MUSICA
Multiscale Infrastructure for Chemistry and Aerosols

Improving fire representation in MUSICA-V0

THE 26th CESM ANNUAL WORKSHOP
JOINT CHEMISTRY AND WHOLE ATMOSPHERE WORKING GROUP MEETING

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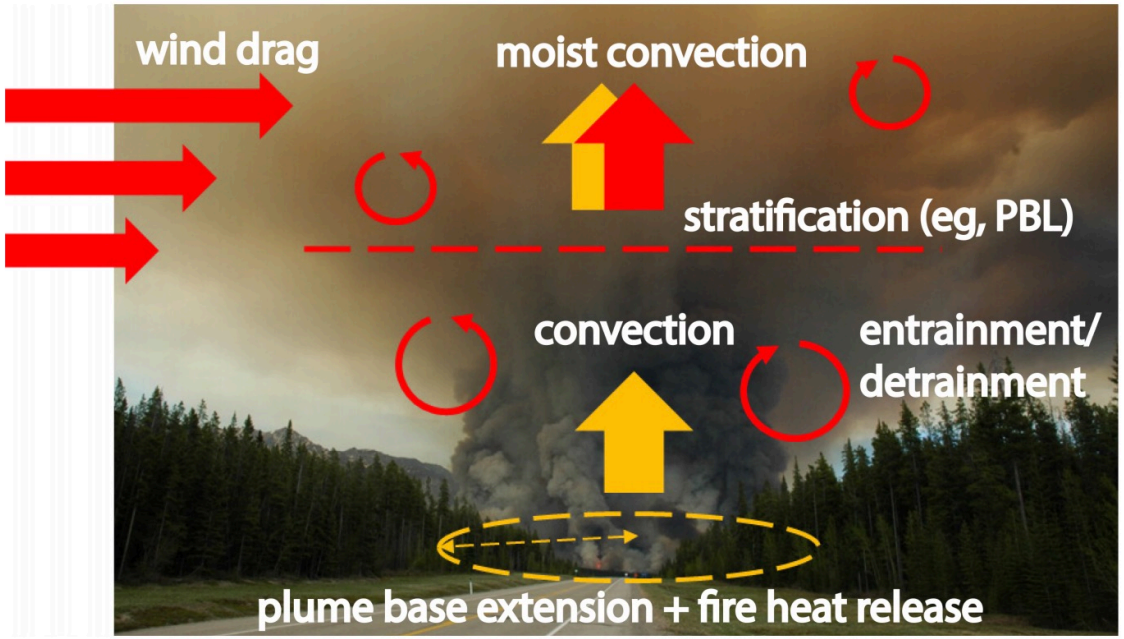
Background

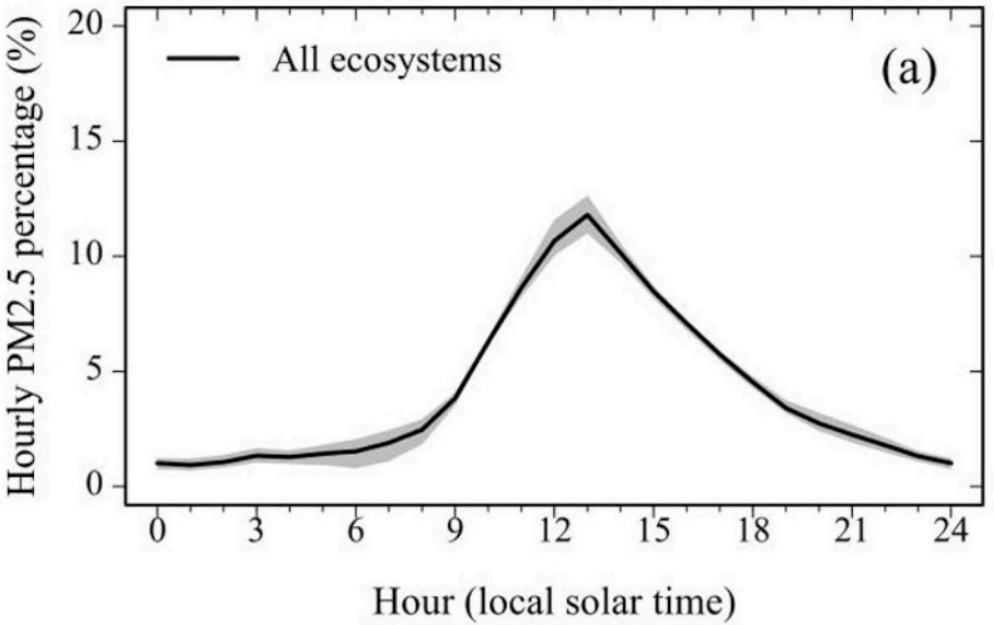
- **Plume rise/injection** and **diurnal cycle of fire** are important as they impact fire emission transport, lifetime, chemistry, and impacts.

