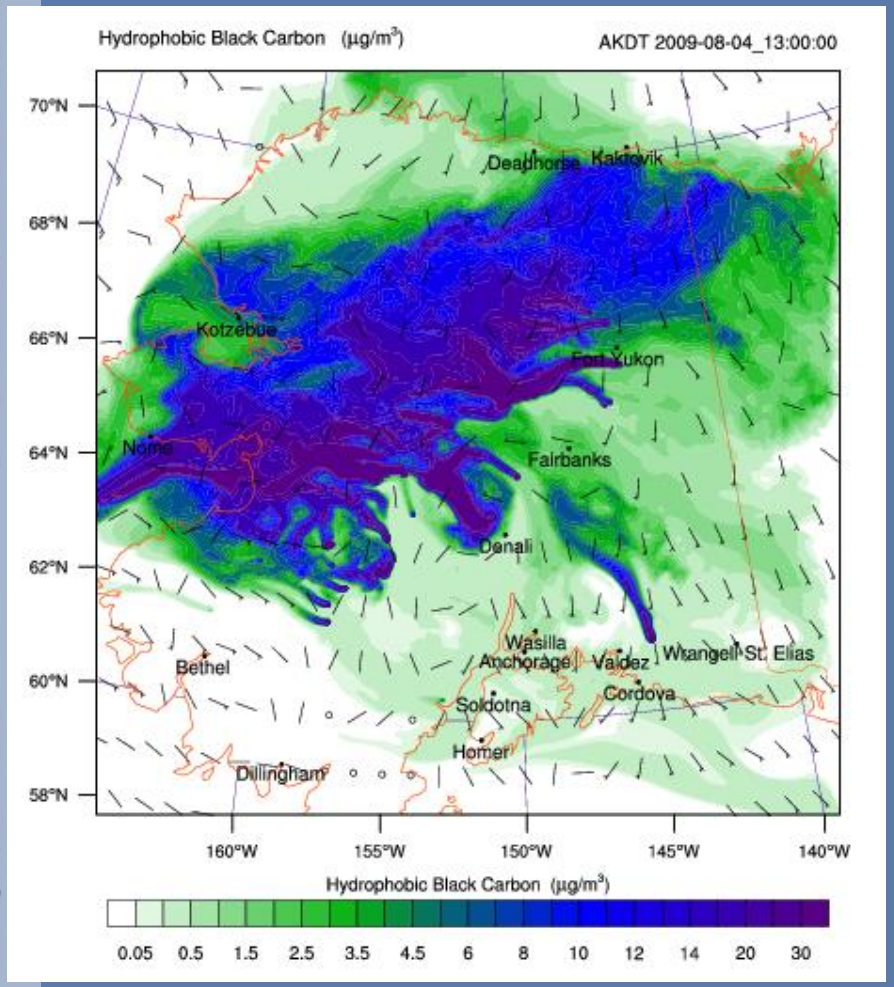
US DOE Atmospheric Radiation Measurement



