Rainfall and climate records from Sharjah Airport: Historical data for the study of recent climatic periodicity in the U.A.E.

by Gary R. Feulner

"A cloud gathers, the rain falls, men live; the cloud disperses without rain, and men and animals die." - Wilfred Thesiger, Prologue to ***Arabian Sands***

Introduction

The most notorious feature of the natural history of Arabia is the extreme aridity of the climate. Coupled with high summer temperatures, this presents a formidable natural challenge to living organisms. Plants, animals and humans all have had to adapt in order to successfully colonise Arabia, including the UAE. Some species (including especially strong fliers such as many butterflies and dragonflies) simply migrate and are not seen during the driest periods. Resident species have evolved mechanisms or strategies for coping with extended periods of drought. There is good evidence, too, that in the pre-modern era, human civilization in Eastern Arabia flourished or declined in parallel with major climatic fluctuations.

Yet we know that rain falls and water flows from time to time. In the UAE, rain is welcomed and even prayed for, but it can also be destructive. Wadis are flooded, roads are washed out, property is damaged and lives may be lost. When and why? It is a commonplace that rainfall in Arabia is erratic and unpredictable. But is this strictly true? Or are there patterns in the rainfall that might allow us to better understand the constraints to which natural life in the UAE must adjust, and which form the basis for the mechanisms and strategies that have been evolved to do so?

Authoritative examination of these questions has been impeded by the lack of data. The countries of eastern Arabia - the UAE and Oman - have only recently been integrated into the modern practice of detailed meteorological record-keeping and, for the most part, systematic data do not pre-date the federation of the UAE.

The Sharjah Airport Data

The records from Sharjah Airport are the exception within the UAE and Oman. Basic climatic data have been recorded and maintained there since 1934, with the result that there now exists a database spanning more than 70 years -- a sufficient time period to give hope that meaningful generalisations can be made about the possible existence of short-term periodicity.

It is true that rainfall in the UAE, even significant rainfall, is often very localised, so that records at any particular site will not constitute an exact record of events at any other site. But it seems reasonable to suppose, at least as a working hypothesis, that patterns (if any) appearing over 70 years at a single site are indicative of patterns in the broader causative phenomena, and are therefore likely to be correlated with events and patterns at UAE sites more generally.

Sharjah's meteorological records are currently maintained and have been compiled by the Meteorological Office, Air Traffic Services, Department of Civil Aviation. Data from 1934 to 1976 were recorded at the old Sharjah Airport, now on the outskirts of downtown Sharjah, about 4 kilometers from the coast. Since 1977, data have been collected at Sharjah International Airport, some 12 kilometres inland. Annual compilations have been privately published by the Meteorological Office and may be requested from the Meteorological Officer (c/o Meteorological Office, Department of Civil Aviation, Sharjah International Airport, P.O. Box 8, Sharjah, U.A.E., e-mail: shjmet@emirates.net.ae, www.sharjahairport.gov.ae). The annual reports include information about the methodology and equipment used. Each annual report also includes updates of the principal historical compilations as well as a capsule summary of the UAE's annual weather patterns. Excerpts from this information are published in the Appendix to this note.

At the urging of UAE naturalists who have seen these publications, the Meteorological Office has very kindly supplied updated compilations of rainfall data, with the express aim of making this information more readily available to the community of individuals and institutions engaged in the study of the natural history of the UAE. In addition to publication in ***Tribulus***, the information has been conveyed in electronic form to each of the UAE's three natural history groups (in Abu Dhabi, Al-Ain and Dubai), among others.

In the following pages are found four of the most significant compilations from the Sharjah Airport data. The Appendix to this note contains a brief description of the general climatic regime of the Arabian Gulf and a summary of the normal annual UAE weather pattern, excerpted from Climatological Report 2003, published by the Meteorological Office.

The compilations presented are:

Fig. 1: Annual rainfall totals (1934-2004)
Fig. 2: Monthly rainfall means and extremes (1934-2004)
Fig. 3: Monthly rainfall totals (1934-2004)
Fig. 4: Monthly temperature and other data (1977-2004)

Among the interesting generalizations that emerge from the Sharjah rainfall data are the following:

(1) Annual rainfall totals show an apparent (visual) periodicity.

(2) June is unequivocally the driest month.

(3) The drought of recent years has been the most severe within the 70-year recording period: the years 2000-2003 had the lowest 4-year rainfall total (with less than half the rainfall of the next lowest 4-year period), as well as 4 of the 16 lowest annual totals.

(4) In contrast, the period 1995-1998 was the wettest 4-year period on record, having 3 of the top 5 annual rainfall totals, and 4 of the top 10.

