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A STUDY OF CLOUDINESS IN MEXICO THROUGH METEOROLOGICAL SATELLITES

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SUMARIO

Se han analizado las fotografías, obtenidas mediante el receptor de señales RAMSA, de los satélites meteorológicos Nimbus III y ESSA 8 correspondientes a tres años (1969-71) con el objeto de conocer los sitios con mayor número de días despejados en la República Mexicana. Además se han hecho dos comparaciones: la primera con fotografías obtenidas con el satélite Tiros de NASA que cubren toda la Tierra; y la segunda con los datos meteorológicos nocturnos del Observatorio Astronómico Nacional en San Pedro Mártir, B. C. N. pertenecientes al año 1971.

Los principales resultados son tres:
1) Los sitios mexicanos con mayor número de días despejados se encuentran en el noroeste de México.
2) La calidad del cielo en estos lugares durante el día y durante la noche es aproximadamente la misma.
3) También es posible que en el noroeste de México se encuentre el mejor sitio de toda la Tierra. Es decir, aquél con el número mínimo de noches nubladas.

ABSTRACT

We have made a study based on the data of three years (1969-71) obtained with the meteorological satellites Nimbus III and ESSA 8 supplied to us by RAMSA to find places in Mexico with highest number of cloudless days. In addition we also have made two comparisons. The first with data obtained with satellite Tiros of NASA; and second, with the night meteorological data of the Observatorio Astronómico Nacional at San Pedro Mártir, B. C. N. for the year 1971.

The main results are:
1) The Mexican sites with the highest number of cloudless days are located in the Northwest of Mexico.
2) Most likely the quality of the sky in these places is the same on the average during daylight and at night.
3) The Northwest of Mexico probably also contains the best place on the whole planet. It is to say, that with a minimum number of cloudy nights per year.

I. Introduction

Ground-based astronomical observations require better astronomical sites than ever to tackle the present scientific problems. On the other hand, modern technology in our civilization spoils sites.

It is generally accepted that the location of an astronomical observatory should be characterized by:

1) Large number of entirely cloudless nights.

2) Dark sky.

3) Low total water content of the overlying atmosphere.

4) Minimum optical turbulence.

5) Large extent of protected area against air-pollution, other forms of atmospheric deterioration, and illumination.

This paper presents a study of the data of three years (1969-71) obtained with the meteorological satellites Nimbus III and ESSA 8 supplied to us by RAMSA. Our main interest is concerned with the knowledge of cloudiness in Mexico as a guide in the search and selection of astronomical sites. This investigation deals with the above first characteristic. An illustration of the data under discussion is given in Figure 1.

The following sections describe and analyse the meteorological data.

II. Meteorological data

A mosaic of the Mexican Republic is obtained through the meteorological satellites described above. A set of these photographs for 1969-71 is the material to be studied primarily to know the amount of cloudiness in several sites, all located in Mexico.

For this purpose we have divided somewhat arbitrarily the Republic of Mexico in 117 squares

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Fig. 1. *A mosaic of Mexico obtained through the meteorological satellite ESSA 8.*

of approximately 130 kilometers across. Each square in every photograph has been designated by one, and only one, of the three following labels:

a) Cloudless, 0% cloud cover.

b) Cloudy, 100% cloud cover.

c) Partially Cloudy, 0% < cloud cover < 100%.

Next, we have collected these data, month by month, normalized to one hundred. This procedure has the advantage that it takes into account the different lengths of the months, and the fact that we lack a few photographs. Finally, we have obtained the average percentage for the three years. These values are given for every month.

Table 1 lists 117 localities in Mexico. Approximately each lies in the center of one of the squares into which the country was divided. This Table is arranged in alphabetical order of the Mexican states and serial numbers in this order are given in column one (Mexico City is given under "D"-Distrito Federal). Column two gives the name of the location or town, if any. The last three columns of Table 1 list the latitude, longitude and altitude (in meters) of the locations given in column 2. Because of the rather large area contained in each square these three columns refer only to a point inside of this area, near the center. Thus, for instance, the altitudes do not represent the mean altitudes of the squares, but only the approximate altitudes of the locations given in column 2.

T A B L E 1

Some Metereological Zones in Mexico

Nr.	*Place*	*Latitude*	*Longitude*	*Altitude*
1.	Aguascalientes, Ags.	21°53′	102°18′	1888m
2.	Mexicali, B. C. N.	32 40	112 51	0
3.	San Borja, B. C. N.	28 40	113 40	~0
4.	San Fernando, B. C. N.	29 55	115 20	~0
5.	San Pedro Mártir, B. C. N.	31 03	115 27	2850
6.	Bahía Tortugas, B C. S.	27 40	114 50	~0
7.	Cerro de la Giganta, B. C. S.	26 10	111 35	1767
8.	Paz La, B. C. S.	24 10	110 21	10
9.	Punta Sto. Domingo, B. C. S.	26 20	112 35	~0
10.	San Javier, B. C. S.	25 50	111 35	~0
11.	San Luis Gonzaga, B. C. S.	24 55	111 20	~0
12.	Volcán de las Vírgenes, B. C. S.	27 30	112 35	2054
13.	Pustunich, Camp.	19 07	90 25	~0
14.	Tenalso, Camp.	20 02	90 15	~0
15.	Animas Las, Coah.	28 28	103 15	~2500
16.	Palo Verde, Coah.	26 20	101 30	~1000
17.	Saltillo, Coah.	25 27	100 59	1599
18.	Sierra Mojada, Coah.	27 17	102 04	742
19.	Unión, Coah.	28 14	100 44	~500
20.	Colima, Col.	19 14	103 44	508
21.	Comitán, Chis.	16 15	92 44	677
22.	Ocosingo, Chis.	16 55	92 06	908
23.	Tuxtla Gutiérrez, Chis.	16 45	93 07	528
24.	Villa Flores, Chis.	16 14	93 16	610
25.	Ahumada, Chih.	30 37	106 31	1181
26.	Allende, Chih.	26 55	105 25	~1000
27.	Cerro Mahinora, Chih.	25 58	107 03	3300
28.	Corrisal, Chih.	30 30	106 35	~1000
29.	Chapo, Chih.	29 20	104 25	~1000

