CHAPTER 9

East Mediterranean Trajectories of Dust-carrying Storms from the Sahara and Sinai

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ABSTRACT

A detailed study of desert dust reaching and settling in Israel indicates that some 25 million tons of dust reaches annually the East Mediterranean Basin mostly settling into the Mediterranean Sea. Computed trajectories of the dust particles showed that the dust originates from the Libyan, Egyptian, Sinai, and Negev deserts. Quantity and mean particle size of the deposited dust in Israel decreases with distance from the desert as dust washed out by rainfall is finer grained than dry dust settling out in stable atmospheric conditions in the desert fringe regions.

9.1 INTRODUCTION

Atmospheric dust penetrates into Israel in the rainy and late spring seasons when barometric cyclones cross the Eastern Mediterranean Basin. Measurements of suspended and deposited dust were carried out over a period of 6 years, mainly from 1968 to 1973, in Jerusalem and at various climatological stations of Israel. Over 1,200 dust samples were obtained by different instruments and methods (Ganor, 1975).

Dust concentration of suspended dust with height during two dust storms in Jerusalem is indicated in Figure 9.1. The grain size distribution of deposited dust at several stations collected during a single dust storm is shown in Figure 9.2. The stations are arranged from South (Avdat and Beer-Sheva) to North (Kefar Gileadi and Mt. Hermon) indicating a decreasing mean size, mainly due to a gradually increasing clay content as the coarse silt population settles out on the fringes of the desert. A similar trend is obtained when total annual deposition is calculated, as has been reported elsewhere (Yaalon and Ganor, 1975). The total annual accretion decreases from the semi-arid to the subhumid Mediterranean region and amounts to some 50 to 200 ton/km^2. This constant accretion is identifiable in the soils and has had a significant effect on the nature of the soils of Israel (Yaalon and Ganor, 1973).

The usual composition of the clay mineral-free fractions in the dust was

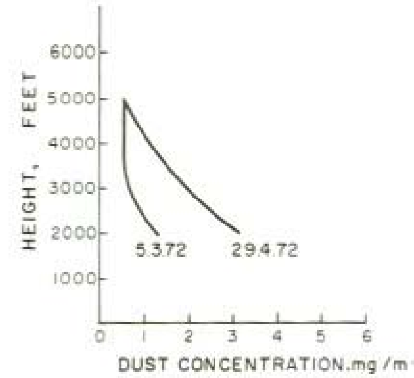

Figure 9.1 Dust concentration at various heights during two dust storms in 1972 in the coastal plain of Israel. The modal near surface concentration during dusty days is 1 mg/m^3 or 10 to 400 times more than during clear days (One foot equals 0.3048 metres)

35%–45% quartz, 30%–40% calcite, 10%–20% dolomite, 5%–10% feldspar and less than 1% halite. Carbonates were common both in the silt and in the clay fraction, some of it as forams and calcareous nanoplankton. Among the clay minerals montmorillonite and mixed layer minerals are dominant, followed in

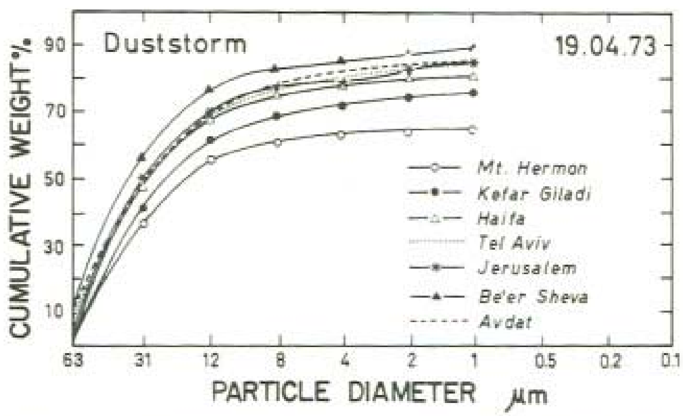

Figure 9.2 Cumulative grain size curves for dust collected during the storm of April 19, 1973. Note the decreasing coarse silt content going from the desertic South (Avdat, Beer Sheva) to the Mediterranean North (Kefar Gileadi, Mt. Hermon)

TABLE 9.1 Estimates of Suspended and Deposited Dust Quantities During Selected Dust Storms in the Eastern Mediterranean Basin