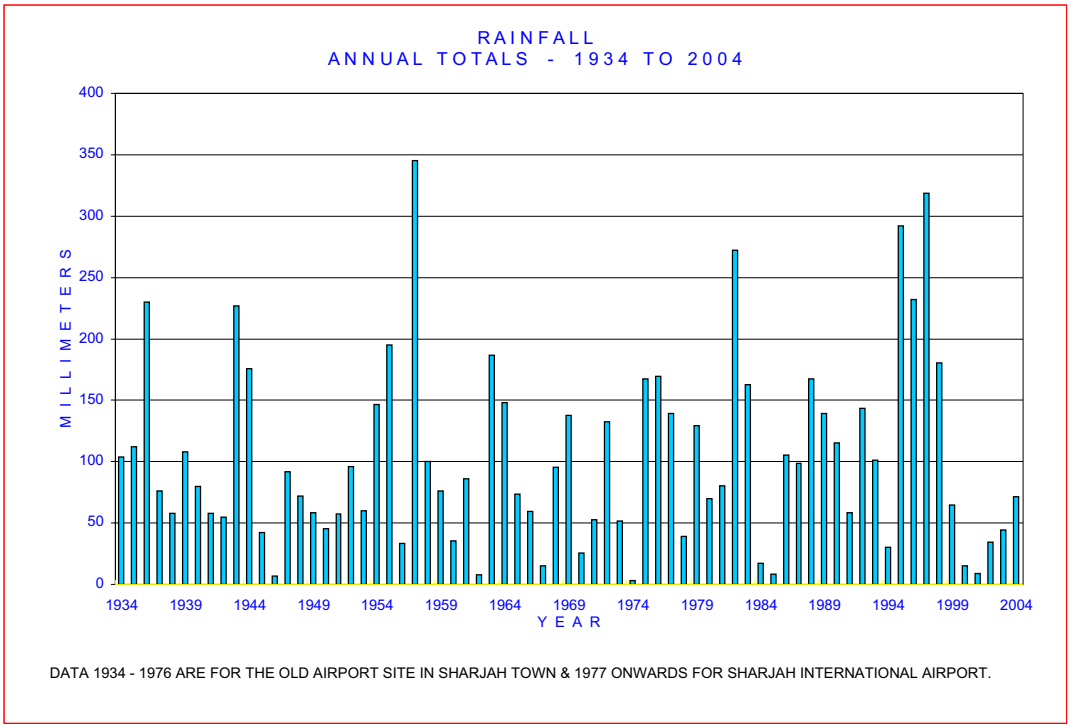

Figure 1: Annual rainfall totals at Sharjah Airports (1934-2004).

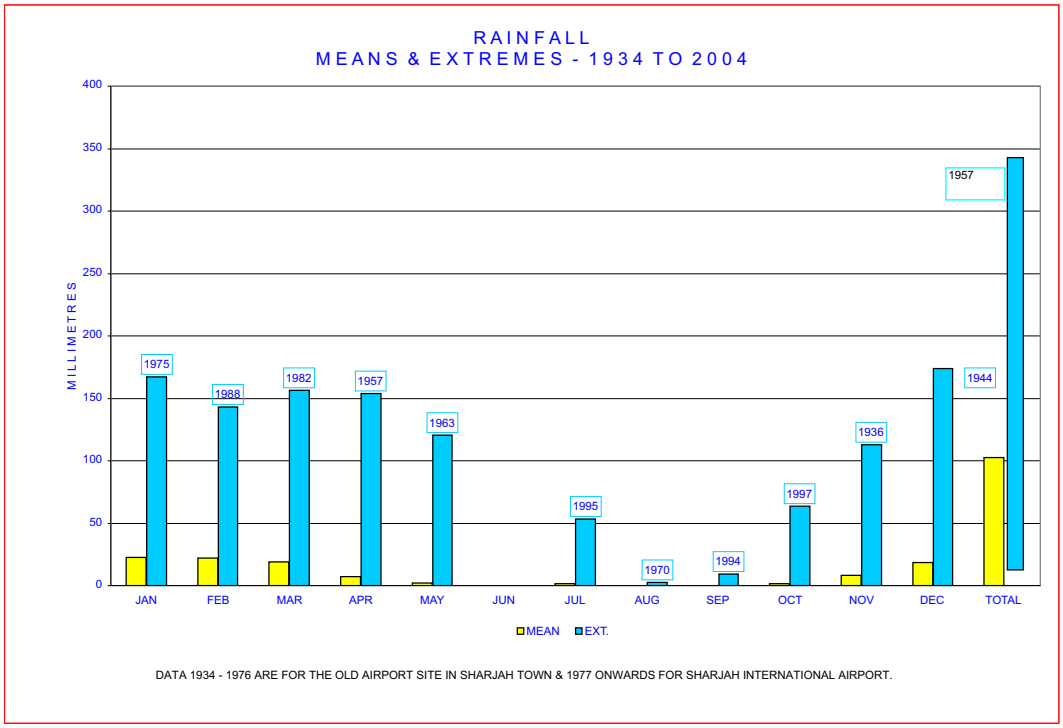

Figure 2: Monthly rainfall means and extremes at Sharjah Airports (1934-2004).