TABLE 1 (continued)

Nr.	*Place*	*Latitude*	*Longitude*	*Altitude*
30.	Chihuahua, Chih.	28 38	106 05	1430
31.	Delicias, Chih.	28 15	105 45	~1000
32.	Flores Magón Ricardo, Chih.	29 55	106 55	~1000
33.	Gómez Flores V., Chih.	30 32	105 50	~1000
34.	Guachochic, Chih.	26 52	107 10	~2000
35.	Maguarichie, Chih.	27 50	108 03	~2000
36.	Sierra Tasajera, Chih.	29 20	105 35	~1000
37.	MEXICO, DISTRITO FEDERAL	19 26	99 08	2233
38.	Ciudad Lerdo, Dgo.	25 32	103 31	1135
39.	Cuencamé, Dgo.	24 52	103 38	1889
40.	Durango, Dgo.	24 02	104 40	1889
41.	Nombre de Dios, Dgo.	23 51	104 15	1855
42.	Sta. Ma. de Otaez, Dgo.	24 40	105 59	1889
43.	Sta. Ma del Oro, Dgo.	25 57	105 20	1871
44.	Chilpancingo, Gro.	17 33	99 30	1360
45.	San Luis de la Loma, Gro.	17 55	100 54	~0
46.	Teloloapan, Gro.	18 22	99 53	1620
47.	Tepecoacuilco, Gro.	18 17	99 28	1012
48.	Guanajuato, Gto.	21 01	101 15	2050
49.	San Luis de la Paz, Gto.	21 18	100 31	2020
50.	Ixmiquilpan, Hgo.	20 29	99 13	1745
51.	Pisaflores, Hgo.	21 12	99 00	~1000
52.	Cihuatlán, Jal.	19 14	104 34	~0
53.	Guadalajara, Jal.	20 41	103 23	1567
54.	Talpa de Allende, Jal.	20 24	104 50	1039
55.	Aguililla, Mich.	18 44	102 44	970
56.	Huajumbaro, Mich.	19 41	100 44	2390
57.	Morelia, Mich.	19 42	101 12	1941
58.	Tequicheo, Mich.	18 54	100 44	440
59.	Acaponeta, Nay.	22 29	105 22	30
60.	Huajimic, Nay.	21 41	104 18	1170
61.	Jesús María, Nay.	22 15	104 31	610
62.	Ruiz, Nay.	21 57	105 09	24
63.	Aldama, Los, N. L.	26 04	99 11	288
64.	Galeana, N. L.	24 50	100 04	1654
65.	Monterrey, N. L.	25 40	100 18	538
66.	Villaldama, N. L.	26 30	100 26	469
67.	Juquila, Oax.	16 14	97 18	1500
68.	Juxtlahuaca, Oax.	17 20	98 01	1650
69.	Oaxaca de Juárez, Oax.	17 04	96 43	1550
70.	Tecomayaca, Oax.	17 58	97 01	660
71.	Tequisistlán, Oax.	16 24	95 36	1000
72.	Chiautla de Tapia, Pue.	18 17	98 36	1025
73.	Huachinango, Pue.	20 11	98 03	1472
74.	Malinche, La, Pue.	19 14	98 02	4461

TABLE 1 (continued)

Nr.	*Place*	*Latitude*	*Longitude*	*Altitude*
75.	Querétaro, Qro.	20 36	100 23	1821
76.	Cozumel, Q. R.	20 31	86 57	~0
77.	Polyuc, Q. R.	19 37	88 34	~0
78.	Cerritos, S. L. P.	22 26	100 17	1153
79.	Matehuala, S. L. P.	23 39	100 38	1615
80.	Sto. Domingo, S. L. P.	23 20	101 44	1971
81.	Vieja, S. L. P.	22 02	99 25	~100
82.	Cruz, Sin.	23 55	106 55	~0
83.	Culiacán, Sin.	24 49	107 24	52
84.	Laguna, La, Sin.	26 35	108 27	600
85.	Topolobampo, Sin.	25. 36	109 03	3
86.	Altar, Son.	30 43	111 44	~0
87.	Bacadéhuachi, Son.	29 40	109 07	~0
88.	Bacanora, Son.	28 59	109 23	446
89.	Cerro Viejo, Son.	30 15	112 15	1625
90.	Hermosillo, Son.	29 04	110 58	237
91.	Libertad, Son.	29 54	112 45	~0
92.	Onabas, Son.	28 28	109 15	251
93.	Punta Peñasco, Son.	29 55	113 33	61
94.	Quiriego, Son.	27 31	109 15	251
95.	Comalcalco, Tab.	18 16	93 13	5
96.	Villahermosa, Tab.	17 59	92 55	10
97.	Abasolo, Tam.	24 04	98 23	61
98.	Camargo, Tam.	26 19	98 50	68
99.	Casas, Tam.	23 44	98 44	120
100.	Guerrero, Tam.	26 47	99 20	34
101.	Jaumave, Tam.	23 24	99 22	735
102.	Jiménez (Santander) Tam.	24 13	99 29	101
103.	Matamoros, Tam.	25 53	97 31	12
104.	Tampico, Tam.	22 13	97 51	12
105.	Coatzacoalcos, Ver.	18 09	94 25	2
106.	Coatzintla, Ver.	20 29	97 26	144
107.	Cosamaloapan, Ver.	18 22	95 48	96
108.	Ozuluama, Ver.	21 40	97 51	229
109.	Pico Orizaba, Ver.	19 02	97 16	5700
110.	San Felipe, Yuc.	21 34	88 14	~0
111.	Sisal, Yuc.	21 10	90 02	~0
112.	Valladolid, Yuc.	20 41	89 13	22
113.	Concepción del Oro, Zac.	24 37	101 26	2070
114.	Ojo Caliente, Zac.	22 35	102 15	2114
115.	Pinos, Zac.	22 18	101 34	2419
116.	Valparaíso, Zac.	22 46	103 34	2140
117.	Villa de Cos, Zac.	23 18	102 21	2050

