

Supplement of Atmos. Chem. Phys., 19, 15157–15181, 2019  
<https://doi.org/10.5194/acp-19-15157-2019-supplement>  
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*Supplement of*

## **Evaluating wildfire emissions projection methods in comparisons of simulated and observed air quality**

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**Table S1.** Model performance statistics for monthly averaged sulfate ( $\text{SO}_4$ ) vs. IMPROVE<sup>a</sup> observations

Month	SO <sub>4</sub> ( $\mu\text{g m}^{-3}$ )				NME <sup>b</sup> (%)			NMB <sup>c</sup> (%)			$r^d$		
	IMP <sup>a</sup>	Stat. d-s <sup>e</sup>	Dyn. d-s <sup>f</sup>	NEI Bmrk <sup>g</sup>	Stat. d-s	Dyn. d-s	NEI Bmrk	Stat. d-s	Dyn. d-s	NEI Bmrk	Stat. d-s	Dyn. d-s	NEI Bmrk
Jan	1.7	2.4	2.4	2.4	53.6	53.6	53.6	37.6	37.6	37.6	0.63	0.63	0.63
Feb	2.4	2.9	2.9	2.9	45.7	45.7	45.7	22.8	22.8	22.8	0.46	0.46	0.46
Mar	2.0	3.5	3.5	3.6	83.7	83.7	83.9	77.2	77.2	77.3	0.72	0.72	0.72
Apr	2.2	4.1	4.1	4.1	89.4	89.3	89.2	81.8	81.5	81.4	0.65	0.65	0.65
May	2.4	3.9	3.9	3.9	77.1	76.9	76.6	63.3	63.1	62.6	0.58	0.58	0.57
Jun	2.6	3.9	3.9	3.9	56.6	58.3	56.3	47.9	49.2	47.4	0.64	0.67	0.64
Jul	2.9	4.5	4.4	4.5	66.0	61.9	65.8	56.4	51.4	56.1	0.79	0.8	0.79
Aug	3.0	4.9	4.8	4.9	72.6	72.4	70.6	61.0	60.6	58.9	0.68	0.68	0.69
Sep	2.1	4.4	4.4	4.4	113.0	113.0	113.0	107.0	107.0	107.0	0.66	0.65	0.65
Oct	1.7	3.8	3.8	3.8	126.0	126.0	125.0	123.0	122.0	122.0	0.79	0.79	0.79
Nov	1.5	3.1	3.1	3.1	116.0	116.0	115.0	107.0	107.0	106.0	0.43	0.4	0.43
Dec	1.9	1.9	2.0	1.9	38.7	38.3	38.7	-1.4	0.6	-1.4	0.51	0.5	0.51

<sup>a</sup> Interagency Monitoring of PROtected Visual Environments network. <sup>b</sup> Normalized mean error. <sup>c</sup> Normalized mean bias.<sup>d</sup> Correlation coefficient. <sup>e</sup> Statistical d-s. <sup>f</sup> Dynamical d-s. <sup>g</sup> NEI Benchmark.

**Table S2.** Model performance statistics for monthly averaged ammonium ( $\text{NH}_4$ ) vs. IMPROVE<sup>a</sup> observations

Month	NH <sub>4</sub> ( $\mu\text{g m}^{-3}$ )				NME <sup>b</sup> (%)			NMB <sup>c</sup> (%)			$r^d$		
	IMP <sup>a</sup>	Stat. d-s <sup>e</sup>	Dyn. d-s <sup>f</sup>	NEI Bmrk <sup>g</sup>	Stat. d-s	Dyn. d-s	NEI Bmrk	Stat. d-s	Dyn. d-s	NEI Bmrk	Stat. d-s	Dyn. d-s	NEI Bmrk
Jan	1.2	1.3	1.3	1.3	40.4	40.4	40.4	8.6	8.6	8.6	0.68	0.68	0.68
Feb	1.6	2.0	2.0	2.0	44.8	44.8	44.8	25.6	25.6	25.6	0.7	0.7	0.7
Mar	1.1	1.7	1.7	1.7	68.0	68.0	68.1	53.7	53.7	53.7	0.66	0.66	0.66
Apr	1.0	1.5	1.4	1.4	67.7	67.0	66.3	42.2	41.1	40.4	0.48	0.47	0.47
May	1.0	1.1	1.1	1.1	57.0	56.6	56.2	7.4	6.6	5.5	0.47	0.47	0.47
Jun	1.1	1.1	1.1	1.1	47.1	48.0	47.2	7.4	8.0	6.4	0.49	0.48	0.49
Jul	1.2	1.3	1.3	1.3	49.7	45.7	48.9	15.0	7.8	11.7	0.71	0.73	0.69
Aug	1.2	1.3	1.3	1.3	54.7	54.6	53.5	9.3	8.0	7.3	0.51	0.5	0.52
Sep	0.9	1.3	1.3	1.2	75.0	73.3	69.1	48.7	46.8	42.2	0.52	0.53	0.54
Oct	0.7	1.3	1.3	1.3	93.8	92.2	91.8	80.0	78.2	77.6	0.63	0.62	0.62
Nov	0.8	1.4	1.4	1.4	97.4	97.2	95.8	81.2	79.4	79.4	0.53	0.53	0.53
Dec	1.3	1.1	1.1	1.1	31.7	31.5	31.7	-16.2	-16.8	-16.2	0.76	0.76	0.76

<sup>a</sup> Interagency Monitoring of PROtected Visual Environments network. <sup>b</sup> Normalized mean error. <sup>c</sup> Normalized mean bias.<sup>d</sup> Correlation coefficient. <sup>e</sup> Statistical d-s. <sup>f</sup> Dynamical d-s. <sup>g</sup> NEI Benchmark.

