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Supplement of

60 years of UK visibility measurements: impact of meteorology and atmospheric pollutants on visibility

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Supplementary Figures

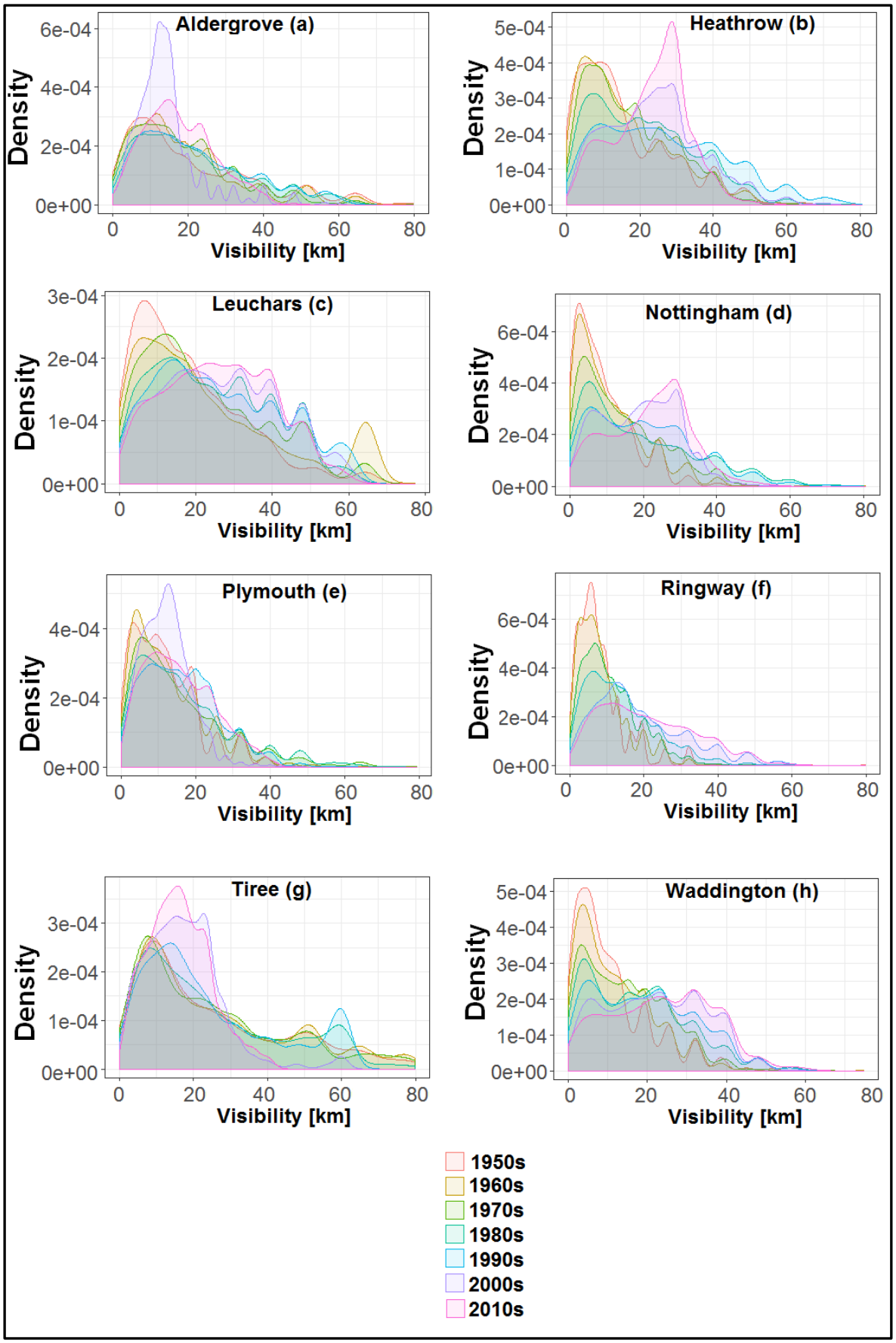


Figure S1 Density of different visibility ranges for different sub periods (1950s to 2010s) for 8 sites.

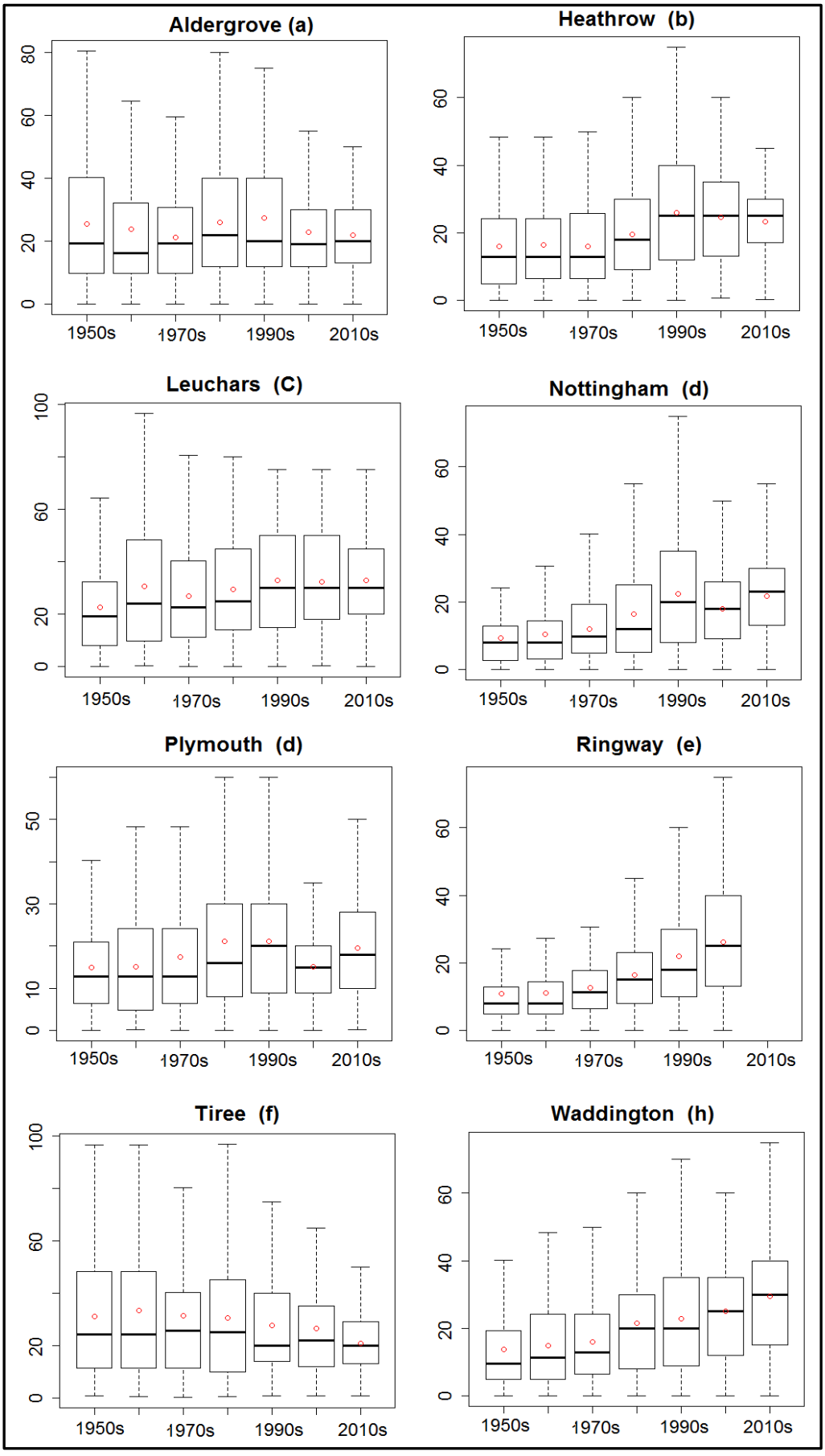


Figure S2 Boxplot of decadal visibility at eight different study sites, where red dot denotes mean value of decadal visibility

