

Exploring the Vertical Distribution of Wildland Fire Smoke in CMAQ

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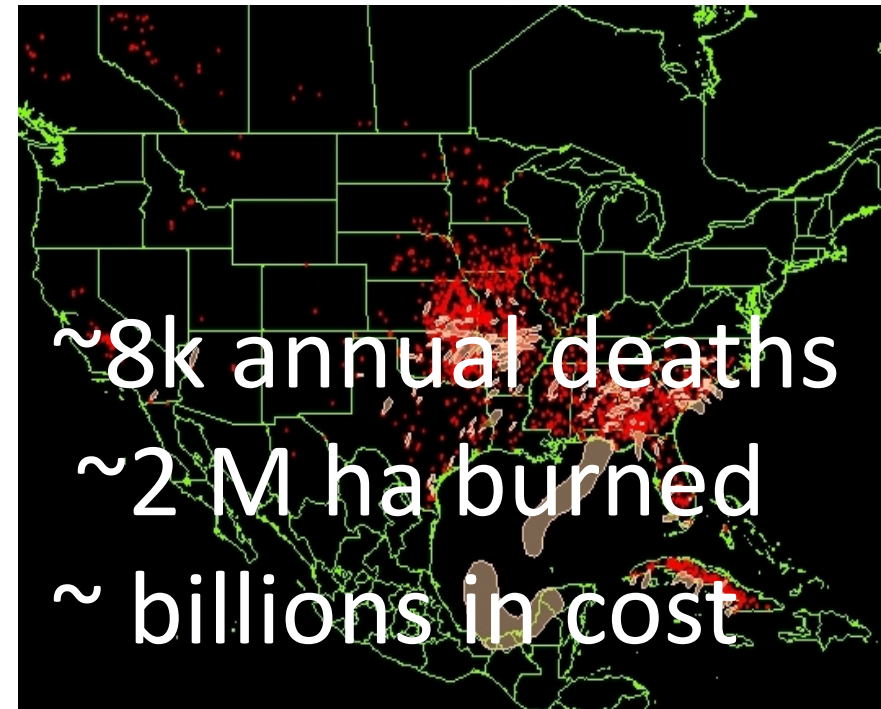
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Motivation

Worldwide



Continental U.S.



