Downwind of the Flames:

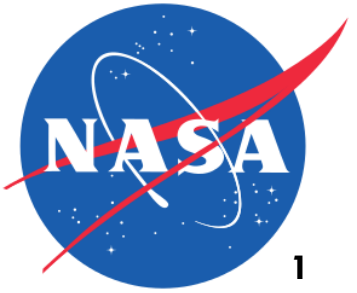
Assessing and Predicting Wildfire Smoke Related Morbidity Using Satellites, In-Situ Measurements, and Models

Jeff Pierce

Sheryl Magzamen, Emily Fischer, John Volckens, Gabriele Pfister

Bonne Ford, Ryan Gan, Will Lassman, Katelyn O'Dell

This work is funded by NASA project number **NNX15AG35G.**



Project Overview

Objectives:

1: Estimate the respiratory and cardiovascular health risks for specific demographic populations exposed to wildfire PM.

2: Evaluate and develop forecast tools that predict wildfire PM concentrations, population exposure, and the potential increased morbidity due to wildfire smoke.

Team:

CSU Atmospheric Science: Jeff Pierce, Emily Fischer, Bonne Ford, Katelyn O'Dell

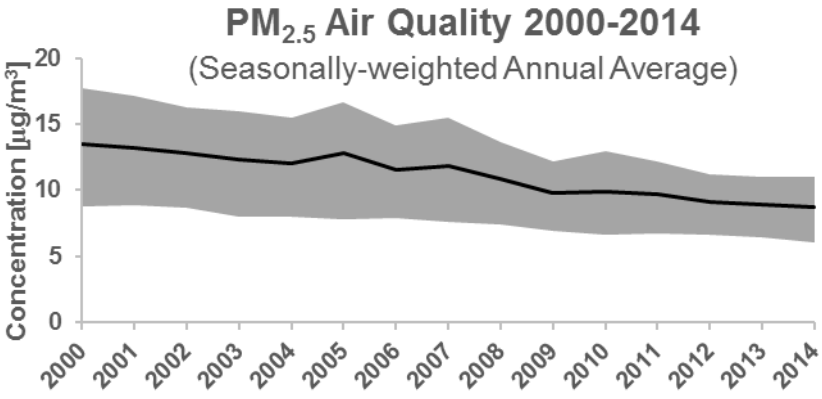
CSU Mechanical Engineering: John Volckens

CSU Environmental Health: Sheryl Magzamen, Ryan Gan

NCAR: Gabriele Pfister

Role of wildfire emissions in air quality is increasing

Anthropogenic Emissions have decreased



epa.gov

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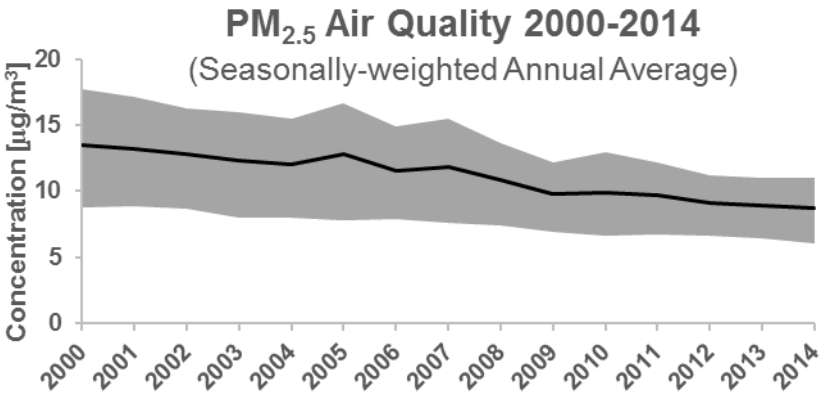

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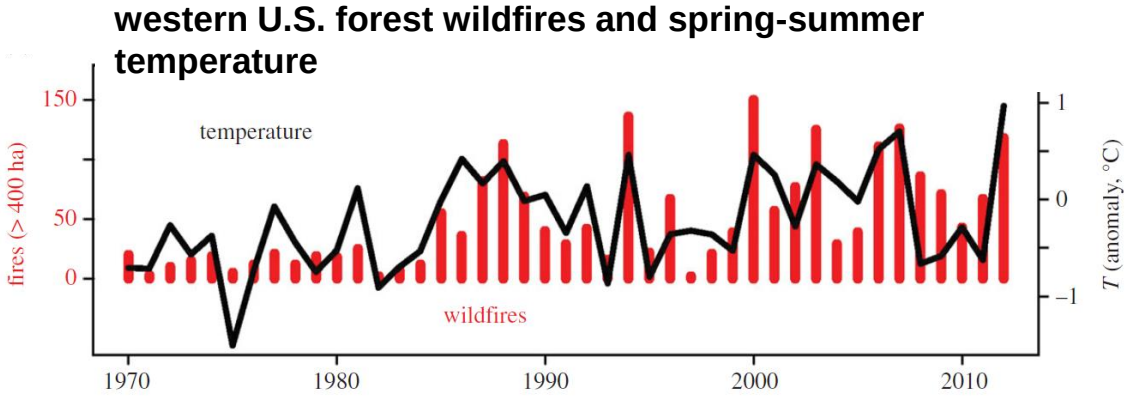
Wildfire Frequency has increased



Westerling et al., 2016

Role of wildfire emissions in air quality is increasing

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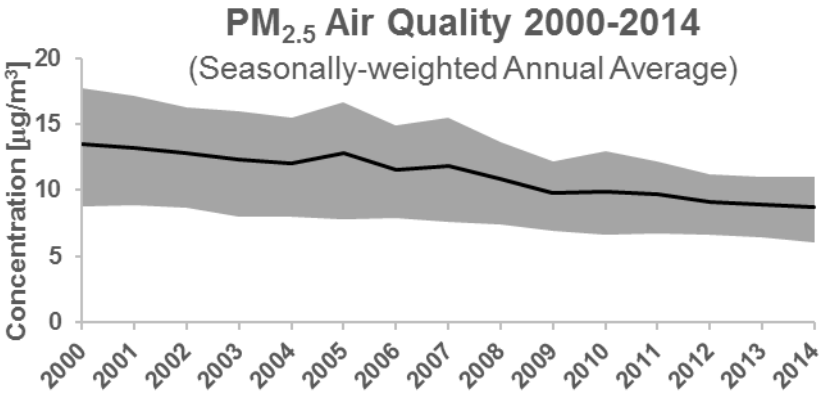
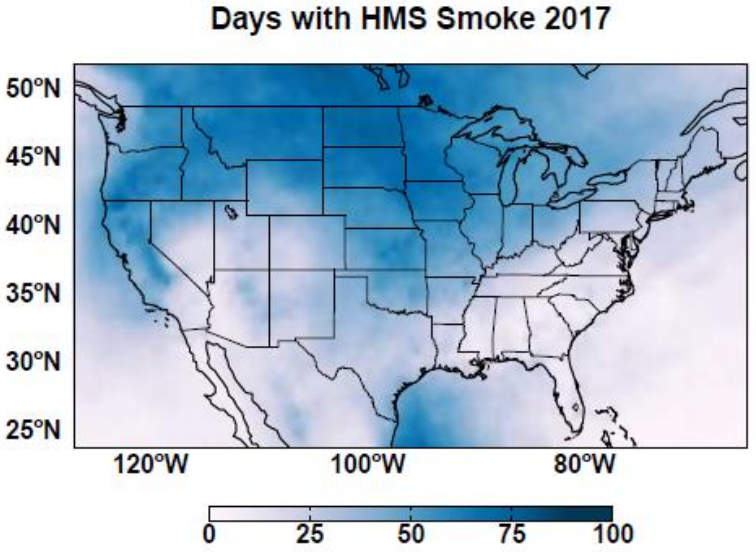