Tables 2 and 3 contain the statistics of the analysis performed with the meteorological photographs. Table 2 gives the average percentage of cloudless days (clear sky). Table 3 gives the information which corresponds to partially cloudy days (partially clear sky). The columns of Table 2

TABLE 2

THREE YEARS (1969-71) AVERAGE OF CLOUDLESS DAYS IN MEXICO

Nr.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	MEAN
1	59.7	50.2	66.2	85.9	76.7	56.6	47.1	36.4	19.3	60.1	77.0	75.8	59.2
2	70.6	59.3	83.4	71.4	80.6	78.0	68.3	66.0	82.6	82.0	87.8	74.3	75.4
3	74.2	58.2	85.6	82.4	90.1	88.8	77.3	78.6	86.3	87.9	86.3	74.5	80.8
4	74.3	74.9	87.8	69.3	87.4	81.1	76.5	71.5	82.3	85.6	86.7	83.4	80.1
5	73.5	65.0	92.2	70.6	75.3	82.4	73.0	67.3	88.7	83.3	83.5	76.9	77.6
6	65.6	55.8	69.1	61.9	54.3	42.4	69.9	66.8	51.4	67.6	78.5	69.0	62.7
7	82.2	67.3	80.1	81.8	96.9	91.2	85.6	76.6	86.3	74.4	88.1	81.2	82.6
8	86.5	70.9	77.2	74.7	97.3	88.0	83.3	77.2	70.9	83.1	86.3	63.5	79.9
9	80.0	67.9	77.4	74.0	90.0	84.1	86.6	74.1	70.0	77.4	82.3	73.2	78.1
10	80.6	63.6	80.6	80.8	92.9	87.2	87.6	81.1	80.1	82.3	81.9	77.7	81.4
11	86.5	70.9	77.2	74.7	97.3	88.0	83.3	77.2	70.9	83.1	86.3	63.5	79.9
12	70.6	55.8	74.2	72.1	81.0	77.4	76.8	73.4	65.9	72.6	82.0	69.6	72.6
13	61.8	52.6	52.8	77.6	73.6	57.8	67.4	58.5	42.9	64.3	67.4	74.1	62.6
14	55.2	43.8	70.9	86.7	70.0	64.8	68.2	51.1	43.1	59.8	63.6	76.8	62.8
15	73.1	61.6	64.5	70.2	84.8	77.1	63.6	66.1	62.9	77.3	86.7	72.1	71.7
16	61.7	52.8	61.8	67.9	71.4	65.8	64.9	59.6	45.9	54.4	77.1	67.2	62.5
17	71.9	45.9	70.8	85.0	72.4	67.0	70.6	61.0	49.1	53.0	73.5	72.3	66.0
18	73.9	56.6	58.5	68.9	80.8	80.0	66.6	65.0	50.7	68.8	76.5	72.1	68.2
19	46.8	58.7	54.4	42.1	52.1	37.9	79.8	64.9	50.3	35.1	51.7	39.0	51.1
20	79.8	78.2	76.6	91.8	90.1	47.0	41.1	25.8	23.1	57.5	65.9	76.3	62.8
21	49.3	35.1	70.1	71.5	51.4	24.1	32.0	28.5	16.7	35.1	15.7	61.0	40.9
22	46.3	45.0	60.3	65.4	53.1	29.8	40.9	23.2	29.8	29.6	44.3	40.6	42.4
23	41.7	39.9	57.6	65.2	59.6	34.1	32.8	20.2	15.8	30.7	33.8	60.7	41.0
24	54.7	36.1	63.9	78.6	60.3	37.3	38.2	30.7	23.6	43.6	63.2	79.3	50.8
25	74.9	56.3	82.7	82.1	70.4	77.5	64.4	77.1	75.9	70.0	76.3	60.3	72.3
26	77.8	73.5	71.9	72.2	80.1	81.7	57.5	61.0	68.0	73.8	83.6	77.3	73.2
27	84.2	65.2	75.4	77.5	80.5	74.5	44.0	44.6	51.9	71.6	89.6	76.5	69.6
28	75.4	70.4	79.2	76.3	74.4	76.0	71.3	70.4	65.4	74.9	59.8	67.7	71.8
29	69.4	54.8	70.2	72.1	76.2	80.0	63.3	67.5	71.9	72.4	74.4	76.9	70.8
30	81.4	68.8	73.6	79.8	84.7	82.4	50.8	58.1	73.8	76.2	82.1	77.5	74.1
31	76.3	60.4	69.9	74.7	84.7	82.4	57.1	64.8	73.2	74.9	87.0	72.7	73.2
32	79.9	68.8	78.1	78.2	81.5	80.5	58.3	62.0	78.1	72.7	78.5	71.0	74.0
33	76.9	61.0	77.0	69.9	73.0	81.0	64.8	73.0	74.9	74.8	70.8	66.2	71.9
34	79.0	79.1	76.9	78.5	81.7	81.4	47.5	53.5	61.1	77.5	80.4	77.1	72.8
35	84.7	71.4	86.3	79.8	81.5	79.0	61.3	62.2	72.4	81.2	83.5	74.0	76.4
36	69.4	70.3	74.0	70.5	73.0	83.7	62.1	66.1	73.7	73.7	75.6	72.5	72.0
37	69.5	66.1	63.9	87.8	80.1	43.8	40.4	20.9	23.1	55.2	81.7	89.9	60.2
38	80.6	58.9	67.9	68.3	76.4	72.4	69.9	57.6	50.7	71.1	83.7	70.3	69.0
39	72.5	61.0	68.2	75.6	82.3	62.7	64.1	51.6	45.9	77.2	91.0	73.1	68.8
40	80.1	53.9	59.5	85.2	82.6	62.3	63.3	51.5	38.6	70.0	89.5	76.2	67.7
41	74.7	65.7	70.5	85.2	70.5	60.7	45.2	34.2	35.6	67.5	84.4	71.0	63.8
42	70.5	68.4	70.9	78.5	74.1	63.8	55.1	38.6	37.8	74.8	87.4	68.7	65.7
43	82.0	69.3	75.2	74.7	80.0	79.4	58.9	53.3	56.5	72.4	87.4	73.7	71.9
44	91.0	78.2	85.1	97.4	80.3	32.0	47.6	35.0	33.0	65.7	97.3	82.3	68.7
45	94.7	88.5	85.5	97.4	93.3	50.8	46.7	38.0	34.5	74.3	85.7	85.9	72.9
46	90.2	81.3	73.2	95.8	83.3	37.4	36.2	24.0	41.1	51.8	84.8	84.4	65.3
47	82.2	61.0	74.4	95.8	83.2	51.3	35.1	25.3	26.2	60.7	89.3	82.7	63.9
48	69.7	64.7	69.5	90.1	84.1	57.0	37.6	31.3	34.5	63.7	79.3	82.9	63.7
49	66.7	73.9	57.4	77.3	68.3	49.0	39.8	32.2	13.8	46.4	56.4	73.3	54.5
50	57.1	41.4	58.4	77.6	78.2	44.8	35.1	25.0	27.1	48.8	64.6	73.3	52.6

