

Supplementary Material

Organic and Elemental Carbon in the Urban Background in an Eastern Mediterranean City

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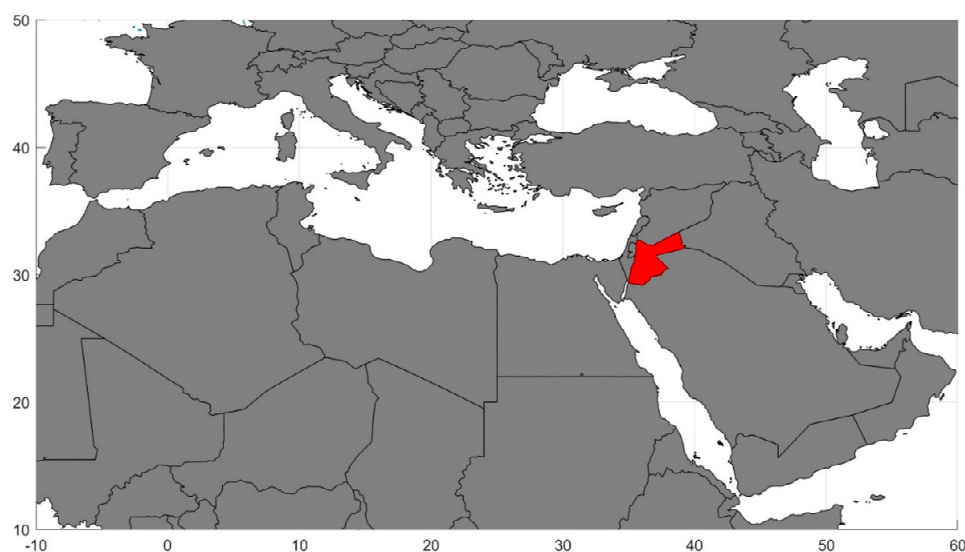
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S1 Measurement Site Locations



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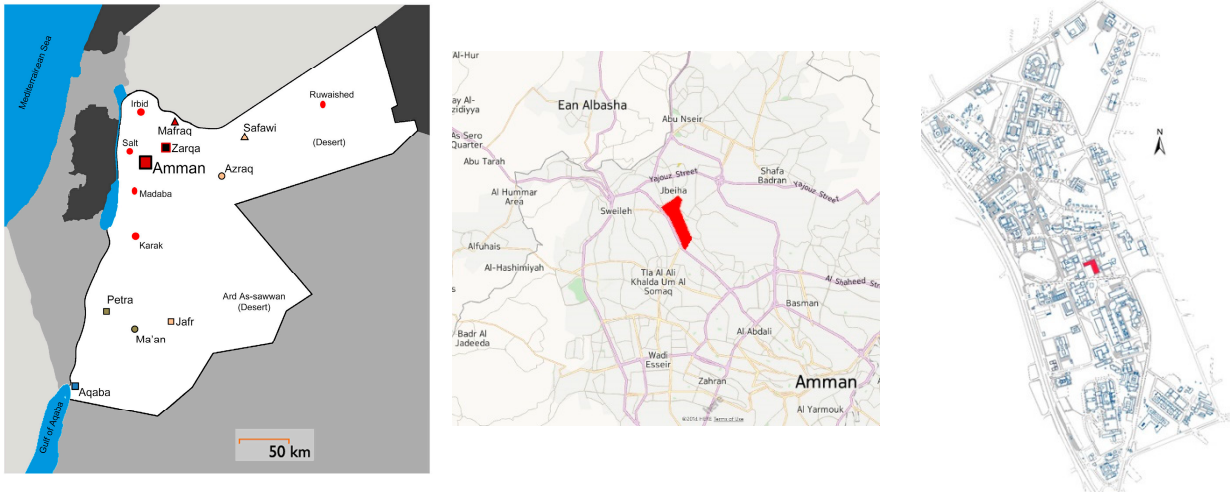


Figure S1: Maps showing (a) the Mediterranean Sea region with Jordan highlighted in red, (b) Jordan with highlights on the geographical locations of main cities, (c) road network and the campus of the University of Jordan (red shaded area) inside Amman, and (d) details of the campus of the University of Jordan with the sampling location (red shaded area) at the middle of the campus.

S2 Weather conditions

The hourly, daily, and monthly means of the meteorological conditions (ambient temperature (T), relative humidity (RH), absolute pressure (P), wind speed (WS), and hourly precipitation) are presented in Figure S2. The monthly mean, standard deviation, minimum, and maximum values are listed in Table S1.

The ambient temperature (T) showed a clear seasonal variation with high values during the summer (June–August) and low values during the winter (December–February). During the summer, the monthly mean T was around 24°C and during the winter it was around 9°C. During May 2018–March 2019, the daily mean T was in the range 3–30°C (overall mean $17 \pm 7^\circ\text{C}$).

The seasonal variation of the relative humidity and the absolute pressure was opposite to that of T. For example, the monthly RH was about 55% and 82% during the summer and the winter; respectively. As for P, it was about 896 hPa and 901 hPa during the summer and the winter; respectively. During May 2018–March 2019, the daily mean RH was in the range 20–100% (overall mean $68 \pm 21\%$) and the daily mean P was in the range 890–908 hPa (overall mean 899 ± 4 hPa).

The wind speed (WS) showed a different monthly variation than T, RH, and P. The monthly mean wind speed was minimum during the autumn (September–November) and maximum during the summer. The maximum monthly WS value was about 2.1 m s^{-1} (August) and the minimum was about 0.8 m s^{-1} (November). During May 2018–March 2019, the maximum daily mean WS was about 3.6 m s^{-1} (March 1, 2019).

The rain season started in October 2018 with a small amount (cumulative ~13 mm). During December 2018, the cumulative precipitation was about 180 mm. During January–February 2019, the cumulative precipitation was about 120 mm. By the end of the measurement campaign (i.e., March 2019), the cumulative precipitation was about 470 mm.