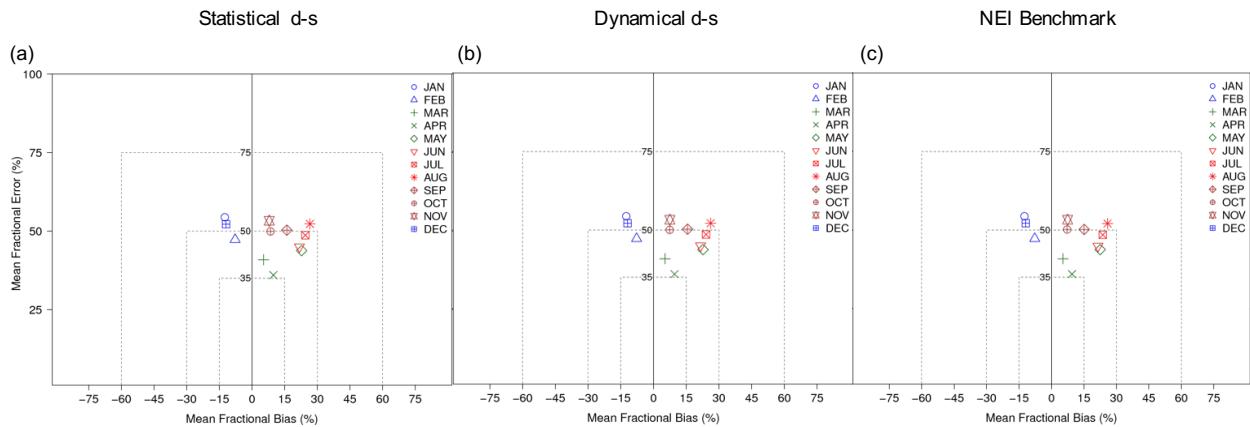
**Table S3.** Model performance statistics for monthly averaged nitrate ( $\text{NO}_3$ ) vs. IMPROVE<sup>a</sup> observations

Month	$\text{NO}_3$ ( $\mu\text{g m}^{-3}$ )				NME <sup>b</sup> (%)			NMB <sup>c</sup> (%)			$r^d$		
	IMP <sup>a</sup>	Stat. d-s <sup>e</sup>	Dyn. d-s <sup>f</sup>	NEI Bmrk <sup>g</sup>	Stat. d-s	Dyn. d-s	NEI Bmrk	Stat. d-s	Dyn. d-s	NEI Bmrk	Stat. d-s	Dyn. d-s	NEI Bmrk
Jan	1.8	2.4	2.4	2.4	77.4	77.4	77.4	36.2	36.2	36.2	0.65	0.65	0.65
Feb	2.3	3.9	3.9	3.9	87.8	87.8	87.8	68.2	68.2	68.2	0.73	0.73	0.73
Mar	1.2	2.4	2.4	2.4	132.0	132.0	132.0	109.0	109.0	109.0	0.66	0.66	0.66
Apr	0.6	1.0	1.0	1.0	134.0	132.0	130.0	66.1	63.0	61.1	0.38	0.38	0.38
May	0.4	0.5	0.5	0.5	123.0	121.0	118.0	35.0	32.2	28.7	0.38	0.39	0.41
Jun	0.2	0.3	0.3	0.3	140.0	141.0	139.0	44.9	41.3	41.6	0.26	0.23	0.26
Jul	0.2	0.4	0.3	0.4	168.0	146.0	164.0	59.5	31.7	52.2	0.15	0.17	0.16
Aug	0.2	0.4	0.4	0.4	207.0	200.0	198.0	110.0	102.0	95.3	0.18	0.18	0.17
Sep	0.2	0.5	0.5	0.5	238.0	232.0	216.0	154.0	146.0	128.0	0.22	0.22	0.25
Oct	0.3	1.1	1.1	1.1	278.0	270.0	267.0	234.0	223.0	220.0	0.48	0.48	0.48
Nov	0.8	2.0	2.0	2.0	189.0	182.0	185.0	165.0	157.0	160.0	0.55	0.55	0.55
Dec	1.8	2.2	2.2	2.2	55.5	52.6	55.5	18.4	14.2	18.4	0.76	0.76	0.76

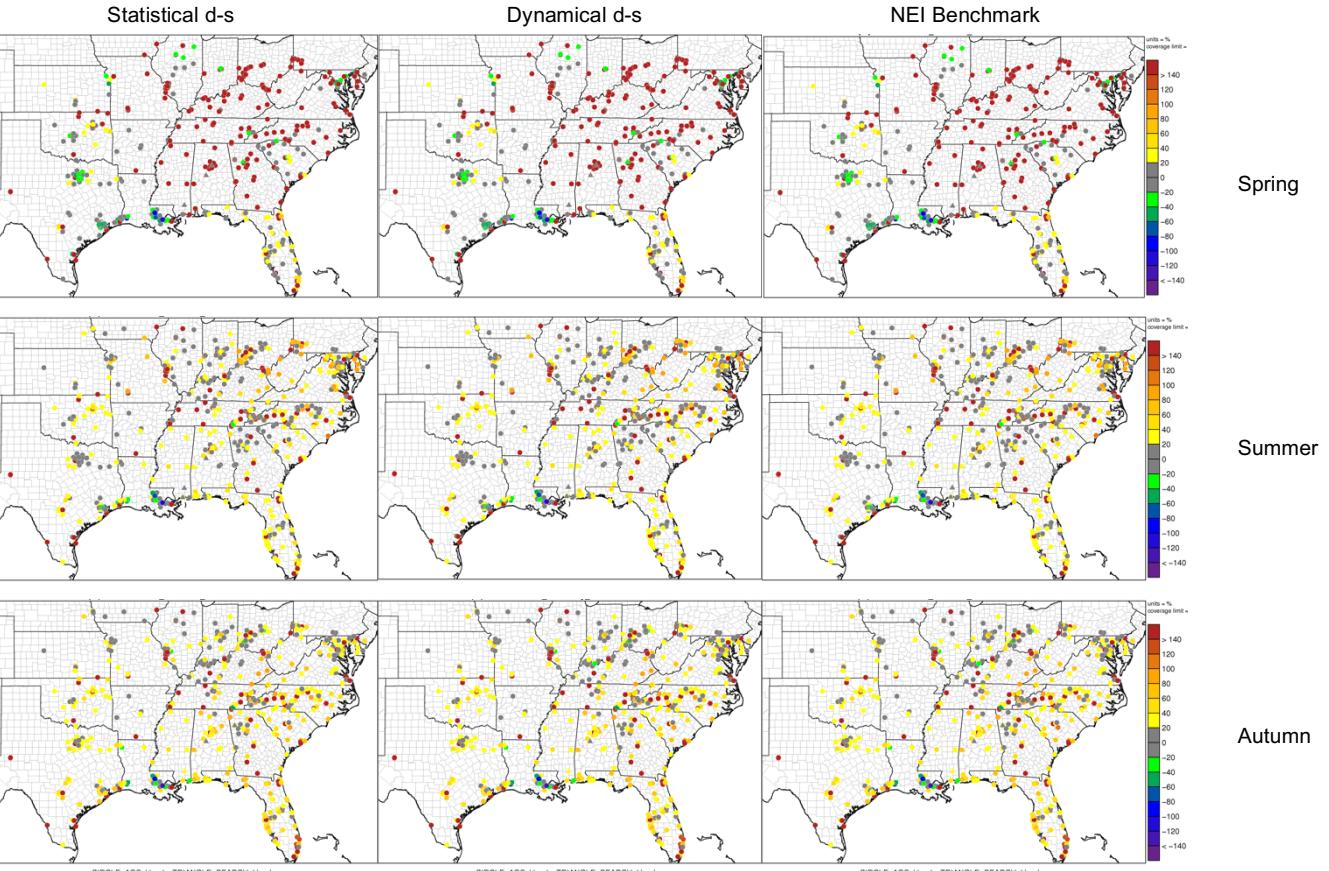
N.B.: Emery et al. (2017) recommend no goal or criterion for  $r$  for  $\text{NO}_3$  but modeled values are provided for completeness.

