

**Seasonal Variability in Local Carbon Dioxide Combustion Sources over the Central and Eastern US using Airborne In-Situ Enhancement Ratios**

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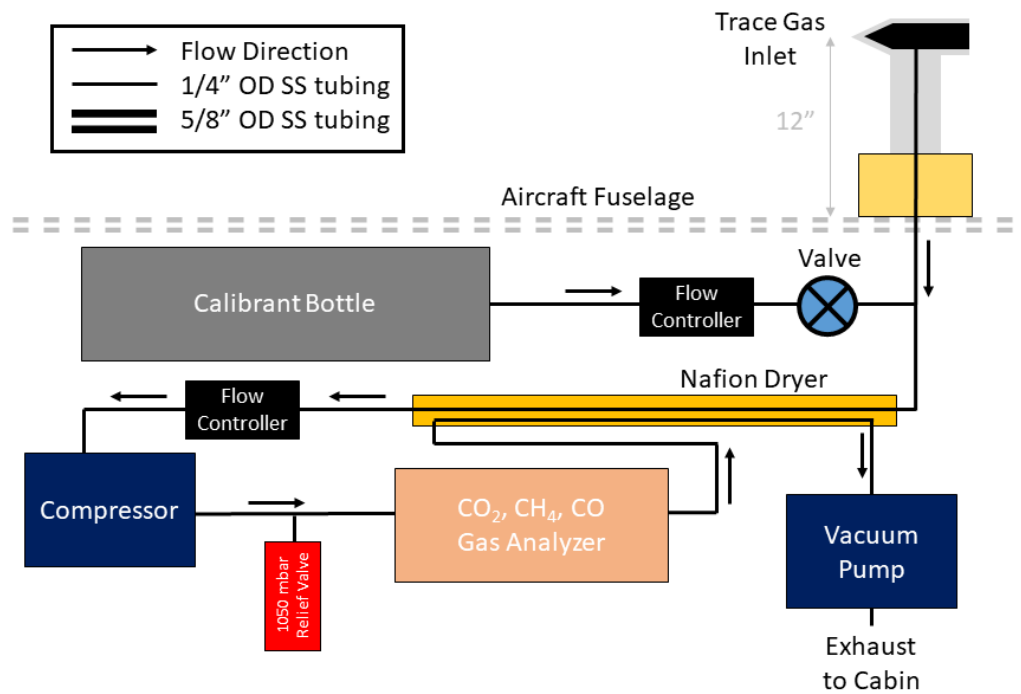
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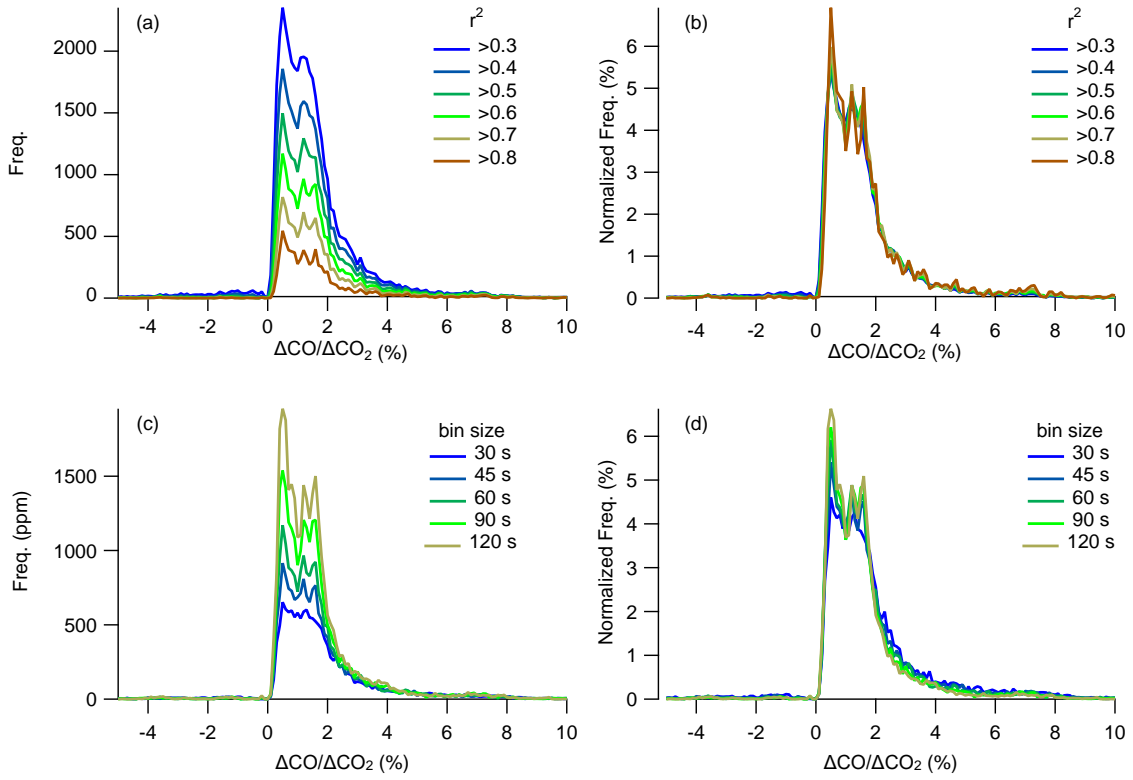
