

Supporting Information

RELATIVE INFLUENCE OF TRANS-PACIFIC AND REGIONAL ATMOSPHERIC TRANSPORT OF PAHS IN THE PACIFIC NORTHWEST, USA

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Appendix I. Sampling Sites and Sample Collection

Forty-three 24 hr PM_{2.5} air samples (~2500 m³ of air per sample) were collected at MBO from March to May in 2010 (27 samples) and March to May in 2011 (16 samples). Daily site access for changing the air sampling media was not possible in times of extreme weather. During the sampling periods, measurements of submicron aerosols (nephelometer) and meteorological parameters (wind speed/direction, temperature, and humidity) were conducted at MBO by the Jaffe Group (University of Washington-Bothell)¹⁻⁴.

Eighty-six 24 hr PM_{2.5} air samples (~1900 m³ of air per sample) were collected between March and December in 2010 (43 samples) and March and September in 2011 (43 samples) at Cabbage Hill, on an alternate 6 day sampling schedule. During the sampling period, direct mass measurements of PM_{2.5} were made at CTUIR's Mission sampling site (45.68°N 118.65°W, 391.7 m asl, ~10 km from Cabbage Hill site) using a Thermo Scientific Taper Oscillating Microbalance (TEOM) monitor (Thermo Scientific, Franklin, MA, USA) (see Figure 1). Direct PM_{2.5} mass measurements were also made during the sampling period at the Oregon Department of Environmental Quality (ODEQ) air quality monitoring station in Pendleton, OR (45.65°N 118.82°W, 318.8 m asl, ~18 km from the Cabbage Hill Sampling site) (see Figure 1).

Appendix II. Sample Extraction and Chemical Analysis

The methods used for the sample extraction and analysis of PAHs⁵, NPAHs⁶, and OPAHs⁶ have been previously validated. The QFFs were extracted using a pressurized liquid extraction (PLE) method validated by Wang et. al. and Jariyasopit et al.⁵ After extracting the filters twice with dichloromethane (DCM), the resulting extract was split in half by weight. One half of the extract was prepared for toxicological testing by evaporating it to dryness under a stream of N₂ with a Turbovap II (Calipur Life Sciences, MA) and then reconstituting this residue with 500 μ L of dimethyl sulfide (DMSO). The other half of the extract was used for chemical analysis and spiked with a standard set of isotopically labeled PAH and NPAH surrogates (d10-fluorene, d10-phenanthrene, d12-triphenylene, d10-pyrene, d12-benzo(a)pyrene, d12-benzo(ghi)perylene d7-1-nitronaphthalene, d9-nitroacenaphthene, d9-5-nitroacenaphthene, d9-3-nitrofluoranthene, d9-1-nitropyrene) for quantitation. This extract was solvent exchanged to hexane and purified using a 20 g silica gel column (Mega BE-SI, Agilent Technologies, New Castle, DE) by eluting three 50 mL fractions of 100% hexane (HEX), 100% dichloromethane (DCM), and 100% ethyl acetate (EA). The DCM fraction (containing the PAHs, NPAHs and OPAHs) was concentrated to 330 μ L under a gentle stream of N₂, solvent exchanged to ethyl acetate and spiked with isotopically labeled PAH and NPAH internal standards (d10-acenaphthene, d10-fluoranthene, d9-2-nitrobiphenyl, d9-2-nitrofluorene).

The chemical analysis extract was analyzed for parent PAHs using gas chromatography mass spectrometry (Agilent 6890 GC coupled with an Agilent 5973N MSD) in selected ion monitoring (SIM) mode, using electron impact ionization (EI).^{7,8} Electron capture negative ionization (ECNI), with a programmed temperature vaporization (PTV) inlet (Gerstel, Germany) and SIM, was used to analyze for NPAHs and OPAHs.⁶ A 5% phenyl substituted methylpolysiloxane GC column (DB-5MS, 30 m x 0.25 mm I.D., 0.25 μ m film thickness, J&W

Scientific) was used to separate and measure the parent PAHs, NPAHs, and OPAHs.

A signal-to-noise ratio of 10:1 was used to define the limit of quantitation. Site specific estimated detection limits (EDLs) were calculated from EPA-method 8280A,⁸ and were defined as a signal-to-noise ratio of 3:1 in the sample matrix.

Appendix III. Air Mass Back Trajectory Generation and Data Analysis

Ten day air mass back-trajectories were calculated using NOAA's ARL HYSPLIT online model⁹ and data from the GDAS (Global Data Assimilation System) archive, which has a time resolution of 3h, and a spatial resolution of 1° latitude by 1° longitude for trajectories ran before July 28, 2010 and a spatial resolution of 0.5 ° latitude by 0.5 ° longitude for trajectories ran after July 28, 2010. Back-trajectories were calculated at three arrival elevations above model ground level (1300, 1500, and 1700 m for MBO and 400, 600 and 800 m for CTUIR), every 3 h over the 24 h sampling period (including the start and stop time) for a total of 27 trajectories per sample. These three elevations were used because the elevations of MBO and CTUIR are ~1400 m and ~1000 m above model ground level, respectively, in HYSPLIT.¹⁰ The 10 day back trajectories were used to determine the impact of different source regions (Oregon, Washington, California, Asia, Siberia, British Columbia, Alaska, West and East) on the air masses sampled (Figure 1). The calculation outlined by Primbs et. al.¹¹ was used to determine source region impact factor (SRIF) percentages. In brief, SRIFs describe the amount of time an air mass spent prior to sampling in a given source region, as compared to the total trajectory time over the sampling period.

Equation 1 describes how the SRIFs were calculated. For each sampling day, the time the back trajectories spent in a given source region (T_{SR}) was assigned a binary response: 1 if it was in the given source region and 0 if it was not. This was done for every hour of the 240 hour back trajectories ($n = 1-240$ h). SRIFs were then calculated by taking the total number of hours spent in a given source region and dividing by 6480 hours [240 (length of time of the back trajectory) x 27 (the total number of trajectories per sample)]. This fraction was then presented as a percentage:

$$SRIF(\%) = \left\{ \frac{[\sum_{n=1}^{240} (n(T_{SR})=1; otherwise=0)] hours}{6480 \text{ hours}} \right\} \times 100 \quad (1)$$

The trajectories were also imported into ArcGIS (ESRI, Redlands, California) and Google Earth[®] (Google, Mountain View, CA) for spatial representation. R version 3.0.2 (Free Software Foundation, Inc., Boston, MA) and Sigma Plot version 12.3 (Systat Software Inc., San Jose, CA) were used for statistical analysis. To corroborate the back trajectory analysis at CTUIR, meteorological data was retrieved from the National Climatic Data Center Archive¹² for Eastern Oregon's Municipal Airport (45.70 °N 118.83°W, 452.9 asl) located ~20 km north west of the Cabbage Hill sampling site.

Appendix IV. AMES Assay

The method reported by Maron et. al.¹³ was followed and has been described in detail elsewhere.⁶ In this study, Salmonella strains TA98 (Xenometrix, Inc, Allschwil, Switzerland) were used. In brief, the test was ran without and with metabolic activation by quickly mixing; 2 mL molten top agar (45°C), 30 µL samples in DMSO, 0.1 mL of bacteria, and 0.5 mL of phosphate buffered saline or rat S9 mix (an exogenous metabolic activation system based on rat liver enzymes) in a sterile disposable tube. The mixture was poured onto a Vogel-Bonner minimal agar plate and solidified. After the plates had solidified they were inverted and incubated at 37°C for 48 hr. The histidine revertant colonies were then counted with a Sorcerer Colony Counter (Perceptive Instruments, Haverhill, Suffolk, UK). All air samples were tested in triplicate. The positive control for direct mutagenicity (without metabolic activation) was (4-nitro-1,2-phenylenediamine) (NPD). The positive control for the indirect mutagenicity (with metabolic activation) was 2-Aminoanthracene (2-AA). Corresponding doses were 20 µg and 1 µg respectively. The negative control (DMSO) was dosed at 30 µL. The average background revertant counts in the negative control were comparable to the control field blanks.

Figure S1 Temporal variation of mean 24 hr sum of PM₁ (bars), OC,(black line and stars) , and EC (blue line and squares) concentrations measured at MBO over the sampling period. “N.A.” indicates the PM₁ concentration for that day was not available.