TABLE 2 (continued)

Nr.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	MEAN
51	48.7	35.2	47.8	48.9	46.5	38.1	39.4	29.0	17.8	39.4	55.0	42.6	40.7
52	85.0	92.3	84.3	93.2	93.7	68.7	54.8	42.3	34.8	68.4	86.8	79.8	73.7
53	80.6	76.7	68.0	90.1	81.7	50.3	36.7	26.6	29.2	61.2	81.0	77.4	63.3
54	86.5	82.4	70.9	91.0	94.1	67.4	45.6	34.0	35.1	56.1	89.5	79.5	69.3
55	93.3	81.3	76.9	90.6	87.8	51.5	45.7	25.5	32.5	53.8	83.7	80.7	66.9
56	80.5	70.9	73.8	90.3	81.4	39.3	36.4	17.6	18.1	58.8	85.2	90.8	61.9
57	81.4	71.0	76.9	89.4	87.7	36.2	39.4	21.3	17.9	50.4	76.8	84.2	61.0
58	94.7	88.5	78.6	91.9	90.6	60.5	58.6	29.8	32.1	70.7	84.2	82.5	71.9
59	88.8	65.2	64.8	85.0	92.2	60.3	55.8	49.2	36.8	69.8	84.1	75.5	69.0
60	81.2	80.9	63.2	85.7	79.0	60.0	53.8	30.9	37.3	68.8	78.9	69.9	65.8
61	66.5	62.2	59.8	91.6	80.3	58.8	47.1	39.2	32.1	63.7	84.0	77.6	63.6
62	82.8	74.7	66.4	89.1	93.0	61.8	57.6	40.9	45.5	69.6	79.3	73.0	69.5
63	33.2	36.5	48.5	52.3	41.1	59.8	86.5	60.1	51.2	32.9	55.0	46.8	50.3
64	65.7	50.0	51.7	63.5	50.0	55.8	73.3	53.5	46.8	44.6	65.0	68.2	57.3
65	53.2	46.8	60.7	56.5	50.0	49.3	74.8	61.0	49.4	36.1	60.9	63.1	55.1
66	39.1	42.3	61.9	45.3	56.1	42.4	81.0	37.1	43.7	30.6	67.5	49.5	49.7
67	88.1	54.4	82.5	98.4	69.7	58.4	31.7	33.8	25.1	67.7	87.2	94.1	65.9
68	72.5	45.6	74.7	92.9	80.5	62.8	39.8	33.5	22.8	56.5	70.2	68.9	60.1
69	54.0	25.8	58.6	80.2	65.6	37.4	43.7	22.5	8.3	37.5	47.3	61.5	45.2
70	49.2	31.5	47.8	69.3	55.6	39.3	17.5	23.8	15.8	30.7	38.8	38.7	38.2
71	46.0	31.5	55.4	61.7	52.9	28.1	19.0	20.2	7.1	45.2	28.4	49.6	37.1
72	59.2	38.3	63.8	90.1	69.9	51.7	17.5	30.6	58.6	56.5	88.8	66.0	57.6
73	45.1	33.7	34.6	52.7	50.8	36.3	26.1	28.5	21.1	42.5	44.6	51.6	39.0
74	49.4	46.7	48.7	78.3	61.3	34.6	40.1	32.8	22.5	50.0	55.4	74.7	49.5
75	70.9	52.2	63.7	88.8	83.2	46.2	40.4	28.6	27.9	63.9	83.6	82.7	61.0
76	59.7	69.2	59.4	81.1	69.1	58.8	71.2	60.5	50.6	65.7	75.5	92.5	67.8
77	64.0	71.9	64.4	79.8	77.3	49.6	64.9	52.9	45.3	63.2	65.9	71.2	64.2
78	63.9	48.3	53.8	69.6	52.5	60.8	72.3	54.8	30.3	53.9	64.4	69.1	57.8
79	39.1	42.3	61.9	45.3	56.1	42.4	81.8	37.1	43.7	30.6	67.5	49.5	49.8
80	68.5	44.6	50.2	73.1	68.6	54.7	59.0	35.1	19.4	47.7	54.2	56.5	52.6
81	50.2	36.7	36.4	43.8	47.1	46.0	46.0	51.7	24.1	31.8	58.5	39.7	42.7
82	86.5	66.6	73.2	86.5	84.5	70.1	56.2	39.2	54.4	77.9	85.5	70.1	70.9
83	82.0	65.1	72.6	82.4	86.9	74.5	49.2	42.8	47.4	76.3	83.9	74.9	69.8
84	85.7	77.6	80.1	80.1	83.8	83.4	56.0	56.8	66.8	78.7	80.3	75.2	75.4
85	82.0	70.2	77.3	81.4	92.4	86.7	59.8	58.4	58.1	82.3	92.5	78.5	76.6
86	73.4	65.1	81.6	83.1	94.9	86.7	77.2	70.9	83.2	77.3	79.2	75.5	79.0
87	71.9	71.9	84.3	84.2	78.1	82.8	72.4	80.7	79.2	75.0	81.9	64.2	77.2
88	79.9	68.7	89.1	82.6	84.4	81.8	72.4	66.9	77.1	70.4	83.9	74.2	77.6
89	72.8	73.4	92.0	84.9	92.6	60.2	77.1	69.3	88.2	87.6	84.3	74.8	79.8
90	78.0	64.6	85.0	86.8	94.5	90.2	76.9	75.6	86.5	90.7	85.8	77.1	82.6
91	73.4	79.1	90.7	87.1	88.3	86.8	73.8	72.4	85.1	80.0	78.9	74.0	80.8
92	76.4	68.9	84.8	83.1	91.4	89.8	72.5	67.0	77.3	84.5	83.9	74.0	79.5
93	70.4	61.9	92.2	79.7	93.1	91.4	76.9	77.0	85.7	85.6	86.3	75.4	81.3
94	82.8	64.6	83.1	80.1	88.7	83.4	73.8	70.9	71.9	83.4	89.0	74.8	78.9
95	37.3	31.4	42.6	62.6	58.1	38.4	42.3	26.8	29.0	37.8	36.9	39.0	40.2
96	47.0	60.0	48.8	69.3	72.4	54.1	61.2	51.0	37.4	47.1	52.1	64.5	55.4
97	44.8	50.4	58.9	51.4	50.6	55.0	85.2	72.9	46.9	43.9	54.4	55.4	55.8
98	33.2	36.5	48.5	52.3	41.1	59.8	86.5	60.1	51.2	32.9	55.0	46.8	50.3
99	44.5	68.1	37.7	47.9	46.5	51.0	81.4	65.4	52.6	34.0	49.1	53.5	52.6
100	33.2	46.0	52.6	44.1	32.2	47.2	91.8	67.1	64.8	38.9	59.3	47.7	52.1