<sup>a</sup> Interagency Monitoring of PROtected Visual Environments network. <sup>b</sup> Normalized mean error. <sup>c</sup> Normalized mean bias.

<sup>d</sup> Correlation coefficient. <sup>e</sup> Statistical d-s. <sup>f</sup> Dynamical d-s. <sup>g</sup> NEI Benchmark.

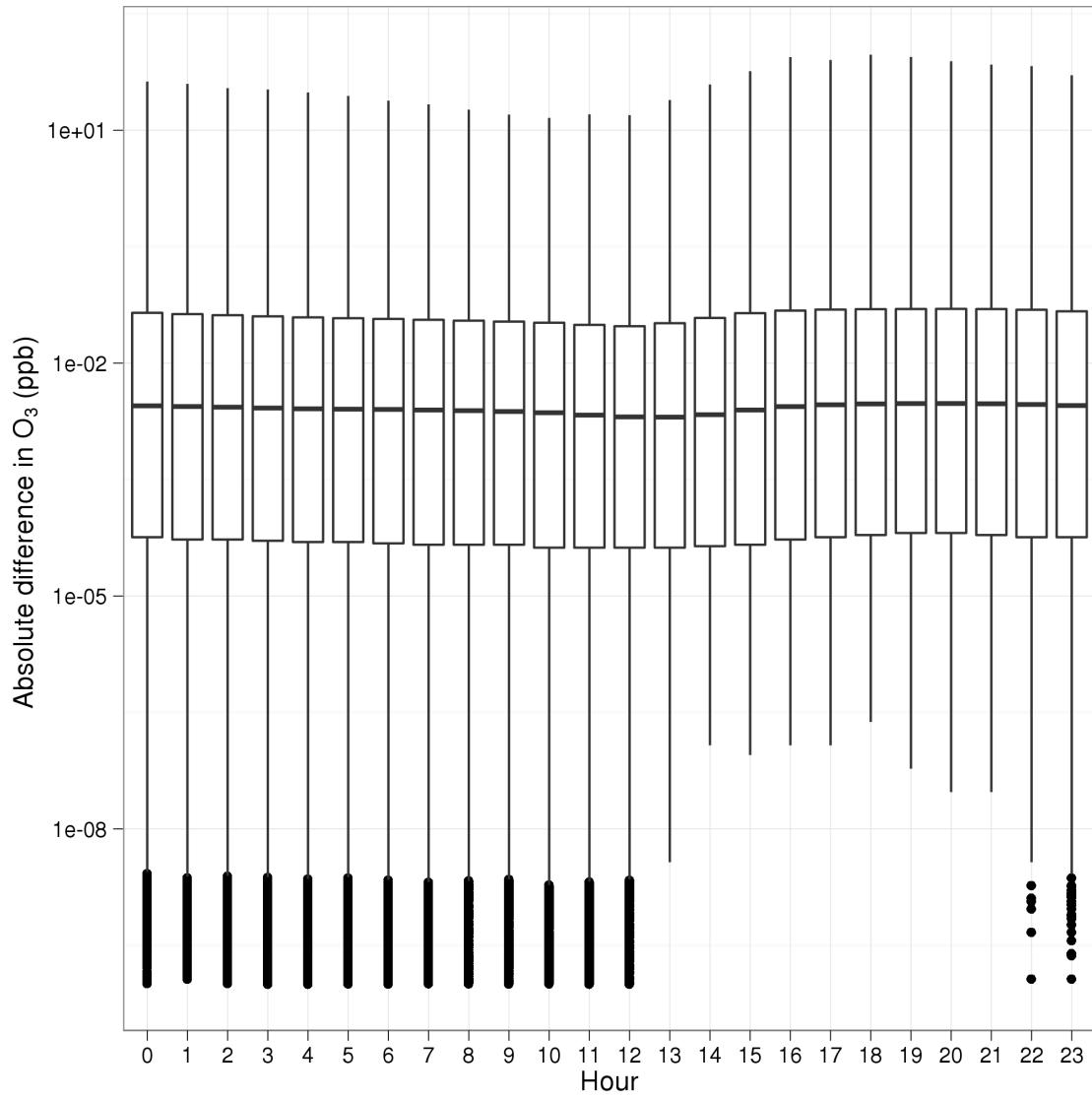


**Figure S1.** Monthly averaged model performance for 1-hr ozone relative to observations from the Air Quality System. **(a)** statistical d-s, **(b)** dynamical d-s and **(c)** NEI benchmark.