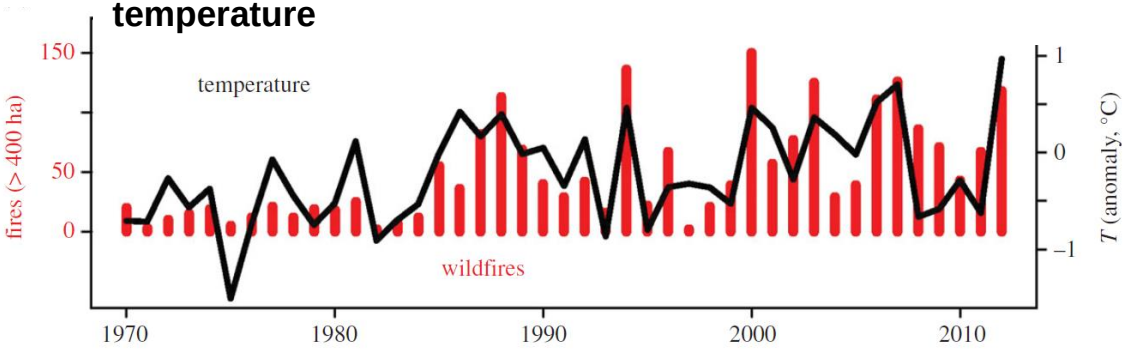
epa.gov

Large portions of the US experience smoke



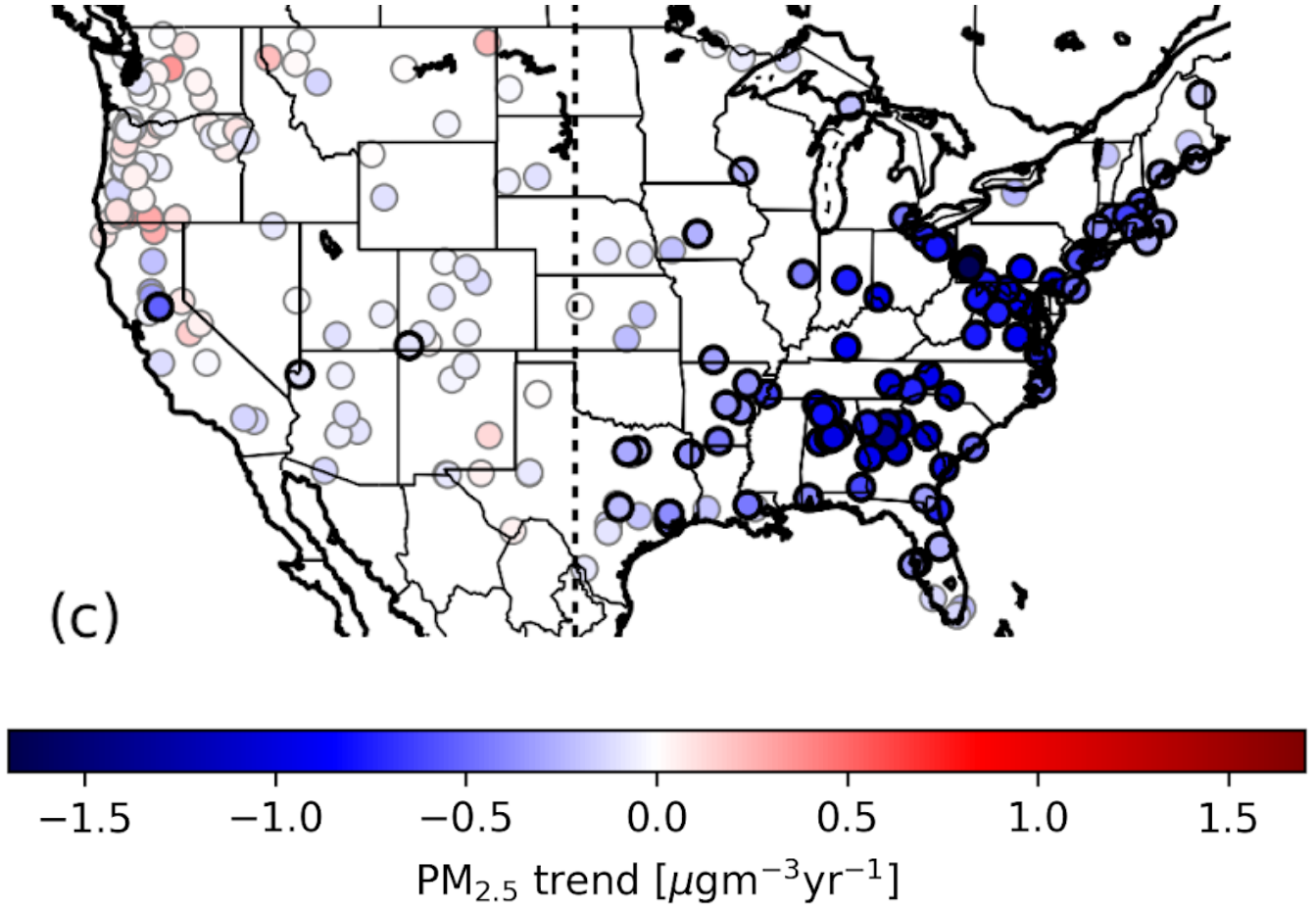
Wildfire Frequency has increased

western U.S. forest wildfires and spring-summer temperature



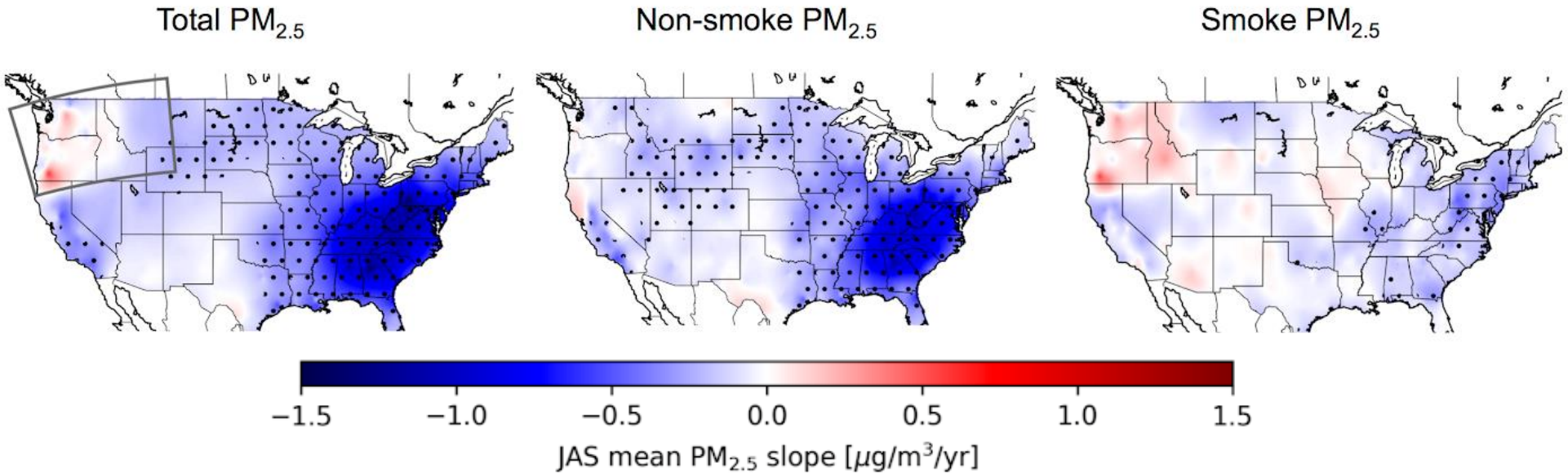
Westerling et al., 2016

PM2.5 is not improving in the summer in much of the west



Summer PM2.5 trends from 2006-2016 (O'Dell et al., 2018)

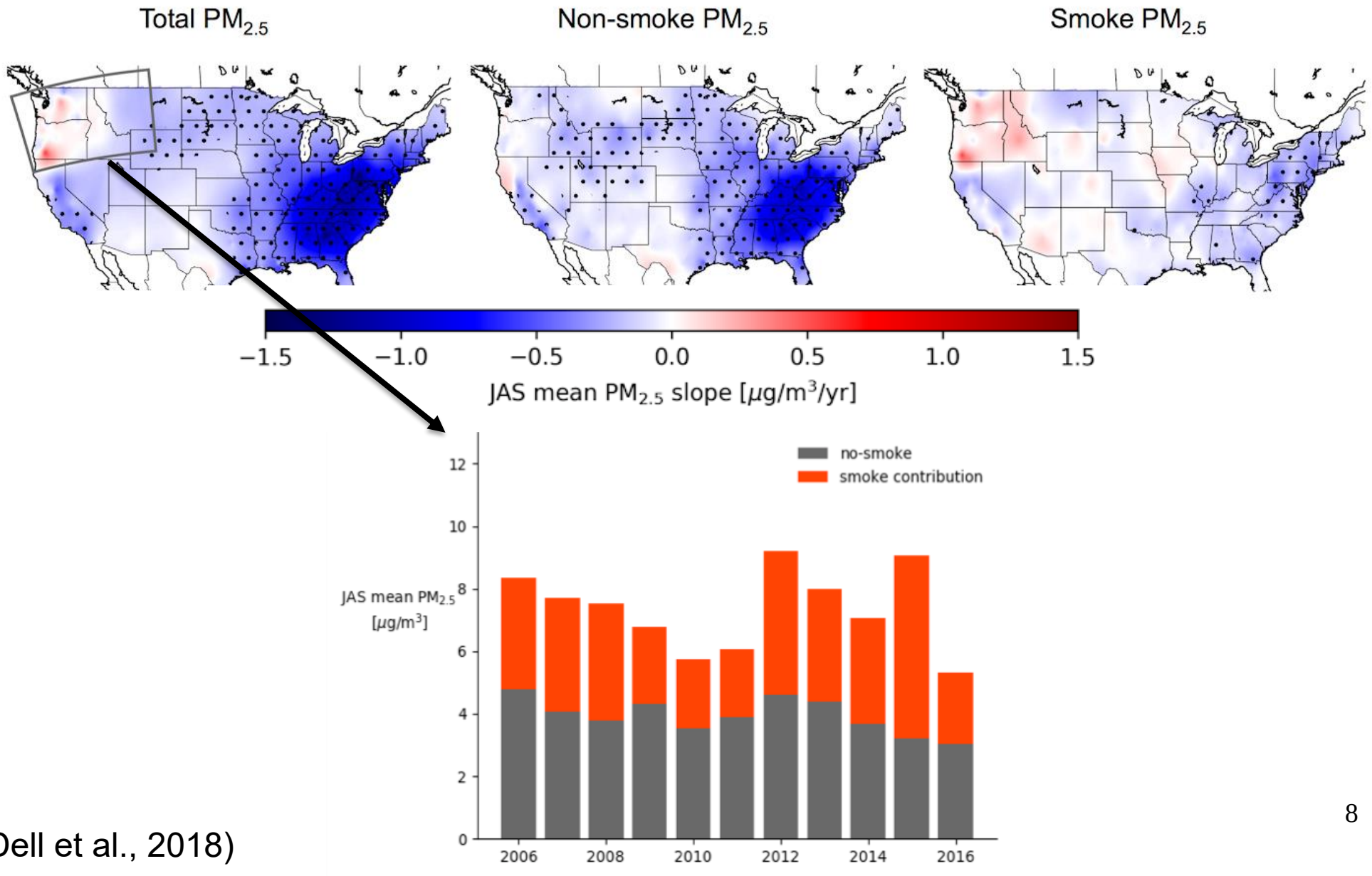
Using satellites, we can split this trend into smoke and non-smoke trends (2006-2016)



Split using Hazard Mapping System smoke product with information from NASA and NOAA satellites.

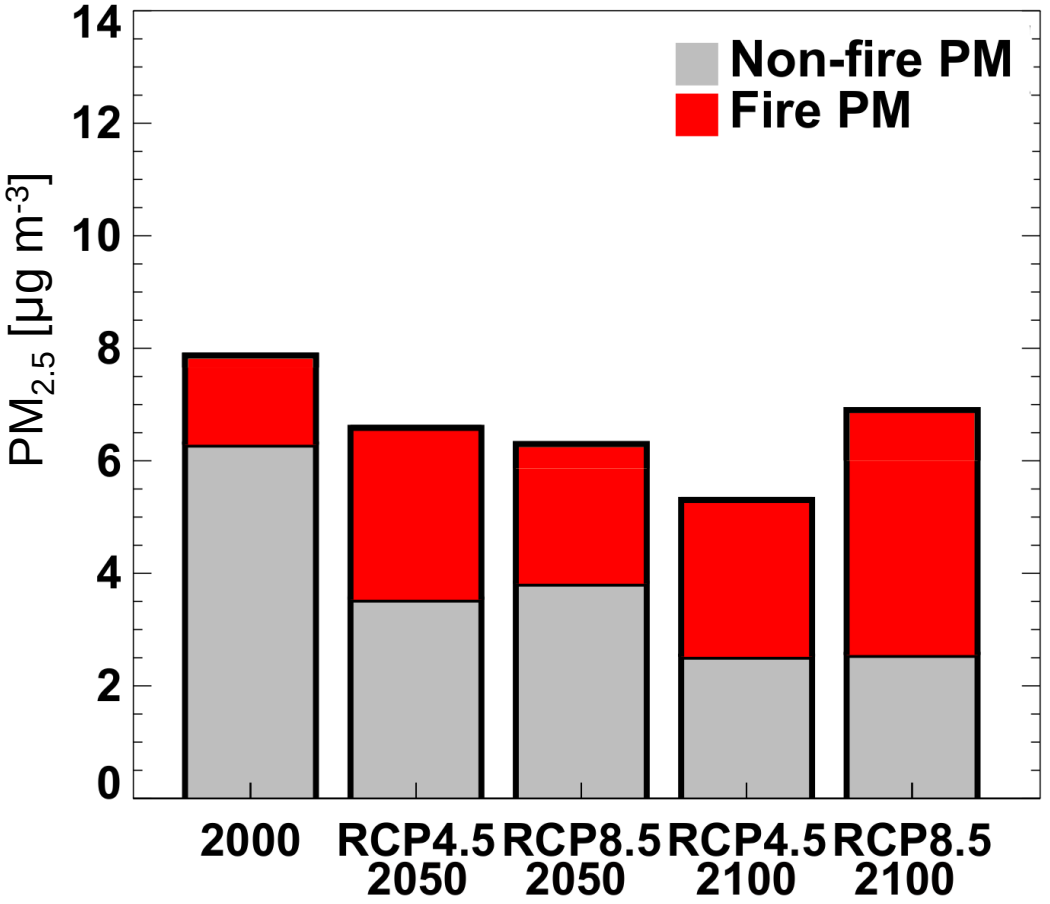
(O'Dell et al., 2018)

Using satellites, we can split this trend into smoke and non-smoke trends (2006-2016)



(O'Dell et al., 2018)

Using an Earth System Model, we predict smoke to continue to offset improvements in anthropogenic emissions



Ford et al. (2018)

What risk does this wildfire smoke exposure pose to the population?

