# Prescribed Fire Impacts on $PM_{2.5}$ and Air Quality Benefits from Biomass Harvesting for a Biofuel Industry in the Pacific Northwest

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## Introduction

The Energy Independence and Security Act of 2007 mandated an increase in the use of biofuels. Various operations such as feedstock growth, harvesting, processing and transportation are expected to emit a wide range of air pollutants. Air pollution affects human and vegetative health and also imposes climate risks. Therefore it is important to understand the impact of biofuel supply chain emissions on air quality. The Northwest Advanced Renewables Alliance (NARA) project focuses on woody biomass from forest residue as biofuel feedstock. Since this residue is conventionally burned for removal, using it as a feedstock will reduce both the need for biomass burning and the resulting emissions. Emissions from fires contribute up to 30% of total atmospheric loading of $PM_{2.5}$ for some parts of the United States (Achteimer et. al., 2011). To investigate the potential air quality benefits of biofuels from woody biomass industry, we look at the impact of prescribed fire emissions on air quality in the Pacific Northwest. The regional air quality modeling system, called AIRPACT-4, is used for this analysis.

## Objectives

- To assess the impacts of prescribed fire emissions on the air quality in Pacific Northwest, particularly for non-attainment areas and areas with high $PM_{2.5}$ concentration
- To assess the environmental benefits associated with biomass harvesting (i.e. prevention of biomass burning) for biofuel feedstock

## Methods

- Prescribed fire emissions for the model domain were extracted from the National Fire Emission Inventory (NFEI) 2011 available from the US EPA.
- An analysis of the fire emission data shows that emissions peak during the months of October and November (Figure1).
- Model simulations were completed for the period 10 October – 15 November, 2011 for three different emission scenarios:
  - **100% Fire Case:** includes all the fire emissions as per NFEI 2011
  - **30% Fire Case:** includes all the fire sources as per NFEI 2011, but all fire emissions uniformly reduced by 30%
  - **No Fire Case:** none of the fires from NFEI 2011 were included
- The WSU Laboratory for Atmospheric Research daily air quality forecasting system AIRPACT-4 (Figure 2) is used for this study. We specifically analyze the results for Pinehurst (ID) and Springfield (OR), areas with $PM_{2.5}$ attainment issues (Figure 6).

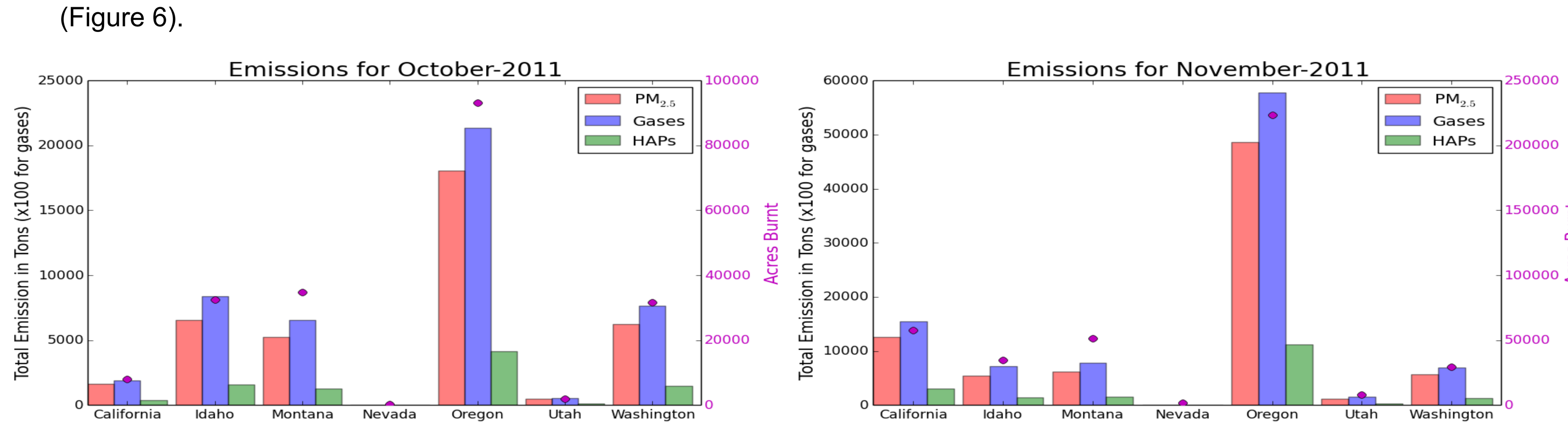


Figure 1: Prescribed Fire emissions for AIRPACT-4 domain as per NFEI 2011 (Dots refer to Acres Burned)

