Supplement of Atmos. Chem. Phys., 20, 15743–15759, 2020
https://doi.org/10.5194/acp-20-15743-2020-supplement
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Atmospheric Chemistry and Physics
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Supplement of

UK surface NO_2 levels dropped by 42 % during the COVID-19 lockdown: impact on surface O_3

James D. Lee et al.

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Supplementary information

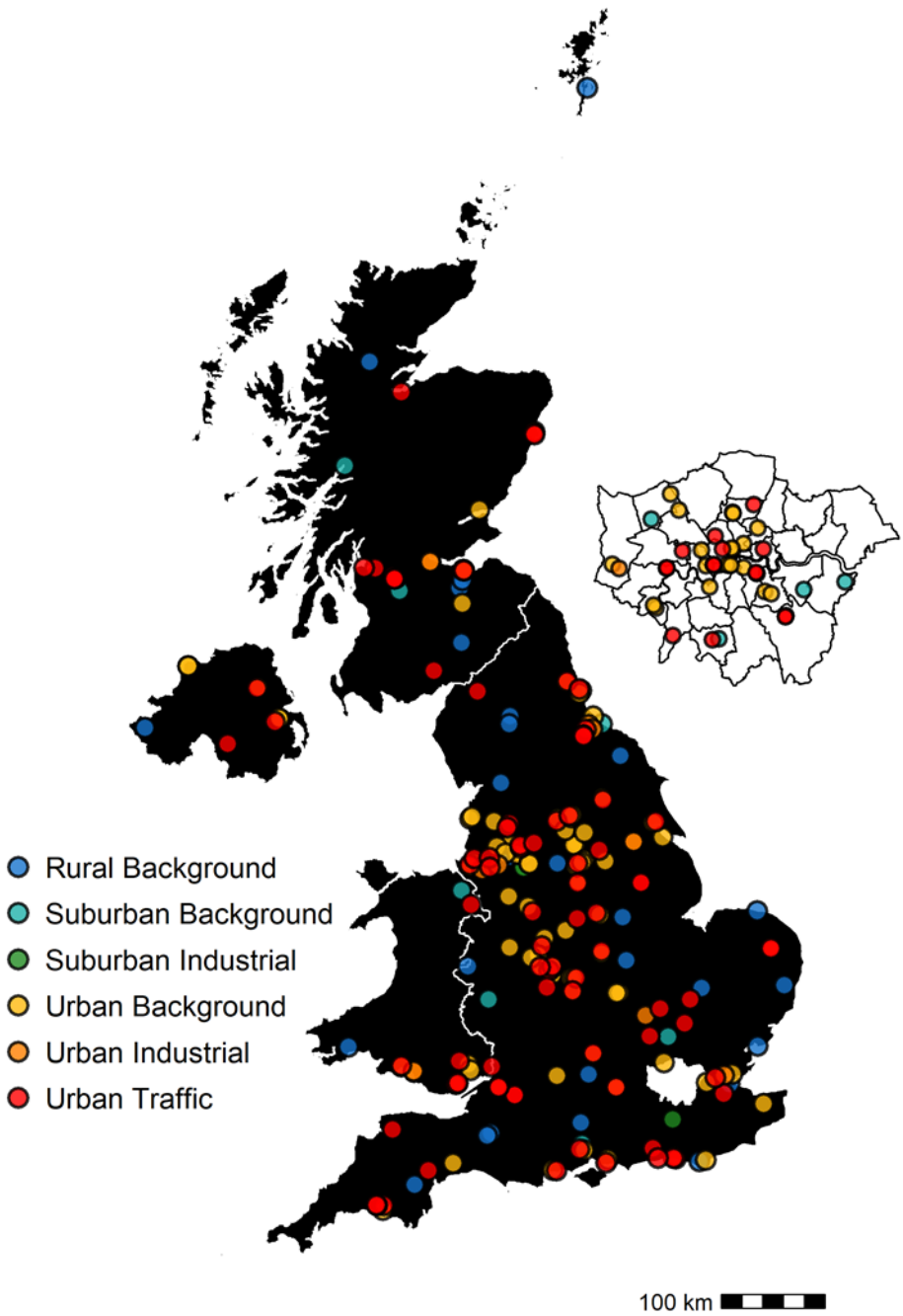
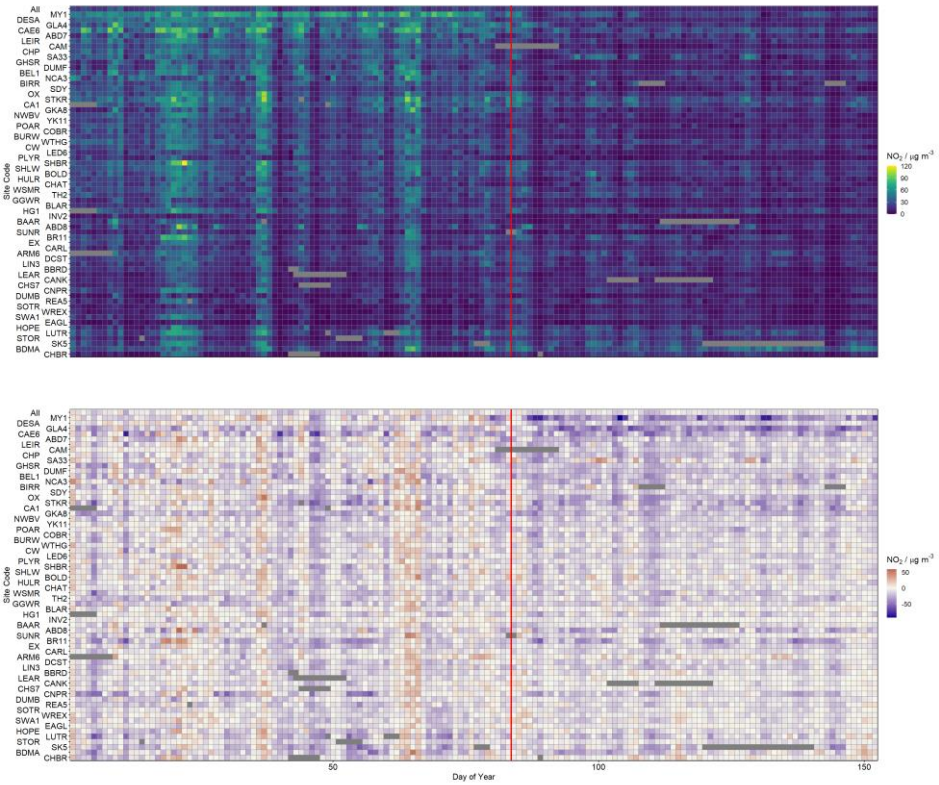


Figure S1: Map showing the location and type of AURN sites across the UK.

A:



B:

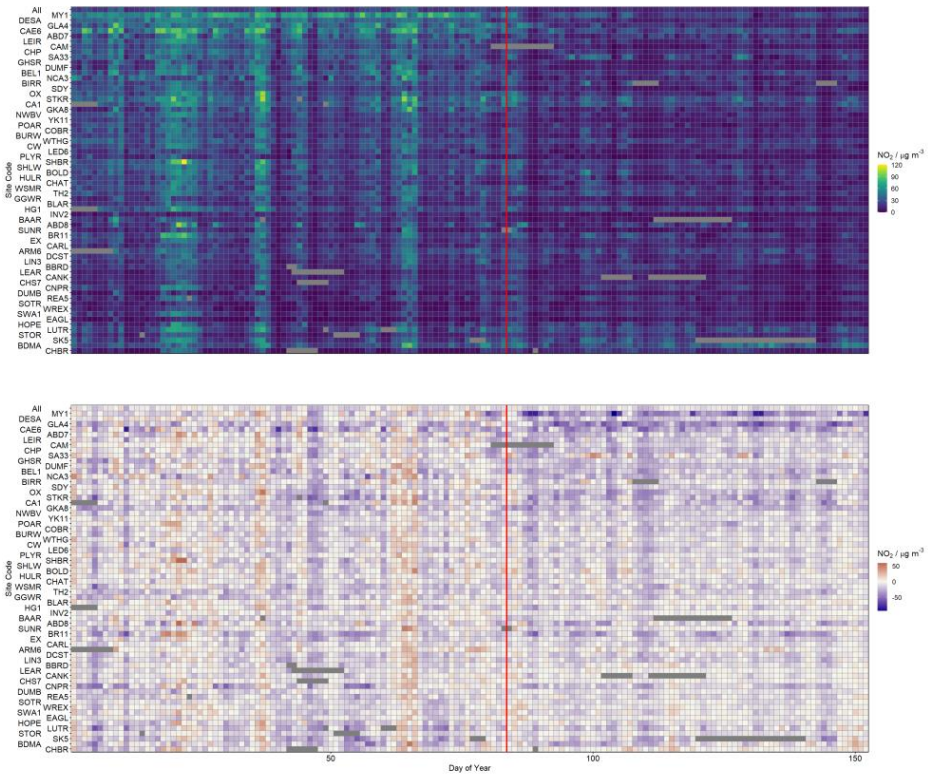


Figure S2: Daily median NO_2 concentrations in 2020 and the difference of detrended daily median NO_2 concentrations in 2020 from the mean of detrended daily median NO_2 concentrations between 2015 - 2019, at 66 Urban Traffic sites (A) and 62 Urban Background sites (B). The first row of all panels shows the mean across all sites in a given group. Red vertical line marks the boundary between 23rd and 24th March; the onset of the lockdown period in the UK.

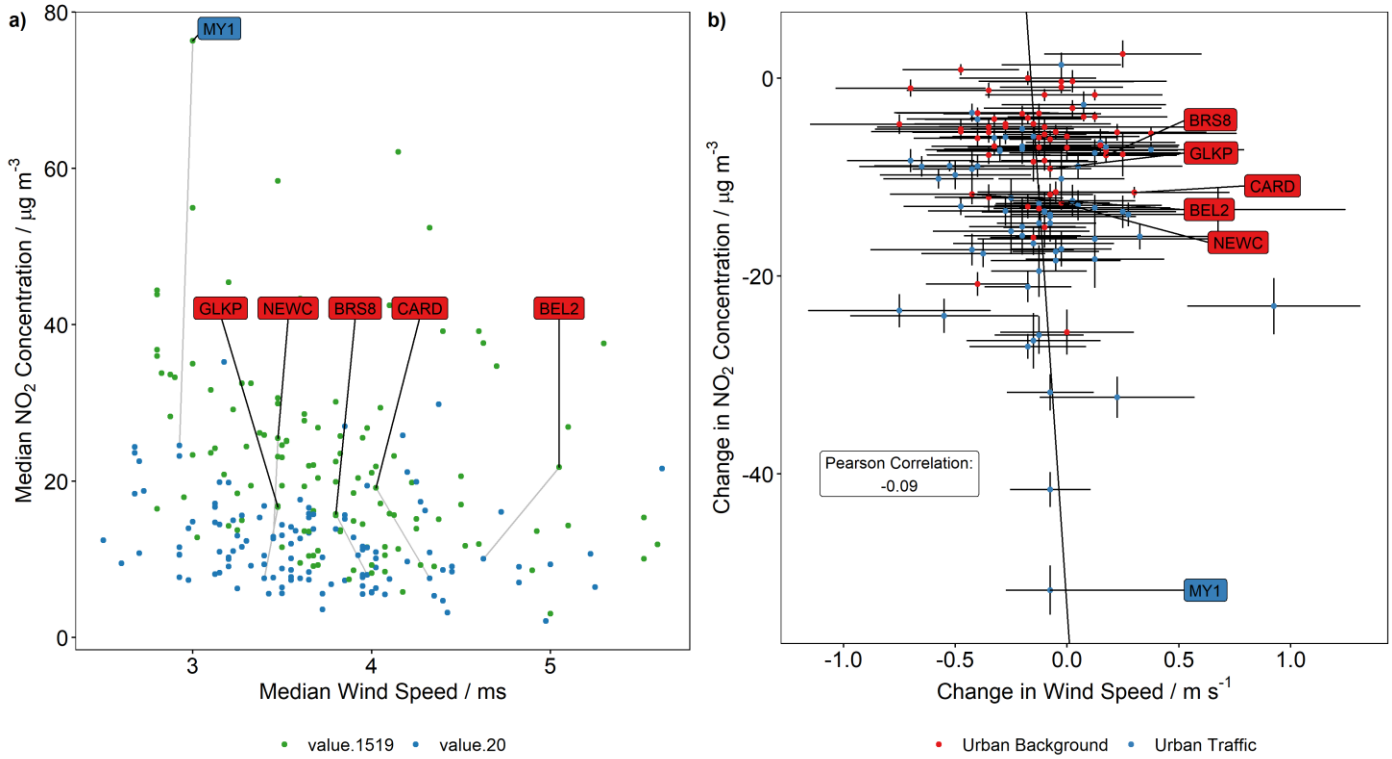


Figure S3: (a) shows the median NO_2 at each site, plotted against the median wind speed. Blue points show 2020 data and green points show the average of 2015-2019. The grey lines join up one of the sites in 6 cities (London (MY1), Glasgow (GLKP), Newcastle (NEWC), Bristol (BRS8), Cardiff (CARD) and Belfast (BEL2). (b) shows the change in NO2 in 2020 compared to the average of 2015-2019, plotted against the change in wind speed between those years.

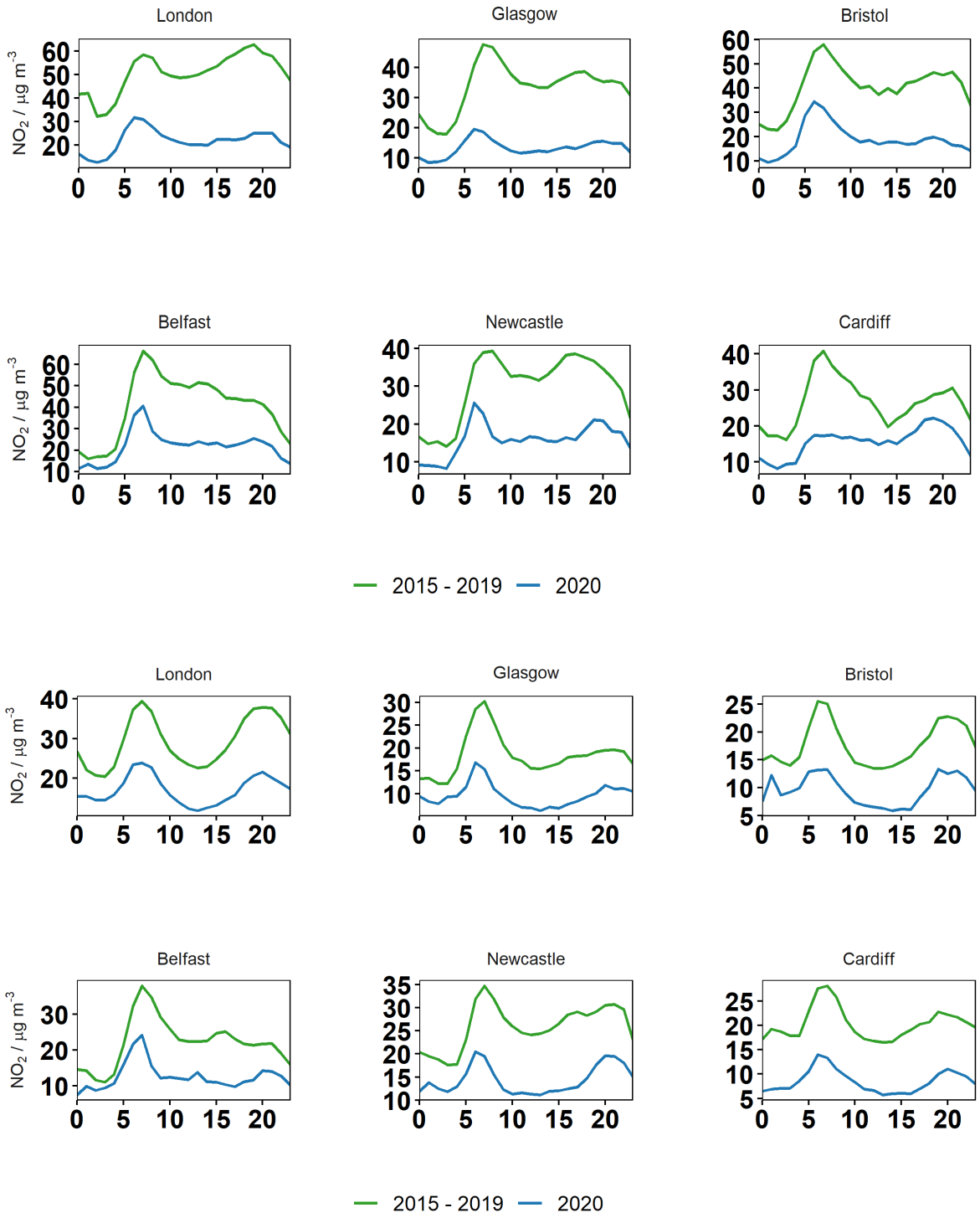


Figure S4: NO_2 Diurnal cycle from urban traffic (top), urban background (bottom) sites in 6 cities.