Geophysical Institute, University of Alaska ACUASI UAS program

2009: FORECAST COMPARISON WITH MODIS

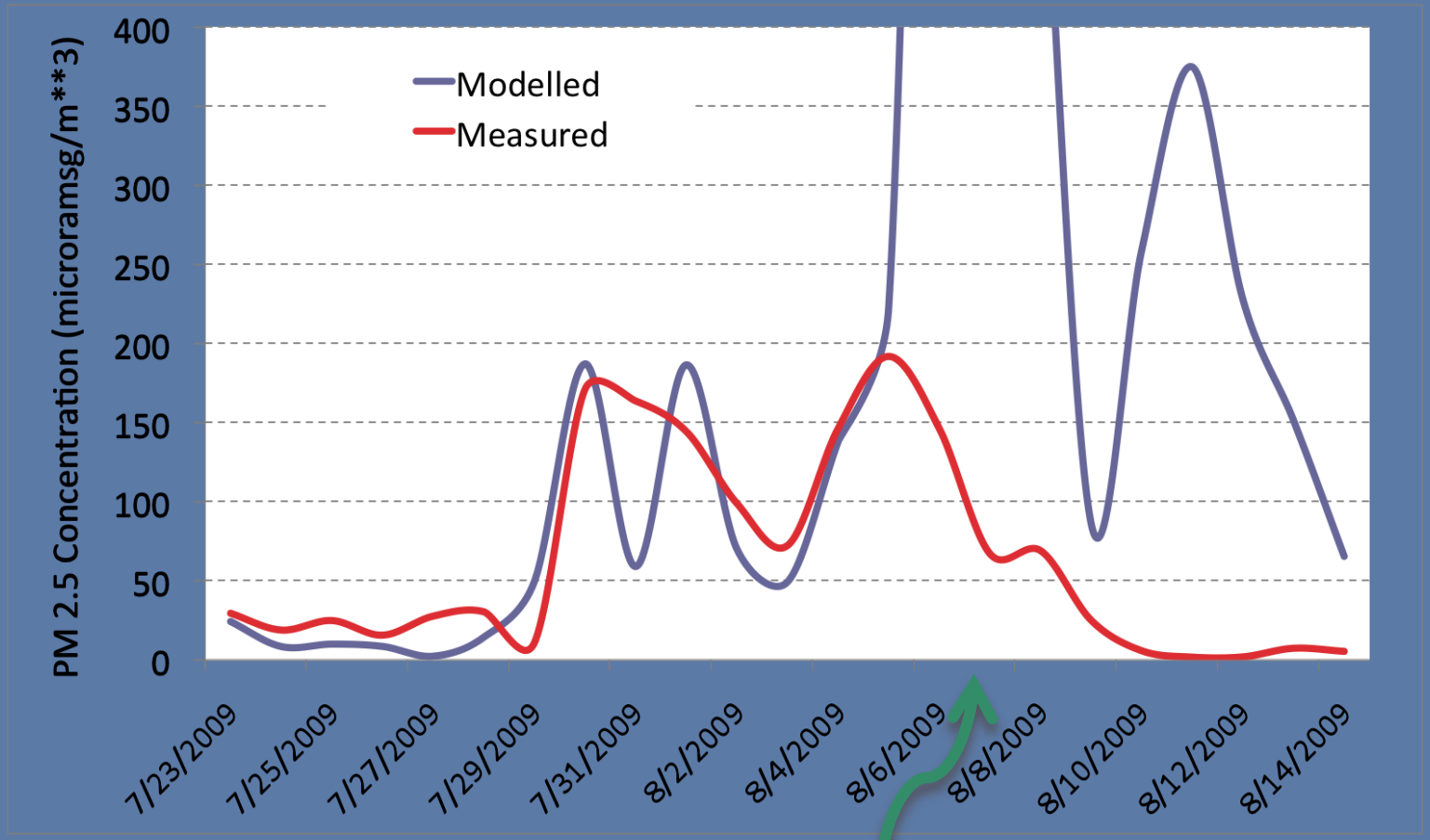




MODIS - TERRA 4 Aug 2009 01:14 PM AKDT

Data courtesy Geographic Information Network of Alaska

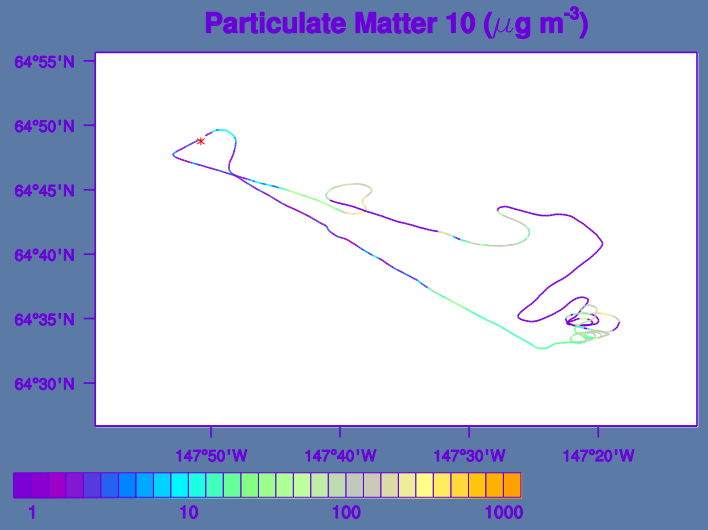
2009: FORECAST COMPARISON FOR PARTICULATE MATTER (PM2.5)



