Supplement of Atmos. Chem. Phys. Discuss., 15, 14843–14887, 2015
http://www.atmos-chem-phys-discuss.net/15/14843/2015/
doi:10.5194/acpd-15-14843-2015-supplement

Atmospheric Chemistry and Physics Discussions

Supplement of

The importance of Asia as a source of black carbon to the European Arctic during springtime 2013

D. Liu et al.

Correspondence to: D. Liu (dantong.liu@manchester.ac.uk)

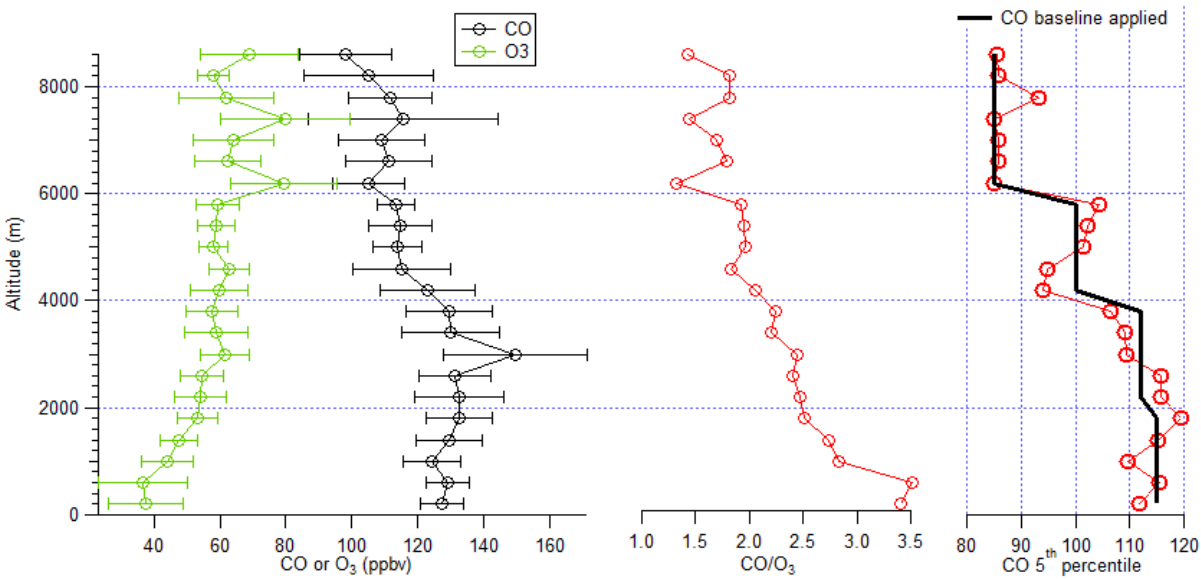
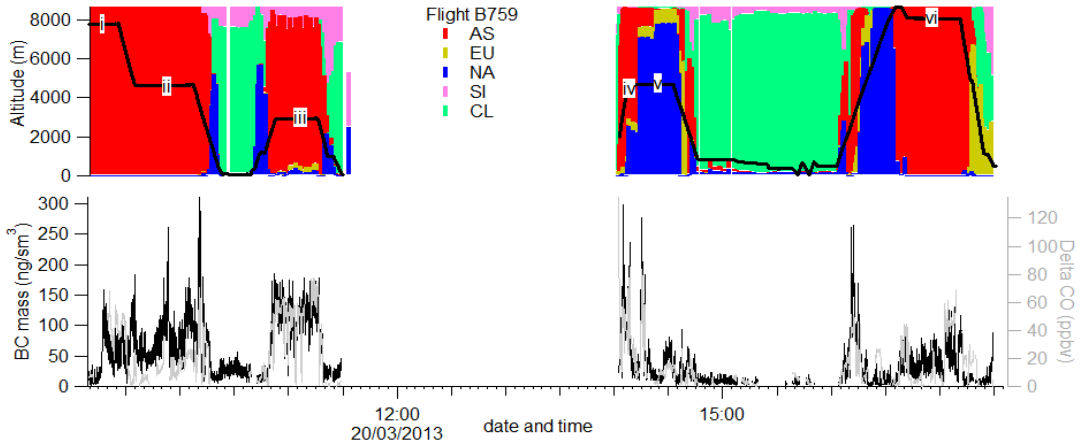
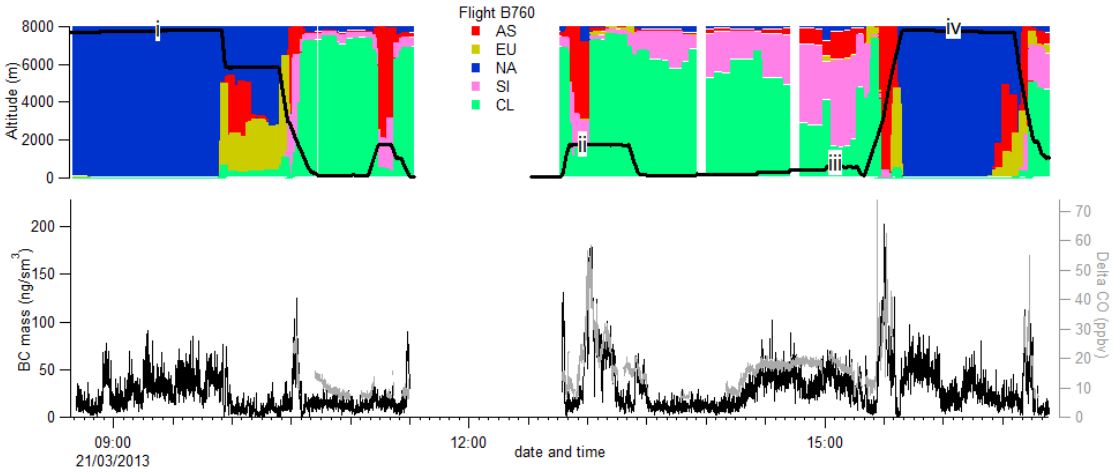


