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Composition and sources of carbonaceous aerosol in the European Arctic at Zeppelin Observatory, Svalbard (2017 to 2020)

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Table S1: Equations used for source apportionment of carbonaceous aerosol, following the Latin Hypercube Sampling (LHS) approach. See sect. 2.8 and Yttri et al. (2011a) for more details.

$EC = [EC] \times \Phi_{EC}$	(eq.1)
$OC = [OC_p] + \Phi_{NA} \times ([OC_F] - [OC_B])$	(eq.2)
$TC = OC + EC$	(eq.3)
$F_{14C\text{-}TC} = [F_{14C\text{-}TC}] \times \Phi^{14}C\text{-}TC$	(eq.4)
$F_{14C\text{-}EC} = [F_{14C\text{-}EC}] \times \Phi^{14}C\text{-}EC$	(eq.5)
$F_{14C\text{-}OC} = (F_{14C\text{-}TC} - F_{14C\text{-}EC} \times EC/TC) / (1 - EC/TC)$	(eq.6)
$F_{EC\text{-}NF} = F_{14C\text{-}EC} / F_{14C\text{-}BB}$	(eq.7)
$EC_{BB} = F_{EC\text{-}NF} \times EC$	(eq.8)
$OC_{BB} = EC_{BB} \times (OC/EC)_{BB}$	(eq.9)
$EC_{FF} = [EC] - [EC_{BB}]$	(eq.10)
$OC_{PBC} = [Cellulose] \times (OC / Cellulose)_{PBC}$	(eq.11)
$OC_{PBS} = [Mannitol] \times (OC / Mannitol)_{PBS}$	(eq.12)
$OC_{BSOA} = \frac{F_{14C\text{-}OC} \times OC - (F_{14C\text{-}BB} \times OC_{BB} + F_{14C\text{-}PBC} \times OC_{PBC} \times OC_{PBS})}{F^{14}C\text{-}BSOA}$	(eq.13)

Notes:
Square brackets denote measured quantities.
Equation (6) is derived from:

$TC \times F_{14C\text{-}TC} = OC \times F_{14C\text{-}OC} + EC \times F_{14C\text{-}EC}$

$F_{14C\text{-}OC} = (TC \times F_{14C\text{-}TC}\ 1 - EC \times F_{14C\text{-}EC})/OC = (TC \times F_{14C\text{-}TC} - EC \times F_{14C\text{-}EC})/(TC\text{-}EC) = F_{14C\text{-}TC} - EC/TC \times F_{14C\text{-}EC})/(1 - EC/TC)$

Table S2. Emission ratios used for the LHS source apportionment approach of carbonaceous aerosol. Low, central, and high values are listed. See sect. 2.8, Yttri et al. (2011a) for more details.

Parameter	Low	Central	High	Eqn.	Accounts for
Φ_{EC}	0.75	1.0	1.25	1	Uncertainty in EC measurement
Φ_{NA}	0.0	0.2	1.0	2	Negative sampling artefact of OC
$\Phi^{14}C\text{-}TC$	0.95	1.0	1.05	4	Uncertainty in $^{14}C\text{-}TC_{Measurement}$
$\Phi^{14}C\text{-}EC$	0.85	1.0	1.15	5	in $\Phi 14C - EC_{Measurement}$
$\Phi F^{14}C$	1.055	-	1.25	7	Variability in modern carbon age of BB; Notation includes RWC, WF and AWB
$(OC/EC)_{BB}$	3.3	6.2	9.1	9	Wildfires. Derived from Saarikoski et al., (2007); Yttri et al. (2014).
$(OC/Cellulose)_{PBC}$	0.8	1.6	3.2	11	OC_{PBC} calculation
$(OC/Mannitol)_{PBS}$	5.2	-	10.8	12	OC_{PBS} calculation
$F_{14CBSOA}$		1.055		13	Modern carbon
F_{14CPBS}	1.055	-	1.25	13	Fungal Spores
F_{14CPBC}	1.055	-	1.25	13	Plant debris

Table S3: Source apportionment of CA by LHS for samples collected at the Zeppelin Observatory (2017 to 2018). Mean (10th, 50th, 90th percentiles) are provided. Unit: ng C m^{-3}. N/A = Not Available

