

# Electronic Supplementary Material to: Vertical Evolution of Boundary Layer Volatile Organic Compounds in Summer over the North China Plain and the Differences with Winter\*

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**Table S1.** Measured VOCs and their method detection limits (ppbv).

Alkanes							
Ethane	0.05	Propane	0.03	iso-Butane	0.03	n-Butane	0.02
Cyclopentane	0.02	iso-Pentane	0.02	n-Pentane	0.02	2-Methylpentane	0.02
3-Methylpentane	0.01	2,3-Dimethylbutane	0.03	2,2-Dimethylbutane	0.01	n-Hexane	0.02
2,4-Dimethylpentane	0.01	Methylcyclopentane	0.01	2,3-Dimethylpentane	0.02	2-Methylhexane	0.02
Cyclohexane	0.02	3-Methylhexane	0.02	2,2,4-Trimethylpentane	0.02	n-Heptane	0.02
Methylcyclohexane	0.02	2,3,4-Trimethylpentane	0.01	2-Methylheptane	0.02	3-Methylheptane	0.01
n-Octane	0.01	n-Nonane	0.01	n-Decane	0.04	n-Undecane	0.04
Alkenes							
Ethene	0.02	Propene	0.03	trans-2-Butene	0.02	1-Butene	0.02
cis-2-Butene	0.01	1,3-Butadiene	0.03	1-Pentene	0.01	trans-2-Pentene	0.01
cis-2-Pentene	0.01	Isoprene	0.01	1-Hexene	0.01	iso-Butene	0.04
Aromatics							
Benzene	0.04	Toluene	0.07	Ethylbenzene	0.01	m/p-Xylene	0.02
o-Xylene	0.02	Styrene	0.01	Isopropylbenzene	0.01	n-Propylbenzene	0.01
m-Ethyltoluene	0.05	p-Ethyltoluene	0.05	1,3,5-Trimethylbenzene	0.06	o-Ethyltoluene	0.03
p-Diethylbenzene	0.06	1,2,4-Trimethylbenzene	0.08	1,2,3-Trimethylbenzene	0.05	m-Diethylbenzene	0.04
Halohydrocarbons							
Freon-114	0.06	Chloromethane	0.04	Vinylchloride	0.02	Bromomethane	0.01
Chloroethane	0.01	Freon-11	0.01	1,1-Dichloroethene	0.01	Freon-113	0.02
Methylenechloride	0.02	1,1-Dichloroethane	0.01	cis-1,2-Dichloroethene	0.02	Chloroform	0.01
1,1,1-Trichloroethane	0.02	Carbon tetrachloride	0.02	1,2-Dichloroethane	0.01	Trichloroethylene	0.01
1,2-Dichloropropane	0.01	Bromodichloromethane	0.01	trans-1,3-Dichloropropene	0.02	Chlorobenzene	0.01
1,2-Dibromoethane	0.01	Tetrachloroethylene	0.02	cis-1,3-Dichloropropene	0.02	Bromoform	0.01
1,3-Dichlorobenzene	0.04	1,4-Dichlorobenzene	0.04	1,1,2,2-Tetrachloroethane	0.04	Benzylchloride	0.04
1,1,2-Trichloroethane	0.01	1,2-Dichlorobenzene	0.05				
Acetylene	0.03						

\*The online version of this article can be found at <https://doi.org/10.1007/s00376-020-0254-9>.