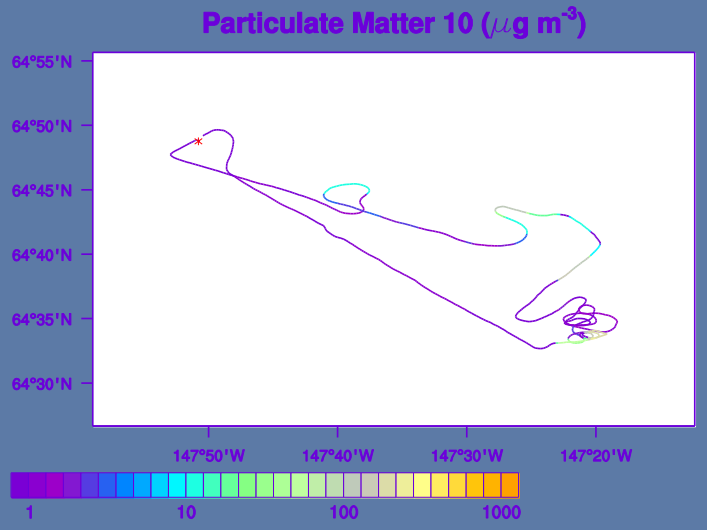
Measurement Source: Fairbanks North Star Borough

VERIFICATION– DRY CREEK FIRE 2012

OBSERVED

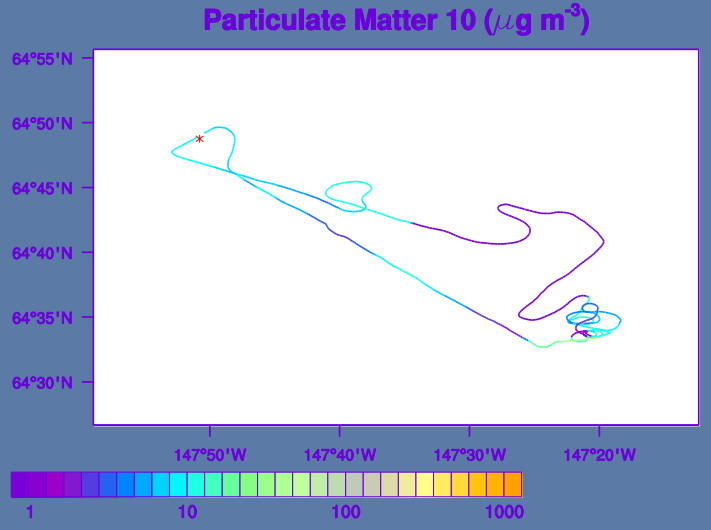


WRF-CHEM -- MADE/SORGAM



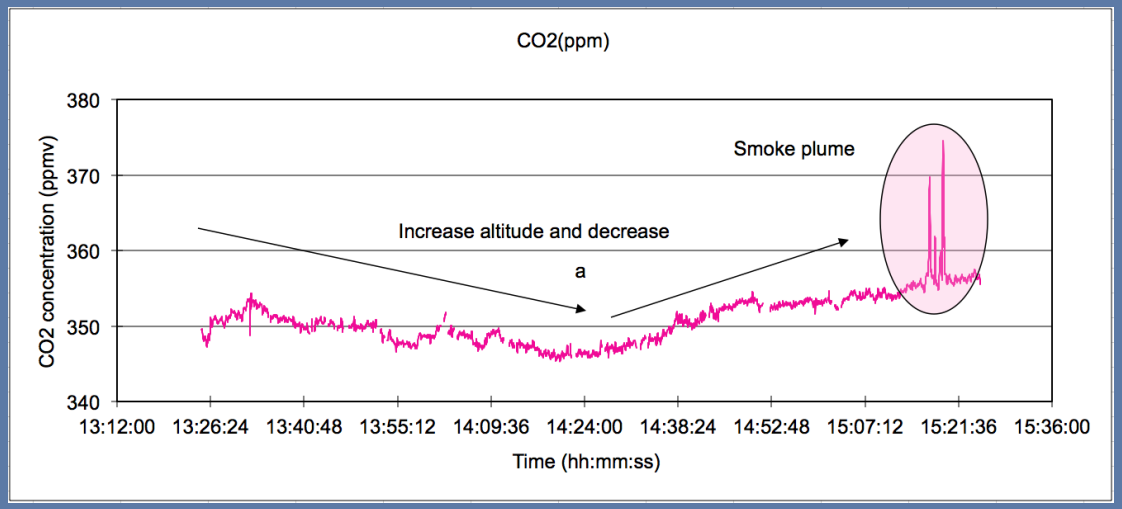
Simulation with different aerosol modules