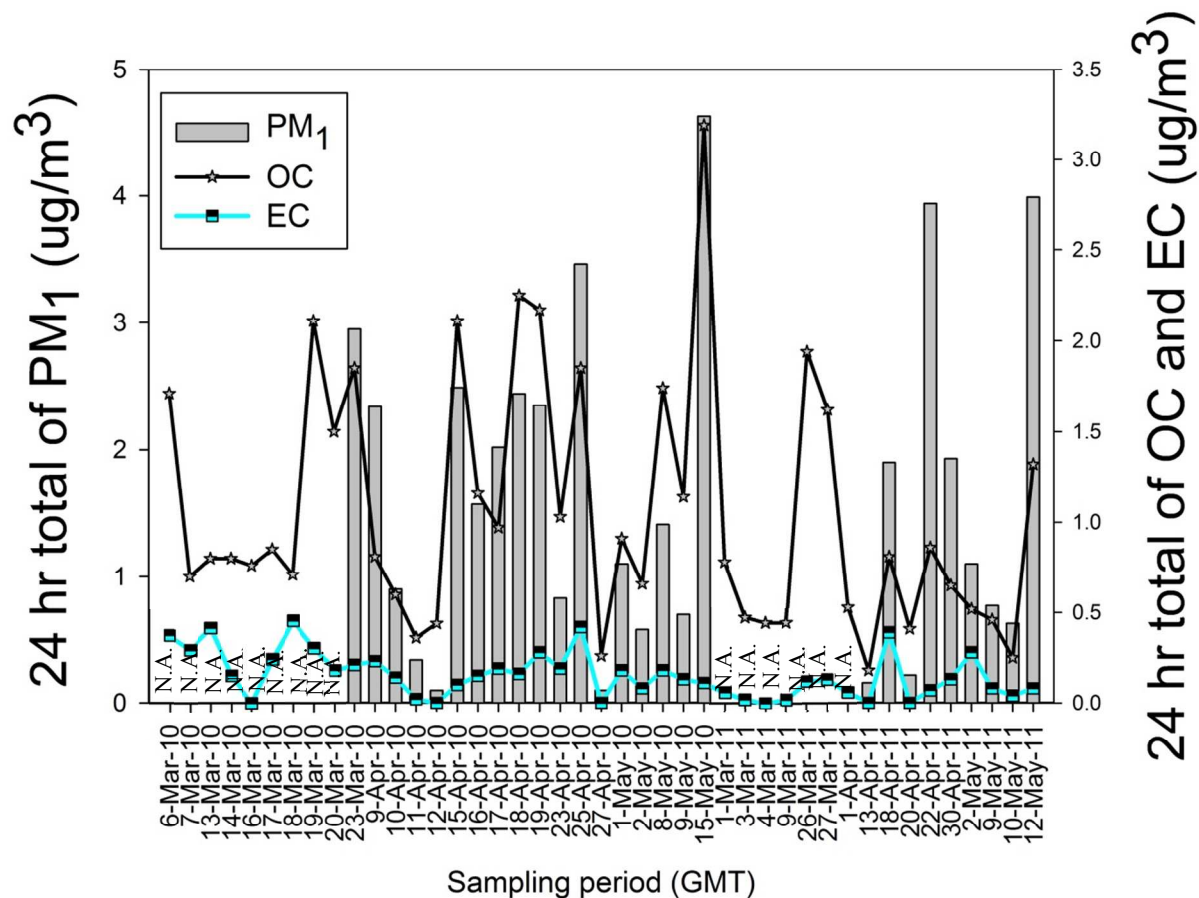


Figure S2 Source region impact factors (SRIFs) for MBO calculated using the 10 day back trajectories.

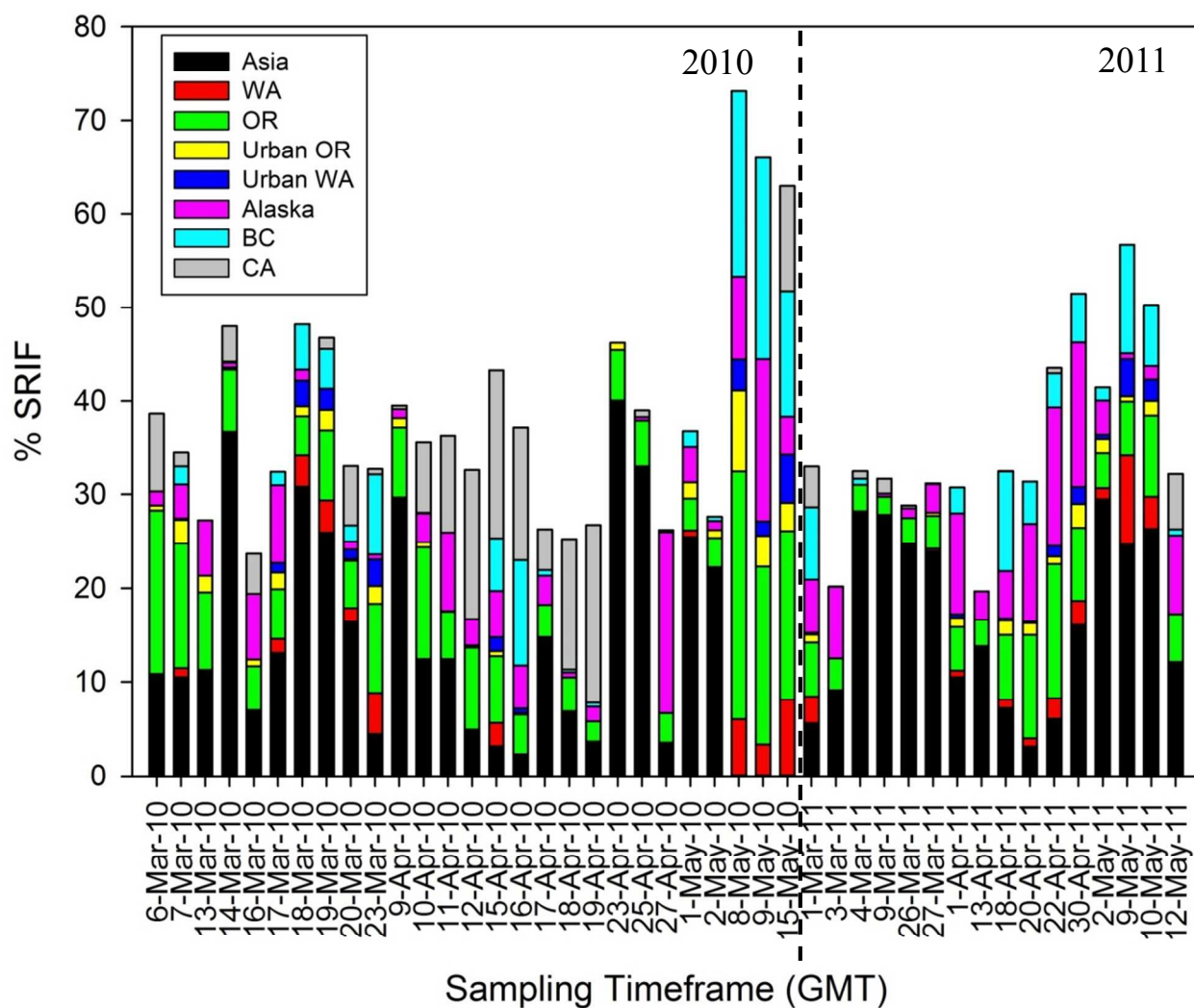


Table S1 Statistically significant correlations between PAH, NPAH, OPAH, PM_{2.5}, OC concentrations with SRIFs at MBO. (Adjusted R-square, (+) positive correlation, (-) negative correlation *p<0.05, **P<0.001).

	% Asia	% OR	% Urban OR	% WA	% Urban WA	% Alaska	% BC	%CA
2-MNAP		-0.08*						-0.07*
1,3-MNAP		-0.08*						-0.08*
6-MCHR						-0.09*		
NAP		-0.08*						
BghiP						-0.12*		
ΣPAH _{2ring}		-0.07						
1-NP						0.08*	0.12*	
6-NCH								0.11*
1,8-DNP	0.12*							
ΣNPAH ₂₇	0.08*							
BENZANT					0.08*			
OC					0.10*			0.17*
EC						-0.07*		
Ozone								0.18*
CO								0.22*
OWV	-0.09*	0.07*						0.23*
RH					0.14*			
1000/T				-0.18**	-0.28*			
Amb Pressure					0.11*			
Above BL %	0.11*	-0.08*				-0.08*		
Below BL %	-0.11	0.08*				0.08*		

Table S2: Statistically significant correlations between PAH concentrations, HYSPLIT model output (Σ precipitation during the trajectory (ppt (mm/hr)) and the amount of time the trajectories spent above or below the boundary layer (% above and % below, respectively)), weather conditions (water vapor (OWV) (g/kg), relative humidity (RH) and Ambient pressure (mbar) and Mean reciprocal site temperature ($1000/T$) (K^{-1})), and atmospheric pollutant concentrations (Ozone (ppbv) and CO (ppbv)) at MBO. (Adjusted R-square, (+) positive correlation, (-) negative correlation * $p < 0.05$).

	$\Sigma ppt.$ (mm/hr)	% Above BL	% Below BL	$1000/T$ (K^{-1})	WV (g/kg)	PM_{10} ($\mu g/m^3$)	CO (ppbv)	Ozone (ppbv)	OC ($\mu g/m^3$)	EC ($\mu g/m^3$)
2-MNAP	0.09*						-0.34*	-0.45*		
1-MNAP	0.10*						-0.28*	-0.30*		
2,6- DMNAP							-0.18*		-0.14	
1,3- DMNAP							-0.33*	-0.39*		
2-MPHE							-0.12*	-0.31*		
2-MANT								-0.23*		
1-MPHE					-0.08*		-0.13*	-0.21*		
3,6- DMPHE								-0.19*		
6-MCHR		0.09*	-0.09*					0.12*	0.10*	0.44*
NAP	0.09*						-0.30*	-0.46*		
ACY							-0.13*	-0.13*	-0.10*	-0.07*
ACE	0.07*						-0.15*			
FLO								-0.28*		
PHE								-0.25*		
ANT								-0.25*		
FLA								-0.22*		
PYR								-0.24*		
RET						0.12*			0.17*	
BcFLO								-0.23*		
BaA						0.11*		-0.22*		
CHR+TRI						0.11*		-0.21*		
BbF						0.30*		-0.25*		
BkF						0.39*		-0.24*		
BeP						0.36*		-0.17*		
BaP						0.25*		-0.20*		

Table S2(continued)

	$\Sigma ppt.$ (mm/hr)	% Above BL	% Below BL	$1000/T$ (K ⁻¹)	WV (g/kg)	PM_{10} (ug/m ³)	CO (ppbv)	Ozone (ppbv)	OC (ug/m ³)	EC (ug/m ³)
IcdP						0.37*		-0.22*		
DcaA								-0.26*		
BghiP	-0.10*			-0.09*		0.19*	0.17*	0.24*	0.19*	0.17*
ΣPAH_{2ring}	0.10*						-0.31*	-0.46*		
ΣPAH_{4ring}								-0.20*		
ΣPAH_{56ring}						0.44*		-0.23*		
ΣPAH_{USpri}								-0.25*		
ΣPAH_{32}								-0.24*		

Table S3: Statistically significant correlations between NPAH, OPAH, OC, EC, HYSPLIT model output (Σ precipitation during the trajectory (ppt (mm/hr)) and the amount of time the trajectories spent above or below the boundary layer (% above and % below, respectively)), weather conditions (water vapor (OWV) (g/kg), relative humidity (RH) and Ambient pressure (mbar) and Mean reciprocal site temperature ($1000/T$) (K^{-1})), and atmospheric pollutant concentrations (Ozone (ppbv) and CO (ppbv)) at CTUIR. (Adjusted R-square, (+) positive correlation, (-) negative correlation * $p < 0.05$).

