Effects of fire diurnal variation and plume rise on U.S. air quality during FIREX-AQ based on the Multi-Scale Infrastructure for Chemistry and Aerosols (MUSICA-V0)

Wenfu Tang[1], Louisa Emmons[1], Rebecca Buchholz[1], Christine Wiedinmyer[2], Becky Schwantes[2,3], Cenlin He[4], Rajesh Kumar[4], Helen Worden[1], Simone Tilmes[1], Benjamin Gaubert[1], Gabriele Pfister[1], and Forrest Lacey[1]

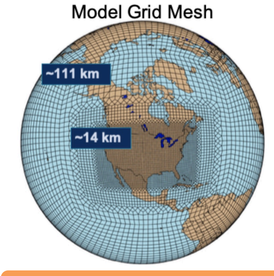
[1]Atmospheric Chemistry Observations and Modeling, National Center for Atmospheric Research (NCAR), Boulder, CO, USA; [2]Cooperative Institute for Research in Environmental Sciences, University of Colorado Boulder, Boulder, CO, USA; [3]NOAA Chemical Sciences Laboratory, Boulder, CO, USA; [4]Research Applications Laboratory, NCAR, Boulder, CO, USA

Email: wenfut@ucar.edu

Background

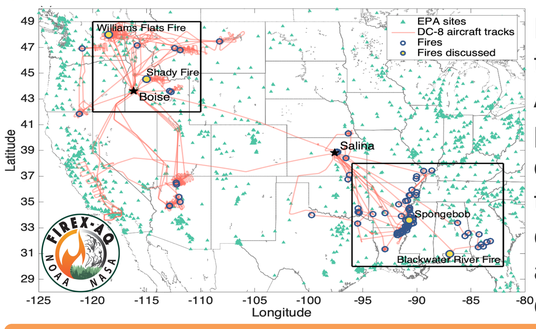
The Multi-Scale Infrastructure for Chemistry and Aerosols (**MUSICA**) is a state-of-the-art community modeling infrastructure that enables the study of atmospheric composition and chemistry across all relevant scales. Air quality modeling and forecasting is an important application of MUSICA. Given the significant impacts of fire emissions on air quality, it is necessary to improve the representation of fire behaviors and emissions. **Fire plume injection and the diurnal cycle of fire emissions are two important features. They are both important because they impact the transport, lifetime, and chemistry of fire-emitted trace gases and aerosols.**

MUSICA-V0



MUSICA-V0 is a regionally refined version of the Community Earth System Model Version 2 (CESM2) Community Atmosphere Model with comprehensive chemistry (CAM-chem). This model allows global simulations with regional refinement over the U.S. (resolution of ~14 km).

FIREX-AQ

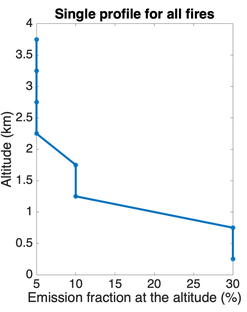


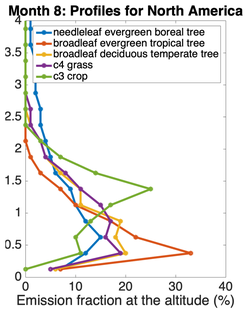
Fire Influence on Regional to Global Environments and Air Quality (FIREX-AQ) provides comprehensive observations to investigate the impact on air quality and climate from wildfires and agricultural fires across the continental United States.

Methods to add plume rise

1. Climatology: single profile

2. Climatology: month-, region-, vegetation-dependent



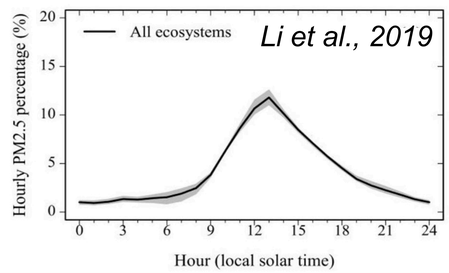


3. Parameterization: Freitas
(1) using a simple one-dimensional time dependent entrainment plume model
(2) We used calculated plume profile from WRF-Chem directly