MONTHLY RAINFALL TOTALS (mm) FOR SHARJAH, UNITED ARAB EMIRATES.
1934 TO 2004

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1934	10.0	NIL	48.0	NIL	NIL	NIL	NIL	NIL	NIL	NIL	1.0	45.0	104.0
1935	2.0	106.0	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	4.0	112.0
1936	48.0	1.0	2.0	3.0	NIL	NIL	NIL	NIL	NIL	NIL	113.0	63.0	230.0
1937	1.0	25.0	16.0	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	34.0	76.0
1938	31.0	5.0	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	22.0	58.0
1939	59.0	36.0	1.0	11.0	NIL	NIL	NIL	NIL	NIL	NIL	NIL	1.0	108.0
1940	46.0	7.0	7.0	NIL	NIL	NIL	NIL	NIL	NIL	NIL	20.0	NIL	80.0
1941	NIL	2.0	26.0	30.0	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	58.0
1942	1.0	41.0	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	13.0	55.0
1943	53.0	62.0	17.0	4.0	NIL	NIL	NIL	NIL	NIL	NIL	NIL	91.0	227.0
1944	NIL	2.0	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	174.0	176.0
1945	39.0	NIL	1.0	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	2.0	42.0
1946	NIL	NIL	7.0	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	7.0
1947	27.0	7.0	24.0	NIL	NIL	NIL	NIL	NIL	NIL	NIL	24.4	9.6	92.0
1948	NIL	41.0	5.0	NIL	NIL	NIL	NIL	NIL	NIL	15.6	2.5	8.1	72.2
1949	4.5	NIL	N/A	N/A	N/A	N/A	N/A	N/A	NIL	TR	45.0	9.0	58.5
1950	18.6	2.0	10.2	TR	2.1	NIL	0.3	NIL	NIL	NIL	3.3	8.8	45.3
1951	0.7	TR	14.4	NIL	5.9	NIL	NIL	NIL	NIL	NIL	NIL	36.4	57.4
1952	65.2	TR	0.5	2.4	TR	NIL	NIL	NIL	NIL	NIL	NIL	27.8	95.9
1953	NIL	53.2	0.5	1.7	TR	NIL	NIL	NIL	NIL	NIL	NIL	4.5	59.9
1954	NIL	59.6	17.4	TR	NIL	NIL	NIL	NIL	NIL	NIL	69.4	0.2	146.6
1955	88.2	0.4	50.1	NIL	TR	NIL	NIL	TR	NIL	NIL	NIL	56.1	194.8
1956	7.1	TR	1.0	0.5	NIL	TR	15.6	NIL	5.4	0.7	NIL	2.9	33.2
1957	95.1	4.9	2.0	154.0	0.6	NIL	NIL	TR	TR	NIL	76.7	12.1	345.4
1958	16.0	TR	0.1	NIL	NIL	NIL	3.0	NIL	NIL	NIL	19.2	61.7	100.0
1959	56.8	4.0	TR	TR	NIL	NIL	NIL	TR	NIL	TR	12.2	3.2	76.2
1960	7.8	TR	4.8	19.6	NIL	NIL	NIL	NIL	TR	TR	TR	3.3	35.5
1961	8.6	34.0	14.6	28.8	NIL	NIL	TR	TR	TR	TR	TR	TR	86.0
1962	TR	NIL	TR	0.3	NIL	TR	TR	NIL	NIL	NIL	NIL	7.5	7.8
1963	TR	2.4	13.2	8.4	120.6	NIL	8.3	NIL	NIL	NIL	30.4	3.4	186.7
1964	35.2	29.6	2.8	TR	NIL	TR	TR	NIL	NIL	NIL	TR	80.7	148.3
1965	59.7	TR	0.7	11.8	TR	NIL	TR	NIL	TR	NIL	NIL	1.4	73.6
1966	0.3	59.1	NIL	TR	NIL	NIL	NIL	TR	NIL	NIL	NIL	TR	59.4
1967	TR	3.4	6.9	1.2	TR	TR	TR	TR	TR	TR	TR	3.6	15.1
1968	1.6	76.3	TR	0.3	TR	TR	TR	TR	TR	TR	TR	17.2	95.4