Fig. S1. (a) The vertical profiles of CO and O_3 (mean±σ) in 400m altitude bins; (b) the CO/O_3 ratio as a function of height; (c) the lowest 5^{th} percentile of CO in each altitude bin, with the black line showing the CO background values as used to calculate ΔCO in this study.

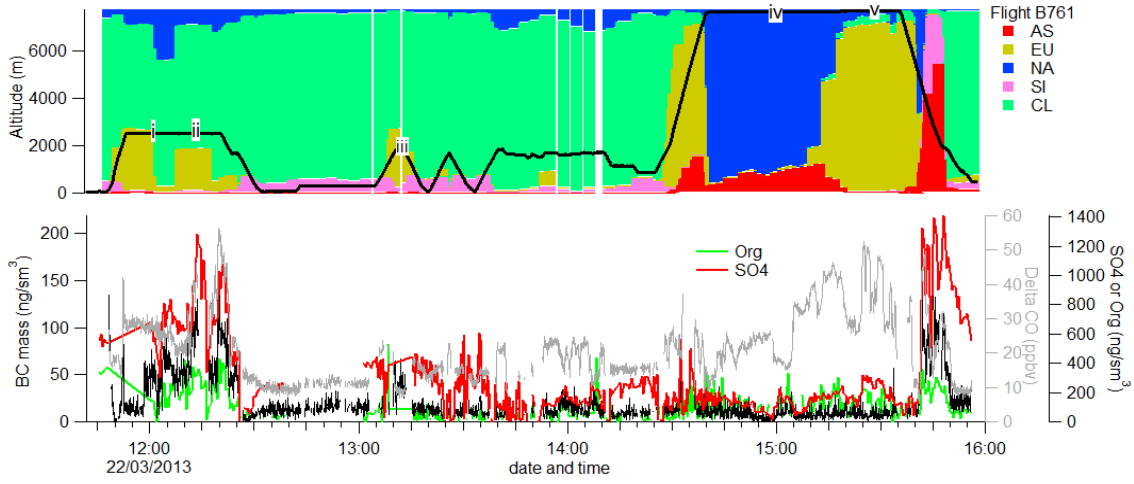
A


Flight B759
AS
EU
NA
SI
CL
Altitude (m)
BC mass (ng/sm3)
Delta CO (ppbv)
i
ii
iii
iv
v
vi
12:00
20/03/2013
date and time
15:00

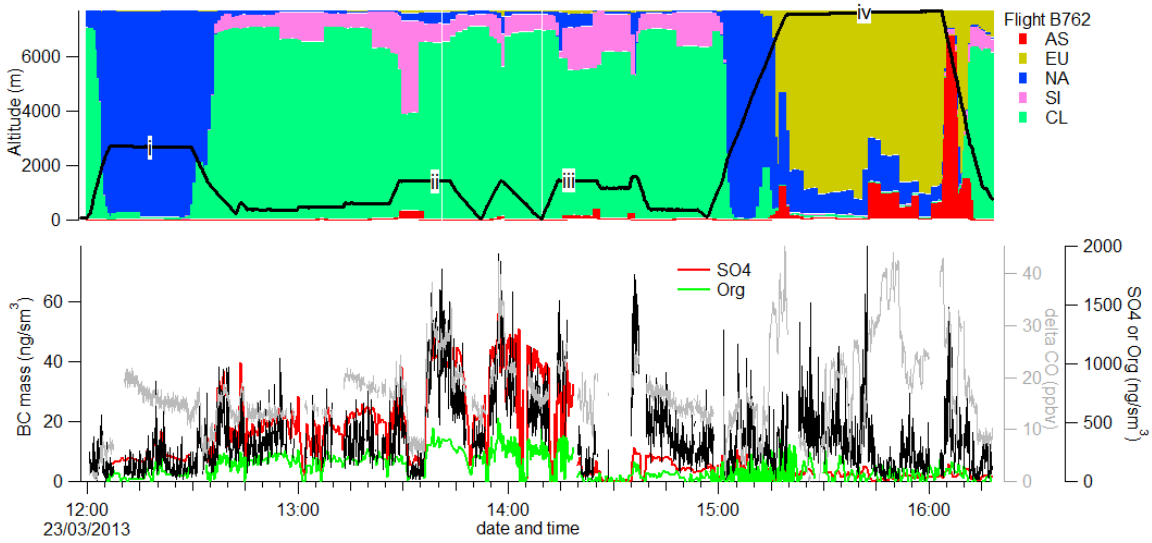
B


Flight B760
AS
EU
NA
SI
CL
Altitude (m)
BC mass (ng/sm3)
Delta CO (ppbv)
i
ii
iii
iv
09:00
21/03/2013
12:00
date and time
15:00

C


Flight B761
AS
EU
NA
SI
CL
Altitude (m)
BC mass (ng/sm3)
Org
SO4
Delta CO (ppbv)
SO4 or Org (ng/sm3)
i
ii
iii
iv
v
12:00
22/03/2013
13:00
14:00
date and time
15:00
16:00