## AIRPACT-4 Air Quality Modeling Framework

- A WRF-SMOKE-CMAQ based modeling system: WRF - Weather Research and Forecasting model, SMOKE - Sparse Matrix Operator Kernel for Emissions, and CMAQ - Community Multi-scale Air Quality model for pollutant fate and transport.
- Boundary conditions from the MOZART-4 global chemistry model (monthly averaged)
- Biogenic emissions from the MEGAN model
- Detailed regional emissions compiled by the Department of Ecology (WA) and Divisions of Environment Quality in Idaho & Oregon
- AIRPACT website: www.lar.wsu.edu/airpact

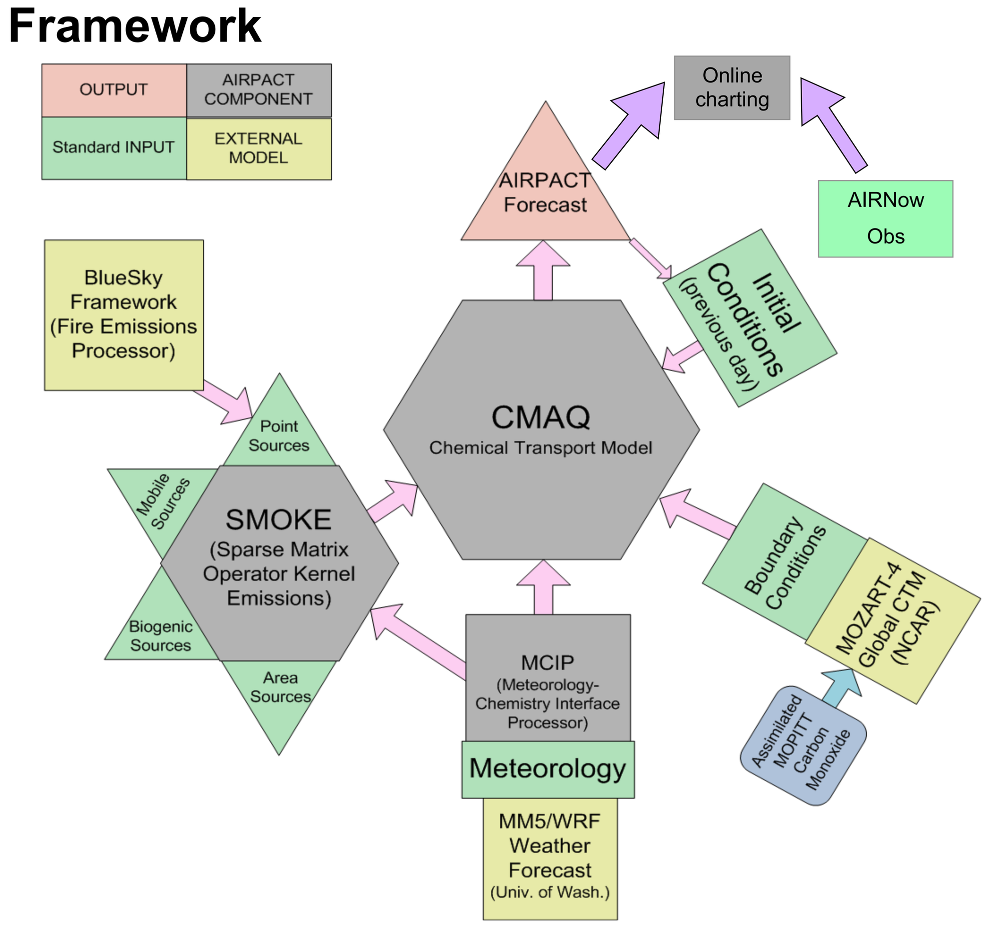


Figure 2: Various components and input and output for AIRPACT-4

