Seasonal variation and sources of elements in urban submicron and fine aerosol in Brno, Czech Republic

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SUPPLEMENTARY MATERIALS

Figure S1: 1-day back trajectories in winter 2018 in Brno
Figure S2: 1-day back trajectories in spring 2018 in Brno

Figure S3: 1-day back trajectories in summer 2018 in Brno
Figure S4: 1-day back trajectories in autumn 2018 in Brno

Figure S5: Comparison of PM2.5 mass concentrations in Brno.
### Table S1: Meteorological parameters during campaigns.

| Season | Temperature (°C) | Humidity (%) | Modelled wind direction (predominant) |
|--------|------------------|--------------|--------------------------------------|
|        | Average | Range     | Average  | Range                     |                               |
| winter | -3.6    | -12.6 – 5.4 | 70.4    | 41.9 – 99.4                | northeast, east               |
| spring | 17.7    | 3.7 – 27.3  | 57.6    | 27.3 – 98.4                | west, south                   |
| summer | 21.3    | 11.3 – 30.6 | 62.8    | 26.0 - 100                 | north, northwest              |
| autumn | 2.5     | -7.2 – 10.4 | 78.7    | 44.9 – 99.6                | east                         |

### Table S2: Comparison of PM$_1$ mass concentrations in studied seasons.

| Probability (P) * | winter | spring | summer | autumn |
|-------------------|--------|--------|--------|--------|
| winter            | ---    | 0.0013 | 0.0004 | 0.0413 |
| spring            | 0.0013 | ---    | 0.1510 | 0.0098 |
| summer            | 0.0004 | 0.1510 | ---    | 0.0010 |
| autumn            | 0.0413 | 0.0098 | 0.0010 | ---    |

* independent T-test: if P ≥ 0.05, means are not statistically different

### Table S3: Comparison of PM$_{2.5}$ mass concentrations in studied seasons.

| Probability (P) * | winter | spring | summer | autumn |
|-------------------|--------|--------|--------|--------|
| winter            | ---    | 0.0003 | 0.0001 | 0.0766 |
| spring            | 0.0003 | ---    | 0.0259 | 0.0038 |
| summer            | 0.0001 | 0.0259 | ---    | 0.0001 |
| autumn            | 0.0766 | 0.0038 | 0.0001 | ---    |

* independent T-test: if P ≥ 0.05, means are not statistically different

### Table S4: Comparison of PM mass concentrations during week-days and weekends

| Probability (P) * |
|-------------------|
| winter PM$_1$      | 0.1525 |
| winter PM$_{2.5}$  | 0.4946 |
| spring PM$_1$      | 0.0907 |
| spring PM$_{2.5}$  | 0.0443 |
| summer PM$_1$      | 0.0340 |
| summer PM$_{2.5}$  | 0.1106 |
| autumn PM$_1$      | 0.8880 |
| autumn PM$_{2.5}$  | 0.5400 |

* one sample T-test: if P ≥ 0.05, means are not statistically different
Table S5: PM1 and PM2.5 mass concentrations (µg m\(^{-3}\)) in literature

| Location       | PM1          | PM2.5         | PM1          | PM2.5         | Reference          |
|----------------|--------------|---------------|--------------|---------------|--------------------|
| Average        | Range        | Average       | Range        | Average       | Range              |
| Brno (CZE)     | 21.9         | 14.5–32.6     | 30.4         | 19.7–42.0     | 9.74               | 7.19–13.7          | 12.4               | 9.34–15.8          | this study         |
| Brno (CZE)     | 12.3         | 10.3–20.3     | -            | -             | 8.9                | 7.7–10.7           | -                  | -                  | Mikuška et al., 2020 |
| Brno (CZE)     | 25.9         | 20.9–32.5     | -            | -             | 10.4               | 5.8–17.6           | -                  | -                  | Mikuška et al., 2020 |
| Brno (CZE)     | 16.5         | 2.80–26.8     | -            | -             | 10.8               | 6.70–15.7          | -                  | -                  | Coufalík et al., 2016 |
| Elche (Spain)  | 8.80         | 2.00–19.9     | 12.3         | 3.60–29.2     | 10.1               | 5.30–16.5          | 14.0               | 4.70–26.8          | Galindo et al., 2010 |
| Warsaw (Poland)| 17.4         | 4.70–39.0     | -            | -             | 11.1               | 5.67–22.6          | -                  | -                  | Rogula-Kozłowska et al., 2018 |
| Milan (Italy)  | -            | -             | 27.5         | -             | -                  | -                  | 11.5               | -                  | Juda-Rezler et al., 2020 |
| Zabrze (Poland)| 47.1         | 8.30–199      | -            | -             | 12.1               | 6.47–19.1          | -                  | -                  | Rogula-Kozłowska et al., 2018 |
|                | -            | -             | 66.9         | -             | -                  | -                  | 18.4               | -                  | Rogula-Kozłowska et al., 2012 |
Table S6: Selected elements concentration (ng m⁻³) in PM₁ during winter and summer campaigns in literature