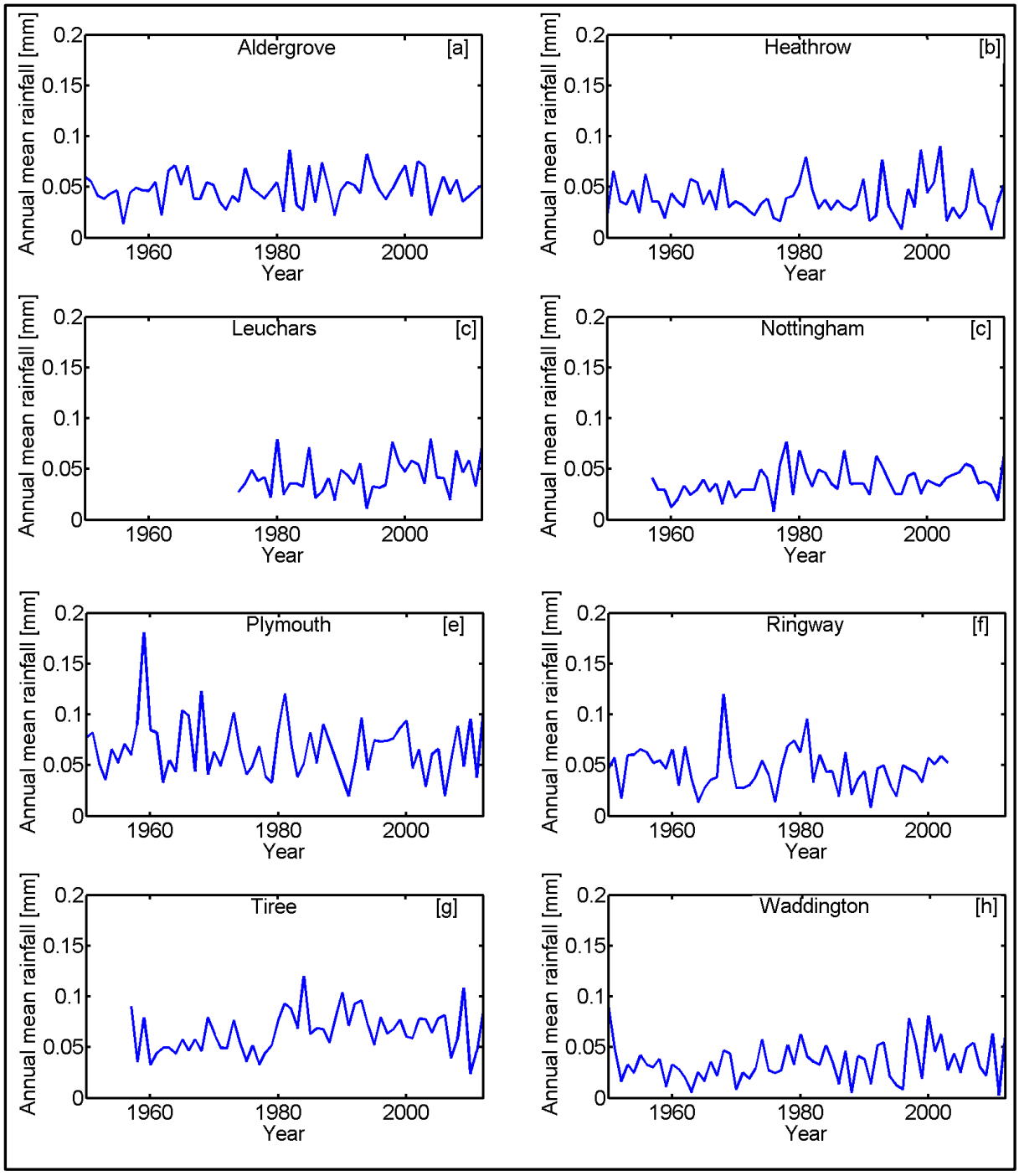


Figure S3 Historical trend of annual mean rainfall derived from daily (12 noon) observations by station: **a)** Aldergrove **b)** Heathrow, **c)** Leuchars, **d)** Nottingham, **e)** Plymouth, **f)** Ringway, **g)** Tiree, **h)** Waddington.

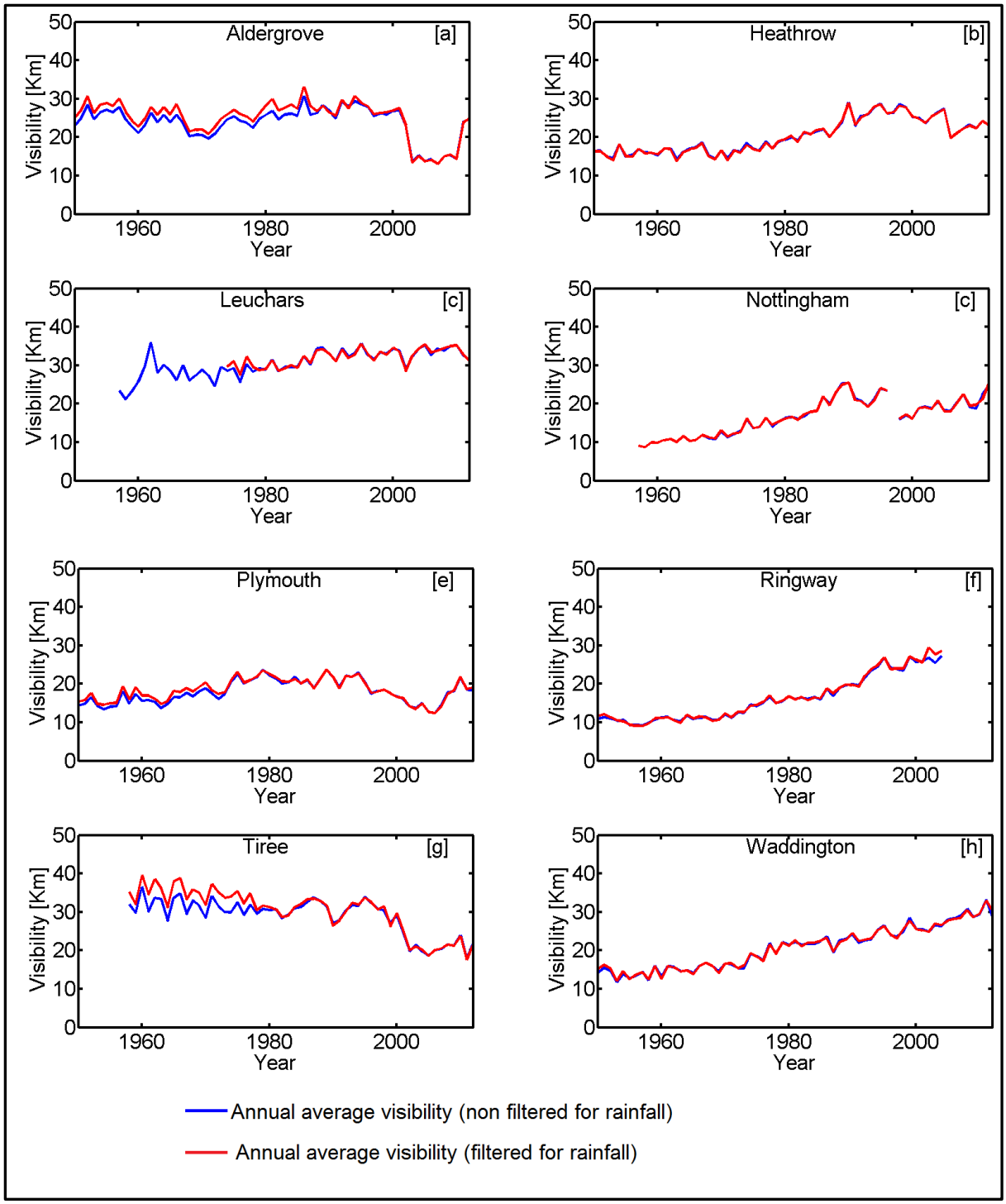


Figure S4 Historical trends of annual mean visibilities (with and without filtering for precipitation) derived from daily (12 noon) observations by station: **a)** Aldergrove **b)** Heathrow, **c)** Leuchars, **d)** Nottingham, **e)** Plymouth, **f)** Ringway, **g)** Tiree, **h)** Waddington.

