# THE GEOGRAPHY OF DUST STORMS

Volume 2

BY

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A Thesis submitted for the degree of

Doctor of Philosophy

Trinity Term, 1986

# FIGURES

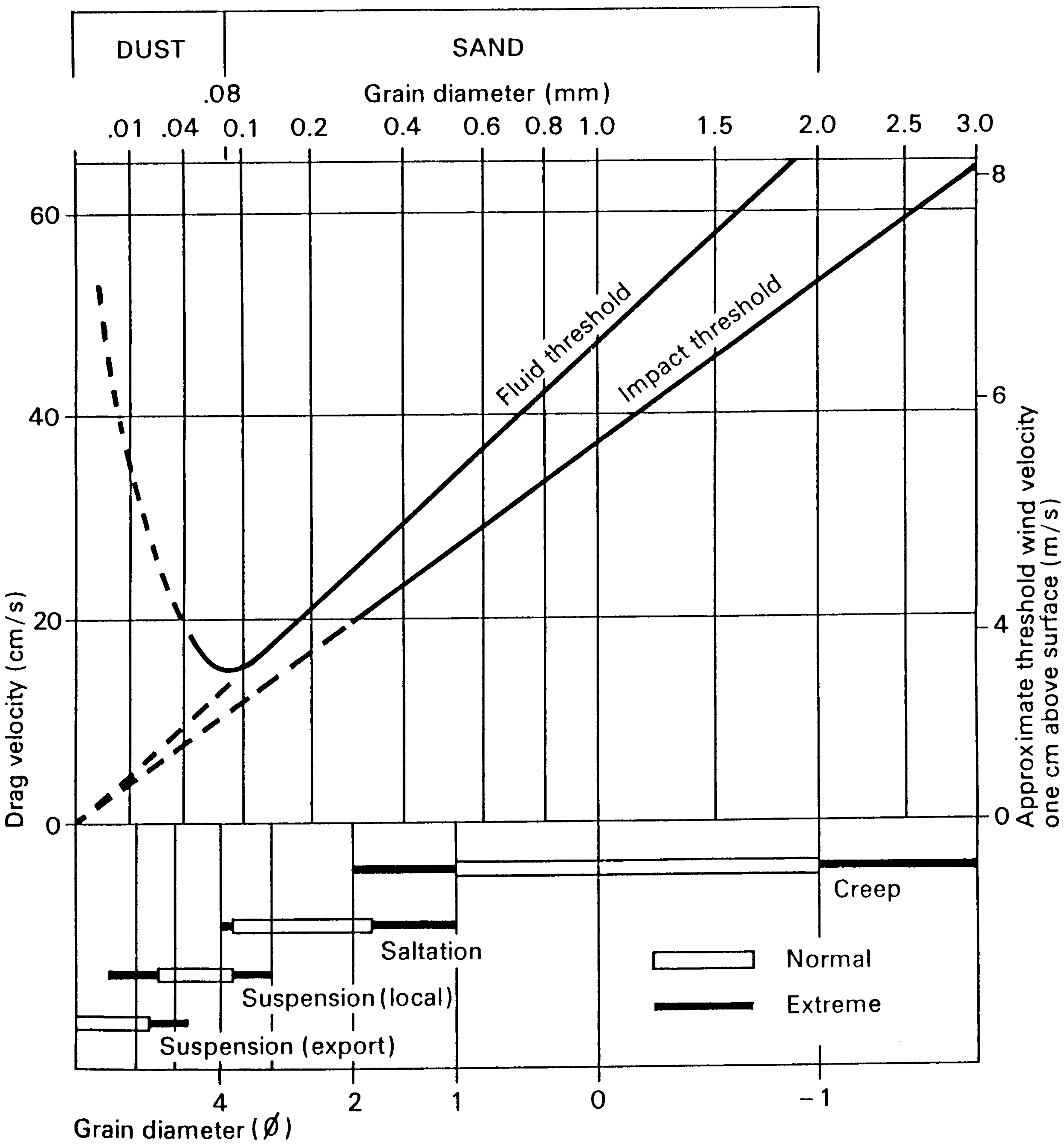



Figure 2.1 Relationship between grain size, fluid & impact threshold wind velocities, & characteristic modes of aeolian transport (after Cooke et al 1983)

| EROSIVITY | | ERODIBILITY | | | |
|---|---|---|---|---|---|
| Wind Variables | | Debris Variables | | Surface Variables | |
| Velocity | - | Particle Size | +<br>- | Vegetation - residue | + |
| | | | | height | + |
| Frequency | - | Soil Clods and Cohesive Properties | + | orientation | |
| | | | | density | + |
| Duration | - | | | fineness | + |
| | | | | cover | + |
| Magnitude | - | Abradability | - | Soil and Moisture | + |
| Shear | - | Transportability | - | Surface Roughness | + |
| Turbulence | - | Organic Matter | + | Surface Length - (distance from shelter) | - |
| | | | | Surface Slope | +<br>- |

Figure 2.2 Key variables in the wind-erosion system. Wind erosion will normally be reduced if the values of variables are increased (+) and if other variables are reduced (-).

After Cooke et al (1983)

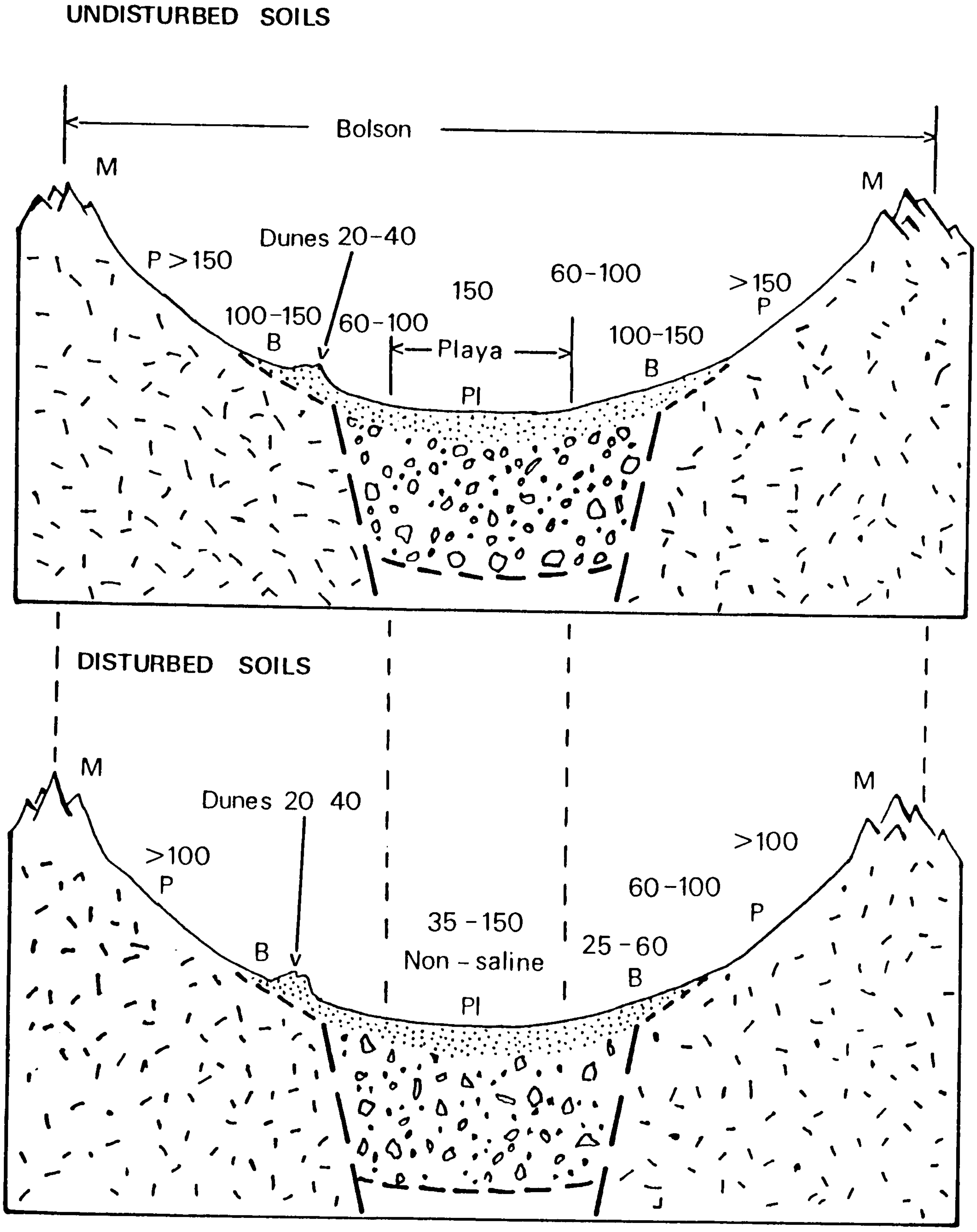



Figure 2.3 Threshold friction velocity (in cm/s) relative to desert geomorphology (after Gillette 1982)

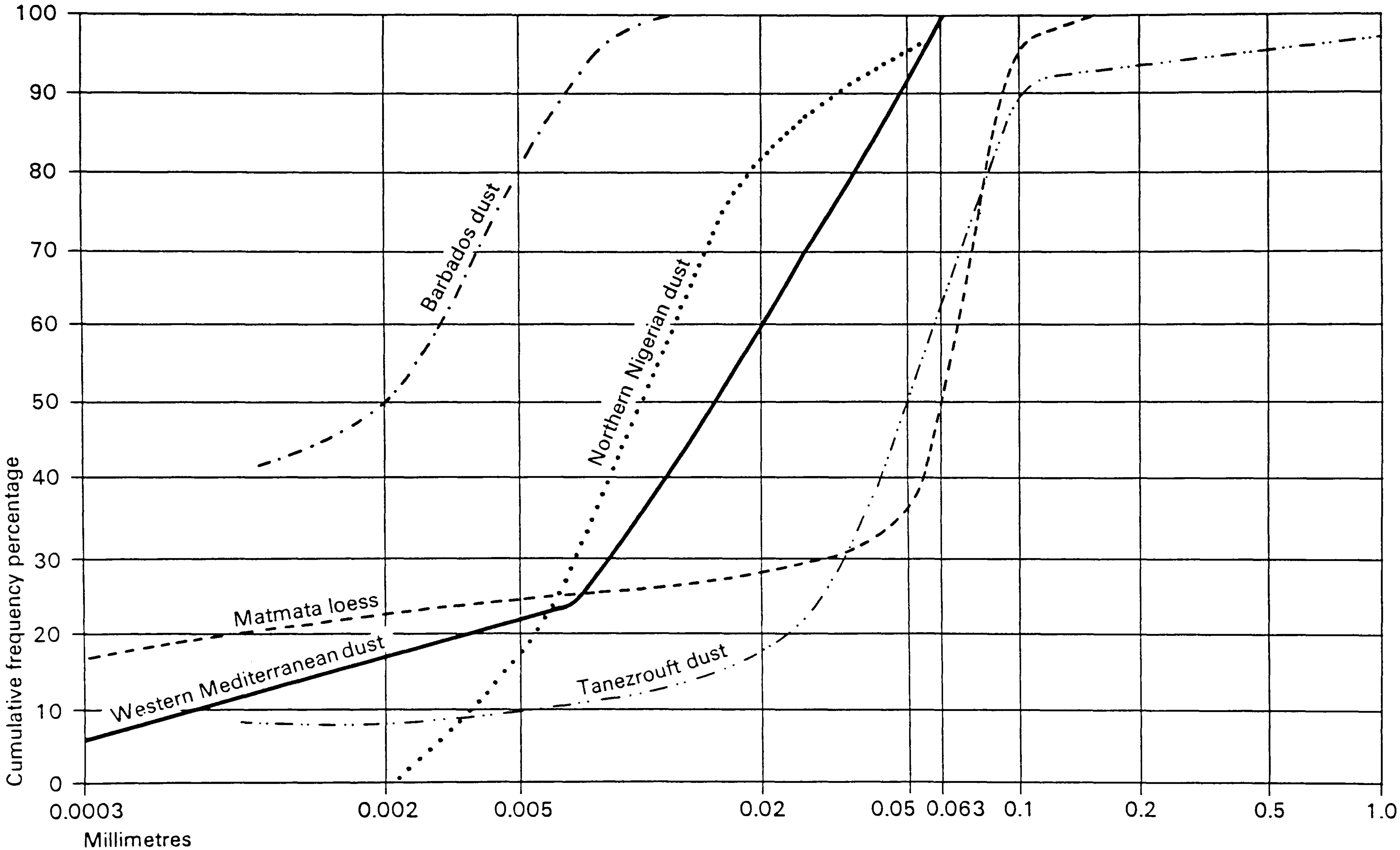



Figure 2.4 Comparison of cumulative frequency curves of dust & loess (after Coudé-Gaussen & Rognon 1983)

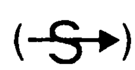
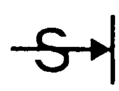
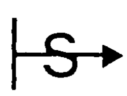
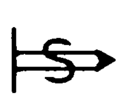
| Code figure ww | Symbol | Description |
|---|---|---|
| 05 | ∞ | Haze |
| 06 | S | Widespread dust in suspension in the air, not raised by wind at or near the station at the time of observation |
| 07 |  | Dust or sand raised by wind at or near the station at the time of observation , but no well-developed dust whirl(s) and no duststorm or sandstorm seen |
| 08 |  | Well-developed dust whirl(s) or sand whirl(s) seen at or near the station during the preceding hour or at the time of observation, but no duststorm or sandstorm |
| 09 |  | Duststorm or sandstorm within sight at the time of observation or at the station during the preceding hour |
| 30 |  | Slight or moderate duststorm or sandstorm – has decreased during the preceding hour |
| 31 |  | Slight or moderate duststorm or sandstorm – no appreciable change during the preceding hour |
| 32 |  | Slight or moderate duststorm or sandstorm – has begun or has increased during the preceding hour |
| 33 |  | Severe duststorm or sandstorm – has decreased during the preceding hour |
| 34 |  | Severe duststorm or sandstorm – no appreciable change during the preceding hour |
| 35 |  | Severe duststorm or sandstorm – has begun or has increased during the preceding hour |
| 98 |  | Thunderstorm combined with duststorm or sandstorm at time of observation |

Figure 2.5 WMO SYNOP Present Weather codes for dust events

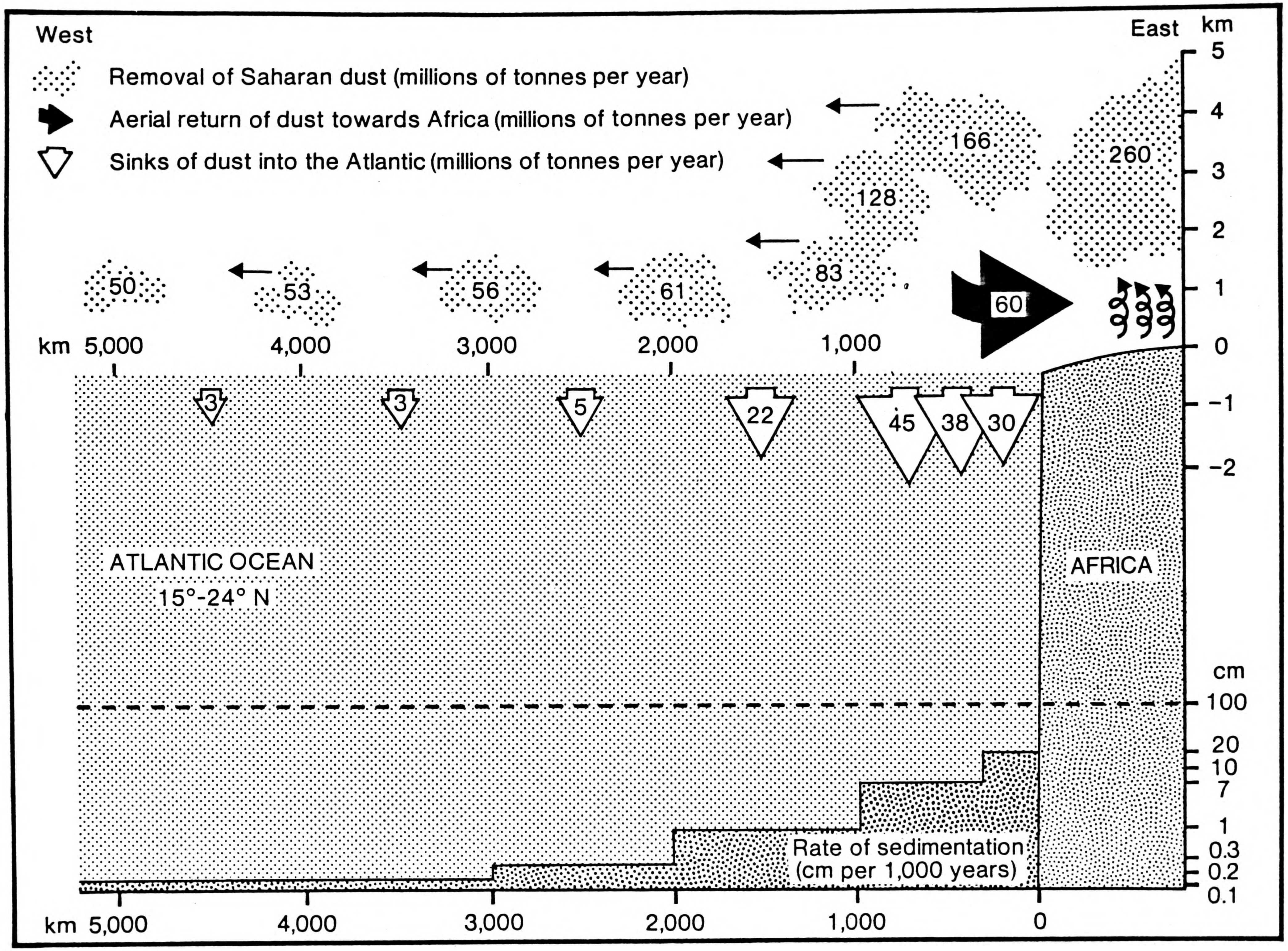



Figure 2.6 Aeolian transatlantic sediment budgets for the Sahara (modified after the works of Coudé-Gaussen & others)

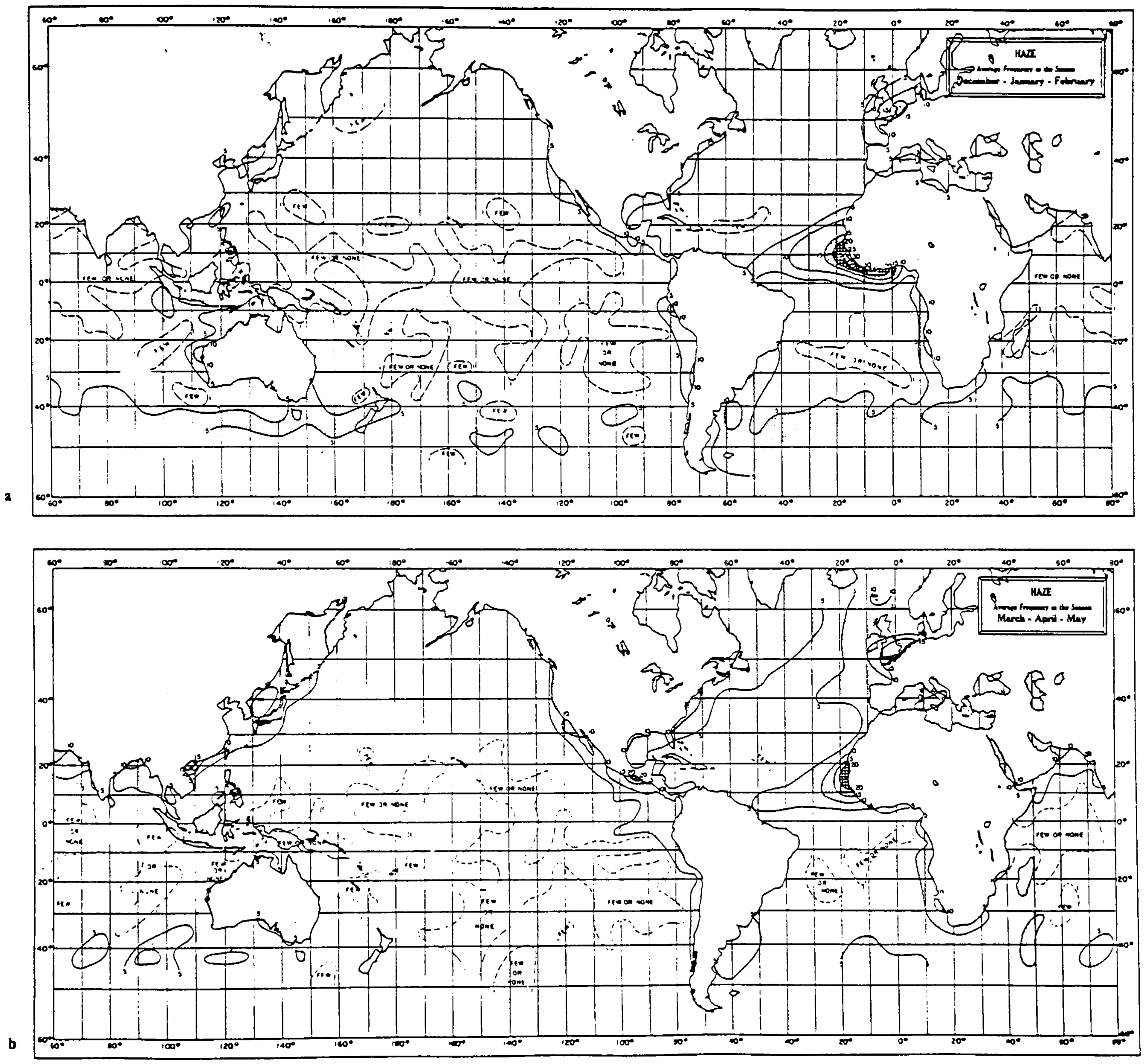
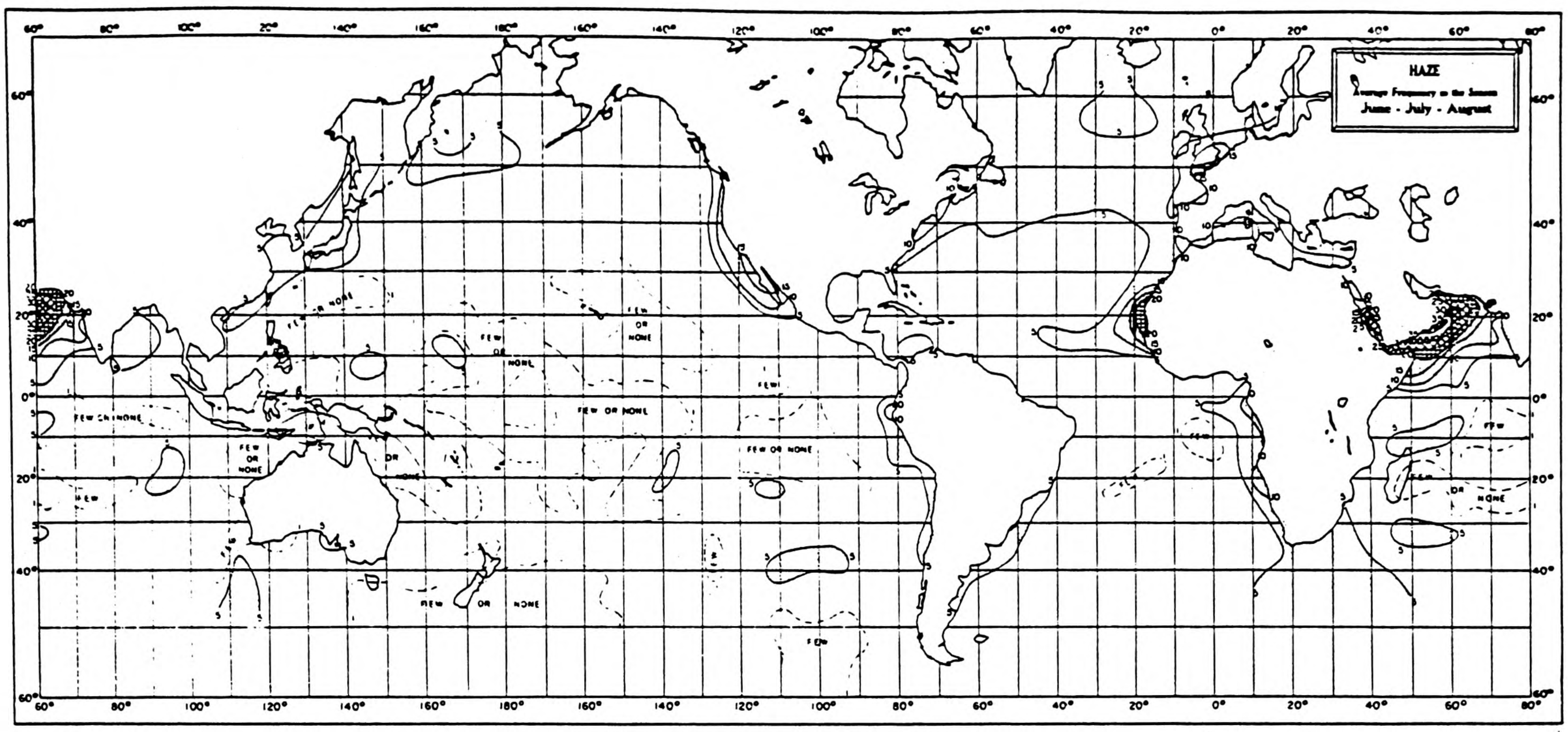



Figure 3.1 Frequency of occurrence of haze at sea by season. Numbers indicate percentage of meteorological observations from ships that report presence of haze at time of observation (after McDonald 1938). (a) December, January, February; (b) March, April, May; (c) June, July, August; (d) September, October, November

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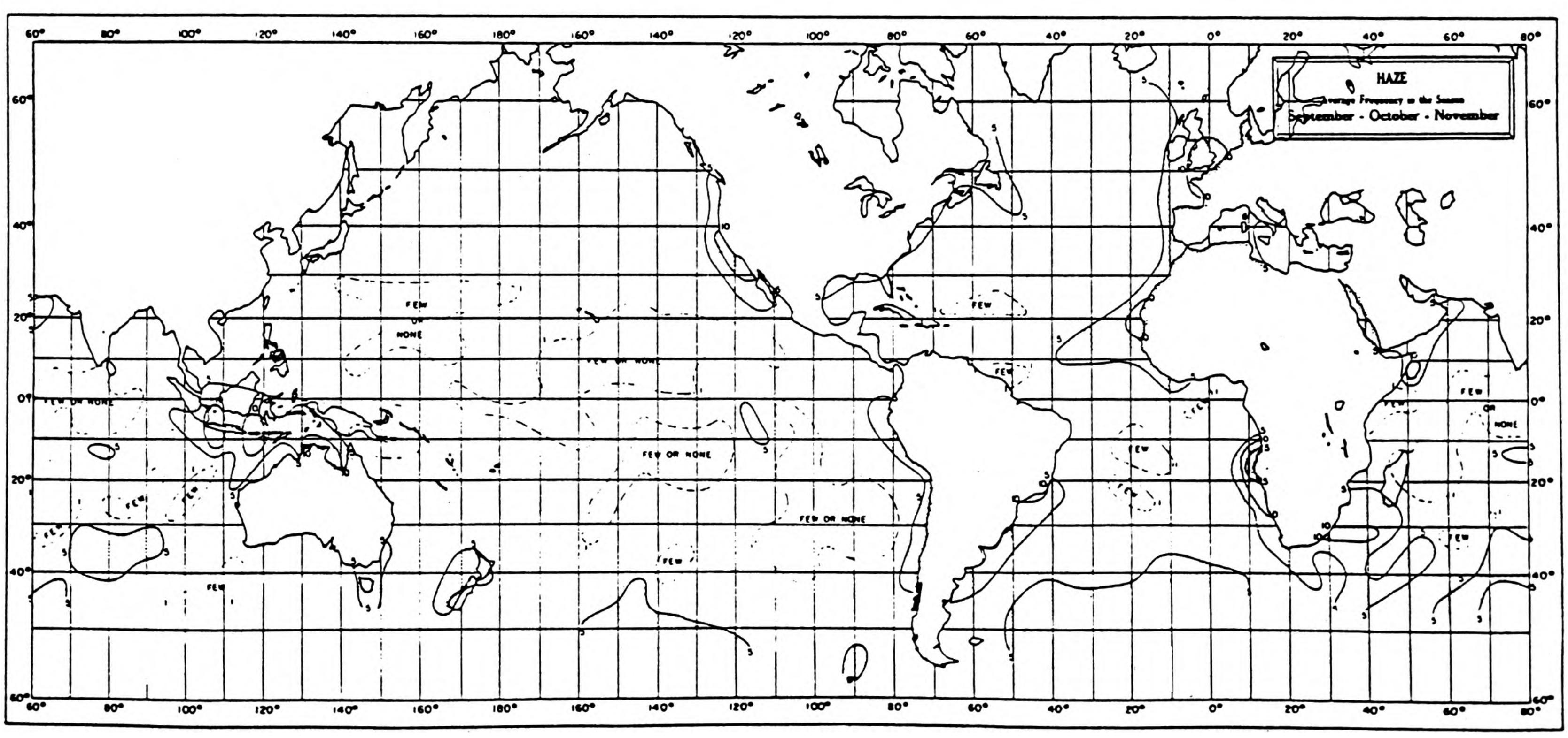


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Figure 3.1 continued

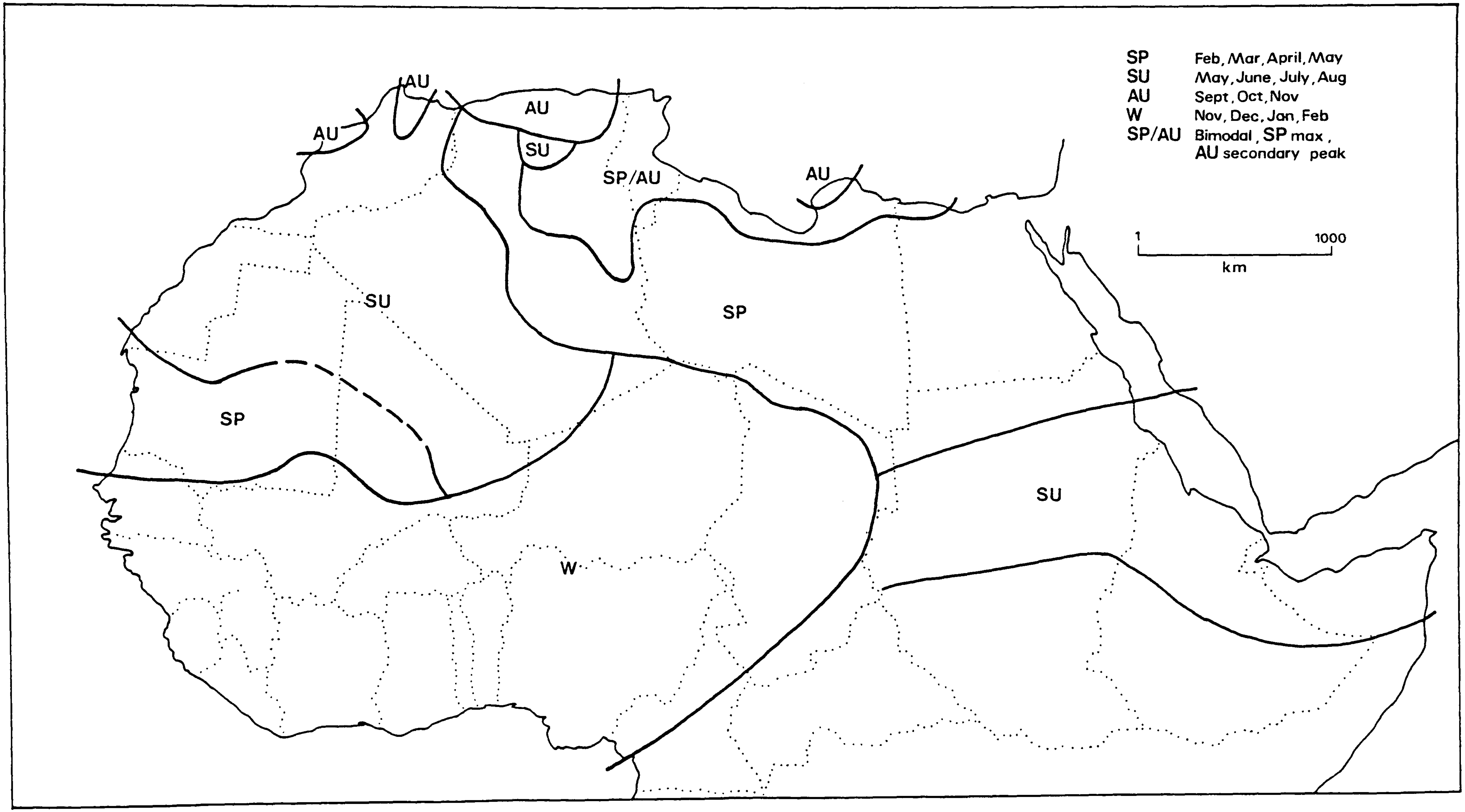



Figure 3.2 Seasonality of dust events in North Africa

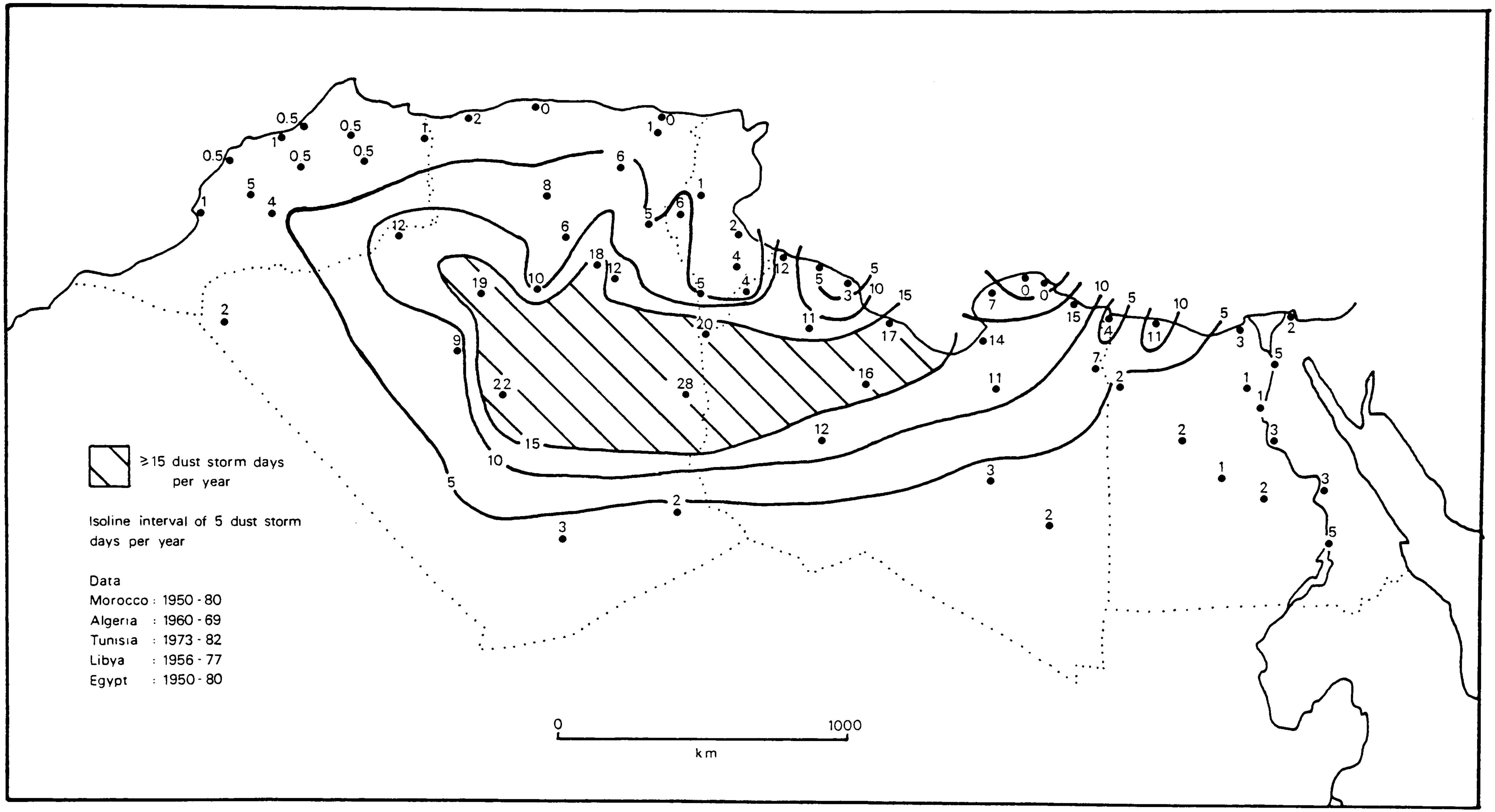



Figure 3.3 Distribution of dust storms in the northern Sahara

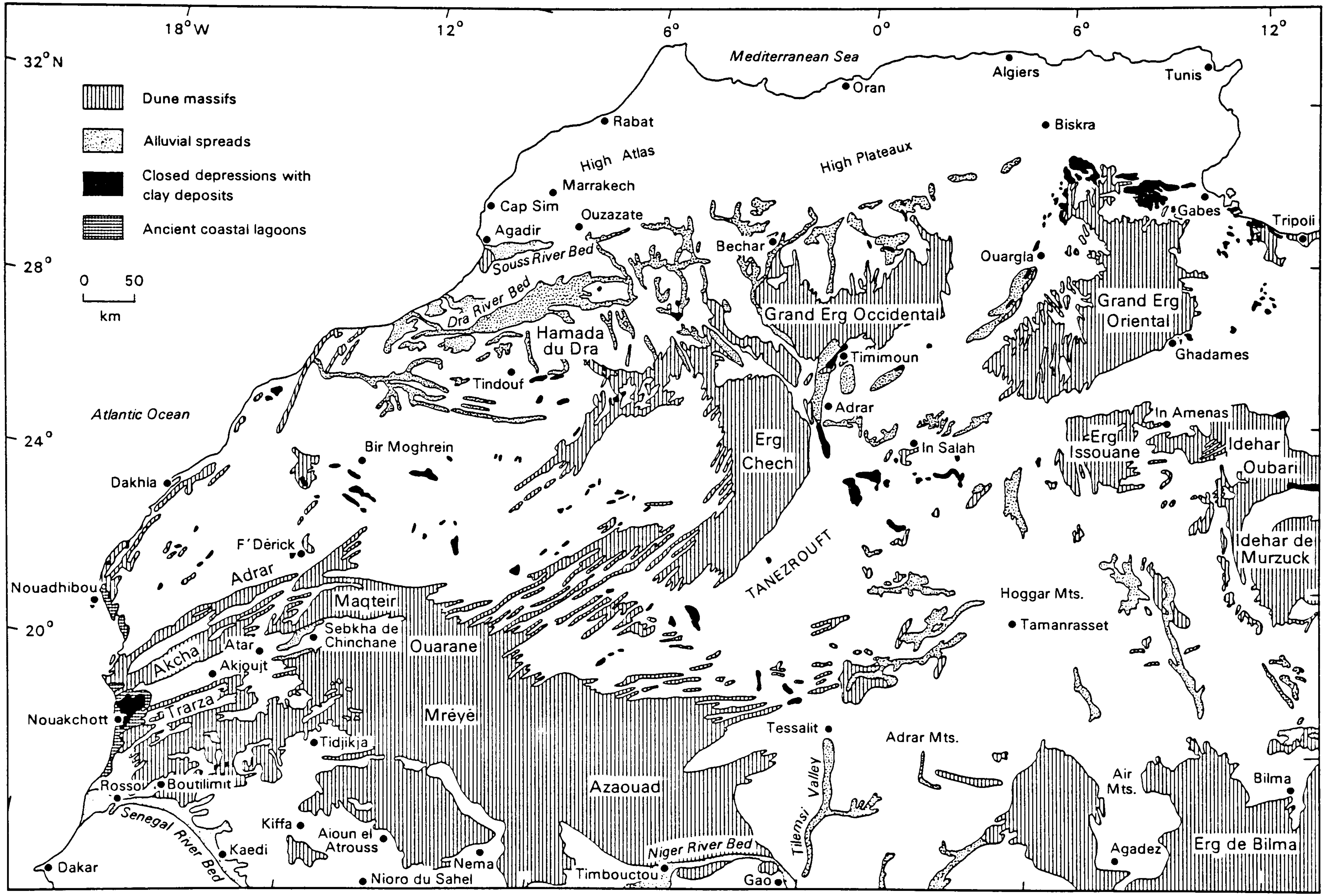



Figure 3.4 Geomorphological environments favourable for the production of dust in West Africa (after Oliva et al 1983)

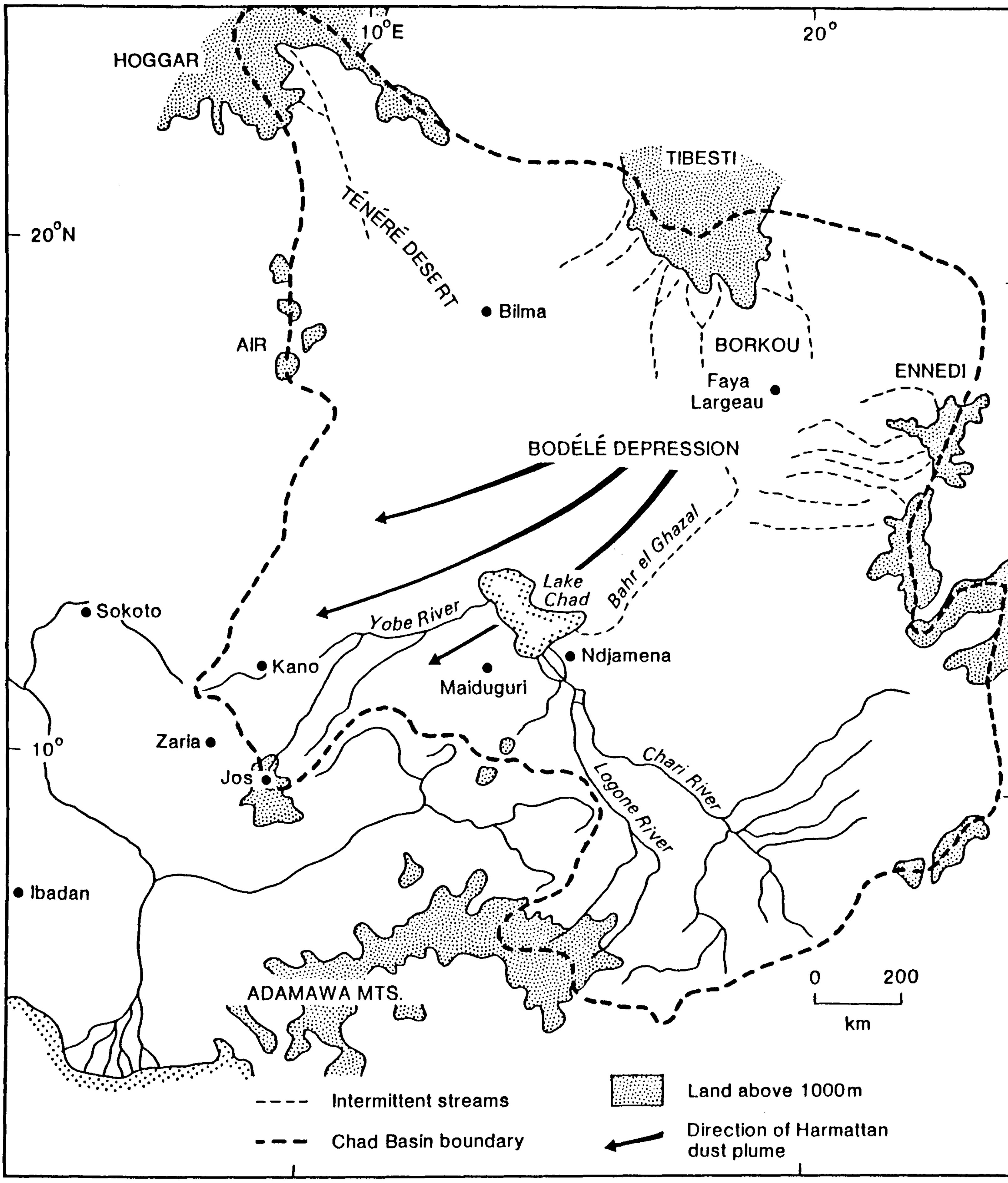



Figure 3.5 The Chad Basin

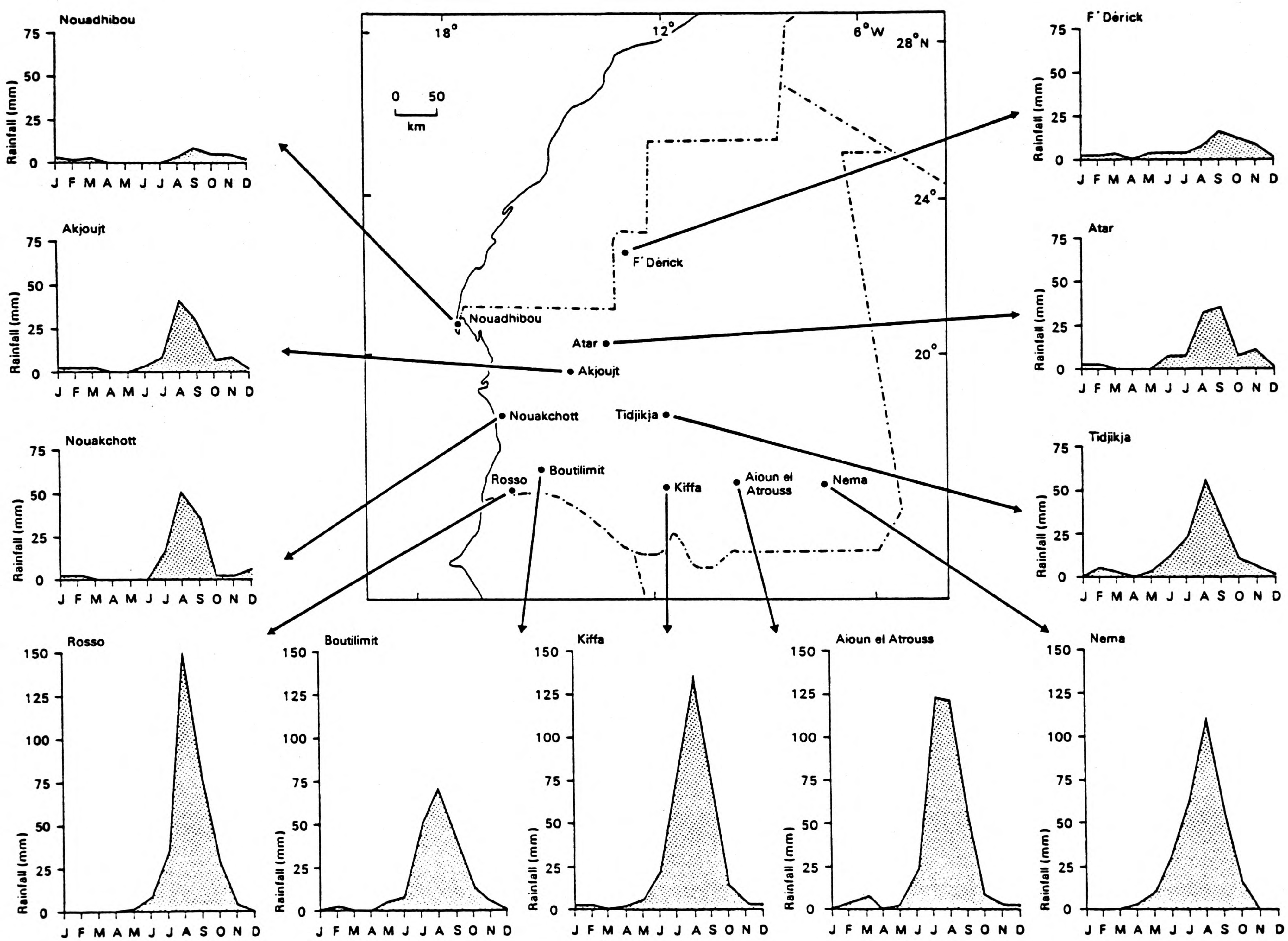



Figure 3.6 Seasonality of rainfall in Mauritania

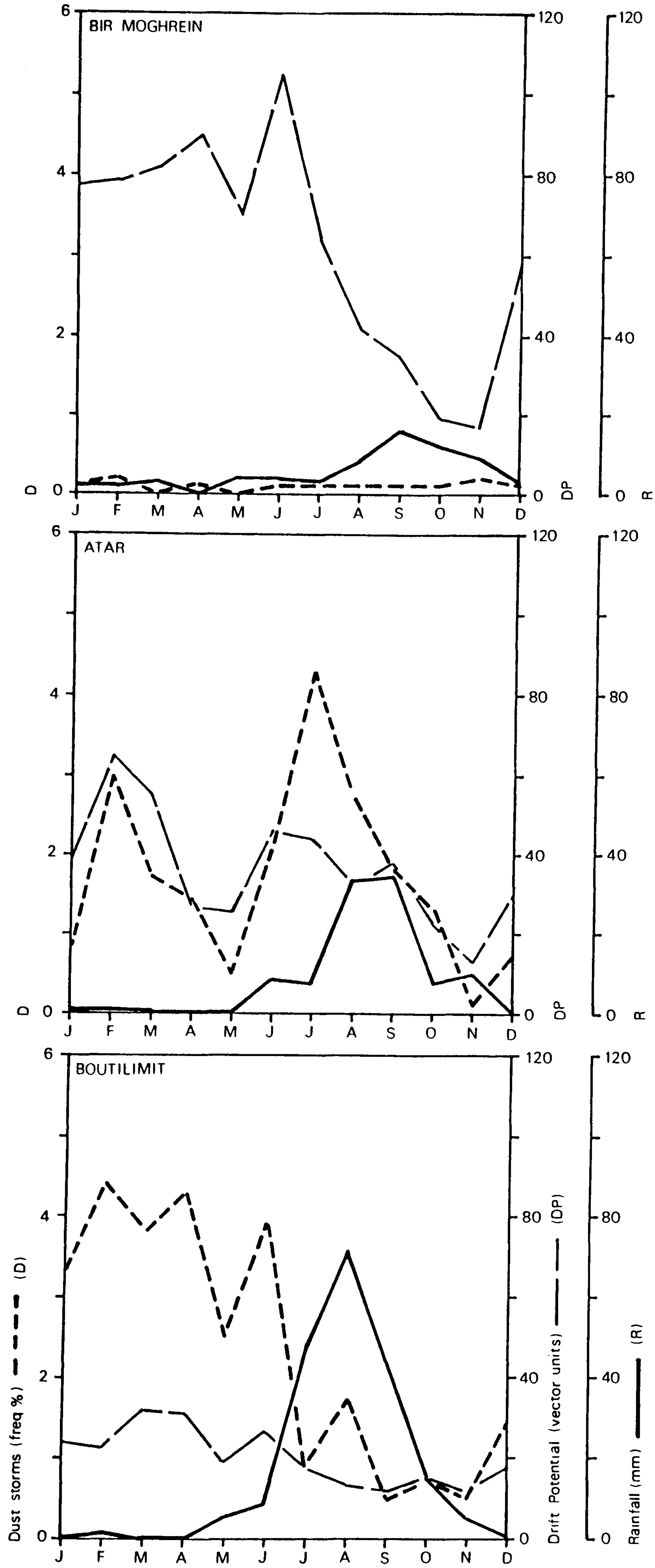



Figure 3.7 Monthly dust storm frequencies, rainfall totals & Drift Potentials for Bir Moghrein, Atar & Boutilimit, Mauritania

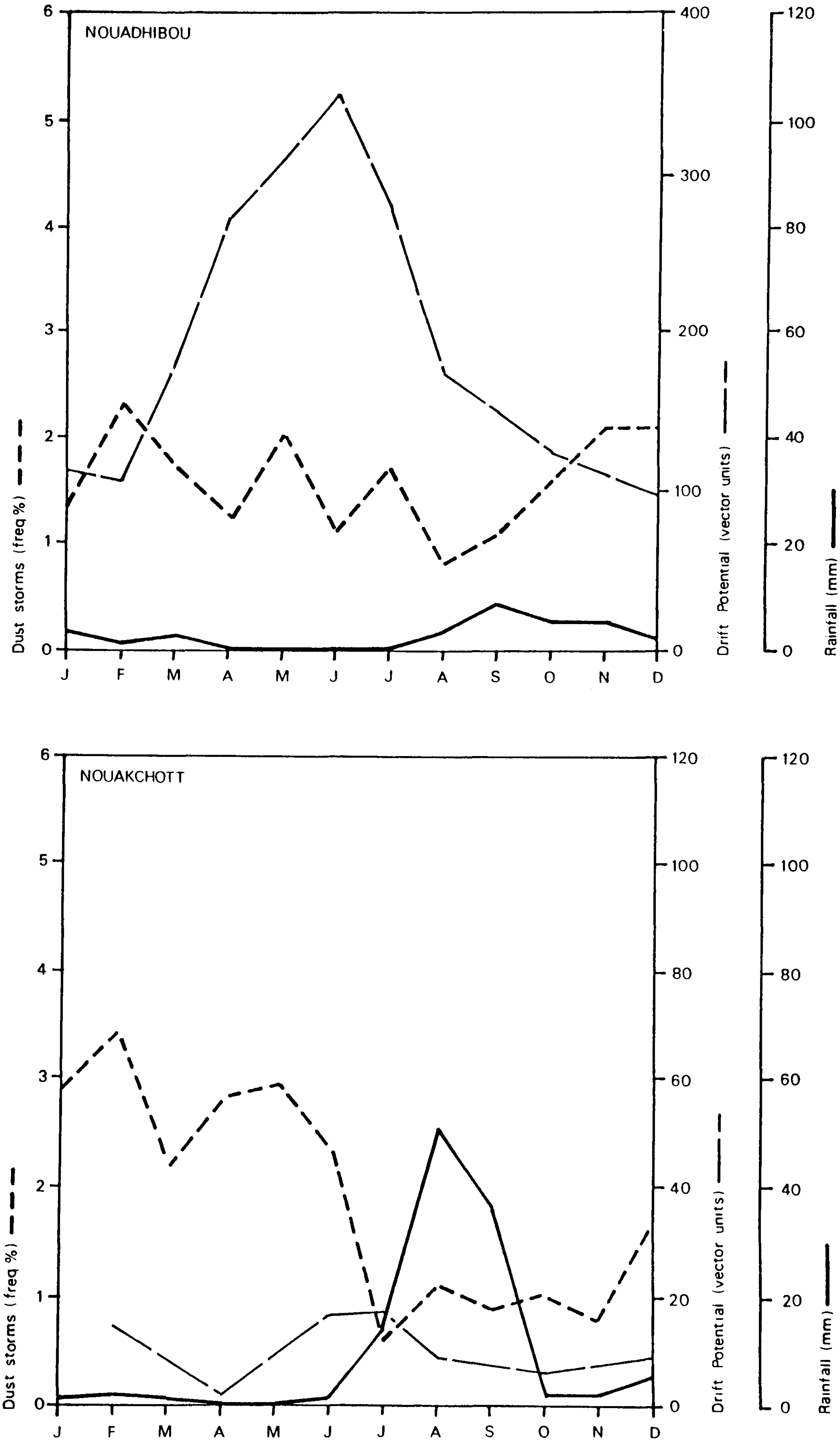



Figure 3.8 Monthly dust storm frequencies, rainfall totals & Drift Potentials for Nouadhibou & Nouakchott, Mauritania

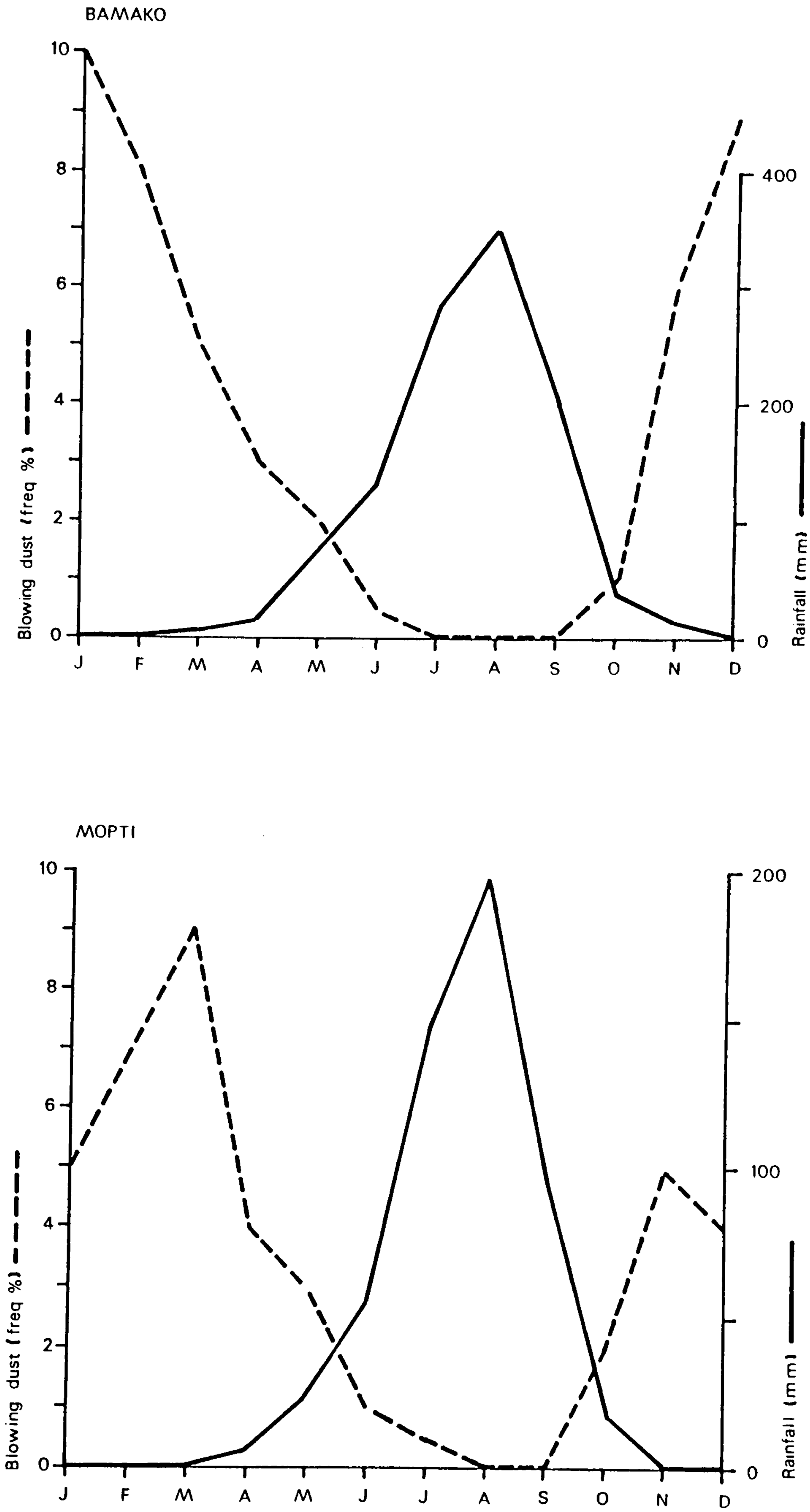



Figure 3.9 Monthly blowing dust frequencies & rainfall totals for Bamako & Mopti, Mali

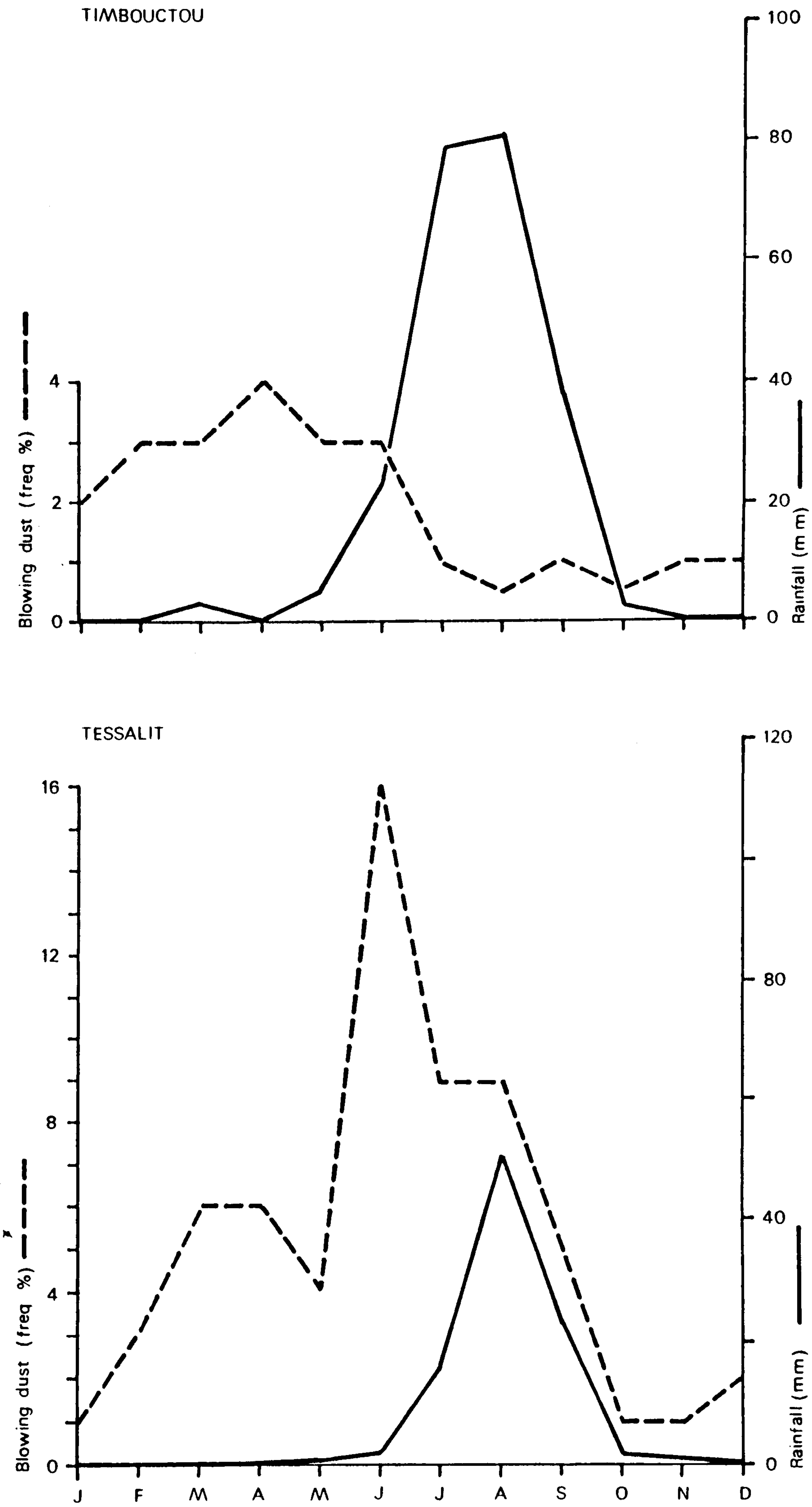



Figure 3.10 Monthly blowing dust frequencies & rainfall totals for Timbouctou & Tessalit, Mali

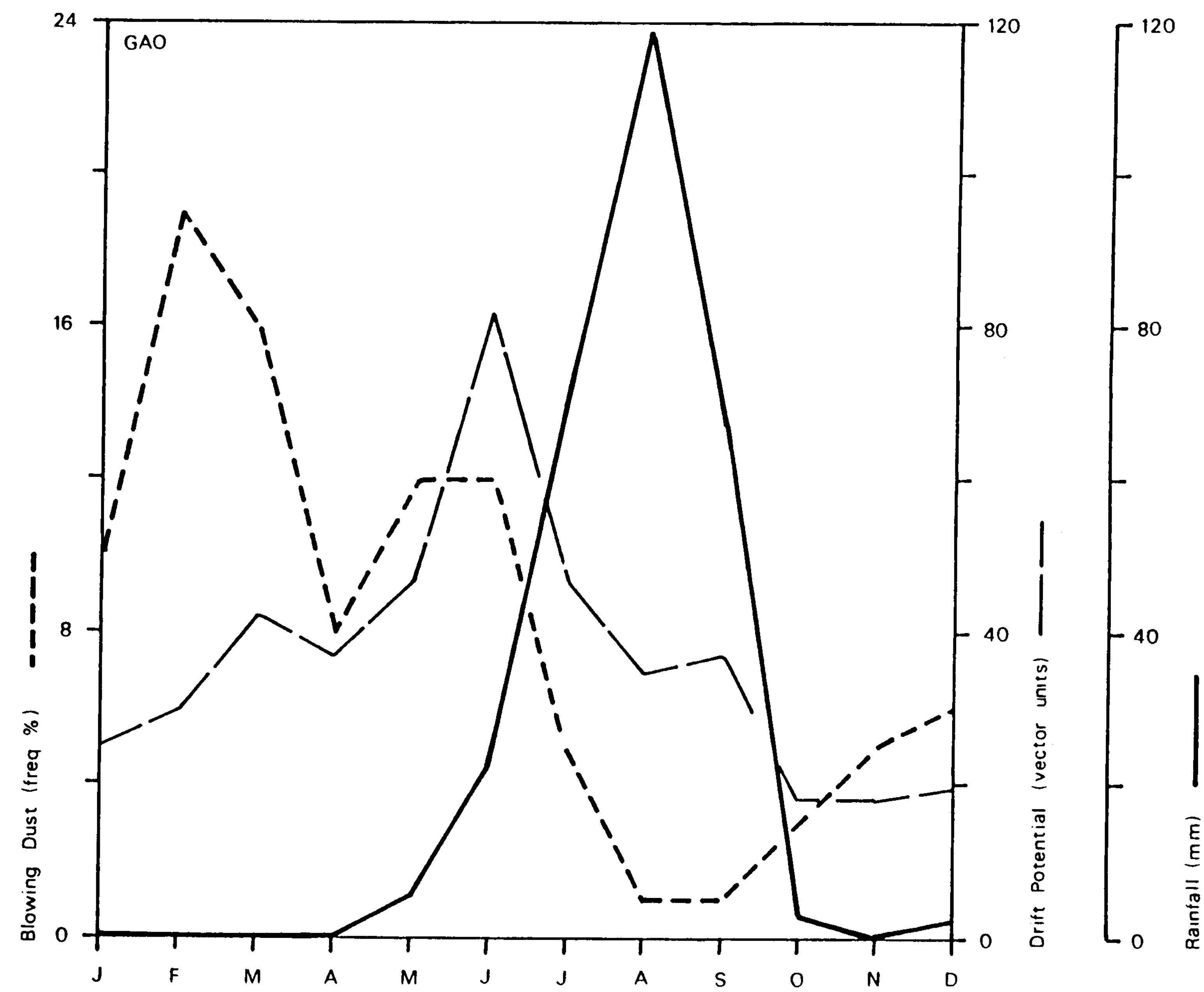



Figure 3.11 Monthly blowing dust frequencies, rainfall totals
& Drift Potentials for Gao, Mali

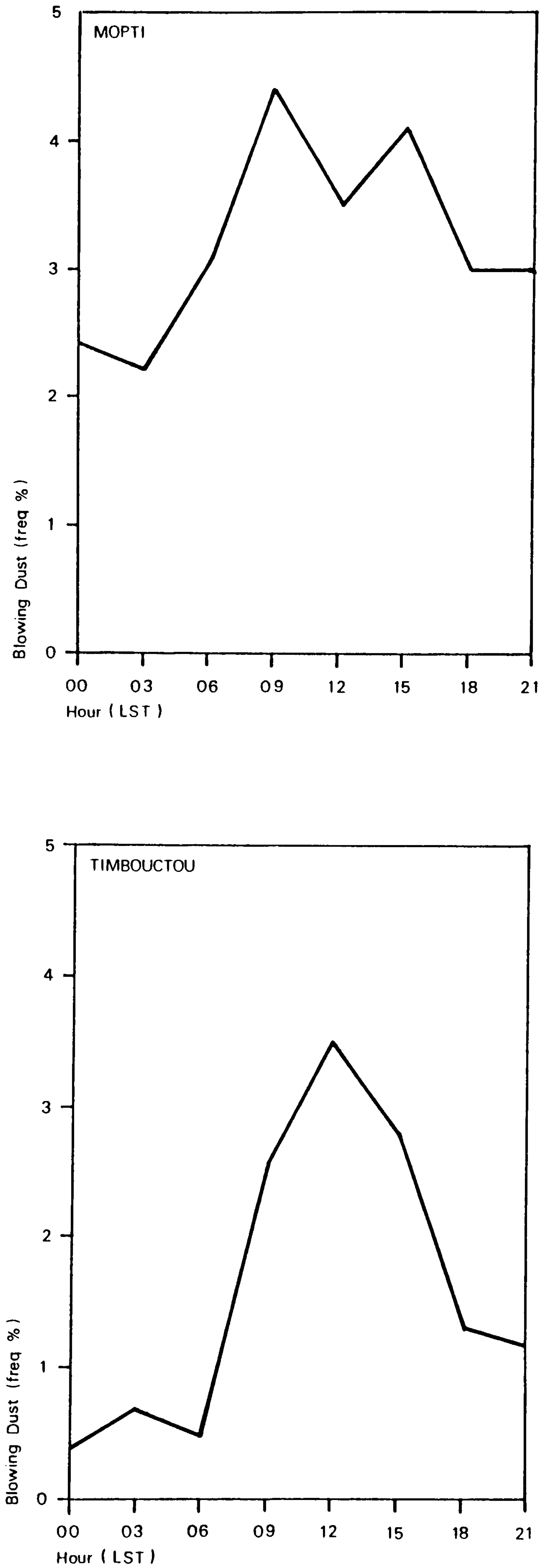



Figure 3.12 Diurnal variation of blowing dust at
Mopti & Timbouctou, Mali

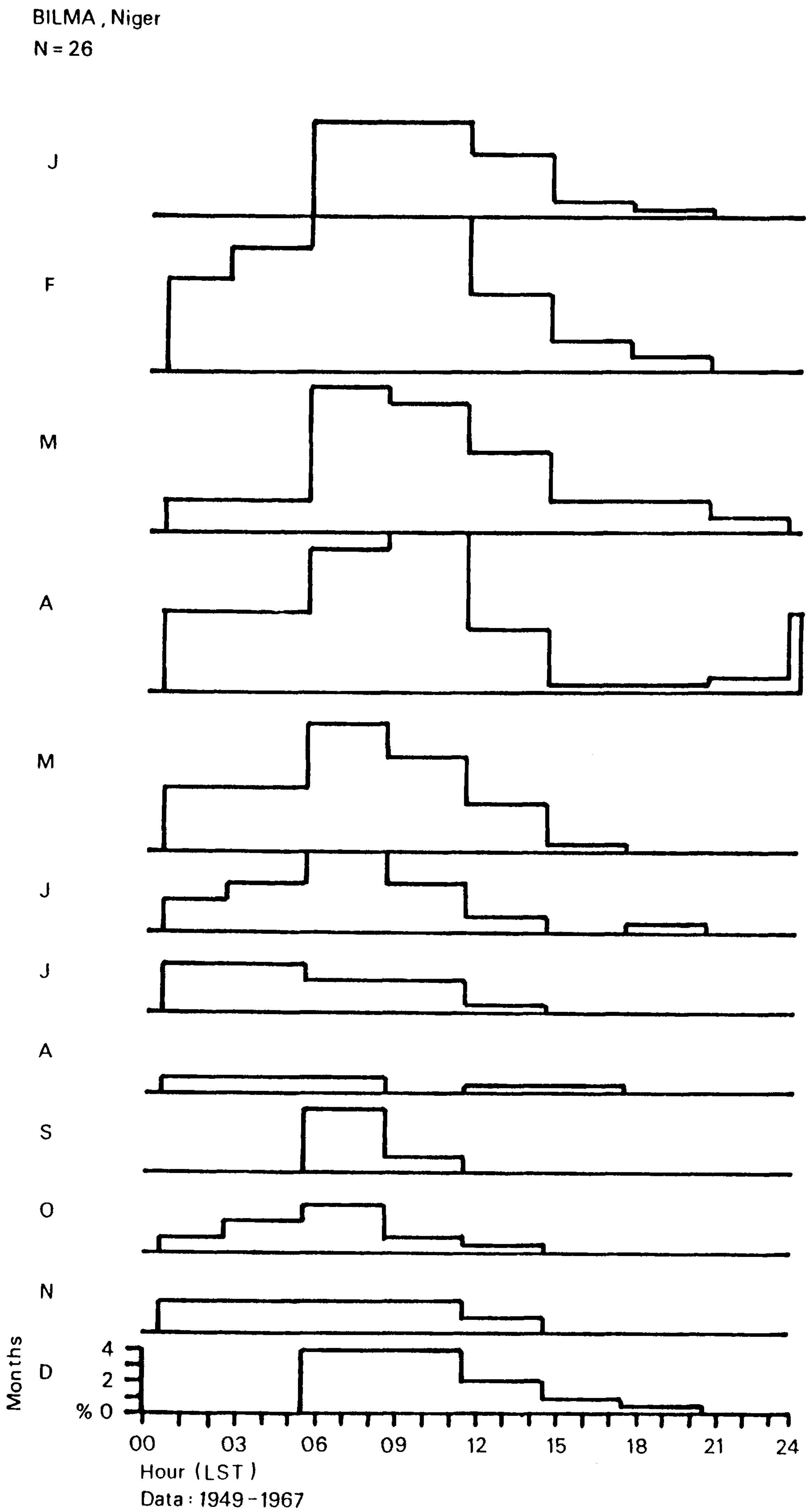



Figure 3.13 Diurnal arithmetic mean frequency percent by Month of visibility reduced to less than 11km by blowing dust at Bilma, Niger

