

Appendix K Wind Speed and Direction and Pollutant Concentrations

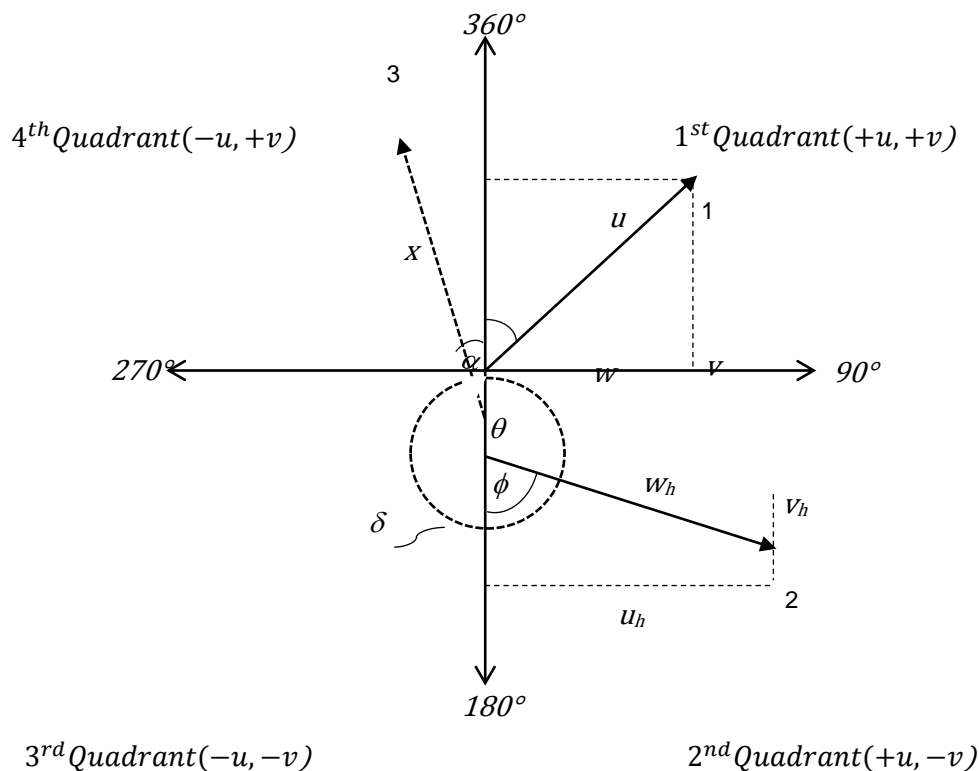
K1.1 Correction of Wind Speed and Direction

This section details the method used to correct mobile measurements of wind speed and direction.

One-minute average measurements of wind speed and direction were recorded during the mobile monitoring exercises. These data were corrected in order to take account of the relative heading and speed of the mobile monitoring trolley during each exercise. Heading measurements were taken using the Lufft met mast and speed measurements were recorded using the GPS watch. Figure K1 shows an example of measured wind and heading vectors together with the calculated resultant wind vector and 4 quadrants.

Figure K1 Measured Wind, Measured Heading and Resultant Vectors

1. Measured wind vector
2. Measured heading vector
3. Resultant wind vector



The following equations were used to calculate the resultant wind vector:

$$u = w \sin \theta \quad (J1)$$

$$v = w \cos \theta \quad (J2)$$

$$u_h = w_h \sin \emptyset \quad (J3)$$

$$v_h = w_h \cos \emptyset \quad (J4)$$

$$\Delta u = u - u_h \quad (J5)$$

$$\Delta v = v - v_h \quad (J6)$$

$$\alpha = \tan^{-1} \frac{\Delta u}{\Delta v} \quad (J7)$$

$$x = \sqrt{\Delta u^2 + \Delta v^2} \quad (J8)$$

Where:

w = the measured wind speed.

w_h = the measured walking speed.

u = the horizontal component of the measured wind speed.

v = the vertical component of the measured wind speed.

u_h = the horizontal component of the measured walking speed.

v_h = the vertical component of the measured walking speed.

θ = angle of measured wind vector relative to the 180°/360° axis.

\emptyset = angle of measured heading vector relative to the 180°/360° axis.

Δu = the difference between the horizontal components of measured wind speed and walking speed.

Δv = the difference between the vertical components of measured wind speed and walking speed.

x = the resultant wind speed.

α = Angle of resultant wind vector relative to the 180°/360° axis.

The following equations were used in order to convert the angle of the resultant wind vector relative to the 180°/360° axis (α) to a resultant wind direction (δ):

$$\text{If } +\Delta u \text{ and } +\Delta v \text{ then: } \delta = \alpha \quad (J9)$$

$$\text{If } +\Delta u \text{ and } -\Delta v \text{ then: } \delta = 180^\circ - \alpha \quad (J10)$$

$$\text{If } -\Delta u \text{ and } -\Delta v \text{ then: } \delta = 180^\circ + \alpha \quad (J11)$$

$$\text{If } -\Delta u \text{ and } +\Delta v \text{ then: } \delta = 360^\circ - \alpha \quad (J12)$$

Figure K2 is the wind rose of 1-minute average wind data as measured during all mobile monitoring exercises and Figure K3 shows the corrected wind rose. Wind roses for each individual mobile monitoring exercise are shown in Figure K6 and Figure K7.

Figure K2 Wind Rose – All Mobile Exercises

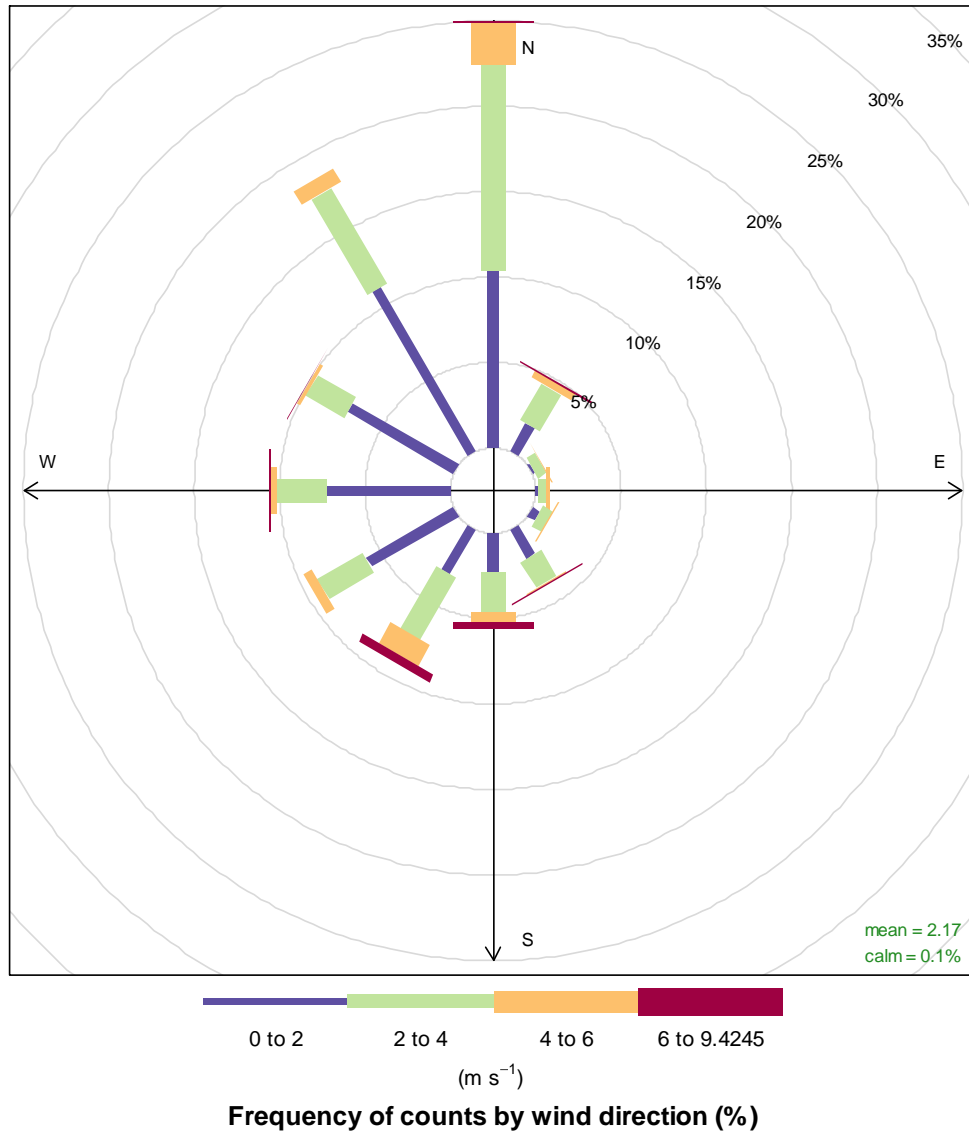
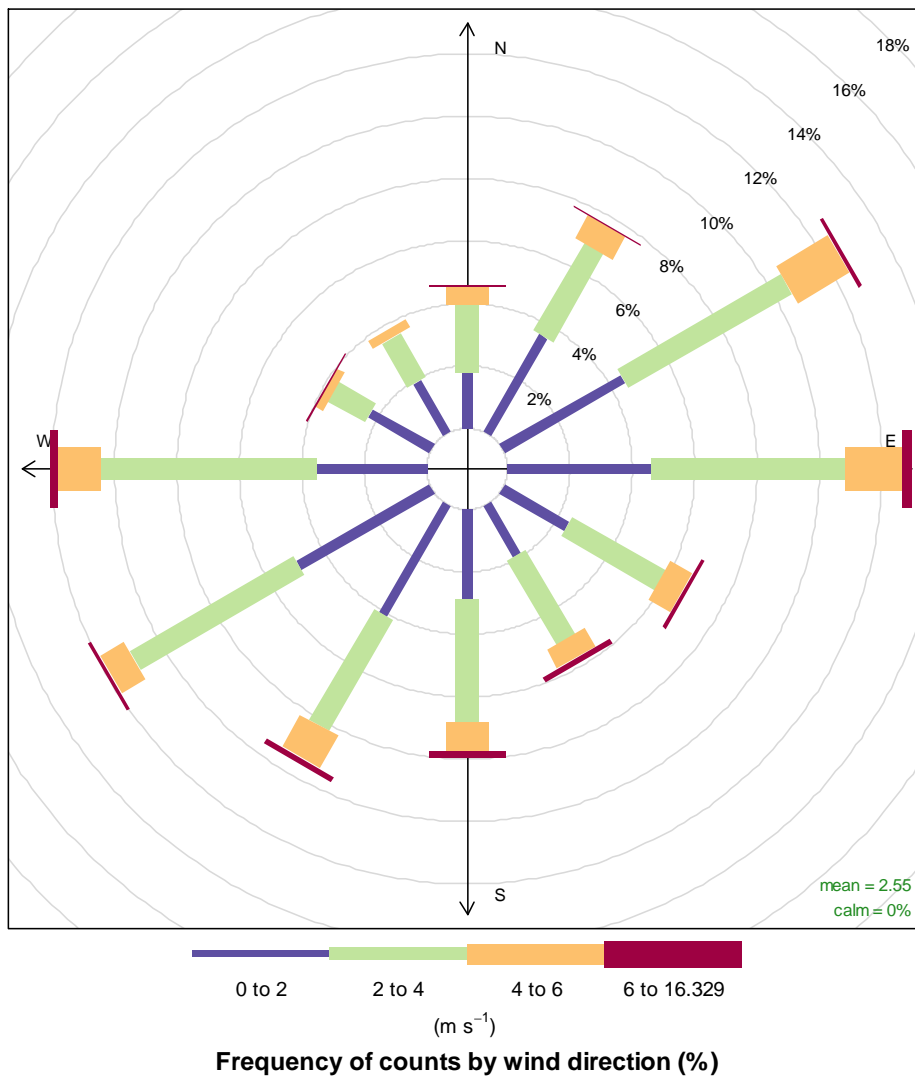