Numbers have grown by 50% in 20 years

1 M ha = 104 km², 1 ha = 2.47 acres

Fire Detection Techniques

Pre 1980's



Post 1980's

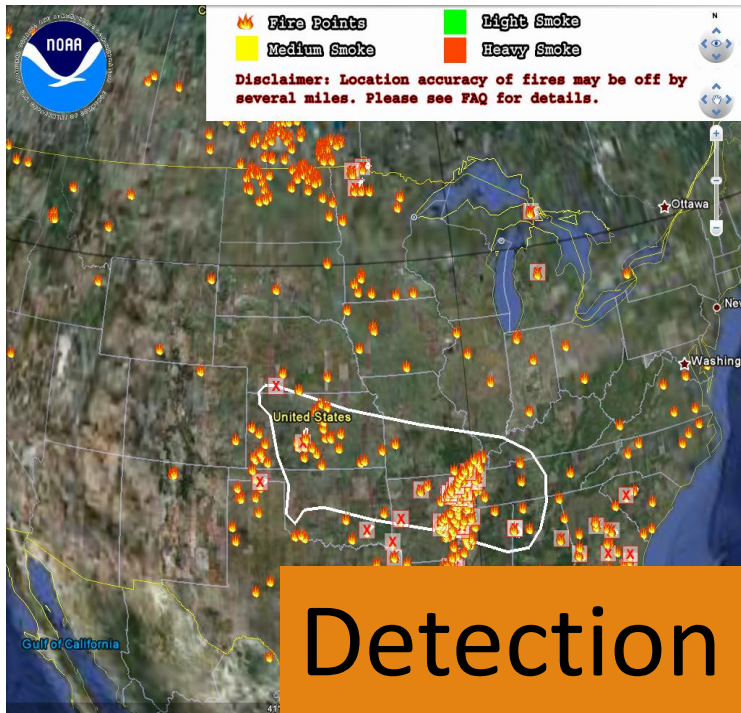


Current



The Fire Modeling Process

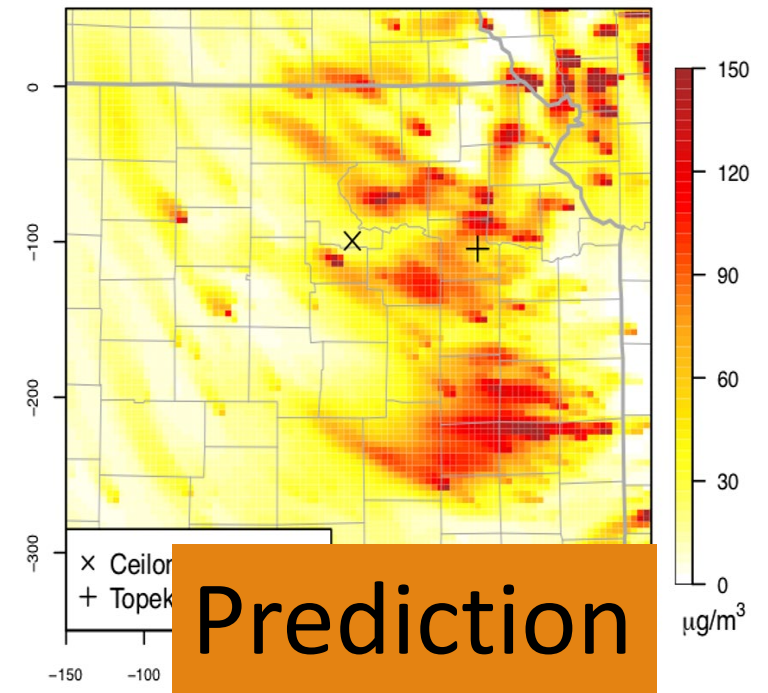
Input



Framework




Output




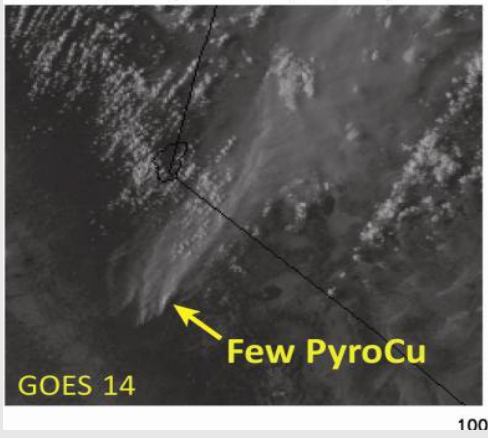
Current Status

- Plume Rise-in-line module in CMAQ needs updating (10+ years old)