Plume rise



Paugam et al., 2016

Typical diurnal cycle:



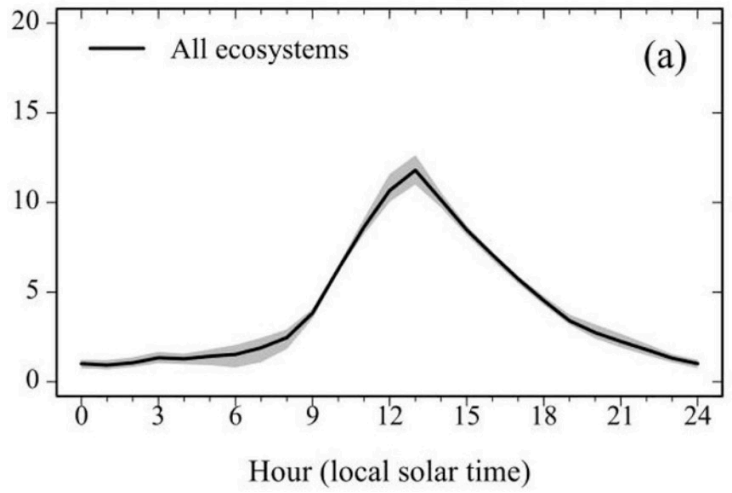
Li et al., 2019

Diurnal cycle of fire emissions

We apply two methods of adding diurnal cycles to the FINNv2.2 fire emissions. The two methods have different levels of complexity but are based on the same assumption – the diurnal cycle of fire emissions can be represented by the diurnal cycle of FRP, since FRP is proportional to biomass consumption (Wooster et al., 2005; Kaiser et al., 2012).

Method 1:

Typical diurnal cycle:



Li et al., 2019

Simple, straightforward, can easily apply to any fire emission inventories.

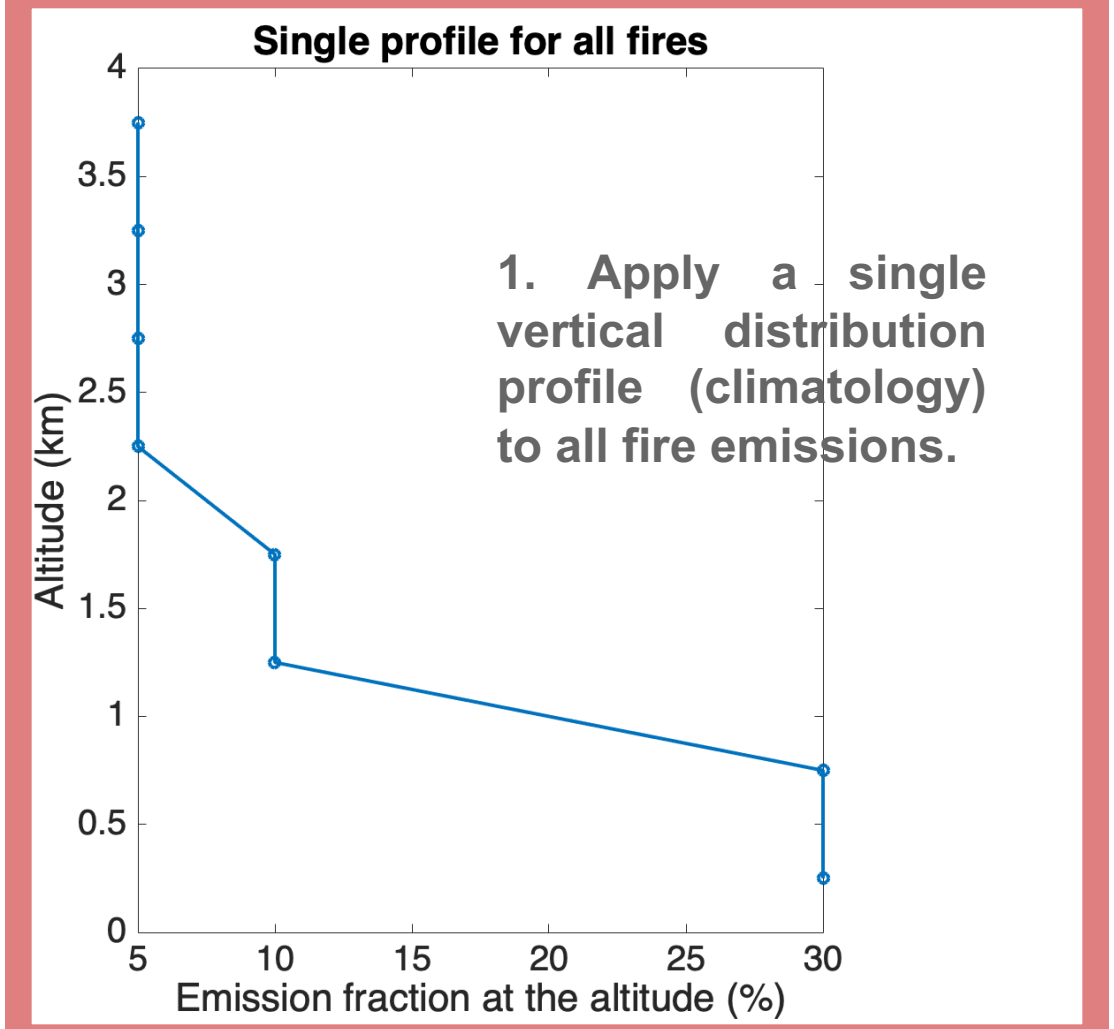
Method 2:

GOES-16 FRP diurnal cycle:
FRP diurnal cycles observed by the GOES-16 (Geostationary Operational Environmental Satellite) are applied to FINN2.2 daily emissions.

