Part 1: Wildland Fire Emission Factor Modeling Sensitivity

June 29, 2022

Wildland Fire Emission Factors

- Emission factors for EPA modeling traditionally based on BlueSky Framework/Pipeline FEPS module

- More recently a comprehensive synthesis with updated emission factors by vegetation type was published by Prichard et al in 2020 (right) called Smoke Emissions Repository Application (SERA)

- SERA emission factors generally higher for PM2.5 and lower for NOX compared to FEPS

- Annual CMAQ simulations done to compare how SERA emission factors impact model performance compared to FEPS

Wildland fire emission factors in North America: synthesis of existing data, measurement needs and management applications

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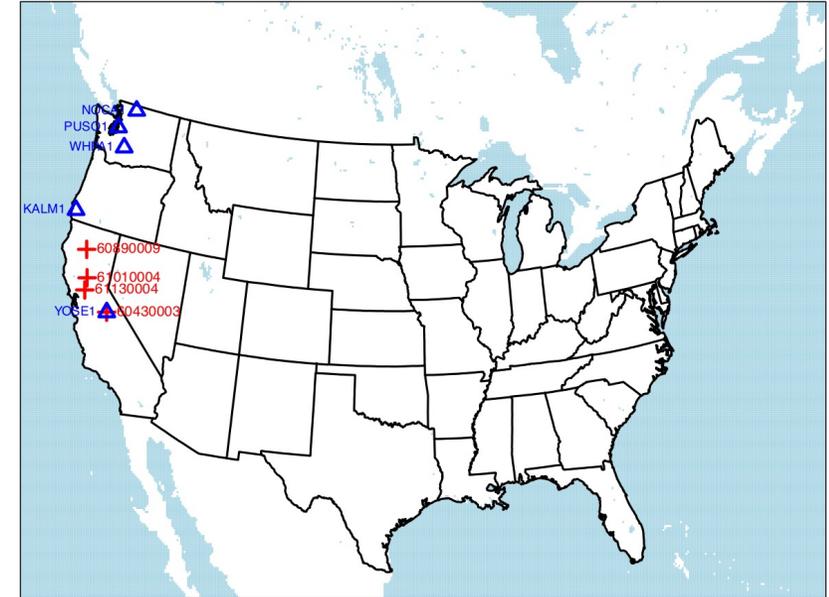
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Abstract. Field and laboratory emission factors (EFs) of wildland fire emissions for 276 known air pollutants sampled across Canada and the US were compiled. An online database, the Smoke Emissions Repository Application (SERA), was created to enable analysis and summaries of existing EFs to be used in smoke management and emissions inventories. We evaluated how EFs of select pollutants (CO, CO_2, CH_4, NO_x, total particulate matter (PM), $PM_{2.5}$ and SO_2) are influenced by combustion phase, burn type and fuel type. Of the 12 533 records in the database, over a third ($n = 5637$) are represented by 23 air pollutants, most designated as US Environmental Protection Agency criteria air pollutants, greenhouse gases, hazardous air pollutants or known air toxins. Among all pollutants in the database, including the most common pollutants PM, CO, CO_2 and CH_4, records are unevenly distributed with a bias towards flaming combustion, prescribed burning and laboratory measurements. Across all EFs, records are most common for south-eastern and western conifer forests and western shrubland types. Based on identified data gaps, we offer recommendations for future studies, including targeting underrepresented air pollutants, smouldering combustion phases and improved source characterisation of wildland fire emissions.
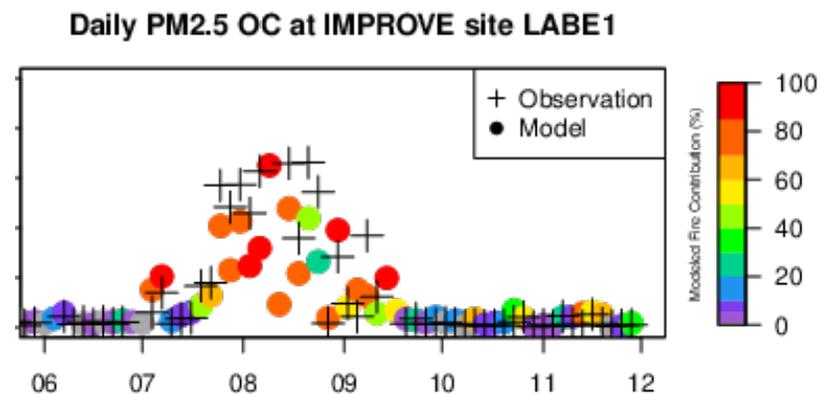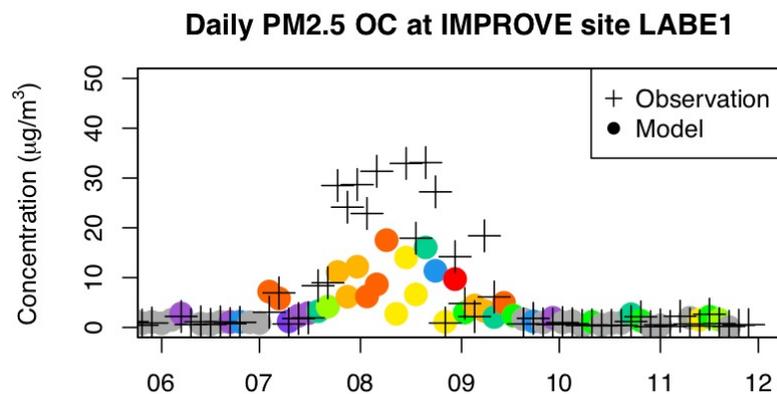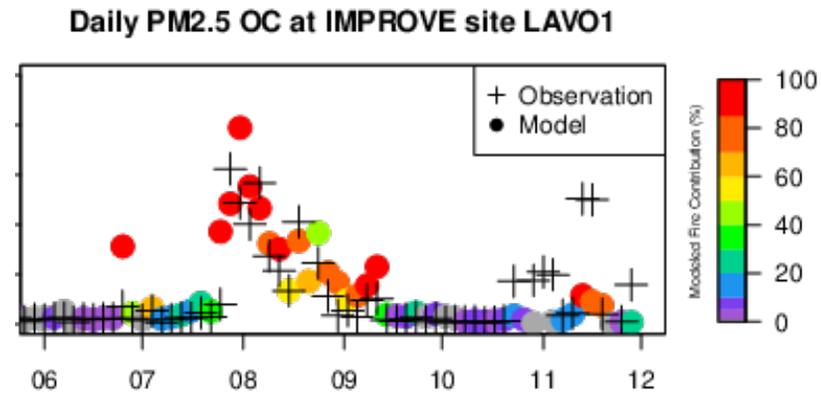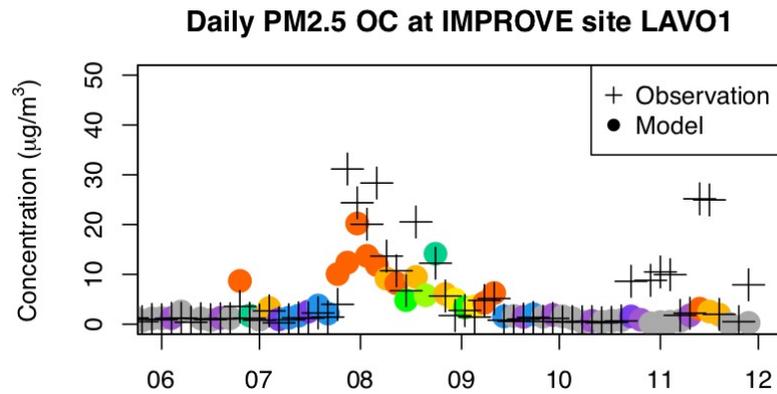
Modeling Background