- Post CMAQv5.3 development users selectable plume rise modules.
- More obs (Lidar and Satellite) validations — plume tops and fire detections.

Test three sensitivities:

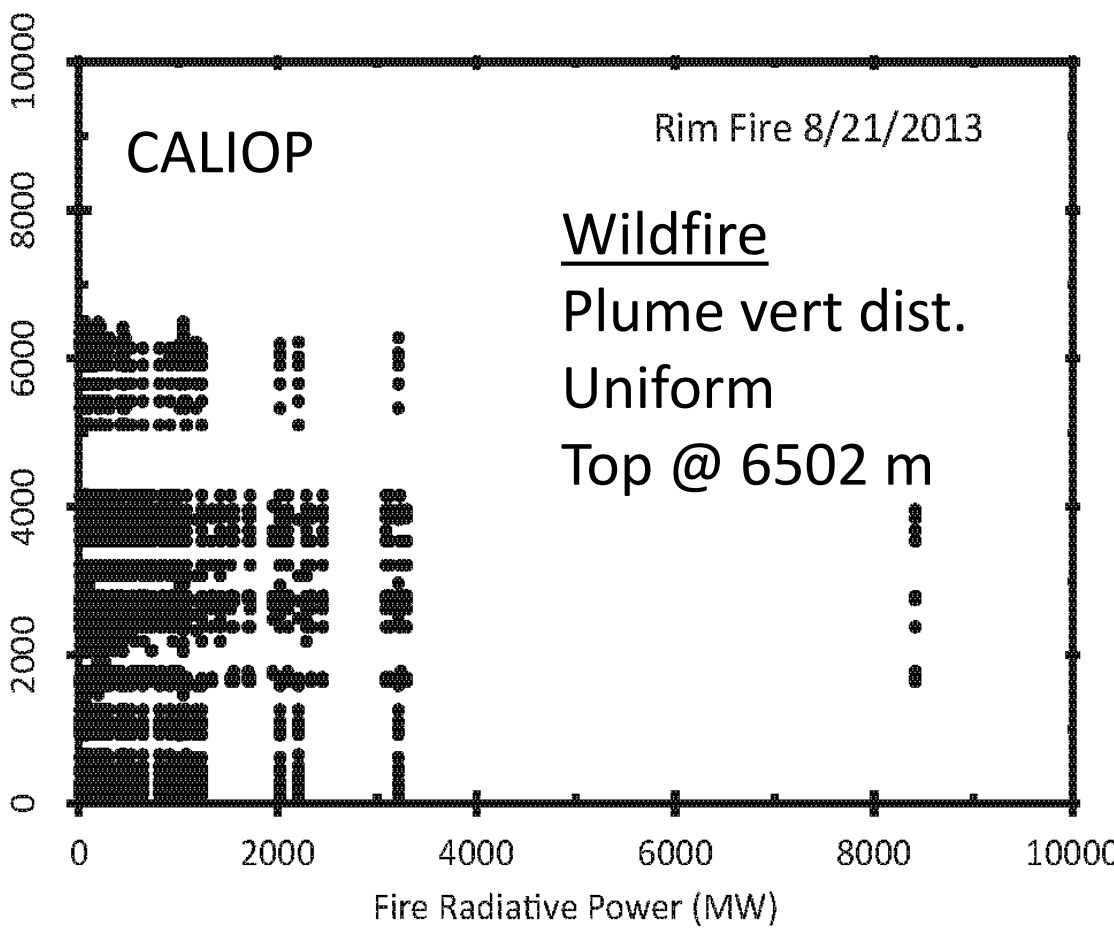
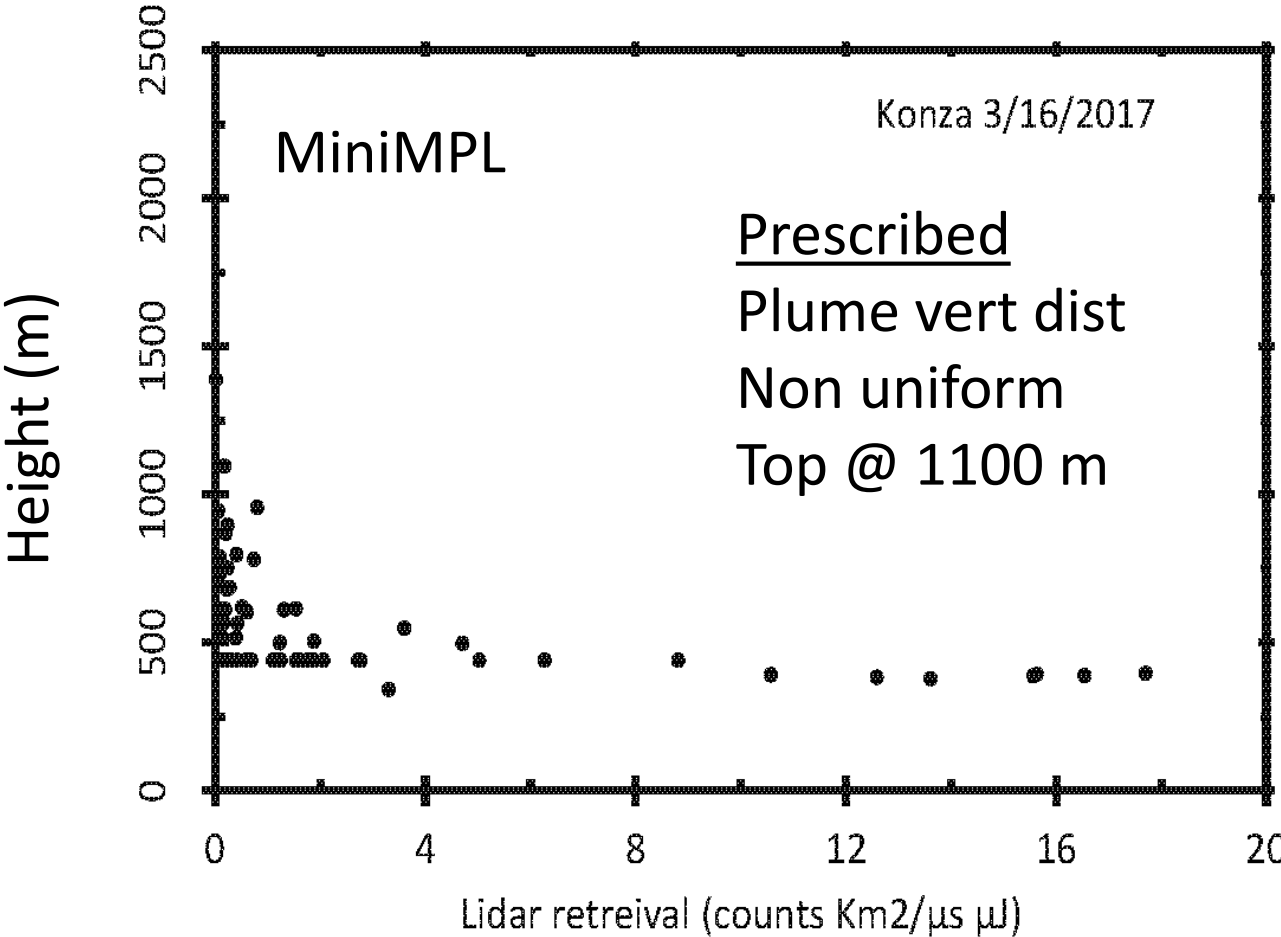
- Grid spacing (12km vs 4km)
 - Briggs vs alt. algorithms (SOFIEV and PBL + 500m)
 - Temporal allocation (diurnal vs 4hr).
- 

