**Supplemental Material**

**Atmospheric oil and natural gas hydrocarbon trends in the Northern Colorado Front Range are notably smaller than inventory emissions reductions**

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**List of Contents**

Figures

Figure S1: Monthly propane mole fractions at NWR for 2012-2017. The horizontal red line in each box is the median, the box spans the 25th and 75th percentiles, the vertical bars the 5th and 95th percentiles, the red pluses values >95th percentile, and the green dots are the mean. N = the number of flask sample observations.

Figure S2: PSCF for the ratio of i-pentane/n-pentane <1 for 2007-2016 (all seasons; n = 2520) in flasks collected during daytime hours at BAO (black dot).

Figure S3: Monthly mole fractions of methane at BAO and NWR for 2008-2015. The box whisker format is the same as in Fig. S1.

Figure S4: Correlation between BAO residual methane (ppm) and propane (ppb) for samples with wind directions from the NE quadrant for 2007-2012 (top left panel) and 2013-2016 (top right panel), and for all daytime samples for 2007-2012 (bottom left panel) and 2013-2016 (bottom right panel).

Figure S5: Photochemical season (May-Sept) mole fractions of methane at NWR (left panel) and BAO (right panel) for 2008-2015 for all daytime samples. The box whisker format is as in Fig. S1.

Figure S6: Ratio of the monthly median mole fractions of methane at BAO and NWR for 2008-2016 for all daytime samples. For each year, there are twelve monthly values (except 2016 where only January-June had samples), and the plotted symbols represent the variability of the twelve-monthly values, but do not include the variability of individual samples within the month. The box whisker format is the same as in Fig. S1.

Figure S7: i-pentane as a function of n-pentane at BAO for photochemical season daytime samples, color-coded for the concurrent propane mole fraction in the sample.

Figure S8: Ratio of the mole fractions of i-pentane to n-pentane at BAO for the years 2008-2015 for the full year (left panel) and photochemical season (right panel) for all daytime samples. The box whisker format is the same as in Fig. S1.

Figure S9: Mole fractions of acetylene at BAO for the years 2008-2015 for the full year (left panel) and photochemical season (right panel). Note the different y-axis scale on the two panels. The box whisker format is the same as in Fig. S1.

Figure S10: Ratio of acetylene/i-pentane (left panel) and acetylene/propane (right panel) mole fractions for samples with wind directions from the south sector. Note the different y-axis scale on the two panels. The box whisker format is as in Fig. S1.

Tables

Table S1: Number of flask samples collected each year at the BAO tower. The number of days on which samples were collected is also shown. During certain periods (primarily 2008-2012), samples were collected in pairs so that the number of days with samples is less than the total number of samples.

Table S2: Trend statistics for propane mole fractions at BAO for 2008-2015 for daytime samples with wind directions from the south sector.

Table S3: Trend statistics for methane mole fractions at NWR for 2008-2015 using all daytime samples.

Table S4a: Trend statistics for methane mole fractions at BAO for 2008-2015 using all daytime samples.

Table S4b: Trend statistics for methane mole fractions at BAO for 2008-2015 using daytime samples with wind directions from the NE quadrant.

Table S5: Trend statistics for the ratio of BAO to NWR methane mole fractions for 2008-2016 using all BAO daytime samples and NWR monthly medians.

Table S6: Trend statistics for the ratio of i-pentane to n-pentane at BAO for 2008-2015 for samples with wind directions from the south sector.

Table S7a: Trend statistics for acetylene mole fractions at BAO for 2008-2015 using daytime samples with wind directions from the NE quadrant.

Table S7b: Trend statistics for acetylene mole fractions at BAO for 2008-2015 for samples with wind directions from the south sector.