| Location          | Al  | Ca  | Cu  | Fe  | K   | Mn  | Ni  | Pb  | V   | Zn  | Reference               |
|-------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------------------------|
| Winter            |     |     |     |     |     |     |     |     |     |     |                         |
| Brno (CZE)        | 11.5| 9.65| 1.97| 38.9| 173 | 2.17| 0.38| 7.36| 0.25| 25.8| this study             |
| Brno (CZE)        | 9.11| 30.0| 0.46| 28.8| 63.3| 1.18| 0.37| 133 | 0.41| 8.49| Mikuška et al., 2020            |
| Brno (CZE)        | 3.89| 20.7| 1.40| 57.4| 273 | 5.90| 1.38| 76.7| 0.57| 46.2| Mikuška et al., 2020            |
| Brno (CZE)        | -   | -   | 1.72| 27.9| -   | 1.66| -   | 4.22| 0.15| 18.4| Coufalík et al., 2016         |
| Milan (Italy)     | 16.0| 24.0| 7.00| 89.0| 257 | 9.00| 7.00| 35.0| 5.00| 66.0| Vecchi et al., 2004          |
| Barcelona (Spain) | -   | -   | 3.91| -   | -   | 2.23| 2.58| 6.02| 5.47| 27.1| Moreno et al., 2011         |
| Kanpur (India)    | -   | 1520| 240 | 1030| -   | 10.0| 240 | 10.0| 860 | Abishek et al., 2010        |
| Summer            |     |     |     |     |     |     |     |     |     |     |                         |
| Brno (CZE)        | 13.0| 19.5| 0.98| 33.1| 31.7| 1.09| 0.21| 1.66| 0.09| 3.86| this study             |
| Brno (CZE)        | 7.07| 54.7| 1.08| 5.45| 68.1| 1.38| -   | 27.3| 0.13| 8.52| Mikuška et al., 2020            |
| Brno (CZE)        | 8.63| 13.0| 1.44| 25.1| 44.0| 1.24| 0.10| 3.05| -   | 12.5| Mikuška et al., 2020            |
| Brno (CZE)        | -   | -   | 1.44| 37.1| -   | 2.43| 0.51| 2.94| 0.22| 11.2| Coufalík et al., 2016         |
| Milan (Italy)     | 14.0| 17.0| 3.00| 42.0| 81.0| 4.00| 2.00| 15.0| 4.00| 32.0| Vecchi et al., 2004          |
| Barcelona (Spain) | -   | -   | 2.05| -   | -   | 1.44| 2.93| 2.34| 8.24| 8.82| Moreno et al., 2011         |
| Kanpur (India)    | -   | 2870| 160 | 1240| -   | 8.00| 360 | 20.0| 390 | Abishek et al., 2010        |
| Katowice (Poland) | 12.4| -   | 7.08| 91.1| -   | 28.6| 0.50| 18.5| 12.3| 38.4| Rogula-Kozlowska, 2015       |
|                   | 8.94| -   | 7.61| 101 | -   | 33.8| 0.52| 18.8| 13.8| 35.8|                         |
Table S7: Selected elements concentration (ng m$^{-3}$) in PM$_{2.5}$ during winter and summer campaigns in literature