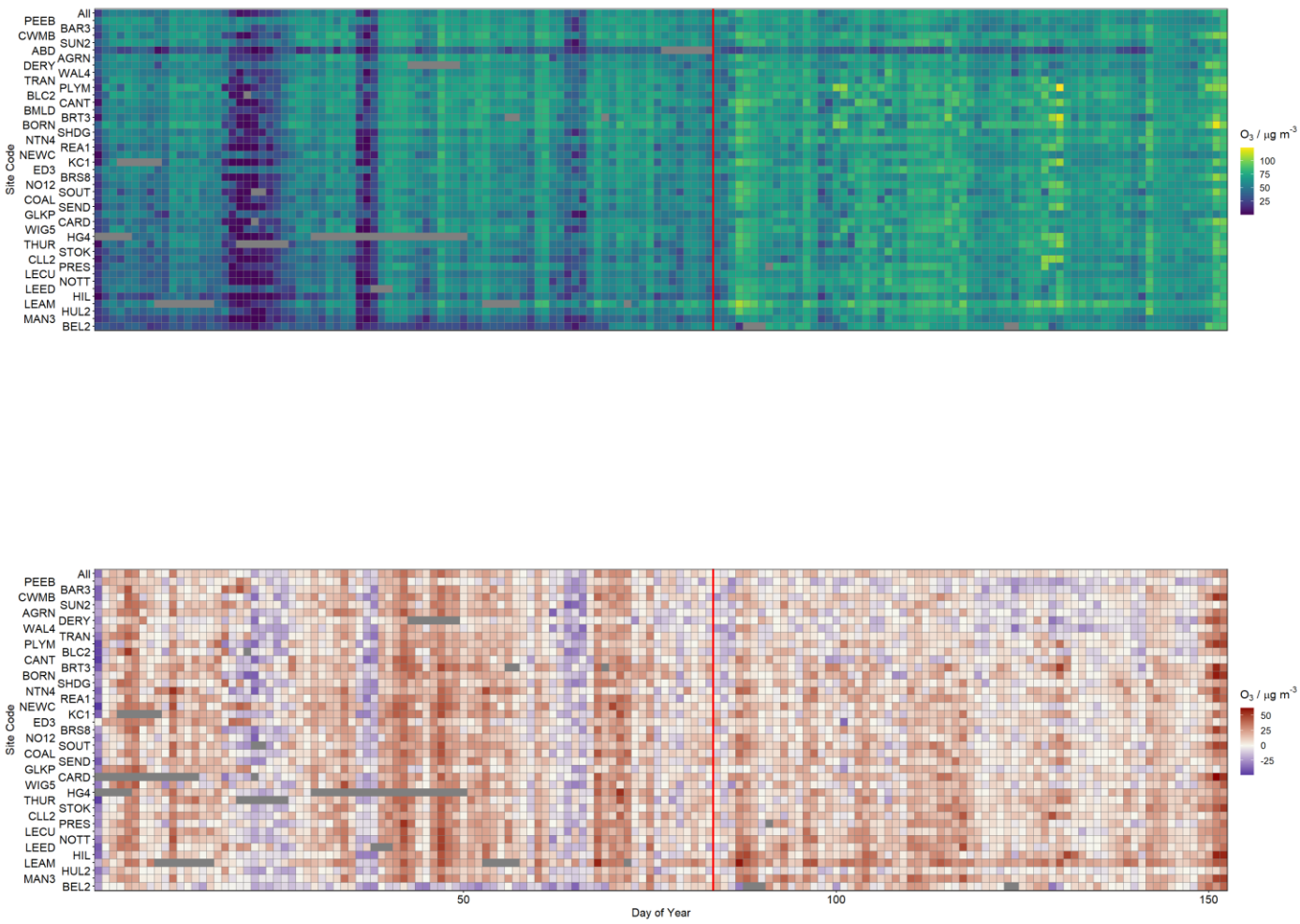


Figure S5: Same as Figure S2 but for O_3.

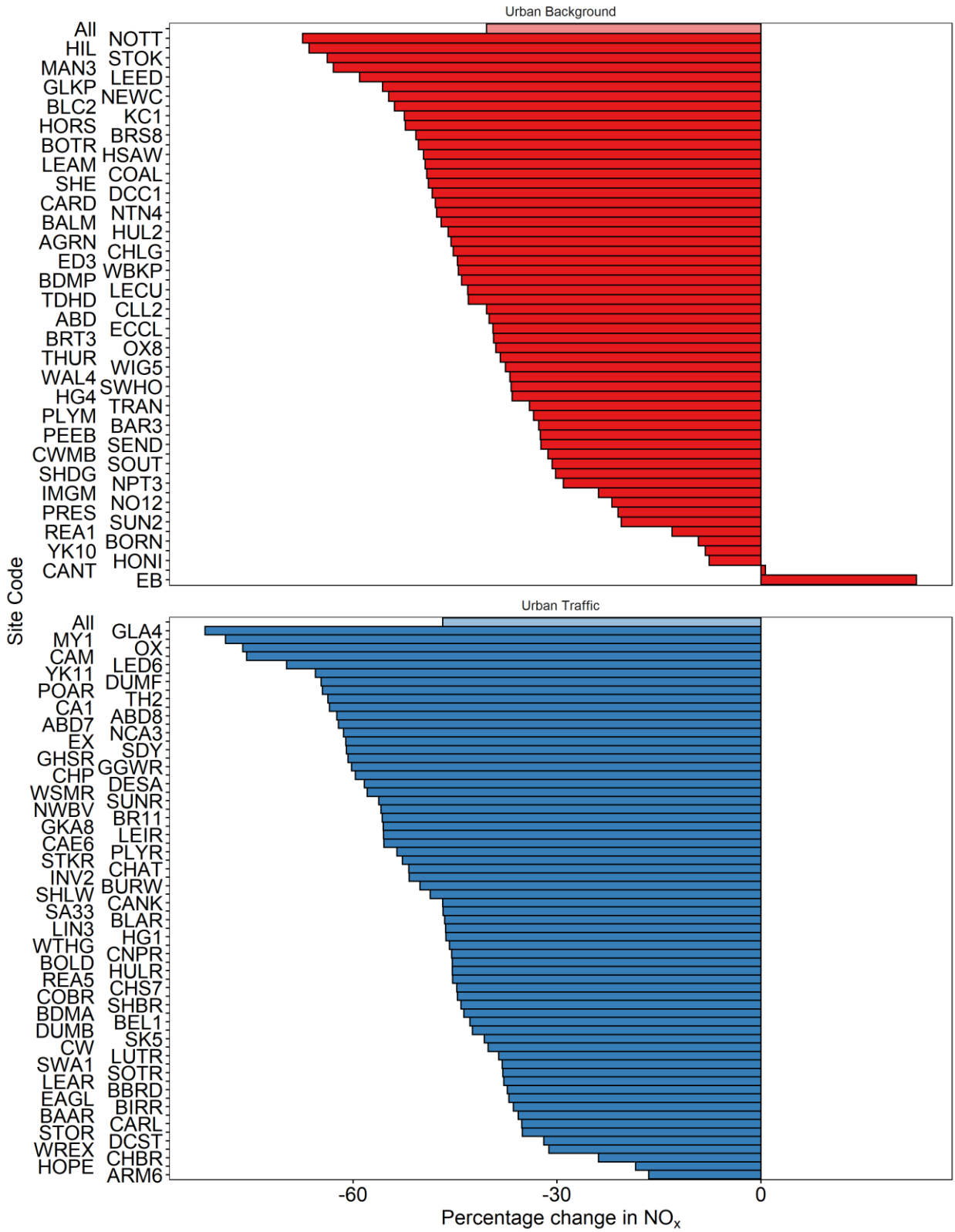


Figure S6: Percentage change in NO_x at all urban background and urban traffic sites for the lockdown period (23rd March – 31st May) in 2020 compared to the same period averaged across the previous 5 years, after removing site-dependent trends. The lighter coloured bar at the top shows the average of all sites. Site acronyms can be found in the tables below.