## Results and Analyses

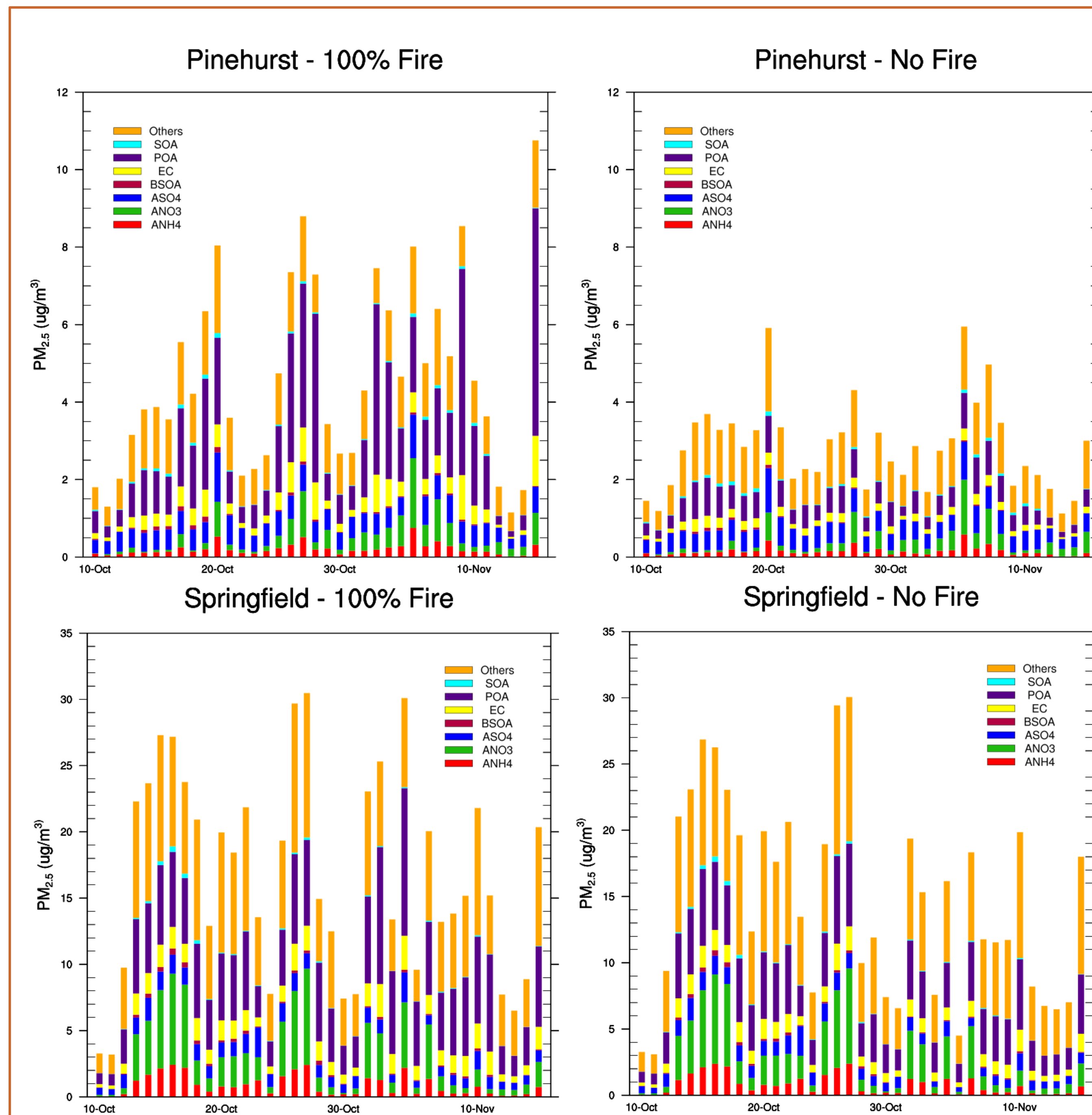


**Figure 3: speciation analysis** – we look at the various organic and inorganic species forming $PM_{2.5}$. Speciation is carried out over 24-hour averaged $PM_{2.5}$ concentration. The high contribution of primary organic aerosol (POA) and elemental carbon (EC) for all the days for Pinehurst and for selected days after 30th October for Springfield shows the influence of fire emissions. For Springfield, a large contribution also comes from nitrate aerosols which have nitric oxides and ammonia as precursors. 'Others' which is mostly unidentified aerosols, also form a large component of $PM_{2.5}$ mass for Springfield.