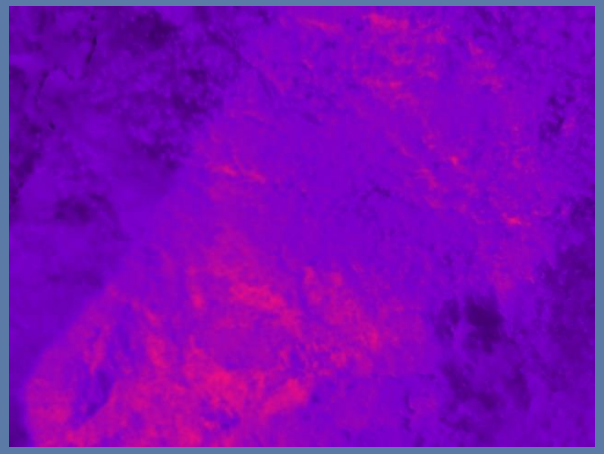
WRF-CHEM -- GOCART



VERIFICATION

- Airborne optical particle counter (Grimm Particle Spectrometer)
- FLIR IR Imaging
- Hyperspectral Fire Data





VERIFICATION

HyLab
University of Alaska Fairbanks Hyperspectral Imaging Laboratory

- 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

SUMMARY - PLANS

- New real time http://smoke.arsc.edu/ WRF-Chem model applications will be available in 2017
- 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.
- **EVALUATION, EVALUATION, EVALUATION, EVALUATION, EVALUATION, EV**

