SHORT NOTE

A note on precipitation at Swakopmund

by

Dr W. A. Nieman, Miss C. Heyns

Geography Department, University of Stellenbosch, Stellenbosch 7600, South Africa

and

Dr M. K. Seely

Desert Ecological Research Unit, P. O. Box 953, Walvis Bay 9190, South West Africa

Swakopmund (22,67°S, 14,52°E) is situated in the central Namib, a desert which extends for 1 500 km along the coast of southwestern Africa. This part of the coast is semi-permanently under the influence of the strong subsidence of the subtropical anticyclone of the southern Atlantic Ocean and rainfall is very meagre. Mostly the precipitation is nothing more than slight drizzles from heavy fog, but occasional light convectional showers do occur. Sometimes a quite heavy downpour is experienced, resulting in precipitation of more than 30 mm. The purpose of this paper is to contrast the precipitation derived from rainfall to that derived from fog at Swakopmund.

The Desert Ecological Research Unit maintains a weather station in Swakopmund where precipitation is measured using a Lambrecht autographic rain gauge. Fog is collected on a cylinder of wire mesh 0,85 mm gauge, 98 mm diameter, 208 mm high situated directly on the collection funnels.

In the period between February 1967 and September 1974 only one heavy rainfall was recorded at Swakopmund. This occurred between 19h30 and 07h30 on 23 / 24 March 1969. The synoptic situation* at that time developed from a blocking anticyclone which at first was centred to the south of the sub-continent but moved northeastwards over Southern Africa on the 21st of March, causing a strong off-shore airflow along the west coast. The next day a low pressure trough developed over the northern part of South West Africa and with anticyclone circulation to the east, resulted in scattered thundershowers over the northwestern part of South West Africa. On the 23rd of March, with strong anticyclonic circulation both on the surface and in the upper-air, the low pressure trough was displaced westwards over the coastal region of South West Africa. Heavy, but scattered showers resulted as tropical air moved southwards over the western part of southern Africa. On the 24th of March the low pressure trough over South West Africa deepened and the high pressure to the east weakened. Moist tropical air still flowed southwards resulting in heavy showers to the east of Swakopmund over the plateau, but the synoptic situation over the western coast returned to the normal dry conditions as a strong Atlantic anticyclone moved onshore. Although almost similar synoptic situations do occur occasionally during the summer, it seldom develops in the way described above and the west coast is thus deprived of substantial precipitation. The convectional showers producing appreciable amounts of rain occur only about once every three to four years during November, December and February and twice every three years during January and March. For the rest of the year drizzle or light rain can be expected only once every seven to eight years.

* From synoptic charts of the South African Weather Bureau.