Episode information

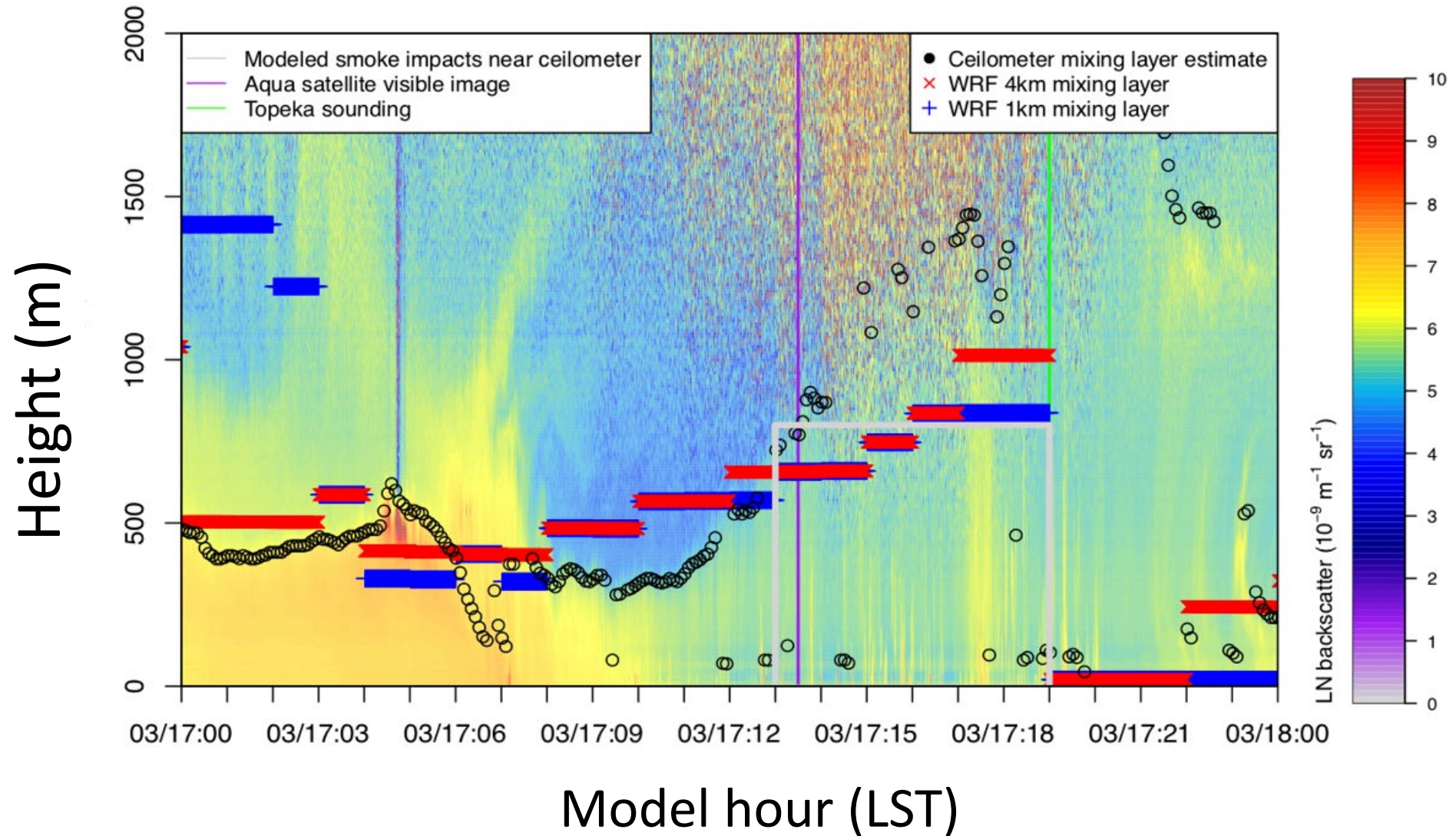
Episode	Prescribed fire	Wild fire
Location	Konza Prairie Biological Station in Flint Hills, Kansas	Stanislaus National Forest in California
Date	Mar. 15 - 20, 2017 (Mar. 16th)	Aug. 17 - Nov. 4, 2013 (Aug 21)
Detection method	Mini Micro Pulse Lidar	CALIOP and GOES
Acres burned	1500 ha total (83 ha)	104K ha total (6,562 ha)
Image		
References	Wilkins et al., in prep	Peterson et al., 2014 BAMS