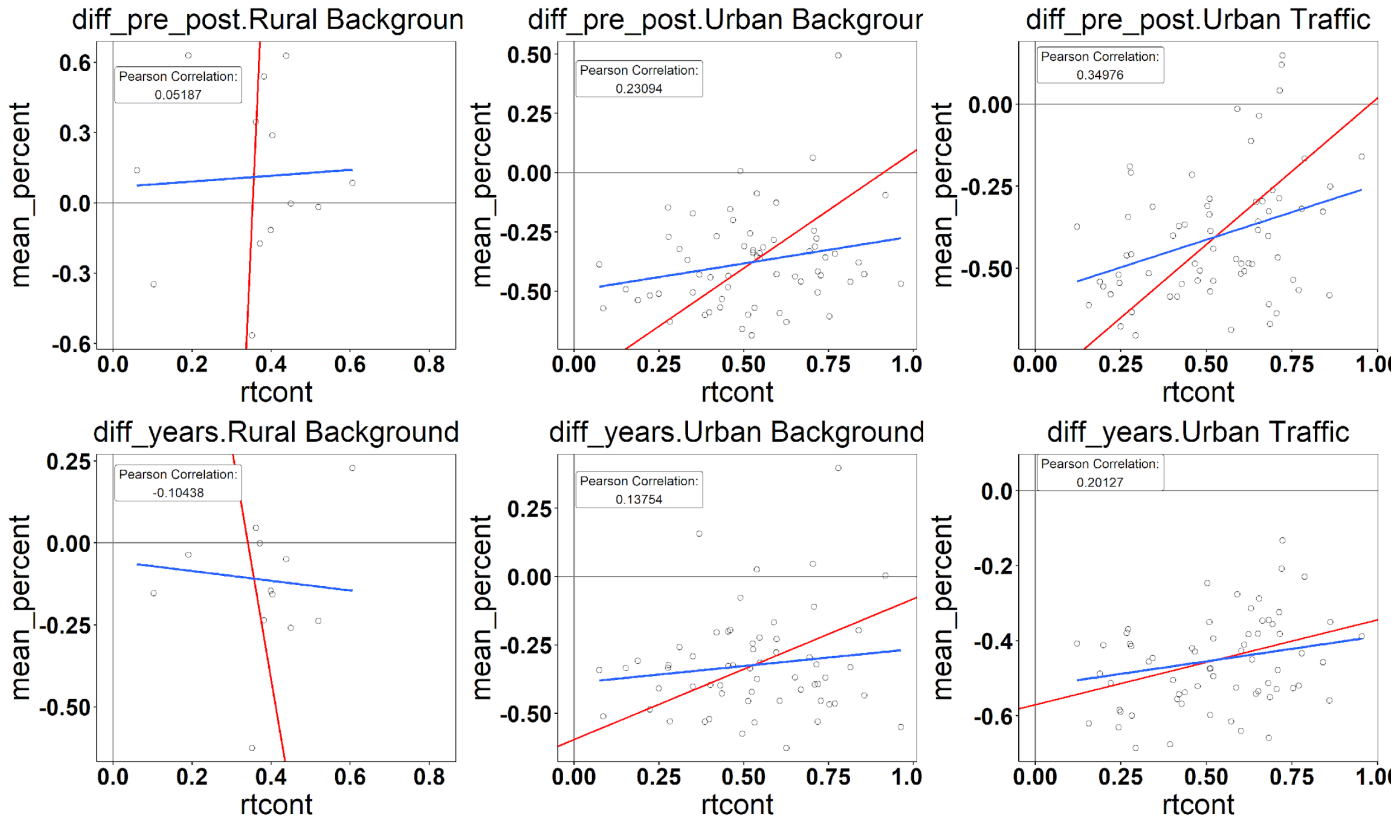
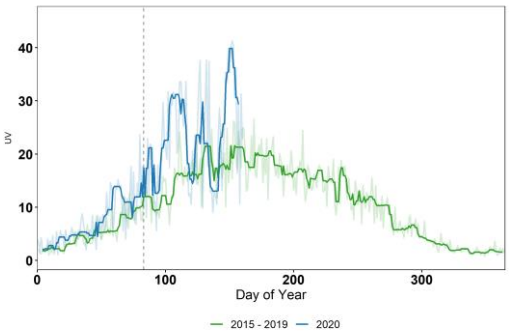
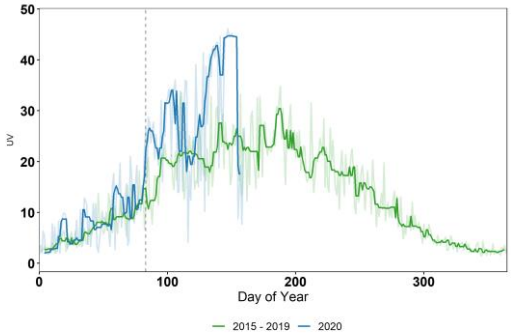


Figure S7: plot of % reduction in NO2 at each site against the contribution of road traffic to NO_x in the 1km x 1km grid square of the NAEI.

