

# **Vertical profiles of volatile organic compounds and fine particles in atmospheric air by using aerial drone with miniaturized samplers and portable devices**

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## **Electronic supplemental information (ESI)**

### **Supplemental information S1. Reagents and materials**

**Supplemental Figure S1.** The schematic of sample collection using SPME Arrow and ITEX from mixed altitudes (from 50 to 400 m). During the flight of the drone, the portable BC monitor and CPC devices carried out measurements.

**Supplemental Figure S2.** The schematic of sample collection using ITEX and SPME Arrow systems at the altitude of 50 m. During the flight of the drone, the portable BC monitor and CPC devices carried out measurements.

**Supplemental Figure S3.** The schematic of sample collection using ITEX and SPME Arrow sampling systems at the altitude of 400 m. During the flight of the drone, the portable BC monitor and CPC devices carried out measurements.

**Supplemental Figure S4.** The schematic of sample collection, specifically those of aerosol particles, using ITEX with filter accessories, during horizontal and vertical concentration gradients. During the flight of the drone, the portable BC monitor and CPC devices carried out measurements.

**Supplemental Figure S5.** Correlation of VOCs detected at the SMEAR II Station at the mixed altitudes from 50 to 400 m.

**Supplemental Figure S6.** Evaluation of ITEX filter accessories in collecting gas phase. The gaseous samples were collected using TENAX-GR-ITEX system with filter accessories (left) and CWR-SPME-Arrow system (right) at the altitudes from 50 to 400 m. White color represents that compound was not detected.

**Supplemental Figure S7.** The comparison studies of portable CPC and portable BC monitor located in the drone with their reference instruments.

**Supplemental Table S1.** The average of ambient pressures and temperatures at certain altitudes between 9 to 11 October 2021 at SMEAR II Station, Hyytiälä. Ambient temperature was measured by a sensor attached in the drone box (Figure 1-D in main article).

**Supplemental Table S2.** Repeatability studies for TENAX-GR-ITEX sampling system (i.e. within ITEX). Table includes all data points from repeatability series done by the lab-made autosampler. All values given for amines are reported as relative peak area per litre of sample. Each ITEX unit was run five times to get the repeatability value.

**Supplemental Table S3.** Reproducibility between ITEX units used in injections by lab-made autosampler.

**Supplemental Table S4.** The tested compositions of the HILIC-MS/MS eluent.

**Supplemental Table S5.** Established MRM method parameters for each compound. Based on the product ion scans, the optimal collision energy (CE) was determined for the compounds to obtain maximum response to the most abundant product ion.

**Supplemental Table S6.** The calculated LOQs for results achieved by ITEX and SPME Arrow systems.

**Supplemental Table S7.** Concentrations of nitrogen-containing compounds detected in gas and particle phases at mixed altitudes (50 – 400 m). Conversion from  $\text{ng m}^{-3}$  to  $\text{ppt}_v$  have been made using the conversion factor ( $\text{ppt}_v = \text{Concentration (ng m}^{-3}) : (0.0409 \times (\text{MW}))$ ).

**Supplemental Table S8.** Concentrations of other volatile organic compounds detected in gas and particle phases at mixed altitudes (50 – 400 m). Conversion from  $\text{ng m}^{-3}$  to  $\text{ppt}_v$  have been made using the conversion factor ( $\text{ppt}_v = \text{Concentration (ng m}^{-3}) : (0.0409 \times (\text{MW}))$ ).

**Supplemental Table S9.** Recoveries obtained for compounds collected by ITEX sampling system with filter accessory.

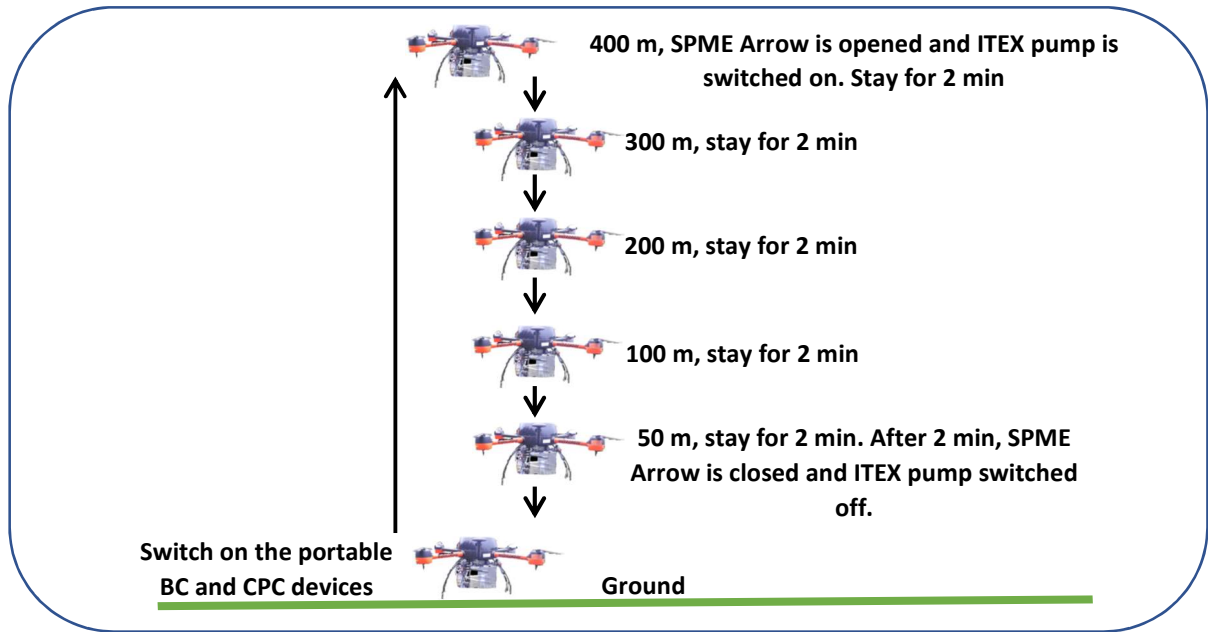
**Supplemental Table S10.** Determined LODs and LOQs for the acids based on parameters provided by linear regression analysis using HILICC/MS-MS

**Supplemental Table S11.** Two minutes average of black carbon (BC) and total particle concentrations measured at the altitudes of 100, 200, 300, and 400 m in three days measurement (9, 10, and 11 October 2021).

**Supplemental Table S12.** Daily average of black carbon (BC) and total particle concentrations measured at the altitudes of 100, 200, 300, and 400 m in three days measurement (9, 10, and 11 October 2021).