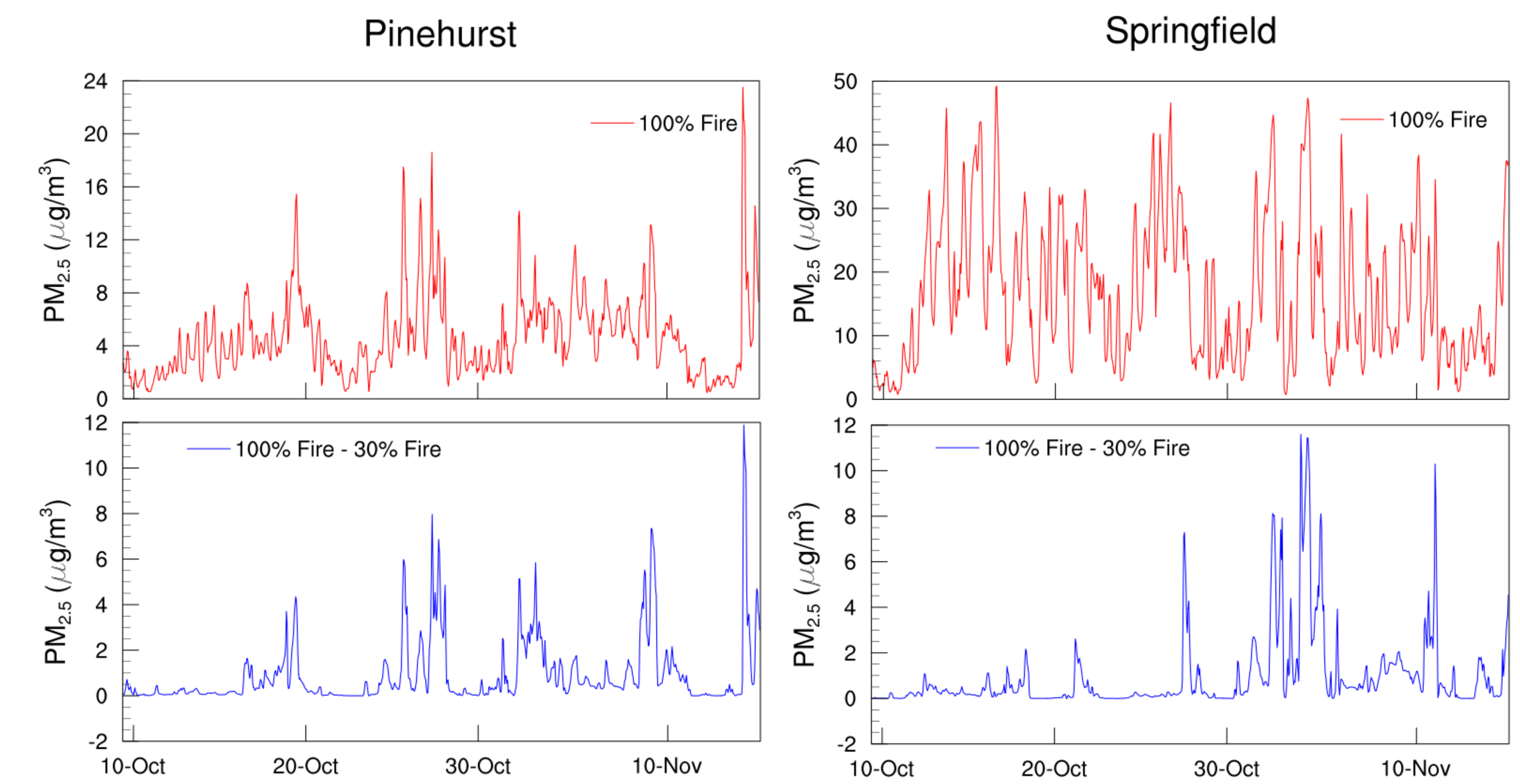


**Figure 4:** Time series of the hourly values at the two locations for 100% fire emission case. The time series of the difference of concentration from 100% and 30% emission runs is also plotted, which shows the benefits associated with fire emission reduction associated with hypothetical scenario when 70% of the biomass is used to produce biofuel instead of burning. Such an emissions reduction can results in $PM_{2.5}$ changes as large as 10-12 ug/m³