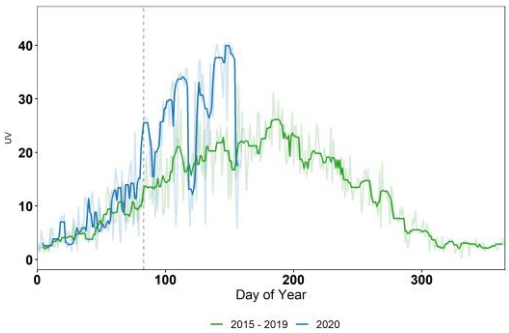
Belfast



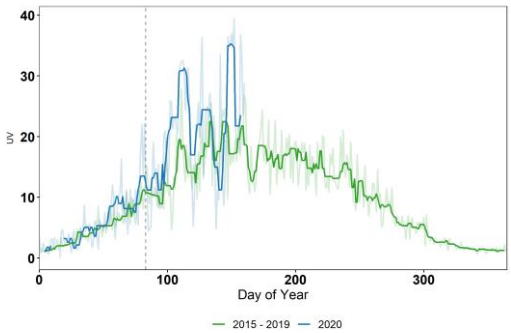
Cambourne



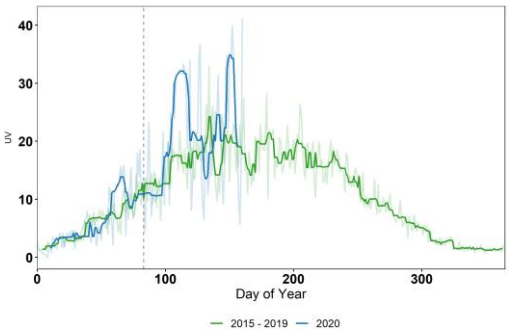
Chilton



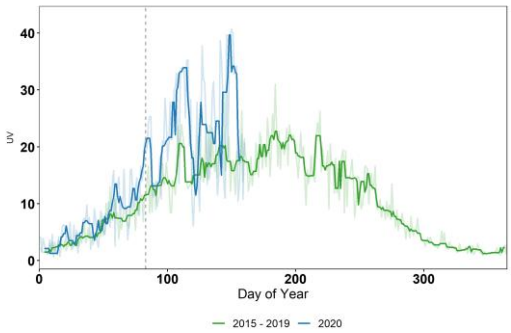
Glasgow



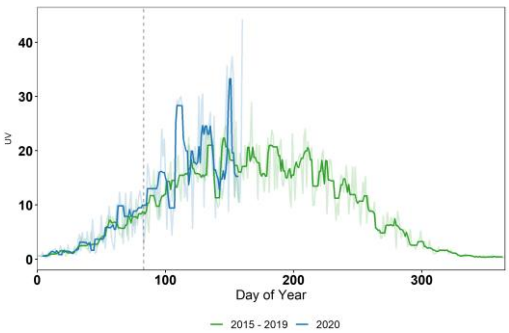
Inverness



Leeds



Lerwick



London

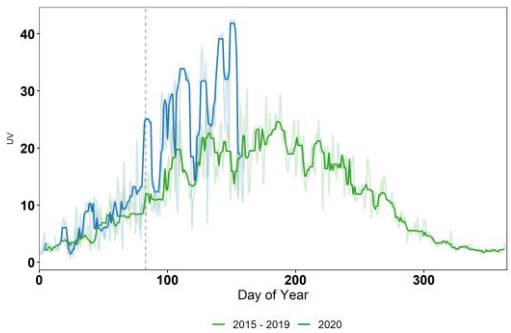
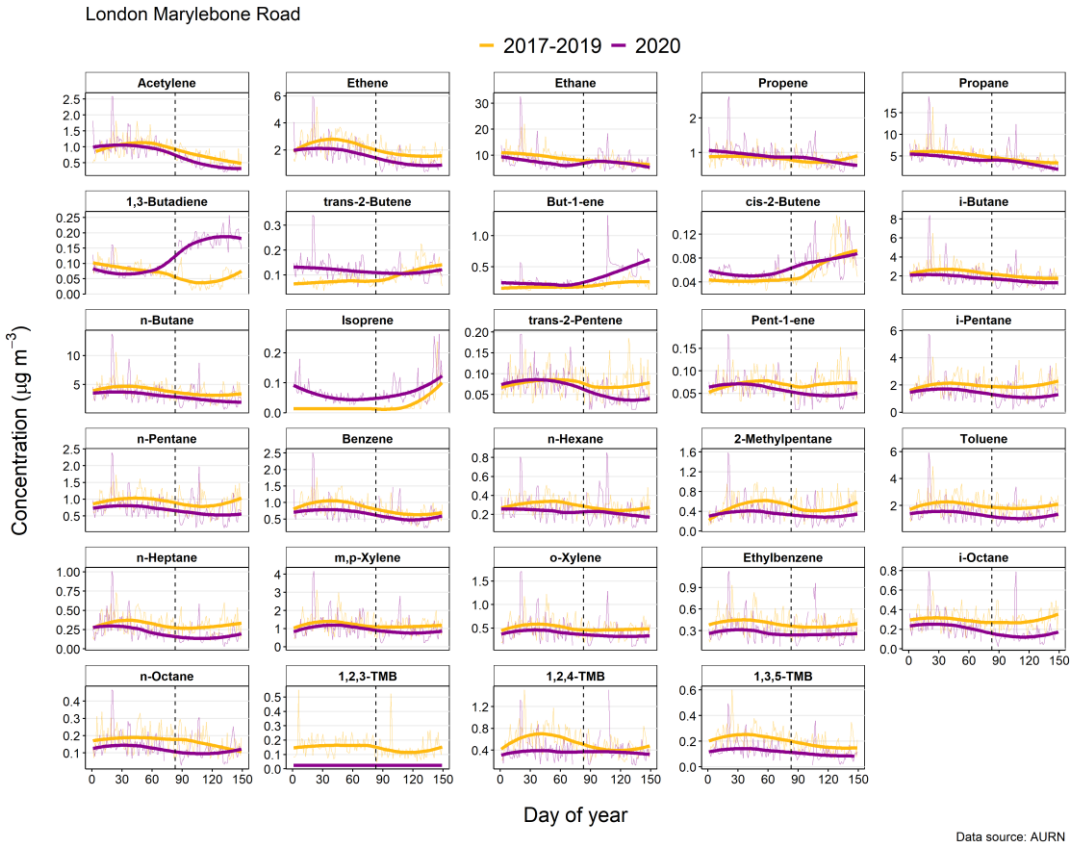


Figure S8 Surface daytime (10:00 - 18:00) UVA radiation for 2020 and the average of 2015-2019.



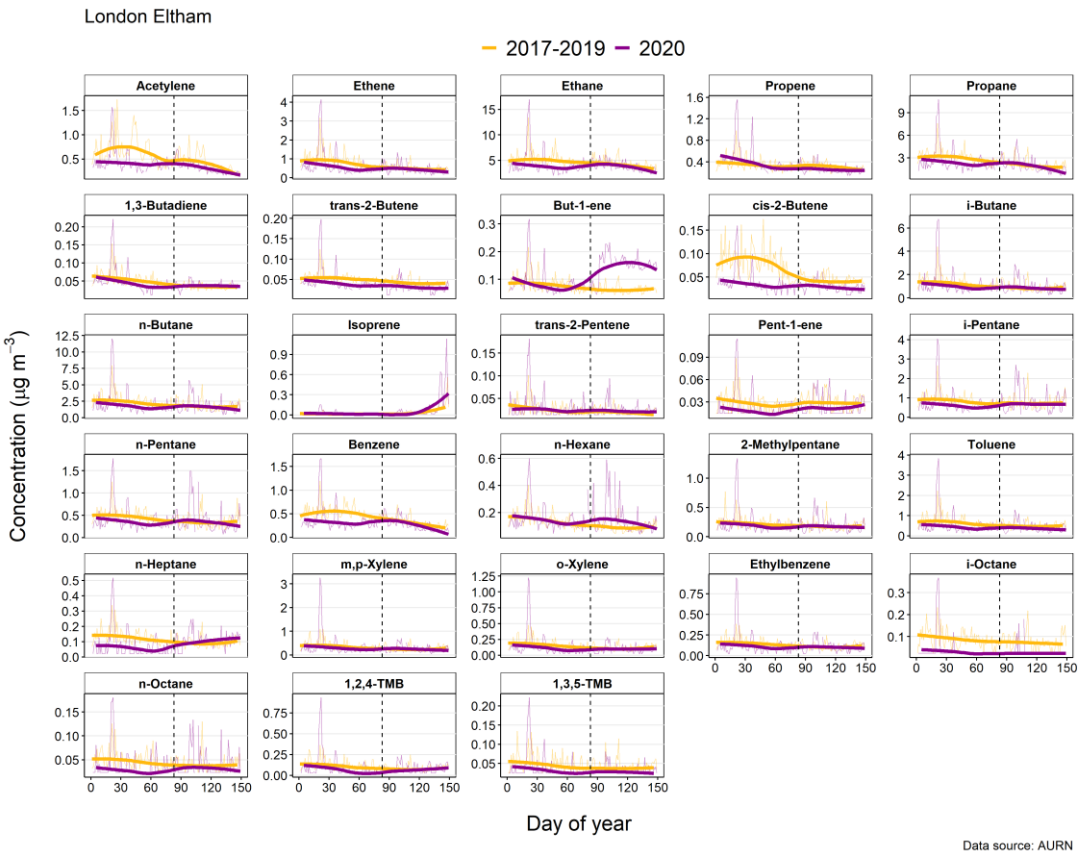


Figure S9: Daily median VOC measurements during 2020 and the average of 2017-2019 from the London Marylebone Road (urban traffic) and London Eltham (urban background) sites. The thick trend lines represent the 7-day rolling median. The dashed black line indicates the start of the lockdown period on 23rd March 2020.