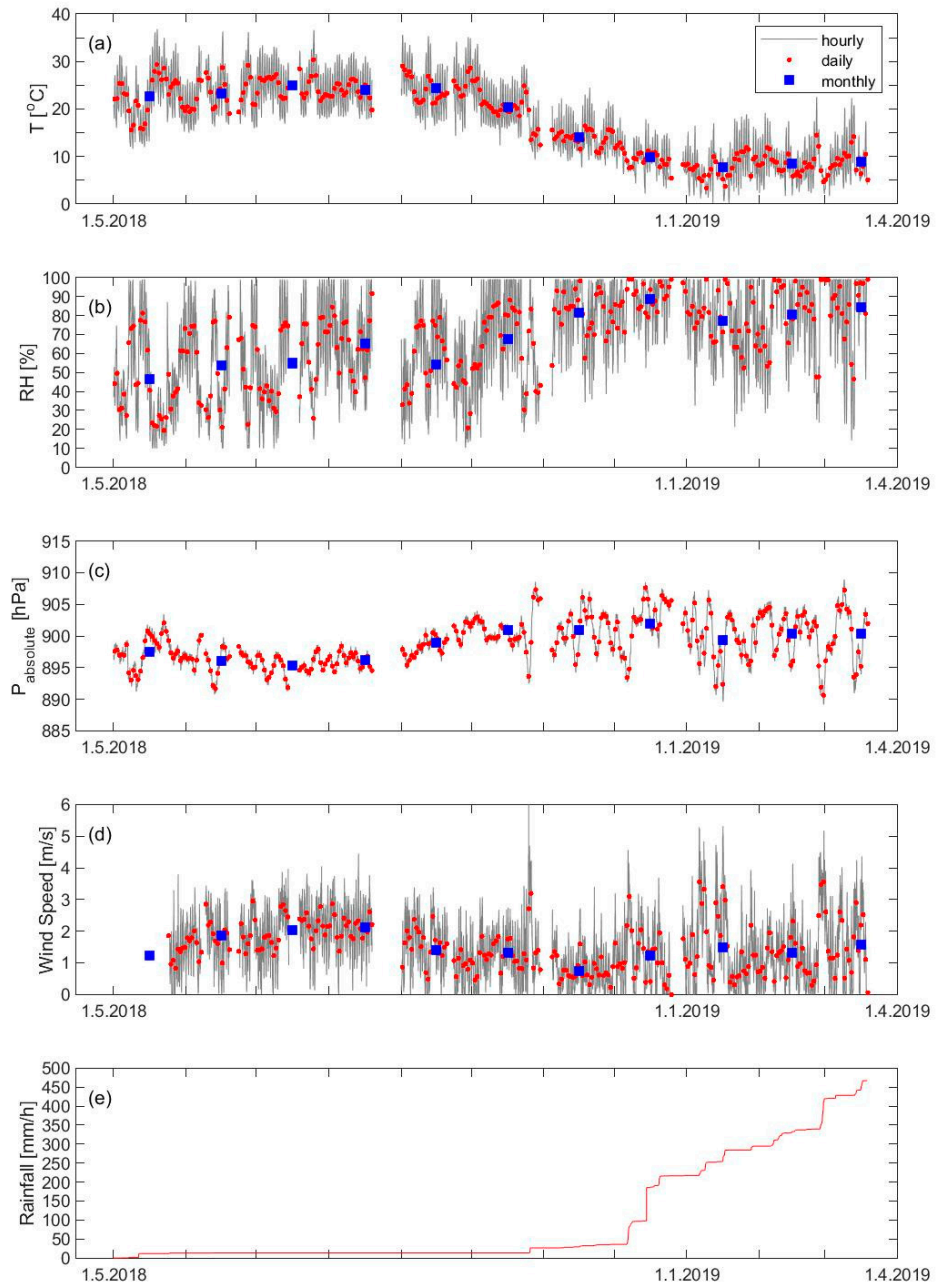


Figure S2. Time series of weather conditions during May 1, 2018 – March 19, 2019 presented as hourly, daily, and monthly means for (a) ambient temperature, (b) relative humidity, (c) absolute pressure, and (d) wind speed. (e) The rainfall was presented as hourly cumulative precipitation.

Table S1. Particulate matter concentrations and overall average temperature and pressure according to the sampling schedule. The aerosol sampler reported the 24-hour mean temperature (T) and pressure (P) during sampling sessions.