| Location            | Al  | Ca  | Cu  | Fe  | K   | Mn  | Ni  | Pb  | V   | Zn   | Reference       |
|---------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|-----------------|
| Winter              |     |     |     |     |     |     |     |     |     |      |                 |
| Brno (CZE)          | 97.2| 102 | 4.53| 176 | 226 | 5.09| 0.62| 9.90| 0.53| 39.9 | this study      |
| Nanjing (China)     | 113 | -   | 34.6| -   | -   | 70.3| 8.76| 72.2| 4.19| 310  | Qi et al., 2016 |
| Karachi (Pakistan)  | 28.1| 26.3| 0.04| 3.71| 20.6| 0.05| -   | 0.13| -   | 2.89 | Mansha et al., 2012 |
| Milan (Italy)       | 53.0| 69.0| 18.0| 309 | 342 | 18.0| 9.00| 55.0| 7.00| 135  | Vecchi et al., 2004 |
| Barcelona (Spain)   | -   | -   | 8.06| -   | -   | 6.08| 3.11| 9.13| 6.98| 45.7 | Moreno et al., 2011 |
| Nanjing (China)     | -   | -   | 70.3| -   | -   | 48.9| -   | 70.8| 8.48| -    | Wu et al., 2019  |
| Wuhan (China)       | -   | 2270| 30.6| 1420| 2170| 125 | 5.95| 204 | -   | 366  | Zhang et al., 2015 |
| Summer              |     |     |     |     |     |     |     |     |     |      |                 |
| Brno (CZE)          | 57.6| 73.5| 2.54| 106 | 54.3| 2.21| 0.29| 1.69| 0.14| 6.48 | this study      |
| Nanjing (China)     | 141 | -   | 17.8| -   | -   | 37.9| 7.69| 62.9| 3.48| 167  | Qi et al., 2016  |
| Karachi (Pakistan)  | 51.4| 43.9| 0.06| 3.36| 51.4| 0.05| -   | 0.12| -   | 2.89 | Mansha et al., 2012 |
| Milan (Italy)       | 49.0| 65.0| 10.0| 186 | 124 | 8.00| 2.00| 22.0| 5.00| 66.0 | Vecchi et al., 2004 |
| Barcelona (Spain)   | -   | -   | 5.97| -   | -   | 5.42| 5.14| 5.01| 12.5| 25.8 | Moreno et al., 2011 |
| Nanjing (China)     | -   | -   | 21.4| -   | -   | 27.3| -   | 39.7| 7.17| -    | Wu et al., 2019  |
| Wuhan (China)       | -   | 5590| 17.7| 1340| 410 | 48.7| 3.26| 88.9| -   | 159  | Zhang et al., 2015 |
Table S8: Average enrichment factors of elements in different seasons.

|        | Al  | As  | Ba  | Ca  | Cd  | Co  | Cr  | Cu  | K   | Mg  | Mn  | Na  | Ni  | Pb  | Sb  | Se  | Sn  | Ti  | V   | Zn  |
|--------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| PM1    |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| winter | 0.14| 0.60| 0.38| 3562| 2.18| 3.59| 71  | 7.46| 0.32| 2.82| 2.14| 8.03| 434 | 1211| 7246| 336 | 0.14| 2.45| 386 |
| spring | 0.35| 0.85| 0.62| 673 | 0.79| 2.17| 32  | 2.00| 0.50| 1.30| 2.10| 2.72| 92  | 625 | 3577| 141 | 0.25| 1.91| 103 |
| summer | 0.19| 0.35| 0.90| 445 | 0.75| 3.07| 41  | 1.61| 0.37| 1.67| 0.90| 5.25| 117 | 6586| 7018| 184 | 0.22| 1.10| 68  |
| autumn | 0.07| 0.23| 0.60| 2282| 1.59| 6.09| 80  | 7.56| 0.40| 2.45| 3.82| 5.47| 439 | 1804| 7024| 398 | 0.07| 1.22| 424 |
| PM2.5  |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| winter | 0.26| 0.86| 0.87| 1184| 1.04| 2.45| 35  | 2.14| 0.53| 1.45| 1.60| 2.89| 128 | 411 | 2060| 121 | 0.29| 1.20| 131 |
| spring | 0.35| 0.85| 0.56| 205 | 0.70| 1.79| 21  | 0.83| 0.51| 0.99| 0.63| 1.45| 28  | 209 | 1112| 68  | 0.29| 0.99| 37  |
| summer | 0.26| 0.66| 1.06| 140 | 0.57| 2.14| 33  | 0.86| 0.49| 1.06| 0.73| 2.29| 36  | 1694| 2336| 101 | 0.28| 0.53| 35  |
| autumn | 0.16| 0.74| 0.71| 1094| 0.91| 4.17| 61  | 3.44| 0.30| 1.64| 1.29| 2.61| 177 | 627 | 3131| 189 | 0.12| 0.77| 259 |

Table S9: Summary of PMF diagnostics.

| Diagnostic                  | PM2.5 | PM1  |
|-----------------------------|-------|------|
| Qexpected/theoretical       | 231   | 255  |
| Qtrue                       | 231   | 255  |
| Qrobust                     | 231   | 255  |
| Species Q/Qexpected >2      | -     | V    |
| DISP                        | -0.002| 0    |
| BS mapping                  | 92 – 100| 95 – 100  |