Figure K3 Corrected Wind Rose – All Mobile Exercises



K1.2 Summary Statistics - Wind Speed and Direction

Table K 1 Summary Statistics of Wind Direction and Speed – Mobile Monitoring Exercises

Statistic	Channel	Mobile Exercises (°, m s ⁻¹)							
		14-Mar	21-May	23-Jun	08-Jul	13-Jul	09-Aug	15-Aug	ALL
Min	Wind Direction	0.20	0.01	0.50	1.00	7.90	7.14	0.33	0.01
2nd Q		63.68	56.34	114.40	89.58	91.49	80.98	85.42	78.92
Med		144.90	101.40	196.00	172.60	190.90	191.30	191.10	170.70
Mean		152.30	140.90	184.40	169.40	174.70	178.10	175.60	165.80
3rd Q		223.00	223.60	255.00	245.50	253.90	256.00	258.10	248.40
Max		359.60	359.40	355.80	356.30	355.70	359.80	353.30	359.80

Statistic	Channel	Mobile Exercises ($^{\circ}$, $m\ s^{-1}$)							
		14-Mar	21-May	23-Jun	08-Jul	13-Jul	09-Aug	15-Aug	ALL
Min	Wind Speed	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1
2nd Q		1.8	1.4	1.7	1.5	1.7	1.6	1.4	1.5
Med		3.0	2.2	2.6	2.1	2.6	2.4	1.9	2.3
Mean		3.2	2.4	2.6	2.2	2.8	2.7	2.0	2.6
3rd Q		4.4	3.2	3.4	2.8	3.6	3.4	2.5	3.3
Max		8.2	8.0	6.1	4.8	13.2	16.3	7.0	16.3

Figure K4 Box Plot of Wind Direction – Mobile Monitoring Exercises

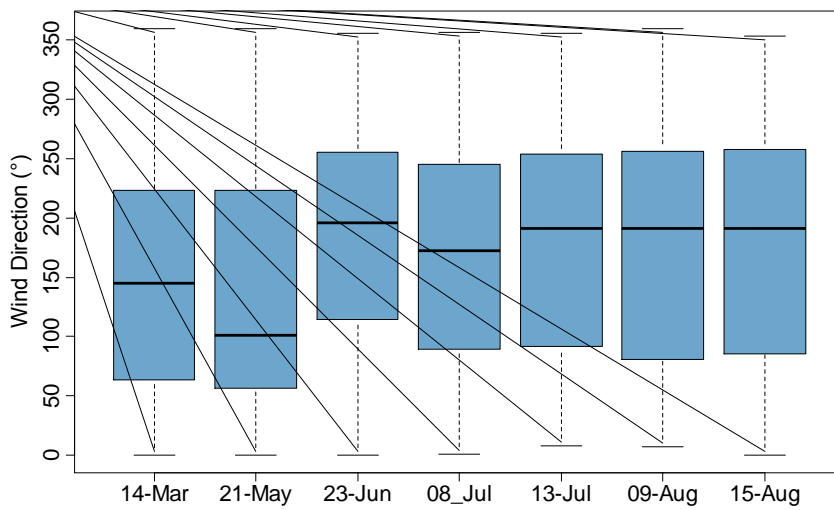
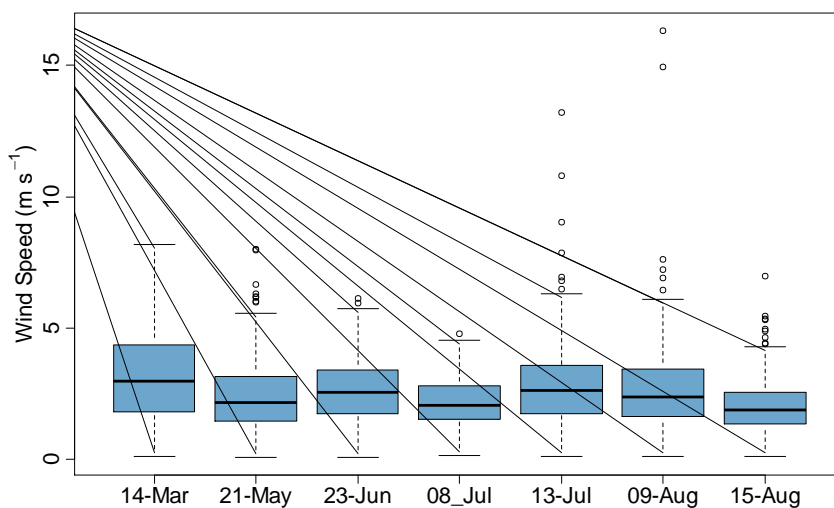


Figure K5 Box Plot of Wind Speed – Mobile Monitoring Exercises



K1.3 Corrected Wind Roses by Day and Street

Figure K6 Corrected Wind Roses – 14-Mar, 21-May, 23-Jun and 08-Jul

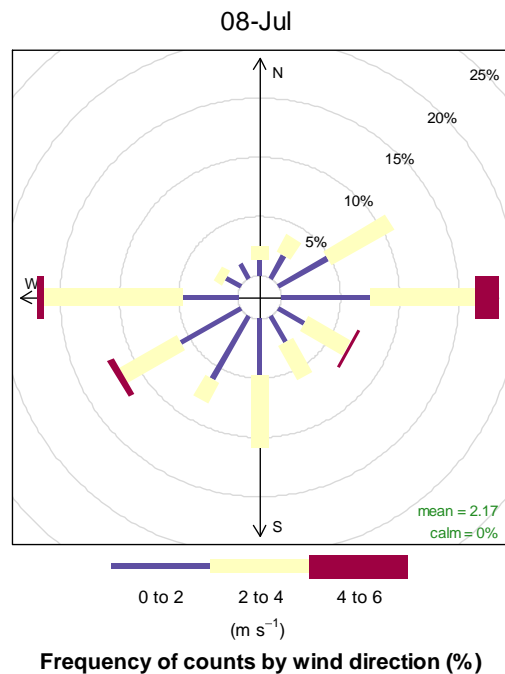
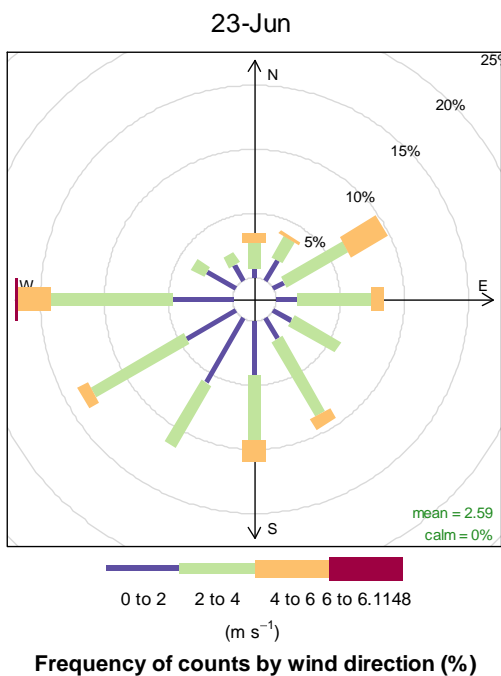
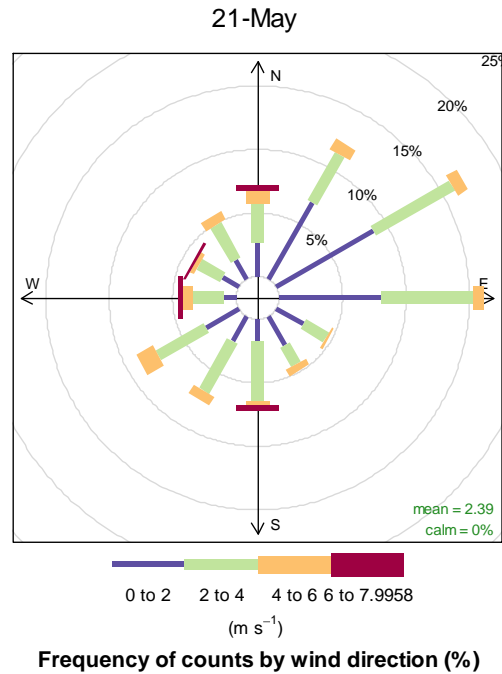
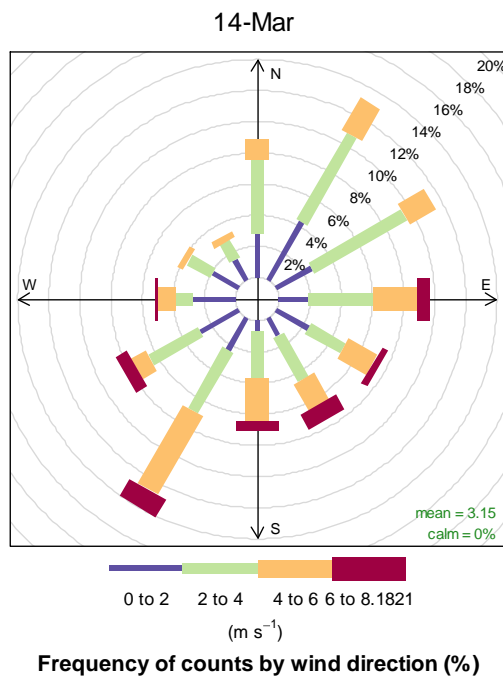