A screenshot of a cell phone

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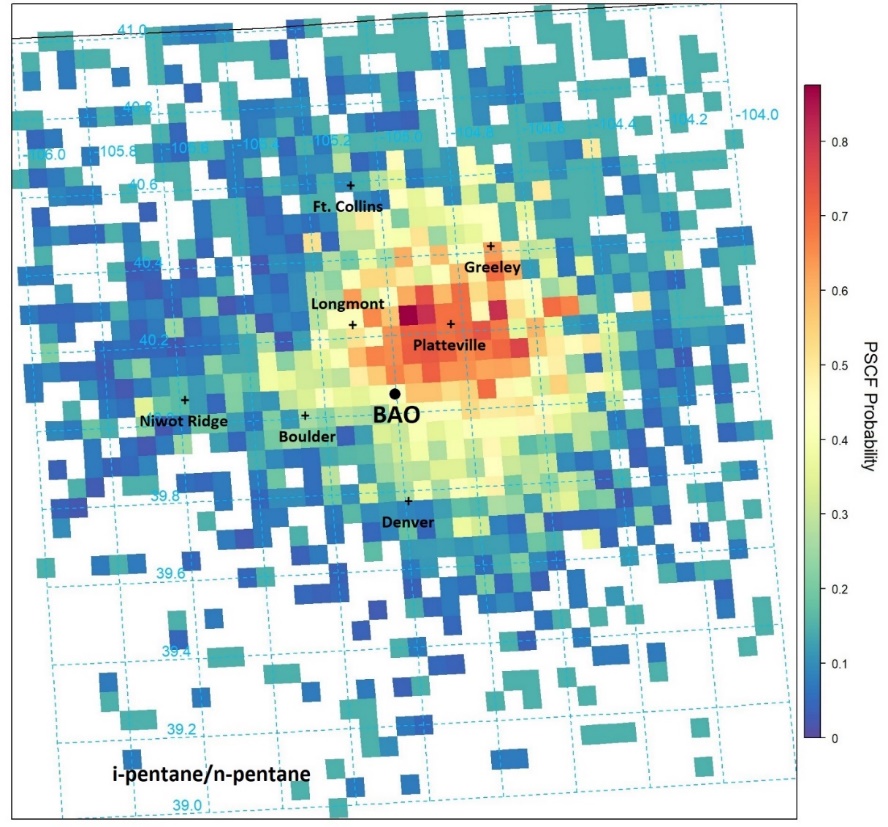


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Chart, scatter chart

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Figure S5: Photochemical season (May-Sept) mole fractions of methane at NWR (left panel) and BAO (right panel) for 2008-2015 for all daytime samples. The box whisker format is as in Fig. S1.

A close up of text on a white background

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Description automatically generated

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A close up of text on a white background

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A close up of a piece of paper

Description automatically generated

Figure S9: Mole fractions of acetylene at BAO for the years 2008-2015 for the full year (left panel) and photochemical season (right panel) for all daytime samples. Note the different y-axis scale on the two panels. The box whisker format is as in Fig. S1.

Chart, scatter chart, box and whisker chart

Description automatically generated

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Table S1: Number of flask samples collected each year at the BAO tower. The number of days on which samples were collected is also shown. During certain periods (primarily 2008-2012) samples were collected in pairs so that the number of days with samples is less than the total number of samples.

|  |  |  |
| --- | --- | --- |
| Year | Daytime  Samples | Days with  Samples |
| 2007 (Aug-Dec) | 144 | 94 |
| 2008 | 529 | 325 |
| 2009 | 504 | 263 |
| 2010 | 503 | 322 |
| 2011 | 399 | 202 |
| 2012 | 407 | 263 |
| 2013 | 298 | 298 |
| 2014 | 285 | 285 |
| 2015 | 374 | 254 |
| 2016 (Jan-Jul) | 144 | 137 |

Table S2: Trend statistics for propane mole fractions at BAO for 2008-2015 for daytime samples with wind directions from the south sector.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Propane | Full Year | | | | Photochemical Season (May-Sept) | | | |
|  | Value (ppb) | Slope  (ppb yr-1) | 2 Sigma Standard Deviation (ppb yr-1) | P-Value | Value (ppb) | Slope  (ppb yr-1) | 2 Sigma Standard Deviation (ppb yr-1) | P-Value |
| Mean | 8.151 | -1.663 | 8.317 | 0.301 | 2.809 | -0.118 | 0.281 | 0.055 |
| Median | 2.318 | -0.118 | 0.283 | 0.056 | 1.755 | -0.029 | 0.357 | 0.662 |
| 5th %ile | 0.428 | -0.024 | 0.073 | 0.117 | 0.397 | -0.023 | 0.165 | 0.457 |
| 25th %ile | 1.072 | -0.060 | 0.170 | 0.094 | 0.940 | -0.045 | 0.216 | 0.288 |
| 75th %ile | 4.664 | -0.109 | 0.674 | 0.395 | 3.644 | -0.057 | 0.866 | 0.721 |
| 95th %ile | 14.922 | -10.685 | 56.498 | 0.326 | 8.854 | -0.518 | 0.872 | 0.015 |