Start		End		T _{sampler} [°C]	P _{sampler} [hPa]	T _{station} [°C]	P _{station} [hPa]
20-05-2018	13:24	21-05-2018	13:24	25.6	902.7	26.4	899.1
26-05-2018	14:02	27-05-2018	14:02	24.7	900.3	25.5	896.7
01-06-2018	16:15	02-06-2018	16:15	18.8	899.8	19.5	896.3
07-06-2018	10:10	08-06-2018	10:10	27.4	902.8	32.4	900.6
13-06-2018	11:05	14-06-2018	11:05	21	896	21.7	892.5
19-06-2018	11:00	20-06-2018	10:45	23.3	902.3	25.3	897.8
25-06-2018	12:30	26-06-2018	12:30	23.3	900.8	24.2	897.0
01-07-2018	09:16	02-07-2018	09:16	24.2	900.9	25.1	897.1
07-07-2018	08:59	08-07-2018	08:59	25.2	898.4	25.8	894.5
13-07-2018	09:31	14-07-2018	09:31	22.8	896.3	23.4	892.4
19-07-2018	09:28	20-07-2018	09:28	24.4	898.7	25.1	894.7
25-07-2018	09:26	26-07-2018	09:26	28.9	900.8	29.7	896.6
31-07-2018	09:23	01-08-2018	09:23	22.2	900.3	--	--
06-08-2018	09:28	07-08-2018	09:28	23	901.8	23.8	897.9
12-08-2018	09:32	13-08-2018	09:32	24.3	901.3	25.2	897.1
18-08-2018	10:08	19-08-2018	10:08	21.5	898.9	22.3	894.9
24-08-2018	10:43	25-08-2018	10:43	26.8	901	--	--
30-08-2018	08:15	31-08-2018	08:15	25.8	901.4	--	--
05-09-2018	07:51	06-09-2018	07:51	24.9	901.3	26.5	896.9
11-09-2018	18:16	12-09-2018	18:16	25.3	903.8	26.4	899.1
23-09-2018	08:17	24-09-2018	08:17	21.9	905.5	23.0	901.5
29-09-2018	09:09	30-09-2018	09:09	27.2	906.3	28.2	901.7
05-10-2018	09:39	06-10-2018	09:39	20	906	20.9	902.0
11-10-2018	08:36	12-10-2018	08:36	18.8	903.3	19.6	899.5
17-10-2018	08:37	18-10-2018	08:37	18.8	902.8	19.8	898.9
23-10-2018	08:14	24-10-2018	08:14	24.2	904.2	25.2	899.7
04-11-2018	09:09	05-11-2018	09:09	13.3	900.8	14.0	897.3
10-11-2018	09:07	11-11-2018	09:07	12.7	904.4	13.9	900.7
16-11-2018	10:00	17-11-2018	10:00	10.3	908.1	11.1	904.9
22-11-2018	09:20	23-11-2018	09:20	11.6	902	12.6	898.7
28-11-2018	08:37	29-11-2018	08:37	15	904.8	16.2	901.1
04-12-2018	08:52	05-12-2018	08:52	9.4	900.3	10.3	897.0
10-12-2018	09:42	11-12-2018	09:42	9.3	905.4	10.5	902.2
16-12-2018	16:05	17-12-2018	16:05	9.8	904.5	10.6	900.9
22-12-2018	08:39	23-12-2018	08:39	7.1	908.6	8.3	905.6
03-01-2019	08:25	04-01-2019	08:25	5.2	907.8	6.0	904.9
09-01-2019	13:10	10-01-2019	13:10	3.6	907.8	4.4	904.9
15-01-2019	08:45	16-01-2019	08:45	6.5	899.2	7.7	895.9
21-01-2019	08:20	22-01-2019	08:20	8.5	902.9	10.0	900.4
27-01-2019	08:15	28-01-2019	08:15	5.3	901.6	10.2	895.0
02-02-2019	07:37	03-02-2019	07:37	7.2	906.7	8.2	903.5
08-02-2019	08:53	09-02-2019	08:53	7.5	901.9	8.4	898.5
14-02-2019	07:54	15-02-2019	07:54	6.3	898.6	7.1	895.3
20-02-2019	07:47	21-02-2019	07:47	7.6	896.9	8.6	903.3
26-02-2019	08:04	27-02-2019	08:04	9.5	896.9	10.2	893.2
28-02-2019	08:40	01-03-2019	08:40	2.5	895	--	--
04-03-2019	08:25	05-03-2019	08:25	9.5	896.9	7.7	899.3
10-03-2019	09:04	11-03-2019	09:04	9.1	907	9.8	903.6

S3 Air Mass Back Trajectories

The 4-day back trajectories crossing maps are presented in Figure S3 for arrival heights 100 m and 1500 m. The spatial extent of the trajectories crossing for 1500 m arrival height was broader than that for 100 m arrival height. For back trajectories arrived at 1500 m height, they covered the whole Mediterranean Sea Basin and included north Africa, Red Sea, north and middle region of the Arabia Peninsula, the Levant with an extension to the Caspian Sea, and Europe. As for arrival height at 100 m, the back trajectories covered the middle and eastern parts of the Mediterranean Sea, northeast Africa, north Red Sea, north Arabian Peninsula, the Levant, and southeast Europe. Furthermore, trajectories arrived at 100 m showed a predominant crossing path over the eastern part of the Mediterranean Sea.

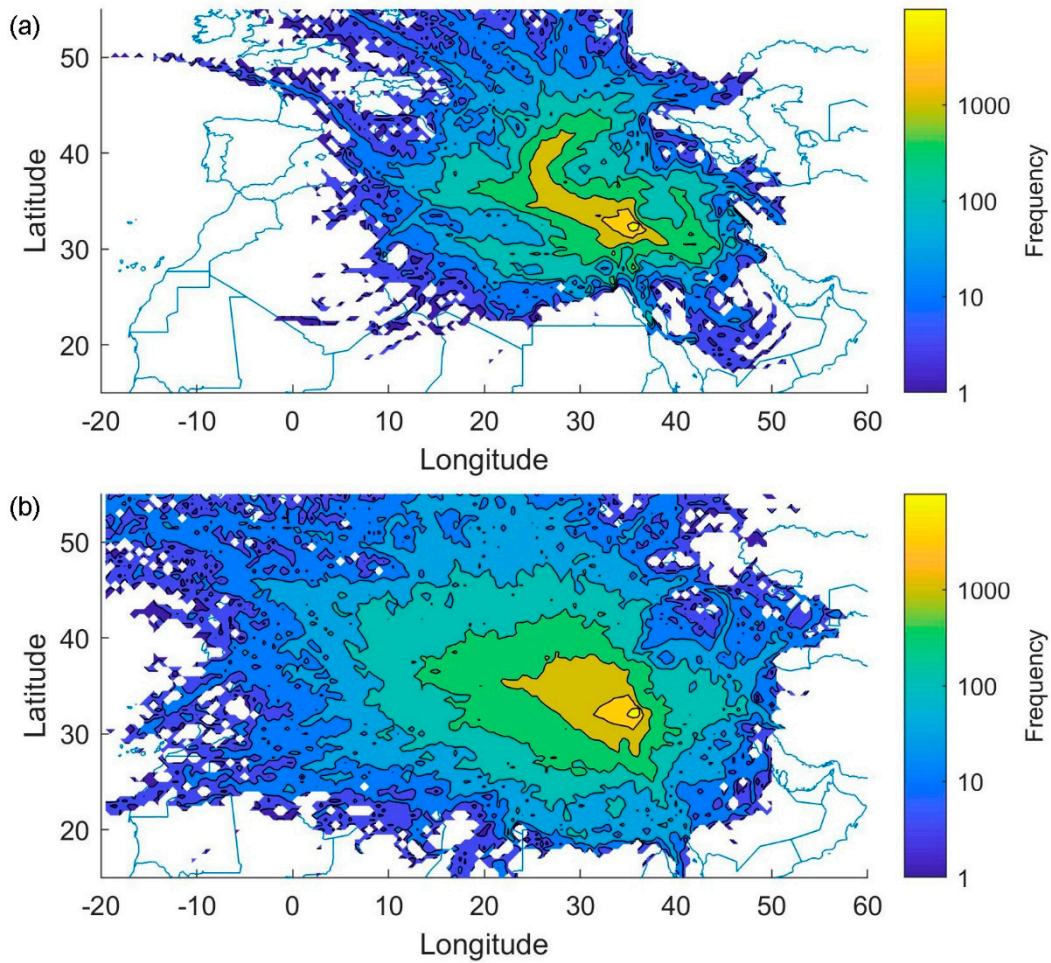


Figure S3. Back trajectories (96 hours) crossing maps at arrival heights (a) 100 meters and (b) 1500 meters. The arrival location was the campus of the University of Jordan, Amman, Jordan. These maps were generated from the hourly trajectories during May 1, 2018 – March 31, 2019.