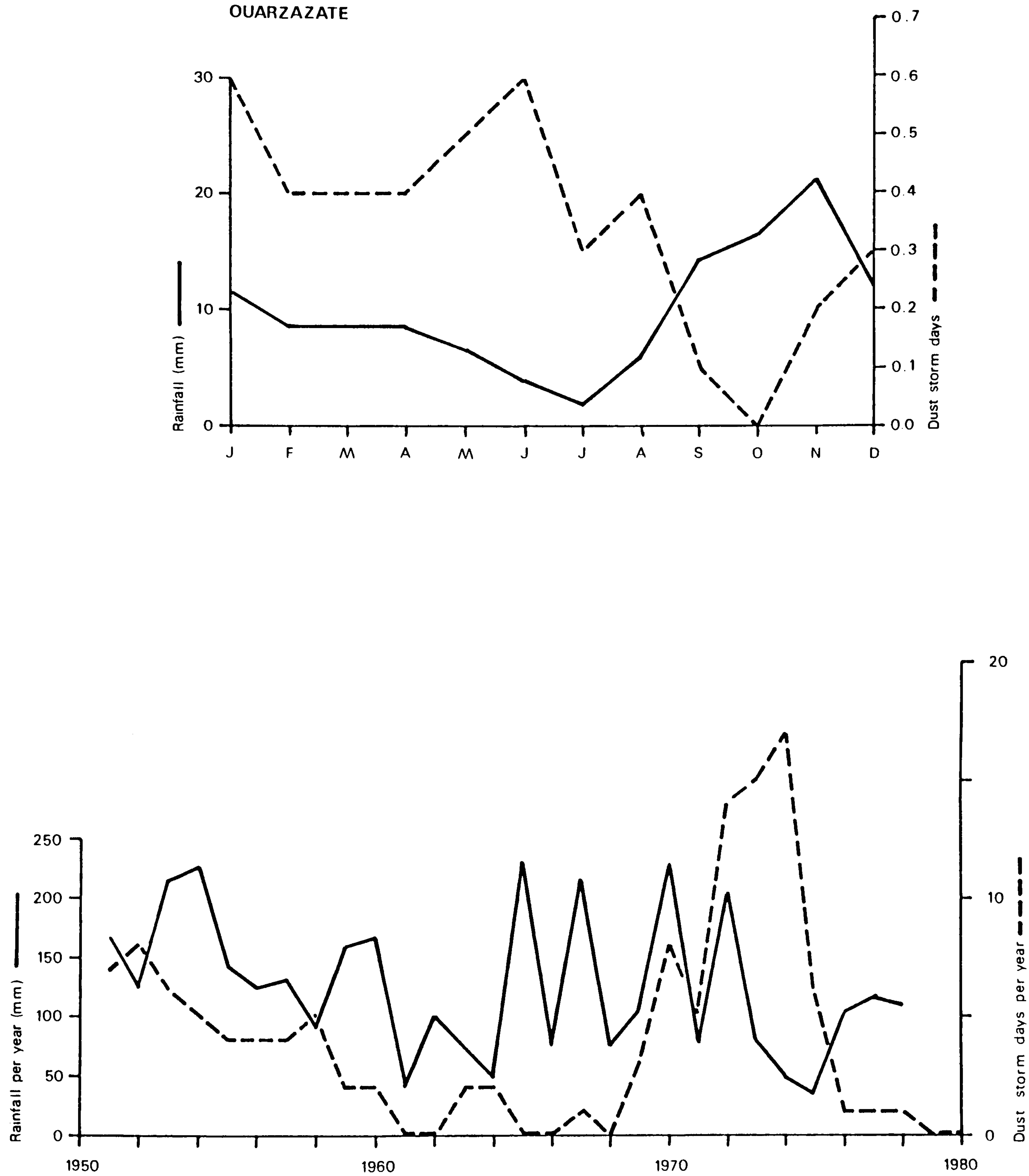



Figure 3.14 Monthly dust storm frequencies & rainfall totals, & annual totals (1951-80) for Ouarzazate, Morocco

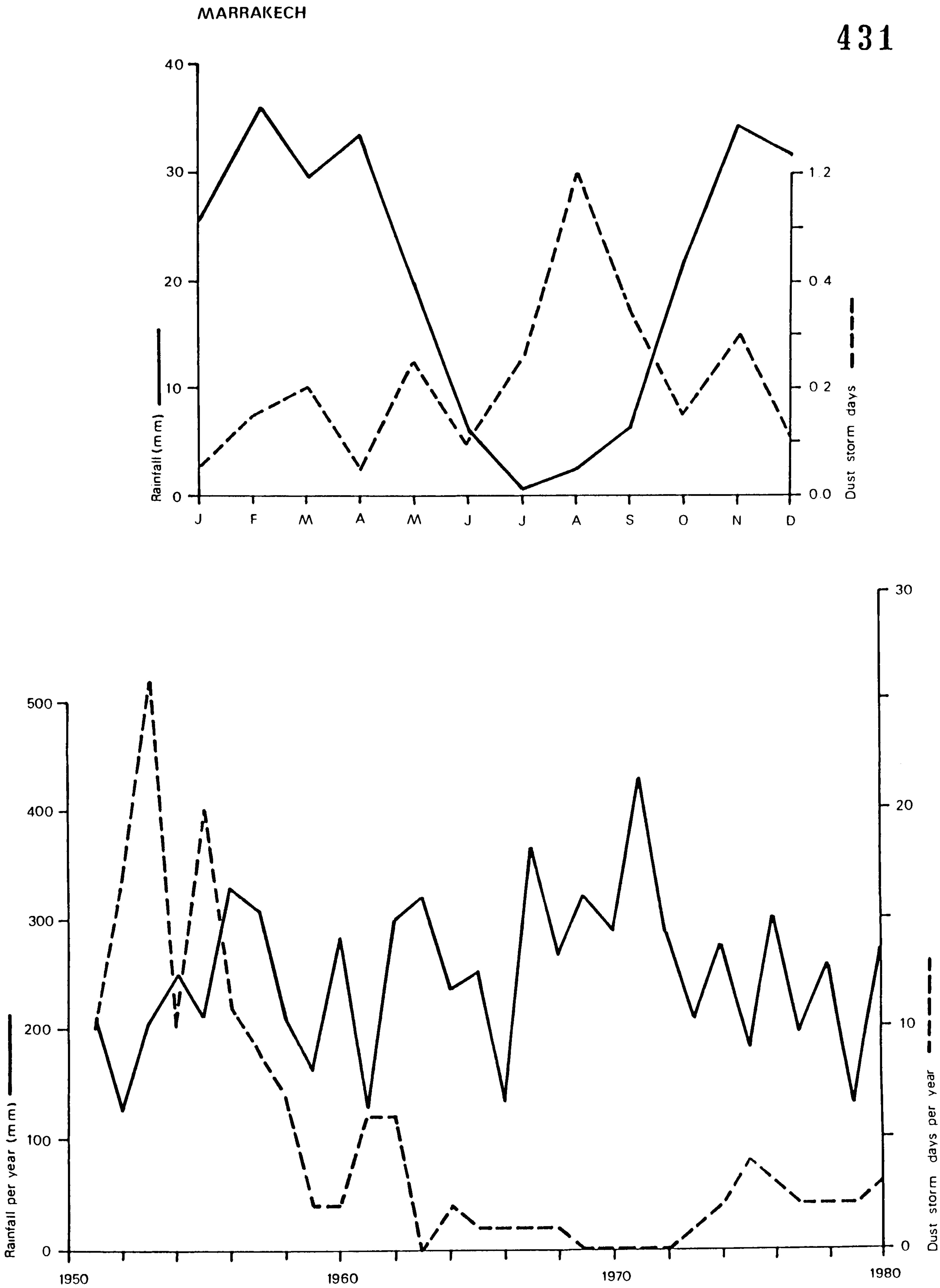



Figure 3.15 Monthly dust storm frequencies & rainfall totals, & annual totals (1951-80) for Marrakech, Morocco

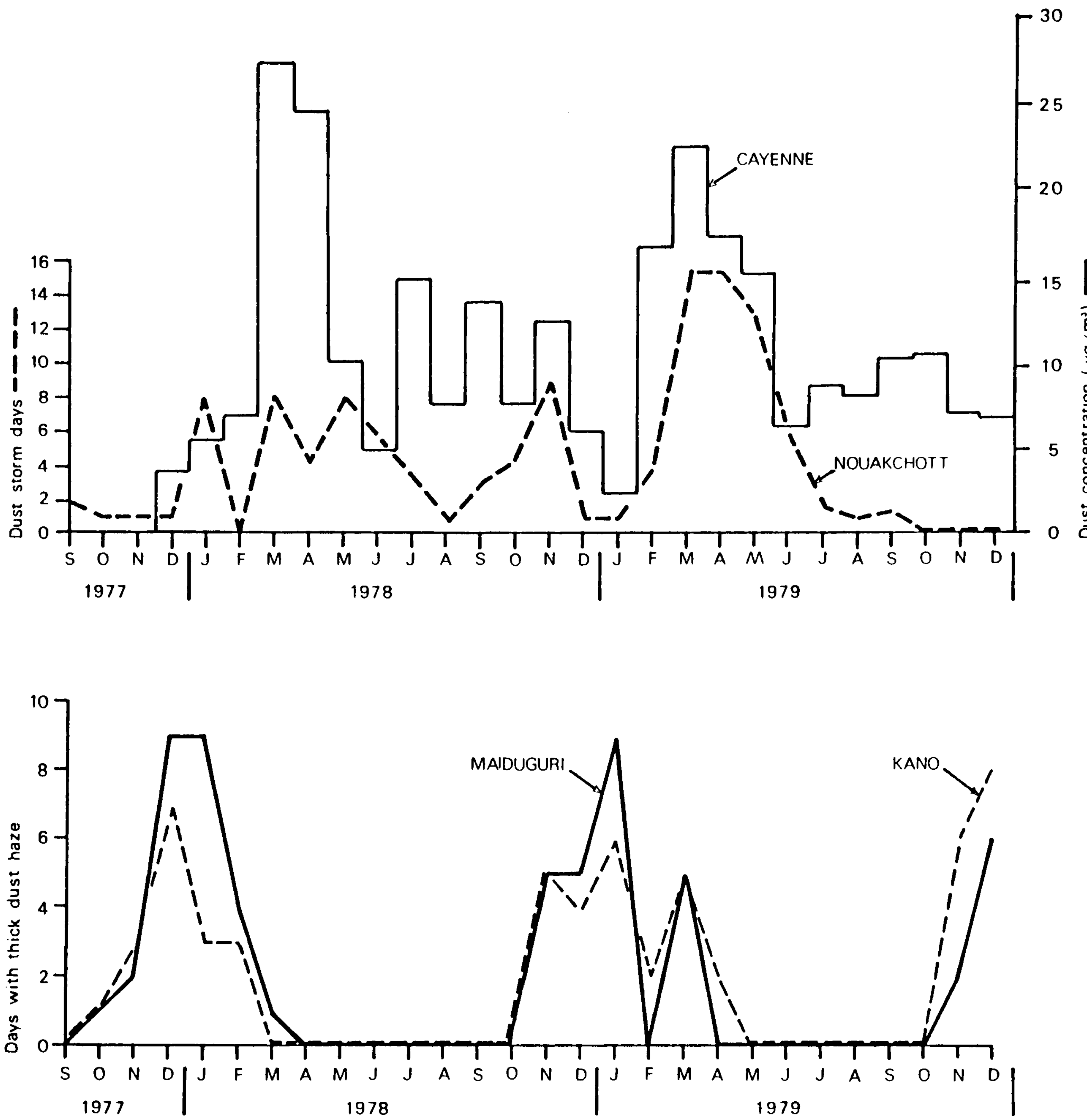



Figure 3.16 Monthly arithmetic mean mineral dust concentrations in surface-level air at Cayenne, French Guiana (after Prospero et al 1981) with monthly numbers of dust storm days at Nouakchott, Mauritania & monthly numbers of days with thick dust haze (visibility less than 1000m) at Maiduguri & Kano, Nigeria (1978-79)

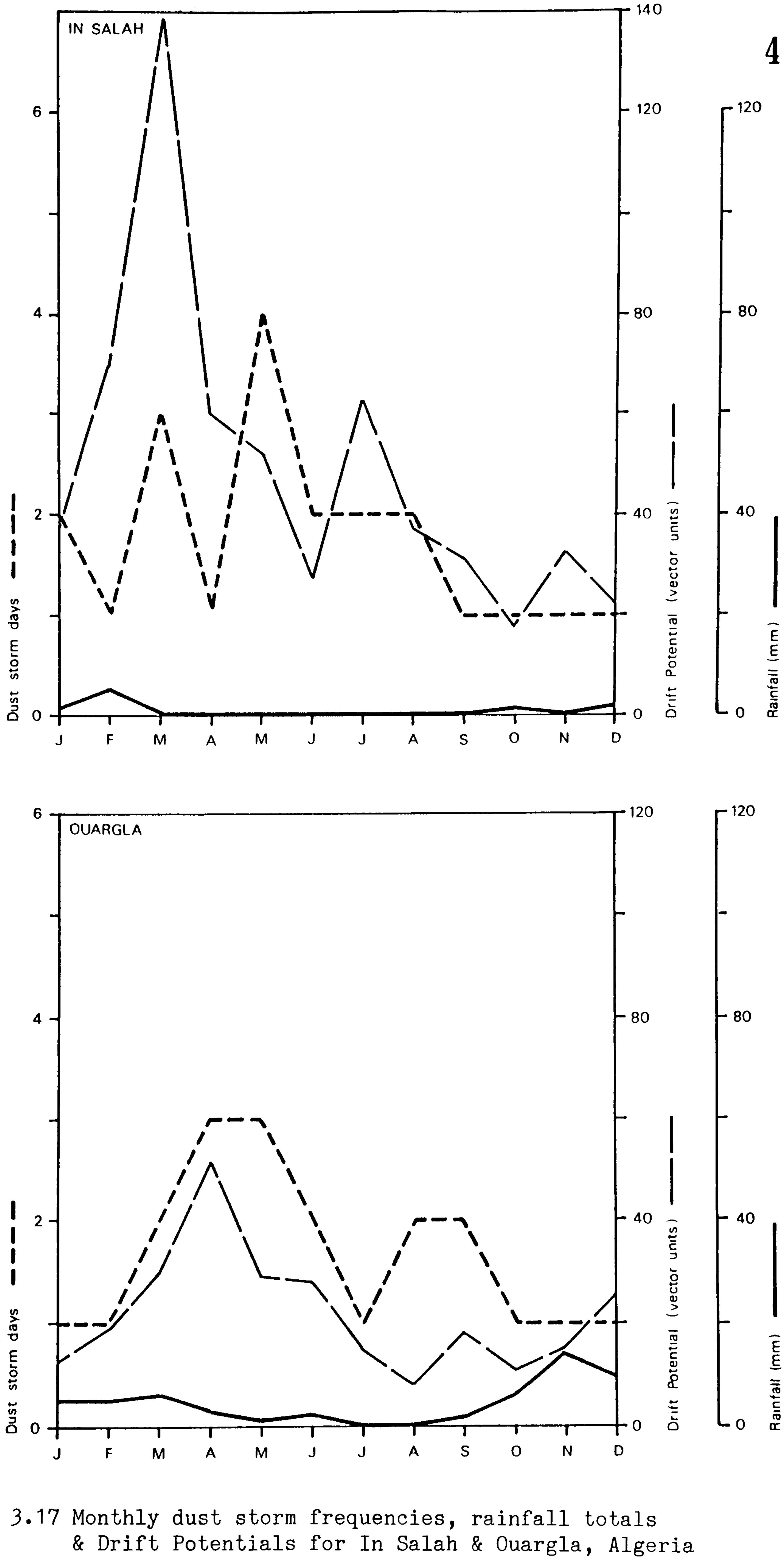



Figure 3.17 Monthly dust storm frequencies, rainfall totals & Drift Potentials for In Salah & Ouargla, Algeria

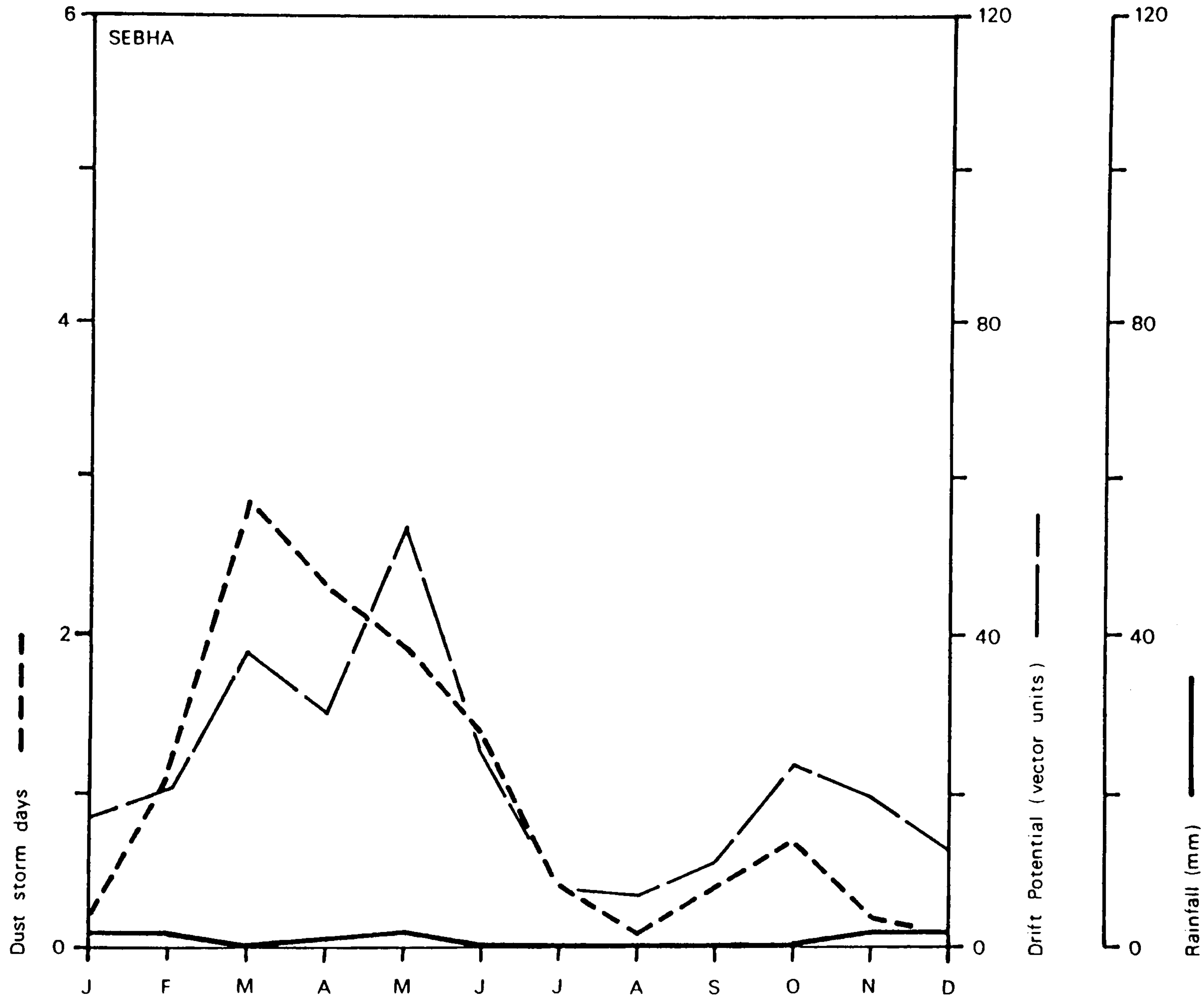



Figure 3.18 Monthly dust storm frequencies, rainfall totals & Drift Potentials for Sebha, Libya

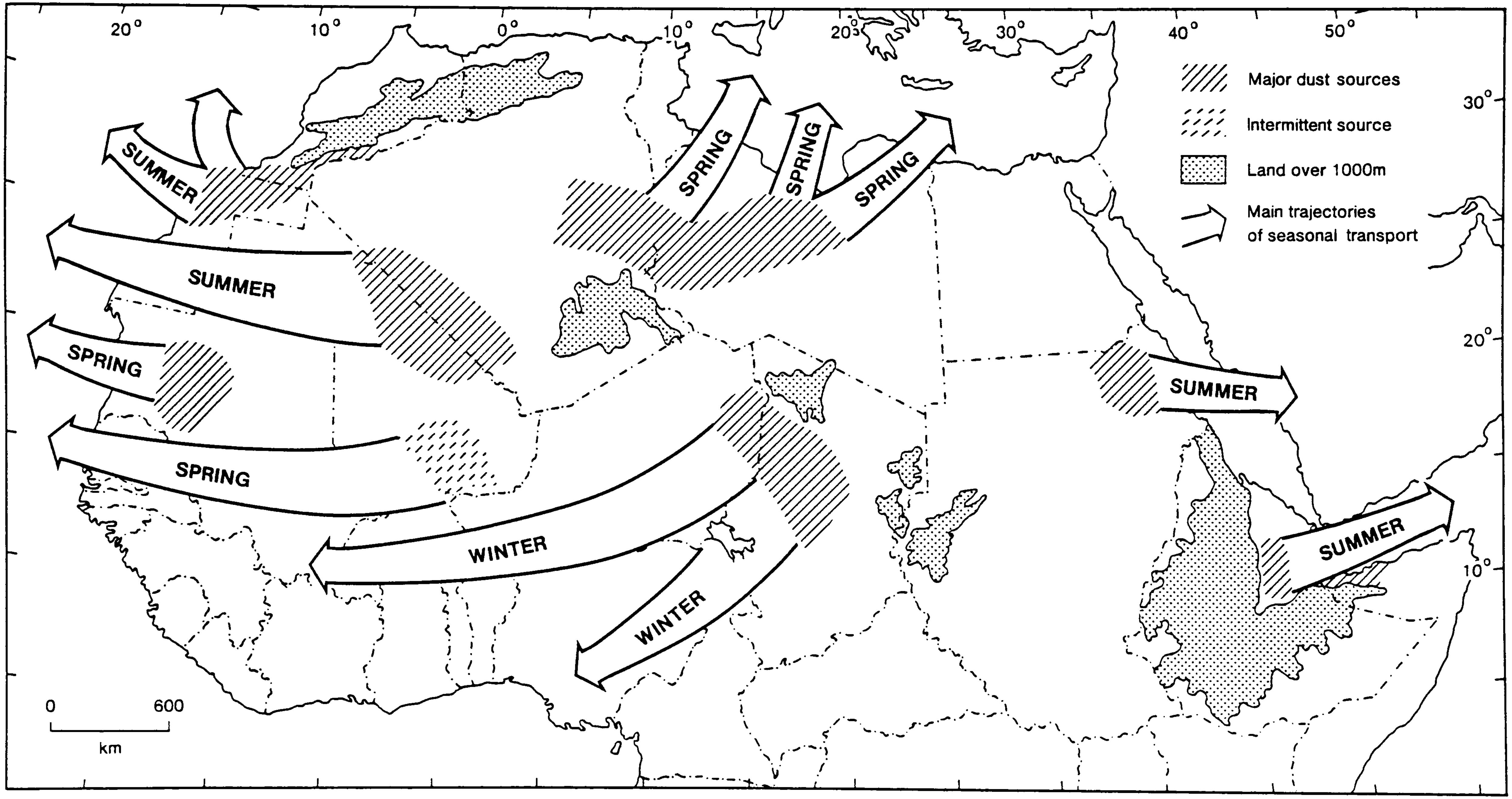



Figure 3.19 Model of Saharan dust sources with directions of seasonal long-range transport

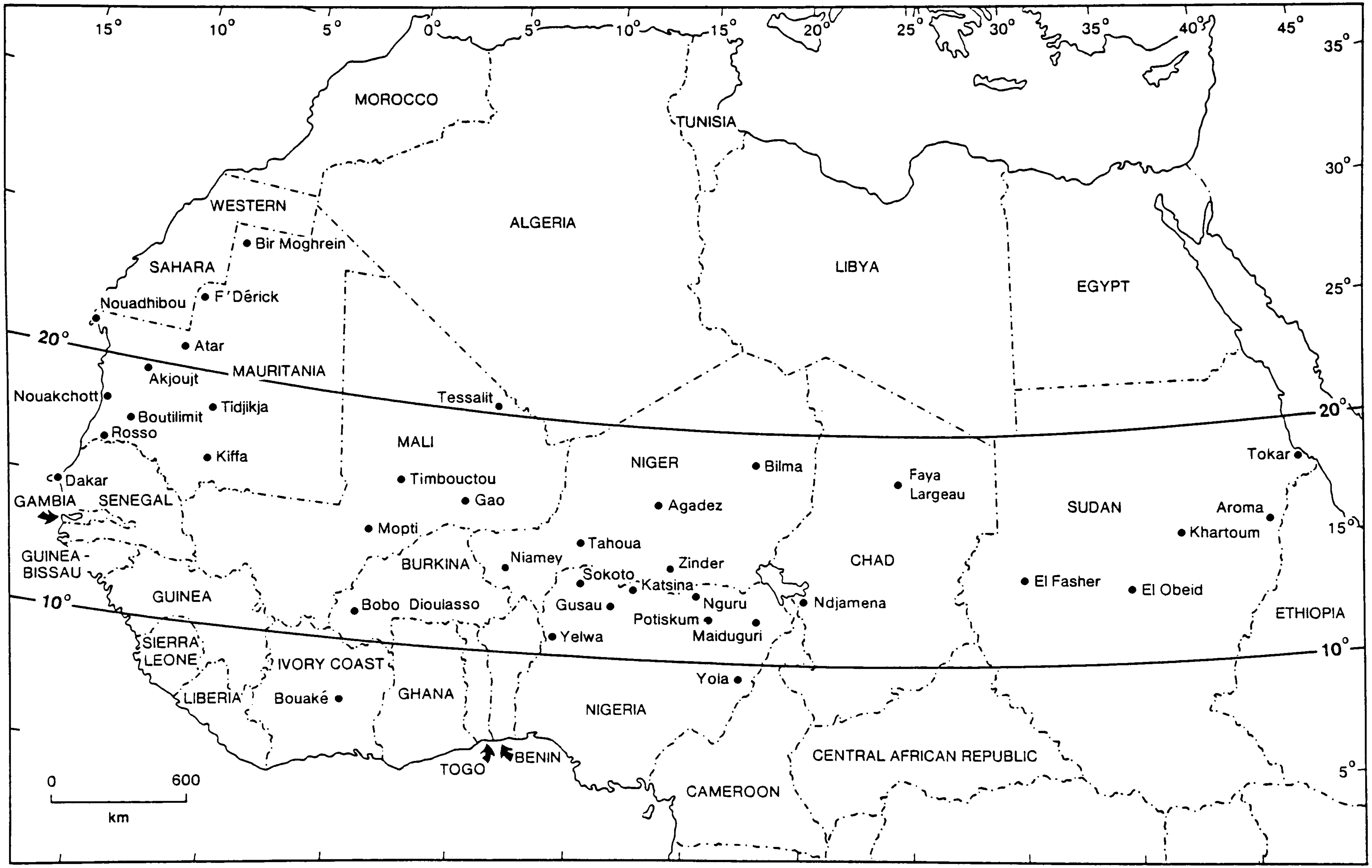



Figure 4.1 Geographical distribution of stations referred to in chapter 4

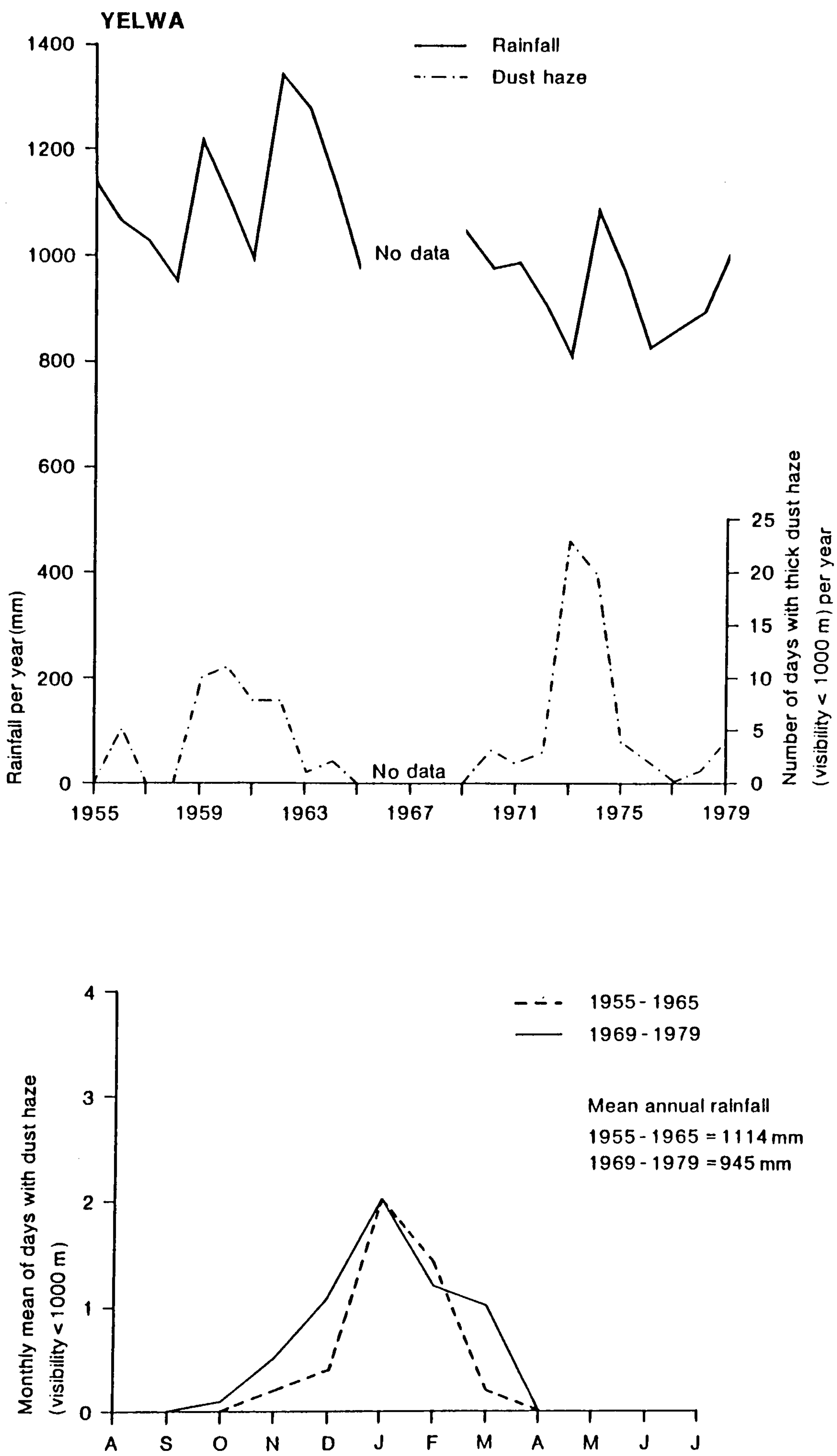
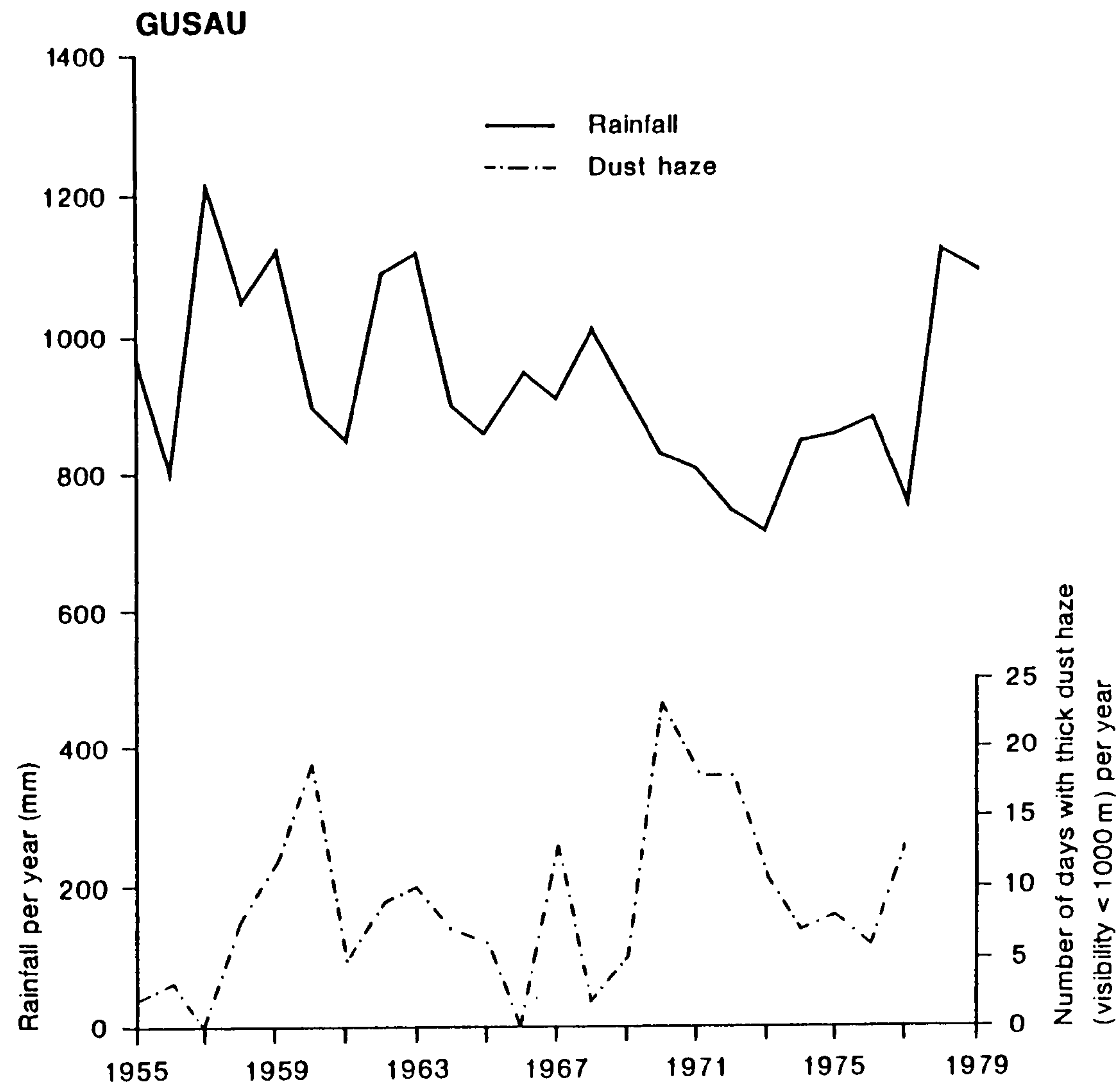



Figure 4.2A Annual rainfall totals & frequencies of days with thick dust haze (1955-79) with average monthly frequencies of thick dust haze for two periods (1955-65 & 1969-79) for Yelwa, Nigeria



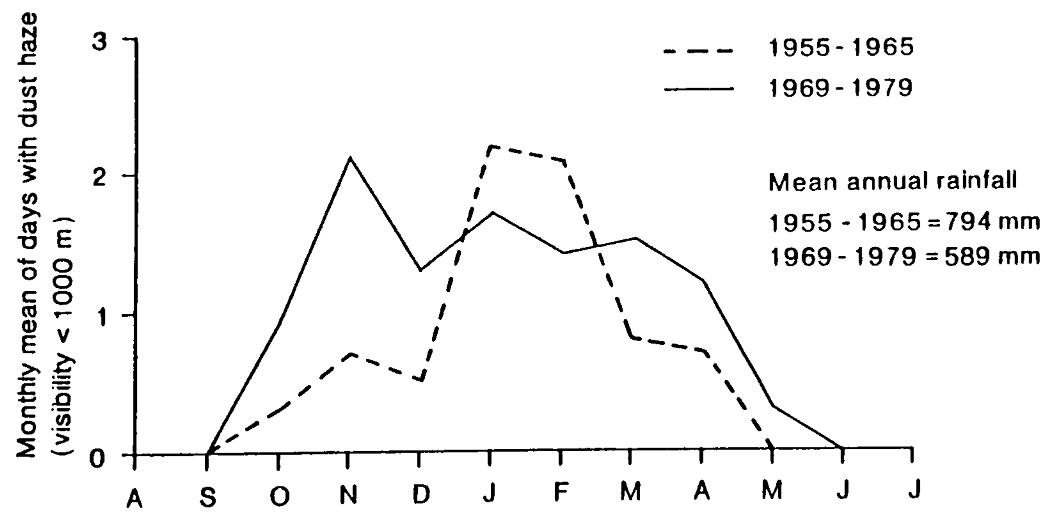




Figure 4.2B Annual rainfall totals & frequencies of days with thick dust haze (1955-79) with average monthly frequencies of thick dust haze for two periods (1955-65 & 1969-79) for Gusau, Nigeria

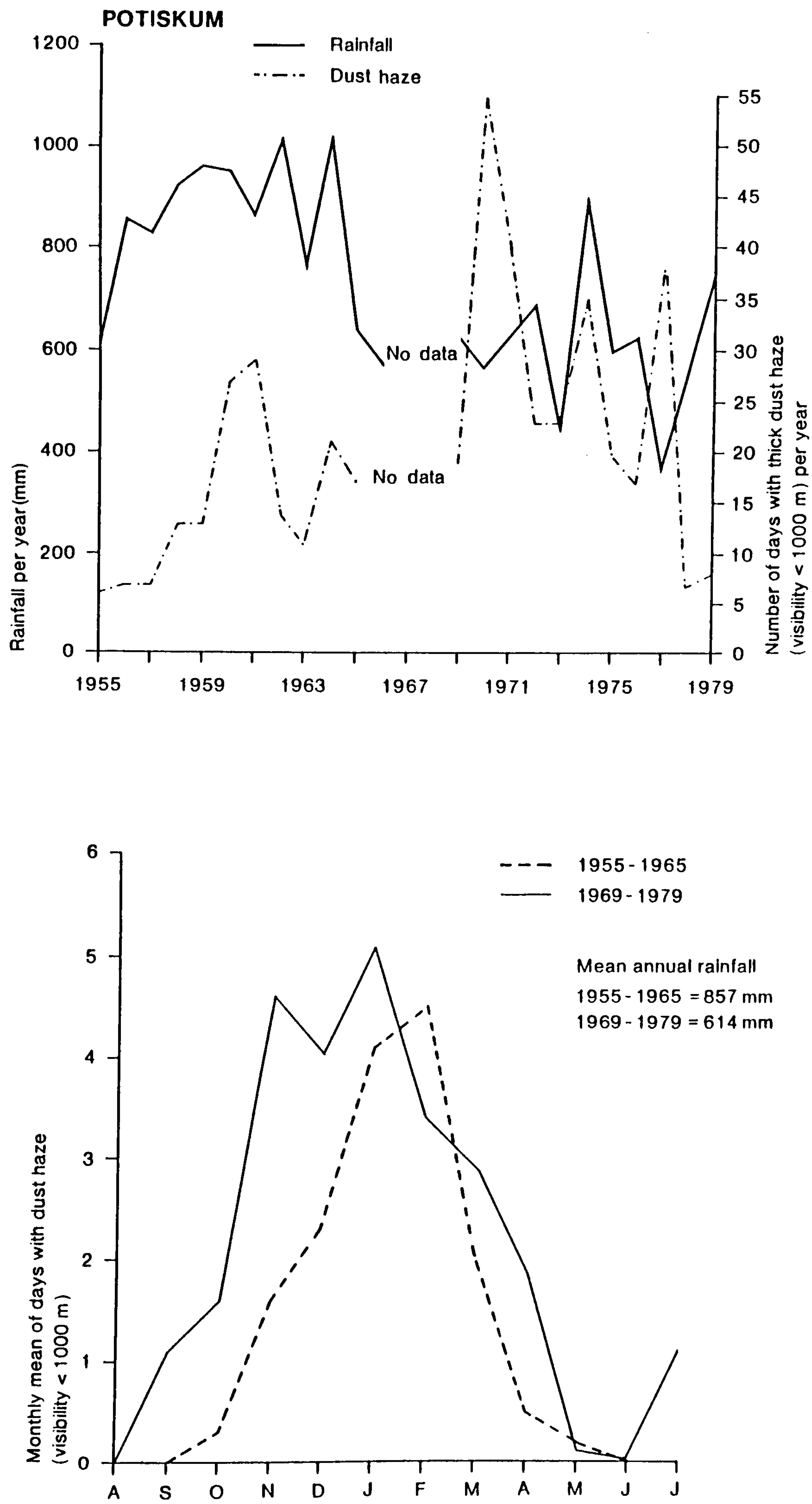
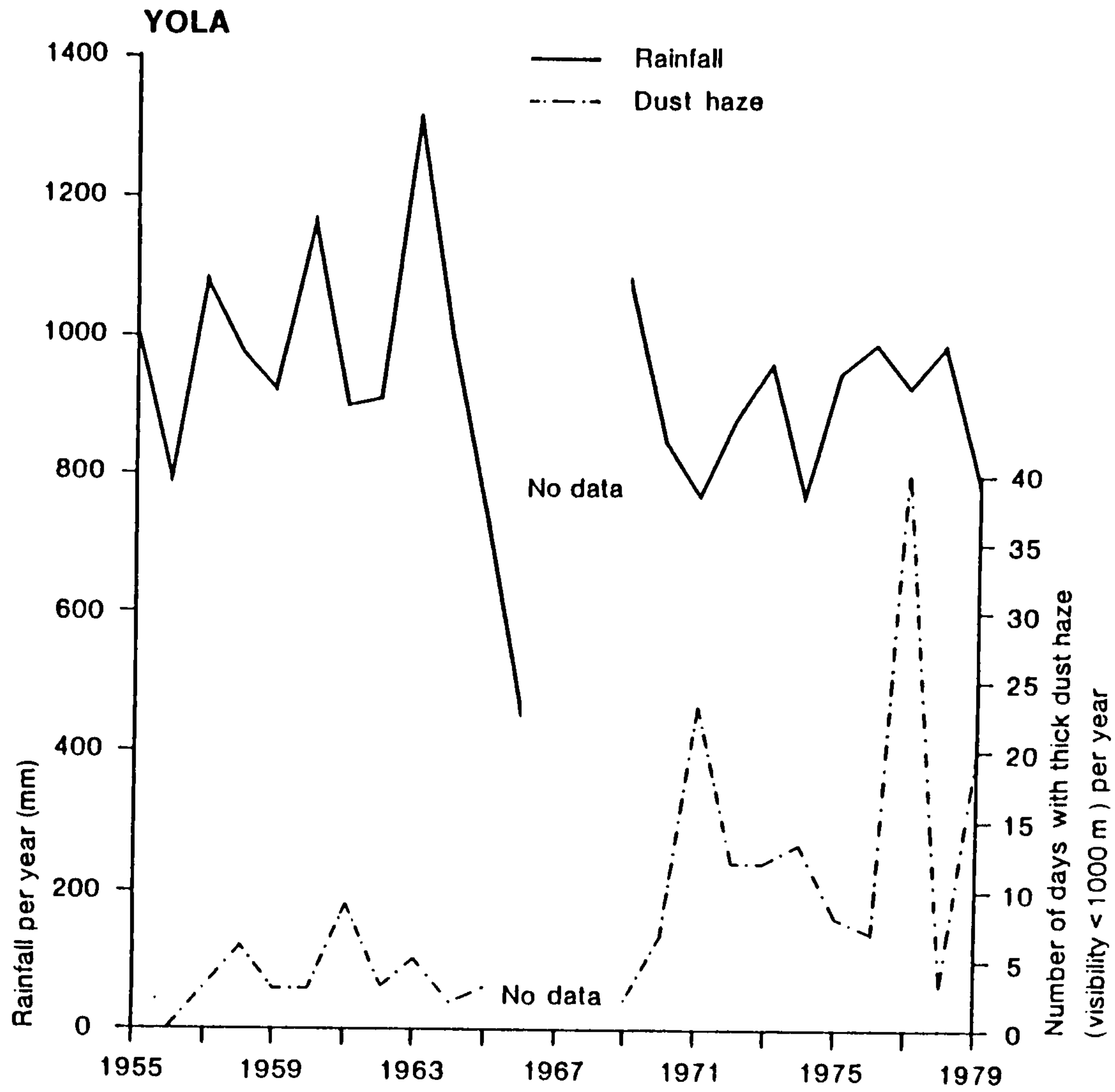



Figure 4.2C Annual rainfall totals & frequencies of days with thick dust haze (1955-79) with average monthly frequencies of thick dust haze for two periods (1955-65 & 1969-79) for Potiskum, Nigeria



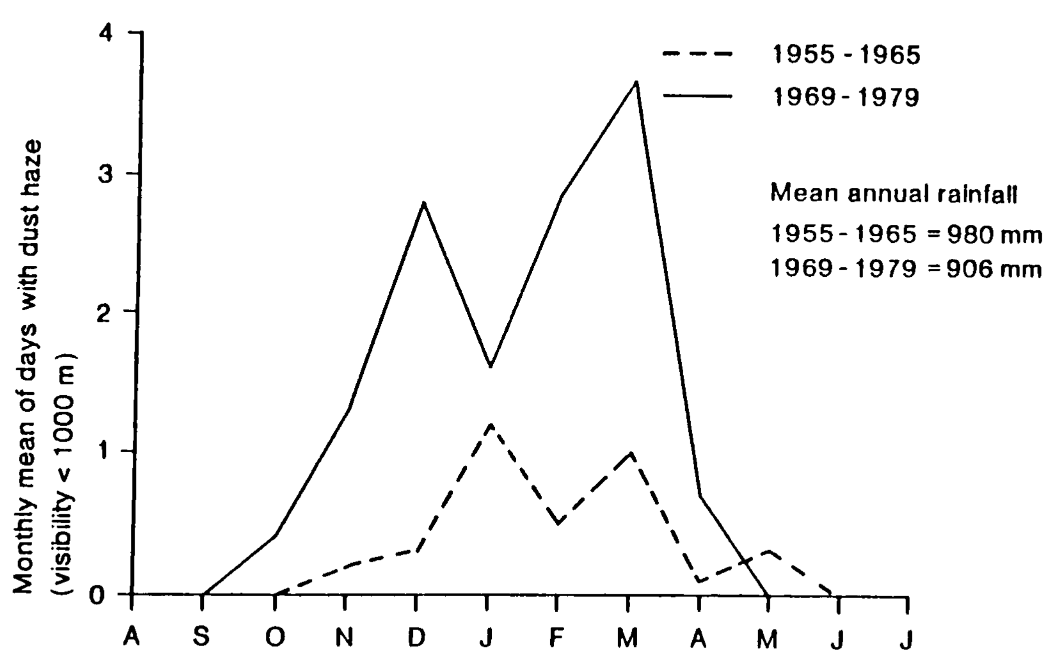




Figure 4.2D Annual rainfall totals & frequencies of days with thick dust haze (1955-79) with average monthly frequencies of thick dust haze for two periods (1955-65 & 1969-79) for Yola, Nigeria

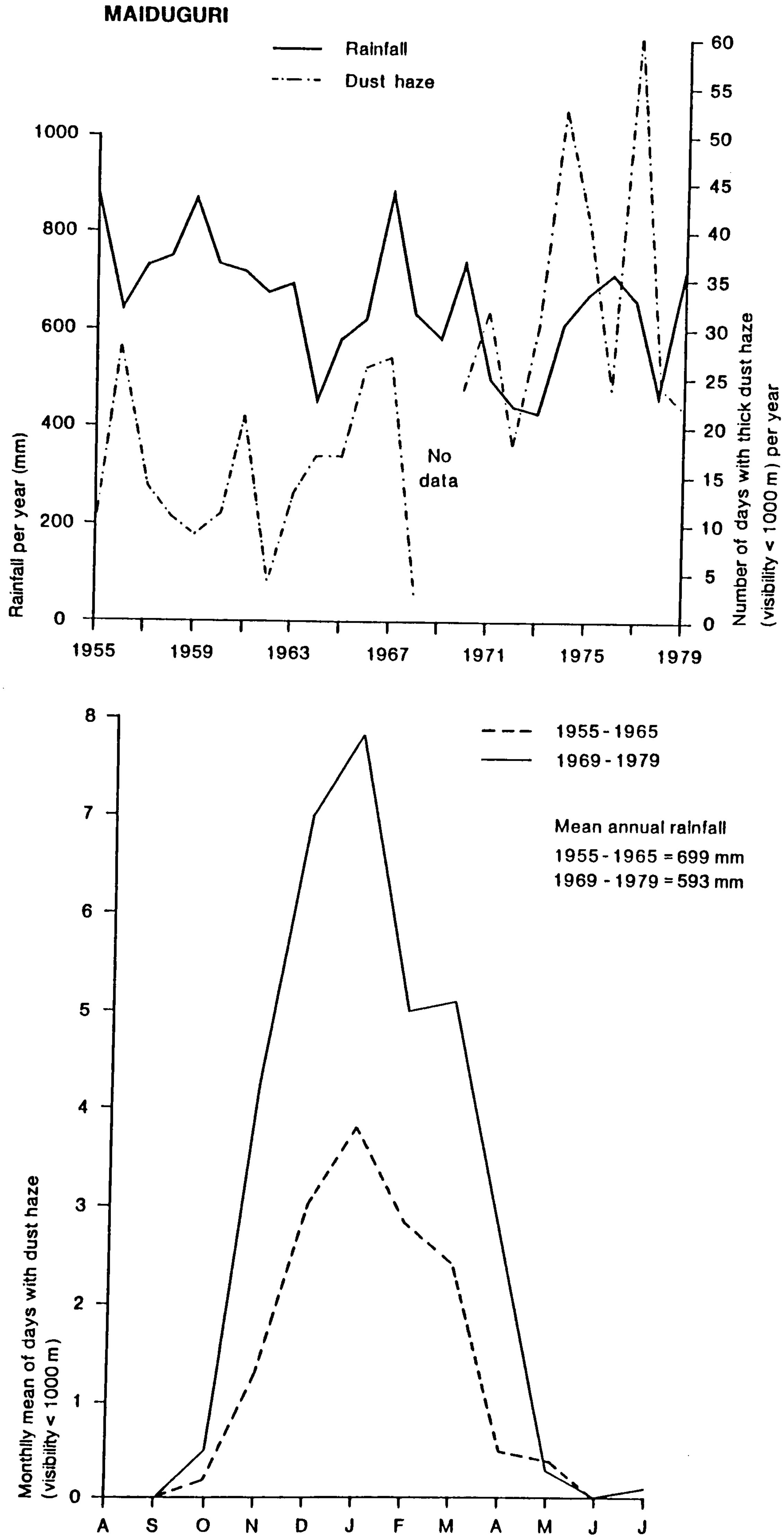
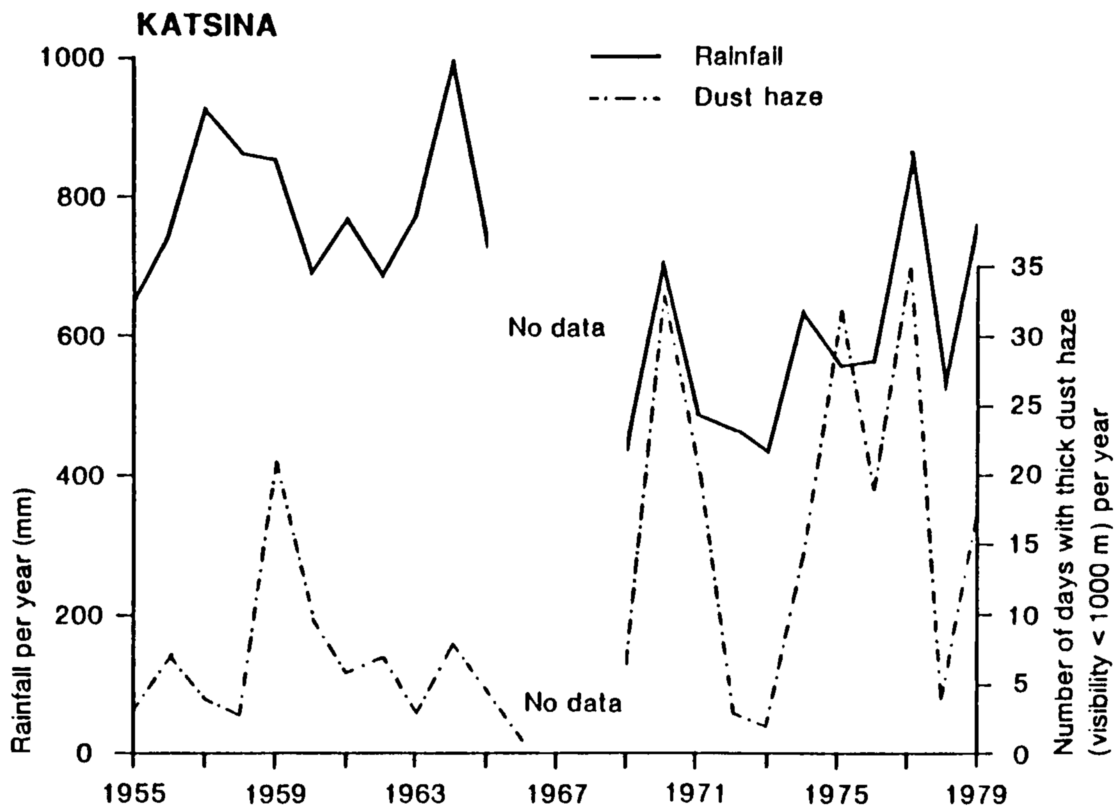



Figure 4.2E Annual rainfall totals & frequencies of days with thick dust haze (1955-79) with average monthly frequencies of thick dust haze for two periods (1955-65 & 1969-79) for Maiduguri, Nigeria



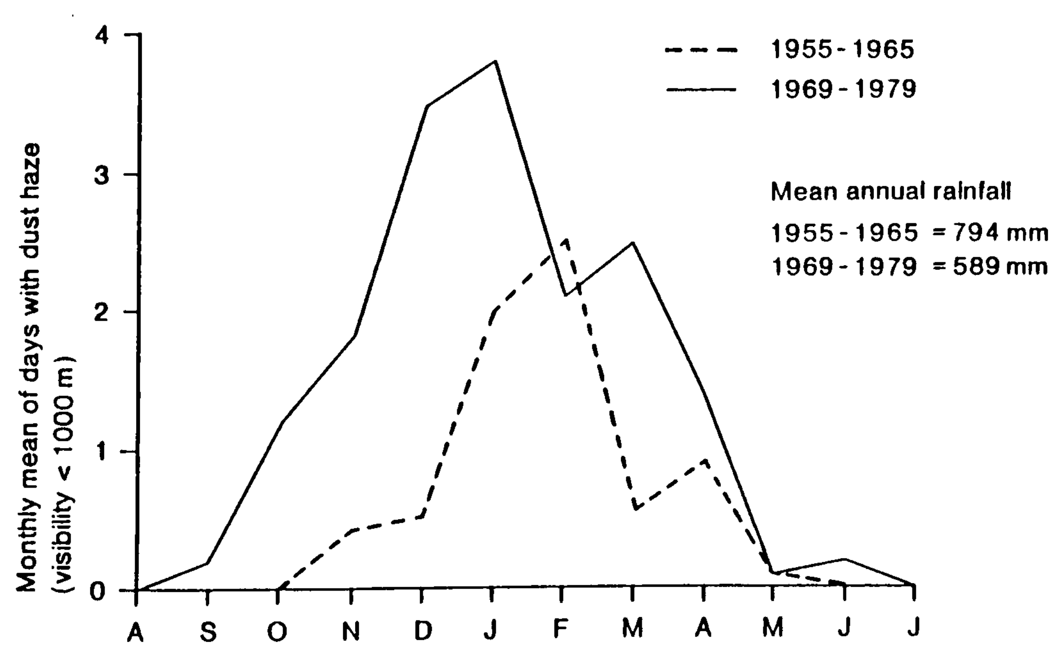




Figure 4.2F Annual rainfall totals & frequencies of days with thick dust haze (1955-79) with average monthly frequencies of thick dust haze for two periods (1955-65 & 1969-79) for Katsina, Nigeria

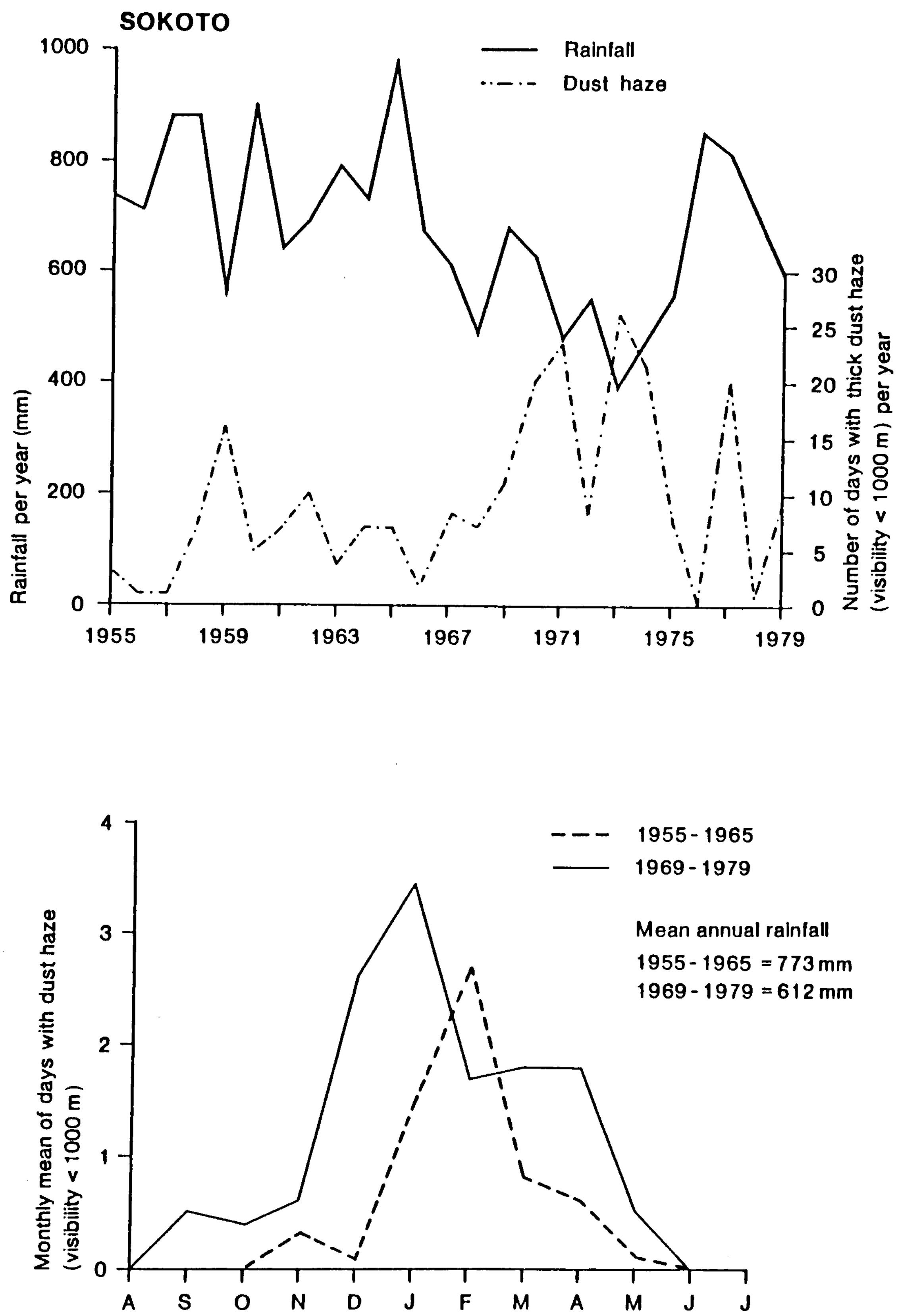



Figure 4.2G Annual rainfall totals & frequencies of days with thick dust haze (1955-79) with average monthly frequencies of thick dust haze for two periods (1955-65 & 1969-79) for Sokoto, Nigeria

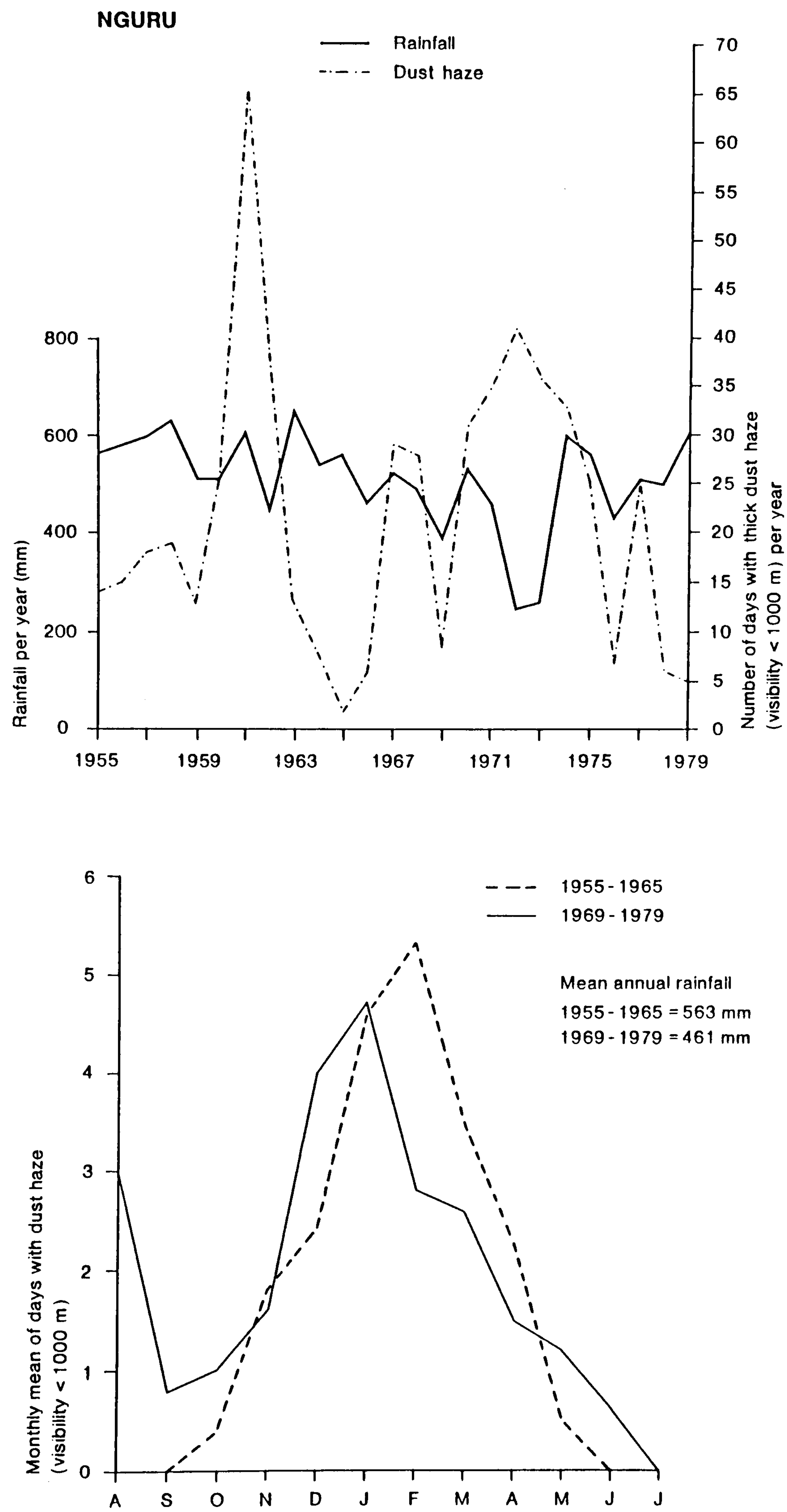



Figure 4.2H Annual rainfall totals & frequencies of days with thick dust haze (1955-79) with average monthly frequencies of thick dust haze for two periods (1955-65 & 1969-79) for Nguru, Nigeria

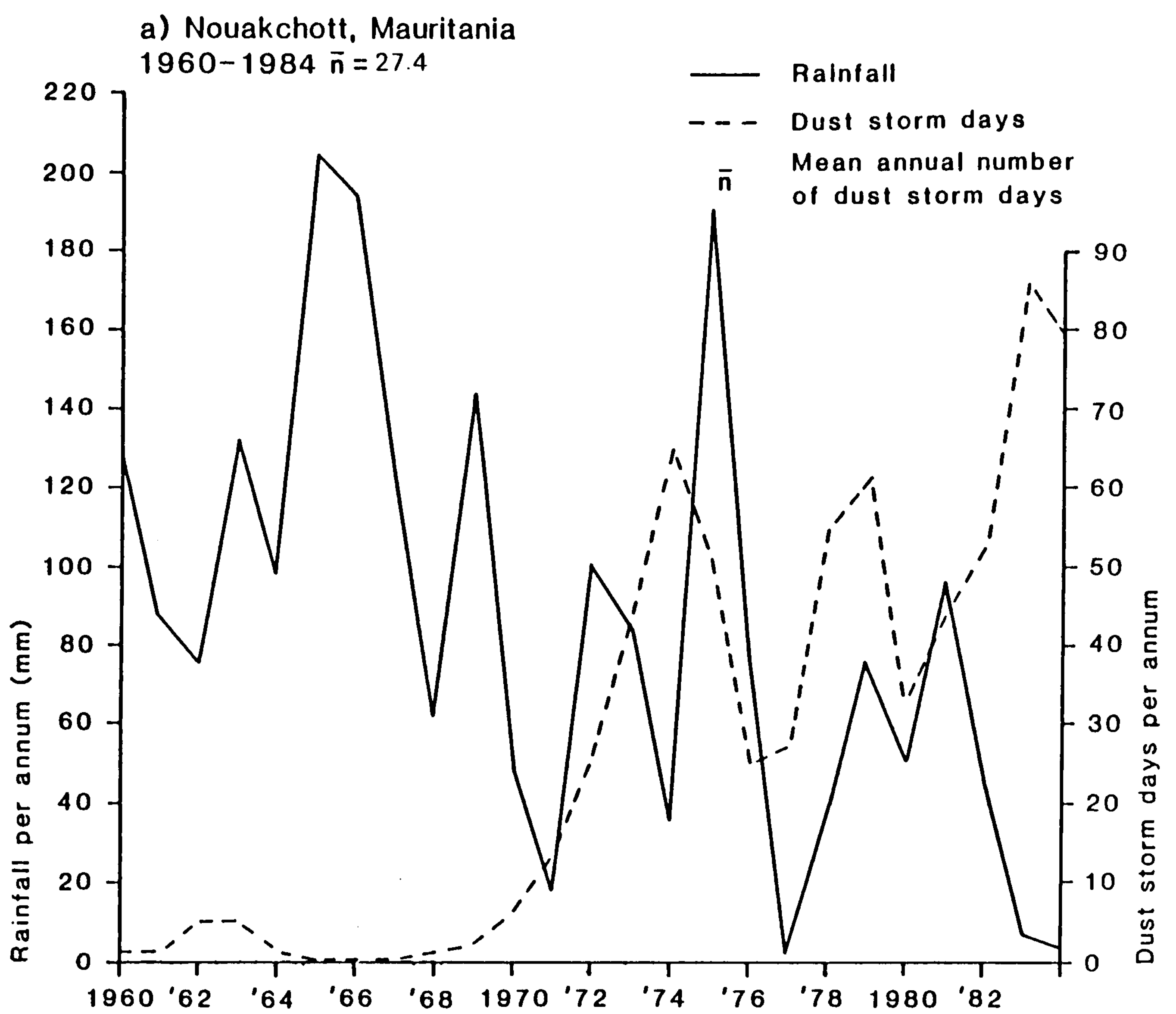



Figure 4.3 Annual rainfall totals & dust storm frequencies at Nouakchott, Mauritania (1960-84)

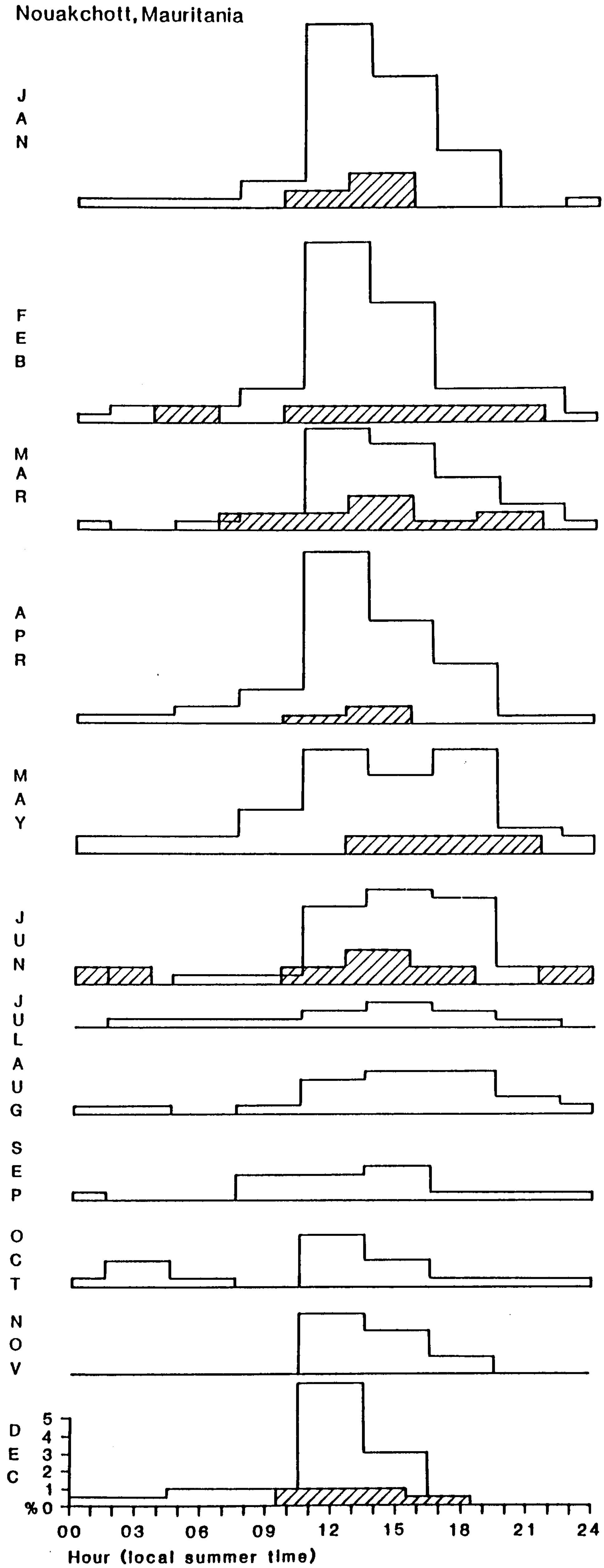



Figure 4.4 Diurnal arithmetic mean frequency percent by month of visibility reduced to less than 1000m by dust storms at Nouakchott. Hatched area for 1949-67; unhatched area for 1968-77

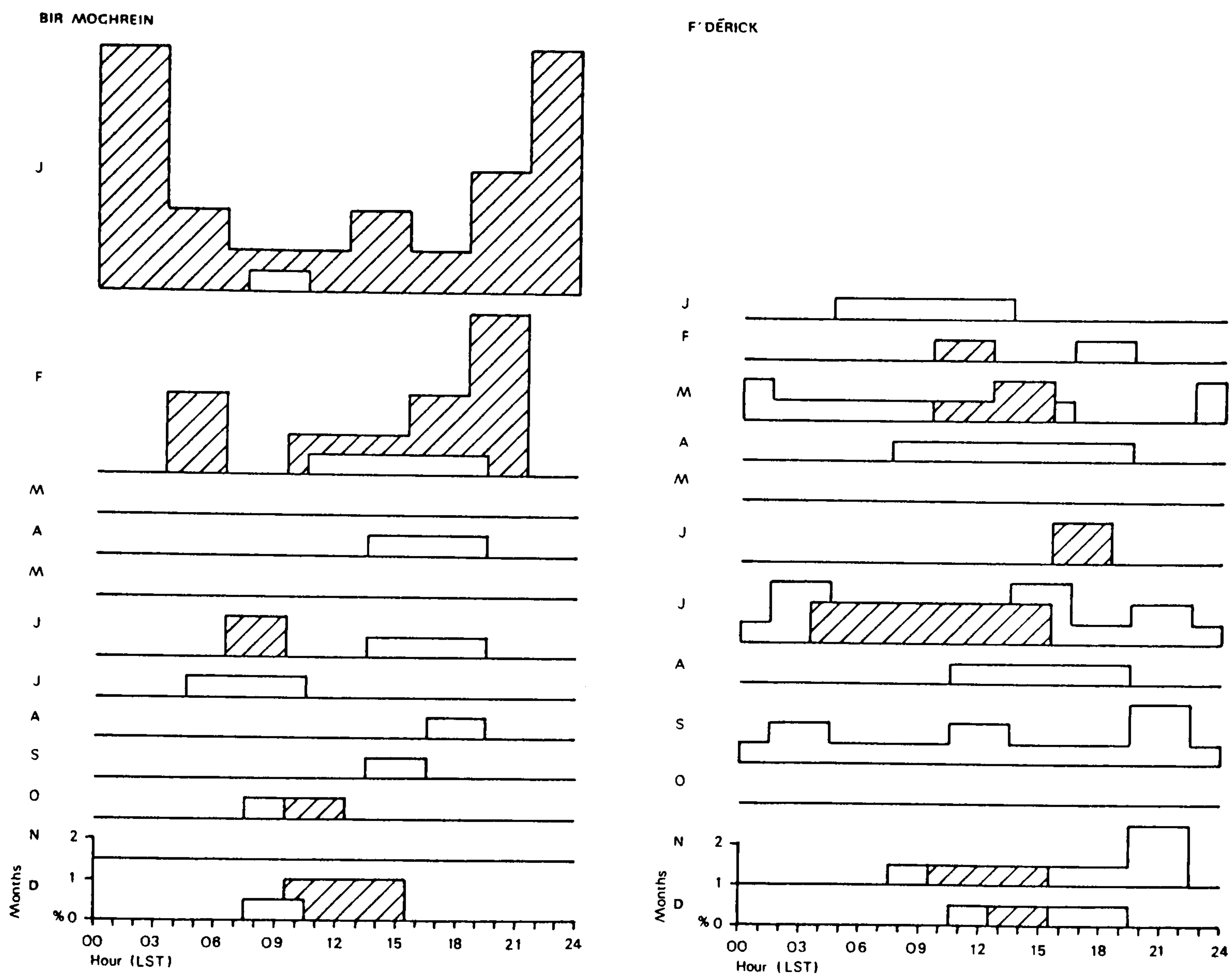
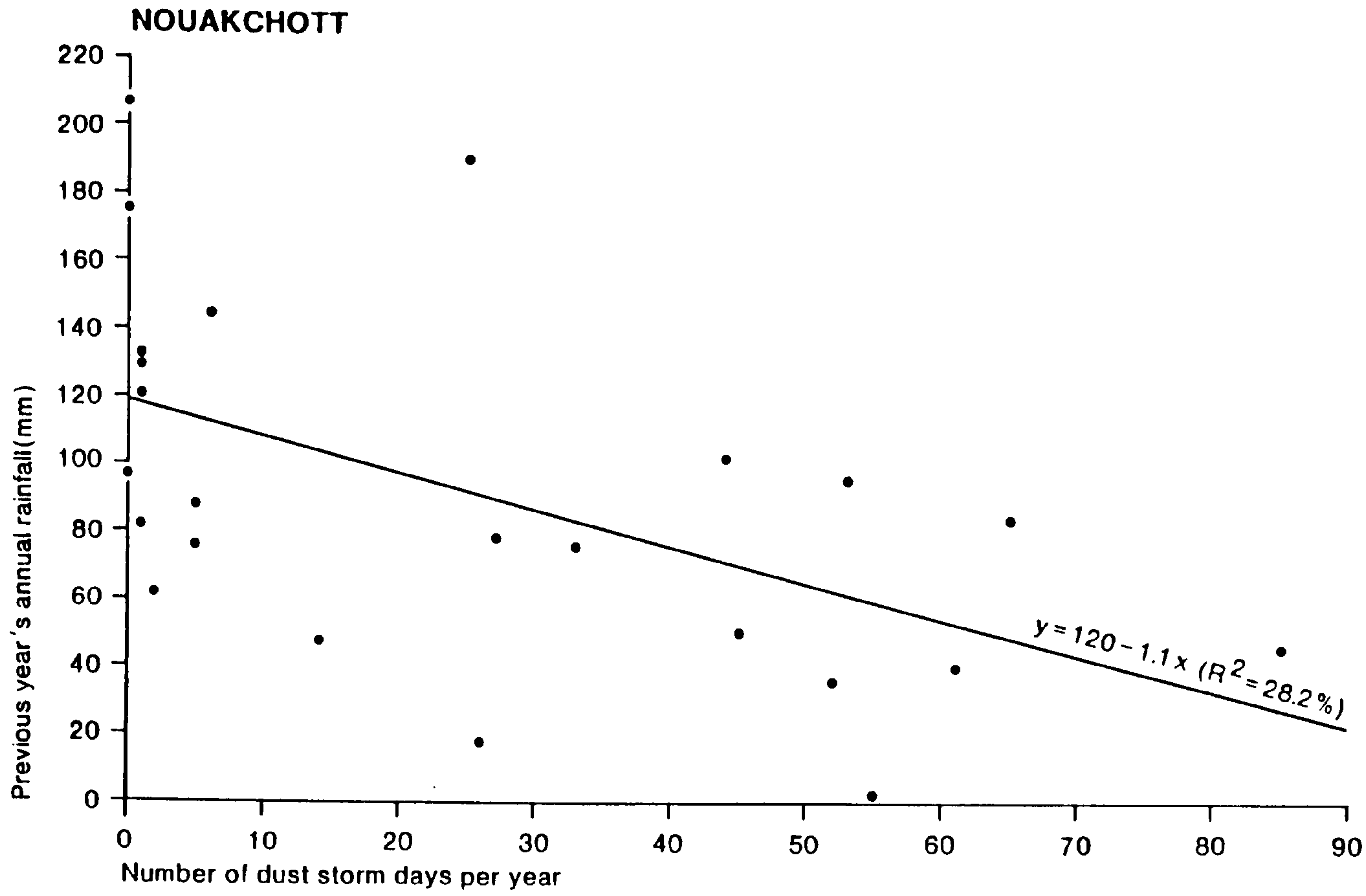



