Future Fire Impacts on Smoke Concentrations and Health in the United States

Bonne Ford

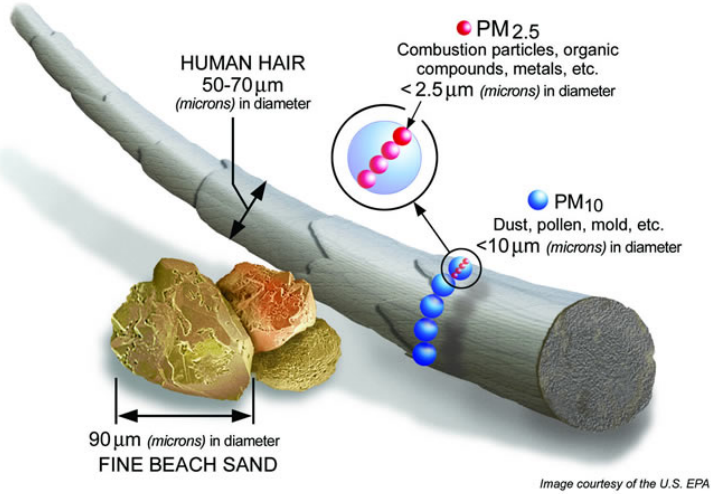
Maria Val Martin

Sarah Zelasky, Emily V. Fischer, Susan C. Anenberg, Colette L. Heald, and Jeffrey R. Pierce

Colorado State University

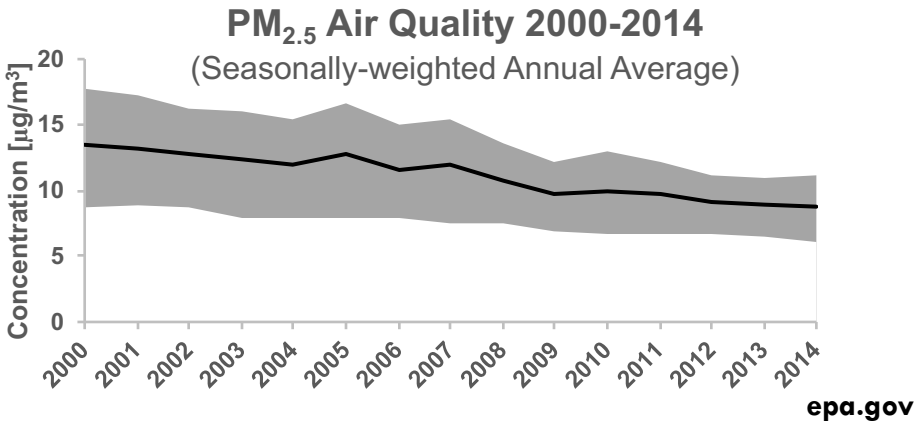
Terminology (and caveats)

- **$PM_{2.5}$**: fine particulate matter
  - Caveat for this presentation: smoke can contain more than just particulate matter
- **Health**
  - Premature mortality attributable to $PM_{2.5}$ exposure
  - Caveat: Smoke exposure is associated with a variety of negative physical and mental health outcomes
- **Future**
  - Caveat: (single) model projections



Motivation: Role of wildfire emissions in air quality is already increasing

Anthropogenic Emissions have decreased



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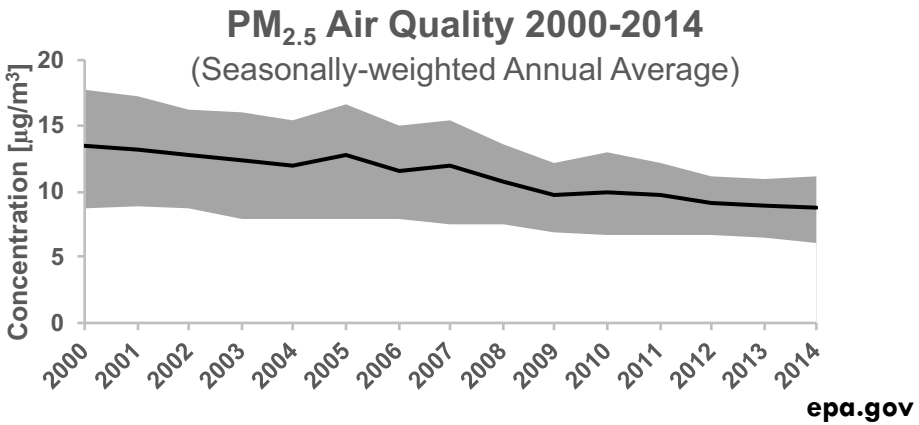