D



E

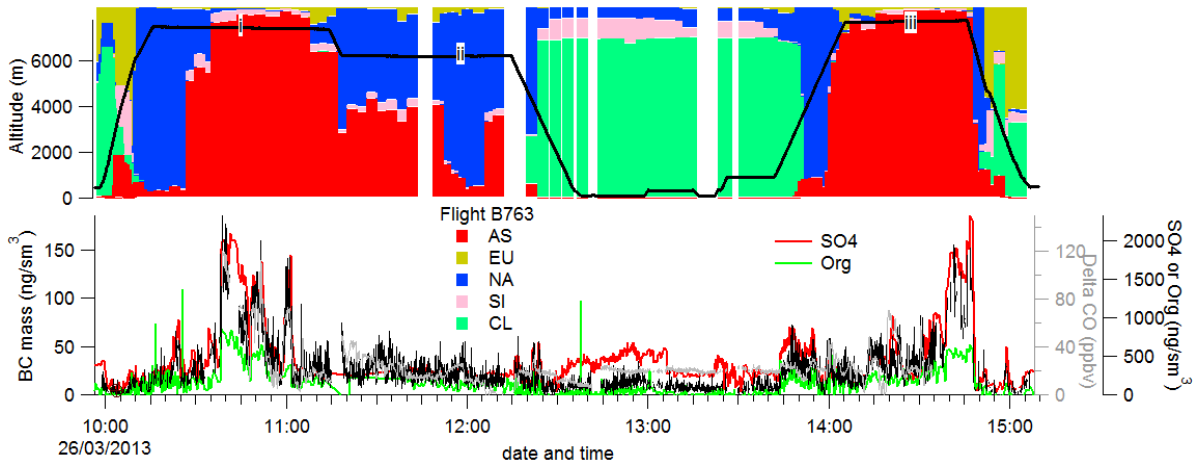


Fig. S2. In each graph, top panel shows the altitude and FLEXPART FPES fractions for each source region, the plume locations during SLR are marked as Roman numerals along the flight altitude track; the bottom panel shows the time series of BC mass, CO concentration, mass of organic matter and sulphate. (a) to (e) represents the data for different flights. Note that the AMS data was not available for the flight B759 and B760.