TABLE 2 (continued)

Nr.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	MEAN
101	44.6	46.2	41.0	58.5	48.9	47.2	74.6	54.3	40.2	25.8	46.2	56.3	48.6
102	49.6	45.1	48.7	53.4	46.1	56.7	79.9	62.0	46.8	34.1	42.7	57.1	51.8
103	29.2	33.5	44.4	49.5	53.0	59.8	86.5	78.6	54.3	41.3	56.5	42.1	52.4
104	50.7	53.4	35.1	45.7	42.4	43.2	59.9	52.8	38.2	44.1	42.6	42.5	45.9
105	54.8	60.0	39.2	66.4	59.4	48.1	40.1	33.5	26.4	34.2	39.2	41.1	45.2
106	52.6	55.4	34.6	51.4	64.7	39.8	42.9	43.6	32.1	42.6	51.0	54.3	47.1
107	38.0	30.1	43.2	57.5	57.4	32.9	18.3	21.9	13.2	29.5	22.3	22.7	32.2
108	46.5	42.1	38.6	37.4	40.5	35.2	43.8	42.5	27.6	41.6	51.7	27.3	39.6
109	40.1	49.6	39.2	56.9	48.3	44.4	29.1	32.3	34.3	34.4	44.1	39.9	41.0
110	53.3	49.5	54.9	77.3	68.8	66.7	76.7	65.3	44.6	56.0	67.7	86.1	63.9
111	63.1	49.5	66.8	83.0	72.2	67.7	83.2	69.0	54.6	60.6	70.0	86.2	68.8
112	57.3	69.4	53.2	76.5	58.9	54.2	75.3	52.3	44.6	60.8	65.9	78.7	62.3
113	70.5	49.6	58.8	76.9	74.8	67.2	69.6	57.4	50.0	64.9	68.2	74.9	65.2
114	68.2	47.7	62.1	82.7	77.2	60.3	59.5	42.9	29.0	68.4	74.4	79.9	62.7
115	81.2	63.7	63.2	85.7	79.0	60.0	53.8	30.9	37.3	68.8	78.9	69.9	64.4
116	66.5	62.2	59.8	91.6	80.3	58.8	47.1	39.2	32.1	63.7	84.0	77.6	63.6
117	71.4	47.0	60.3	69.8	83.7	67.6	72.1	52.8	35.8	69.8	78.5	79.5	65.7