	Σ ppt. (mm/hr)	% Above BL	% Below BL	$1000/T$ (K^{-1})	WV (g/kg)	PM_{10} ($\mu g/m^3$)	CO (ppbv)	Ozone (ppbv)	OC ($\mu g/m^3$)	EC ($\mu g/m^3$)
1-NN								-0.19*		
2-NN		0.09*	-0.09*		-0.32*					
2-NBP								0.13*		
3-NBP								0.12*	0.08*	0.08*
9-NAN								-0.20*		
(2+3)-NF										
2-NP	-0.10*	-0.12*	0.12*	-0.19*						
1,8-DNP										0.09*
9-FLU								-0.23*		
9,10-ANQ								-0.24*		
2-MANQ								-0.22*		
BaFLO							0.38*	0.17*	0.15*	0.31*
BENZANT					-0.08*					
Ben[c]-1,4							-0.10*	-0.29*		
Σ OPAH								-0.23*		
Ozone							0.32*			
PM_{10} ($\mu g/m^3$)	-0.19*									
CO		-0.17*	0.17*							
OC	-0.07*			-0.31*		0.12*				
EC		0.18*	-0.18*		-0.08*	0.13*		0.10*		

Figure S3 Ames Assay Direct Acting Mutagenicity Assay (-S9 rat liver enzyme) for sampling period A.) 2010 and B.) 2011 at MBO. [(n=3), * signifies ($p < 0.05$) significant from negative control. Error bars = 2SE (n=3)]. N.A. indicates data for that given day was not collected or not available.

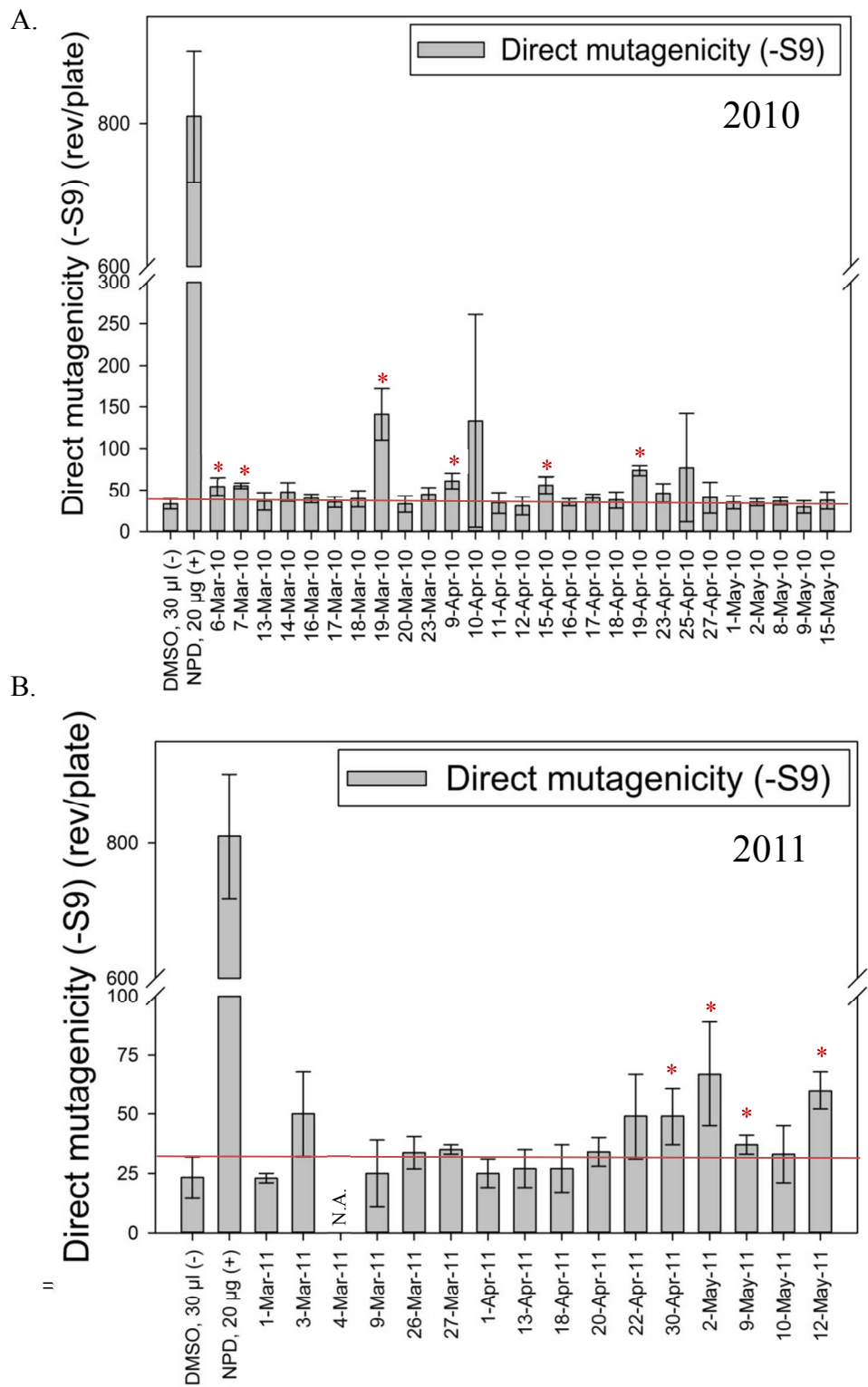


Figure S4 Source region impact factors (SRIFs) for CTUIR calculated using the 10 day back trajectories.

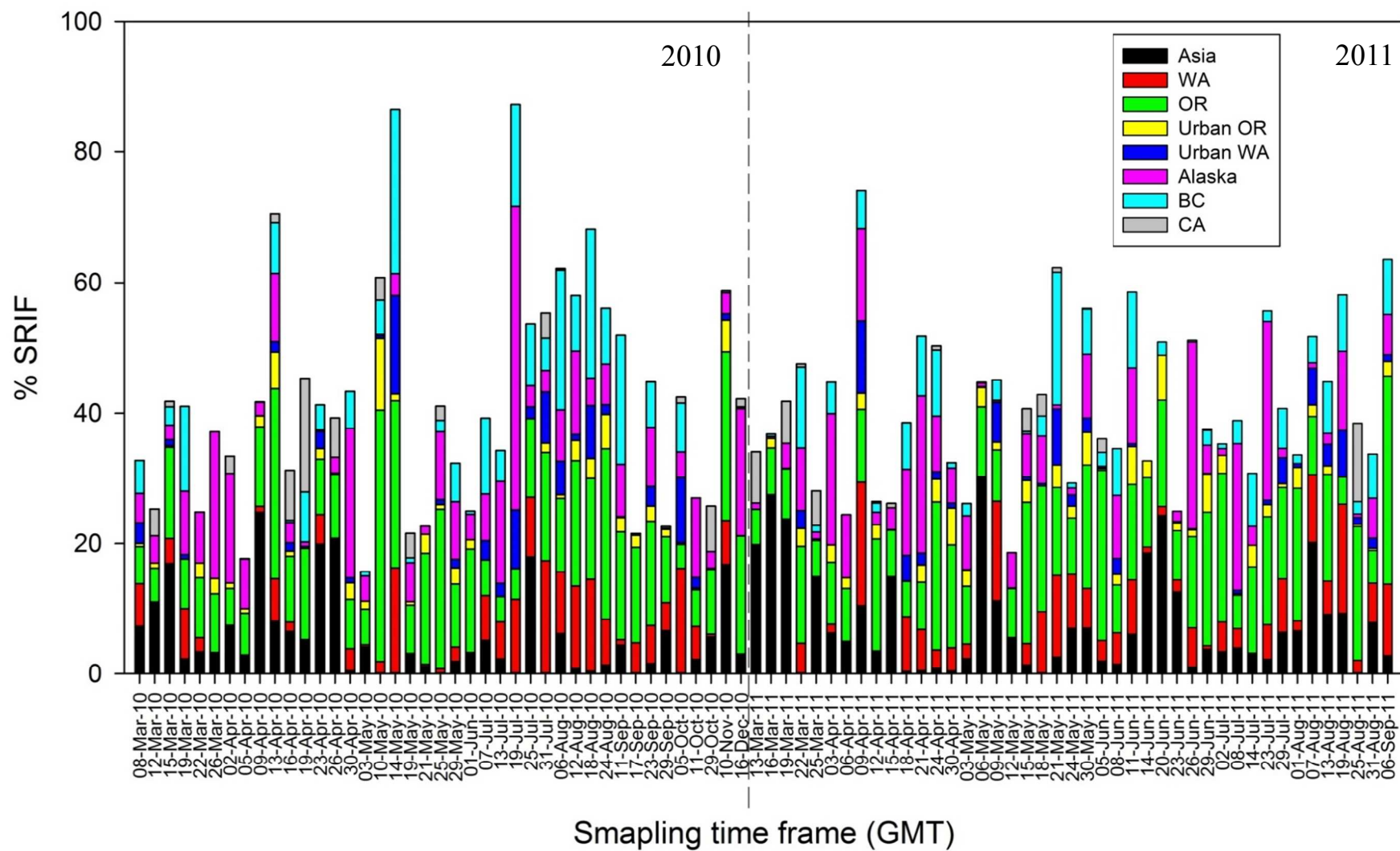
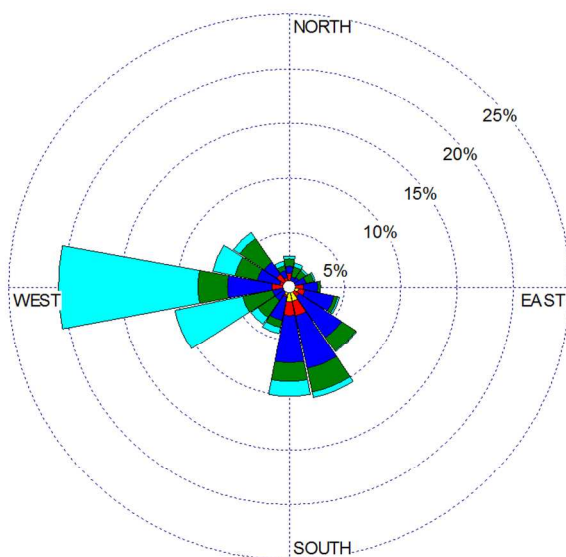