CONTACT: MSTUEFER@ALASKA.EDU

Health Effects of Wood Smoke

Stacey Cooper
Environmental Public Health Program
Alaska Section of Epidemiology

Sources of Wood Smoke

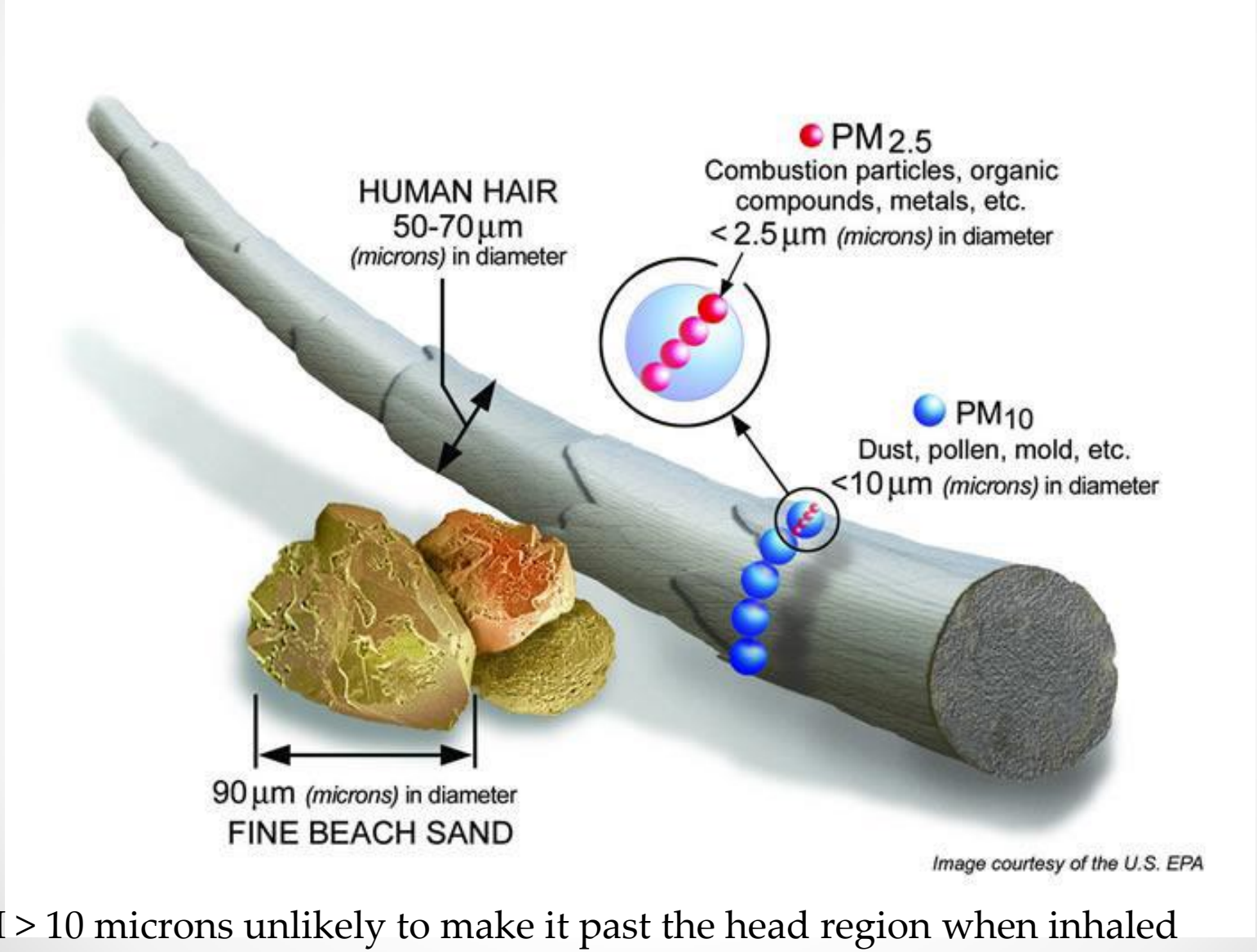
Outdoor

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

Indoor

- Fireplace
- Wood stove
- Coal or pellet stove

Particulate Matter (PM) Size

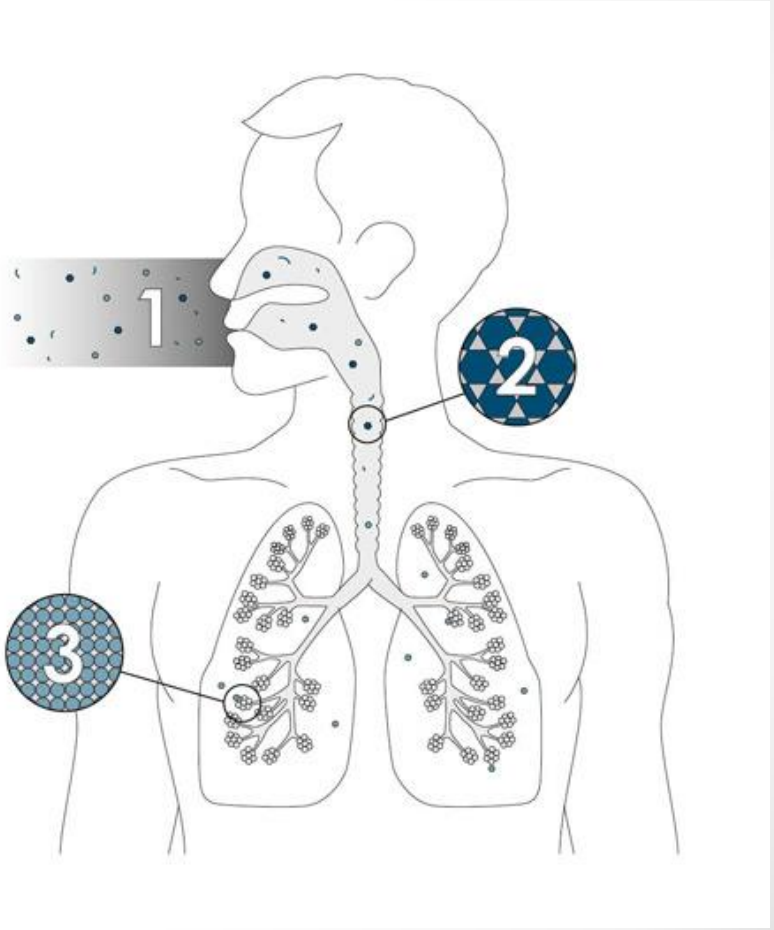


PM > 10 microns unlikely to make it past the head region when inhaled

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
  - Higher in early childhood
  - Lower in adolescents and young adults
  - Increasing in middle- through old-age, as the incidence of heart and lung diseases increases

Sensitive Populations

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

- Pregnant women
  - Potential harm to fetus