Figure K7 Corrected Wind Roses – 13-Jul, 09-Aug and 15-Aug

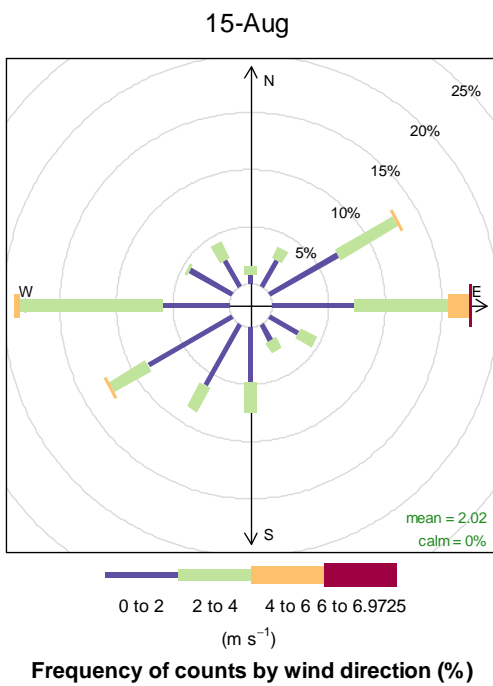
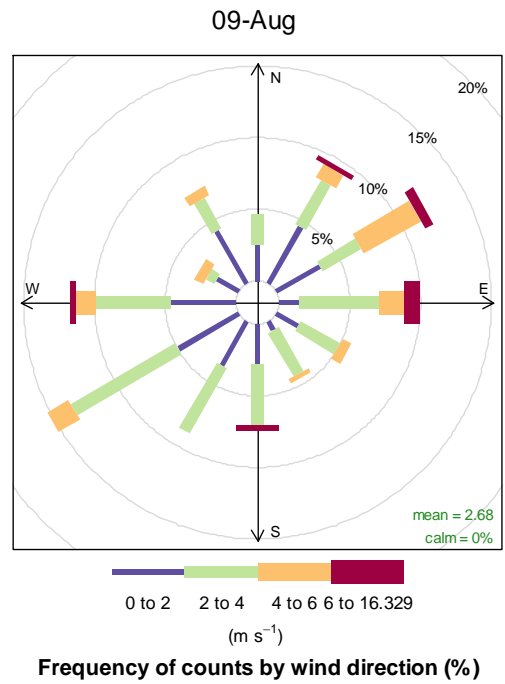
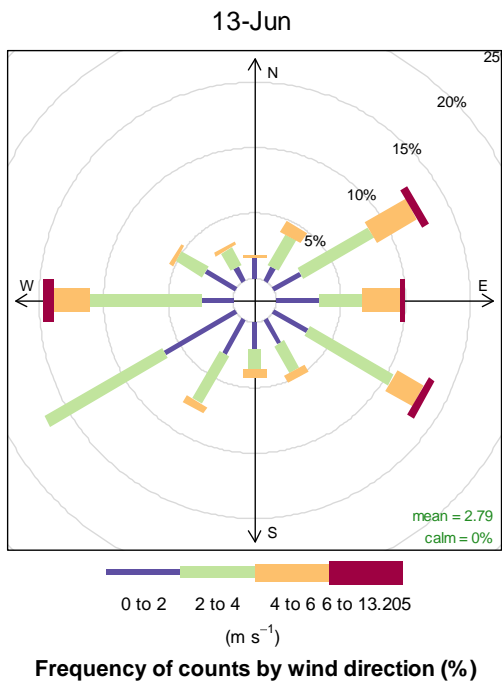
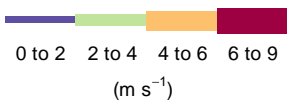
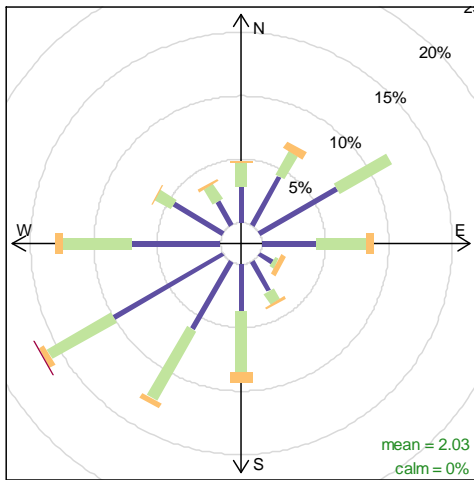


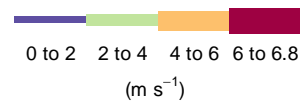
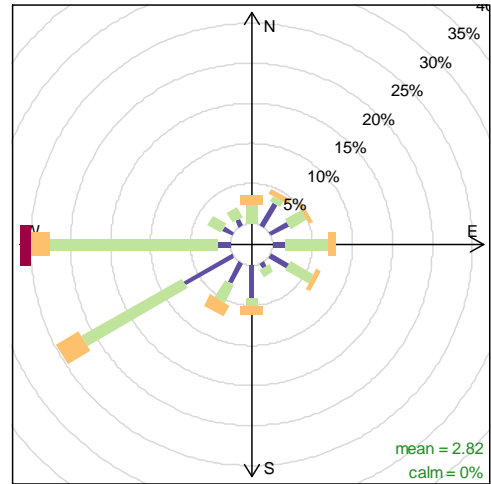
Figure K8 Wind Roses – Hope St, Sauchiehall St/Buchanan St and High St

Wind Rose - Hope St



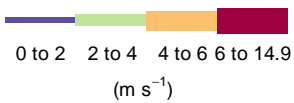
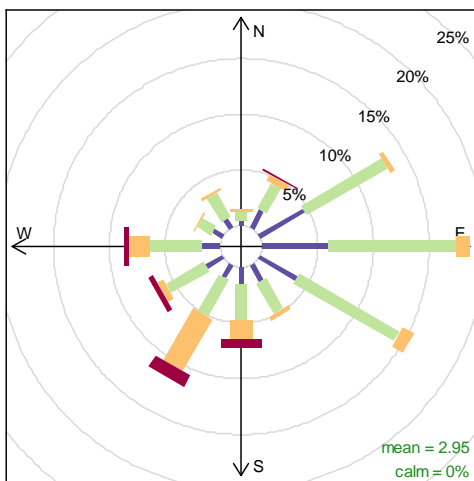
Frequency of counts by wind direction (%)

Wind Rose - Buchanan St



Frequency of counts by wind direction (%)

Wind Rose - High St



Frequency of counts by wind direction (%)