Episode information

Plume structure

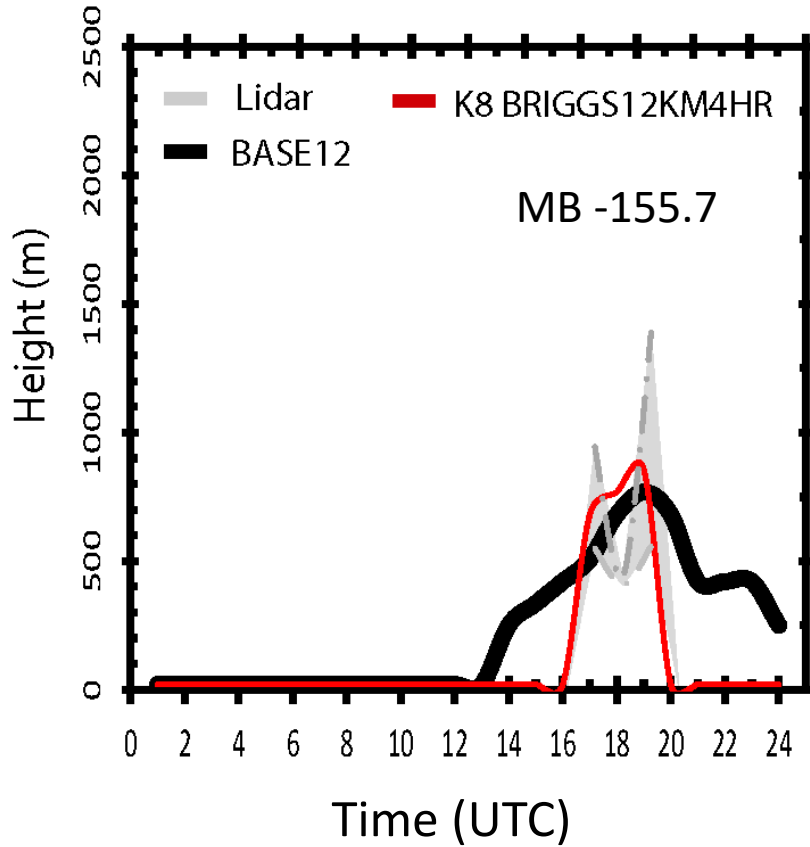


MiniMPL – plume top heights

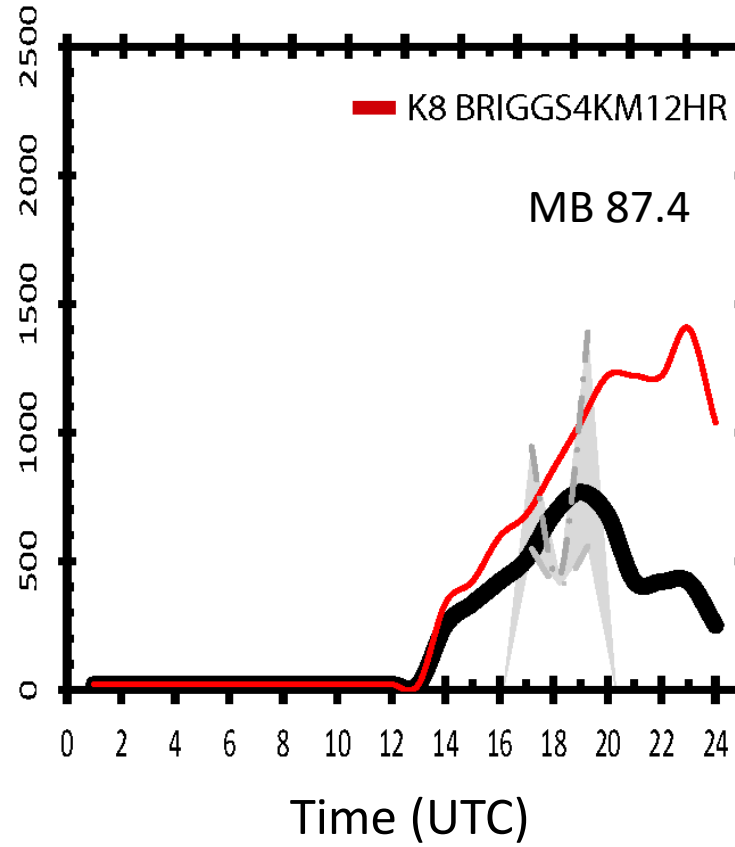


MiniMPL – plume top heights

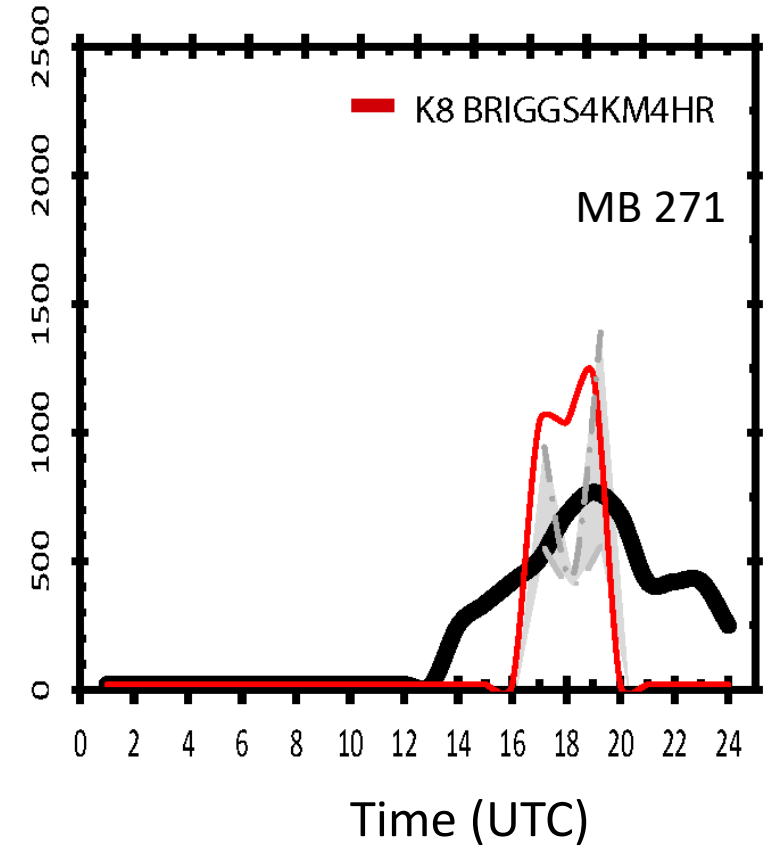
Temporal



Spatial

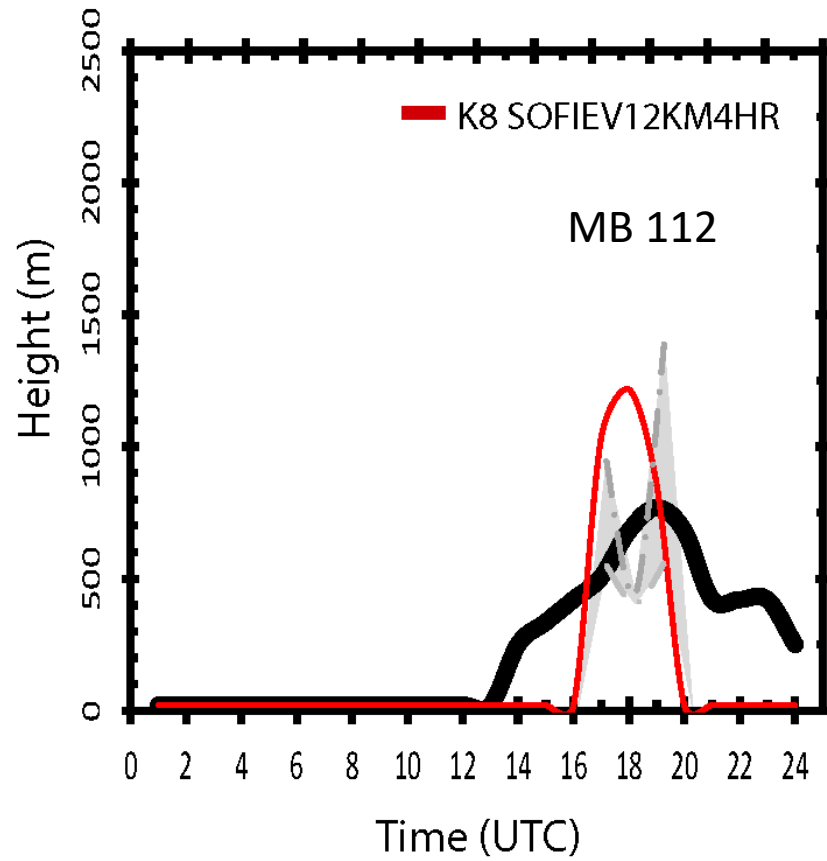


Both

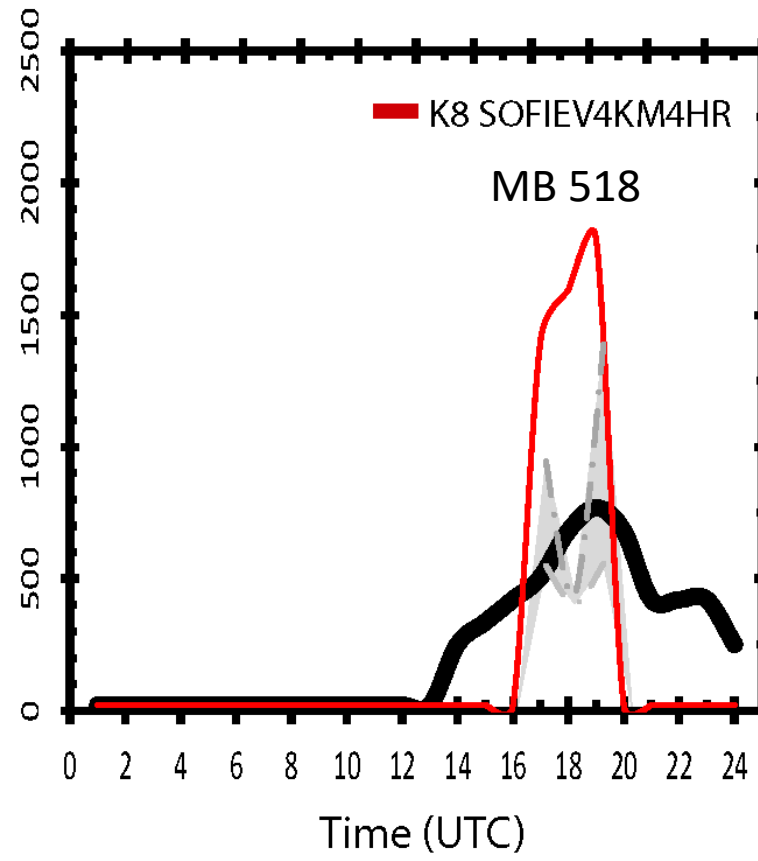


MiniMPL – plume top heights

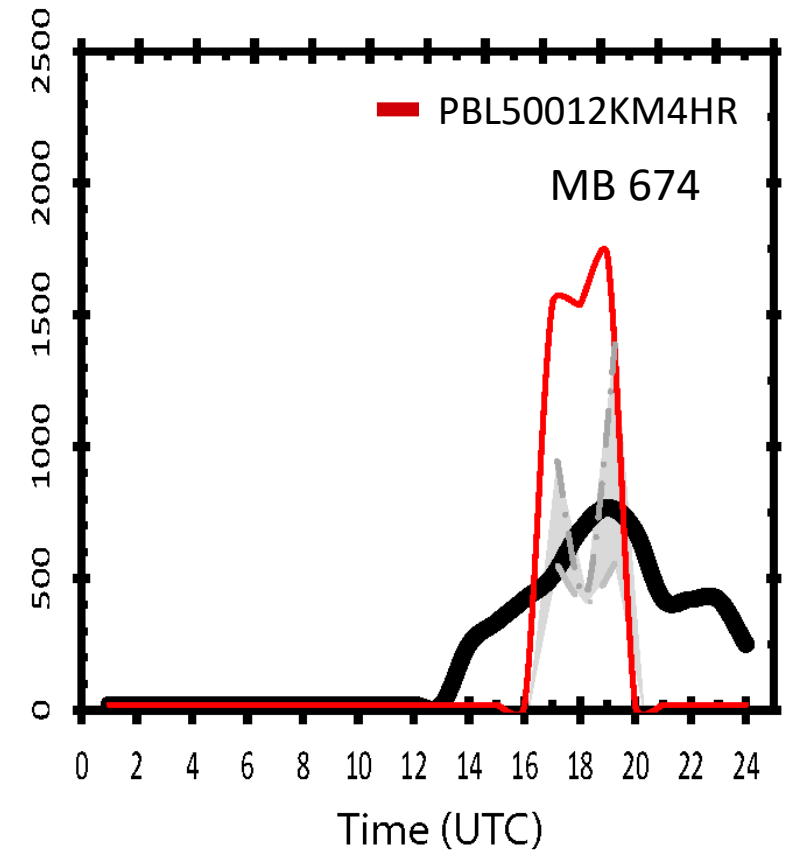
Sofiev-Temporal



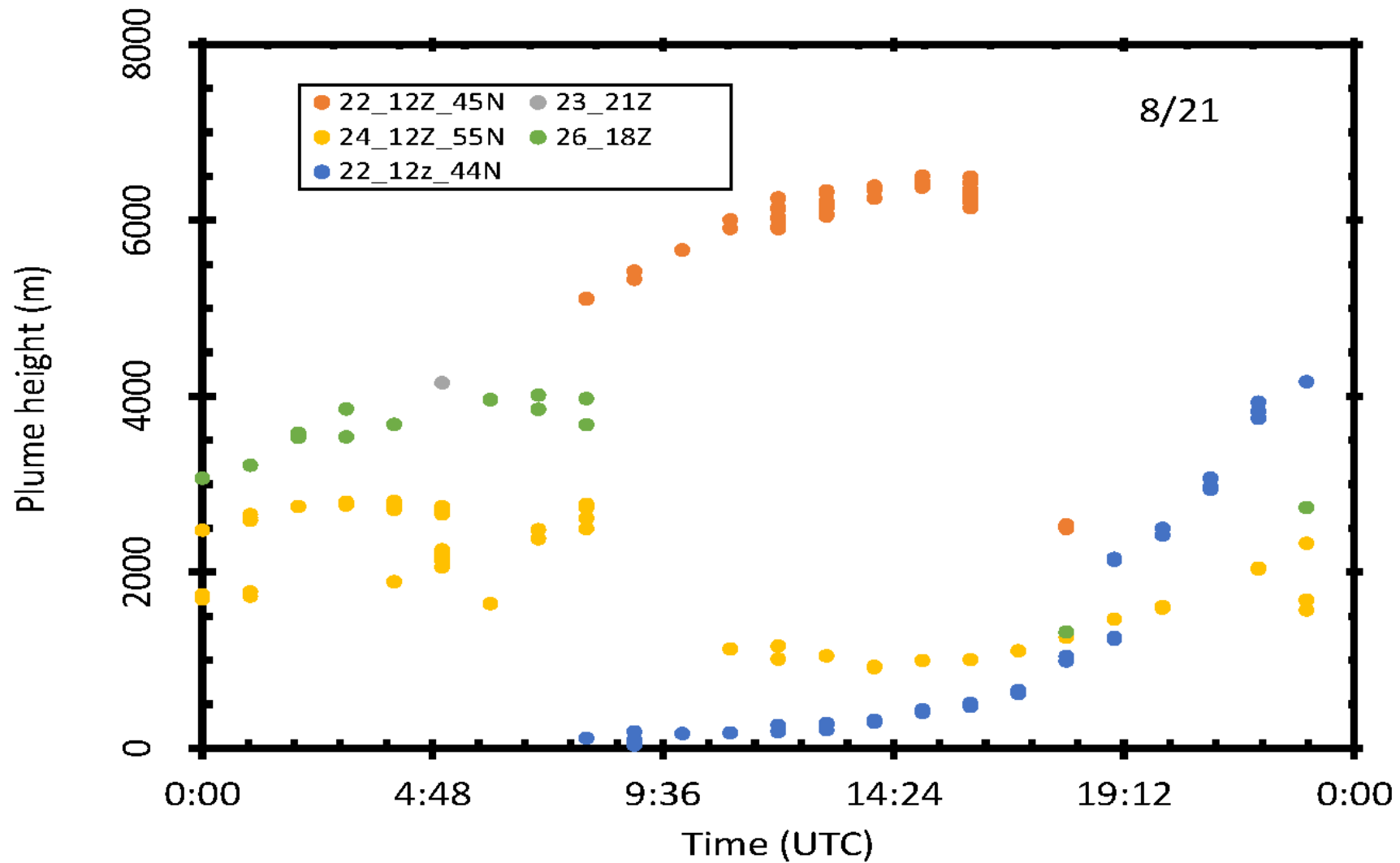
Sofiev-Spatial



PBL500

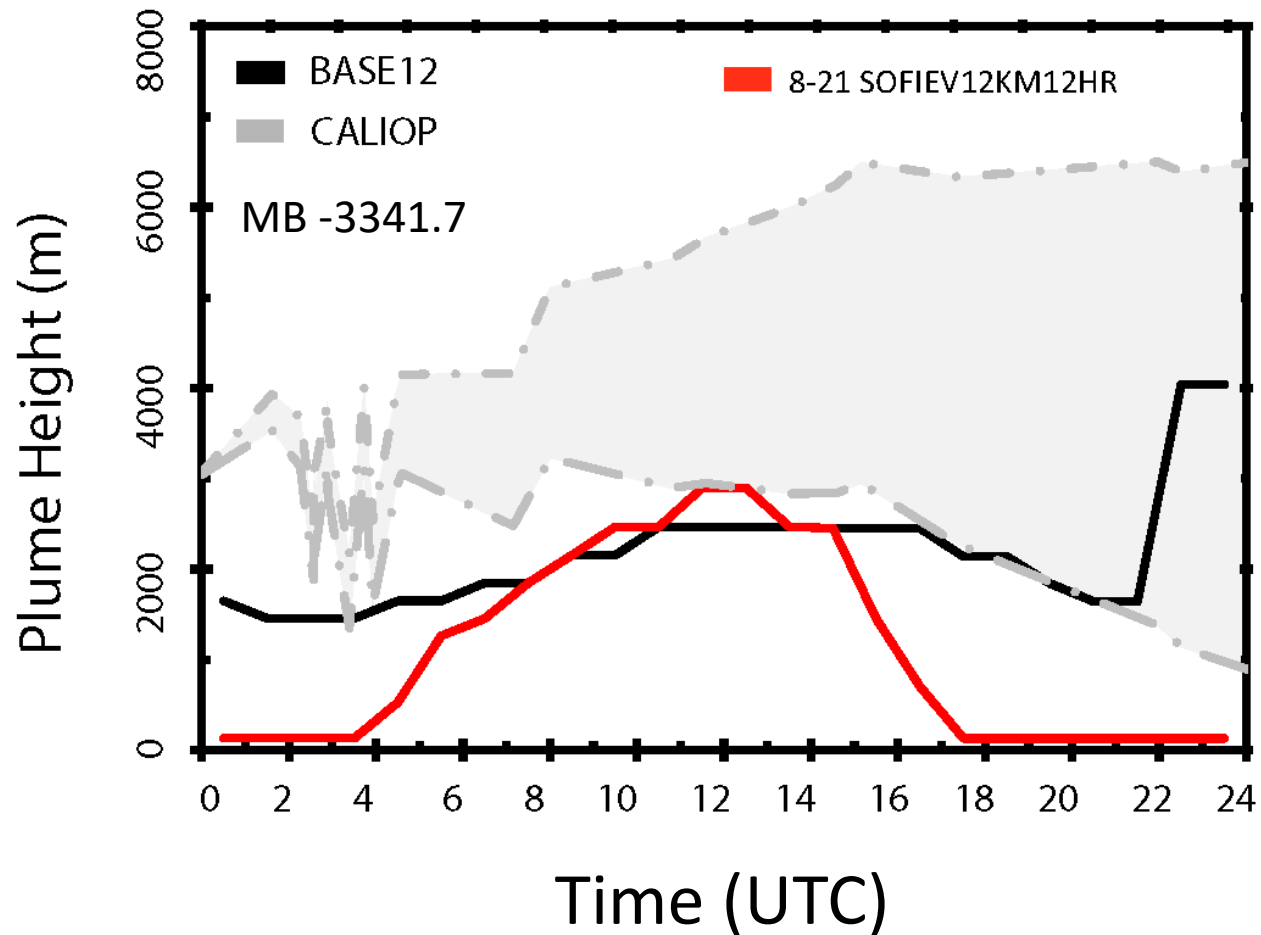


CALIOP – plume top heights

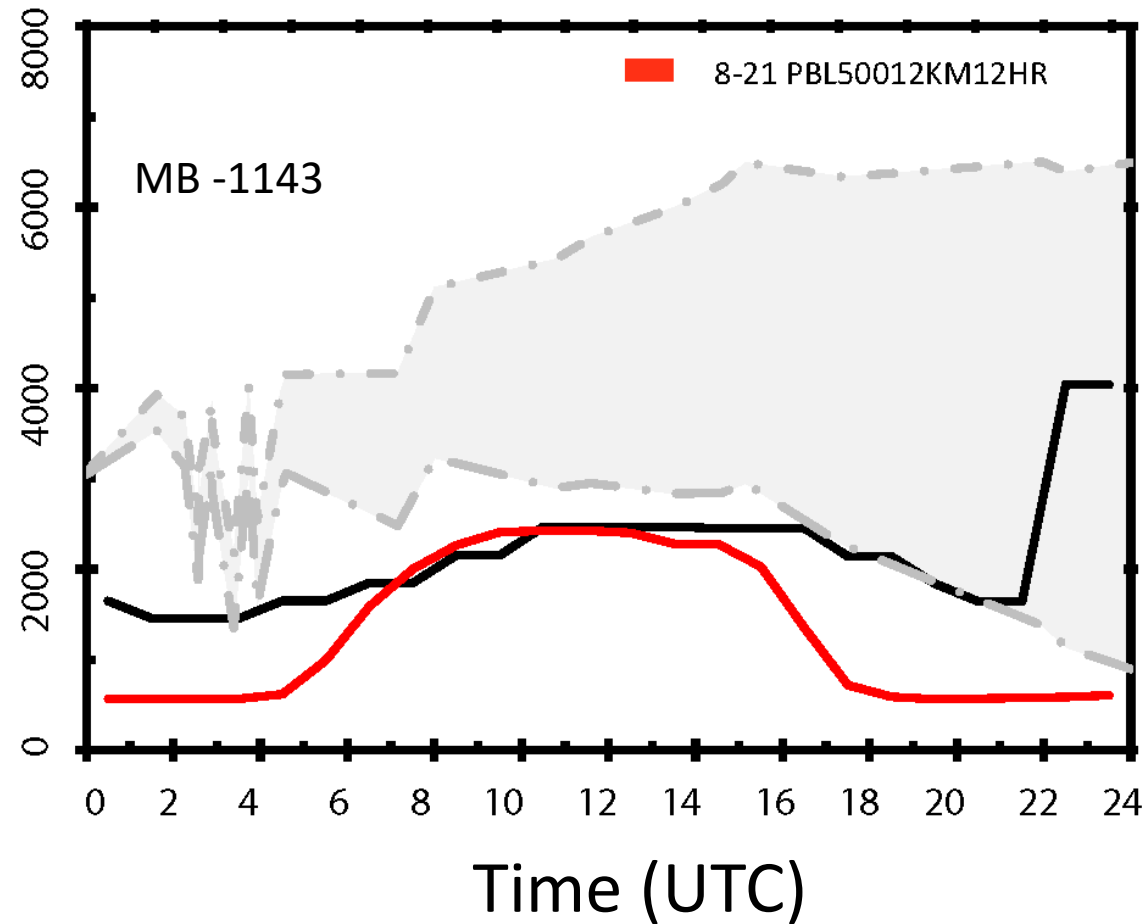


CALIOP – plume top heights

Sofiev



PBL500