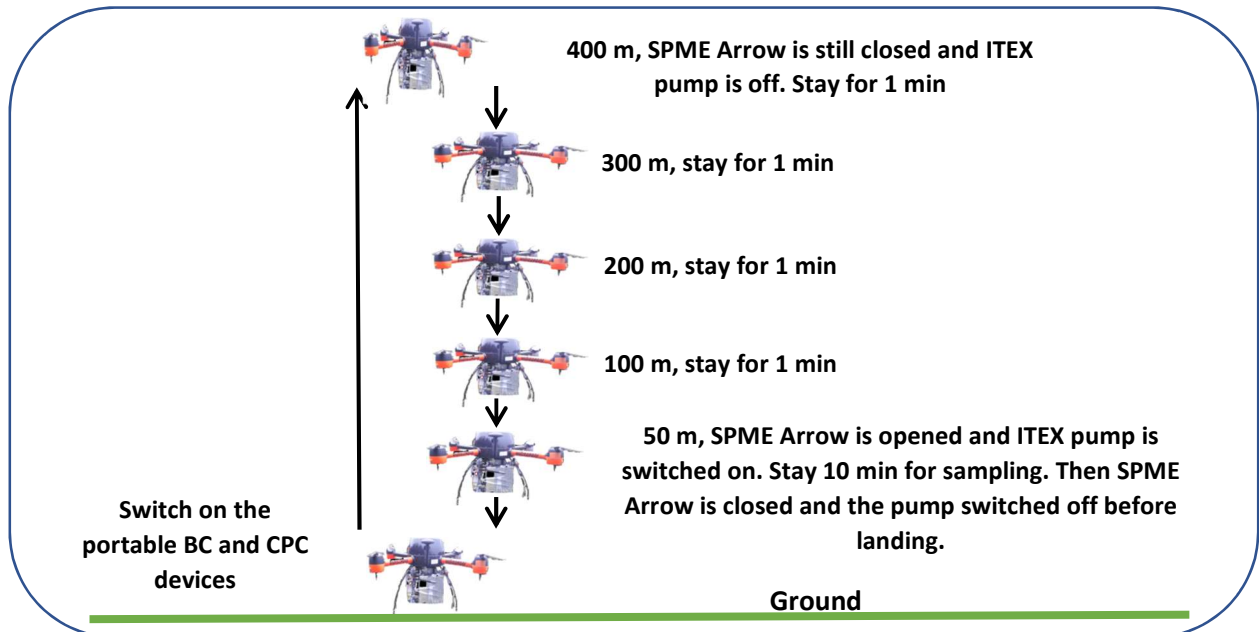
## Supplemental information S1. Reagents and materials

1-Butanamine (99%), 2-propen-1-amine (98%), 4-ketopimelic acid (98%), citric acid ( $\geq 99,5\%$ ), crotonic acid (98%), cis-pinonic acid (98%), decafluorobiphenyl (99%), ethylbenzene (99%), hexanal (98%), hexylamine (99%), isobutylamine (99%), N,N-dimethylformamide ( $\geq 99,9\%$ ), methyl isobutyl ketone (98.5%), p-cymene (99%), trimestic acid (95%), L-tartaric acid (99%), suberic acid (98%), and triphenyl phosphate ( $\geq 99\%$ ) were purchased from Sigma-Aldrich (St. Louis, MO, USA). Pyridine ( $\sim 100\%$ ) and formic acid (99-100%) were purchased from VWR Chemicals (Fontenay-sous-Bois, France). 2,3-Butanedione (97%) and ethyl acetate ( $\geq 99.7\%$ ) were purchased from Sigma-Aldrich Chemie GmbH (Steinheim, Germany). 1-Butanenitrile (99%), 2-butanol (99.5%), acetic acid ( $\geq 99,8\%$ ), glutaric acid ( $\geq 99\%$ ), isobutanol ( $\geq 98.5\%$ ), phthalic acid ( $\geq 99.5\%$ ), and succinic acid (99%) were purchased from Merck KGaA (Darmstadt, Germany). Acetonitrile ( $\geq 99,9\%$ ) and methanol ( $\geq 99,9\%$ ) were purchased from Honeywell (USA). Ammonium carbonate (chem. Pure) was purchased from Riedel de Haen. Ammonium acetate (99.9 %) was purchased from Fisher Scientific. Azelaic acid ( $\geq 99\%$ ), benzaldehyde ( $\geq 99\%$ ), diethylamine (99%), fumaric acid ( $\geq 98\%$ ), glycolic acid ( $\geq 99\%$ ), maleic acid ( $\geq 99\%$ ), malonic acid ( $\geq 98\%$ ), sebaric acid (p.a.), and vanillic acid ( $\geq 97\%$ ) were purchased from Fluka AG (Switzerland). Adipic acid ( $\geq 99,9\%$ ) and mandelic acid ( $\geq 99,5\%$ ) were purchased from BDH Laboratory Reagent. Acetophenone was from The British Drug Houses Ltd. (Poole, England). Trimethylamine filled Dynacal Permeation Tube (type HE-XLT2) was from VICI Metronics Inc., (Poulsbo, USA).