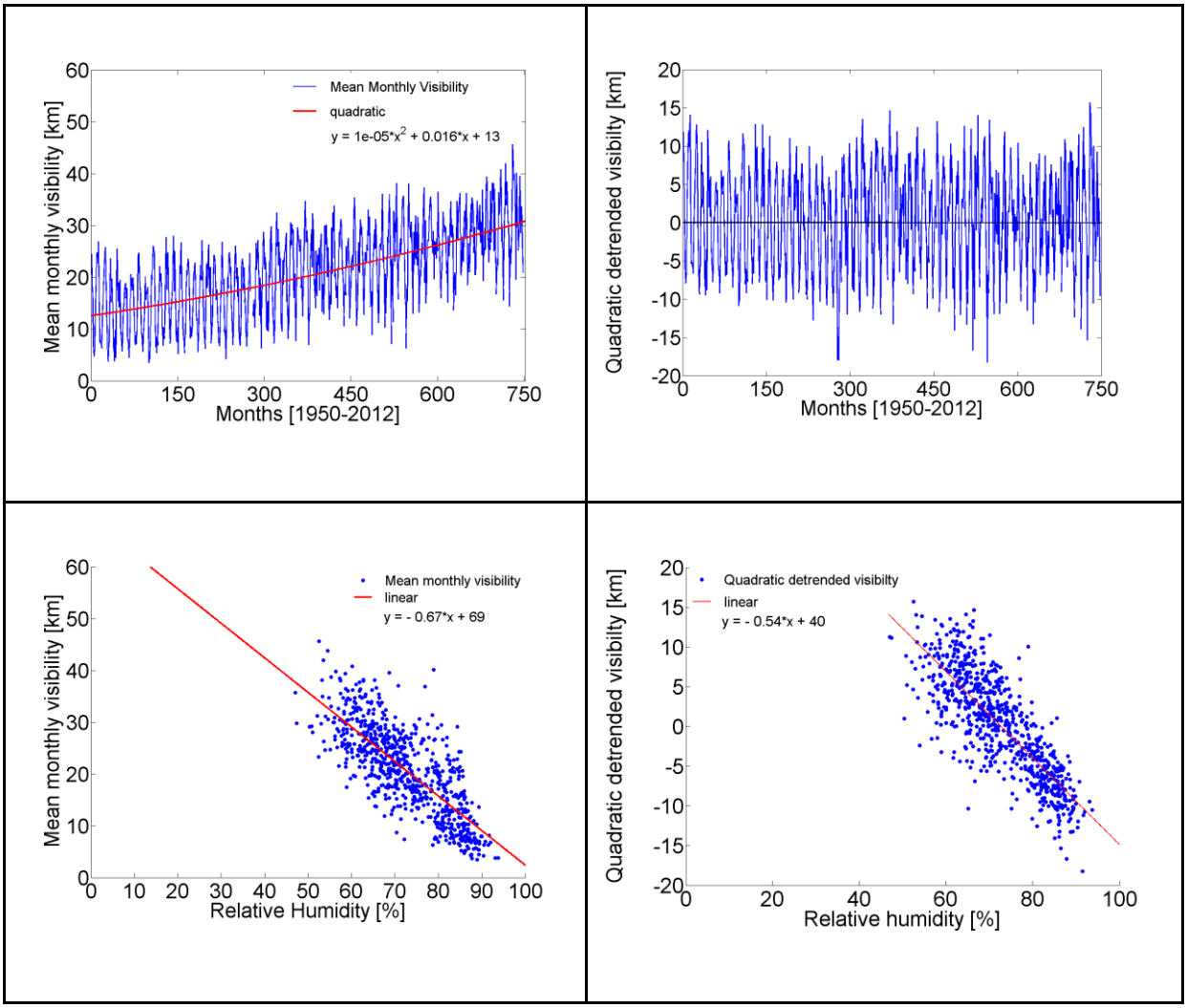


Figure S5 Mean monthly visibility at different RH conditions at Waddington

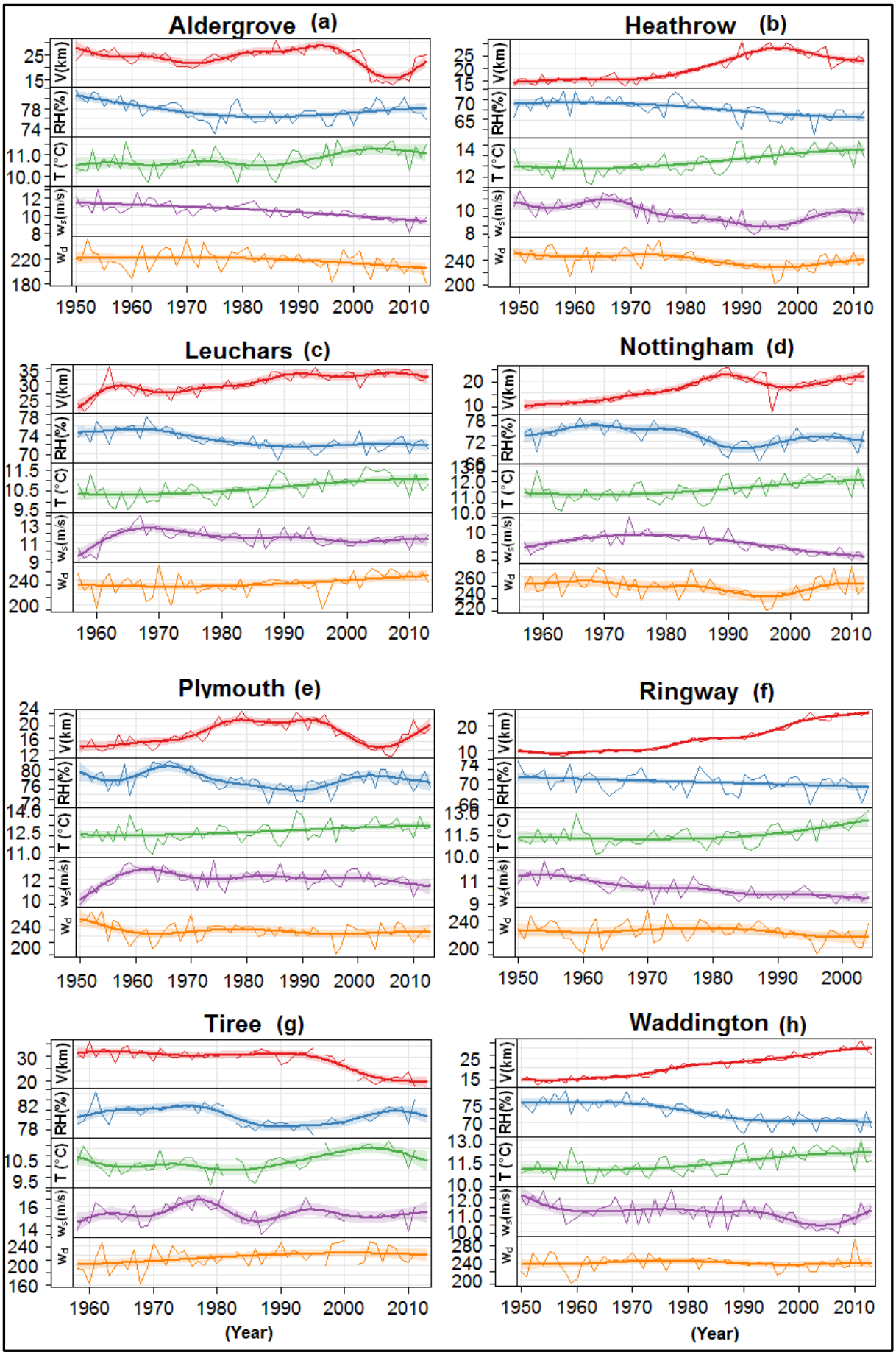