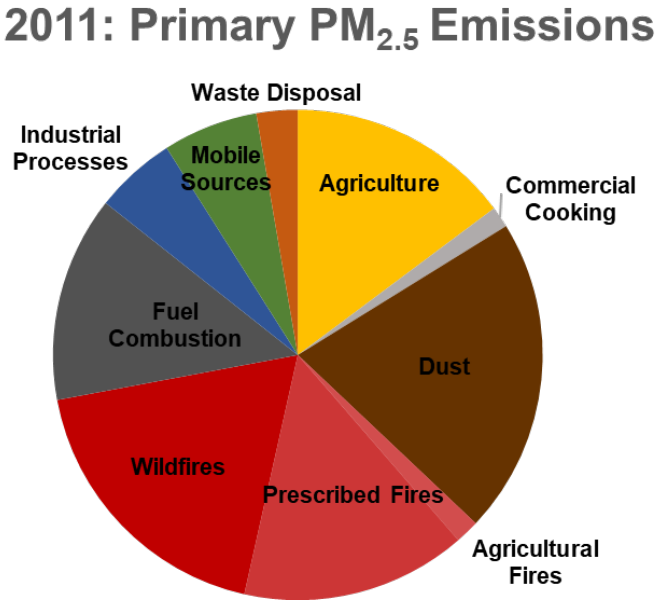

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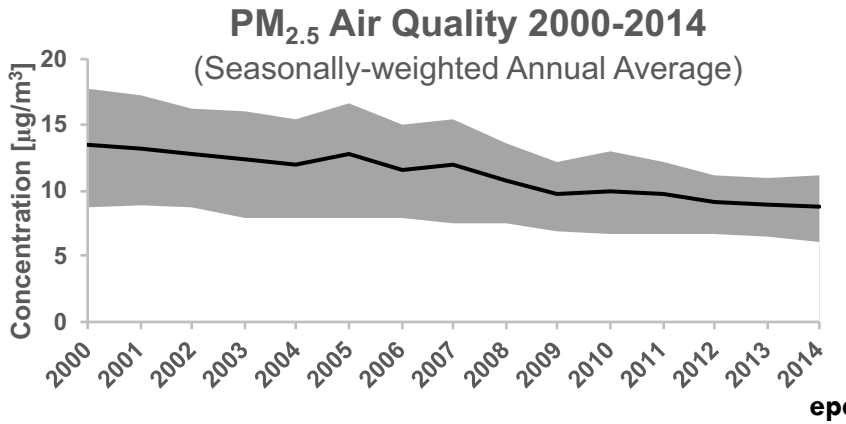
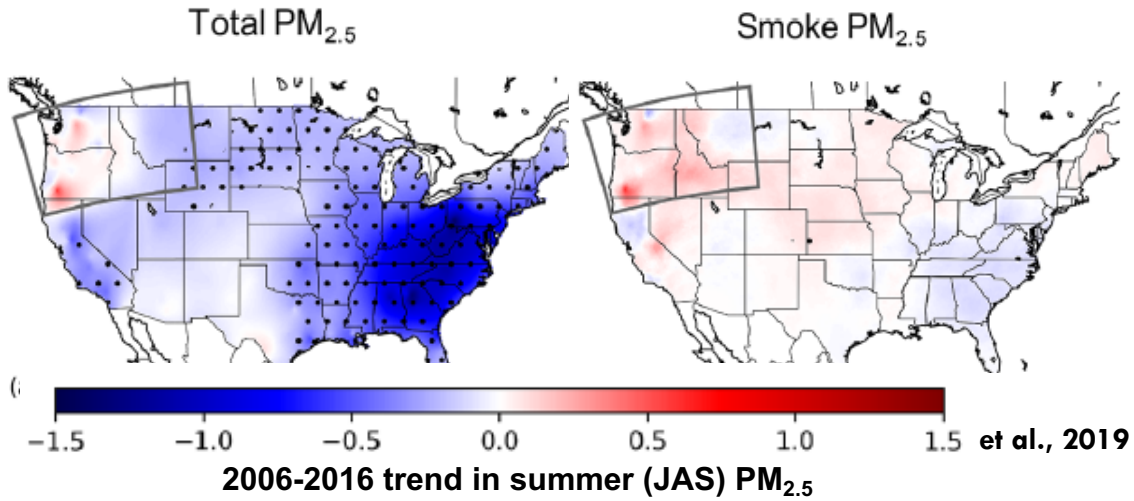
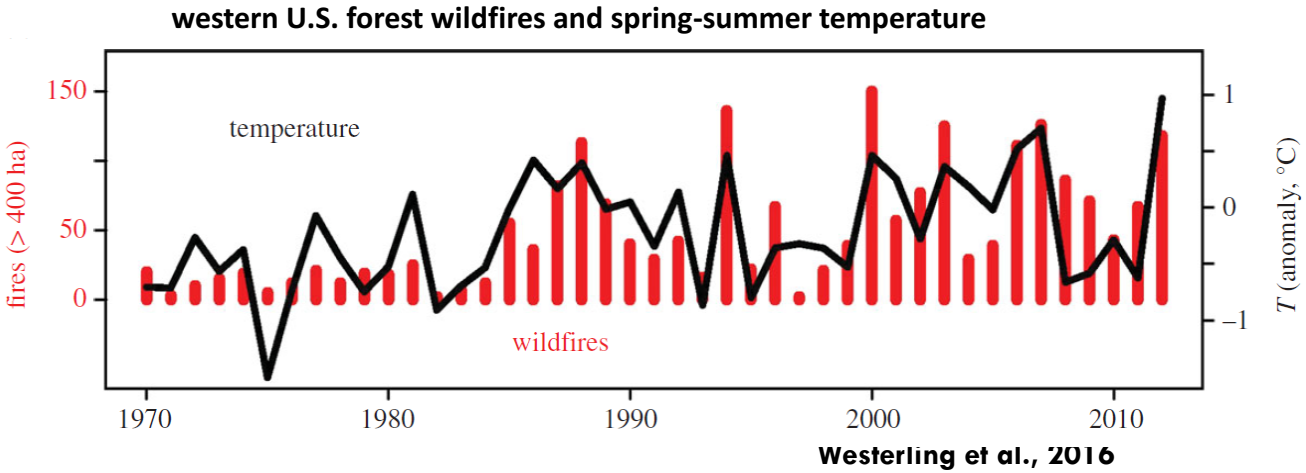




Wildfire frequency and intensity have increased



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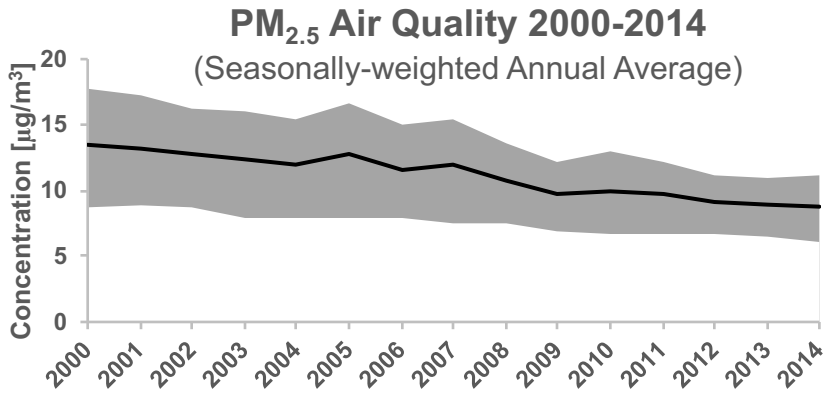
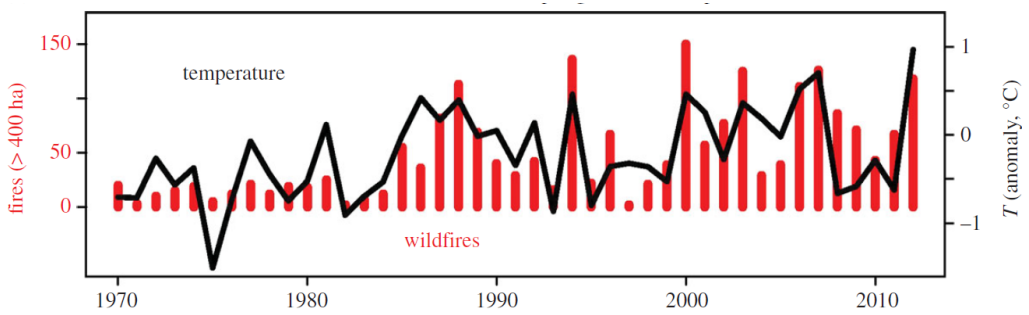


epa.gov

Wildfire frequency and intensity have increased

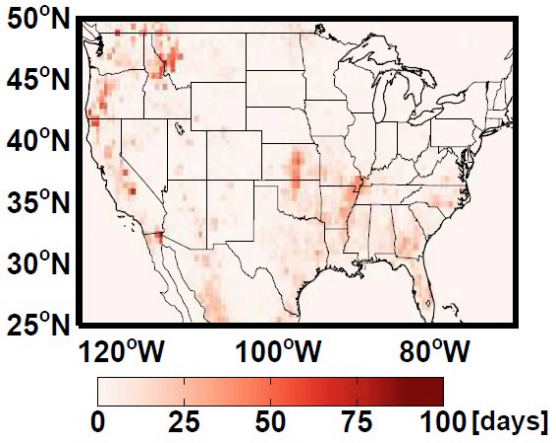
western U.S. forest wildfires and spring-summer temperature



Westerling et al., 2016

Large portions of the US experience smoke

Days with a Fire Reported*
June – September 2017



Days with Smoke*
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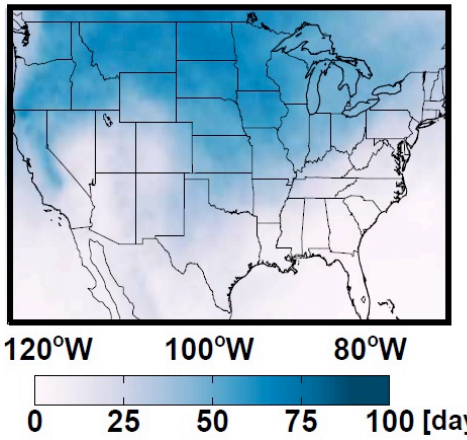


*using HMS products

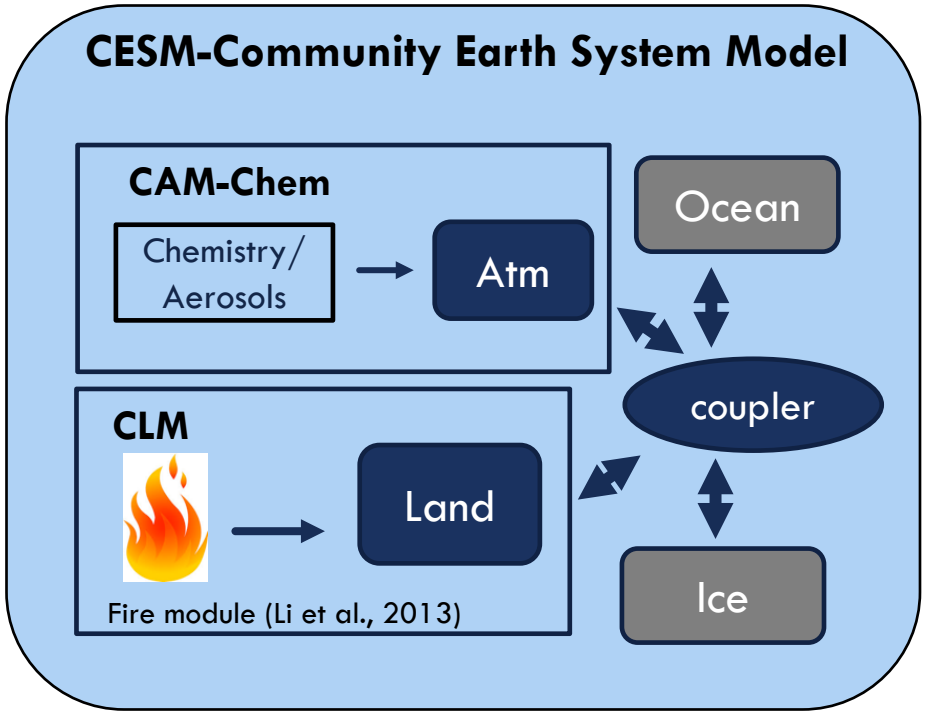
Known:

- Climate change is already increasing the frequency and intensity of fires
- Smoke from wildfires already causes air quality degradation
- Exposure to smoke from wildfires is already a significant health and economic burden

Question: If fires are projected to continue to increase, what does that mean for smoke concentrations and health in the US?