Start date	End date	OC_{BSOA}	OC_{FF}	OC_{BB}	OC_{PBC}	OC_{PBS}	EC_{FF}	EC_{BB}
23.02.2017	02.03.2017	33 (4.4-27-70)	92 (67-93-115)	137 (107-132-175)	5.7 (3.0-5.1-9.0)	0.1 (0.1-0.1-0.1)	7.7 (3.3-8.0-12)	32 (28-32-37)
05.05.2017	15.05.2017	55 (9.3–49-113)	5.7 (0.8-4.9-12)	97 (63-98-128)	0.7 (0.4-0.6-1.1)	0.0 (0.0-0.0-0.0)	9.0 (6.7-9.0-11)	15 (13-15-17)
31.05.2017	09.06.2017[1)]	64 (37–58-98)	25 (18-24-34)	24 (15-24-34)	3.4 (1.8-3-5.4)	0.41 (0.29-0.41-0.52)	2.1 (1.4-2.1-2.7)	3.9 (3.3-3.9-4.6)
16.06.2017	26.06.2017							
08.09.2017	28.09.2017	52 (27-47-83)	10 (5.7-10-16)	26 (16-25-36)	2.9 (1.6-2.6-4.7)	1.2 (0.84-1.2-1.5)	1.9 (1.2-1.9-2.5)	4.1 (3.5-4.1-4.8)
28.09.2017	06.10.2017	422 (241-384-657)	27 (4.9-24-51)	194 (119-195-266)	13 (7-12-21)	8.9 (6.4-8.9-11)	22 (17-22-26)	30 (26-30-35)
06.10.2017	24.10.2017	18 (3.6-16-37)	20 (13-19-27)	33 (22-31-46)	1.4 (0.7-1.3-2.3)	0.9 (0.6-0.9-1.1)	2.0 (1.1-2.1-2.9)	6 (5.1-5.9-6.9)
05.12.2017	21.12.2017	N/A	N/A	N/A	N/A	N/A	N/A	N/A
23.01.2018	31.01.2018	73 (48-67-106)	74 (56-67-102)	21 (13-21-29)	1.3 (0.7-1.2-2.1)	0.1 (0.1-0.1-0.1)	13 (12-13-13)	3.4 (2.9-3.4-3.9)
21.03.2018	29.03.2018	50 (12-46-94)	14 (5.5-13-23)	62 (39-62-87)	0.7 (0.4-0.6-1.1)	0.1 (0.1-0.1-0.1)	7.6 (5.9-7.6-9.1)	10 (8.9-10-12)
06.04.2018	16.04.2018	66 (24-62-114)	13- (5.1-13-22)	58 (36-57-81)	0.4 (0.2-0.3-0.6)	0.1 (0.0-0.1-0.1)	7.6 (6.1-7.6-9)	9.4 (8-9.4-11)
12.07.2018	30.07.2018	30 (17-27-47)	18 (13-17-24)	13 (7.7-12-18)	1.4 (0.7-1.2-2.2)	1.4 (1.0-1.4-1.7)	1.0 (0.6-1.0-1.3)	2 (1.7-2-2.4)
30.07.2018	15.08.2018	192 (130-174-280)	18 (6.8-17-30)	42 (25-41-59)	4.8 (2.5-4.3-7.7)	2.1 (1.5-2.2-2.7)	2.3 (1.2-2.2-3.3)	6.7 (5.7-6.7-7.8)
23.11.2018	03.12.2018	10 (1.5-7.9-21)	23 (15-24-30)	33 (25-31-42)	1.9 (1-1.7-3.1)	0.2 (0.2-0.2-0.3)	5.6 (4.4-5.7-6.6)	7.4 (6.4-7.3-8.6)

1. Two non-consecutive samples are merged, i.e., 31.05.2023 – 09.06.2023 and 16.06.2023 – 26.06.2023.

Table S4: Source apportionment of CA by LHS for samples collected at the Zeppelin Observatory (2017 to 2018). Mean (10th, 50th, 90th percentiles) percentiles are provided. Unit: %. N/A = Not Available.