    - Some evidence of low birth rates when mothers were exposed to wildfire smoke[1]
  - Increased respiratory rate
  - Increased blood and plasma volume

Holstius et al. 2012

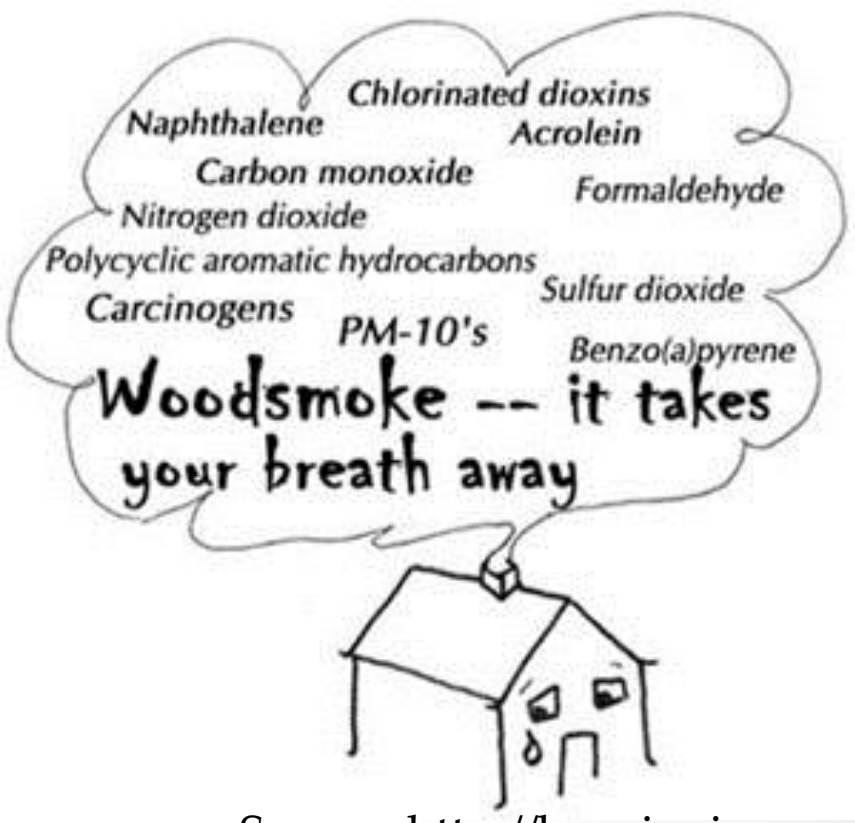
Sensitive Populations

- Older adults
  - Are more likely to suffer from pre-existing heart or respiratory conditions
  - Decrease in defense mechanisms with age
- People with pre-existing respiratory conditions
  - Asthma
  - Chronic Obstructive Pulmonary Disease
- People with pre-existing cardiovascular conditions
  - Hypertension
  - Heart Failure
  - Coronary artery disease
  - Cerebrovascular conditions (artherosclerosis)

How to tell if you're affected

Experiencing:

- Coughing
- Scratchy throat
- Irritated sinuses
- Shortness of breath
- Chest pain
- Headaches
- Stinging eyes
- Runny nose