More Specific Question: Will increases in smoke emissions offset our gains in regulation of anthropogenic emissions?

Method: Use an Earth System Model for Fires

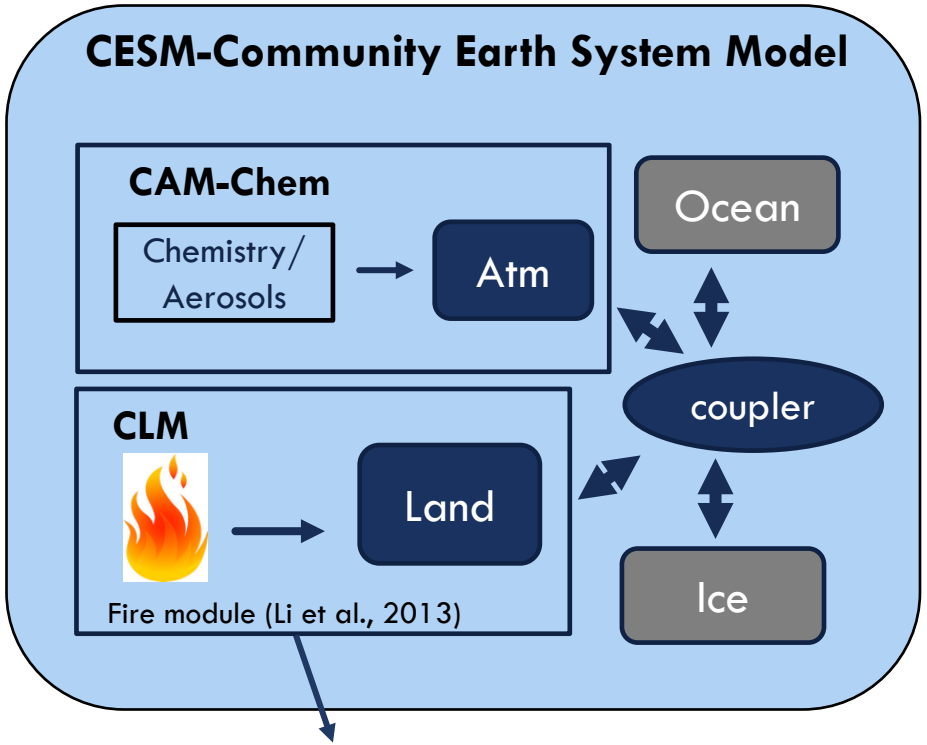


$PM_{2.5}$ Concentrations

- **2000-2010**
- **2040-2050**
- **2090-2100**

Health Impact Assessment

Method: Use an Earth System Model for Fires



Fire-related

$PM_{2.5}$ Concentrations

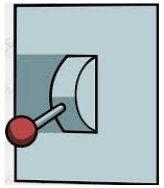
- **2000-2010**
- **2040-2050**
- **2090-2100**

Health Impact Assessment

Population
GDP
Lightning
Land Cover
Vegetation
Climate

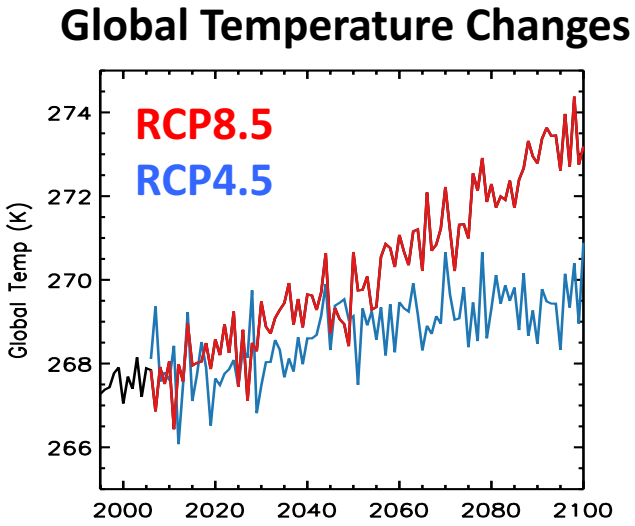
Agricultural Fires
Landscape Fires
Peat Fires

Biomass Burning Emissions



Model scenarios for climate and population

- **RCP:** Representative Concentration Pathway
  - greenhouse gas trajectories for IPCC