1969	112.5	0.3	TR	5.2	TR	TR	TR	TR	TR	19.5	TR	0.3	137.8
1970	22.7	0.5	TR	TR	TR	TR	TR	2.4	TR	TR	TR	TR	25.6
1971	4.9	0.6	0.2	5.1	TR	TR	TR	TR	TR	TR	27.8	14.2	52.8
1972	12.0	NIL	114.8	5.6	NIL	NIL	NIL	NIL	NIL	NIL	NIL	TR	132.4
1973	45.0	6.7	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	51.7
1974	3.1	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	3.1
1975	167.4	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	167.4
1976	NIL	128.2	20.0	19.9	NIL	NIL	NIL	NIL	NIL	NIL	NIL	1.6	169.7
1977	34.6	29.8	13.1	14.7	NIL	NIL	NIL	NIL	NIL	TR	41.6	5.4	139.2
1978	NIL	25.6	11.1	2.5	TR	NIL	TR	NIL	NIL	NIL	TR	NIL	39.2
1979	4.0	TR	68.2	NIL	NIL	NIL	NIL	TR	NIL	NIL	NIL	57.1	129.3
1980	1.2	38.2	28.6	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	1.7	69.7
1981	TR	0.3	21.8	37.7	20.6	NIL	TR	TR	NIL	NIL	NIL	NIL	80.4
1982	2.7	82.4	156.4	TR	TR	NIL	NIL	NIL	NIL	NIL	15.0	15.8	272.3
1983	26.4	85.7	25.9	20.1	NIL	NIL	NIL	0.6	NIL	NIL	NIL	3.9	162.6
1984	0.5	TR	7.6	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	9.2	17.3
1985	5.7	NIL	2.0	0.7	TR	NIL	NIL	NIL	NIL	NIL	NIL	0.2	8.6
1986	21.2	24.5	6.7	2.5	NIL	NIL	TR	NIL	NIL	NIL	0.5	49.9	105.3
1987	NIL	TR	90.0	1.2	NIL	NIL	NIL	TR	NIL	NIL	NIL	7.2	98.4
1988	1.4	142.9	0.5	17.7	NIL	NIL	0.7	NIL	NIL	NIL	NIL	4.0	167.2
1989	TR	13.8	40.4	6.5	NIL	NIL	0.5	NIL	NIL	NIL	18.5	59.7	139.4
1990	30.4	75.3	1.2	8.2	NIL	NIL	NIL	TR	NIL	NIL	TR	TR	115.1
1991	15.1	3.2	21.6	TR	NIL	NIL	NIL	NIL	NIL	NIL	0.7	17.9	58.5
1992	29.3	34.8	0.7	43.7	TR	NIL	NIL	TR	NIL	NIL	NIL	35.0	143.5
1993	2.1	95.8	1.0	TR	NIL	NIL	NIL	NIL	NIL	NIL	NIL	2.2	101.1
1994	14.2	TR	3.7	0.2	3.0	NIL	TR	NIL	9.2	NIL	TR	TR	30.3
1995	NIL	33.2	58.4	0.9	NIL	NIL	53.1	NIL	NIL	NIL	NIL	146.5	292.1
1996	53.3	24.5	152.6	1.0	NIL	NIL	NIL	NIL	NIL	NIL	TR	0.5	231.9
1997	71.6	TR	125.0	2.7	NIL	NIL	NIL	NIL	TR	63.4	39.1	17.1	318.9
1998	97.8	18.0	17.5	16.5	NIL	NIL	29.6	NIL	NIL	NIL	NIL	0.9	180.3
1999	20.7	37.2	6.9	NIL	NIL	NIL	TR	NIL	NIL	NIL	NIL	TR	64.8
2000	TR	NIL	0.2	NIL	NIL	NIL	NIL	NIL	NIL	TR	2.0	12.8	15.0
2001	8.2	TR	TR	NIL	NIL	NIL	TR	NIL	NIL	NIL	0.8	NIL	9.0
2002	3.6	0.2	29.4	0.4	TR	TR	NIL	TR	NIL	NIL	NIL	0.6	34.2
2003	3.6	7.3	20.7	12.5	0.0	0.0	TR	TR	0.0	0.0	TR	TR	44.1
2004	12.5	NIL	TR	TR	0.0	0.0	0.0	0.0	NIL	NIL	8.5	50.5	71.5
MEAN	22.7	22.2	18.9	7.1	2.2	0.0	1.6	0.0	0.2	1.4	8.1	18.6	102.8
EXT.	167.4	142.9	156.4	154.0	120.6	TR	53.1	2.4	9.2	63.4	113.0	174.0	345.4