**Table S2.** The compounds that fall within each SAPRC category.

ALK1 ( $200 \text{ ppm}^{-1} \text{ min}^{-1} < k_{\text{OH}} < 500 \text{ ppm}^{-1} \text{ min}^{-1}$ )			
Ethane			
ALK2 ( $500 \text{ ppm}^{-1} \text{ min}^{-1} < k_{\text{OH}} < 2500 \text{ ppm}^{-1} \text{ min}^{-1}$ )			
Propane	2,3-Dimethylpentane		
ALK3 ( $2500 \text{ ppm}^{-1} \text{ min}^{-1} < k_{\text{OH}} < 5000 \text{ ppm}^{-1} \text{ min}^{-1}$ )			
iso-Butane	n-Butane	2,2-Dimethylbutane	2,2,4-Trimethylpentane
ALK4 ( $5000 \text{ ppm}^{-1} \text{ min}^{-1} < k_{\text{OH}} < 10,000 \text{ ppm}^{-1} \text{ min}^{-1}$ )			
Cyclopentane	iso-Pentane	n-Pentane	2,3-Dimethylbutane
2-Methylpentane	3-Methylpentane	n-Hexane	2,4-Dimethylpentane
Methylcyclopentane	2-Methylhexane	3-Methylhexane	n-Heptane
2,3,4-Trimethylpentane			
ALK5 ( $k_{\text{OH}} > 10,000 \text{ ppm}^{-1} \text{ min}^{-1}$ )			
Cyclohexane	Methylcyclohexane	2-Methylheptane	3-Methylheptane
n-Octane	n-Nonane	n-Decane	n-Undecane
ETHENE			
ISOPRENE			
OLE1 ( $k_{\text{OH}} < 70,000 \text{ ppm}^{-1} \text{ min}^{-1}$ )			
Propene	1-Butene	1-Pentene	1-Hexene
OLE2 ( $k_{\text{OH}} > 70,000 \text{ ppm}^{-1} \text{ min}^{-1}$ )			
trans-2-Butene	cis-2-Butene	iso-Butene	1,3-Butadiene
trans-2-Pentene	cis-2-Pentene		
BENZENE			
ARO1 ( $k_{\text{OH}} < 20,000 \text{ ppm}^{-1} \text{ min}^{-1}$ )			
Toluene	Ethylbenzene	Isopropylbenzene	n-Propylbenzene
ARO2 ( $k_{\text{OH}} > 20,000 \text{ ppm}^{-1} \text{ min}^{-1}$ )			
o-Xylene	m/p-Xylene	Styrene	1,3,5-Trimethylbenzene
p-Ethyltoluene	m-Ethyltoluene	o-Ethyltoluene	1,2,4-Trimethylbenzene
1,2,3-Trimethylbenzene	p-Diethylbenzene	m-Diethylbenzene	

