Photochemical model estimated fire impacts on O_3 and $PM_{2.5}$ evaluated with field studies and routine data sources

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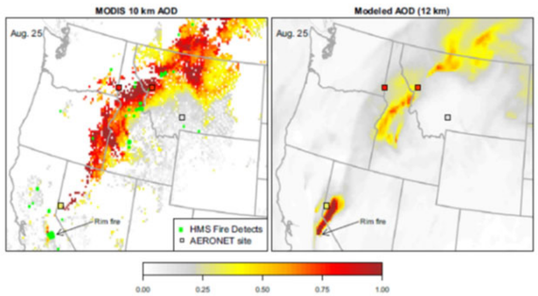
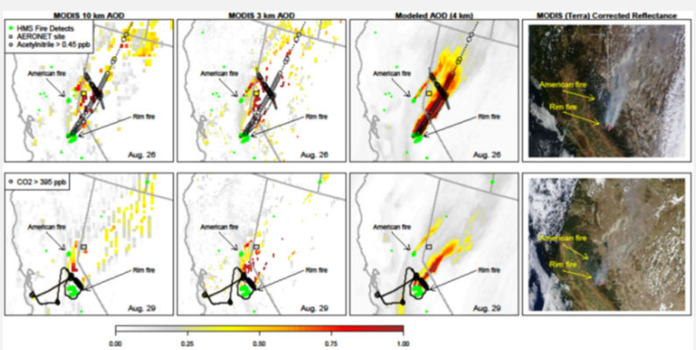
Local to Regional Scale Plume Transport

Highly instrumented field studies provide a unique opportunity to evaluate multiple aspects of photochemical grid model representation of fire emissions, dispersion, and chemical evolution. However, most local to regional scale field campaigns to date have made relatively few transects through plumes from fires with well characterized fuel type and consumption. While more comprehensive field studies are being planned for 2018 and beyond (WE-CAN and FIREX-AQ), existing measurement data from multiple field campaigns including 2013 AgBurn study, 2013 SEAC4RS, satellite data, and routine surface networks were used to assess how a regulatory modeling system captures fire impacts on local to regional scale plume transport and chemical representation of O_3 and PM2.5. The Community Multiscale Air Quality (CMAQ) model does well at capturing local (Zhou et al., 2018) to regional (Baker et al., 2018) scale plume height and transport when provided realistic inputs about fire size and meteorology.

A comparison model estimated speciated PM2.5 from specific fires with routine PM2.5 organic carbon surface measurements at rural locations in proximity to the 2013 Rim fire, 2011 Wallow fire, and 2011 Flint Hills fires show overprediction downwind from the 2011 Flint Hills prescribed fires while results were mixed at sites downwind of the 2013 Rim fire and 2011 Wallow fire (Baker et al., 2016; Baker et al., 2018). These results suggest differences in fuel characterization (e.g., emission factors, emissions speciation, burn period, etc.) between these areas may contribute to differences in PM2.5 model prediction.

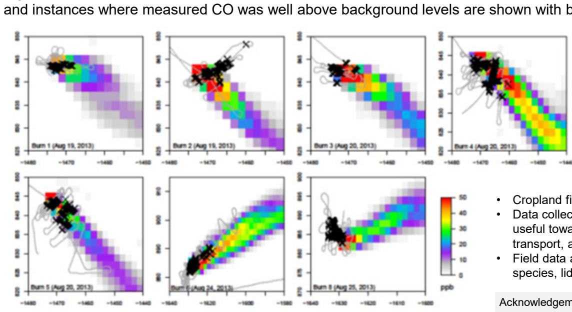
Figure at right: MODIS aerosol optical depth at 10 km resolution on August 25, 2013 at 18 UTC. CMAQ 12 km modeled AOD and visible smoke are also shown





MODIS aerosol optical depth at 3 and 10 km resolution on August 26 (top row) and August 29 (bottom row), 2013 at 21 UTC. Modeled AOD at 4 km resolution. Warmer colors indicate the presence of aerosols, most notably for the Rim and American wildfires in east-central California. The largest aerosol concentrations in the downwind plume from the Rim fire are not part of the satellite AOD product due to the MODIS cloud filtering algorithm but are captured in the corrected reflectance true color images. Larger open symbols show aircraft transects in wildfire plume based on chemical measurements and small dots indicate aircraft positions outside wildfire plumes.

Fig. below left. Modeled CO levels are shown for each of the burns at Nez Perce and Walla Walla. The aircraft flight path is shown with the gray trace and instances where measured CO was well above background levels are shown with black crosses to illustrate the densest area of the smoke plume.