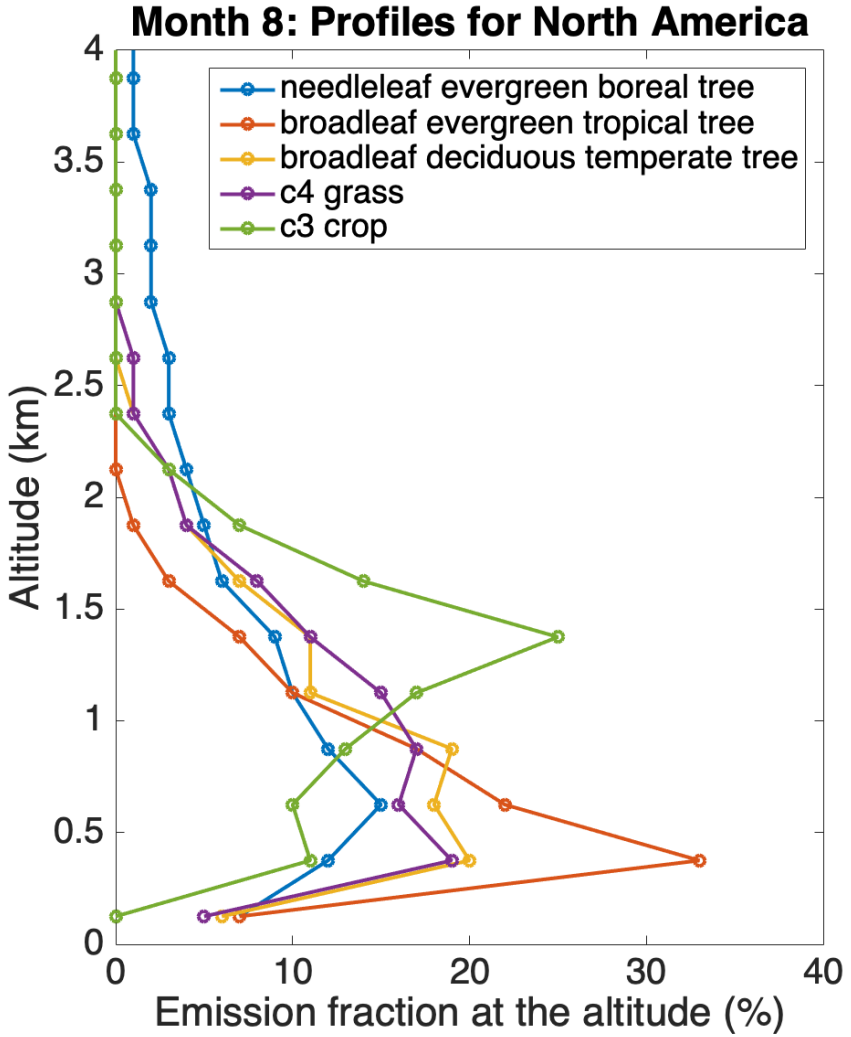
More realistic, but also more complicated

Plume rise/injection

We tested two methods of adding climatology plume injection to the FINNv2.2 fire emissions.



1. Apply a single vertical distribution profile (climatology) to all fire emissions.



MUSICA-V0 simulations

	Case	Model grid	Fire emission inventory		
1	M-control-daily	MUSICA (ne0CONUSne30x8)	FINN2.2	Daily emissions	w/o diurnal cycle or plume rise
2	M-char-diurnal	MUSICA (ne0CONUSne30x8)	FINN2.2	Typical diurnal cycle applied to global fires	w/ diurnal cycle
3	M-GOES-diurnal	MUSICA (ne0CONUSne30x8)	FINN2.2	GOES FRP diurnal cycle applied to CONUS	
4	M-plumerise1-daily	MUSICA (ne0CONUSne30x8)	FINN2.2	Single plume profile applied	w/ plume rise
5	M-plumerise2-daily	MUSICA (ne0CONUSne30x8)	FINN2.2	vegetation-, region-, and month-dependent plume profiles applied	
6	M-plumerise1-char-diurnal	MUSICA (ne0CONUSne30x8)	FINN2.2	Typical diurnal cycle and Single plume profile applied	w/ diurnal cycle & plume rise
…	…	MUSICA (ne0CONUSne30x8)	FINN2.2	Other combinations and approaches	