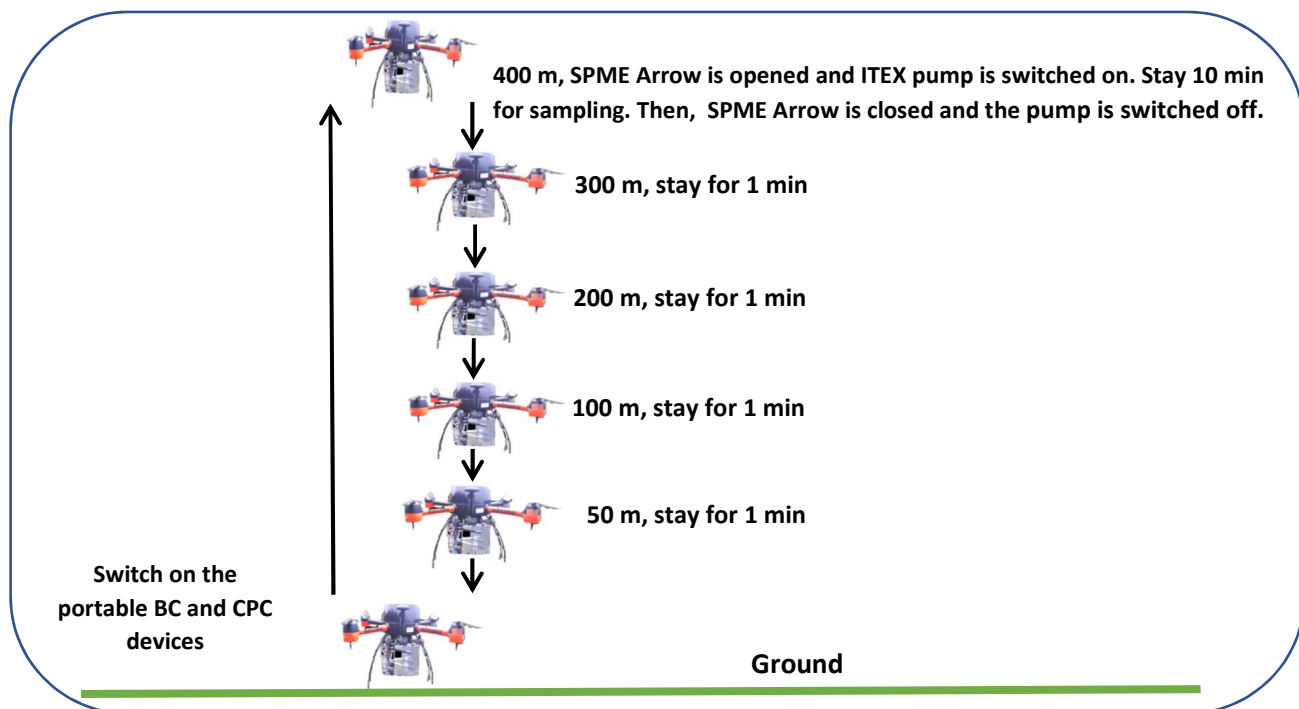
**Supplemental Figure S1**

The schematic of sample collection using SPME Arrow and ITEX from mixed altitudes (from 50 to 400 m). During the flight of the drone, the portable BC monitor and CPC devices carried out measurements.



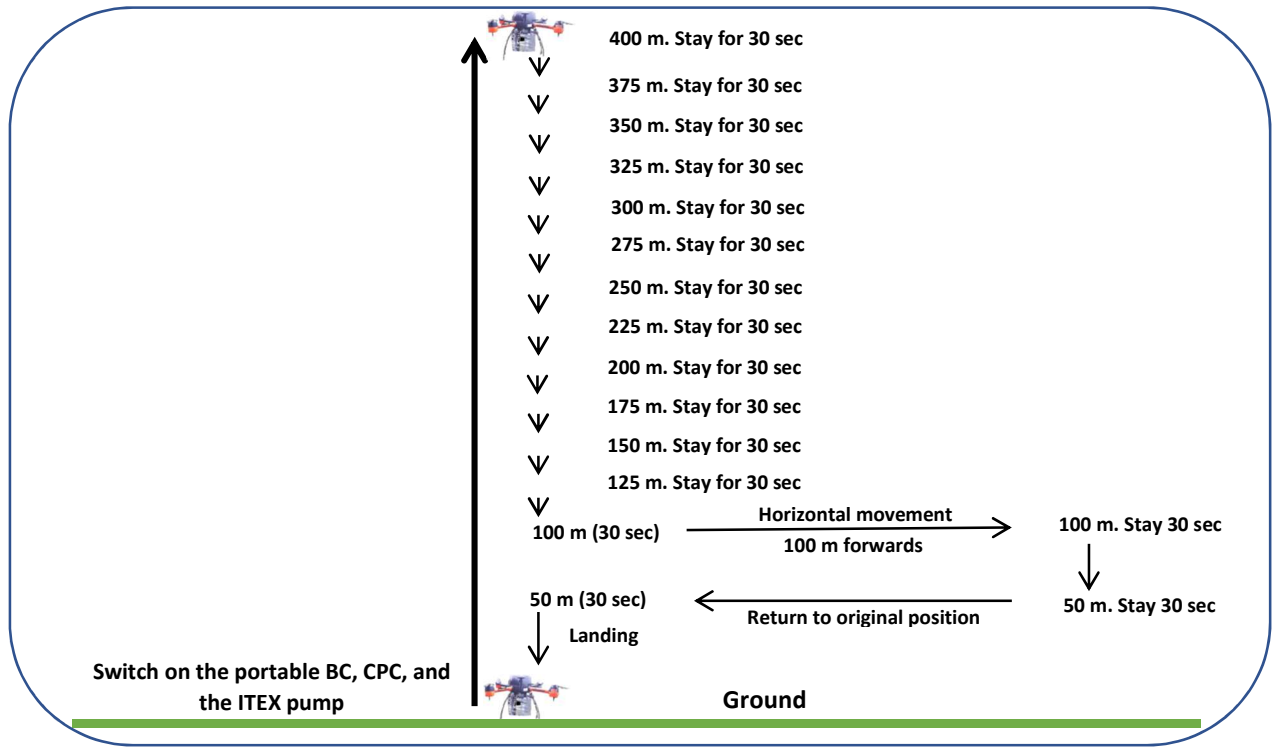
**Supplemental Figure S2**

The schematic of sample collection using ITEX and SPME Arrow at the altitude of 50 m. During the flight of the drone, the portable BC monitor and CPC devices carried out measurements.



### Supplemental Figure S3

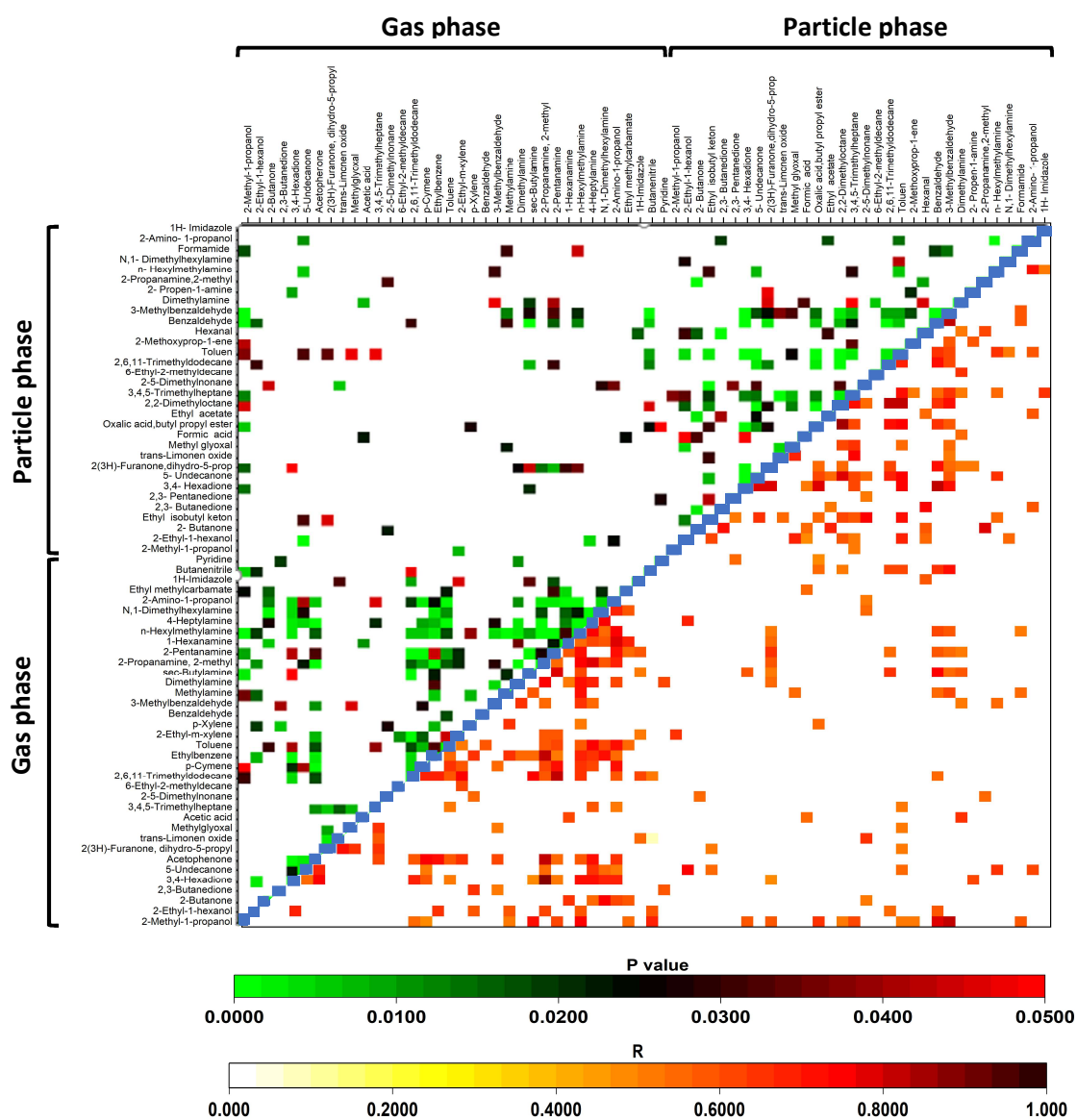
The schematic of sample collection using ITEX and SPME Arrow sampling systems at the altitude of 400 m. During the flight of the drone, the portable BC monitor and CPC devices carried out measurements.