- CMAQ v5.3.2
  - CB6r3 AE7
  - POA treated as semi-volatile for all sectors including fires and PCSOA was off
- Model simulations for 12US1 domain (at right)
  - 12 km sized grid cells; 35 vertical layers
  - Annual 2018 simulations: 1) FEPS emission factors, 2) SERA emission factors, and 3) wildland fire zero-out simulation
  - 2018gc anthropogenic and BEIS biogenics

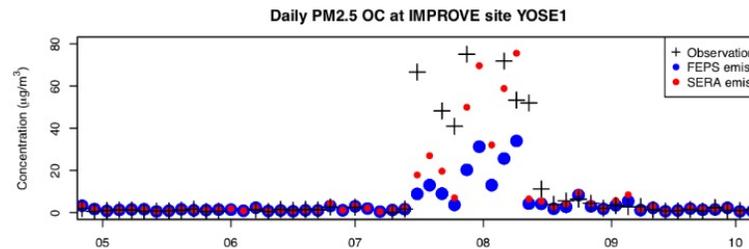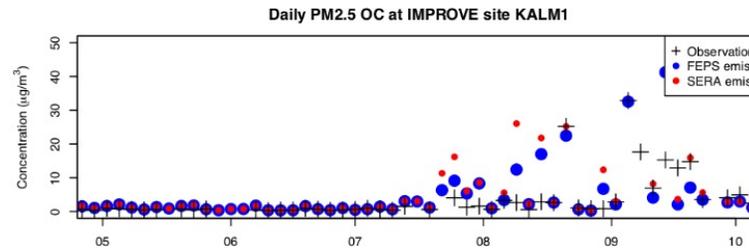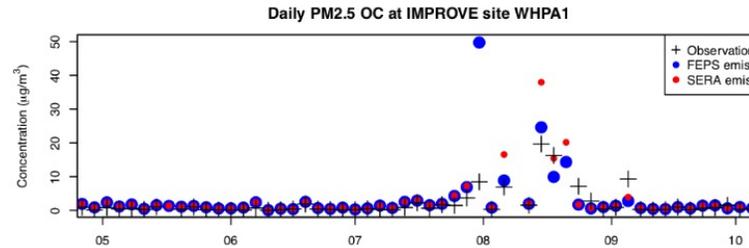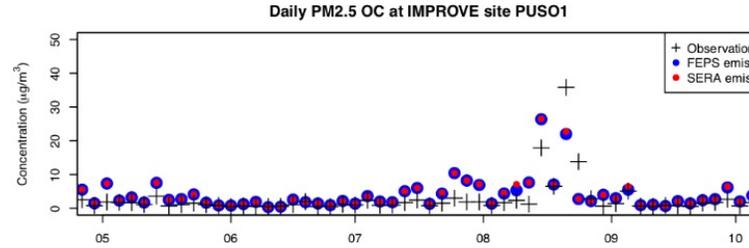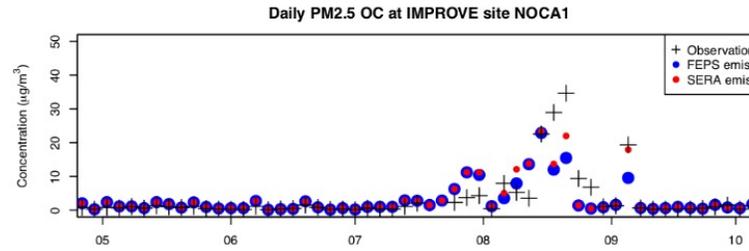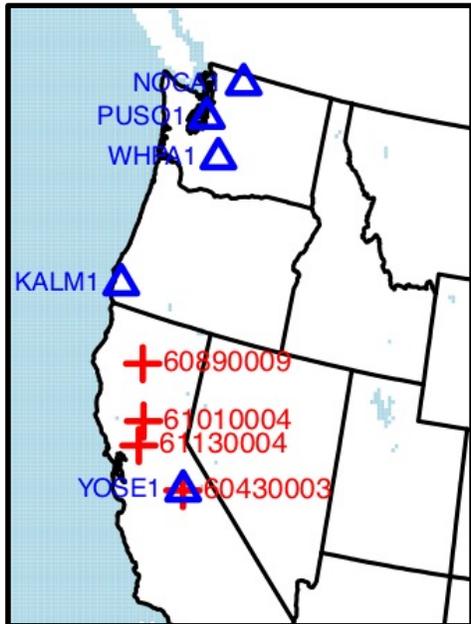# Emission factor sensitivity – FEPS vs. SERA

FEPS emission factors

SERA emission factors

Daily PM2.5 OC at IMPROVE site LAVO1

Daily PM2.5 OC at IMPROVE site LAVO1
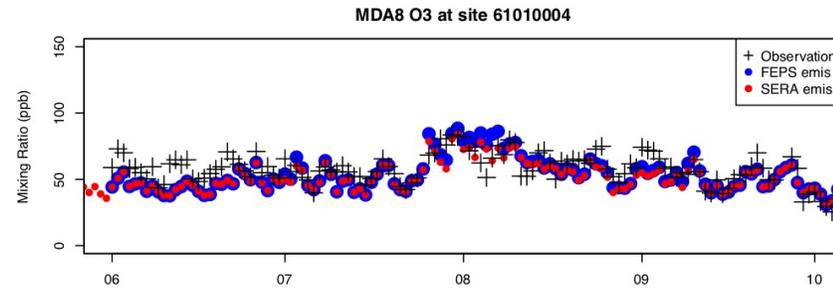
Daily PM2.5 OC at IMPROVE site LABE1
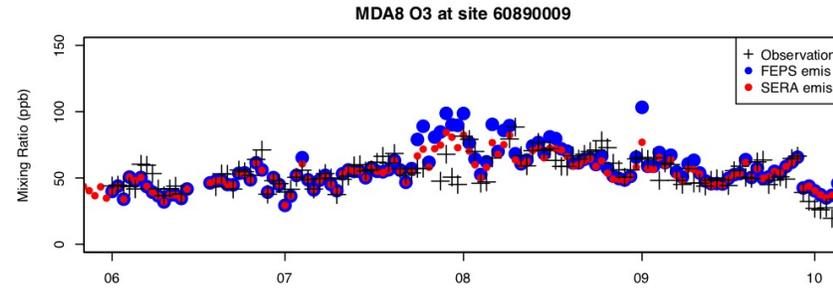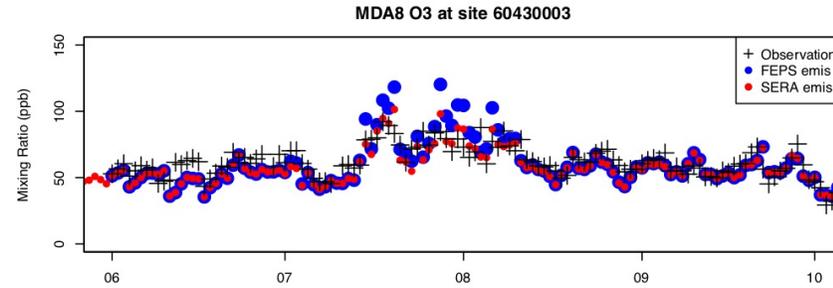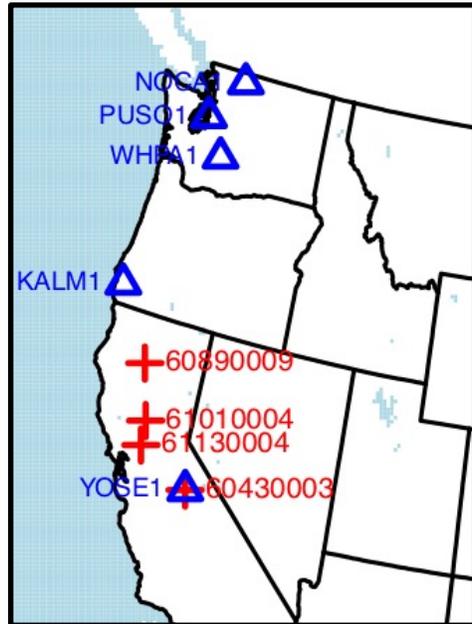
Daily PM2.5 OC at IMPROVE site LABE1