4. Parameterization: Sofiev
(1) Considers the conservation of the heat energy
(2) Used satellite FRP and MERRA-2

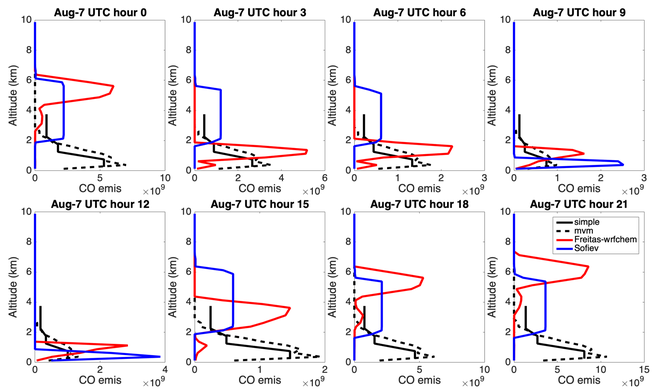
Methods to add diurnal cycle

Applying a typical diurnal cycle to all fires:



Resulting emissions

Emissions on Aug 7, 2019 over the Williams Flats



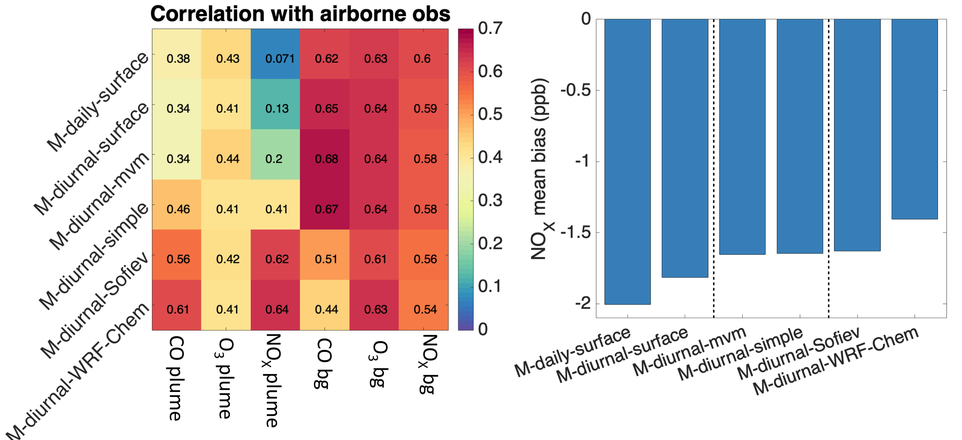
MUSICA-V0 Simulations

	Case	Diurnal cycle	Plume rise
1	M-daily-surface	N	N
2	M-diurnal-surface	Y	N
3	M-diurnal-simple	Y	1
4	M-diurnal-mvm	Y	2
5	M-diurnal-WRF-Chem	Y	3
6	M-diurnal-Sofiev	Y	4

Ongoing & next step

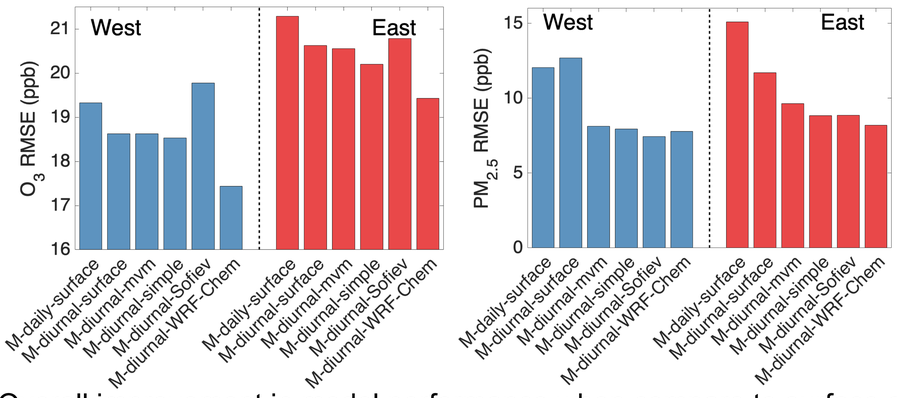
1. More detailed and thorough evaluation and understanding of the impacts of including Diurnal cycle and Plume rise in the model.
2. Case study over Williams Flats fires.
3. Compare model results to **WE-CAN**.

Compare to DC-8 aircraft measurements



1. Improvements in CO and NO_X but not O_3.
2. Improvements in correlations but not in mean bias.
3. Improvements in model agreement with plume but not background.
4. Parameterizations seem to be better than climatology.
5. Plume rise improves model over the Northwest for wildfires, but not over the Southeast for agriculture fires.
6. Diurnal cycle itself seems to improve model agreement over the East but not over the West.

Compare to EPA AQS data



Overall improvement in model performance when compare to surface obs over both west and east.
Largely reduced RMSE for PM2.5, and slightly reduced RMSE for O3.

Reference

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Sofiev et al., ACP, 1995-2006, 2012.
Sofiev et al., ACP, 7039-7052, 2013.
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Li et al., *AE*, *211*, 274-287, 2019.