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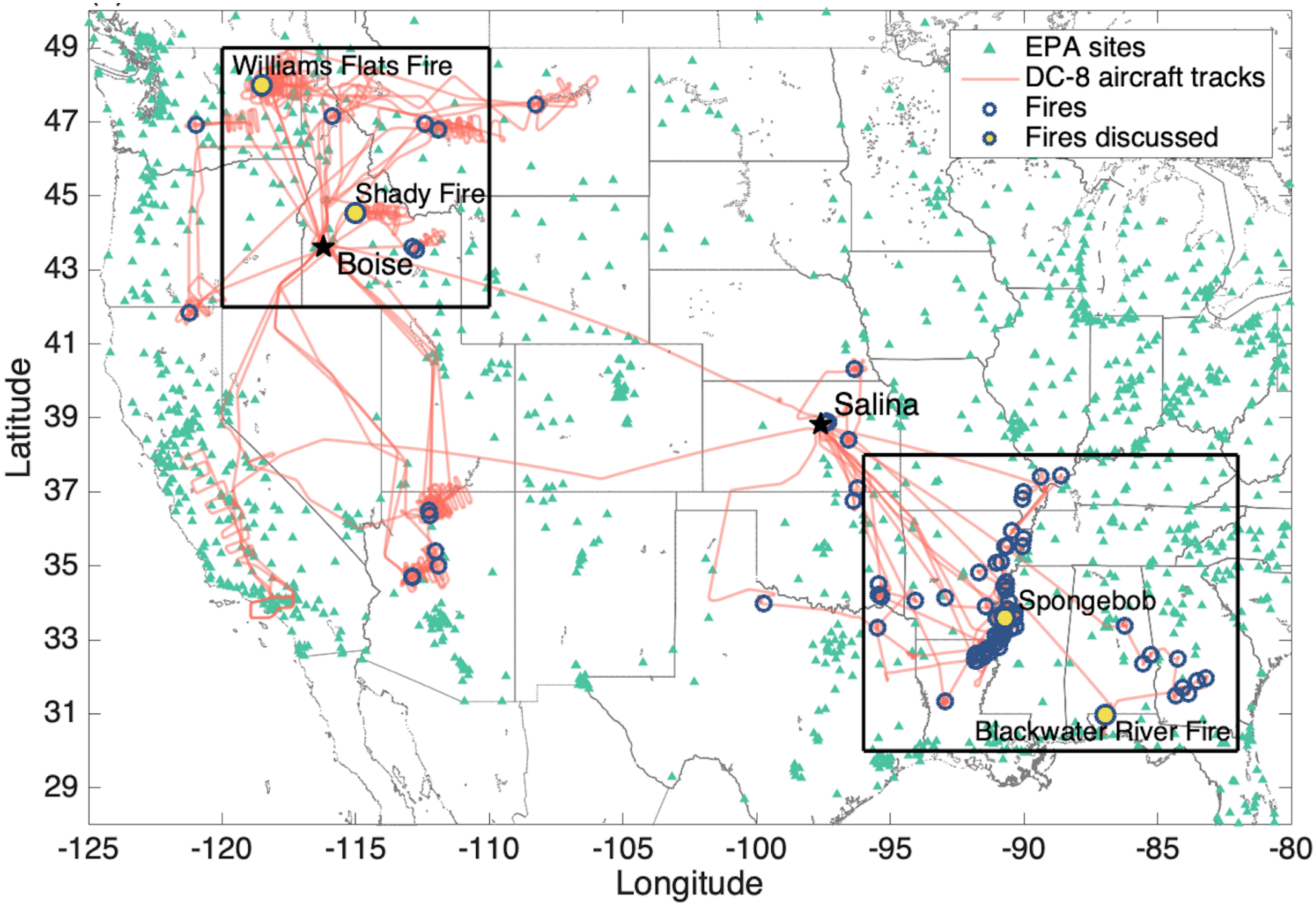
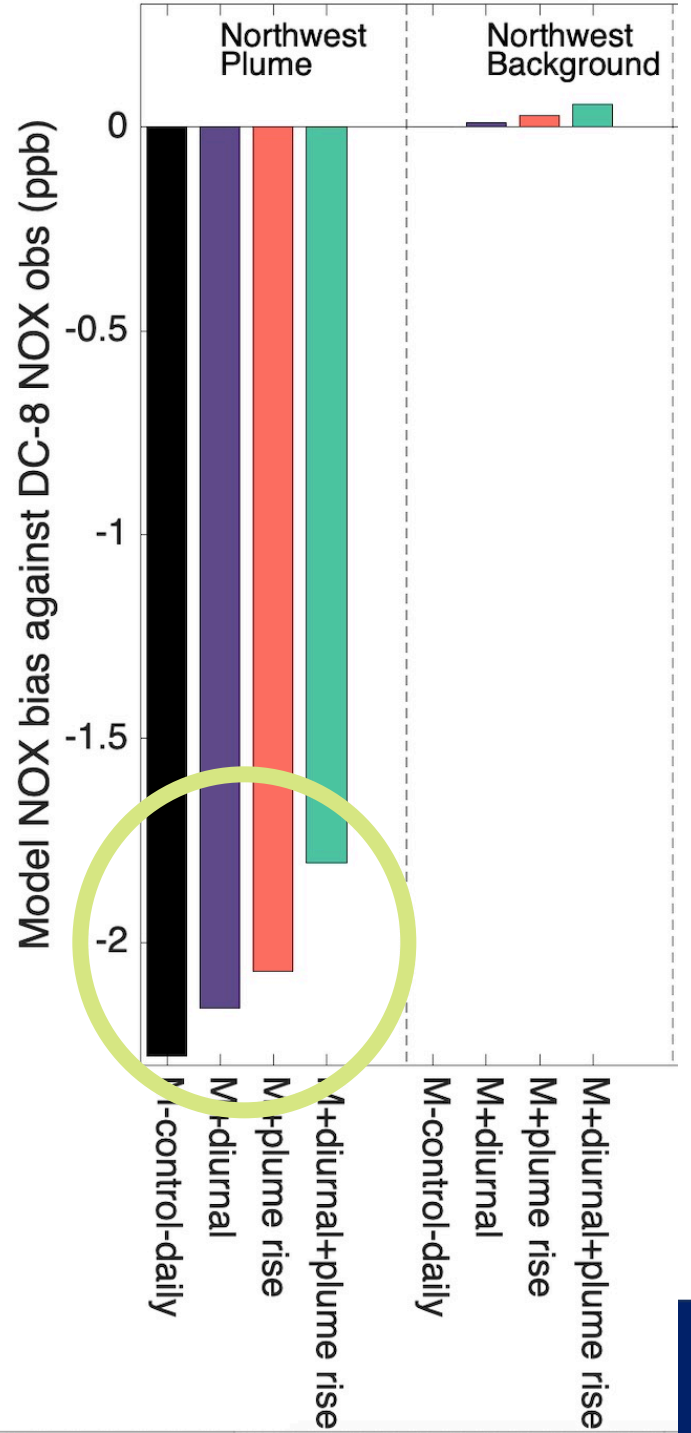
FIREX-AQ (Jul-Sep, 2019)