S4 PM and OC, EC, and TC concentrations

Table S2. PM_{2.5} and PM₁₀ concentrations [$\mu\text{g}/\text{m}^3$] and corresponding OC and EC concentrations [$\mu\text{g}/\text{m}^3$].

Start		End		Fine							Coarse						
Date	Time	Date	Time	PM _{2.5}	OC	unc	EC	unc	TC	unc	PM ₁₀	OC	Unc	EC	unc	TC	unc
20-05-2018	13:24	21-05-2018	13:24	52.4	7.7	0.4	1.2	0.1	8.9	0.5	58.3	5.4	0.3	1.7	0.1	7.2	0.4
26-05-2018	14:02	27-05-2018	14:02	96.3	7.3	0.4	1.8	0.1	9.0	0.5	107.8	7.6	0.4	1.6	0.1	9.2	0.5
01-06-2018	16:15	02-06-2018	16:15	19.1	3.3	0.2	0.4	0.0	3.8	0.2	28.3	3.6	0.2	0.6	0.1	4.2	0.3
07-06-2018	10:10	08-06-2018	10:10	127.2	10.8	0.6	1.5	0.1	12.3	0.7	126.7	11.4	0.6	2.0	0.1	13.4	0.7
13-06-2018	11:05	14-06-2018	11:05	20.3	3.5	0.2	0.8	0.1	4.3	0.3	34.3	4.2	0.2	1.0	0.1	5.2	0.3
19-06-2018	11:00	20-06-2018	10:45	25.7	4.4	0.2	1.1	0.1	5.5	0.3	31.3	4.7	0.3	1.1	0.1	5.9	0.3
25-06-2018	12:30	26-06-2018	12:30	24.0	4.0	0.2	0.6	0.1	4.6	0.3	28.9	5.0	0.3	0.7	0.1	5.7	0.3
01-07-2018	9:16	02-07-2018	9:16	26.9	5.3	0.3	1.2	0.1	6.5	0.4	34.2	6.0	0.3	1.2	0.1	7.1	0.4
07-07-2018	8:59	08-07-2018	8:59	34.6	6.9	0.4	1.1	0.1	8.1	0.4	39.6	6.7	0.4	1.1	0.1	7.7	0.4
13-07-2018	9:31	14-07-2018	9:31	32.5	5.1	0.3	0.5	0.0	5.6	0.3	46.5	5.3	0.3	0.9	0.1	6.2	0.4
19-07-2018	9:28	20-07-2018	9:28	47.0	5.8	0.3	1.0	0.1	6.7	0.4	57.7	5.1	0.3	0.9	0.1	6.1	0.3
25-07-2018	9:26	26-07-2018	9:26	108.5	10.1	0.5	2.0	0.1	12.0	0.6	120.9	9.1	0.5	1.8	0.1	10.8	0.6
31-07-2018	9:23	01-08-2018	9:23	28.0	4.4	0.2	0.9	0.1	5.3	0.3	33.4	4.6	0.3	1.2	0.1	5.8	0.3
06-08-2018	9:28	07-08-2018	9:28	26.0	3.5	0.2	0.7	0.1	4.2	0.3	33.3	3.5	0.2	0.9	0.1	4.5	0.3
12-08-2018	9:32	13-08-2018	9:32	35.8	5.4	0.3	0.8	0.1	6.2	0.4	43.0	6.1	0.3	1.0	0.1	7.1	0.4
18-08-2018	10:08	19-08-2018	10:08	25.2	3.4	0.2	0.8	0.1	4.2	0.3	34.2	3.4	0.2	1.1	0.1	4.4	0.3
24-08-2018	10:43	25-08-2018	10:43	33.7	5.9	0.3	1.0	0.1	6.9	0.4	36.9	6.3	0.3	1.1	0.1	7.4	0.4
30-08-2018	8:15	31-08-2018	8:15	35.1	5.7	0.3	1.7	0.1	7.4	0.4	49.2	6.6	0.4	1.9	0.1	8.5	0.5
05-09-2018	7:51	06-09-2018	7:51	45.4	6.6	0.4	1.1	0.1	7.7	0.4	43.8	6.7	0.4	1.2	0.1	7.9	0.4
11-09-2018	18:16	12-09-2018	18:16	53.1	7.8	0.4	2.4	0.1	10.2	0.6	53.7	7.4	0.4	2.4	0.1	9.8	0.5
23-09-2018	8:17	24-09-2018	8:17	38.3	7.7	0.4	1.7	0.1	9.4	0.5	46.2	6.9	0.4	1.9	0.1	8.8	0.5
29-09-2018	9:09	30-09-2018	9:09	59.9	8.8	0.5	3.3	0.2	12.1	0.6	60.9	8.4	0.4	3.1	0.2	11.6	0.6
05-10-2018	9:39	06-10-2018	9:39	26.5	4.8	0.3	0.7	0.1	5.5	0.3	30.9	4.0	0.2	0.9	0.1	4.9	0.3
11-10-2018	8:36	12-10-2018	8:36	60.6	4.7	0.3	0.9	0.1	5.6	0.3	105.7	5.4	0.3	1.1	0.1	6.4	0.4