Start date	End date	OC_{BSOA}/TC	OC_{FF}/TC	OC_{BB}/TC	OC_{PBC}/TC	OC_{PBS}/TC	EC_{FF}/TC	EC_{BB}/TC	EC_{FF}/EC	EC_{BB}/EC
23.02.2017	02.03.2017	11 (1.7-9.1-21)	30 (25-30-34)	45 (36-45-53)	1.9 (1.0-1.8-2.9)	0.0 (0.0-0.0-0.0)	2.6 (1.0-2.6-4.2)	11 (8.7-10-13)	19 (8.3-20-29)	81 (71-80-92)
05.05.2017	15.05.2017	28 (6-28-52)	3.1 (0.4-2.7-6.6)	54 (34-55-73)	0.4 (0.2-0.3-0.6)	0.0 (0.0-0.0-0.0)	5.1 (3.3-5.1-7.1)	8.5 (6.2-8.5-11)	38 (53-38-72)	62 (28-62-47)
31.05.2017	09.06.2017	51 (37-52-63)	20 (16-20-24)	21 (12-20-31)	2.9 (1.4-2.6-4.8)	0.3 (0.2-0.3-0.5)	1.8 (1.1-1.7-2.5)	3.3 (2.3-3.4-4.3)	34 (24-35-44)	66 (56-65-76)
16.06.2017	26.06.2017									
08.09.2017	28.09.2017	51 (34-53-67)	11 (6.2-11-15)	27 (15-26-41)	3.1 (1.6-2.8-5.2)	1.2 (0.8-1.2-1.7)	2.0 (1.1-1.9-2.9)	4.4 (3.1-4.4-5.7)	31 (20-31-42)	69 (58-69-80)
28.09.2017	06.10.2017	57 (41-58-72)	3.7 (0.7-3.5-7.0)	28 (16-28-42)	1.9 (1.0-1.7-3.7)	1.3 (0.8-1.2-1.8)	3.2 (2.1-3.1-4.3)	4.4 (3.1-4.4-5.6)	42 (33-42-51)	58 (49-58-67)
06.10.2017	24.10.2017	22 (5-21-39)	24 (19-24-29)	41 (27-41-55)	1.8 (0.9-1.7-3.0)	1.1 (0.71-1.1-1.6)	2.6 (1.3-2.6-4.1)	1.9 (1.0-1.7-3.7)	25 (14-26-36)	75 (64-74-86)
05.12.2017	21.12.2017	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
23.01.2018	31.01.2018	38 (32-39-45)	40 (37-40-43)	12 (7-11-18)	0.7 (0.4-0.7-1.2)	0.0 (0.0-0.0-0.1)	7.1 (5.1-7.4-8.7)	7.6 (5.6-7.5-10)	79 (75-79-82)	21 (18-21-25)
21.03.2018	29.03.2018	33 (9-34-55)	9.3 (4.1-9.3-14)	44 (26-43-64)	0.5 (0.2-0.4-0.8)	0.1 (0.1-0.1-0.1)	5.4 (3.7-5.4-7.3)	7.4 (5.4-7.5-9.5)	42 (33-42-51)	58 (49-58-67)
06.04.2018	16.04.2018	41 (18-43-61)	8.5 (3.5-8.5-13)	39 (22-38-58)	0.2 (0.1-0.2-0.4)	0.0 (0.0-0.0-0.1)	5.1 (3.5-5.1-6.7)	6.3 (4.5-6.38.1)	45 (36-45-53)	55 (47-55-64)
12.07.2018	30.07.2018	44 (31-45-56)	27 (23-27-30)	20 (11-19-30)	2.2 (1.1-1.9-3.6)	2.1 (1.4-2.1-3.0)	1.5 (0.9-1.5-2.2)	3.2 (2.2-3.2-4.1)	32 (21-3.2-42)	68 (58-68-79)
30.07.2018	15.08.2018	71 (60-72-81)	6.8 (2.7-6.7-11)	16 (9-15-24)	1.9 (0.9-1.7-3.2)	0.8 (0.5-0.8-1.2)	0.9 (0.9-1.4-2.0)	2.6 (1.8-2.6-3.4)	25 (13-26-37)	75 (63-74-87)
23.11.2018	03.12.2018	11 (2.1-10-23)	28 (23-28-33)	41 (31-41-49)	2.5 (1.3-2.3-3.8)	0.3 (0.2-0.3-0.4)	7.2 (5.0-7.0-9.9)	9.4 (7.4-9.2-12)	43 (34-44-51)	57 (59-56-66)

Table S5: Annual and seasonal mean concentrations of OC, EC, and organic tracers at Birkenes Observatory (Norway) and at Ispra (Italy), 2017 to 2020.