Table S3: Trend statistics for methane mole fractions at NWR for 2008-2015 using all daytime samples.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Methane | | Full Year | | | | Photochemical Season (May-Sept) | | | |
|  | | Value (ppm) | Slope  (ppm yr-1) | 2 Sigma Standard Deviation (ppm yr-1) | P-Value | Value (ppm) | Slope  (ppm yr-1) | 2 Sigma Standard Deviation  (ppm yr-1) | P-Value |
| Mean | 1.860 | | 0.007 | 0.003 | 0.000 | 1.847 | 0.006 | 0.004 | 0.000 |
| Median | 1.859 | | 0.007 | 0.002 | 0.000 | 1.845 | 0.006 | 0.003 | 0.000 |
| 5th %ile | 1.820 | | 0.005 | 0.006 | 0.003 | 1.813 | 0.005 | 0.007 | 0.004 |
| 25th %ile | 1.841 | | 0.007 | 0.003 | 0.000 | 1.828 | 0.006 | 0.006 | 0.002 |
| 75th %ile | 1.875 | | 0.007 | 0.005 | 0.000 | 1.861 | 0.007 | 0.005 | 0.000 |
| 95th %ile | 1.908 | | 0.006 | 0.011 | 0.020 | 1.896 | 0.006 | 0.019 | 0.132 |

Table S4a: Trend statistics for methane mole fractions at BAO for 2008-2015 using all daytime samples.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Methane | Full Year | | | | Photochemical Season (May-Sept) | | | |
|  | Value (ppm) | Slope  (ppm yr-1) | 2 Sigma Standard Deviation (ppm yr-1) | P-Value | Value (ppm) | Slope  (ppm yr-1) | 2 Sigma Standard Deviation (ppm yr-1) | P-Value |
| Mean | 1.912 | 0.005 | 0.010 | 0.029 | 1.896 | 0.004 | 0.009 | 0.050 |
| Median | 1.896 | 0.005 | 0.008 | 0.014 | 1.883 | 0.006 | 0.009 | 0.009 |
| 5th %ile | 1.836 | 0.006 | 0.004 | 0.000 | 1.828 | 0.006 | 0.005 | 0.001 |
| 25th %ile | 1.867 | 0.006 | 0.005 | 0.001 | 1.857 | 0.004 | 0.004 | 0.002 |
| 75th %ile | 1.938 | 0.005 | 0.012 | 0.056 | 1.924 | 0.004 | 0.016 | 0.219 |
| 95th %ile | 2.036 | 0.005 | 0.027 | 0.314 | 1.996 | -0.007 | 0.019 | 0.078 |

Table S4b: Trend statistics for methane mole fractions at BAO for 2008-2015 using daytime samples with wind directions from the northeast quadrant.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Methane | Full Year | | | | Photochemical Season (May-Sept) | | | |
|  | Value (ppm) | Slope  (ppm yr-1) | 2 Sigma Standard Deviation (ppm yr-1) | P-Value | Value (ppm) | Slope  (ppm yr-1) | 2 Sigma Standard Deviation (ppm yr-1) | P-Value |
| Mean | 1.940 | 0.005 | 0.015 | 0.095 | 1.917 | 0.004 | 0.011 | 0.089 |
| Median | 1.924 | 0.004 | 0.011 | 0.088 | 1.904 | 0.005 | 0.014 | 0.098 |
| 5th %ile | 1.854 | 0.006 | 0.005 | 0.001 | 1.845 | 0.006 | 0.004 | 0.000 |
| 25th %ile | 1.888 | 0.006 | 0.008 | 0.005 | 1.876 | 0.007 | 0.008 | 0.003 |
| 75th %ile | 1.968 | 0.002 | 0.019 | 0.499 | 1.941 | 0.002 | 0.015 | 0.431 |
| 95th %ile | 2.077 | 0.011 | 0.043 | 0.198 | 2.029 | -0.002 | 0.030 | 0.775 |