17-10-2018	8:37	18-10-2018	8:37	55.2	3.1	0.2	1.3	0.1	4.4	0.3	158.6	6.5	0.3	1.5	0.1	8.0	0.4
23-10-2018	8:14	24-10-2018	8:14	188.9	17.1	0.9	6.1	0.3	23.2	1.2	188.3	15.9	0.8	5.5	0.3	21.4	1.1
04-11-2018	9:09	05-11-2018	9:09	43.6	5.1	0.3	1.5	0.1	6.7	0.4	58.0	6.1	0.3	1.9	0.1	8.1	0.4
10-11-2018	9:07	11-11-2018	9:07	37.3	4.3	0.2	1.4	0.1	5.6	0.3	41.6	2.4	0.1	3.1	0.2	5.6	0.3
16-11-2018	10:00	17-11-2018	10:00	21.2	3.8	0.2	0.8	0.1	4.6	0.3	30.7	3.9	0.2	1.3	0.1	5.2	0.3
22-11-2018	9:20	23-11-2018	9:20	35.0	4.5	0.2	2.1	0.1	6.7	0.4	47.5	5.1	0.3	2.0	0.1	7.1	0.4
28-11-2018	8:37	29-11-2018	8:37	51.3	5.1	0.3	3.0	0.2	8.1	0.4	88.3	6.4	0.3	2.9	0.2	9.3	0.5
04-12-2018	8:52	05-12-2018	8:52	32.7	4.8	0.3	2.3	0.1	7.1	0.4	49.0	6.4	0.3	2.7	0.2	9.1	0.5
10-12-2018	9:42	11-12-2018	9:42	27.6	3.8	0.2	1.8	0.1	5.5	0.3	51.8	5.5	0.3	1.9	0.1	7.4	0.4
16-12-2018	16:05	17-12-2018	16:05	43.8	6.9	0.4	2.4	0.1	9.3	0.5	88.5	8.1	0.4	4.3	0.2	12.4	0.7
22-12-2018	8:39	23-12-2018	8:39	29.0	5.3	0.3	3.9	0.2	9.2	0.5	41.1	7.3	0.4	4.3	0.2	11.6	0.6
03-01-2019	8:25	04-01-2019	8:25	89.3	7.0	0.4	2.6	0.2	9.6	0.5	141.9	9.5	0.5	2.7	0.2	12.3	0.7
09-01-2019	13:10	10-01-2019	13:10	24.6	4.0	0.2	1.4	0.1	5.4	0.3	27.5	4.1	0.2	2.0	0.1	6.1	0.3
15-01-2019	8:45	16-01-2019	8:45	79.7	8.1	0.4	1.5	0.1	9.6	0.5	92.6	7.6	0.4	1.4	0.1	9.0	0.5
21-01-2019	8:20	22-01-2019	8:20	56.9	9.2	0.5	3.7	0.2	12.9	0.7	104.0	11.8	0.6	3.6	0.2	15.4	0.8
27-01-2019	8:15	28-01-2019	8:15	48.6	6.6	0.4	1.9	0.1	8.5	0.5	53.1	6.4	0.3	2.3	0.1	8.7	0.5
02-02-2019	7:37	03-02-2019	7:37	23.9	5.0	0.3	2.3	0.1	7.3	0.4	36.6	5.5	0.3	2.4	0.1	7.9	0.4
08-02-2019	8:53	09-02-2019	8:53	23.8	2.0	0.1	0.7	0.1	2.7	0.2	54.4	2.9	0.2	0.6	0.1	3.6	0.2
14-02-2019	7:54	15-02-2019	7:54	69.2	6.7	0.4	1.9	0.1	8.6	0.5	111.8	7.8	0.4	2.3	0.1	10.1	0.5
20-02-2019	7:47	21-02-2019	7:47	31.4	4.5	0.2	1.7	0.1	6.2	0.4	38.0	4.9	0.3	1.9	0.1	6.9	0.4
26-02-2019	8:04	27-02-2019	8:04	--	--	--	--	--	--	--	137.7	17.5	0.9	2.4	0.1	19.9	1.0
28-02-2019	8:40	01-03-2019	8:40	14.9	1.2	0.1	0.5	0.0	1.7	0.1	19.3	2.2	0.1	0.5	0.0	2.7	0.2
04-03-2019	8:25	05-03-2019	8:25	37.7	5.8	0.3	2.7	0.2	8.5	0.5	62.2	6.3	0.3	2.6	0.1	8.9	0.5
10-03-2019	9:04	11-03-2019	9:04	49.4	12.6	0.7	1.0	0.1	13.6	0.7	53.5	11.6	0.6	3.4	0.2	15.0	0.8
16-03-2019	8:26	17-03-2019	8:26	--	--	--	--	--	--	--	23.9	2.4	0.1	0.7	0.1	3.1	0.2

S5 Sand and Dust Storm (SDS) Episodes

As indicated in Figure S4, the Sand and Dust Storm (SDS) episodes were considered when $PM_{10} > 70 \mu g m^{-3}$. This arbitrary threshold was selected based on the distribution of daily PM_{10} concentrations. Accordingly, 14 days of SDS episodes were identified Table S3. According to the air mass back trajectories analysis, the atmospheric SDS was transported from three main source regions: (1) long-range transport from north Africa (Sahara, Figure S5), (2) medium range transport from the Arabian Peninsula (Figure S6), and (3) short-range transported from the Levant. Sometimes, the transport was a combination of two or three regions (Figure S7). Accordingly, type identification was suggested: S-type originated from Sahara region, SL-type originated from Sahara region and the Levant region (i.e., SDS combined from these two regions), and SLA-type originated from all three regions. The SLA was the most common SDS type because the back trajectories originated from north Africa crosses or circulates over the northern part of the Arabian Peninsula and the Levant region.

