Wildfire in the western United States in the mid-21st century and consequences for air quality:
Results from an ensemble of climate model projections.

Xu Yue  
L.J. Mickley and J.A. Logan  
Harvard

Michelle Bell and Coco Liu  
Yale

AQM partners  
Susan Anenberg and  
Carey Jang  
EPA

Beaver Complex Fire, Oregon, July 2014
Fires had a big impact on Western air quality in 2012-2014.

Spread of fires was driven by hot, dry, and sometimes windy weather.

**Will fire change in a warming climate?**

**What effects will increasing fires have on air quality and health?**

Influence of Canadian fires on US air quality, August 2014

“We don't recall such a consistently smoky summer.”
Smog Blog, U Maryland, Aug 2014
Observations suggest that fires are increasing in N. America.

Area burned in Canada increased from 1960 to 2000, correlated with temperature increase.

Westerling et al., 2007

Wildfire frequency has increased in the western U.S. since 1970, due to warmer temperatures and earlier snow melt.

Gillett et al., 2004
How can we predict fires in a future climate?

Start with the past.

Relationship between observed meteorology + area burned

+ Future meteorology

→ Future area burned

We use ensemble of climate models to gain confidence in prediction.

Ensemble includes two NASA climate models.

IPCC 2007
Approach to predicting future wildfires and smoke for 2000-2050

1. Build fire prediction tool using observed sensitivity of area burned to meteorology.

Area Burned = \( f(\text{temperature}, \text{RH}, \text{SLP gradients}, \ldots) \). .. all variables that can be easily diagnosed in global climate models. Includes lagged variables.

2. Apply fire prediction tool to archived meteorology from an ensemble of models to calculate future area area burned.

3. Implement future area burned into GEOS-Chem CTM to calculate PM\(_{2.5}\).

Yue et al., 2013; 2014
Ensemble of climate models shows robust changes in JJA temperature across West by 2050s, but not in all variables.

Use of model ensemble allow identification of robust changes.

Yue et al., 2013; 2014
We apply our fire prediction tool to meteorology archived from an ensemble of IPCC climate models.

Median of models

Spread of freely running models

Obs

Models predict increases in area burned of 20-100% by midcentury across the West.

Previous model studies showed large inconsistencies in future area burned.

Use of multiple models provides confidence in results.

Yue et al., 2013; 2014
We implement modeled area burned into GEOS-Chem to project future levels of smoke $\text{PM}_{2.5}$.

Many populous counties experience 40-150% increases in smoke $\text{PM}_{2.5}$ by mid-century.

Much of California sees a doubling of “smoke waves” – episodes of enhanced smoke at the 98th% level.

Next step: Examine health effects with Yale collaborators, using Medicare data.

Liu et al., in prep.
Main findings.

• Smoke PM$_{2.5}$ increases by 20-150% across much of the western US by 2050s, depending on the ecosystem, leading to more exceptional events.

• Increasing smoke from wildfires may thwart efforts to regulate air quality in coming decades. This is a climate penalty.

Stay tuned for Lu Shen’s talk using same multi-model approach to forecast future U.S. ozone exceedances.

Sample press