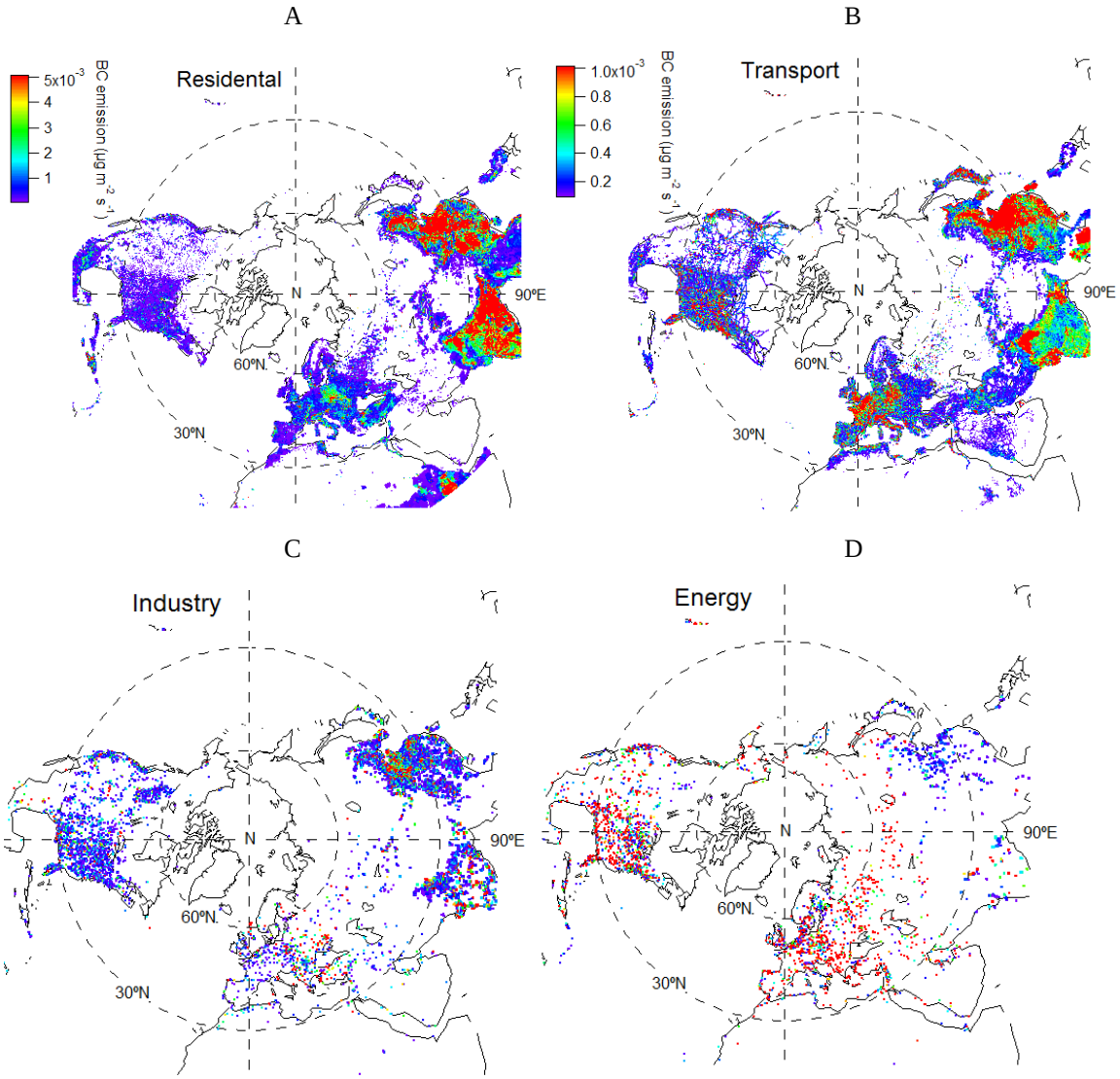


Fig. S3. The BC anthropogenic emission inventories in Mar. 2010 from HTAPv2 for the following sectors (a) residential activity, (b) transport, (c) industry and (d) energy.