**Table S3.** Average concentrations of measured VOCs at different heights.

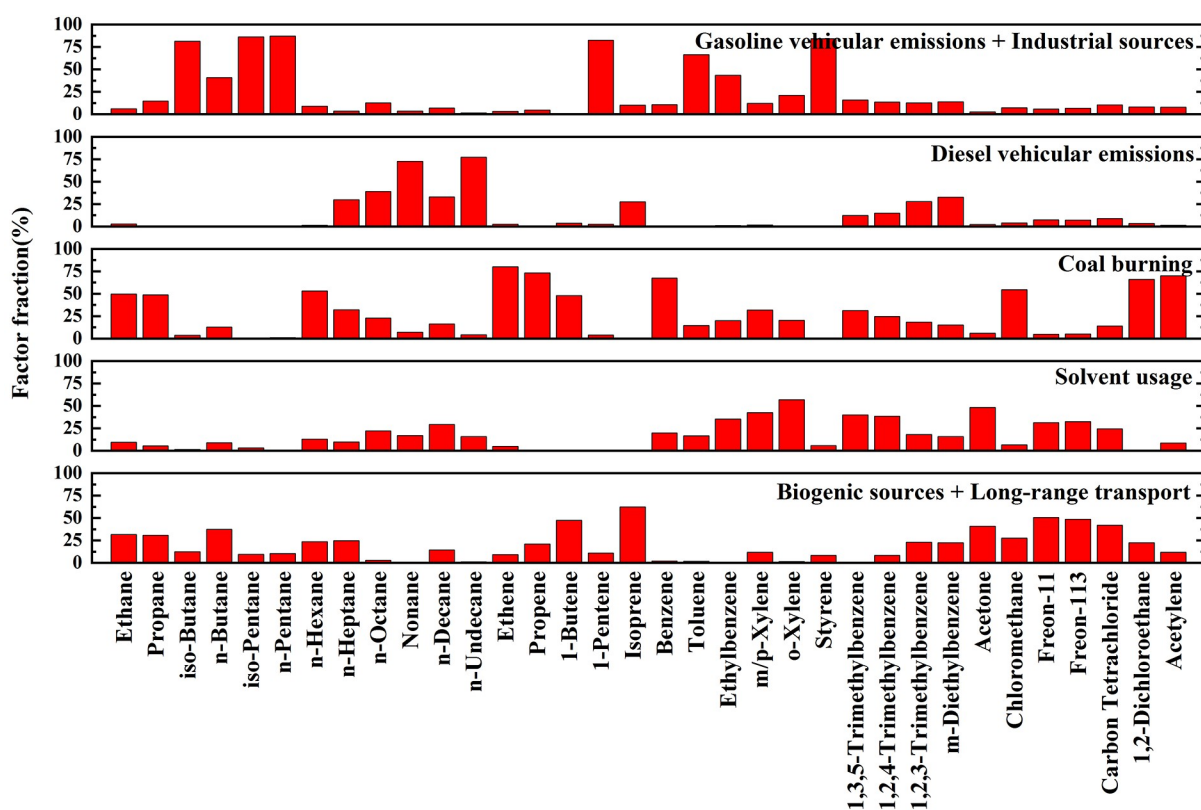
Concentration (ppbv)	Surface	100 m	200 m	300 m	400 m	500 m	600 m	800 m	1000 m
Ethane	3.654	3.499	3.395	3.319	3.176	3.249	3.384	3.232	3.408
Propane	1.993	1.974	1.918	1.791	1.720	1.665	1.810	1.915	1.842
iso-Butane	0.827	0.800	0.855	0.782	0.709	0.647	0.699	0.748	0.833
n-Butane	1.891	1.938	1.901	1.722	1.585	1.521	1.531	1.966	1.351
Cyclopentane	0.038	0.057	0.035	0.038	0.031	0.029	0.030	0.033	0.035
iso-Pentane	20.442	18.671	23.496	19.315	19.633	19.700	23.809	29.137	31.292
n-Pentane	1.939	1.724	2.025	1.772	1.769	1.733	2.032	2.529	2.812
2,2-Dimethylbutane	0.098	0.123	0.100	0.095	0.085	0.085	0.094	0.105	0.101
2,3-Dimethylbutane	0.245	0.278	0.227	0.200	0.213	0.197	0.213	0.283	0.241
2-Methylpentane	0.165	0.172	0.143	0.148	0.124	0.120	0.133	0.140	0.143
3-Methylpentane	0.105	0.126	0.092	0.093	0.081	0.082	0.087	0.098	0.106
n-Hexane	0.161	0.182	0.140	0.140	0.122	0.121	0.128	0.140	0.142
2,4-Dimethylpentane	0.100	0.082	0.086	0.059	0.086	0.066	0.081	0.098	0.066
Methylcyclopentane	0.051	0.044	0.042	0.042	0.037	0.035	0.034	0.047	0.040
2-Methylhexane	0.039	0.102	0.044	0.036	0.029	0.029	0.030	0.033	0.034
Cyclohexane	0.053	0.092	0.060	0.059	0.051	0.047	0.046	0.057	0.053
2,3-Dimethylpentane	0.069	0.039	0.068	0.071	0.105	0.088	0.069	0.106	0.043
3-Methylhexane	0.072	0.150	0.066	0.058	0.053	0.058	0.054	0.061	0.048
2,2,4-Trimethylpentane	0.063	0.024	0.045	0.051	0.086	0.071	0.055	0.091	0.024
n-Heptane	0.061	0.102	0.057	0.049	0.041	0.043	0.044	0.105	0.049
Methylcyclohexane	0.043	0.049	0.037	0.034	0.028	0.028	0.029	0.032	0.029