Source: http://burningissues.org/

Smoke may make pre-existing respiratory conditions worse

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

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

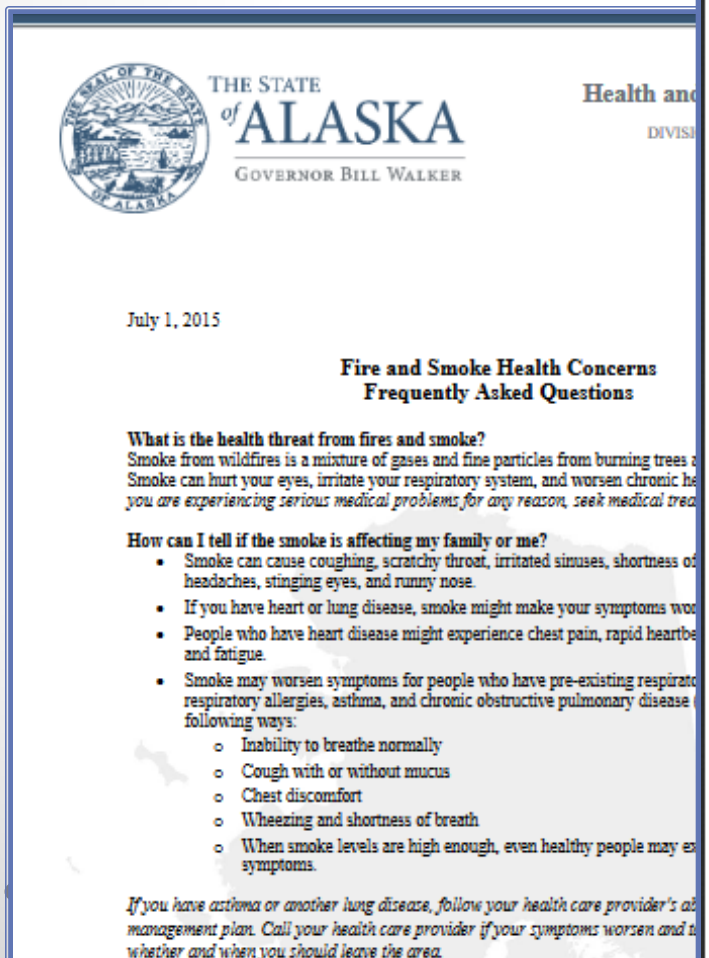
Resources

Environmental Public Health Program's Webpage

http://dhss.alaska.gov/dph/Epi/eph/Pages/wildfire/default.aspx

Resources

Environmental Public Health Program's Webpage



THE STATE of ALASKA
GOVERNOR BILL WALKER

Health and

DIVISI

July 1, 2015

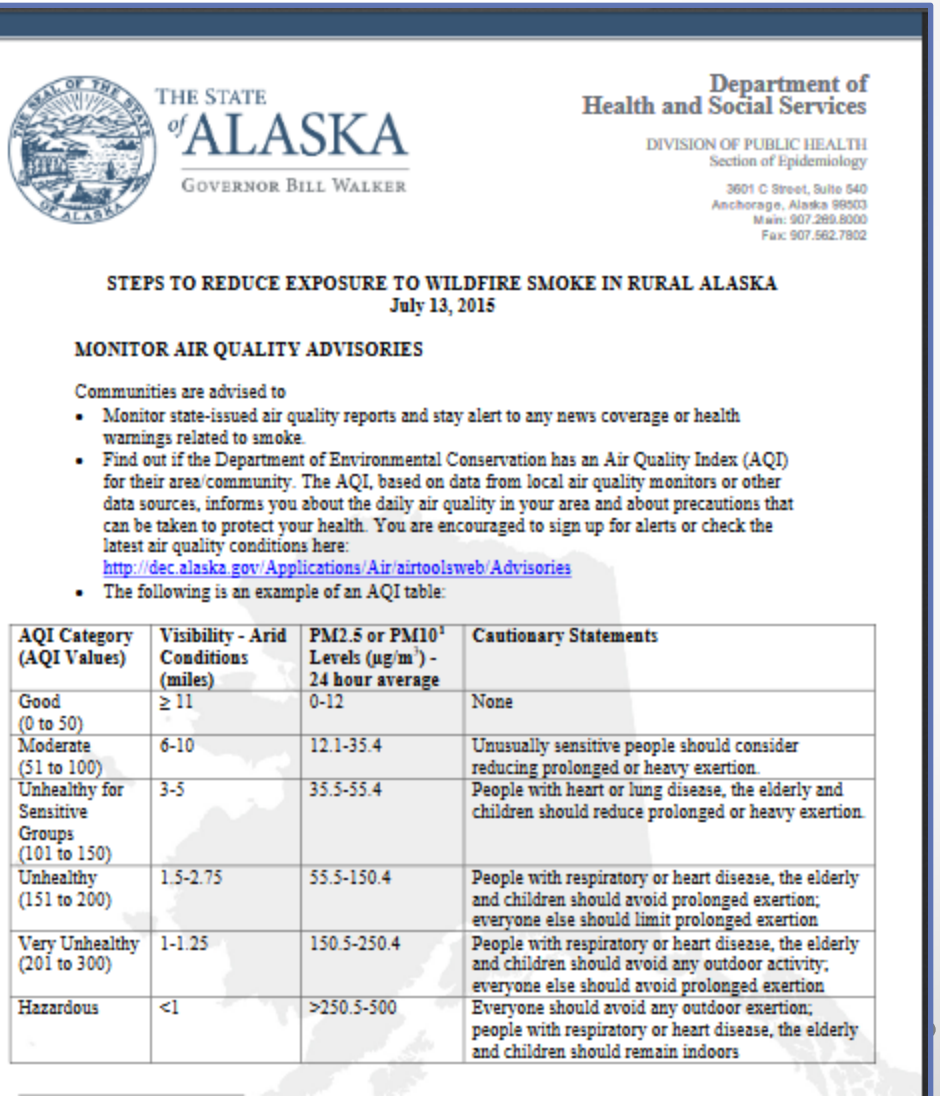
Fire and Smoke Health Concerns
Frequently Asked Questions

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

How can I tell if the smoke is affecting my family or me?

- Smoke can cause coughing, scratchy throat, irritated sinuses, shortness of
  headaches, stinging eyes, and runny nose.
- If you have heart or lung disease, smoke might make your symptoms wor
- People who have heart disease might experience chest pain, rapid heartbe
  and fatigue.
- Smoke may worsen symptoms for people who have pre-existing respirato
  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 ex
    symptoms.

If you have asthma or another lung disease, follow your health care provider's ad
management plan. Call your health care provider if your symptoms worsen and t
whether and when you should leave the area.



THE STATE of ALASKA