K1.4 Polar Plots

Figure K9 Polar Plots – BC, UFP, PM_{0.5} and PM_{1.0}

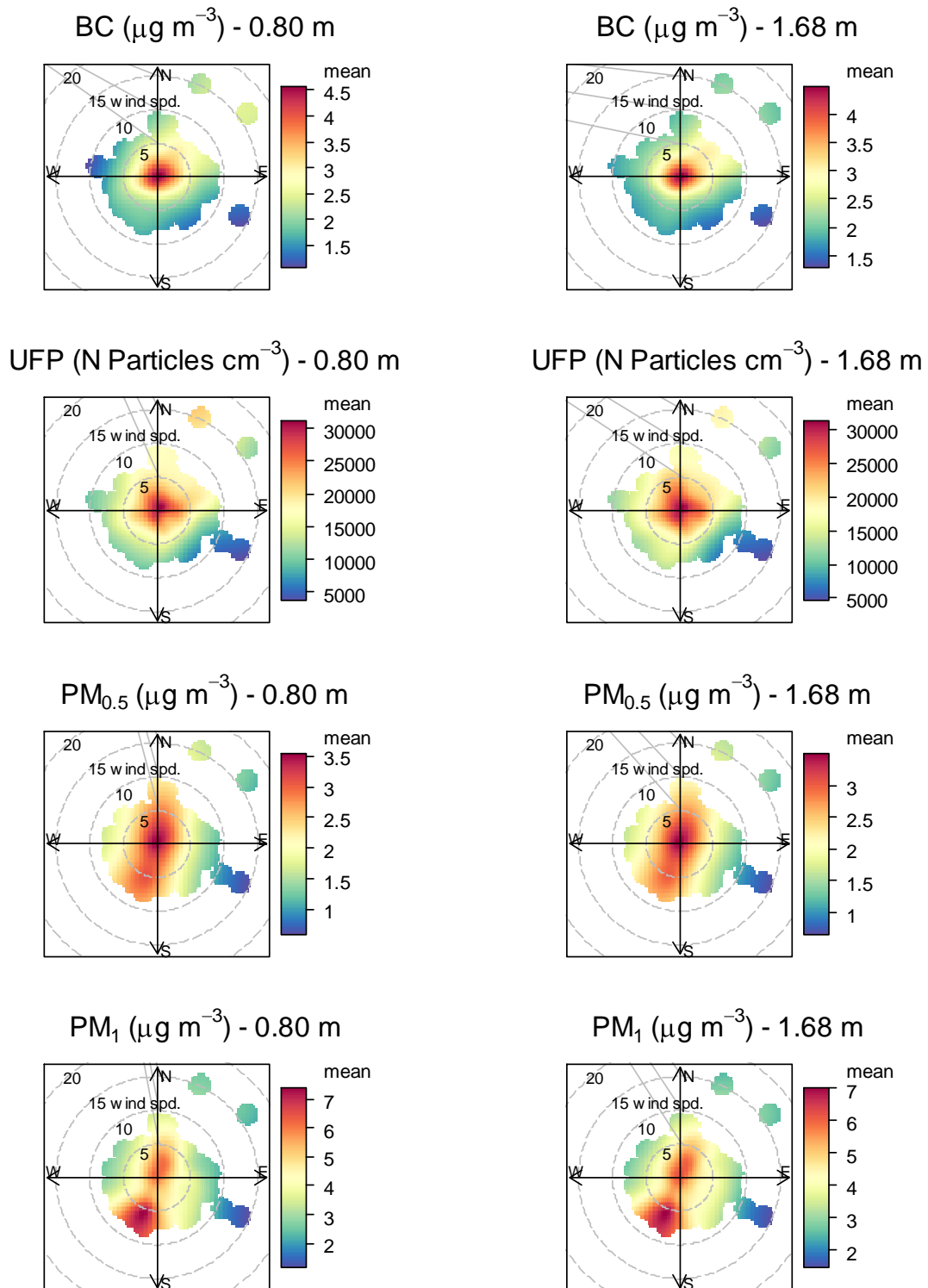


Figure K10 Polar Plots – $PM_{2.5}$, $PM_{5.0}$, PM_{10} and TPM

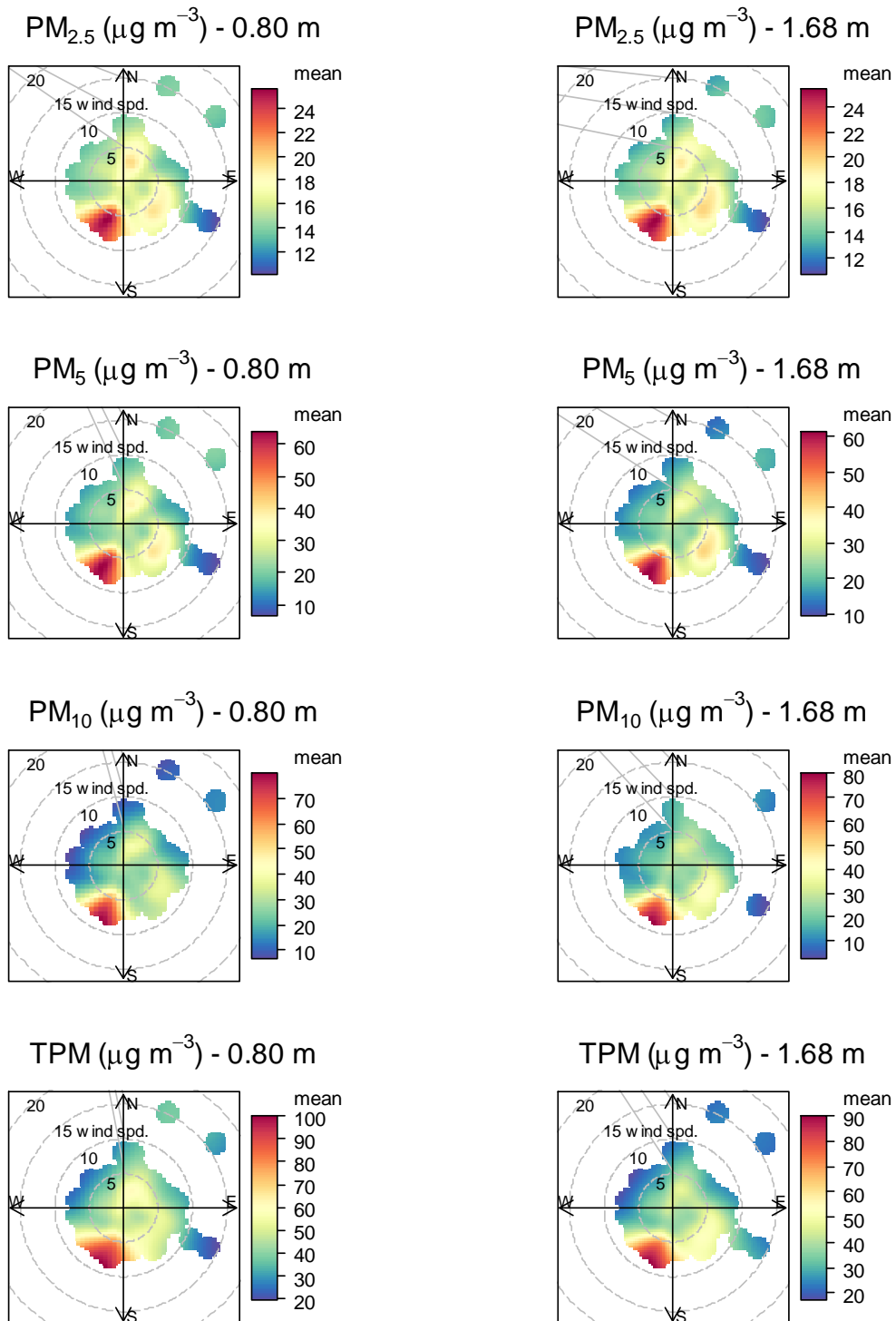


Figure K11 Polar Plots – NO₂, NO, CO and SO₂

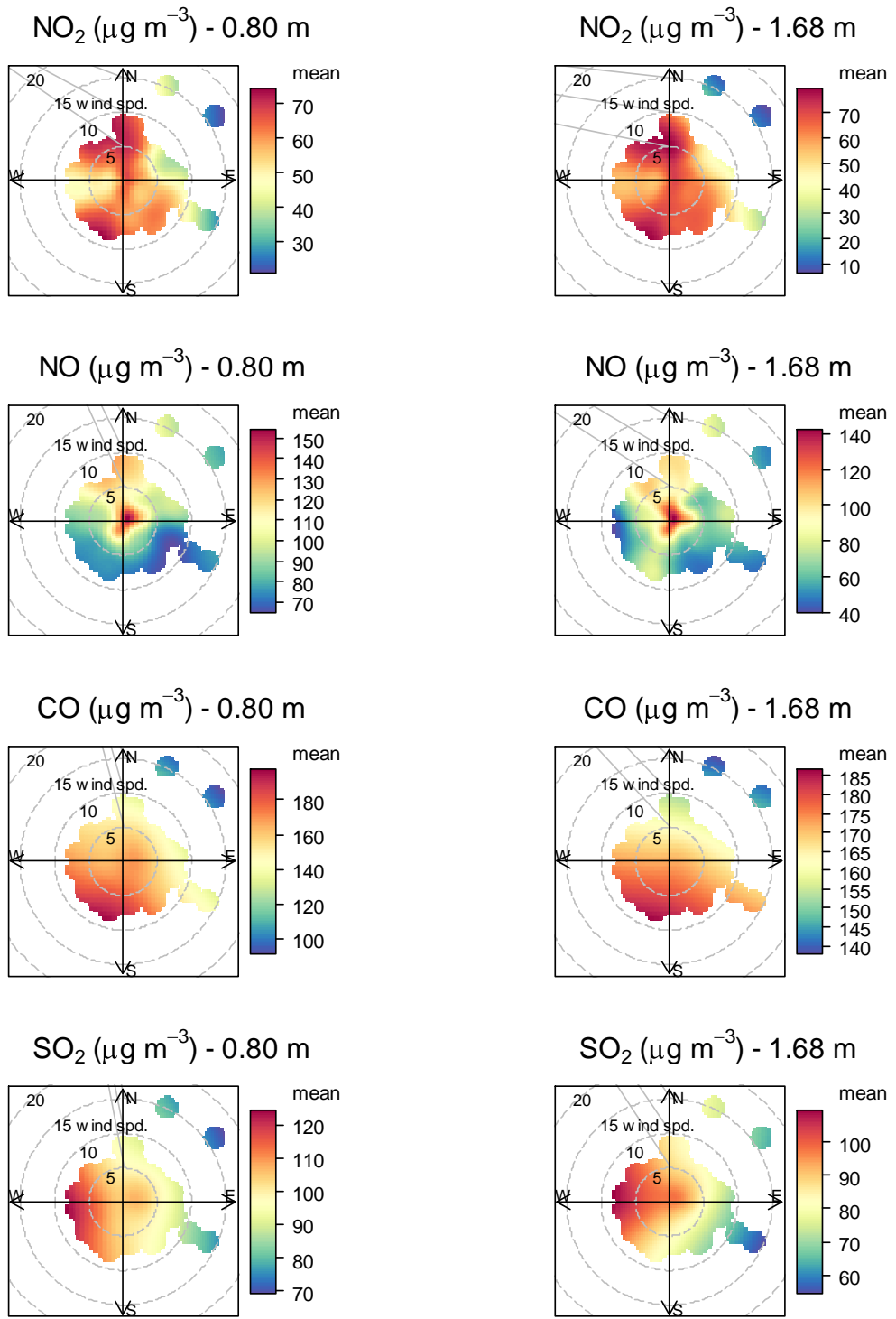


Figure K12 Polar Plots of BC, UFP, PM_{0.5} and PM_{1.0} – Hope St

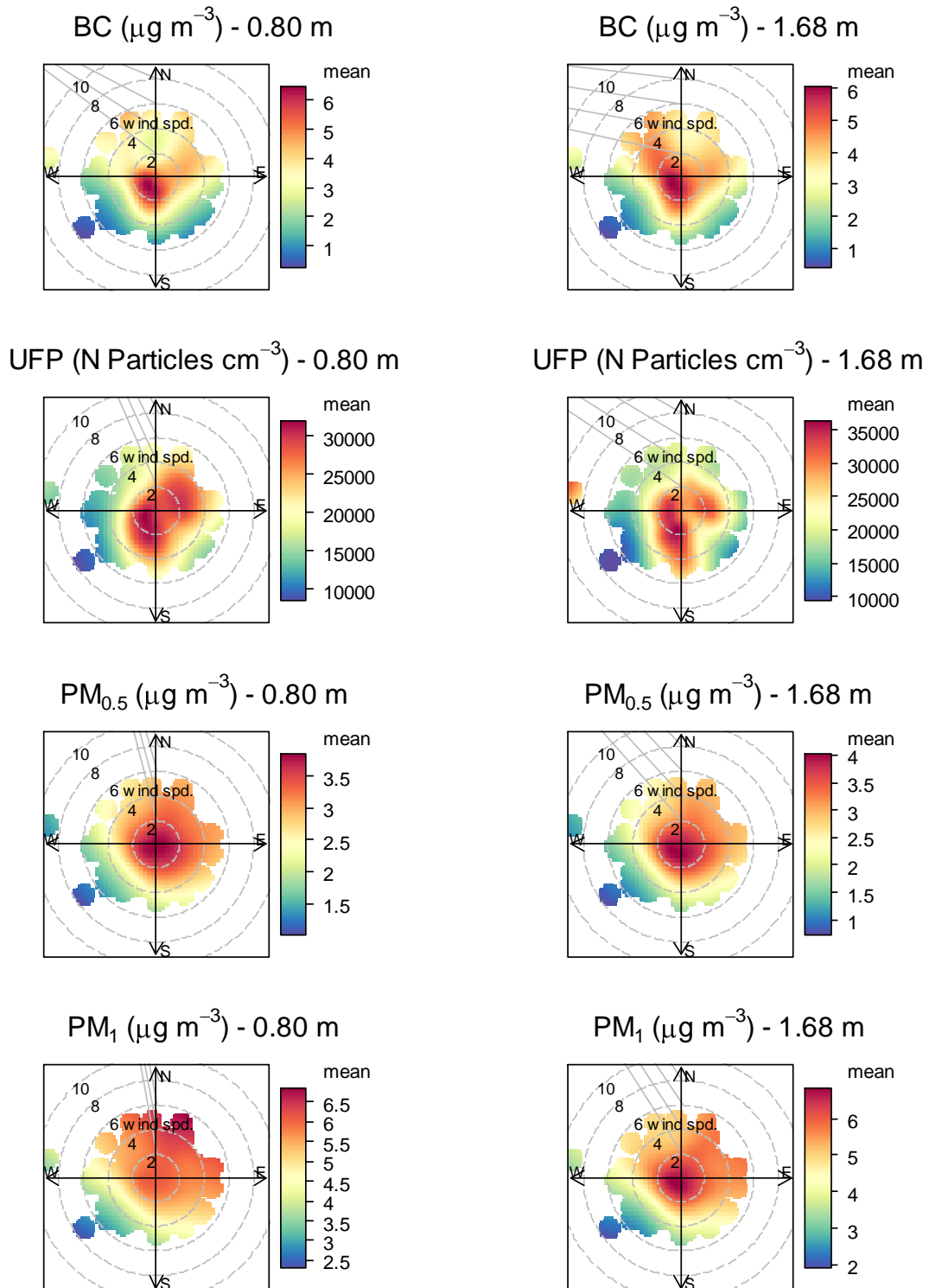