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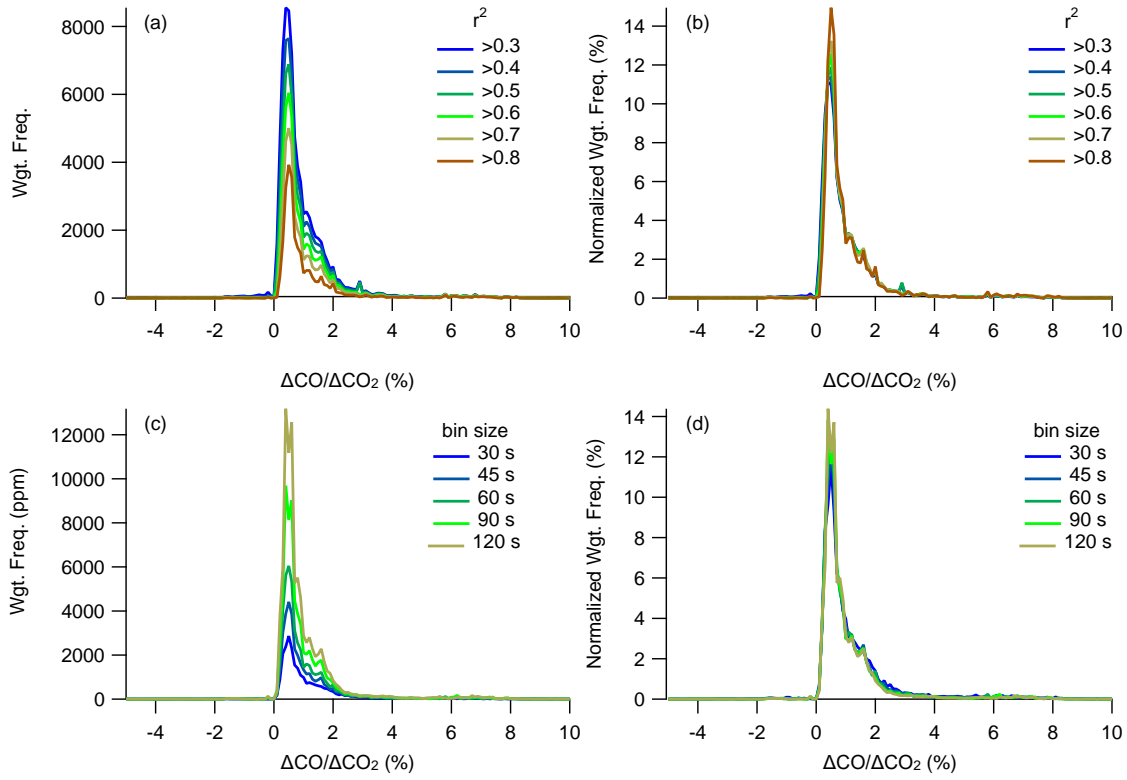
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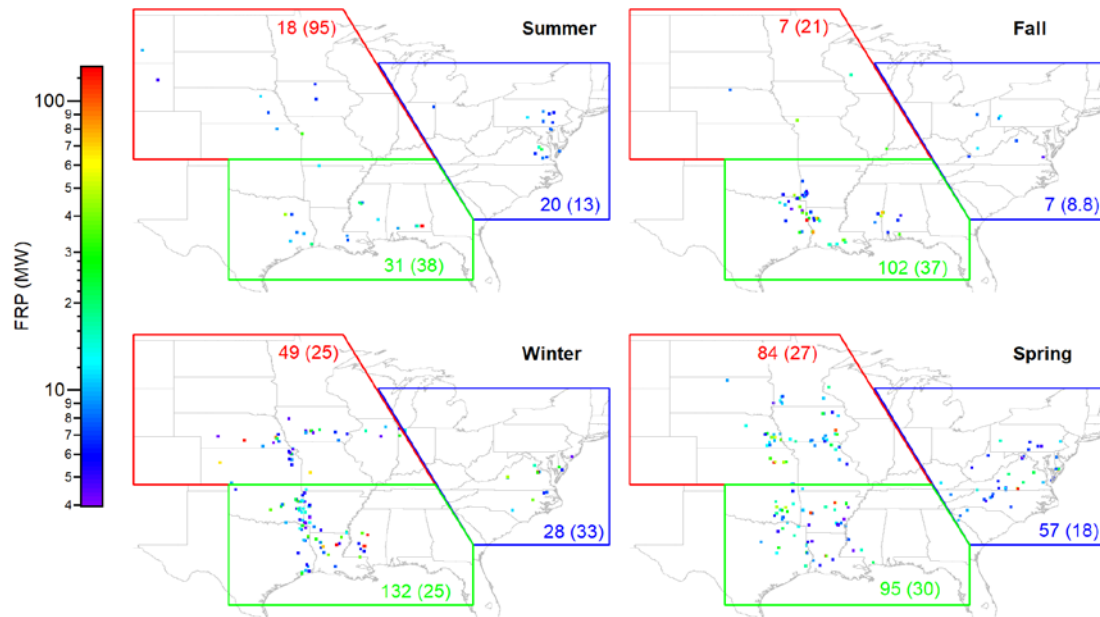
**Figure S1.** Gas system diagram for airborne trace gas analyzer used on both aircraft during all ACT-America campaigns.