TABLE 3

THREE YEARS (1969-71) AVERAGE OF PARTIALLY CLOUDY DAYS IN MEXICO

Nr.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	MEAN
1	17.0	14.2	13.6	8.6	6.9	10.3	22.1	25.3	24.7	19.9	12.6	7.9	15.3
2	17.5	14.7	9.1	13.3	13.7	11.5	13.5	0.6	11.9	9.7	5.7	13.7	11.2
3	7.4	13.6	5.6	10.7	6.7	4.4	8.9	10.1	7.6	7.5	3.2	10.4	8.0
4	7.3	7.3	4.8	16.7	8.1	10.3	10.8	12.7	7.6	7.4	1.7	3.2	8.2
5	13.3	20.5	3.4	15.7	20.8	7.3	14.0	17.3	6.8	5.0	4.9	9.7	11.6
6	17.2	14.1	14.7	21.8	21.7	23.2	22.7	8.5	21.9	16.9	11.8	0.0	16.2
7	8.8	19.3	7.7	4.5	3.1	3.7	10.7	11.3	9.1	21.0	6.8	4.6	9.2
8	13.5	6.2	10.6	9.1	1.4	3.4	11.3	4.1	12.4	10.6	6.0	21.0	9.1
9	8.8	16.1	10.3	11.0	6.8	14.1	3.0	12.4	19.9	9.6	12.0	11.0	11.3
10	5.1	10.4	9.2	4.2	5.8	7.8	6.7	8.4	7.4	4.8	8.0	7.2	7.1
11	12.7	14.6	8.4	10.6	4.6	4.6	6.9	6.8	9.6	7.0	8.8	16.4	9.3
12	13.9	20.9	19.6	18.4	12.3	13.9	17.9	14.0	21.9	19.2	11.7	18.1	16.8
13	17.7	19.2	14.7	10.7	9.1	16.0	11.0	9.8	10.8	7.6	8.7	11.0	12.2
14	23.6	19.8	14.1	1.2	10.0	14.5	15.3	13.9	17.5	9.7	16.7	10.7	13.9
15	11.0	10.4	14.0	5.5	10.7	9.9	18.9	15.8	13.6	3.7	4.0	9.4	10.6
16	14.8	4.8	18.4	8.4	16.5	16.3	19.8	17.9	24.9	14.5	5.3	5.9	14.0
17	4.4	7.8	9.8	0.0	16.8	10.8	12.0	14.3	23.7	18.2	6.6	12.4	11.4
18	7.3	20.9	12.2	11.3	9.3	4.6	18.8	15.1	28.7	6.2	3.6	10.9	12.4
19	8.1	10.4	10.2	14.8	16.7	18.6	8.5	11.0	7.6	5.4	7.3	10.4	10.8
20	13.5	6.2	17.2	5.6	4.1	24.6	25.9	20.8	18.8	24.4	8.6	14.5	15.4
21	12.8	29.4	9.9	14.2	14.9	14.1	13.1	9.8	20.3	14.6	32.4	10.4	16.3
22	10.2	21.6	11.1	14.8	20.1	20.1	20.0	21.5	10.8	14.6	11.9	15.8	16.0
23	5.9	20.7	9.8	14.5	9.5	14.0	22.4	20.4	7.6	16.7	16.9	13.5	14.3
24	9.0	23.3	17.3	14.4	8.3	22.0	19.7	12.8	21.5	14.3	9.7	9.0	15.1
25	15.5	13.6	7.6	5.5	14.4	7.6	18.9	10.3	10.9	4.9	21.3	9.4	11.7
26	9.5	7.2	8.9	8.3	11.3	6.0	15.4	14.5	11.0	7.1	5.1	1.5	8.8
27	9.0	14.5	15.2	9.1	1.4	13.2	33.0	17.7	18.0	10.8	9.1	8.1	13.3
28	10.6	9.3	4.4	4.6	14.4	11.3	12.7	12.7	14.3	8.4	23.4	4.4	10.9
29	9.7	16.7	6.7	7.8	10.8	8.5	23.1	11.3	7.5	5.0	7.1	7.4	10.1
30	12.0	12.1	6.6	2.7	8.6	10.5	13.8	21.3	4.4	4.8	5.3	5.2	8.9
31	9.5	11.0	8.7	2.6	8.7	7.4	22.5	15.8	10.6	5.0	4.1	8.0	9.5
32	10.5	18.2	3.0	7.8	8.6	4.1	22.0	18.5	8.8	9.6	10.1	8.1	10.8
33	9.8	11.9	5.0	8.1	15.2	14.5	13.6	14.8	6.8	4.9	5.7	6.3	9.7
34	9.8	9.4	12.6	11.9	9.2	6.5	25.1	9.2	20.6	1.4	6.8	3.0	10.5
35	7.5	16.1	1.5	5.2	6.8	13.5	10.8	15.5	10.9	8.3	5.5	6.2	9.0
36	13.5	13.6	4.0	7.8	15.3	7.0	18.8	24.0	4.6	4.9	3.7	8.1	10.4
37	15.0	15.7	14.3	9.7	10.5	23.0	21.6	25.6	19.9	20.8	11.8	5.1	16.1
38	7.4	11.9	15.8	9.4	9.9	10.9	12.1	17.3	21.4	10.1	4.1	7.6	11.5
39	14.9	11.5	13.7	15.2	8.3	15.9	23.6	21.2	16.7	9.9	1.7	9.5	13.5
40	9.6	11.8	24.9	12.0	12.4	21.4	18.7	15.6	21.0	16.2	6.0	4.9	14.5
41	17.9	3.1	19.3	11.0	16.8	19.3	35.1	20.4	19.0	14.8	7.2	9.7	16.1
42	12.1	13.0	16.9	11.0	8.3	16.2	24.5	26.3	21.3	10.0	4.1	12.6	14.7
43	6.8	14.6	14.6	8.4	6.9	10.3	20.8	37.6	19.1	9.9	5.2	6.1	13.4
44	3.0	4.6	7.2	0.1	14.4	22.3	18.1	19.1	15.6	16.9	0.0	14.4	11.3
45	3.1	5.7	10.0	1.4	2.7	11.0	6.4	8.1	12.6	10.9	8.2	11.1	7.6
46	6.7	7.2	18.1	3.9	11.0	22.8	22.2	21.7	9.9	25.8	10.2	11.1	14.2
47	8.2	18.9	8.7	1.7	11.0	16.0	35.1	22.0	17.1	14.8	6.8	11.1	14.3
48	18.4	13.6	12.4	7.4	14.1	13.3	26.1	15.7	28.0	14.8	8.7	7.6	15.0
49	17.7	11.9	16.3	7.1	22.7	16.5	30.1	26.8	17.8	25.7	15.6	14.1	18.5
50	21.4	16.6	14.3	9.9	12.3	20.0	26.1	20.9	17.2	27.0	15.2	11.3	17.7

TABLE 3 (continued)