Data for April & December 1976 are not available for Sharjah. In the table, Dubai Airport totals have been used for these two months. There is no data for the period March to August 1949.

Data Sources:1934-1946 from SHARJAH TOWN, 1949-1971 from the OLD AIRPORT SHARJAH and 1977 onwards, from SHARJAH INTERNATIONAL AIRPORT, 13 Km East of the OLD AIRPORT.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
MEAN	22.7	22.2	18.9	7.1	2.2	0.0	1.6	0.0	0.2	1.4	8.1	18.6	102.8
EXT.	167.4	142.9	156.4	154.0	120.6	TR	53.1	2.4	9.2	63.4	113.0	174.0	345.4
YEAR	1975	1988	1982	1957	1963	2000	1995	1970	1994	1997	1936	1944	1957

Figure 3: Monthly rainfall totals at Sharjah Airports (1934-2004).

Climatological Data for Sharjah International Airport - 1977 To 2004 inclusive

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC	YEAR	TOTALS
DRYBULB TEMPERATURE - °C														
Mean daily max.	24.4	25.7	29.0	34.2	39.1	41.3	42.4	42.2	40.1	36.3	31.1	26.5	34.4	=
Mean daily min.	12.1	13.0	15.5	18.4	22.2	25.0	27.9	27.8	24.6	21.0	16.9	13.8	19.9	=
Extreme max.	32.5	35.4	42.5	44.6	46.4	49.2	47.8	48.2	46.7	43.0	37.3	33.9	49.2	=
Exterme min.	3.4	2.5	5.8	10.9	13.0	17.8	21.7	22.2	18.4	12.3	8.1	4.9	2.5	=
WETBULB TEMPERATURE - °C														
Mean daily max.	14.4	15.1	16.9	19.1	21.6	24.5	26.1	26.4	24.9	22.3	18.5	16.0	20.5	=
Extreme max.	22.0	23.1	25.0	26.7	30.2	32.1	33.0	33.5	31.5	32.1	27.2	24.1	33.5	=
RELATIVE HUMIDITY - %														
Mean daily max.	90	90	88	82	76	82	80	80	87	89	87	90	85	=
Mean daily min.	41	38	33	25	21	23	26	27	26	28	33	40	30	=
SUNSHINE - hours														
Mean total hours	234	225	251	293	340	337	320	317	300	294	265	234	284	3410
Percentage of possible	73	74	70	80	85	85	79	82	85	86	84	75	80	=
Mean daily hours	7.4	8.0	8.1	9.8	11.0	11.3	10.3	10.2	10.0	9.5	8.8	7.6	9.3	=
RAINFALL - millimeters														
Monthly mean	17.9	31.9	38.0	7.9	1.0	0.0	3.5	0.0	0.4	2.6	4.9	21.0	10.8	=
Monthly extreme	97.8	142.9	156.4	43.7	20.6	TR	53.1	0.6	9.2	63.4	41.6	146.5	156.4	=
Highest 24 hr. max.	62.7	115.5	76.7	36.6	14.4	TR	35.2	0.6	5.5	62.6	41.6	60.7	115.5	=
Mean no. of rain days	6.0	5.9	8.1	2.5	0.4	0.1	0.7	0.4	0.1	0.2	1.3	4.6	2.5	30.3
ATMOSPHERIC PRESSURE - hPa														
Mean m.s.l. pressure	1018	1016	1014	1010	1006	1000	997	999	1005	1012	1016	1018	1009	=
WEATHER - Mean no. of days														
Fog - vis.1Km or less	1.7	2.3	3.6	2.5	1.9	3.1	1.0	1.1	3.3	3.8	1.3	1.3	2.2	26.9
Dust/haze - vis. 1 Km or less	0.2	0.1	0.5	0.1	0.0	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	1.7
Thunder	0.5	1.4	2.3	0.9	0.1	0.0	0.3	0.3	0.1	0.2	0.8	0.8	0.6	7.7
Hail	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.5
WINDSPEED - knots *														
Monthly mean	6	6	7	7	7	7	7	6	6	5	5	5	6	=
Highest monthly mean	11	12	13	13	13	13	13	13	12	12	11	10	12	=
Monthly extreme	40	33	42	36	34	32	41	29	28	25	32	28	42	=
GUST - knots **														
Monthly extreme	61	70	61	58	45	45	72	39	38	39	45	43	72	=

NB: (a) The data in this table refer to the Airport only and are not representative of coastal locations.

(b) A gust of 72 kts occurred during the storm of the 20th July 1998.

* Windspeeds are '**10 minute mean**' values. ** Gust is an '**instantaneous**' value.

Figure 4: Monthly temperature and other data at Sharjah International Airport (1977-2004).

Scope for Further Investigation

Basic data such as these should both inform and empower students of UAE natural history. Several preliminary efforts seem called for. Perhaps foremost among such efforts, the apparent rainfall periodicity should be investigated using recognised mathematical methods such as Fourier analysis. [Fourier analysis would first represent the annual rainfall totals as a curve of deviations from the long-term annual mean, and then attempt to reproduce that curve mathematically as the sum of a set of sine waves of different wavelengths (periodicity), weighted as necessary to match the actual curve. If certain sine waves make a significantly greater contribution to the result, this is indicative of a fundamental periodicity at the corresponding wavelengths.]

In addition, the observed pattern of low summer rainfall, with a consistent rainfall minimum in June, means that a recalculation of annual rainfall, based on a July 1 to June 30 year, has the potential to clarify any possible periodicity in the annual pattern, by consolidating each winter season's rainfall within a single annual total. The data show that the Sharjah Airport area does not generally receive significant rain from localised summer showers of the sort that more frequently affect the UAE's mountain regions. [In only seven years did summer rain (May through September) constitute 10% or more of total annual rainfall, and in only four of those years did it constitute 25% or more. Of the latter, three were years with total rainfall 20-70% below the annual mean. The fourth was exceptional: the 120.6 mm that fell in May 1963 exceeded the annual mean and constituted 66% of that year's total of 186.7 mm.]

The author has performed such a recalculation of the annual data, using a July to June year. The results are shown in *Fig. 5.* These do not appear to make a great difference, visually or otherwise, in the patterns recorded. In particular, the same rainfall minima are shown at essentially the same intervals (approximately 12-16 years) and the overall distribution of departures from the mean annual rainfall remains the same (in each case, only 24 years are more than 10% above the mean, whereas 37 years are more than 10% below the mean). The recalculation does, however, re-order somewhat the ranking of peak rain years, most notably by highlighting the record winter rains of 1995-96. The recalculation also further emphasizes the severity of the drought of mid-1999 to mid-2004.