The answer to this question will help public health agencies better inform the public

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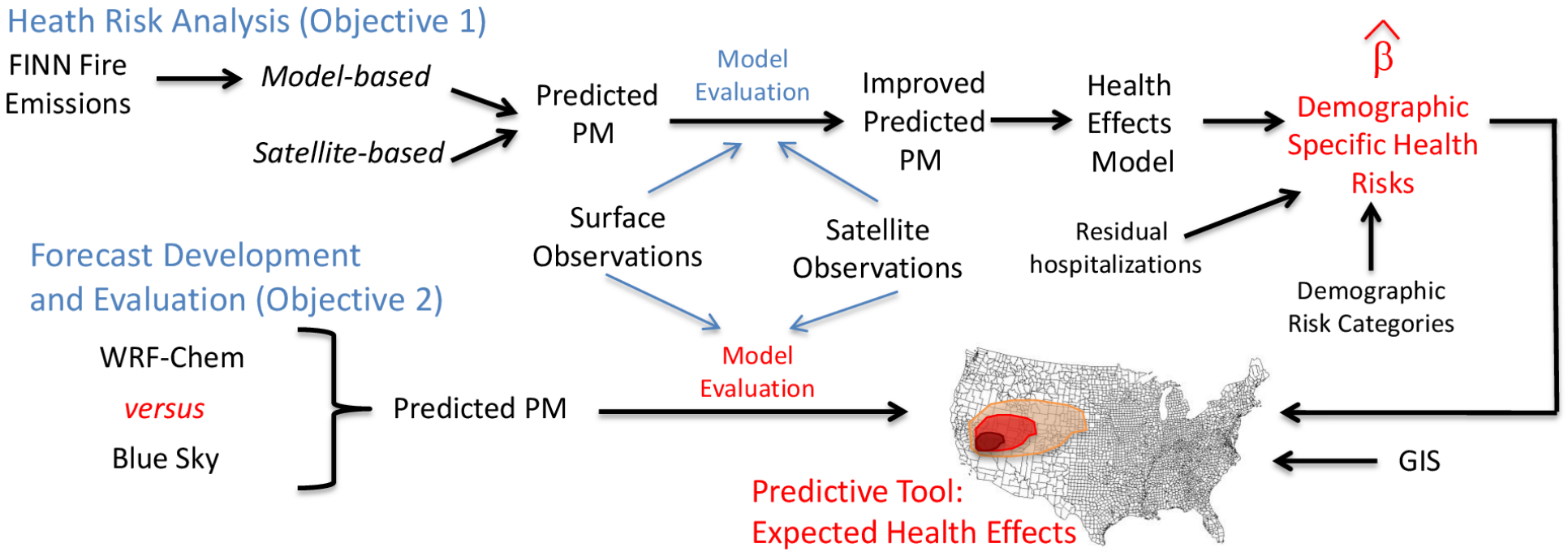
The answer to this question will help public health agencies better inform the public

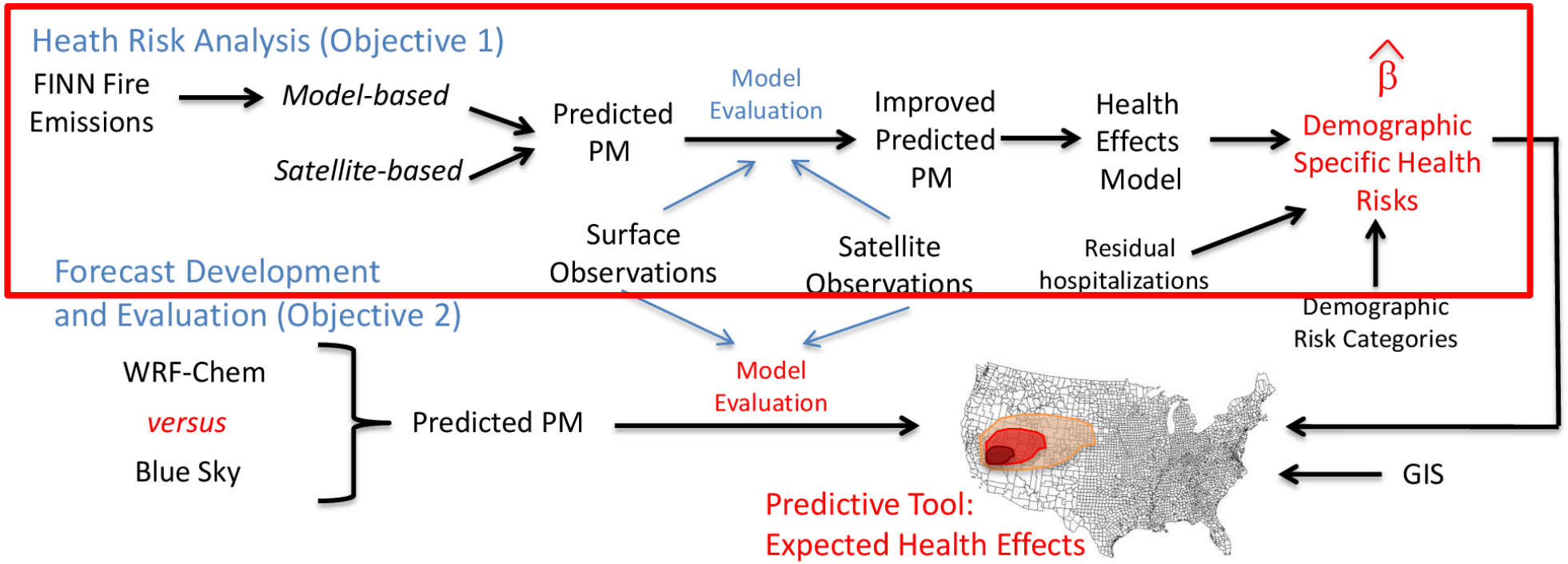
But means that we need to know:

where, when, who, and what?

Project Overview



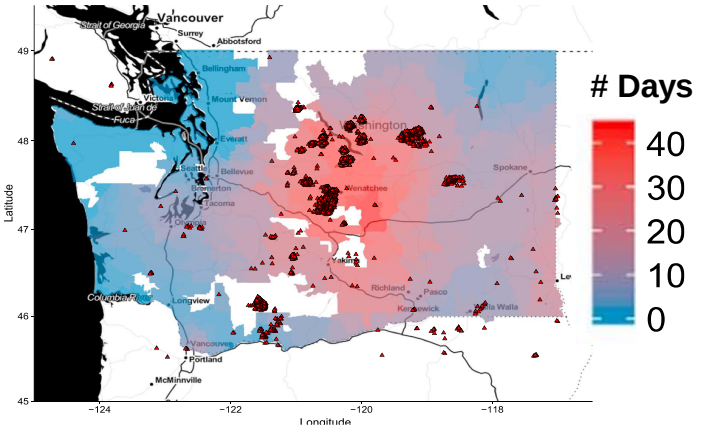
Objective 1: Health risks



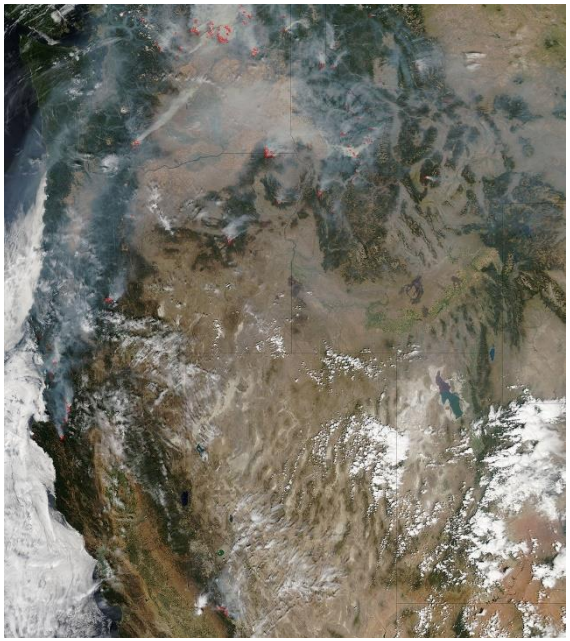
Fire seasons and locations

Washington 2012:

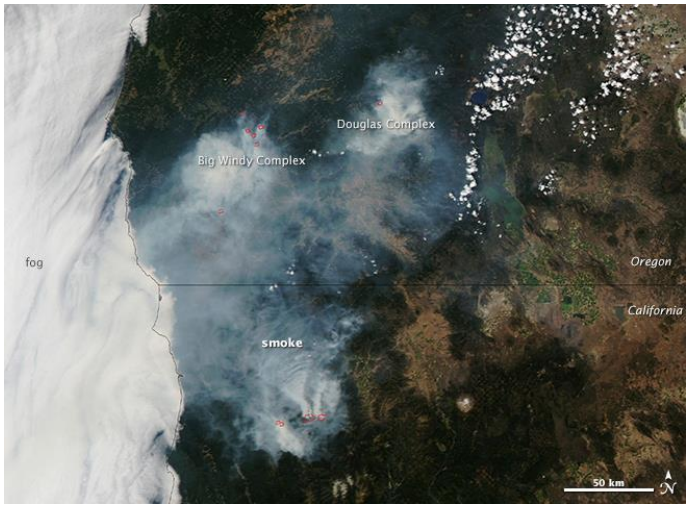
NASA image courtesy LANCE/EOSDIS MODIS Rapid Response Team, GSFC



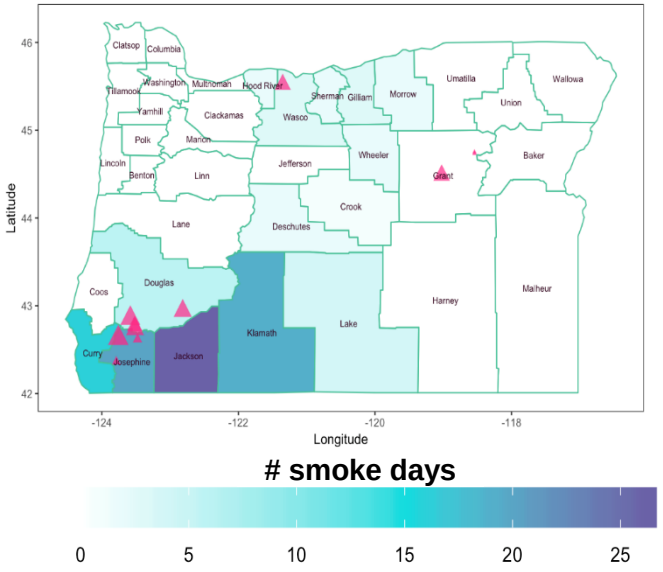
Western US 2015:



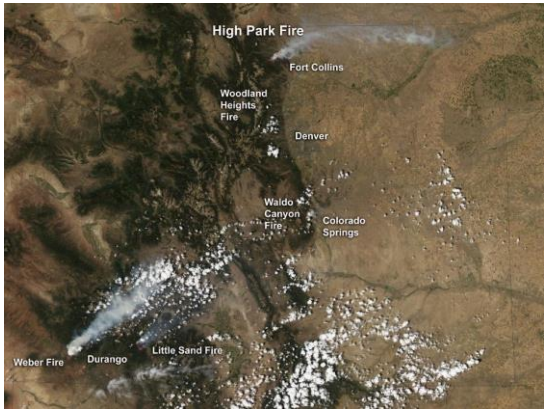
Oregon 2013:



NASA image courtesy LANCE/EOSDIS MODIS Rapid Response Team, GSFC



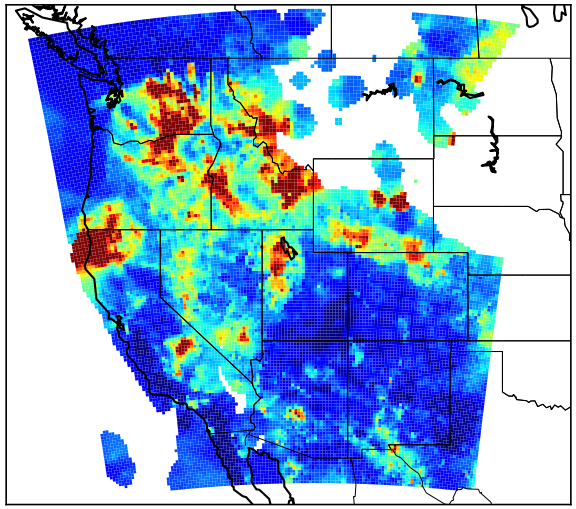
Colorado 2012:



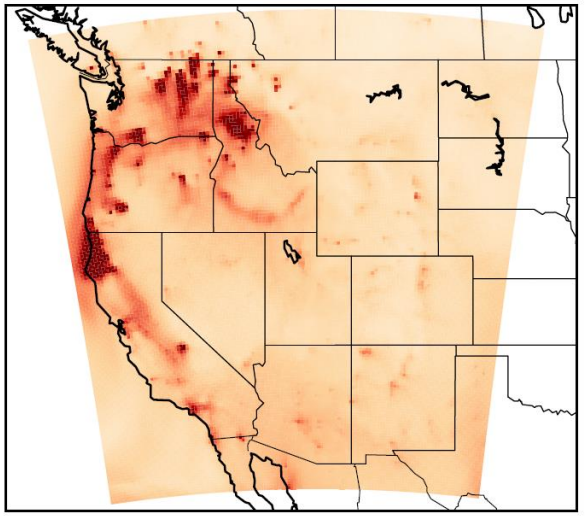
NASA images courtesy LANCE/EOSDIS

We model wildfire smoke $PM_{2.5}$ using geographically weighted regression

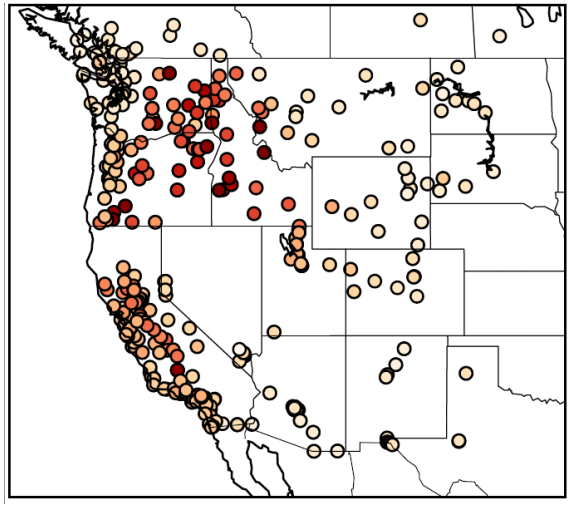
MODIS AOD

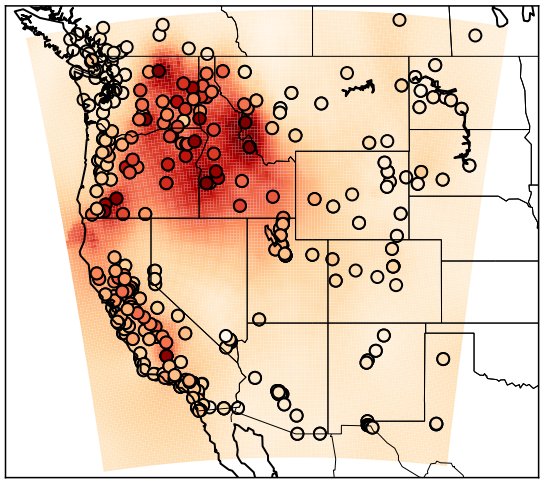


WRF-Chem $PM_{2.5}$



Surface Monitors



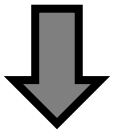


GWR $PM_{2.5}$

(Methods described in Lassman et al., 2017)

Method to Assess Relationship Between Wildfire Smoke and Health Outcome

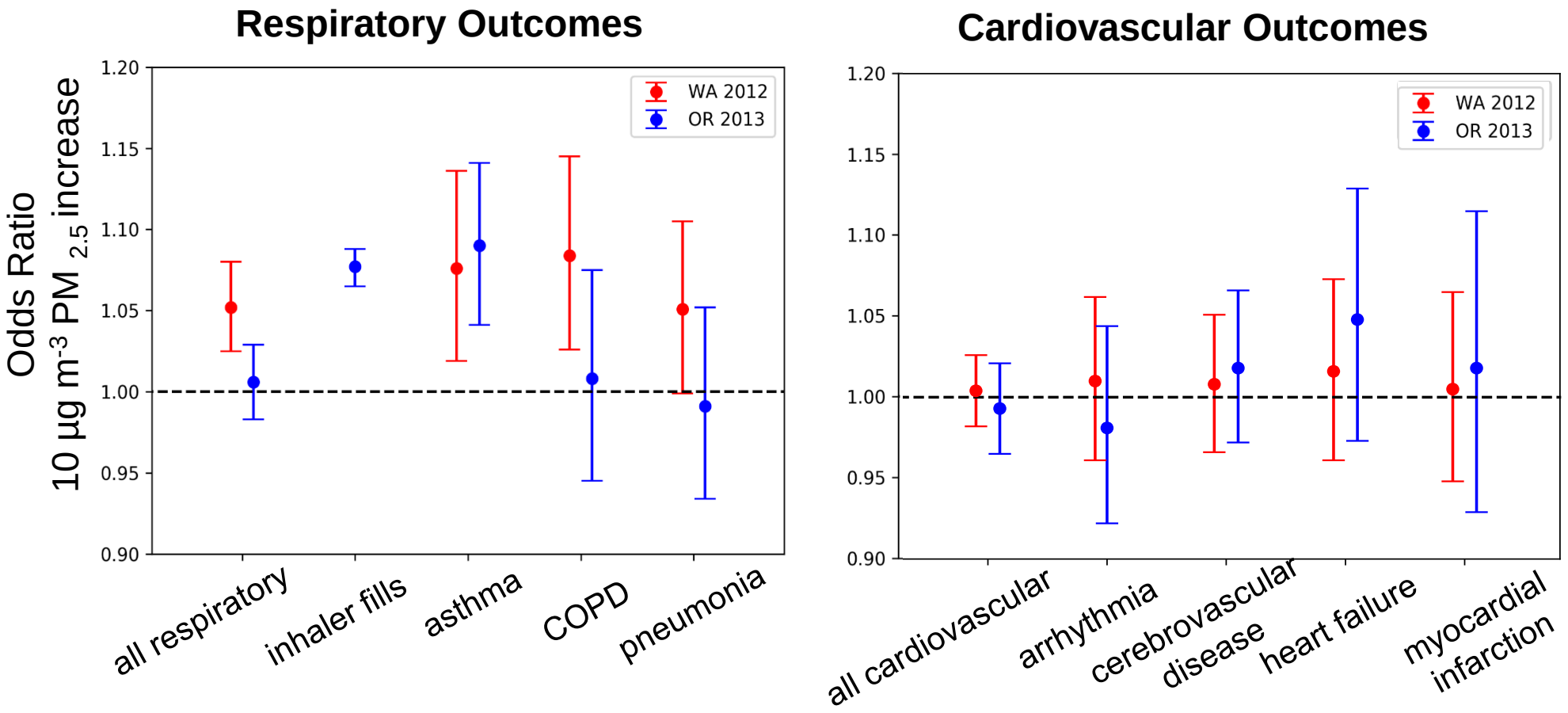
Blended wildfire smoke $PM_{2.5}$ concentrations



Join smoke estimates to health data

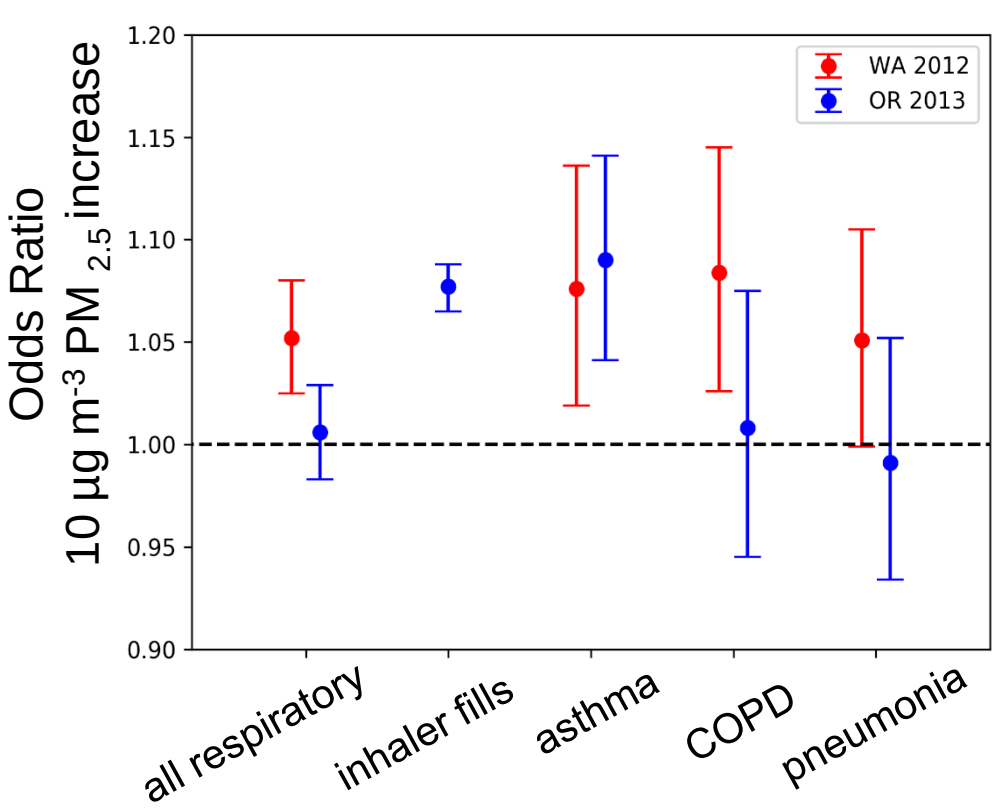
Assess relationship using case-crossover study design