Table S4: Statistically significant correlations between PAH, NPAH, OPAH, PM_{2.5}, OC concentrations with SRIFs at CTUIR. (Adjusted R-square, (+) positive correlation, (-) negative correlation *p<0.05, **P<0.001)

	%Asia	%OR	% Urban OR	% WA	% Urban WA	% Alaska	% BC	% CA	% Siberia
2,6-DMNAP								+0.04	
1-MPYR							+0.09*		
ACY								+0.04*	
DBT				-0.03*					+0.04*
FLA					+0.05*		+0.10*		
PYR							+0.09*		
BcFLO							+0.07*		
BaA					+0.04*		+0.21*		
DacA									+0.07*
ΣPAH _{4ring}							+0.05*		
3-NBP						+0.05*			
3-NBF					+0.05*				
1-NP									+0.03*
6-NCH									+0.04*
2-NTP			+0.02*						+0.04*
9,10-ANQ							+0.07*		
Benz(c)-1,4								+0.04*	
BcdPYRO								+0.04*	
ΣOPAH ₁₀							+0.05*		
OC				+0.24**	+0.13**		+0.21**		+0.05*
Mission PM _{2.5} (ug/m ³) 24 hr –MC				+0.17**	+0.11*		+0.25**		
ODEQ PM _{2.5} (ug/m ³)				+0.04*			+0.04*		

Figure S5 Average wind roses for 2010 and 2011 for the duration of the sampling period at Eastern Oregon airport 20 km north of CTUIR using the hourly site wind speed and direction data from NOAA.

2010

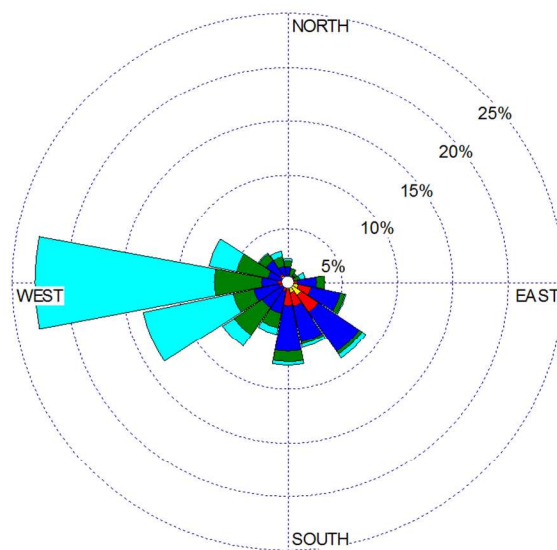


WIND SPEED
(m/s)

Cyan	≥ 11.1
Dark Green	8.8 - 11.1
Blue	5.7 - 8.8
Red	3.6 - 5.7
Yellow	2.1 - 3.6
Light Green	0.5 - 2.1

Calms: 0.00%

2011



WIND SPEED
(Knots)

Cyan	≥ 22
Dark Green	17 - 21
Blue	11 - 17
Red	7 - 11
Yellow	4 - 7
Light Green	1 - 4

Calms: 0.00%

Figure S6 Three operational timeframes (plant on (Before Upgrade), plant on (After Upgrade) and plant off) of PM_{2.5} (at Mission (bars) and ODEQ (pink line and hexagons) concentrations and OC (black line and stars) concentrations during the sampling periods N.A. indicates data for that given day was not available.

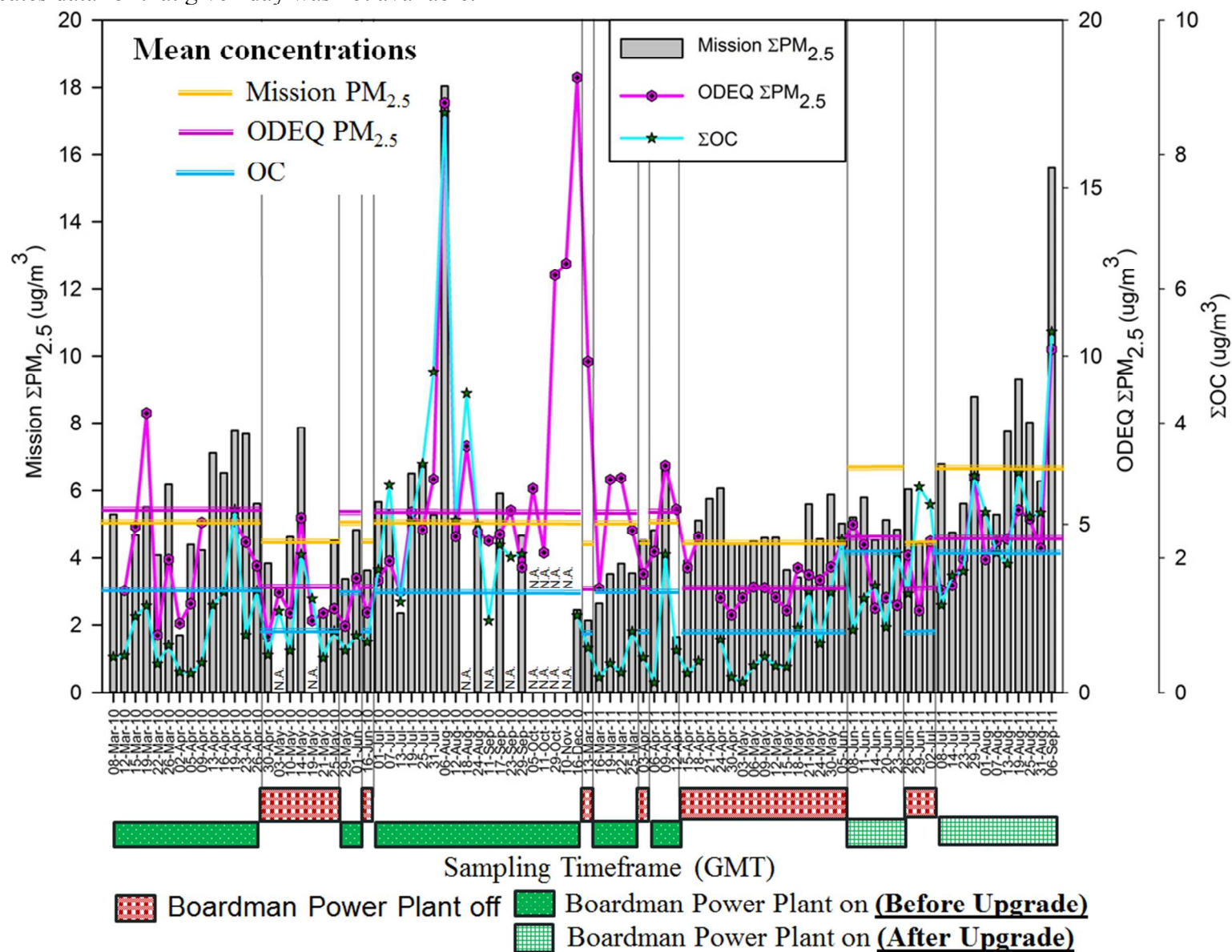
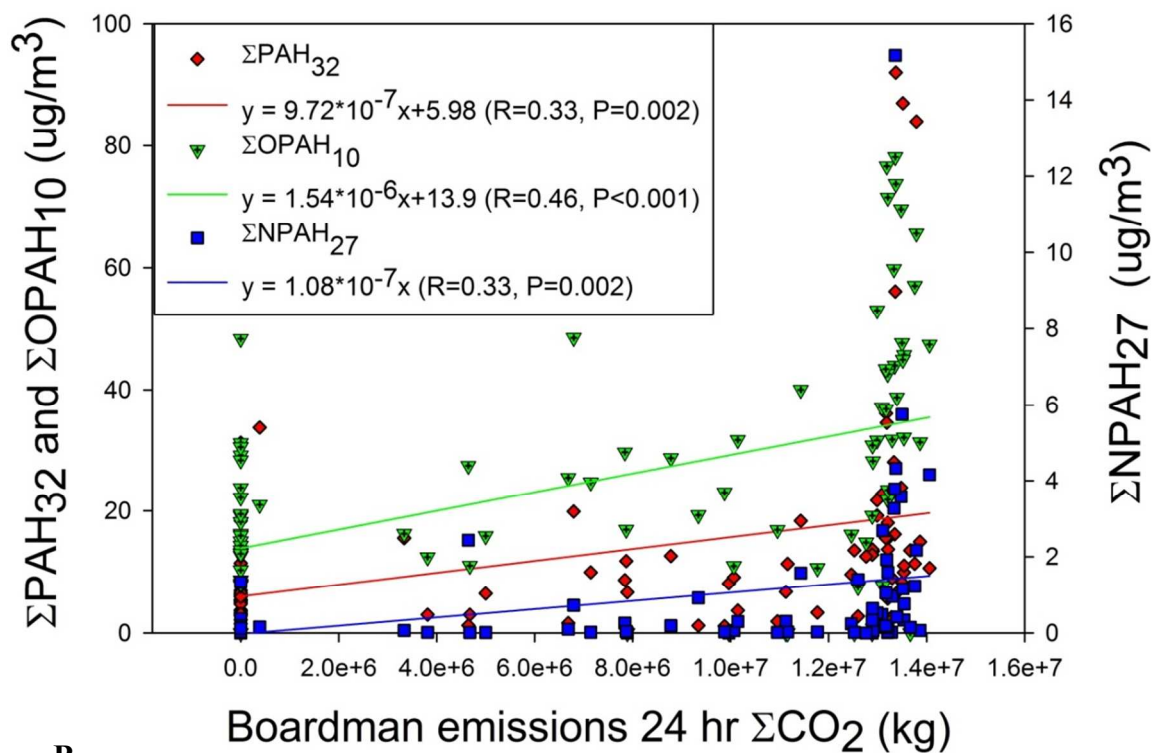