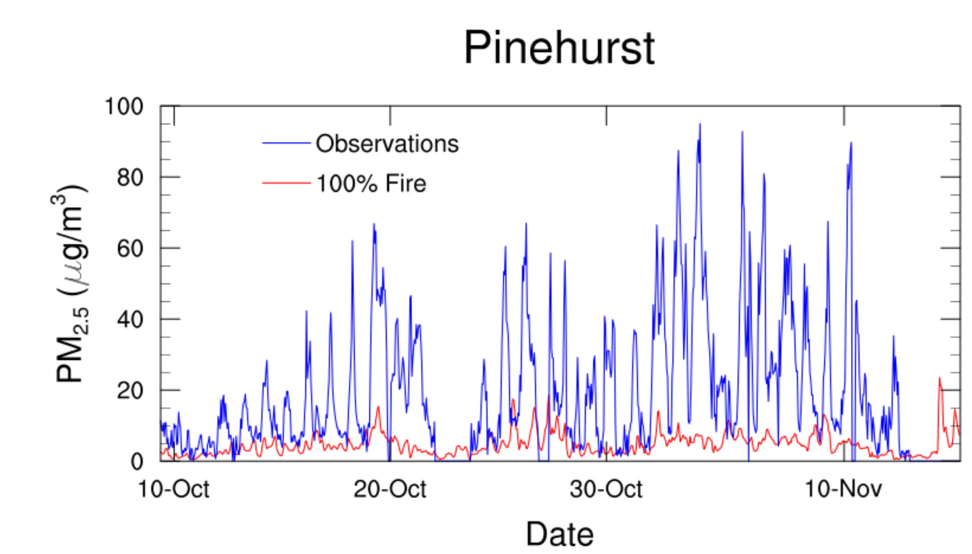


**Figure 5:** Comparison of AIRPACT-4 modeled and observed $PM_{2.5}$ concentration at Pinehurst, Idaho. Inclusion of 100% Fire case increased $PM_{2.5}$ concentrations (Figure 3), but model still under-predicts observations. Possible reasons could be point to grid cell comparison, and also wood stove emissions during wintertime.