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



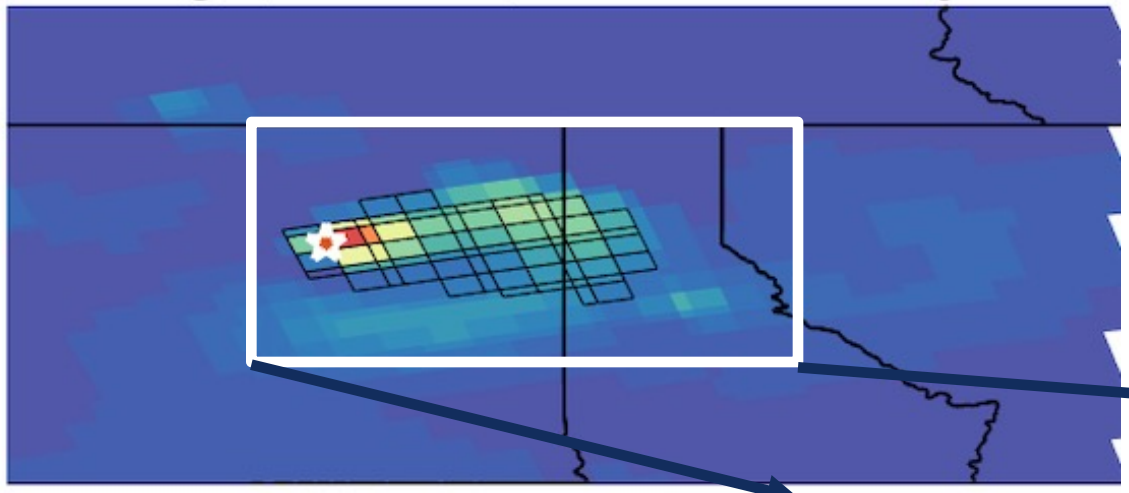
Compare to DC-8 aircraft measurements of CO

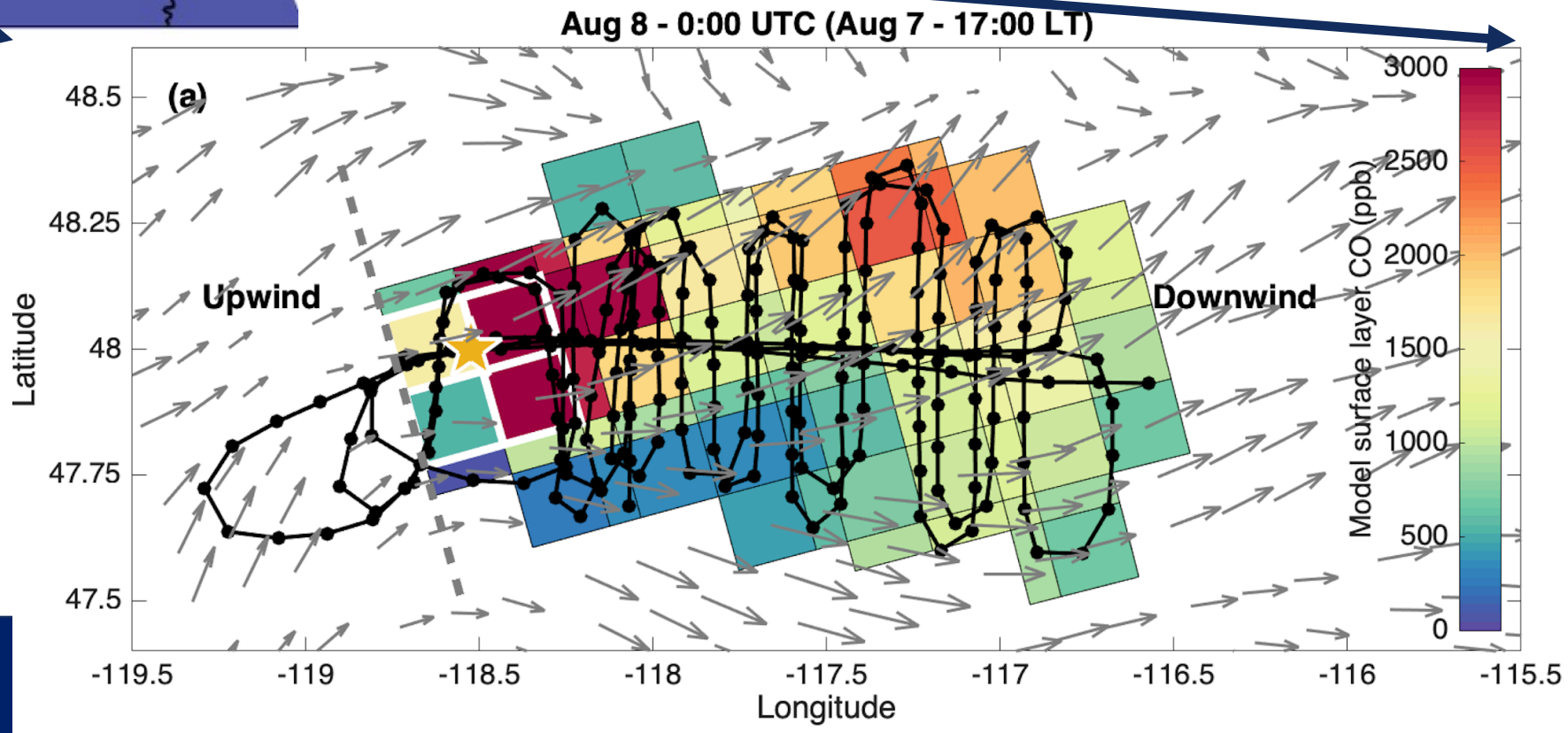
	CO			
	Plume		Background	
	Mean bias (ppb)	r	Mean bias (ppb)	r
M-control-daily	-241.68	**0.38**	-7.71	0.62
M+diurnal	-239.88	**0.34**	-6.93	0.65
M+plume rise	-244.60	**0.42**	-7.90	0.68
M+diurnal+plume rise	-238.66	**0.46**	-6.70	0.67
	NOX			
	Plume		Background	
	Mean bias (ppb)	r	Mean bias (ppb)	r
M-control-daily	**-2.00**	**0.07**	-0.04	0.60
M+diurnal	**-1.82**	**0.13**	-0.01	0.59
M+plume rise	**-1.91**	**0.35**	-0.03	0.60
M+diurnal+plume rise	**-1.65**	**0.42**	0.01	0.58