	OC (μg C m^{-3})	**EC** (μg C m^{-3})	**Levoglucosan** (ng m^{-3})	**Mannosan** (ng m^{-3})	**Galactosan** (ng m^{-3})	**Arabitol** (ng m^{-3})	**Mannitol** (ng m^{-3})	**Glucose** (ng m^{-3})	**Trehalose** (ng m^{-3})	**2-methylerythritol** (ng m^{-3})	**2-methylerythritol** (ng m^{-3})
Birkenes											
2017	**0.72**	**0.05**	**8.24**	**1.35**	**0.32**	**5.52**	**5.70**	**5.17**	**3.37**	**0.37**	**0.10**
DJF	0.57	0.07	15.77	2.49	0.65	1.16	1.40	2.03	1.03	0.01	0.01
MAM	0.65	0.05	7.62	0.98	0.23	3.90	3.65	4.11	1.58	0.05	0.02
JJA	0.92	0.03	2.37	0.48	0.06	9.15	8.45	7.09	4.21	1.32	0.35
SON	0.77	0.06	7.92	1.31	0.29	8.18	9.49	7.58	6.61	0.17	0.06
2018	**0.96**	**0.08**	**9.77**	**1.62**	**0.39**	**5.76**	**5.65**	**4.16**	**2.83**	**0.45**	**0.16**
DJF	0.49	0.07	13.50	2.21	0.60	0.72	0.94	2.74	0.60	0.01	0.01
MAM	1.32	0.11	13.64	2.04	0.54	4.18	4.21	3.59	1.91	0.24	0.08
JJA	1.20	0.05	1.38	0.25	0.04	8.66	7.94	4.52	2.90	1.24	0.42
SON	0.81	0.08	10.64	2.01	0.41	9.38	9.47	5.79	5.91	0.25	0.12
2019	**0.93**	**0.08**	**8.30**	**1.37**	**0.29**						
DJF	0.55	0.09	16.8	2.73	0.61						
MAM	1.44	0.12	8.36	1.20	0.26						
JJA	1.13	0.05	1.32	0.27	0.04						
SON	0.57	0.05	6.91	1.29	0.23						
2020	**0.82**	**0.08**	**7.73**	**1.31**	**0.33**						
DJF	0.31	0.06	7.73	1.29	0.33						
MAM	0.96	0.10	10.7	1.69	0.42						
JJA	1.34	0.06	1.62	0.32	0.04						
SON	0.70	0.09	10.61	1.88	0.50						
Mean ±SD											
Annual	**0.86±0.11**	**0.07±0.01**	**8.51±0.88**	**1.41±0.14**	**0.33±0.04**	**5.64±0.17**	**5.68±0.04**	**4.67±0.71**	**3.10±0.38**	**0.41±0.06**	**0.13±0.04**
DJF	0.48±0.12	0.07±0.01	13.45±4.05	2.18±0.63	0.55±0.15	0.94±0.31	1.17±0.33	2.39±0.50	0.82±0.30	0.01±0.00	0.01±0.00
MAM	1.09±0.36	0.10±0.03	10.08±2.71	1.48±0.48	0.36±0.14	4.04±0.20	3.93±0.40	3.85±0.37	1.75±023	0.15±0.13	0.05±0.04
JJA	1.15±0.18	0.05±0.01	1.67±0.48	0.33±0.10	0.05±0.01	8.91±0.35	8.20±0.36	5.81±1.82	3.56±0.93	1.28±0.06	0.39±0.05
SON	0.71±0.11	0.07±0.02	9.02±1.90	1.62±0.38	0.36±0.12	8.78±0.85	9.48±0.01	6.69±1.27	6.26±0.49	0.21±0.06	0.09±0.04
H-S	0.75±0.18	0.08±0.02	11.90±1.79	1.91±0.30	0.48±0.08	2.50±0.11	2.55±0.14	3.94±0.75	1.39±0.10	0.09±0.04	0.03±0.02
NH-S	1.02±0.09	0.06±0.01	3.70±0.52	0.70±0.09	0.12±0.02	10.11±0.12	10.14±0.46	6.81±1.55	5.56±1.17	0.86±0.04	0.28±0.06
Ispra											
2017	**5.53**	**1.11**									
DJF	10.5	2.19									
MAM	3.37	0.66									