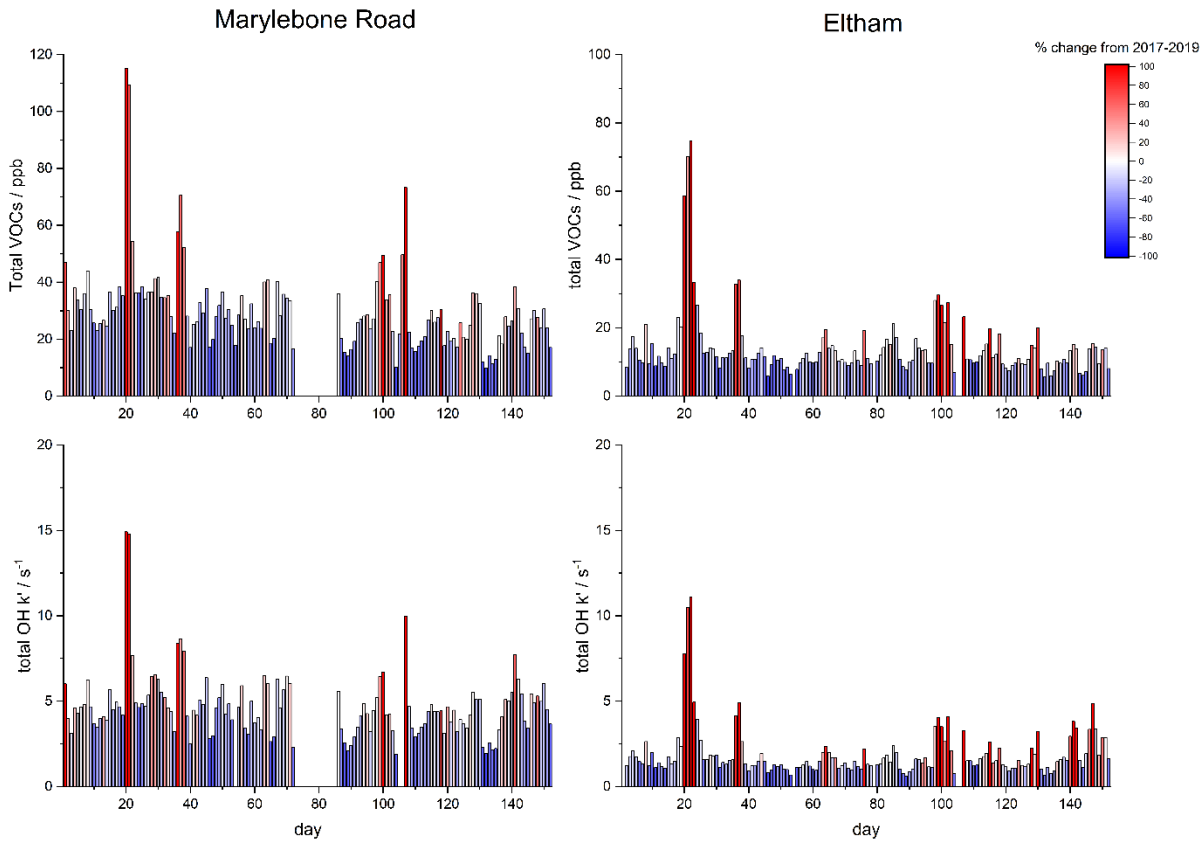


Figure S10: Daily total VOCs and total OH reactivity (k'). The colour scale of the bars indicates the change on that day compared to the average of the same day in 2017-2019.

Table S1: List of Urban Traffic sites used in NO_2 analysis.

Site	AURN code	Latitude	Longitude
Aberdeen Union Street Roadside	ABD7	57.144555	-2.106472
Aberdeen Wellington Road	ABD8	57.133888	-2.094198
Armagh Roadside	ARM6	54.353728	-6.654558
Ballymena Antrim Road	BAAR	54.851491	-6.274961
Birkenhead Borough Road	BBRD	53.388511	-3.025014
Bradford Mayo Avenue	BDMA	53.771245	-1.759774
Belfast Stockman's Lane	BEL1	54.572586	-5.974944
Birmingham A4540 Roadside	BIRR	52.47609	-1.875024
Blackburn Accrington Road	BLAR	53.747751	-2.452724
Oldbury Birmingham Road	BOLD	52.502436	-2.003497
Bristol Temple Way	BR11	51.457968	-2.583975
Bury Whitefield Roadside	BURW	53.559029	-2.293772
Camden Kerbside	CA1	51.54421	-0.175269
Hafod-yr-ynys Roadside	CAE6	51.680579	-3.133508
Cambridge Roadside	CAM	52.20237	0.124456
Cannock A5190 Roadside	CANK	52.687298	-1.980821
Carlisle Roadside	CARL	54.894834	-2.945307
Chatham Roadside	CHAT	51.374264	0.54797
Christchurch Barrack Road	CHBR	50.735454	-1.780888
Chepstow A48	CHP	51.638094	-2.678731
Chesterfield Roadside	CHS7	53.231722	-1.456944
Cardiff Newport Road	CNPR	51.49096	-3.152305
Coventry Binley Road	COBR	52.407708	-1.490082
Shaw Crompton Way	CW	53.579283	-2.093786

Doncaster A630 Cleveland Street	DCST	53.51824	-1.138057
Derby St Alkmund's Way	DESA	52.922983	-1.469507
Dumbarton Roadside	DUMB	55.943197	-4.55973
Dumfries	DUMF	55.070033	-3.614233
Stockton-on-Tees Eaglescliffe	EAGL	54.516667	-1.358547
Exeter Roadside	EX	50.725083	-3.532465
Glasgow Great Western Road	GGWR	55.872038	-4.270936
Glasgow High Street	GHSR	55.860936	-4.238214
Greenock A8 Roadside	GKA8	55.944079	-4.734421
Glasgow Kerbside	GLA4	55.85917	-4.258889
Haringey Roadside	HG1	51.5993	-0.068218
Stanford-le-Hope Roadside	HOPE	51.518167	0.439548
Hull Holderness Road	HULR	53.758971	-0.305749
Inverness	INV2	57.481308	-4.241451
Leamington Spa Rugby Road	LEAR	52.294884	-1.542911
Leeds Headingley Kerbside	LED6	53.819972	-1.576361
Leicester A594 Roadside	LEIR	52.638677	-1.124228
Lincoln Canwick Road	LIN3	53.221373	-0.534189
Luton A505 Roadside	LUTR	51.892293	-0.46211
London Marylebone Road	MY1	51.52253	-0.154611
Newcastle Cradlewell Roadside	NCA3	54.986405	-1.595362
Nottingham Western Boulevard	NWBV	52.969377	-1.188851
Oxford Centre Roadside	OX	51.751745	-1.257463
Plymouth Tavistock Road	PLYR	50.411058	-4.130288
Portsmouth Anglesea Road	POAR	50.798339	-1.095558

Reading London Road	REA5	51.454896	-0.940382
Southampton A33	SA33	50.920265	-1.463484
Sandy Roadside	SDY	52.132417	-0.300306
Sheffield Barnsley Road	SHBR	53.40495	-1.455815
St Helens Linkway	SHLW	53.451826	-2.742134
Southwark A2 Old Kent Road	SK5	51.480499	-0.05955
Stockton-on-Tees A1305 Roadside	SOTR	54.565819	-1.3159
Stoke-on-Trent A50 Roadside	STKR	52.980436	-2.111898
Storrington Roadside	STOR	50.916932	-0.449548
Sunderland Wessington Way	SUNR	54.91839	-1.408391
Swansea Roadside	SWA1	51.632696	-3.947374
Tower Hamlets Roadside	TH2	51.52253	-0.042155
Wrexham	WREX	53.04222	-3.002778
Widnes Milton Road	WSMR	53.365391	-2.73168
Worthing A27 Roadside	WTHG	50.832947	-0.379916
York Fishergate	YK11	53.951889	-1.075861

Table S2: List of Urban Background sites used in NO_2 and O_3 analysis.