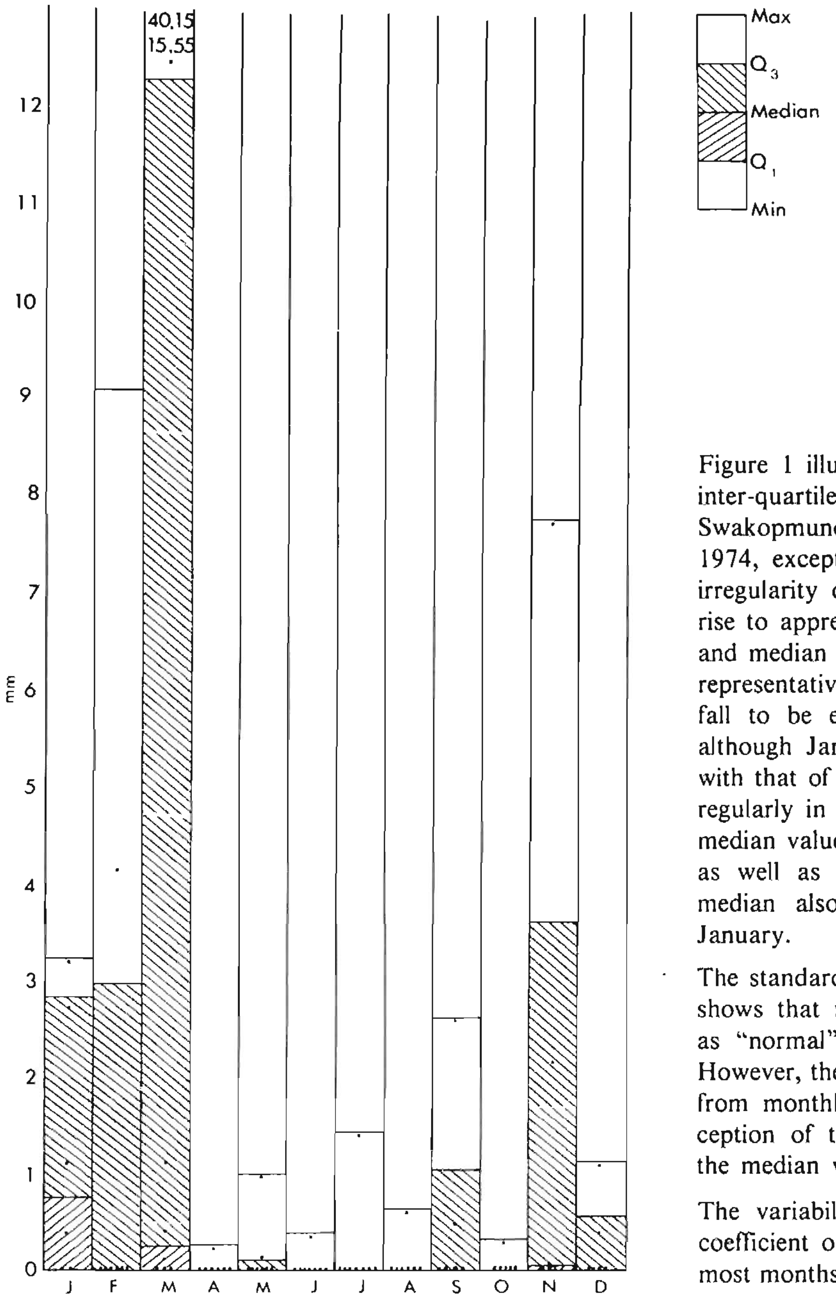

FIGURE 1: **True and Quartile Dispersion Diagrams of Rainfall at Swakopmund, 1967 — 1974.** The true dispersion of the total monthly amounts of recorded rainfall is represented by the dots in each column. Note the frequent occurrence of no rainfall in every month of the year (row of dots at bottom of columns). Two heavy rainfalls in March (15,55 mm in 1967, and 40,15 mm in 1969) are not represented according to the verticle scale. The quartile rainfall dispersion is superimposed on the true monthly dispersion and shown by the shaded and unshaded sections of each month's column. Except in January, March and November, the median monthly rainfall is zero at Swakopmund.

Figure 1 illustrates the true dispersion as well as the inter-quartile dispersion of the monthly rainfall at Swakopmund between February 1967 and August 1974, excepting August 1973 to January 1974. The irregularity of the rainfall in this coastal desert gives rise to appreciable differences between monthly mean and median values (Table 1). The latter value is more representative of the "usual" monthly amount of rainfall to be expected at Swakopmund. For example, although January's mean is very low in comparison with that of March, greater amounts of rain fall more regularly in January than in March according to the median values. The standard deviation from the mean as well as the average quartile deviation from the median also indicate greater likelihood of rain in January.

The standard deviation from the annual rainfall mean shows that no rain at all during a calendar year is as "normal" (Landsberg, 1960) as 30 mm of rain. However, the annual total of nearly 13 mm, calculated from monthly means, is likely to create a false perception of the coastal desert's rainfall. The sum of the median values is slightly more than 1 mm.

The variability of the rainfall, as expressed by the coefficient of variation (Gregory, 1968), is large. For most months it is above 200 %, and the annual rainfall

TABLE 1: Rainfall at Swakopmund, February 1967 – August 1974.