**Table S3.** (Continued.)

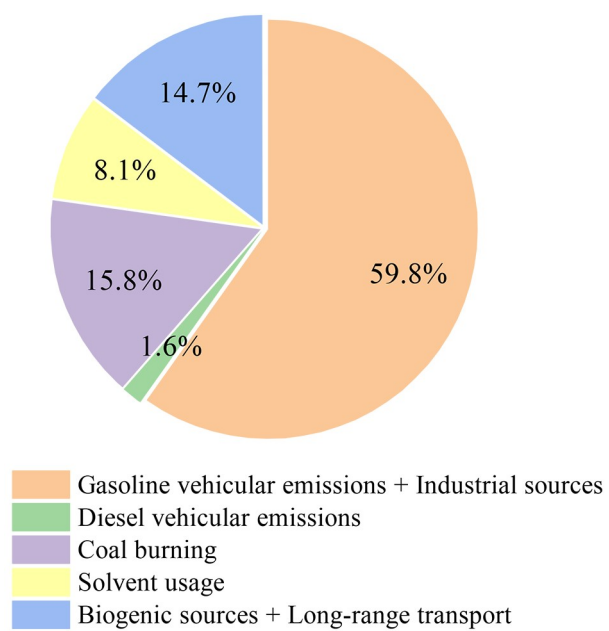
Concentration (ppbv)	Surface	100 m	200 m	300 m	400 m	500 m	600 m	800 m	1000 m
2,3,4-Trimethylpentane	0.028	0.008	0.020	0.022	0.040	0.031	0.023	0.042	0.008
2-Methylheptane	0.022	0.038	0.022	0.018	0.015	0.016	0.015	0.018	0.017
3-Methylheptane	0.071	0.054	0.071	0.062	0.049	0.066	0.068	0.009	0.008
n-Octane	0.073	0.108	0.102	0.106	0.107	0.108	0.110	0.121	0.128
n-Nonane	0.099	0.088	0.109	0.106	0.121	0.111	0.088	0.186	0.064
n-Decane	0.114	0.075	0.086	0.092	0.109	0.095	0.077	0.118	0.058
n-Undecane	0.335	0.170	0.183	0.213	0.258	0.243	0.159	0.195	0.141
Ethene	1.188	1.362	1.235	1.171	1.089	1.070	1.098	0.995	1.000
Propene	0.219	0.255	0.276	0.209	0.200	0.205	0.194	0.234	0.289
trans-2-Butene	0.030	0.021	0.016	0.016	0.017	0.015	0.014	0.017	0.022
1-Butene	0.141	0.062	0.067	0.062	0.048	0.053	0.053	0.042	0.052
cis-2-Butene	0.036	0.035	0.028	0.026	0.027	0.023	0.024	0.027	0.034
iso-Butene	0.865	0.771	0.806	0.781	0.708	0.716	0.728	0.773	0.743
1,3-Butadiene	0.021	0.022	0.014	0.010	0.009	0.009	0.011	0.009	0.009
1-Pentene	0.060	0.066	0.064	0.066	0.059	0.066	0.067	0.089	0.086
trans-2-Pentene	0.012	0.007	0.005	0.004	0.005	0.004	0.005	0.005	0.005
Isoprene	0.239	0.160	0.164	0.160	0.137	0.145	0.137	0.163	0.309
cis-2-Pentene	0.008	0.006	0.006	0.004	0.008	0.005	0.006	0.006	0.010
1-Hexene	0.008	0.015	0.015	0.017	0.014	0.019	0.030	0.017	0.019
Benzene	0.459	0.452	0.409	0.443	0.374	0.376	0.392	0.401	0.383
Toluene	2.893	1.845	2.092	1.992	2.143	2.106	2.233	2.902	3.037
Ethylbenzene	0.255	0.207	0.222	0.217	0.220	0.217	0.235	0.315	0.323
m/p-Xylene	0.136	0.127	0.121	0.123	0.109	0.106	0.109	0.141	0.123
o-Xylene	0.263	0.207	0.207	0.203	0.192	0.180	0.190	0.258	0.197
Styrene	1.310	1.035	1.332	1.261	1.412	1.437	1.565	2.168	2.658
Isopropylbenzene	0.015	0.012	0.013	0.014	0.014	0.014	0.014	0.017	0.018
n-Propylbenzene	0.023	0.020	0.020	0.021	0.021	0.020	0.022	0.023	0.020
p-Ethyltoluene	0.026	0.021	0.021	0.022	0.021	0.020	0.021	0.041	0.020
m-Ethyltoluene	0.012	0.010	0.010	0.010	0.010	0.011	0.010	0.032	0.009
1,3,5-Trimethylbenzene	0.017	0.015	0.016	0.015	0.015	0.015	0.015	0.028	0.013
o-Ethyltoluene	0.015	0.011	0.011	0.011	0.011	0.011	0.011	0.012	0.010
1,2,4-Trimethylbenzene	0.046	0.035	0.038	0.038	0.039	0.037	0.037	0.060	0.035
1,2,3-Trimethylbenzene	0.029	0.021	0.023	0.023	0.024	0.022	0.022	0.026	0.021
p-Diethylbenzene	0.018	0.014	0.017	0.015	0.019	0.017	0.017	0.018	0.015
m-Diethylbenzene	0.027	0.016	0.018	0.020	0.022	0.019	0.018	0.021	0.017
Freon-114	0.013	0.013	0.014	0.015	0.014	0.013	0.013	0.014	0.014
Chloromethane	2.139	1.792	1.258	1.025	1.154	0.921	1.051	1.298	1.699
Vinylchloride	0.009	0.014	0.015	0.011	0.011	0.009	0.010	0.013	0.013
Bromomethane	0.010	0.010	0.011	0.010	0.010	0.010	0.013	0.010	0.009
Chloroethane	0.209	0.245	0.115	0.072	0.085	0.057	0.068	0.101	0.120
Freon-11	0.271	0.252	0.254	0.252	0.254	0.250	0.242	0.246	0.253
Freon-113	0.066	0.063	0.065	0.065	0.065	0.064	0.061	0.063	0.066
1,1-Dichloroethene	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001
Methylenechloride	1.150	1.277	1.227	1.274	1.161	1.132	1.116	1.234	1.123
1,1-Dichloroethane	0.013	0.014	0.014	0.013	0.012	0.012	0.014	0.017	0.015
cis-1,2-Dichloroethene	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.010	0.004
Chloroform	0.208	0.195	0.189	0.186	0.180	0.184	0.192	0.217	0.235
1,1,1-Trichloroethane	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.002
Carbon tetrachloride	0.088	0.096	0.093	0.090	0.091	0.092	0.092	0.098	0.093
1,2-Dichloroethane	0.543	0.559	0.480	0.455	0.435	0.435	0.457	0.547	0.566
Trichloroethylene	0.015	0.015	0.016	0.014	0.013	0.015	0.015	0.024	0.015
1,2-Dichloropropane	0.276	0.276	0.242	0.246	0.235	0.248	0.255	0.262	0.309
Bromodichloromethane	0.003	0.003	0.003	0.003	0.002	0.003	0.003	0.009	0.002
trans-1,3-Dichloropropene	0.018	0.019	0.018	0.018	0.021	0.021	0.018	0.025	0.013