### Supplemental Figure S4

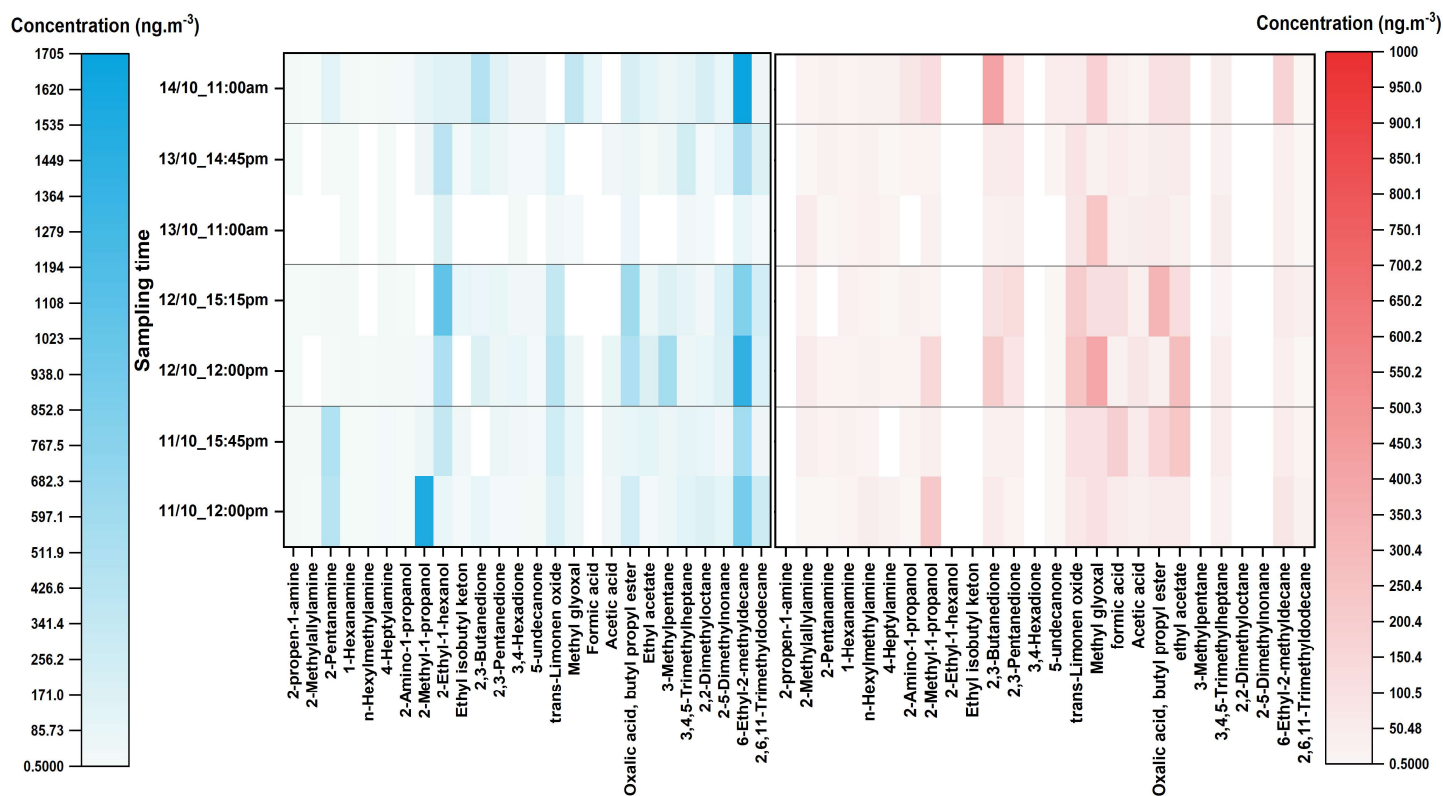
The schematic of sample collection, specifically those of aerosol particles, using ITEX with filter accessories, during horizontal and vertical concentration gradients. During the flight of the drone, the portable BC monitor and CPC devices carried out measurements.