Nr.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	MEAN
51	19.8	6.2	12.8	16.8	23.0	17.5	23.7	22.5	16.9	21.8	10.4	18.2	17.5
52	12.0	6.2	8.8	3.0	0.1	7.6	11.7	4.4	16.6	4.8	7.1	7.7	7.5
53	12.7	16.1	16.0	4.3	10.6	22.9	26.3	21.2	14.3	12.6	8.6	8.2	14.5
54	8.2	11.9	14.0	4.6	1.9	11.3	23.5	12.7	22.9	22.4	1.7	4.7	11.7
55	6.7	8.7	16.7	4.3	7.8	17.1	15.7	14.8	17.5	24.3	5.2	9.9	12.4
56	14.9	9.4	13.8	5.9	9.7	29.3	27.2	21.7	29.8	21.7	4.3	4.5	16.0
57	11.9	9.2	16.7	5.5	7.8	26.6	31.6	15.0	25.4	25.2	15.3	8.2	16.5
58	3.1	8.4	15.2	3.0	6.8	12.3	22.6	16.8	16.1	7.2	4.8	6.4	10.2
59	6.0	21.8	13.9	6.8	3.3	12.2	23.5	12.9	25.3	15.9	3.6	6.9	12.7
60	10.6	23.2	13.7	8.9	13.3	15.0	19.5	25.9	20.5	12.4	5.7	9.2	14.8
61	21.5	16.4	21.4	4.3	8.1	13.0	34.9	21.7	22.1	17.2	2.1	8.4	15.9
62	11.3	14.9	11.9	5.5	2.0	13.0	16.9	18.6	14.3	11.3	6.8	6.3	11.1
63	8.1	10.5	12.9	22.5	24.0	10.0	1.5	13.3	7.5	14.6	3.3	17.2	12.1
64	15.3	3.0	18.1	12.5	32.4	12.8	10.3	12.1	20.8	20.6	10.4	15.6	15.3
65	13.2	4.7	11.1	21.5	22.4	16.2	12.0	14.3	12.5	13.7	11.2	14.5	13.9
66	12.4	8.0	19.5	30.4	21.2	22.2	12.7	36.9	22.0	18.4	2.9	16.6	18.6
67	8.1	21.6	4.1	0.0	22.6	13.4	11.0	11.3	13.4	6.3	8.2	4.4	10.4
68	13.3	18.5	11.4	4.6	9.6	5.7	6.3	19.1	14.7	12.5	10.4	17.2	11.9
69	19.1	25.8	11.7	9.0	14.3	15.4	8.9	21.2	15.1	15.8	17.0	17.6	15.9
70	12.3	22.9	11.7	7.1	38.1	21.6	25.1	22.8	15.2	10.5	11.3	10.1	17.4
71	11.9	21.3	16.7	16.0	23.0	18.7	15.8	15.8	20.6	1.9	19.5	14.2	16.3
72	12.4	19.9	14.2	4.5	16.4	15.8	25.1	16.0	11.8	11.3	0.5	10.6	13.2
73	26.3	17.0	15.9	12.6	11.9	22.7	34.9	16.7	26.5	21.1	19.5	16.7	20.2
74	14.7	14.2	12.8	9.6	17.5	33.0	24.8	13.9	23.2	14.7	20.4	15.6	17.9
75	20.9	9.5	14.2	4.5	12.3	24.6	26.4	24.5	21.3	22.9	5.2	6.3	16.1
76	17.0	9.5	17.3	5.3	8.1	16.7	11.6	11.0	17.6	17.4	8.4	4.8	12.1
77	17.7	13.4	18.3	7.2	13.2	15.8	10.7	11.4	11.4	6.3	8.6	7.6	11.8
78	16.3	11.9	14.8	14.8	33.1	13.0	14.9	8.5	22.5	14.8	10.0	10.4	15.4
79	12.4	8.0	19.5	30.4	21.2	22.2	11.9	36.9	22.0	18.4	4.9	16.6	18.7
80	17.4	14.0	16.9	8.8	4.3	15.9	21.3	26.8	17.8	14.9	11.6	21.5	15.9
81	22.2	10.7	16.3	18.0	16.3	16.6	27.0	28.1	20.1	19.7	7.4	23.6	18.8
82	8.2	6.2	8.7	6.9	3.8	5.9	18.8	18.6	14.8	7.7	9.1	13.1	10.2
83	10.5	16.1	13.9	3.3	2.7	7.8	27.7	11.2	29.1	10.8	11.2	8.6	12.7
84	8.3	9.4	7.7	9.0	7.7	5.3	26.1	12.9	19.3	6.1	9.6	6.5	10.7
85	3.7	8.0	9.5	5.2	4.6	4.5	13.4	10.7	16.8	4.8	7.5	4.5	7.8
86	14.9	21.9	9.2	7.8	3.3	5.0	12.4	17.0	0.0	9.8	2.0	8.0	9.3
87	10.4	12.5	3.3	5.6	15.1	9.2	11.9	8.5	9.2	12.0	5.2	11.6	9.5
88	11.9	15.7	3.2	5.6	8.4	11.9	9.6	15.2	13.6	15.6	5.1	10.7	10.5
89	12.5	7.3	4.0	8.7	0.1	23.3	8.9	5.8	6.0	2.9	10.7	8.7	8.2
90	6.5	12.1	4.0	8.1	0.1	2.0	12.9	8.5	4.5	3.7	5.7	6.0	6.2
91	4.4	9.4	3.5	2.7	6.4	7.9	14.4	14.1	4.4	7.2	8.2	4.8	7.3
92	12.5	15.5	7.6	8.0	5.1	3.9	12.0	21.0	10.5	5.0	4.0	11.2	9.7
93	14.9	17.8	3.4	9.9	5.6	3.6	13.3	9.7	7.3	8.5	3.7	14.1	9.3
94	9.0	23.5	6.2	9.4	4.1	11.8	11.8	7.2	6.4	7.2	2.1	6.9	8.8
95	19.6	26.6	10.2	10.7	13.7	20.3	40.5	19.6	17.2	13.6	17.3	16.7	18.8
96	14.5	21.5	19.9	8.1	6.5	12.9	12.0	12.7	12.8	11.4	7.7	7.7	12.3
97	10.9	10.4	10.2	10.4	16.8	12.6	6.9	16.5	10.6	12.1	6.3	7.8	11.0
98	8.1	10.5	12.9	22.5	24.0	10.0	1.5	13.3	7.5	14.6	3.3	17.2	12.1
99	11.5	5.8	13.7	10.7	16.1	12.0	6.8	25.4	8.4	23.4	4.8	9.8	12.4
100	3.6	12.5	14.8	23.7	31.6	9.1	4.4	10.9	18.3	7.5	1.6	6.2	12.0