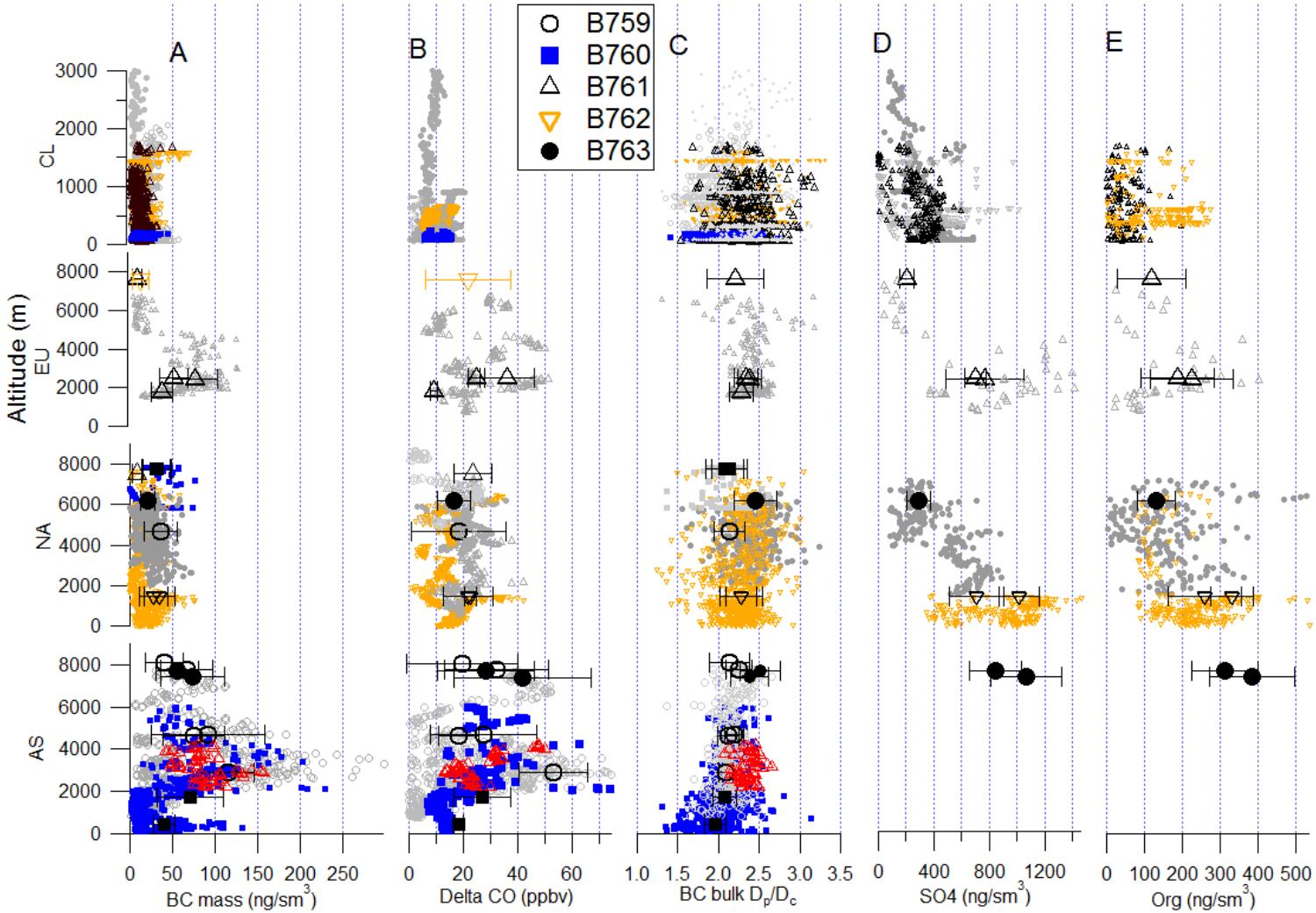


Fig. S4. A summary of all plumes and profiles. Columns (a) to (e) show the BC mass, ΔCO, BC D_p/D_c, the mass of sulphate and organic matter respectively. The larger markers with error bar show data collected in plumes during straight and level runs and the small markers show data collected during profiles. Each marker shape denotes the flight index and these shapes are applied to all of the plumes and profiles. Note for Clean Air periods, the altitude scale extends to only 3km.