Figure S7 The 24 hr CO₂ emission from the Boardman Power Plant correlated with A.) ΣPAH_{32} , ΣOPAH_{10} , ΣNPAH_{27} concentrations and B.) $\text{PM}_{2.5}$, OC, and EC concentrations at CTUIR.

A.



B.

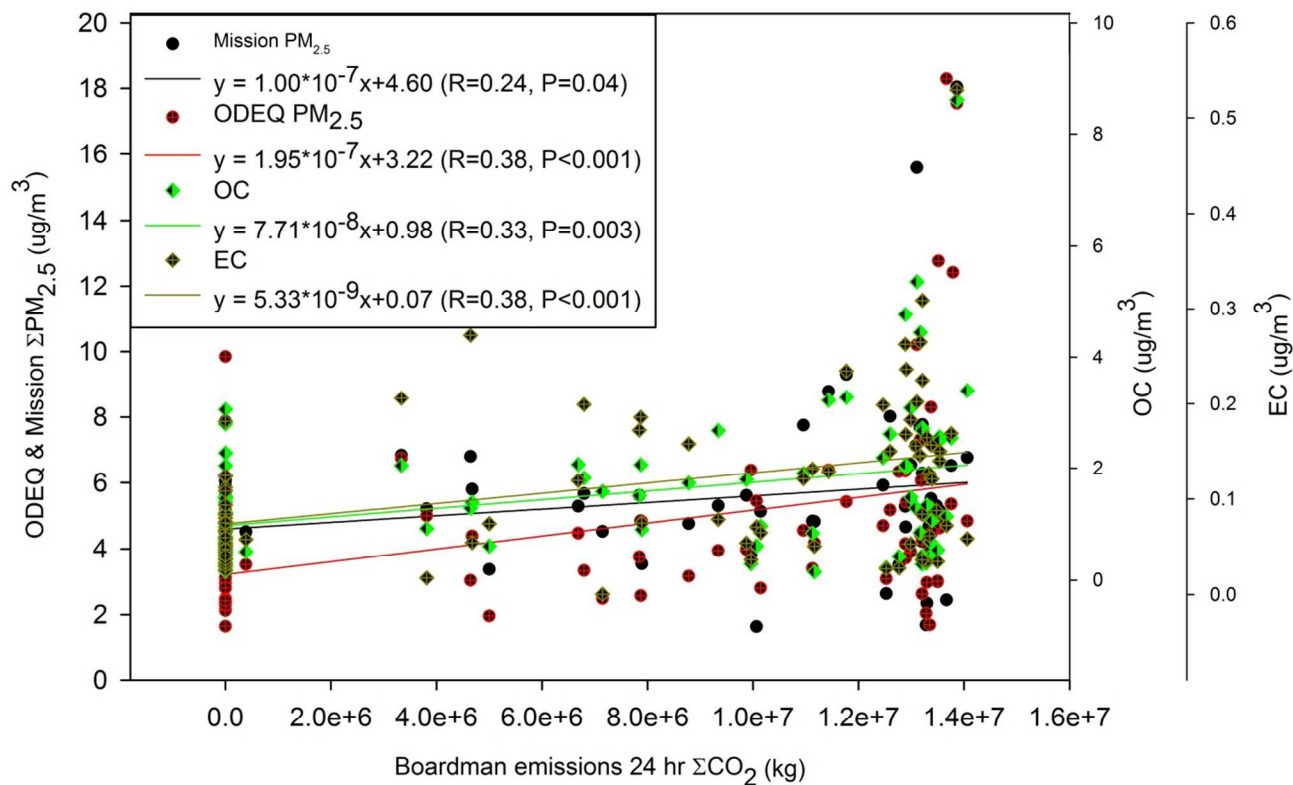


Figure S8 The 24 hr SO₂ emission from the Boardman Power Plant correlated with A.) ΣPAH_{32} , ΣOPAH_{10} , ΣNPAH_{27} concentrations and B.) PM_{2.5}, EC, and OC concentrations at CTUIR.

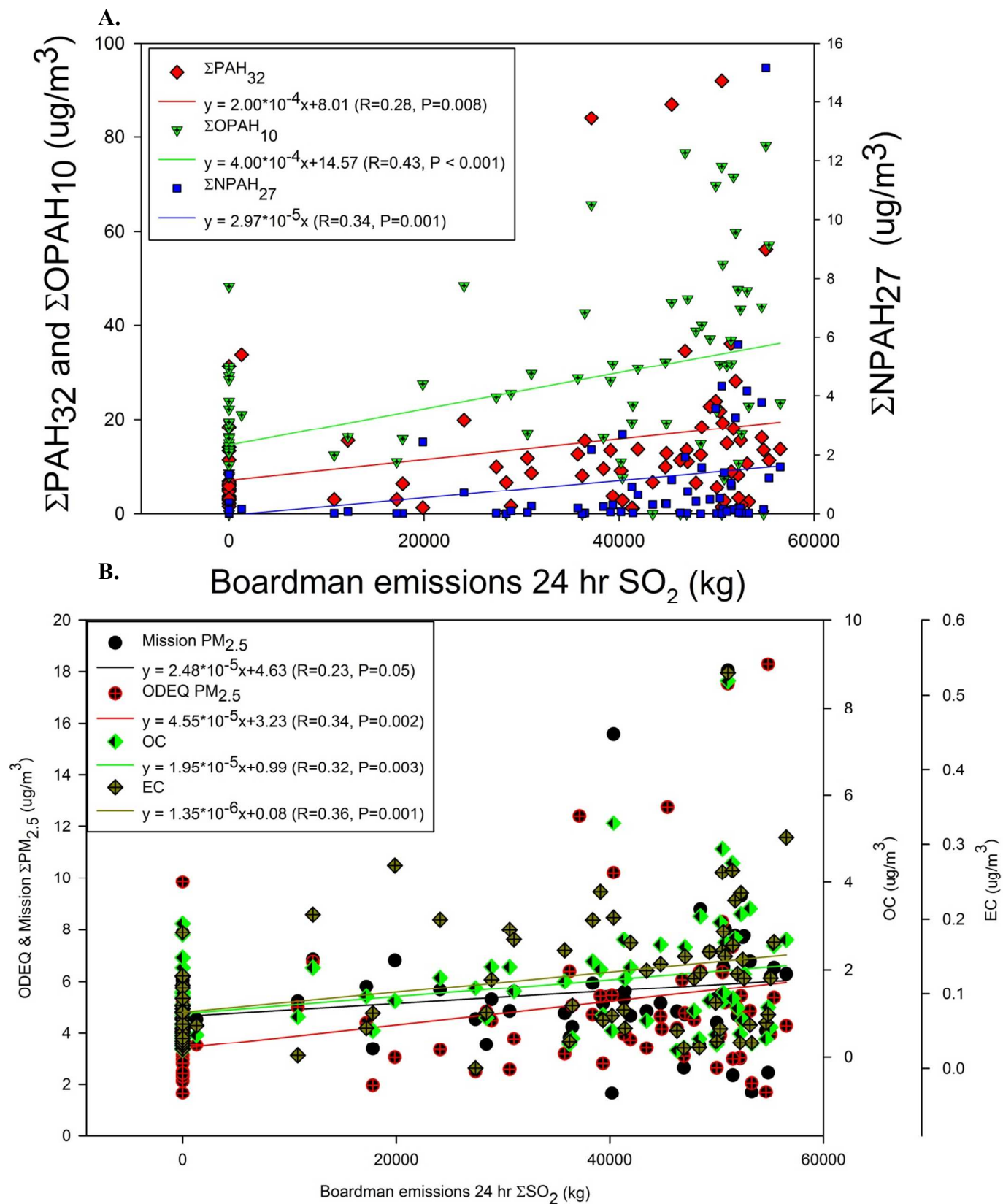


Figure S9 The 24 hr NO_x emission from the Boardman Power Plant correlated with A.) ΣPAH_{32} , ΣOPAH_{10} , ΣNPAH_{27} concentrations and B.) $\text{PM}_{2.5}$, OC, and EC concentrations at CTU00.