	OC (µg C m^{-3})	**EC** (µg C m^{-3})	**Levoglucosan** (ng m^{-3})	**Mannosan** (ng m^{-3})	**Galactosan** (ng m^{-3})	**Arabitol** (ng m^{-3})	**Mannitol** (ng m^{-3})	**Glucose** (ng m^{-3})	**Trehalose** (ng m^{-3})	**2-methylerythritol** (ng m^{-3})	**2-methylerythritol** (ng m^{-3})
JJA	2.67	0.37									
SON	5.62	1.23									
2018	**3.75**	**0.77**									
DJF	8.30	1.59									
MAM	2.50	0.52									
JJA	1.65	0.31									
SON	2.86	0.73									
2019	**3.82**	**0.80**									
DJF	7.74	1.68									
MAM	2.58	0.57									
JJA	2.46	0.28									
SON	2.40	0.63									
2020	**4.33**	**0.85**									
DJF	7.93	1.74									
MAM	3.06	0.47									
JJA	1.96	0.25									
SON	4.48	0.97									
Mean ±SD											
Annual	4.36±0.82	0.88±0.16									
DJF	8.62±1.28	1.80±0.27									
MAM	2.88±0.41	0.56±0.08									
JJA	2.19±0.46	0.30±0.05									
SON	3.84±1.48	0.89±0.27									
H-S	5.69±0.97	1.19±0.20									
NH-S	2.51±0.64	0.45±0.09									

1. OC, EC, and organic tracers for Birkenes 2017 and 2018 is taken from Yttri et al., (2021), whereas for data for 2019 and 2020 is extracted from ebas.nilu.
2. OC and EC for Ispra is extracted from ebas.nilu

Table S6: Monthly mean ratios of levoglucosan/mannosan, mannitol/arabitol and 2-methylthreitol/2-methylerythritol at Zeppelin Observatory (2017 to 2020) and Birkenes Observatory (2017 to 2018).

	Levoglucosan/ Mannosan		**Mannitol/ Arabitol**		**2-methylthreitol/ 2-methylerythritol**	
Mean (±SD)	Zeppelin Obs.	Birkenes Obs.	Zeppelin Obs.	Birkenes Obs.	Zeppelin Obs.	Birkenes Obs.
January	7.9 ± 1.4	6.5 ± 0.1	0.7 ± 0.2	1.4 ± 0.8	0.72 ± 0.28	0.69 ± 0.00
February	9.0 ± 2.7	6.8 ± 0.6	1.0 ± 0.5	2.3 ± 1.0	0.51 ± 0.06	0.76 ± 0.10
March	7.9 ± 1.2	6.2 ± 0.3	1.2 ± 0.2	1.2 ± 0.2	0.59 ± 0.13	0.76 ± 0.07
April	7.4 ± 3.0	6.6 ± 0.0	1.9 ± 1.2	1.0 ± 0.1	0.61 ± 0.10	0.60 ± 0.00
May	7.2 ± 1.6	7.5 ± 1.0	1.6 ± 0.7	0.9 ± 0.1	0.65 ± 0.09	0.29 ± 0.05
June	5.3 ± 1.2	5.5 ± 0.2	1.3 ± 0.4	1.0 ± 0.2	0.64 ± 0.07	0.29 ± 0.03
July	4.1 ± 0.8	5.7 ± 0.6	1.0 ± 0.3	0.8 ± 0.2	0.54 ± 0.20	0.29 ± 0.28
August	4.2 ± 0.9	4.4 ± 0.2	1.1 ± 0.3	0.9 ± 0.1	0.52 ± 0.13	0.34 ± 0.00
September	5.0 ± 1.7	6.1 ± 1.4	1.1 ± 0.1	1.1 ± 0.2	0.48 ± 0.07	0.42 ± 0.01
October	5.3 ± 1.1	5.4 ± 0.2	1.2 ± 0.3	1.1 ± 0.0	0.54 ± 0.11	0.55 ± 0.10
November	5.7 ± 0.8	5.6 ± 0.5	1.2 ± 0.1	1.0 ± 0.1	0.65 ± 0.17	0.74
December	6.5 ± 1.8	5.4 ± 0.4	1.0 ± 0.5	0.8 ± 0.0	0.74 ± 0.16	0.77 ± 0.09
Annual	**6.0 ± 1.8**	**6.1 ± 0.1**	**1.1 ± 0.5**	**1.0 ± 0.0**	**0.55 ± 0.16**	**0.32 ± 0.05**
DJF	7.8 ± 1.9	6.3 ± 0.7	0.9 ± 0.4	1.5 ± 0.9	0.65 ± 0.13	0.74 ± 0.07
MAM	7.5 ± 2.1	6.7 ± 0.8	1.5 ± 0.8	1.1 ± 0.2	0.62 ± 0.03	0.55 ± 0.22
JJA	4.5 ± 1.2	5.2 ± 0.7	1.1 ±0.3	0.9 ± 0.1	0.56 ± 0.06	0.31± 0.05
SON	5.9 ± 1.1	5.7 ± 0.7	1.1 ± 0.2	1.1 ± 0.1	0.56 ± 0.09	0.54 ± 0.14
NH-S	4.8 ± 1.2	5.4 ± 0.8	1.1 ± 0.3	1.0 ± 0.1	0.54 ± 0.06	0.38 ± 0.11
H-S	7.5 ± 1.9	6.4 ± 0.8	1.2 ± 0.6	1.2 ± 0.6	0.64 ± 0.08	0.65 ± 0.18