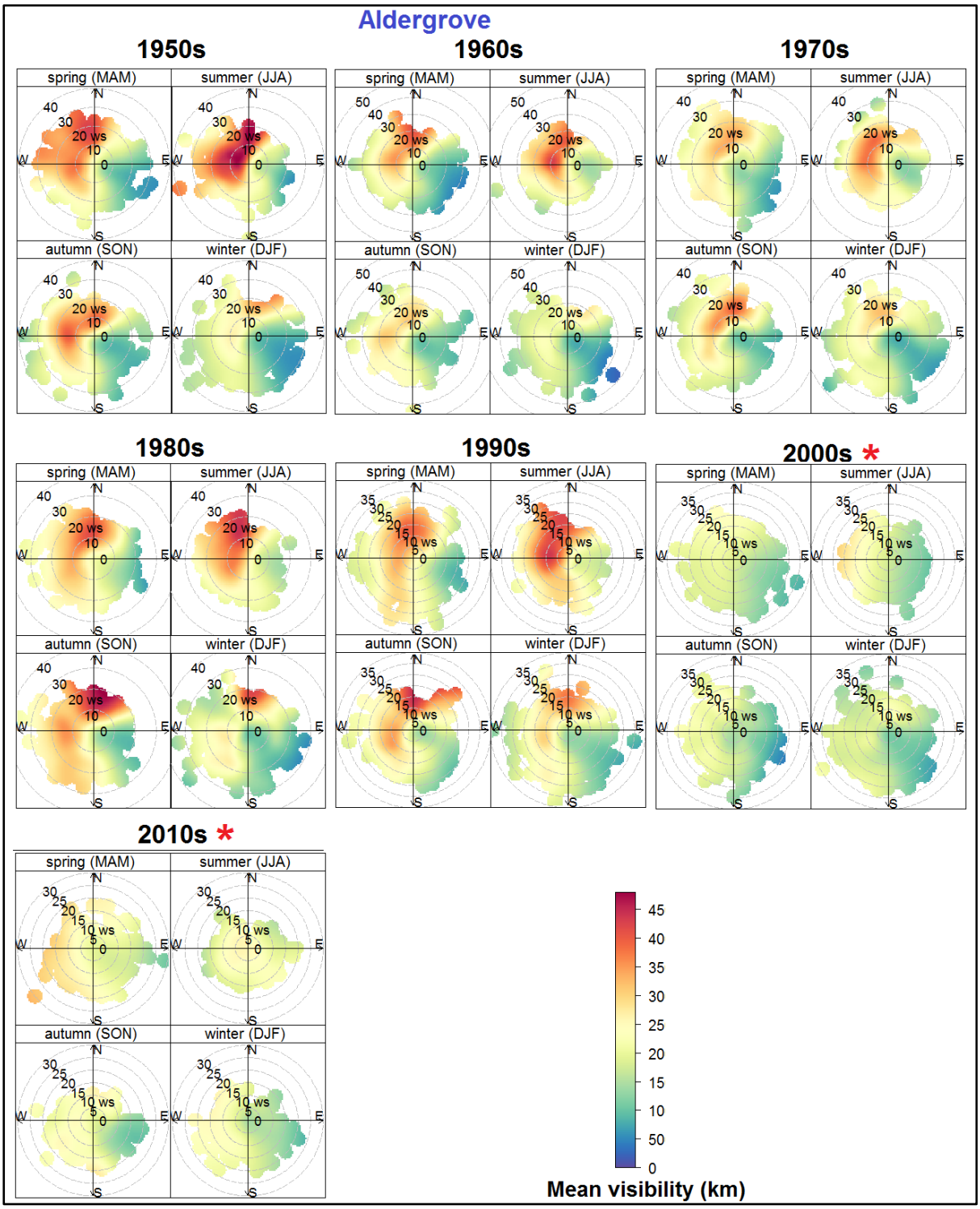
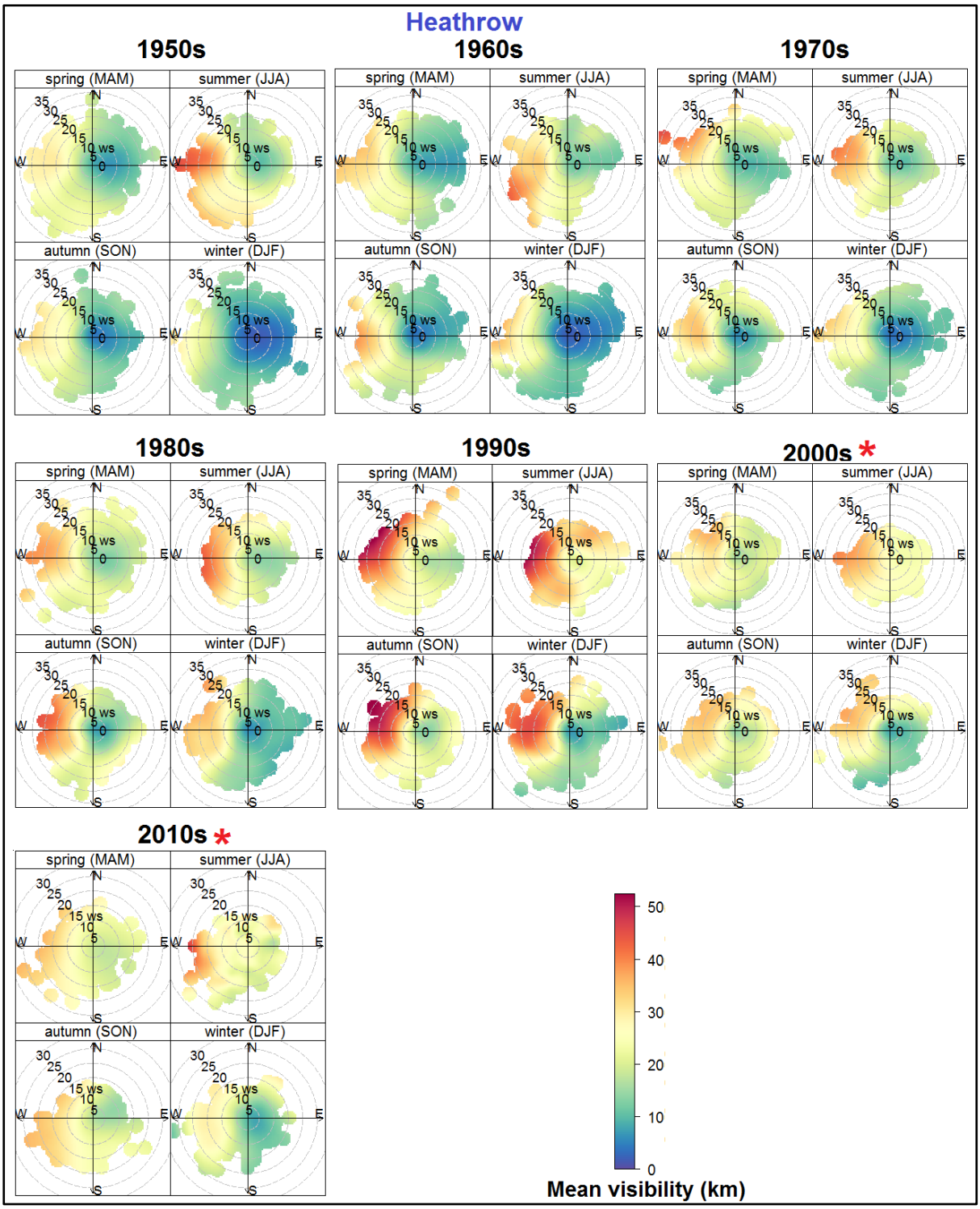
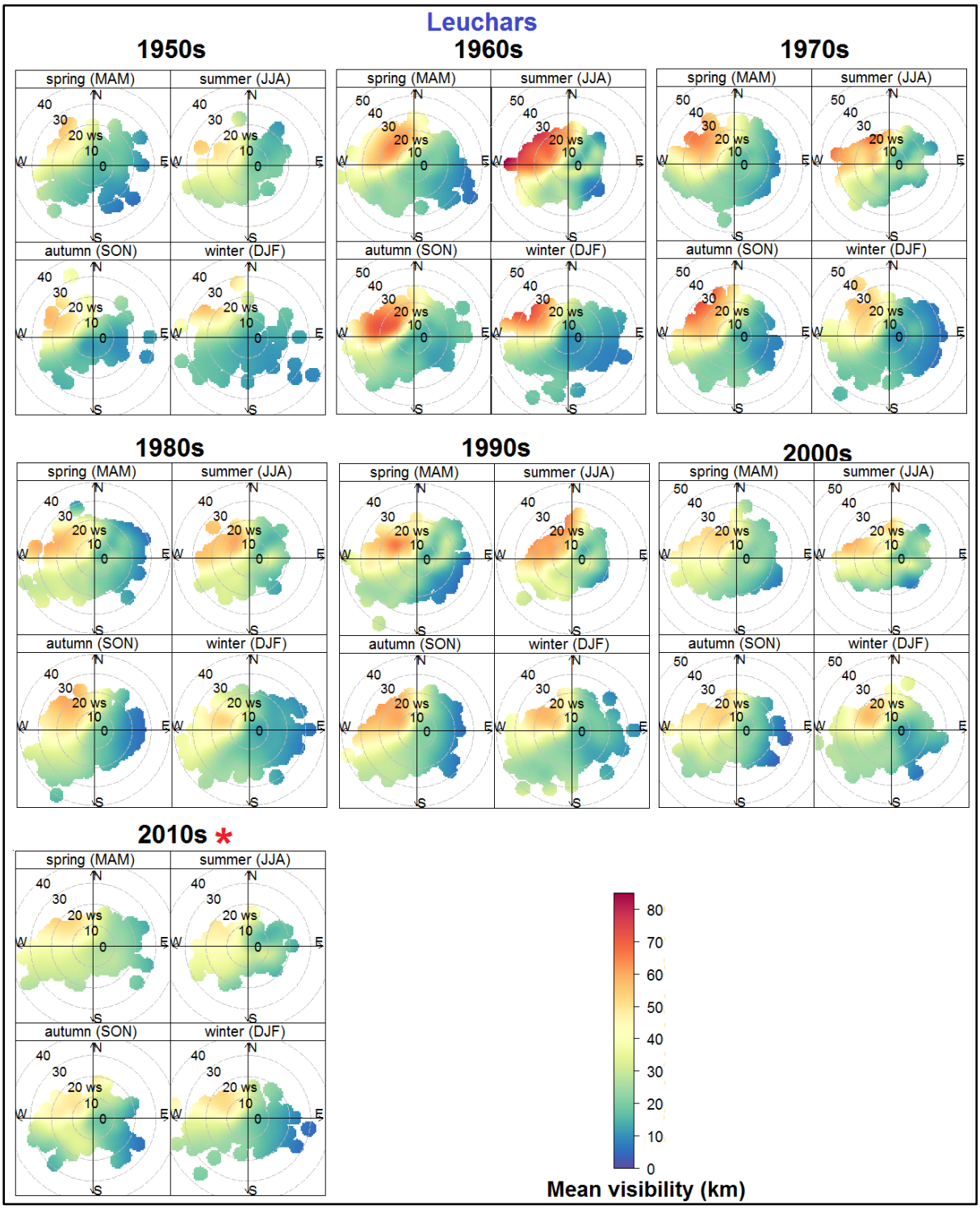
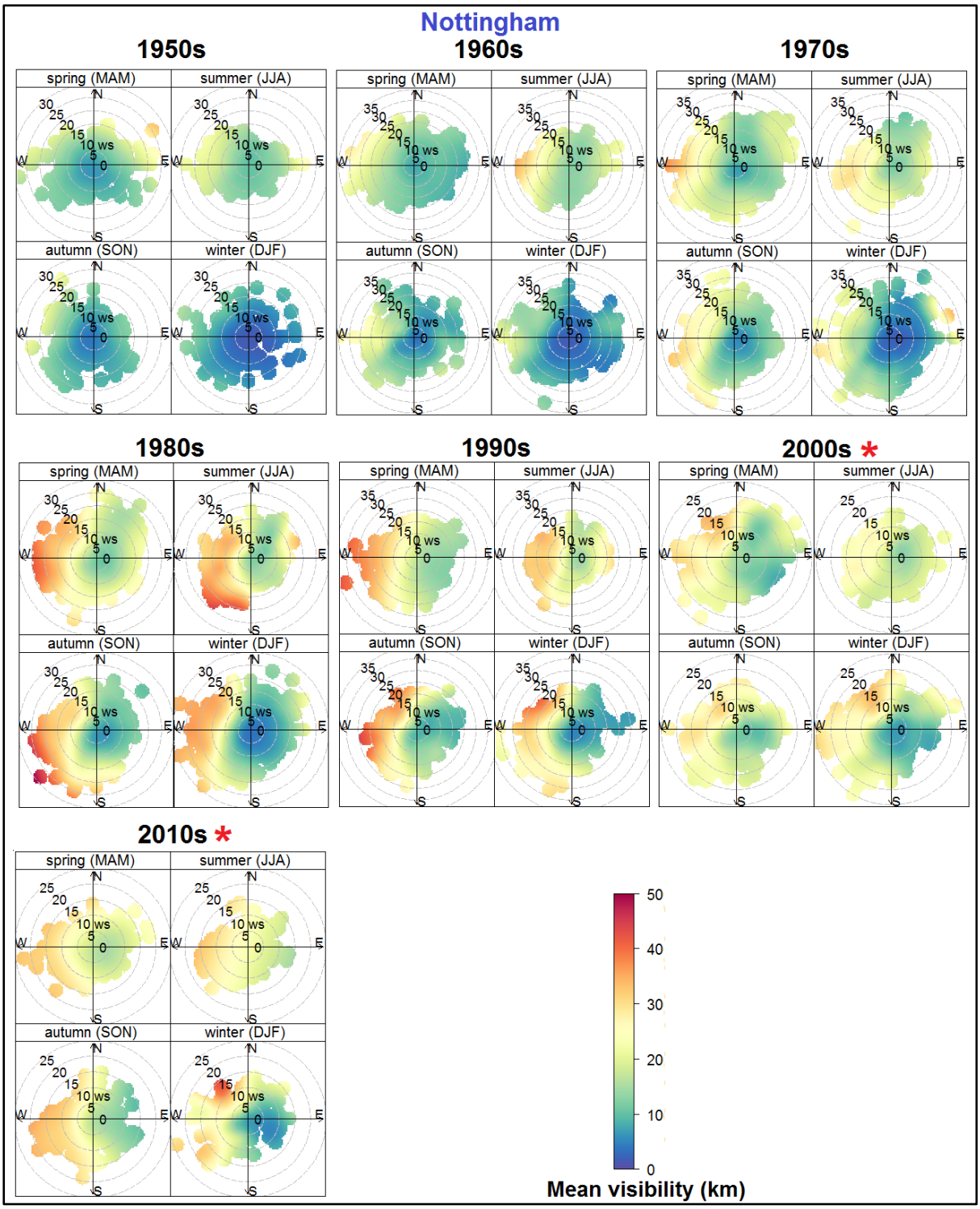