	Mean (mm)	Standard deviation (mm)	Median (mm)	Quartile deviation (mm)	Range (mm)	Variability (%)	Reliability index
JANUARY	1,2	1,4	0,8	1,4	0– 3,2	112	+44,1
FEBRUARY	1,6	3,3	0,0	1,5	0– 9,1	202	- 1,2
MARCH	7,2	14,4	0,2	6,1	0–40,2	201	- 0,3
APRIL	0,0	0,1	0,0	0,0	0– 0,2	271	- 0,4
MAY	0,1	0,3	0,0	0,1	0– 1,0	241	-20,3
JUNE	0,0	0,1	0,0	0,0	0– 0,4	283	-41,6
JULY	0,2	0,5	0,0	0,0	0– 1,4	283	-41,4
AUGUST	0,1	0,2	0,0	0,0	0– 0,6	264	-32,0
SEPTEMBER	0,5	1,0	0,0	0,5	0– 2,6	208	- 4,1
OCTOBER	0,1	0,1	0,0	0,0	0– 0,3	244	-22,0
NOVEMBER	1,6	3,1	0,0	1,8	0– 7,7	187	+ 6,5
DECEMBER	0,2	0,4	0,0	0,3	0– 1,1	178	+10,8
Year	12,9	17,2	—	—	—	134	+33,2