Case study: Williams Flats Fire (Aug 2019 at WA)

The resolution of MUSICA-V0 (~14 km over CONUS) has come down to the scale that is approximately comparable to the fire plume and the 1-minute-merged airborne observations.





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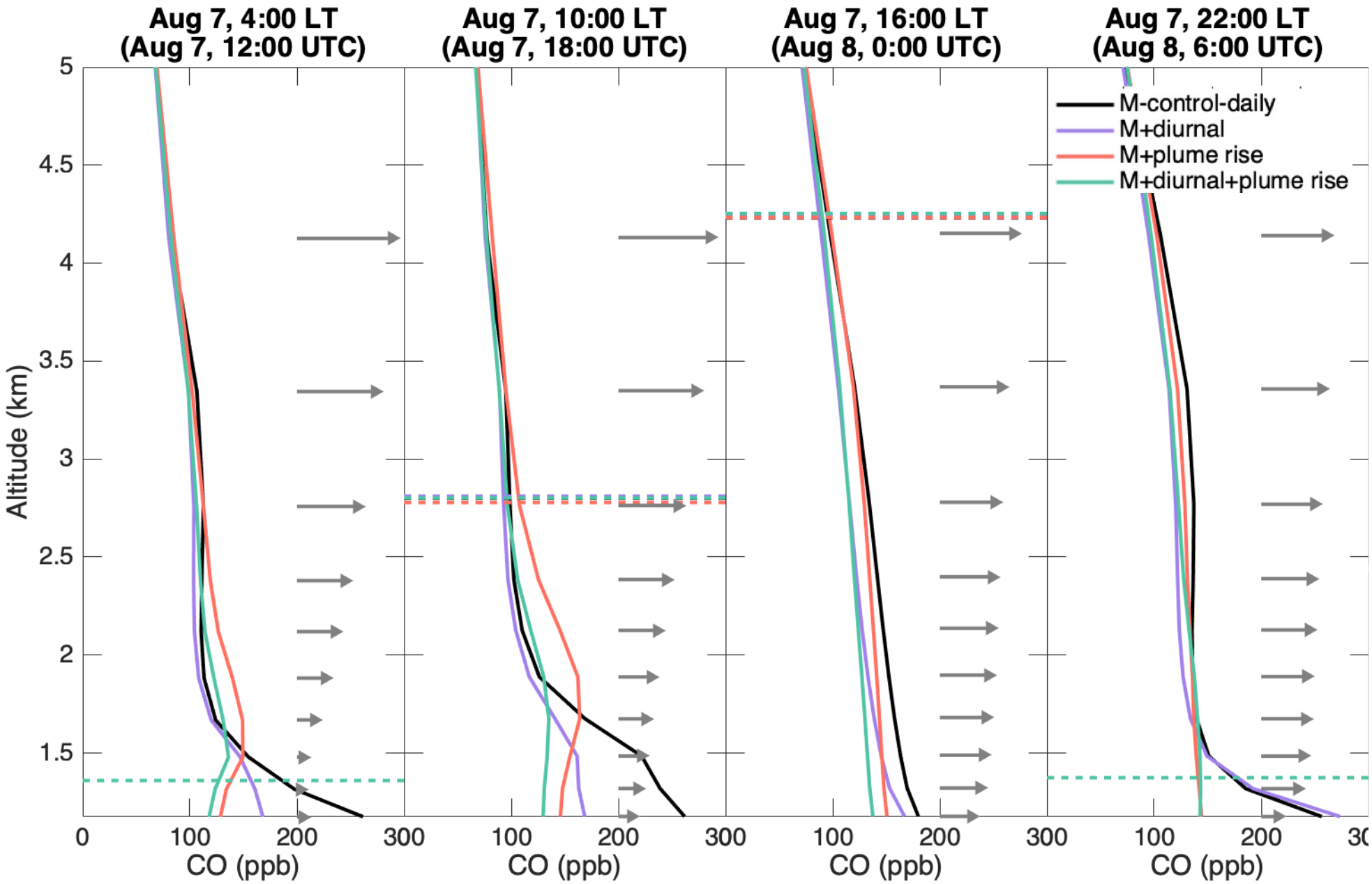
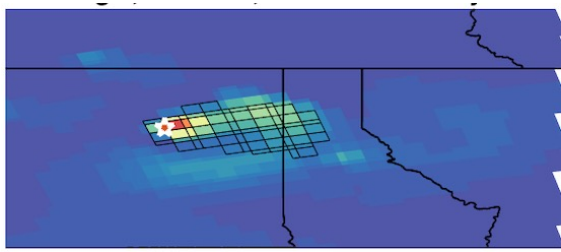
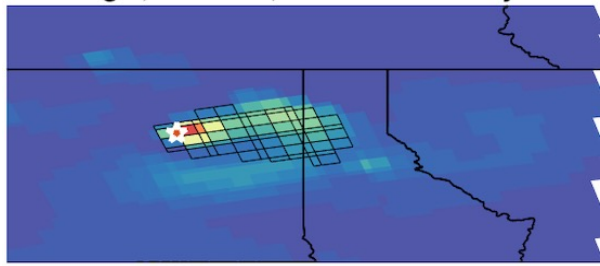
Case study: Williams Flats Fire (Aug 7th 2019 at WA)