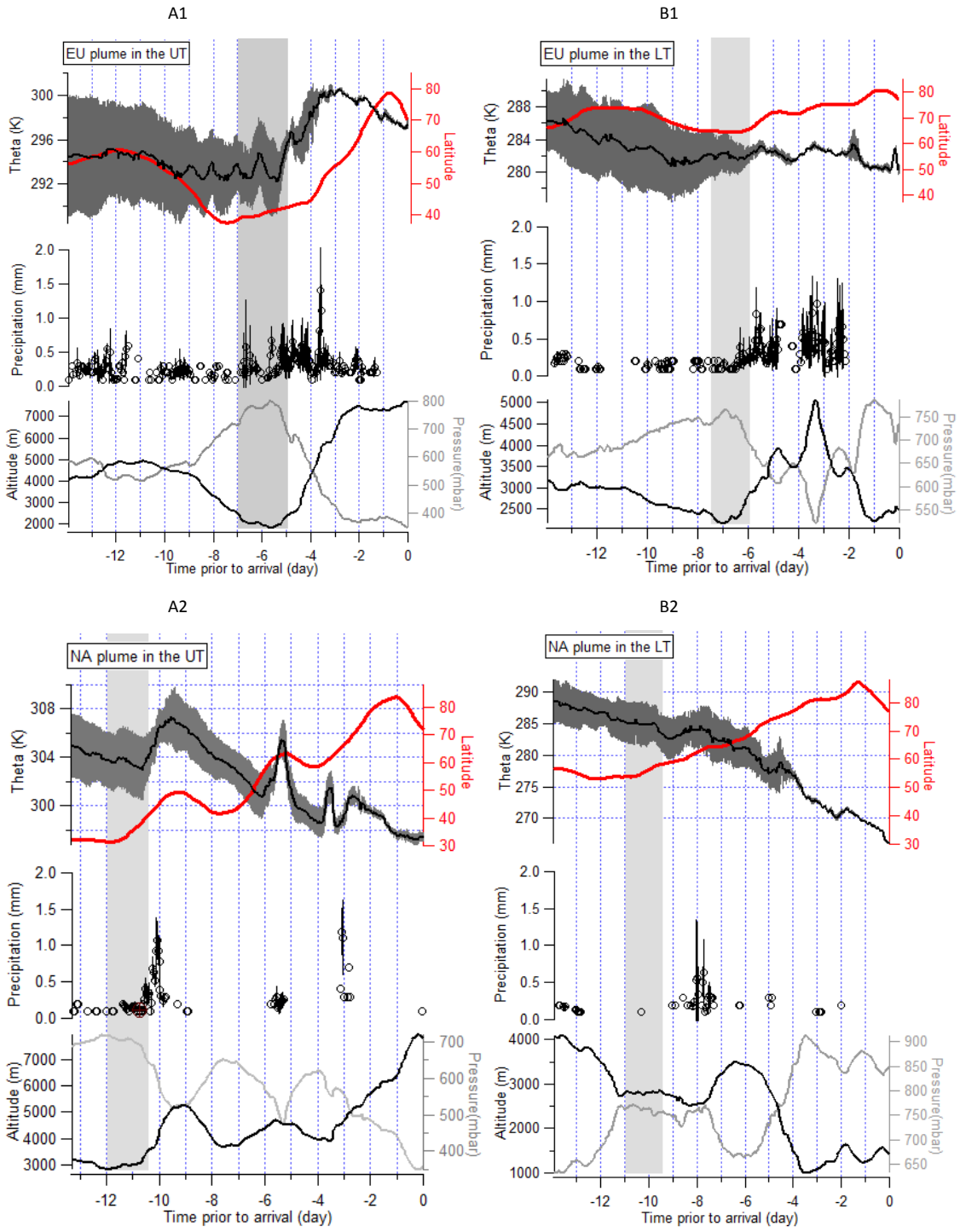


Fig. S5. Average characteristics of sampled air parcel plumes arriving at receptor locations along 12 day backward trajectory pathways, using the identical legends of Fig. 9. A1 is EU plume in the UT (corresponding to plume B761 iv in Table 2); A2 is EU plume in the LT (B761 ii); B1 is NA plume in the UT (B760 i) and B2 is NA plume in the LT (B762 i).