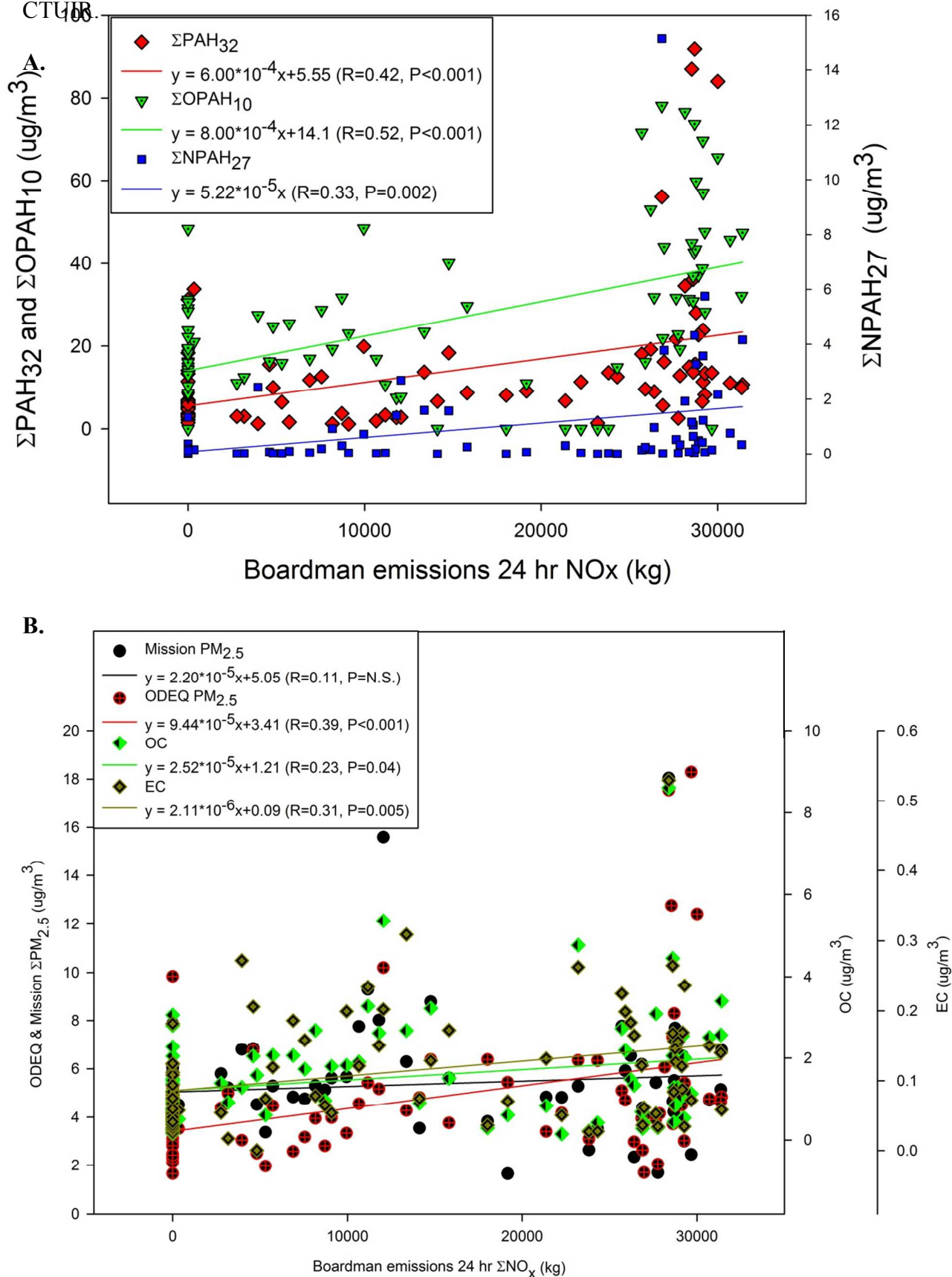


Table S5: Comparison of CTUIR PAH, NPAH, OPAH, OC, EC, and PM_{2.5} concentrations when the Boardman plant was off and when the plant was on (Before Upgrades). Bold font indicates statically different concentration and < D.L. indicates that for the entire sampling period measured concentrations were less than the detection limit.

	Plant off (n=27 days)	Plant on (Before Upgrades) (n=43 days)			
	Mean over entire period (±sd) (Min,Max) (pg/m ³)	Mean over entire period (±sd) (Min,Max) (pg/m ³)	Conc. Change when the plant was on (pg/m ³)	% Contribution from Boardman	t-test (p-value)
PAHs					
2,6-Dimethylnaphthalene	0.43±0.33 (0.21,1.6)	0.73±0.35 (0.22,2.0)	0.30	42%	<0.001**
1,3-Dimethylnaphthalene	0.30±0.53 (0.00,1.4)	0.27±0.58 (0.00,2.0)	-0.03	-9%	N.S.
3,6-Dimethylphenanthrene	0.01±0.04 (0.00,0.19)	0.12±0.16 (0.00,0.58)	0.11	94%	<0.001**
1-Methylpyrene	0.01±0.05 (0.00,0.25)	0.17±0.13 (0.00,0.40)	0.16	94%	<0.001**
Dibenzothiophene	0.01±0.07 (0.00,0.38)	0.17±0.26 (0.00,0.88)	0.16	92%	<0.001**
Phenanthrene	< D. L.	1.2±2.6 (0.00,8.4)	1.2	100%	0.003*
Fluoranthene	0.78±1.9 (0.00,8.8)	2.4±2.3 (0.00,12.4)	1.6	67%	0.002*
Pyrene	0.63±1.3 (0.00,4.0)	3.2±4.1 (0.00,24)	2.6	80%	<0.001**
Benzo(c)fluorene	< D. L.	0.25±0.30 (0.00,1.0)	0.25	100%	<0.001**
Benzo(a)anthracene	0.34±0.06 (0.00,1.6)	0.52±0.46 (0.00,2.0)	0.18	35%	N.S.
Chrysene + Triphenylene	0.62±0.44 (0.30,2.6)	1.0±0.71 (0.10,3.3)	0.38	40%	0.004*
Benzo(k)fluoranthene	0.12±0.06 (0.00,1.5)	0.41±0.59 (0.00,2.3)	0.29	72%	0.010*
Benzo(e)pyrene	0.63±0.66 (0.16,3.09)	1.1±1.1 (0.15,4.5)	0.47	44%	0.021*
Benzo(a)pyrene	0.04±0.02 (0.00,0.55)	0.54±0.59 (0.00,2.5)	0.50	93%	<0.001**
Dibenz(a,h)anthracene	0.02±0.10 (0.00,0.54)	0.14±0.26 (0.00,0.76)	0.12	86%	0.009*
Indeno(1,2,3-cd)pyrene	0.64±0.30 (0.02,1.6)	1.3±0.99 (0.17,4.5)	0.66	51%	<0.001**
Dibenz[a,c]anthracene	0.01±0.05 (0.28,0.28)	0.19±0.29 (0.00,0.99)	0.18	86%	<0.001**
Benzo(ghi)perylene	0.66±0.31 (0.22,1.7)	1.1±0.79 (0.30,4.2)	0.44	42%	<0.001**
ΣPAH _{2ring}	1.1±1.5 (0.21,6.1)	1.7±2.0 (0.44,8.9)	0.60	35%	N.S.
ΣPAH _{3ring}	0.05±0.27 (0.00,1.4)	1.5±3.1 (0.00,10)	1.5	97%	0.003*
ΣPAH _{4ring}	2.4±0.68 (0.40,17)	10±12 (0.20,56)	7.6	76%	<0.001**
ΣPAH _{5-6ring}	3.3±2.9 (0.67,13)	6.9±6.6 (0.64,29)	3.6	53%	0.002*
ΣPAH _{16-US} priority	5.4±5.8 (0.94, 27)	14±12 (0.68,65)	8.6	63%	<0.001**
ΣPAH ₃₂	6.8±6.3 (1.5,31)	20±21 (1.42,92)	13	67%	<0.001**
NPAHs					
3-nitrodibenzofuran	0.00±0.02 (0.00,0.12)	0.18±0.36 (0.00,1.9)	0.18	98%	0.003*
9-nitroanthracene	0.01±0.03 (0.00,0.11)	0.09±0.18 (0.00,1.1)	0.08	89%	0.005*
3-nitrophenanthrene	0.00±0.00 (0.00,0.02)	0.01±0.03 (0.00,0.19)	0.01	92%	0.006*
7-nitrobenz[a]anthracene	< D. L.	0.07±0.19 (0.00,0.75)	0.07	100%	0.025*
1-nitrotriphenylene	< D. L.	0.06±0.16 (0.00,0.62)	0.06	100%	0.025*
6-nitrochrysene	< D. L.	0.17±0.50 (0.00,2.4)	0.17	100%	0.033*
2-nitrotriphenylene	< D. L.	0.12±0.35 (0.00,1.5)	0.12	100%	0.029*
6-nitrobenzo[a]pyrene	0.05±0.25 (0.00,1.3)	0.08±0.55 (0.00,3.6)	0.03	43	N.S.
ΣNPAH ₂₇	0.11±0.26 (0.00,1.3)	1.3±2.6 (0.00,15)	1.19	91%	0.006*
OPAHs					
9-fluorenone	0.55±1.41 (0.00,5.9)	3.0±5.4 (0.00,20)	2.5	82%	0.006*
9,10-anthraquinone	15±11 (0.00,43)	30±20 (0.00,74)	15	51%	<0.001**
Benz[a]anthracene-7,12-dione	0.02±0.07 (0.00,0.35)	0.17±0.28 (0.00,1.1)	0.15	91%	0.001*
Benzo[c]phenanthrene-1,4-quinone	0.03±0.13 (0.00,0.69)	0.12±0.26 (0.00,0.84)	0.09	79%	0.048*
ΣOPAH ₁₀	16±12 (0.00,48)	34±23 (0.00,78)	18	54%	<0.001**
PM_{2.5} Concentration (µg/m³)					
Mission Site (24-hr MC)	4.62±1.20 (2.14,7.87)	5.17±2.72 (1.64,18.0)	0.56	11%	N.S.
ODEQ Pendleton Site	3.41±1.58 (1.65,9.84)	5.60±3.66 (1.69,18.3)	2.19	39%	0.002*
EC(µg/m ³)	0.7±0.04(0.03,0.18)	0.13±0.09(0.03,0.53)	0.06	45%	<0.001**
OC (µg/m ³)	1.0±0.79 (0.16,3.1)	1.6±1.6 (0.15,8.6)	0.62	38%	0.046*

Table S6: Comparison of CTUIR PAH, NPAH, OPAH, OC, EC, and PM_{2.5} concentrations when the Boardman plant was off and when the plant was on (After Upgrades). Bold font indicates statically different concentration and < D.L. indicates that for the entire sampling period measured concentrations were less than the detection limit.