PM2.5

SERA emissions improve PM performance at some sites and degrade sites with overestimates at others

O3 MDA8

SERA emissions improve performance at all sites with O3 impacts from wildfire
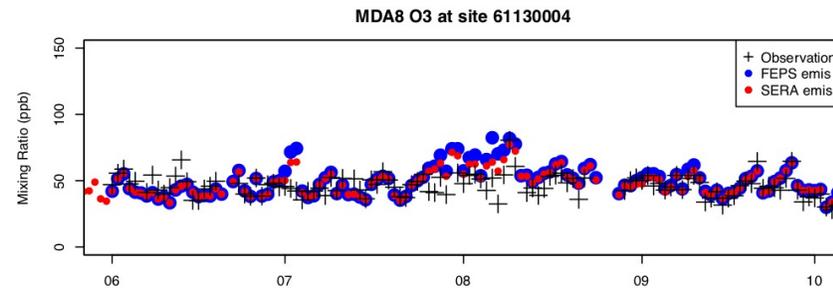
Remarks

- PM2.5 performance with SERA emissions for wildfire in the western U.S. mixed

- Performance systematically improves for O3 impacts from wildfire; likely related to SERA lower NOX emission factors

Part 2: Linking Fire Size and Downwind Fire Impacts on O3 and PM2.5 Using a Model

June 29, 2022

# Wildland Fire Activity and Modeled Impacts on O3 and PM2.5

- Given the large number of wildfire over the past few years more areas are interested in understanding how much PM2.5 and O3 might be related to nearby and distant fires
- Ambient data are often impacted by many sources and meteorology, which is particularly true for O3 during the late spring and summer
  - Summer wildfire season coincides with summer O3 season in many parts of the United States
- Photochemical model source-based attribution approaches provide the most robust approach to differentiate sources of O3; also provides PM2.5 information
  - Photochemical grid models better capture the complex O3 physical and chemical factors important during the summer wildfire season than receptor/regression based modeling systems

# Wildland Fire Activity and Modeled Impacts on O3 and PM2.5

- Daily acres burned is typically easier to obtain for specific fires or fire complexes than emissions, which can be difficult to quickly obtain

- Hypothetical wildfire modeling was done intending to build stronger relationships between acres burned at a given location with downwind impacts on PM2.5 and O3

- Hypothetical fire approach chosen to relate fire size on one single day with downwind impacts; most fires burn more than one day

- Hypothetical wildfires for this project were very large and locations were selected that have potential for wildfire in the future

- Documented in a report
  - https://www.epa.gov/system/files/documents/2022-03/epa_454_r_22_002.pdf

# Hypothetical Fire Modeling Background & Scope

- CMAQ 2018 modeling platform; 12US1 domain; CB6 gas phase chemistry; 5-day simulations

- SERA emission factors, standard speciation and temporal profiles for wildfire

- Multiple fire sizes based on daily acres burned
  - 50000 and 100000 acres

- 11 locations selected: areas that historically have large wildfire and areas that could have large wildfire in the central & eastern U.S.