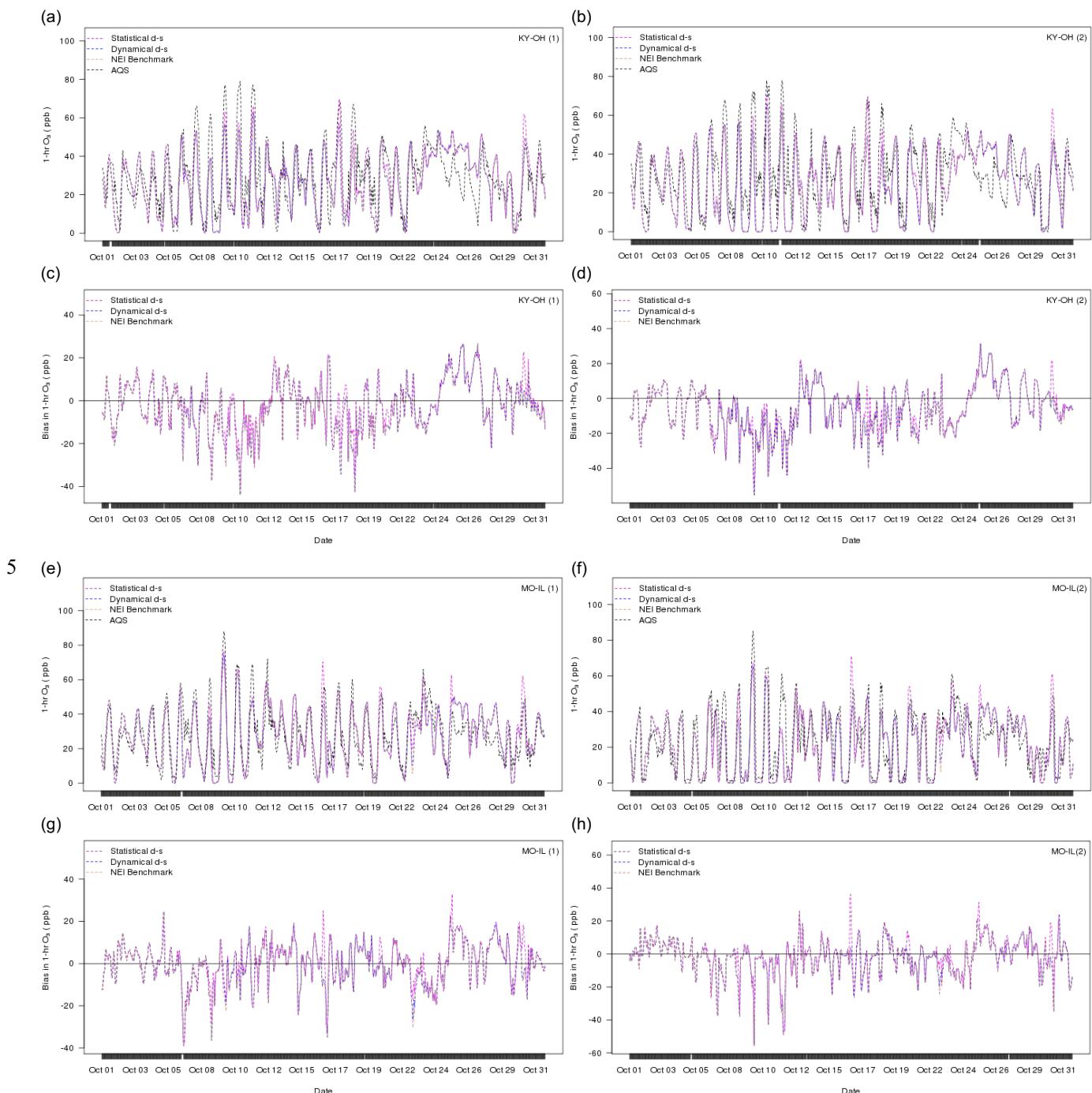


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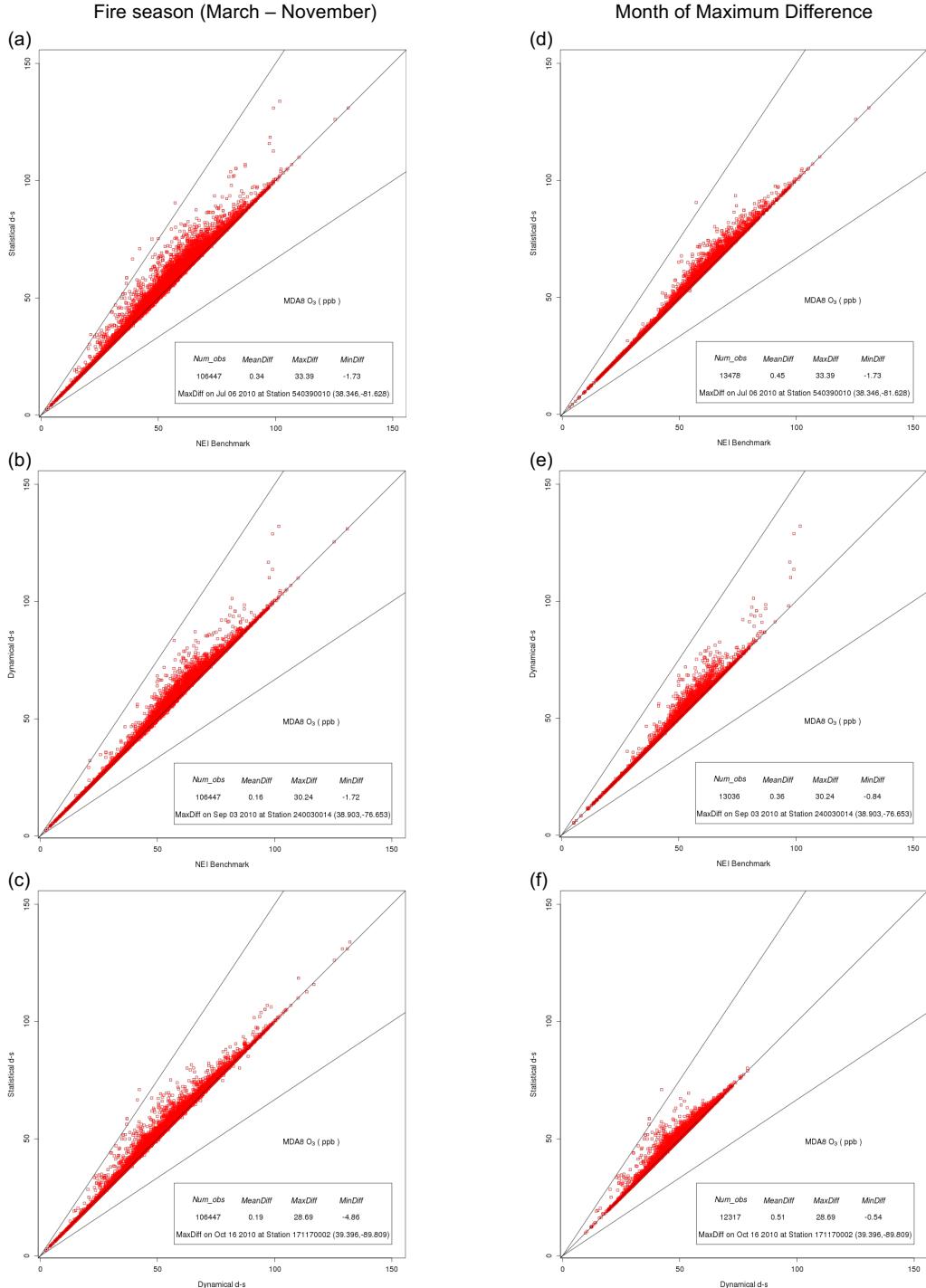
**Figure S2.** Spatial distribution of hourly ozone mean fractional bias with respect to AQS and SEARCH network observations in each season for each case modeled.



