1. Introduction

- Air quality over western US deteriorates severely during wildfire season (June to October) when wildfires release mixture of air pollutants that is dispersed into the atmosphere and carried away to downwind areas.
- Meteorology can be also significantly affected by a large amount of air pollutants released from wildfires via aerosol-radiation and aerosol-cloud interactions.
- Wildfires are expected to intensify in future (Sprintzak et al., 2009), possibly leading to frequent and worse pollution episodes.
- 3D air quality models like WRF-Chem can help to estimate the impacts of wildfires on meteorology and atmospheric chemistry.

2. WRF-Chem configuration

Model version: WRF-Chem 3.9.1
Resolution: 12km (horizontal); 32 vertical levels
Cloud microphysics: Morrison 2-moment scheme
Boundary layer: Bougeault and Lacarrere (BouLac) PBL
Long wave radiation: RRTMG
Short wave radiation: RRTMG
Cumulus parameterization: Grell 3D Ensemble scheme
Urban surface physics: Multi-layer, BEP scheme
Gas phase chemistry: MOZART
Aerosol module: MOSAIC-4 bin
Biomass burning emissions: FINN v1
Anthropogenic emissions: NEI 2011
Biogenic emissions: MEGAN
Chemical boundary conditions: MOZART-4

- Model is run for September 2017 with 4 days ‘spin up’ time starting August 28 which is discarded for analysis. Two simulations are made.

Simulation name | Key details
--- | ---
Wildfire | Includes wildfires emissions and aerosol feedbacks
noFire | Includes aerosol feedbacks but no wildfires emissions

3. Time series at selected stations

- Model predicts the temporal patterns well in both PM2.5 and CO with r values higher than 0.65 for PM2.5 and 0.6 for CO. Model is able to capture peak PM2.5 concentrations quantitatively but shows underprediction especially at Missoula (MT), which is possibly quite close to a wildfire as seen from high PM2.5 levels (> 400 μg m⁻³). Ozone is enhanced due to wildfires with much less degree than PM2.5 but tends to show overprediction even without wildfires at some stations.

- Model captured hourly variations in temperature well (r > 0.8 & |NMB| < 15%) at most stations.
- Wind speeds perform slightly worse than temperature (i.e., |NMB| > 15% at many stations), possibly due to unsmoothed topography at a 12 km grid resolution.
- Model captured temporal patterns of PM2.5 better in the north (r > 0.4 mostly) than south (r < 0.4), esp. over coastal areas in south-west where the model did not predict winds well.
- Ozone is predicted well in term of temporal patterns (r > 0.6 at most stations) but is biased high (|NMB| >15%) at some locations along the coast of California.

4. Model evaluation: Correlation Coefficient (r) and NMB(%)

5. Sensitivity results and discussion

- Wildfires result in reducing temperature at 2 m by 0.04 °C, on average, but up to 0.5 °C in some locations which is primarily attributed to reduction in downward shortwave radiation at surface due to feedback from aerosols released from wildfires.
- Boundary layer height (PBL height) also shows qualitatively similar reduction (-0.5 m on average but up to -50 m in some locations) possibly caused by reduced vertical mixing due to cooling near the surface.
- Droplet number mixing ratio increases (by about 20%) near surface especially in areas close to wildfires due to increased availability of cloud condensation nuclei (CCN).
- Wildfires increase surface PM2.5 concentration (averaged over time and domain) by about 3.6 μg m⁻³ (~70%) with much larger changes (~200 μg m⁻³) observed in areas close to wildfires.
- Ozone mixing ratio (averaged over time and domain) is increased by 1.45 ppbv (~5%) but some locations show larger than 20 ppbv due to wildfires.

6. Summary and future work

- Surface air temperature is reduced down by 0.5 °C in some locations mainly via aerosol-radiation interaction associated with wildfires.
- Boundary layer height (PBL height) is reduced down by 50 m in some locations as cooling near the surface causes less vertical mixing.
- Droplet number mixing ratio is increased by 25% due to PM from wildfires.
- Wildfires increase surface PM2.5 concentration and ozone mixing ratio (averaged over time and domain) by about 70% and 5%, respectively, with a large increase in areas close to wildfires.
- We plan to investigate the role of feedback process with and without wildfires and also analyze the aerosol-radiation and aerosol-cloud interactions separately.