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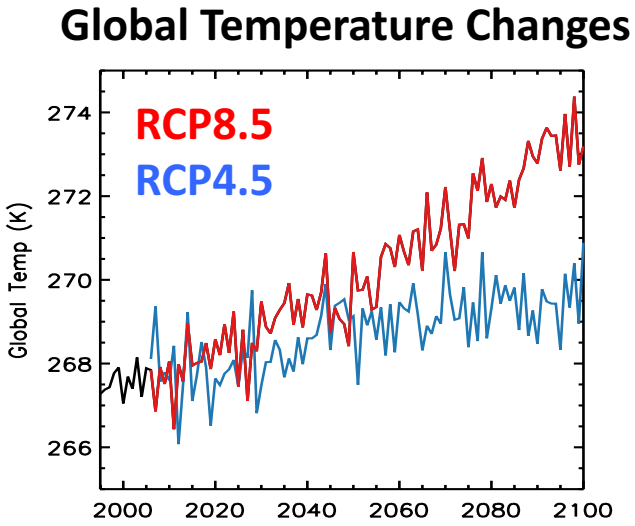
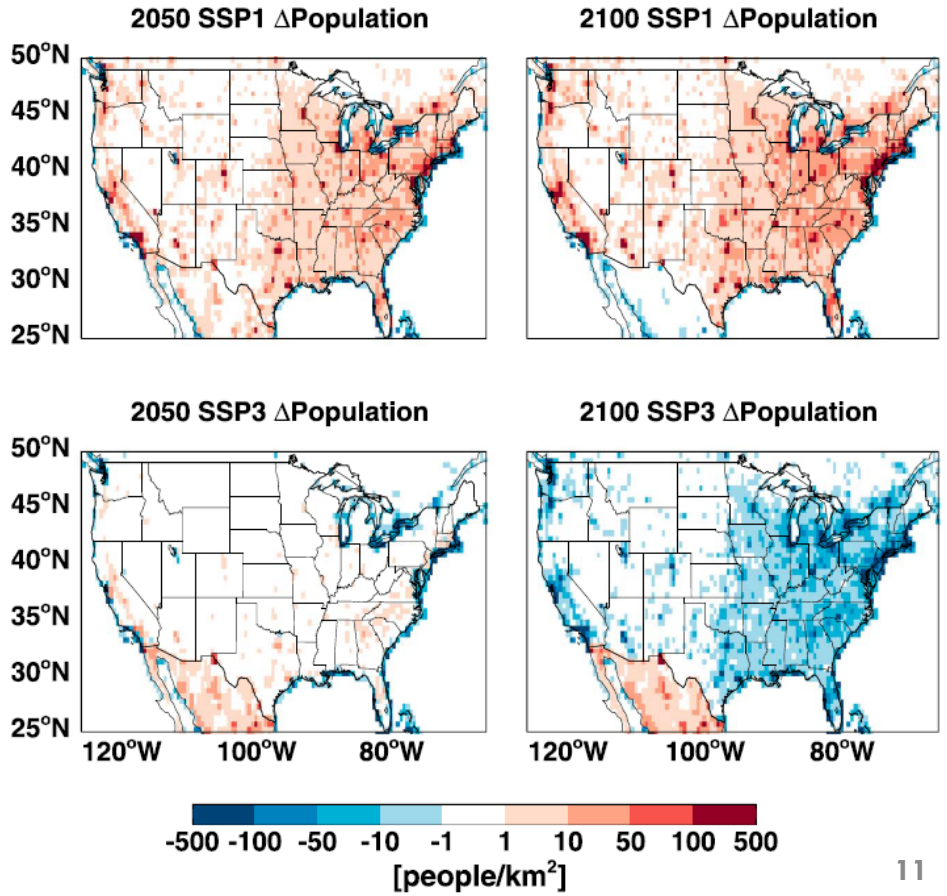
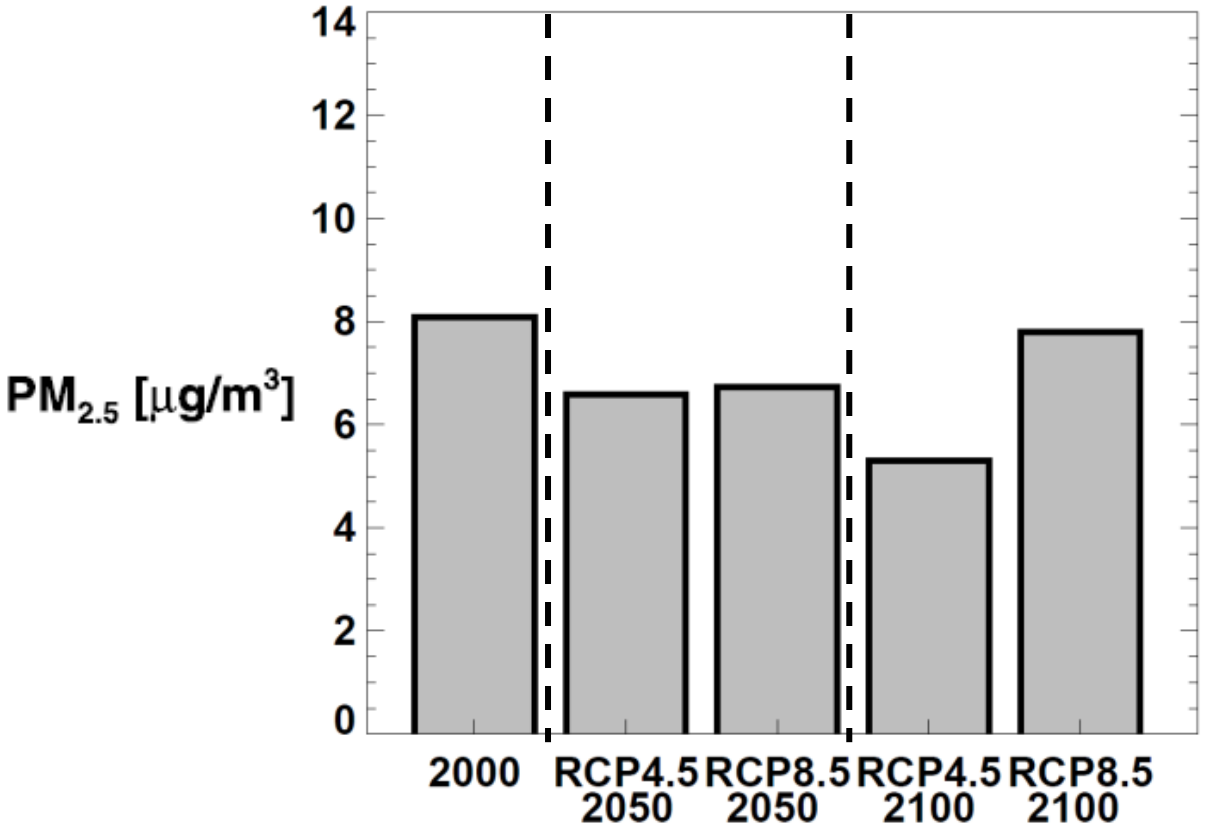


2 scenarios:
(1) RCP8.5/SSP3 and (2) RCP4.5/SSP1
(following recommendation of van Vuuren et al., 2011)

- **SSP:** Shared Socioeconomic Pathway
  - framework to represent plausible trends in the evolution of social and natural systems

