

Board on Atmospheric Sciences and Climate
The National Academies of Sciences

Wildland Fires: Towards Improved Understanding and Forecasting of Air Quality Impacts – A Workshop

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Near-fire ozone (O₃) formation

DOWNWIND

Precursor emissions (VOC, NO, NO₂) and photochemically produced compounds can lead to O₃ formation when conditions are favorable (warm temperatures and sunlight)

Smoke particles emitted during wildland fires can attenuate light and impact O₃ formation

VOC +
NO + NO₂

AT THE FIRE

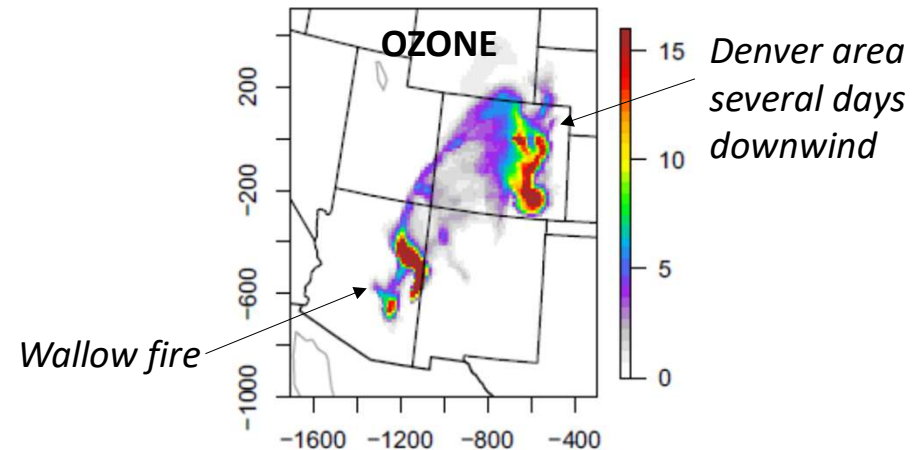
O₃ production is usually inhibited by fresh NO emissions destroying O₃ faster than it can be produced

Photo by Kirk Baker (central Kansas, November 2017)

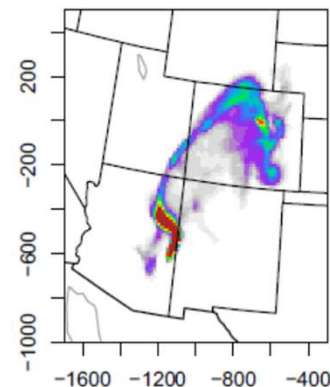
Fire Impacts on Regional Ozone

- Presence of highly reactive VOC results in NOX conversion to longer-lived forms of oxidized nitrogen (PANs)
- PANs can transport downwind and thermally decompose back to NOX and participate in O3 production reactions in NOX limited areas
- Highly reactive VOC emitted from the wildfire and photochemically produced in the plume can also participate in O3 production both at the fire and further downwind in VOC limited (urban) areas

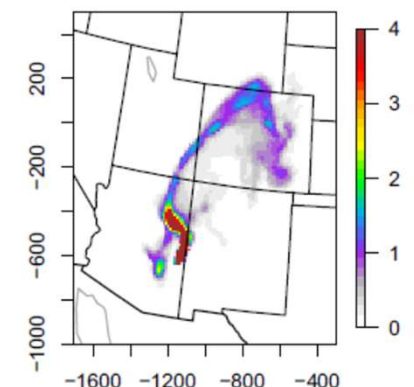
Snapshot of modeled impacts from the 2011 Wallow fire (eastern Arizona)



(g) PAN (ppb)

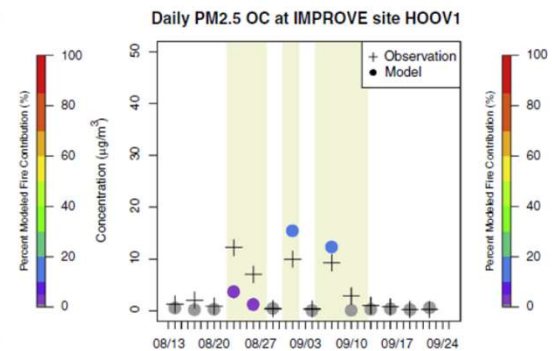
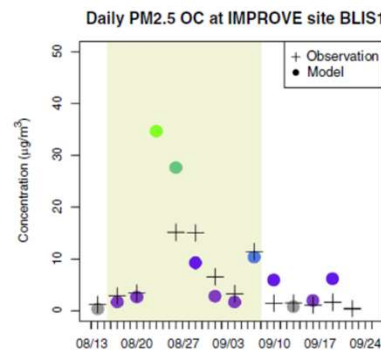
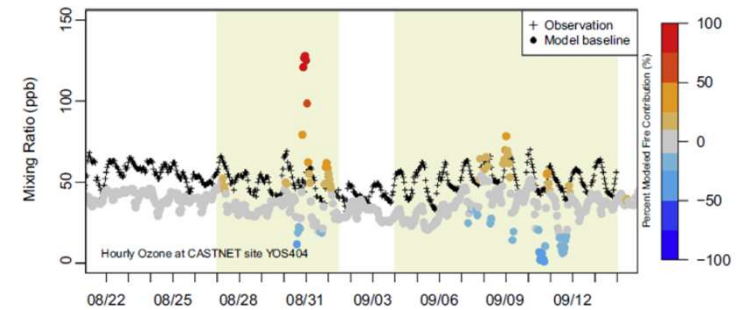
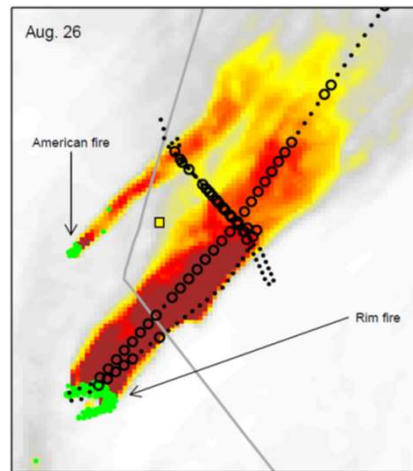