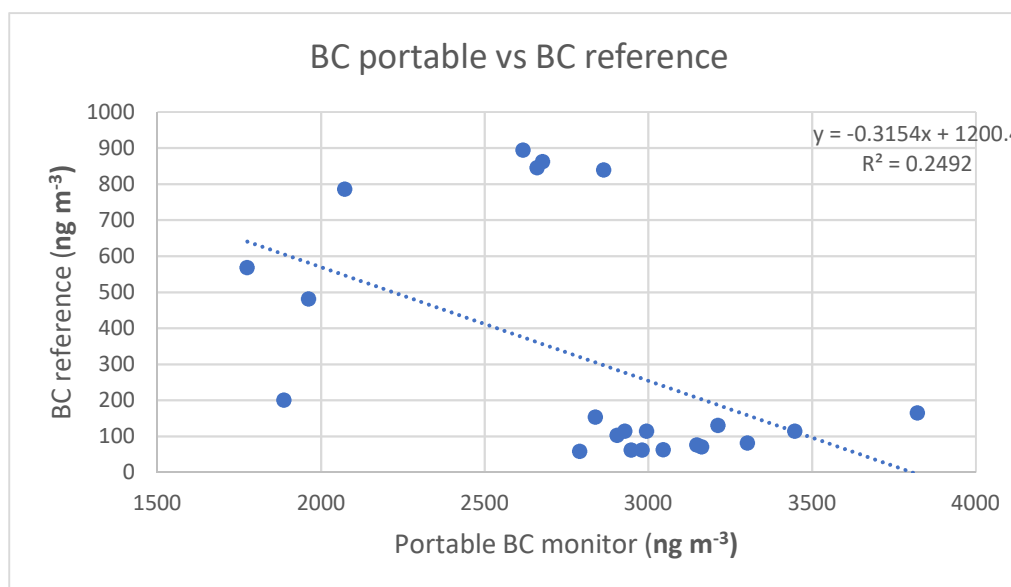
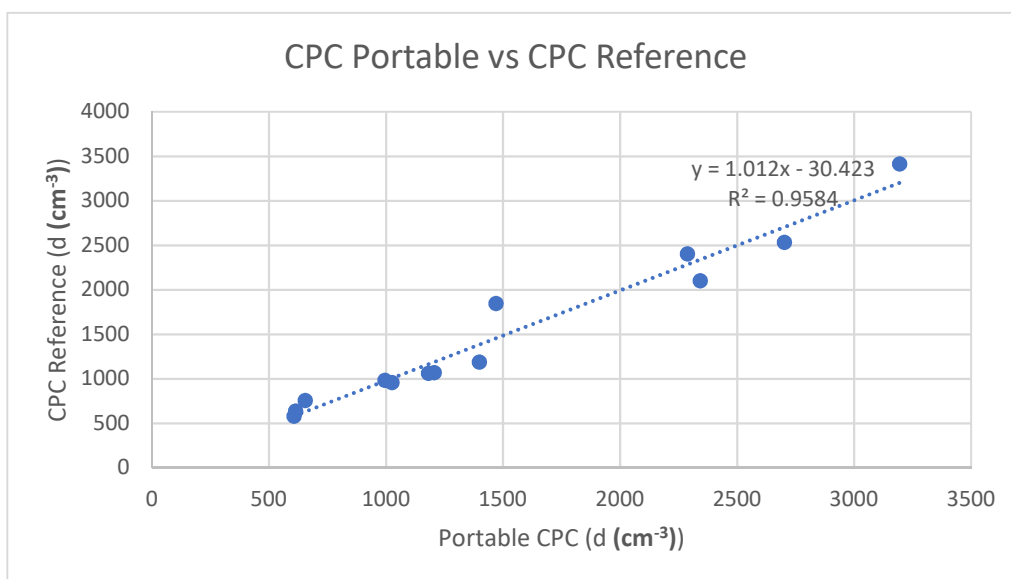
## Supplemental Figure S5

Correlation of VOCs detected at the SMEAR II Station at the mixed altitudes from 50 to 400 m.



## Supplemental Figure S6

Evaluation of ITEX filter accessories in collecting gas phase. The gaseous samples were collected using TENAX-GR-ITEX system with filter accessories (left) and CWR-SPME-Arrow system (right) at the altitudes from 50 to 400 m. White color represents that compound was not detected



**Supplemental Figure S7**

The comparison studies of portable CPC and portable BC monitor located in the drone with their reference instruments.

## Supplemental Table S1

The average of ambient pressures and temperatures at certain altitudes between 9 to 11 October 2021 at SMEAR II Station, Hyytiälä. Ambient temperature was measured by a sensor attached in the drone box (Figure 1-D in main article).

Altitude (m)	P <sub>0</sub> (Pa)	P <sub>1</sub> (Pa)	T <sub>0</sub> (K)	T <sub>1</sub> (°C)	T <sub>1</sub> (K)	<sup>a</sup> Correction factor
400 m	101325	96493	293	7.8	280.8	0.994
375 m	101325	96791	293	7.9	280.9	0.996
365 m	101325	96909	293	7.9	280.9	0.998
350 m	101325	97088	293	7.9	280.9	0.999
325 m	101325	97386	293	7.9	280.9	1.002
300 m	101325	97685	293	8.0	281.0	1.005
275 m	101325	97986	293	8.1	281.1	1.008
250 m	101325	98287	293	8.2	281.2	1.011
225 m	101325	98588	293	8.3	281.3	1.013
200 m	101325	98893	293	8.7	281.7	1.015
175 m	101325	99195	293	8.8	281.8	1.018
150 m	101325	99497	293	8.8	281.8	1.021
125 m	101325	99800	293	8.9	281.9	1.024
100 m	101325	100105	293	9.3	282.3	1.025
50 m	101325	100714	293	9.6	282.6	1.030
0 m	101325	101325	293	10.2	283.2	1.035
<sup>b</sup> Mixed alt	101325	98465	293	8.4	281.4	1.012

\*P<sub>0</sub> = standard atmospheric pressure (101.3 kPa)

\*P<sub>1</sub> = Average of ambient atmospheric pressure at certain altitude

\*T<sub>0</sub> = standard temperature (293 K)

\*T<sub>1</sub> = Average of ambient temperature at certain altitude

\*a = Calculated correction factor at certain altitude, consider different temperature and pressure.

\*b = Mixed altitudes (from 50 m to 400 m).

### Supplemental Table S2.

Repeatability studies for TENAX-GR-ITEX sampling system (i.e. within ITEX). Table includes all data points from repeatability series done by the lab-made autosampler. All values given for amines are reported as relative peak area per litre of sample. Each ITEX unit was run five times to get the repeatability value.

ITEX (Repetition)	#1	#2	#3	#4	#5	Avg (SD)	Avg (RSD)
Model Compounds	Avg	Avg	Avg	Avg	Avg		
2-Propen-1-amine	4.4	4	3.8	4.4	4.2	0.1	3.5
Diethylamine	2.3	2.5	2.4	2.6	2.6	0.2	7.1
Isobutylamine	7.2	6.5	6.3	7	6.7	0.2	3.5
1-Hexanamine	14.1	11.8	11.6	13.9	13.4	0.4	3.5
Triethylamine	48.7	43.7	42.8	43.7	42.6	1.5	3.4
1-Nitropropane	0.3	0.2	0.2	0.3	0.3	0	5.8
Pyridine	8.5	7.7	7.5	8.1	7.9	0.3	3.7
Dipropylamine	28.9	25.9	25.3	26.6	25.6	0.9	3.7

\*Avg = Average

\*SD = Standard deviation

\*RSD = Relative standard deviation

### Supplemental Table S3.

Reproducibility between ITEX units used in injections by lab-made autosampler.