Plume index	Source region	Latitude/Region	BC (ng sm^{-3})					ΔCO (ppbv)				
B759 plumes			RE	TR	IN	EN	OBB	RE	TR	IN	EN	OBB
i	AS	30-40°N; Japan, E China	1.70	0.53	1.04	0.01	0.15	0.11	0.04	0.09	0.00	0.02
ii	AS	30-40°N; Japan, E China	26.58	13.96	18.44	0.09	2.57	1.89	1.07	2.22	0.06	0.41
iii	AS	40-60°N; N China	24.68	8.61	13.35	0.09	0.39	1.87	0.73	1.56	0.05	0.06
iv	AS	30-50°N; N and E China, Japan	8.08	5.43	5.52	0.12	0.51	0.63	0.65	0.63	0.03	0.07
v	NA	30-50°N; N US	16.86	37.30	19.96	1.56	3.95	2.89	6.30	1.51	0.15	0.63
vi	AS	20-40°N;S and E China, Japan	60.46	28.20	40.36	0.17	13.03	4.15	2.19	4.40	0.12	2.11
B760 plumes												
i	NA	20-40°N; S US, Mexico	3.17	11.21	6.54	1.27	2.19	0.55	1.58	0.22	0.41	0.32
ii	AS	40-60°N; E and N China, Japan	17.06	6.25	8.46	0.08	0.28	1.34	0.56	1.03	0.03	0.04
iii	AS	40-75°N; N China, E Russia	10.36	3.27	3.78	0.10	0.20	0.80	0.29	0.47	0.02	0.03
iv	NA	20-40°N; S US, Mexico	0.92	2.17	1.03	0.15	0.20	0.13	0.31	0.05	0.02	0.03
B761 plumes												
i	EU+NA	30-60°N;E US, N Europe	5.45	11.03	5.28	0.58	2.19	0.84	1.77	0.32	0.03	0.34
ii	EU	50-80°N; W and N Europe	15.80	14.89	3.56	0.55	2.11	1.11	1.38	0.33	0.05	0.32
iii	EU	50-80°N; N Europe	5.55	3.36	0.28	0.06	0.03	0.25	0.23	0.07	0.02	0.00
iv	NA	35-60°N; E and S US	6.40	9.7	7.432	0.64	0.18	0.72	1.3	0.53	0.14	0.03
v	EU	50-80°N; N Europe	51.23	43.29	6.375	2.357	1.11	3.2	2.2	0.75	0.19	0.12
B762 plumes												
i	NA	40-60°N; E and N US	20.38	34.61	20.18	1.82	0.28	3.4	6.62	1.68	0.07	0.04
ii	NA	40-60°N; E and N US	3.86	2.90	1.71	0.11	0.11	0.34	0.35	0.17	0.02	0.02
iii	NA	40-60°N; E and N US	19.88	18.85	7.08	1.57	0.30	1.44	1.57	0.57	0.09	0.05
iv	EU	45-75°N; N and S Europe	54.33	36.42	4.183	10.86	0.41	3.38	1.98	0.46	0.18	0.03
B763 plumes												
i	AS	30-60°N; N and E China, Japan	72.85	33.94	53.79	0.25	1.07	5.30	2.53	5.72	0.18	0.16
ii	NA	35-50°N; E US	0.75	1.43	0.84	0.05	0.01	0.11	0.23	0.05	0.00	0.00
iii	AS	30-55°N; E and N China, Japan	169.84	66.00	106.33	0.48	1.40	11.95	4.45	10.11	0.33	0.20

Table S1. BC and CO source attributions for all of the encountered plumes by FLEXPART FPES, in source sectors: residential (RE), transport (TR), industry (IN), energy (EN) and open biomass burning (OBB).

Source origin	$BC/\Delta CO_{measured}$	$BC/\Delta CO_{source}$	SF_{BC}
B759 plumes			
AS	2.06±1.55	13.14	0.84±0.12
AS	5.66±3.68	10.94	0.62±0.34
AS	2.17±0.78	11.05	0.80±0.07
AS	3.33±2.09	9.76	0.66±0.21
NA	1.95±1.58	6.93	0.72±0.23
AS	2.05±1.66	10.97	0.81±0.15
B760 plumes			
NA		7.92	
AS	2.61±1.76	10.73	0.76±0.16
AS	2.23±0.72	11.00	0.80±0.07
NA		8.20	
B761 plumes			
EU+NA	2.05±0.69	7.44	0.72±0.09
EU	2.12±0.93	11.55	0.82±0.08
EU	4.15±1.78	16.04	0.74±0.11
NA	0.37±0.28	8.95	0.96±0.03
EU	0.26±0.18	16.16	0.97±0.01
B762 plumes			
NA	0.36±0.27	6.54	0.94±0.04
NA	1.60±1.06	9.64	0.83±0.11
NA	1.21±0.73	12.81	0.91±0.06
EU	0.59±0.63	17.61	0.96±0.03
B763 plumes			
AS	1.75±1.39	11.67	0.85±0.12
NA	1.25±0.70	7.90	0.84±0.09
AS	1.94±1.39	12.73	0.85±0.11

Table S2. Measured and modelled $BC/\Delta CO$, and derived SF_{BC} for each of the plumes.