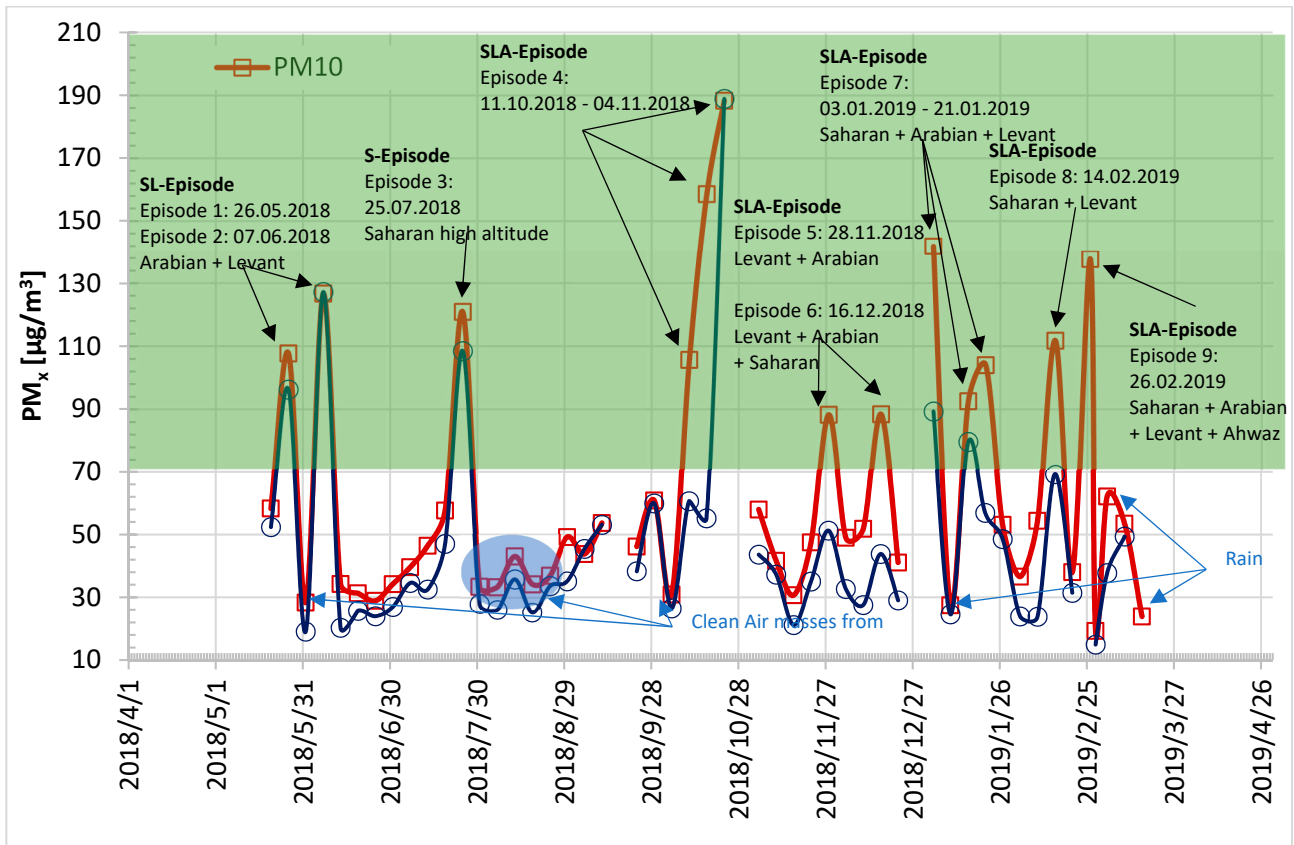


Figure S4. Time series of PM_{10} and $PM_{2.5}$ concentrations with markups for sand and dust episodes (SDS) and clean air periods (i.e. PM_{10} concentrations $< 70 \mu g/m^3$).

Table S3. Sand and Dust Storm (SDS) episodes according to type and observation during the sampling period. The type of SDS is denoted as: Saharan (S); Saharan and Levant (SL); Saharan, Arabian, and Levant (SAL); Saharan, Arabian, Levant, and Ahvaz (SALA). The source region was verified according to the back trajectories analysis for crossing maps on the sampling day (+ following day). The date here indicates the start of the sampling day.

SDS Type	Source Region	Dates	PM ₁₀ (μg m ⁻³)
S	Saharan	25-07-2018	120.9
SL	Saharan and Levant	26-05-2018	107.8
		07-06-2018	126.7
SLA	Saharan, Levant, and Arabian	11-10-2018	105.7
		17-10-2018	158.6
		23-10-2018	188.3
		28-11-2018	88.3
		16-12-2018	88.5
		03-01-2019	141.9
		15-01-2019	92.6
		21-01-2019	104.0
		14-02-2019	111.8
		26-02-2019	137.7
CLEAN	Eastern Mediterranean Sea	01-06-2018	28.4
		31-07-2018	33.4
		06-08-2018	33.3
		12-08-2018	43.0
		18-08-2018	34.2
		24-08-2018	36.9
		28-02-2019	19.3