Model Compounds	ITEX (repetition)					Avg 1-5	SD	RSD
	#1	#2	#3	#4	#5			
2-Propen-1-amine	4.4	4	3.8	4.4	4.2	4.2	0.2	5.6
Diethylamine	2.3	2.5	2.4	2.6	2.6	2.5	0.1	4.7
Isobutylamine	7.2	6.5	6.3	7	6.7	6.7	0.3	4.8
1-Hexanamine	14.1	11.8	11.6	13.9	13.4	13	1.1	8.1
Triethylamine	48.7	43.7	42.8	43.7	42.6	44.3	2.2	5.1
1-Nitropropane	0.3	0.2	0.2	0.3	0.3	0.3	0	18.8
Pyridine	8.5	7.7	7.5	8.1	7.9	7.9	0.3	4.3
Dipropylamine	28.9	25.9	25.3	26.6	25.6	26.5	1.3	4.9

\*Avg = Average

\*SD = Standard deviation

\*RSD = Relative standard deviation

### Supplemental Table S4.

The tested compositions of the HILIC-MS/MS eluent.

Eluent combination	Solvent A	Solvent B	pH of Solvent B
A	ACN (75 %)	100 mM (NH <sub>4</sub> ) <sub>2</sub> CO <sub>3</sub> (25 %)	8*
B	ACN (75 %)	32 mM CH <sub>3</sub> COONH <sub>4</sub> (25 %)	4.99
C	ACN (80 %)	0.05 % FA (20 %)	2.75
D	ACN (80 %)	0.05 % FA (20 %)	3.36

\*Assessed with pH paper

\* ACN = Acetonitrile; FA = Formic acid

### Supplemental Table S5.

Established MRM method parameters for each compound. Based on the product ion scans, the optimal collision energy (CE) was determined for the compounds to obtain maximum response to the most abundant product ion

Compound	Precursor (m/z)	Product (m/z)	Fragmentor (V)	CE (V)	CAV (V)
Triphenyl phosphate	327	77*	150	45	3
		168	150	45	3
<i>cis</i> -Pinonic acid	183	69	100	10	6
Sebacic acid	201	139	100	15	6
Azelaic acid	187	125	100	15	6
Vanillic acid	167	152	100	10	8
Suberic acid	173	111	100	15	1
Mandelic acid	151	107	80	10	1
Adipic acid	145	101	80	15	1
Glutaric acid	131	87	80	10	4
Pyruvic acid	87	N/A	40	0	8
4-Ketopimelic acid	173	155	80	10	1
Glycolic acid	75	N/A	40	0	8
Succinic acid	117	73	60	10	5
Fumaric acid	115	71	40	10	6
Benzoic acid	121	77	100	10	5
Phthalic acid	165	77	80	15	1
Maleic acid	115	71	40	10	0
Trimesic acid	209	165	100	10	6
2-Oxoglutaric acid	145	101	60	5	0
Malonic acid	103	N/A	60	0	0

\* Set as quantifier

\*CE = Collision energy; CAV = Cell acceleration voltage

## Supplemental Table S6.

The calculated LOQs for results achieved by ITEX and SPME Arrow systems.

LOQ	SPME Arrow			ITEX	
	CWR ( $\mu\text{g}/\text{m}^3$ )	DVB/PDMS ( $\mu\text{g}/\text{m}^3$ )	MCM-41 ( $\mu\text{g}/\text{m}^3$ )	Tenax-GR (ng)	MCM-41-TP (ng)
Pyridine	0.066	0.429	0.195	0.186	0.240
Sec-butylamine	0.053	0.019	0.011	1.157	0.025
1-Butanamine	0.209	0.118	0.193	0.431	0.217
1-Butanenitrile	1.171	1.841	1.558	1.776	1.575
1-Propen-1-amine	0.291	2.177	0.019	0.596	0.108
Diethylamine	0.154	0.012	0.271	0.623	0.977
Dimethylformamide	0.220	0.400	0.130	0.791	0.484
Trimethylamine	1.380	0.182	0.096	0.259	0.086
Ethyl acetate	0.705	0.429	0.775	0.676	0.330
Isobutanol	1.114	1.510	0.598	0.003	0.202
Methyl isobutyl ketone	0.105	0.065	0.125	0.175	0.094
Hexanal	0.185	0.061	0.111	0.221	0.050
Nonane	1.006	0.162	1.485	3.236	1.415
2,3-Butanedione	0.034	-	0.144	0.162	2.624
Benzaldehyde	0.031	0.043	0.168	0.080	0.440
Acetophenone	1.611	0.006	0.550	0.113	0.058
p-Cymene	0.571	0.094	1.777	3.021	0.497
Ethylbenzene	0.877	0.362	4.651	11.752	4.324

\*LOQ = Limit of quantification

\*SPME Arrow = Solid-phase micro extraction arrow

\*ITEX = in-tube extraction

## Supplemental Table S7

Concentrations of nitrogen-containing compounds detected in gas and particle phases at mixed altitudes (50 – 400 m). Conversion from  $\text{ng m}^{-3}$  to  $\text{ppt}_v$  have been made using the conversion factor ( $\text{ppt}_v = \text{Concentration (ng m}^{-3}) : (0.0409 \times (\text{MW}))$ ). (Finlayson-Pitts and Pitts, James N., 2000)

Compound	Mr	Concentration in Gas-phase		Concentration in Particle-phase	
		( $\text{ng m}^{-3}$ )	( $\text{ppt}_v$ )	( $\text{ng m}^{-3}$ )	( $\text{ppt}_v$ )
Methylamine	31.1	$\leq 431.6$	$\leq 339.31$	$\leq 212.1$	$\leq 166.7$
Dimethylamine	45.1	$\leq 1004.4$	$\leq 544.5$	$\leq 5908.9$	$\leq 3203.3$
sec-Butylamine	73.1	$\leq 156.3$	$\leq 52.2$	$\leq 4089.6$	$\leq 1367.8$
2-Propen-1-amine	57.1	$\leq 30.0$	$\leq 12.8$	$\leq 134.1$	$\leq 57.4$
2-Propanamine, 2-methyl	73.1	$\leq 196.2$	$\leq 65.6$	$\leq 238.8$	$\leq 79.8$
1-Butanamine	73.1	$\leq 388.9$	$\leq 130.0$	$\leq 711.4$	$\leq 237.9$
2-Pentanamine	87.2	$\leq 395.4$	$\leq 110.8$	$\leq 211.1$	$\leq 59.1$
1-Hexanamine	101.2	$\leq 493.3$	$\leq 119.1$	$\leq 4315.6$	$\leq 1042.6$
n-Hexylmethylamine	115.2	$\leq 340.2$	$\leq 72.2$	$\leq 573.2$	$\leq 121.6$
4-Heptylamine	115.2	$\leq 257.3$	$\leq 54.6$	$\leq 189.9$	$\leq 40.3$
N,1-Dimethylhexylamine	129.2	$\leq 1239.6$	$\leq 234.5$	$\leq 686.3$	$\leq 129.8$
Formamide	45.0	$\leq 396.5$	$\leq 215.4$	-	-
2-Amino-1-propanol	75.1	$\leq 789.9$	$\leq 257.1$	$\leq 129.0$	$\leq 42.0$
Ethyl methylcarbamate	103.1	$\leq 81.3$	$\leq 19.2$	$\leq 125.9$	$\leq 29.8$
2-Propenamide	71.1	$\leq 94.5$	$\leq 32.5$	-	-
1H-Imidazole	68.1	$\leq 136.1$	$\leq 48.8$	$\leq 645.5$	$\leq 231.7$
Butanenitrile	69.1	$\leq 2005.0$	$\leq 709.4$	$\leq 6121.6$	$\leq 2166.0$
Pyridine	79.1	$\leq 491.5$	$\leq 151.9$	$\leq 958.2$	$\leq 296.1$