Figure 4.5 Diurnal arithmetic mean frequency percent by month of visibility reduced to less than 1000m by dust storms at Bir Moghrein & F'Derick, Mauritania. Hatched area for 1957-67 at Bir Moghrein, 1949-67 at F'Dérick; unhatched area for 1968-77



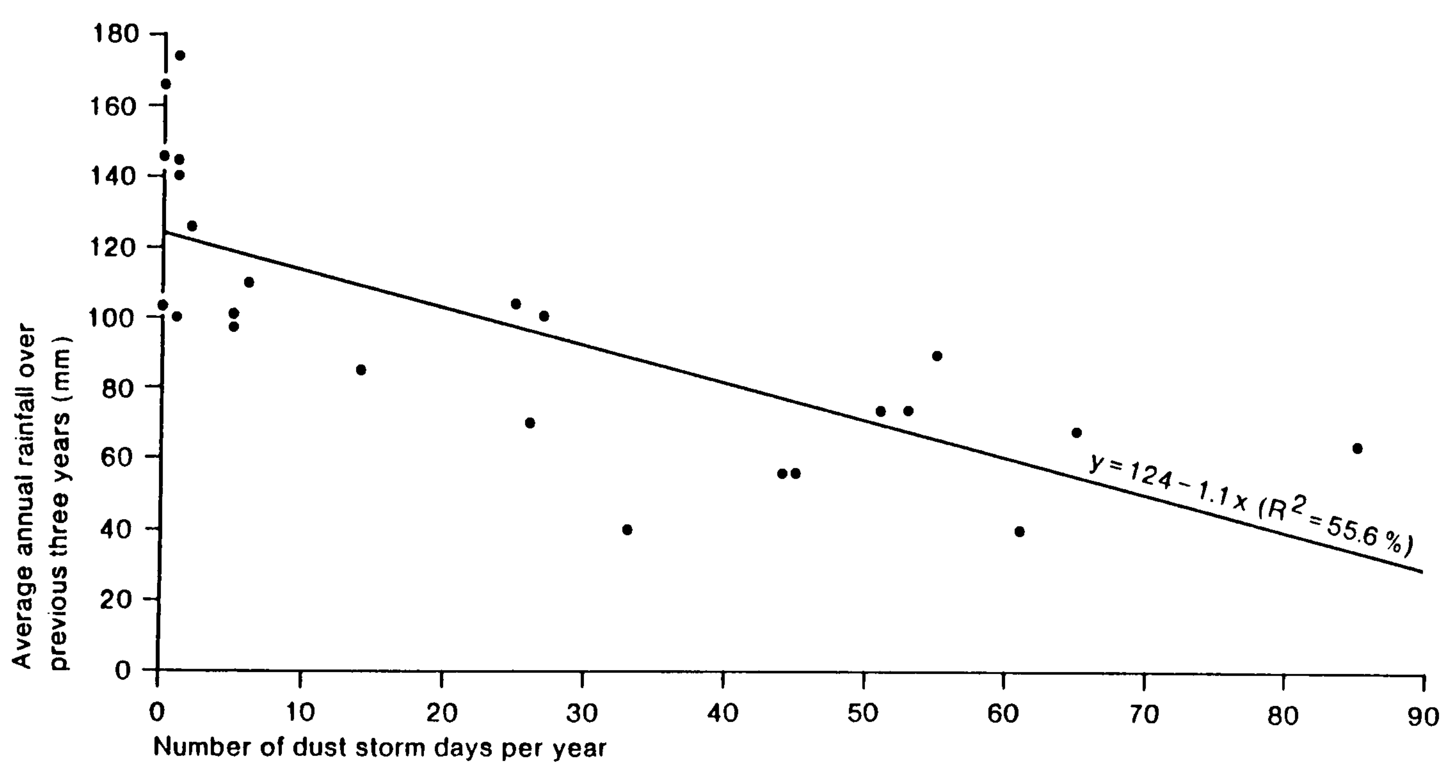




Figure 4.6 (top) Frequency of dust storms in relation to previous year's rainfall at Nouakchott

Figure 4.7 (bottom) Frequency of dust storms in relation to mean annual rainfall over the previous three years at Nouakchott

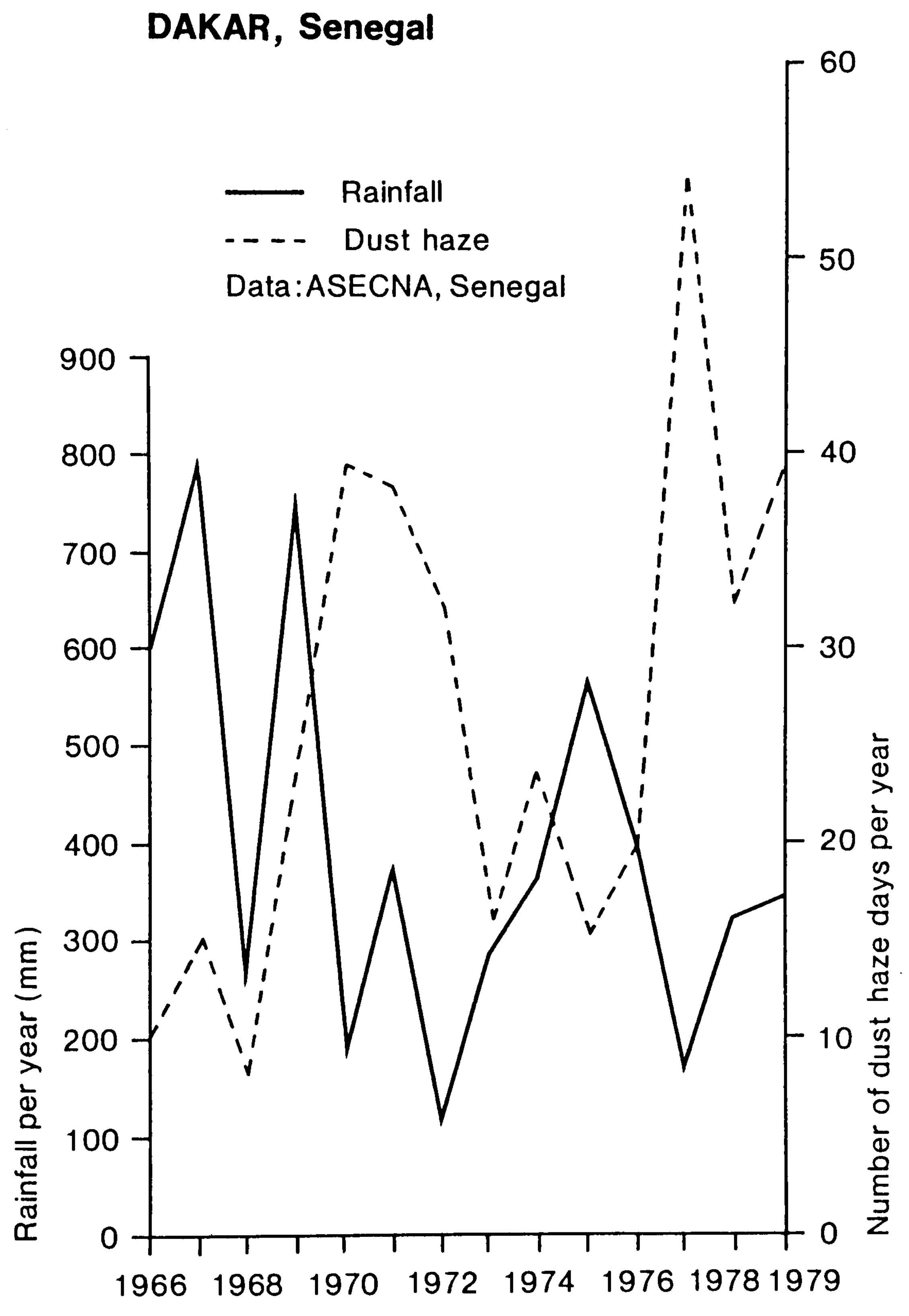



Figure 4.8 Annual rainfall totals & frequency of dust haze days at Dakar, Senegal (1966-79)

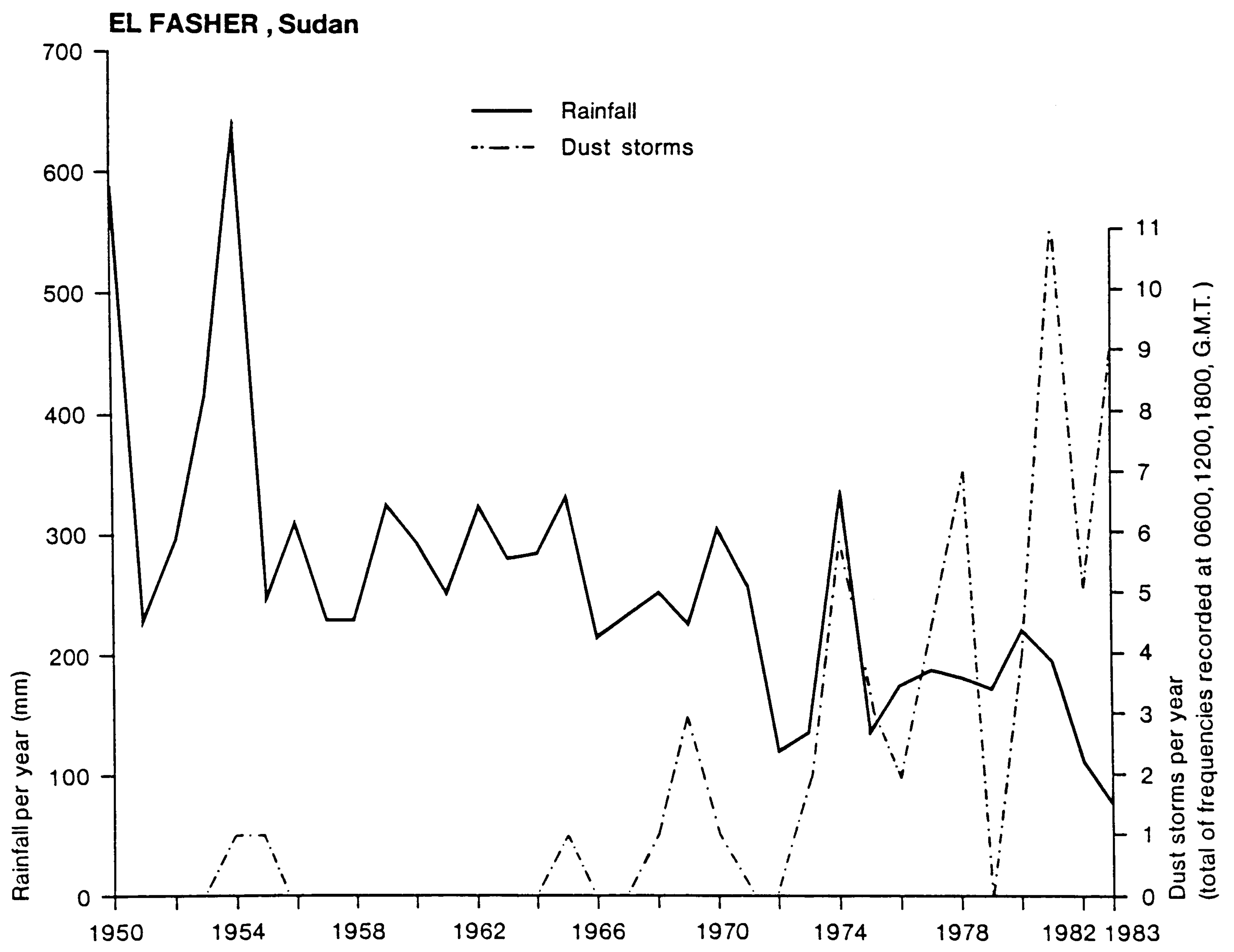



Figure 4.9A Annual rainfall totals & dust storm frequencies for El Fasher, Sudan (1950-83)

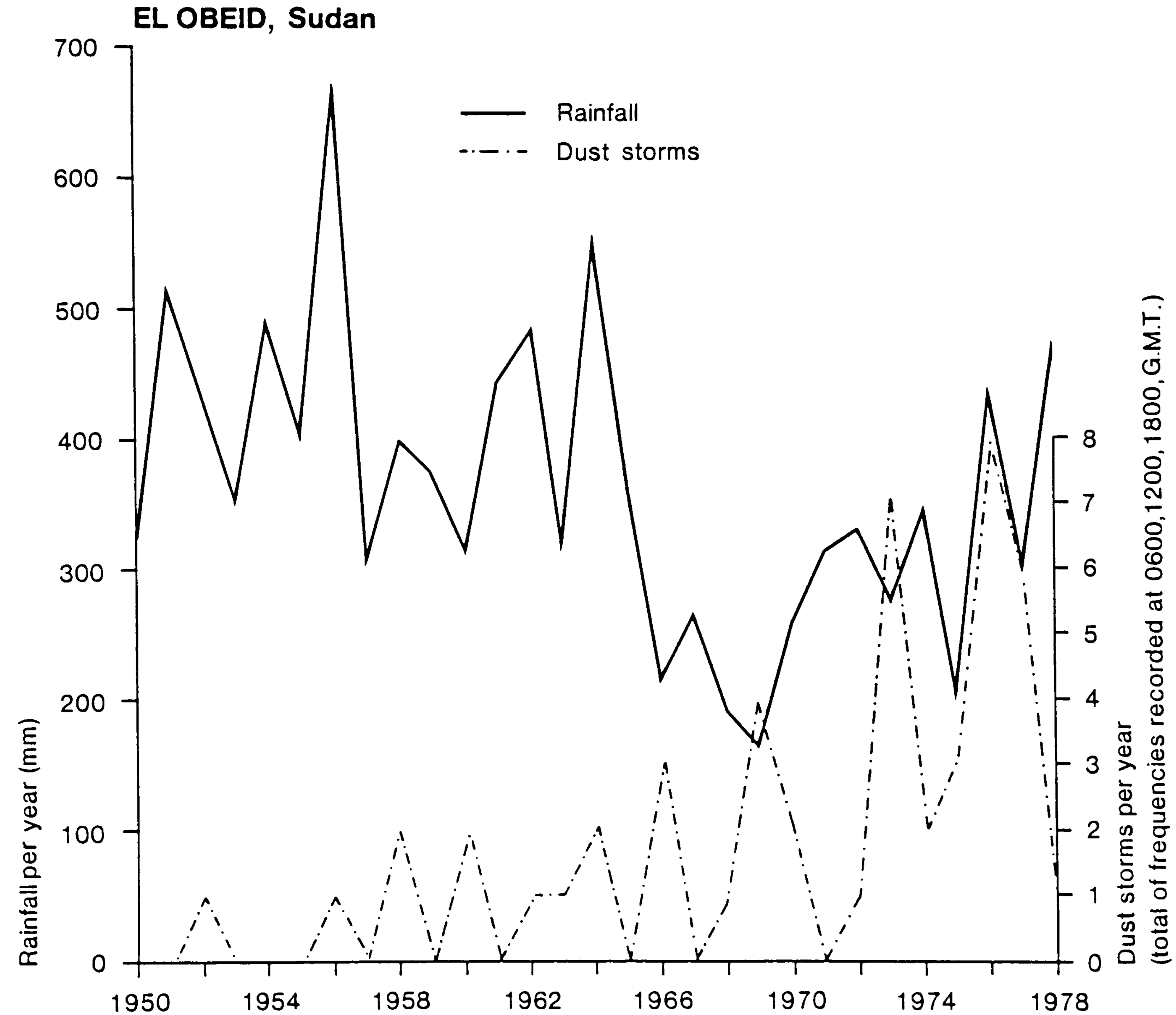



Figure 4.9B Annual rainfall totals & dust storm frequencies for El Obeid, Sudan (1950-78)

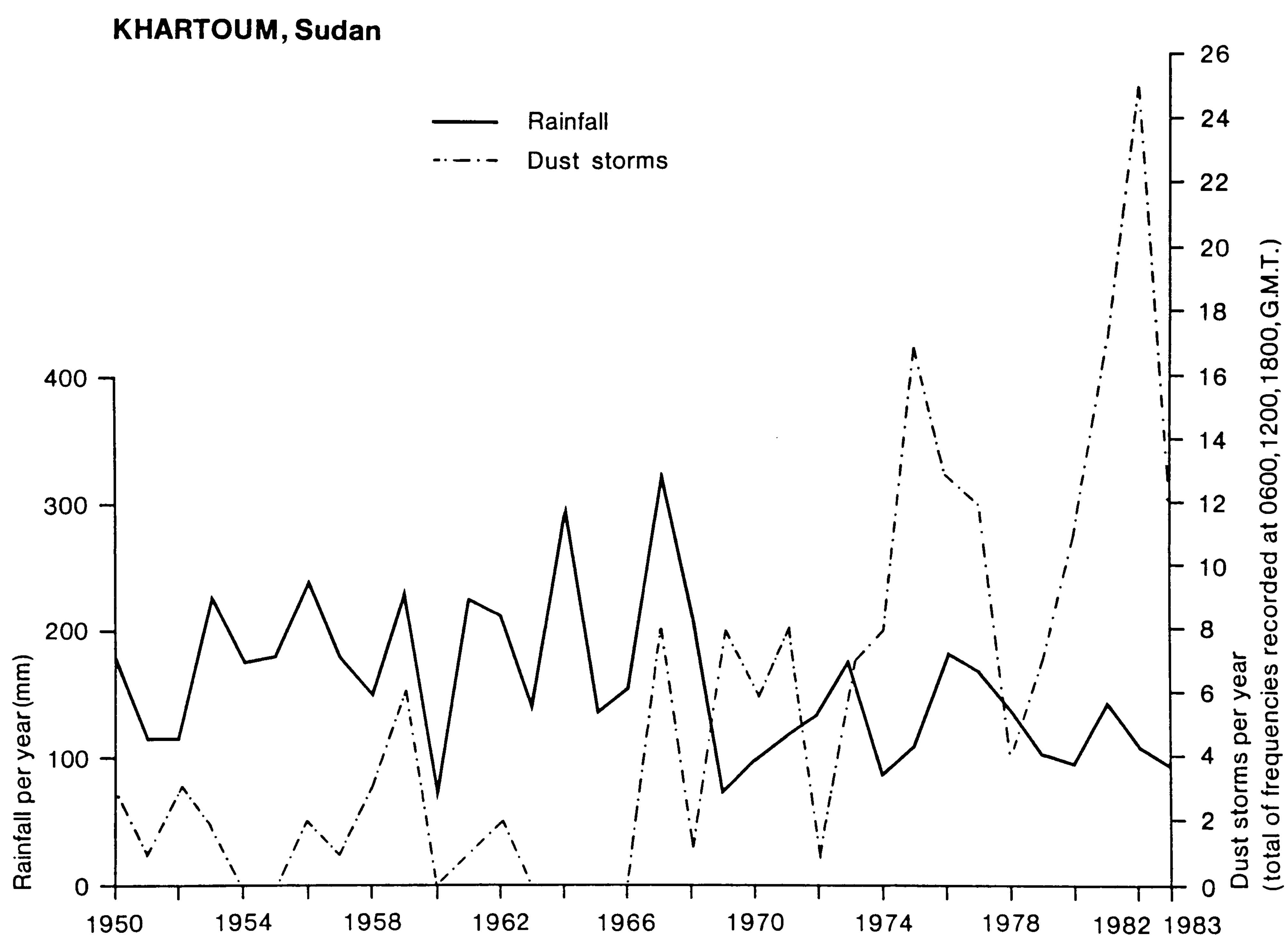



Figure 4.9C Annual rainfall totals & dust storm frequencies for Khartoum, Sudan (1950-83)

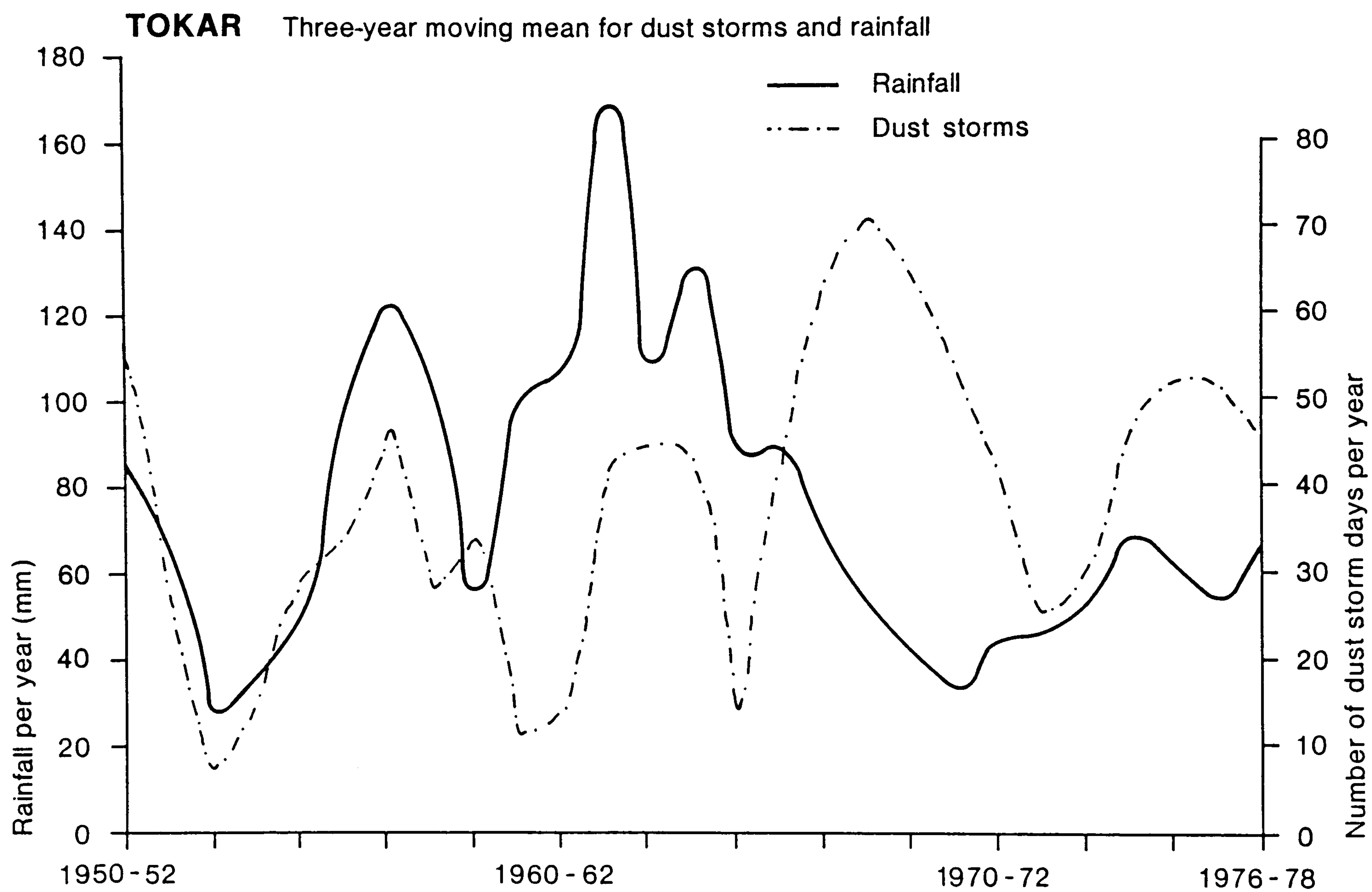



Figure 4.9D Annual rainfall totals & dust storm frequencies for Tokar, Sudan (1950-78)

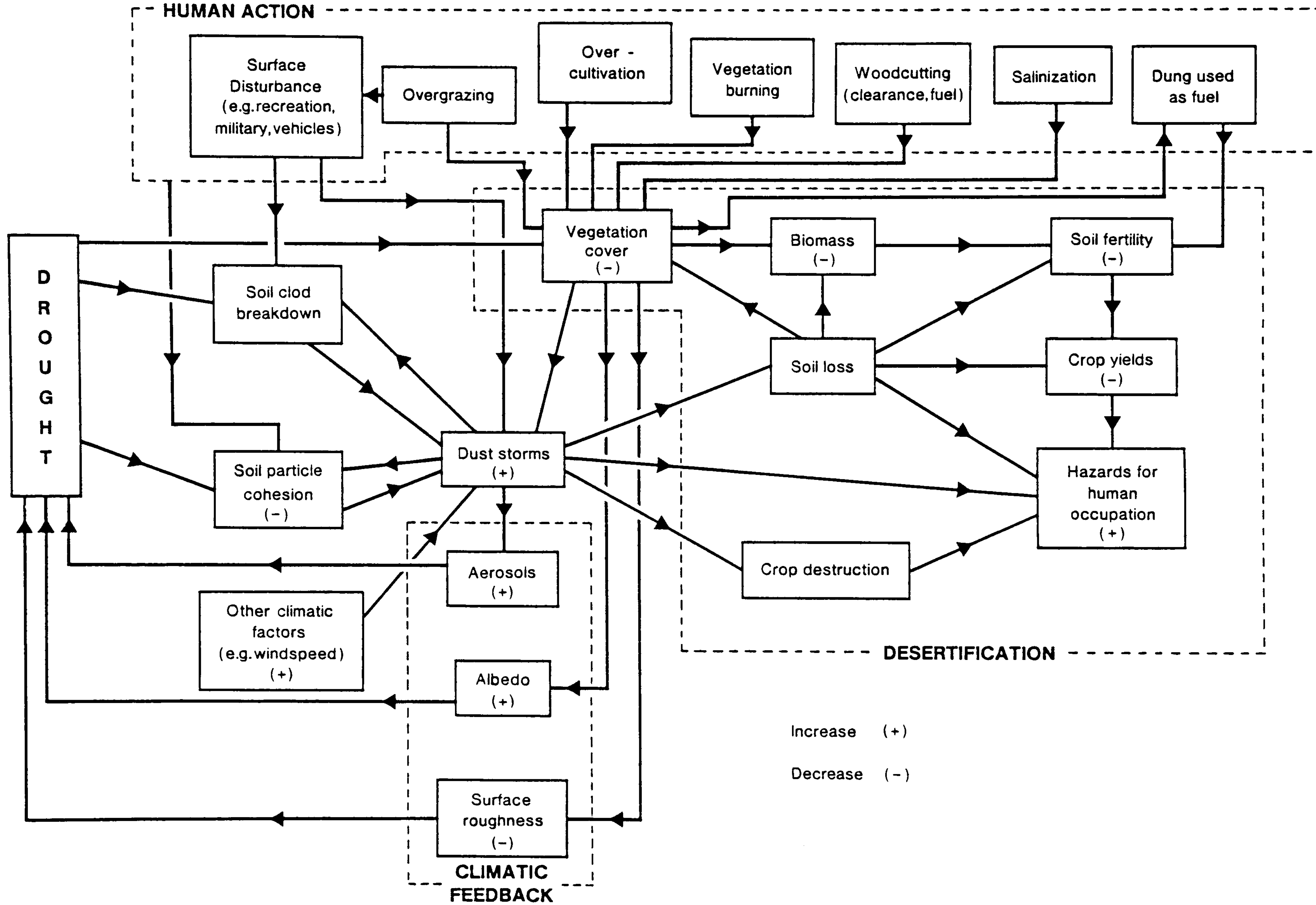



Figure 4.10 Model to show relationship of drought, human activities & desertification to increasing dust storm activity

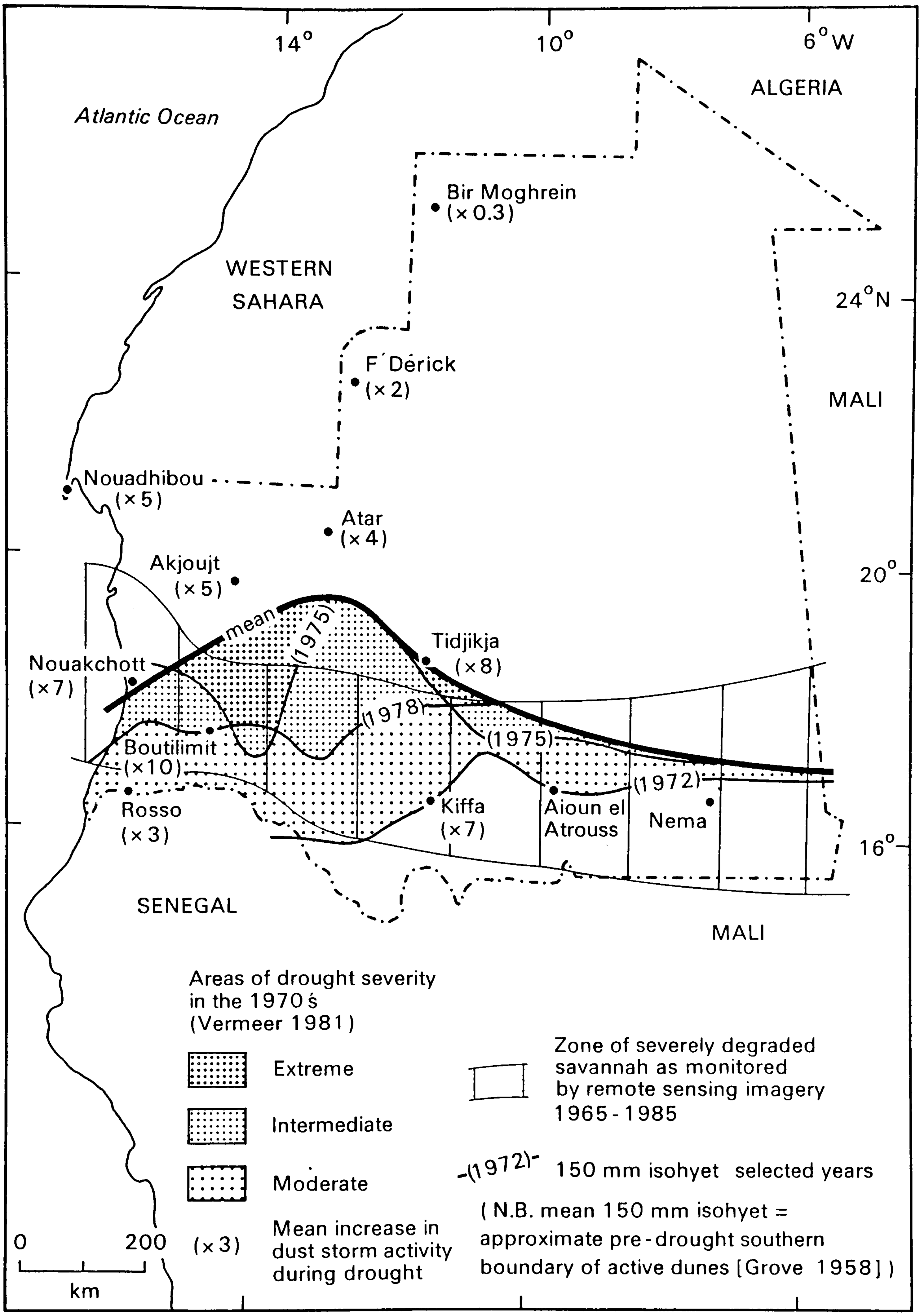



Figure 4.11 Drought severity, desertification & the increase in dust storms during the current Sahel drought in Mauritania

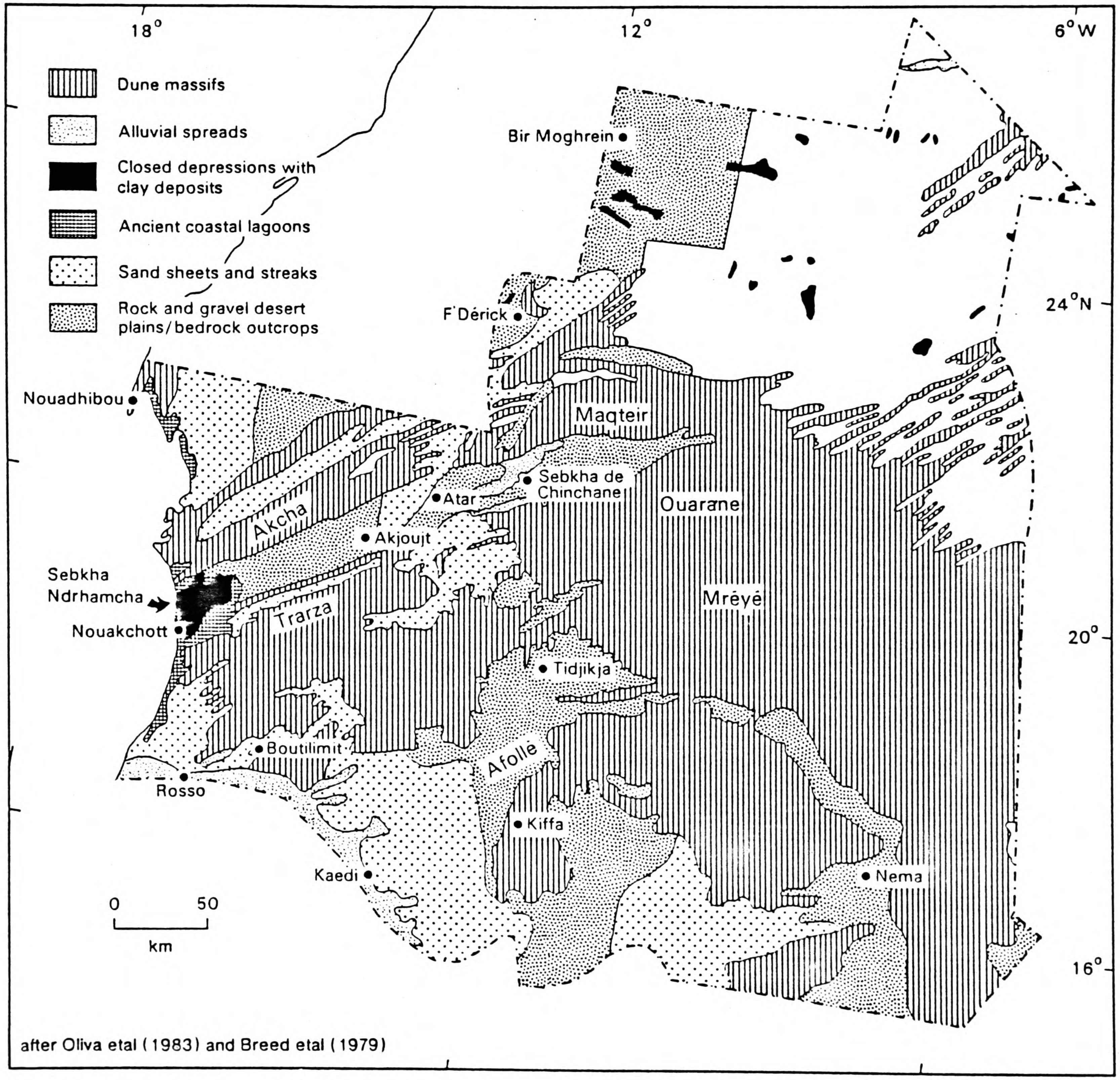



Figure 4.12 Geomorphology of Mauritania

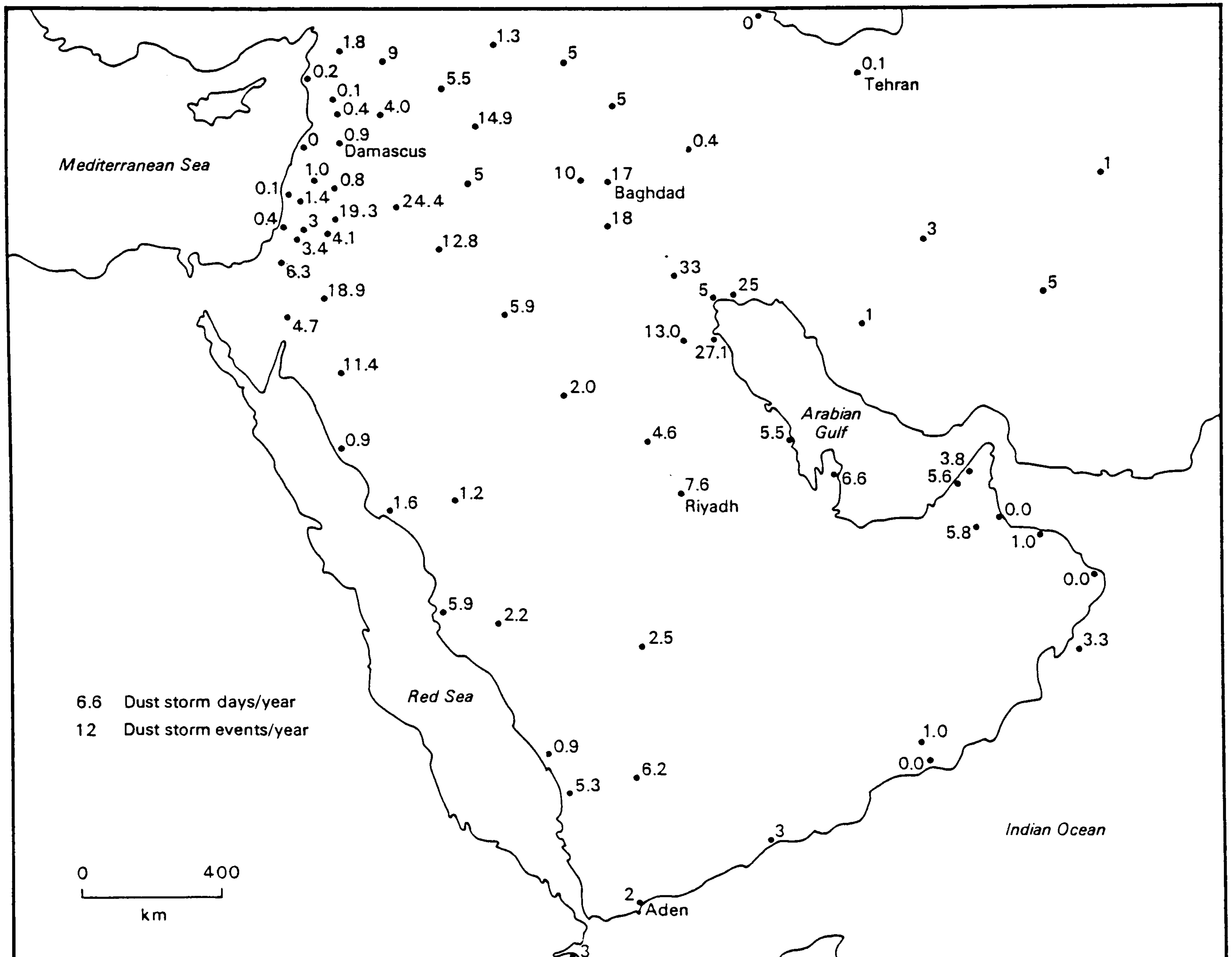



Figure 5.1 Distribution of dust storms in the Middle East

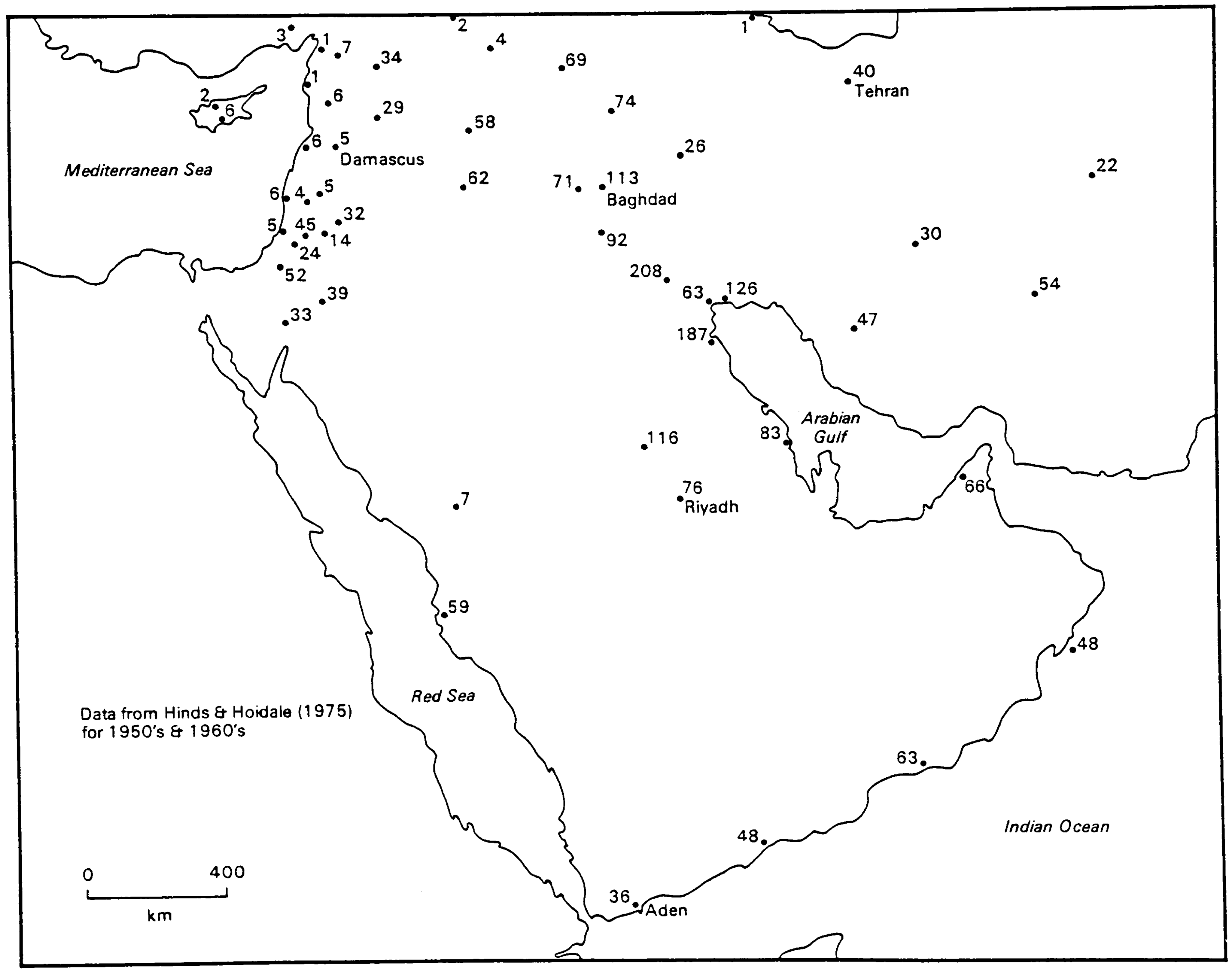



Figure 5.2 Distribution of blowing dust events (visibility less than 11km) in the Middle East

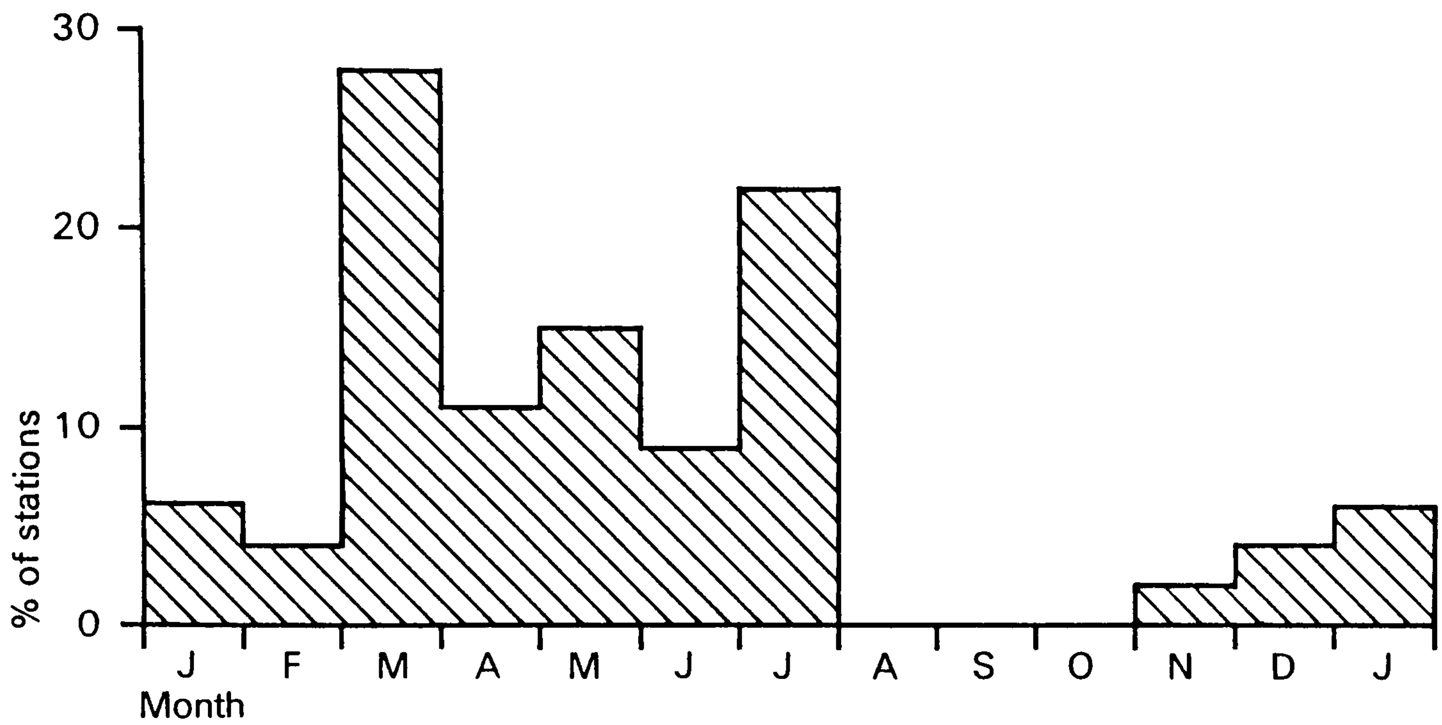



Figure 5.3 Percentages of Middle Eastern meteorological stations with a maximum frequency of dust events during a particular month

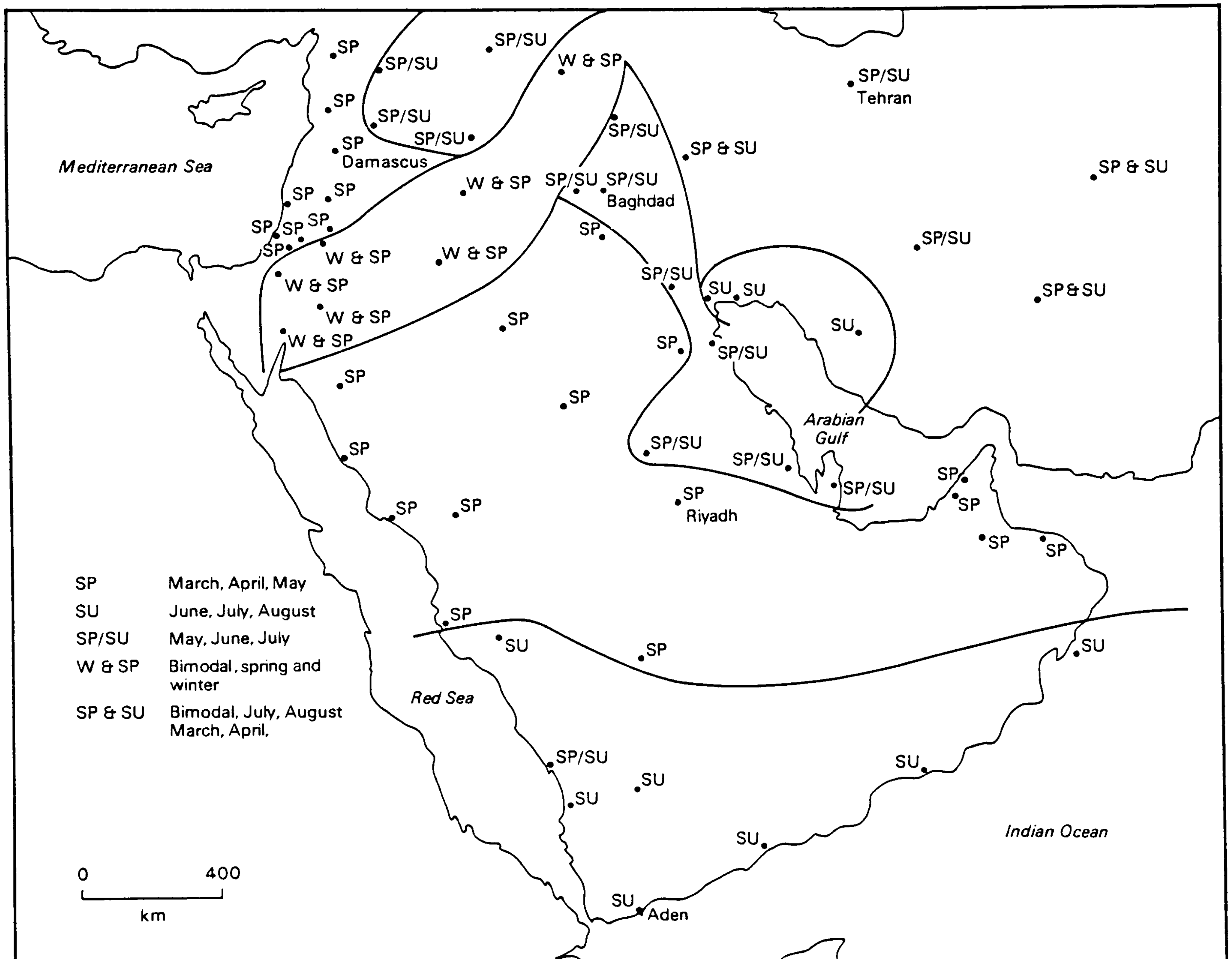



Figure 5.4 Seasonality of dust events in the Middle East

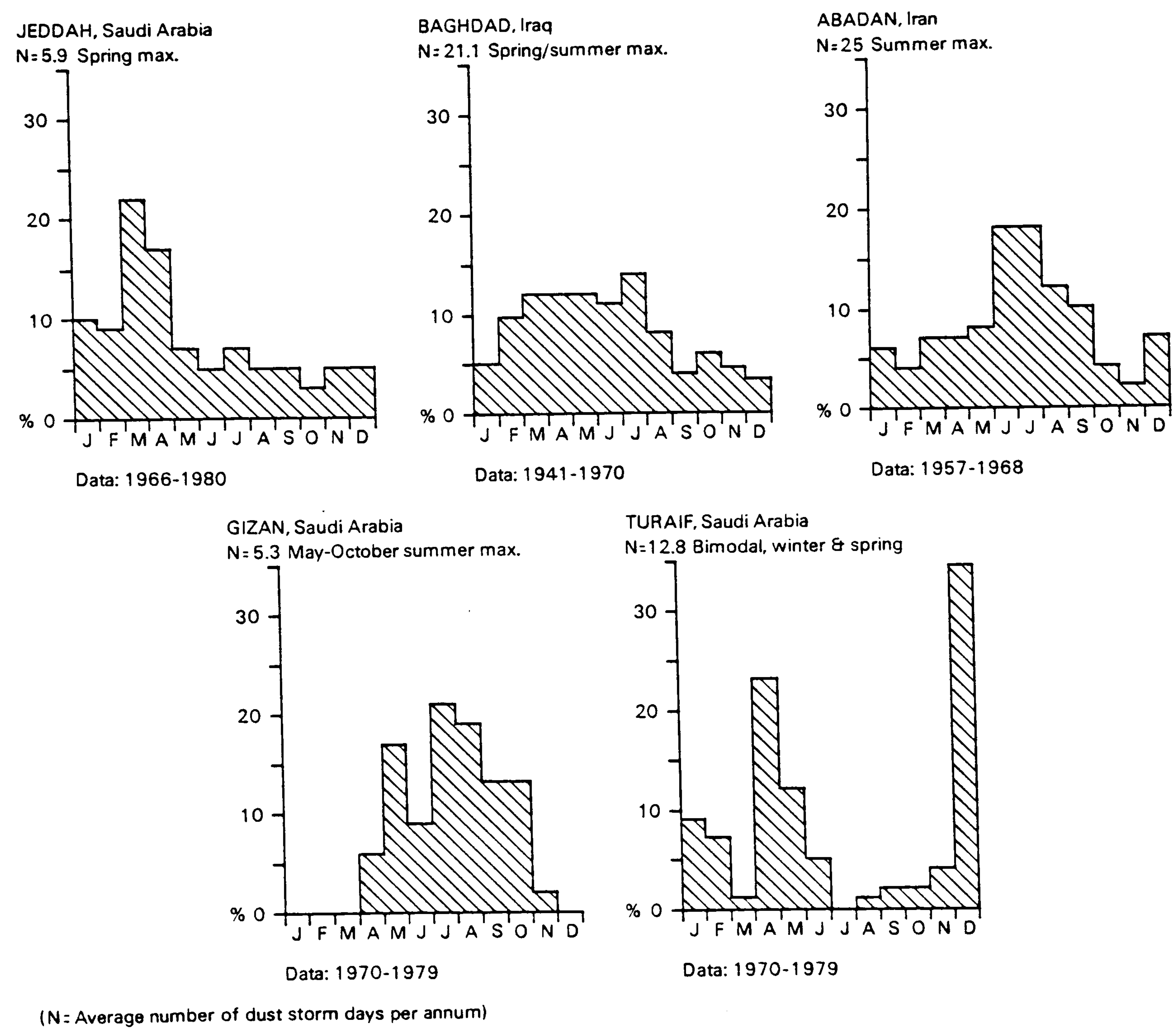



Figure 5.5 Five types of monthly percentage frequency distributions of dust storm occurrence in the Middle East

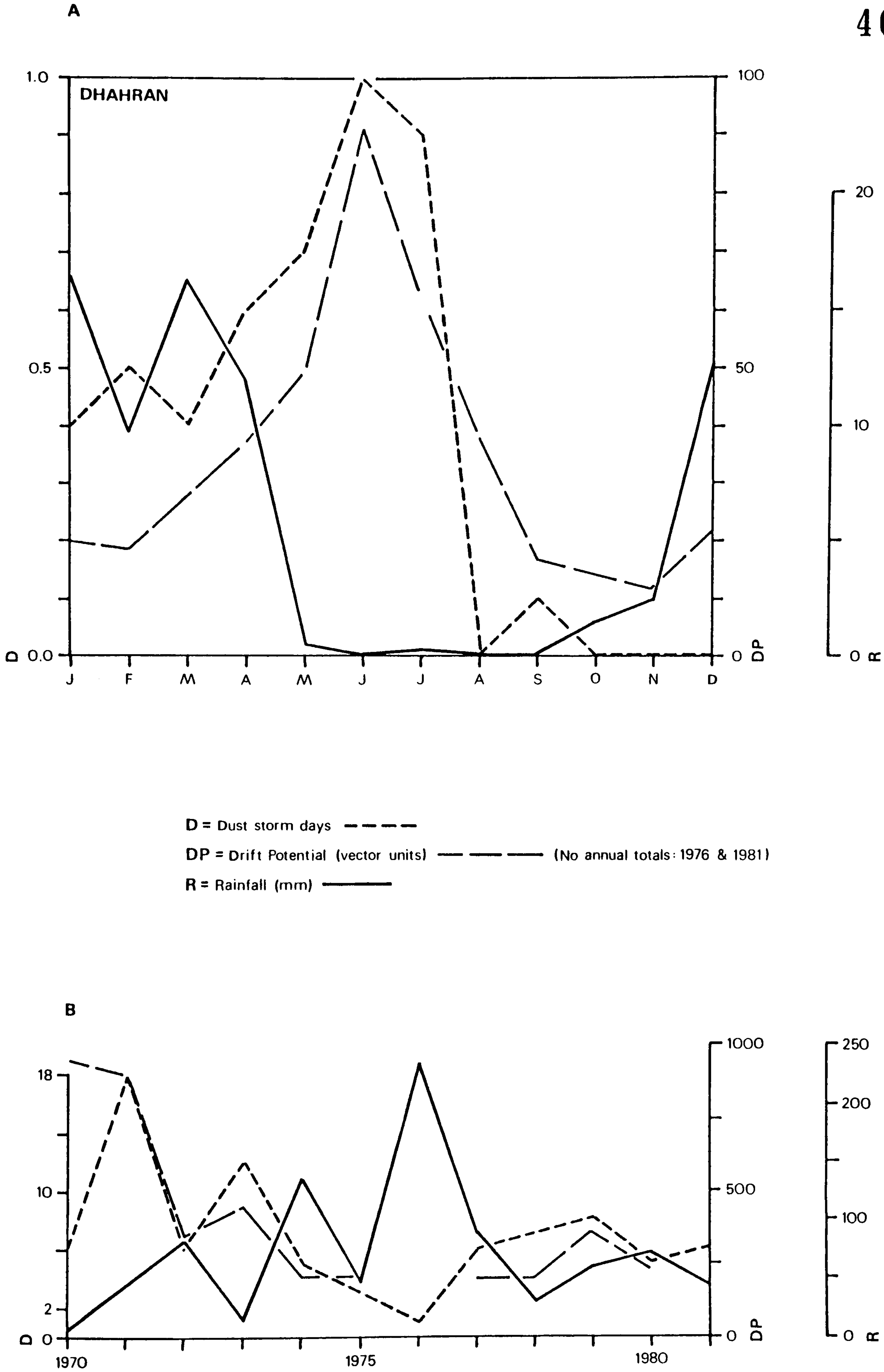



Figure 5.6A&B Monthly dust storm frequencies, rainfall totals & Drift Potentials, with annual totals of dust storms & Drift Potentials (1970-81) for Dhahran, Saudi Arabia

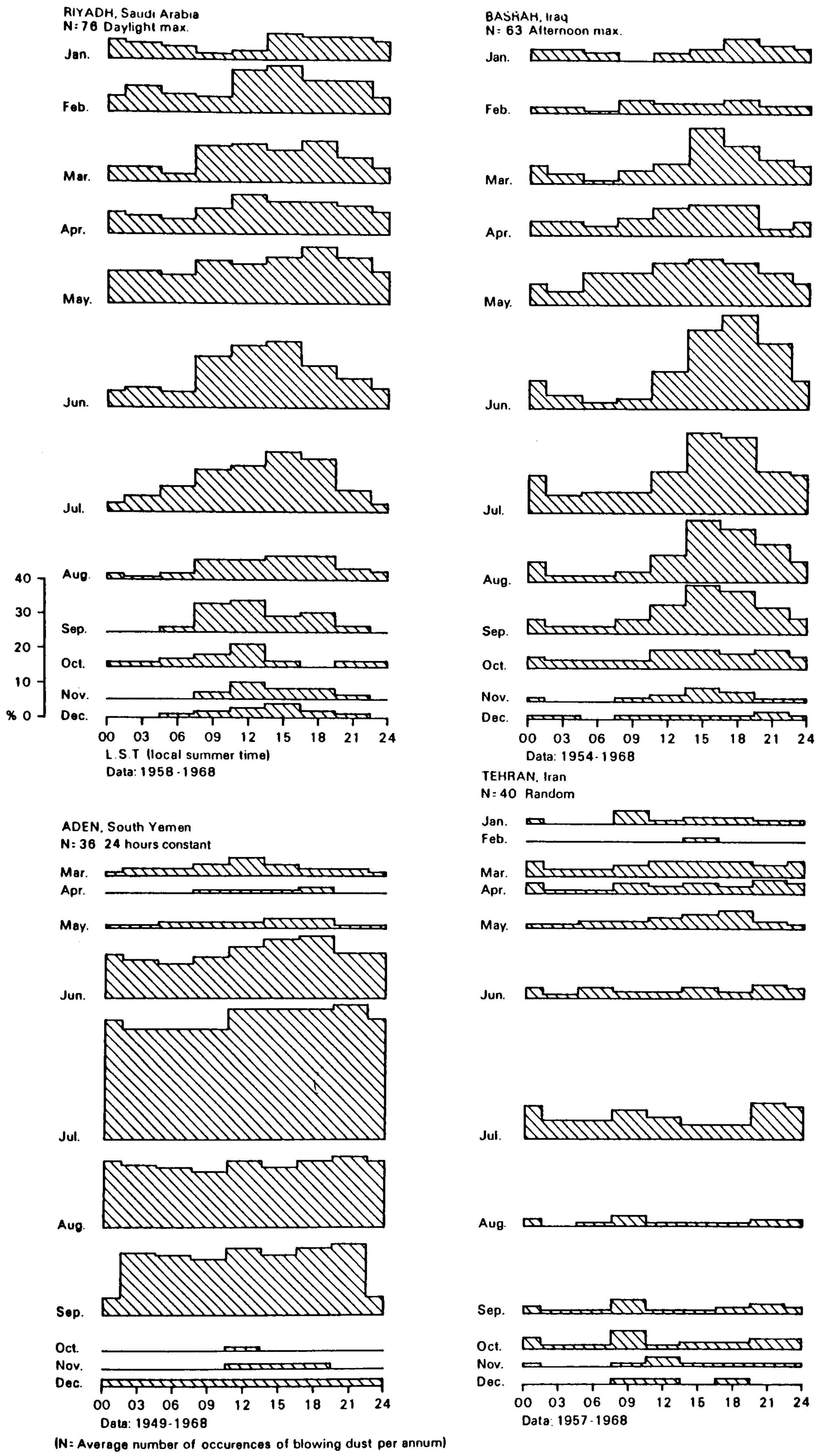



Figure 5.7 Four types of diurnal haze frequency variations in the Middle East

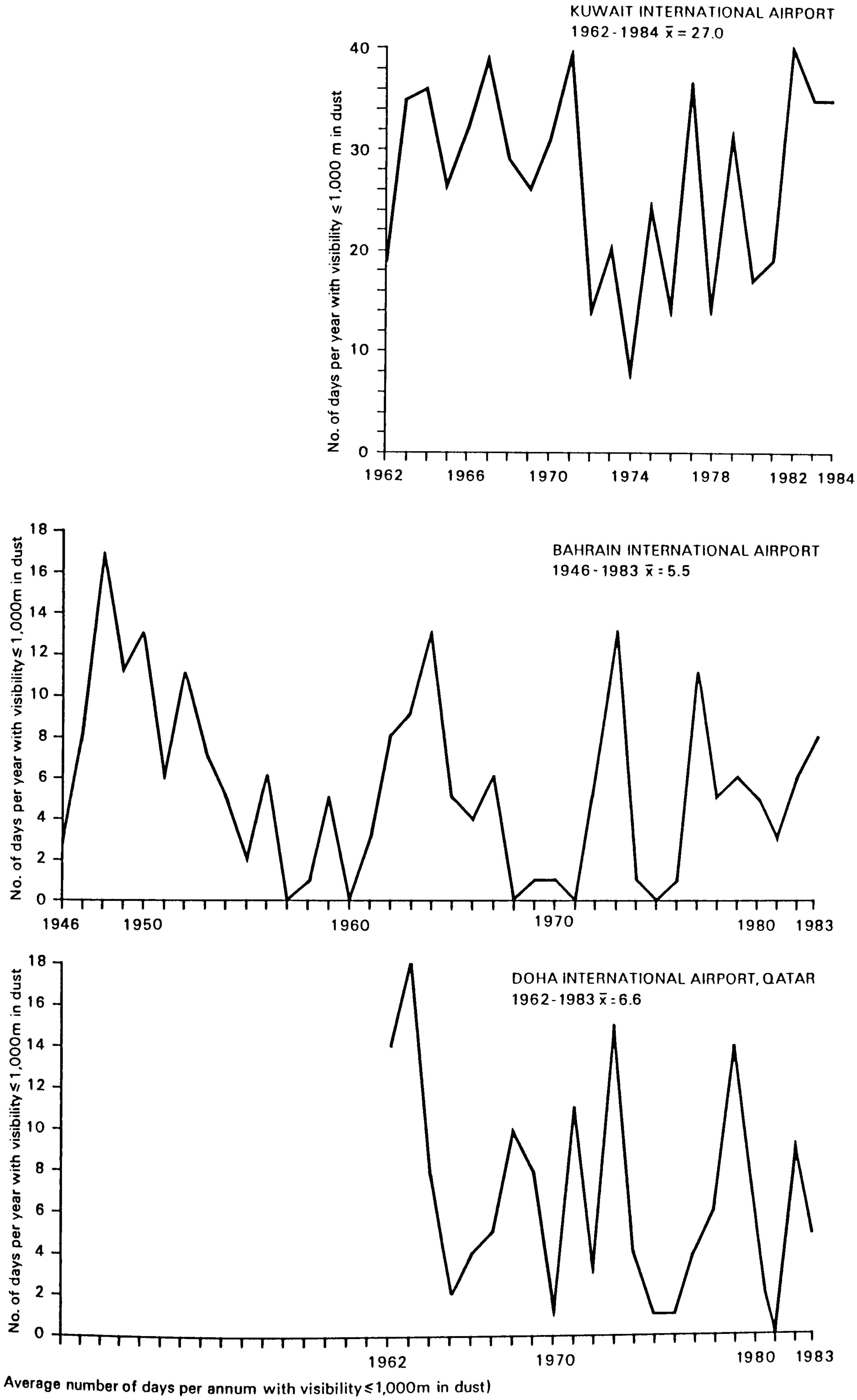



Figure 5.8 Annual frequencies of days with visibility less than 1000m due to dust at Kuwait, Bahrain & Doha

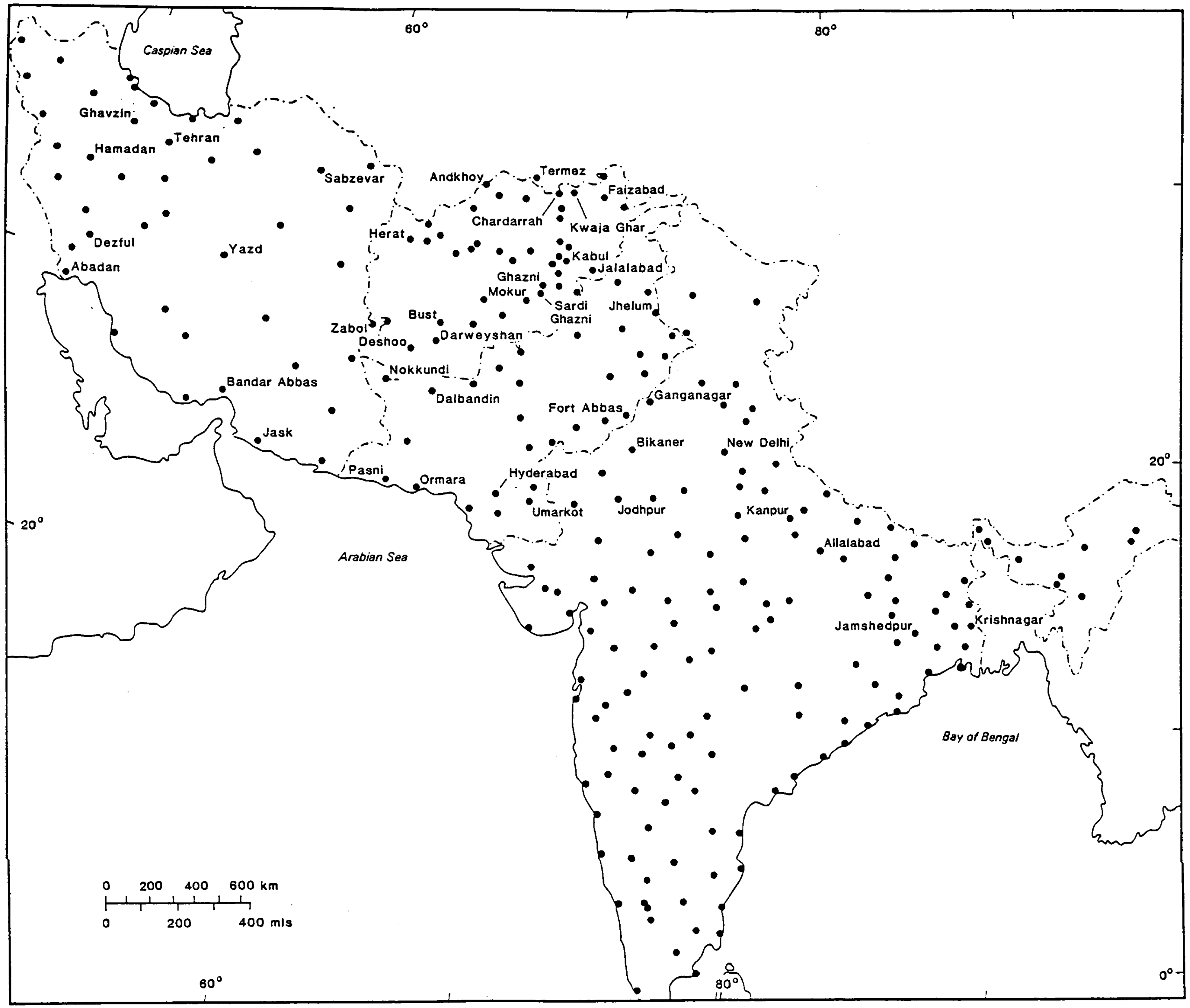



Figure 6.1 Geographical distribution of stations analysed in chapter 6

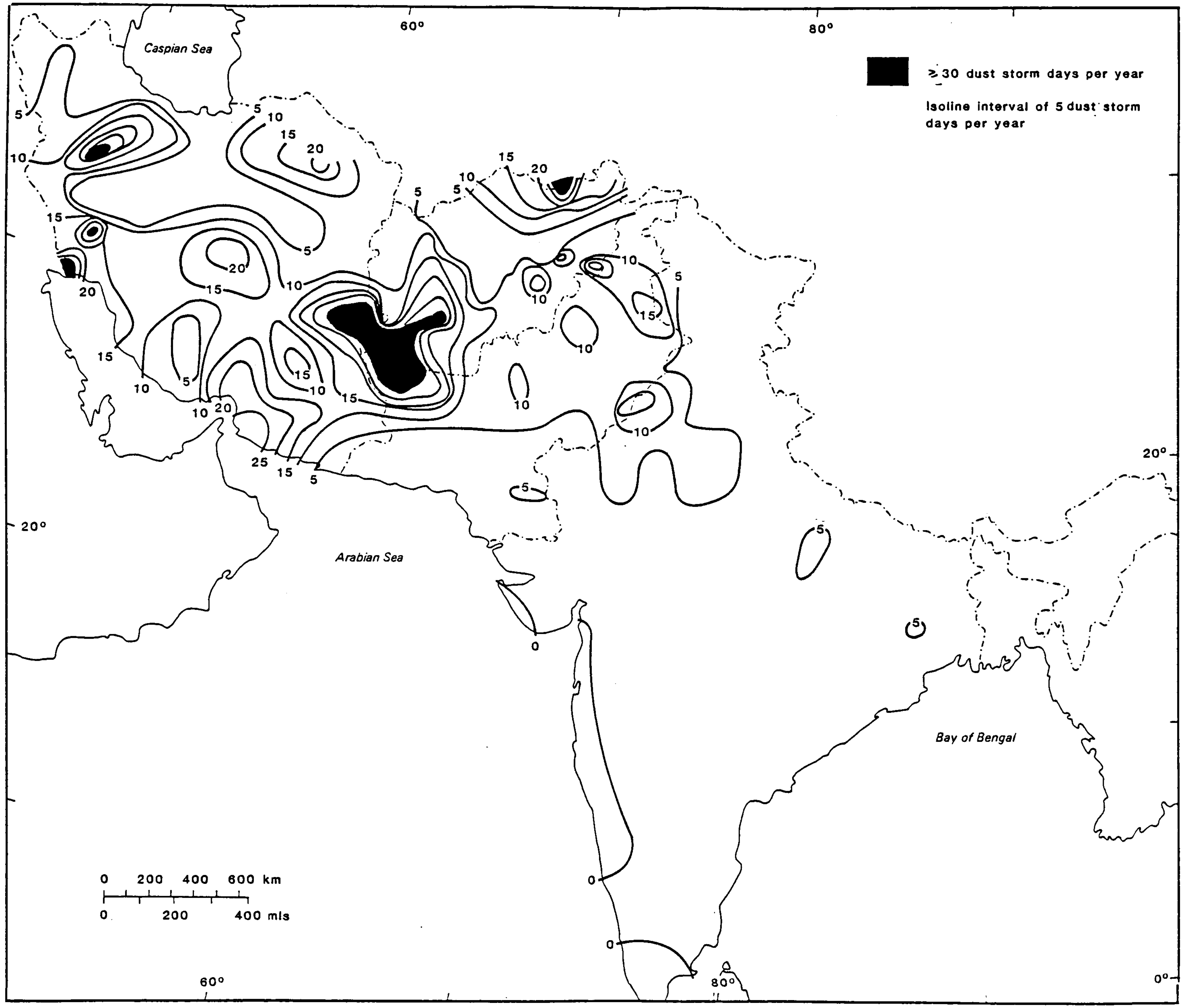



Figure 6.2 Distribution of dust storms in south-west Asia

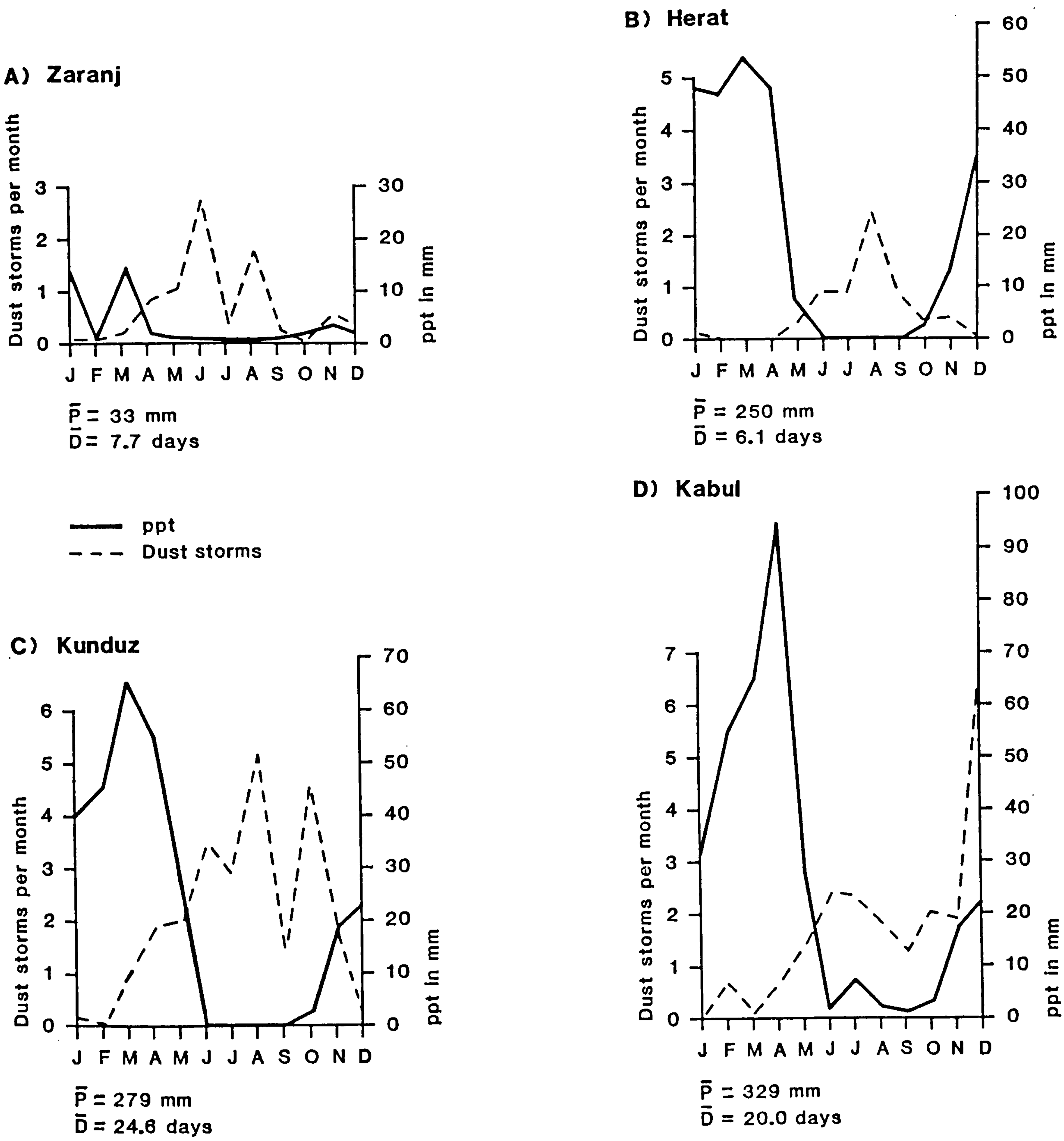



Figure 6.3 Monthly dust storm frequencies & rainfall totals for selected stations in Afghanistan, showing maximum dust-raising activity during the dry season