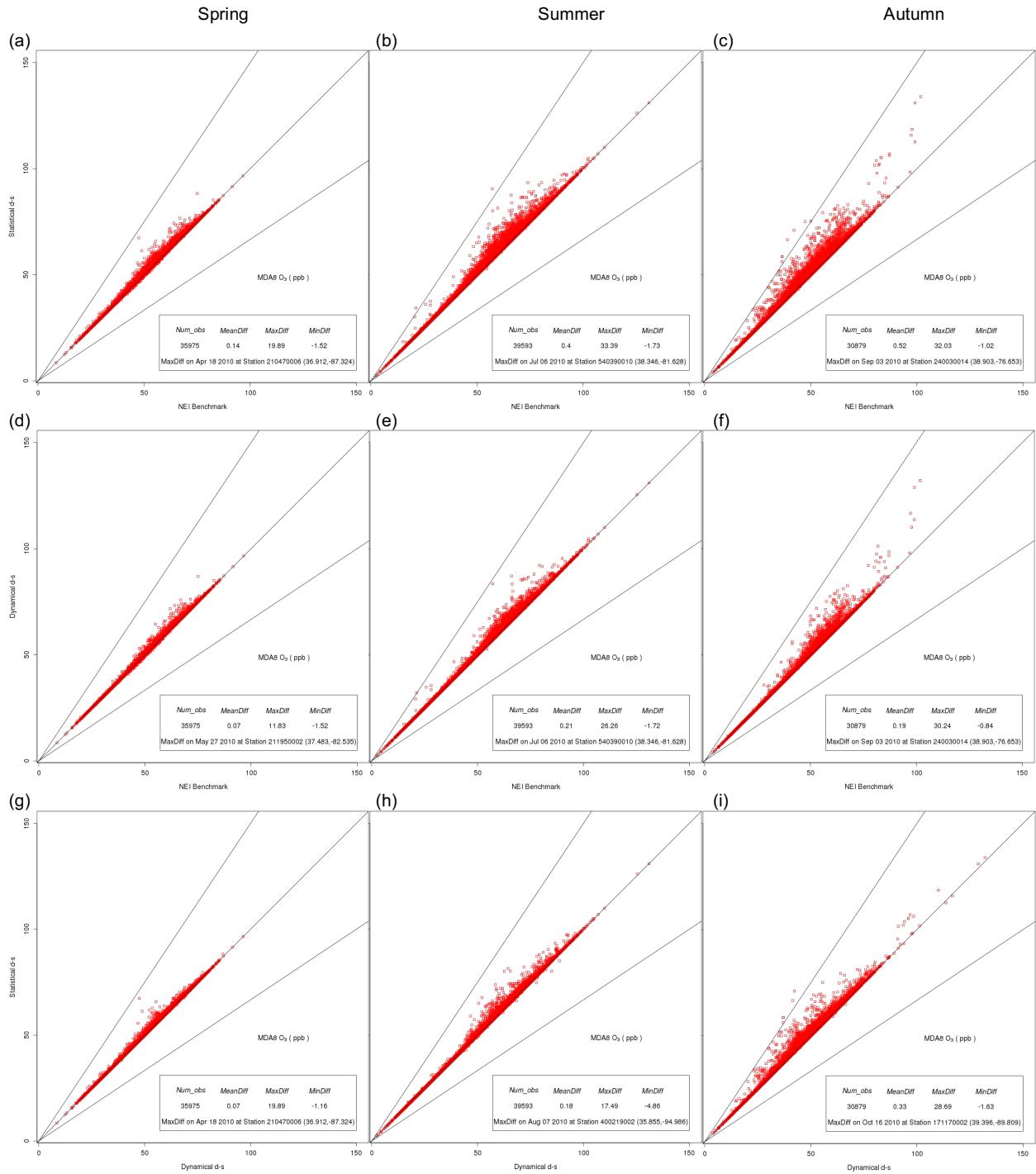
**Figure S3.** Absolute difference between the statistical d-s and dynamical d-s cases in 1-hr  $O_3$  mixing ratios (ppbV) from Hour 0 - 23 (local standard time) for the 2010 fire season (March 1 – November 30) over the whole domain (level 1).



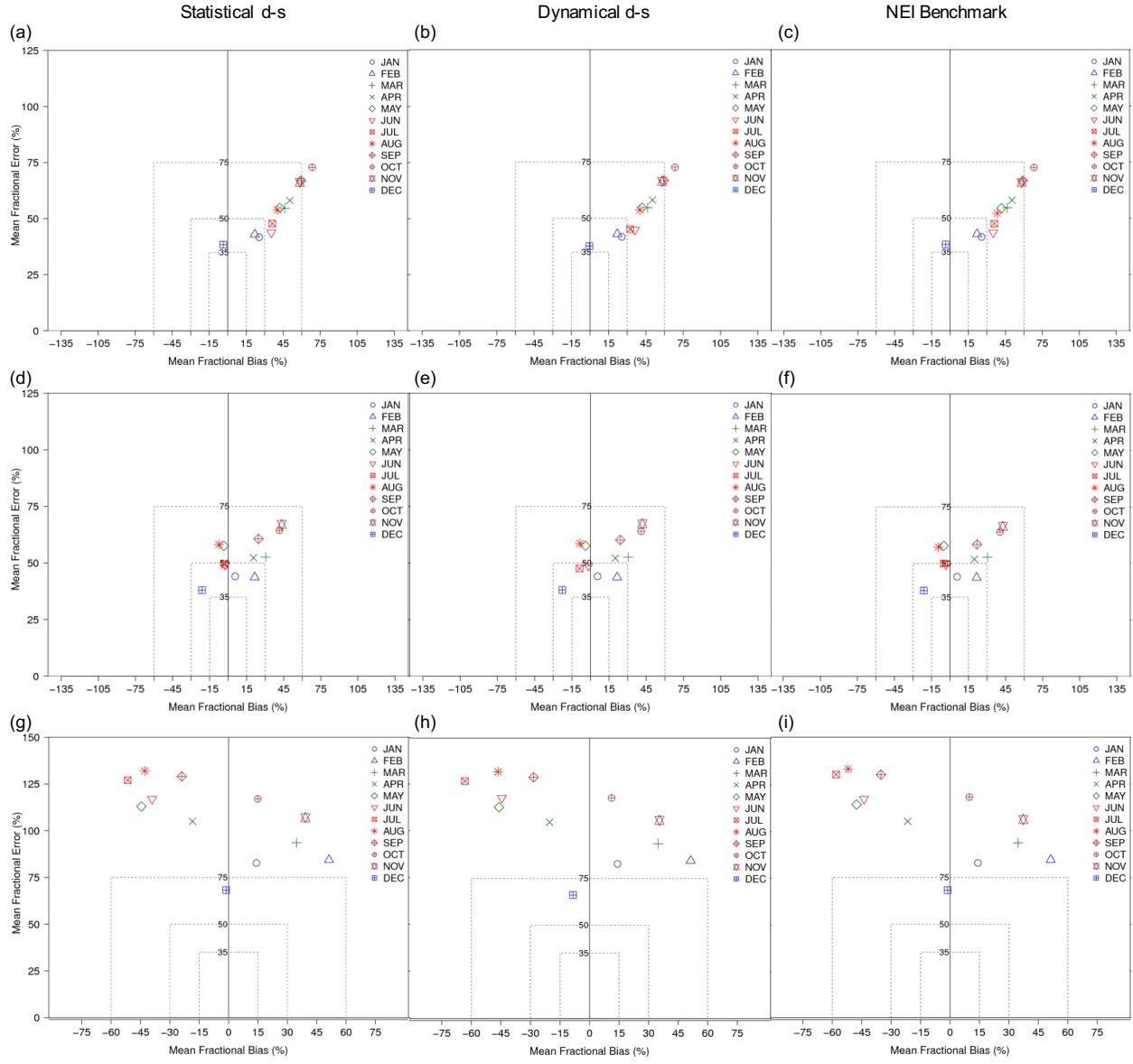
10 **Figure S4.** 1-hr ozone mixing ratios (ppb) and bias (ppb), respectively, relative to AQS observations in October 2010 at (a, c) KY-OH (1), site 210590005 and (b, d) KY-OH (2), site 210910012, located on the Kentucky–Ohio border, and (e, g) MO-IL (1), site 291831002 and (f, h) MO-IL (2), site 295100085, located on the Missouri–Illinois border.