\*Mr = Molecular weight (g/mol)



## Supplemental Table S8

Concentrations of other volatile organic compounds detected in gas and particle phases at mixed altitudes (50 – 400 m). Conversion from  $\text{ng m}^{-3}$  to  $\text{pptv}$  have been made using the conversion factor ( $\text{pptv} = \text{Concentration (ng m}^{-3}) : (0.0409 \times (\text{MW}))$ ). (Finlayson-Pitts and Pitts, James N., 2000)

Compound	Mr	Concentration in Gas-phase		Concentration in Particle-phase	
		( $\text{ng m}^{-3}$ )	(pptv)	( $\text{ng m}^{-3}$ )	(pptv)
2-Methyl-1-propanol	74.1	$\leq 4208.6$	$\leq 1388.6$	$\leq 1064.7$	$\leq 351.3$
2-Ethyl-1-hexanol	130.1	< LOQ	< LOQ	$\leq 4114.1$	$\leq 773.1$
2-Butanone	72.1	$\leq 218.9$	$\leq 74.2$	$\leq 2598.7$	$\leq 881.2$
Ethyl isobutyl keton	114.2	< LOQ	< LOQ	$\leq 806.1$	$\leq 172.5$
2,3-Butanedione	86.1	$\leq 2436.1$	691.7	$\leq 4865.3$	$\leq 1381.6$
2,3-Pentanedione	100.1	$\leq 483.2$	118.0	$\leq 2352.4$	$\leq 574.5$
3,4-Hexadione	114.1	< LOQ	< LOQ	$\leq 4871.9$	$\leq 1043.9$
5-Undecanone	170.3	< LOQ	< LOQ	$\leq 900.8$	$\leq 129.3$
2(3H)-Furanone, dihydro-5-propyl	128.2	$\leq 354.2$	$\leq 67.5$	$\leq 1829.0$	$\leq 348.8$
trans-Limonen oxide	152.2	$\leq 2210.9$	$\leq 355.1$	$\leq 6886.0$	$\leq 1106.2$
Methyl glyoxal	72.1	$\leq 4695.3$	$\leq 1592.2$	$\leq 8613.2$	$\leq 2920.8$
Formic acid	46.0	$\leq 3239.4$	$\leq 1721.8$	$\leq 380.2$	$\leq 202.0$
2-Butenoic acid	86.1	-	0	$\leq 294.8$	$\leq 83.7$
Oxalic acid, butyl propyl ester	188.2	-	0	$\leq 5299.4$	$\leq 688.4$
Acetic acid	60.1	$\leq 6898.3$	$\leq 2806.3$	$\leq 8603.4$	$\leq 3500.0$
Ethyl acetate	88.1	$\leq 2198.8$	$\leq 610.2$	$\leq 5105.2$	$\leq 1416.8$
2,2-Dimethyloctane	142.3	< LOQ	< LOQ	$\leq 4209.2$	$\leq 723.2$
3,4,5-Trimethylheptane	142.3	$\leq 279.2$	$\leq 47.9$	$\leq 5350.4$	$\leq 919.3$
2-5-Dimethylnonane	156.3	< LOQ	< LOQ	$\leq 3408.9$	$\leq 533.2$
6-Ethyl-2-methyldecane	184.4	< LOQ	< LOQ	$\leq 7091.0$	$\leq 940.2$
2,6,11-Trimethyldodecane	212.4	< LOQ	< LOQ	$\leq 1746.1$	$\leq 200.9$
p-Cymene	134.2	$\leq 104.4$	$\leq 19.0$	$\leq 7772.5$	$\leq 1416.0$
Benzene	78.1	$\leq 644.9$	$\leq 201.8$	$\leq 3418.0$	$\leq 1070.0$
Ethylbenzene	106.2	$\leq 363.6$	$\leq 83.7$	$\leq 3041.6$	$\leq 700.2$
Toluene	92.1	$\leq 143.6$	$\leq 38.1$	$\leq 7715.0$	$\leq 2048.1$
2-Ethyl-m-xylene	134.2	$\leq 35.1$	$\leq 6.4$	$\leq 1463.0$	$\leq 266.5$
p-Xylene	106.2	$\leq 198.7$	$\leq 45.7$	$\leq 1195.5$	$\leq 275.2$
Propene	42.1	$\leq 1715.0$	$\leq 995.9$	$\leq 1847.2$	$\leq 1072.7$
2-Methoxypropene	72.1	$\leq 1258.1$	$\leq 426.6$	$\leq 502.2$	$\leq 170.3$
Hexanal	100.2	$\leq 3984.0$	$\leq 972.1$	$\leq 1020.4$	$\leq 248.9$
Benzaldehyde	106.0	$\leq 185.8$	$\leq 42.8$	$\leq 1098.3$	$\leq 253.3$
3-Methylbenzaldehyde	120.2	$\leq 331.7$	$\leq 67.4$	$\leq 684.5$	$\leq 139.2$

\*Mr = Molecular weight (g/mol)

### Supplemental Table S9

Recoveries obtained for compounds collected by ITEX sampling system with filter accessory.

Compounds	Recovery (%)	Compounds	Recovery (%)
2-Methyl-1-propanol	81.4	3,4,5-Trimethylheptane	26.8
2,3-Butanedione	58.3	6-Ethyl-2-methyldecane	37.5
2,3-Pentanedione	84.9	2,6,11-Trimethyldodecane	13.2
5-Undecanone	9.2	2-methyl-2-propen-1-amine	99.2
Trans-limonen oxide	94.4	2-Pentanamine	87.2
Methyl glyoxal	98.8	1-Hexanamine	96.8
Acetic acid	79.7	n-Hexylmethylamine	15.3
Oxalic acid, butyl propyl ester	5.8	4-Heptylamine	64.9
Ethyl acetate	95.1	2-Amino-1-propanol	41.4

## Supplemental Table S10

Determined LODs and LOQs for the acids based on parameters provided by linear regression analysis using HILIC/MS-MS.