Table S5: Trend statistics for the ratio of BAO to NWR methane mole fractions for 2008-2016 using all BAO daytime samples and NWR monthly medians.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Methane | Full Year | | | Photochemical Season (May-Sept) | | |
|  | Slope  (yr-1) | 2 Sigma Standard Deviation (yr-1) | P-Value | Slope  (yr-1) | 2 Sigma  Standard Deviation (yr-1) | P-Value |
| Mean | -0.001 | 0.005 | 0.300 | -0.001 | 0.005 | 0.340 |
| Median | -0.001 | 0.004 | 0.237 | 0.000 | 0.005 | 0.999 |
| 5th %ile | -0.001 | 0.003 | 0.209 | 0.000 | 0.007 | 0.699 |
| 25th %ile | 0.000 | 0.003 | 0.668 | 0.000 | 0.004 | 0.844 |
| 75th %ile | -0.001 | 0.006 | 0.318 | -0.001 | 0.008 | 0.522 |
| 95th %ile | -0.002 | 0.015 | 0.489 | -0.005 | 0.011 | 0.019 |

Table S6: Trend statistics for the ratio of i-pentane to n-pentane at BAO for 2008-2015 for samples with wind directions from the south sector.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| i-pentane/  n-pentane | Full Year | | | Photochemical Season (May-Sept) | | |
|  | Slope  (yr-1) | 2 Sigma Standard Deviation (yr--1) | P-Value | Slope  (yr-1) | 2 Sigma  Standard Deviation (yr-1) | P-Value |
| Mean | -0.002 | 0.029 | 0.651 | -0.010 | 0.059 | 0.399 |
| Median | -0.012 | 0.032 | 0.079 | -0.022 | 0.045 | 0.035 |
| 5th %ile | -0.009 | 0.028 | 0.100 | -0.012 | 0.045 | 0.166 |
| 25th %ile | -0.012 | 0.017 | 0.006 | -0.015 | 0.025 | 0.014 |
| 75th %ile | -0.002 | 0.056 | 0.882 | -0.003 | 0.105 | 0.877 |
| 95th %ile | 0.015 | 0.069 | 0.275 | 0.016 | 0.100 | 0.394 |

Table S7a: Trend statistics for acetylene mole fractions at BAO for 2008-2015 using daytime samples with wind directions from the NE quadrant.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Acetylene | Full Year | | | | Photochemical Season (May-Sept) | | | |
|  | Value (ppb) | Slope  (ppb yr-1) | 2 Sigma Standard Deviation (ppb yr-1) | P-Value | Value (ppb) | Slope  (ppb yr-1) | 2 Sigma Standard Deviation (ppb yr-1) | P-Value |
| Mean | 0.276 | 0.000 | 0.023 | 0.974 | 0.180 | -0.003 | 0.019 | 0.486 |
| Median | 0.232 | 0.005 | 0.022 | 0.208 | 0.158 | -0.000 | 0.020 | 0.915 |
| 5th %ile | 0.089 | -0.001 | 0.009 | 0.529 | 0.081 | -0.001 | 0.009 | 0.534 |
| 25th %ile | 0.152 | 0.001 | 0.018 | 0.795 | 0.117 | 0.002 | 0.013 | 0.538 |
| 75th %ile | 0.352 | -0.003 | 0.022 | 0.447 | 0.206 | -0.003 | 0.018 | 0.349 |
| 95th %ile | 0.590 | -0.011 | 0.059 | 0.322 | 0.383 | -0.012 | 0.067 | 0.335 |

Table 7b: Trend statistics for acetylene mole fractions at BAO for 2008-2015 using daytime samples with wind directions from the south.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Acetylene | Full Year | | | | Photochemical Season (May-Sept) | | | |
|  | Value (ppb) | Slope  (ppb yr-1) | 2 Sigma Standard Deviation (ppb yr-1) | P-Value | Value (ppb) | Slope  (ppb yr-1) | 2 Sigma Standard Deviation (ppb yr-1) | P-Value |
| Mean | 0.331 | -0.001 | 0.025 | 0.768 | 0.169 | -0.003 | 0.019 | 0.432 |
| Median | 0.250 | 0.001 | 0.025 | 0.873 | 0.150 | 0.000 | 0.015 | 0.972 |
| 5th %ile | 0.091 | -0.001 | 0.008 | 0.454 | 0.082 | -0.001 | 0.010 | 0.594 |
| 25th %ile | 0.153 | 0.002 | 0.012 | 0.423 | 0.111 | -0.001 | 0.006 | 0.325 |
| 75th %ile | 0.406 | -0.004 | 0.033 | 0.510 | 0.200 | -0.003 | 0.020 | 0.438 |
| 95th %ile | 0.878 | -0.010 | 0.120 | 0.660 | 0.312 | -0.009 | 0.069 | 0.466 |