Tale S7: Annual mean concentrations of Antarctic baseline aerosol (ABA)[1] OC, EC, and positive artifact corrected OC (OC_P) at Trollhaugen Observatory (Antarctica), 2016 to 2018 and 2021 to 2022. Unit ng C m^{-3}.

	EC	**OC**	**OC_P**
2016	2.0	12.0	7.4
2017	2.3	14.1	10.9
2018	1.4	10.0	7.5
2021	2.0	14.2	9.3
2022	1.7	10.8	7.1
Mean ± SD	**1.9 ± 0.3**	**12.2 ± 1.9**	**8.4 ± 1.6**

Antarctic baseline aerosol (ABA): To differentiate between Antarctic baseline aerosol (ABA) and non-ABA, we relied on input from in-situ on-line nephelometer (TSI 3563) measurements, as defined by Fiebig et al. (2014). We considered values below the 4 weeks running 5th percentile x 2.5 of the aerosol scattering coefficient (σsp, 550 nm) as ABA, while values above this threshold were defined as non-ABA. We made sure not to sample at wind speeds > 10 m s^{-1} to avoid filter damage. We collected ABA and non-ABA using two high-volume samplers (Digitel DHA-80 with a PM_{10} inlet) both with double quartz fibre filters (Pallflex 2500) (McDow and Huntzicker, 1990) to estimate of the positive sampling artifact caused by semi volatile organic compounds (SVOC). The inlet of the nephelometer and high-volume samplers were positioned 5.5 meters above the ground.

Background information to Table S8:

The samples with the highest PBAP and BSOA tracer concentrations were collected in the non-heating Season (June to October). A major fraction of these samples experienced elevated concentrations of the biomass burning tracer levoglucosan, as shown in Table S8. This points to the importance of wildfires for observed concentrations of PBAP and BSOA in the Arctic.

Table S8: Mean concentration of PBAP and BSOA tracers for the top ten highest concentration samples (second column). Mean concentration of PBAP and BSOA tracers for those of the top ten samples collected in the non-heating (NH) season and with a levoglucosan concentration exceeding the long-term mean (third column). Mean concentration of levoglucosan for the samples listed in the third column and their percentiles compared to the long-term mean (fifth column). Zeppelin Observatory, 2017 – 2020.

BSOA and PBAP tracers	**BSOA and PBAP tracers for the top ten highest samples (Mean; Unit ng m^{-3})**	**BSOA and PBAP tracers for those of the top ten samples collected in the NH-season and with $[Levoglucosan]_{Sample} > [Levoglucosan]_{Long\text{-}term\ mean}$ (Mean; Unit: ng m^{-3})**	**BB tracer**	**Levoglucosan for samples listed in column three. Mean (Percentile) (Unit: ng m^{-3})**
Arabitol	1.2	1.3 (n=8)	Levoglucosan	2.7 (96)
Mannitol	1.0	1.1 (n=7)	Levoglucosan	2.4 (95)
Trehalose	1.0	1.0 (n=7)	Levoglucosan	2.4 (95)
Fructose	0.7	1.1 (n=5)	Levoglucosan	3.6 (98)
Glucose	3.5	3.5 (n=9)	Levoglucosan	2.5 (95)
Cellulose	5.7	6.4 (n=3)	Levoglucosan	4.3 (98)
2-Methyltetrols	6.1	7.8 (n=7)	Levoglucosan	2.2 (94)