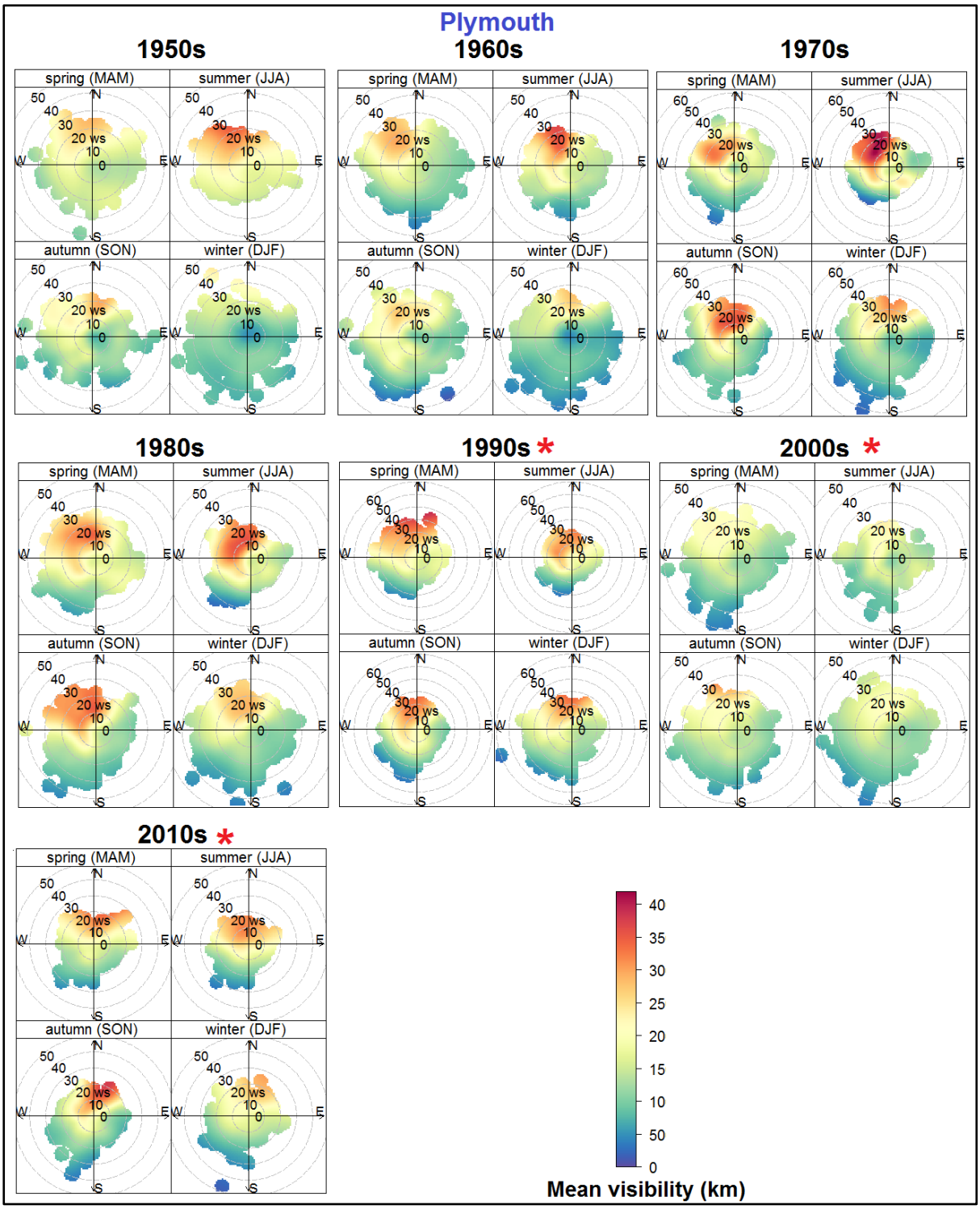
Figure S6 Time-series of meteorological components relative humidity (RH), air temperature (T), wind speed (w_s), and prevailing wind direction (w_d) including visibility (V), where all variables are averaged at 12 noon. Shaded lines show smooth fit line at 95 % confidence interval.

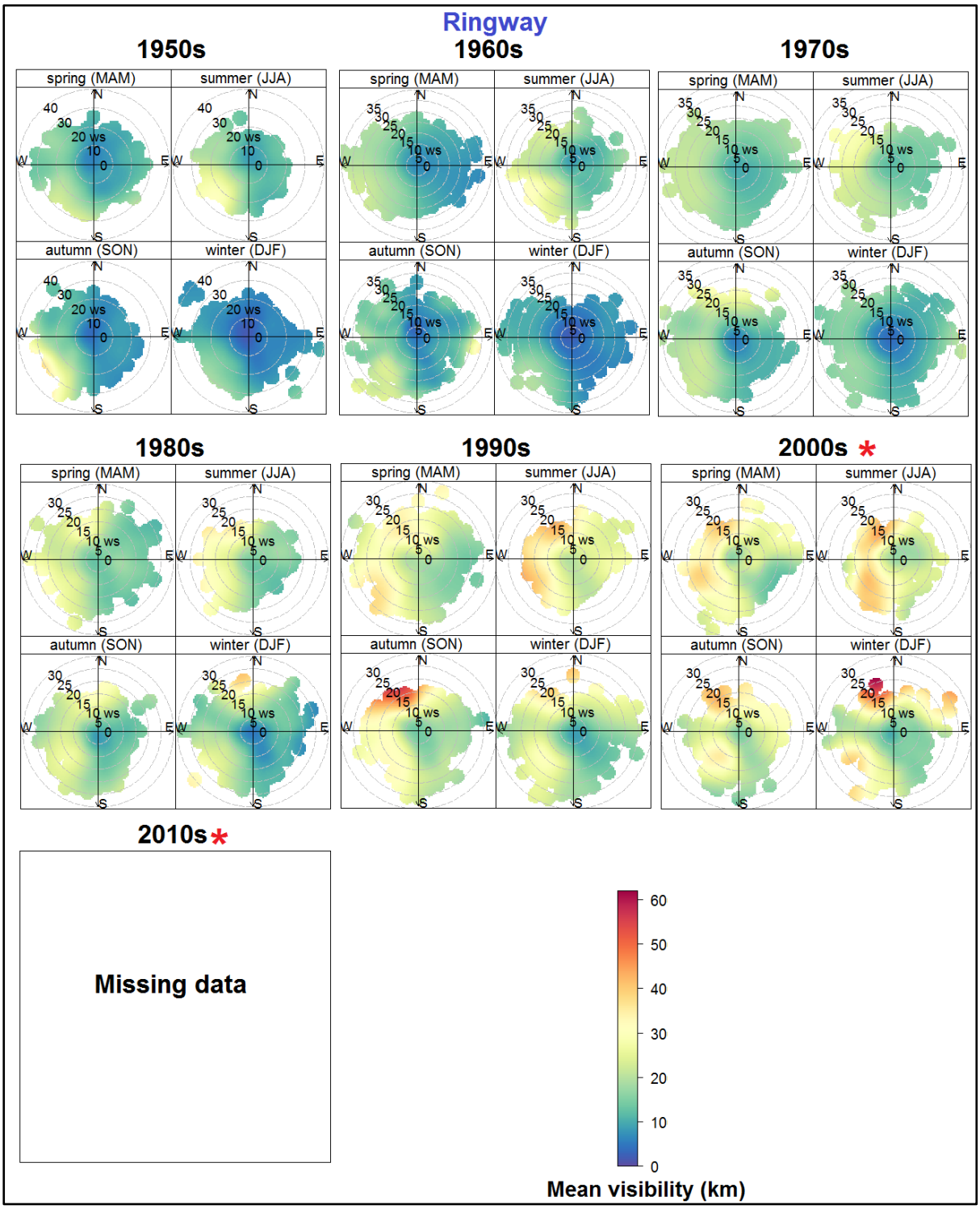

Aldergrove
1950s
1960s
1970s
1980s
1990s
2000s *
2010s *
spring (MAM)
summer (JJA)
autumn (SON)
winter (DJF)
N
E
S
W
ws
Mean visibility (km)
45
40
35
30
25
20
15
10
50
0