Date of dust storm	Wind direction D (azim.)	Visibility L (km)	Wind speed V (km/h)	Dust concentration C (ton/km^3)	Width of storm W (km)	Height of storm H (km)	Cross section of storm A (km^2)	Duration t (h)	Suspended dust T (10^6 ton)	Deposited dust Q (10^3 ton)	Ratio Q/T (%)
21-3-67	250	0.4	50	(3.0)	1200	(4.0)	4800	48	(34.5)	300	(0.8)
21-3-70	270	4.0	40	(1.0)	800	1.5	1200	25	(1.2)	220	(1.8)
30-3-71	200	0.3	35	10.0	1200	3.0	3600	20	25.2	460	(1.8)
7-11-71	260	4.0	20	0.6	1000	2.5	2500	30	0.9	60	6.6
5-3-72	270	2.0	30	2.0	1200	2.5	3000	36	6.5	120	1.8
29-4-72	270	0.8	40	3.0	1000	4.0	4000	40	19.2	160	0.8
5-5-72	270	7.0	60	1.0	1000	5.0	5000	43	14.4	16	0.1
Short duration storm		3.0	50	1.0	1000	1.5	1500	10	0.75	20	2.7
Long duration storm		0.3	60	1.0	1000	3.0	3000	50	9.0	400	4.4

D = Wind direction of dust storm in Jerusalem
L = Minimum horizontal visibility during dust storm
V = Maximal wind speed during dust storm
Q = Estimate of deposited dust quantities over Israel based mainly on measurements in Jerusalem
Q/T = Proportion of dust deposited over Israel in relation to total estimated quantity of suspended dust over the Eastern Mediterranean Basin during the dust storm

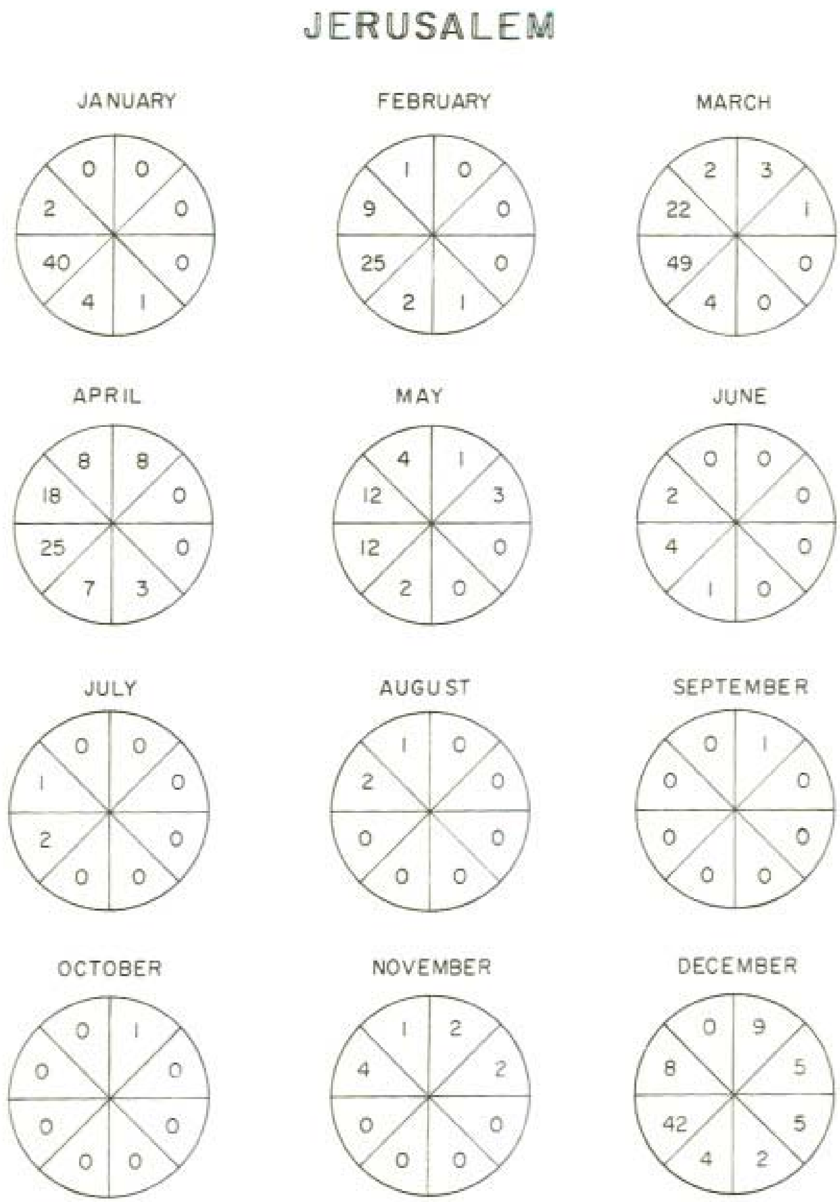

Figure 9.3 Frequency of wind directions during duststorm days (visibility ⩽ 5 km) in Jerusalem, 1957–71. Numbers are total number of observations

abundance by kaolinite, some illite and palygorskite. The angular shapes and rough surface morphologies clearly indicate a desert weathering and origin of the mineral particles.