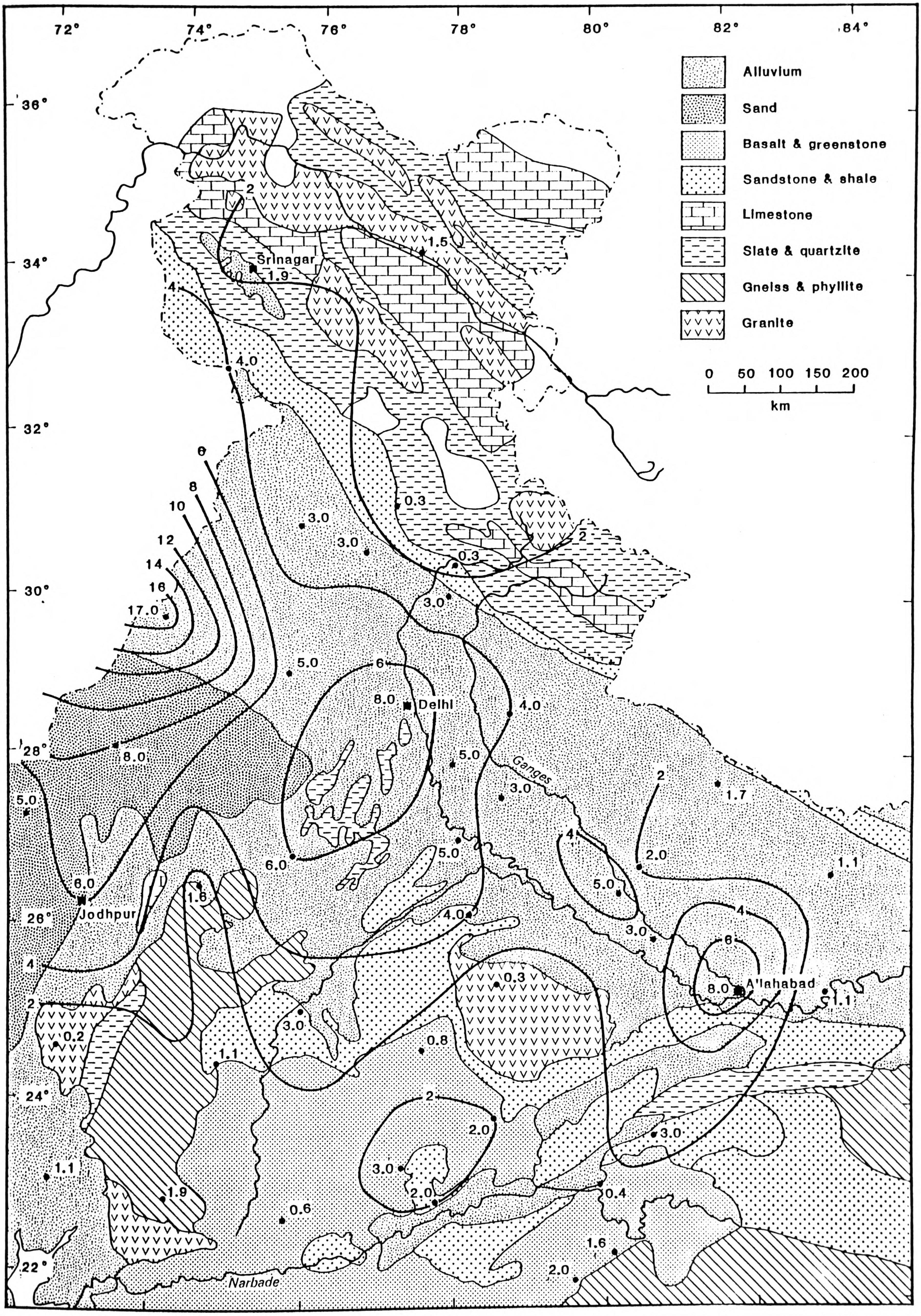



Figure 6.4 Distribution of dust storms in northwestern India, showing a concentration of dust-raising on fine grained sediments

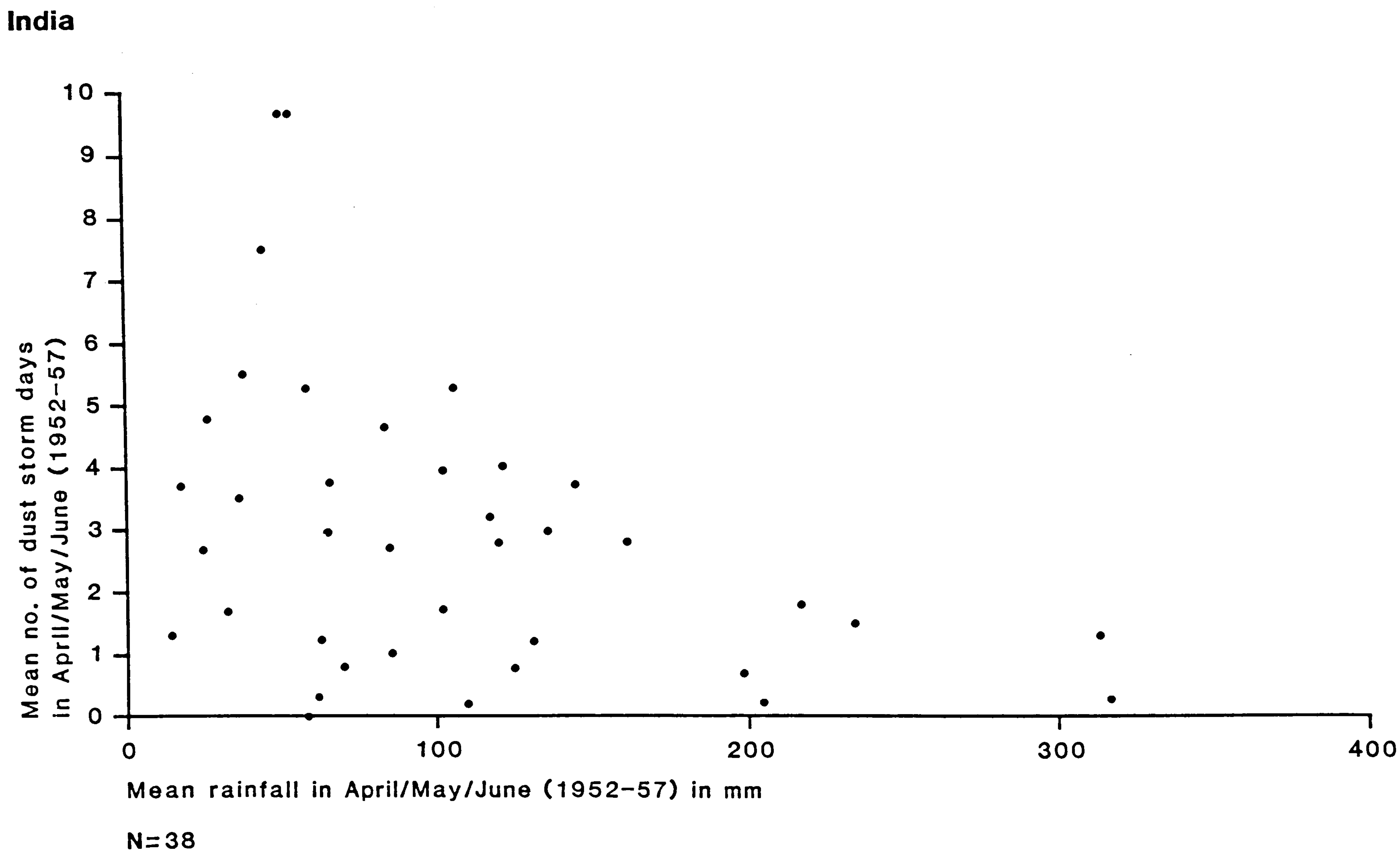



Figure 6.5 Frequency of dust storms in relation to mean rainfall for the period of maximum dust storm activity in northern India (April, May & June)

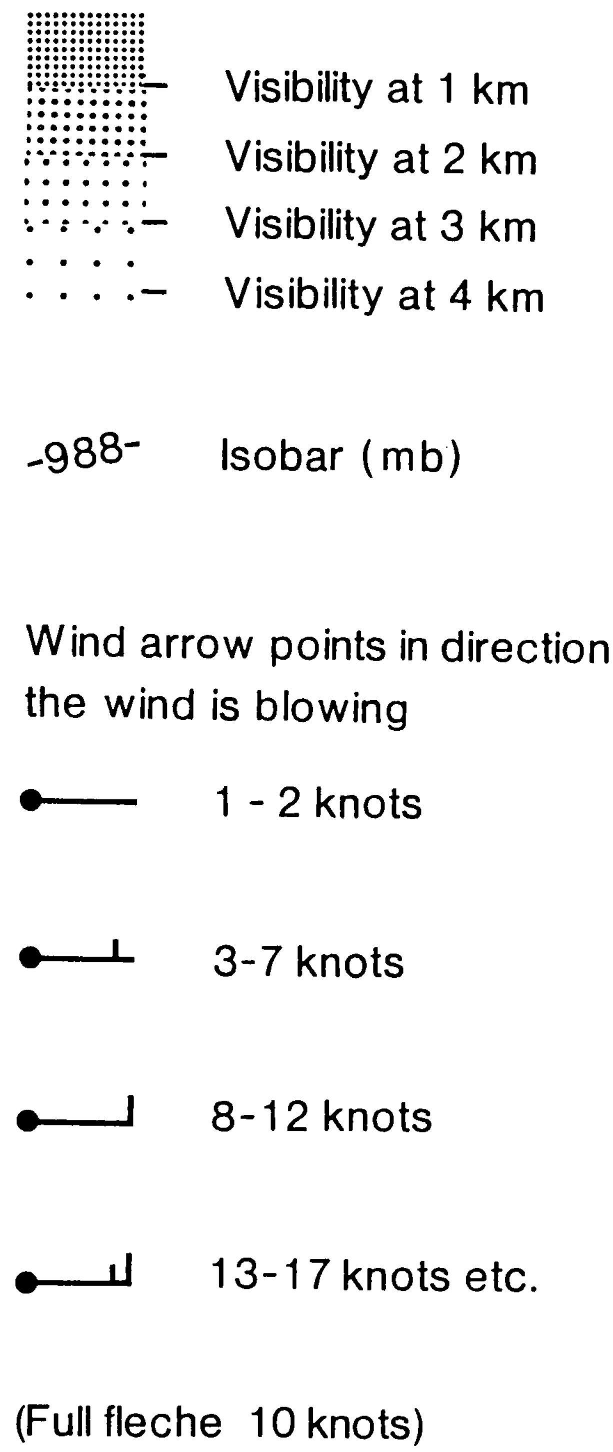



Figure 6.6 Explanation of symbols used in figures 6.8 to 6.11 (see also fig 2.5)

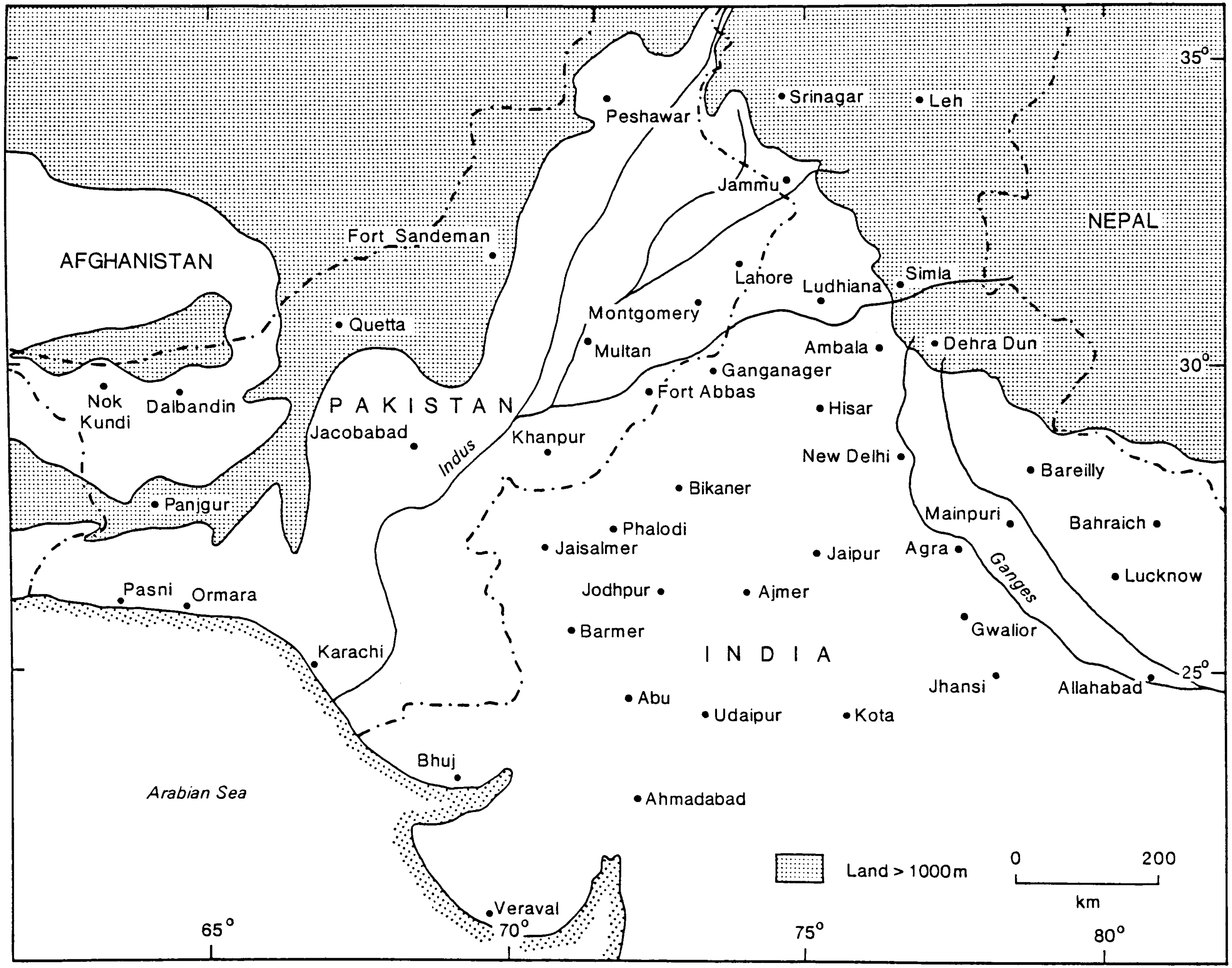



Figure 6.7 Geographical distribution of stations used in figures 6.8 to 6.11

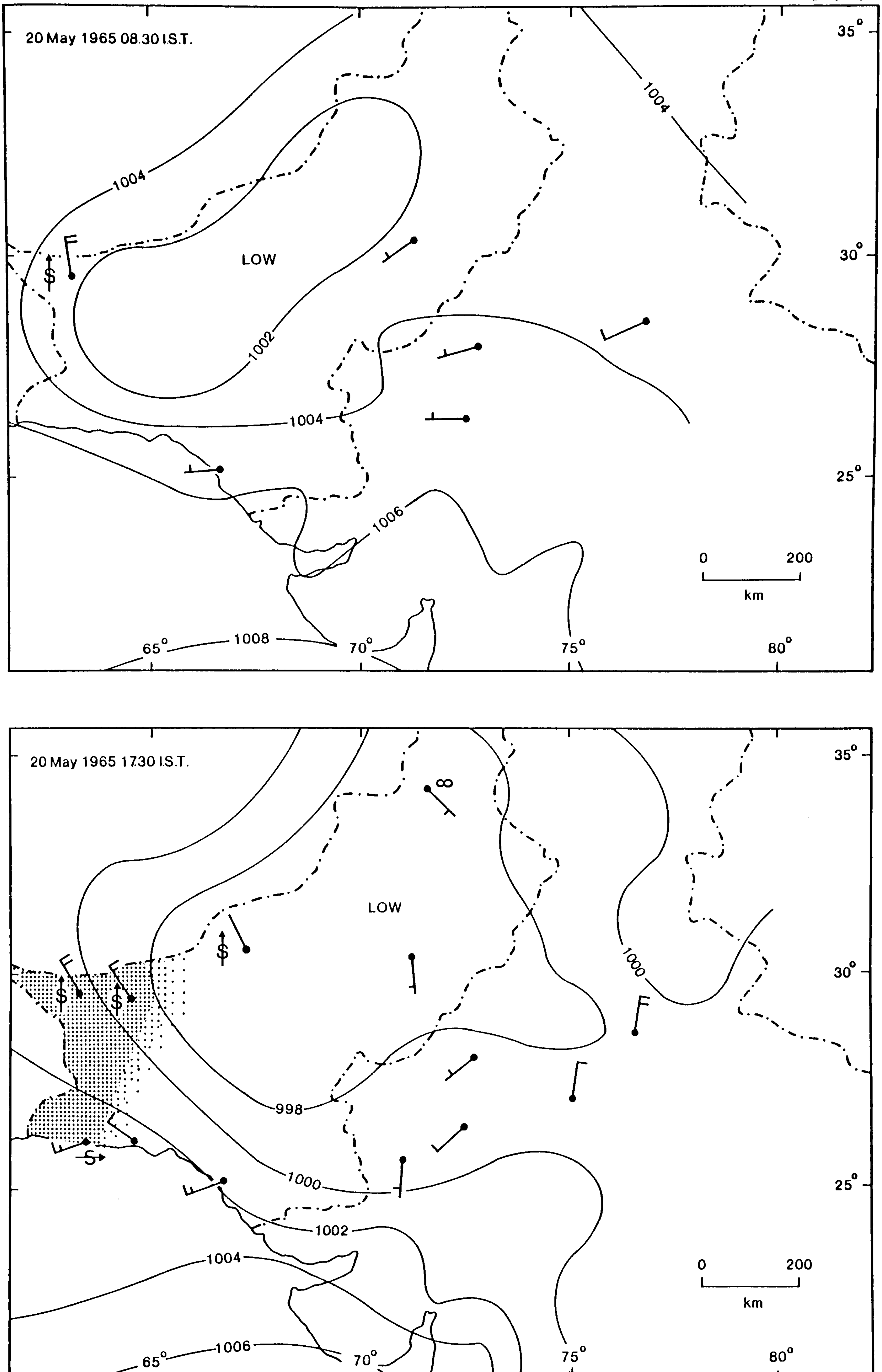
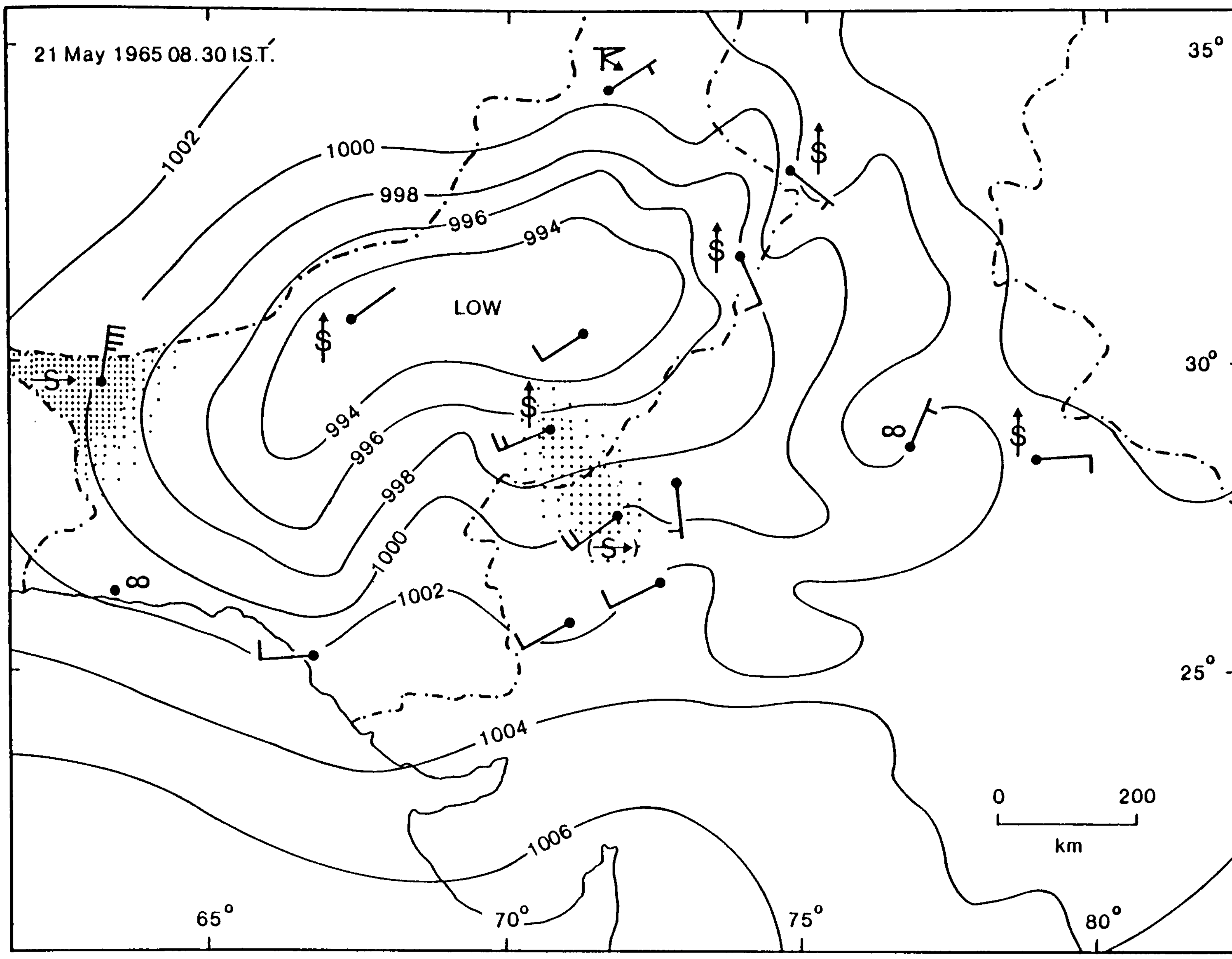



Figure 6.8 Weather charts based on SYNOP observations for 20-22 May 1965



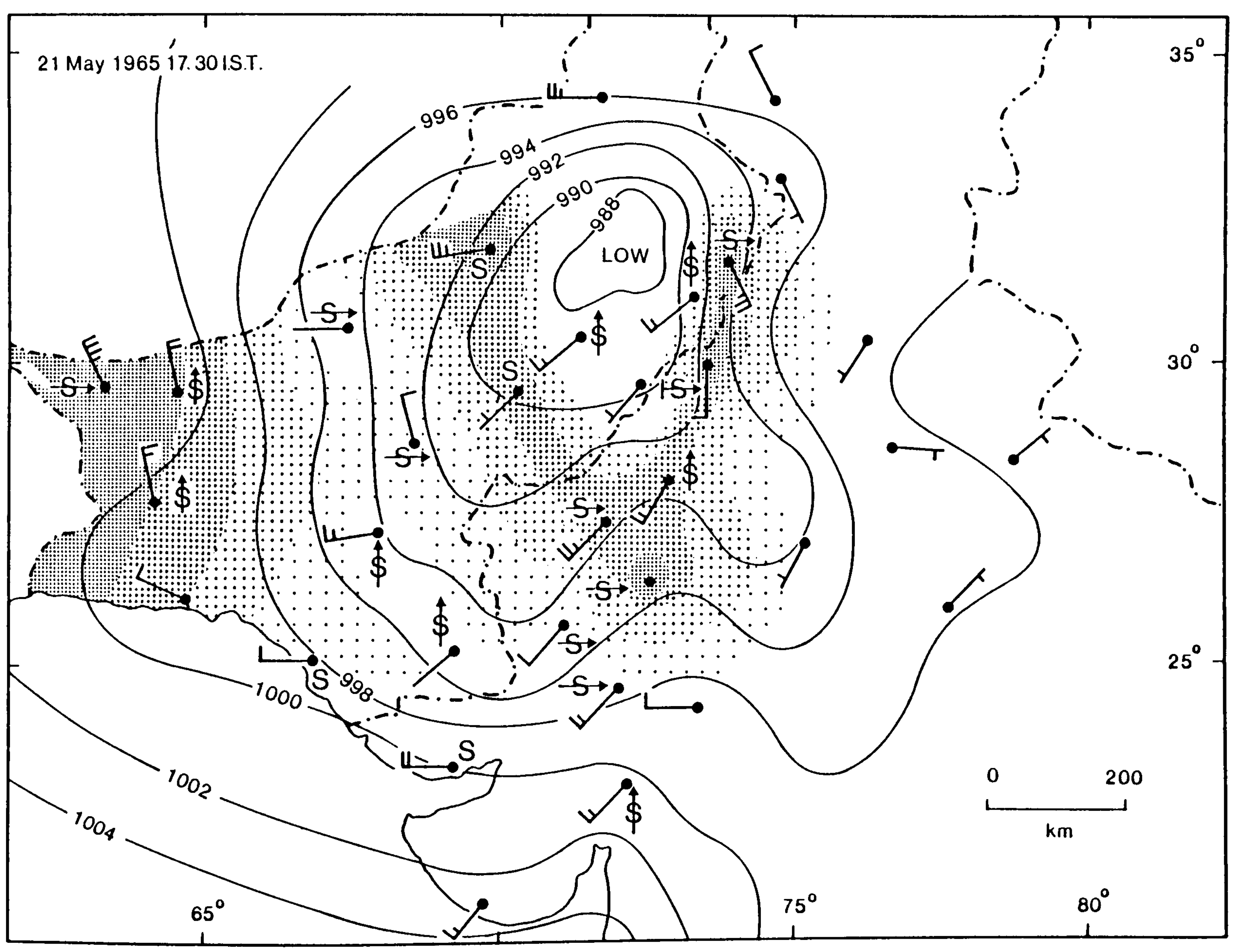




Figure 6.8 continued

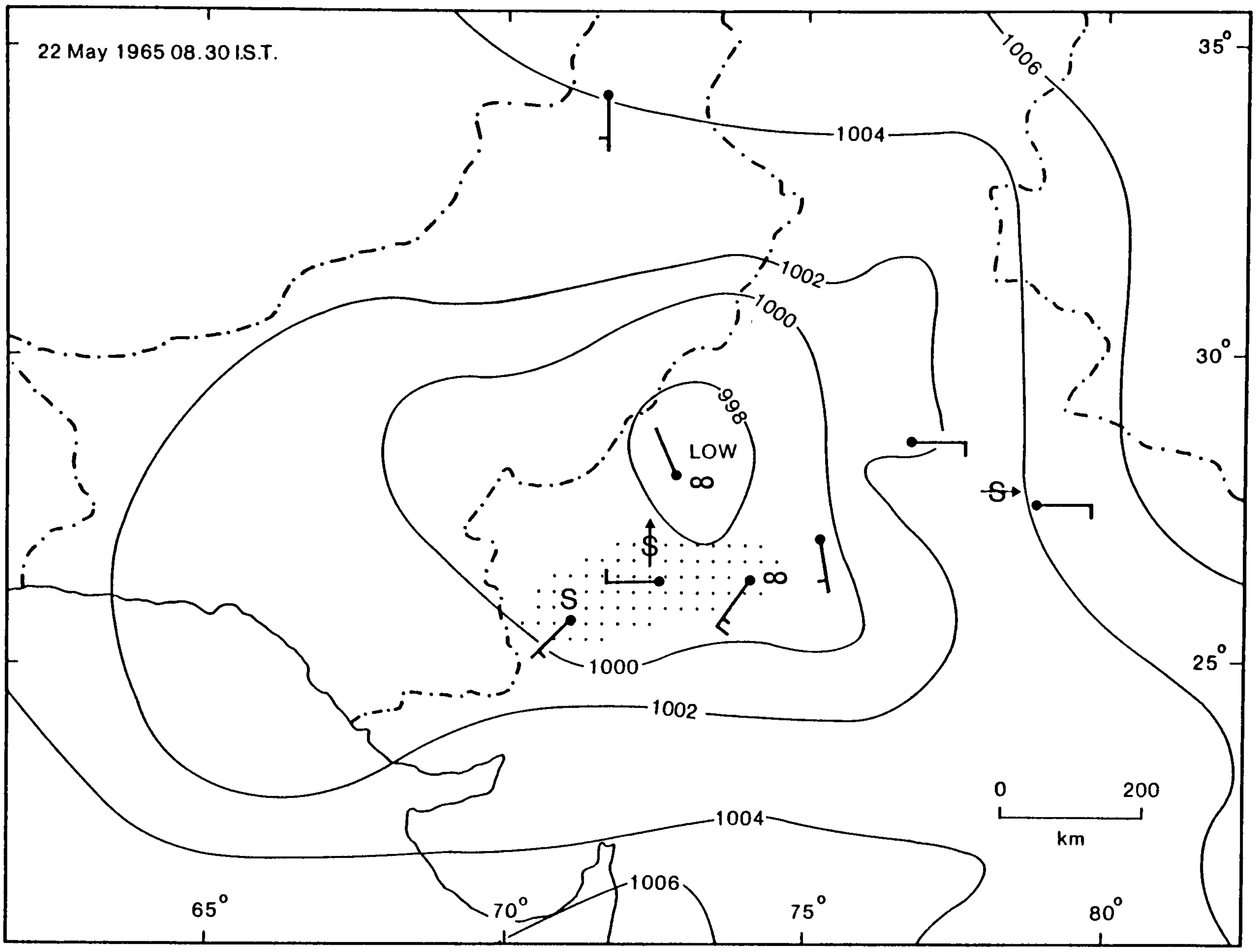
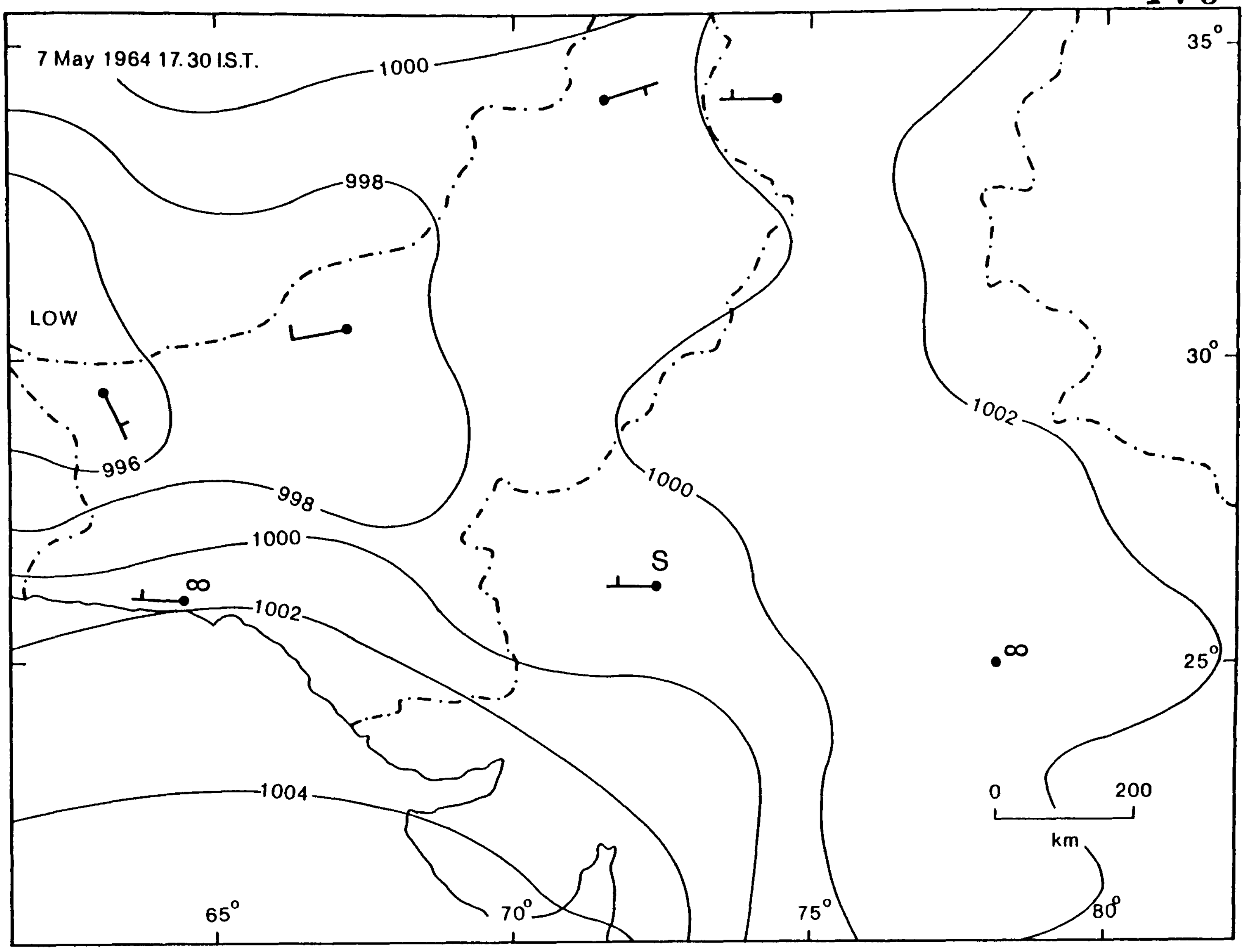



Figure 6.8 continued



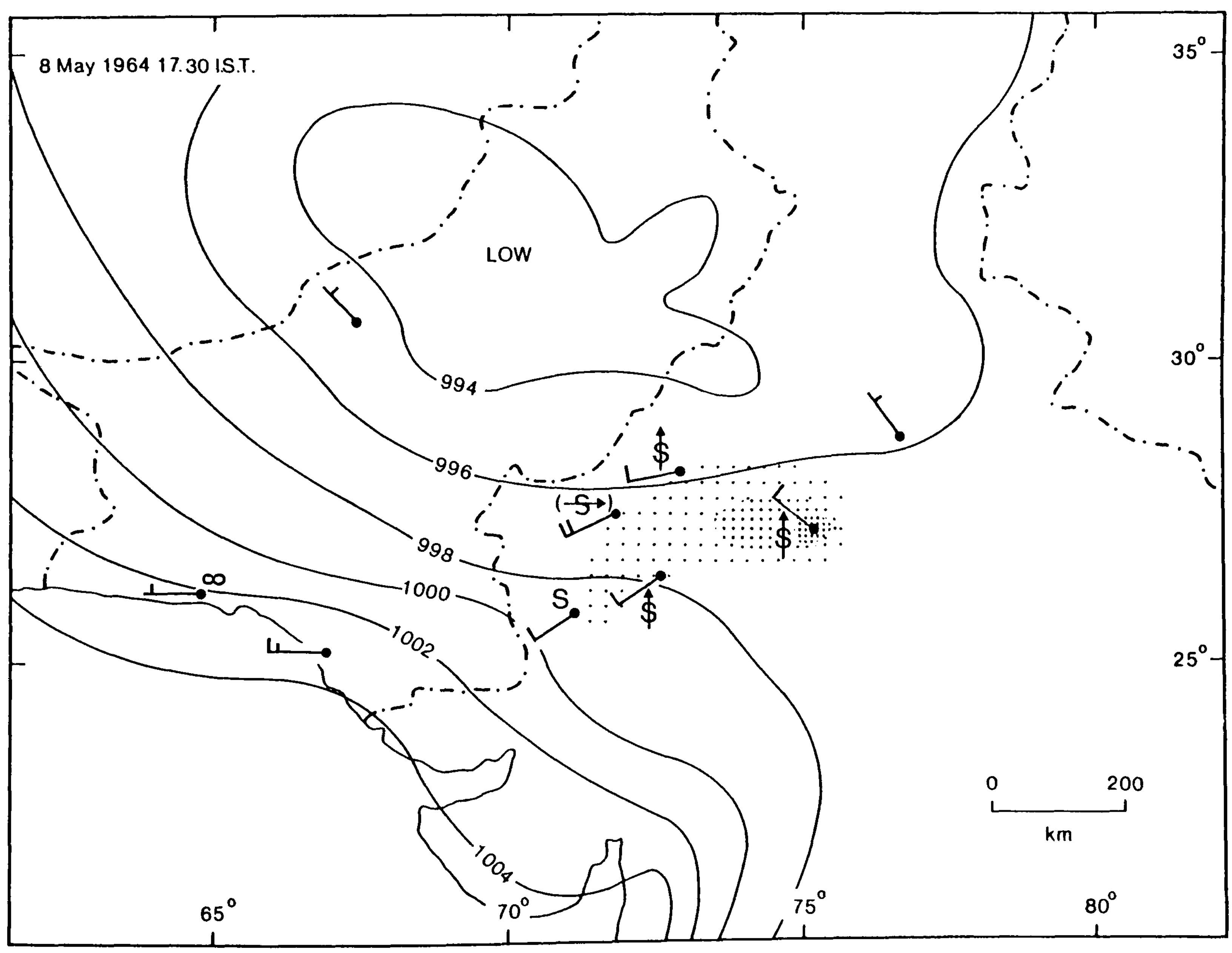
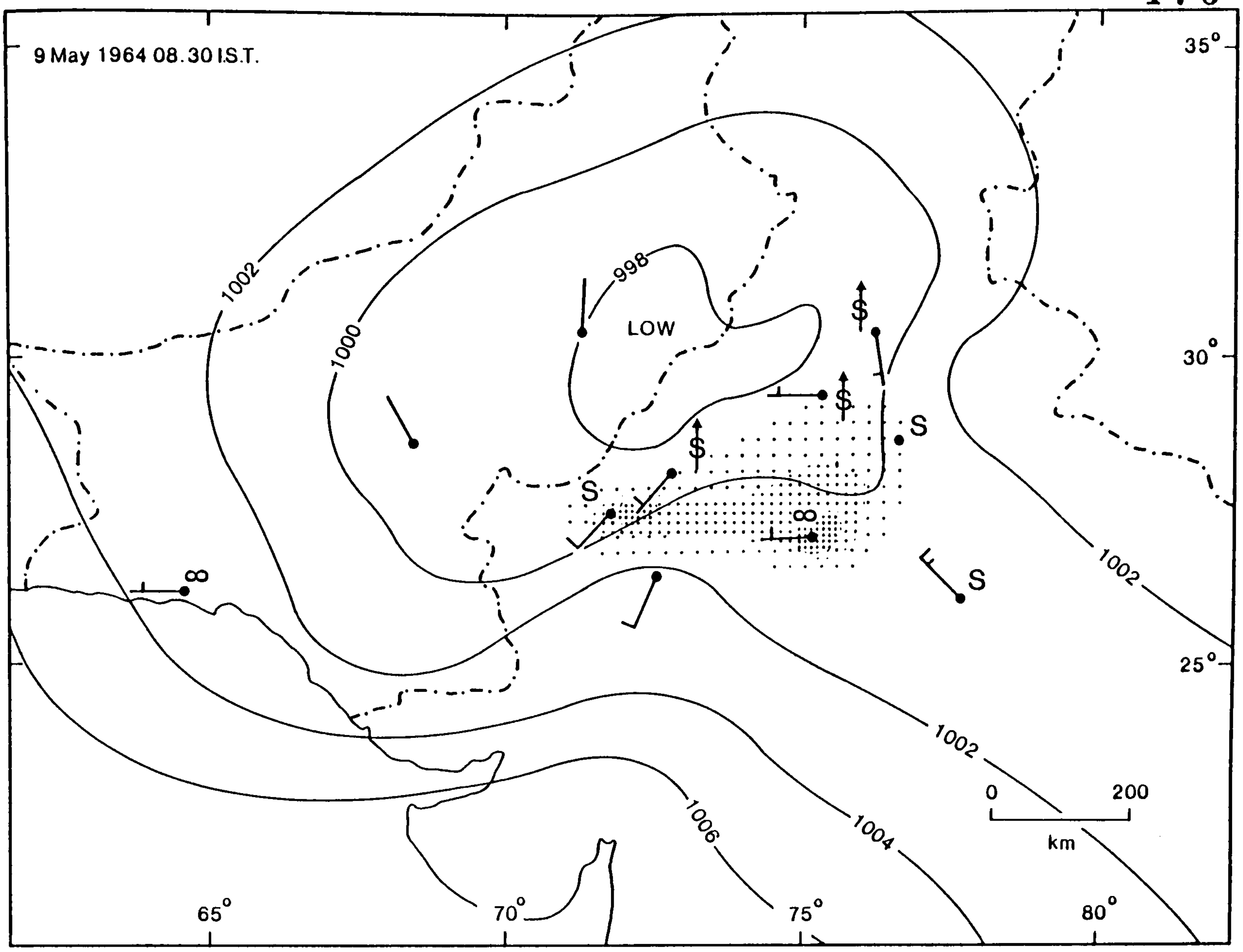




Figure 6.9 Weather charts based on SYNOP observations for 7-12 May 1964



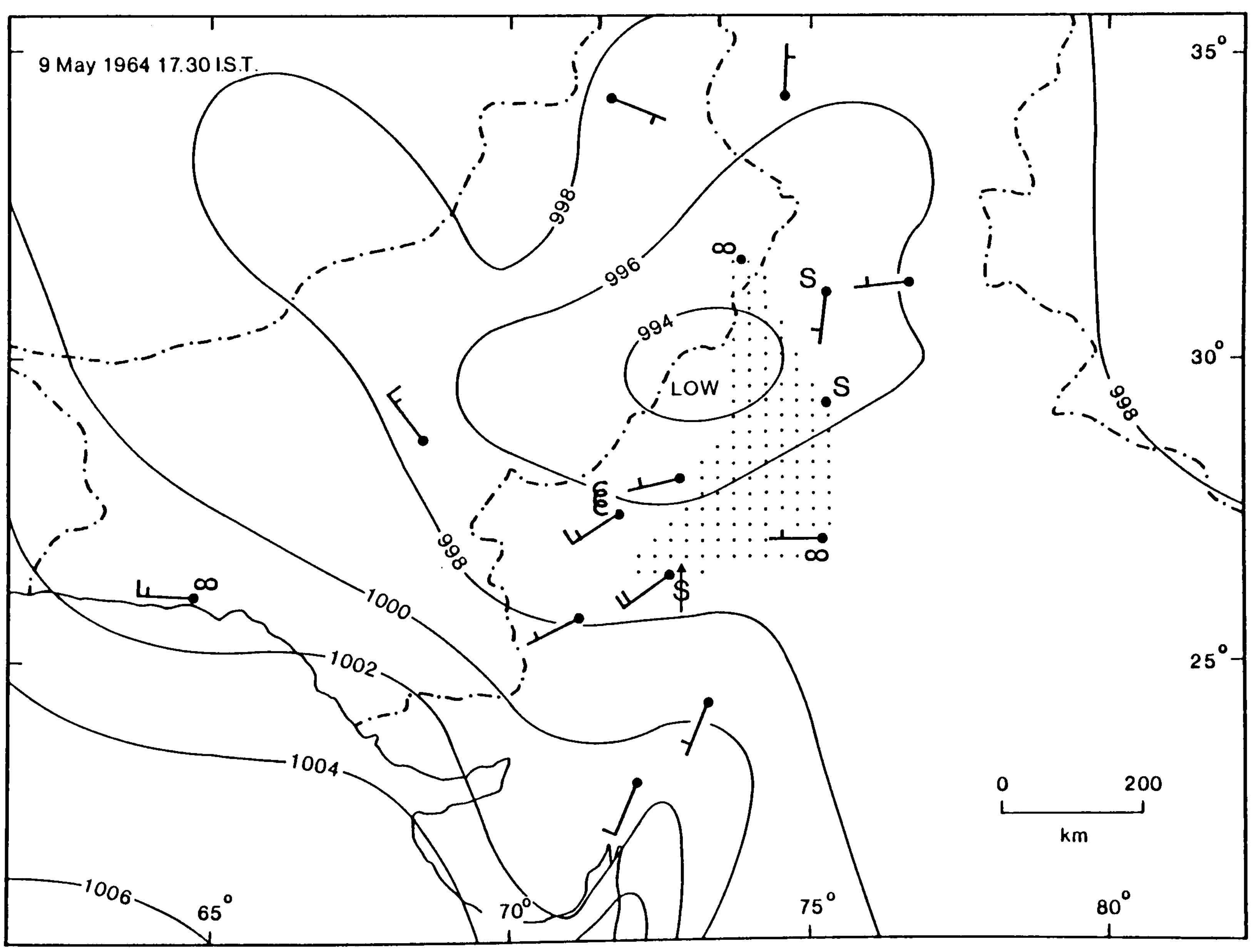
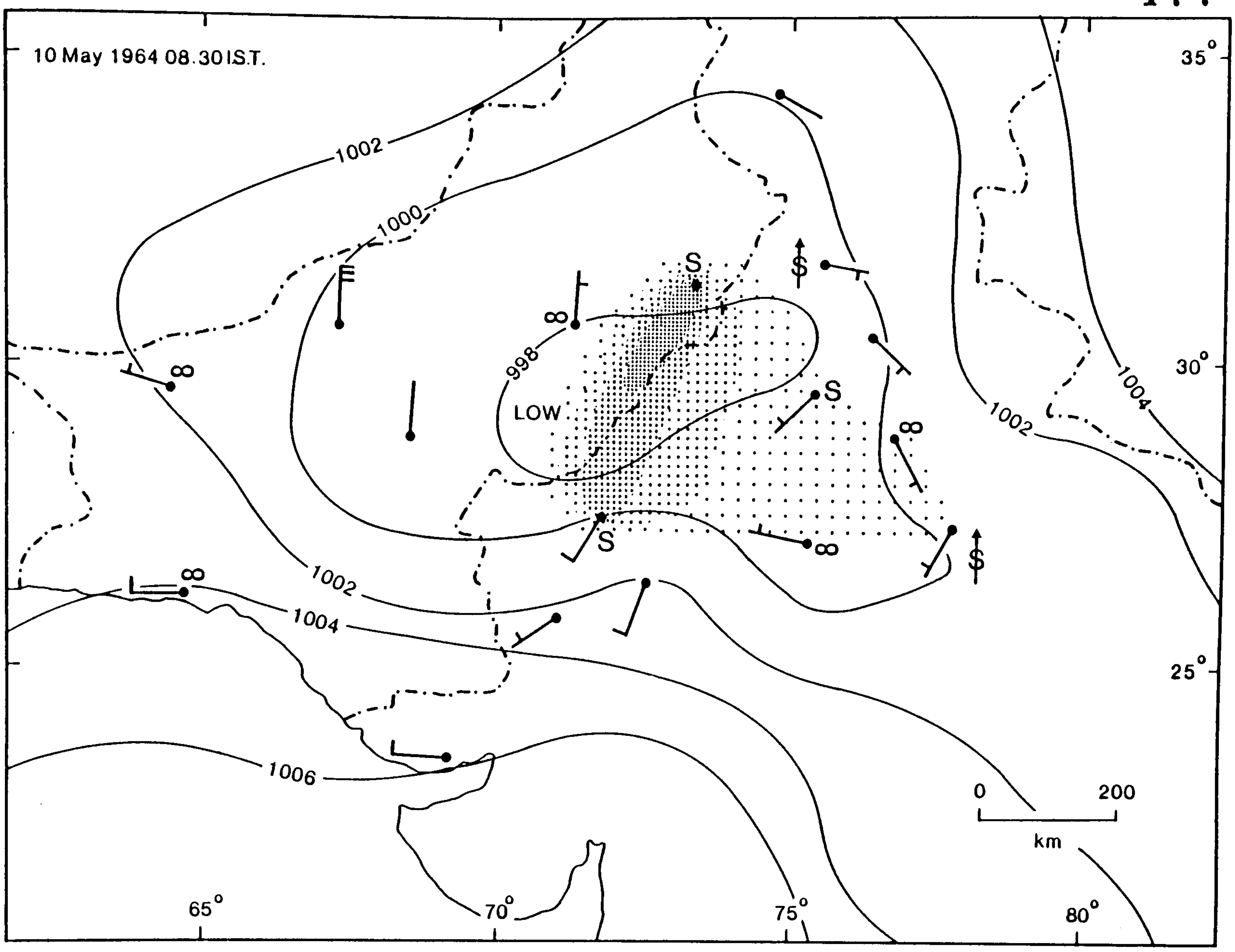




Figure 6.9 continued



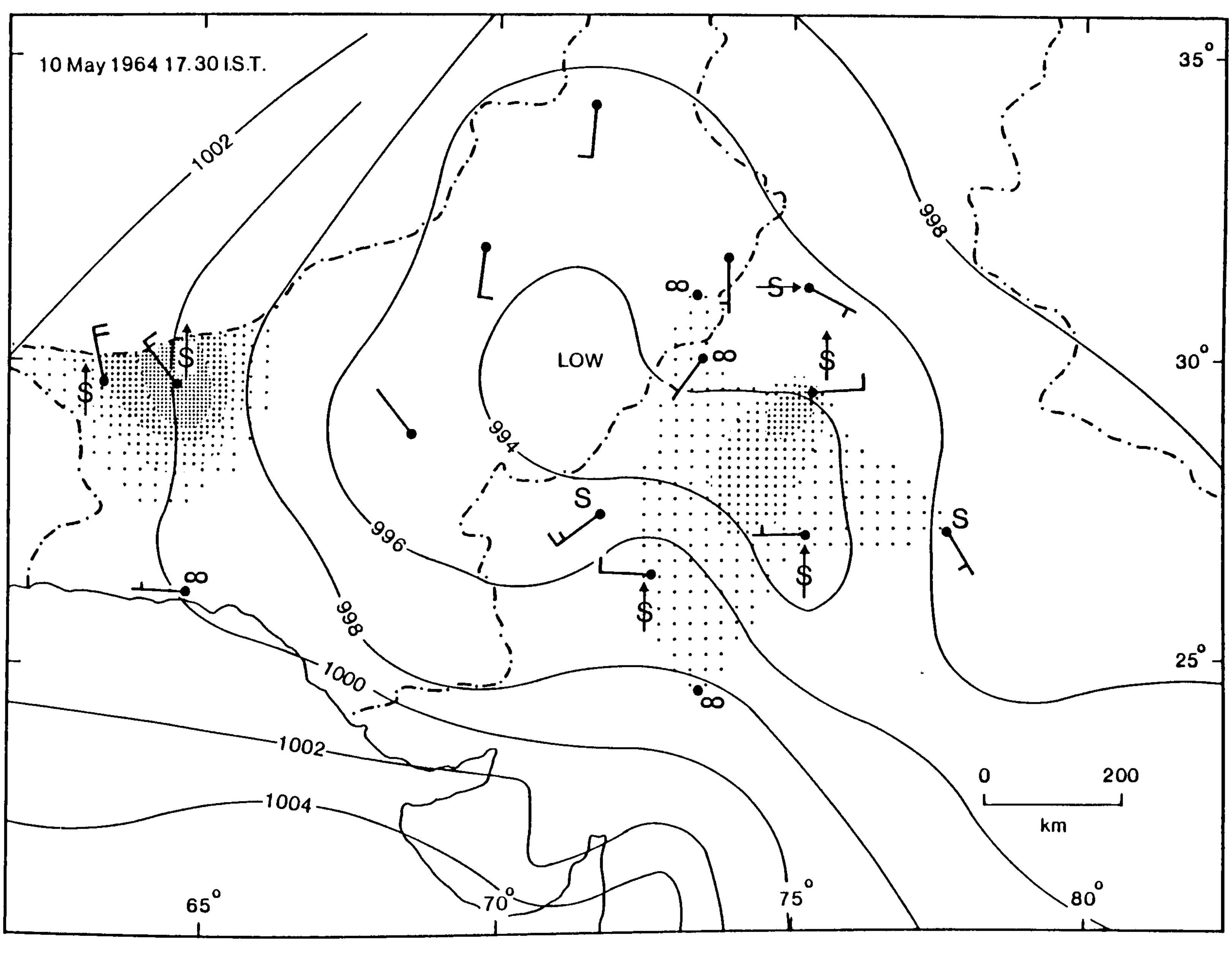
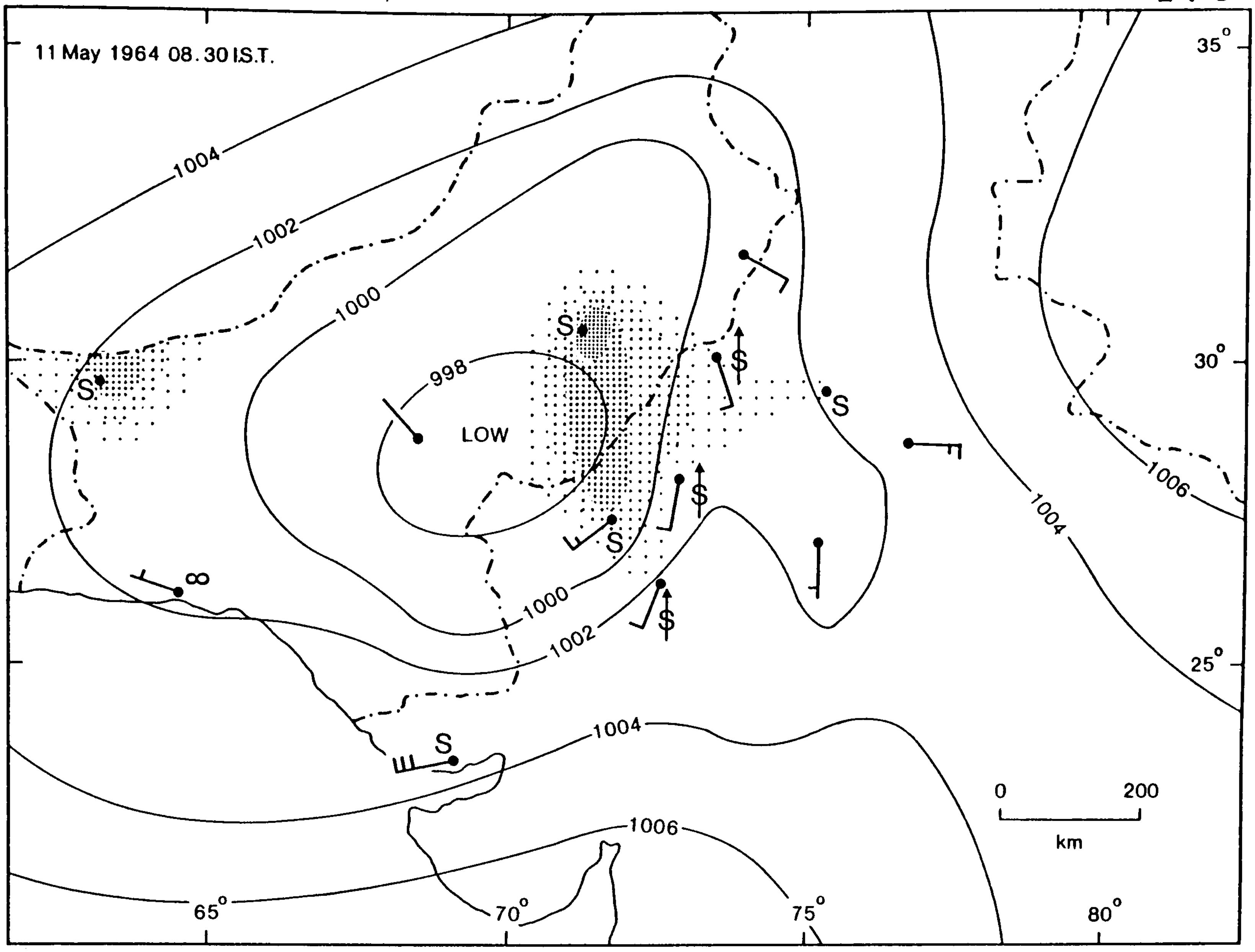




Figure 6.9 continued



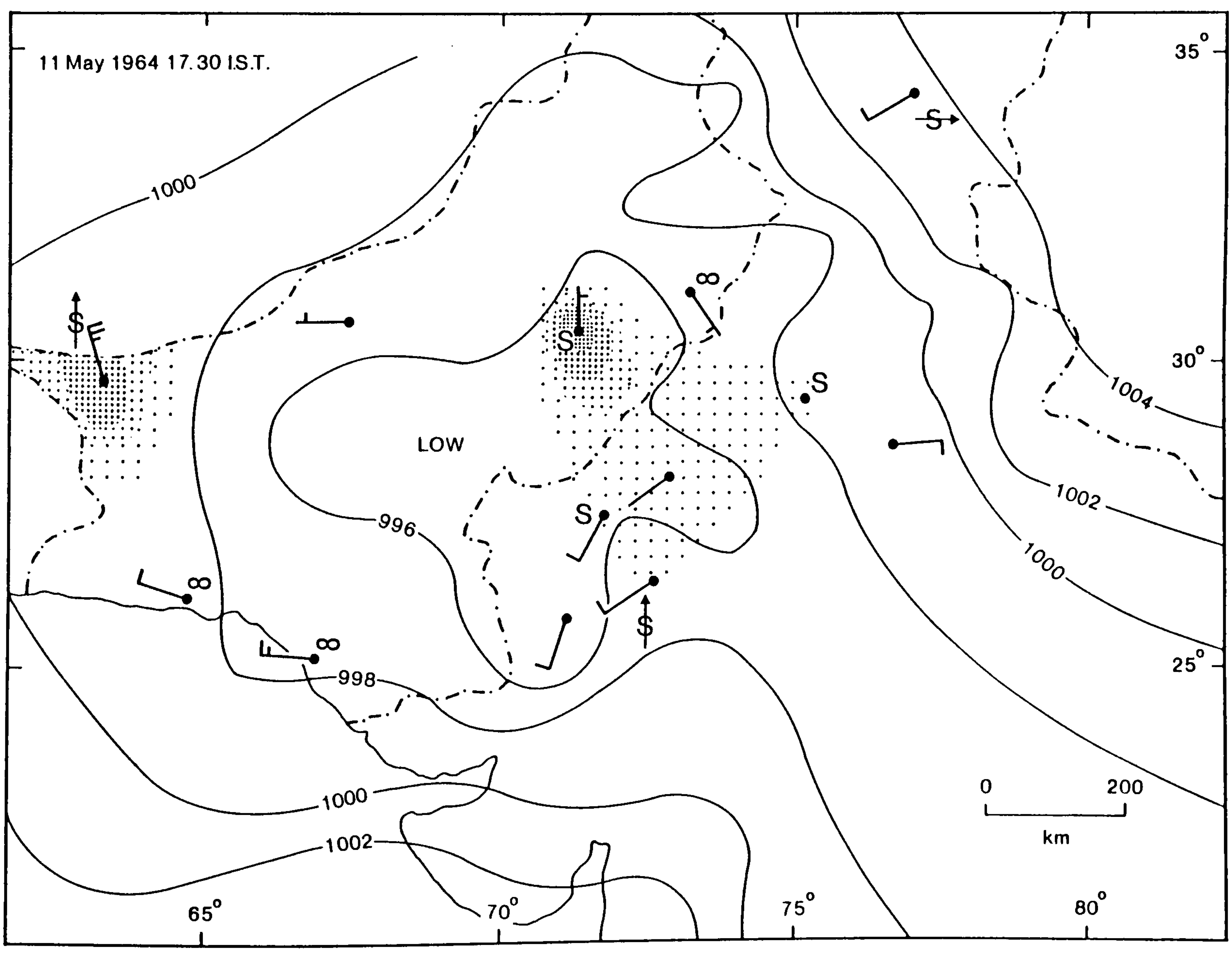
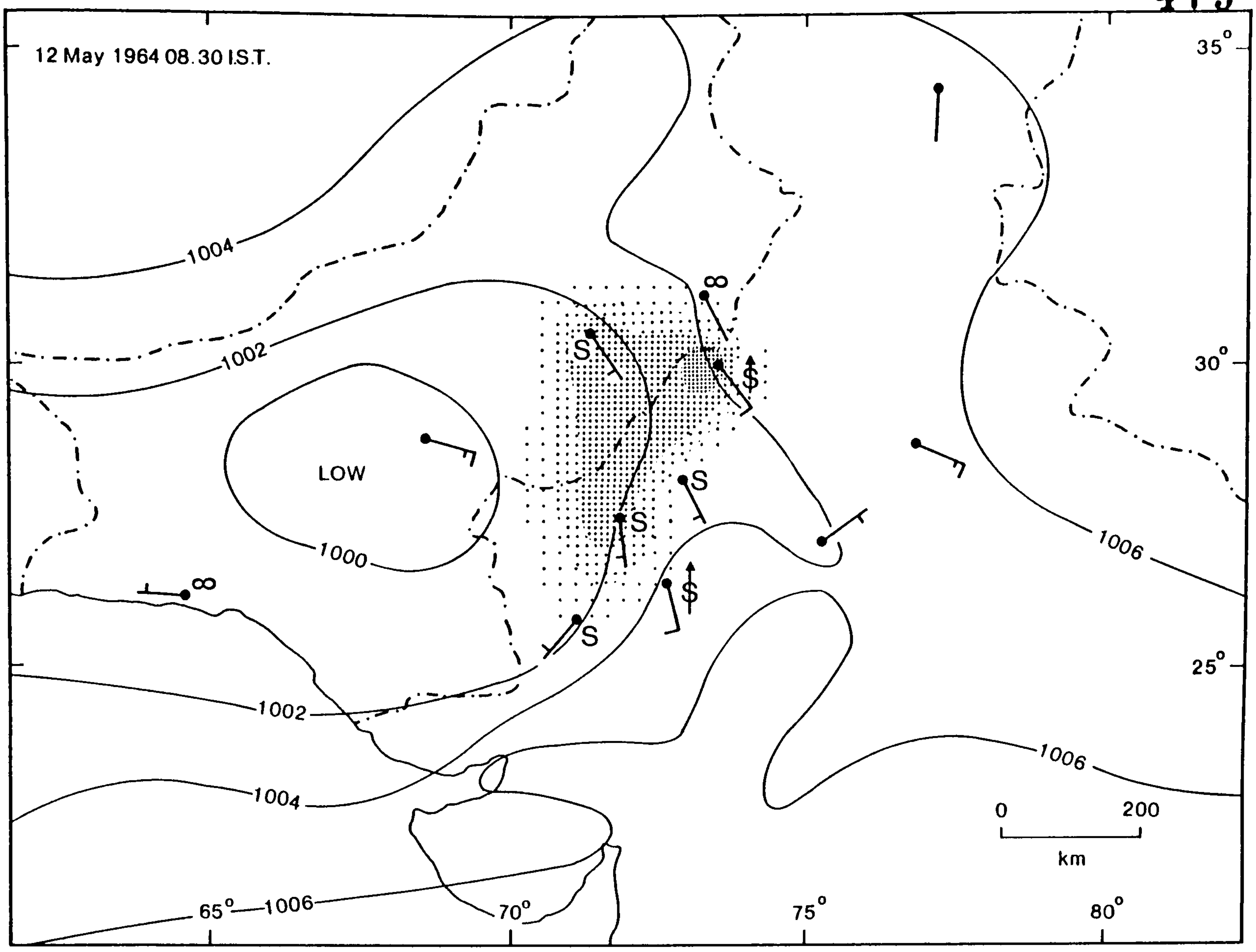




Figure 6.9 continued



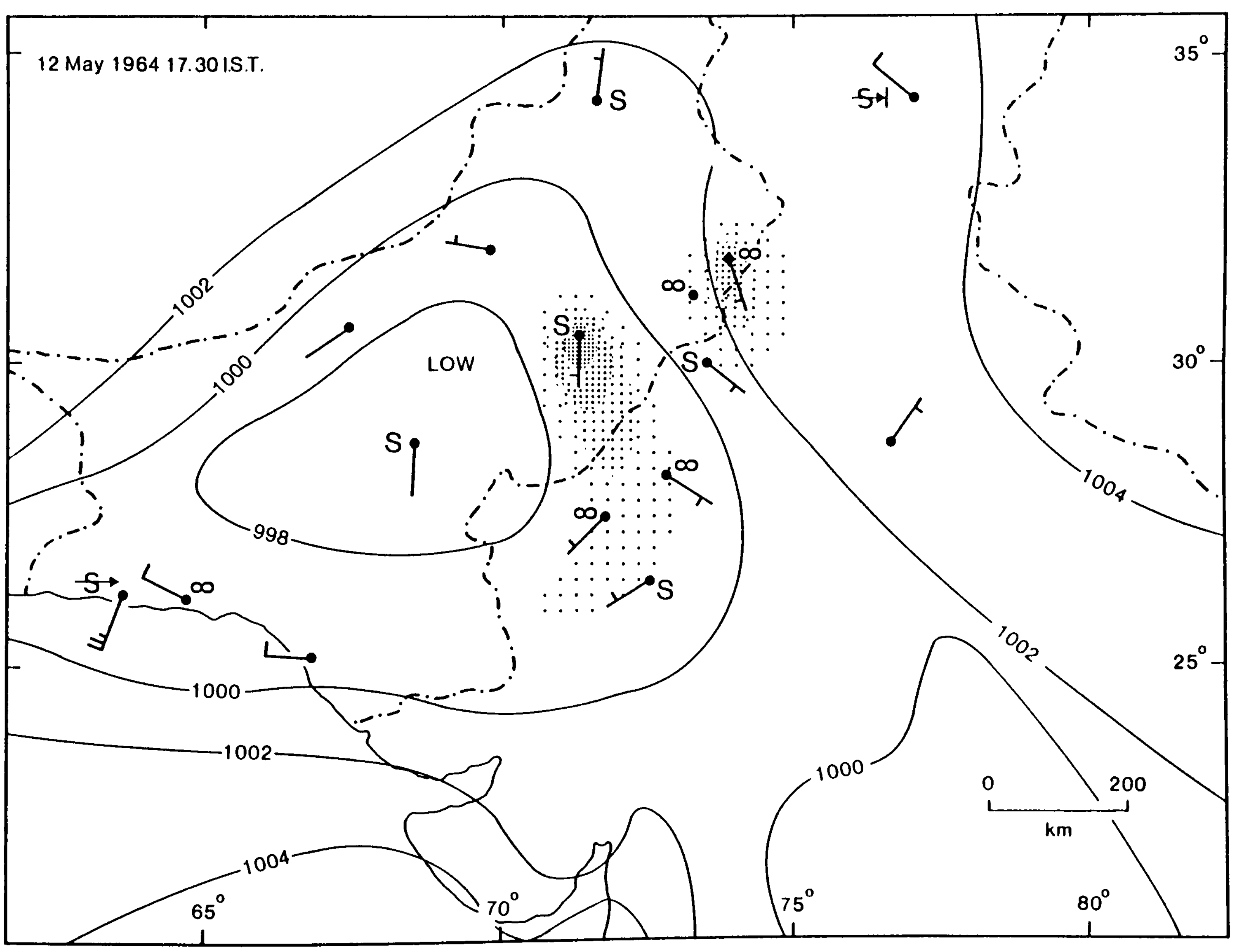




Figure 6.9 continued

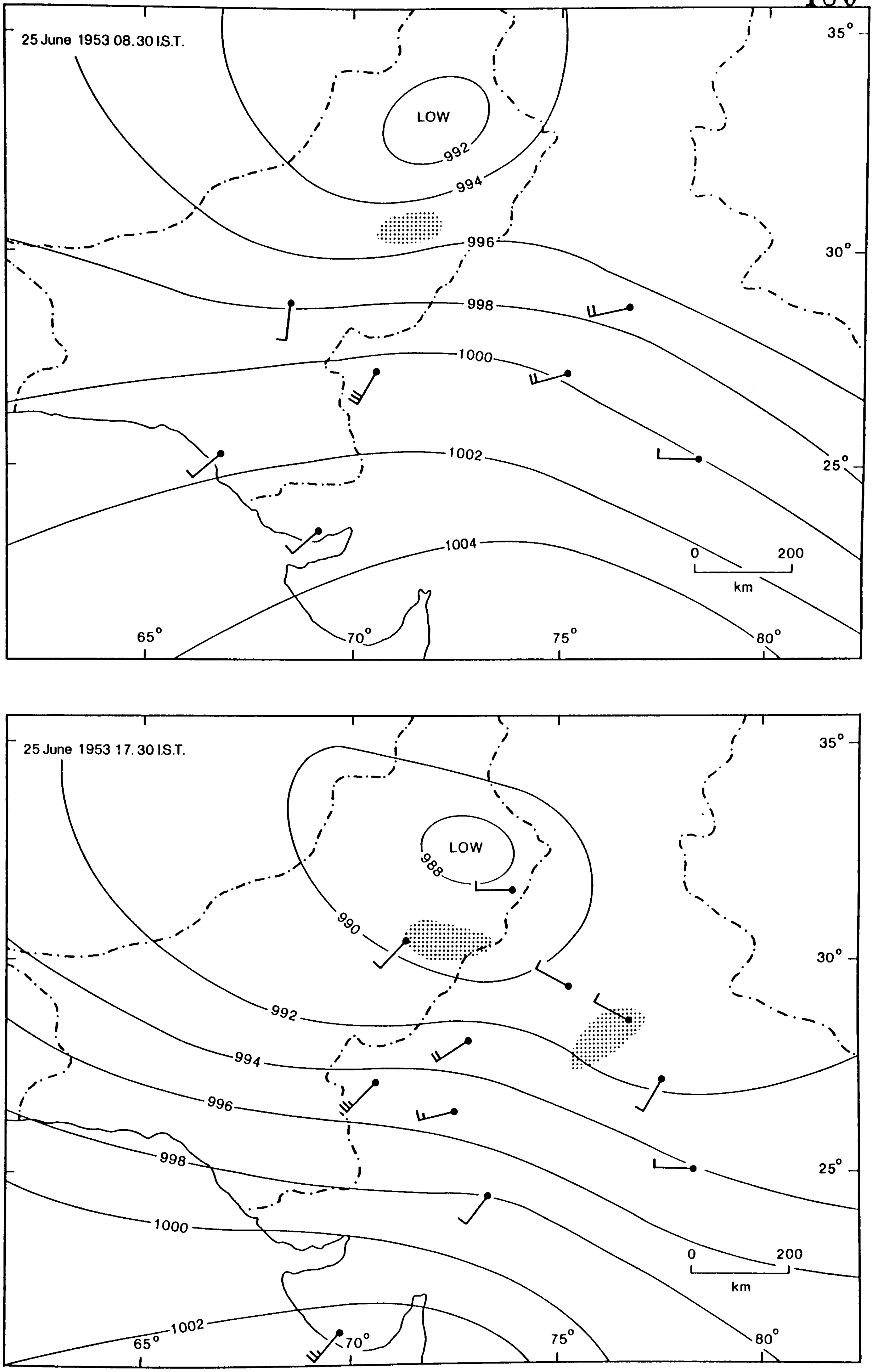
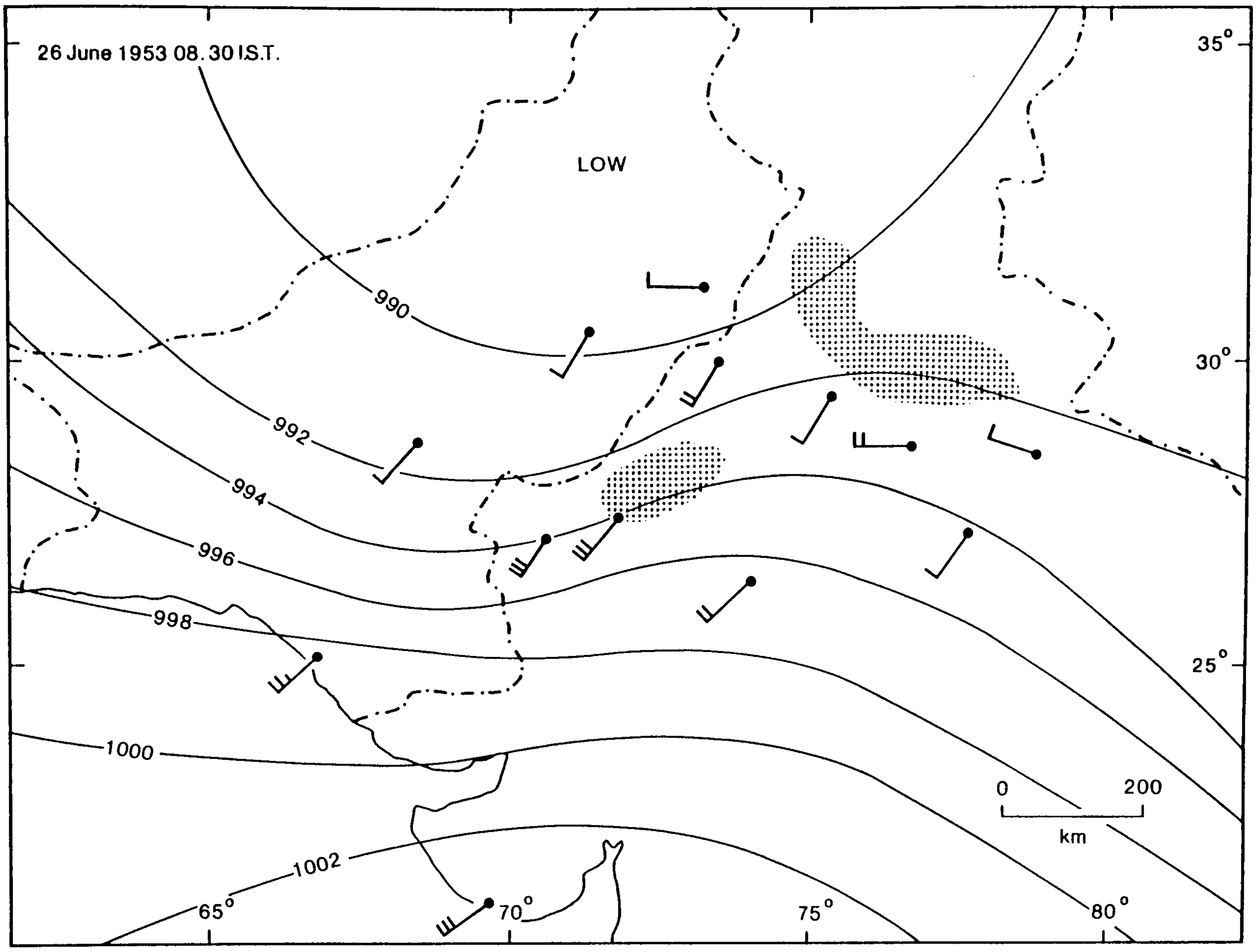