Finally, the Sharjah Airport data should be compared with similar data from other UAE weather stations in order to assess whether any patterns appearing in the one are observable in the other, i.e. whether they are of regional or strictly local significance. *Fig. 6* shows annual rainfall records from Abu Dhabi and Al Ain for the period 1971-2004. [For the period 1971-1992, the sites were Bateen Airport on Abu Dhabi Island and Al Ain Agricultural Station and the data was published in Bottomley (1996). For the period 1993-2004, the information is from Abu Dhabi International Airport and Al Ain International Airport. Al Ain data for 1993 was not available.]

The Abu Dhabi and Al Ain data represent a much shorter period of time than the Sharjah data, and annual rainfall totals are lower at both of the former sites (averaging ~59.1 mm at Abu Dhabi and ~85.8 mm at Al Ain, versus 102.6 mm for Sharjah Airport), but it can be seen that there is a relatively good correlation (i) between the Abu Dhabi and Al Ain sites and (ii) between the Abu Dhabi/Al Ain data and the Sharjah Airport data. In particular, the graphs share essentially the same pattern of peaks and troughs, and all reflect the singular intensity of the drought of recent years (which in the Abu Dhabi/Al Ain data is shifted to 1999-2002). Such a correlation strengthens the working hypothesis that the Sharjah Airport data can tell us something meaningful about climatic periodicity for the country as a whole.

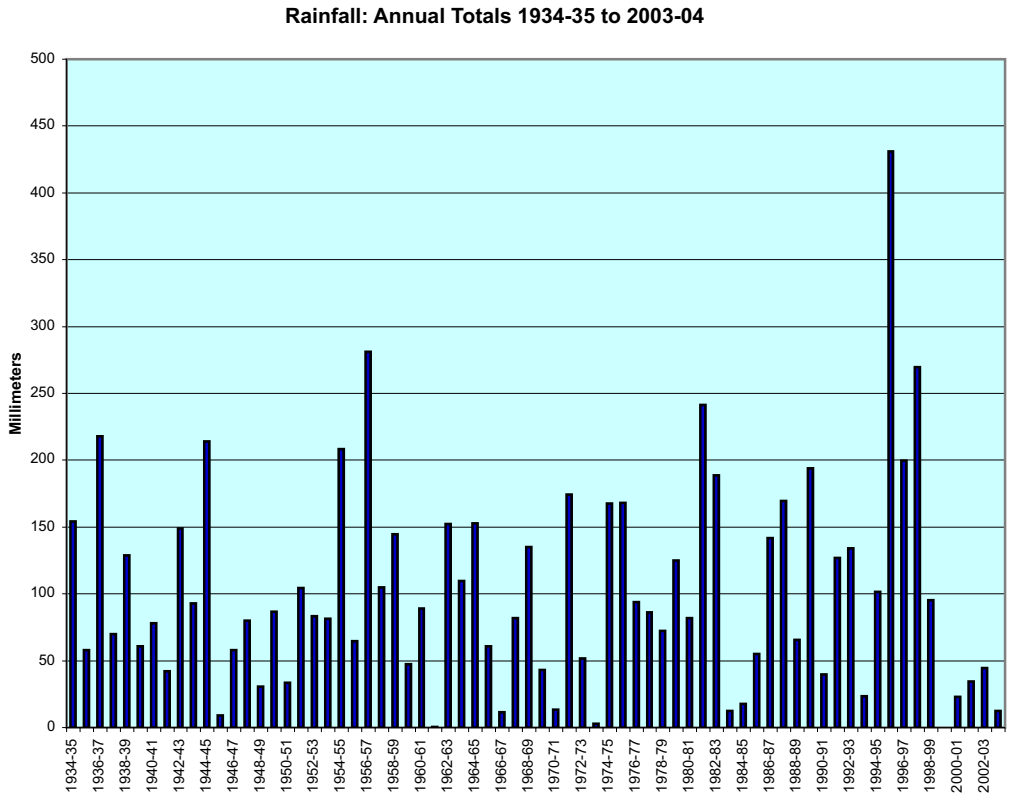

Figure 5: Annual rainfall totals at Sharjah Airports (1934-35 to 2003-04), as recalculated by the author on the basis of a July 1 to June 30 year.

Acknowledgements

It is a pleasure to thank and acknowledge the Meteorological Office of the Sharjah Department of Civil Aviation, and in particular Mr. Abraham Jacob, the current Meteorological Officer, as well as their predecessors over the past 70 years, for their efforts in recording and compiling the Sharjah Airport data and their interest in disseminating it for broader intellectual use. Thanks are also due to the Meteorological Office of the Abu Dhabi Department of Civil Aviation, and especially to Senior Meteorological Officer Mr. Mohammed Al-Abri, for providing a current update of rainfall data for Abu Dhabi and Al-Ain, and to Mr. Humayn Kabir and Ms. Hanna C. Nordell, respectively, for their assistance with the recalculations and the graphics undertaken by the author.