- 13 (5 days in length) episodes modeled for each hypothetical fire
  - Days selected from 2018 with multi-state high O3 events
  - 13 days of multi-state high O3 in 2018: June 6, 8, 18; July 2, 9, 10, 13, 14, 16, 29; August 2, 3, 4
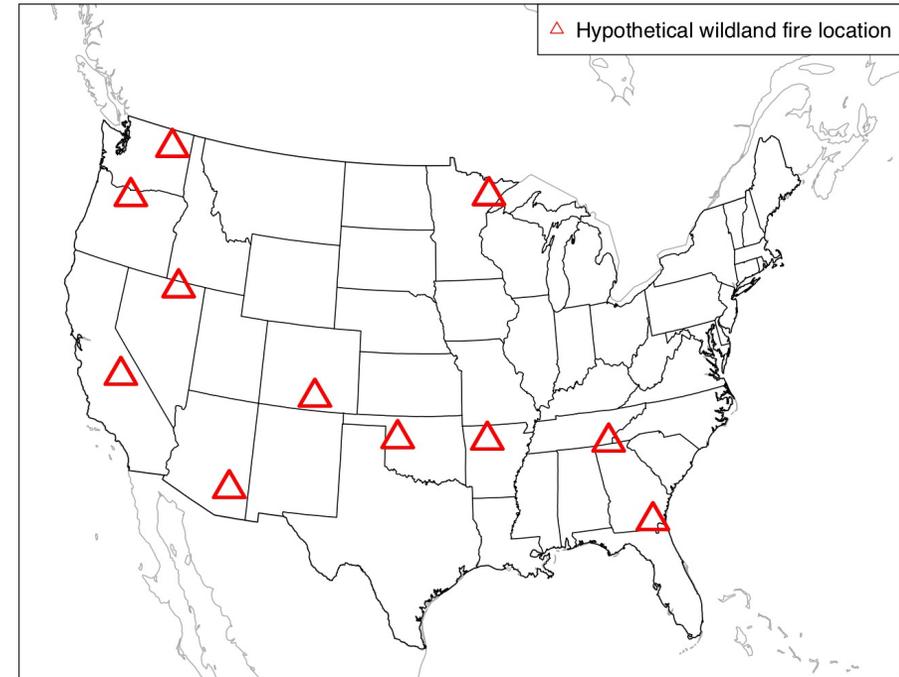
Emissions from the hypothetical fires vary from location to location due to differences in fuel type, fuel load, and fuel moisture
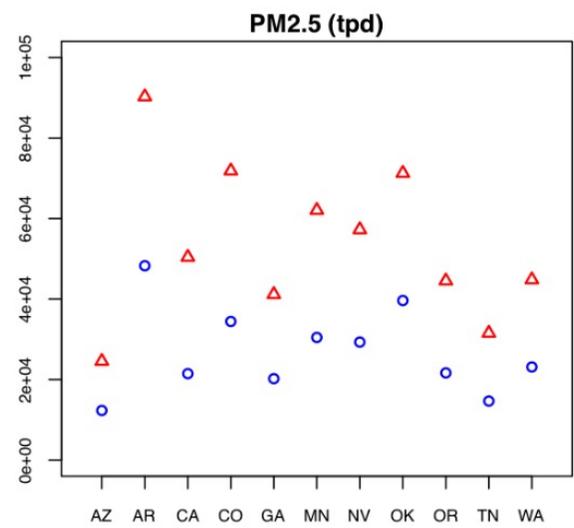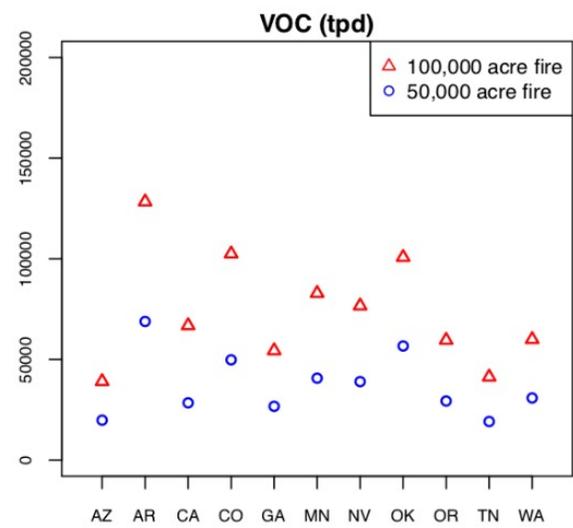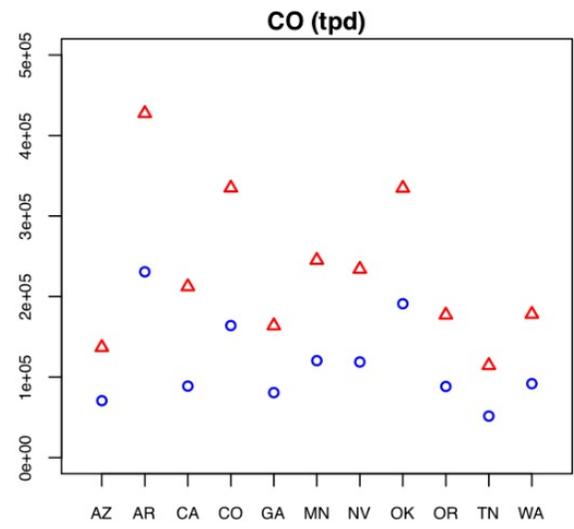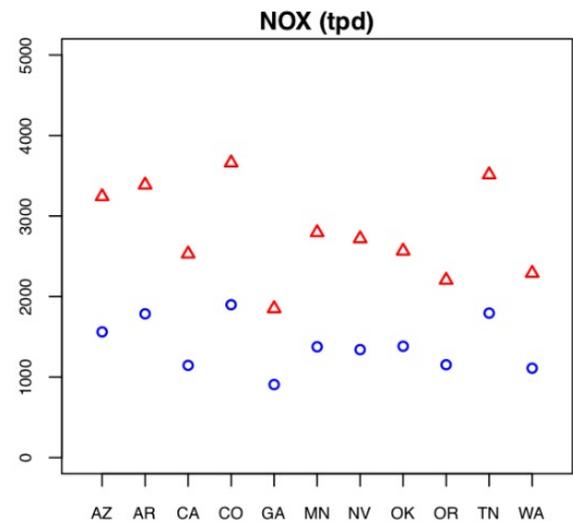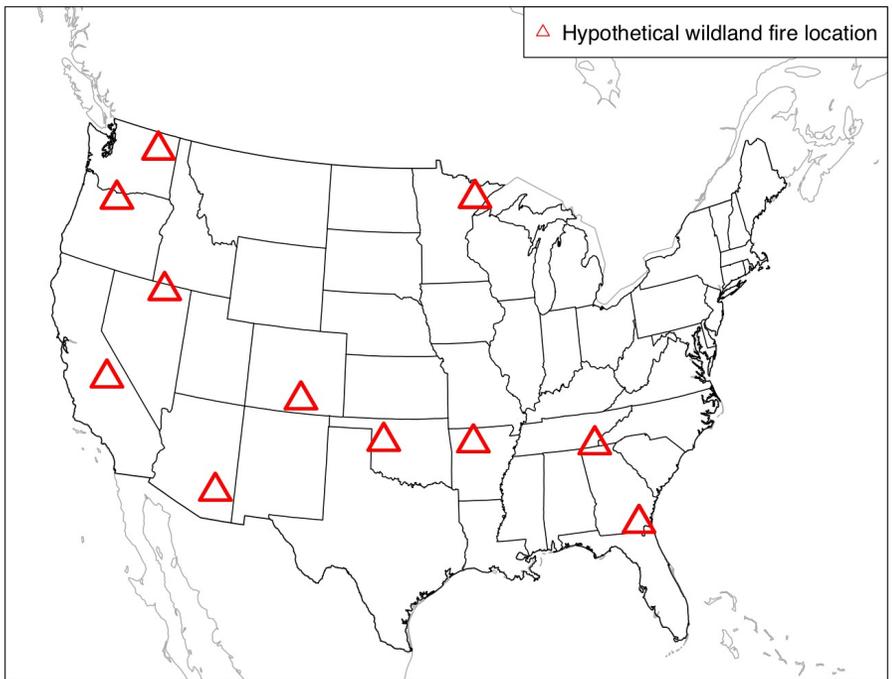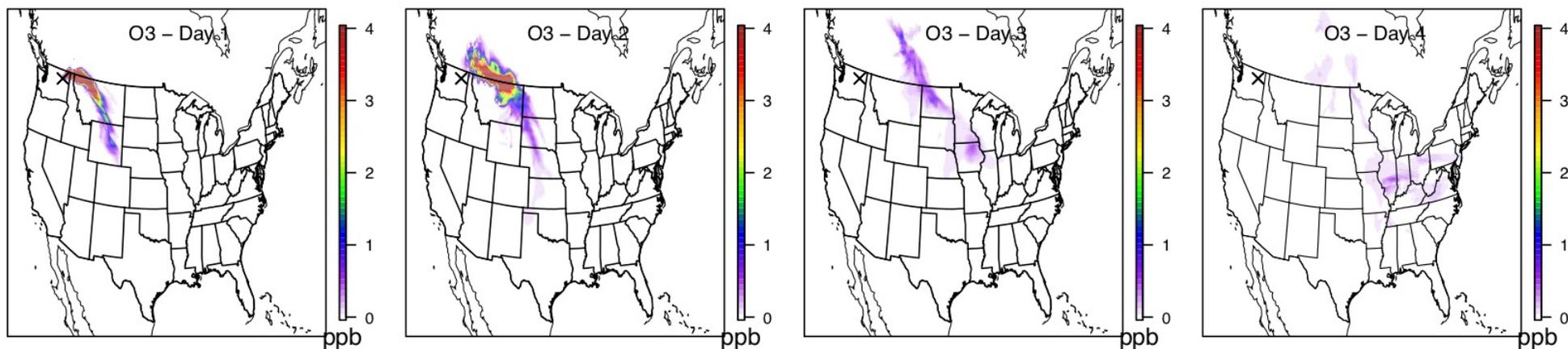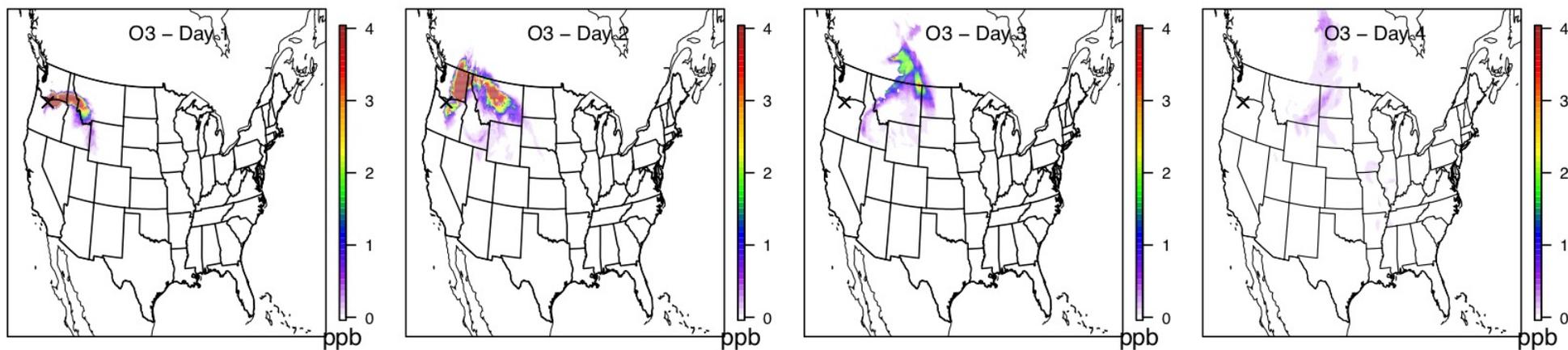
Modeled Daily PM2.5 impacts
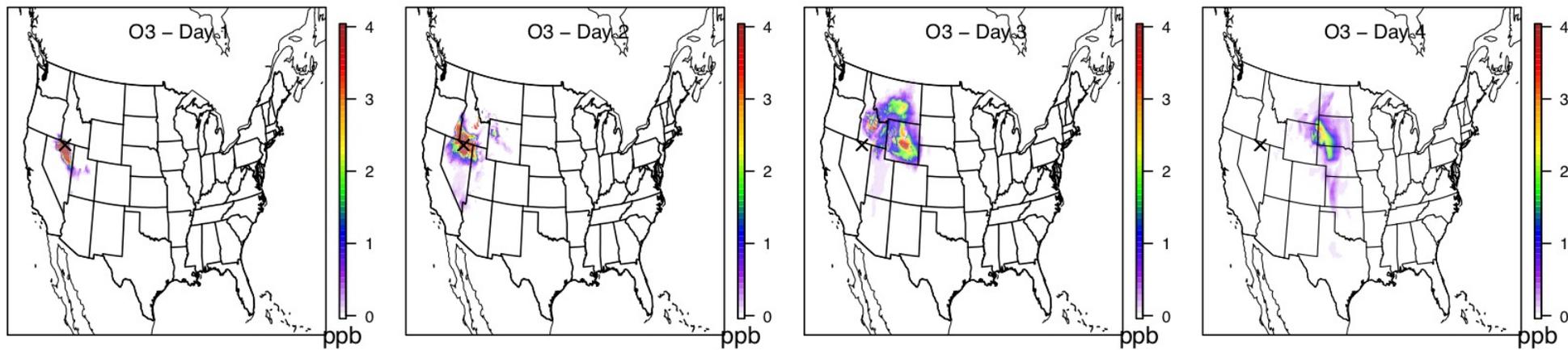
50,000 acre hypothetical fire