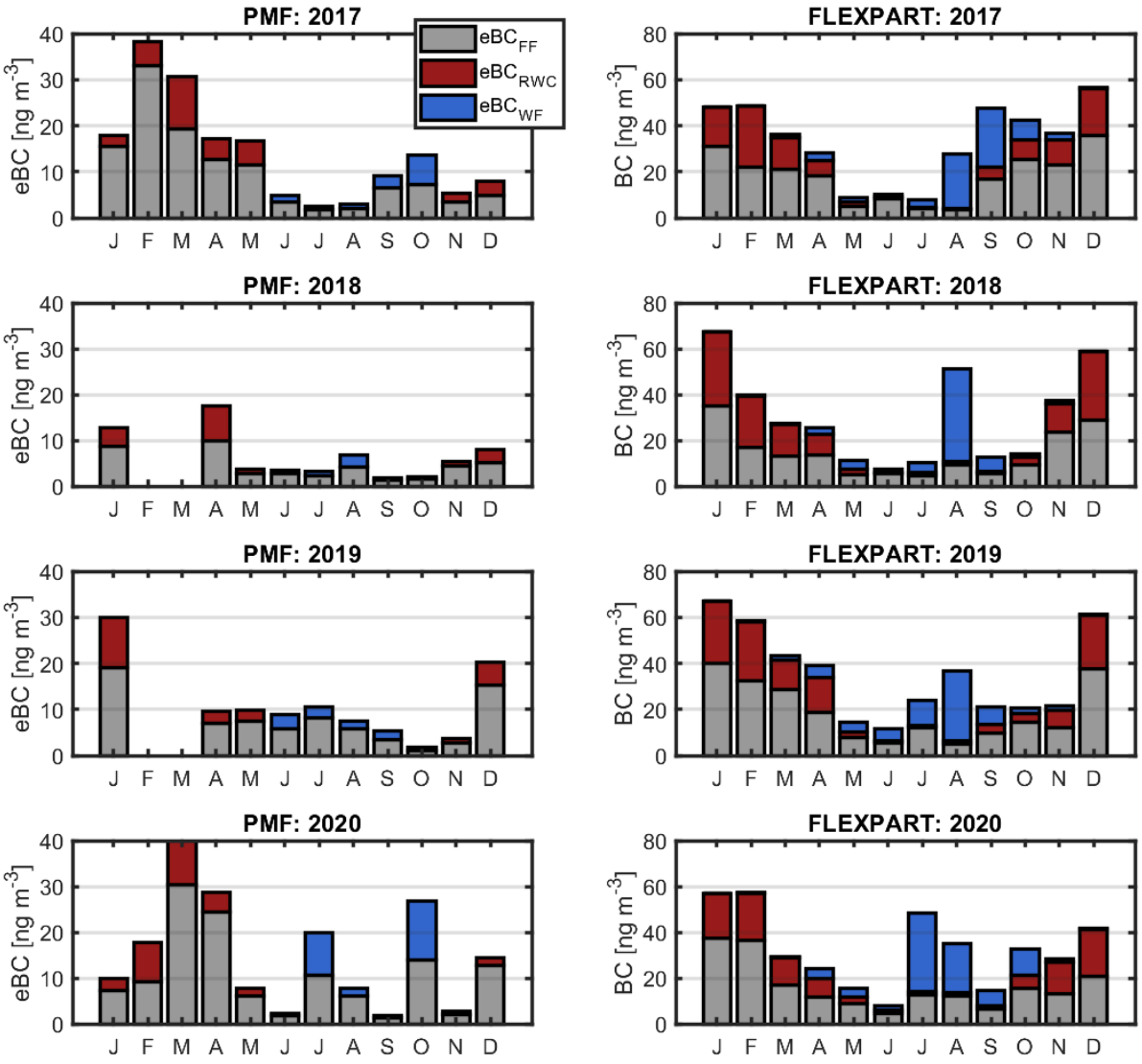

Figure S1. Monthly mean eBC concentrations (PMF) (left) and BC (FLEXPART) (right) apportioned to FF combustion and BB. BB is categorized as RWC in H-Season (red color) and WF in NH-season (blue color). Zeppelin Observatory 2017 to 2020.