9.2 TOTAL QUANTITIES TRANSPORTED

Estimates on the total quantity of dust carried during selected dust storms have been made on the basis of observations of their areal extent, visibility, dust concentration, wind speed and duration of the storm, as indicated in Table 9.1.

It can be seen that during a short duration storm (less than one day) about one million tons of suspended dust is brought into the East Mediterranean Basin. During the more exceptional long duration storms (several days) the amount increases to about 10 million tons of dust and exceptionally to two or three times this amount.

The monthly frequency of 368 dusty days in Jerusalem, by wind direction, is shown in Figure 9.3, clearly indicating the dominance (80%) of the south-western and western dust storms during the four months December to March. Easterly dust storms are very exceptional (Yaalon and Ginzbourg, 1966). The average number of dust storms per year is 10 to 12 (Ganor, 1975; Katsnelson, 1970).

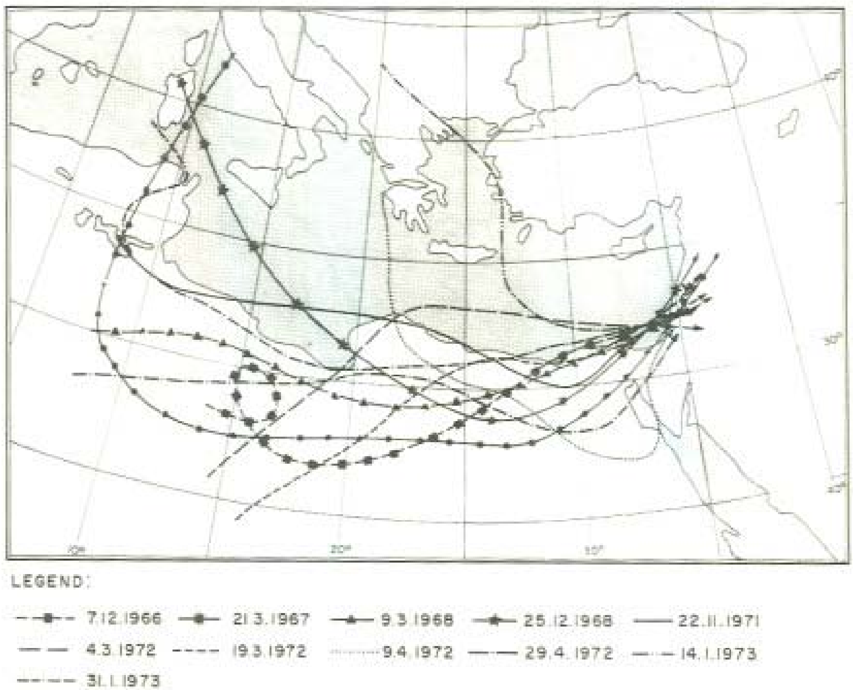

Figure 9.4 Particle trajectories for selected regional dust storms showing the calculated East Mediterranean trajectories

much larger amount must have been deposited in the Saharan and other desert areas. This overall figure is then comparable, though probably still smaller than the estimated annual westward transport from the Sahara of some 200 million tons (Junge, 1979).

9.3 THE DUST TRAJECTORIES

The actual trajectories of the dust carrying storms were calculated (Djuric, 1961; AWS, 1968) and are shown for a number of storms in Figure 9.4.

Earth satellite photos were also used to observe the source area and extent of the dust plumes (Figure 9.5). Both the calculated trajectories and a meteorological analysis of synoptic pressure-patterns clearly indicate that the Libyan, Egyptian, Sinai, and Negev deserts are the main source areas of the dust reaching the Eastern Mediterranean.

Figure 9.5 Aereal extent of the March 21, 1967 dust storm, as traced from satellite photos, superimposed over the synoptic map

The meteorological analysis of different synoptic pressure-pattern types showed two characteristic causes of dust storms. Western dust storms were brought about by barometric cyclones passing the Eastern Mediterranean Basin (Cyprus and 'Sahara' type depressions), while the rare eastern dust storms occurred when a Red Sea trough penetrated from the south or when a small depression developed in the Jordan Rift Valley and northern Negev. Dust particles become air-borne when atmospheric conditions are unstable and when strong turbulent winds are in existence. These conditions occur when the westerly winds pass over the wide flat wadis with their accumulated flood deposits (Yaalon, 1969). Part of the dust is redeposited locally after a relatively short transport but most is carried to the fringes of the desert (Yaalon and Dan, 1974). Settling of the dust is effected by precipitation and also in stable atmospheric conditions.

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