

Wildfire smoke PM_{2.5} exposure and mortality burden in the US under future climate change

Stanford | Doerr
School of Sustainability

Minghao Qiu, Jessica Li, Carlos Gould, Renzhi Jing, Makoto Kelp,
Jeff Wen, Marissa Childs, Yuanyu Xie, Meiyun Lin,
Mathew V. Kiang, Sam Heft-Neal, Noah S. Diffenbaugh, Marshall Burke

pre-print

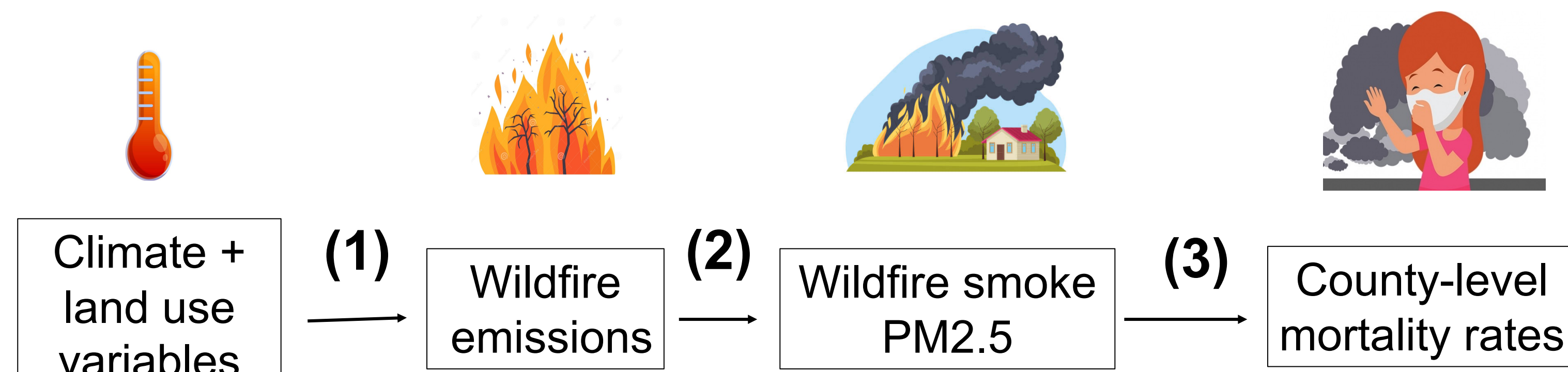


Research question: • What are the climate drivers of the US wildfire smoke PM_{2.5}?
• What are the future wildfire smoke PM_{2.5} concentration and excess mortality under future climate scenarios?

Key uncertainty: wildfire effects on PM_{2.5} + mortality effects of smoke PM_{2.5} (relative to total PM_{2.5})

Contact: Minghao Qiu
mhqu@stanford.edu
minghao.qiu@stonybrook.edu

Method: A data-driven approach that links climate to fire smoke PM_{2.5}, and mortality



- **Project smoke PM_{2.5} and mortality under future climate scenarios:** Combine projected climate variables from CMIP6 with the model above.

(1) Build a machine learning model to predict *fire emissions* with climatic and land use variables.

input variables: temperature, precip, VPD, soil moisture, wind, runoff, humidity, land use types, 2001-2021. **Output:** GFED4s emissions, **Linear, LASSO, NN models**

(2) Build a statistical model to predict *smoke PM_{2.5}* of each 10km grid from fire emissions. **Satellite-derived ML-based smoke PM_{2.5}** (Childs et al. 2022) Regression model accounts for wind and distance

(3) Empirically estimate *smoke-mortality response function* using county-level mortality rate data.

Mortality data: all-age all-cause county-level mortality rates, 2006-2019
Poisson model with binned smoke concentration