Figure K13 Polar Plots of $PM_{2.5}$, $PM_{5.0}$, PM_{10} and TPM – Hope St

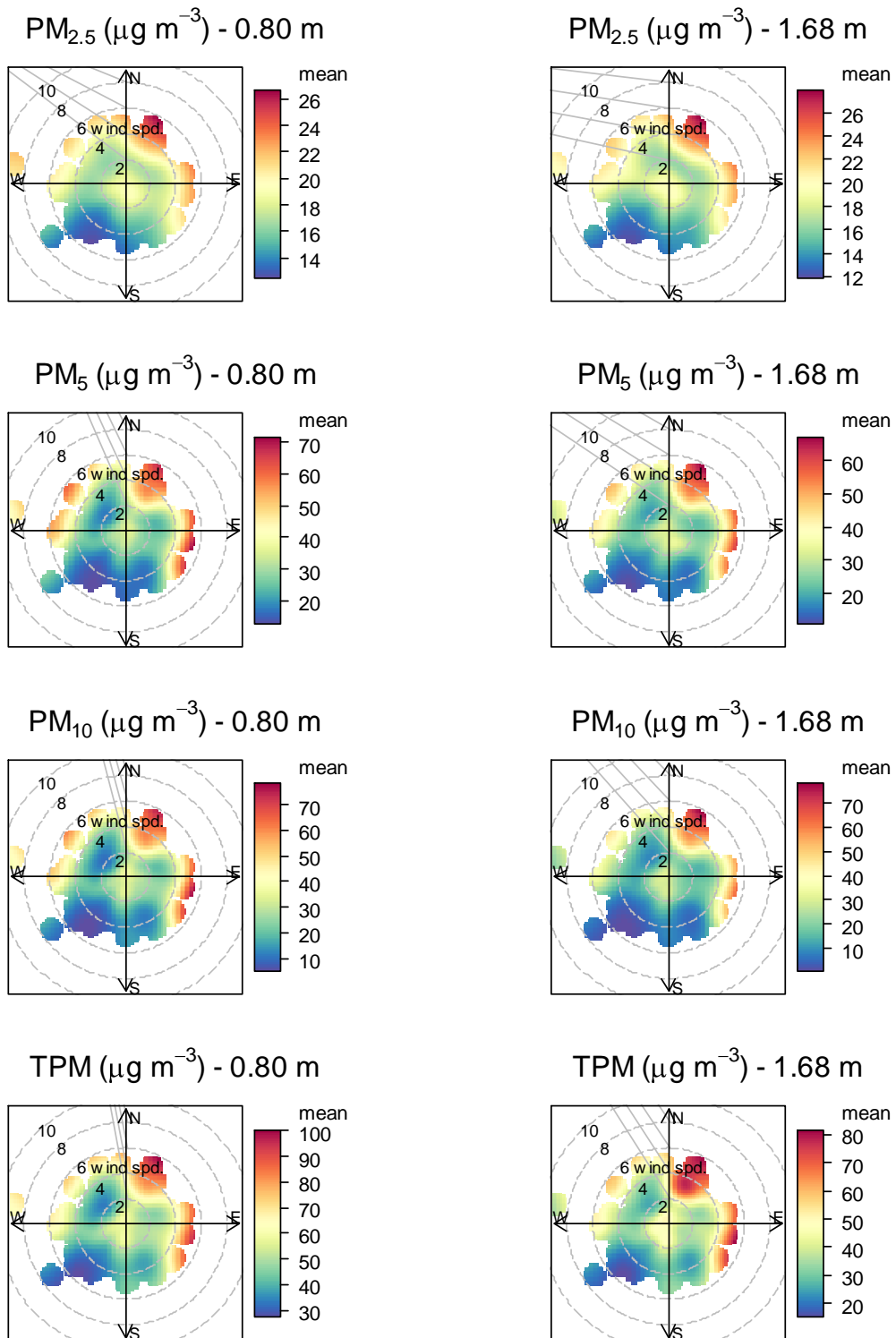


Figure K14 Polar Plots of NO₂, NO, CO and SO₂ – Hope St

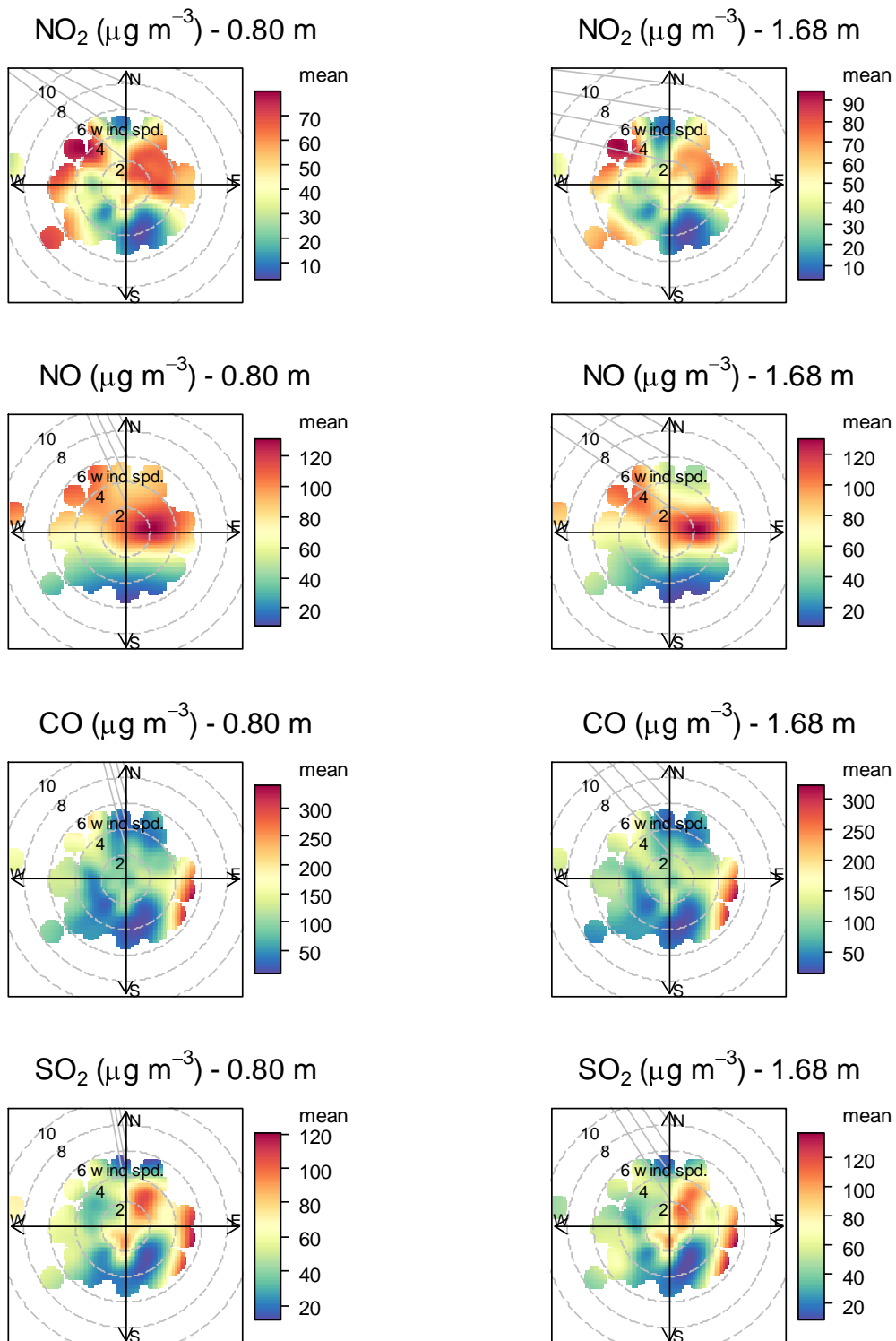


Figure K15 Polar Plots of BC, UFP, PM_{0.5} and PM_{1.0} – Sauchiehall St/Buchanan St

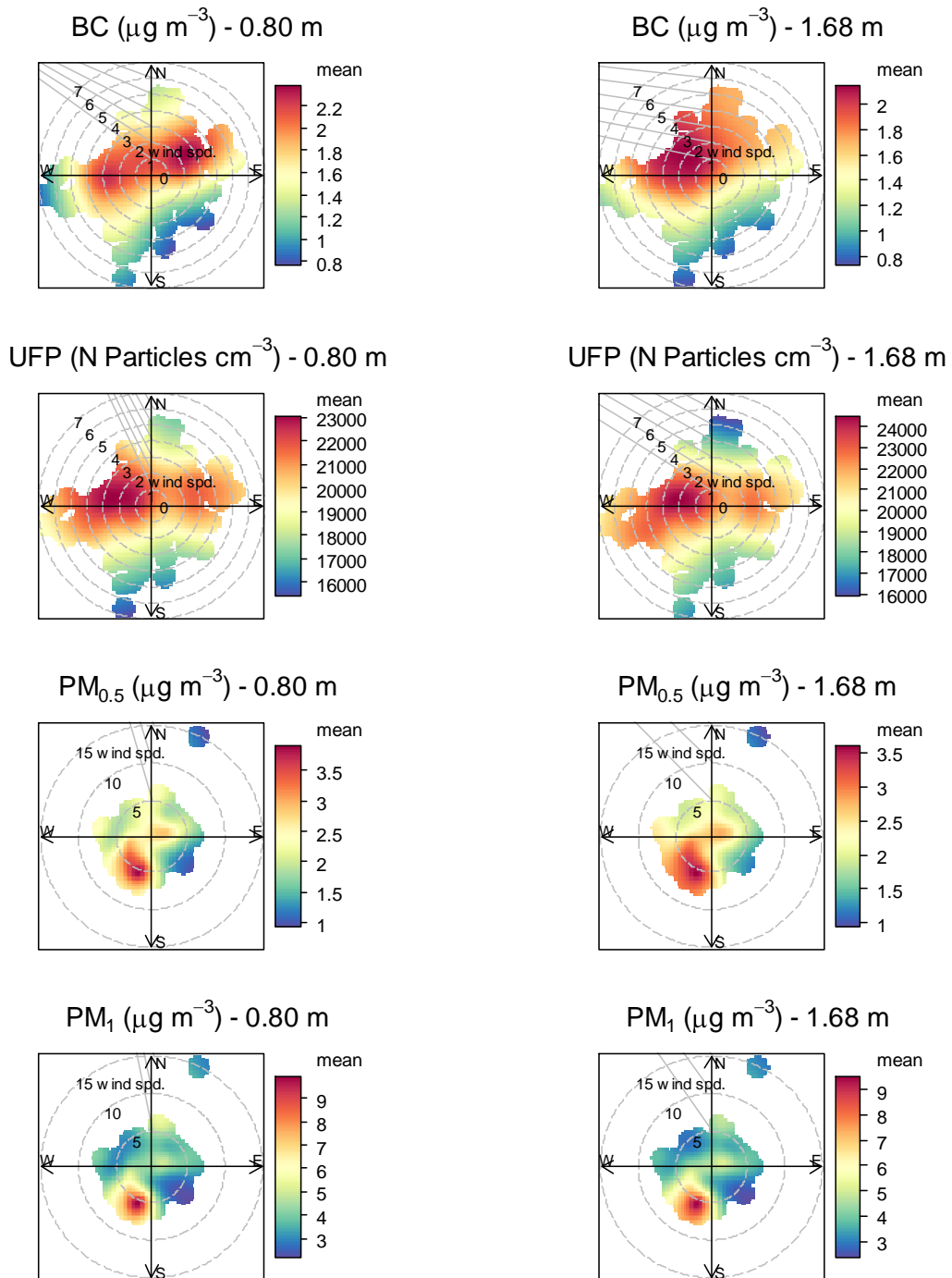


Figure K16 Polar Plots of $PM_{2.5}$, $PM_{5.0}$, PM_{10} and TPM – Sauchiehall St/Buchanan St