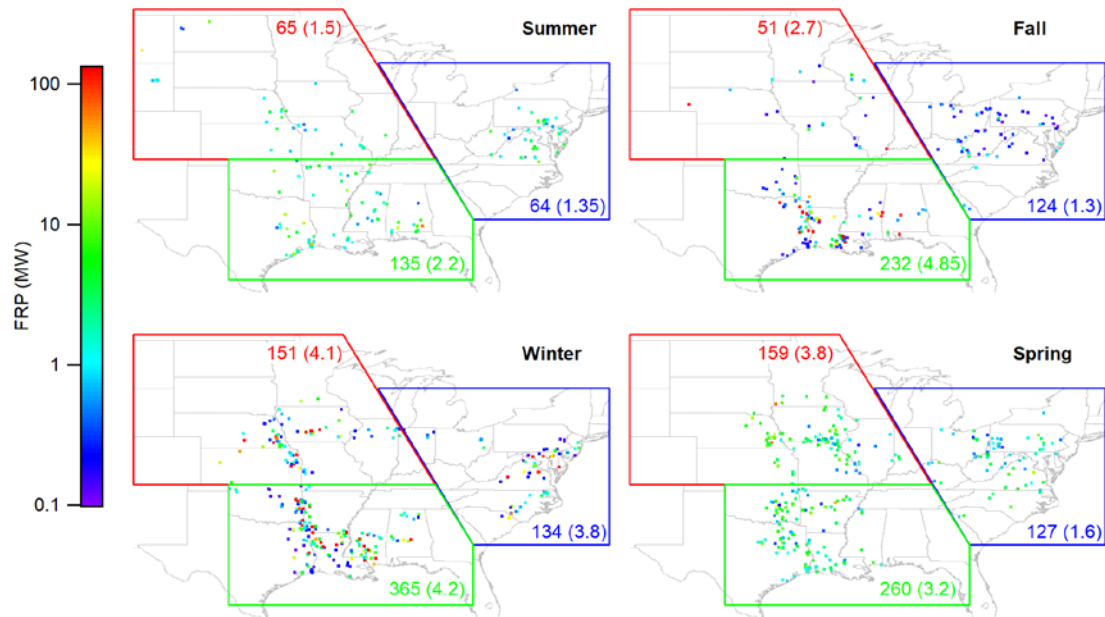
**Figure S2.** Sensitivity tests of frequency of fit  $\Delta\text{CO}/\Delta\text{CO}_2$  slopes during the winter 2017 deployment. (a) Raw frequency and (b) bin-normalized frequency with respect to different  $r^2$  cutoff levels at a constant bin width of 60 s. (c) Raw frequency and (d) bin-normalized frequency normalized by total number of bins with respect to different bin window sizes at a constant  $r^2$  cutoff of 0.6.