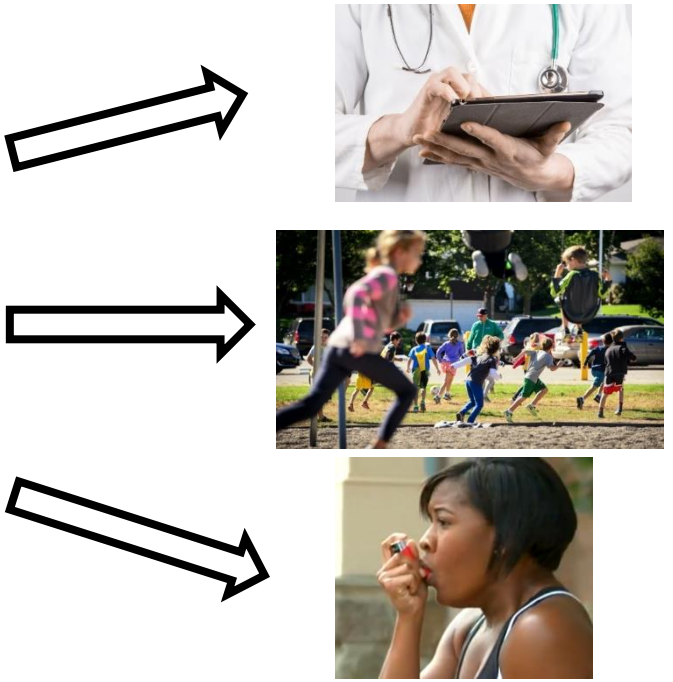
Consistent relationship between smoke and asthma, but no observed association with cardiovascular outcomes



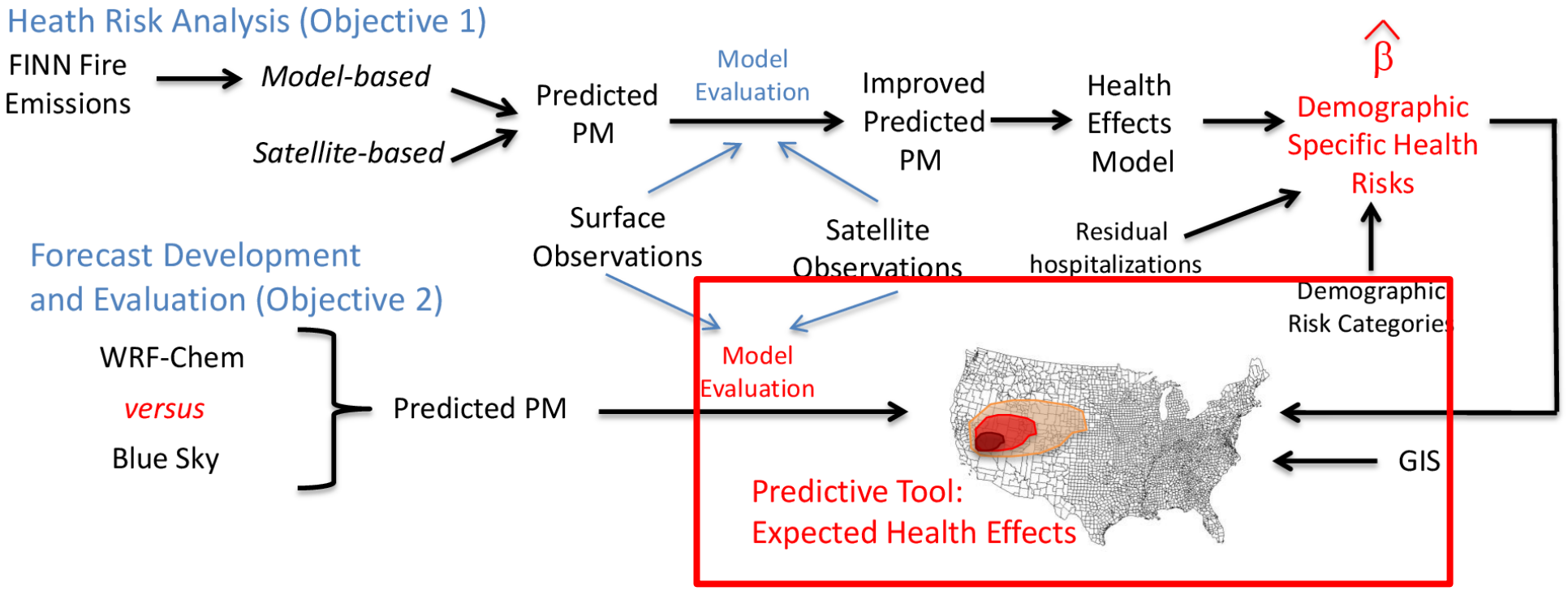
Gan et al. (2017, 2018)

How do we translate this risk?

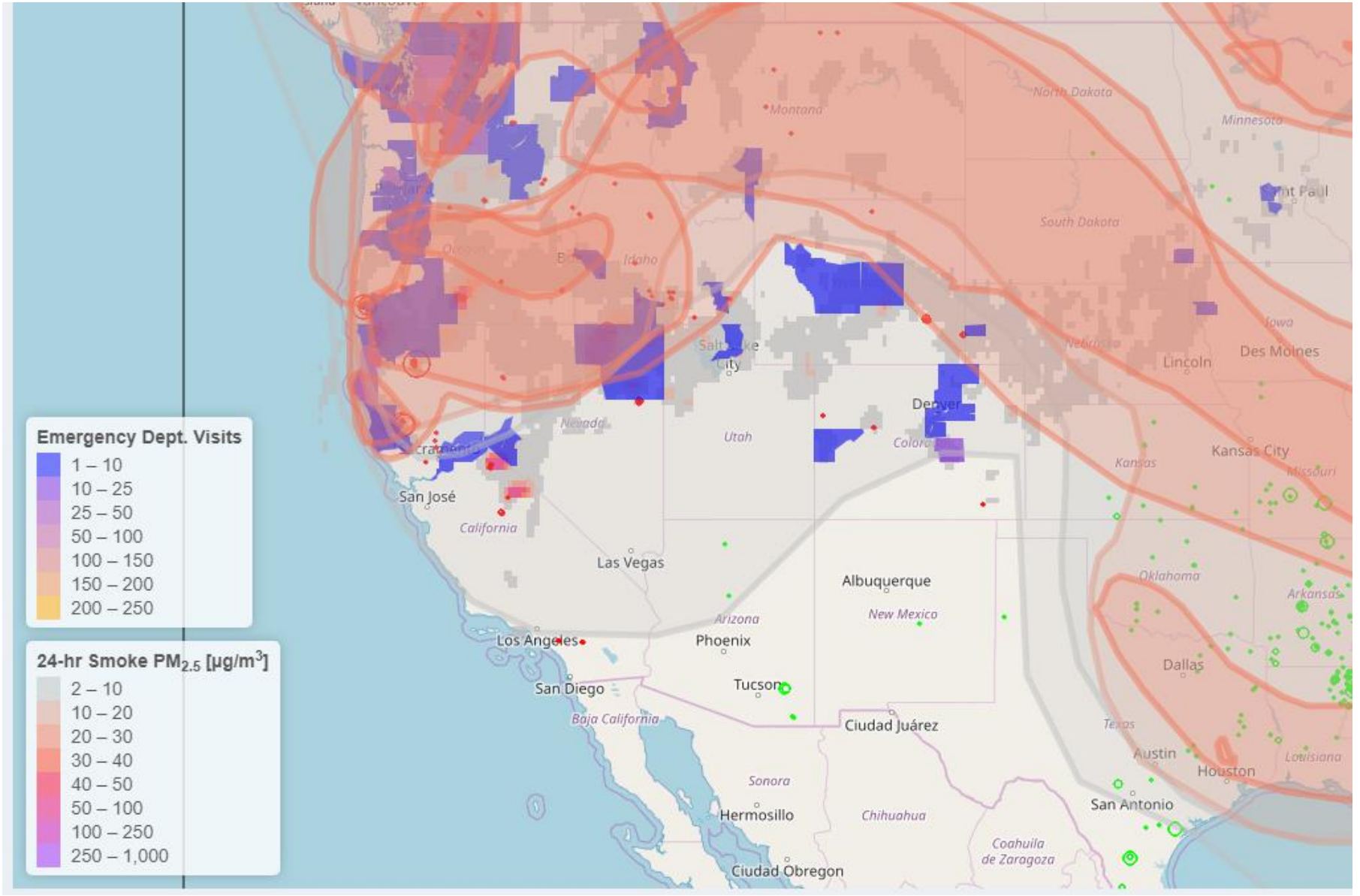




Objective 2: Forecast tool

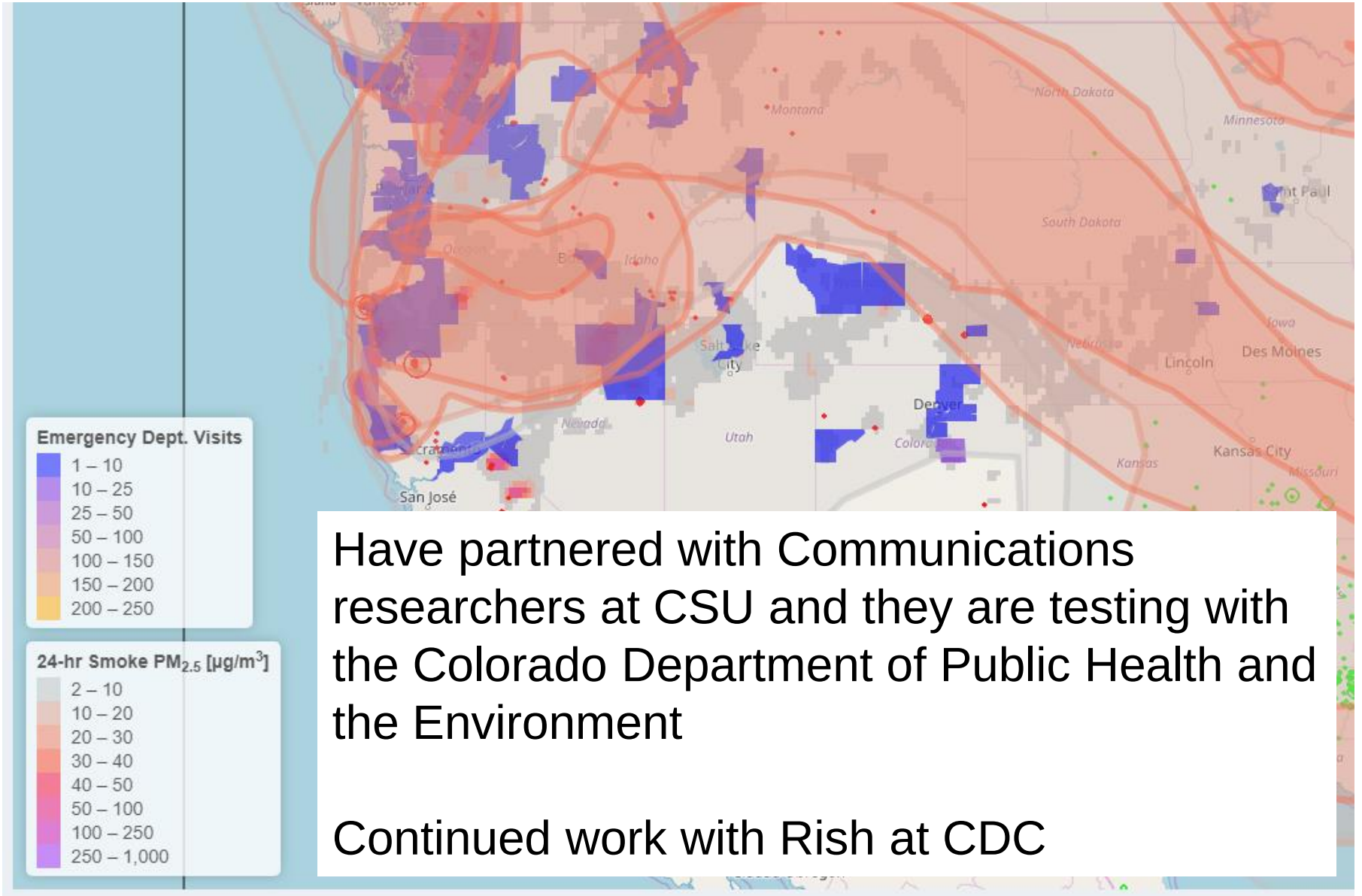


Health Forecast Tool



rgan.atmos.colostate.edu/smoke_forecaster/ as well as CDC smoke-health forecast tool