GOVERNOR BILL WALKER

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Section of Epidemiology

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STEPS TO REDUCE EXPOSURE TO WILDFIRE SMOKE IN RURAL ALASKA
July 13, 2015

MONITOR AIR QUALITY ADVISORIES

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:

AQI Category (AQI Values)	Visibility - Arid Conditions (miles)	PM2.5 or PM10[1] Levels ($\mu g/m^3$) - 24 hour average	Cautionary Statements
Good (0 to 50)	≥ 11	0-12	None
Moderate (51 to 100)	6-10	12.1-35.4	Unusually sensitive people should consider reducing prolonged or heavy exertion.
Unhealthy for Sensitive Groups (101 to 150)	3-5	35.5-55.4	People with heart or lung disease, the elderly and children should reduce prolonged or heavy exertion.
Unhealthy (151 to 200)	1.5-2.75	55.5-150.4	People with respiratory or heart disease, the elderly and children should avoid prolonged exertion; everyone else should limit prolonged exertion
Very Unhealthy (201 to 300)	1-1.25	150.5-250.4	People with respiratory or heart disease, the elderly and children should avoid any outdoor activity; everyone else should avoid prolonged exertion
Hazardous	<1	>250.5-500	Everyone should avoid any outdoor exertion; people with respiratory or heart disease, the elderly and children should remain indoors

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