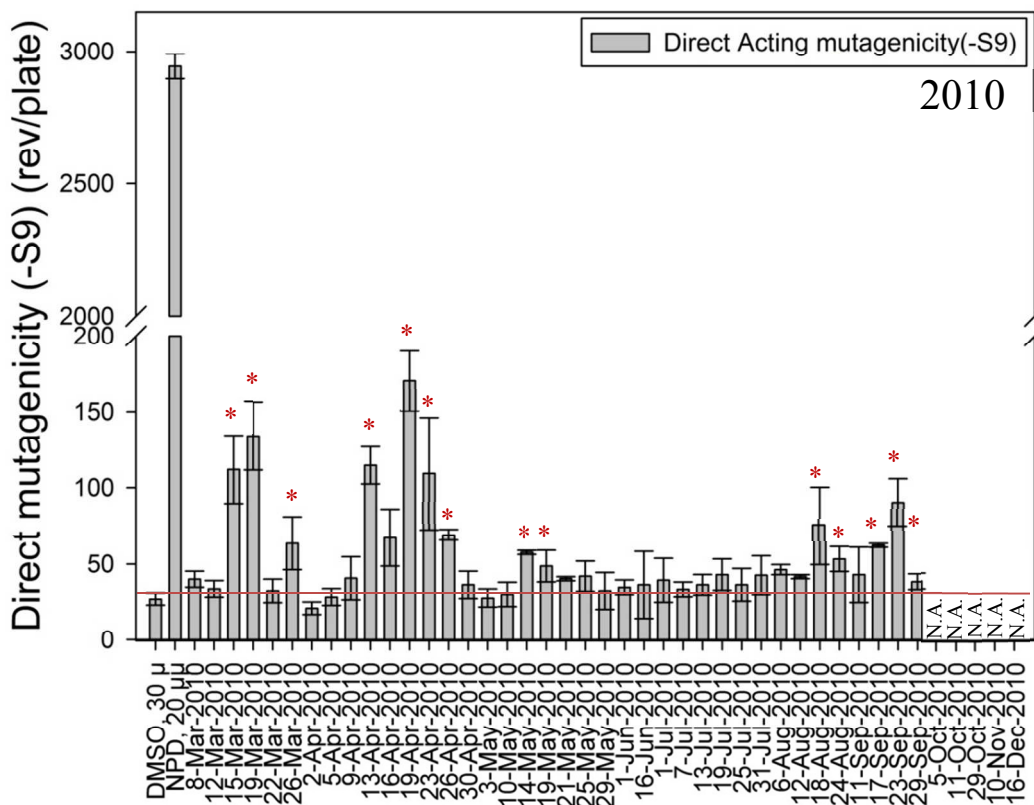
	Just Plant off (n=27 days)	Plant on (After Upgrade) (n=16 days)	Conc. Change when the plant was on (pg/m ³)	% Contribution from Boardman	t-test (p-value)
PAHs	Mean over entire period (±sd) (Min,Max) (pg/m ³)	Mean over entire period (±sd) (Min,Max) (pg/m ³)			
2,6-Dimethylnaphthalene	0.43±0.33 (0.21,1.6)	0.23±0.01 (0.21,0.25)	-0.20	-84%	0.005*
1,3-Dimethylnaphthalene	0.30±0.10 (0.00,1.5)	< D. L.	-0.30	-100%	0.007*
3,6-Dimethylphenanthrene	0.01±0.05 (0.00,0.19)	0.05±0.16 (0.00,0.59)	0.04	87%	N.S.
1-Methylpyrene	0.01±0.04 (0.00,0.25)	0.02±0.06 (0.00,0.24)	0.01	38%	N.S.
Dibenzothiophene	0.01±0.07 (0.00,0.38)	< D. L.	-0.01	100%	N.S.
Phenanthrene	< D. L.	< D. L.			
Fluoranthene	0.78±1.9 (0.00,8.8)	0.76±1.9 (0.00,4.	-0.02	4%	N.S.
Pyrene	0.63±1.3 (0.00,4.0)	0.58±1.1 (0.00,3.45)	-0.05	-10%	N.S.
Benzo(c)fluorene	< D. L.	0.01±0.06 (0.00,0.23)	0.01	100%	N.S.
Benzo(a)anthracene	0.34±0.06 (0.00,1.6)	0.17±0.19 (0.09,0.77)	-0.17	-96%	0.039*
Chrysene + Triphenylene	0.62±0.44 (0.30,2.6)	0.47±0.20 (0.23,1.1)	-0.15	-32%	N.S.
Benzo(k)fluoranthene	0.12±0.06 (0.00,1.5)	< D. L.	-0.12	-100%	N.S.
Benzo(e)pyrene	0.63±0.66 (0.16,3.1)	0.54±0.26 (0.24,1.2)	-0.09	-18%	N.S.
Benzo(a)pyrene	0.04±0.02 (0.00,0.55)	< D. L.	-0.04	-100%	N.S.
Dibenz(a,h)anthracene	0.02±0.10 (0.00,0.54)	< D. L.	-0.02	-100%	N.S.
Indeno(1,2,3-cd)pyrene	0.64±0.30 (0.20,1.6)	0.35±0.16 (0.05,0.56)	-0.29	-81%	<0.001**
Dibenz[a,c]anthracene	0.01±0.05 (0.28,0.28)	< D. L.	-0.01	100%	N.S.
Benzo(ghi)perylene	0.66±0.31 (0.22,1.7)	0.51±0.19 (0.25,0.87)	-0.15	-28%	N.S.
ΣPAH _{2ring}	1.1±1.5 (0.21,6.1)	0.35±0.26 (0.44,8.9)	-0.75	-210%	0.018*
ΣPAH _{3ring}	0.05±0.27 (0.00,1.4)	0.34±0.81 (0.00,2.9)	0.29	84%	N.S.
ΣPAH _{4ring}	2.4±0.68 (0.40,17)	3.1±4.6 (0.33,15)	0.70	22%	N.S.
ΣPAH _{56ring}	3.3±2.9 (0.67,14)	1.9±1.2 (0.55,4.9)	-1.4	-70%	<0.034*
ΣPAH _{16-US} priority	5.4±5.8 (0.94,28)	3.5±3.4 (0.66,11)	-1.9	-53%	N.S.
ΣPAH ₃₂	6.8±6.3 (1.5,31)	5.8±5.5 (1.1,18)	-1.0	-18%	N.S.
NPAHs					
3-nitrodibenzofuran	0.00±0.02 (0.00,0.12)	< D. L.	0.00	-100%	N.S.
9-nitroanthracene	0.01±0.03 (0.00,0.11)	0.04±0.03 (0.00,0.22)	0.03	72%	N.S.
3-nitrophenanthrene	0.00±0.00 (0.00,0.02)	0.00±0.01 (0.00,0.02)	0.00	70%	N.S.
1-nitrotriphenylene	< D. L.	< D. L.			
6-nitrochrysene	< D. L.	< D. L.			
2-nitrotriphenylene	< D. L.	< D. L.			
6-nitrobenzo[a]pyrene	0.05±0.25 (0.00,1.3)	0.62±0.92 (0.00,2.5)	0.57	92%	0.026*
ΣNPAH ₂₇	0.11±0.26 (0.00,1.3)	0.71±0.93 (0.01,2.7)	0.60	84%	0.023*
OPAHs					
9-fluorenone	0.55±1.4 (0.00,5.9)	0.06±0.26 (0.00,1.0)	-0.49	-750%	N.S.
9,10-anthraquinone	15±11 (0.00,43)	20±8.9 (7.5,38)	5.0	26%	N.S.
benz[a]anthracene-7,12-dione	0.02±0.07 (0.00,0.35)	0.00±0.02 (0.00,0.07)	-0.02	-260%	N.S.
benzo[c]phenanthrene-1,4 quinone	0.03±0.13 (0.00,0.69)	< D. L.	-0.03	-100%	N.S.
ΣOPAH ₁₀	16±12 (0.00,48)	20±9.3 (7.5,40)	4.0	32%	N.S.
PM_{2.5} Concentration (µg/m³)					
Mission Site (24-hr MC)	4.62±1.20 (2.14,7.87)	6.83±2.78 (4.52,15.6)	2.20	32%	0.007*
ODEQ Pendleton Site	3.41±1.58 (1.65,9.84)	4.49±1.88 (2.49,10.2)	1.08	24%	0.06
EC(µg/m³)	0.7±0.04(0.03,0.18)	0.13±0.09(0.00,0.31)	0.06	46%	0.017*
OC (µg/m³)	1.0±0.79 (0.16,3.1)	2.2±1.1 (0.92,5.4)	1.21	54%	<0.001**

Table S7: Comparison of CTUIR PAH, NPAH, OPAH, OC, EC, and PM_{2.5} concentrations when the plant was on (Before Upgrades) to when the plant was on (After Upgrades). Bold font indicates statically different concentration and < D.L. indicates that for the entire sampling period measured concentrations were less than the detection limit.