Result (1): climate-fire model

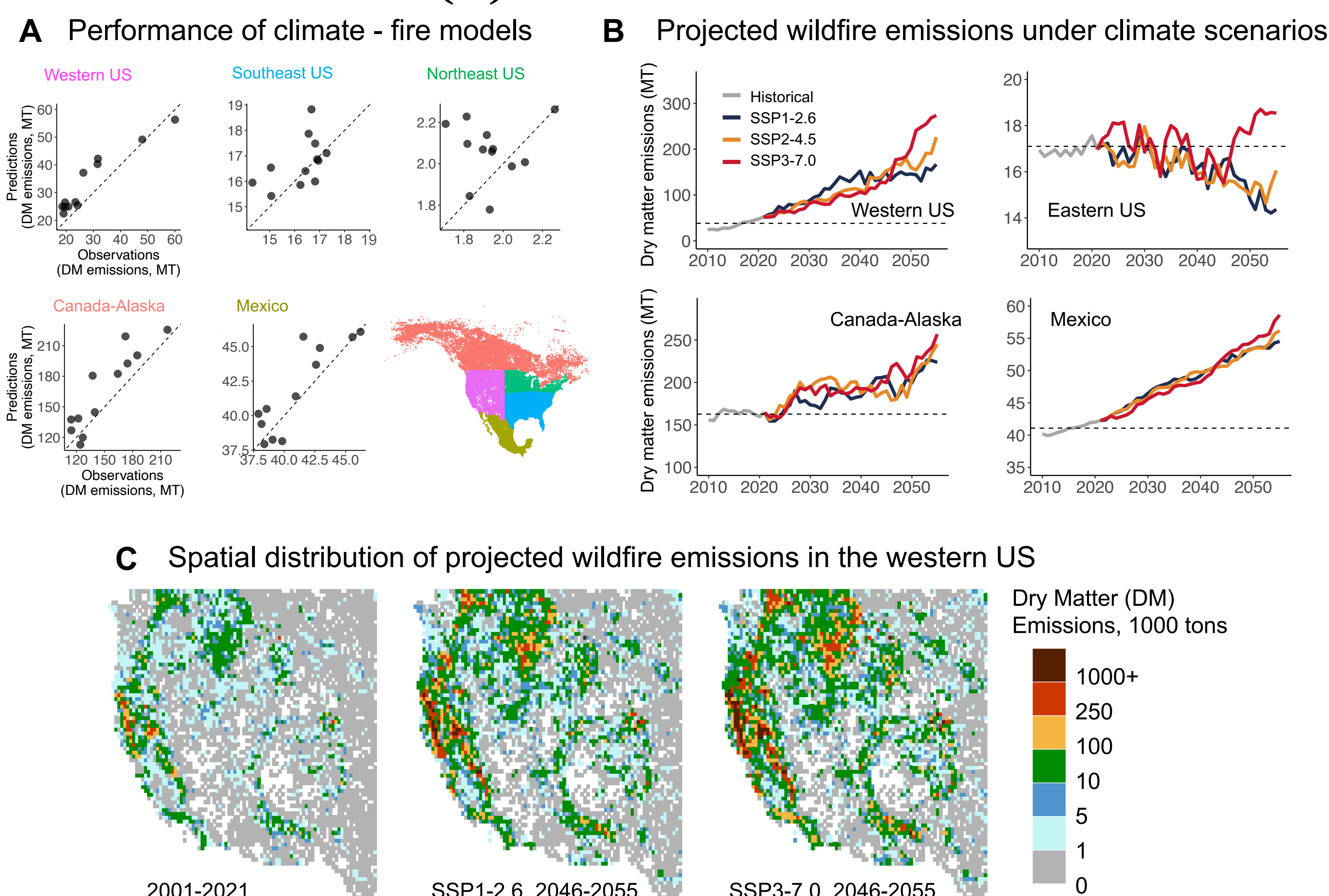


Figure 2: Performance of climate-fire models and the projected wildfire emissions under climate scenarios