| First Day | Second Day | Third Day | Fourth Day |
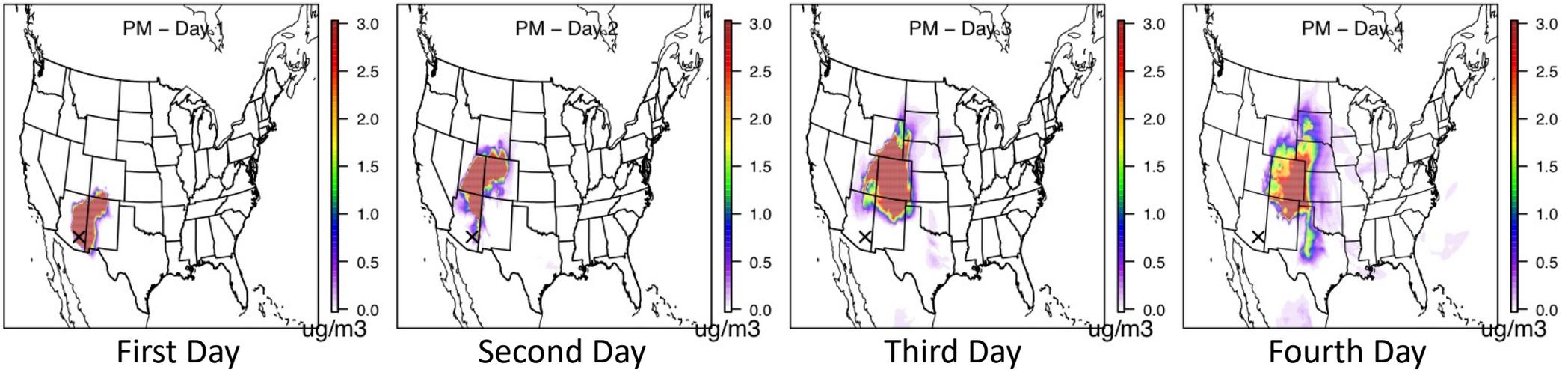
Modeled MDA8 O3 impacts