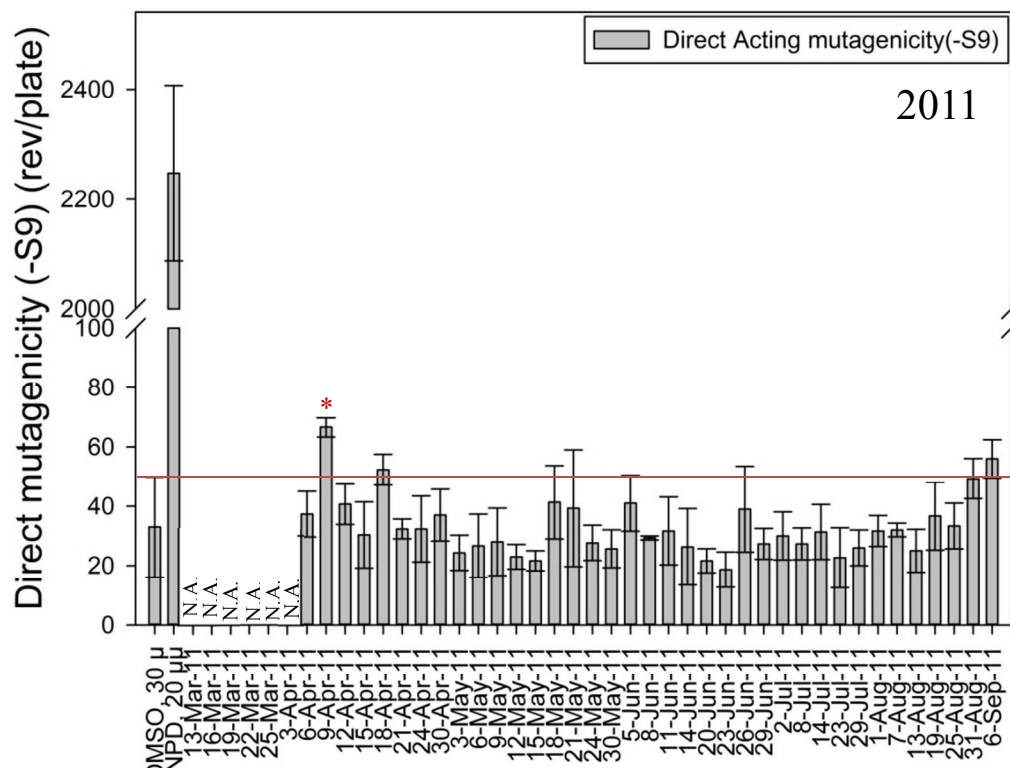
	Plant on (Before Upgrade)	Plant on (After Upgrade)	Conc. Change after upgrade (pg/m ³)	% Change after upgrades installed	t-test (p-value)
	(n=43 days)	(n=16 days)			
	Mean over entire period (±sd) (Min,Max) (pg/m ³)	Mean over entire period (±sd) (Min,Max) (pg/m ³)			
PAHs					
2,6-Dimethylnaphthalene	0.73±0.35 (0.22,2.0)	0.23±0.01 (0.21,0.25)	-0.50	-68%	<0.001**
1,3-Dimethylnaphthalene	0.27±0.27 (0.00,2.0)	< D. L.	-0.27	-100%	0.004*
1-Methylpyrene	0.17±0.13 (0.00,0.40)	0.02±0.06 (0.00,0.24)	-0.15	-91%	<0.001**
Naphthalene	0.43±1.1 (0.00,4.3)	< D. L.	-0.43	-100%	0.015*
Dibenzothiophene	0.17±0.26 (0.00,0.88)	< D. L.	-0.17	-100%	<0.001**
Phenanthrene	1.2±2.6 (0.00,8.4)	< D. L.	-1.2	-100%	0.003*
Fluoranthene	2.4±2.3 (0.00,12)	0.76±1.4 (0.00,4.0)	-1.6	-68%	0.002*
Pyrene	3.2±4.1 (0.00,23)	0.58±1.1 (0.00,3.5)	-2.6	-82%	<0.001**
Benzo(c)fluorene	0.25±0.30 (0.00,1.0)	0.01±0.06 (0.00,0.23)	-0.24	-94%	<0.001**
Benzo(a)anthracene	0.52±0.46 (0.00,2.0)	0.17±0.19 (0.09,0.77)	-0.35	-67%	<0.001**
Chrysene + Triphenylene	1.0±0.71 (0.10,3.3)	0.47±0.20 (0.23,1.1)	-0.53	-54%	<0.001**
Benzo(b)fluoranthene	2.1±2.9 (0.00,10)	0.53±0.76 (0.00,2.4)	-1.5	-75%	0.002*
Benzo(k)fluoranthene	0.41±0.59 (0.00,2.3)	< D. L.	-0.41	-100%	<0.001**
Benzo(e)pyrene	1.1±1.1 (0.15,4.5)	0.54±0.26 (0.24,1.2)	-0.56	-52%	0.002*
Benzo(a)pyrene	0.54±0.59 (0.00,2.5)	< D. L.	-0.54	-100%	<0.001**
Dibenz(a,h)anthracene	0.14±0.26 (0.00,0.76)	< D. L.	-0.14	-100%	0.001*
Indeno(1,2,3-cd)pyrene	1.3±0.99 (0.17,4.5)	0.35±0.16 (0.05,0.56)	-0.95	-73%	<0.001**
Dibenz[a,c]anthracene	0.19±0.29 (0.00,0.99)	< D. L.	-0.19	-100%	<0.001**
Benzo(ghi)perylene	1.1±0.79 (0.30,4.2)	0.51±0.05 (0.25,0.87)	-0.59	-55%	<0.001**
ΣPAH _{2ring}	1.7±2.0 (0.44,9.0)	0.35±0.26 (0.44,8.9)	-1.4	-79%	<0.001**
ΣPAH _{3ring}	1.5±3.1 (0.00,10)	0.34±0.81 (0.00,2.9)	-1.2	-78%	0.024*
ΣPAH _{4ring}	10±12 (0.20,55)	3.1±4.6 (0.33,15)	-7.0	-69%	0.002*
ΣPAH _{5-6ring}	6.9±6.6 (0.64,29)	1.9±1.2 (0.55,4.9)	-5.0	-73%	0.002*
ΣPAH _{16-US} priority	14±12 (0.68,65)	3.5±3.4 (0.66,11)	-11	-75%	<0.001**
ΣPAH ₃₂	20±21 (1.4,91)	5.8±5.5 (1.1,18)	-15	-72%	<0.001**
NPAHs					
3-nitrodibenzofuran	0.18±0.36 (0.00,1.9)	0.00±0.02 (0.00,0.12)	-0.18	-100%	0.002*
3-Nitrophenanthrene	0.01±0.03 (0.00,0.19)	0.00±0.01 (0.00,0.02)	-0.01	-72%	0.034*
7-Nitrobenz[a]anthracene	0.07±0.19 (0.00,0.75)	< D. L.	-0.07	-100%	0.025*
1-nitrotriphenylene	0.06±0.16 (0.00,0.62)	< D. L.	-0.06	-100%	0.025*
6-nitrochrysene	0.17±0.50 (0.00,2.4)	< D. L.	-0.17	-100%	0.033*
2-nitrotriphenylene	0.12±0.35 (0.00,1.5)	< D. L.	-0.12	-100%	0.029*
6-nitrobenzo[a]pyrene	0.08±0.55 (0.00,3.6)	0.62±0.92 (0.00,2.5)	0.54	650%	0.039*
ΣNPAH ₂₇	1.3±2.6 (0.00,15)	0.71±0.93 (0.01,2.7)	-0.59	-44%	N.S.
OPAHs					
9-fluorenone	3.0±5.4 (0.00,20)	0.06±0.26 (0.00,1.0)	-2.9	-98%	<0.001**
9,10-anthraquinone	30±20 (0.00,74)	20±8.9 (7.5,37)	-9.9	-33%	0.010*
Aceanthrenequinone	0.12±0.35 (0.00,1.2)	< D. L.	-0.12	-100%	0.024*
benz[a]anthracene-7,12-dione	0.17±0.28 (0.00,1.1)	0.00±0.02 (0.00,0.07)	-0.17	-97%	<0.001**
benzo[c]phenanthrene-1,4 quinone	0.12±0.26 (0.00,0.84)	< D. L.	-0.12	-100%	0.004*
ΣOPAH ₁₀	33±23 (0.00,78)	20±9.3 (7.5,40)	-13	-40%	<0.001**
PM_{2.5} Concentration (µg/m³)					
Mission Site (24-hr MC)	5.17±2.72 (1.64,18.0)	6.83±2.78 (4.52,15.6)	1.64	31%	0.06
ODEQ Pendleton Site	5.60±3.66 (1.69,18.3)	4.49±1.88 (2.49,10.2)	-1.10	-19%	0.14
EC(µg/m ³)	0.13±0.09(0.03,0.53)	0.13±0.09(0.00,0.31)	0.00	0%	N.S.
OC (µg/m ³)	1.6±1.6 (0.15,88)	2.2±1.1 (0.92,5.4)	0.59	36%	N.S.

Figure S10. Ames Assay Direct Acting Mutagenicity Assay (without metabolic activation) for sampling period A.) 2010 and B.) 2011 at CTUIR [(n=3), *(p < 0.05) significant from negative control]. N.A. indicates data for that given day was not collected or not available.

A.



B.



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