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Appendix

[Excerpts from Climatological Report 2003, Meteorological Office,
Department of Civil Aviation, Sharjah (2004)]

Early Climatological Stations and Recordings

The earliest meteorological observatories to be established in the Arabian Gulf region were at Bushire (1876), Muscat (1893) and Jask (1892). It was not until the 1930s that stations were set up on the shores of the Gulf, following the discovery of oil and the simultaneous expansion of aviation operations requiring staging posts on routes to the Far East. Observatories were opened at Bahrain in 1931 and Sharjah in 1993. The latter, near Al Mahatta district: 25º20'N, 55º24'E , 18 ft. (5.5 m) above mean sea level, was the first meteorological office in the U.A.E. In 1977, the observatory moved to the new location of Sharjah International Airport: 25º19'N, 55º31'E, 33.3 m (111 ft.) above mean sea level. Now several of the larger meteorological stations are equipped with the latest weather satellite systems together with high speed communications, modern computers, weather radar, radio-sonde units, automatic weather stations and cloud base recorders, etc. Only 20 years ago these stations probably had little more than a thermometer screen, barometer and rain gauge.

Present Day Climate of the Arabian Gulf

The Arabian Gulf is almost totally enclosed by the arid landmasses of the northern desert belt. Prevailing winds over the area are north-westerly because of the very frequent pressure pattern of a ridge of high pressure extending southwards into central Saudi Arabia and low pressure over the eastern Gulf. The mountain barrier along the Iranian coast further enhances this prevailing flow by naturally channeling any eastward moving low-level airflow towards the south-east.

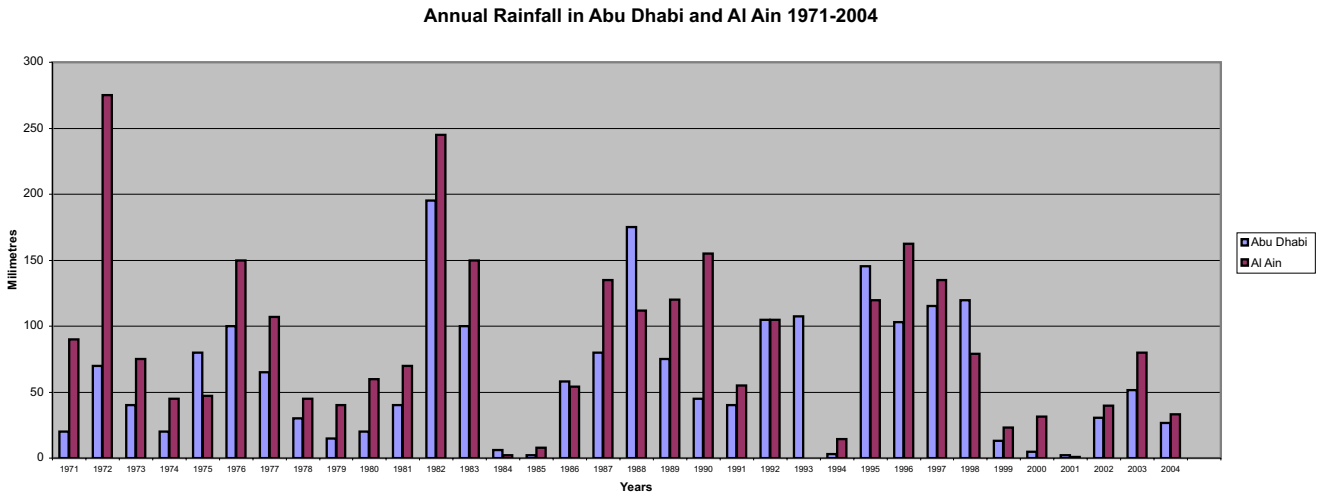

Figure 6: Annual rainfall totals for Abu Dhabi and Al Ain (1971-2004). Data for 1971-1992 is from Al Bateen Airport, Abu Dhabi, and Al Ain Agricultural Station (Bottomley 1996). Data for 1993-2004 is from Abu Dhabi International Airport and Al Ain International Airport, courtesy of the Meteorological Office, Abu Dhabi Department of Civil Aviation. Al Ain data for 1993 was unavailable.

All areas experience sporadic winter rainfall derived from Mediterranean-type depressions and local convergence phenomena. Cold fronts associated with the Mediterranean depressions travel east across Saudi Arabia and Iraq, sometimes penetrating as far as the Arabian Sea, but generally producing only small amounts of rain. Most of the rainfall seems to be derived from the warm waters of the Gulf itself, which provides a reservoir of moist air at low levels. Local boundary fronts develop between this warm, moist air and the cooler drier continental air to produce convergence situations which can give very heavy rainfall, thunderstorms, and line squalls and occasionally hailstorms.

The Gulf waters also have a major effect on the temperature and humidity of the surrounding coastal zones, with places near the shore having higher humidity and a smaller diurnal temperature range than interior sites.