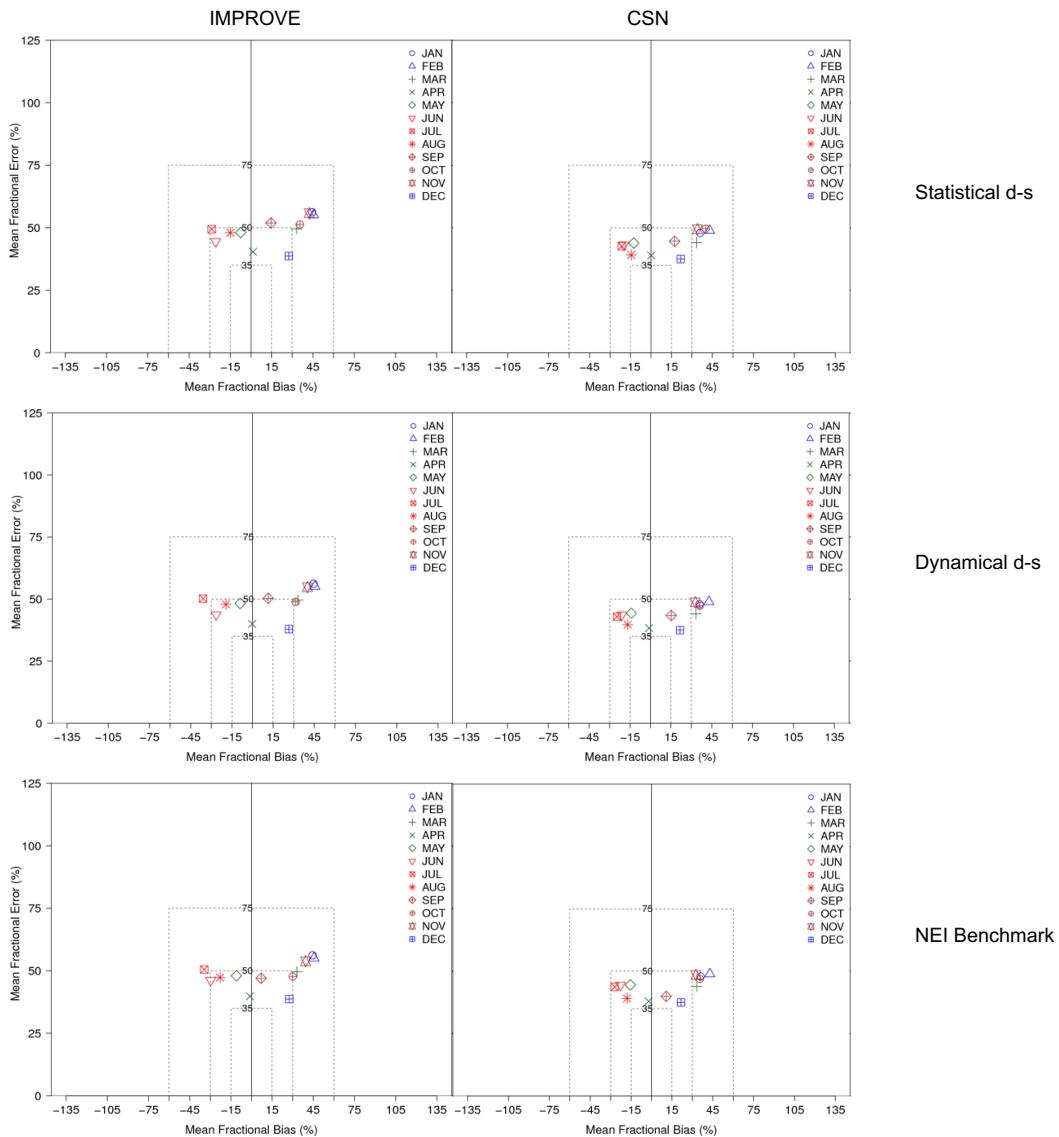
**Figure S5.** Comparisons of each pair of wildfire emissions methods for daily maximum 8-hr average (MDA8)  $O_3$  (ppb) predicted at grid cells containing both Air Quality System (AQS) monitors and wildfires in 2010: (a, d) statistical d-s vs. NEI benchmark, (b, e) dynamical d-s vs. NEI benchmark and (c, f) statistical d-s vs. dynamical d-s. Monthly simulations are for (d) July, (e) September and (f) October.