Site	**Code**	**Latitude**	**Longitude**
Aberdeen	ABD	57.15736	-2.094278
Birmingham Acocks Green	AGRN	52.437165	-1.829999
Ballymena Ballykeel	BALM	54.861595	-6.250873
Barnsley Gawber	BAR3	53.56292	-1.510436
Borehamwood Meadow Park	BDMP	51.661229	-0.270671
Belfast Centre	BEL2	54.59965	-5.928833
Blackpool Marton	BLC2	53.80489	-3.007175
Birmingham Ladywood	BMLD	52.481346	-1.918235
Bournemouth	BORN	50.73957	-1.826744
Burton-on-Trent Horninglow	BOTR	52.82105	-1.635718
Bristol St Paul's	BRS8	51.462839	-2.584482

Brighton Preston Park	BRT3	50.840836	-0.147572
Canterbury	CANT	51.27399	1.098061
Cardiff Centre	CARD	51.48178	-3.17625
Chesterfield Loundsley Green	CHLG	53.244131	-1.454946
Central London	CLL	51.494722	-0.138333
Coventry Allesley	COAL	52.411563	-1.560228
Crewe Coppenhall	COPP	53.115941	-2.453492
Cwmbran	CWMB	51.6538	-3.006953
Dundee Mains Loan	DCC1	56.475434	-2.959861
Dewsbury Ashworth Grove	DYAG	53.693104	-1.637111
Eastbourne	EB	50.805778	0.271611
London Bloomsbury	CLL2	51.52229	-0.125889
Edinburgh St Leonards	ED3	55.945589	-3.182186
Glasgow Townhead	GLKP	55.865782	-4.243631
London Haringey Priory Park South	HG4	51.584128	-0.125254
London Hillingdon	HIL	51.49633	-0.460861
Honiton	HONI	50.792287	-3.196702
London Westminster	HORS	51.49467	-0.131931
Hartlepool St Abbs Walk	HSAW	54.683242	-1.203838
Hull Freetown	HUL2	53.74878	-0.341222
Immingham Woodlands Avenue	IMGM	53.619241	-0.213324
London N. Kensington	KC1	51.52105	-0.213492
Leamington Spa	LEAM	52.28881	-1.533119
Leicester University	LECU	52.619823	-1.127311
Leeds Centre	LEED	53.80378	-1.546472
Manchester Piccadilly	MAN3	53.48152	-2.237881
Newcastle Centre	NEWC	54.97825	-1.610528
Norwich Lakenfields	NO12	52.614193	1.301976
Nottingham Centre	NOTT	52.95473	-1.146447
Newport	NPT3	51.601203	-2.977281
Northampton Spring Park	NTN4	52.272257	-0.916605
Oxford St Ebbes	OX8	51.744806	-1.260278
Peebles	PEEB	55.657472	-3.196527
Plymouth Centre	PLYM	50.37167	-4.142361
Preston	PRES	53.76559	-2.680353
Reading	READ	51.45352	-0.95518
Southend-on-Sea	SEND	51.544206	0.678408
Sheffield Devonshire Green	SHDG	53.378622	-1.478096
Sheffield Tinsley	SHE	53.41058	-1.396139
Southampton Centre	SOUT	50.90814	-1.395778
Stoke-on-Trent Centre	STOK	53.02821	-2.175133
Sunderland Silksworth	SUN2	54.88361	-1.406878

Swindon Walcot	SWHO	51.558061	-1.765678
Telford Hollinswood	TDHD	52.673471	-2.436692
Thurrock	THUR	51.47707	0.317969
Wirral Tranmere	TRAN	53.37287	-3.022722
Walsall Woodlands	WAL4	52.605621	-2.030523
West Bromwich Kenrick Park	WBKP	52.508337	-1.986008
Wigan Centre	WIG5	53.54914	-2.638139
York Bootham	YK10	53.967513	-1.086514

Table S3: List of LAQN sites used in analysis:

Site	LAQN code	Latitude	Longitude	Site type
Camden - Bloomsbury	BL0	51.522287	-0.12585	Urban Background
Bexley - Belvedere West	BQ7	51.49464868	0.137279	Urban Background
Bexley - Belvedere West FDMS	BQ8	51.49464868	0.137279	Urban Background
Brent 4 - aethalometer	BT0	51.55244463	-0.25812	Roadside
Brent - Ikea	BT4	51.552476	-0.25809	Roadside
Brent - John Keble Primary School	BT6	51.537799	-0.24779	Roadside
Bromley - Harwood Avenue	BY7	51.405546	0.018882	Roadside
Camden - Swiss Cottage	CD1	51.544219	-0.17528	Kerbside
Camden - Euston Road	CD9	51.527975	-0.12877	Roadside
CO2 network	CO2	51.52250936	-0.15462	Roadside
Croydon - Norbury	CR5	51.411349	-0.12311	Kerbside
Croydon - Purley Way A23	CR7	51.36223057	-0.1176	Roadside
Croydon - Norbury Manor	CR8	51.410039	-0.12752	Urban Background
City of London - Farringdon Street	CT2	51.51452534	-0.10452	Kerbside
City of London - Sir John Cass School	CT3	51.51384718	-0.07777	Urban Background
City of London - Beech Street	CT4	51.52022527	-0.09611	Roadside
City of London Black Smoke (CITY 16)	CT5	51.5159887	-0.09327	Urban Background
City of London - Walbrook Wharf	CT6	51.510499	-0.09163	Roadside
City of London - Upper Thames Street	CT8	51.50954369	-0.08736	Roadside
Ealing - Hanger Lane Gyratory	EA6	51.53085	-0.29249	Roadside
Ealing - Western Avenue	EI1	51.52360782	-0.2655	Roadside
Enfield - Derby Road	EN4	51.61486401	-0.05077	Roadside
Enfield - Bowes Primary School	EN5	51.613865	-0.12534	Roadside
Enfield Black Smoke (ENFIELD 14)	EN6	51.64506051	-0.06762	Urban Background
Enfield - Prince of Wales School	EN7	51.66864335	-0.02201	Urban Background
Greenwich - Falconwood FDMS	GB0	51.4563	0.085606	Roadside
Greenwich - Falconwood	GB6	51.4563	0.085606	Roadside
Greenwich - A206 Burrage Grove	GN0	51.490532	0.074003	Roadside
Greenwich - Plumstead High Street	GN3	51.486957	0.095111	Roadside
Greenwich - Fiveways Sidcup Rd A20	GN4	51.43466271	0.064222	Roadside

Greenwich Black Smoke (GREENWICH 9)	GR2	51.47775825	-0.01134	Urban Background
Greenwich - Blackheath	GR7	51.472504	-0.01238	Roadside
Greenwich - Woolwich Flyover	GR8	51.486884	0.017901	Roadside
Greenwich - Westhorne Avenue	GR9	51.456357	0.040725	Roadside
Haringey - Haringey Town Hall	HG1	51.599302	-0.06822	Roadside
Haringey - Priory Park South	HG4	51.5839769	-0.1254	Urban Background
Hackney - Old Street	HK6	51.526454	-0.08491	Roadside
Honor Oak Park Aethalometer	HP3	51.4496729	-0.03742	Urban Background
Harrow - Stanmore	HR1	51.617327	-0.29878	Urban Background
Harrow - Pinner Road	HR2	51.588417	-0.36299	Roadside
Havering - Rainham	HV1	51.52078746	0.205461	Roadside
Havering - Romford	HV3	51.572976	0.179079	Roadside
Camden - Holborn (Bee Midtown)	IM1	51.51736751	-0.12019	Kerbside
Islington - Holloway Road	IS2	51.555378	-0.11615	Roadside
Islington - Arsenal	IS6	51.557895	-0.10699	Urban Background
Portable Sensor - CanariT 405	JC1	51.52250936	-0.15462	Kerbside
Portable Sensor - CanariT 406	JC2	51.52250936	-0.15462	Kerbside
Kensington and Chelsea - North Ken	KC1	51.52104675	-0.21349	Urban Background
Kens and Chelsea 6 - N Ken Par PM10	KC6	51.52104675	-0.21349	Urban Background
Kings Micromet Kings Bldg Sonic	KSJ	51.51142974	-0.1161	Urban Background
Kings Micromet Kings Building	KSK	51.51142974	-0.1161	Urban Background
Kings Micromet Strand Bldg Sonic	KSR	51.51197332	-0.11635	Urban Background
Kings Micromet Strand Building	KSS	51.51197332	-0.11635	Urban Background
Lambeth - Brixton Road	LB4	51.46411354	-0.11458	Kerbside
Lambeth - Streatham Green	LB6	51.42821314	-0.13187	Urban Background
Hillingdon - Harlington	LH0	51.48878	-0.44163	Urban Background
UKMO Heathrow Airport	LH1	51.47900762	-0.45196	Urban Background
T5 - Main Road	LH4	51.46884028	-0.4929	Urban Background
T5 - Moorbridge	LH5	51.47862817	-0.49815	Urban Background
T5 - Bedfont	LH6	51.47145097	-0.49734	Urban Background
T5 - Green Gates	LH8	51.48145675	-0.48665	Urban Background
Lewisham - Catford	LW1	51.445468	-0.02027	Urban Background
Lewisham - New Cross	LW2	51.474954	-0.03964	Roadside
Lewisham - Loampit Vale	LW4	51.46469106	-0.01607	Roadside
Merton - Merton Road	ME2	51.41613848	-0.19223	Roadside
Marylebone Rd - Traffic	MG1	51.52250936	-0.15462	Kerbside
Marylebone Rd - Traffic	MG2	51.52250936	-0.15462	Kerbside
Marylebone Rd - Traffic	MG3	51.52250936	-0.15462	Kerbside
Marylebone Rd - Traffic	MG4	51.52250936	-0.15462	Kerbside