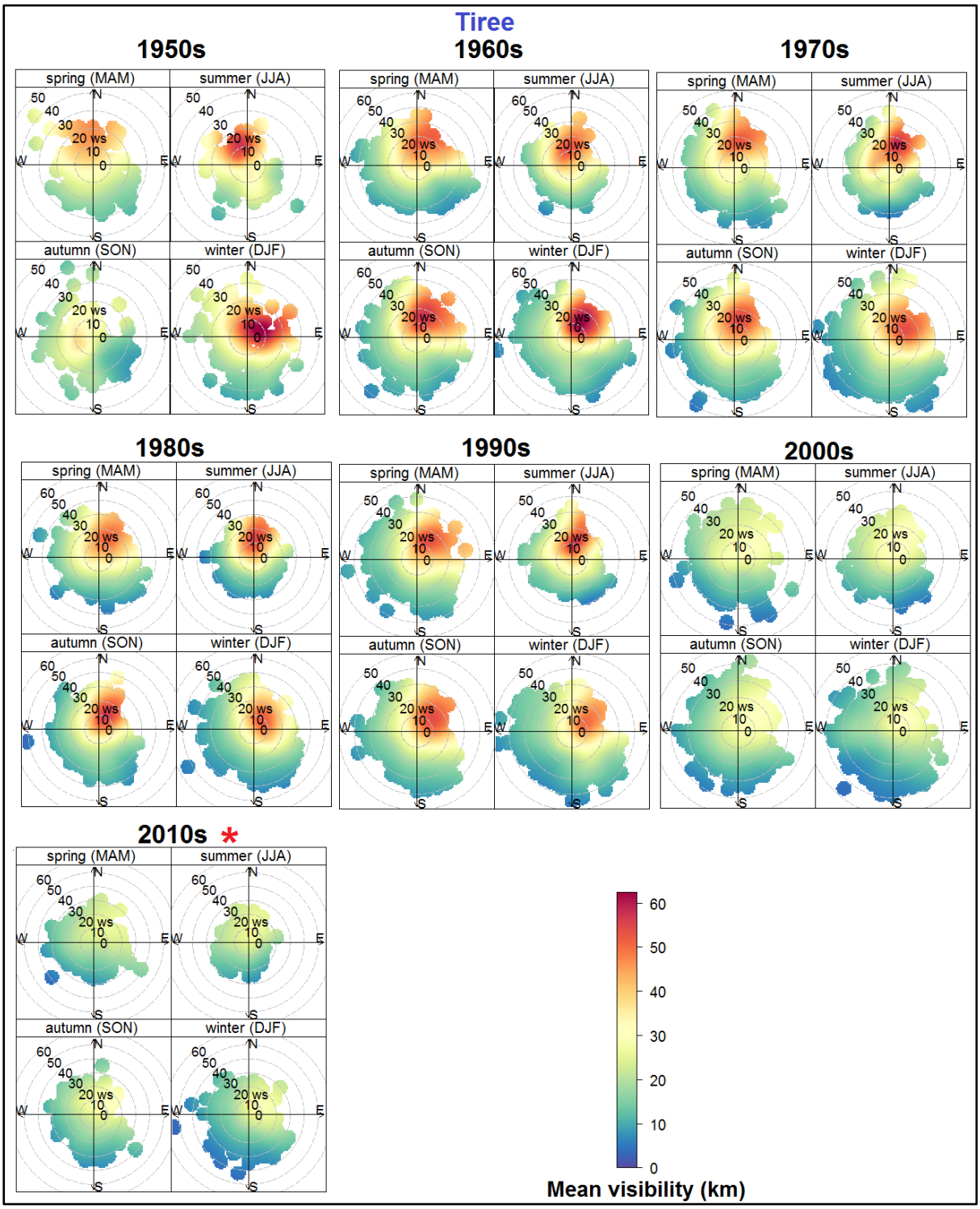

Heathrow
1950s
1960s
1970s
1980s
1990s
2000s *
2010s *
spring (MAM)
summer (JJA)
autumn (SON)
winter (DJF)
N
E
S
W
ws
0
5
10
15
20
25
30
35
50
40
30
20
10
0
Mean visibility (km)


Leuchars
1950s
1960s
1970s
1980s
1990s
2000s
2010s *
spring (MAM)
summer (JJA)
autumn (SON)
winter (DJF)
N
E
S
W
20 ws
Mean visibility (km)
0
10
20
30
40
50
60
70
80


Nottingham
1950s
1960s
1970s
1980s
1990s
2000s *
2010s *
spring (MAM)
summer (JJA)
autumn (SON)
winter (DJF)
N
E
S
W
ws
Mean visibility (km)
0
10
20
30
40
50


Plymouth
1950s
1960s
1970s
1980s
1990s *
2000s *
2010s *
spring (MAM)
summer (JJA)
autumn (SON)
winter (DJF)
N
E
S
W
20 ws
Mean visibility (km)
40
35
30
25
20
15
10
50
0


Ringway
1950s
1960s
1970s
1980s
1990s
2000s *
2010s *
spring (MAM)
summer (JJA)
autumn (SON)
winter (DJF)
ws
N
E
S
W
Missing data
60
50
40
30
20
10
0
Mean visibility (km)


Tiree
1950s
1960s
1970s
1980s
1990s
2000s
2010s *
spring (MAM)
summer (JJA)
autumn (SON)
winter (DJF)
N
E
S
W
ws
Mean visibility (km)

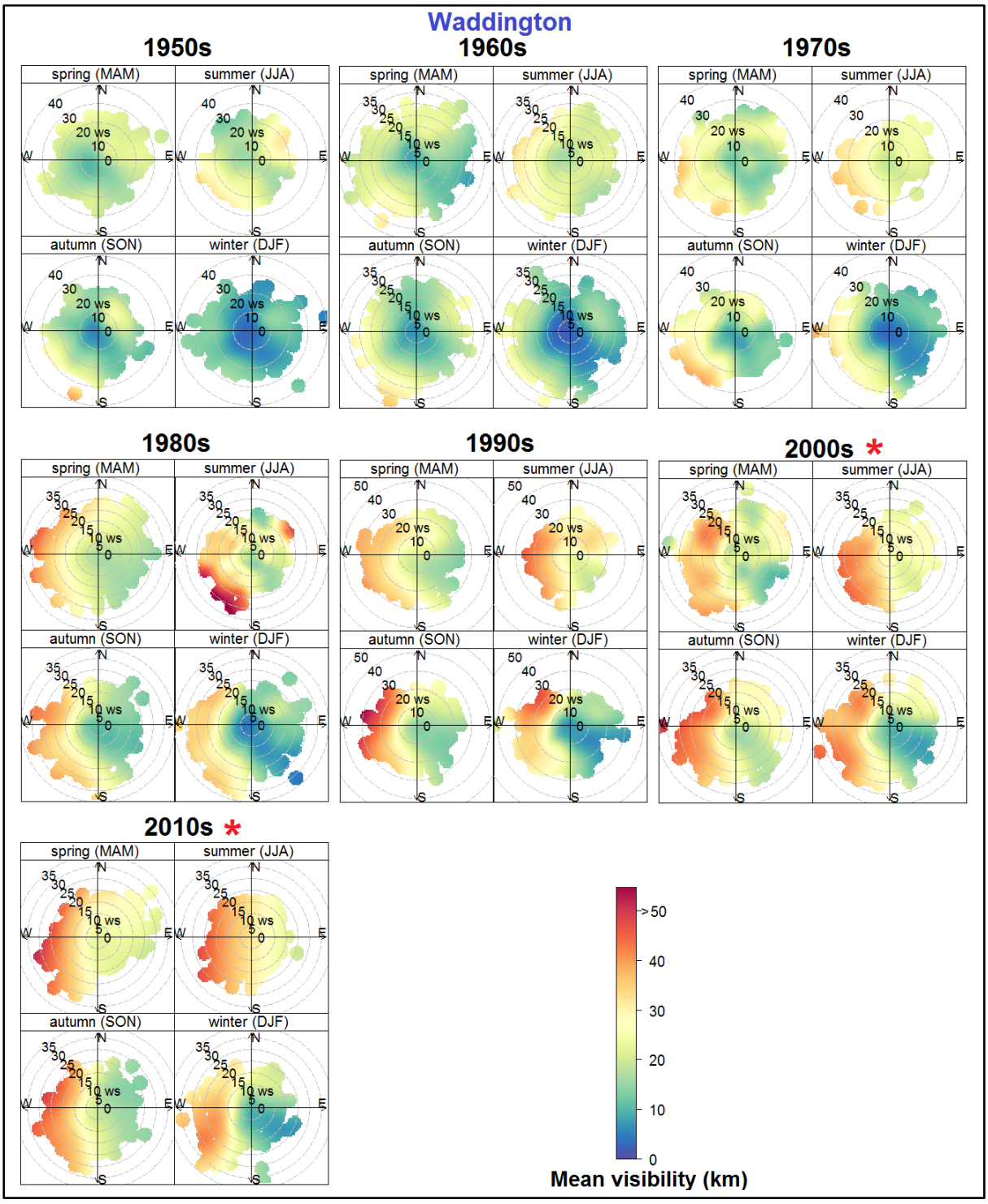


Figure S7 Decadal seasonal polar plots for all eight stations for 1950s, 1960s, 1970s, 1980s, 1990s, 2000s and 2010s (left to right). * represents years where visiometer measured data is included.