Result (2): fire-smoke model

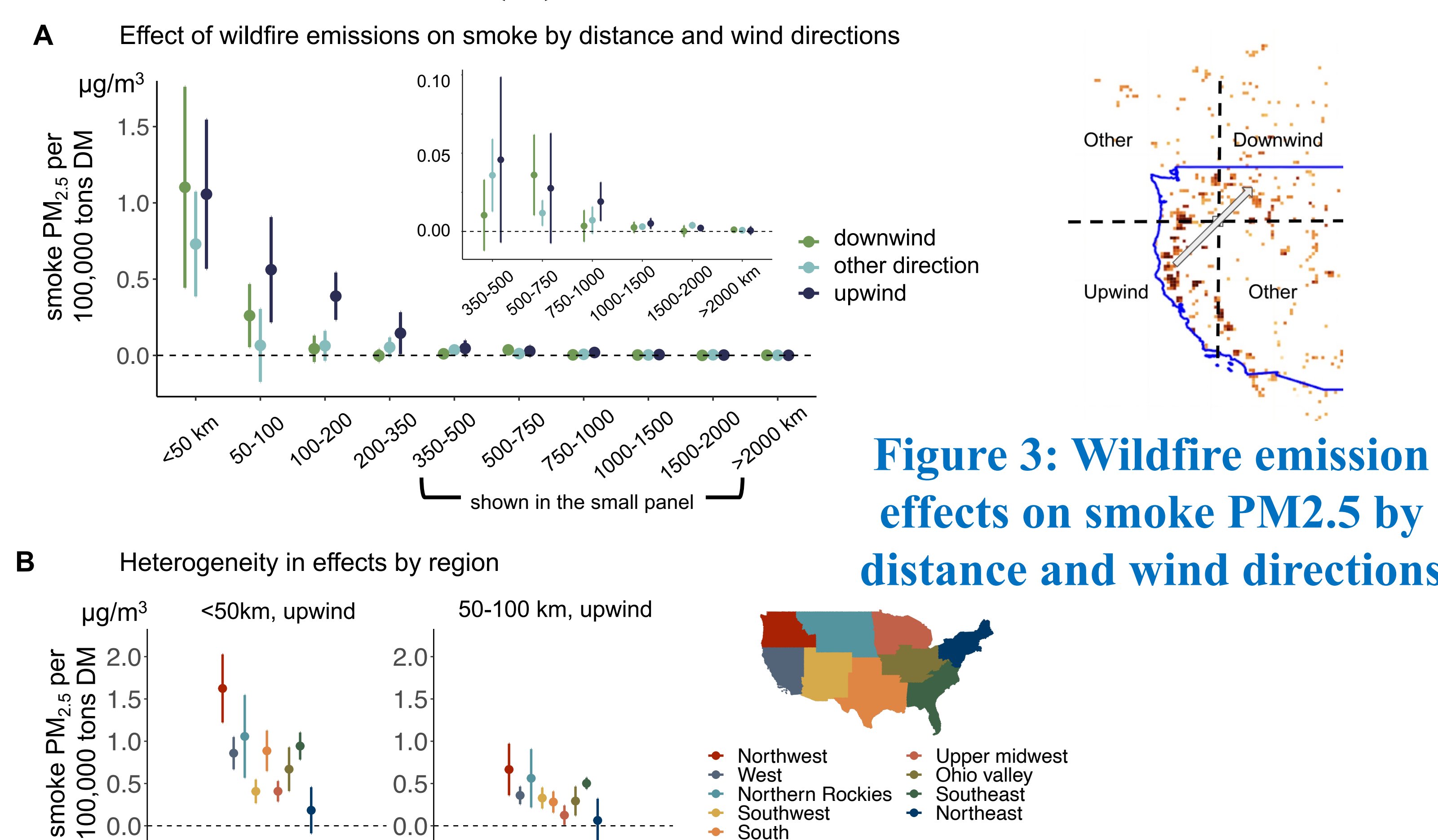


Figure 3: Wildfire emission effects on smoke PM_{2.5} by distance and wind directions

Potential reasons for regional differences:

- Fire intensity (should be large enough to have detectable impacts)
- Agriculture fires more common in Upper Midwest/Ohio
- Vegetation denser in the Northwest (Jaffe, 2020)
- Smoldering is more often seen in Northwest