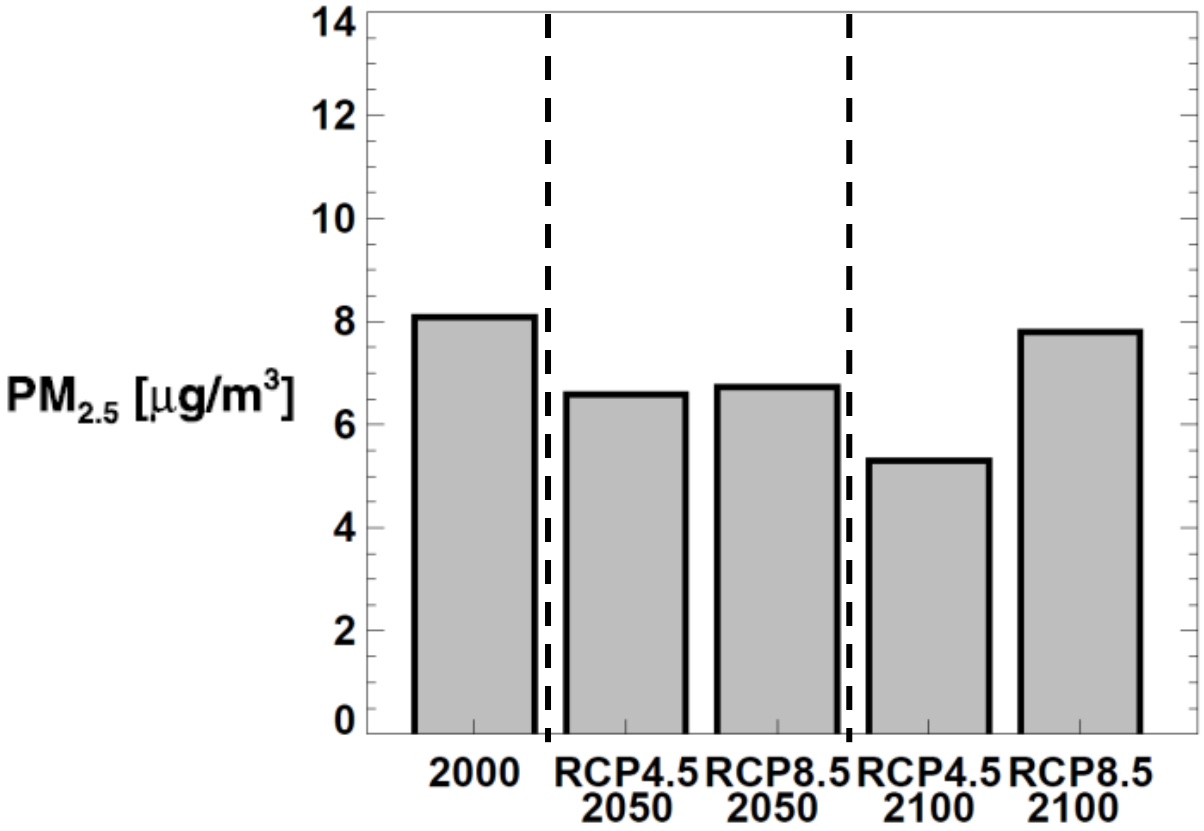


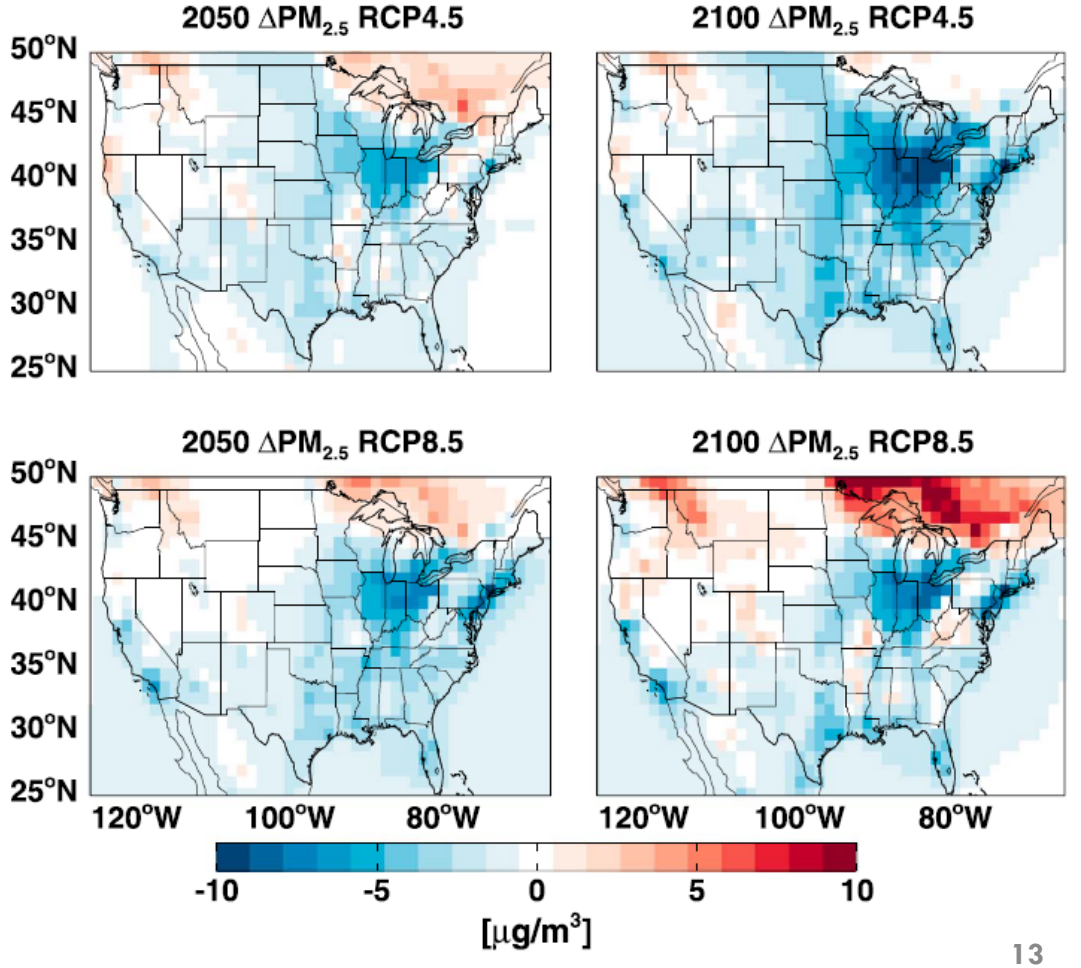
Total US Average $PM_{2.5}$ concentrations should continue to decline



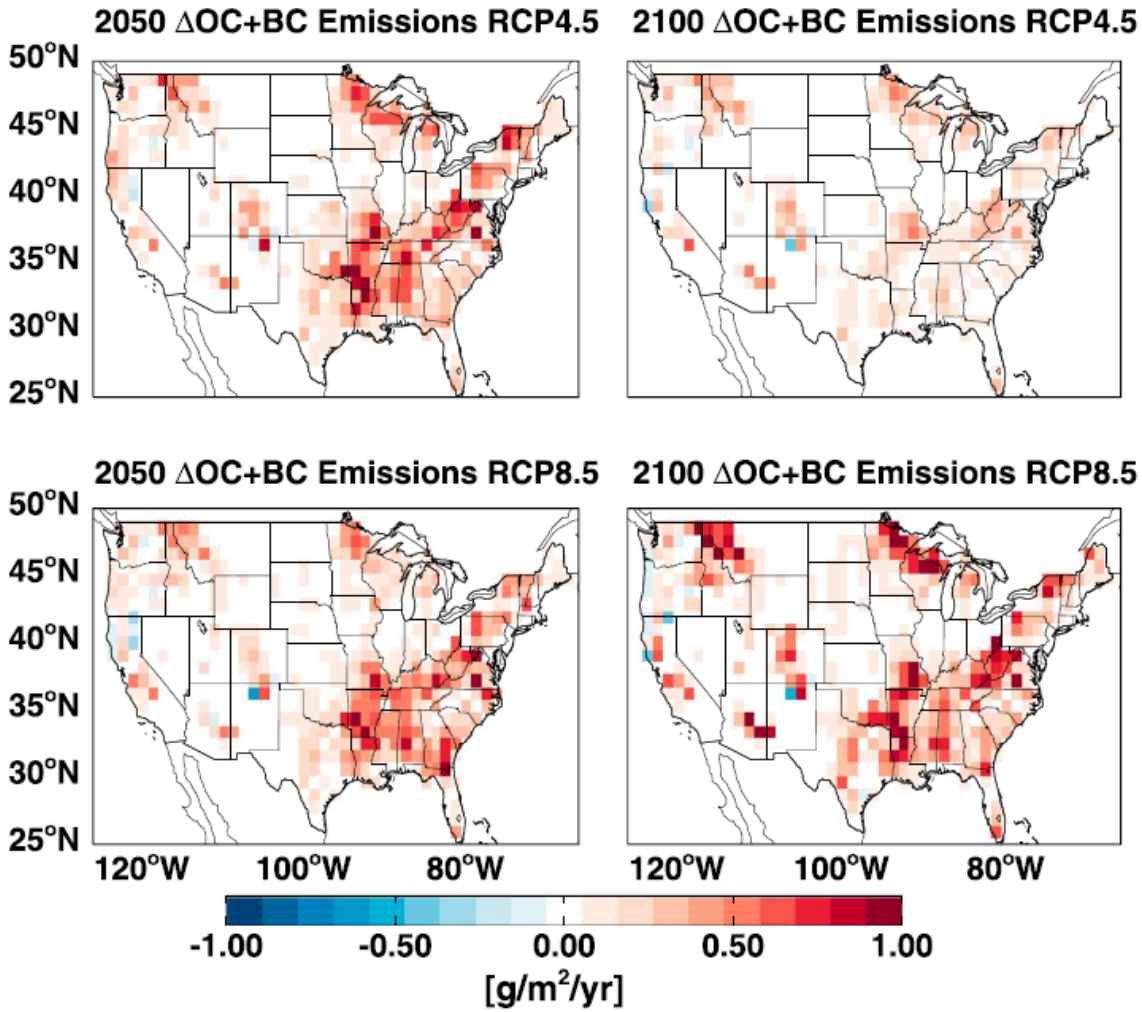
Total US Average $PM_{2.5}$ concentrations should continue to decline