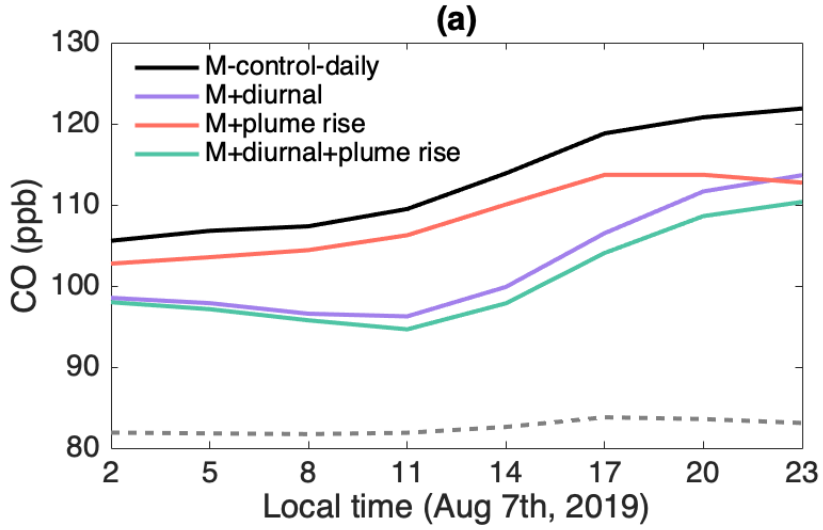


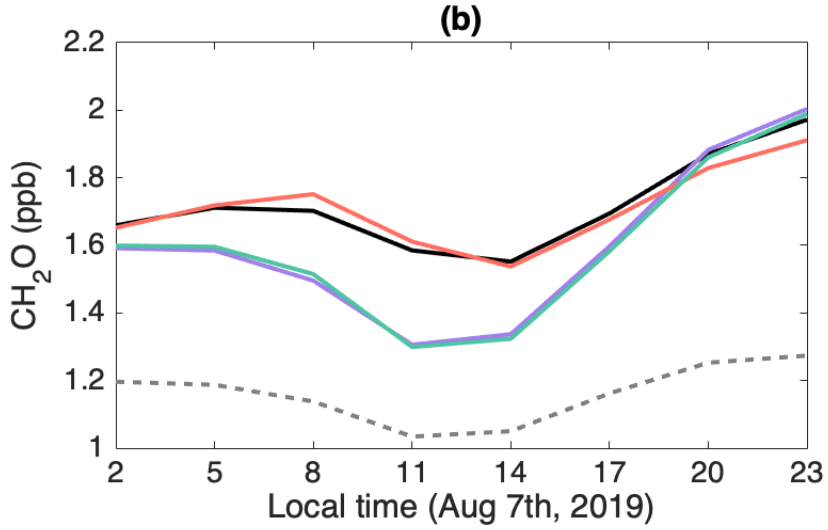


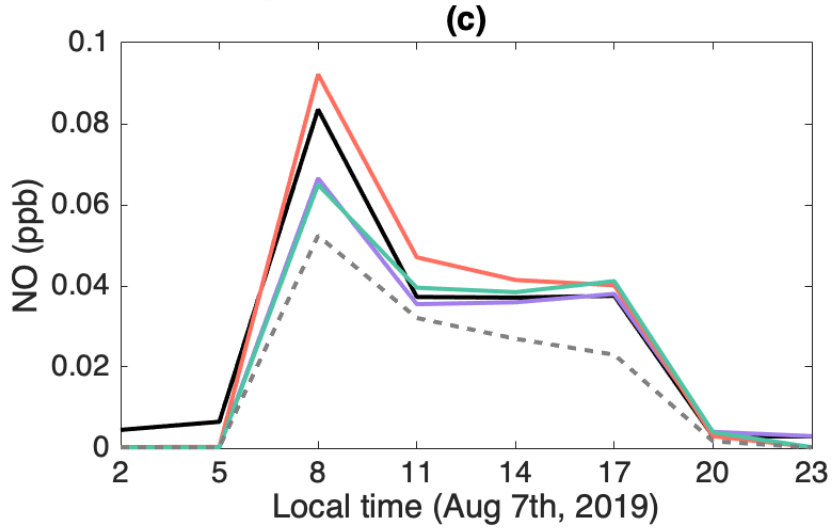
Trace gases and aerosols emitted at different times of a day and different altitude are subject to different meteorological conditions and should be transported differently.