Preliminary conclusions

- Temporal resolution (time of burn) shows most improvement overall.
- Algorithms are highly dependent on input information and design
- Nighttime plume rise needs investigation
- WF needs to be treated different than RX

Future work

A lot of work remains; the solution to a changing climate is to increase research efforts, knowledge, and action.

Field campaigns



Satellite missions



Lab experiments



Acknowledgements

Thanks to co-authors and collaborators at NASA, US Forest Service, US Dep. of Agriculture, and the U.S. EPA.



Number	Simulation name	plume rise method description	Reference
1	BASE12	Briggs simulation using 12 hour and 12 km grid	Pouliot et al. 2005
2	BRIGGS12KMHR	Modified Briggs using field data for duration of fire (3 and 4 hr)	Luxi et al. 2018
3	SOFIEV12KMHR	Sofiev simulation using hour (3 and 4) modification and 12 km grid	Sofiev et al. 2012
4	PBL50012KM	Plume height top is set to the boundary layer top plus 500 m	Kahn et al. 2007
5	BRIGGS4KMHR	Modified Briggs using 4km grid resolution, 12, 4, and 3 hours	-
6	SOFIEV4KMHR	Modified Sofiev using 4km grid resolution, 12,4, and 3 hours	-
7	BRIGGS4KM12HR	Briggs simulation using 12 hour and 4 km grid	

SI Table x. Fig statistics model-obs bias (MB and RMSE)

model bias							
mean bias							
	simulation						
Burn	BASE12	BRIGGS12KMHR	SOFIEV12KMHR	PBL50012KM	BRIGGS4KMHR	SOFIEV4KMHR	BRIGGS4KM12HR
1	-2356.2	—	-3420.7	-3209.9	—	—	—
2	-2663.0	—	-3341.7	-1143.2	—	—	—
3	-272.4	-155.7	112.5	674.8	174.8	518.5	22.9
4	-449.2	-35.6	-215.5	322.9	271.7	527.1	87.4
5	-3586.2	-3405.0	-2975.1	-3205.2	-3255.6	-3101.5	-3437.1
root mean square error							
	simulation						
Burn	BASE12	BRIGGS12KMHR	SOFIEV12KMHR	PBL50012KM	BRIGGS4KMHR	SOFIEV4KMHR	BRIGGS4KM12HR
1	2803.9	—	3519.8	3315.2	—	—	—
2	3215.0	—	3667.1	2325	—	—	—
3	459.6	391.6	546.4	746.0	358.8	705.8	349.6
4	717.8	330.3	496.3	484.1	450.8	818.2	371.6
5	3169.5	3056.2	2715.5	2904.9	2916.5	2826.6	3091.6