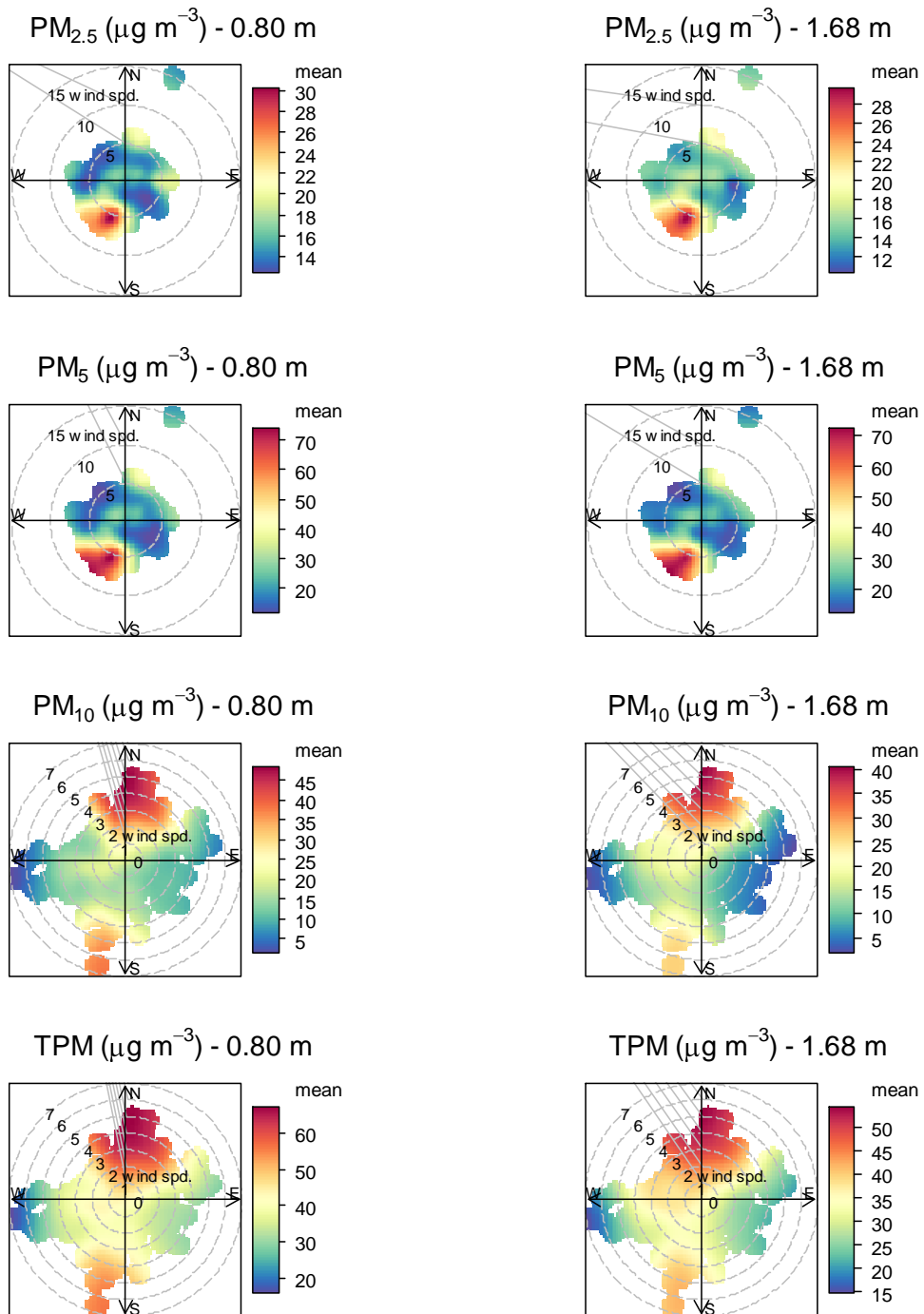


Figure K17 Polar Plots of NO₂, NO, CO and SO₂ – Sauchiehall St/Buchanan St

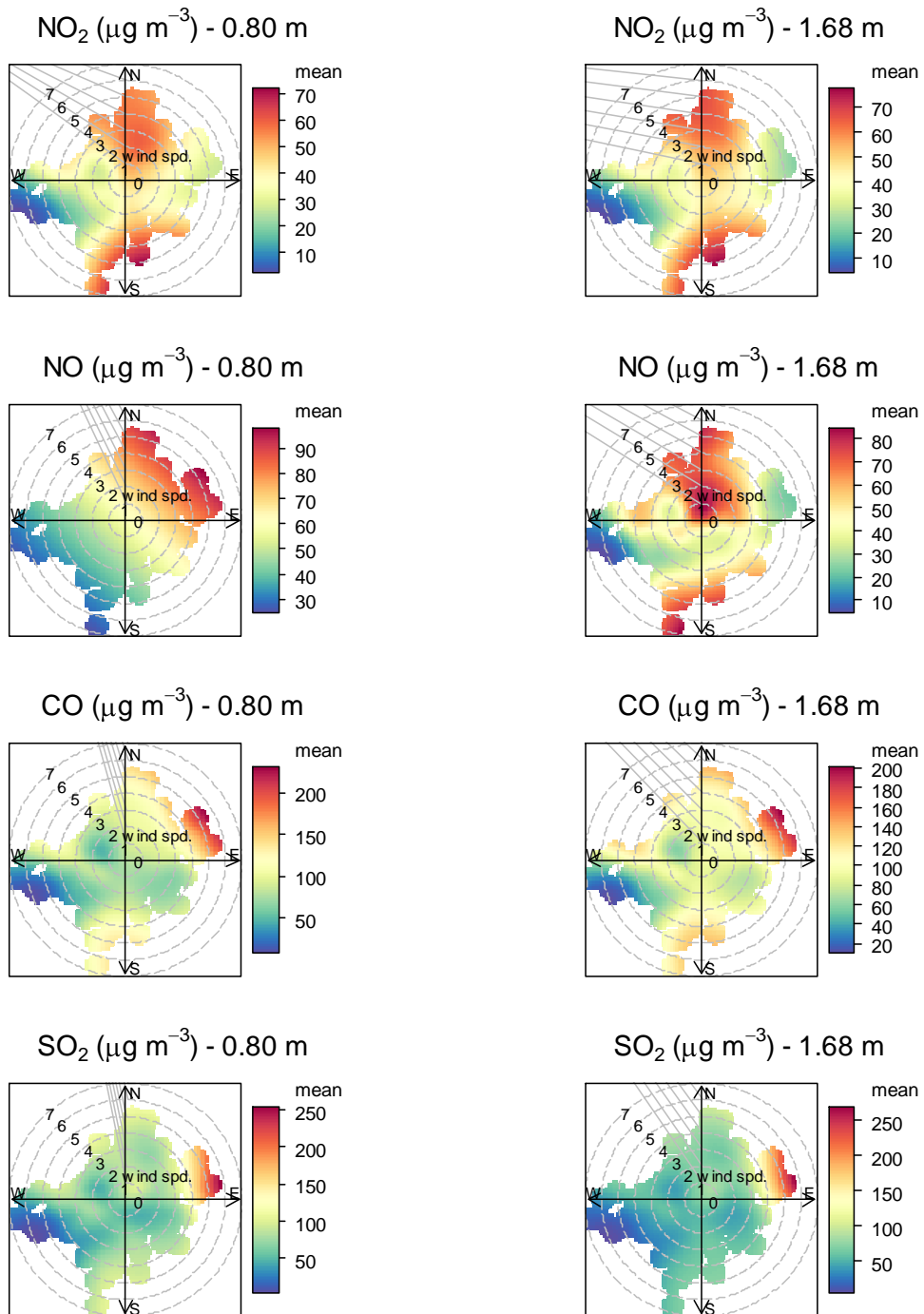


Figure K18 Polar Plots of BC, UFP, PM_{0.5} and PM_{1.0} – High St

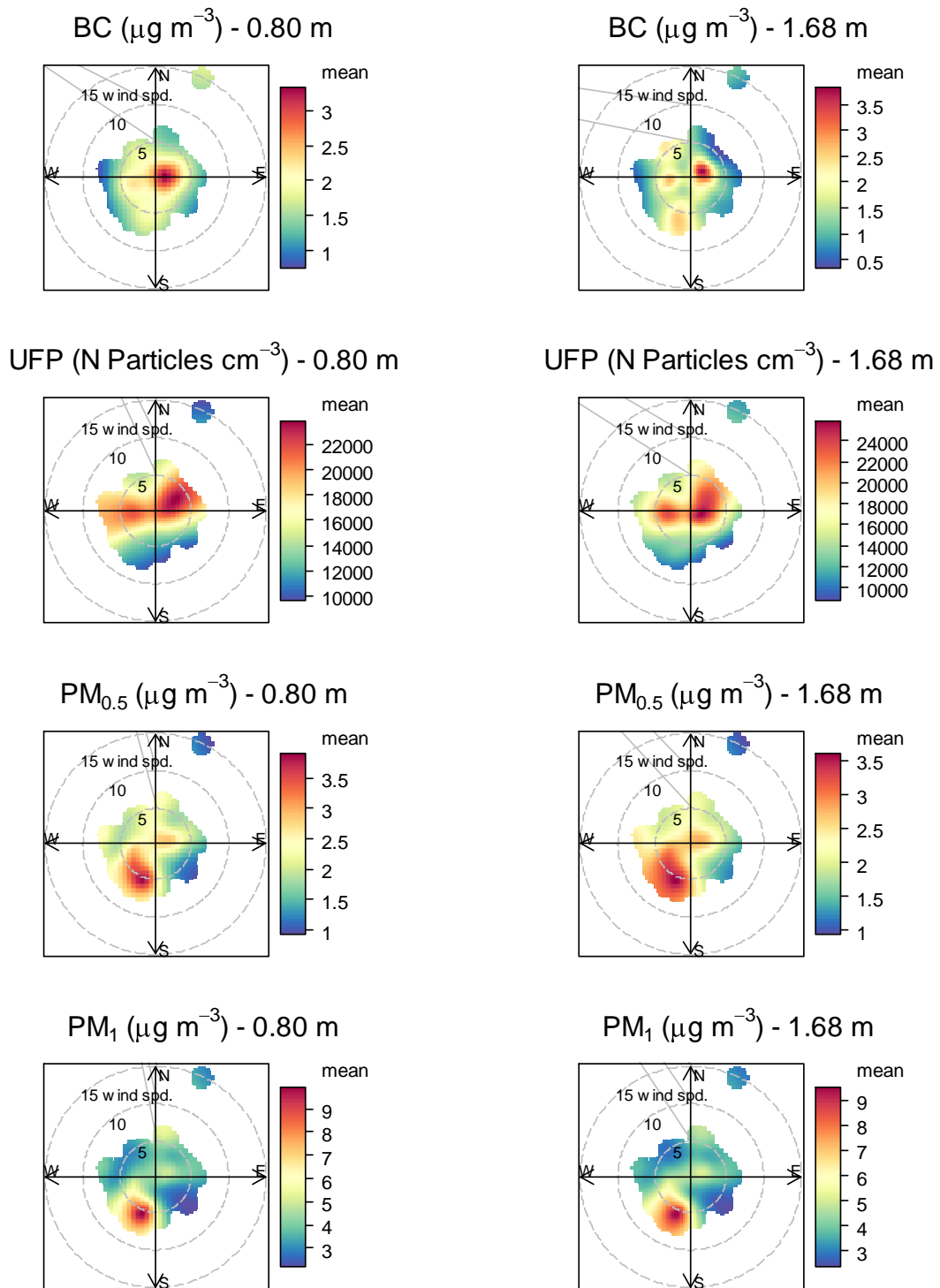


Figure K19 Polar Plots of $PM_{2.5}$, $PM_{5.0}$, PM_{10} and TPM – High St

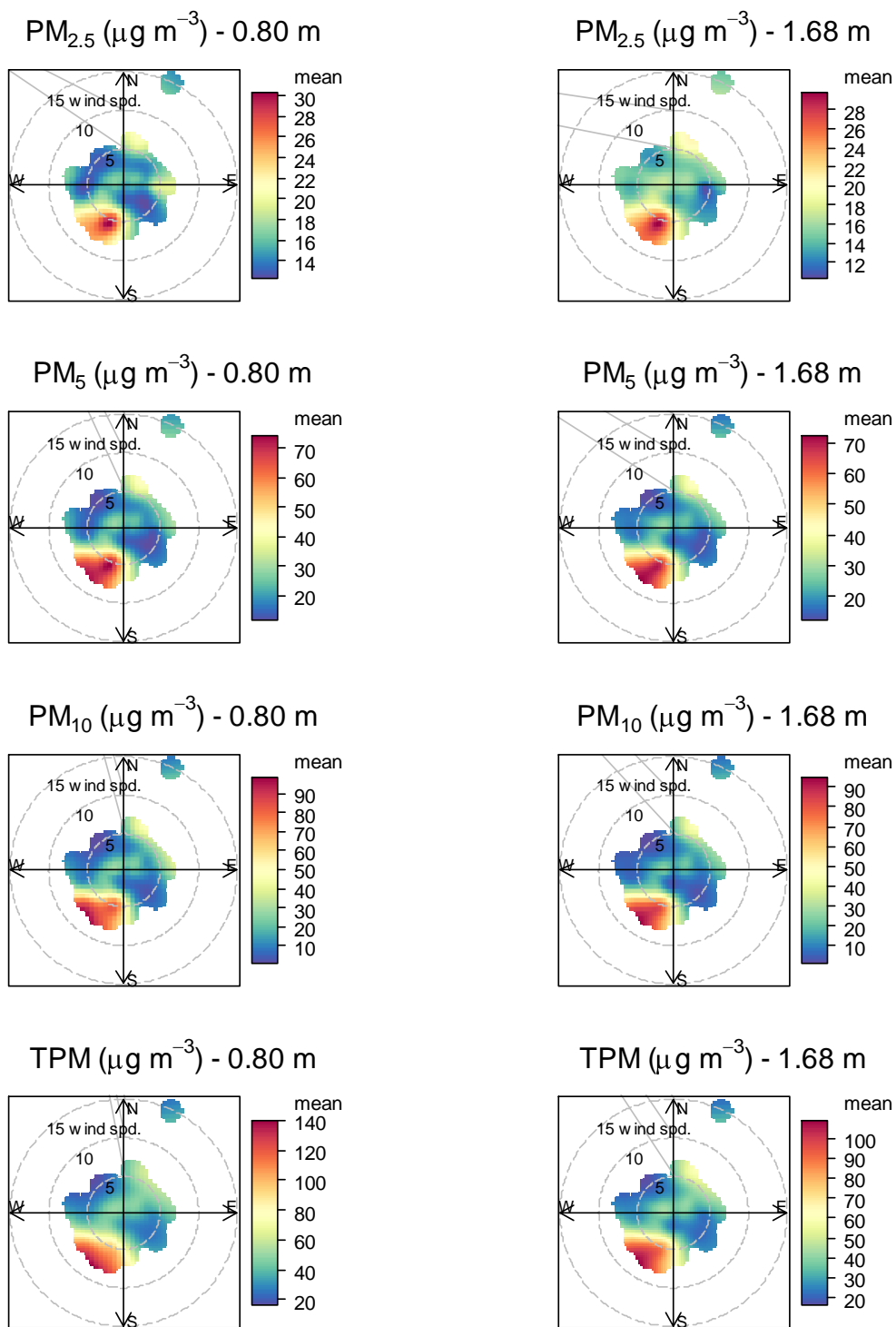
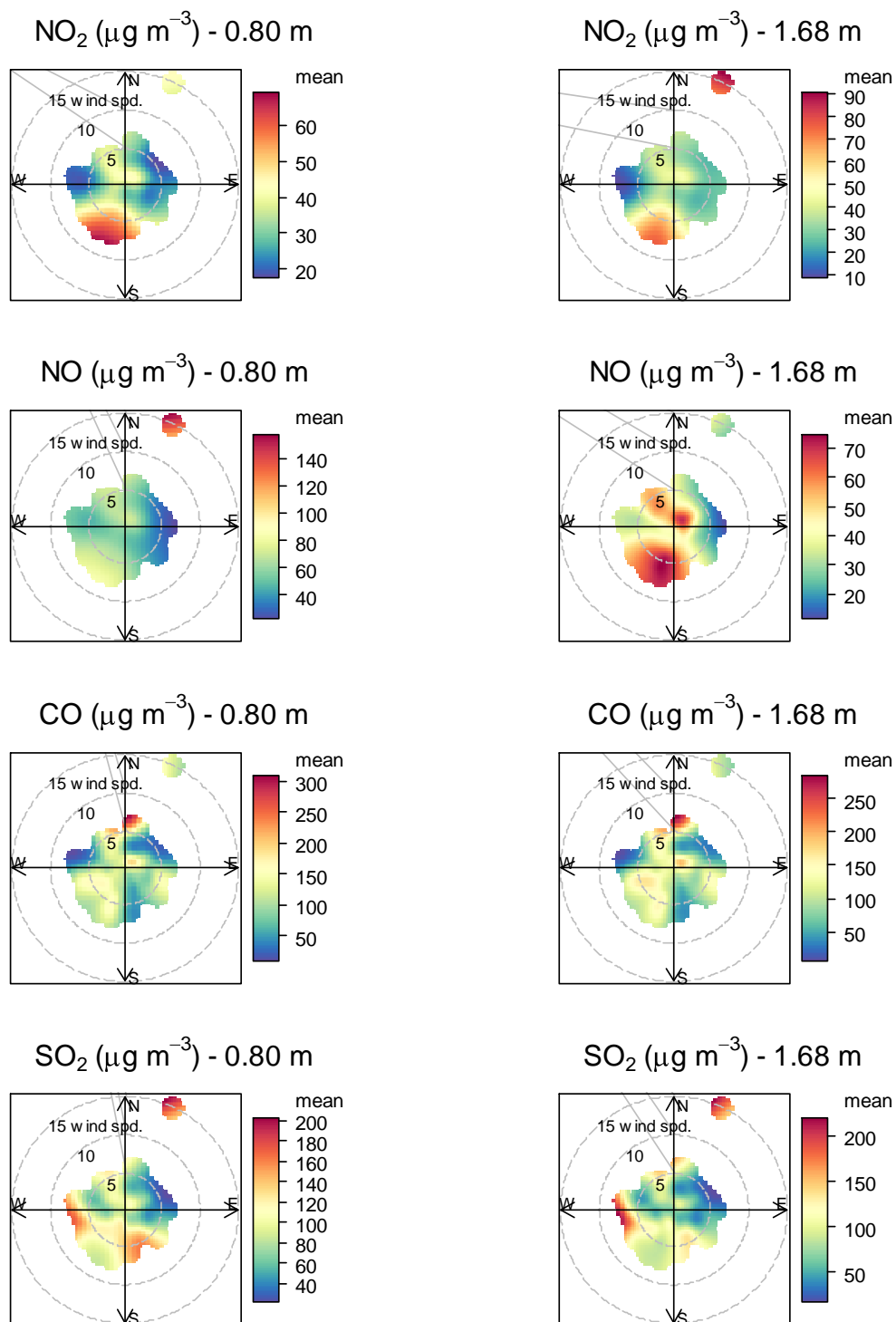


Figure K20 Polar Plots of NO₂, NO, CO and SO₂ – High St



K1.5 Pollutant Concentrations vs Wind Speed and Direction

The following Figures show regression plots of particulate species and CO₂ vs wind speed and direction as recorded at Glasgow Airport.

Figure K21 One minute averaged data for particulate species and CO₂ vs. windspeed (m/s), as recorded at Glasgow Airport. Where UFP = ultrafine particles (units: N Particles cm⁻³); PM = particle mass (the figure refers to size in μm); TPM = total particile mass (units: μg m⁻³); BC = Black Carbon (units: ng m⁻³); and CO₂ is Carbon Dioxide (units: ug m⁻³).