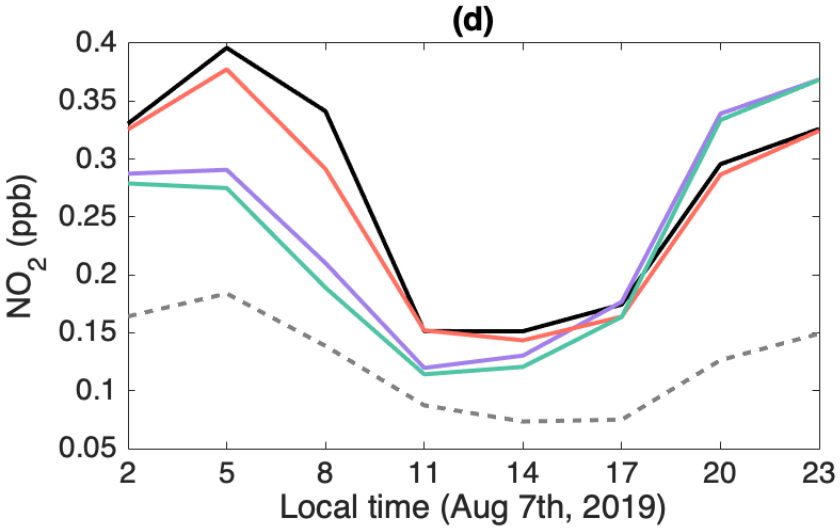
Case study: Williams Flats Fire (Aug 7th 2019 at WA)

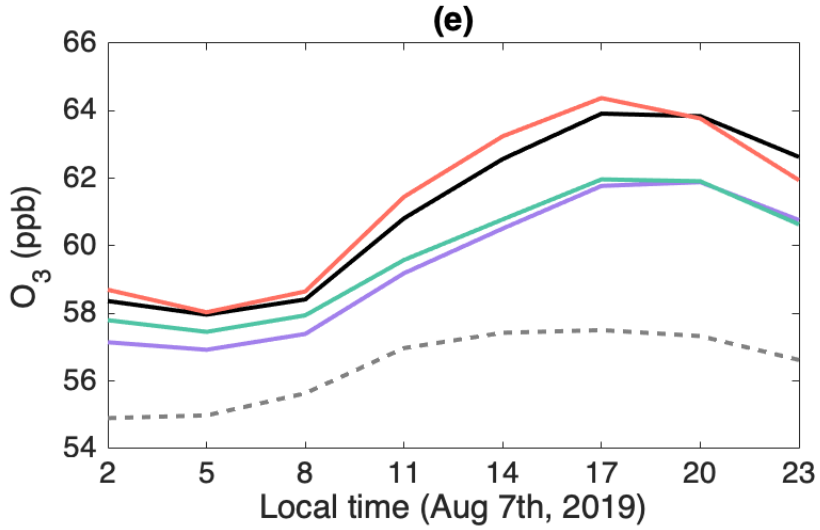


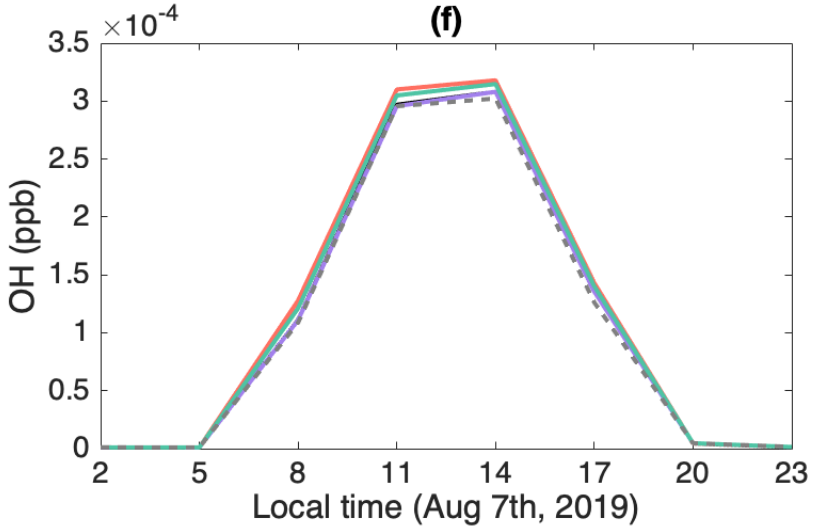












Implications

1. **Diurnal cycle** of fire emissions interacts with/has impacts on
- diurnal cycles/variations of meteorology/transport
- diurnal cycles/variations atmospheric chemistry
- fire impacts on public health due to diurnal variations of exposure to fire emissions
- diurnal cycle and reactions with of anthropogenic emissions

2. **Plume rise** also plays a role in the story of interactions between diurnal cycle of fire emissions and diurnal variations of meteorology/transport.

3. Preliminary results show that considering **Diurnal cycle** and **Plume rise** together improves model agreement with observations.

Next step

1. **Testing other plume rise schemes.**
2. **More detailed and thorough evaluation and understanding of the impacts of including Diurnal cycle and Plume rise in the model.**

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Thank you!