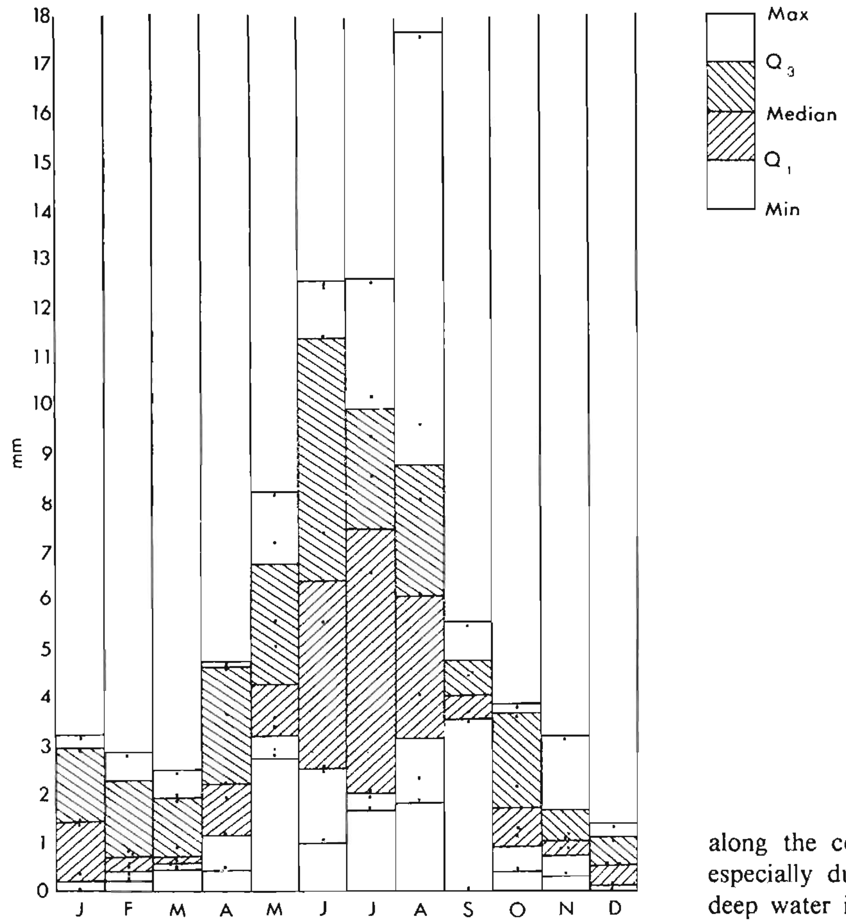

FIGURE 2: **True and Quartile Dispersion Diagrams of Fog Precipitation at Swakopmund, 1967 – 1974.** The true dispersion of the recorded total monthly amount of precipitated fog is represented by the dots in each column. Note that lack of precipitated fog was only recorded three times (January 1970, December 1971 and September 1972, although the records are incomplete for 1973 and 1974). The quartile dispersion of monthly precipitated fog, superimposed on the true monthly dispersions, is shown by the shaded and unshaded sections of each month's column. Above normal values lie between the upper quartile (Q_3) and the maximum recorded value, below normal values between the minimum value and the lower quartile (Q_1). The shaded part of each column represents the normal amounts of precipitated fog recorded between 1967 and 1974. Note that those months with relatively low median values of precipitated fog also have rather small interquartile range (Q_3-Q_1) whereas the winter months' normal range of fog precipitation is much higher. The normal amount of fog to be expected in September is fairly constant although it has a comparatively high median amount of precipitated fog; September, nevertheless, was also one of the months during which no precipitated fog was recorded.

has a variability in excess of 100 % (Table 1). A modified Index of Reliability (Schumann and Mostert, 1949; Nieman, 1975) shows negative values even during the months with the highest mean rainfall (Table 1). January has the smallest rainfall variability and also the best reliability.

The figures for fog precipitation for the period between February 1967 and August 1974 show quite a different picture. The strong subsidence and prevailing winds along the coast act together to produce heavy fog, especially during the winter months. Cold, upwelling deep water is produced by the wind direction almost parallel to the shore. The resulting relatively low air temperature creates ideal conditions for fog formation in the subsiding air masses.

Figure 2 illustrates the true and quartile dispersion of the precipitated fog measured at Swakopmund in the period 1968 – 74. In a number of months the dispersion of fog precipitation shows very regular distributions, contrasting strongly with the irregular rainfall dispersion (Figure 1). Only in three months was no fog precipitation measured. This regular source of water from the atmosphere is of great importance

TABLE 2: Precipitated fog at Swakopmund, February 1967 – August 1974.

	Mean (mm)	Standard deviation (mm)	Median (mm)	Quartile deviation (mm)	Range (mm)	Variability (%)	Reliability index
JANUARY	1,5	1,3	1,4	1,4	0– 3,2	85	57
FEBRUARY	0,9	0,8	0,6	1,0	0,2– 2,8	95	52
MARCH	1,2	0,8	0,7	0,7	0,5– 2,4	68	66
APRIL	2,6	1,7	2,2	1,7	0,4– 4,7	64	68
MAY	4,8	2,0	4,2	1,7	2,8– 8,2	43	78
JUNE	6,9	4,7	6,4	4,4	1,0–12,5	69	66
JULY	6,6	4,2	7,4	3,9	1,6–12,6	65	68
AUGUST	7,0	5,4	6,0	2,8	1,8–17,6	77	61
SEPTEMBER	3,8	1,9	4,0	0,6	0– 5,8	50	75
OCTOBER	2,0	1,4	1,6	1,4	0,4– 3,8	68	66
NOVEMBER	1,2	1,0	1,0	0,5	0,3– 8,9	78	61
DECEMBER	0,6	0,5	0,5	0,2	0– 2,4	89	55
Year	40,4	6,3	–	–	–	16	92

to the environment. It was calculated by Taljaard (1970), that the average amount of water present in the atmosphere over the west coast of Southern Africa varies from 12 mm to 21 mm per day. This water and / or water vapour is to be found chiefly in the lower 500 m of the air over the west coast.

Table 2 summarizes a number of the monthly fog precipitation parameters. The normality of the distributions is shown by the agreement between mean and median for almost every month. Variability is remarkably low for the year as a whole. In September the variability of fog precipitation is relatively small, with a deviation of just over half a millimeter from the median amount of 4 mm of fog. The month with the smallest coefficient of variability is May. However, the actual and expected deviations from both the mean and median fog precipitation figures in May are still in excess of the 15 % deviation from September's median amount. Swakopmund can be assured of fog precipitation almost every month of the year although the Index of Reliability is the highest in May and September.