50,000 acre hypothetical fire

| First Day | Second Day | Third Day | Fourth Day |

50,000 acre hypothetical fire
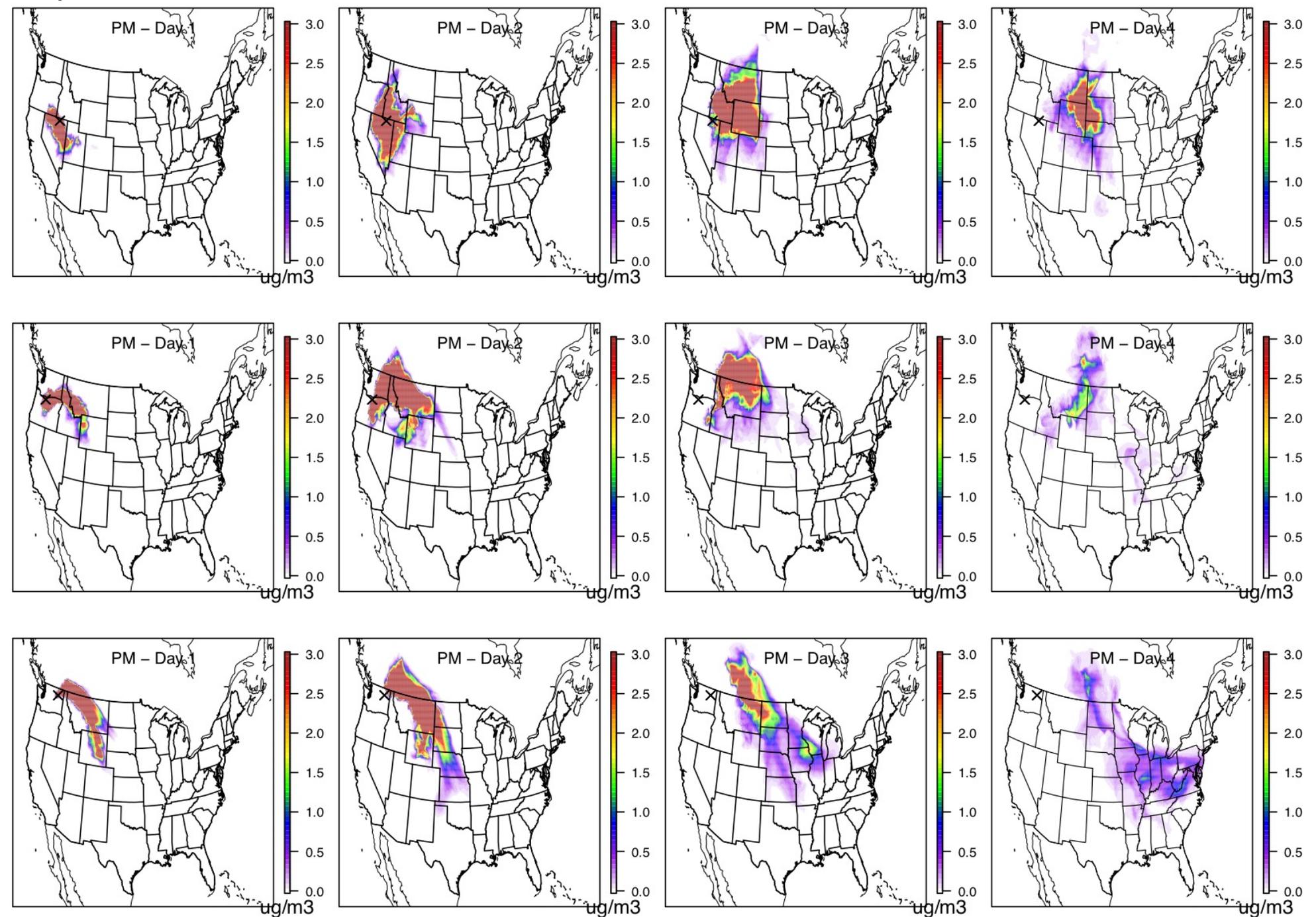
MDA8 O3

50,000 acre hypothetical fire
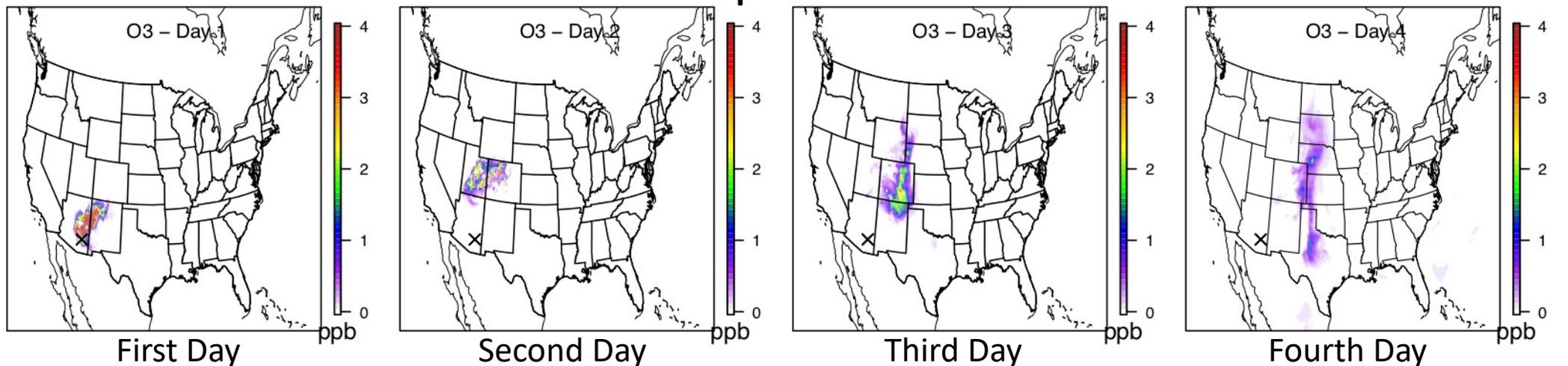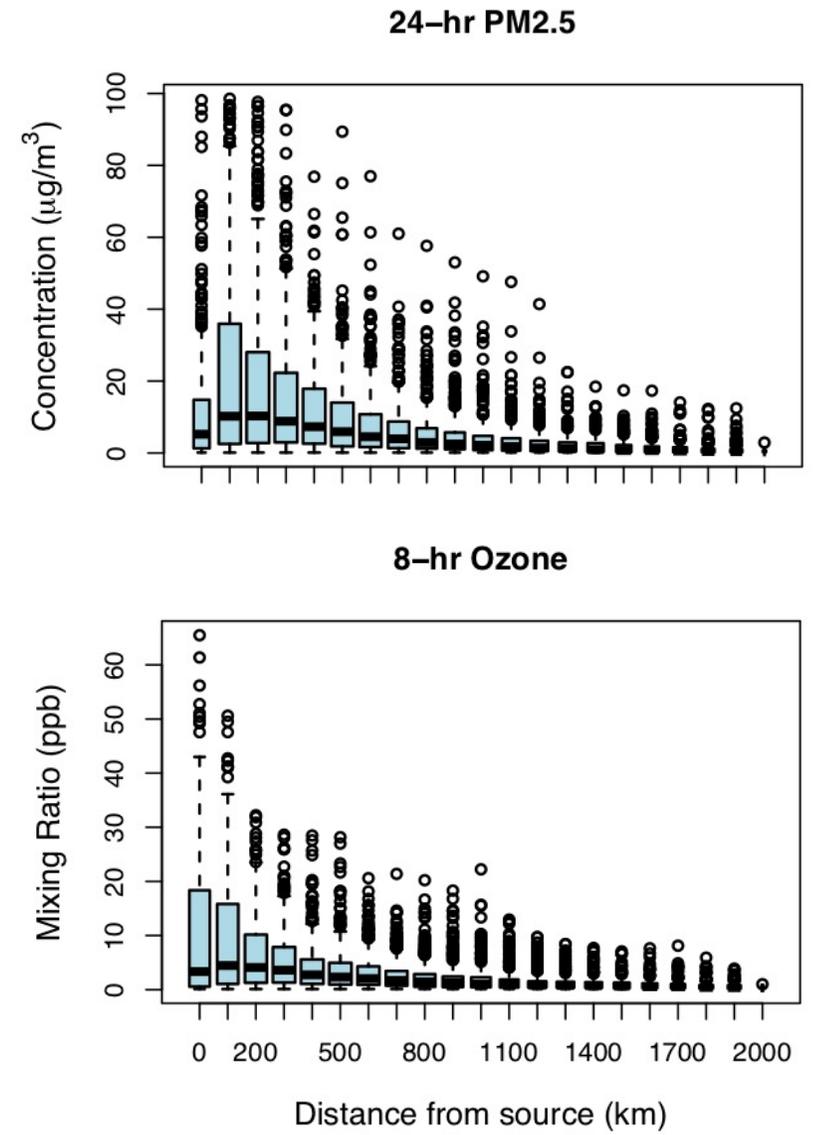
Daily PM2.5

- These distributions show downwind impacts of 50,000 acre fires from all 11 locations