**Table S3.** (Continued.)

Concentration (ppbv)	Surface	100 m	200 m	300 m	400 m	500 m	600 m	800 m	1000 m
cis-1,3-Dichloropropene	0.004	0.003	0.003	0.004	0.003	0.004	0.003	0.016	0.003
1,1,2-Trichloroethane	0.022	0.020	0.018	0.019	0.017	0.017	0.018	0.026	0.018
Tetrachloroethylene	0.020	0.023	0.024	0.021	0.020	0.023	0.022	0.041	0.025
1,2-Dibromoethane	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.018	0.001
Chlorobenzene	0.019	0.019	0.019	0.019	0.019	0.019	0.021	0.039	0.021
Bromoform	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.024	0.001
1,1,1,2-Tetrachloroethane	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.023	0.003
1,3-Dichlorobenzene	0.004	0.003	0.003	0.004	0.004	0.007	0.010	0.095	0.003
1,4-Dichlorobenzene	0.038	0.036	0.039	0.039	0.037	0.039	0.051	0.159	0.035
Benzylchloride	0.032	0.031	0.036	0.034	0.035	0.037	0.044	0.129	0.028
1,2-Dichlorobenzene	0.015	0.012	0.011	0.011	0.011	0.014	0.015	0.088	0.008
Acetylene	1.099	1.174	0.972	0.902	0.853	0.813	0.874	0.916	0.853



**Fig. S1.** Vertical source profiles of VOCs in Shijiazhuang derived by PMF.



**Fig. S2.** Vertical source contributions of VOCs in Shijiazhuang derived by PMF.