- Cropland fires in the Pacific Northwest are a concern for local to regional scale air quality
- Data collected as part of the 2013 Region 10 RARE (AgBurn) Washington/Idaho field study useful toward 1) evaluating cropland emissions modeling approach, 2) near-fire plume transport, and 3) plume rise and vertical emissions distribution
- Field data allows us to know the fuel type, amount consumed, emission factors for some species, lidar estimated plume top

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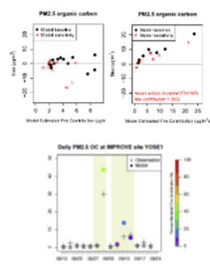
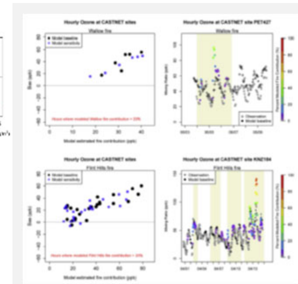
Surface Level Chemical Contribution

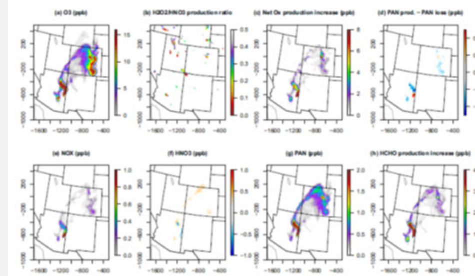
The contribution of two specific fires from 2011 (Wallow and Flint Hills) and 2013 (Rim) are tracked for local to regional scale contribution to ozone (O_3) using CMAQ. The modeling system tends to overestimate hourly surface O_3 at routine rural monitors near these fires when the model predicts elevated fire impacts on O_3 and Hazard Mapping System (HMS) data indicates possible fire impact. A sensitivity simulation in which solar radiation and photolysis rates were more aggressively attenuated by aerosol in the plume reduced model O_3 but does not eliminate this bias.



Modeled Wallow (top left), Flint Hills (top right), and Rim fire (bottom) contribution paired with bulk model speciated PM2.5 OC bias.



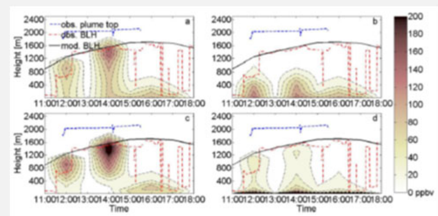
Hourly modeled fire contribution paired with bulk model O_3 bias at rural CASTNET monitors. The shaded areas of the time series plots indicate days with possible fire impacts based on HMS data.



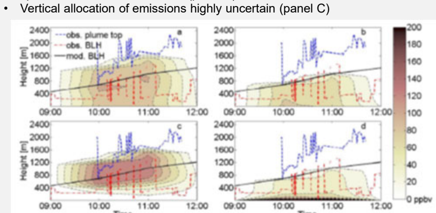
Right Figure. Modeled Wallow fire contribution for June 5, 2011 at 19:00 UTC (2 pm local): O_3, bulk model H_2O_2/HNO_3 production ratio, O_x production, PAN production – PAN loss, NO_X, HNO_3, PAN, formaldehyde production.

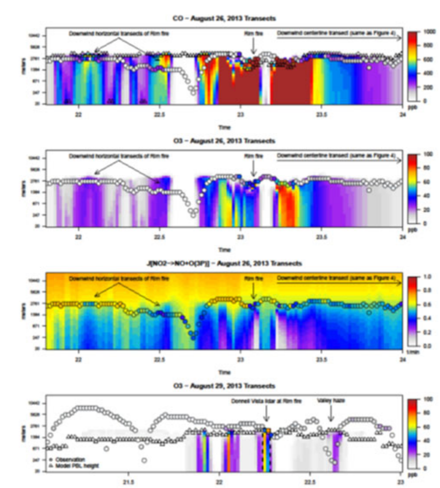
Vertical Plume Transport

Color contours of simulated CO from prescribed fire emissions with ceilometer detected boundary layer height, modeled (WRF) boundary layer height, and lidar estimated plume top at Nez Perce (top) and Walla Walla (bottom).



- WRF model (solid black line) does well at predicting the surface mixing layer height compared to ceilometer (dashed red line)
- Default approach surface level releases unrealistic (panel d)
- Using wildfire plume rise right better than the default approach (panel b)
- Using wildfire plume rise, model can replicate plume top when using field study specific data such as field size (panel a)
- Vertical allocation of emissions highly uncertain (panel C)





Aircraft measurements (circles) compared with column model predictions of photolysis rates, CO and O_3 on August 26, 2013. Both model and measurements of CO and O_3 have been adjusted to remove background and reflect only wildfire contribution. Modeled surface layer mixing height is also shown (triangles).

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