(i) Formaldehyde (ppb)



Photochemical Model Performance

- Photochemical models can reasonably replicate local to regional scale smoke plume transport
- Over-estimates of surface level O_3 at rural routine monitors when model predicts fire impact
- Performance for surface level $PM_{2.5}$ mixed (over and under-estimates)



It is important to constrain as many aspects of the system as possible to evaluate and develop models

**Plume Transport
& Chemistry**

Plume rise

Emissions

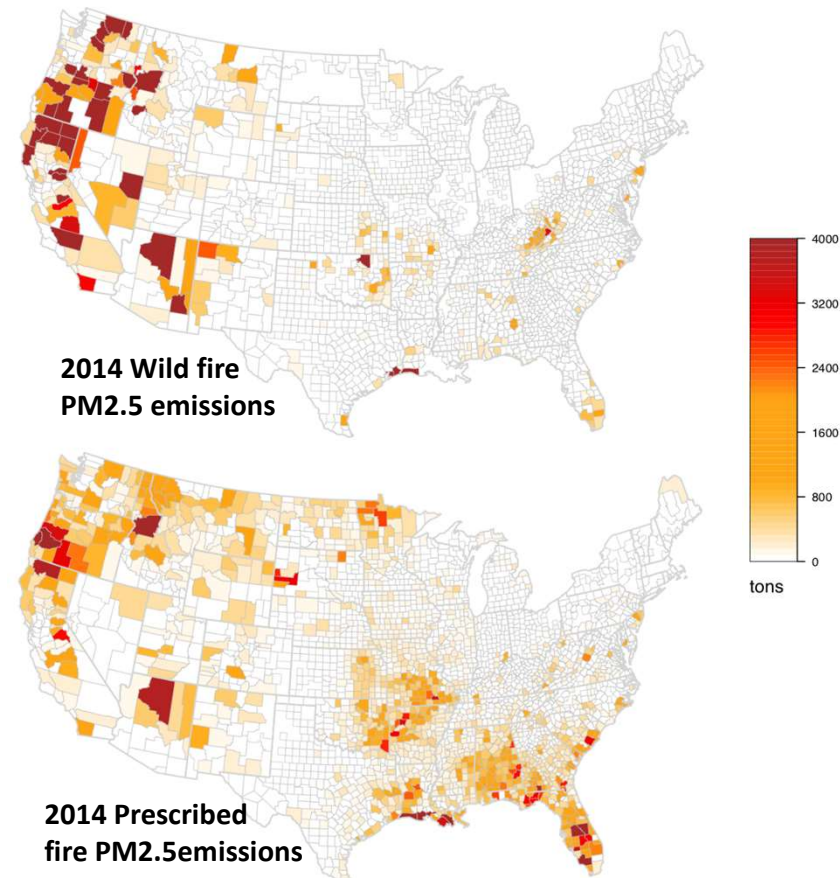
**Fuel & Consumption
Location/Area Burned**

- **Field study data allows verification of key aspects of the modeling system**
- **Ideally a field study or combination of studies would inform these components**

Photo courtesy USFS Fishlake National Forest

Consideration of Model Scale

- Challenges associated with modeling specific fires and when modeling all fires over a broad region
- Activity data: large wildfires detected by satellites, but numerous smaller prescribed fires often missed
 - Need better tracking of prescribed fire activity
- How important are combustion phase, moisture, and fuel type for emissions in regional scale grid models?
 - Is combustion phase somewhat accounted for in emission factors by fuel type (e.g., grasses mostly flaming, peat mostly smoldering)?
 - In many wildfires flaming and smoldering are happening in the same hour and spatial area (relative to model grid cell sizes of 1 to 36 km)
 - How can we simplify an overwhelming amount of data for model application?



Summary

- We are increasingly challenging our models to more accurately characterize O₃ and PM_{2.5} impacts of wildland fire and specific fires for regulatory assessments
 - Models can differentiate fire impacts from other sources
- Many different aspects of the modeling system need evaluation and potentially improvement: meteorology, fuels, emissions, chemistry, plume placement
- Important to synthesize recent chamber and field work relevant for local to regional scale photochemical grid modeling
 - Being able to make simplified treatment of fuels/processes ideal where possible considering that these models typically have hourly input/output and 1+ km sized grid cells
- How do we know we are getting a reasonable answer?
 - Comparison of model predictions with ambient data (field studies, remotely sensed, routine)
 - Field studies provide test cases important for identification of model improvements as different aspects of the system are improved
- Models may be a valuable tool for understanding the trade-offs between prescribed fire and wildfire air quality impacts on ozone and particulate matter