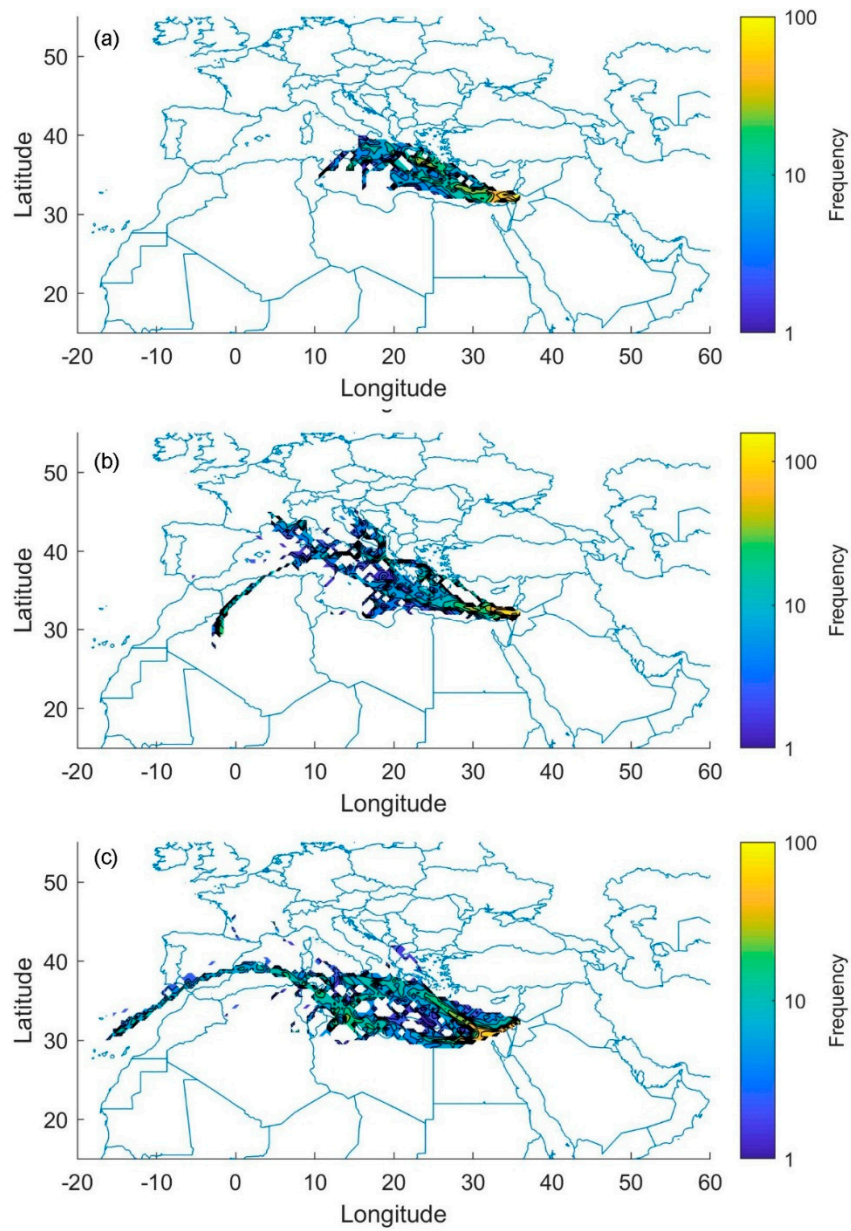


Figure S5. Back trajectories (96 hours) crossing maps during S-type SDS-episodes (indicated on Figure S4) at arrival heights (a) 100 meters, (b) 500 meters, and (c) 1500 meters. The arrival location was the campus of the University of Jordan, Amman, Jordan. These maps were generated from the hourly back trajectories during the sampling dates (+ following day).

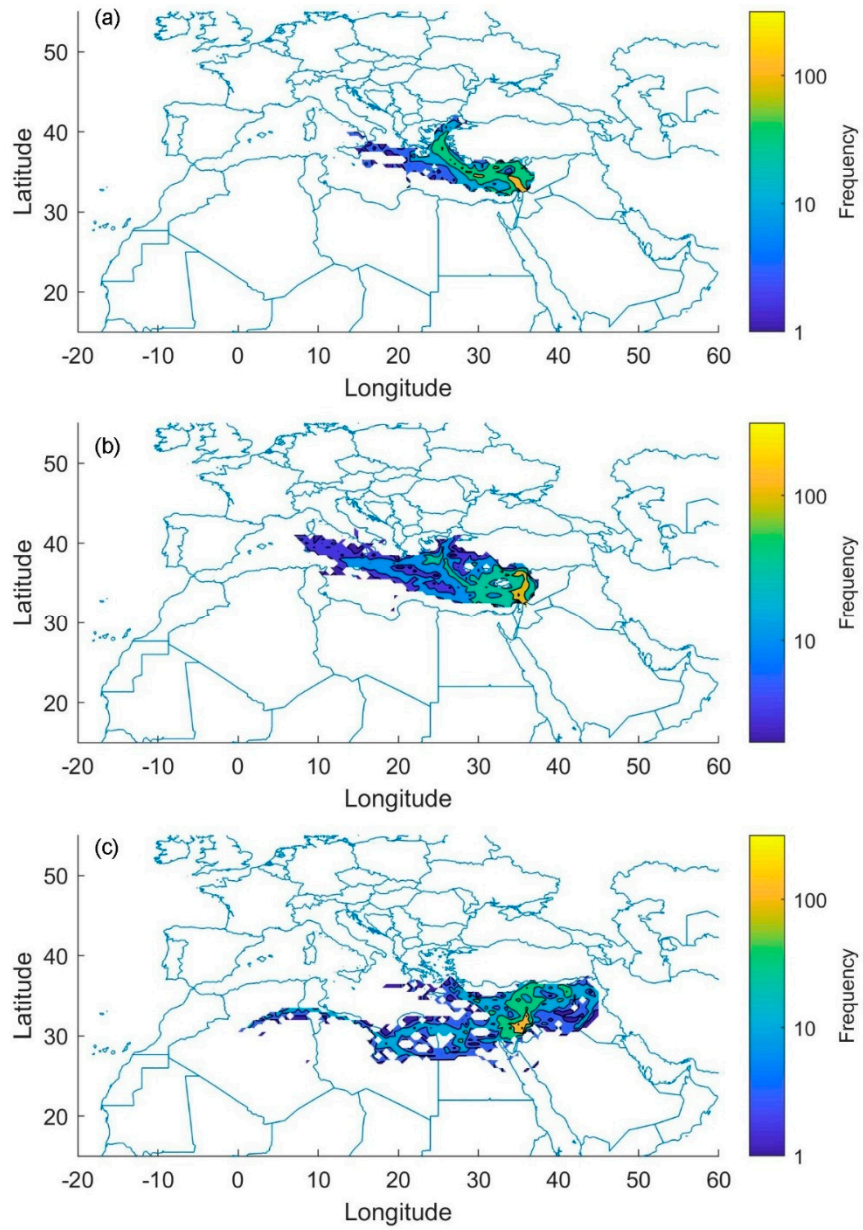


Figure S6. Back trajectories (96 hours) crossing maps during SL-type SDS-episodes (indicated on Figure S4) at arrival heights (a) 100 meters, (b) 500 meters, and (c) 1500 meters. The arrival location was the campus of the University of Jordan, Amman, Jordan. These maps were generated from the hourly back trajectories during the sampling dates (+ following day).