- O3 and PM2.5 impacts decrease as distance from the fire increases

- Similarly, impacts decrease as days since the fire increase

- O3 impacts in particular become very small several days and hundreds to thousands of miles downwind of these large hypothetical fires
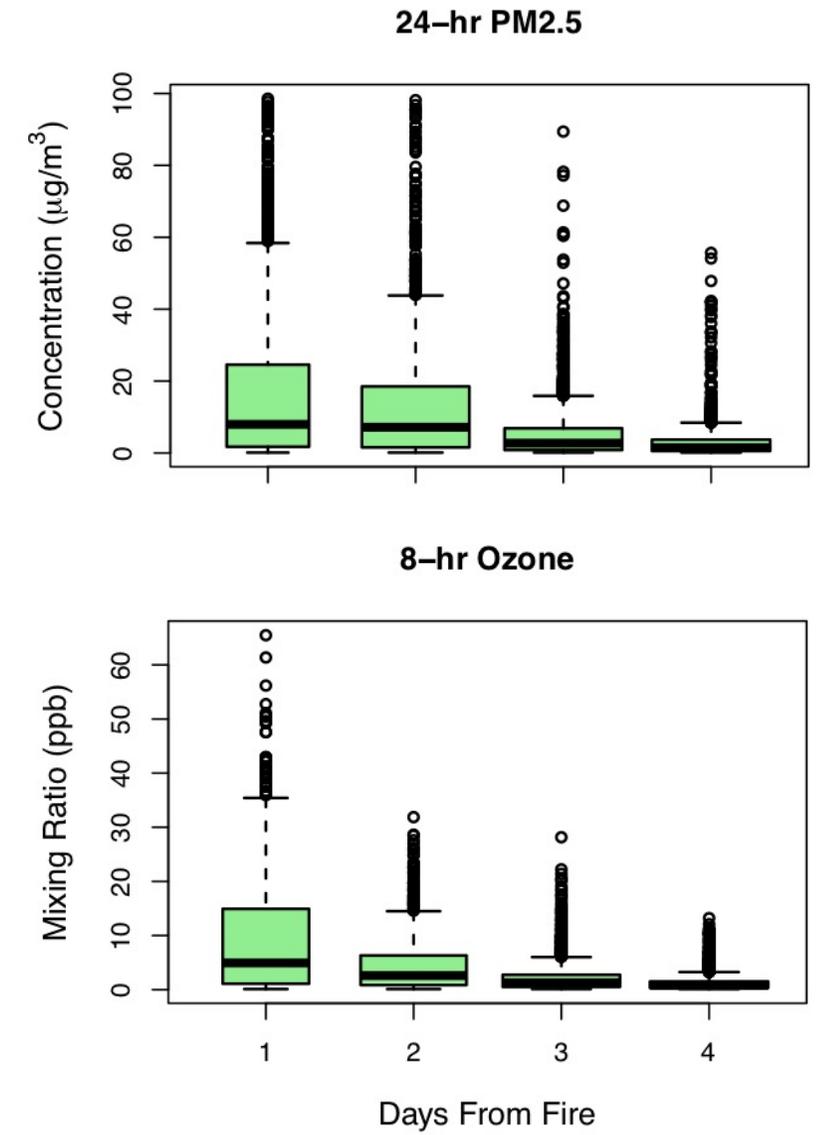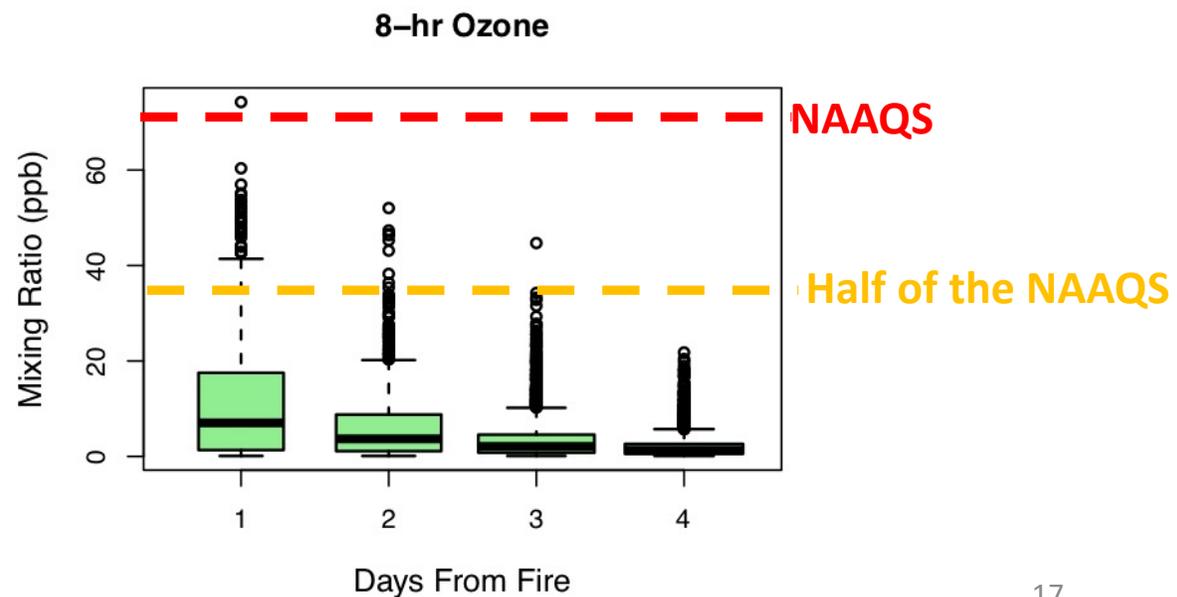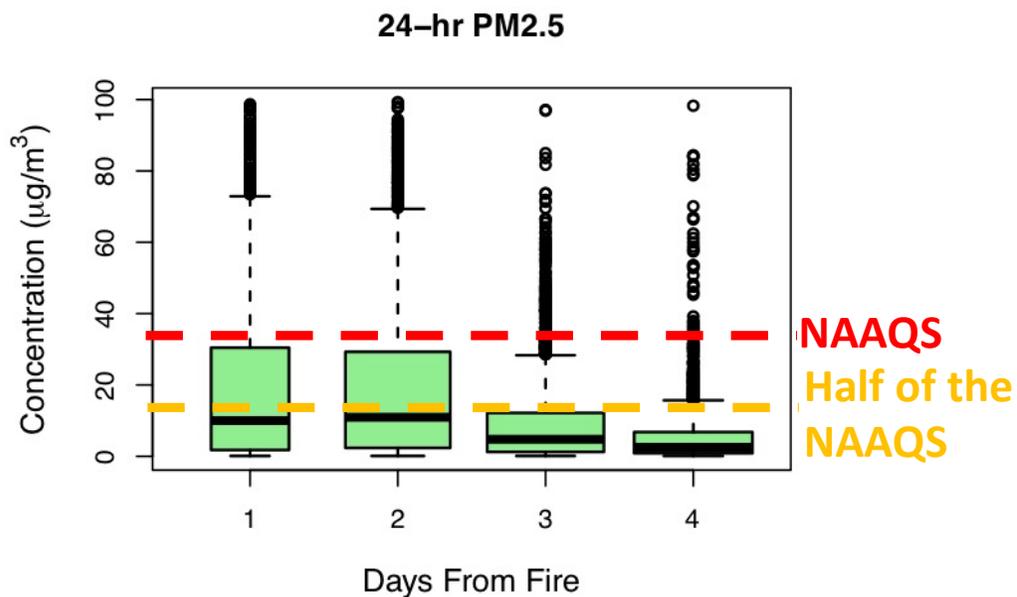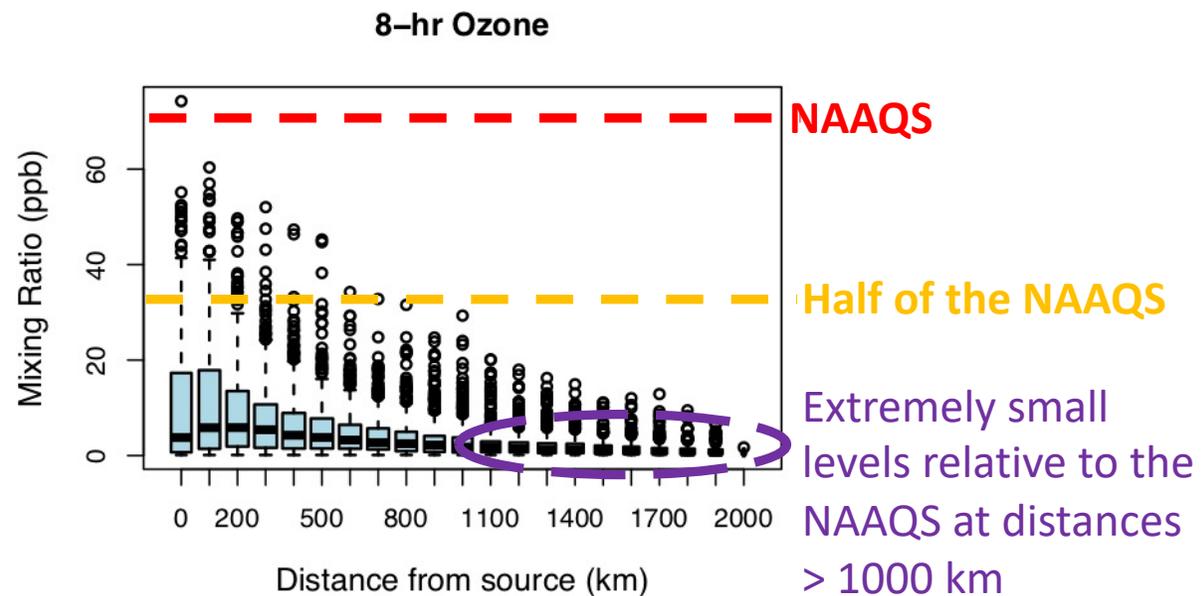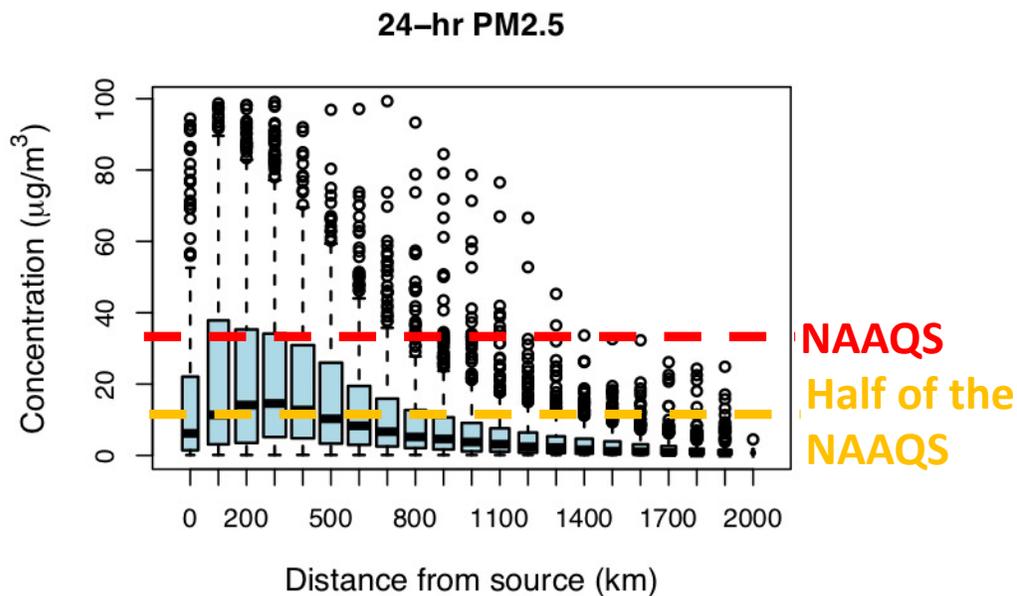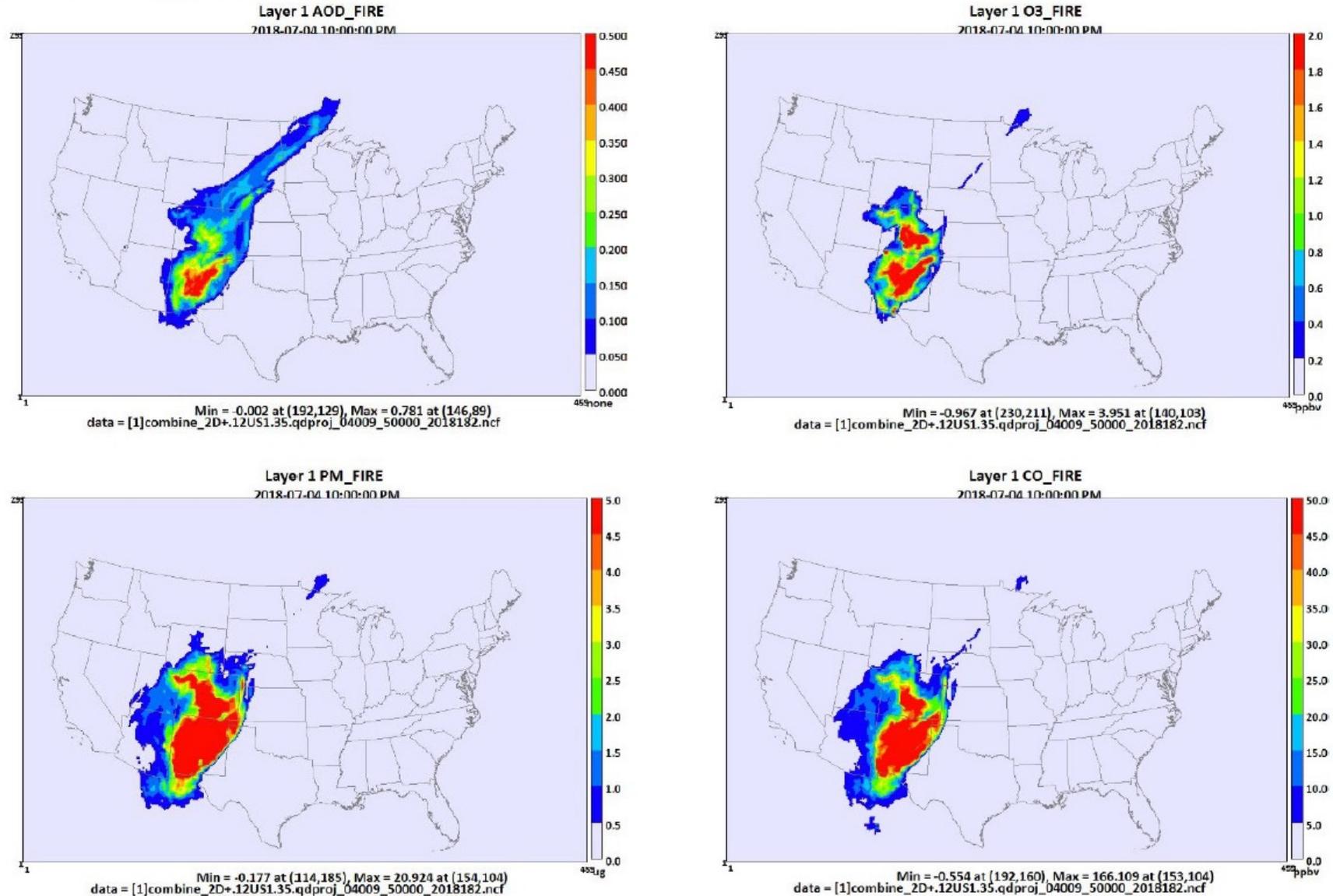
Modeled 100,000 acre fires

Figure 7. Downwind modeled impacts from a hypothetical 50,000 acre fire in southern Arizona: aerosol optical depth (top left), O_3 (top right), $PM_{2.5}$ (bottom left), and CO (bottom right). Impacts shown for 10 pm UTC July 4, 2018.

Remarks

- O3 and PM2.5 impacts from large hypothetical wildfires decrease as distance from the fire and time since emission increases
  - O3 impacts hundreds to thousands of miles downwind of even extremely large fires very small at the surface
  - This is more important for areas in the central and eastern U.S. since the largest fires are usually in the western U.S.
- Surface level O3 impacts, surface level PM2.5 impacts, and aerosol optical depth (AOD) not always coincident spatially especially several days downwind after fire
  - Better agreement between these in areas close to a fire (hundreds of miles or less) and in the first day or two since emission
- This information could potentially be used with HYSPLIT back trajectories to provide a conservative potential impact by modulating "worst-case" impacts from 50,000 or 100,000 acre fires with actual daily acres burned