Health Forecast Tool



Have partnered with Communications researchers at CSU and they are testing with the Colorado Department of Public Health and the Environment

Continued work with Rish at CDC

rgan.atmos.colostate.edu/smoke_forecaster/ as well as CDC smoke-health forecast tool

Goals for remainder of grant

- Test/implement app with CDPHE
  and continue work with CDC
- Finish Colorado 2012 and 2015 analysis
  - Comparing concentration-response functions assigned using address, ZIP-code, and county (estimating smoke exposure at different grid resolutions).
- A multi-state and year investigation of wildfire smoke on morbidity and mortality (with CDC)
  - Using distributed lag models
  - Exposure estimates for western US and individual states

Papers

Gan, R. W., B. Ford, W. Lassman, G. Pfister, A. Vaidyanathan, E. Fischer, J. Volckens, J. R. Pierce, S. Magzamen (2017): Comparison of wildfire smoke estimation methods and associations with cardiopulmonary-related hospital admissions, *GeoHealth*, 1, doi:10.1002/2017GH000073.

Lassman, W., B. Ford , R. W. Gan, G. Pfister, S. Magzamen, E. V. Fischer, and J. R. Pierce (2017): Spatial and Temporal Estimates of Population Exposure to Wildfire Smoke during the Washington State 2012 Wildfire Season Using Blended Model, Satellite, and In-Situ Data, *GeoHealth*, 1, doi: 10.1002/2017GH000049.

Ford, B., M. Burke, W. Lassman, G. Pfister, and J. R. Pierce: Status Update: Is smoke on your mind? Using social media to assess smoke exposure, *Atmos. Chem. Phys.*, doi:10.5194/acp-17-7451-2017, 17, 7541-7554, 2017.

Ford, B., M. Val Martin, S. E. Zelasky, E. V. Fischer, S. C. Anenberg, C. L. Heald, J. R. Pierce: Future Fire Impacts on Smoke Concentrations, Visibility, and Health in the Contiguous United States, *GeoHealth*, https://doi.org/10.1029/2018GH000144, 2018

Pratt, J. R., R. W. Gan, B. Ford, S. Brey, J. R. Pierce, E. V. Fischer, S. Magzamen: A National Burden Assessment of Estimated Pediatric Asthma Emergency Department Visits that May be Attributed to Elevated Ozone Levels Associated with the Presence of Smoke, *Env. Mon. Assess.*, in press, 2018.

O'Dell, K., B. Ford, E.V. Fischer, J.R. Pierce: Wildfires and Summer PM2.5 Trends in the United States, *submitted to Env. Sci. Tech.*, 2018.

Gan, R.W., J. Liu, B. Ford, K. O'Dell, A. Vaidyanathan, A. Wilson, J. Volckens, G. Pfister, E. V. Fischer, J.R. Pierce, S. Magzamen: The association between wildfire smoke exposure and asthma-specific medical care utilization following the 2013 Douglas Complex fire in Oregon, *submit within several weeks to Env. Health Perspectives*, 2018

ARL Review

Starting ARL: **2**

Current ARL: **8 (Objective 1), *7* (Objective 2)**

Projected Ending: **8**

ARL *7* –Application Prototype in Partner's Decision Making

Extra slides

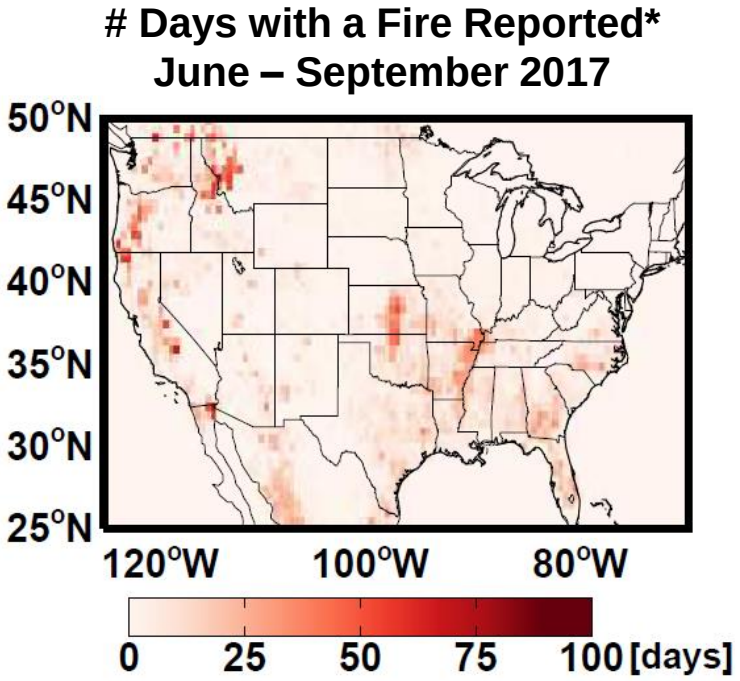
Health Outcomes

Hospital claims data from the **Washington State Comprehensive Hospital Abstract Reporting System** (CHARS) for the year of 2012; hospital claims only

All payers all claims (APAC) data from the **Oregon Health Authority** (OHA) for the year of 2013; any filed claim (including hospital claims) and pharmacy claims

Hospital claims data from the **Colorado Hospital Association** (CHA) for the years 2011 to 2015; hospital claims only

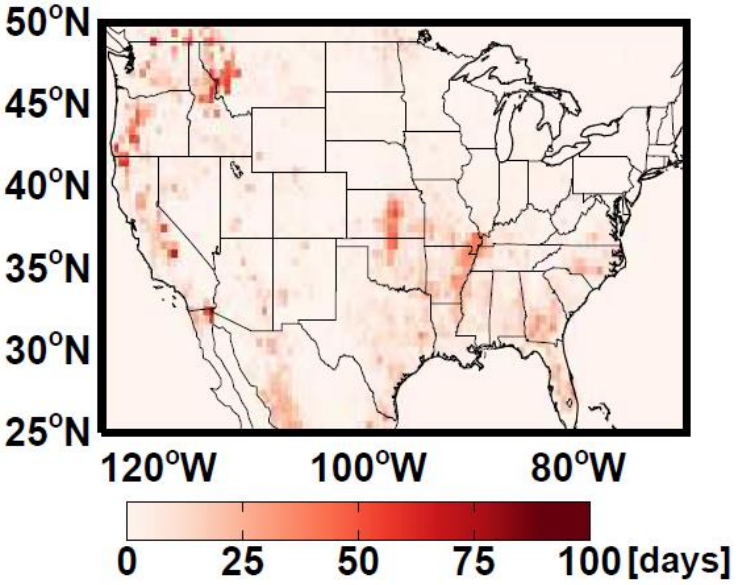
Exposure to wildfire smoke can be difficult to assess



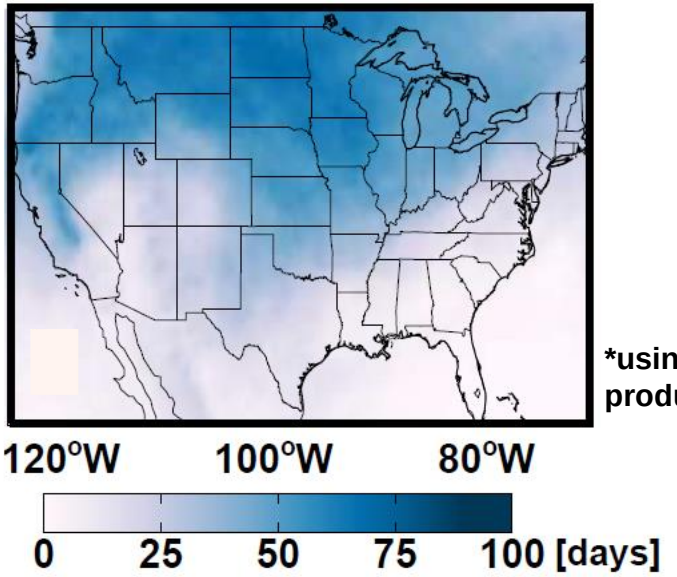
*using HMS products

Exposure to wildfire smoke can be difficult to assess

 # Days with a Fire Reported*
June – September 2017



 # Days with Smoke*
June – September 2017



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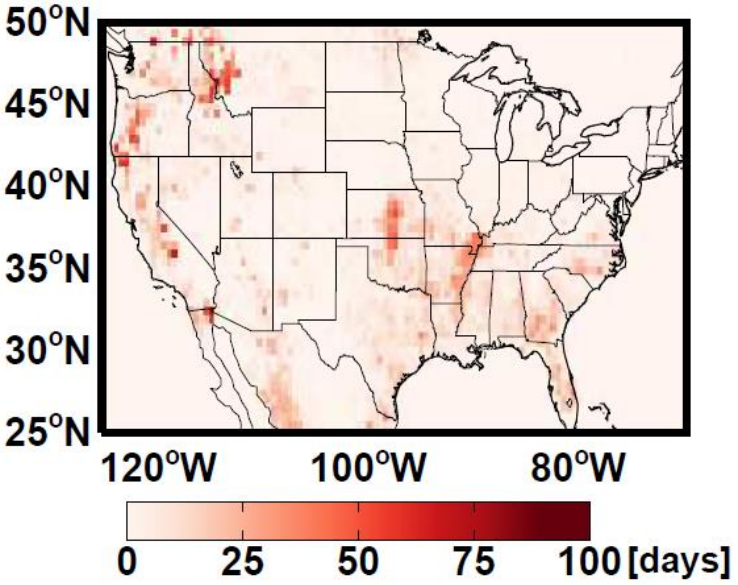