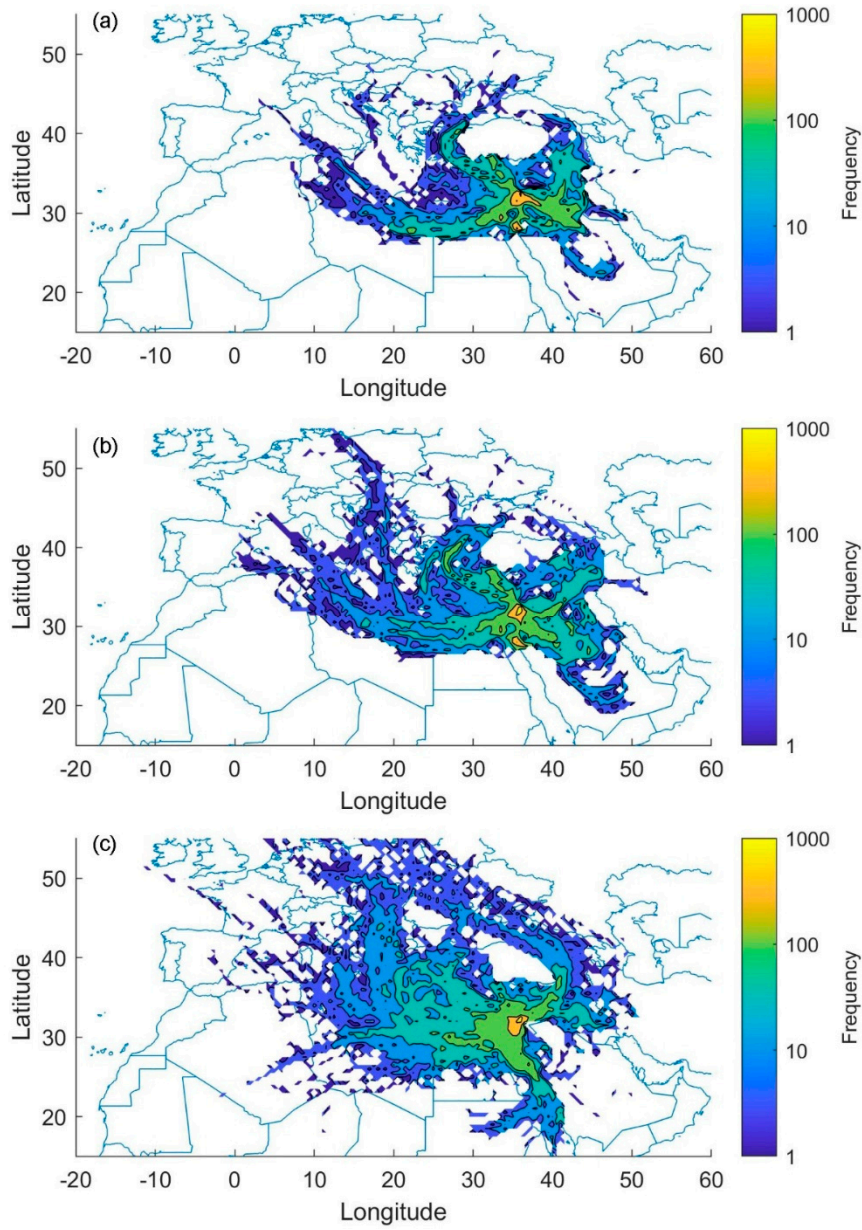


Figure S7. Back trajectories (96 hours) crossing maps during SLA-type SDS-episodes (indicated on Figure S4) at arrival heights (a) 100 meters, (b) 500 meters, and (c) 1500 meters. The arrival location was the campus of the University of Jordan, Amman, Jordan. These maps were generated from the hourly back trajectories during the sampling dates (+ following day).

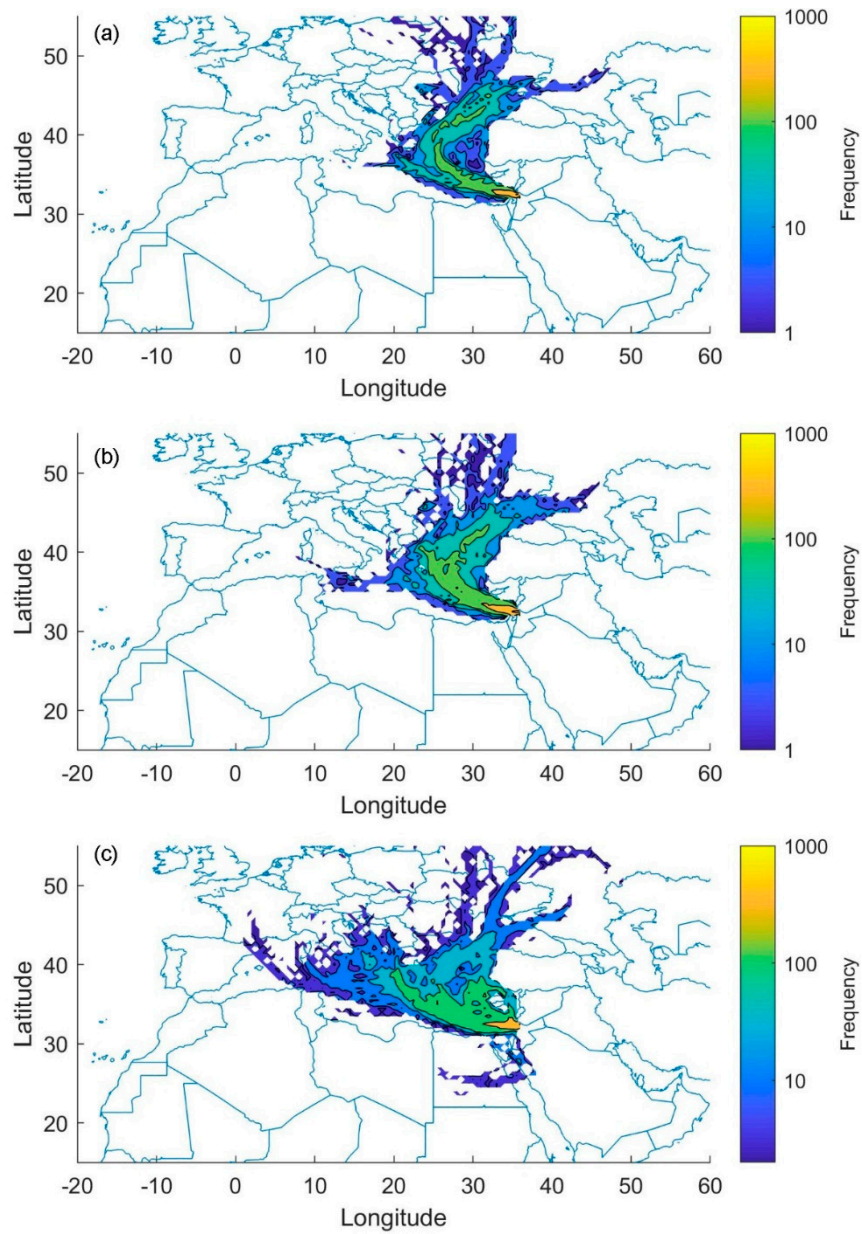


Figure S8. Back trajectories (96 hours) crossing maps during low PM10 concentrations (indicated on Figure S4) at arrival heights (a) 100 meters, (b) 500 meters, and (c) 1500 meters. The arrival location was the campus of the University of Jordan, Amman, Jordan. These maps were generated from the hourly back trajectories during the sampling dates (+ following day).