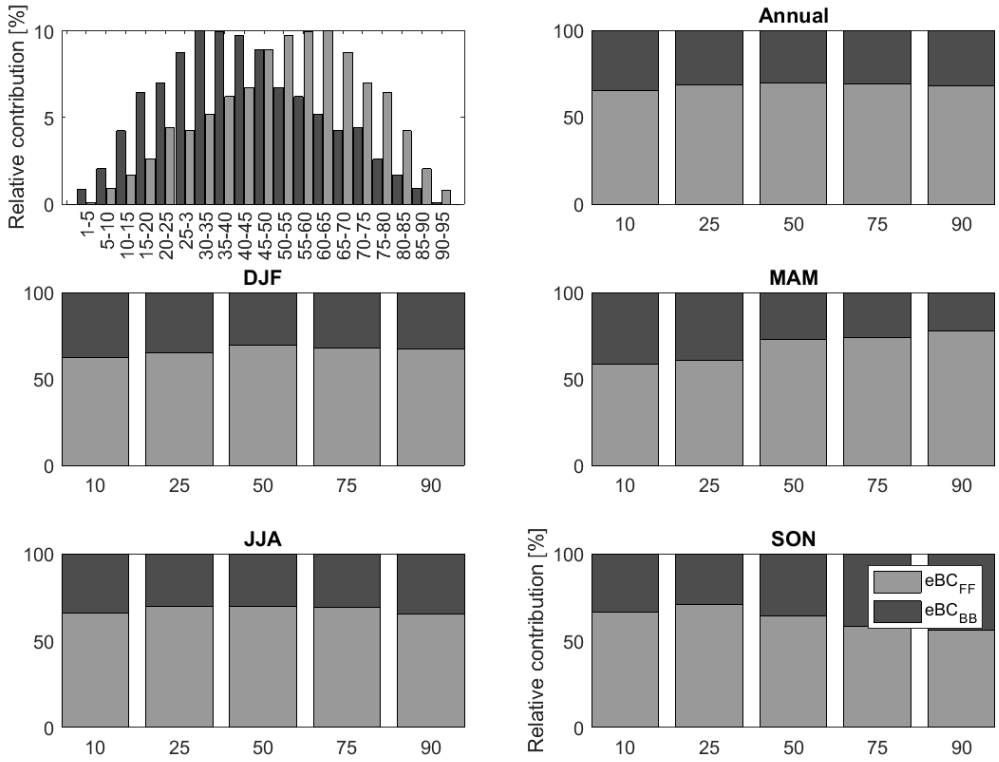

Figure S2. Frequency distribution of eBC_{BB}/eBC and eBC_{FF}/eBC fractions (left top panel), and average eBC_{BB}/eBC and eBC_{FF}/eBC fractions for eBC concentrations below the 10th and the 25th percentile, all observations (50th percentile), and above the 75th and 90th percentiles, for the Zeppelin Observatory, 2017 to 2020. Results obtained by PMF.

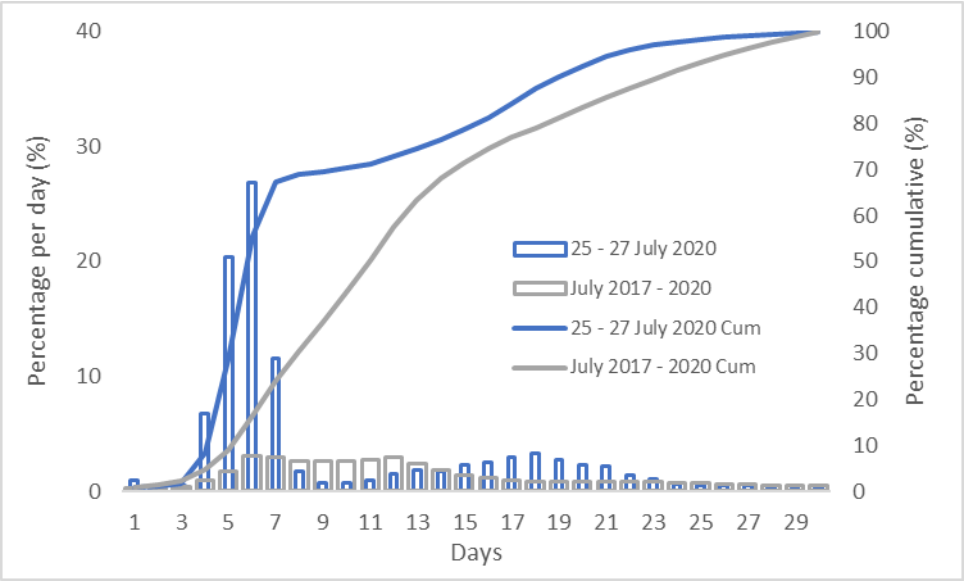

Figure S3. Transport time of modelled BC concentrations from the respective emission sources to Zeppelin Observatory. The blue line are the results for the part of the pollution episode spanning from 25 to 27 July 2020 compared to the reference period (July 2017 to 2020, grey line).