But some regions will experience increased $PM_{2.5}$ concentrations

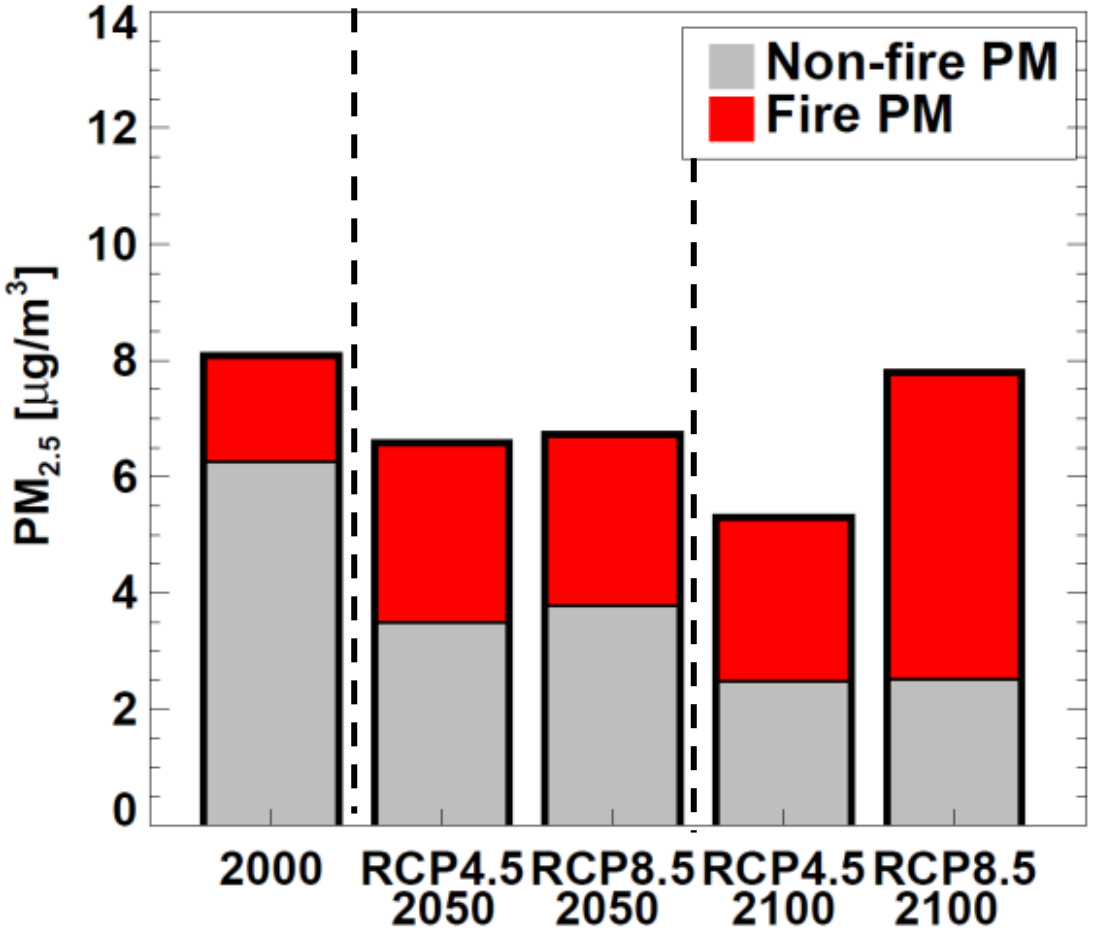


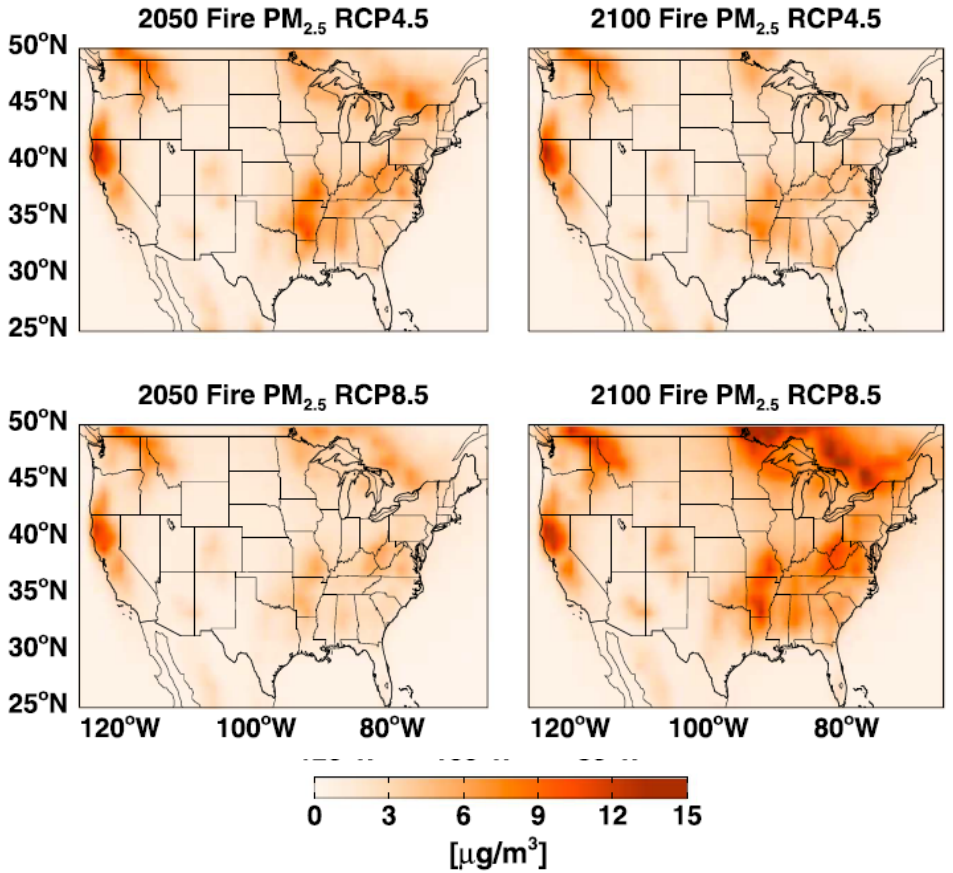


Both scenarios suggest that fire emissions will increase in the future

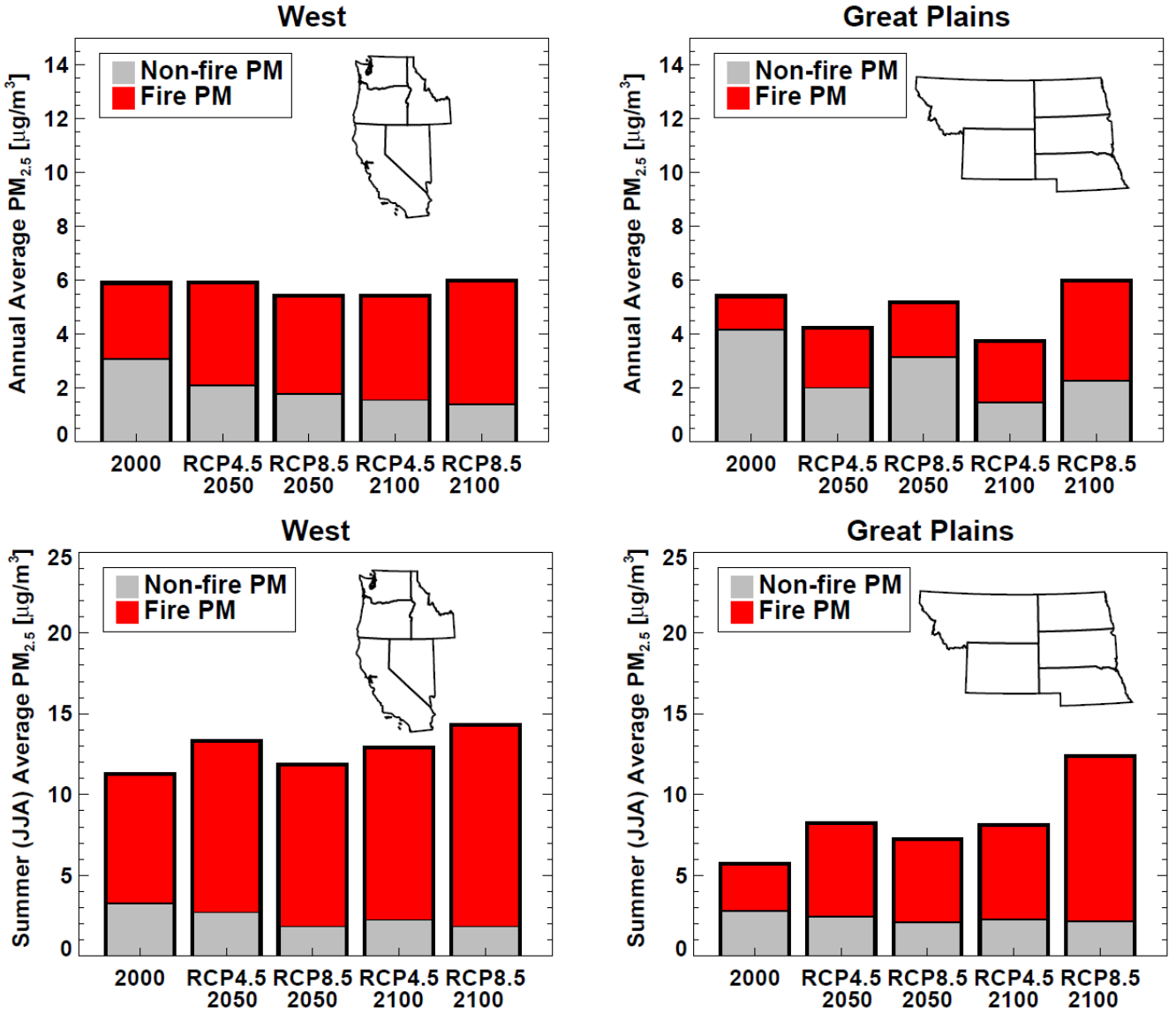


Increases in smoke-related PM could offset the benefits gained by reducing anthropogenic PM