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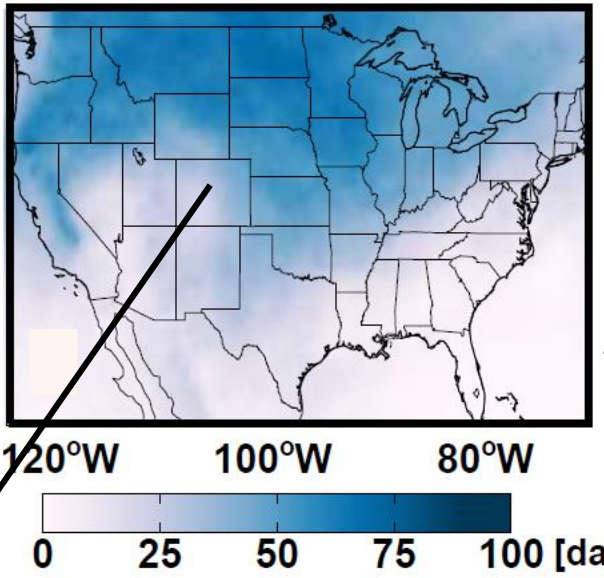
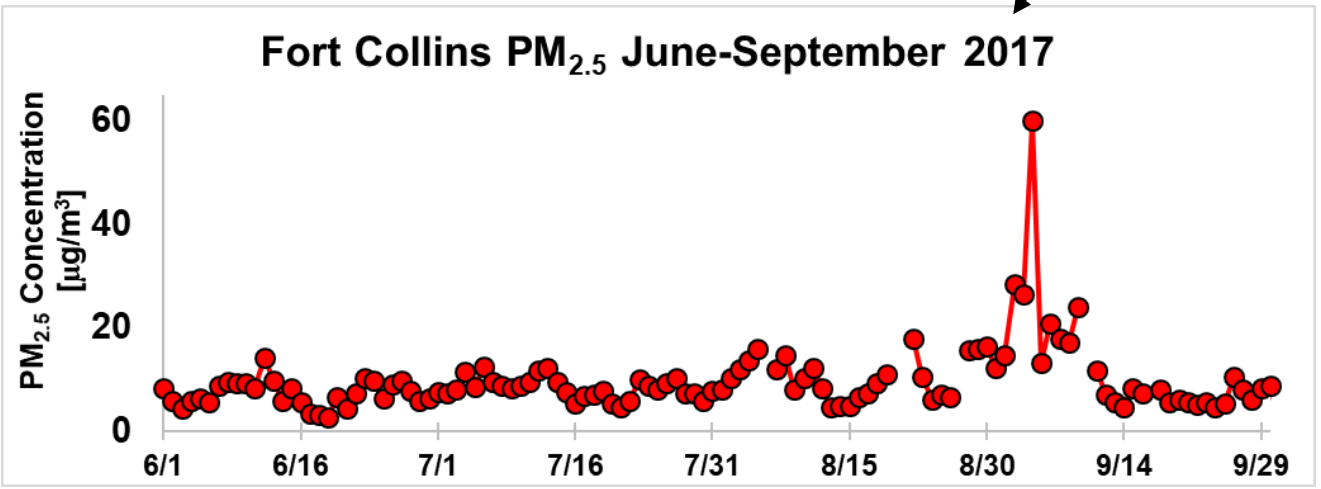


***using HMS products**

Fort Collins $PM_{2.5}$ June-September 2017

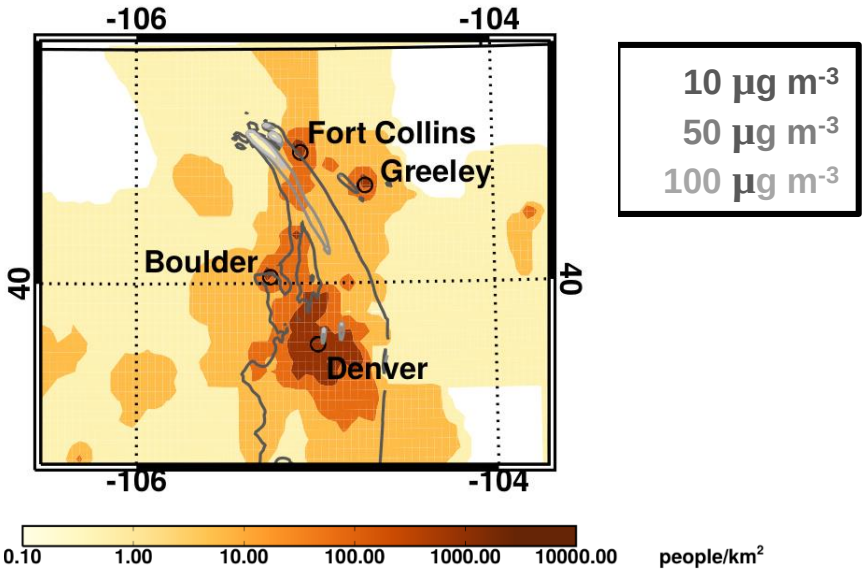


Smoke events are episodic, maybe of short duration, have varying magnitude and may impact a small population

Team Goals:

1. Produce accurate smoke exposure data for several different wildfires

2. Determine health effects specific to (short-term) smoke exposure



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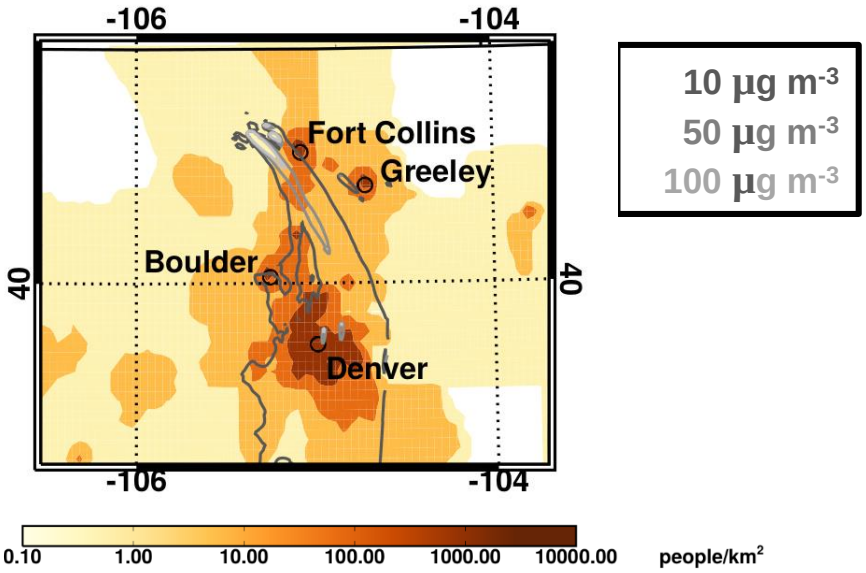


Methods:

Estimate wildfire smoke $PM_{2.5}$ concentrations

⇩

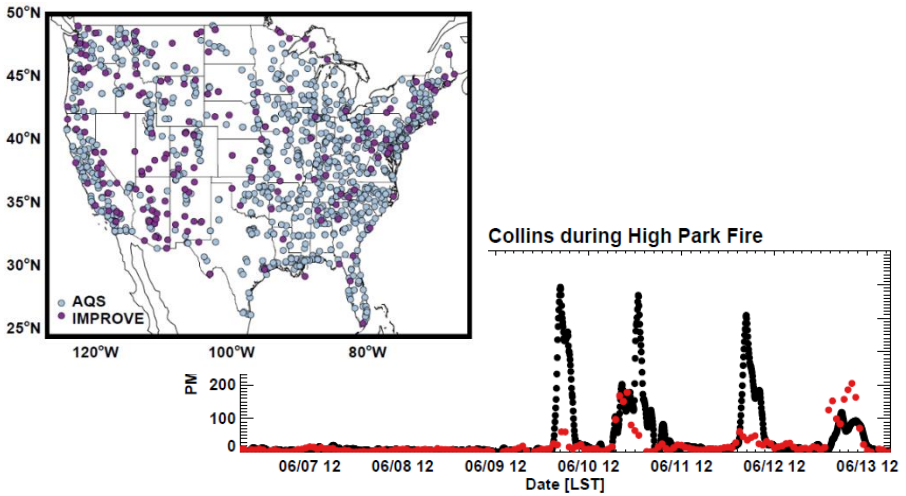
Use smoke estimates with hospital/health claims data

⇩

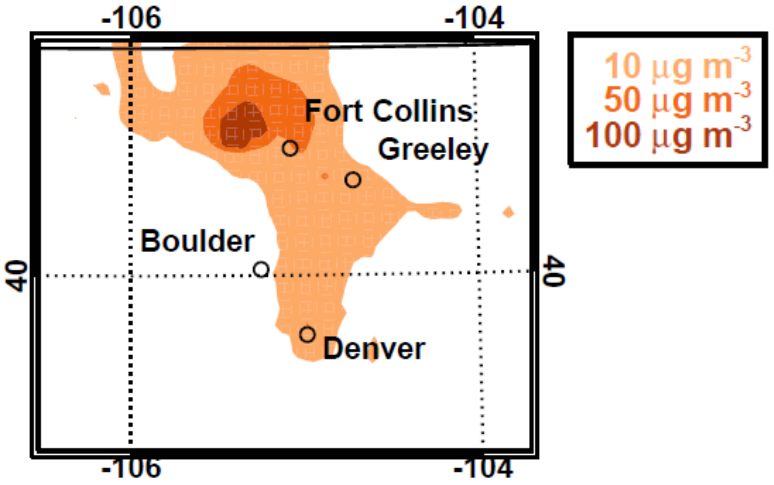
Assess relationship using case-crossover study design