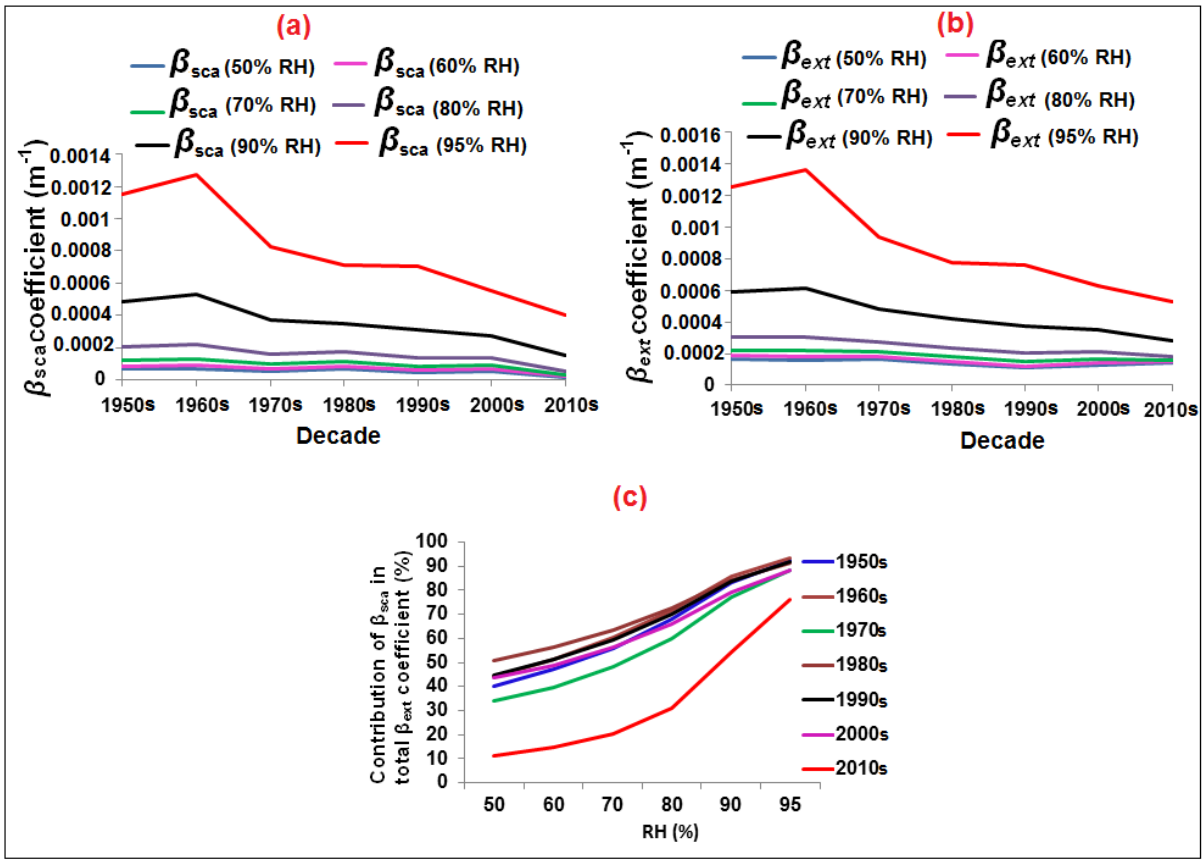


Figure S8 **(a)** Scattering coefficient (*βsca*), **(b)** total extinction coefficient (*βext*) and **(c)** contribution of scattering coefficient in total extinction coefficient at Heathrow. Estimates of error are not included here to improve clarity.

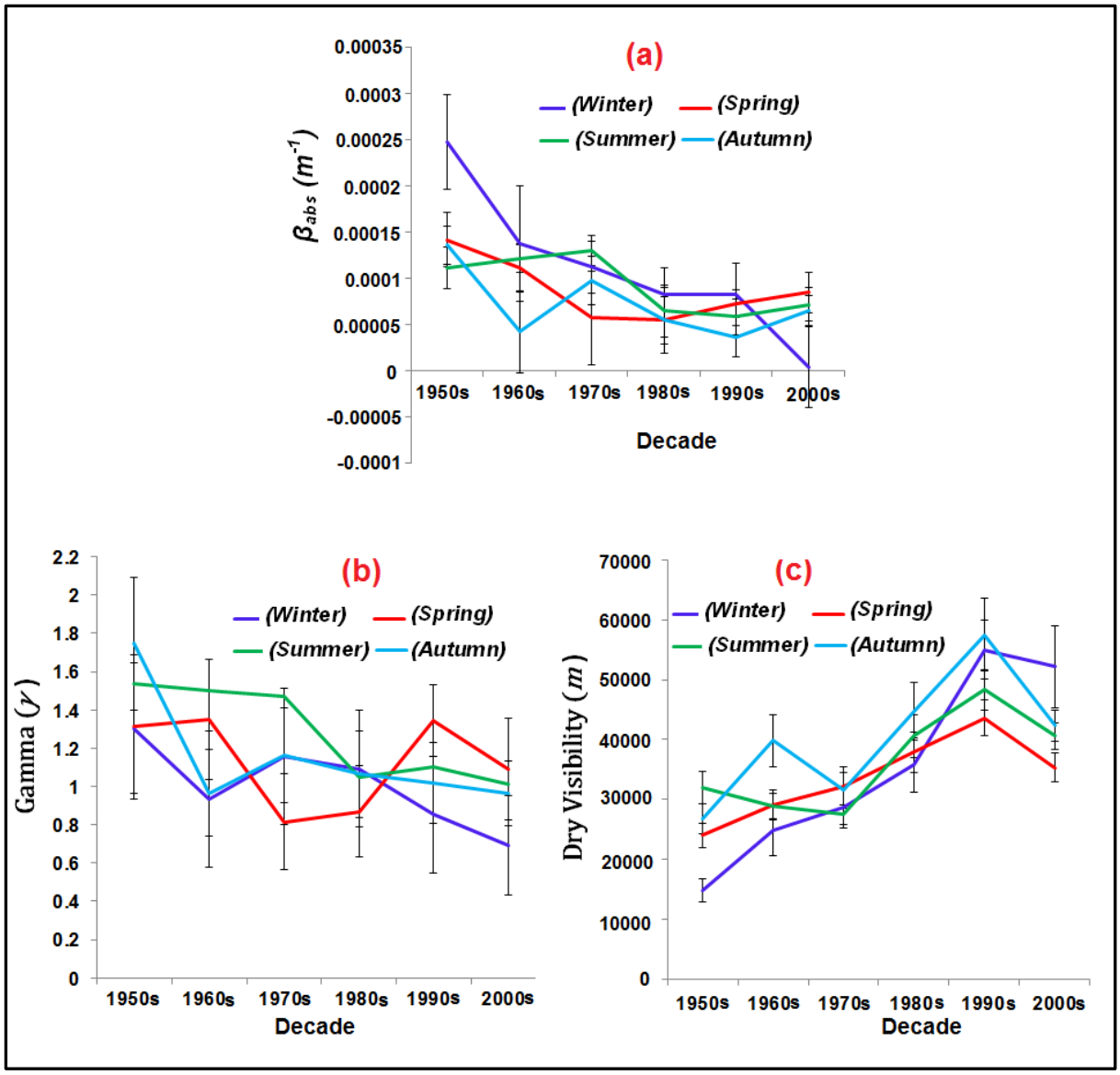


Figure S9 Model output parameters **a)** absorption coefficient **(β_{abs}), b)** Gamma (γ), and **c)** dry visibility at different seasons for Heathrow site.

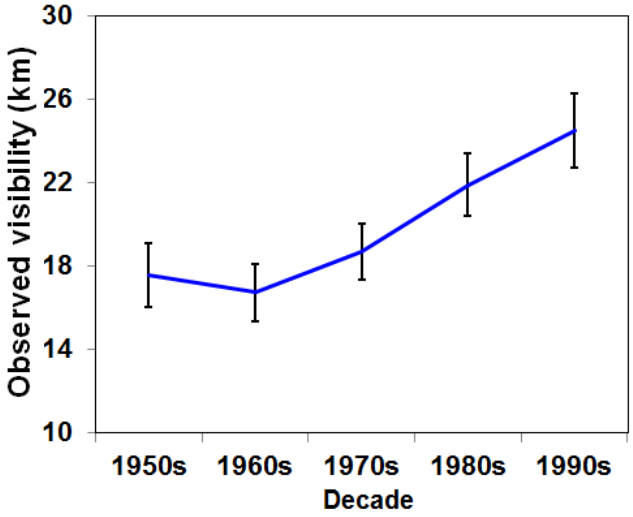


Figure S10 Decadal observed visibility at 70 % RH (range 67.5 -72.5 %) for Heathrow site. Error bars represent standard error at 95 % confidence interval.

Supplementary Tables

Table S1 Method of visibility measurement at different station with its used time period, where present indicates the sensor is still installed and being used.

	Method/ Sensor/ Equipment Type Name with their working period					
Station Name	**Manually**		**Sensor 1**		**Sensor 2**	
Aldergrove			**VISMETER -BELFORT 6230A**		**PRESENT WEATHER SENSOR - FD12P**	
	01/01/1926	24/01/2003	24/01/2003	28/08/2012	28/08/2012	Present
Heathrow			**VISMETER -BELFORT 6230A**		**VISMETER -BELFORT (Replaced with new one)**	
	01/01/1947	01/01/2000	01/01/2000	15/06/2005	15/06/2005	Present
Ringway			**VISIBILITY: VISIOMETER**		**Manually**	
	01/01/1941	01/01/2000	01/01/2000	01/11/2004	01/11/2004	Present
Nottingham			**VISMETER -BELFORT 6230A**		----------	
	01/01/1941	01/01/2000	01/01/2000	Present		
Plymouth			**VISMETER -BELFORT 6230A**		**PRESENT WEATHER SENSOR - FD12P**	
	01/01/1920	23/01/1997	23/01/1997	16/12/2010	16/12/2010	Present
Tiree			**VISMETER -BELFORT 6230A**		----------	
	01/01/1926	16/12/2010	16/12/2010	present		
Leuchars			**VISMETER -BELFORT 6230A**		----------	
	01/01/1921	16/12/2010	16/12/2010	present		
Waddintgon			**VISMETER -BELFORT 6230A**		----------	
	01/01/1946	01/01/2000	01/01/2000	present		

Table S2 Correlation coefficient (r) values between different variables, where daily data at 12 noon was used for calculation for last six decades

Aldergrove

	Visibility	RH	Temp	Wind speed
Visibility	1			
RH	-.519**	1		
Temp	.199**	-.373**	1	
Wind speed	.095**	-.028**	-.050**	1

Heathrow

	Visibility	RH	Temp	Wind speed
Visibility	1			
RH	-.542**	1		
Temp	.322**	-.540**	1	
Wind speed	.261**	-.084**	-0.008	1

Leuchars

	Visibility	RH	Temp	Wind speed
Visibility	1			
RH	-.688**	1		
Temp	.179**	-.353**	1	
Wind speed	.124**	-.208**	-.084**	1

Norringham

	Visibility	RH	Temp	Wind speed
Visibility	1			
RH	-.583**	1		
Temp	.299**	-.511**	1	
Wind speed	.272**	-.072**	-.054**	1