A significant feature of Gulf weather is visibility restrictions caused by sandstorms, dust storms, thick dust haze, mist and fog, all of which are occasionally experienced in the UAE. Such phenomena can sometimes be the cause of much personal discomfort as well as being potential hazards to air and maritime navigation. Dust from the Iraqi dustbowl is frequently carried across the Gulf by the prevailing north-west winds, which can be strong at times and are then known locally as *shamal*, from the Arabic word for north. Not all *shamals* are dusty but when the wind speed exceeds force six, rising dust and sand can be expected to reduce visibility significantly.

During May and June, and sometimes well into July, the "40-day *shamal*" occurs. This is a seasonal increase in the frequency of strong, dry, hot and dust-laden, north-westerly winds associated with the developing monsoon low pressure centre over Pakistan.

As is well known, the Gulf is blessed with abundant sunshine. Even in winter, there is an average of at least eight hours of bright sunshine per day and this rises to over 12 hours per day in the summer.

Annual U.A.E. Weather Patterns

Winter (December - March)

This is the most unsettled time of the year and over 80% of the annual rainfall can be expected during this 4-month period. Some of the rainfall comes from eastward-moving cold fronts arriving from temperate the Mediterranean latitudes. To the rear of those fronts the stronger north-westerly *shamals* may develop. Most of the rain, however, usually originates from extensive cloud adverted across the Arabian Peninsula from the Sudan and Ethiopia ahead of sow-moving frontal disturbances. Rain can be expected on an average of 4 to 8 days per month but variations are considerable and some winters have been known to be completely dry.

The wind pattern throughout the year is dominated by the diurnal land and sea breezes. Typically, the overnight land breeze is 4 to 8 knots south-easterly and the sea breeze is 8 to 13 knots north-westerly. The sea breeze sets in by midday and dies quickly after sunset. Mean wind speeds in excess of 20 knots are rare and usually only last for a few hours. However, during thunderstorms, gusts of more than 70 knots have been recorded. February and March have the highest incidence of thunderstorms, the most severe usually occurring during the passage of active cold fronts.

Exceptionally good visibility is a feature of early winter and the mountains of the Northern Emirates, more than 80 km away, can sometimes be seen.

Spring (April - May)

Winter disturbances now decrease as they fail to penetrate south into the Arabian Peninsula and consequently skies are mainly clear with an average of 10 or 11 hours of bright sunshine per day. Rainfall is infrequent and is usually associated with an isolated thunderstorm.

Temperatures increase, with the mean maxima reaching 34ºC to 39ºC and extremes of 43ºC to 46ºC are not uncommon.

The sea breeze phenomenon tends to be stronger during these months due to the higher land/sea temperature contrast. On rare occasions, a strong southeasterly wind can overcome the sea breeze, and when this happens very high temperature and low humidity results. At the end of May, the "40-day shamal" often becomes a major feature of the weather.

Summer (June - September)

Early summer is dominated by the presence of a deep monsoon low pressure area centered over Pakistan. As this low develops, the north-westerly wind strengthens over the Arabian Gulf. This increase in frequency and persistence of the north-west wind is known as the "40-day shamal." This is characterised by a fall in daily temperatures as winds blow in from the sea.

Sometimes thick dust haze can be advected into the Emirates from Iraq, occasionally giving visibilities below 1000 metres. Visibilities are generally at their worst during the summer, with a great deal of dust haze. Early morning radiation fog is quite frequent in June, early July and September due to a favourable combination of light winds and clear skies.

Dry dust squalls from distant storms can sometimes affect the airfield and lightning can often be seen in the evenings, but rain is rare during the summer months. Such occurrences have been either as a result of afternoon thunderstorms over the Hajar Mountains moving westwards or, exceptionally, from a westward extension of the Indian Monsoon.

Temperatures exceed 40ºC on most days and with humidity slowly increasing during the summer, late August and September can be very uncomfortable. Some relief can be expected after the onset of the sea breeze, but sea temperatures in the Arabian Gulf during this period are the highest in the world, reaching 35ºC in the open sea and up to 40ºC in some of the shallow coastal lagoons.

Autumn (October - November)

These months experience the most settled weather conditions of the year and rainfall is again rare, especially in October. The first of the winter rains usually come in late November and December. Winds are generally light, the land/sea breezes being weak during this period.

Although there is a marked improvement in visibility as the dust of the summer clears, October has the second highest incidence of radiation fog, which can be rather reluctant to clear at times, especially late in the season. During November the mountains to the north and east can sometimes be seen.

Nighttime temperatures fall to around 16ºC by the end of November and with daytime temperatures rising to near 30ºC, the weather can be very pleasant and favourable for outdoor recreational activities.

Temperature Extremes

Absolute maximum temperatures have reached 50ºC at many places in the Arabian Gulf region and are within a few degrees of this at all recording stations except islands and offshore installations. The highest temperature so far recorded is 53.5ºC at Ahwaz. Kuwait recorded an absolute maximum of 50.8ºC in June 1954 and Sharjah recorded an absolute maximum of 49.2ºC in June 1978. It can easily be seen that inland can expect daily summer maximums of around 45ºC while locations on the coast may be a good bit cooler, although not necessarily more comfortable as increased humidity will often make conditions seem worse.