We combine information from different tools to determine smoke concentrations

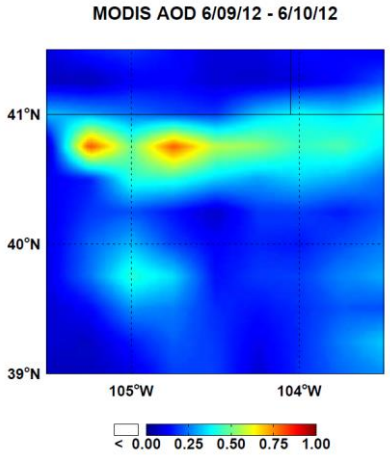
In-situ monitors



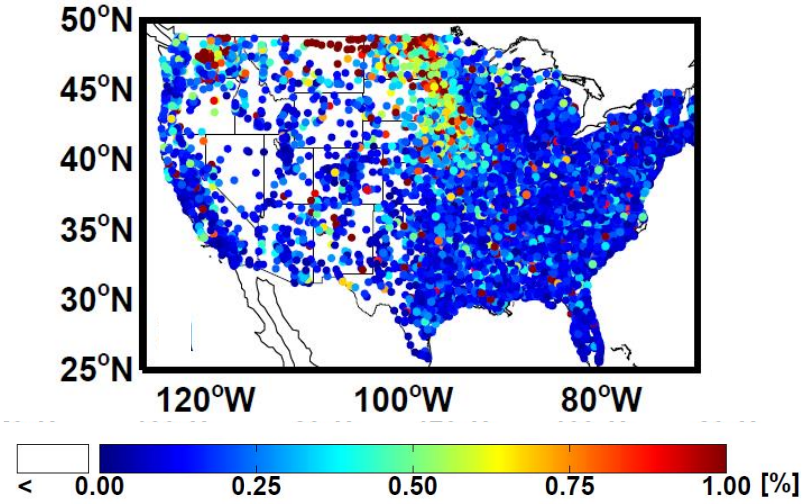
Chemical Transport Model



Satellite observations

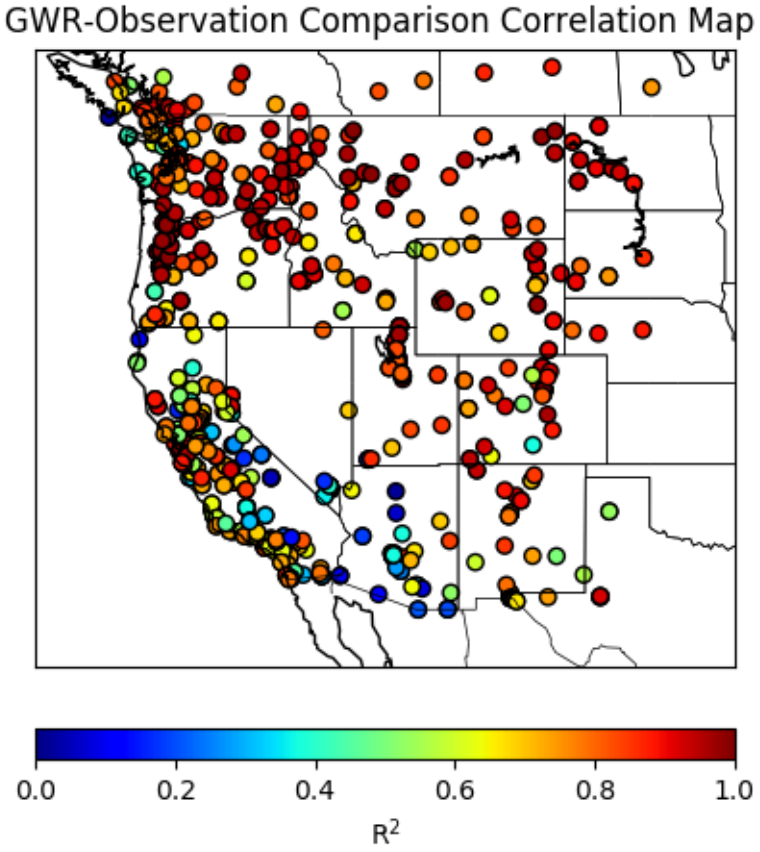


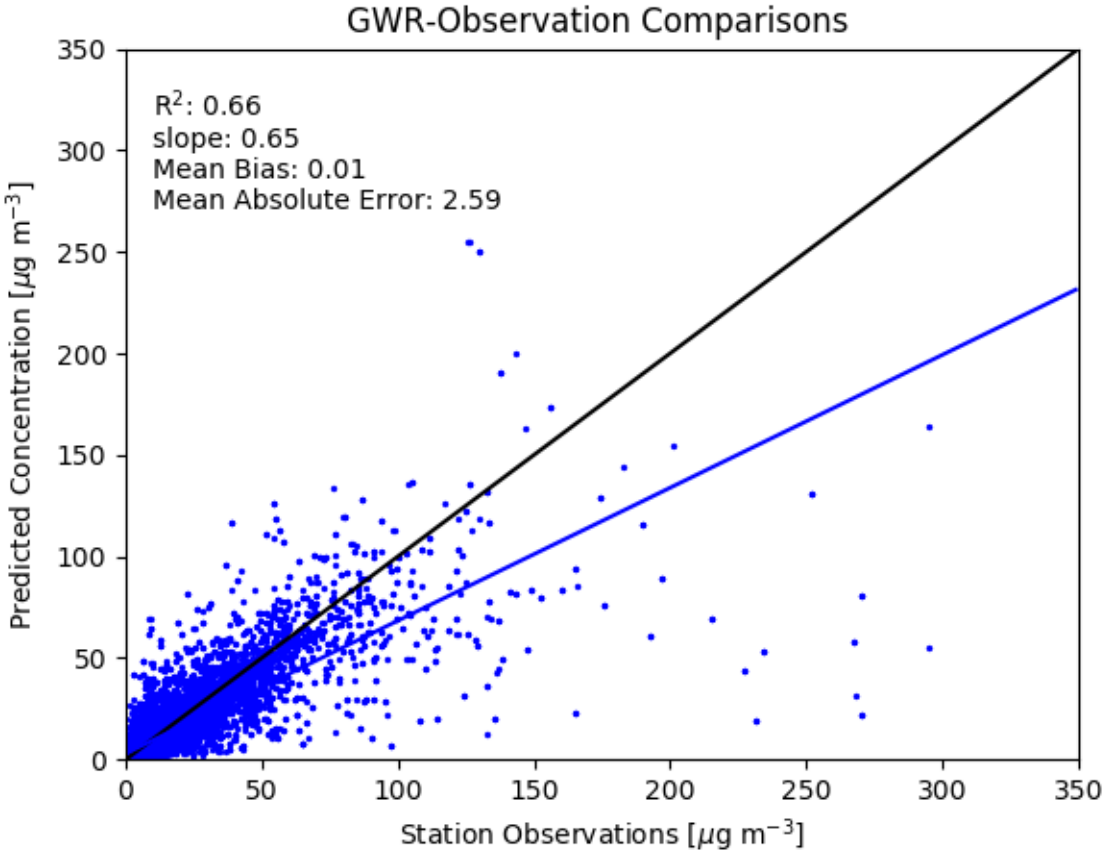
% of Facebook posts (only for 2015/2016)



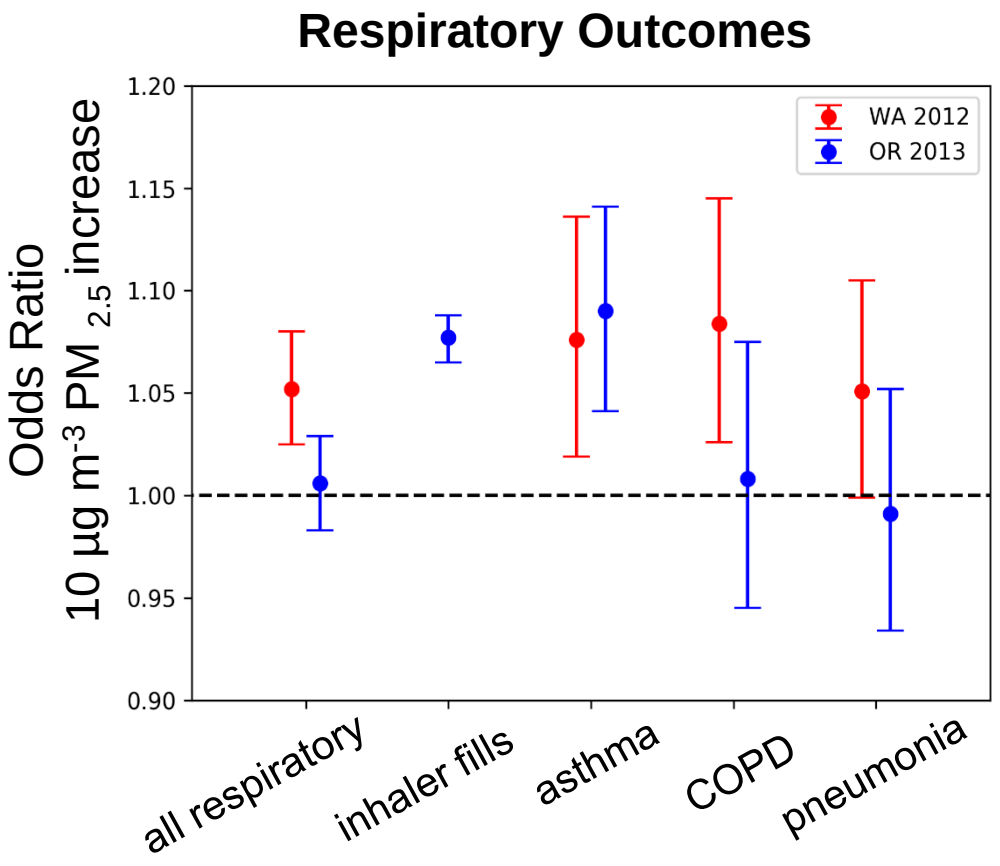
We combine information using Geographically Weighed Regression

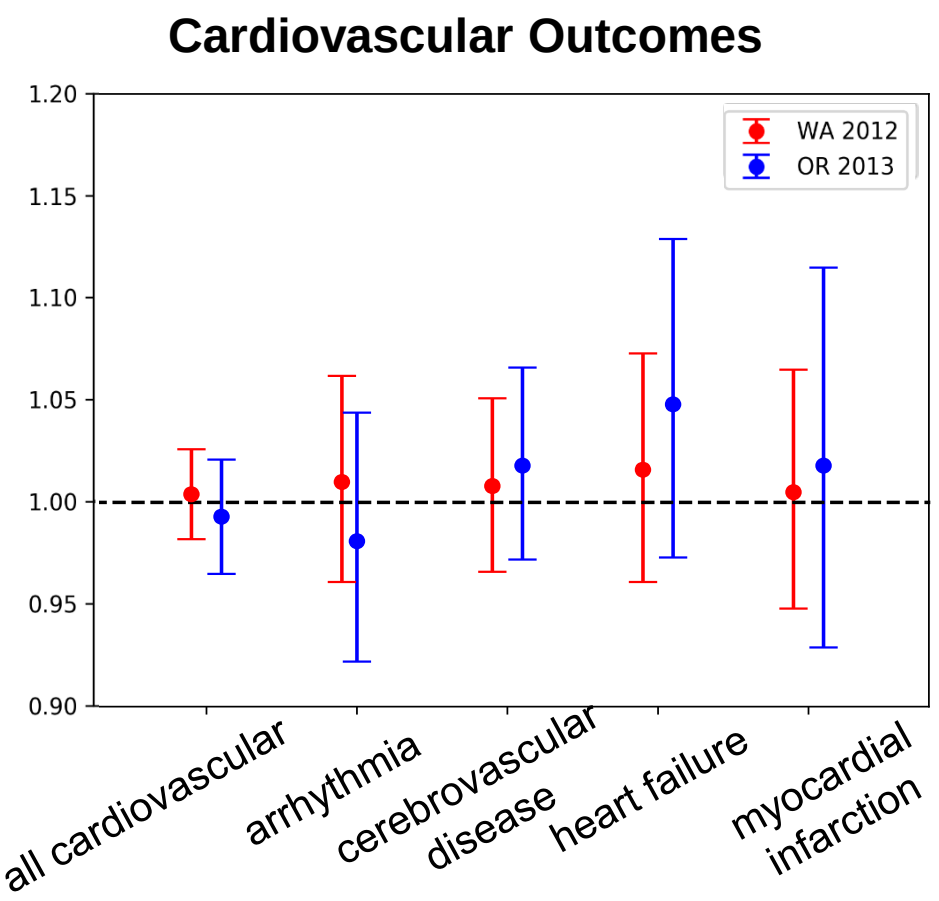
$$PM_{est} = A + B * PM_{krige} + C * PM_{wrf} + D * AOD_{MODIS}$$





Consistent relationship between smoke and asthma, but no observed association with cardiovascular outcomes





Results for Washington 2012 and Oregon 2013

	Washington 2012 10 µg m^{-3} increase		Oregon 2013 10 µg m^{-3} increase	
Health Outcome	Odds Ratio	95% CI	Odds Ratio	95% CI
All Respiratory	1.05	1.03-1.08	1.01	0.98-1.03
Asthma	1.08	1.02-1.14	1.09	1.04-1.14
Cardiovascular Disease	1.00	0.98-1.03	0.99	0.97-1.02
Heart Failure	1.02	0.96 – 1.07	1.05	0.97-1.13
Respiratory Rescue Medication	--	--	1.08	1.07-1.09