Acid	Intercept	Std. Error of Intercept	Slope	LOD (ng/mL)	LOQ (ng/mL)
<b>2-Oxoglutaric acid</b>	-36.166	37.247	2.292	49	161
<b>4-Ketopimelic</b>	-641.995	54.629	16.508	9.9	33
<b>Adipic acid</b>	-188.943	27.922	23.168	3.6	12
<b>Azelaic acid</b>	-50.384	43.565	17.113	7.6	25
<b>Benzoic acid</b>	4.711	1.729	4.504	1.2	3.8
<b>cis-Pinonic acid</b>	23.434	4.790	2.386	6.0	20
<b>Fumaric acid</b>	-149.825	3.048	3.986	2.3	7.6
<b>Glutaric acid</b>	-62.521	32.090	21.988	4.4	14
<b>Glycolic acid</b>	-100.415	17.613	3.723	14	47
<b>Maleic acid</b>	28.810	22.979	8.818	7.8	26
<b>Malonic acid</b>	-4.592	0.598	1.185	1.5	5.0
<b>Mandelic acid</b>	18.588	17.224	17.813	2.9	10
<b>Phthalic acid</b>	33.560	15.300	10.644	4.3	14
<b>Pyruvic acid</b>	-1944.231	204.268	1.987	308	1 018
<b>Sebacic acid</b>	-179.209	34.928	28.576	3.7	12
<b>Suberic acid</b>	-55.378	6.770	22.078	0.92	3.0
<b>Succinic acid</b>	-17.288	24.260	20.605	3.5	12
<b>Trimesic acid</b>	499.680	294.814	3.477	254	839
<b>Vanillic acid</b>	15.056	0.361	0.915	1.2	3.9

## Supplemental Table S11

Two minutes average of black carbon (BC) and total particle concentrations measured at the altitudes of 100, 200, 300, and 400 m in three days measurement (9, 10, and 11 October 2021).

100 m						
Time	BC (ng m <sup>-3</sup> )	STDev	RSD (%)	TPC (d(cm <sup>-3</sup> ))	STDev	RSD (%)
10.30 am	2930.7	1133.6	39.7	739.6	31.6	4.4
13.00 pm	2461.5	1299.9	54.2	591.7	0.0	0.0
17.00 pm	2567.6	1202.4	48.0	1113.9	15.4	1.4
10.23 am	3054.7	1348.8	45.3	1087.8	42.9	4.0
12.54 pm	2845.7	941.3	33.9	1316.2	12.9	1.0
13.30 pm	1429.7	1140.4	81.8	1263.3	91.2	7.4
17.00 pm	1841.6	1487.9	82.8	1467.6	41.1	2.9
09.00 am	2175.9	891.4	73.9	2530.6	62.3	2.5
12.00 pm	1744.9	1116.6	77.5	2082.9	177.9	8.8
12.30 pm	1750.4	1318.4	77.2	409.5	103.9	26.0
200 m						
Time	BC (ng m <sup>-3</sup> )	STDev	RSD (%)	TPC (d(cm <sup>-3</sup> ))	STDev	RSD (%)
10.30 am	2356.2	625.9	27.0	584.5	35.7	6.2
13.00 pm	2392.3	1637.5	69.5	608.1	0.0	0.0
17.00 pm	2335.8	985.3	42.8	1091.5	16.9	1.6
10.23 am	3265.4	1701.2	52.9	1178.6	86.5	7.5
12.54 pm	3433.7	2343.5	69.3	1366.7	24.1	1.8
13.30 pm	2795.2	1332.5	48.4	1175.4	22.6	1.9
17.00 pm	2394.6	1810.8	76.8	1477.5	34.5	2.4
09.00 am	2690.2	1464.3	55.3	2372.3	117.7	5.0
12.00 pm	2240.8	1062.0	48.1	2108.4	42.7	2.1
12.30 pm	1568.9	2012.6	130.2	389.1	69.7	18.2
300 m						
Time	BC (ng m <sup>-3</sup> )	STDev	RSD (%)	TPC (d(cm <sup>-3</sup> ))	STDev	RSD (%)
10.30 am	3349.9	412.3	12.4	595.5	57.2	9.7
13.00 pm	3364.1	929.8	27.8	564.3	4.1	0.7
17.00 pm	3507.9	641.0	18.4	1016.3	46.9	4.6
10.23 am	4076.5	981.5	24.2	827.6	114.9	14.0
12.54 pm	3531.7	2208.4	62.9	1436.3	135.5	9.5
13.30 pm	2896.5	4880.1	169.4	1178.0	32.6	2.8
17.00 pm	3986.7	1728.5	43.6	1432.4	36.9	2.6
09.00 am	4285.0	1693.2	39.7	2383.2	90.9	3.8
12.00 pm	3495.6	1623.1	46.7	2003.9	363.7	18.2
12.30 pm	3205.5	1388.5	43.5	1058.8	33.3	3.2
400m						
Time	BC (ng m <sup>-3</sup> )	STDev	RSD (%)	TPC (d(cm <sup>-3</sup> ))	STDev	RSD (%)
10.30 am	3423.2	631.9	18.3	622.0	33.1	5.3
13.00 pm	3386.3	382.6	11.2	615.9	70.1	11.3
17.00 pm	3692.4	434.3	11.7	768.3	17.0	2.2
10.23 am	4723.6	332.9	7.0	530.0	130.0	24.4
12.54 pm	4843.3	963.0	19.8	1065.0	138.1	12.9
13.30 pm	2798.7	530.2	18.8	843.0	73.8	8.7
17.00 pm	5304.9	1120.9	21.0	1276.1	80.0	6.2
09.00 am	5513.9	961.0	17.3	2049.7	101.5	4.9

12.00 pm	3765.9	724.4	19.1	1971.1	39.6	2.0
12.30 pm	2146.8	1218.3	56.4	946.2	60.8	6.4

\* BC = Black carbon

\* TPC = Total particle concentration

### Supplemental Table S12

Daily average of black carbon (BC) and total particle concentrations measured at the altitudes of 100, 200, 300, and 400 m in three days measurement (9, 10, and 11 October 2021).

Day	Average at 100 m		Average at 200 m		Average at 300 m		Average at 400 m	
	BC (ng m <sup>-3</sup> )	TPC (d(cm <sup>-3</sup> ))	BC (ng m <sup>-3</sup> )	TPC (d(cm <sup>-3</sup> ))	BC (ng m <sup>-3</sup> )	TPC (d(cm <sup>-3</sup> ))	BC (ng m <sup>-3</sup> )	TPC (d(cm <sup>-3</sup> ))
1	2653.3	815.1	2361.4	761.3	3407.3	725.4	3500.6	668.8
2	2293.0	1283.7	2972.2	1299.5	3622.9	1218.6	4417.6	928.5
3	1890.4	1674.3	2166.7	1623.2	3662.0	1815.3	3808.9	1655.7

\* BC = Black carbon

\* TPC = Total particle concentration

### Reference

Finlayson-Pitts, B.J., Pitts, James N., J., 2000. Chemistry of the upper and lower atmosphere : theory, experiments, and applications. Academic Press, San Diego.