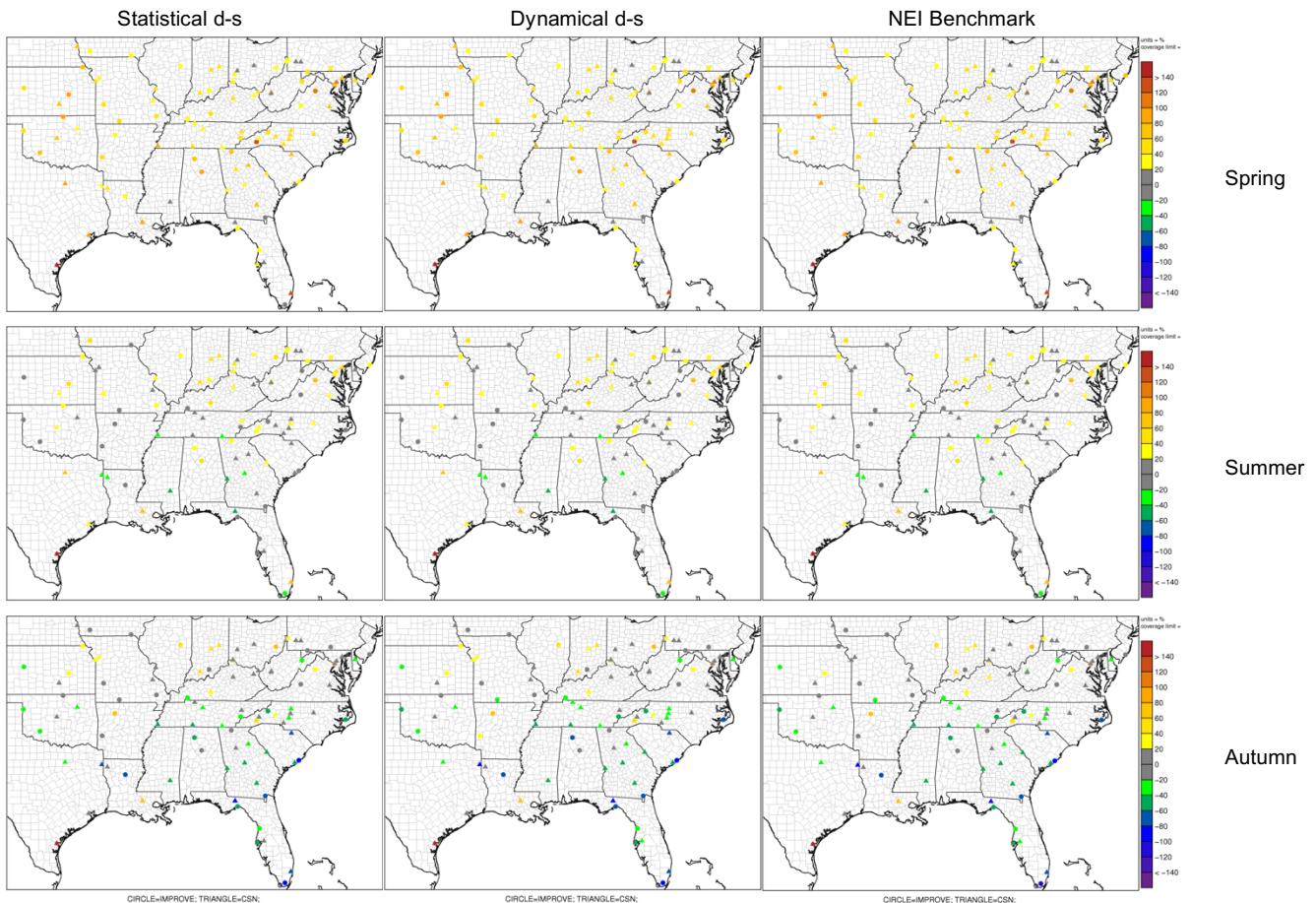
**Figure S6.** Seasonal comparisons of each pair of wildfire emissions methods for daily maximum 8-hr average (MDA8)  $O_3$  (ppb) at grid cells containing both Air Quality System (AQS) monitors and wildfires in 2010: **(a, b, c)** statistical d-s vs. NEI benchmark, **(d, e, f)** dynamical d-s vs. NEI benchmark, and **(g, h, i)** statistical d-s vs. dynamical d-s.



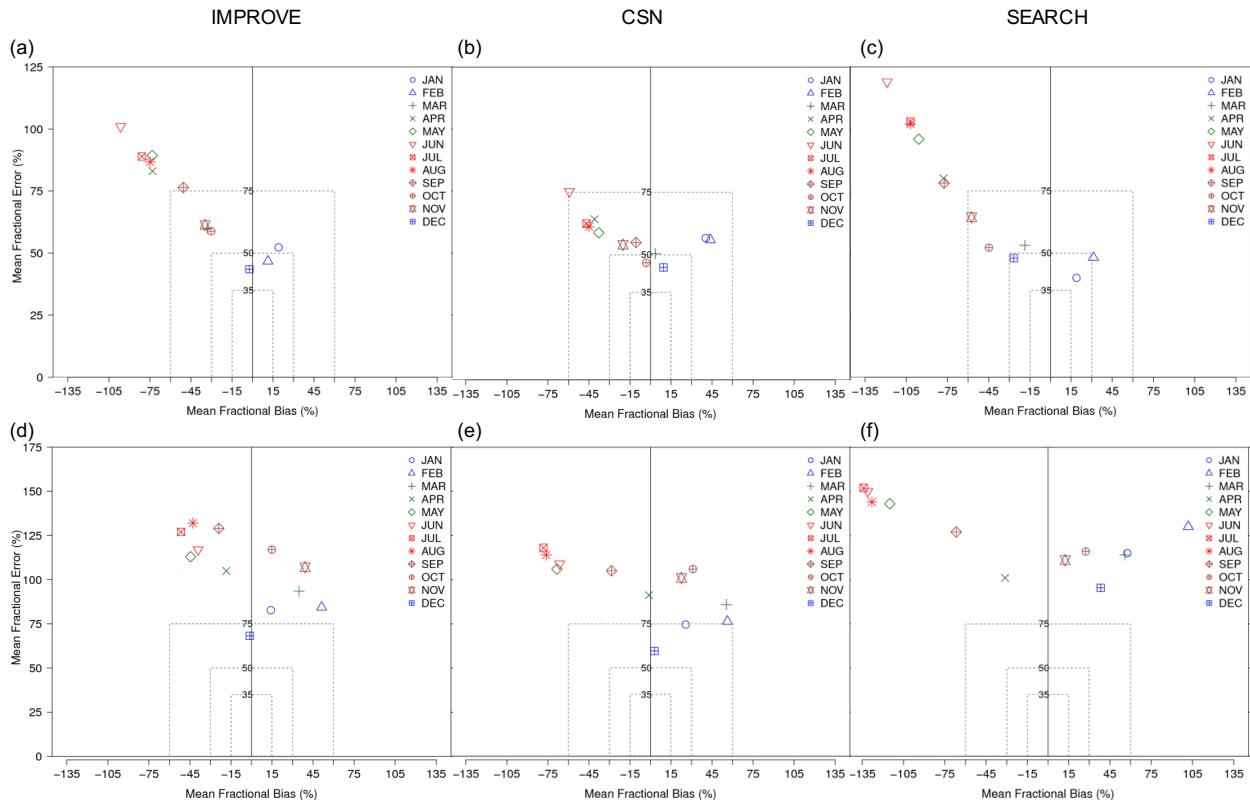
**Figure S7.** Monthly averaged model performance for inorganic PM constituents relative to observations from the IMPROVE monitoring network: (a, b, c) sulfate ( $\text{SO}_4$ ), (d, e, f) ammonium ( $\text{NH}_4$ ) and (g, h, i) nitrate ( $\text{NO}_3$ ).