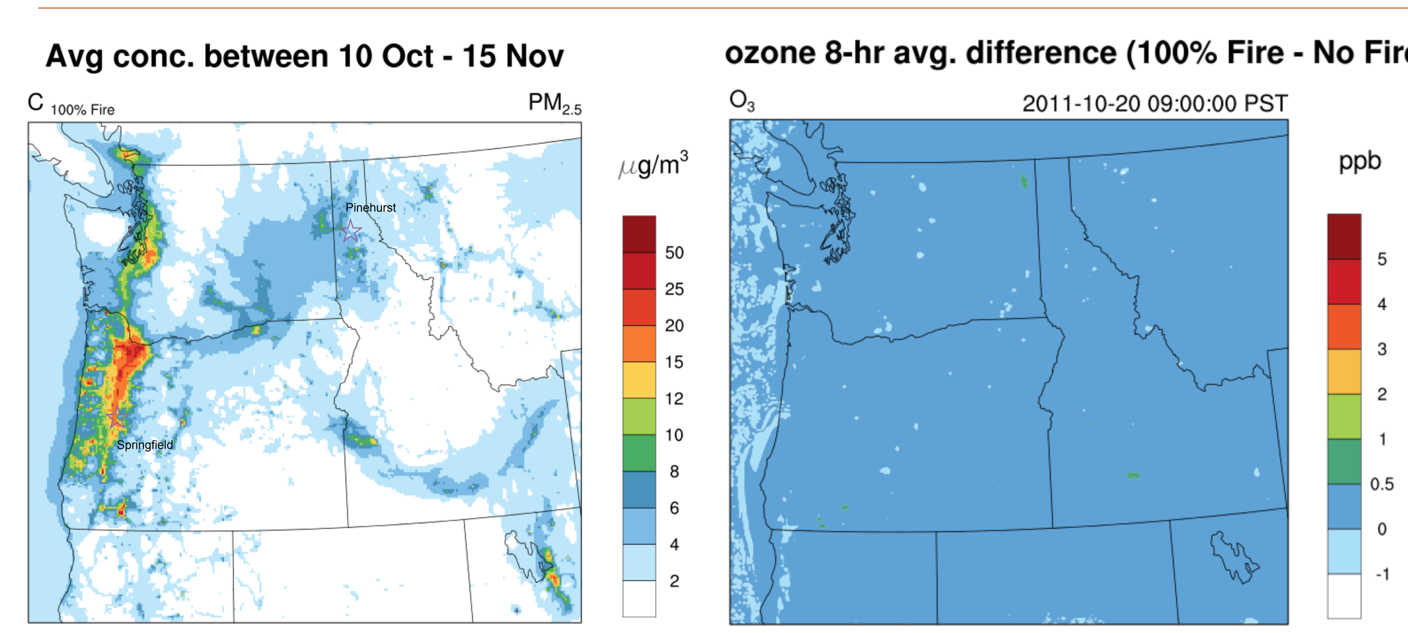


**Figure 6**
Key air quality issues in the Pacific Northwest are $PM_{2.5}$ and Ozone. Average $PM_{2.5}$ (averaged over the study period) can be much higher than 12 μg/m³ (Annual National Ambient Air Quality Standard, NAAQS). Also shown is the 8-hour average difference in ozone between 100% Fire and No-Fire case for a single day. Fire emissions don't cause an significant changes in $O_3$ concentration in this study.

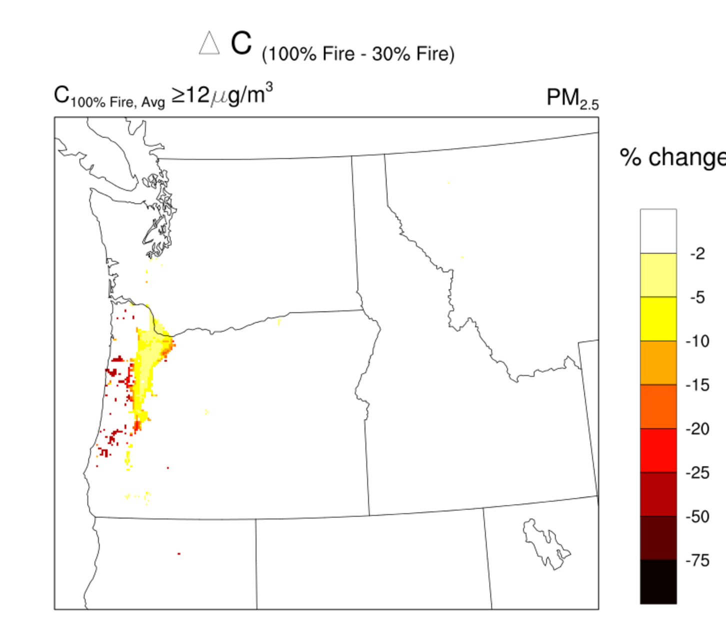


**Figure 6** shows the % change in $PM_{2.5}$ concentration when all the fire emissions are uniformly reduced by 70%. Results for only those model grid cells where $PM_{2.5}$ concentration for 100% fire case is greater than 12 μg/m³ are shown.

## Conclusions

- Most of prescribed fire emissions occur during October and November, with Oregon emitting the most among all the PNW states (within the AIRPACT-4 domain).
- AIRPACT-4 simulations show that the impact on $O_3$ is almost zero, with some large prescribed fires contributing 0.5ppb - 1ppb.
- Impacts on $PM_{2.5}$ concentrations can be significant and 24-hour average contributions can be 10-15 μg/m³ at some places having $PM_{2.5}$ attainment issues
- Under a hypothetical scenario of 70% decrease in fire emissions, we could see significant decrease in 37-day averaged $PM_{2.5}$ concentration. This decrease is mostly for areas in Oregon, near where most fire emissions take place. This is an indication of potential benefits of biomass harvesting for a biofuel industry

## Future work

- Modeling impacts of different supply chain emission scenarios as well as various process related emissions, developed through life cycle analysis and ASPEN process modeling for the woody biomass data available within the NARA project.

## References


- National Emission Inventory 2011 Database, available at US EPA's website: http://www.epa.gov/ttnchie1/net/2011inventory.html and 2011 NEI Technical Support Document (November 2013 Draft)
- Achteimer et. al., Modeling smoke plume rise and dispersion from Southern United States, Atmosphere, 2011, 2, 358-388


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NARA
Northwest Advanced Renewables Alliance

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