Figure 6.10 Weather charts based on SYNOP observations for 25-28 June 1953 (after Roy 1954)



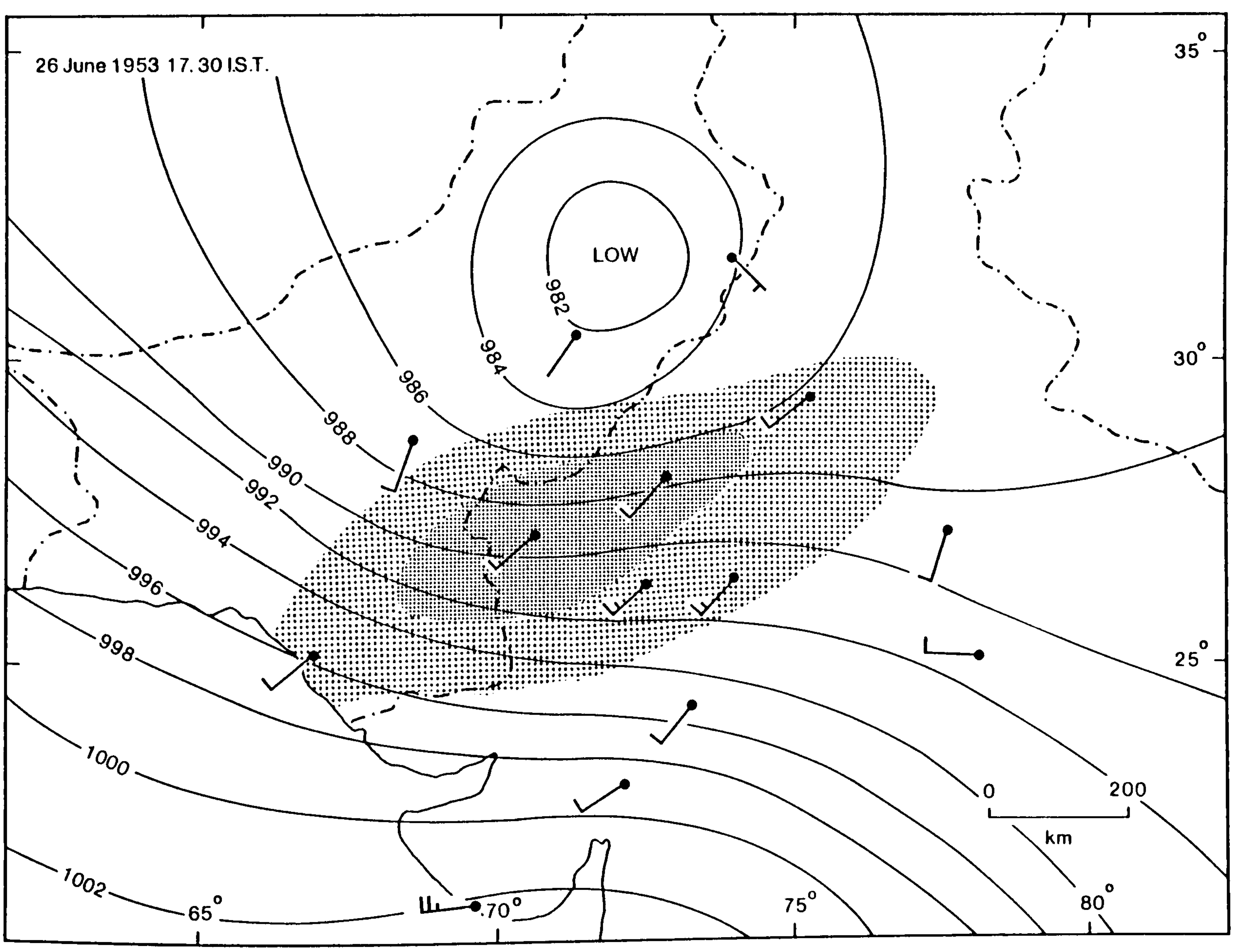
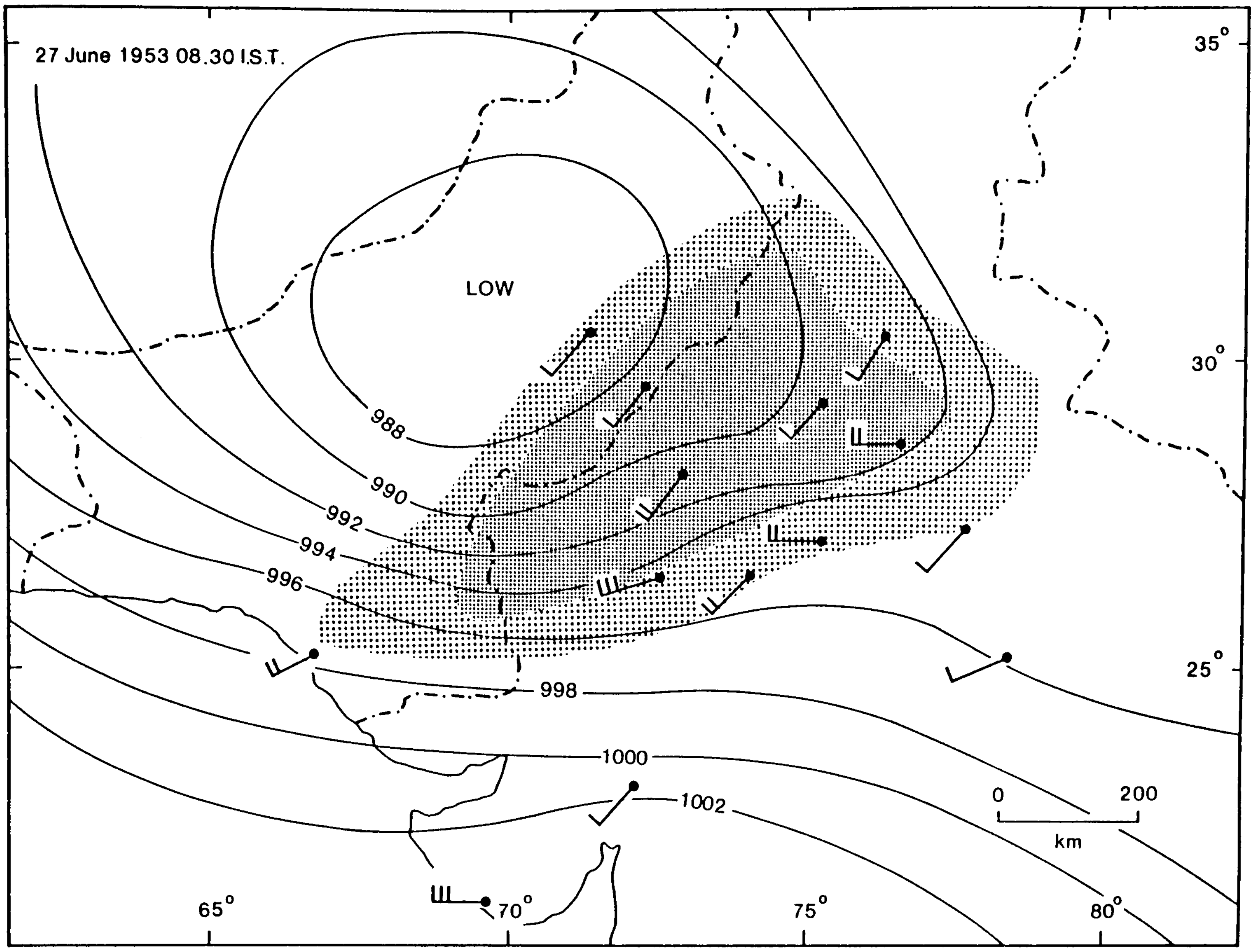




Figure 6.10 continued



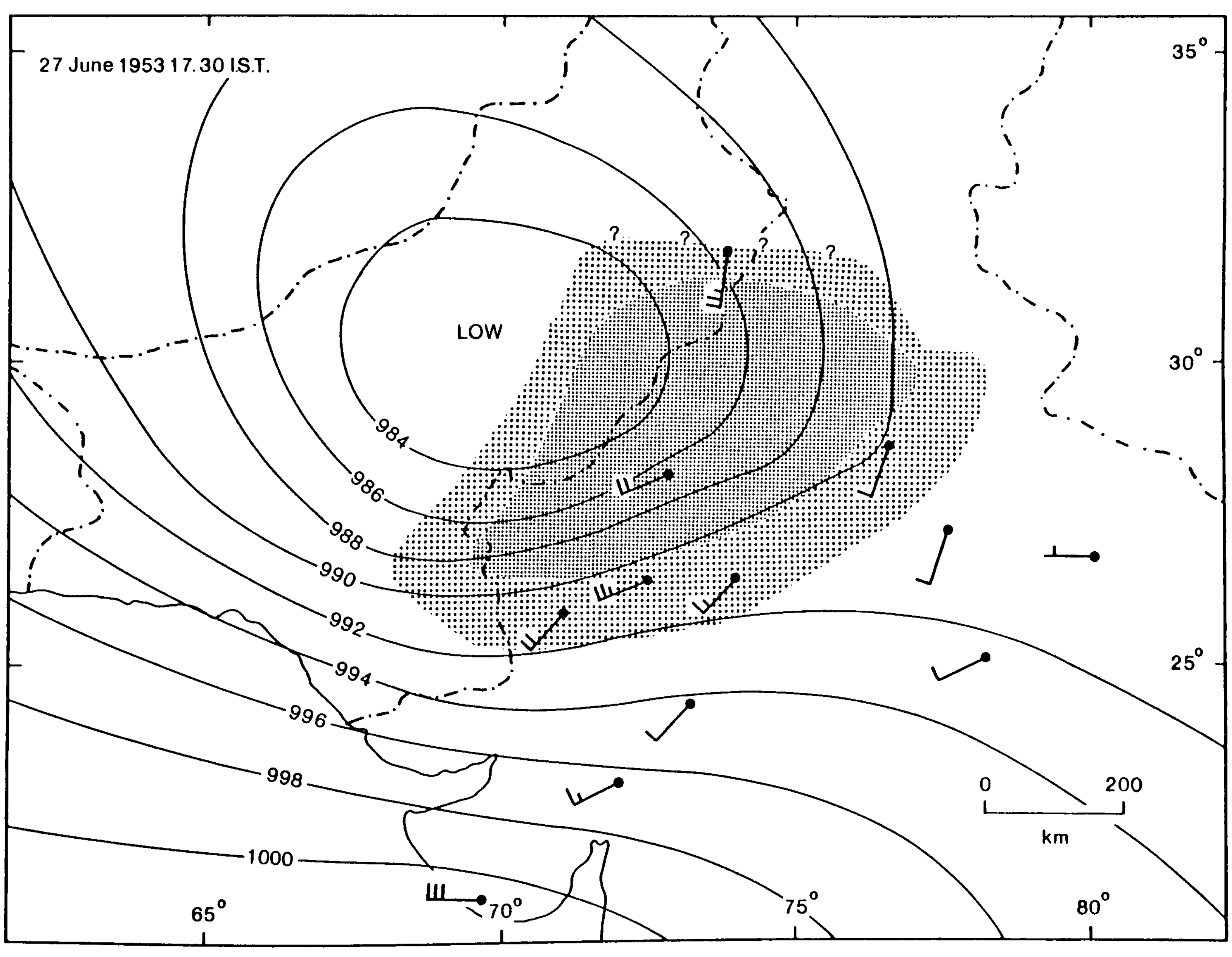
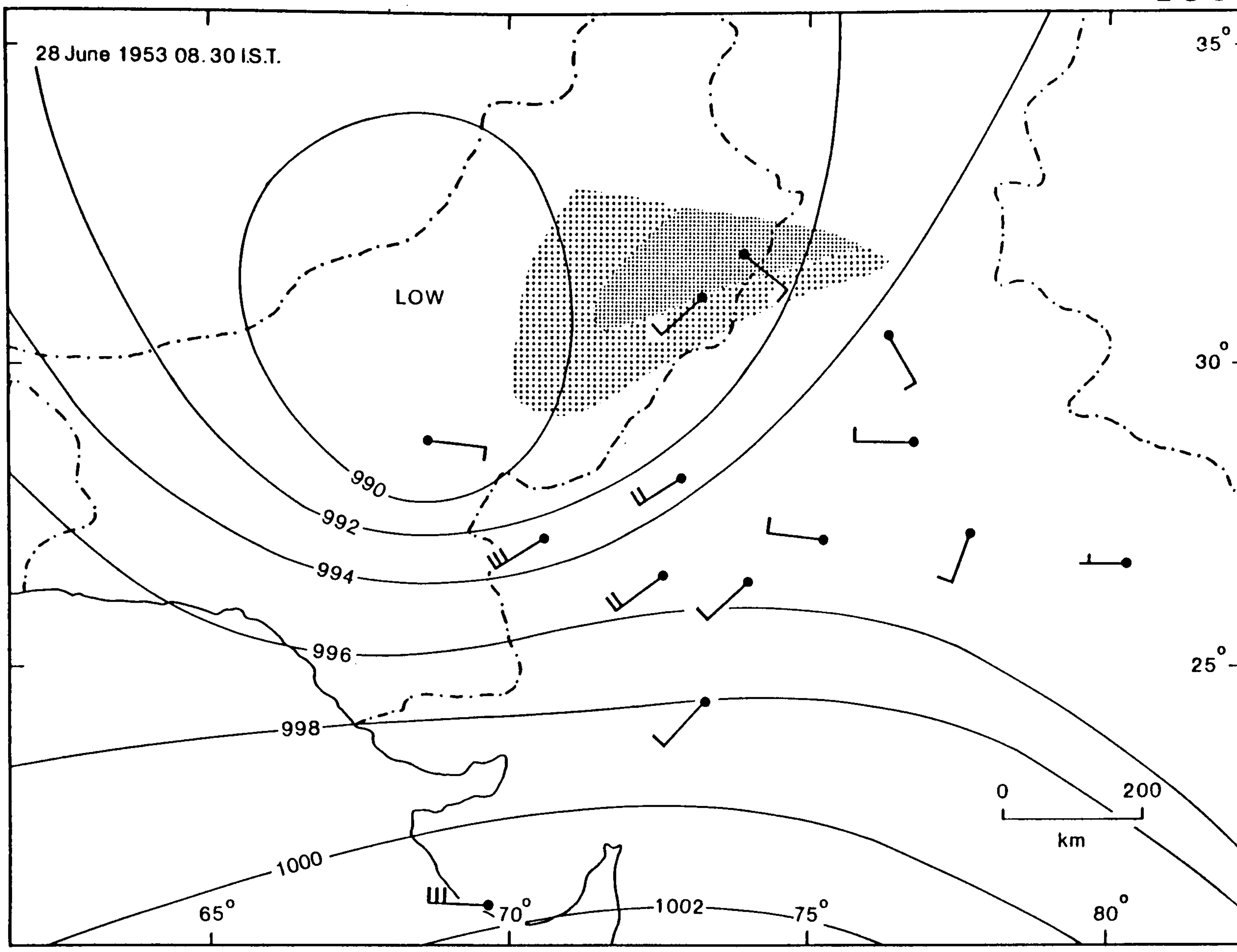




Figure 6.10 continued



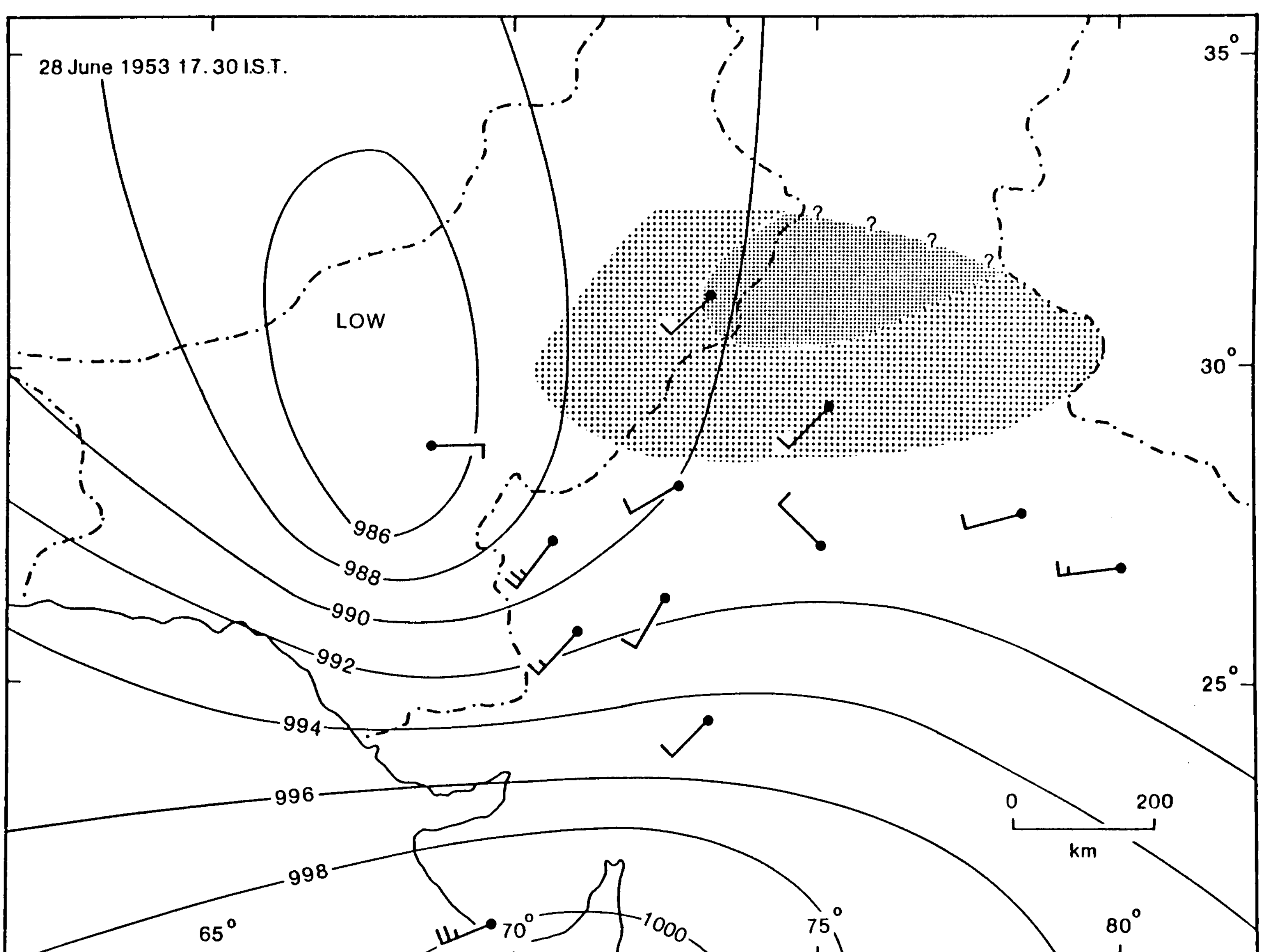
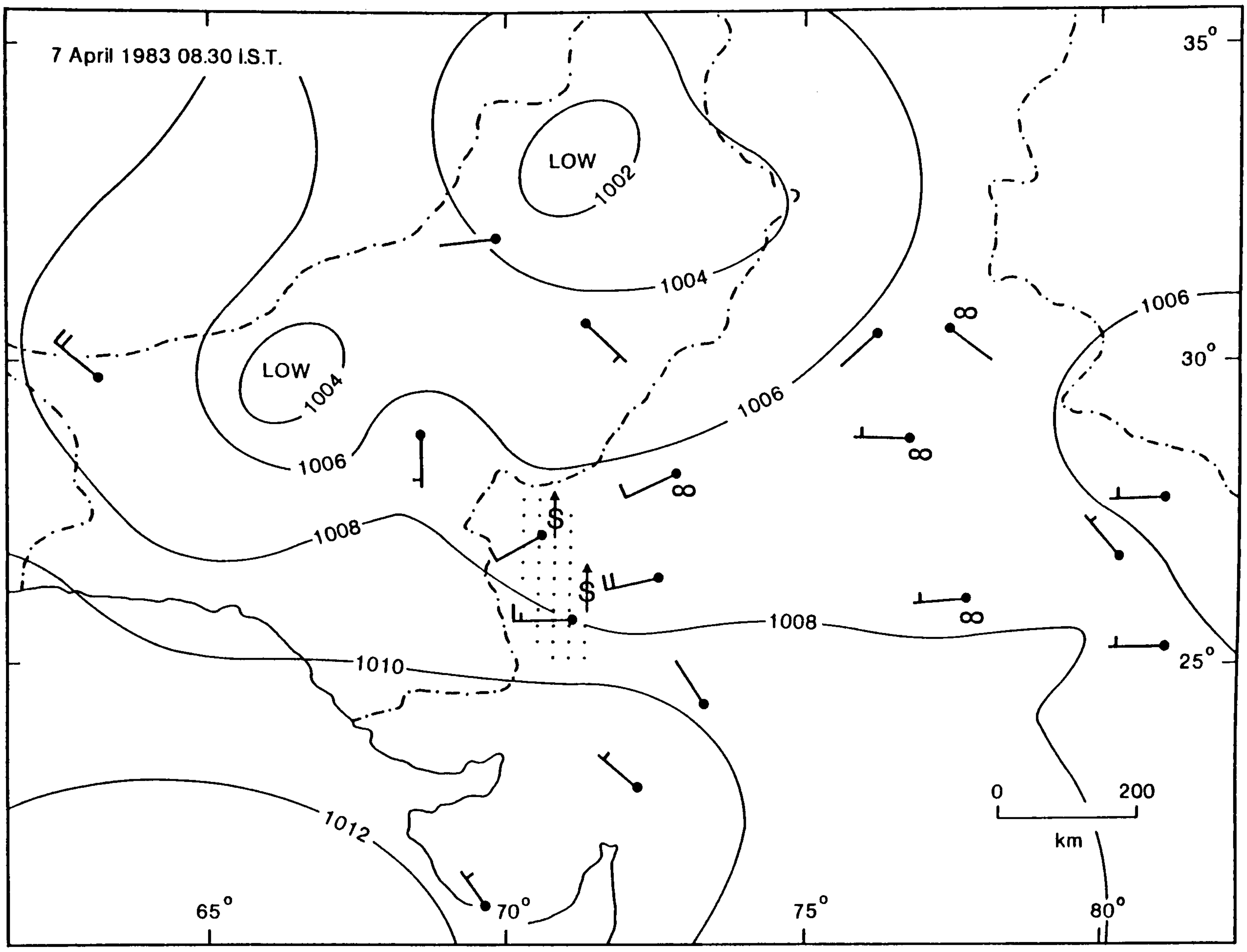




Figure 6.10 continued



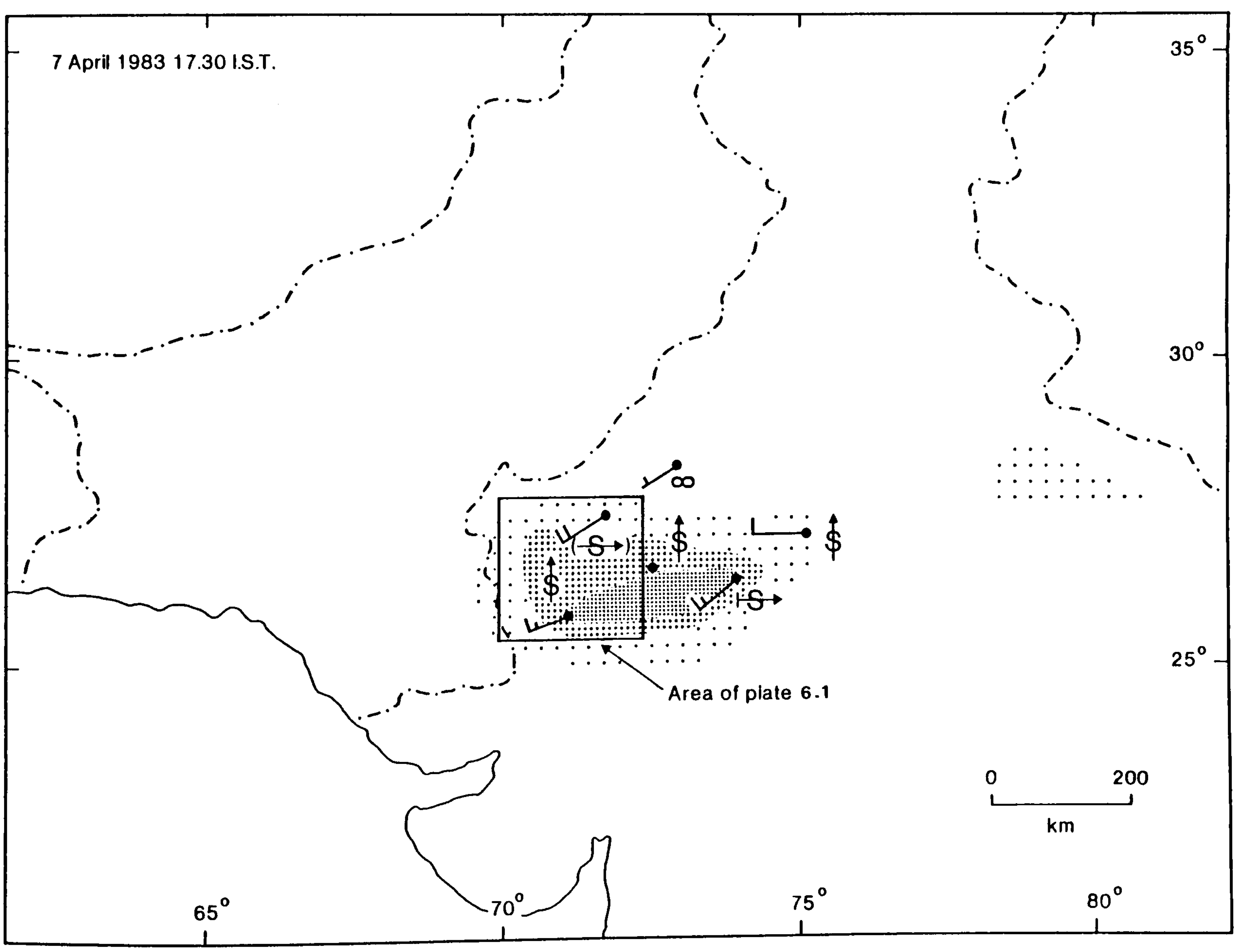
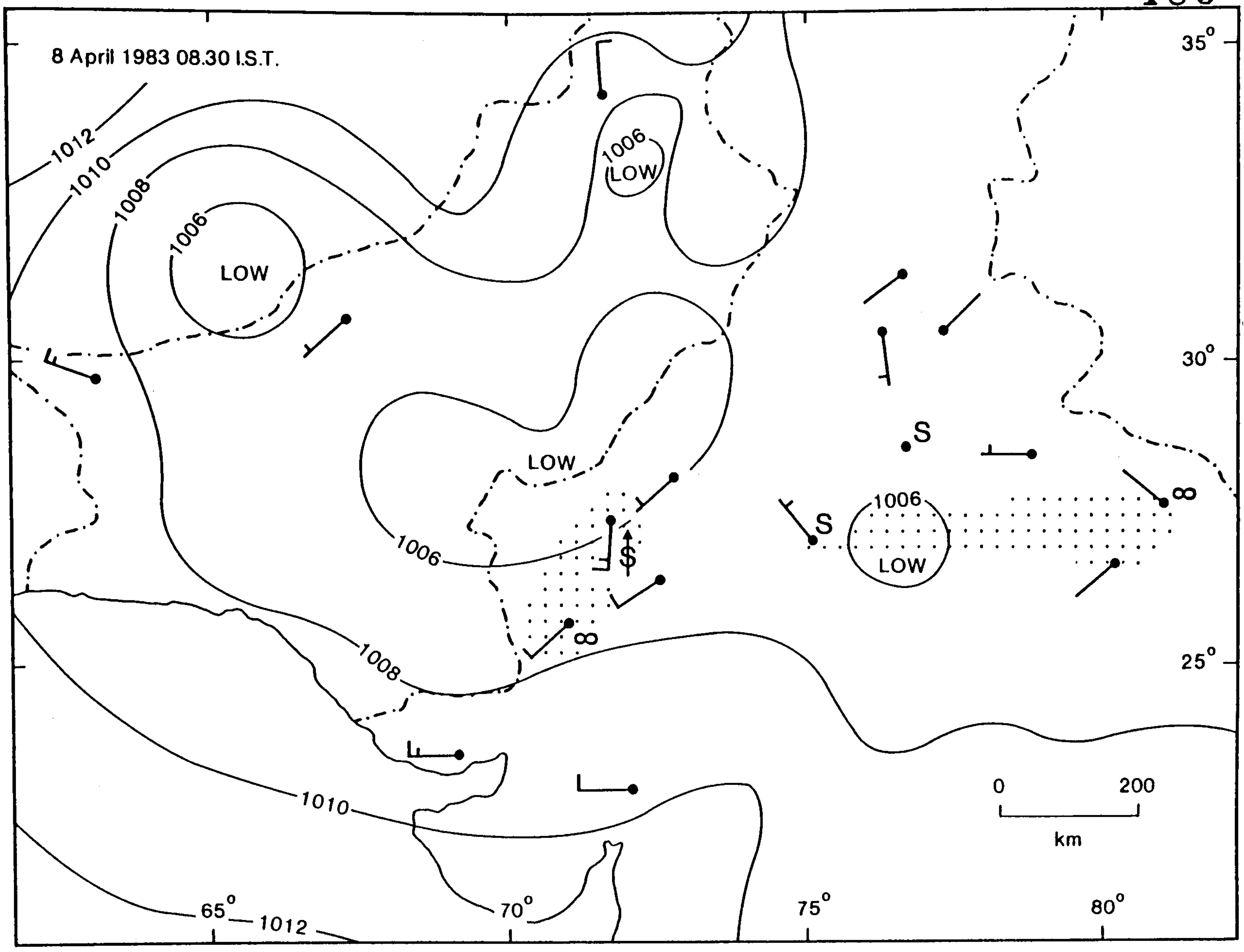




Figure 6.11 Weather charts based on SYNOP observations for 7-10 April 1983



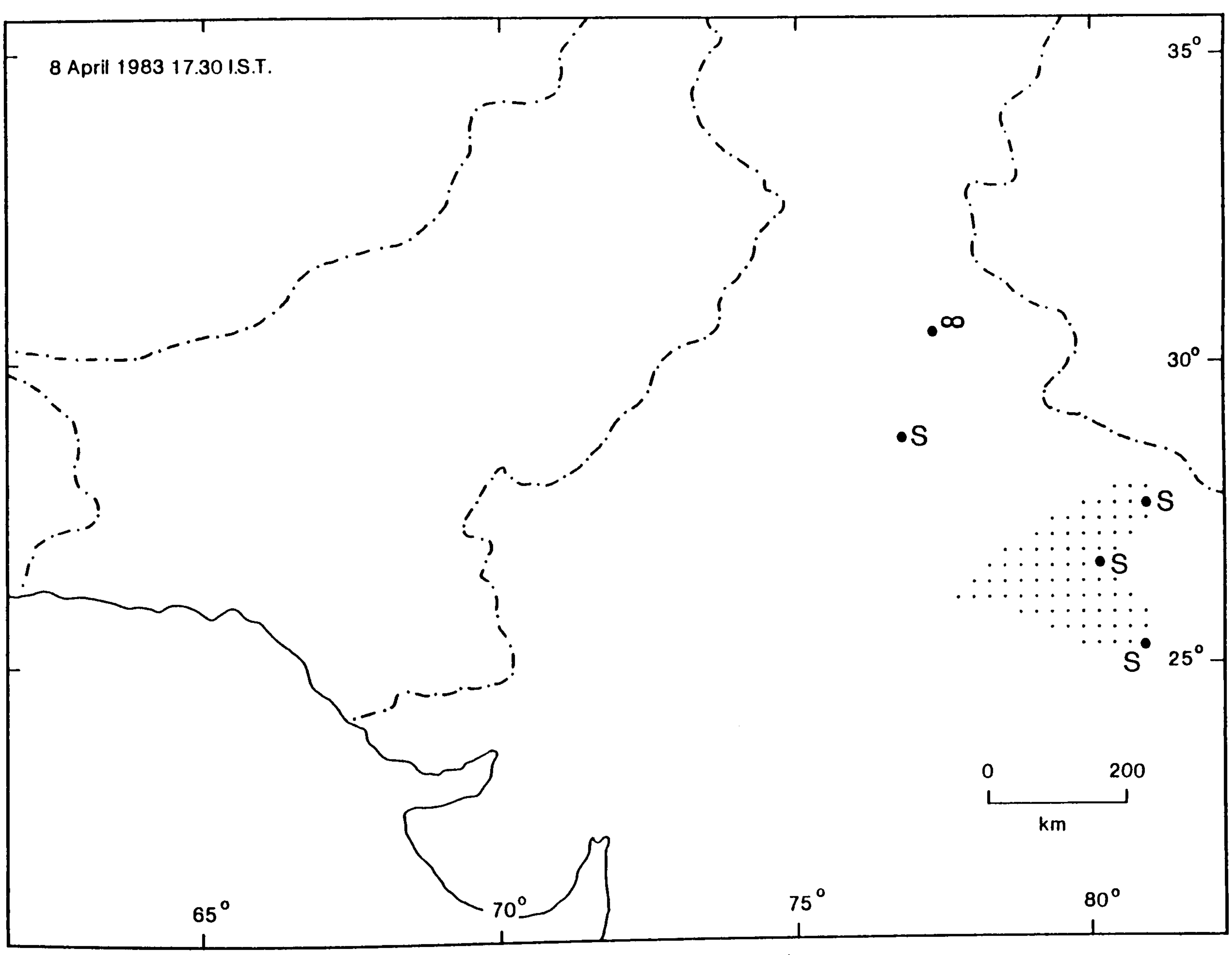
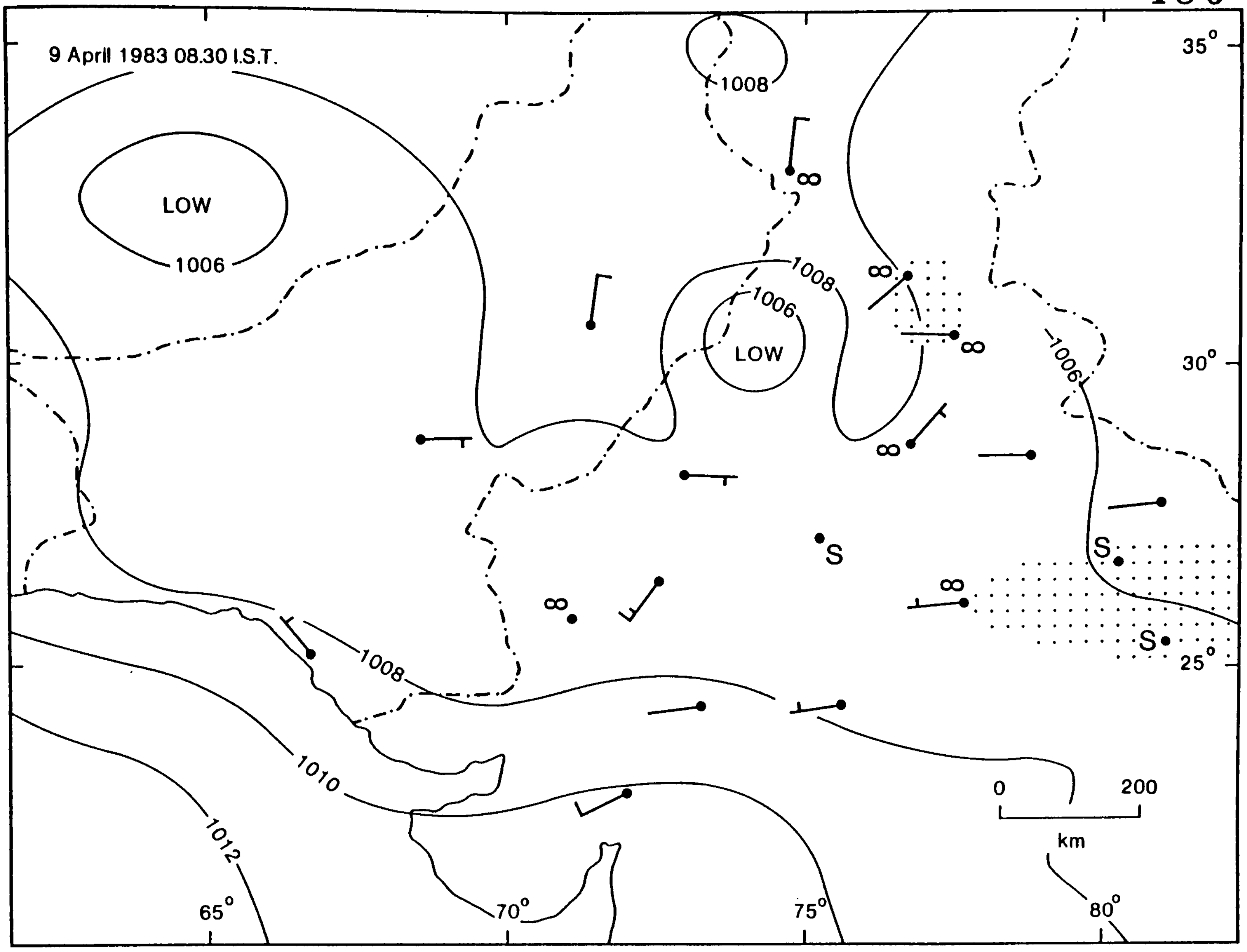




Figure 6.11 continued



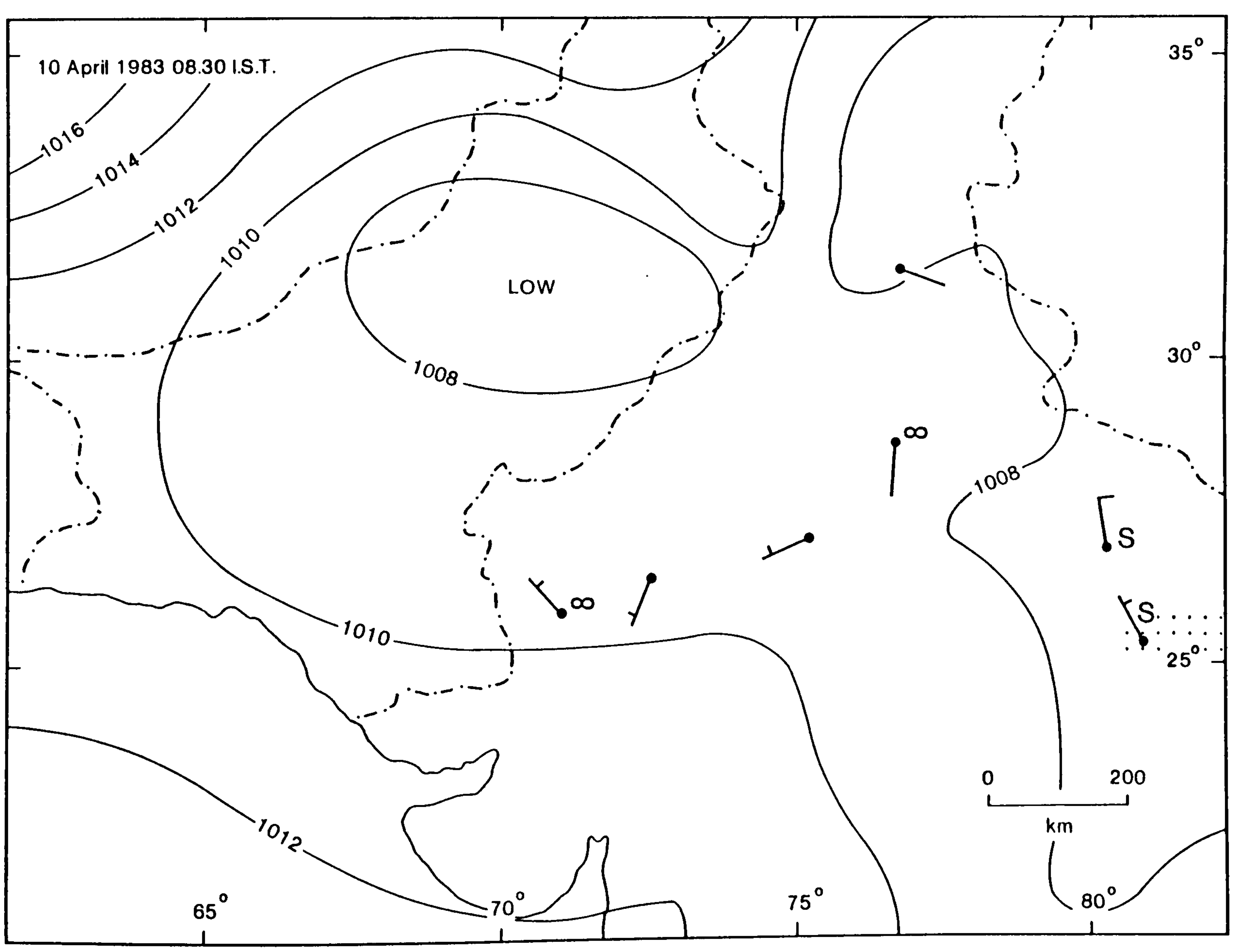




Figure 6.11 continued

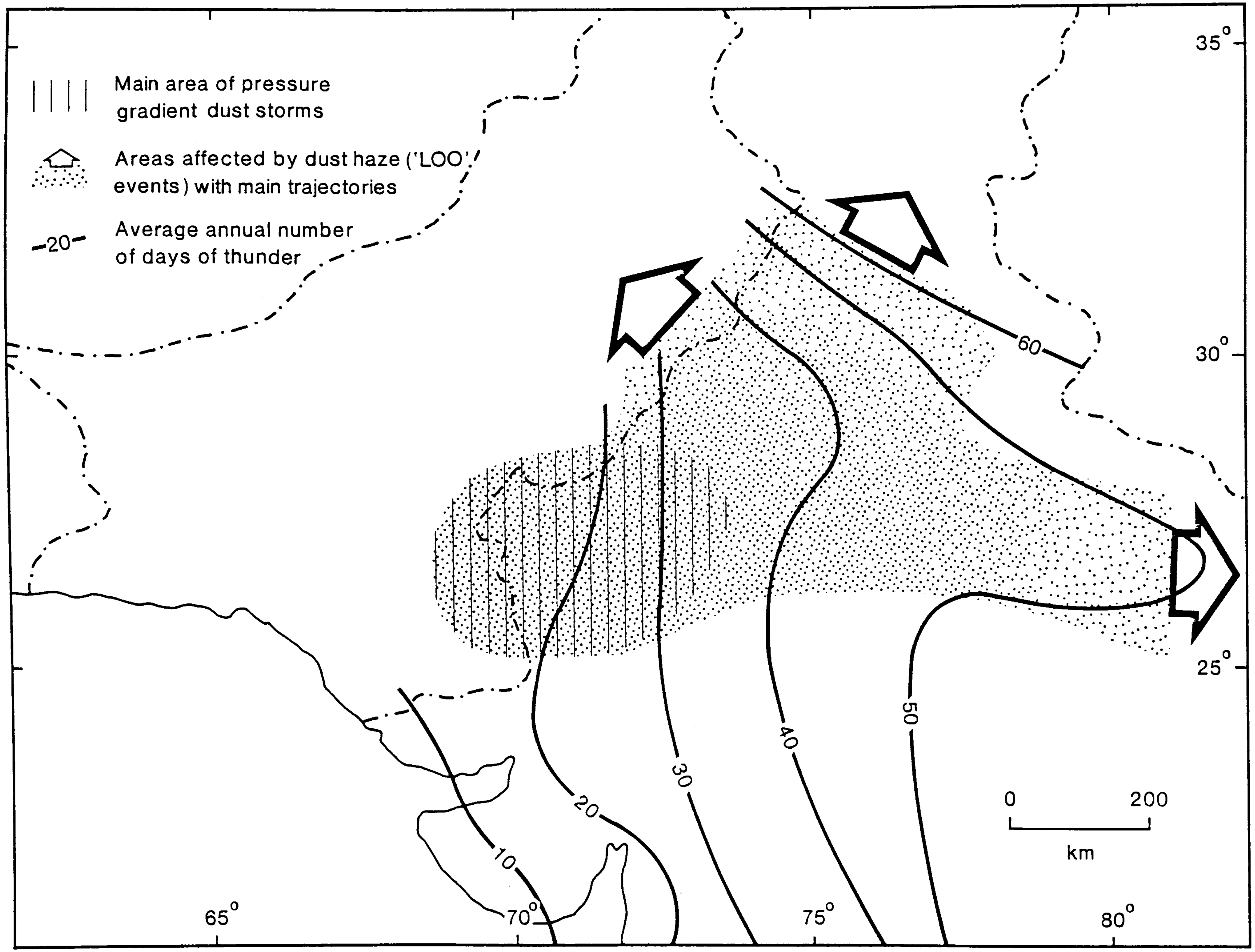



Figure 6.12 Model of the dust storm system in northern India

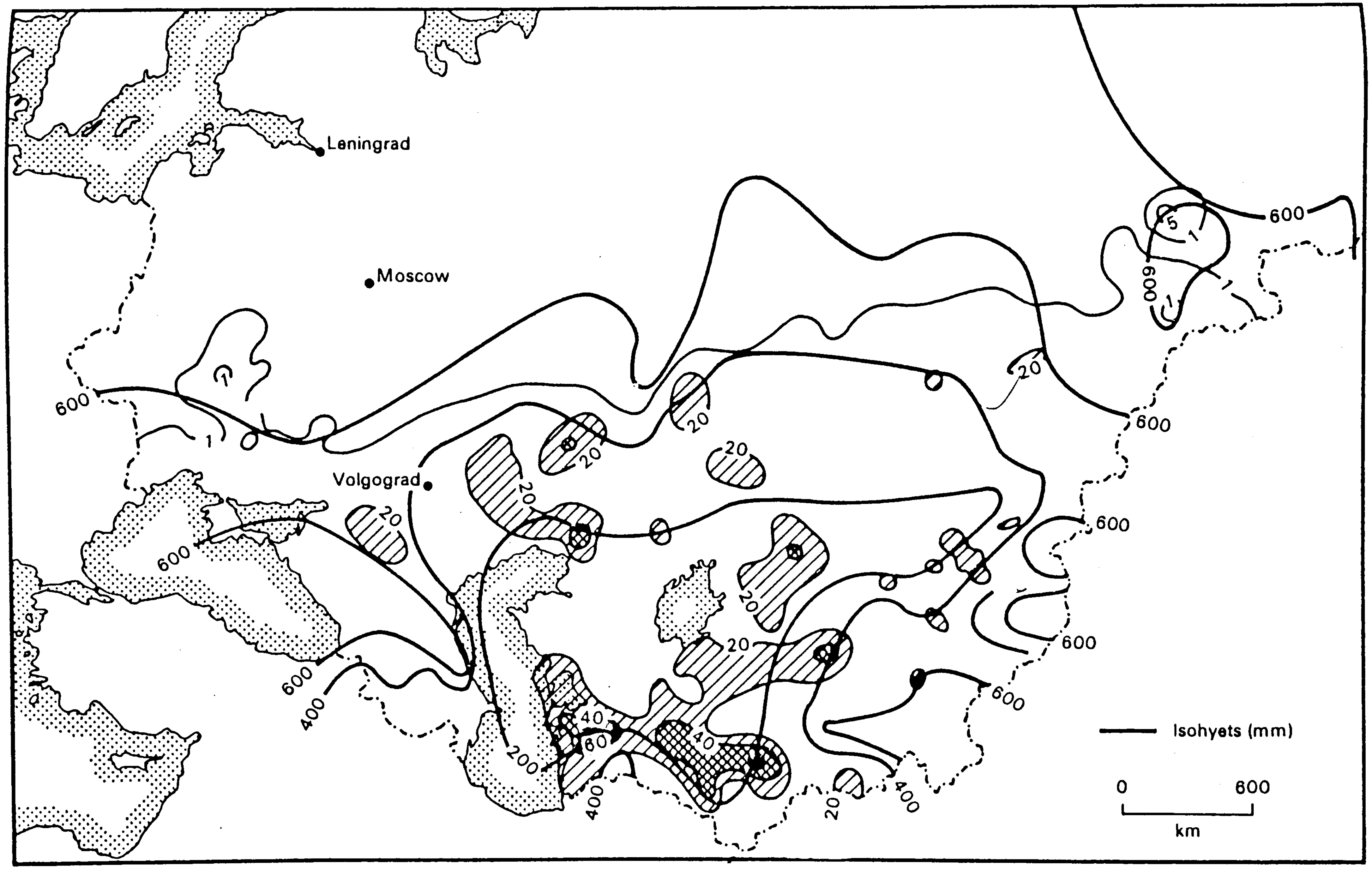



Figure 7.1 Distribution of dust storms in the USSR (modified after Klimenko & Moskaleva 1979)

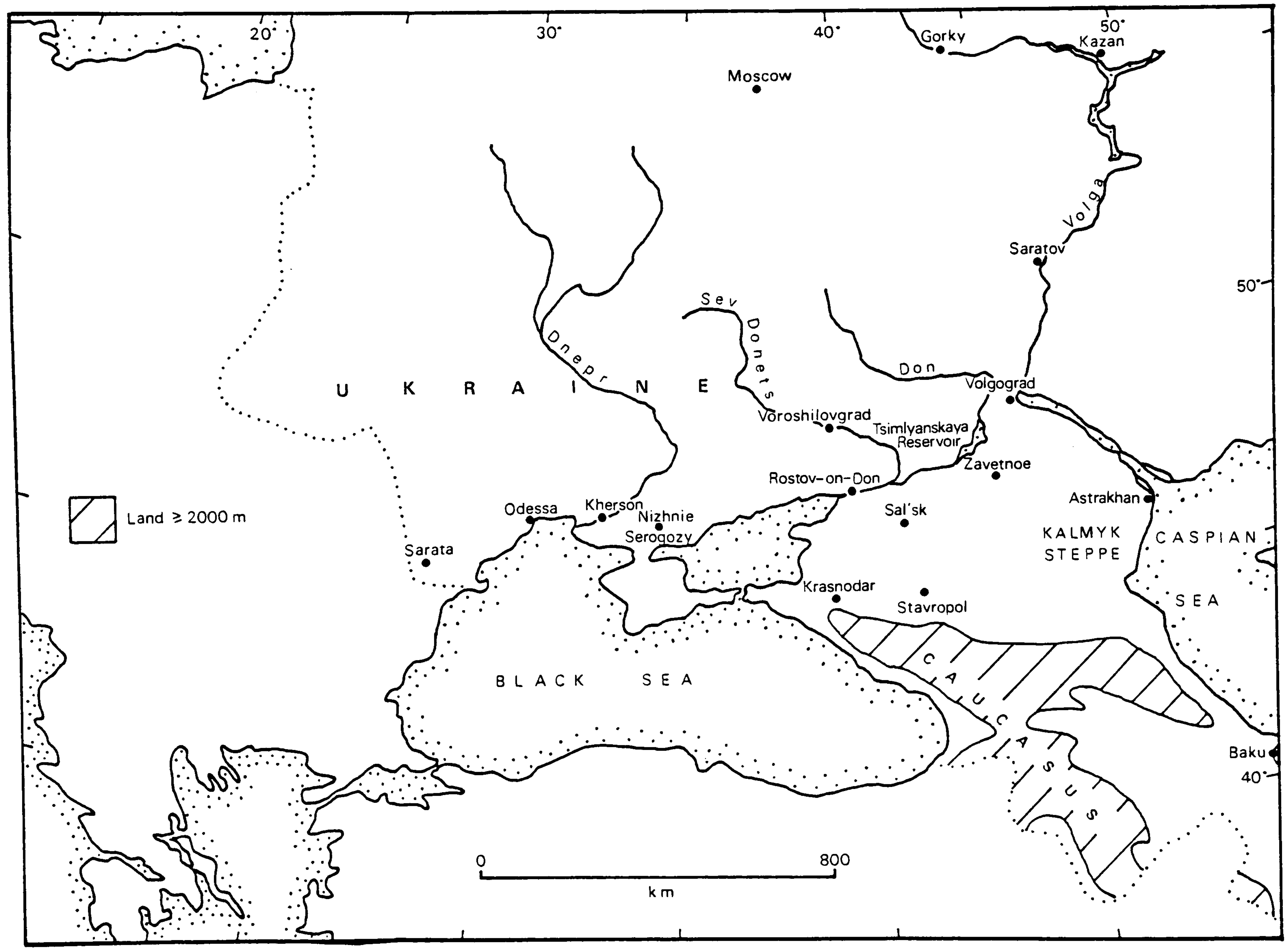



Figure 7.2 Ukraine & southeastern European USSR location map

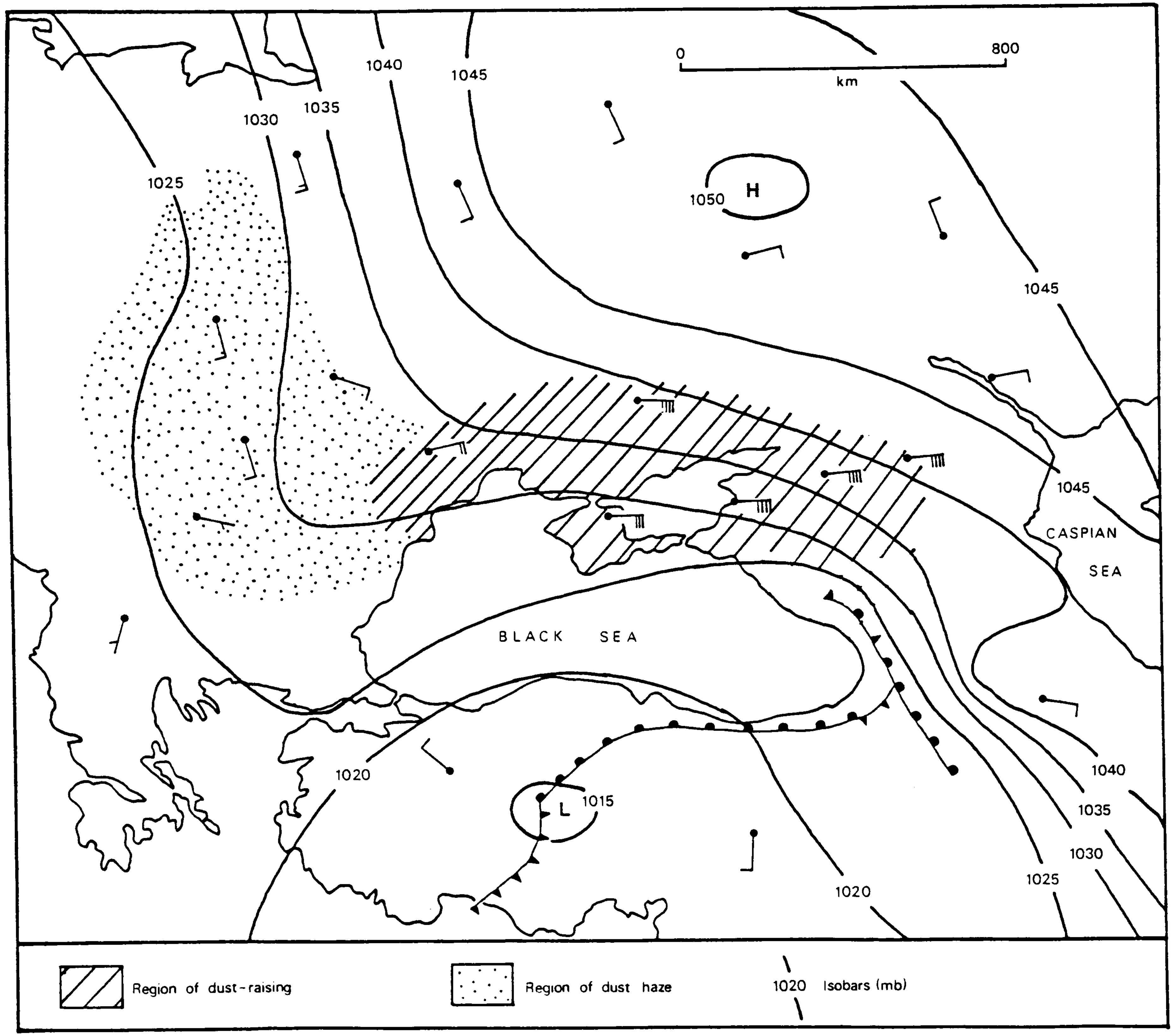



Figure 7.3 Pressure distribution & dust storm area over the Ukraine, 1500 LST, 7 April 1960 (after Kravchenko 1961)

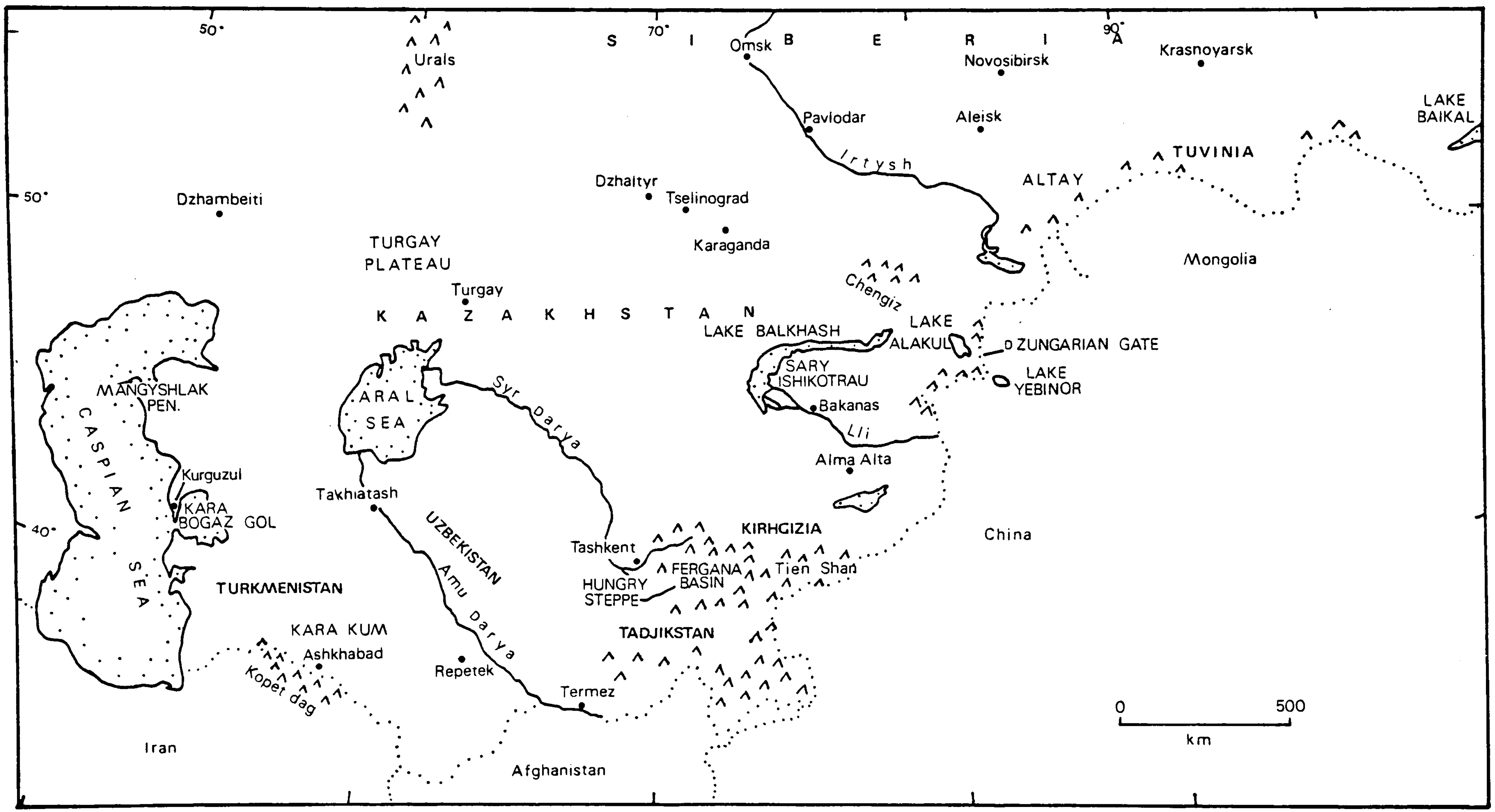



Figure 7.4 Kazakhstan, Siberia & Central Asia location map

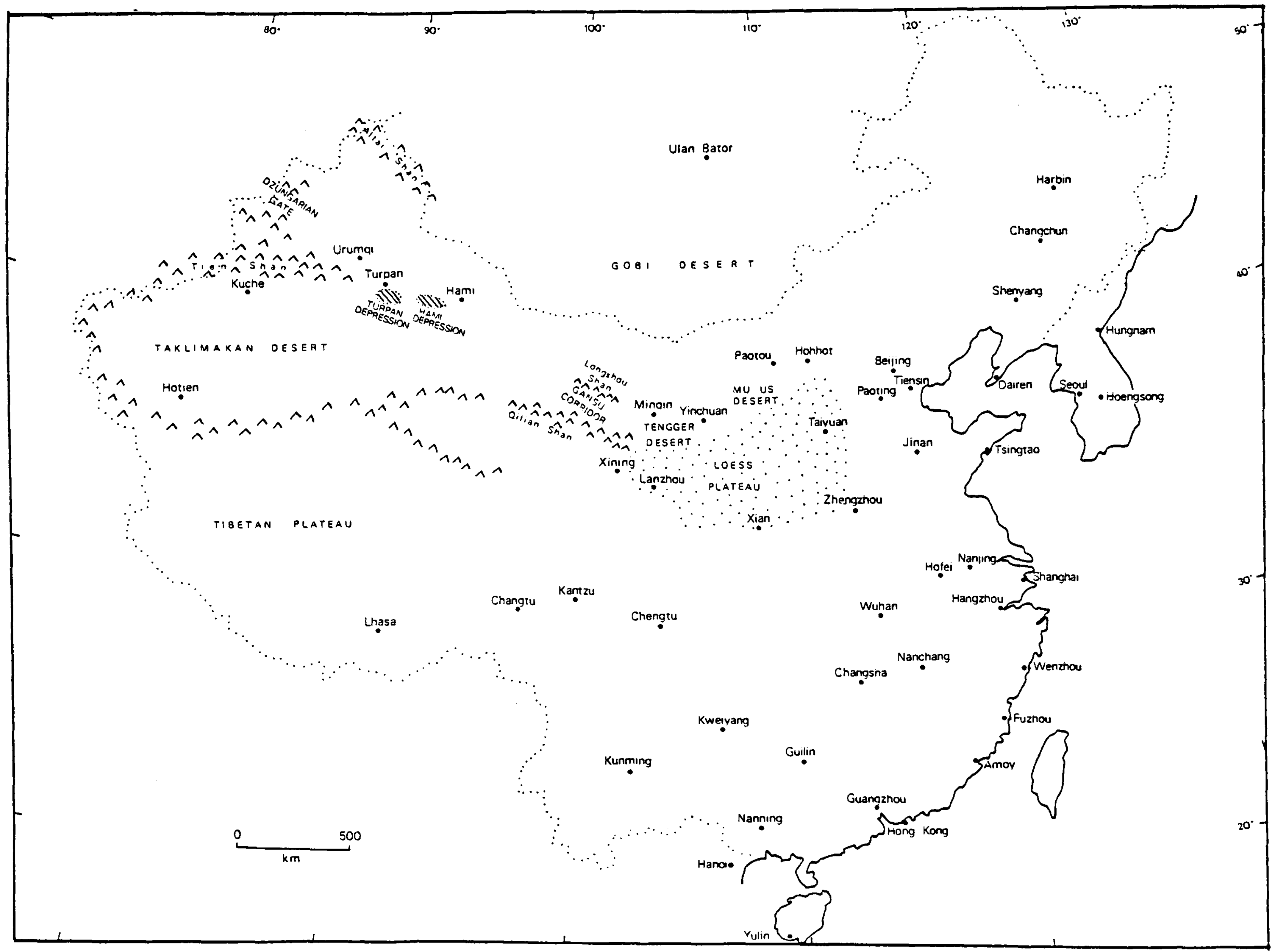



Figure 8.1 China location map

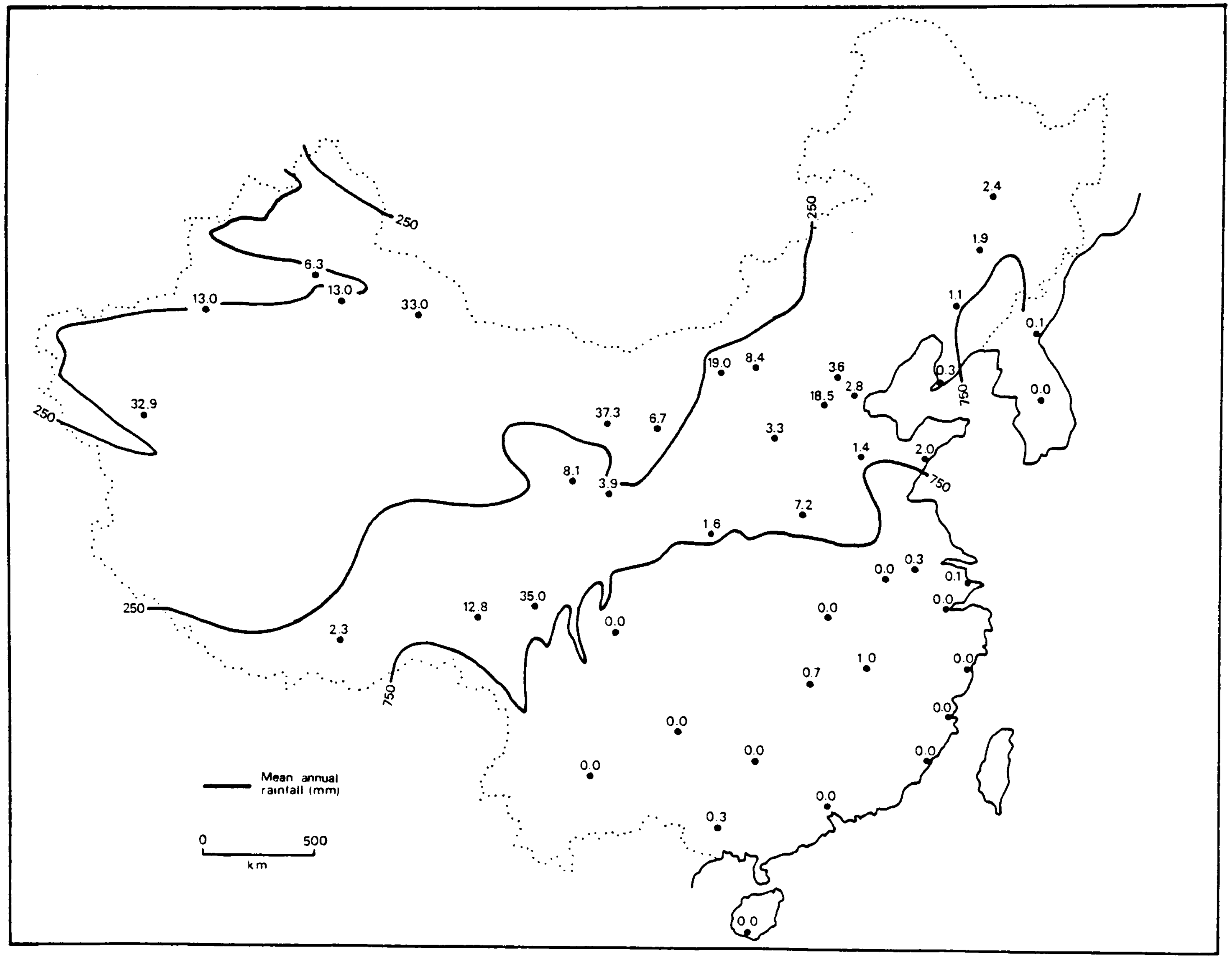



Figure 8.2 Distribution of dust storms in China

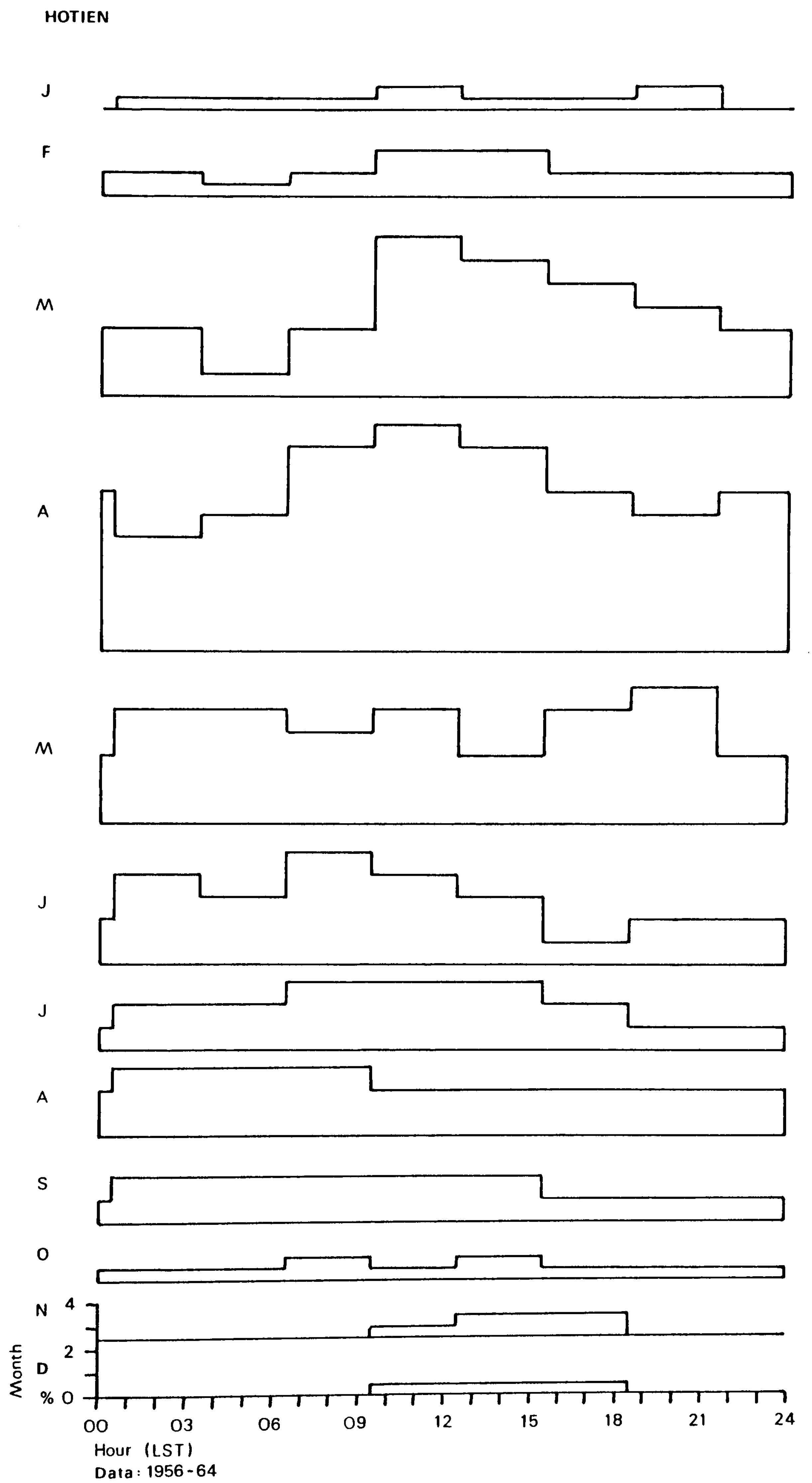



Figure 8.3 Diurnal arithmetic mean frequency percent by month of visibility reduced to less than 1000m by dust storms at Hotien, China