**Figure S3.** Sensitivity tests of  $\Delta\text{CO}_2$ -weighted frequency of fit  $\Delta\text{CO}/\Delta\text{CO}_2$  slopes during the winter 2017 deployment. (a)  $\Delta\text{CO}_2$ -weighted frequency and (b)  $\Delta\text{CO}_2$ -weighted bin-normalized frequency with respect to different  $r^2$  cutoff levels at a constant bin width of 60 s. (c)  $\Delta\text{CO}_2$ -weighted frequency and (d)  $\Delta\text{CO}_2$ -weighted bin-normalized frequency with respect to different bin window sizes at a constant  $r^2$  cutoff of 0.6.



**Figure S4.** MODIS 1 km fire counts (dots) and FRP in MW (dot color) on flight dates within 50 km of flight track when below 1 km AGL separated by season and region. Colored boxes denote the different flight regions (Mid-Atlantic: blue, Midwest: red, South: green).



**Figure S5.** VIIRS 375 m fire counts (dots) and FRP in MW (dot color) on flight dates within 14 km of flight track when below 1 km AGL altitude separated by season and region. Colored boxes denote the different flight regions (Mid-Atlantic: blue, Midwest: red, South: green).

$\Delta\text{CO}:\Delta\text{CO}_2$  NWF

Season	Region	FF				BB
		0 – 0.5%	0.5 – 1%	1 – 2%	2 – 4%	> 4%
Summer 2016	All	92.92±2.90%	5.75±0.30%	1.15±0.21 %	0.13±0.06%	0.04±0.02%
	Mid-Atlantic	93.17±5.48%	5.67±0.67%	0.92±0.34%	0.11±0.06%	0.12±0.04%
	Midwest	94.14±4.25%	4.48±0.74%	1.21±0.42%	0.17±0.06%	0.0002±0.0006%
	South	92.24±2.84%	6.36±0.50%	1.26±0.30%	0.12±0.09%	0.02±0.03%
Fall 2017	All	79.62±1.46%	15.97±1.94%	3.60±0.62%	0.55±0.24%	0.26±0.10%
	Mid-Atlantic	87.84±2.44%	10.03±1.21%	1.89±0.74%	0.21±0.12%	0.03±0.03%
	Midwest	70.39±2.92%	21.85±3.41%	6.67±1.31%	0.78±0.25%	0.31±0.08%
	South	76.95±1.69%	18.26±2.19%	3.61±0.69%	0.75±0.45%	0.43±0.23%
Winter 2017	All	55.12±2.27%	32.51±3.55%	6.30±0.82%	1.84±0.63%	4.23±0.68%
	Mid-Atlantic	36.02±4.87%	56.38±6.93%	5.98±1.81%	1.51±0.51%	0.11±0.15%
	Midwest	77.32±4.48%	15.87±2.22%	3.24±1.38%	0.91±0.52%	2.65±0.65%
	South	51.71±2.81%	25.65±1.79%	9.79±1.21%	3.06±0.93%	9.80±1.68%
Spring 2018	All	69.34±5.16%	20.99±4.48%	4.42±0.54%	2.35±0.95%	2.89±0.83%
	Mid-Atlantic	68.37±7.72%	26.90±8.11%	4.32±0.61%	0.33±0.21%	0.08±0.09%
	Midwest	82.34±4.60%	13.24±1.57%	3.27±1.36%	0.85±0.54%	0.29±0.26%
	South	58.32±7.57%	18.13±2.63%	5.66±1.15%	7.37±2.64%	10.51±2.81%

**Table S1.** Positive NWF values from airborne  $\Delta\text{CO}:\Delta\text{CO}_2$  ratios separated combustion regime.