Result (3): smoke PM_{2.5} effects on mortality rates

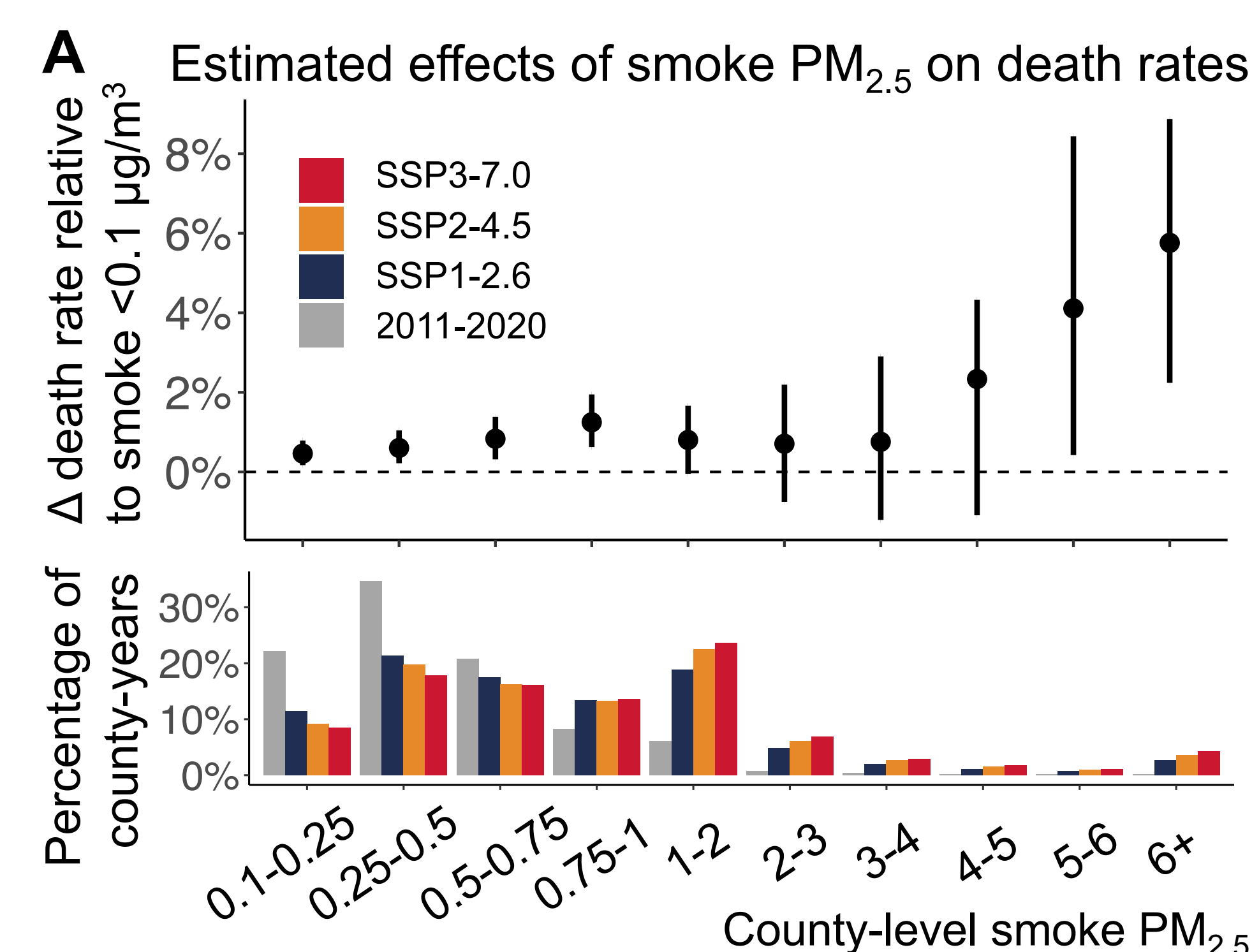


Figure 4: Mortality effects of annual smoke PM_{2.5} on annual mortality rates

Result (4): projected smoke PM_{2.5} and mortality in the US

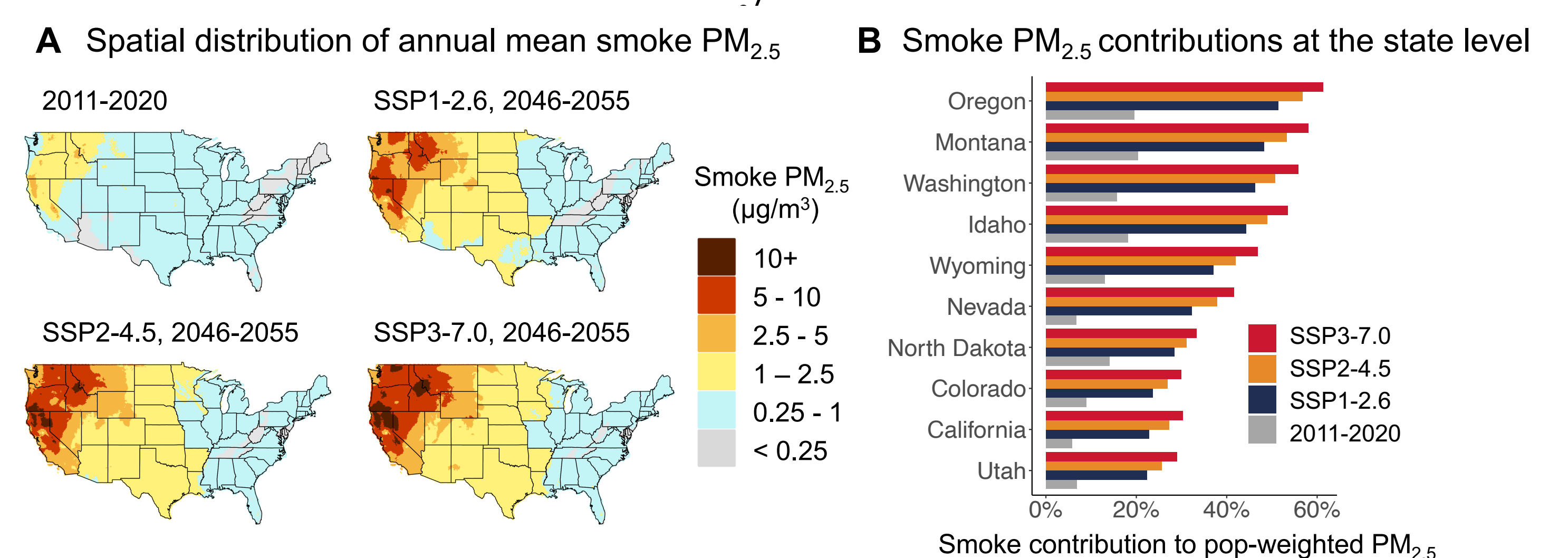


Figure 5: Projected smoke PM_{2.5} concentrations and contribution to total PM_{2.5}