Marylebone Rd - Traffic	MG5	51.52250936	-0.15462	Kerbside
Marylebone Rd - Traffic	MG6	51.52250936	-0.15462	Kerbside
Marylebone Road - CPC	MR1	51.52236671	-0.1547	Kerbside
Marylebone Road SMPS	MR2	51.52236671	-0.1547	Kerbside
Marylebone Road Aethalometer	MR3	51.52236671	-0.1547	Kerbside
Marylebone Road - URG	MR6	51.52236671	-0.1547	Kerbside
Marylebone Road - WIBS	MR8	51.52250936	-0.15462	Kerbside
Marylebone Road Aethalometer	MS3	51.52250936	-0.15462	Kerbside
Westminster - Marylebone Road	MY1	51.52254	-0.15459	Kerbside
Marylebone Rd - Partisol PM10 and Magee	MY4	51.52236671	-0.1547	Kerbside
Marylebone Rd - KFG and MAAP	MY5	51.52236671	-0.1547	Kerbside
Westminster - Marylebone Road FDMS	MY7	51.52254	-0.15459	Kerbside
Marylebone Road - Partisol SO4	MY9	51.52250936	-0.15462	Kerbside
Marylebone Road Increment	MYI	51.52250936	-0.15462	Kerbside
North Kensington - CO High Sensitivity	NK8	51.52104675	-0.21349	Urban Background
Honor Oak Park Aethalometer	OP3	51.4496729	-0.03742	Urban Background
Redbridge - Gardner Close	RB4	51.57661	0.030858	Roadside
Redbridge - Ley Street	RB7	51.56948433	0.082907	Urban Background
Richmond Upon Thames - Castelnau	RI1	51.480189	-0.23734	Roadside
Southwark - A2 Old Kent Road	SK5	51.48049949	-0.05955	Roadside
Southwark - Elephant and Castle	SK6	51.4931557	-0.10153	Urban Background
Sutton - Wallington	ST4	51.35865961	-0.14972	Kerbside
Sutton - Worcester Park	ST6	51.377923	-0.24041	Kerbside
Tower Hamlets 4 aethalometer	TH0	51.51504617	-0.00842	Roadside
Tower Hamlets - Mile End Road	TH2	51.52252949	-0.04216	Roadside
Tower Hamlets - Blackwall	TH4	51.51504617	-0.00842	Roadside
Vaisala Road Sensor - Gutteridge Wood	VVG	51.548806	-0.42502	Kerbside
Vaisala Road Sensor - Regents Park	VVR	51.52373176	-0.1466	Kerbside
Wandsworth - Wandsworth Town Hall	WA2	51.456962	-0.19107	Urban Background
Wandsworth - Putney High Street	WA7	51.463429	-0.21587	Kerbside
Wandsworth - Putney High Street Facade	WA8	51.4637206	-0.21589	Roadside
Wandsworth - Putney	WA9	51.46503251	-0.21582	Urban Background
Wandsworth - Battersea	WAA	51.47943953	-0.14179	Roadside
Westminster - Horseferry Road	WM0	51.494681	-0.13194	Urban Background
Westminster Black Smoke (WESTMINSTER 17)	WM2	51.49468163	-0.13159	Urban Background
Westminster - Covent Garden	WM5	51.51197698	-0.12163	Urban Background
Westminster - Oxford Street	WM6	51.51392874	-0.15279	Kerbside
North Kensington Composite site	XK1	51.52104675	-0.21349	Urban Background
North Kensington PIXE	XK2	51.52104675	-0.21349	Urban Background
North Kensington Aethalometer 7WL	XK3	51.52104675	-0.21349	Urban Background
North Kensington APS	XK5	51.52104675	-0.21349	Urban Background
Canterbury Roadside - St Dunstans	ZY2	51.37356776	-0.29173	Roadside

Table S4: List of Urban Background sites used for individual city analysis.

Site	AURN Code	Latitutde	Longitude
Belfast Centre	BEL2	54.59965	-5.928833
Belfast East	BEL	54.59653	-5.901667
Belfast South	BEL3	54.59918	-5.912416
Bristol Centre	BRIS	51.45718	-2.585622
Bristol East	BRS	51.45365	-2.578496
Bristol St Paul's	BRS8	51.462839	-2.584482
Cardiff Centre	CARD	51.48178	-3.17625
Cardiff East	CAR2	51.48887	-3.163711
Glasgow Centre	GLA3	55.85773	-4.255161
Glasgow City Chambers	GLA	55.860414	-4.245959
Glasgow Townhead	GLKP	55.865782	-4.243631
London Bloomsbury	CLL2	51.52229	-0.125889
London Brent	BREN	51.589769	-0.276223
London Bridge Place	BRI	51.49521	-0.141655
London Hackney	HK4	51.55877	-0.056592
London Haringey	HG2	51.58603	-0.126486
London Haringey Priory Park South	HG4	51.584128	-0.125254
London Harrow Stanmore	HR3	51.617333	-0.298777
London Hillingdon	HIL	51.49633	-0.460861
London Honor Oak Park	HP1	51.449674	-0.037418
London Islington	ISL	51.531362	-0.096954
London Lewisham	LW1	51.44541	-0.020139
London N. Kensington	KC1	51.52105	-0.213492
London Southwark	SK1	51.49055	-0.096667
London Teddington	TED	51.42099	-0.339647
London Teddington Bushy Park	TED2	51.425286	-0.345606
London UCL	LON5	51.52378	-0.128958
London Wandsworth	WA2	51.45696	-0.191164
London Westminster	HORS	51.49467	-0.131931
Newcastle Centre	NEWC	54.97825	-1.610528

Table S5: List of Urban Traffic sites used for individual city analysis.

Site	AURN Code	Latitutde	Longitude
Belfast Stockman's Lane	BEL1	54.572586	-5.974944
Bristol Old Market	BRS2	51.45603	-2.583519
Bristol Temple Way	BR11	51.457968	-2.583975
Cardiff Kerbside	CAR	51.482431	-3.17794
Cardiff Newport Road	CNPR	51.49096	-3.152305
Glasgow High Street	GHSR	55.860936	-4.238214
Glasgow Hope St	GLAS	55.858317	-4.259062
Glasgow Kerbside	GLA4	55.85917	-4.258889
London A3 Roadside	A3	51.37348	-0.291853
London Bromley	BY2	51.40555	0.018869

London Cromwell Road	CRD	51.49492	-0.180564
London Cromwell Road 2	CRD2	51.495483	-0.178709
London Marylebone Road	MY1	51.52253	-0.154611
Newcastle Cradlewell Roadside	NCA3	54.986405	-1.595362