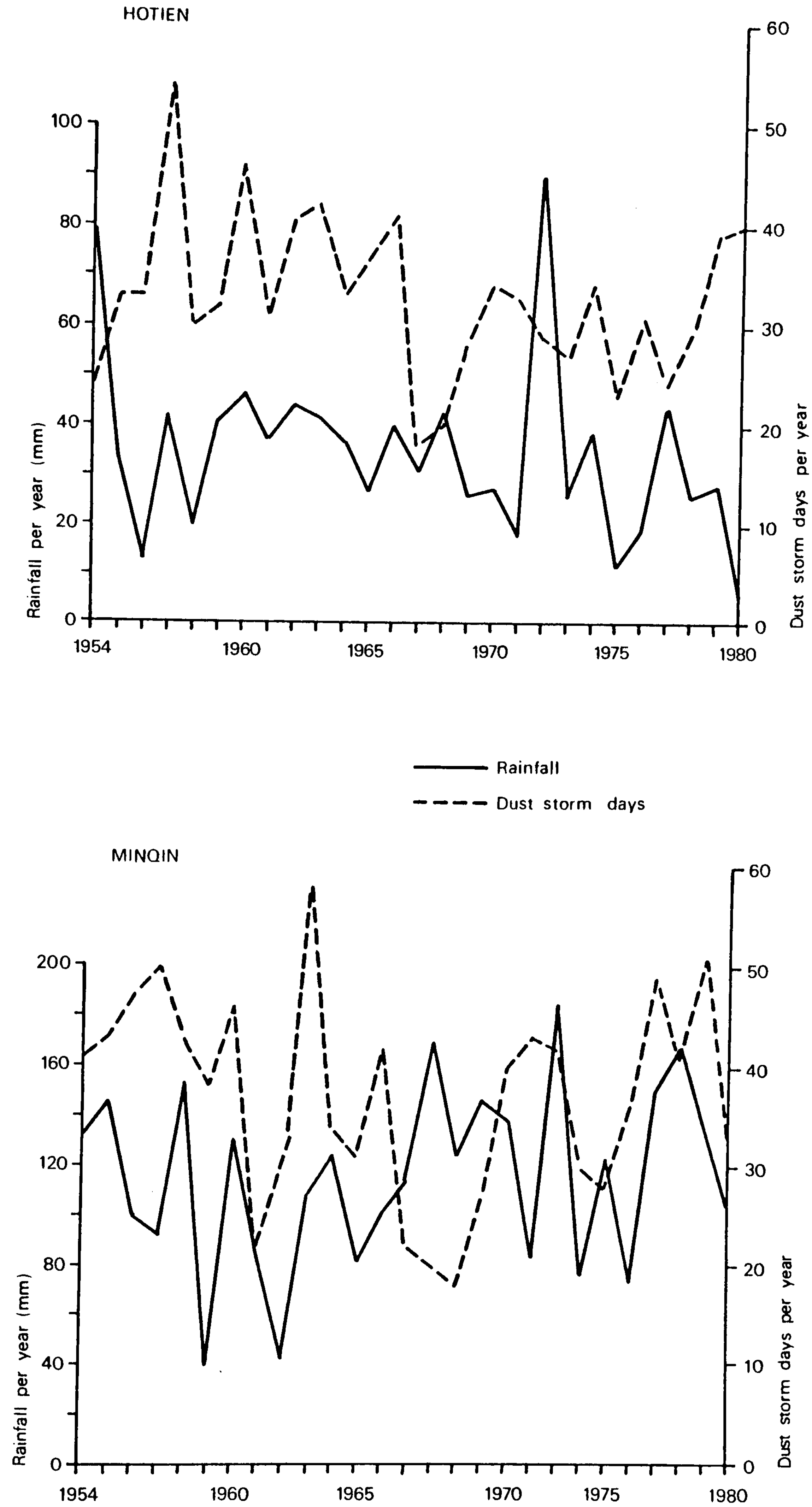



Figure 8.4 Annual rainfall totals & dust storm frequencies at Hotien & Minqin, China (1954-80)

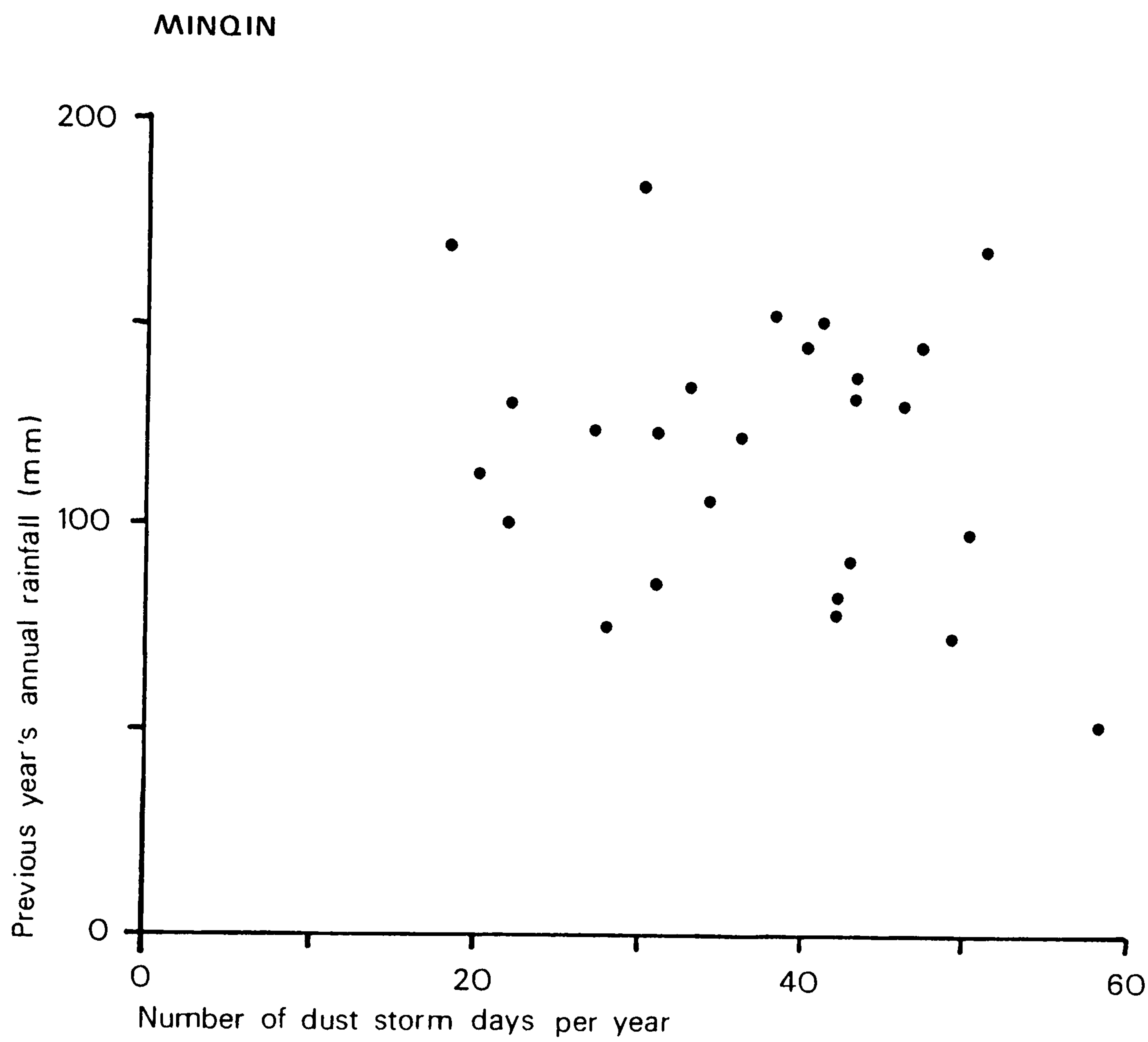



Figure 8.5 Frequency of dust storms in relation to previous year's rainfall at Minqin, China

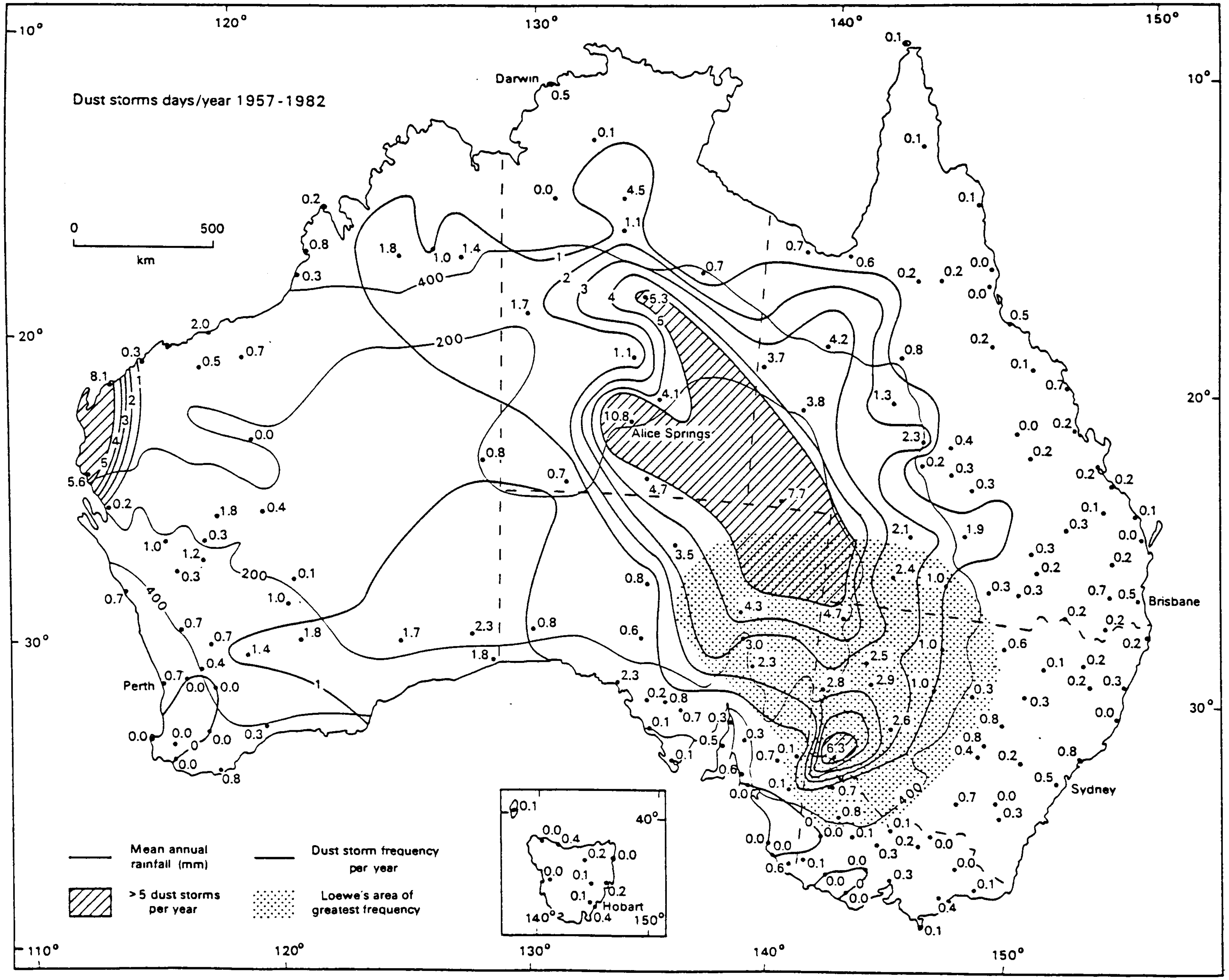



Figure 9.1 Distribution of dust storms in Australia (1957-82)

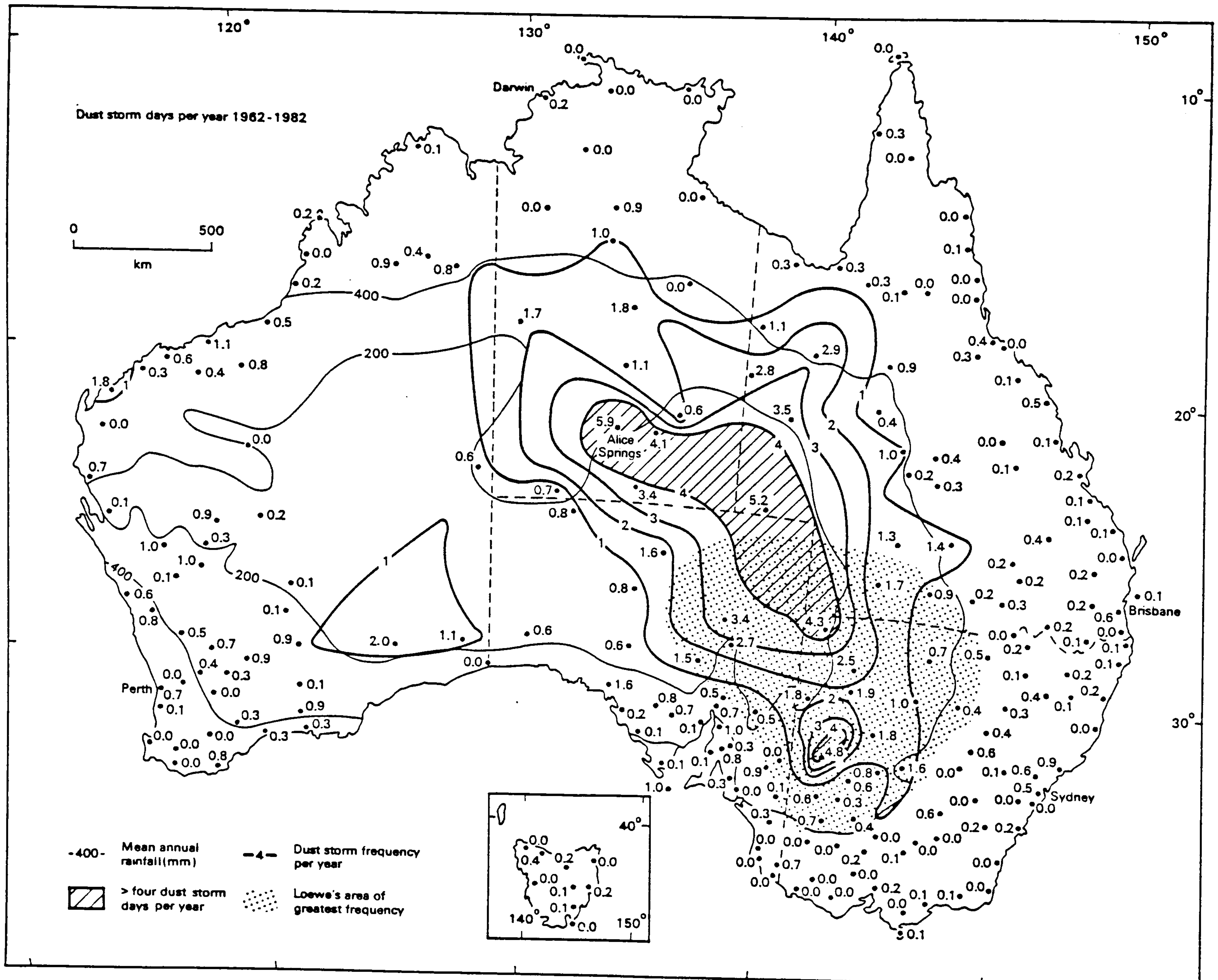



Figure 9.2 Distribution of dust storms in Australia (1962-82)

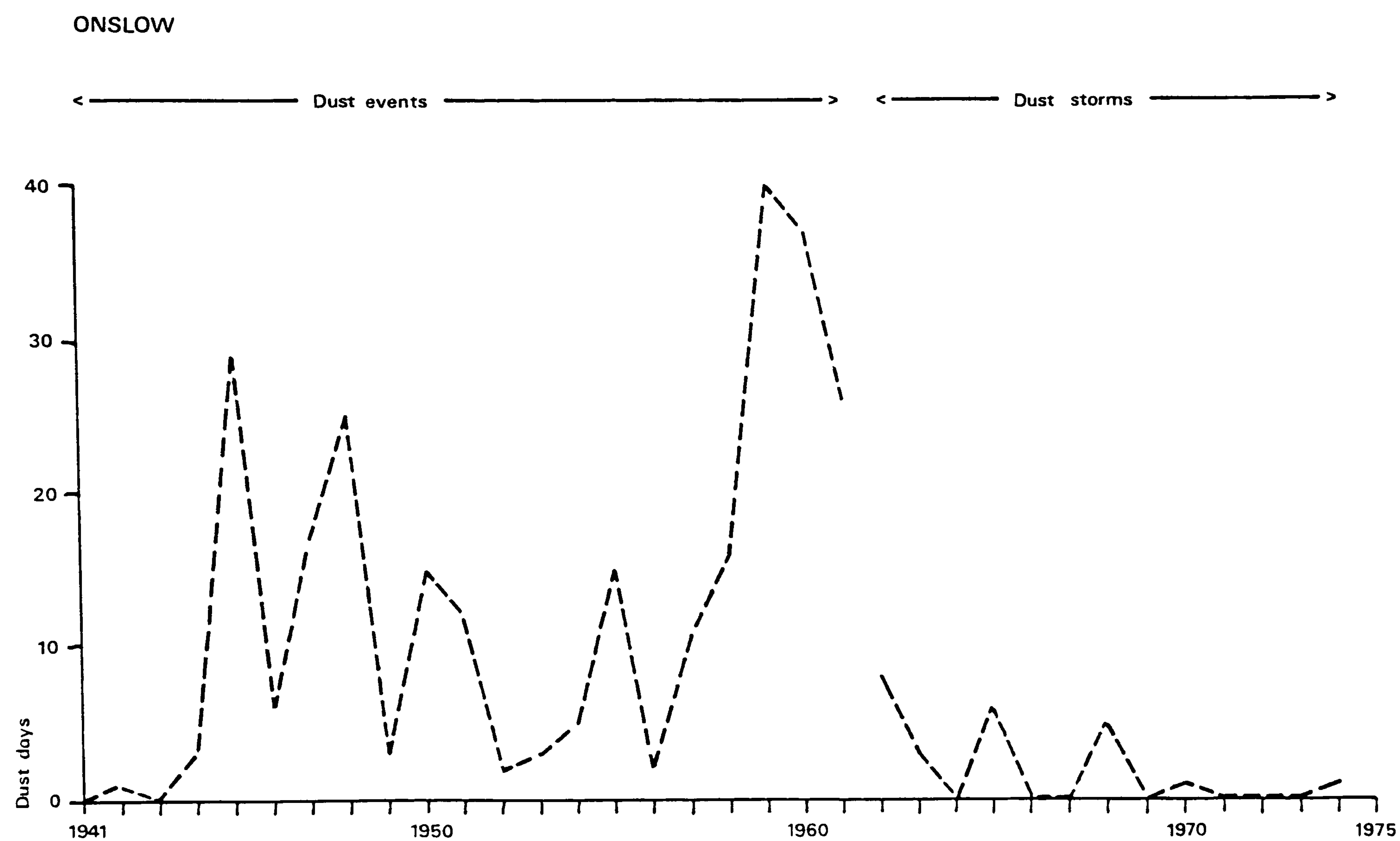



Figure 9.3 Frequency of dust days at Onslow (1941-74)

ALICE SPRINGS

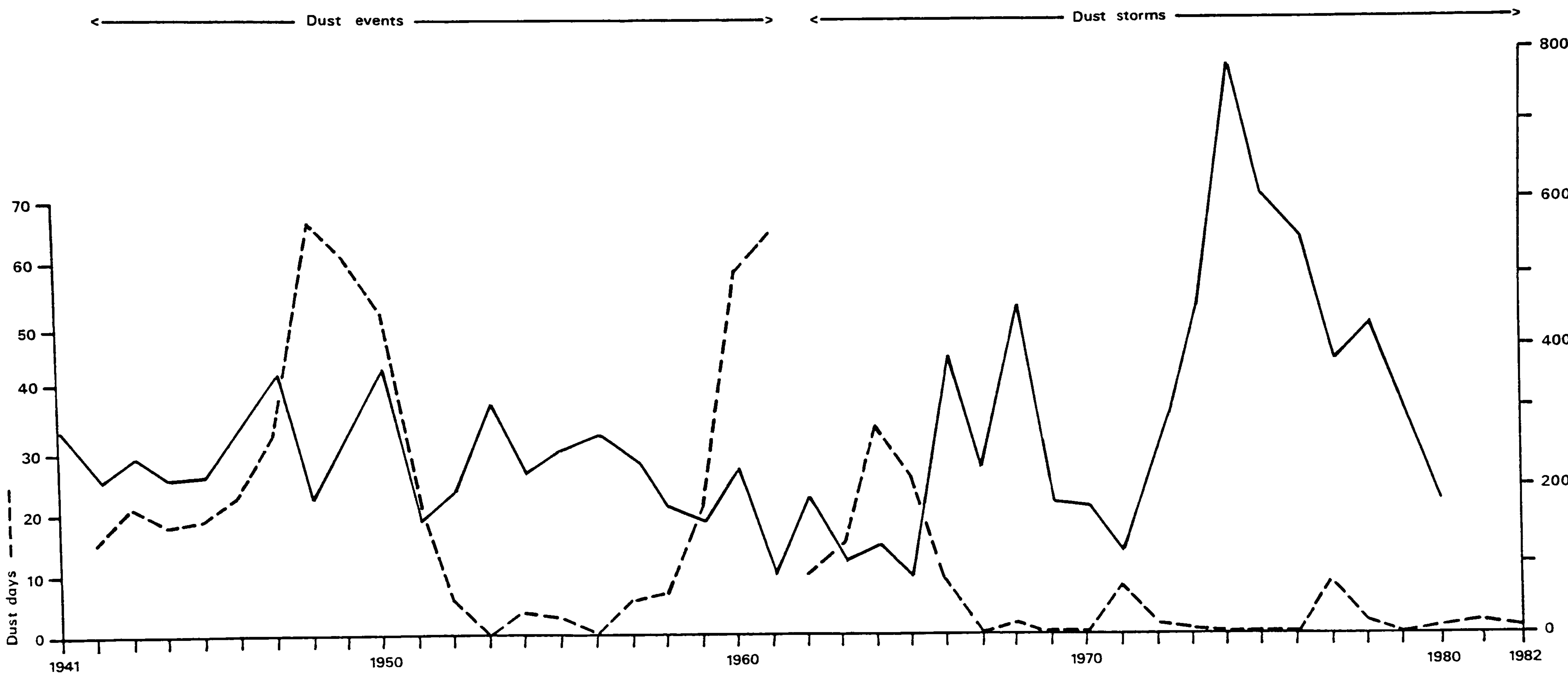



Figure 9.4 Frequency of dust days & annual rainfall at Alice Springs (1941-82)

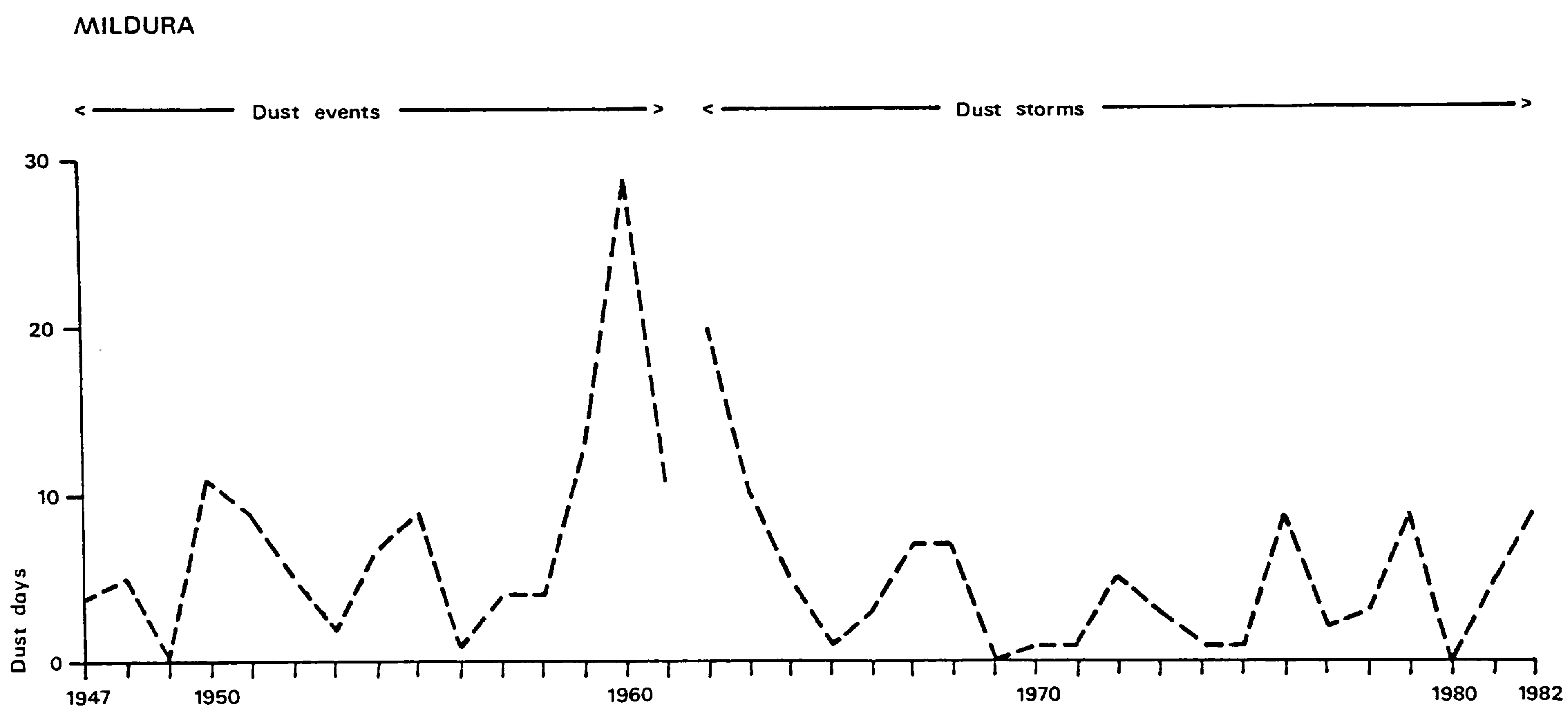
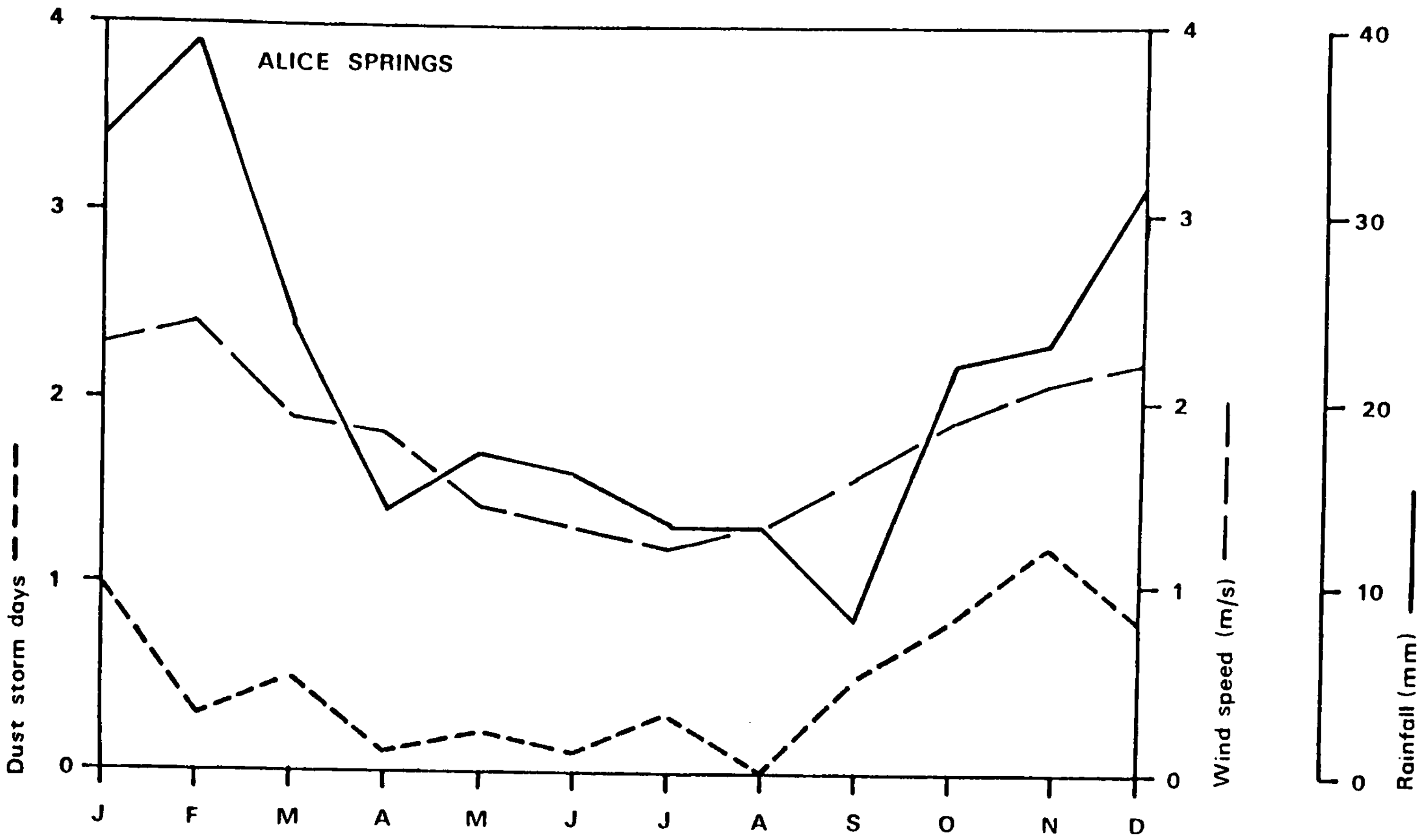



Figure 9.5 Frequency of dust days at Mildura (1947-82)



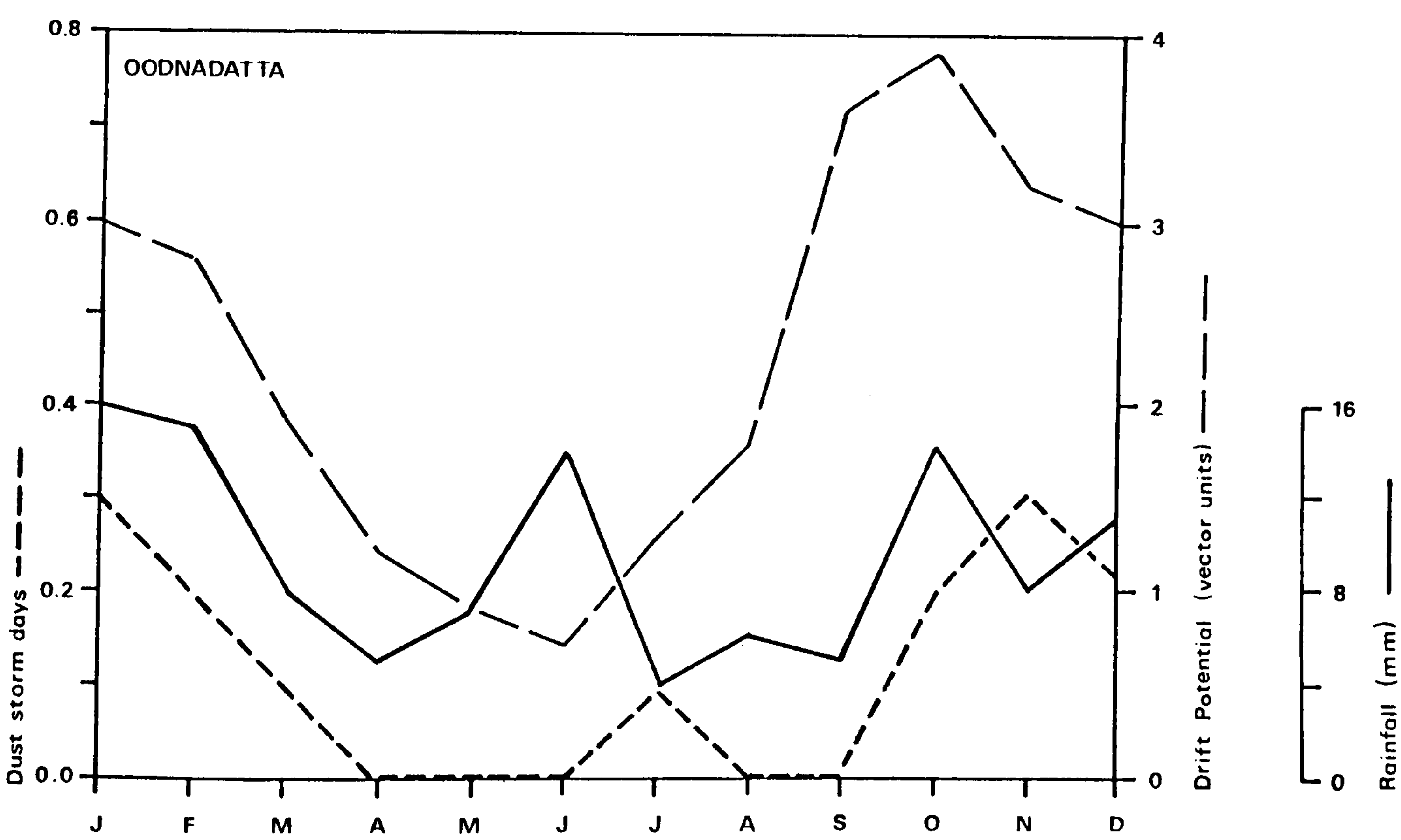




Figure 9.6 Monthly dust storm frequencies, rainfall totals & wind speed measures at Alice Springs & Oodnadatta

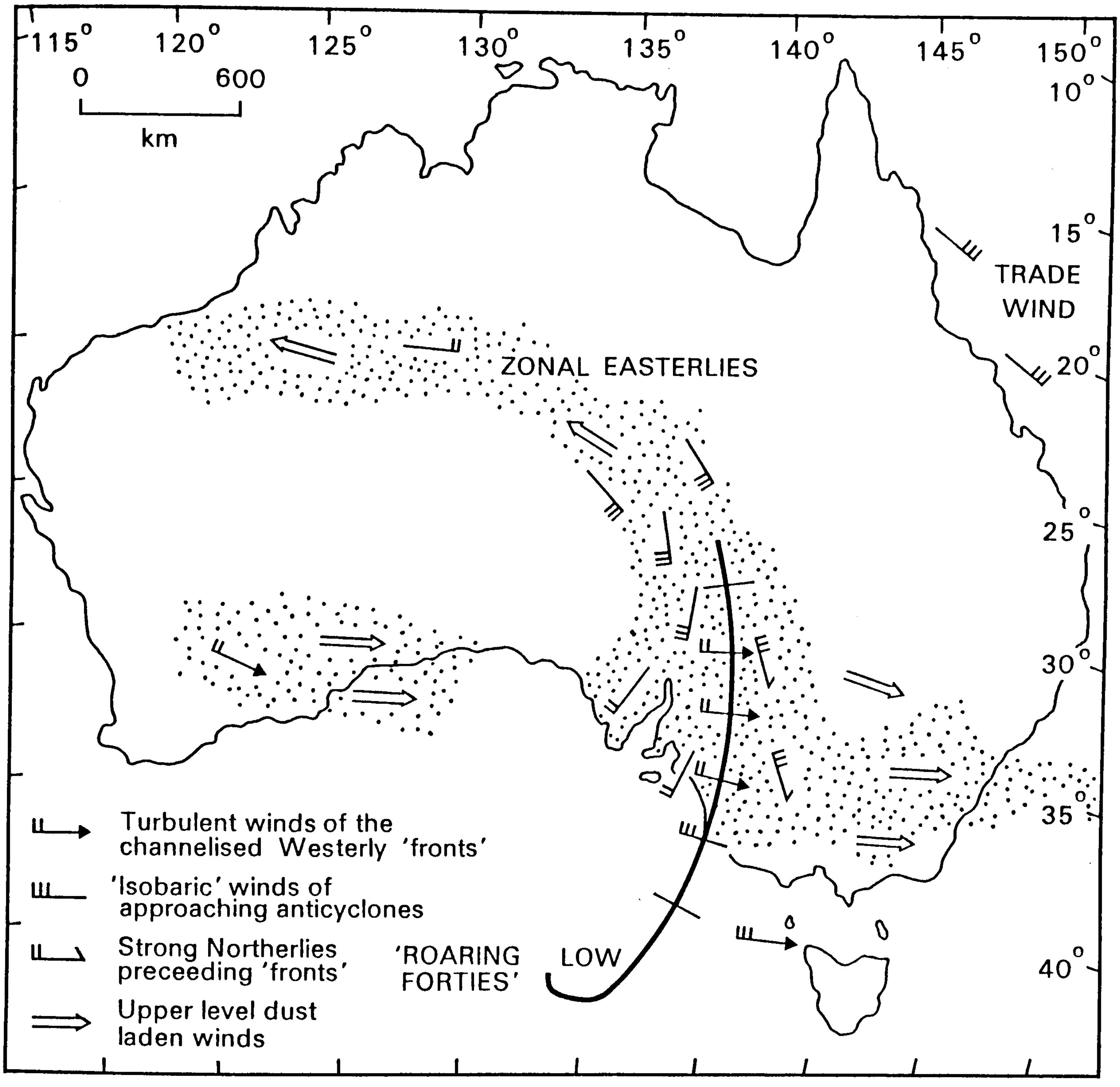



Figure 9.7 Proposed model for dust-bearing winds in Australia (after Sprigg 1982)

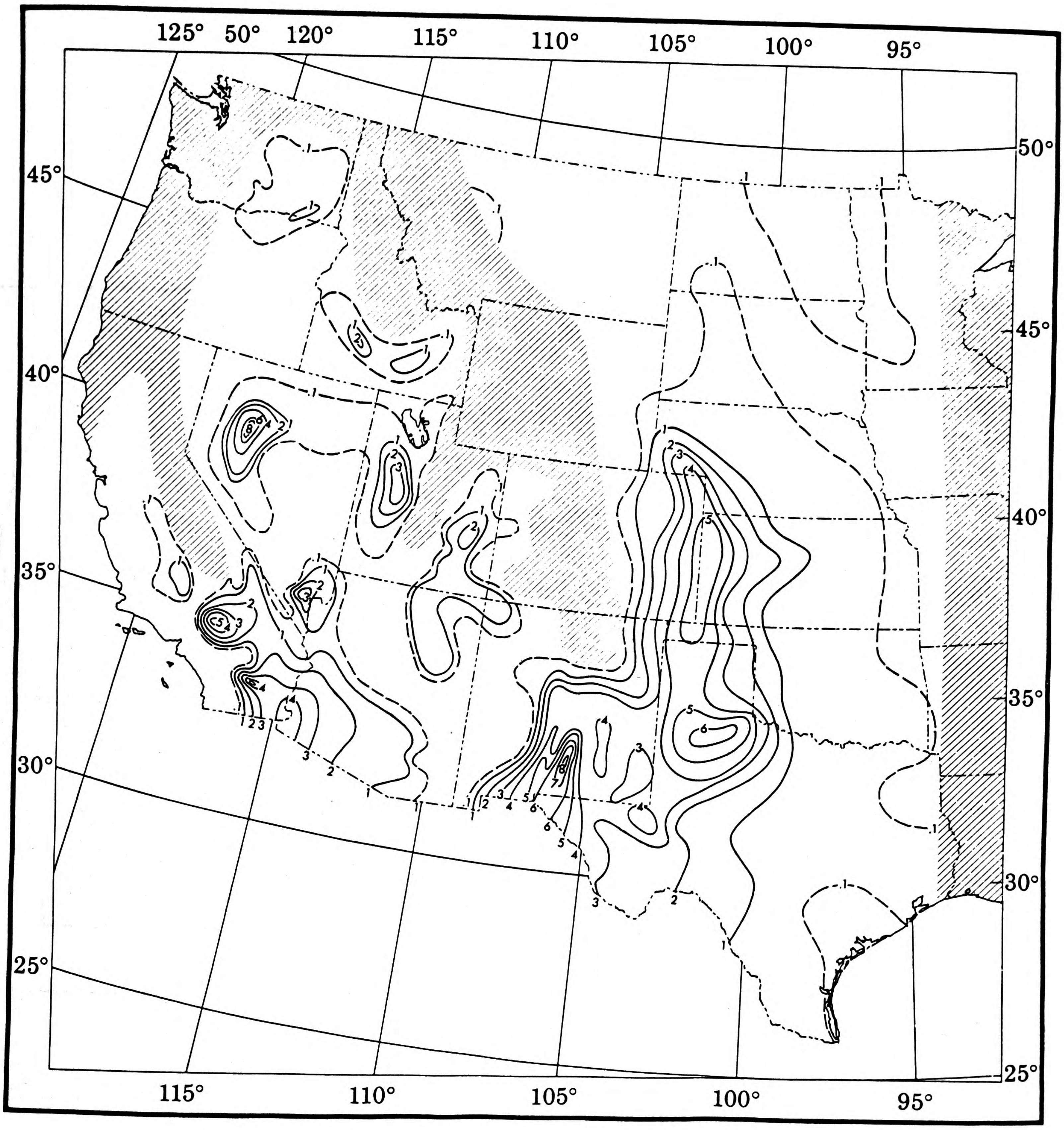



Figure 10.1 Distribution of dust storms in the western USA (data are for average annual number of dust episodes with visibility less than 5/8 mile, after Changery 1983)

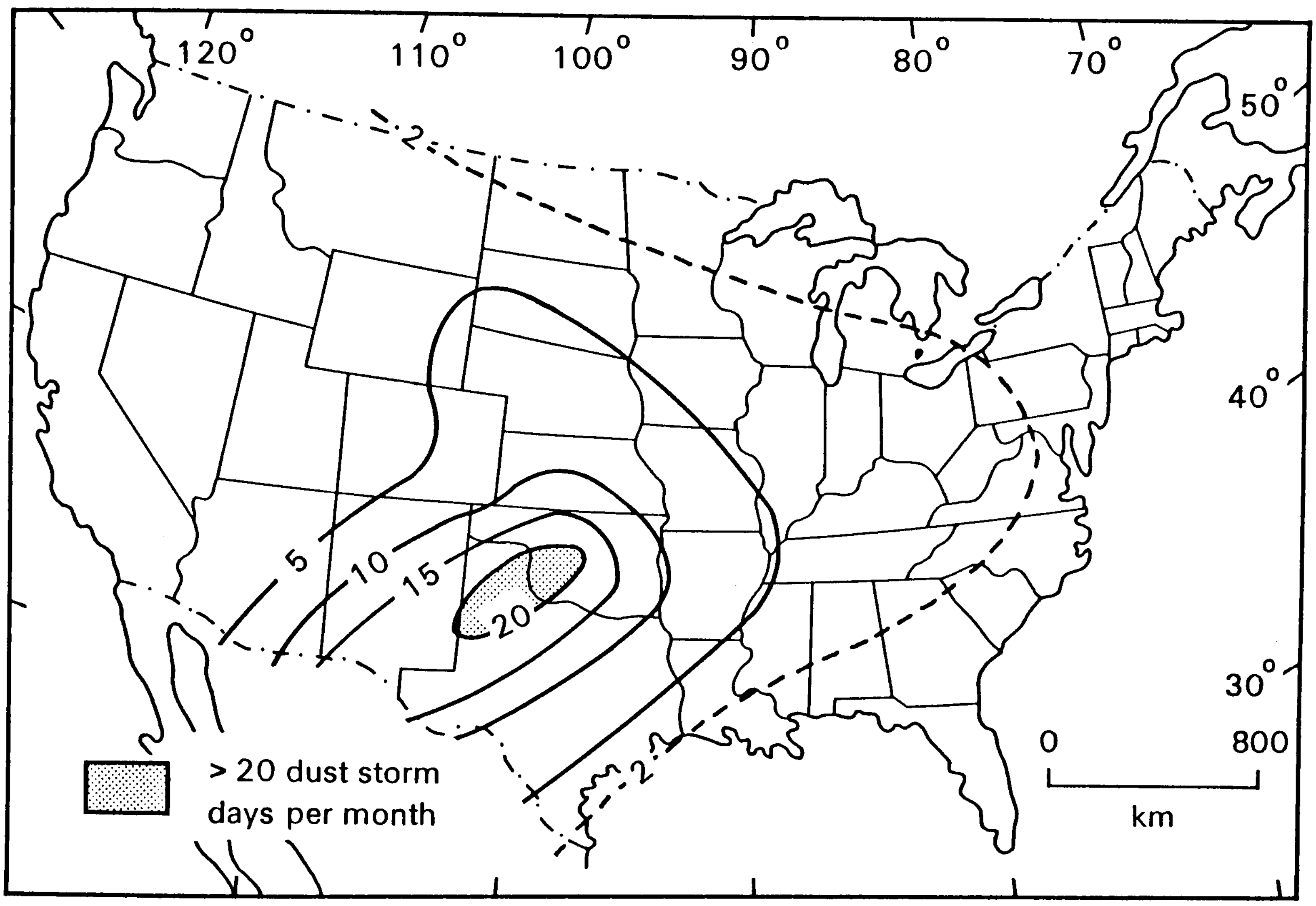



Figure 10.2 Concentration of dust storms in the USA in March 1936, showing extreme localisation on the Great Plains (after Goudie 1978)

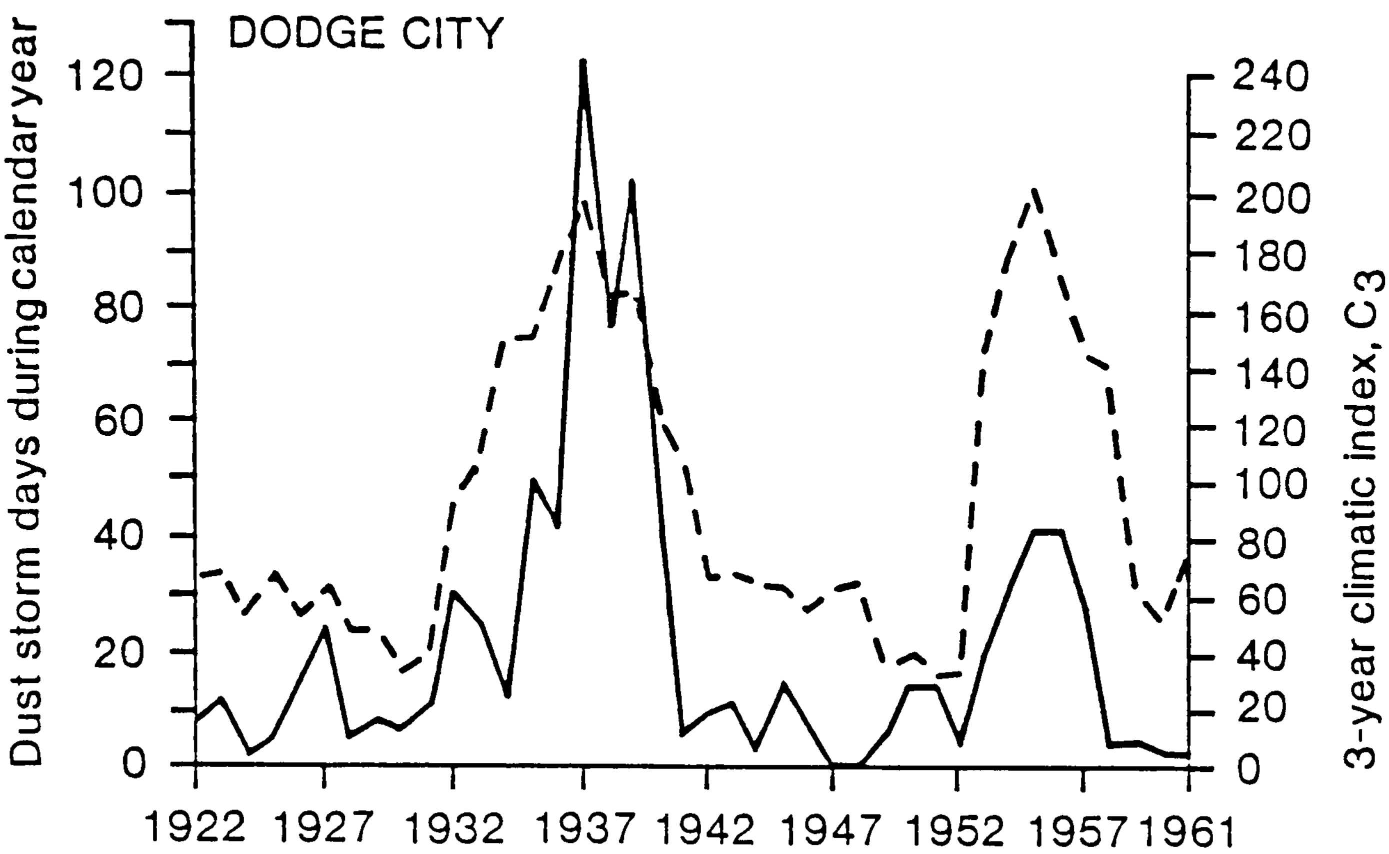



Figure 10.3 Annual dust storm frequencies & values of the climatic index, C (after Chepil **et al** 1963) at Dodge City (1922-61)

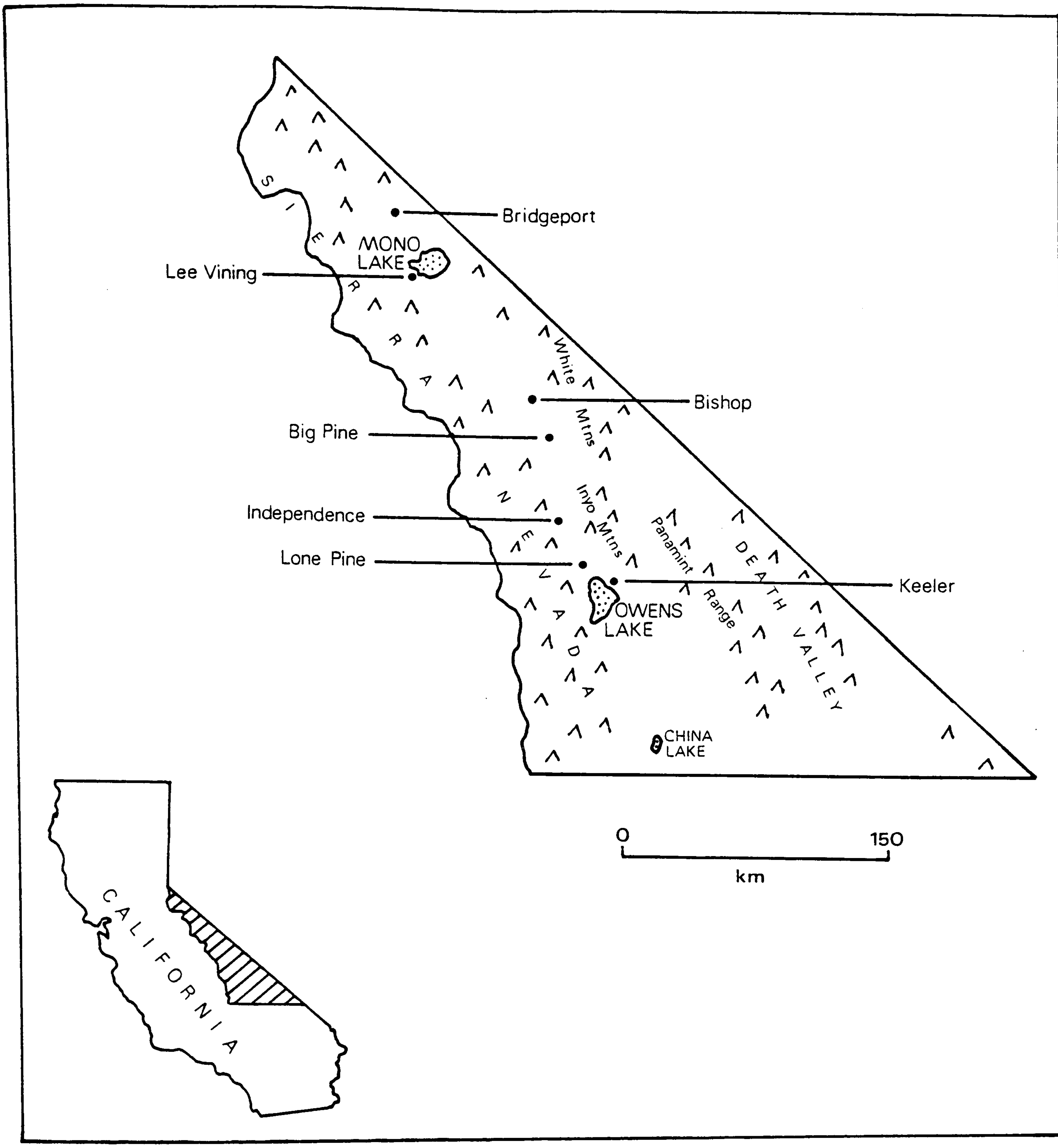



Figure 10.4 Great Basins Air Valleys Basin location map

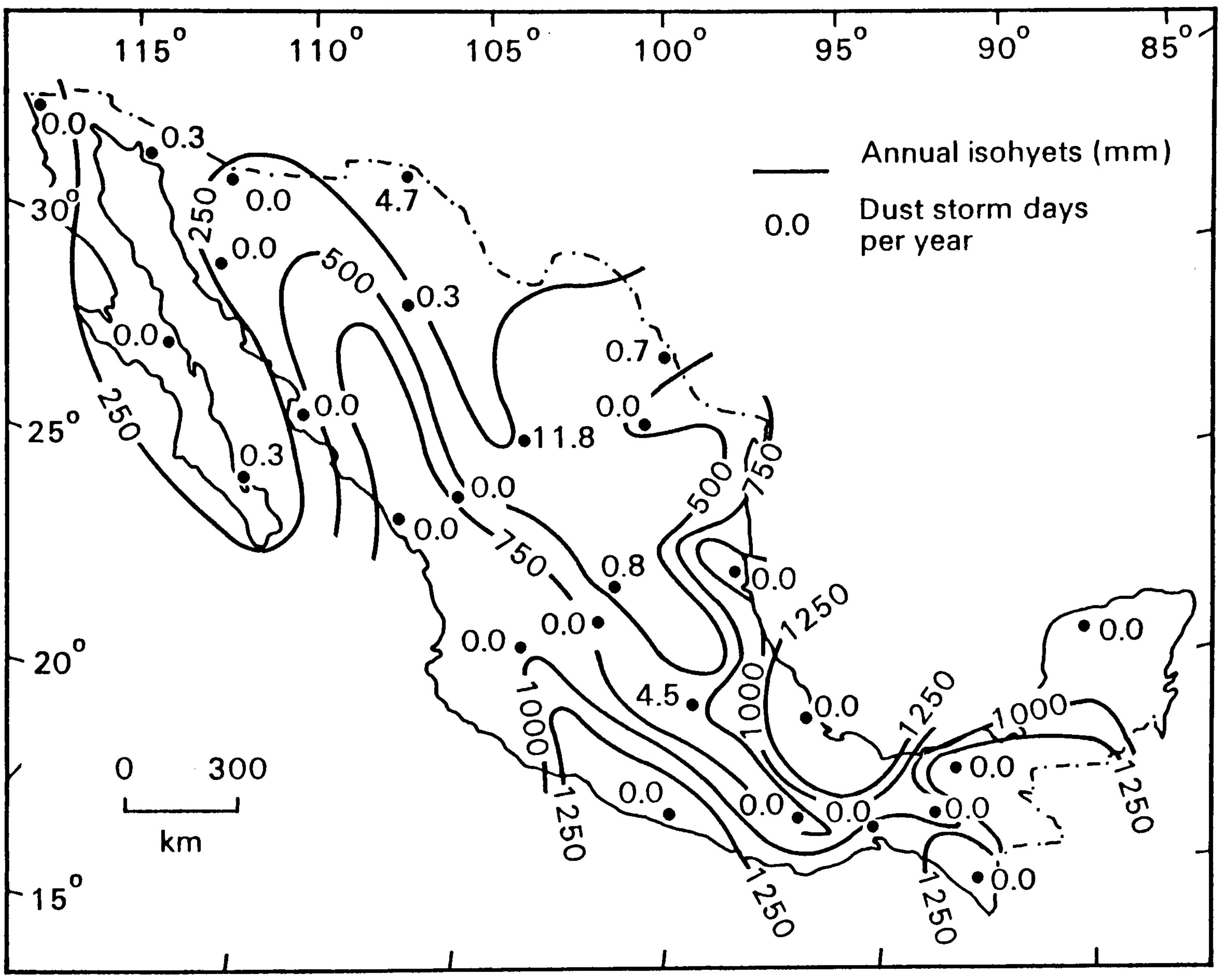



Figure 11.1 Distribution of dust storms in Mexico

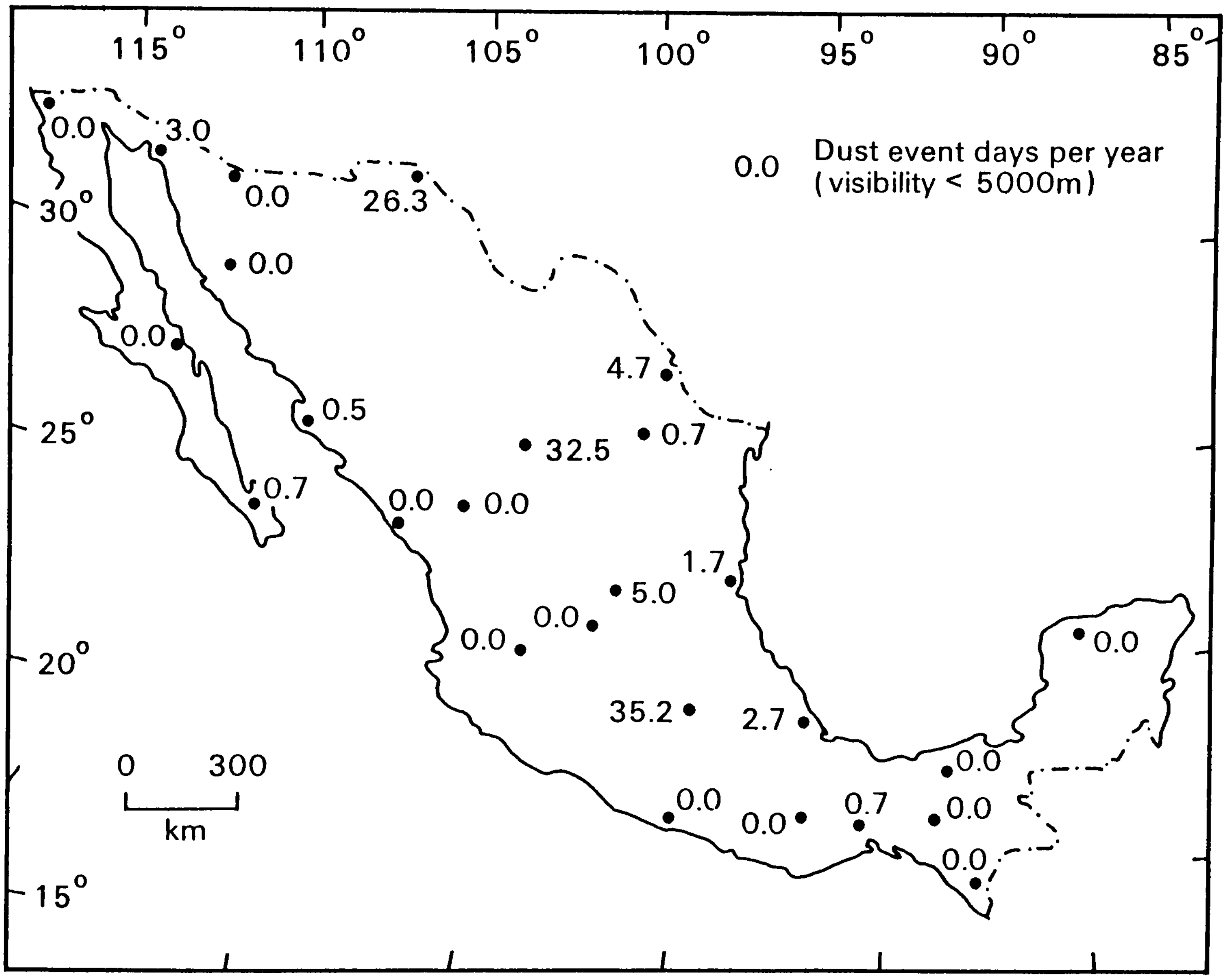



Figure 11.2 Distribution of blowing dust events in Mexico (visibility less than 5000m)

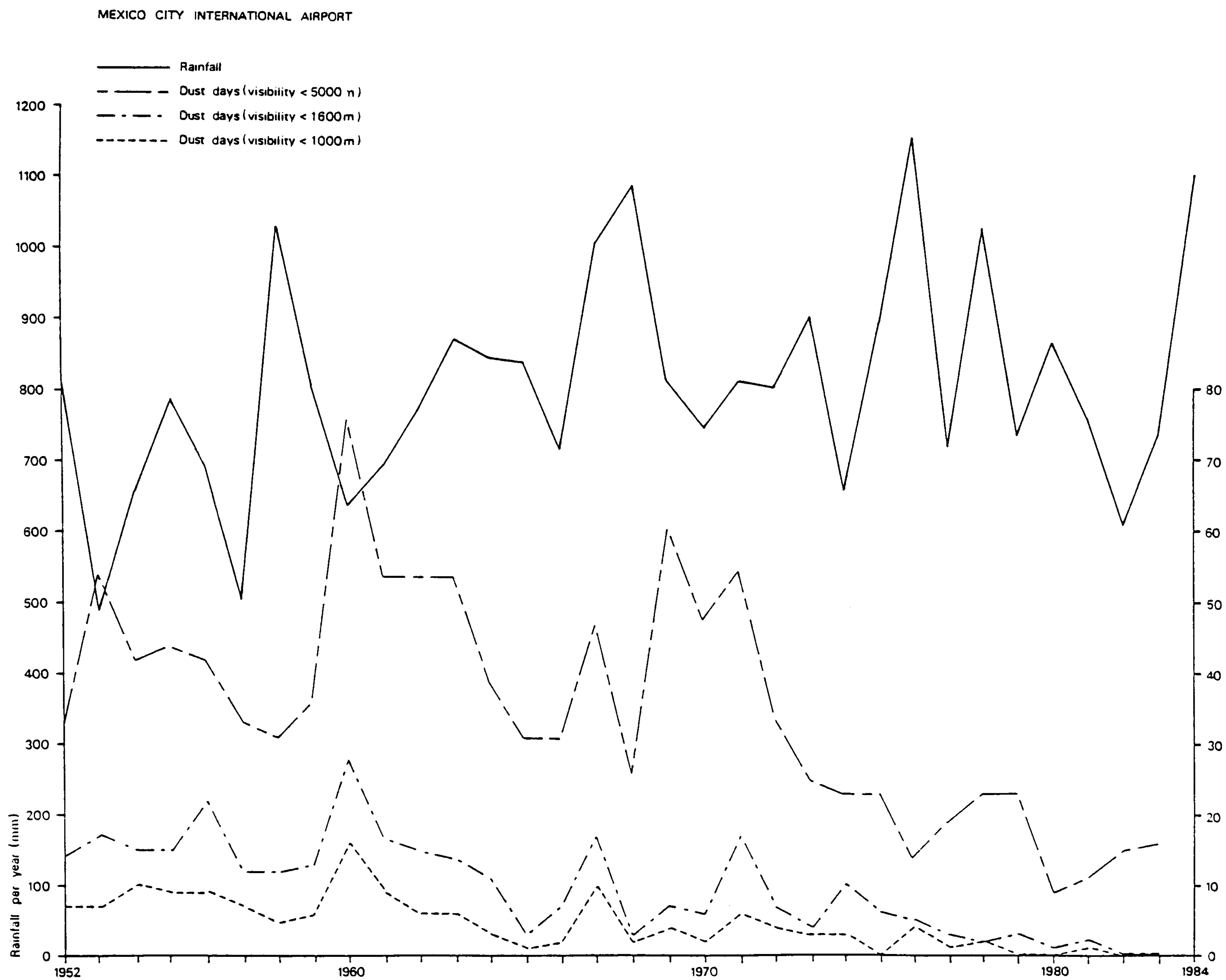



Figure 11.3 Annual rainfall totals & dust day frequencies at three visibility limits for Mexico City (1952-83)

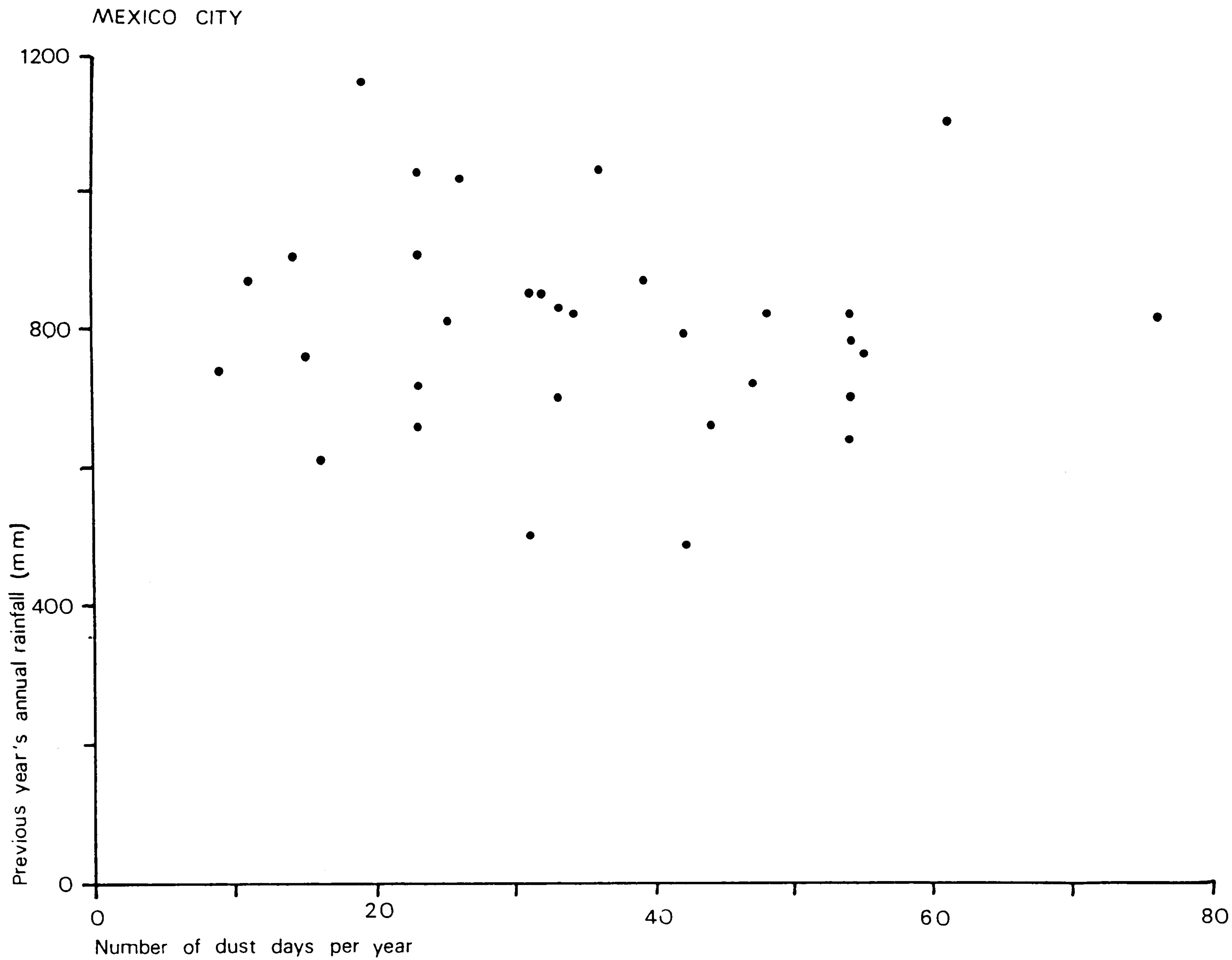



Figure 11.4 Frequency of dust days (visibility less than 5000m)in relation to previous year's rainfall at Mexico City

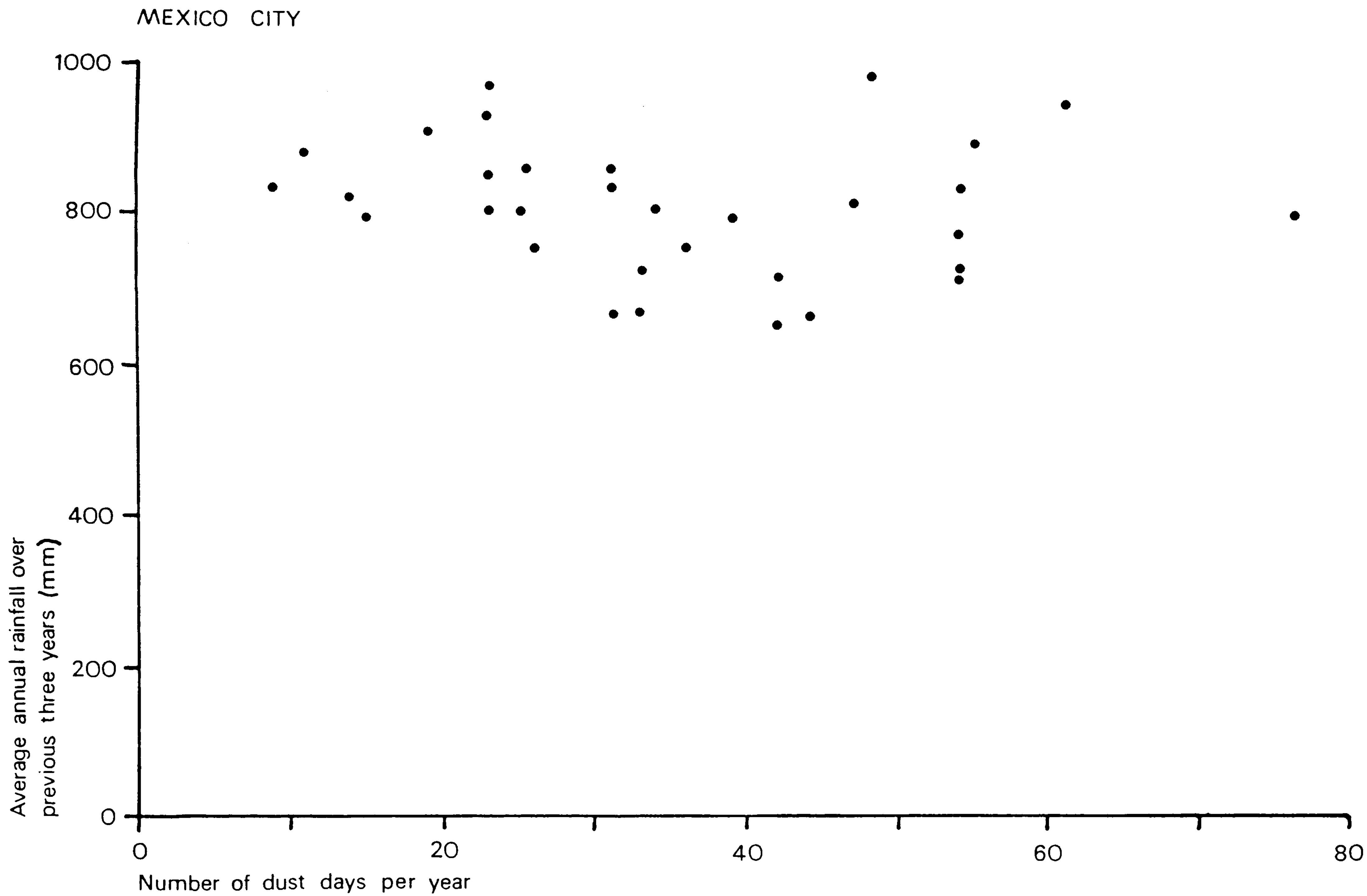
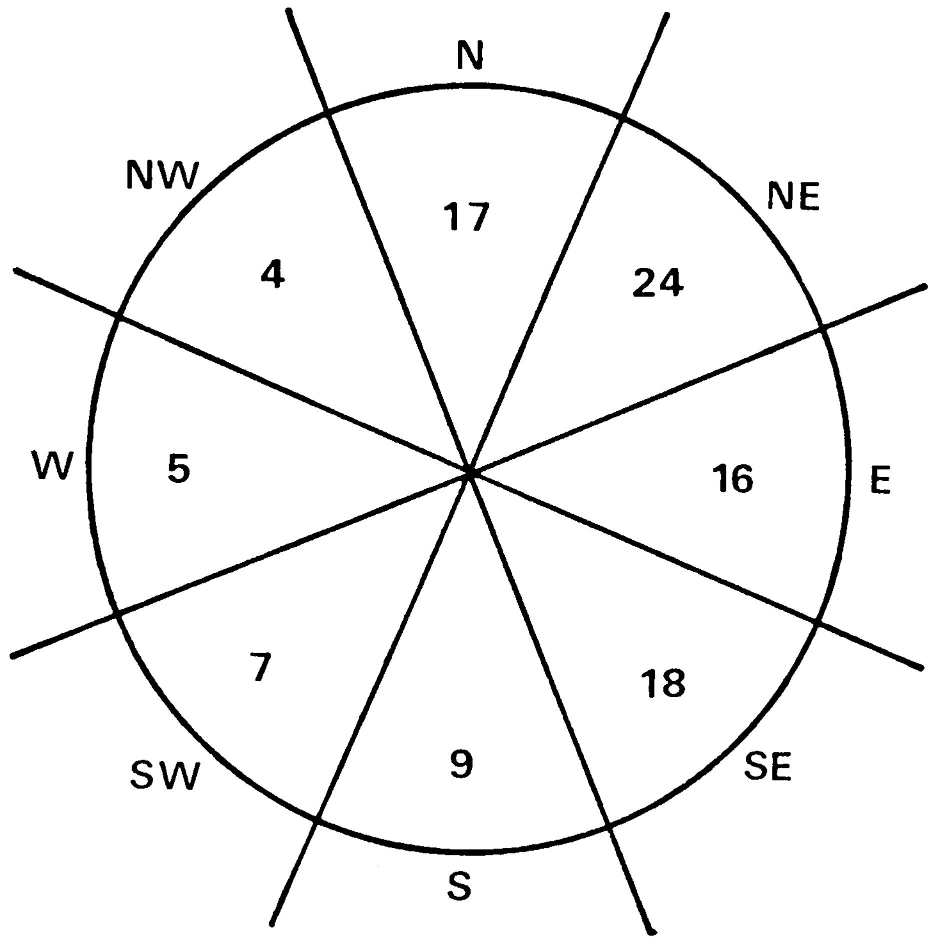