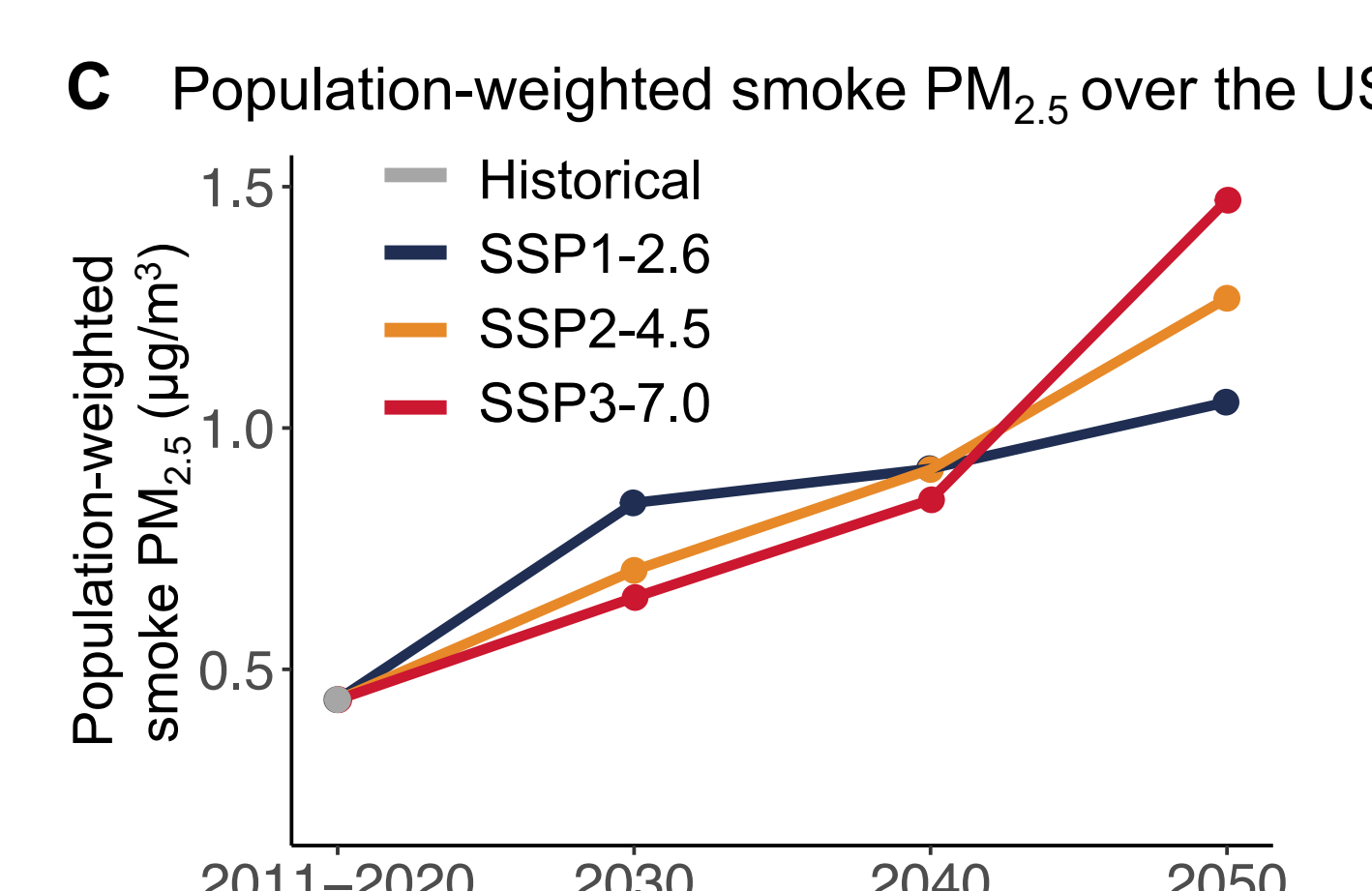


Figure 6: Projected smoke-PM_{2.5} related excess mortality