$\Delta\text{CO}/\Delta\text{CO}_2$  NWF

Season	Region	FF					BB
		< 0%	0 – 0.5%	0.5 – 1%	1 – 2%	2 – 4%	> 4%
Summer 2016	All	36.48±2.86%	59.02±2.90%	3.66±0.30%	0.73±0.21%	0.08±0.06%	0.03±0.02%
	Mid-Atlantic	50.93±5.89%	45.72±5.48%	2.78±0.67%	0.46±0.34%	0.05±0.06%	0.06±0.04%
	Midwest	48.86±4.19%	48.14±4.25%	2.29±0.74%	0.62±0.42%	0.09±0.06%	0.000±0.001%
	South	11.86±2.77%	81.30±2.84%	5.61±0.50%	1.11±0.30%	0.11±0.09%	0.01±0.03%
Fall 2017	All	4.45±1.51%	76.08±1.46%	15.26±1.94%	3.44±0.62%	0.53±0.24%	0.25±0.10%
	Mid-Atlantic	8.33±1.67%	80.52±2.44%	9.20±1.21%	1.73±0.75%	0.19±0.12%	0.03±0.03%
	Midwest	3.33±1.91%	68.04±2.92%	21.12±3.41%	6.45±1.31%	0.76±0.25%	0.30±0.08%
	South	1.45±1.19%	75.84±1.69%	17.99±2.19%	3.56±0.70%	0.74±0.45%	0.43±0.23%
Winter 2017	All	1.20±0.95%	54.46±2.27%	32.11±3.55%	6.22±0.82%	1.82±0.63%	4.18±0.68%
	Mid-Atlantic	1.13±0.89%	35.61±4.87%	55.74±6.93%	5.92±1.81%	1.49±0.51%	0.11±0.15%
	Midwest	0.78±0.74%	76.72±4.48%	15.75±2.22%	3.22±1.38%	0.90±0.52%	2.63±0.65%
	South	1.68±1.34%	50.84±2.81%	25.22±1.79%	9.62±1.21%	3.01±0.93%	9.63±1.68%
Spring 2018	All	16.06±2.19%	58.20±5.16%	17.62±4.48%	3.71±0.54%	1.97±0.95%	2.43±0.83%
	Mid-Atlantic	19.23±2.72%	55.22±7.72%	21.73±8.11%	3.49±0.61%	0.27±0.21%	0.06±0.09%
	Midwest	5.73±3.41%	77.64±4.60%	12.48±1.57%	3.08±1.36%	0.80±0.54%	0.28±0.26%
	South	18.58±1.75%	47.49±7.57%	14.76±2.63%	4.61±1.15%	6.00±2.64%	8.56±2.81%

**Table S2.** All NWF values from airborne  $\Delta\text{CO}:\Delta\text{CO}_2$  ratios separated combustion regime.



Season	Summer				Fall			
Region	All	MA	MW	S	All	MA	MW	S
Total CO <sub>2</sub> (mol km <sup>-1</sup> hr <sup>-1</sup> )	3107	3571	2231	3724	3210	4963	2528	2306
Electrical Production (%)	40	41	29	47	47	49	47	42
Onroad (%)	36	39	44	28	27	25	28	31
Industrial (%)	12	8.2	9.3	17	11	10	5.7	16
Commercial (%)	1.6	1.6	2.5	0.9	5.6	6.2	7.0	2.8
Nonroad (%)	5.7	5.7	8.9	3.5	3.3	2.7	4.6	3.2
Residential (%)	1.0	1.3	1.4	0.6	3.8	4.1	5.0	2.1
Rail (%)	1.0	0.3	2.5	0.4	0.8	0.3	1.8	0.5
Airport (%)	1.6	1.4	2.2	1.4	1.1	0.8	1.2	1.7
CMV (%)	0.7	1.6	0.0	0.5	0.7	0.9	0.0	0.9
Cement (%)	0.3	0.8	0.2	0.1	0.4	0.3	0.9	0.1

Season	Winter				Spring			
Region	All	MA	MW	S	All	MA	MW	S
Total CO <sub>2</sub> (mol km <sup>-1</sup> hr <sup>-1</sup> )	3031	4091	1966	3190	2625	3369	2054	2427
Electrical Production (%)	36	40	19	41	32	35	25	36
Onroad (%)	32	33	39	28	41	43	45	32
Industrial (%)	13	6.8	12	21	13	8.3	11	23
Commercial (%)	6.6	7.3	12	2.5	2.8	2.8	3.9	1.7
Nonroad (%)	4.1	4.1	6.5	2.6	5.6	5.2	7.7	3.9
Residential (%)	4.5	5.2	7.8	1.7	2.2	2.7	2.7	0.9
Rail (%)	0.9	0.4	2.5	0.5	0.9	0.5	2.0	0.5
Airport (%)	1.6	1.4	1.9	1.6	1.8	1.6	2.1	1.6
CMV (%)	1.1	1.7	0.0	1.2	0.6	0.9	0.0	0.7
Cement (%)	0.1	0.3	0.1	0.0	0.2	0.2	0.3	0.1

**Table S3.** All average Vulcan emission values along separated by sector, season, and region (MA:Mid-Atlantic, MW:Midwest, S:South). Individual sector percent contributions are relative to the total CO<sub>2</sub> emission in the top row.