Figure 11.5 Frequency of dust days (visibility less than 5000m) in relation to mean annual rainfall over the previous three years at Mexico City



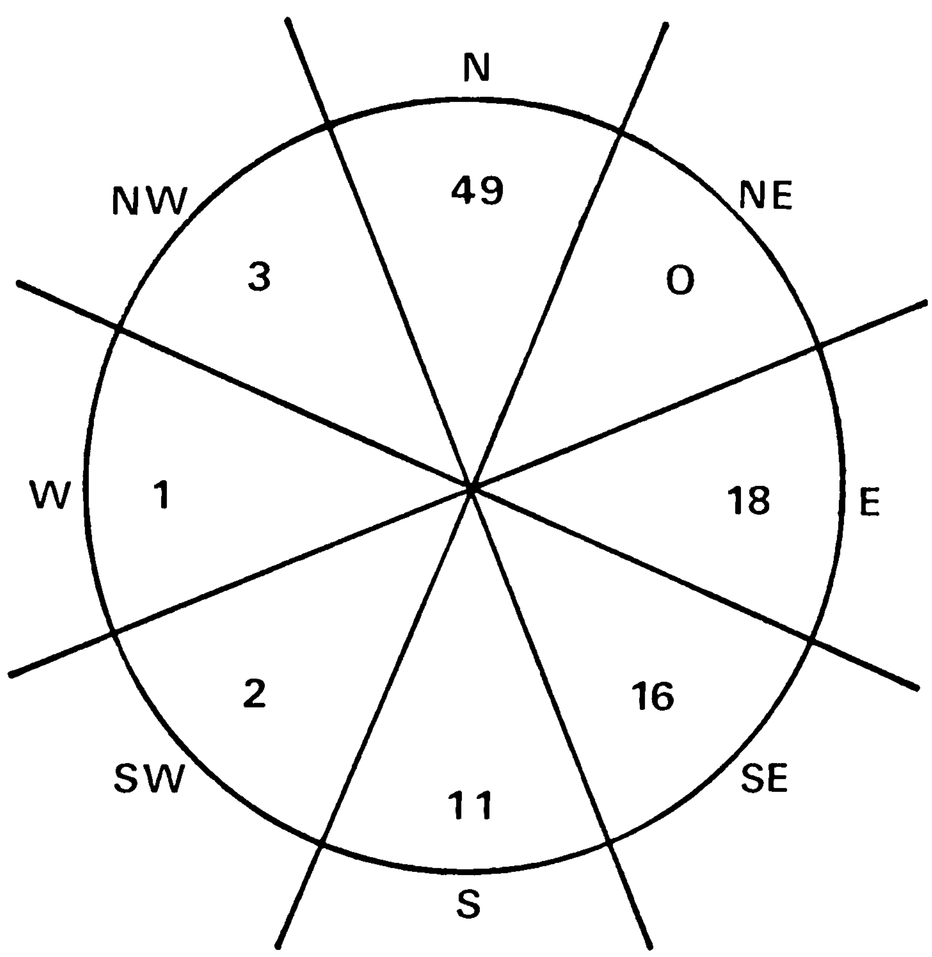




Figure 11.6 Dust events (visibility less than 5000m) by direction at Mexico City. Values are in percent

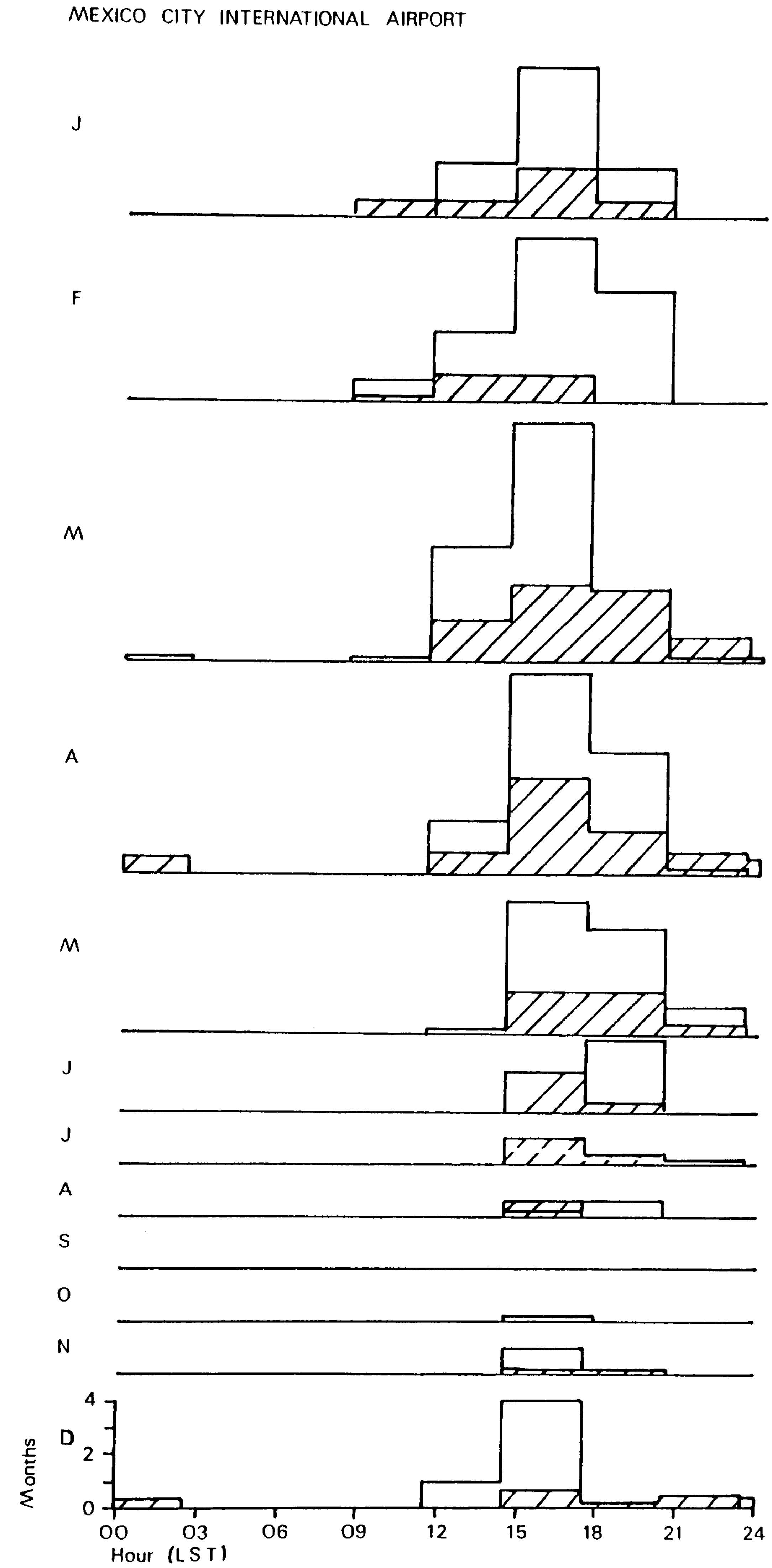



Figure 11.7 Diurnal arithmetic mean frequency percent by month of visibility reduced to less than 5000m by dust at Mexico City. Unhatched area for 1952-61; hatched area for 1975-83

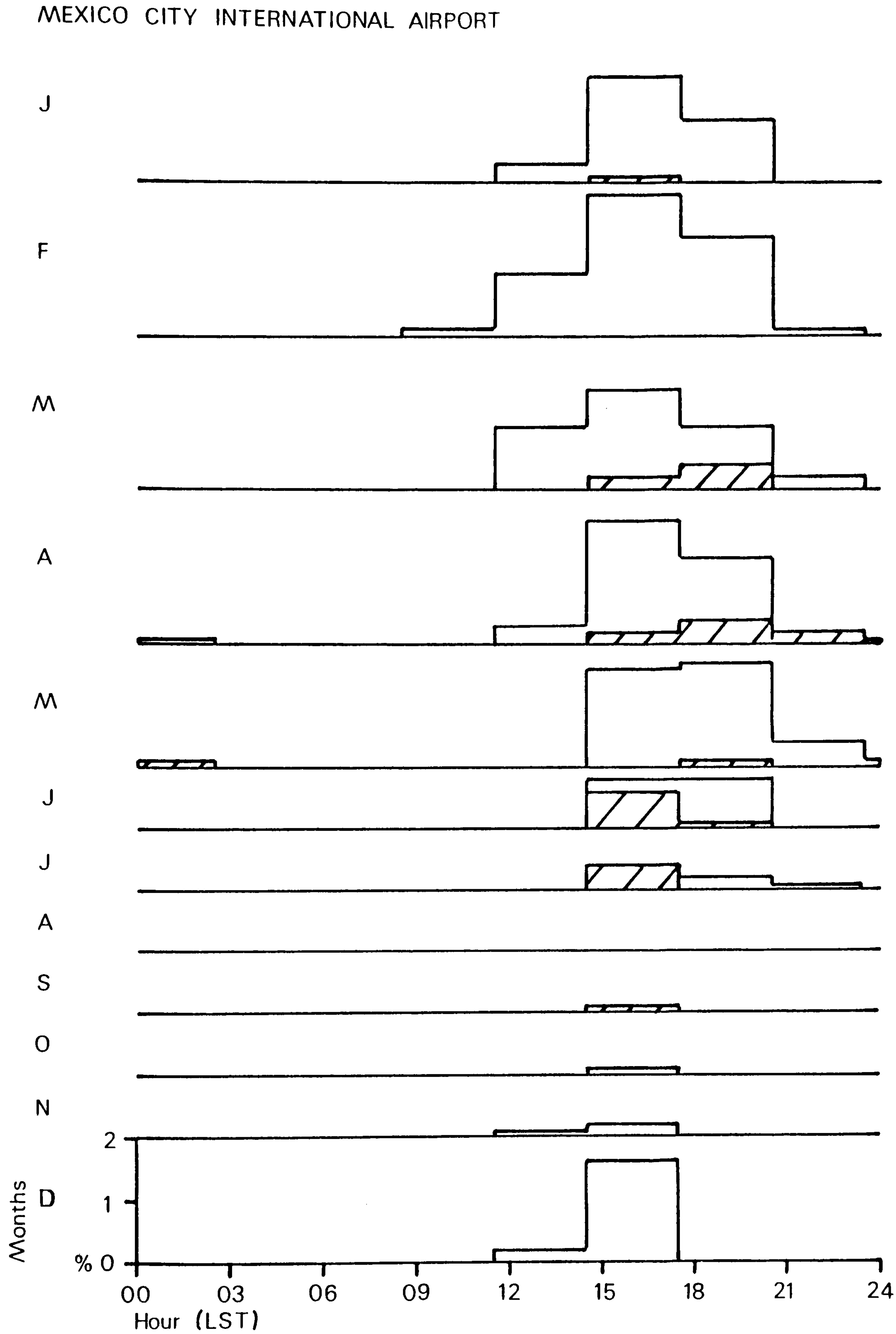



Figure 11.8 Diurnal arithmetic mean frequency percent by month of visibility reduced to less than 1600m by dust at Mexico City. Unhatched area for 1952-61; hatched area for 1975-83

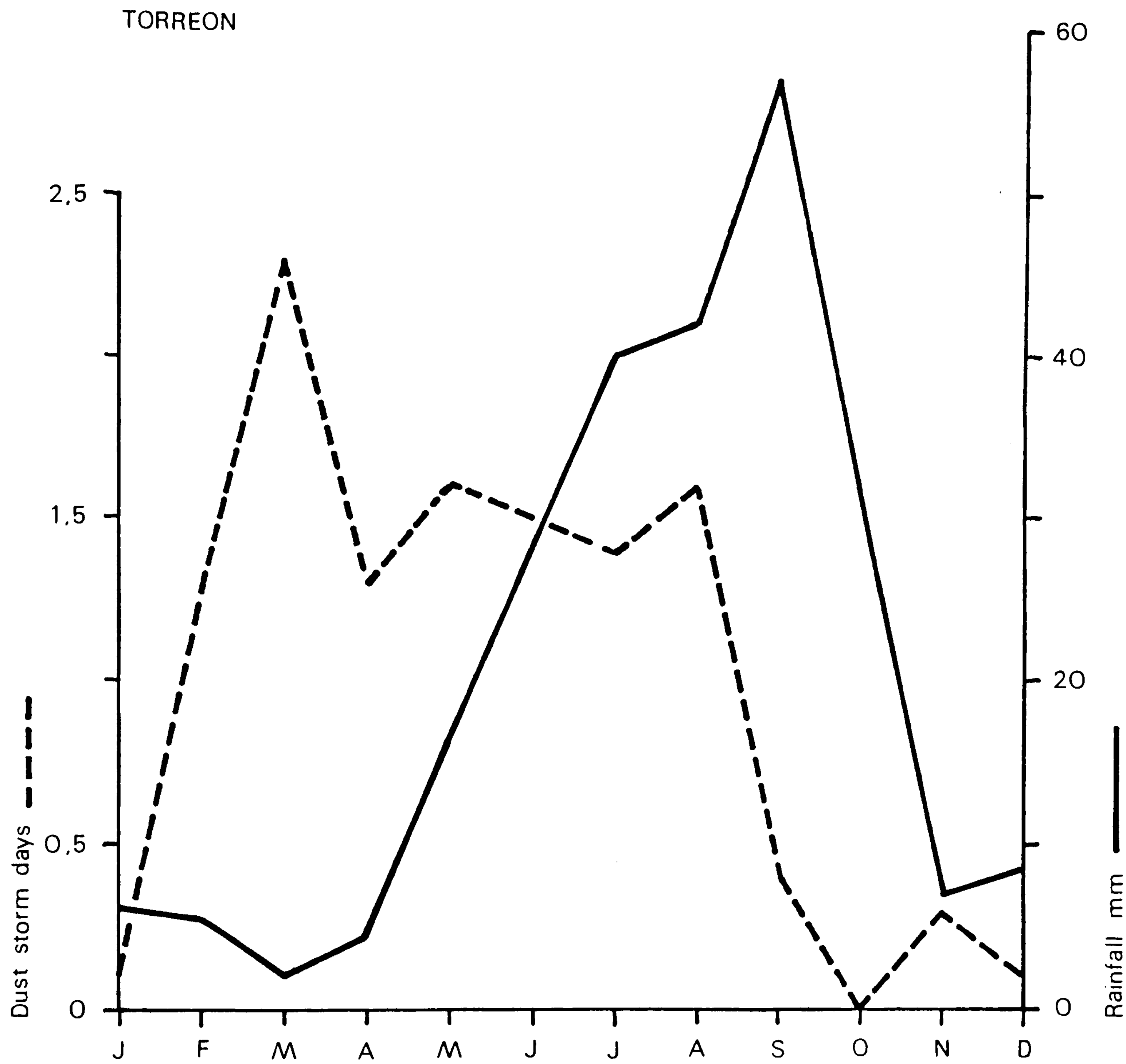



Figure 11.9 Monthly dust storm frequencies & rainfall totals
at Torreon, Mexico

TORREON 1962-69

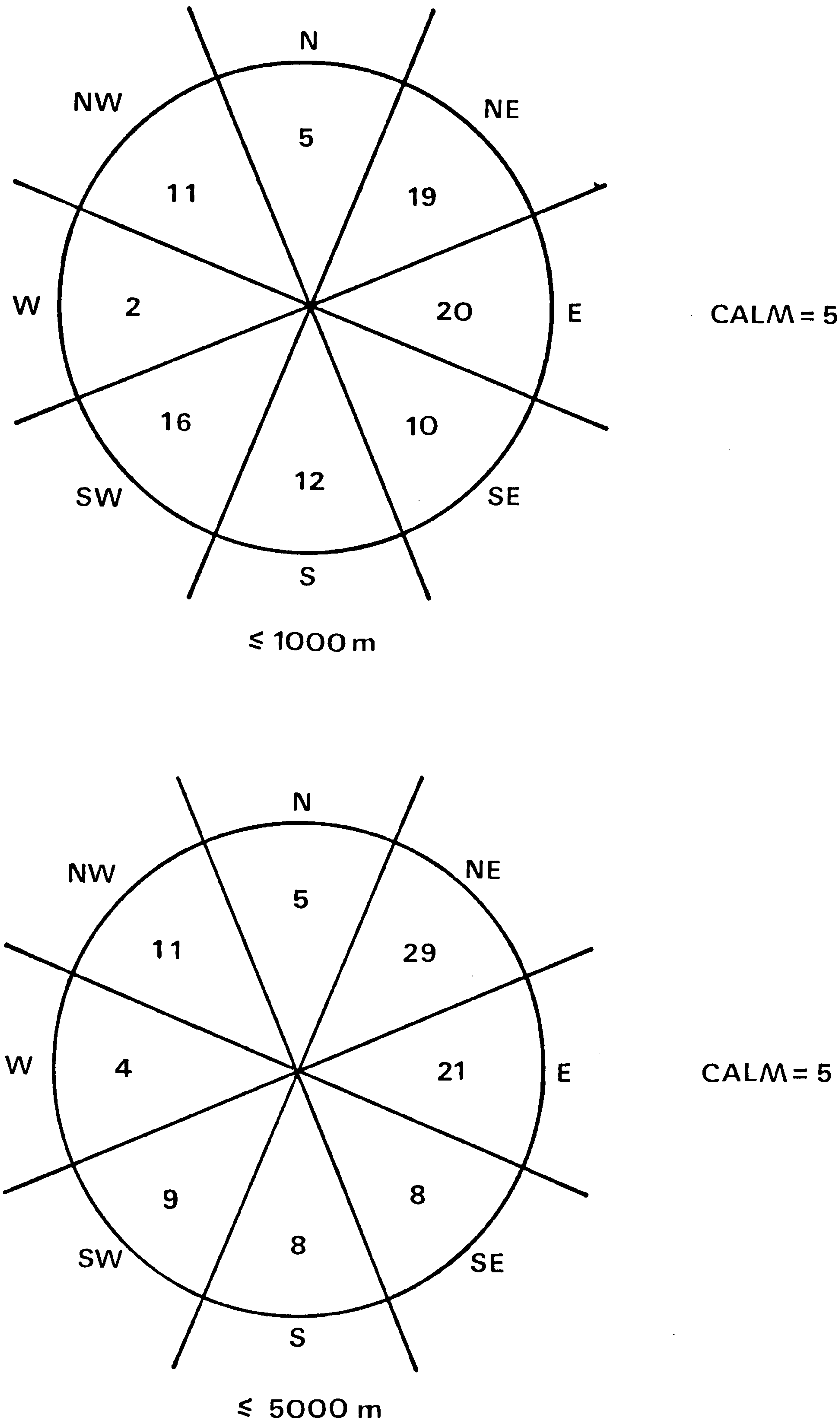



Figure 11.10 Dust events by direction & wind speed at Torreon (1962-69). Values are in percent

TORREON, Mexico

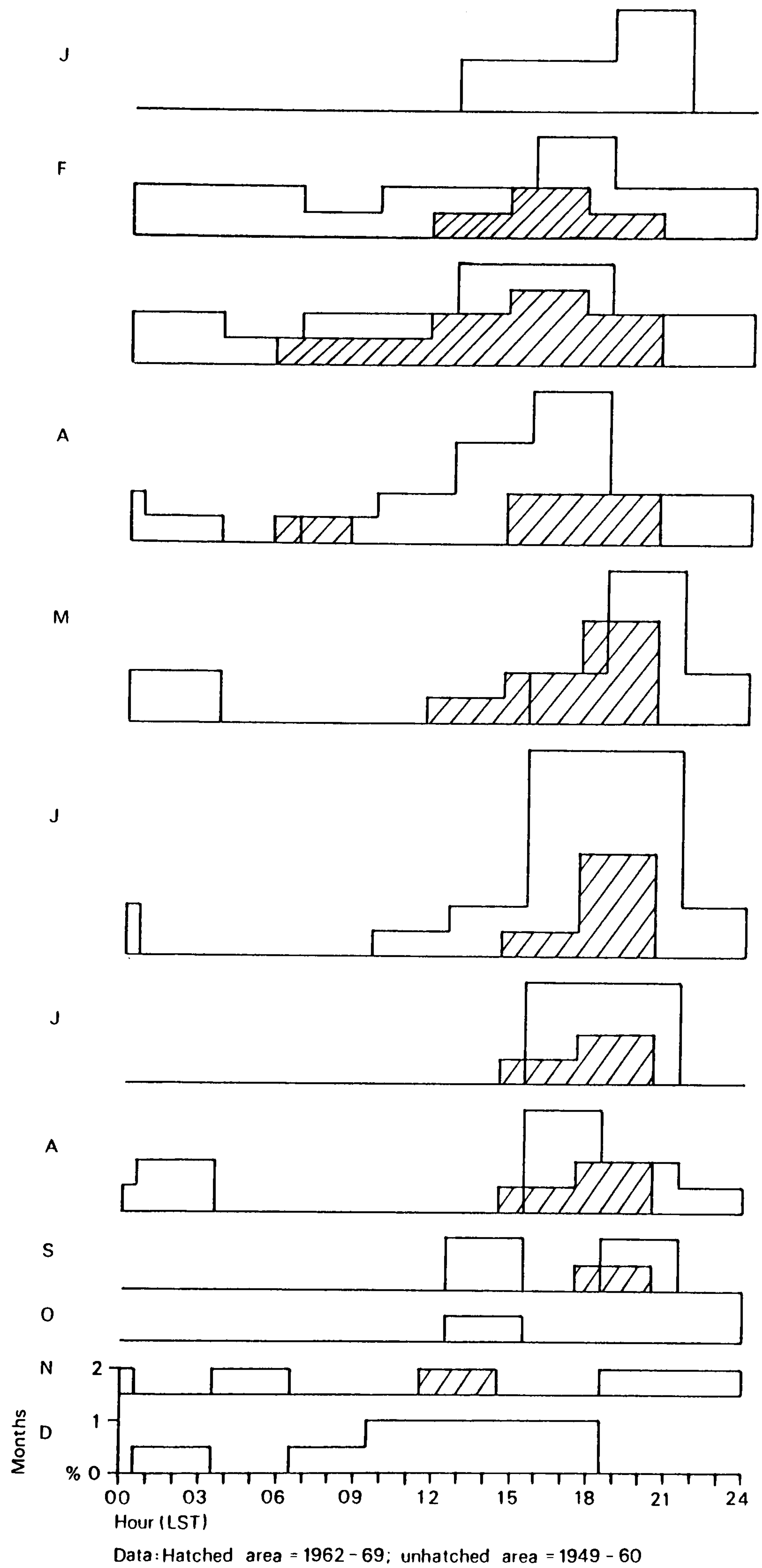



Figure 11.11 Diurnal arithmetic mean frequency percent by month of visibility reduced to less than 1000m by dust at Torreon

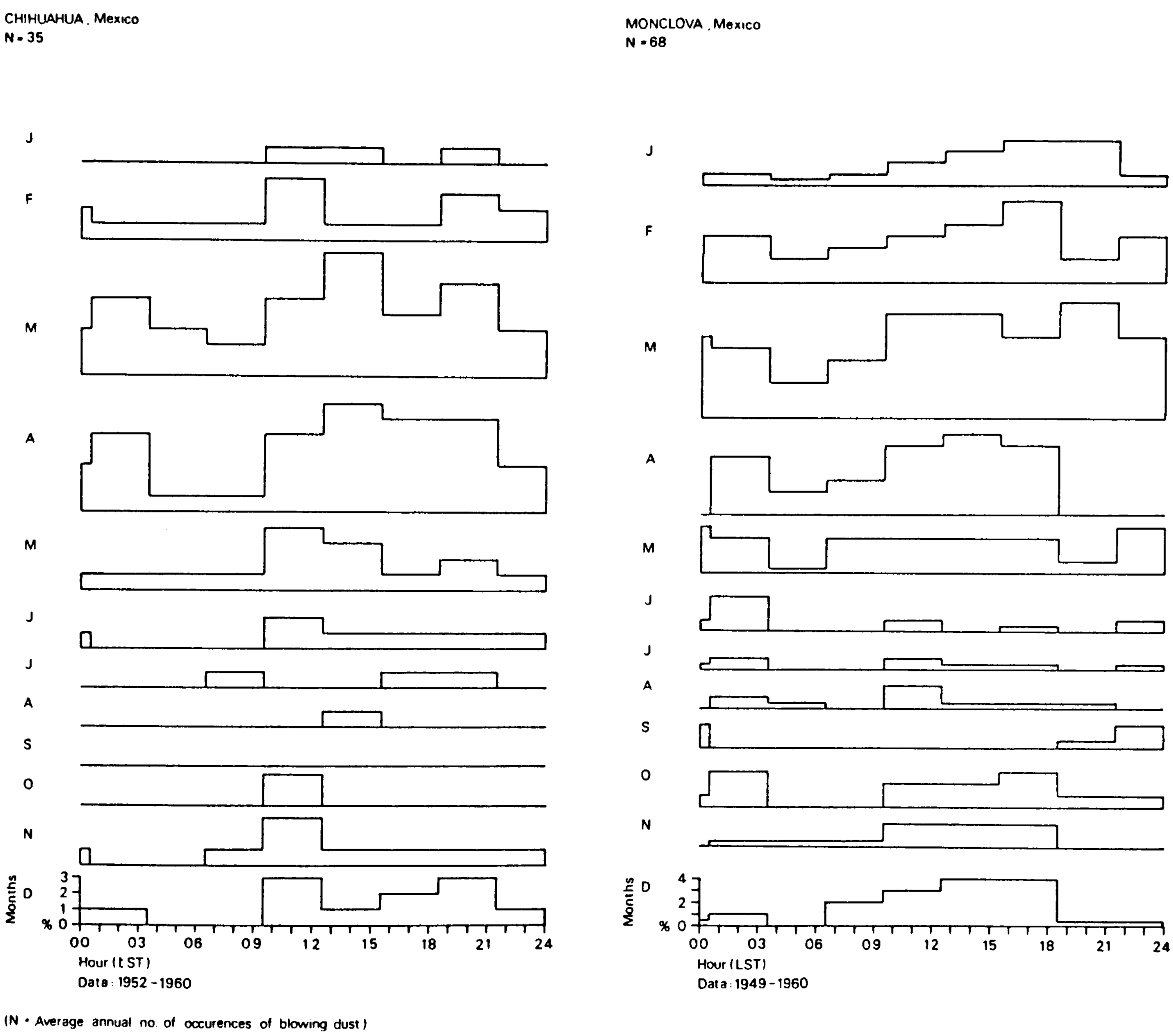



Figure 11.12 Diurnal arithmetic mean frequency percent by month of visibility reduced to less than 11km by blowing dust at Chihuahua & Monclova, Mexico

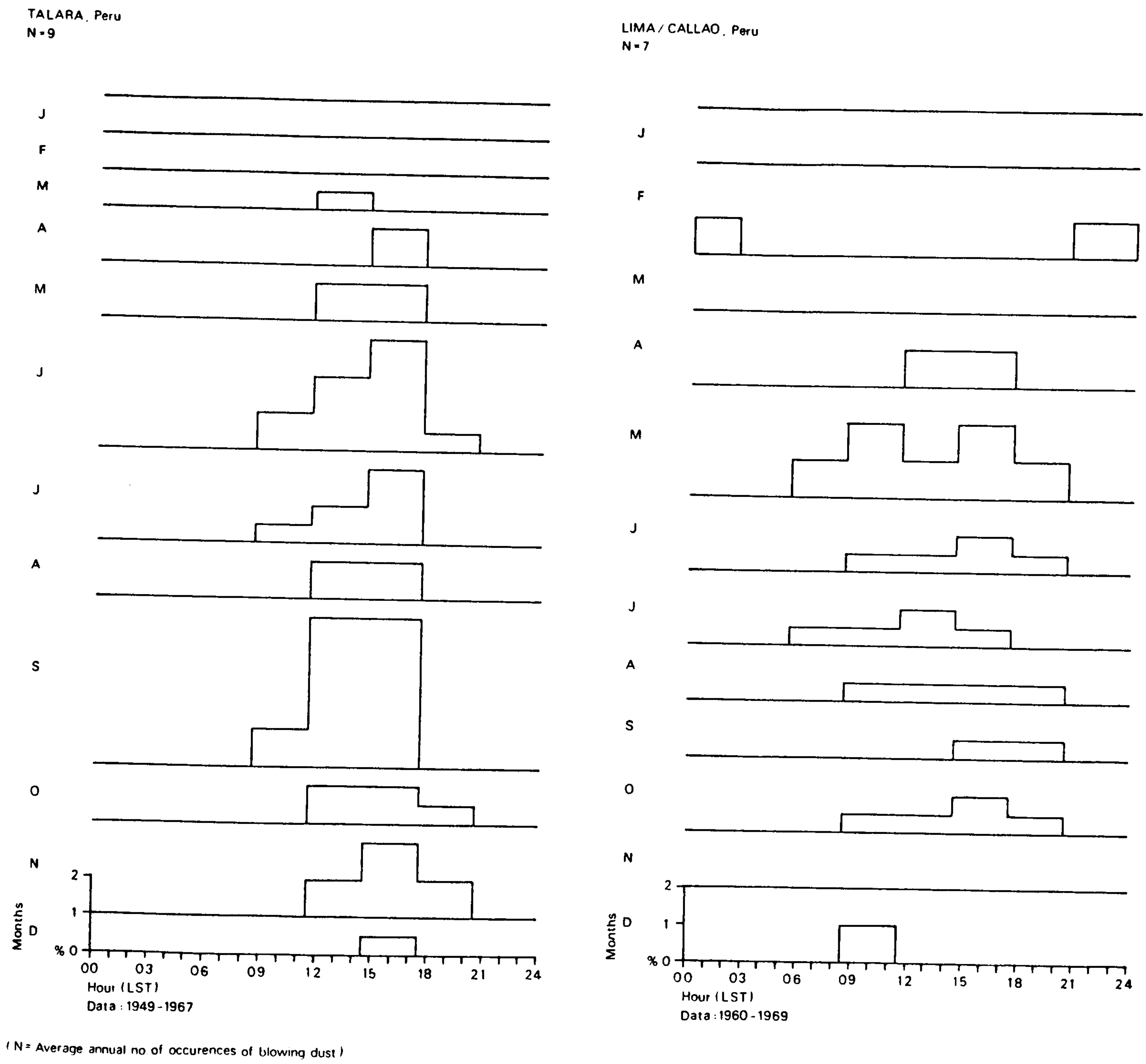



Figure 11.13 Diurnal arithmetic mean frequency percent by month of visibility reduced to less than 11km by blowing dust at Talara & Lima, Peru

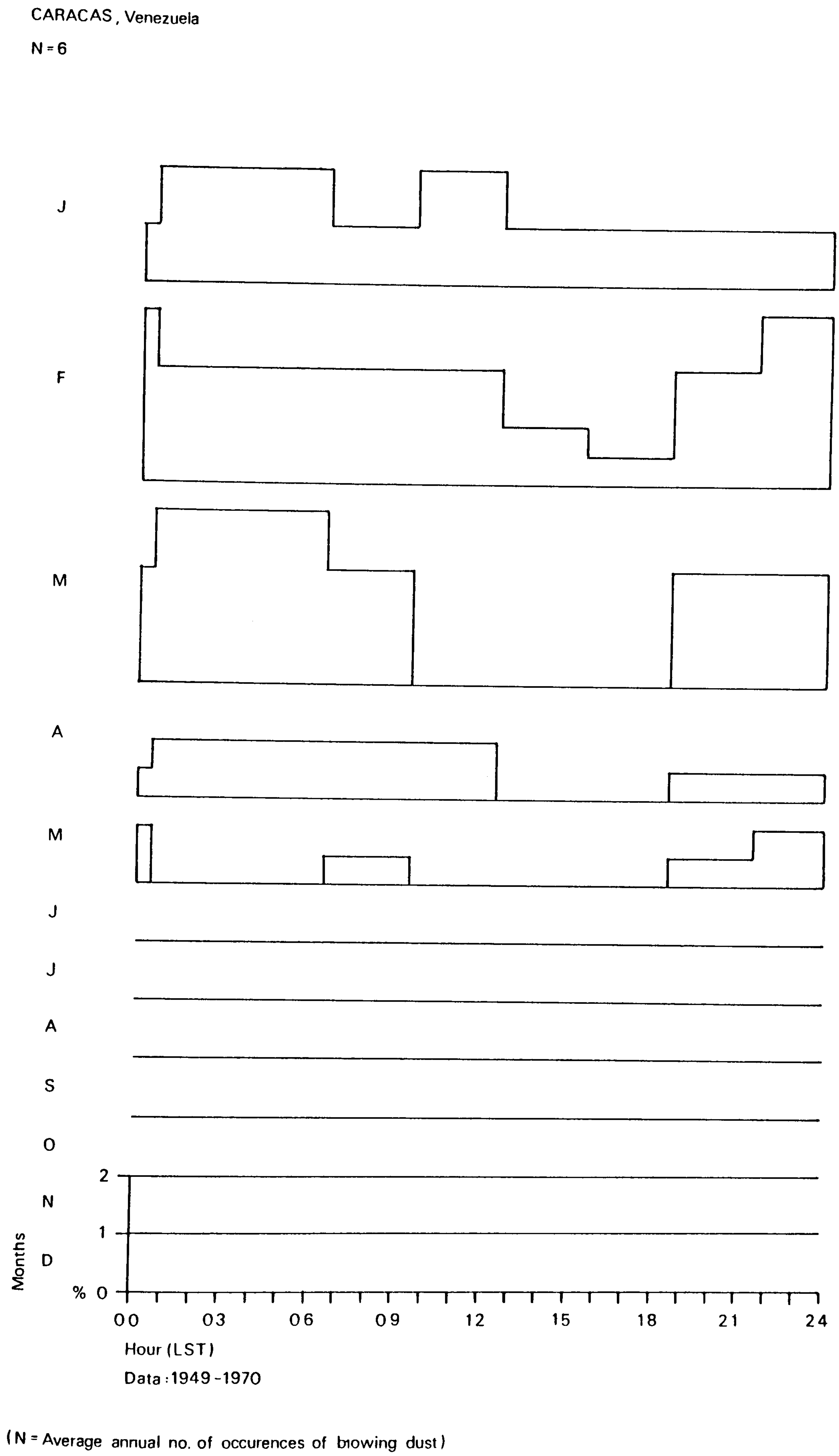



Figure 11.14 Diurnal arithmetic mean frequency percent by month of visibility reduced to less than 11km by blowing dust at Caracas, Venezuela

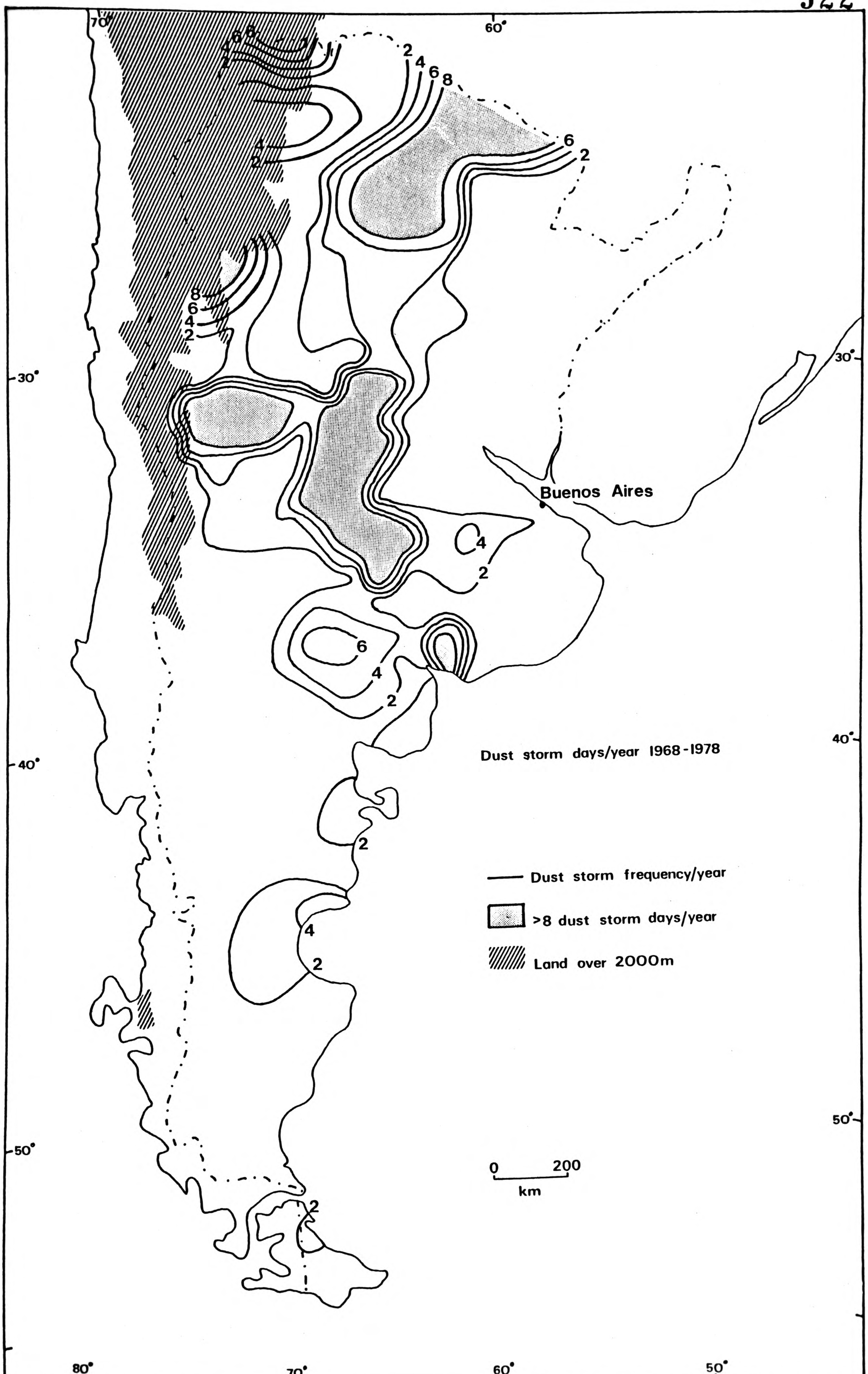



Figure 11.15 Distribution of dust storms in Argentina (Note: no visibility limit used)

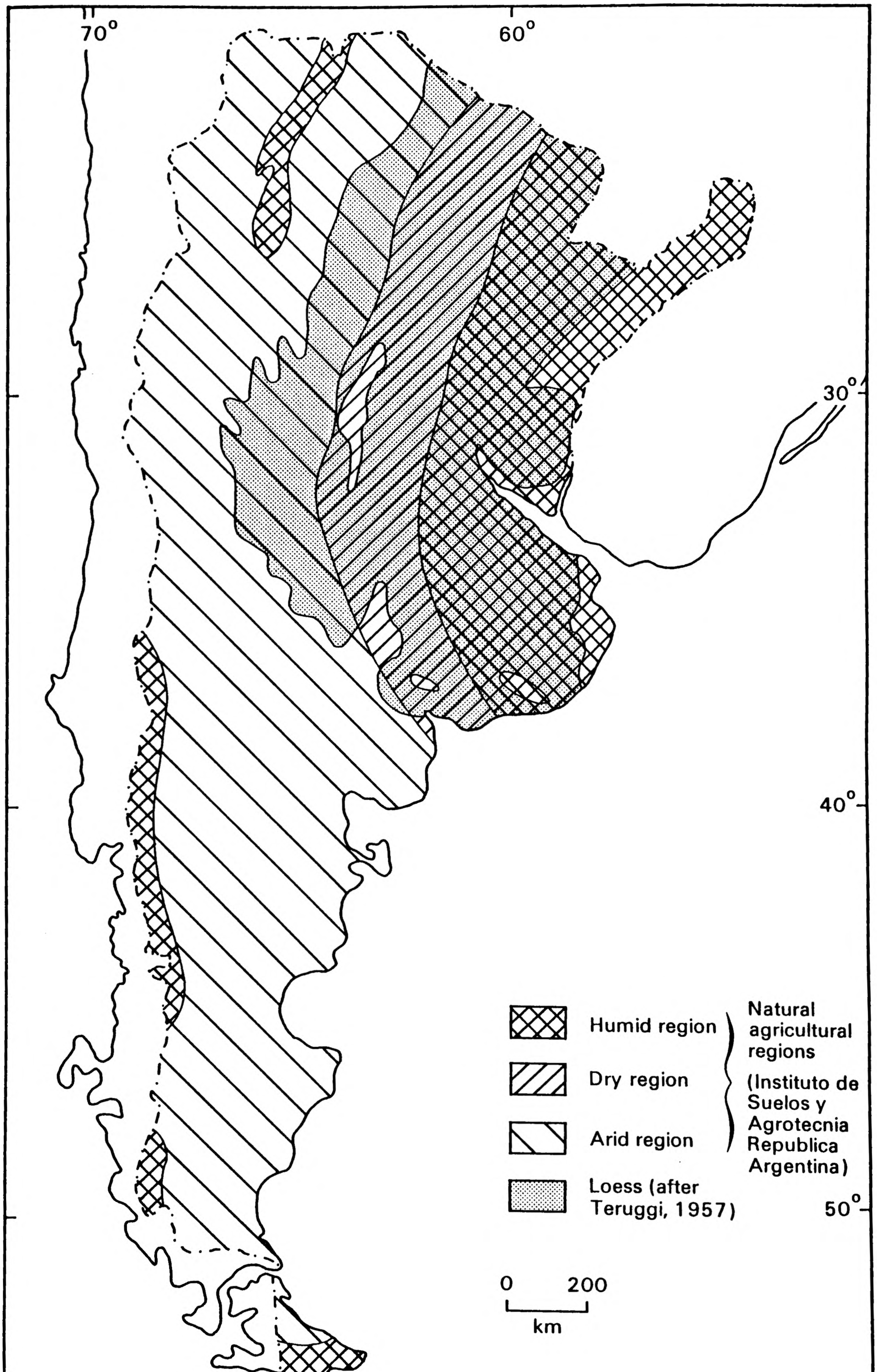



Figure 11.16 Distribution of loess & natural farming regions in Argentina

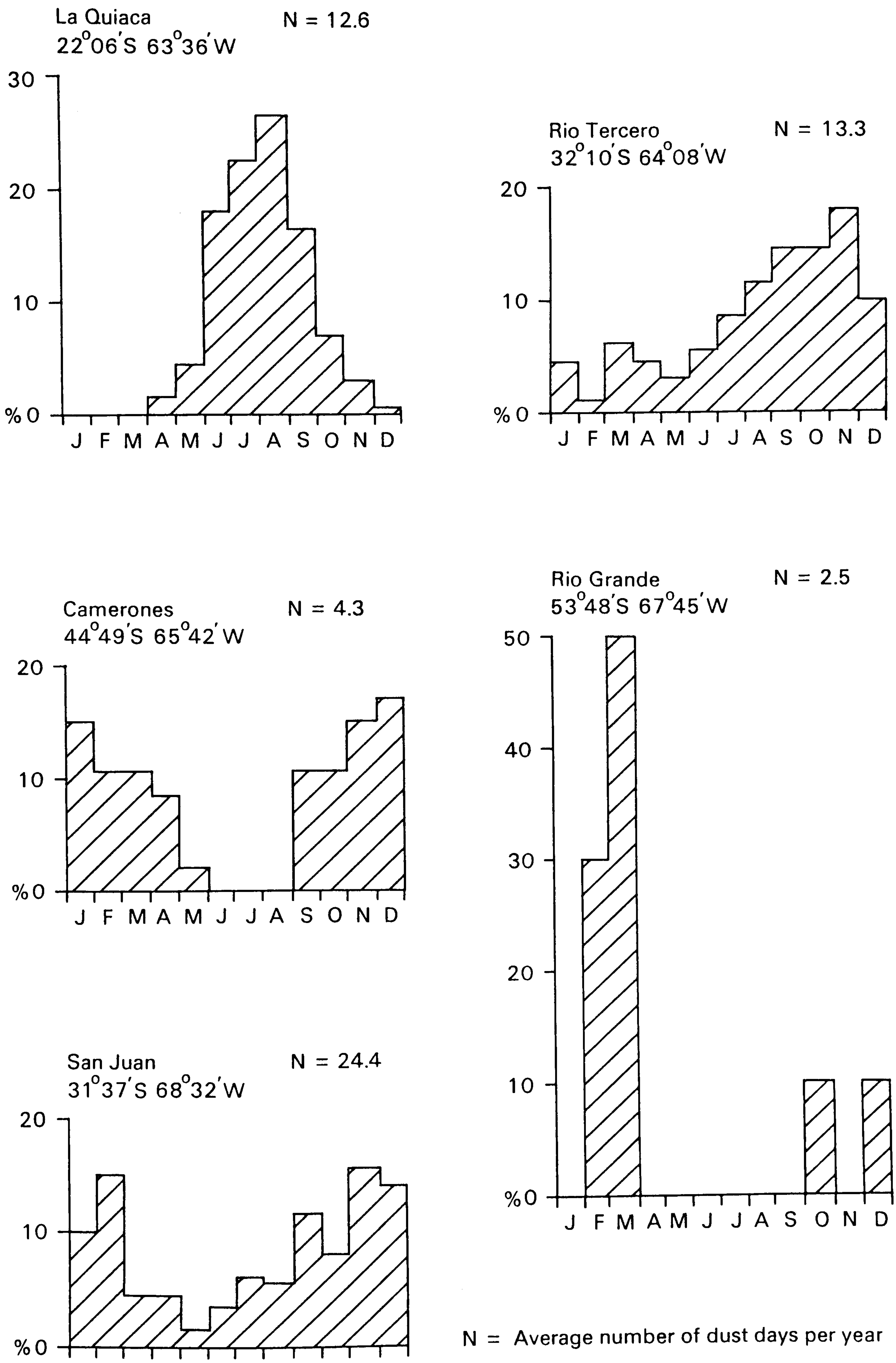



Figure 11.17 Seasonality of dust storms in Argentina

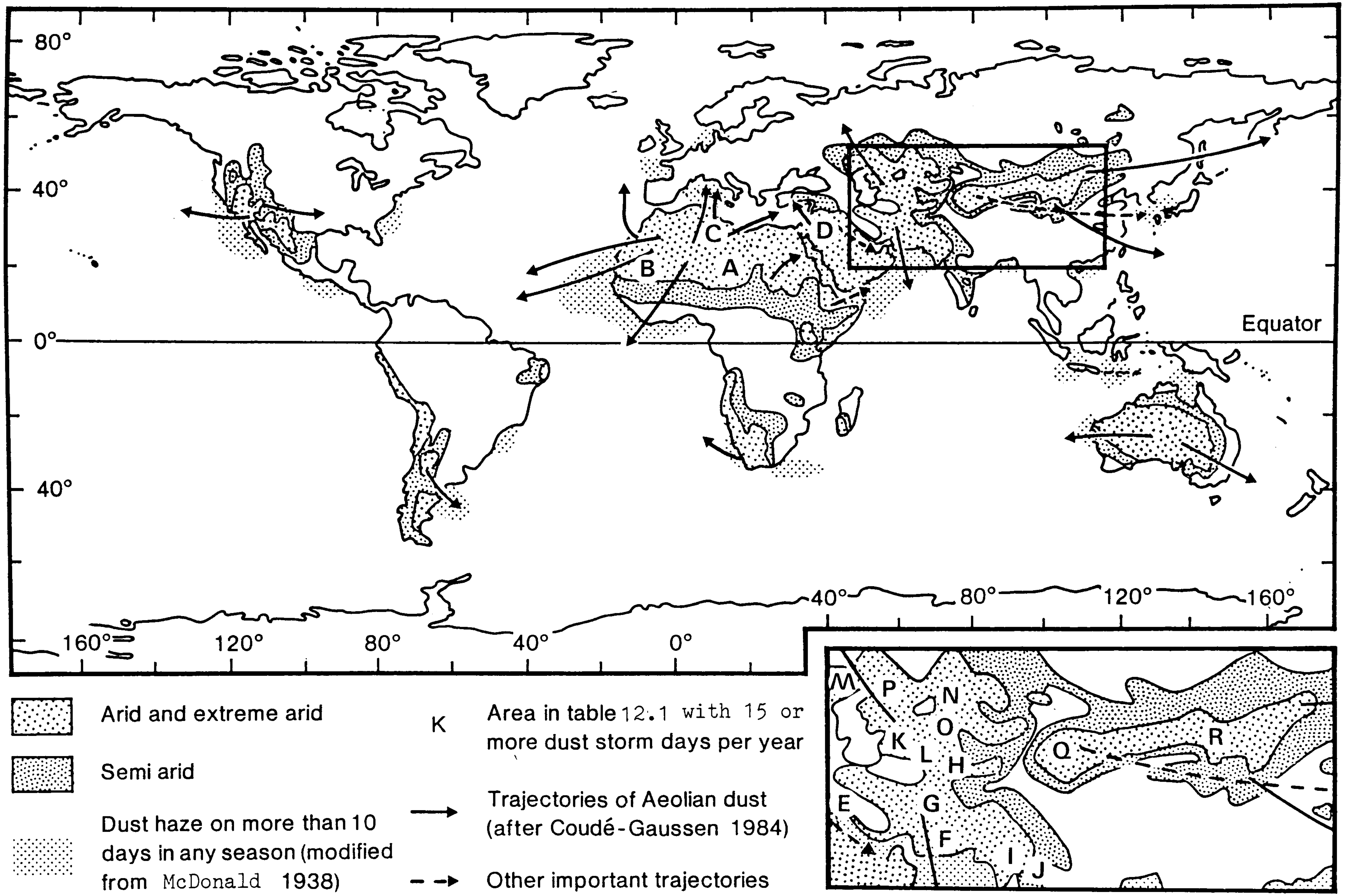



Figure 12.1 Global distribution of major dust storm areas with main seasonal dust trajectories

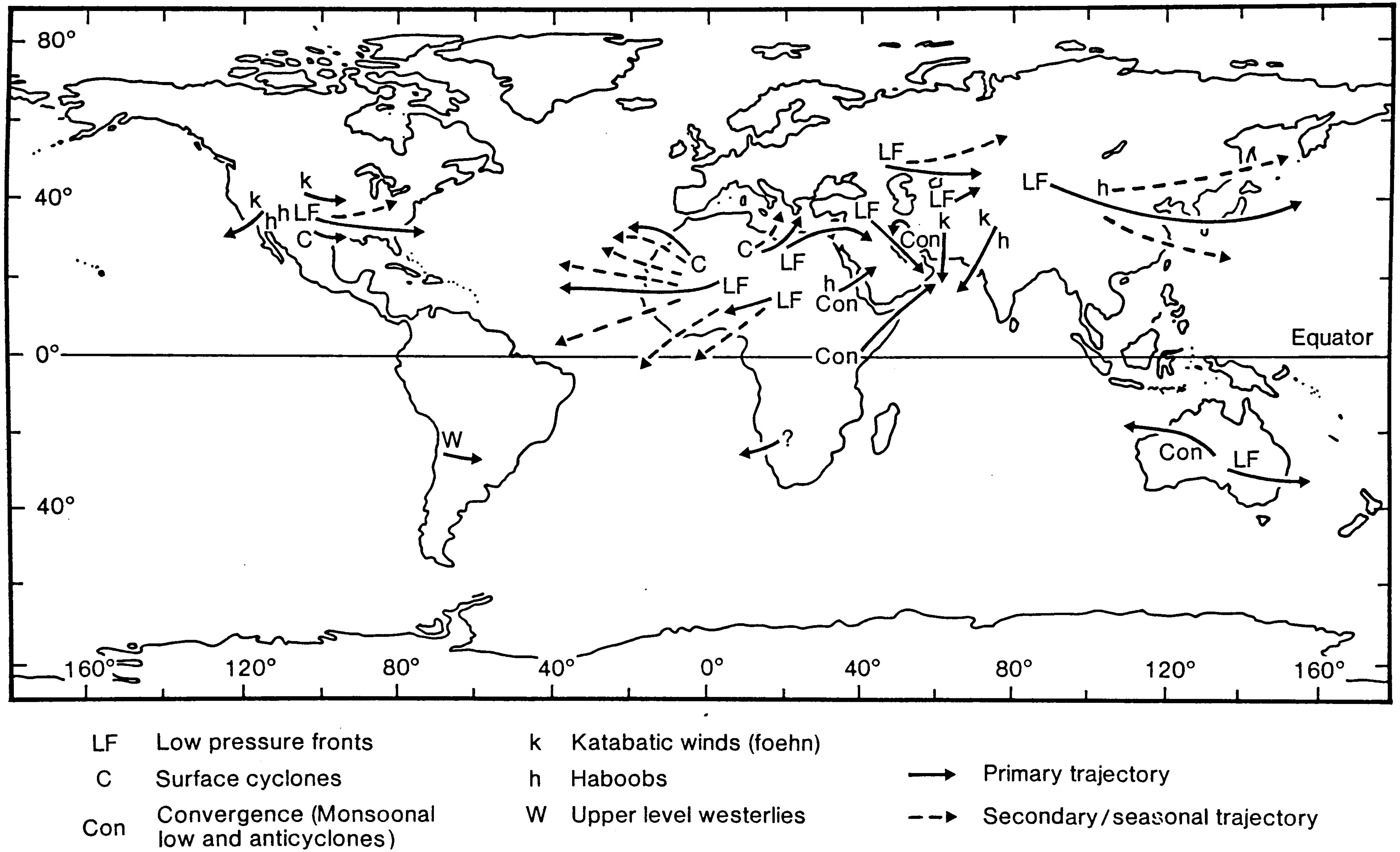



Figure 12.2 Global map of main meteorological systems associated with dust events

# TABLES

Table 1.1 Some environmental consequences and hazards to human populations caused by dust storms (modified after Goudie 1983)

| Consequence | Example of recent work |
|---|---|
| Soil erosion | Cooke **et al** (1983) |
| Soil nutrient gain | Syers **et al** (1969) |
| Salt deposition & groundwater salinization | Logan (1974) |
| Playa formation & relief inversion | Khalaf **et al** (1982) |
| Sediment input to streams | Goudie (1978) |
| Case hardening | Conca & Rossman (1982) |
| Desert varnish formation | Whalley (1983) |
| Loess formation | Liu **et al** (1981) |
| Duricrust development | Summerfield (1983) |
| Climatic change | Bryson & Baerreis (1967) |
| Ocean sedimentation | Kolla & Biscaye (1977) |
| Glacier mass budget alteration | Davitaya (1969) |
| Ventifact sculpture | Whitney & Dietrich (1973) |
| Polished rock surfaces, flutes & grooves | Lancaster (1984) |
| Transport disruption | Houseman (1961) |
| Disease transmission | Human :Leathers (1981)<br>Plants: Rotem (1965) |
| Radioactive dust transport | Becker (1986) |
| DDT transport | Riseborough **et al** (1968) |
| Air pollution | Hagen & Woodruff (1973) |
| Radio communication problems | Martin (1937) |
| Animal suffocation | Choun (1936) |
| Rainfall acidity | Stensland & Semorin (1982) |
| Acid rain neutralisation | Bohn (1985) |
| Machinery problems | Hilling (1969) |
| Defense warfare | Agence France Press (1985) |
| Closing of business | Gillette (1981) |
| Reduction of property values | Gillette (1981) |
| Reduction of solar power potential | Reinking **et al** (1975) |
| Car ignition failure | Clements **et al** (1963) |
| Drinking water contamination | Clements **et al** (1963) |
| Electrical insulator failure | Kes (1983) |

Table 1.2 Human activities that may lead to increases in dust storm occurrence

| Activity | Example of recent work |
| --- | --- |
| Ploughing | US Dust Bowl (Worster 1979) |
| Livestock trampling | Sahel (This work) |
| Vegetation removal for agriculture | Sahel (This work) |
| Woodcutting for fuel | Sahel (This work) |
| Salinization due to poor irrigation | Tricart (1954) |
| Abandoned cropland | Arizona (Hyers & Marcus 1981) |
| Lake drainage | Mexico City (This work) |
| Urban development | Denver, Colorado (Hall 1981) |
| River channel modification | California (Wilshire 1980) |
| Roads & utility corridors | California (Wilshire 1980) |
| Mining | California (Wilshire 1980) |
| Warfare | North Africa (Oliver 1945) |
| Economic factors (goverment policies) | Great Plains (McCauley **et al** 1981) |
| Offroad vehicle use | California (Wilshire 1980) |

Table 2.1 Processes that produce silt sized particles through operation on larger particles or rock outcrops

| Process | Reference |
| --- | --- |
| IN SITU | |
| Salt weathering | Goudie **et al** (1979)<br>Pye & Sperling (1983) |
| Chemical solution | Nahon & Trompette (1982) |
| Frost Weathering | Zeuner (1949)<br>Moss **et al** (1981) |
| Stresses induced by moisture | Whalley **et al** (1982a) |
| Crushing beneath overlying sand column? | Pye (1983) |
| Crack-tip stress corrosion? | Pye (1983) |
| IN TRANSPORT | |
| Aeolian abrasion | Whalley **et al** (1982b) |
| Spalling during fluvial & fluvioglacial transport | Kuenen (1959)<br>Moss **et al** (1973) |
| Glacial crushing & grinding | Collins (1979)<br>Sharp & Gomez (1986) |

Table 2.2 Examples of Long-Range Transport

| Traced from | Traced to | Distance (km) | Reference |
|---|---|---|---|
| AFRICA | | | |
| West Africa | Cape Verde Islands | 1000+ | Jaenicke & Schütz (1978) |
| West Africa | Barbados | 6500 | Delany et al (1967) |
| West Africa | Miami | 8000 | Prospero (1981) |
| West Africa | Cayenne | 6500 | Prospero et al (1981) |
| Bilma/Faya Largeau | Gulf of Guinea | 2000 | Schutz (1980) |
| Tunisia/ Libya | Central Caucasus | 5000 | Zamorskii (1964) |
| Libya/Egypt | Negev | 2000 | Yaalon & Ganor (1979) |
| Algeria | Britain | 2500 | Wheeler (1986) |
| Algeria/Tunisia | Italian Peninsula | 1000+ | Prodi & Fea (1979) |
| NE Sudan | E Mediterranean | 2500 | This work |
| Horn of Africa | Makran coast | 3000 | Wells (pers. comm. 1985) |
| Namib | S Atlantic | 4000 | Parkin et al (1972) |
| MIDDLE EAST | | | |
| Lower Mesopotamia | Sharjah, UAE | 1000 | This work |
| Arabian Peninsula | Turkmenistan | 1500 | Nalivkin (1983) |
| S-W ASIA | | | |
| Thar Desert | SE Asia | 4500 | Prospero (1981) |
| USSR | | | |
| W Kazakhstan | Gorky | 1200 | Kes (1983) |
| S Ukraine | Sweden | 1500 | Kes (1983) |
| Caucasus | E Europe | 3500 | Lisitzin (1972) |
| E ASIA | | | |
| Loess Plateau | Japan | 2500 | Ishizaka (1973) |
| Gobi Desert | Barrow, Alaska | 10,000 | Rahn et al (1981) |
| Mongolian Gobi | Hawaii | 10,000 | Shaw (1980) |
| AUSTRALIA | | | |
| Central Australia | Singapore | 3500 | Durst (1935) |
| S Australia | New Zealand | 3500 | Kidson & Gregory (1930) |
| N AMERICA | | | |
| Great Plains | Mid-Atlantic | 3500 | McCauley et al (1981) |
| Nebraska & Dakotas | Washington DC | 2500 | Hand (1934) |

Table 2.3 Examples of annual dustfall deposition rates (modified after Goudie 1983)

| Location | Reference | Rate (tonnes/km$^2$/year) |
|---|---|---|
| Northern Nigeria | McTainsh & Walker (1982) | 137-181 |
| Cairo | Kolkila (1975) | 114-410 |
| Corsica | Loÿe-Pilot et al (1986) | 14 |
| Jeddah | Behairy et al (1985) | 13-109 |
| Kuwait | Safar (1980) | 55 |
| Negev | Yaalon & Ganor (1975) | 50-200 |
| Caspian Sea | Kukal (1971) | 39.5 |
| SW USA | Table 10.2 (This work) | 1.4-125.8 |
| Mexico City | Jauregui (1973) | less than 10-<br>more than 50 |

Table 2.4 Methods used for dust monitoring and identification of source areas

| Dust characteristic | Selected Reference |
|---|---|
| Mass size distribution | Prospero **et al** (1970) |
| Mineralogy & Elemental composition | Paquet **et al** (1984) |
| Oxygen isotopes | Clayton **et al** (1972) |
| Thorium isotopes | Hirose & Sugimura (1984) |
| Lead isotopes | Turekian & Graustein (1984) |
| Rb-Sr isotopes | Biscaye **et al** (1974) |
| Radon-222 | Prospero & Carlson (1970) |
| Magnetic mineral assemblages | Oldfield **et al** (1985) |
| Aluminium concentration | Duce **et al** (1980) |
| Aerosol-crust enrichment factor | Rahn **et al** (1981) |
| SEM features of individual grains | Prodi & Fea (1979) |
| Continentally-derived lipids | Gagosian **et al** (1981) |
| Pollen | Campo & Quet (1982) |
| Foraminifera | Ehrenburg (1849) |

Table 3.1 Events of Saharan dust deposition over the British Isles this century

| Date | Area of Deposition | Reference |
|---|---|---|
| 9/3/1901 | Central England | Mill (1902) |
| 21-23/1/1902 | SW England & Wales | Mill (1902) |
| 21-22/2/1903 | S England, E Anglia & Wales | Mill & Lempfert (1904) |
| 1/7/1968 | England & Wales | Pitty (1968)<br>Stevenson (1969) |
| 6/3/1977 | N Ireland, Isle of Skye | Tullett (1978)<br>Bain & Tait (1977) |
| 15/5/1979 | N Ireland | Tullett (1980) |
| 28-29/11/1979 | Eire, NW & Central England, N Wales, S Scotland | Pringle & Bain (1981) |
| 28-29/1/1981 | N Ireland | Richardson (1981)<br>George (1981) |
| 11/2/1982 | Home Counties | Thomas (1982)<br>Moon (1982) |
| 26-27/1/1983 | Kent, Sussex, Wilts & Somerset | Thomas (1983) |
| 24/9/1983 | N Ireland, W Berks | Tullett (1984)<br>Pike (1984) |
| 22/4/1984 | S Wales, Devon | This work |
| 9/11/1984 | Soton, Oxford, NE England | Cinderey (1985)<br>Thomas (1985)<br>Wheeler (1985,86)<br>File (1986) |
| 4/4/1985 | Kent, Cambridge | Thomas (1985) |

Table 4.1 Duirnal arithmetic mean frequency per cent and increase of dust storms at stations in central and southern Mauitania for two periods: 1949-67; 1968-77

| Hour (LST) | Nouakchott Frequency % 1949-67 | Nouakchott Frequency % 1968-77 | Nouakchott Increase* | Kiffa Frequency % 1949-67 | Kiffa Frequency % 1968-77 | Kiffa Increase* | Nouadhibou Frequency % 1949-67 | Nouadhibou Frequency % 1968-77 | Nouadhibou Increase* | Rosso Frequency % 1949 67 | Rosso Frequency % 1968 77 | Rosso Increase* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 00 | 0.1 | 0.5 | 500 | 0.2 | 1.2 | 600 | 0.1 | 1.3 | 1,300 | 0.1 | 0.0 | - |
| 03 | 0.1 | 0.4 | 400 | 0.0 | 0.8 | - | 0.2 | 1.4 | 700 | 0.0 | 0.0 | 0 |
| 06 | 0.1 | 0.6 | 600 | 0.1 | 0.6 | 600 | 0.3 | 2.6 | 867 | 0.0 | 0.0 | 0 |
| 09 | 0.4 | 1.0 | 250 | 0.6 | 1.0 | 167 | 0.3 | 2.0 | 667 | 0.0 | 0.1 | - |
| 12 | 0.8 | 5.4 | 675 | 0.2 | 1.7 | 850 | 0.9 | 0.9 | 0 | 0.1 | 0.9 | 900 |
| 15 | 0.3 | 4.1 | 1,367 | 0.1 | 1.6 | 1,600 | 0.9 | 1.3 | 144 | 0.2 | 0.7 | 350 |
| 18 | 0.3 | 2.4 | 800 | 0.3 | 1.6 | 533 | 0.5 | 2.3 | 460 | 0.1 | 0.7 | 700 |
| 21 | 0.1 | 0.7 | 700 | 0.0 | 1.0 | - | 0.3 | 0.7 | 233 | 0.0 | 0.0 | 0 |
| | | Mean | 662 | | | 725 | | | 546 | | | 325 |

| Hour (LST) | Tidjika Frequency % 1949-67 | Tidjika Frequency % 1968-77 | Tidjika Increase* | Akjoujt Frequency % 1949-67 | Akjoujt Frequency % 1968-77 | Akjoujt Increase* | Atar Frequency % 1949-67 | Atar Frequency % 1968-77 | Atar Increase* | Boutilimit Frequency % 1949-67 | Boutilimit Frequency % 1968-77 | Boutilimit Increase* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 00 | 0.0 | 3.6 | - | 0.0 | 3.6 | - | 0.5 | 1.5 | 300 | 0.0 | 1.7 | - |
| 03 | 0.0 | 0.6 | - | 0.0 | 0.8 | - | 0.6 | 1.4 | 233 | 0.1 | 0.8 | 800 |
| 06 | 0.1 | 0.8 | 800 | 0.3 | 0.8 | 267 | 0.5 | 1.5 | 300 | 0.3 | 1.4 | 467 |
| 09 | 0.2 | 1.2 | 600 | 0.5 | 1.9 | 380 | 0.6 | 1.6 | 267 | 0.4 | 1.7 | 425 |
| 12 | 0.2 | 2.0 | 1,000 | 0.3 | 2.4 | 800 | 0.3 | 2.7 | 900 | 0.4 | 3.9 | 975 |
| 15 | 0.1 | 1.4 | 1,400 | 0.2 | 1.4 | 700 | 0.3 | 1.8 | 600 | 0.3 | 3.2 | 1,067 |
| 18 | 0.3 | 0.8 | 267 | 0.0 | 0.7 | - | 0.3 | 1.6 | 533 | 0.1 | 2.3 | 1,300 |
| 21 | 0.0 | 1.7 | - | 0.0 | 3.4 | - | 0.4 | 1.2 | 300 | 0.0 | 3.4 | - |
| | | Mean | 813 | | | 537 | | | 429 | | | 1,005 |

The mean increase between 1948-67 and 1968-77 is 630. Data for 1949-67 is from Hinds & Hoidale (1977); data for 1968-77 from the Service Meteorologique, Nouakchott. *1968-77 values are expressed as percentage of 1949-67 values.

Table 4.2 Arithmetic mean number of dust storm observations (totals of readings taken at 0600, 1200 and 1800 GMT) and mean rainfall per year at stations in Sudanese Sahel for two periods: 1950-67 and 1968-78 and the corresponding increase/decrease

| | | Average dust storms | | | Average rainfall ($mm\ yr^{-1}$) | | |
|---|---|---|---|---|---|---|---|
| Station | Location | 1950-67 | 1968-78 | Increase* | 1950-67 | 1968-78 | Decrease* |
| El Fasher | $13^o32'$ N $25^o21'$ E | 0.2 | 2.7 | 1350 | 317.5 | 208.5 | 66 |
| El Obeid | $13^o11'$ N $30^o14'$ E | 0.7 | 3.2 | 457 | 400.1 | 301.6 | 75 |
| Khartoum | $15^o33'$ N $32^o35'$ E | 1.8 | 7.7 | 428 | 186.4 | 134.7 | 72 |
| Aroma | $15^o50'$ N $36^o09'$ E | 3.3 | 6.5 | 197 | 245.7 | 189.4 | 77 |
| Tokar | $18^o26'$ N $37^o44'$ E | 36.6 | 47.2 | 129 | 90.8 | 55.5 | 61 |
| | | | | | | Mean | 70 |

* 1968-78 values are expressed as percentage of 1950-67 values (data from Sudan Meteorological Department Annual Meteorological Reports).