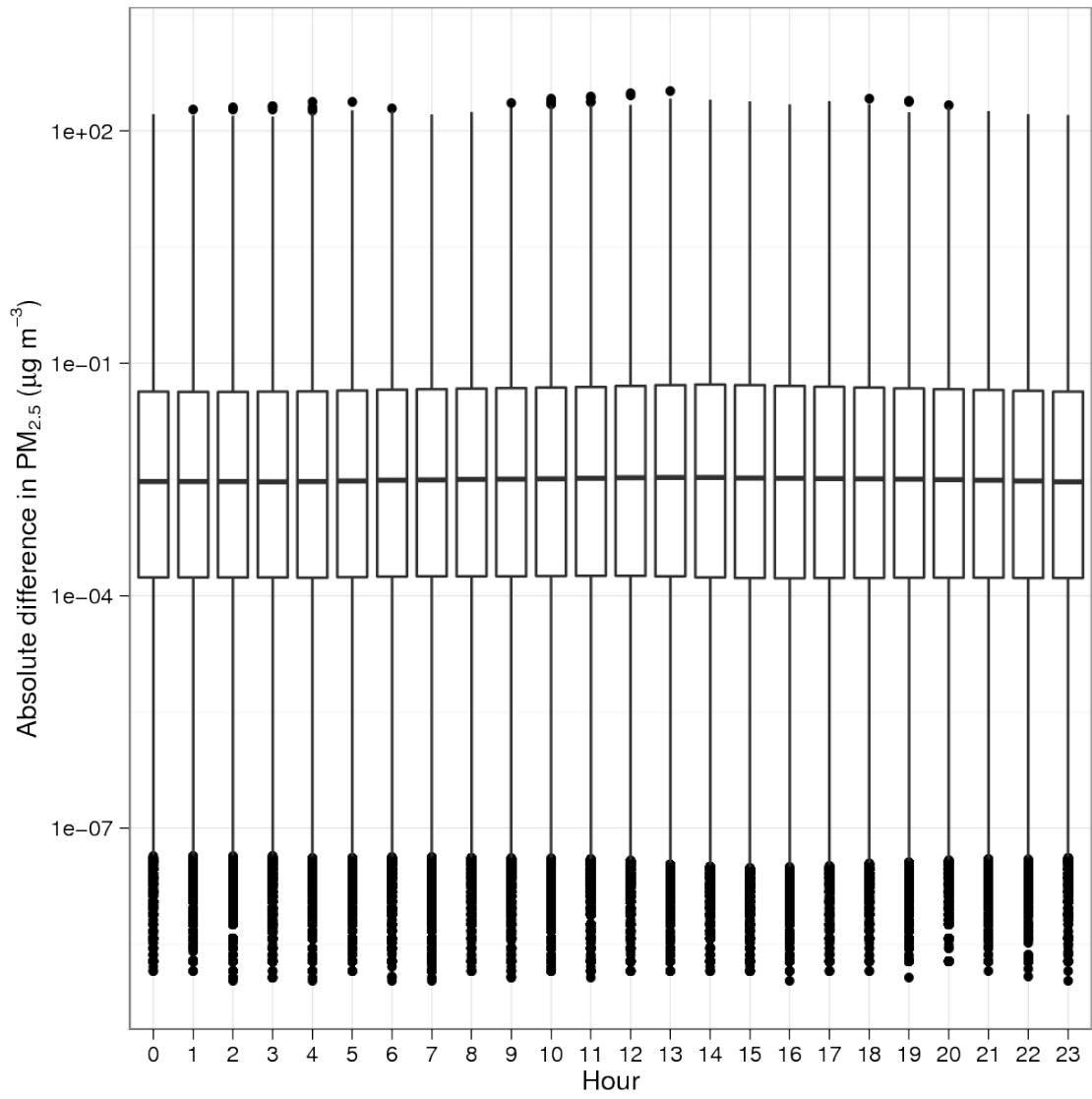
**Figure S8.** Monthly averaged model performance comparisons for total PM<sub>2.5</sub> between the IMPROVE and CSN monitoring networks for each case modeled.



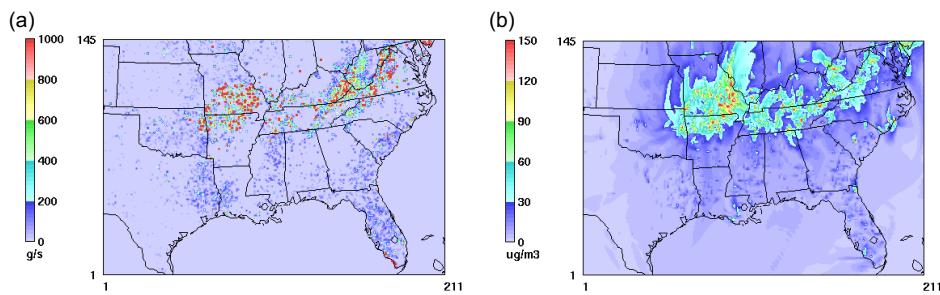
**Figure S9.** Spatial distribution of total PM<sub>2.5</sub> mean fractional bias with respect to IMPROVE and CSN measurements in each season for each case modeled.



**Figure S10.** Monthly averaged model performance comparisons for PM constituents from statistical d-s among multiple monitoring network sites: **(a, b, c)** organic carbon (OC), and **(g, h, i)** nitrate ( $\text{NO}_3$ ).



**Figure S11.** Absolute difference between the statistical d-s and dynamical d-s cases in in  $\text{PM}_{2.5}$  concentrations ( $\mu\text{g m}^{-3}$ ) from Hour 0 - 23 (local standard time) for the 2010 fire season (March 1 – November 30) over the whole domain (level 1).



**Figure S12.** Maximum absolute difference between statistical d-s and dynamical d-s in each grid cell over the fire season in: (a) hourly wildfire PM<sub>2.5</sub> column emissions ( $\text{g s}^{-1}$ ), and (b) hourly PM<sub>2.5</sub> concentrations ( $\mu\text{g m}^{-3}$ ) in model layer 1. Here the fire season is defined as April 23 – November 30; almost all grid cell maxima in absolute hourly PM<sub>2.5</sub> concentration differences occurred in this time period.

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