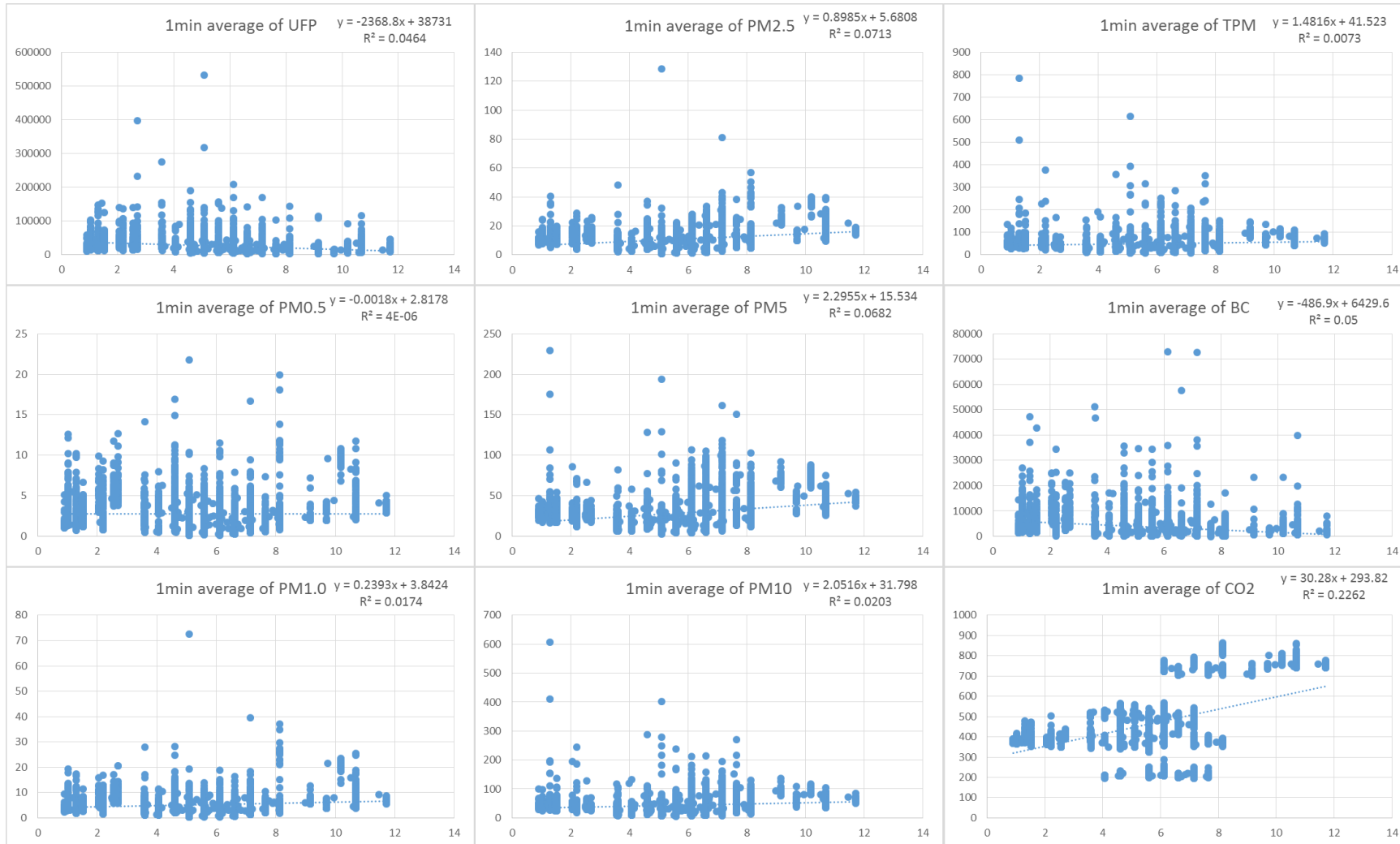


Figure K 22 Thirty minute averaged data for particulate species and CO₂ vs. windspeed (m/s), as recorded at Glasgow Airport

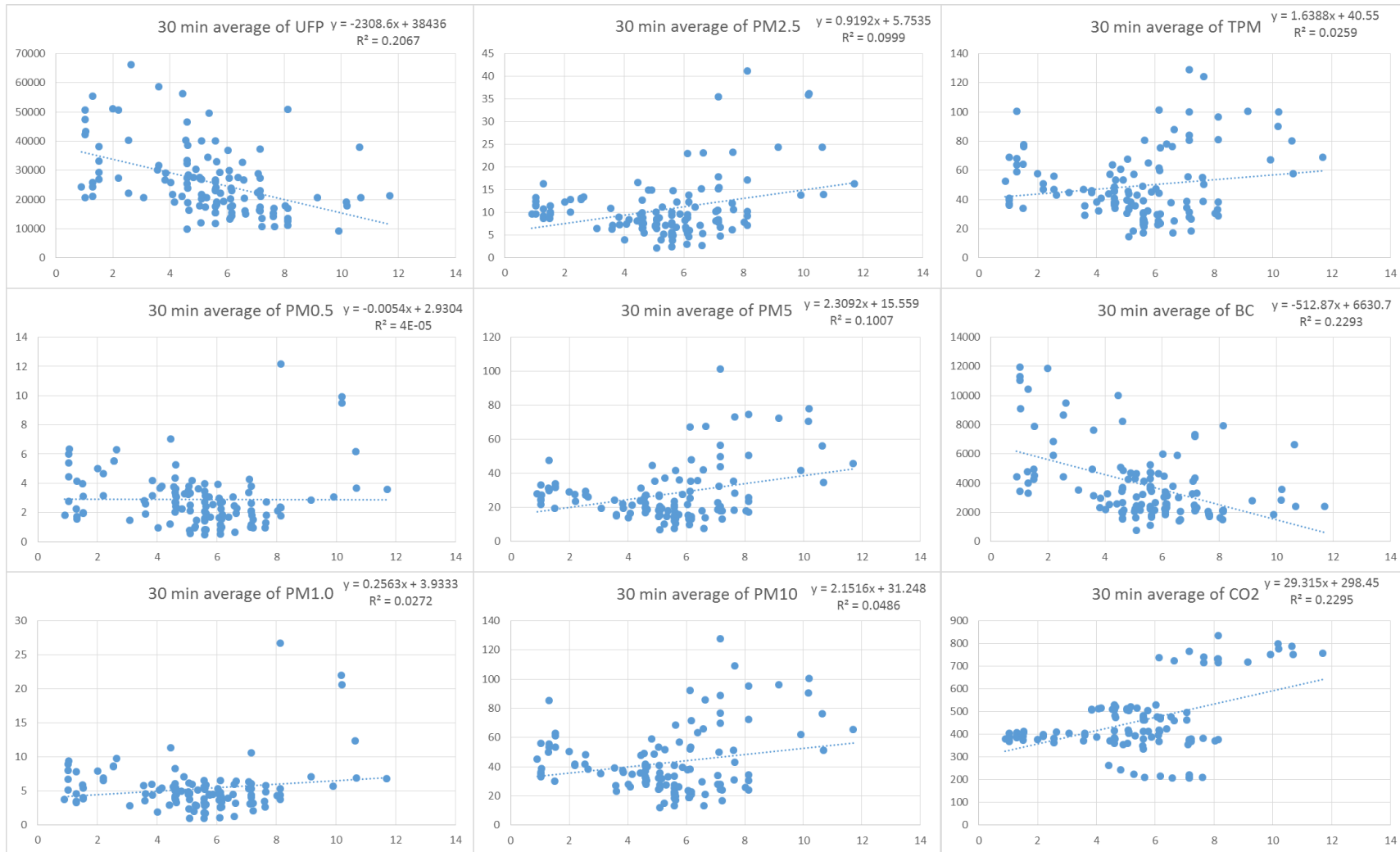


Figure K23 One minute averaged data for particulate species and CO₂ vs. wind direction (°), as recorded at Glasgow Airport

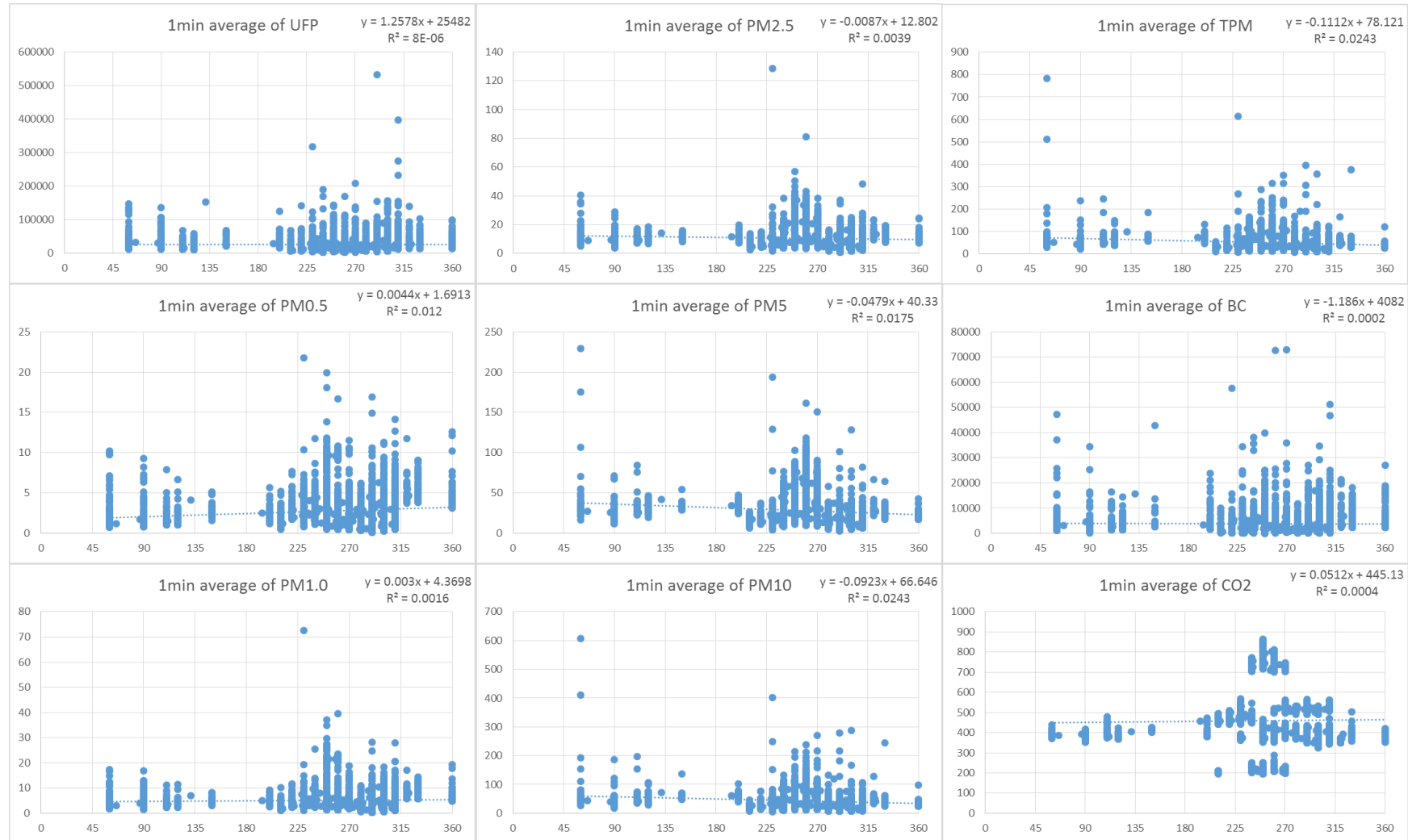


Figure K24 Thirty minute averaged data for particulate species and CO₂ vs. wind direction (°), as recorded at Glasgow Airport