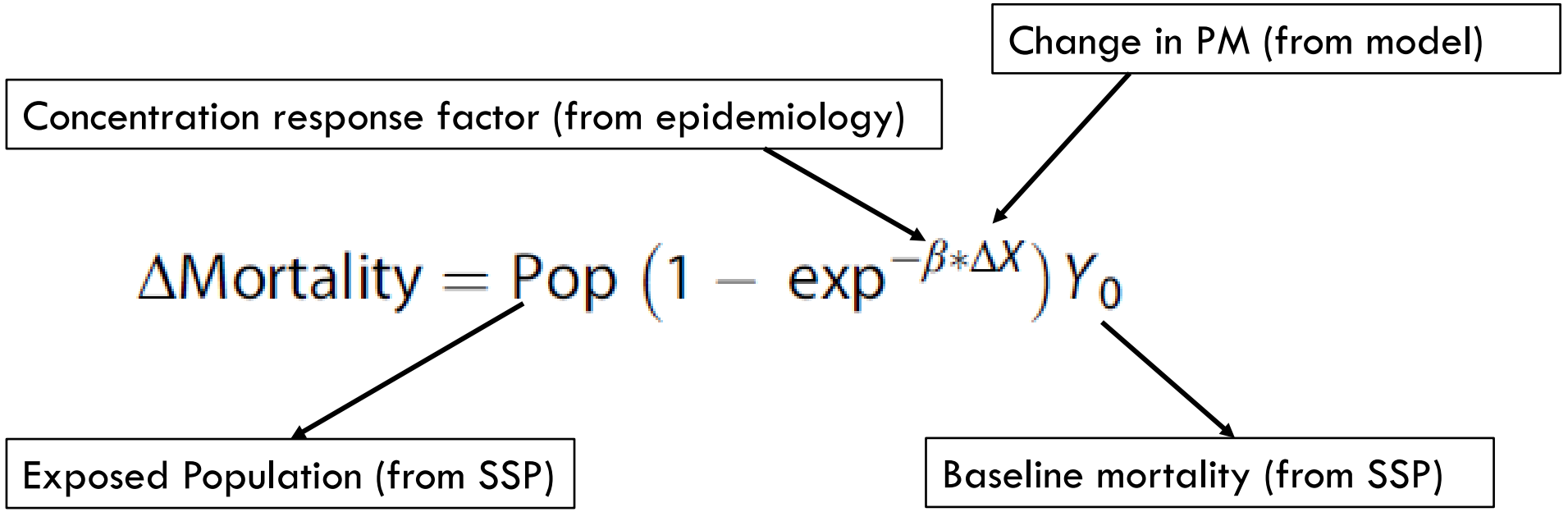
Smoke could become the dominant contributor to poor air quality in many regions of the US



*Note the change in scale here

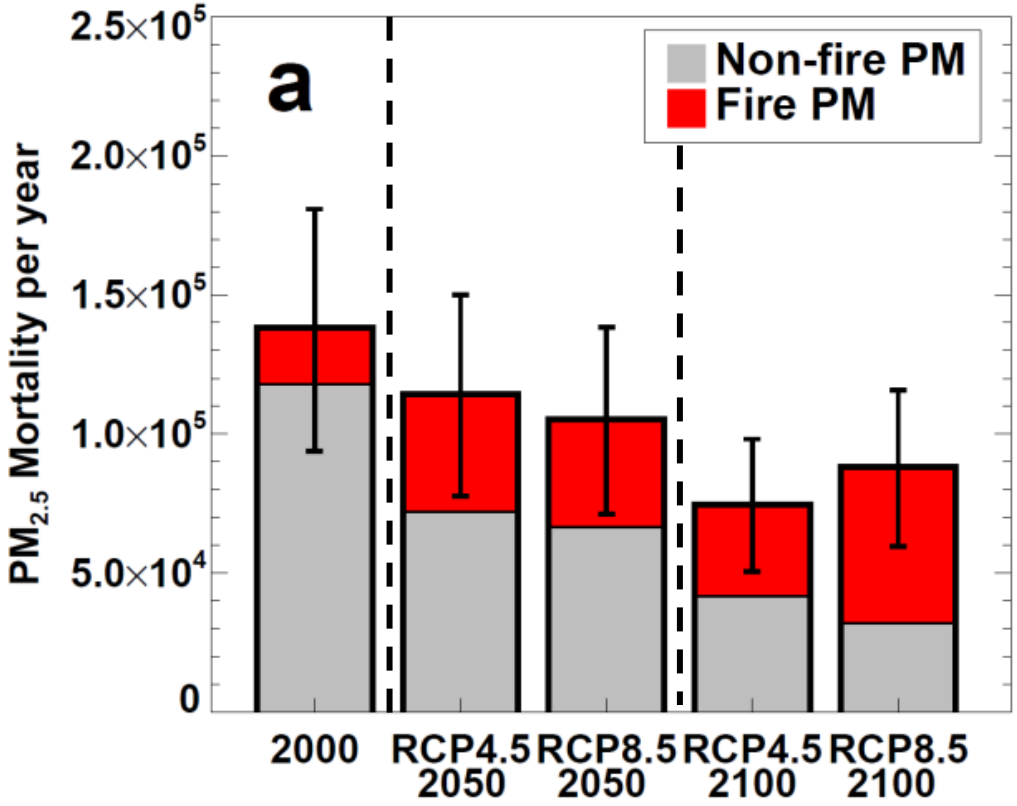
What does this mean for the health burden associated with $PM_{2.5}$ in the US?

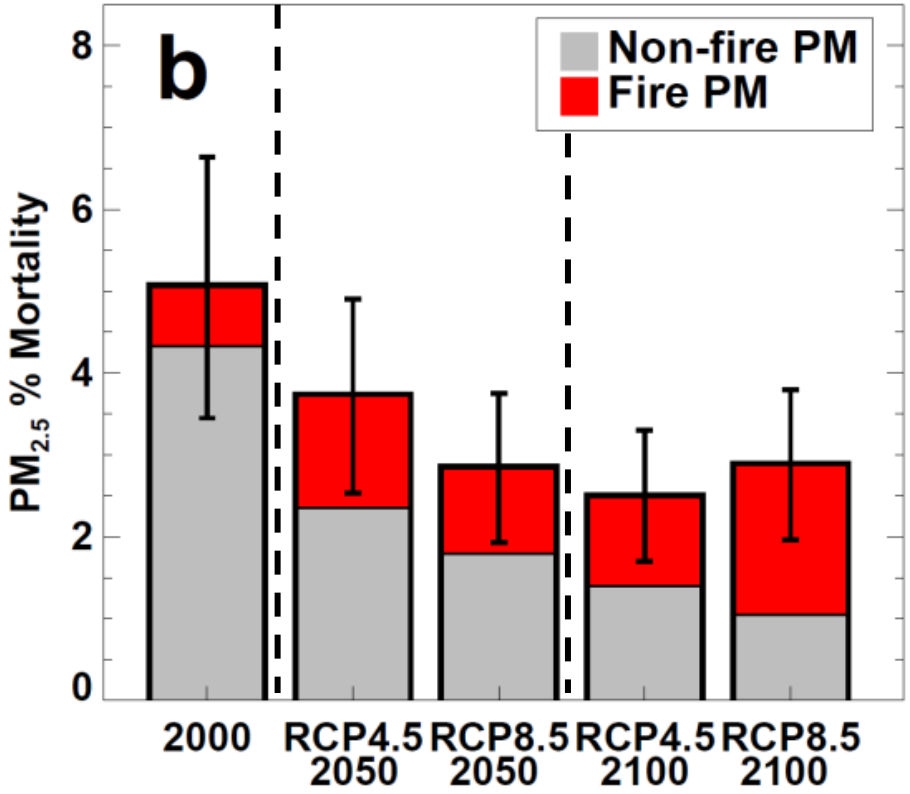
- Method: Health Impact Assessment



Caveat: Using CRF from studies of urban pollution. There are no epidemiology studies of the health effects associated with long-term exposure to smoke $PM_{2.5}$.

Total mortalities attributable to $PM_{2.5}$ exposure will decrease.