Plymouth

	Visibility	RH	Temp	Wind speed
Visibility	1			
RH	-.589**	1		
Temp	.185**	-.186**	1	
Wind speed	.220**	-.059**	-.073**	1

Ringway

	Visibility	RH	Temp	Wind speed
Visibility	1			
RH	-.549**	1		
Temp	.342**	-.423**	1	
Wind speed	.269**	-.070**	-.018**	1

Tiree

	Visibility	RH	Temp	Wind speed
Visibility	1			
RH	-.612**	1		
Temp	.041**	-.389**	1	
Wind speed	.331**	-.099**	-.226**	1

Waddington

	Visibility	RH	Temp	Wind speed
Visibility	1			
RH	-.633**	1		
Temp	.340**	-.550**	1	
Wind speed	.232**	-.091**	-.015*	1

* **Statistically significant value (p < 0.05)**

** **Statistically significant value (p < 0.01)**

Temp- Air Temperature **RH- Relative Humidity**

Table S3 Model output parameters (*Vis(dry), βabs,* Gamma (γ) and *βsca)*

Station		Output parameters			
	Decade	***Vis(dry)* [m]**	**β_{abs} [m^{-1}]**	**Gamma (γ)**	**β_{sca} [m^{-1}]**
Aldergrove	1950s	66168.94 ± 6406.58	1.91E-05 ± 2.07E-05	0.72 ± 0.13	0.000108 ± 0.000104
	1960s	67145.63 ± 6770.0	1.42E-05 ± 1.87E-05	0.78 ± 0.11	0.00013 ± 7.87E-05
	1970s	46450.98 ± 2542.37	5.54E-05 ± 1.25E-05	0.89 ± 0.11	9.93E-05 ± 5.27E-05
	1980s	60581.79 ± 3474.03	3.68E-05 ± 1.04E-05	0.91 ± 0.09	9.80E-05 ± 5.08E-05
	1990s	72645.1 ± 5414.83	4.30E-07 ± 1.77E-05	0.65 ± 0.09	0.000132 ± 4.29E-05
	2000s	33033.3 ± 2175.54	0 ± 6.14E-05	0.38 ± 0.11	0.0002 ± 2.86E-05
	2010s	27816.69 ± 1028.35	0.000134 ± 8.58E-06	1.05 ± 0.19	2.65E-05 ± 4.21E-05
Heathrow	1950s	30712.64 ± 1505.63	9.99E-05 ± 1.42E-05	1.28 ± 0.15	0.000104 ± 0.000161
	1960s	33724.2 ± 1690.38	8.65E-05 ± 1.32E-05	1.26 ± 0.13	7.87E-05 ± 0.000168
	1970s	29053.48 ± 1034.41	0.00011 ± 1.10E-05	1.26 ± 0.12	5.27E-05 ± 0.000127
	1980s	39380.87 ± 1684.78	6.63E-05 ± 1.23E-05	1.03 ± 0.11	5.08E-05 ± 0.000138
	1990s	47969.8 ± 1723.021	6.00E-05 ± 7.77E-06	1.17 ± 0.11	4.29E-05 ± 0.000109
	2000s	39486.93 ± 1182.31	7.14E-05 ± 8.96E-06	0.10 ± 0.10	2.86E-05 ± 0.000111
	2010s	29442.48 ±782.86	0.000127 ± 5.86E-06	1.40 ± 0.18	4.21E-05 ± 4.22E-05
Ringway	1950s	19009.64 ± 970.33	0.000165 ± 2.34E-05	1.22 ± 0.15	0.000222 ± 0.000104
	1960s	24280.22 ± 1312.52	9.83E-05 ± 2.43E-05	1.10 ± 0.12	0.000287 ± 7.87E-05
	1970s	28983.71 ± 1337.76	8.77E-05 ± 1.69E-05	1.09 ± 0.11	0.000215 ± 5.27E-05
	1980s	38266.72 ± 1971.32	4.22E-05 ± 1.91E-05	0.89 ± 0.10	0.000208 ± 5.08E-05
	1990s	50337.53 ± 2318.8	4.59E-05 ± 1.03E-05	1.06 ± 0.10	0.000139 ± 4.29E-05
	2000s	50433.99 ± 2835.64	5.67E-05 ± 1.07E-05	1.18 ± 0.15	0.000107 ± 2.86E-05
	2010s	----------	----------	----------	----------
Nottingham	1950s	23730.96 ±458.202	9.08E-05 ± 4.96E-05	1.10 ± 0.22	0.00034 ± 0.000104
	1960s	31058.79 ± 2110.9	7.17E-05 ± 2.07E-05	1.15 ± 0.11	0.000267 ± 7.87E-05
	1970s	35827.23 ± 1938.96	6.68E-05 ± 1.45E-05	1.11 ± 0.10	0.000197 ± 5.27E-05
	1980s	60996.37 ± 4725.79	7.06E-06 ± 1.72E-05	1.0 ± 0.10	0.000204 ± 5.08E-05
	1990s	39257.86 ± 1923.46	7.24E-05 ± 1.22E-05	1.10 ± 0.12	0.000127 ± 4.29E-05

	2000s	29994.36 ± 905.23	0.0001 ± 1.12E-05	0.80 ± 0.084	9.25E-05 ± 2.86E-05
	2010s	28622.94 ± 935.70	0.00013 ± 7.48E-06	1.21 ± 0.18	3.55E-05 ± 4.21E-05
Plymouth	1950s	37567.9 ± 2677.97	3.23E-05 ± 2.92E-05	0.73 ± 0.11	0.000197 ± 0.000104
	1960s	43782.5 ± 3244.77	3.92E-05 ± 1.89E-05	0.84 ± 0.10	0.000161 ± 7.87E-05
	1970s	46748.18 ± 2948.9	5.74E-05 ± 1.22E-05	1.06 ± 0.11	0.000114 ± 5.27E-05
	1980s	49226.96 ± 2903.94	4.95E-05 ± 1.20E-05	1.03 ± 0.11	0.000124 ± 5.08E-05
	1990s	38659.78 ± 1743.28	3.84E-05 ± 2.16E-05	0.56 ± 0.08	0.000137 ± 4.29E-05
	2000s	22827.89 ± 786.67	0.000115 ± 2.33E-05	0.53 ± 0.08	0.000118 ± 2.86E-05
	2010s	36199.28 ± 2242.56	5.56E-05 ± 2.63E-05	0.62 ± 0.12	0.000124 ± 4.21E-05
Tiree	1950s	91524.38 ± 22121.51	1.24E-05 ±3.19E-05	0.83 ± 0.27	9.62E-05 ± 0.00010
	1960s	95940.8 ± 9045.804	1.43E-05 ± 1.10E-05	0.79 ± 0.10	7.92E-05 ± 7.87E-05
	1970s	108150.7 ± 11993.07	1.69E-06 ± 1.28E-05	0.74 ± 0.09	9.58E-05 ± 5.27E-05
	1980s	79744.05 ± 5324.328	3.21E-05 ± 7.33E-06	1.02 ± 0.10	6.96E-05 ± 5.08E-05
	1990s	72533.1 ± 4859.271	3.85E-05 ± 7.47E-06	1.10 ± 0.11	7.08E-05 ± 4.29E-05
	2000s	40831.35 ± 2358.797	6.26E-05 ± 1.53E-05	0.73 ± 0.09	9.12E-05 ± 2.86E-05
	2010s	35281.66 ± 2462.969	7.74E-05 ± 2.19E-05	0.71 ± 0.13	8.96E-05 ±4.21E-05
Leuchars	1950s	68678.15 ± 8261.79	2.89E-05 ± 1.70E-05	1.22 ±0.18	0.000151 ± 0.000104
	1960s	91554.03 ± 5428.33	2.86E-05 ± 5.05E-06	1.43± 0.09	0.000103 ± 7.87E-05
	1970s	77735.19 ± 4208.63	2.93E-05 ± 6.50E-06	1.21 ± 0.09	0.000112± 5.27E-05
	1980s	66272.27 ± 2493.00	4.19E-05 ± 5.22E-06	1.18 ± 0.08	8.82E-05 ± 5.08E-05
	1990s	78279.2 ± 3279.53	2.56E-05 ± 6.22E-06	1.02 ± 0.08	9.99E-05 ± 4.29E-05
	2000s	62485.8 ± 1901.10	4.97E-05 ± 4.21E-06	1.18 ± 0.08	6.64E-05 ± 2.86E-05
	2010s	56086.63 ± 2125.58	6.11E-05 ± 4.97E-06	1.34 ± 0.13	5.56E-05 ± 4.21E-05
Waddington	1950s	36683.17 ± 2690.569	6.47E-05 ± 1.93E-05	1.12± 0.13	0.000198 ± 0.000104
	1960s	37699.07 ± 2375.559	6.34E-05 ± 1.62E-05	1.05 ± 0.10	0.000172 ± 7.87E-05
	1970s	39651.07 ± 1685.186	7.30E-05 ± 9.43E-06	1.14 ± 0.09	0.000125 ± 5.27E-05
	1980s	49441.39 ± 2317.583	5.18E-05 ± 9.29E-06	1.13 ± 0.09	0.00013 ± 5.08E-05

	1990s	45305.49 ± 1503.447	6.99E-05 ± 6.24E-06	1.28 ± 0.10	9.71E-05 ± 4.29E-05
	2000s	46205.36 ± 1299.249	6.84E-05 ± 5.59E-0	1.08 ± 0.09	7.29E-05 ± 2.86E-0
	2010s	44260.81 ± 1370.792	8.24E-05 ± 4.57E-06	1.47 ± 0.15	4.60E-05 ± 4.21E-05