The true inter-quartile range in June and August (see Figure 2) corresponds with the theoretical ranges for those months as calculated with the average quartile deviation from the respective median values. This, and the high reliability indices, leads one to expect that a normality diagram (Landsberg, 1960) might have some prognostic value. Figure 3 shows the ranges of expected fog precipitation for every month. Values between $(\bar{x} + 0)$ and $(\bar{x} - 0)$ are taken as normal; values of fog precipitation ranging between $(\bar{x} + 0)$ and $(\bar{x} + 20)$ will be above normal, and below normal if it is less than $(\bar{x} - 0)$ but greater than $(\bar{x} - 20)$; abnormally high values will be those between $(\bar{x} + 20)$ and $(\bar{x} + 30)$ and extremely high values will be greater than $(\bar{x} + 30)$; abnormally low values of monthly fog precipitation will be less than $(\bar{x} - 20)$ but higher than $(\bar{x} - 30)$.

According to this scheme an annual amount of precipitated fog totalling between 34 mm and 46,7 mm can be considered as normal. In 1972 the total amount of precipitated fog was only 30,7 mm and therefore below normal; only once during the period under consideration was an annual amount of precipitated fog above normal, namely the 55,1 mm in 1967. No extremely high fog precipitation was measured in any month between February 1967 and August 1974. An abnormally high monthly total of precipitated fog was measured only once, in February 1972. This would indicate the existence of a maximum amount of precipitable moisture in the air masses over Swakopmund and adjacent territory. At the same time conditions for fog formation seem to recur with high frequency. Above normal monthly totals of precipitated fog were measured at a frequency of about 20 %; below normal monthly totals had a frequency of about 10 %. These higher than normal, as well as lower than normal precipitations from fog have a tendency to occur in consecutive months. This can be attributed to a general and large-scale change in the circulation pattern of the lower troposphere during those particular periods.

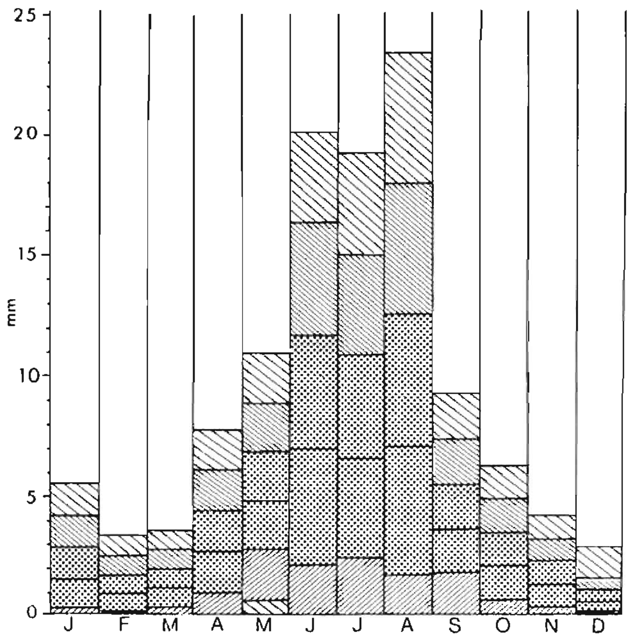

FIGURE 3: **Normality Diagram of Fog Precipitation at Swakopmund.** The expected range of monthly amounts of fog precipitation is shown with the aid of the computed standard deviation from the mean value of each month's recorded fog precipitation (see text for detail). All values within the limits of one standard deviation above or below the mean, can be considered in the normal range of expected fog precipitation. Note the pronounced 'winter precipitation' character of the annual march of expected fog precipitation. Fog precipitation normally occurs in every month.

The overall low frequencies of above or below normal monthly amounts of precipitated fog suggest that the provision of moisture to living organisms in the coastal desert zone from precipitated fog can be relied upon within the limits of normality illustrated in Figure 3. Since the monthly march of fog precipitation suggests a 'winter rainfall' pattern, the specialized desert fauna and flora dependent upon the fog as a moisture source might well exhibit characteristics analogous to organisms living in areas with a winter rainfall régime.

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