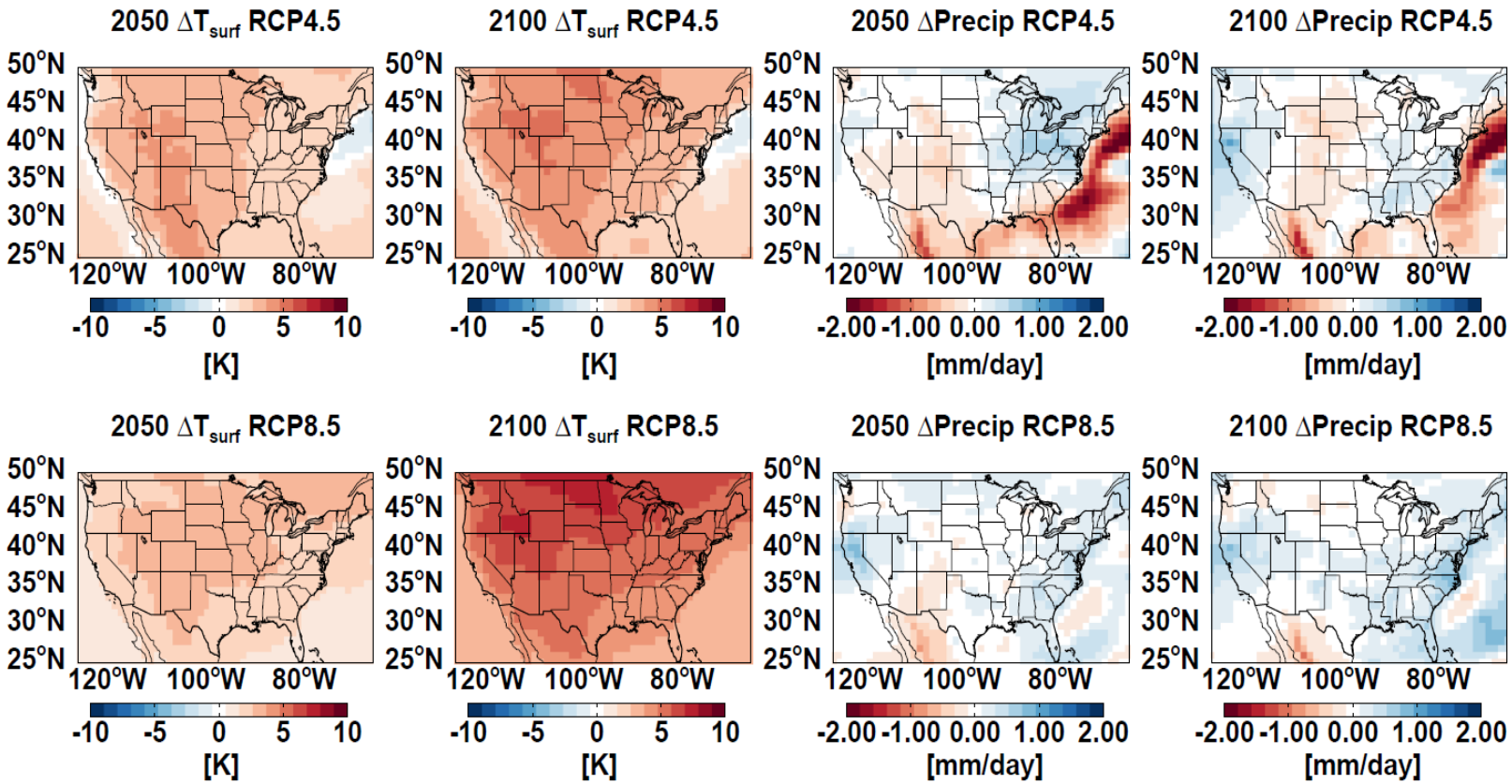


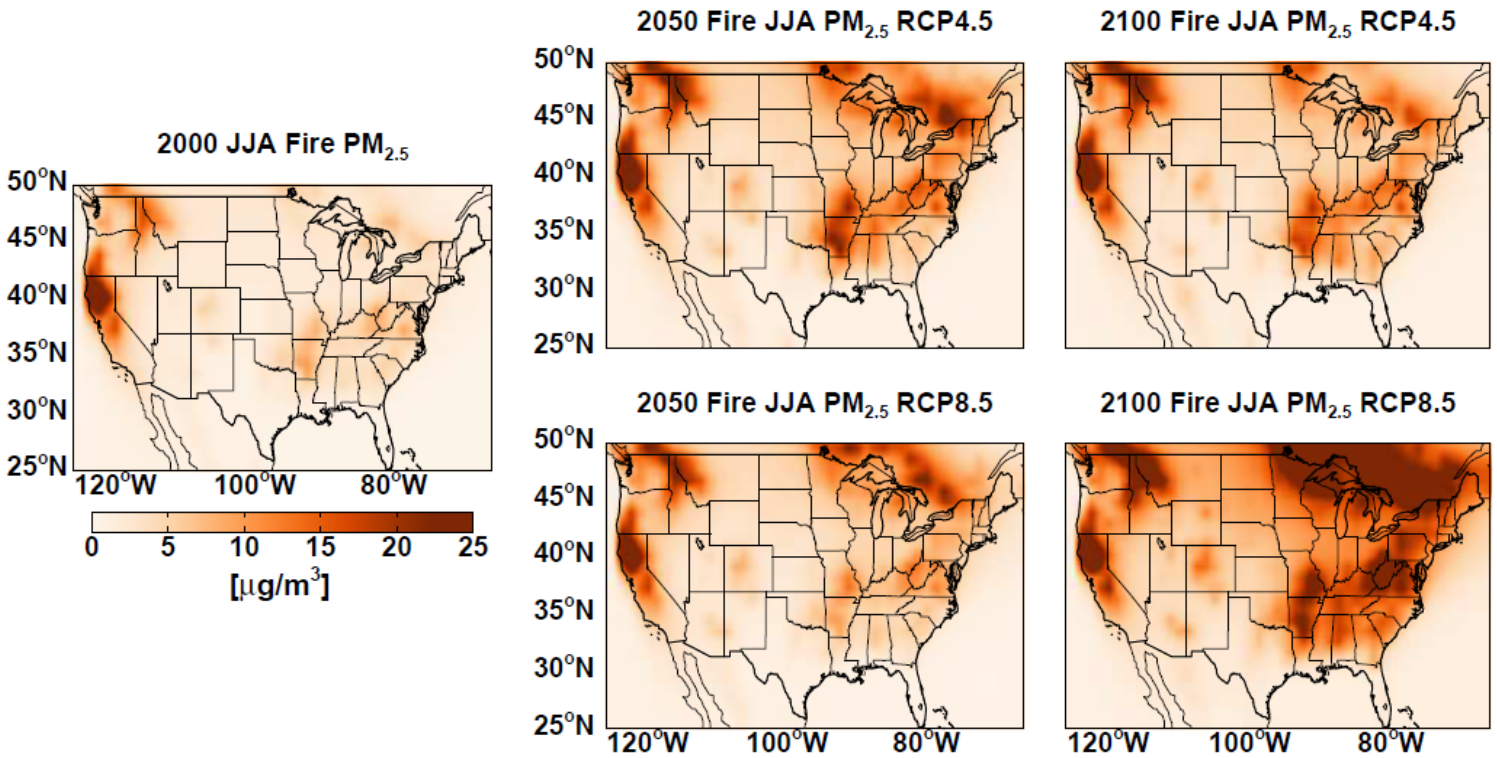
But, mortalities attributable to smoke exposure will increase.

Final Thoughts: These are projections, but why are they important?

- Majority of research studies (with different models and different scenarios) suggest more burn area in the US in the future and more smoke.
- Smoke exposure is no longer just a community issue. A large portion of the US experiences smoke from wildfires.
- US has no cohesive strategy for wildfire smoke exposure adaption or mitigation.

Extra Slides


2050 ΔT$_{surf}$ RCP4.5
2100 ΔT$_{surf}$ RCP4.5
2050 ΔPrecip RCP4.5
2100 ΔPrecip RCP4.5
2050 ΔT$_{surf}$ RCP8.5
2100 ΔT$_{surf}$ RCP8.5
2050 ΔPrecip RCP8.5
2100 ΔPrecip RCP8.5
50°N
45°N
40°N
35°N
30°N
25°N
120°W 100°W 80°W
-10 -5 0 5 10
[K]
-2.00 -1.00 0.00 1.00 2.00
[mm/day]


2000 JJA Fire PM2.5
50°N
45°N
40°N
35°N
30°N
25°N
120°W
100°W
80°W
0
5
10
15
20
25
[μg/m3]
2050 Fire JJA PM2.5 RCP4.5
2100 Fire JJA PM2.5 RCP4.5
2050 Fire JJA PM2.5 RCP8.5
2100 Fire JJA PM2.5 RCP8.5