Table 5.1 Hourly meteorological observations at Seeb International Airport, Oman, 26 April 1981

| Time (LST) | Wind Dir (°) | Wind Speed (kn) | Visibility (km) | Present Weather (ww) | Temp (°C) | Pressure (mb) |
|---|---|---|---|---|---|---|
| 0650 | 040 | 10 | 20 | -- | 34.0 | 1009 |
| 0750 | 040 | 09 | 20 | -- | 34.4 | 1008 |
| 0850 | 020 | 09 | 20 | -- | 35.8 | 1007 |
| 0950 | 030 | 09 | 20 | -- | 36.4 | 1006 |
| 1050 | 040 | 10 | 15 | -- | 35.4 | 1006 |
| 1150 | 010 | 05 | 10 | 17 | 34.2 | 1007 |
| 1215 | 210 | 30 | 500m | 98 | -- | -- |
| 1235 | 030 | 18 | 10 | 95 | -- | -- |
| 1250 | 080 | 15 | 10 | 95 | 35.3 | 1006 |
| 1350 | 180 | 30 | 500m | 98 | 34.0 | 1007 |
| 1450 | 260 | 15 | 12 | 29 | 33.5 | 1010 |
| 1530 | 240 | 28 | 10 | -- | -- | -- |
| 1550 | 250 | 25 | 10 | -- | 30.5 | 1011 |
| 1650 | 120 | 18 | 10 | -- | 30.0 | 1009 |
| 1750 | 360 | 04 | 10 | -- | 32.5 | 1008 |
| 1850 | 190 | 18 | 10 | -- | 32.6 | 1007 |
| 1950 | 190 | 20 | 10 | -- | 34.0 | 1006 |

(Note : Temperature = Dry Bulb; Pressure = at mean sea level)

Table 6.1 Seasonality of dust storms in south-west Asia, frequency as percentage by month

| Station | J | F | M | A | M | J | J | A | S | O | N | D | Annual average number of dust storm days |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IRAN | | | | | | | | | | | | | |
| Abadan | 2.0 | 3.3 | 5.3 | 7.9 | 9.3 | 23.8 | 20.2 | 8.6 | 7.6 | 5.3 | 4.3 | 2.3 | 43.1 |
| Shahroud | 0.0 | 3.9 | 5.9 | 19.6 | 11.8 | 9.8 | 19.6 | 11.8 | 15.7 | 2.0 | 0.0 | 0.0 | 13.0 |
| Yazd | 3.0 | 12.5 | 12.5 | 18.5 | 14.3 | 9.5 | 13.1 | 7.1 | 4.8 | 0.6 | 0.6 | 3.6 | 24.0 |
| Jask | 9.6 | 13.9 | 14.8 | 8.7 | 11.3 | 13.9 | 4.3 | 5.2 | 0.9 | 5.2 | 7.8 | 4.3 | 27.3 |
| Zabol | 2.7 | 2.7 | 3.9 | 6.4 | 9.6 | 17.9 | 19.3 | 16.8 | 12.4 | 5.5 | 1.4 | 1.6 | 80.7 |
| AFGHANISTAN | | | | | | | | | | | | | |
| Bust | 4.7 | 9.5 | 10.4 | 13.7 | 10.4 | 8.5 | 10.4 | 14.2 | 5.7 | 4.3 | 3.3 | 4.7 | 30.1 |
| Ghazni | 0.0 | 0.0 | 2.2 | 20.0 | 13.3 | 11.1 | 13.3 | 14.8 | 8.1 | 10.3 | 5.2 | 1.5 | 19.3 |
| Mazarisharif | 0.8 | 0.8 | 4.8 | 4.8 | 4.0 | 15.9 | 15.1 | 13.5 | 7.1 | 23.0 | 8.7 | 1.6 | 18.7 |
| Faizabad | 0.0 | 0.0 | 1.4 | 7.1 | 4.3 | 14.3 | 20.0 | 22.9 | 8.6 | 17.1 | 4.3 | 0.0 | 17.5 |
| PAKISTAN | | | | | | | | | | | | | |
| Rawalpindi | 0.0 | 1.4 | 4.3 | 14.2 | 21.3 | 21.3 | 14.2 | 9.9 | 7.1 | 5.7 | 0.7 | 0.0 | 14.1 |
| Jacobabad | 1.1 | 0.0 | 16.3 | 12.0 | 18.5 | 12.0 | 21.7 | 12.0 | 4.3 | 0.0 | 0.0 | 2.2 | 9.2 |
| Panjgur | 3.4 | 17.2 | 31.0 | 3.4 | 6.9 | 17.2 | 13.8 | 3.4 | 0.0 | 3.4 | 0.0 | 0.0 | 3.6 |
| INDIA | | | | | | | | | | | | | |
| Ganganagar | 8.9 | 0.0 | 11.1 | 0.0 | 33.3 | 24.4 | 13.3 | 8.9 | 0.0 | 0.0 | 0.0 | 0.0 | 17.0 |
| New Delhi | 0.0 | 0.0 | 10.0 | 10.0 | 40.0 | 35.0 | 3.3 | 0.0 | 0.0 | 1.7 | 0.0 | 0.0 | 8.0 |
| Kanpur | 4.4 | 2.2 | 8.9 | 13.3 | 44.4 | 20.0 | 0.0 | 0.0 | 0.0 | 4.4 | 2.0 | 0.0 | 5.0 |
| Jamshedpur | 0.0 | 0.0 | 7.1 | 23.8 | 50.0 | 16.7 | 2.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 6.0 |

Data : National meteorological yearbooks - Iran (1967-73); Afghanistan (1974-80); Pakistan (1951-58); India (1931-60)

Table 6.2 Classification of dust storms in India according to intensity

| Intensity of dust storm | Wind force on Beaufort scale | Visibility |
|---|---|---|
| Light | 4 to 6 | Less than 1000m, upto 500m |
| Moderate | 6 to 8 | Less than 500m, upto 200m |
| Severe | 9 or more | Less than 200m |

Table 7.1 Seasonality of dust storms in the USSR, frequency as percentage by month (after Klimenko & Moskaleva 1979)

| Station | J | F | M | A | M | J | J | A | S | O | N | D | Annual average number of dust storm days |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nizhnie Serogozy | 0.0 | 0.6 | 5.8 | 17.3 | 7.5 | 8.7 | 15.0 | 17.3 | 19.1 | 6.9 | 1.2 | 0.6 | 17.3 |
| Zavetnoe | 0.0 | 0.0 | 0.4 | 8.2 | 10.3 | 16.7 | 19.3 | 22.3 | 15.5 | 5.2 | 2.1 | 0.0 | 23.3 |
| Dzhambeiti | 0.0 | 0.0 | 0.0 | 4.4 | 17.0 | 19.2 | 18.7 | 19.2 | 13.9 | 6.8 | 0.4 | 0.4 | 45.9 |
| Dzaltyr | 0.0 | 0.0 | 0.0 | 4.2 | 21.5 | 18.8 | 18.1 | 14.0 | 13.2 | 9.4 | 0.8 | 0.0 | 26.5 |
| Aleisk | 0.0 | 0.0 | 0.1 | 6.0 | 19.1 | 20.5 | 17.0 | 15.6 | 12.8 | 7.1 | 1.4 | 0.4 | 28.2 |
| Repetek | 6.9 | 9.1 | 11.1 | 10.4 | 10.4 | 10.6 | 13.7 | 10.4 | 4.9 | 4.3 | 3.8 | 4.4 | 65.6 |
| Bakanas | 0.2 | 0.2 | 2.7 | 11.5 | 14.7 | 16.8 | 17.3 | 14.7 | 11.3 | 7.1 | 2.7 | 0.8 | 47.7 |

Data : 25-year period, mostly 1936-60

Table 7.2 The effects of the Virgin Lands scheme on the frequency of dust storm days in the Omsk region, Western Siberia (after Sapozhnikova 1973)

| Station | Mean annual number of dust storm days 1936-50 | 1951-62 | Increase |
|---|---|---|---|
| Omsk, steppe | 7 | 16 | x2.3 |
| Isil'-Kul' | 8 | 15 | x1.9 |
| Pokrov-Irtyshsk | 4 | 22 | x5.5 |
| Poltavka | 9 | 12 | x1.3 |
| Cherlak | 6 | 19 | x3.2 |
| mean | 6.8 | 16.8 | x2.5 |

Table 7.3 Proportion of stations (in %) according to the annual average number of dust storm days in the hot zone of the USSR (after Sapozhnikova 1973)

| Region | Number of days more than 1 | 5 | 10 | 20 | 30 | 40 | 50 | 60 | 80 | 100 | Number of stations |
|---|---|---|---|---|---|---|---|---|---|---|---|
| HOT DRY REGION | | | | | | | | | | | |
| Uzbekistan | 100 | 58 | 30 | 9 | 7 | | | | | 2 | 43 |
| Turkmenistan | 96 | 96 | 84 | 52 | 36 | 12 | 8 | 8 | 4 | | 25 |
| Tadjikstan | 100 | 28 | 14 | 9 | | | | | | | 22 |
| VERY HOT DRY REGION | | | | | | | | | | | |
| Uzbekistan | 100 | 90 | 70 | 30 | 10 | | | | | | 10 |
| Turkmenistan | | 100 | 97 | 79 | 61 | 43 | 21 | 7 | | | 28 |
| Tadjikstan | | 100 | 50 | 33 | 33 | | | | | | 6 |

Table 7.4 Dust storms by wind speed in Turkmenistan (1933-60) (after Kes 1983)

| Wind speed (m/s) | Total number of storms | Percent |
| --- | --- | --- |
| 1-3 | 2 | 0.02 |
| 4-6 | 127 | 1.4 |
| 7-10 | 3921 | 42.3 |
| 11-14 | 4086 | 44.1 |
| 15-20 | 1120 | 12.1 |
| more than 20 | 14 | 0.2 |

Table 8.1 Seasonality of dust storms in China, frequency as percentage by month

| Station | J | F | M | A | M | J | J | A | S | O | N | D | Annual average number of dust storm days |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hotien | 0.9 | 1.8 | 10.3 | 18.5 | <u>20.7</u> | 18.2 | 11.9 | 9.7 | 4.6 | 1.5 | 0.9 | 0.3 | 32.9 |
| Minqin | 7.8 | 7.8 | 12.6 | <u>15.8</u> | 11.3 | 11.5 | 11.3 | 6.7 | 1.6 | 2.7 | 4.3 | 6.7 | 37.3 |
| Lanzhou | 0.0 | 12.8 | 23.1 | <u>28.2</u> | 15.4 | 15.4 | 5.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.9 |
| Yinchuan | 14.9 | 17.9 | 14.9 | <u>20.9</u> | 11.9 | 3.0 | 3.0 | 1.5 | 0.0 | 0.0 | 3.0 | 6.0 | 6.7 |
| Hohhot | 6.0 | 6.0 | 15.5 | <u>33.3</u> | 15.5 | 9.5 | 2.4 | 0.0 | 3.6 | 2.4 | 2.4 | 3.6 | 8.4 |
| Taiyuan | 6.1 | 9.1 | 15.2 | <u>36.4</u> | 15.2 | 9.1 | 3.0 | 0.0 | 3.0 | 0.0 | 0.0 | 6.1 | 3.3 |
| Zhengzhou | 12.5 | 12.5 | 18.1 | <u>20.8</u> | 11.1 | 12.5 | 2.8 | 0.0 | 1.4 | 1.4 | 1.4 | 4.2 | 7.2 |
| Beijing | 16.7 | 11.1 | 16.7 | <u>22.2</u> | 8.3 | 8.3 | 5.6 | 0.0 | 0.0 | 0.0 | 2.8 | 8.3 | 3.6 |
| Harbin | 0.0 | 4.2 | 16.7 | <u>54.2</u> | 25.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 2.4 |

Data : Meteorological Administration, Beijing (1951-80)

Table 9.1 Seasonality of dust storms in Australia, frequency as percentage by month

| Station | J | F | M | A | M | J | J | A | S | O | N | D | Annual average number of dust storm days |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alice Springs | 16.9 | 5.6 | 8.1 | 1.6 | 4.0 | 2.4 | 5.6 | 0.0 | 8.1 | 12.9 | 21.0 | 13.7 | 5.9 |
| Mildura | 6.8 | 10.8 | 14.7 | 6.8 | 2.0 | 2.0 | 3.9 | 3.9 | 6.8 | 9.8 | 14.7 | 17.6 | 4.8 |

Data : Australian Bureau of Meteorology (1962-82)

Table 9.2 Comparative annual numbers of dust storm days at pairs of stations in selected Australian cities

| Station | Annual mean number of dust storm days (1962-82) |
|---|---|
| Sydney Airport | 0.5 |
| Sydney Regional Office | 0.0 |
| Adelaide Airport | 0.5 |
| Adelaide (West Terrace) | 0.3 |
| Brisbane AMO | 0.6 |
| Brisbane Regional Office | 0.0 |

Table 9.3 Rainfall, wet dust deposition & numbers of dust events at Merbein, Victoria (modified after Hutton 1980)

| | 1954 | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 |
|---|---|---|---|---|---|---|---|
| Rainfall (mm) | 280 | 350 | 420 | 240 | 440 | 190 | 310 |
| $CaCO_3$ (kg/ha) | 24.5 | 23.8 | 16.5 | 20.5 | 24.5 | 26.8 | 41.0 |
| Dust event days | 7 | 9 | 1 | 4 | 4 | 13 | 29 |

Table 10.1 **Hierarchy of weather - duststorm systems on the Great Plains** (after Henz & Woiceshyn 1980)

| | GENRE | MECHANISM | TIME FRAME (hr) | SPACE SCALE (km) | PREDICTABILITY |
|---|---|---|---|---|---|
| 1 | Dust Devil | Micro-temperature differences | 0.1-0.5 | 0.01-0.5 | Observe only in real time |
| 2 | Haboob | Thunderstorm downdraft into dry air, gravity flow | 0.5-6.0 | 25-75 | 1-12 hrs |
| 3 | Severe mountain downslope windstorm | Complex terrain enhancement of downward transport of mid-tropcspheric momentum | 0.5-18 | 25-250 | 12-36 hrs |
| 4 | Frontal | Gravity flow, pressure gradient gradient + dynamic assist | 1-8 | 500-1000 | 24-48 hrs |
| 5 | Cyclogenic | | | | |
| a | Low level jet | Boundary layer thermal diffs. momentum transfer within shallow adiabatic PBL | 6-12 | 500-1000 | 24-48 hrs |
| b | Upper level jet | Deep adiabatic heating of topo-sphere thru dynamic subsidence | 8-24 | 500-1000 | 24-72 hrs |
| c | Surface storm circulation | Deeper-gradient winds | 8-18 | 50-150 | 12-36 hrs |
| d | Severe mountain downslope windstorm | (Mechanism No.3 above) | | | |

**Table 10.2 Dustfall deposition rates in the USA**

| LOCATION | REFERENCE | RATE (tonnes/$km^2$/year |
|---|---|---|
| San Clemente Island, California | Muhs (1983) | 24-31 |
| White Mountains, California | Marchand (1970) | 1.4-15 |
| Tempe, Arizona | Péwé et al. (1981) | 54 |
| Las Cruces, New Mexico | Gile & Grossman (1979) | 9.3-125.8 |
| Riesal, Texas | Smith et al. (1970) | 28 |
| Water Valley, Texas | Smith et al. (1970) | 26 |
| Edwards Plateau, Texas | Rabenhorst et al. (1984) | 12 |
| Central Nevada | Young & Evans (1986) | 20-30 |

Table 11.1 Dust storms by direction and wind speed at Mexico City for two visibility classes (1952-61)

VISIBILITY <1000m : Number of events

| Wind BFT | speed knots | N | NE | E | SE | S | SW | W | NW | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1-3 | | | | | | | | | 0 |
| 2 | 4-6 | | | 2 | 1 | | | | | 3 |
| 3 | 7-10 | 2 | 3 | 1 | 1 | | | | 1 | 8 |
| 4 | 11-16 | 3 | 5 | 3 | 1 | | 1 | 1 | 1 | 15 |
| 5 | 17-21 | 6 | 9 | 3 | 2 | | 3 | 2 | | 25 |
| 6 | 22-27 | 3 | 6 | 2 | 2 | | 3 | | 1 | 17 |
| 7 | 28-33 | 1 | 6 | 2 | | 1 | 1 | 2 | 1 | 14 |
| 8 | 34-40 | | 1 | | | | | | 1 | 2 |
| 9 | 41-47 | | 1 | | | | | | | 1 |
| 10 | 48-55 | | | | 1 | | | | | 1 |
| | Total | 15 | 31 | 13 | 8 | 1 | 8 | 5 | 5 | 86 |

VISIBILITY <5000m : Number of events

| Wind BFT | speed knots | N | NE | E | SE | S | SW | W | NW | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1-3 | | | | | 1 | | | | 1 |
| 2 | 4-6 | 3 | 2 | 3 | 5 | | | | 1 | 14 |
| 3 | 7-10 | 9 | 9 | 5 | 5 | 2 | | 3 | 3 | 36 |
| 4 | 11-16 | 26 | 28 | 17 | 13 | 8 | 7 | 6 | 7 | 112 |
| 5 | 17-21 | 30 | 40 | 26 | 29 | 18 | 13 | 9 | 5 | 170 |
| 6 | 22-27 | 8 | 21 | 17 | 24 | 10 | 9 | 2 | 3 | 94 |
| 7 | 28-33 | 3 | 10 | 6 | 8 | 5 | 5 | 3 | 2 | 42 |
| 8 | 34-40 | 1 | 2 | | 1 | 1 | | | 1 | 6 |
| 9 | 41-47 | | 1 | | | | | | | 1 |
| 10 | 48-55 | | | | 1 | | | | | 1 |
| | Total | 80 | 113 | 74 | 86 | 45 | 34 | 23 | 22 | 477 |

Table 11.2 Dust storms by direction and wind speed at Mexico City for two visibility classes (1975-83)

VISIBILITY <1000m : Number of events

| Wind BFT | speed knots | N | NE | E | SE | S | SW | W | NW | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1-3 | | | | | | | | | 0 |
| 2 | 4-6 | | | | | | | | | 0 |
| 3 | 7-10 | | | | | | | | | 0 |
| 4 | 11-16 | | | 1 | | | | | | 1 |
| 5 | 17-21 | 1 | | | | | | | | 1 |
| 6 | 22-27 | 3 | | | | | | | | 3 |
| 7 | 28-33 | 2 | | | | | | | | 2 |
| 8 | 34-40 | | | | | | | | | 0 |
| 9 | 41-47 | | | | | | | | | 0 |
| 10 | 48-55 | | | | | | | | | 0 |
| | Total | 6 | | 1 | | | | | | 7 |

VISIBILITY <5000m : Number of events

| Wind BFT | speed knots | N | NE | E | SE | S | SW | W | NW | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1-3 | | | | | | | | | 0 |
| 2 | 4-6 | | | | | | | | | 0 |
| 3 | 7-10 | 2 | | 2 | 3 | 1 | 1 | 1 | 1 | 11 |
| 4 | 11-16 | 12 | | 9 | 8 | 4 | 1 | | 1 | 35 |
| 5 | 17-21 | 24 | | 12 | 10 | 8 | | | 1 | 55 |
| 6 | 22-27 | 27 | | 2 | 2 | 3 | 1 | 1 | 2 | 38 |
| 7 | 28-33 | 6 | | 1 | | | | | | 7 |
| 8 | 34-40 | 2 | | | | | | | | 2 |
| 9 | 41-47 | | | | | | | | | 0 |
| 10 | 48-55 | | | | | | | | | 0 |
| | Total | 73 | | 26 | 23 | 16 | 3 | 2 | 5 | 148 |

Table 11.3 Duration of dust events at Mexico City for two periods

| Duration (hours) | Total number of events for two periods | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 1 | 2 | 1 | 2 |
| | <1000m | <1000m | <1600m | <1600m | <5000m | <5000m |
| <1 | 79(96) | 8(100) | 155(91) | 20(91) | 383(82) | 107(69) |
| 1-2 | 3(4) | | 10(6) | 1(4.5) | 55(12) | 29(19) |
| 2-3 | | | 4(2) | 1(4.5) | 19(4) | 11(7) |
| 3-4 | | | 1(1) | | 7(1) | 4(3) |
| 4-5 | | | | | 2(0.5) | 1(1) |
| 5-6 | | | | | | |
| 6-7 | | | | | 1(0.5) | |
| 7-8 | | | | | | 1(1) |
| Total | 82(100) | 8(100) | 170(100) | 22(100) | 467(100) | 155(100) |

Note: Numbers in parenthesis = percentages
1 = Period 1952-61
2 = Period 1975-83

Table 11.4 Dust storms by direction and wind speed at Torreon for two visibility classes (1962-69)

VISIBILITY <1000m : Number of dust events

| Wind speed BFT | knots | N | NE | E | SE | S | SW | W | NW | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Calm | | | | | | | | | | 4 |
| 1 | 1-3 | | | | | | | | | 0 |
| 2 | 4-6 | | 1 | 1 | | | | | | 2 |
| 3 | 7-10 | | 2 | 1 | | | | | | 3 |
| 4 | 11-16 | 1 | 3 | 7 | 2 | 1 | 1 | | | 15 |
| 5 | 17-21 | 1 | 7 | 4 | 5 | 4 | 2 | | 2 | 25 |
| 6 | 22-27 | 2 | 4 | 3 | 2 | 1 | 5 | | 2 | 19 |
| 7 | 28-33 | 1 | | 2 | 1 | 3 | 4 | 2 | 6 | 19 |
| 8 | 34-40 | | 1 | 1 | | 3 | 2 | | 1 | 8 |
| 9 | 41-47 | | | | | | | | | 0 |
| 10 | 48-55 | | | | | | | | | 0 |
| 11 | 56-63 | | | | | | 1 | | | 1 |
| | Total | 5 | 18 | 19 | 10 | 12 | 16 | 2 | 11 | 96 |

VISIBILITY <5000m : Number of dust events

| Wind speed BFT | knots | N | NE | E | SE | S | SW | W | NW | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Calm | | | | | | | | | | 11 |
| 1 | 1-3 | | | | | | | | | 0 |
| 2 | 4-6 | 1 | 4 | 2 | | | | 3 | 1 | 11 |
| 3 | 7-10 | 3 | 18 | 8 | 1 | | | 1 | 3 | 34 |
| 4 | 11-16 | 2 | 29 | 23 | 10 | 2 | 3 | | 3 | 72 |
| 5 | 17-21 | 5 | 16 | 13 | 8 | 6 | 5 | 2 | 5 | 60 |
| 6 | 22-27 | 1 | 7 | 7 | 1 | 6 | 9 | 2 | 10 | 43 |
| 7 | 28-33 | 1 | 1 | 1 | 1 | 3 | 4 | 2 | 6 | 19 |
| 8 | 34-40 | | 1 | 1 | | 3 | 2 | | 1 | 8 |
| 9 | 41-47 | | | | | | | | | 0 |
| 10 | 48-55 | | | | | | | | | 0 |
| 11 | 56-63 | | | | | | 1 | | | 1 |
| | Total | 13 | 76 | 55 | 21 | 20 | 24 | 10 | 29 | 259 |

Table 12.1 Major global dust source areas with key station dust storm day frequency per year (D)

| Source area | Ref to fig 12.1 | Station | D | Data source | Data period | Number of years |
|---|---|---|---|---|---|---|
| AFRICA | | | | | | |
| Bodélé Depression | A | Maiduguri (Nigeria) | 22.5 | Nigerian Met Dept | 1955-79 | 25 |
| S Mauritania/N Mali/C Algeria | B | Nouakchott (Mauritania) | 27.4 | Service Mét Mauritania | 1960-84 | 25 |
| Libya/E Algeria | C | Sirte (Libya) | 17.8 | Libyan Met Dept | 1956-77 | 22 |
| MIDDLE EAST | | | | | | |
| N Saudi/Jordan/Syria | D | Abou Kamal (Syria) | 14.9 | Syrian Met Dept | 1959-79 | 21 |
| Lower Mesopotamia | E | Kuwait Int Airport | 27.0 | Safar (1985) | 1962-84 | 23 |
| S-W ASIA | | | | | | |
| Makran coast | F | Jask (Iran) | 27.3 | Iranian Met Org | 1970-73 | 4 |
| Seistan Basin | G | Zabol (Iran) | 80.7 | Iranian Met Org | 1967-73 | 7 |
| Afghan Turkestan plains | H | Chardarrah (Afghanistan) | 46.7 | Autorité Mét Afghan | 1974-80 | 7 |
| Upper Indus plains | I | Jhelum (Pakistan) | 18.9 | Pakistan Met Dept | 1951-58 | 8 |
| Thar Desert | J | Fort Abbas (Pakistan) | 17.8 | Pakistan Met Dept | 1951-59 | 8 |
| USSR | | | | | | |
| Turkmenistan | K | Repetek | 65.5 | Klimenko & Moskaleva (1979) | 1936-60 | 25 |
| Kara Kum | L | Nebit Dag | 60.0 | " | " | " |
| Rostov | M | Zavetnoe | 23.3 | " | " | " |
| Altay | N | Rubtsovsk | 25.1 | " | " | " |
| Alma Alta | O | Bakanas | 47.7 | " | " | " |
| Kazakhstan | P | Dzhambeiti | 45.9 | " | " | " |
| CHINA | | | | | | |
| Taklimakan Desert | Q | Hotien | 32.9 | Chinese Met Admin | 1953-80 | 28 |
| Gansu Corridor | R | Minqin | 37.3 | Chinese Met Admin | 1953-80 | 28 |

Table 12.2 Geomorphological units from which substantial deflation occurs

| Geomorphological unit | Regional example |
| --- | --- |
| Floodplain | Lower Mesopotamia, Iraq |
| Alluvial fan | Tibesti & Hoggar Mtns, N Africa |
| Wadi | Negev |
| Glacial outwash plain | Slims River Valley, Yukon |
| Salt pan | Puna de Atacama, Argentina |
| Other desert depressions | Seistan Basin, Iran |
| Former lake bed | Lake Texcoco, Mexico City |
| Active dunes/ergs | Erg In Koussamene, Mali |
| Devegetated fossil dunes | Erg du Trarza, Mauritania |
| Loess | Loess Plateau, N China |

Table 12.3 Classification of dust-generating weather systems

| | |
|---|---|
| 1. Dust devil | |
| 2. Thunderstorm downdraft | a) Single cell<br>b) Severe thunderstorm |
| 3. Mountain downslope wind (katabatic/foehn-type) | |
| 4. Valley channelling (Venturi effect) | |
| 5. Tropical cyclone | |
| 6. Frontal | a) Pre frontal<br>b) Post frontal |
| 7. Cyclogenic | a) Low level jet<br>b) Upper level jet<br>c) Surface storm circulation (gyre)<br>d) Mountain downslope |
| 8. Pressure gradient (convergence zone) | a) Stationary systems<br>b) Travelling systems |
| 9. Upper Westerlies | |

Table 12.4 Dust-bearing winds of the world

DUST-BEARING WINDS: NORTH AND WEST AFRICA I

| NAME | AREA AFFECTED | SEASON | DIRECTION (from) | METEOROLOGICAL CONDITIONS | REFERENCE |
|---|---|---|---|---|---|
| HARMATTAN (Fantee: 'aharaman' - to blow and 'ta' grease locals cover their skin with) | Bilma/Faya Largeau area + much of W Africa south of 20° N | October-April | ENE | Pressure surge after cold air outbreaks from mid-latitudes | Kalu (1979) |
| HABOOB (Arabic: 'habb' - to blow) | Sudan (but has become almost generic in its use) | May-July | | Single cell thunderstorm downdraft | Sutton (1925) |
| KHAMSIN (Fifty) | Egypt | Spring | | Pre-frontal | see Middle East |
| CHILI (CHEHILI - a desert sirocco) | S Tunisia S.Algeria | Spring | SW | Pre-frontal | Naval Intelligence Division (1943) |
| SHEKHELI | Algeria | Spring | | | Borushko (1972) |
| CHERGUI (East wind) | Moroccan Sahara West Morocco | Summer | NE | | Naval Intelligence Division (1941) |

Table 12.4

DUST-BEARING WINDS: NORTH AND WEST AFRICA II

| NAME | AREA AFFECTED | SEASON | DIRECTION (from) | METEOROLOGICAL CONDITIONS | REFERENCE |
|---|---|---|---|---|---|
| IRIFI | Western Sahara (Spanish Sahara) | | SE | Frontal | Morales (1946) |
| DSCHANI | South Sahara | | | | Goudie (1978) |
| GHIBLI (free trans: 'wind from Mecca') | Tripolitania | | | Pre-frontal | Sivall (1957) |
| SAHEL | Morocco | | SW | Frontal | Mainguet (1980) |
| LESTE | Madeira | | | | Goudie (1978) |
| LEVANTO | Canary Islands | | | | Nalivkin (1983) |

Table 12.4

DUST-BEARING WINDS: NORTH & WEST AFRICA III

| NAME | AREA AFFECTED | SEASON | DIRECTION (from) | METEOROLOGICAL CONDITIONS | REFERENCE |
|---|---|---|---|---|---|
| GUEBLI (South wind) | Tunisia and Algeria (Northern regions) | All year but most prevalent May-October | S | Pre-frontal and katabatic effects from interior uplands to coastal plains | Naval Intelligence Division (1943) |
| BRUME SÈCHE (French: dry haze) | West Africa | October-April | ENE | Harmattan haze in light winds | |

Table 12.4

DUST - BEARING WINDS: EAST & SOUTHERN AFRICA

| NAME | AREA AFFECTED | SEASON | DIRECTION (from) | METEOROLOGICAL CONDITIONS | REFERENCE |
|---|---|---|---|---|---|
| KHARIF | Somalia/Horn of Africa | June-September | SW | | Brooks (1920) |
| KHAMSIN | Horn of Africa | June-September | NW | | Griffiths (1972) |
| GOBAR | Ethiopia | | | | Goudie (1978) |
| BERG WIND | SW African coast | All seasons, esp. May-August | E-NE | Katabatic? | Höflich (1984) |

Table 12.4

DUST - BEARING WINDS: MIDDLE EAST I

| NAME | AREA AFFECTED | SEASON | DIRECTION (from) | METEOROLOGICAL CONDITIONS | REFERENCE |
|---|---|---|---|---|---|
| SHAMAL ('North') | Mesopotamia and Arabian Gulf | Regularly: Feb-Oct Peak: June & July | NW | Pressure gradient | Membery (1983) |
| SAD-OU-BIST BAD ('Wind of 120 days') | SE Iran/W Afghanistan esp. Seistan | May-September | N-NW | Pressure gradient and funnelling effects | Grant (1983) |
| BELAT | SE coast Arabia esp. between Ras Sahar and Masira Island | mid December-mid March | N-NW | Frontal? | Grant (pers. comm. 1986) |
| SIMOOM ('Poison wind') | Kuwait | Summer | NW | Local name for Shamal | Bull (1956) |
| KHAMSIN ('Fifty') * | Egypt. As generic type over much of area under local names (see below) | Spring and Winter | varies predom. S | Frontal | |
| SHARAV | Israel | April-June | SW S or SE ) | | Winstanley (1972) |
| SHLOUR | Syria and Lebanon | Spring and Winter | S-SW ) | Khamsin-type | |
| SHARGI | Iraq | Spring | SE ) | | |

*Variously taken to refer to average duration of wind (50 hr), its annual frequency (50 times) and its season of maximum onset (the 50 days either side of spring solstice). The third explanation seems closest to the truth. (Fisher 1978)

Table 12.4

DUST - BEARING WINDS: MIDDLE EAST II

| NAME | AREA AFFECTED | SEASON | DIRECTION (from) | METEOROLOGICAL CONDITIONS | REFERENCE |
|---|---|---|---|---|---|
| TOZE | Kuwait | | | Local name for any sand or dust storm | Khalaf et al. (1985) |
| BADÉ ALVAR | Baluchistan | | | Local name for SIMOOM | Djavadi (1965) |
| SCIROCCO | Arabia<br>Palestine and<br>Mesopotamia | | | Frontal | Sivall (1957) |
| SCHAITAN | Baluchistan | | | | Goudie (1978) |

Table 12.4

DUST-BEARING WINDS: AFGHANISTAN AND INDIA

| NAME | AREA AFFECTED | SEASON | DIRECTION (from) | METEOROLOGICAL CONDITIONS | REFERENCE |
|---|---|---|---|---|---|
| AFGHAN WIND (or AFGANETS) | Turkestan Plains - Amu Darya and Termez | June-October | SW-W | Cold air outbreak behind frontal low | Nalivkin (1983) |
| BOROW WIND | Nangarhar Valley, SE Afghanistan | June-August | SW | Foehn-tyne | Middleton (1986b) |
| PARWAN WIND | From Salang Mtns into basins of Parwan, Kapisa and Kabul | June-August | N | Pressure gradient | Middleton (1986b) |
| LOO | Upper Indus plain and NW India | Summer (April-June) | W | Haze in light winds from pressure gradient dust-raising | Joseph (Pers. comm. 1986) |
| ANDHI (Sanskrit: 'Andha' - blind man) | NW India | April-June | | Thunderstorm (usually severe) downdraft | Joseph et al. (1980) |
| NOR'WESTER | Bengal | April-June | | Thunderstorm downdraft | Singh (1971) |
| KAL-BAISAKHI ('Doom of the Baisakh month') | Bengal | April-June | | Thunderstorm downdraft | Mull et al. (1963) |
| MUNCHIN | Ganges Valley | ?April-June | | | Borushko (1972) |

Table 12.4

DUST - BEARING WINDS: EUROPE (EX. USSR)

| NAME | AREA AFFECTED | SEASON | DIRECTION (from) | METEOROLOGICAL CONDITIONS | REFERENCE |
|---|---|---|---|---|---|
| CALINA | Spain | | | | Goudie (1978) |
| KOSSAVA | Hungary | | | | Goudie (1978) |
| SCIROCCO | Southern Europe | Spring | S | Frontal | Goudie (1978) |
| LEVECHE | Spanish Mediterranean coast Malaga-Alicante | Spring | SE to SW | Scirocco type - material from N Africa | Tout & Kemp (1985) |
| BLOWS | Fens, UK | | | Frontal | Spence (1955) |
| MISTUR | Central region, Iceland | Summer | | Localised off-glacier katabatic | Vivian (pers.comm. 1986) |
| LESTE | Madeira | | | Frontal | Bull (1956) |

Table 12.4

DUST-BEARING WINDS: USSR

| NAME | AREA AFFECTED | SEASON | DIRECTION (from) | METEOROLOGICAL CONDITIONS | REFERENCE |
|---|---|---|---|---|---|
| AFGANETS (or AFGHAN wind) | Tadjikstan | June-October | SW / W | Cold air outbreak behind frontal low | Iarovitskii (1932) |
| GARMSIL (Russian: 'hot wind' or 'hot storm') | From mountains to S Turkmenistan | | S | Foen-type | Astapovich (1955) |
| KARA BURAN (Russian - 'dark' or 'bad storm') | Common on Amu Darya and Termez - local name for AFGHAN WIND (op.cit) | Spring | E | Pressure gradient | Nalivkin (1983) |
| SUKHOVEY (Russian - 'Sukho' - dry) | All dry parts of USSR | Most frequent in Summer | | Often dust-bearing, though high temperatures and low humidities stressed rather than dustiness | Lydolph (1977) |
| CHERNYE BURAN (Russian - 'Black storm') | Southern USSR - Ukraine Caucasus, Don, etc. | | | | Kravchenko (1961) |
| IBE | Jungar Gate between Yebinor Lake and Balkhash-Alakul depression | Summer = dust raising (Winter = blizzards) | | Katabatic and funnelling | Nalivkin (1983) |
| NORD (KHAZRI) | Caspian coast | | N | | Nalivkin (1983) |
| BALKHASH BORA | Crest of Chengiz Mtns. to shores of Lake Balkhash | Spring and Summer = dust-raising (Winter = blizzards) | NE | Katabatic | Nalivkin (1983) |

Table 12.4

DUST - BEARING WINDS: CHINA AND JAPAN

| NAME | AREA AFFECTED | SEASON | DIRECTION (from) | METEOROLOGICAL CONDITIONS | REFERENCE |
|---|---|---|---|---|---|
| FUHJIN | Kanto Plains, Japan | Late January, February and early March | | Frontal | Fortner & Ihara (1964) |
| KOSA (strictly a dust fall) | Japan - from E Asian deserts | | W | | Hirose _et al._ (1983) |
| KYZYL BURAN ('Red storm') | Inner Mongolia and Xianjiang, China | | | Frontal | Tregear (1980) |
| YAMAN ('Evil storm') | Inner Mongolia and Xianjiang, China | | | Frontal | Tregear (1980) |
| KARA BURAN ('Black storm') | Inner Mongolia and Xianjiang, China | | | Frontal | Tregear (1980) |
| HYI-FYN ('Black wind') | China | | | Frontal | Nalivkin (1983) |
| HUAN-FYN ('Yellow wind') | China | | | Frontal | Nalivkin (1983) |

Table 12.4

DUST - BEARING WINDS: AUSTRALIA

| NAME | AREA AFFECTED | SEASON | DIRECTION (from) | METEOROLOGICAL CONDITIONS | REFERENCE |
|---|---|---|---|---|---|
| BRICKFIELDER (originally because S'ly busters blow across Sydney brick fields raising dust | Southern interior, especially Victoria | Spring and Summer | N | Pressure gradient winds in advance of eastward moving anticylcone across Southern Australia | Gentilli (1971) |
| COBAR SHOWER | New South Wales | | | | Gentilli (1971) |
| DARLING SHOWER | New South Wales | | | | Gentilli (1971) |

Table 12.4

DUST-BEARING WINDS: UNITED STATES OF AMERICA

| NAME | AREA AFFECTED | SEASON | DIRECTION (from) | METEOROLOGICAL CONDITIONS | REFERENCE |
|---|---|---|---|---|---|
| SANTA ANA (SANTANA) | Southern California | | N/NE | Katabatic | Sergius *et al.* (1962) |
| CHINOOK | Rockies - eastward | | | Foehn-type | |
| WASATCH | From Wasatch ridge, Utah | | | | Williams (1952) |
| PALOUSER | Idaho, Montana | | | | Goudie (1978) |
| KEELER FOG | Keeler, NW shore Owens dry lake | Winter | | | Fryxell (1980) |

Table 12.4

DUST - BEARING WINDS: LATIN AMERICA

| NAME | AREA AFFECTED | SEASON | DIRECTION (from) | METEOROLOGICAL CONDITIONS | REFERENCE |
|---|---|---|---|---|---|
| TOLVANERA | Mexico | January - May | Dom. NE | Thunderstorm downdraft in Mexico City | Jauregui (1973) |
| PAMPERO SUCIO | Argentine coast | | Usually SE | | Alaimo (pers.comm. 1984) |
| VOLCAN (Spanish='volcano') | Pampas of Argentina | | Usually N | | Prego (1961) |
| ZONDA | Argentina - Andean foothills | More freq. in winter | W | Foehn-type/katabatic | Alaimo (pers. comm. 1984) |
| CHUBASCO | Pacific coast of Mexico and California | | | | Idso (1976b) |
| PARACAS | Peruvian coast S. of Pisco ($14^{o}S$) for 200 km | | Sly | Katabatic | Lettau & Costa (1978) |

# PLATES

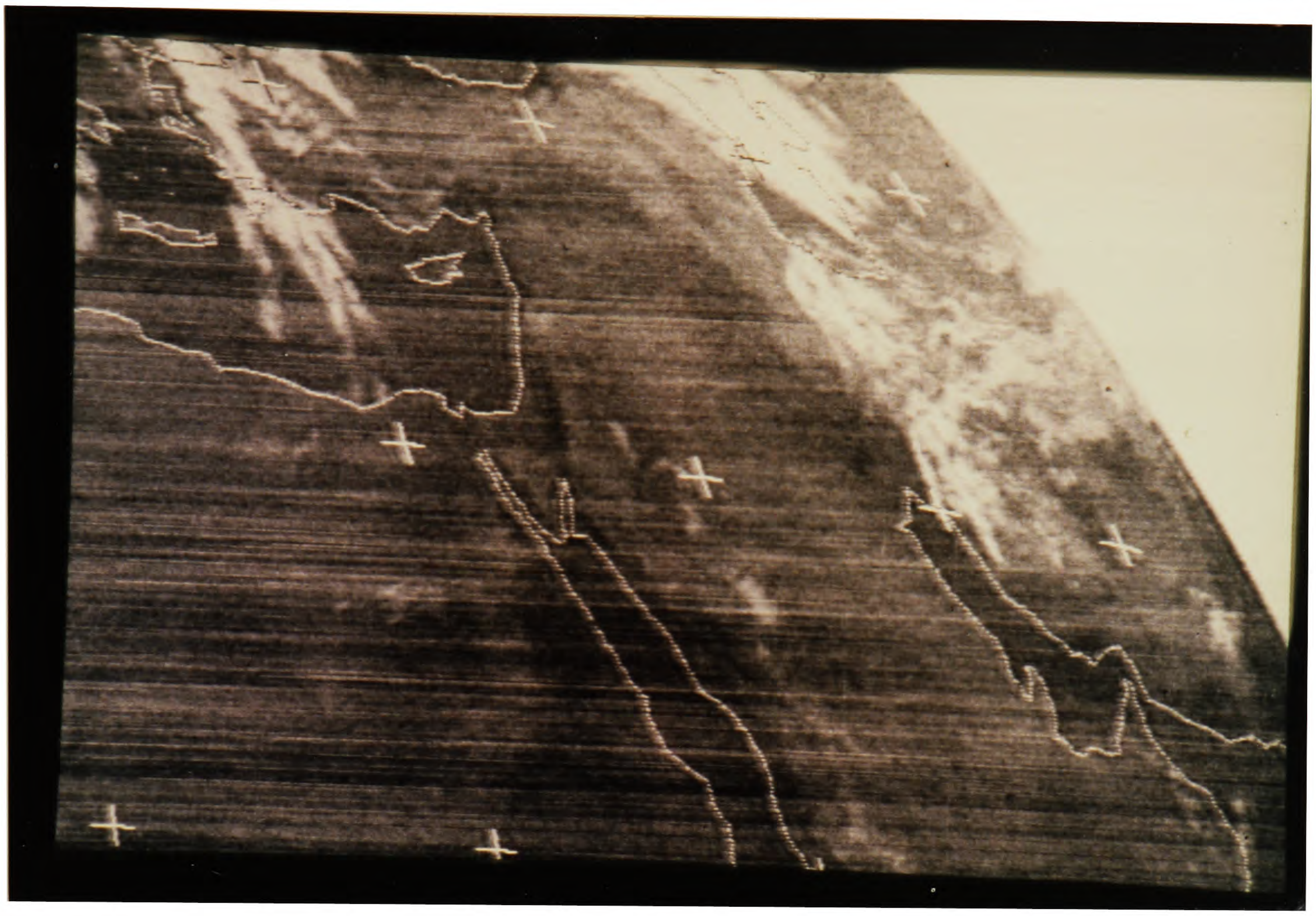


Plate 2.1 Meteosat-2 infrared image of the eastern Mediterranean area (0600 GMT, 17 April 1985)

Plate 2.2 Space Shuttle photograph of the eastern Mediterranean area (06:16:04 GMT, 17 April 1985)

Plate 2.3 NOAA-9 AVHRR image showing dust plumes from the northern coast of the Western Sahara over the Canary Islands. Note also the dust haze over the Mauritanian coast (14:58:58 GMT, 16 April 1985)

Plate 2.4 NOAA-9 AVHRR image of dust layer from plate 2.3 travelling northeastwards over the Atlantic (14:46:16 GMT, 17 April 1985)

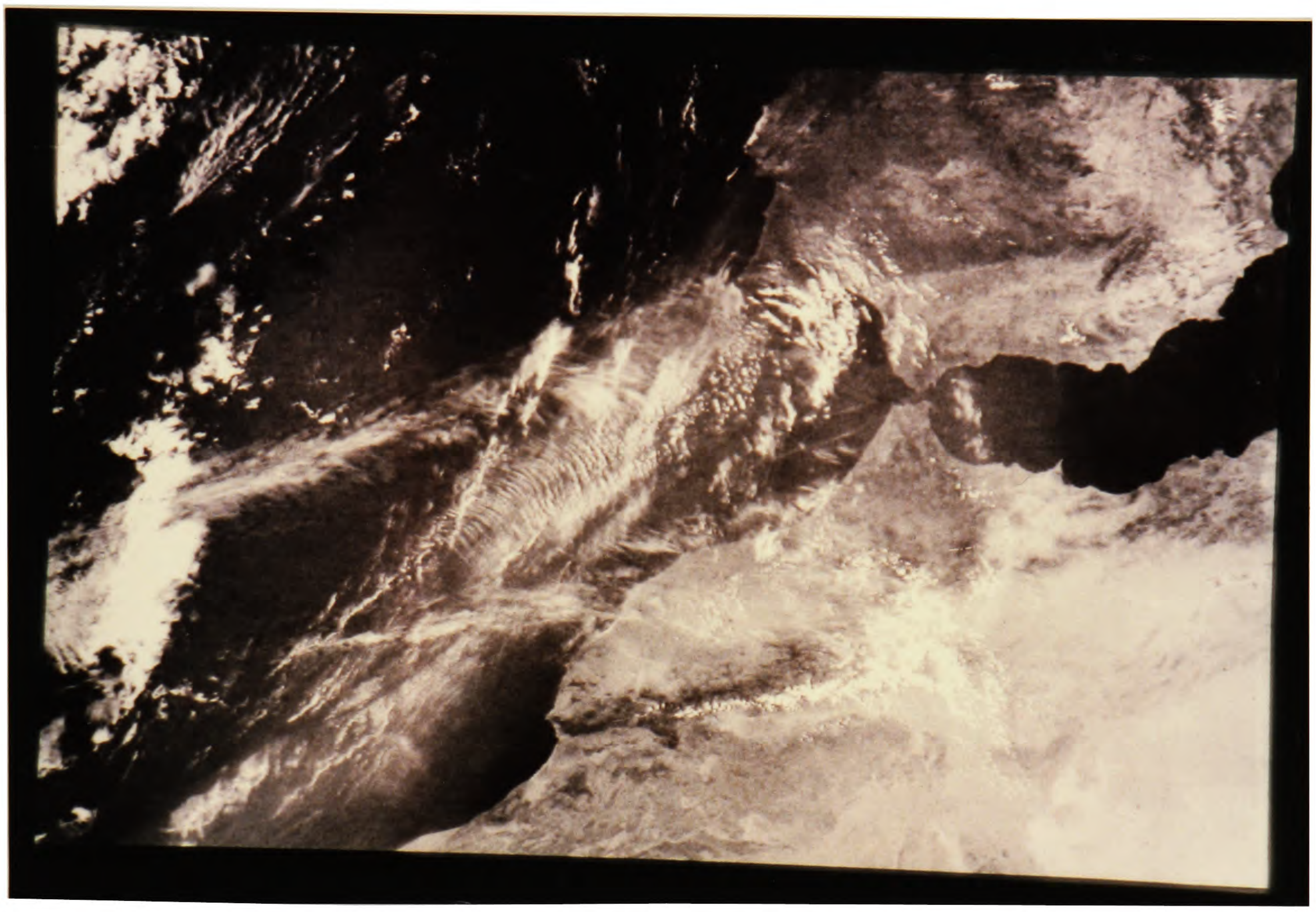


Plate 2.5 NOAA-9 AVHRR image of dust layer from plates 2.3 & 2.4
reaching south-west Spain & Portugal
(14:36:12 GMT, 18 April 1985)

Plate 2.6 Space Shuttle photograph of a dust plume blowing northwards from the Red Sea coast of north-east Sudan (15:22 GMT, 5 October 1984)

Plate 2.7 Space Shuttle photograph of dust haze from plume shown in plate 2.6 over Crete & the Cyclades Islands (12:11 GMT, 6 October 1984)

Plate 3.1 Space Shuttle photograph of a severe thunderstorm downdraft dust storm advancing towards the coast of Mauritania (February 1982)

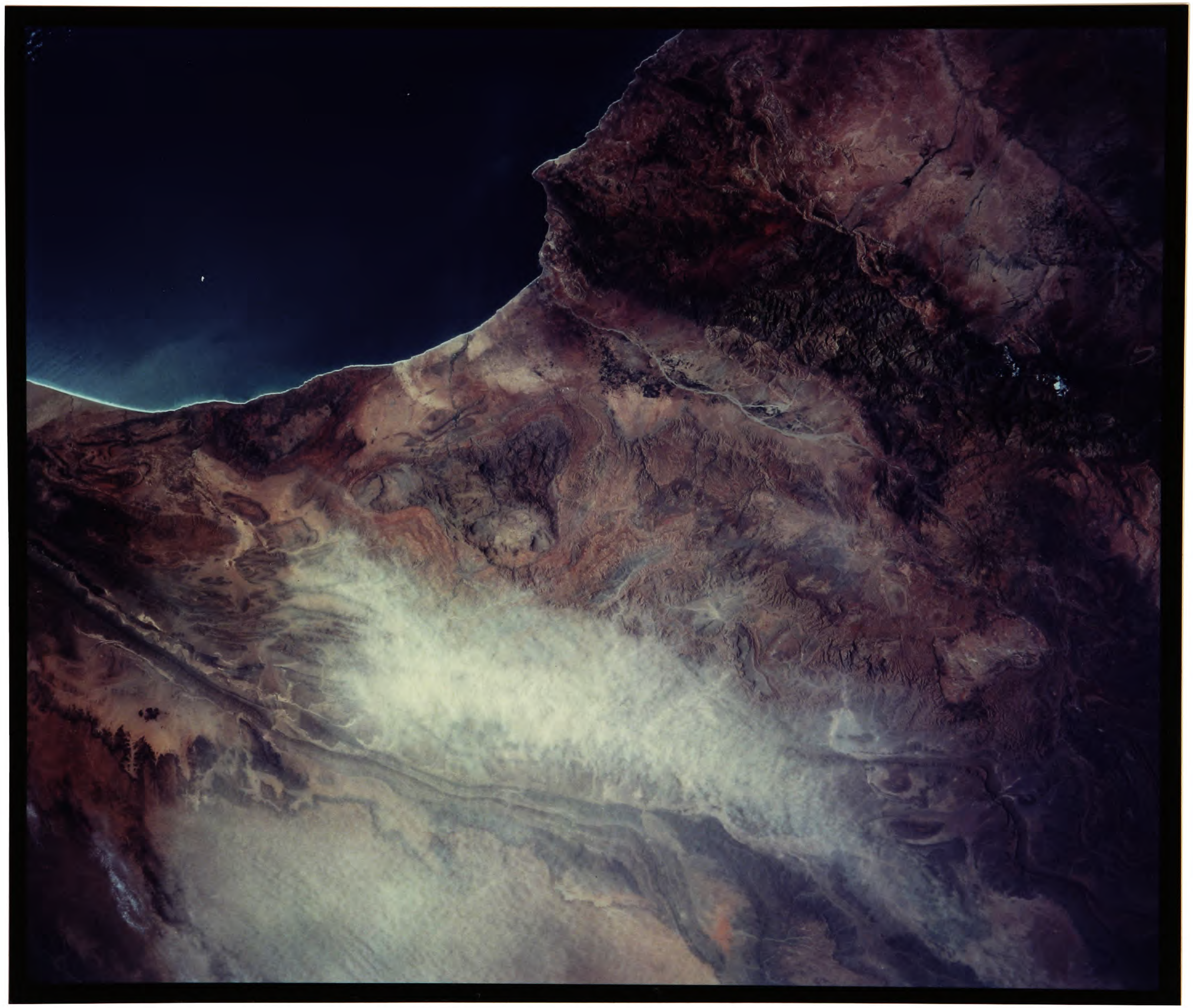
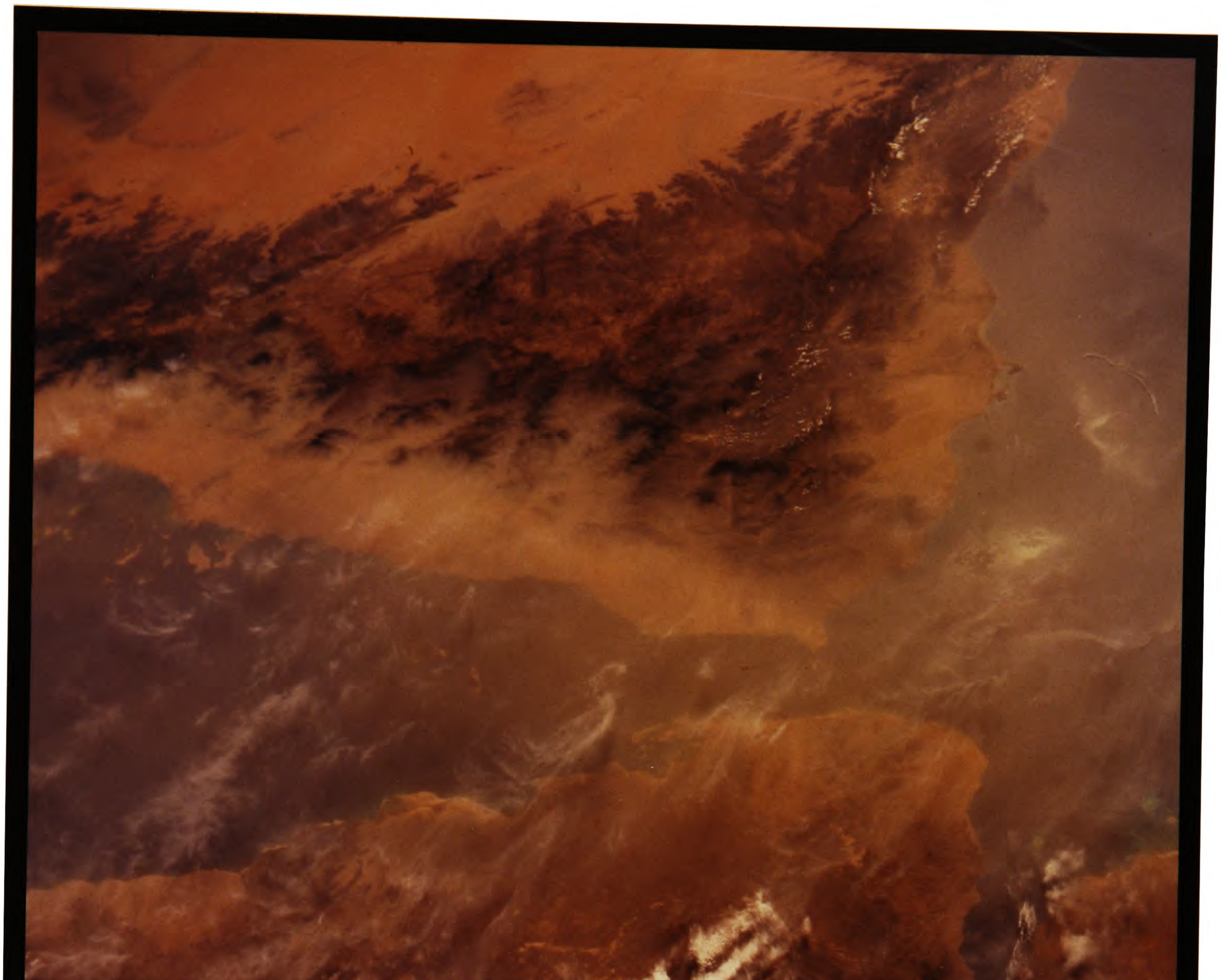


Plate 3.2 Space Shuttle photograph of a dust event on the floodplain of the Dra River, southern Morocco (15:22 GMT, 5 October 1984)

Plate 3.3 A typical Haboob over Khartoum, Sudan (from Freeman 1952)



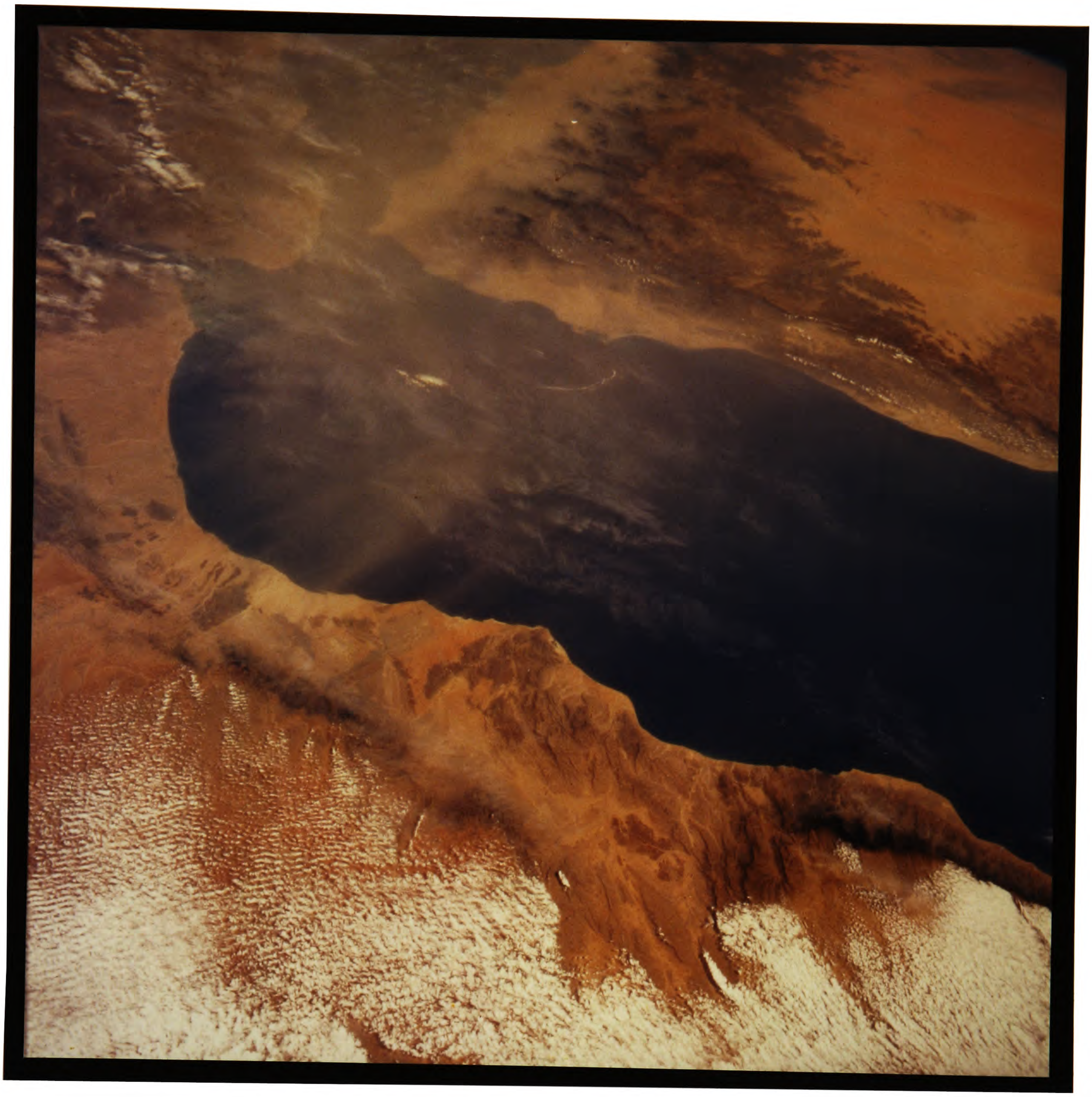


Plate 3.5 Space Shuttle photograph showing dust events over southern Ethiopia, Djibouti & the Somali coast & transport over the Gulf of Aden & the Arabian Peninsula (June 1985)

Plate 3.6 Space Shuttle photograph showing dust transported from areas shown in plates 3.4 & 3.5 over the Arabian Peninsula & the Gulf of Aden (June 1985)

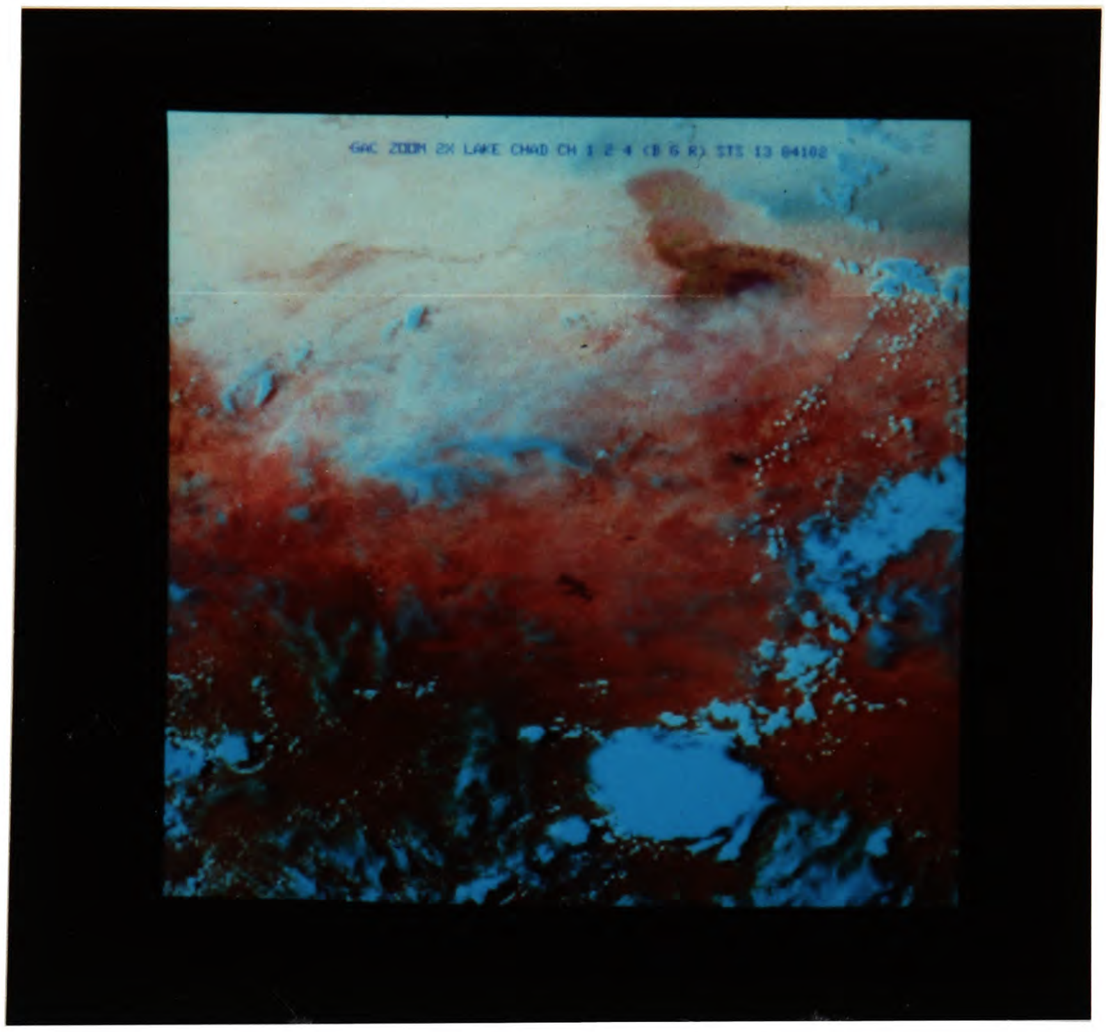



Plate 4.1 NOAA-7 AVHRR image of widespread dust-raising over the southern portion of Lake Chad (11 April 1984)

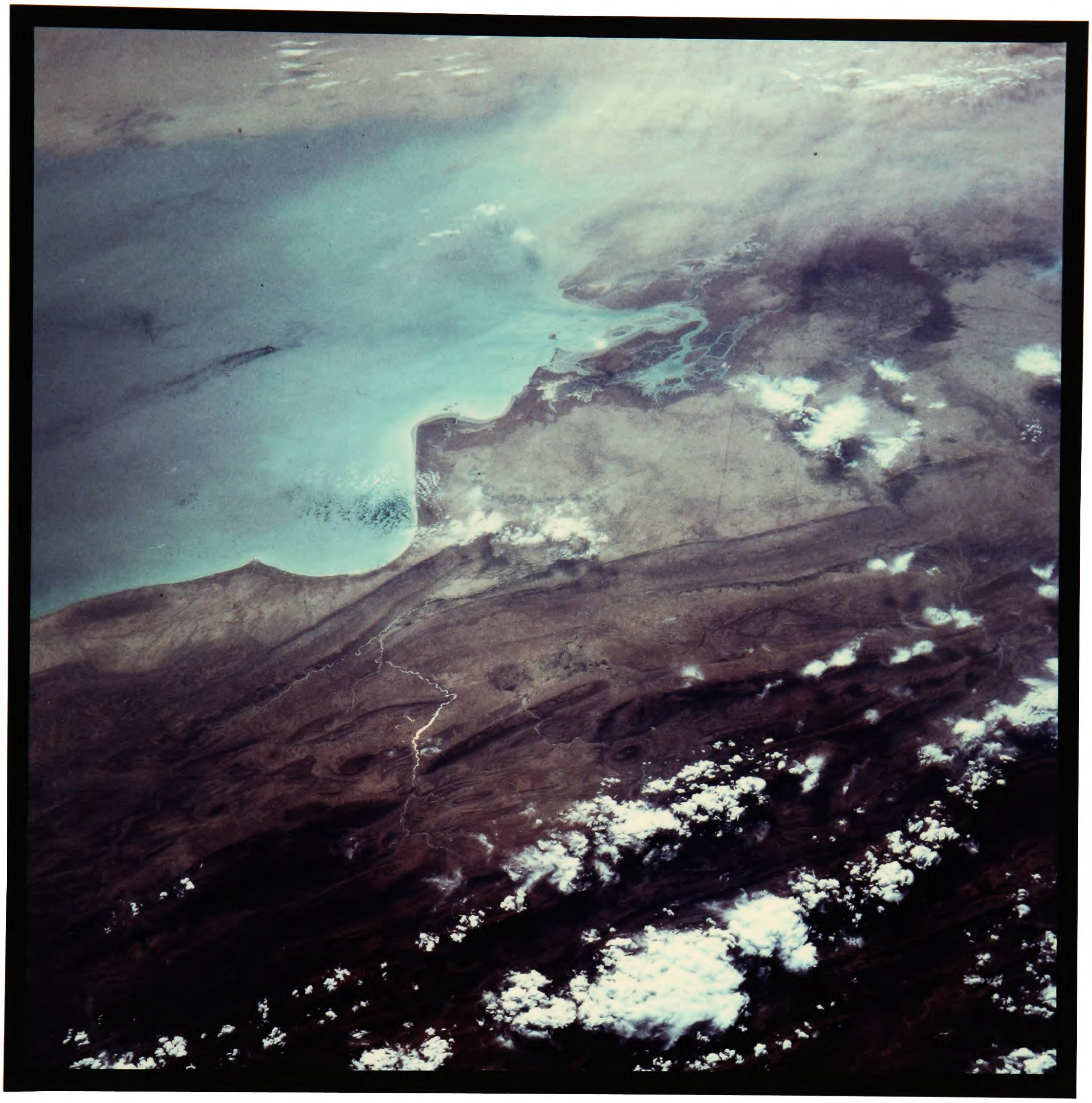


Plate 5.1 Space Shuttle photograph of **Shamal** dust blowing from the southern coast of Iraq & Kuwait over the northern Arabian Gulf (10:33:44 GMT, 6 October 1984)

[redacted]

Plate 8.1 Watercolour painting of a dust storm in the Tarim Basin (from Hedin 1903)

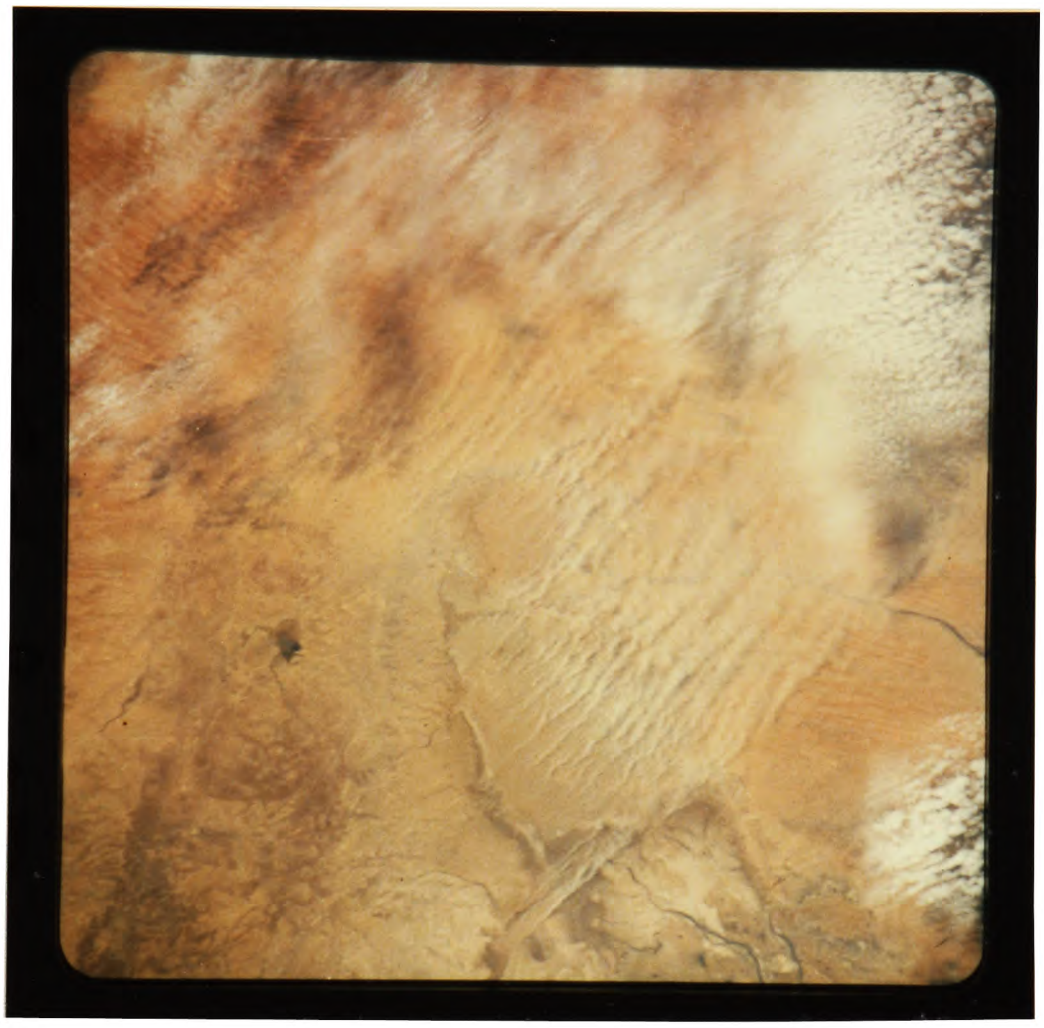


Plate 9.1 Space Shuttle photograph of point source dust-raising on alluvial plains in the Simpson Desert (April 1983)

[redacted]

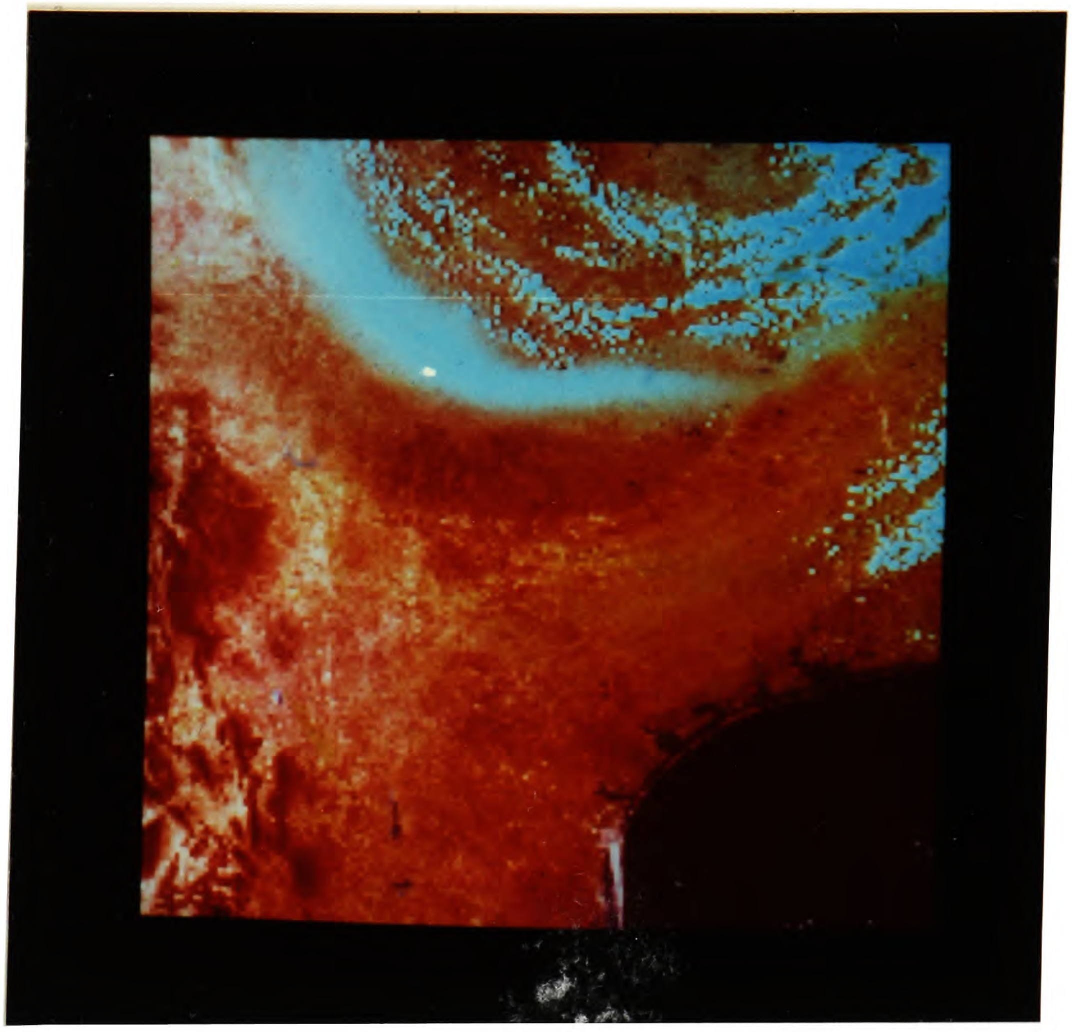


Plate 10.1 NOAA-7 AVHRR image of dust storm over the Great Plains, USA by intense cyclonic gyre (9 April 1984)

Plate 11.1 Dust-raising from the dry bed of the River Altzayanca, Cuenca de Oriental, Mexico (22 August 1983)

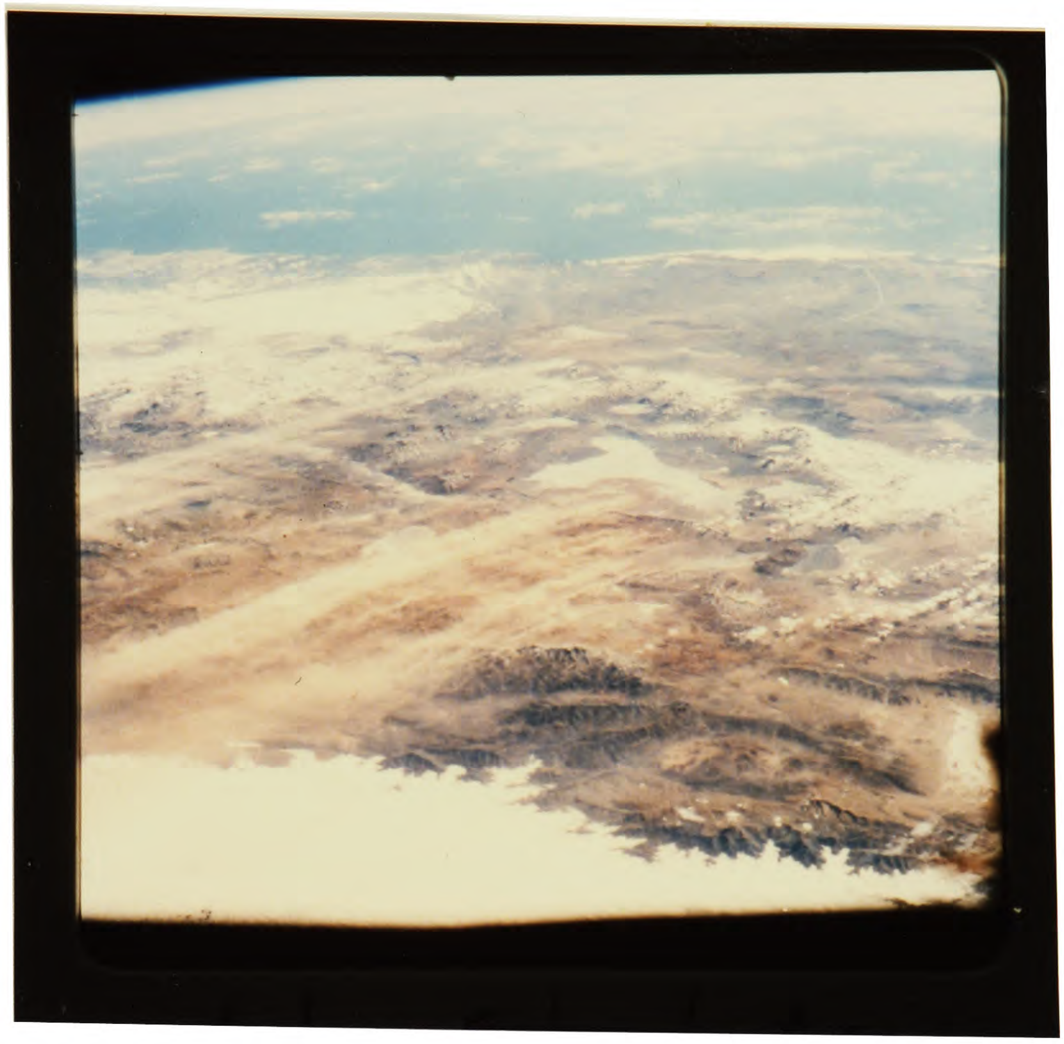


Plate 11.2 Space Shuttle photograph of point source dust plumes in the region of the Salar de Arizaro, Pune de Atacama, northern Argentina. Dust is raised by the prevailing upper westerlies (September 1983)

## APPENDIX : ABBREVIATIONS USED

| | |
|---|---|
| BFT | Beaufort Number (wind speed measure) |
| BP | Before Present |
| CIA | Central Intelligence Agency (USA) |
| DP | Drift Potential (Fryberger 1979) |
| GARP | Global Atmospheric Research Program |
| GATE | GARP Atlantic Tropical Experiment |
| GMT | Greenwich Mean Time |
| IAL | International Aeradio plc |
| IST | Indian Summer Time |
| ITCZ | Intertropical Convergence Zone |
| ITF | Intertropical Front |
| LST | Local Summer Time |
| LT | Local Time |
| SADS | SEAREX Asian Dust Study |
| SARH | Secretaria de Agricultura y Recursos Hidraulicos (Mexico) |
| SEAREX | Sea/Air Exchange Program |
| SENEAM | Servicios a la Navigacion en el Espacio Aereo Mexicano |
| SYNOP | Coded weather reports from the meteorological network of so-called SYNOP stations |
| TSP | Total Suspended Particulates |
| UN | United Nations |
| UNEP | United Nations Environment Programme |
| WMO | World Meteorological Organisation |

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