TABLE 3 (continued)

Nr.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	MEAN
101	12.4	4.7	8.2	14.2	18.1	17.8	12.3	12.4	22.6	20.9	9.5	7.3	13.4
102	4.6	4.7	8.9	19.2	14.9	14.0	9.3	12.2	12.0	10.0	13.2	15.8	11.6
103	10.7	16.2	16.4	9.1	12.6	12.4	7.1	3.1	8.4	11.0	8.1	8.2	10.3
104	12.1	9.3	17.9	12.6	26.2	16.2	15.4	10.9	17.4	14.7	9.8	21.6	15.3
105	13.3	7.3	17.4	8.1	12.0	9.2	12.1	8.1	15.4	32.0	8.3	6.5	12.5
106	12.7	5.2	15.9	8.4	6.4	13.8	20.7	9.9	14.0	11.1	5.4	9.4	11.1
107	15.1	24.4	8.9	10.3	36.3	16.2	22.0	18.9	13.2	8.4	11.7	9.2	16.2
108	14.9	11.9	12.8	13.8	14.8	13.2	23.4	2.8	12.7	11.4	2.1	17.6	12.6
109	14.8	6.2	17.4	10.3	18.9	19.8	27.7	11.4	6.2	8.8	13.5	18.6	14.5
110	23.4	16.7	18.2	10.7	7.6	16.9	14.3	11.2	30.2	28.2	19.5	8.0	17.1
111	21.6	16.7	6.3	6.5	6.9	13.9	9.0	11.8	20.6	12.4	17.3	7.9	12.6
112	20.8	13.7	18.9	9.1	26.5	12.5	9.1	13.9	17.5	8.6	16.4	11.9	14.9
113	9.0	9.2	19.6	15.5	18.8	6.6	17.0	15.4	16.0	16.3	12.3	7.7	13.6
114	15.6	15.7	11.8	8.1	8.4	11.3	21.4	21.0	14.7	12.7	9.7	3.2	12.8
115	10.6	23.2	13.7	8.9	13.3	15.0	19.5	22.9	20.5	12.4	5.7	9.2	14.6
116	21.5	16.4	21.4	4.3	8.1	13.0	34.9	22.7	22.1	7.2	2.1	8.4	15.2
117	12.6	14.9	18.4	24.8	8.2	12.4	12.3	18.7	20.8	11.2	3.7	7.9	13.8

list first, the serial number given in Table 1; second through thirteenth, the 1969-1971 average percentages of cloudless days for each month; and last, the mean value of averages given in columns 2-13. The columns of Table 3 contain the 1969-71 average percentages of partially cloudy days. They are arranged as in Table 2.

The data on cloudy days can easily be obtained from Tables 2 and 3, and equation 1; since for every entry:

$$100.0 = \text{cloudless} + \text{partially cloudy} + \text{cloudy} \qquad (1)$$

III. Discusion

The analysis of the meteorological data contained in Tables 2 and 3 could include many comparisons of the several parameters. We begin by constructing a histogram for *clear sky* and *latitude*. This is shown in Figure 2. The data given in Tables 1 and 2 have been divided in six zones three degrees wide in latitude. Thus this figure shows the average percentage of clear sky

Figure 2

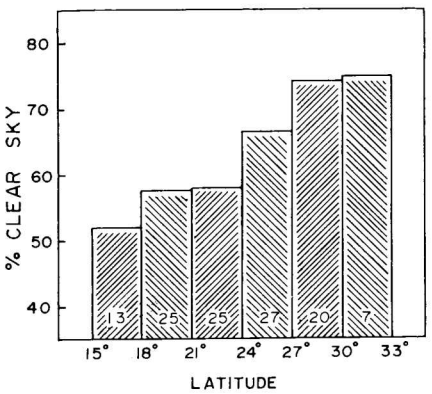

Figure 3

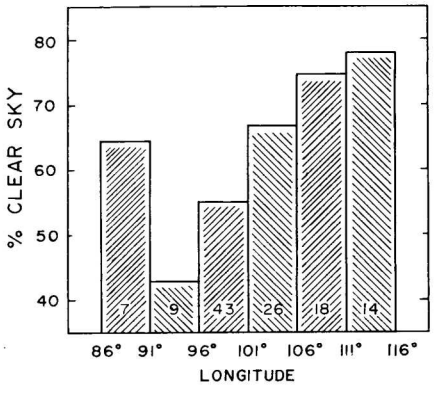

Figure 4

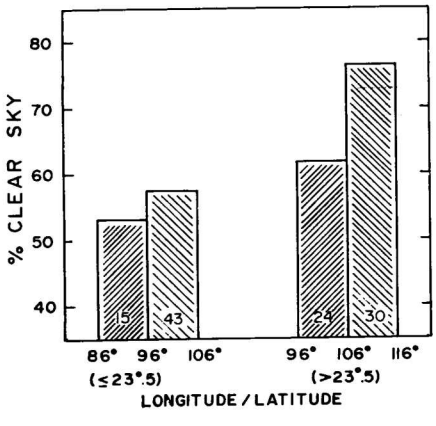

Fig. 2. *A histogram showing the distribution of cloudless days in Mexico during 1969-71 as a function of latitude.*

Fig. 3. *A histogram showing the distribution of cloudless days in Mexico during 1969-71 as a function of longitude.*

Fig. 4. *A histogram showing the distribution of cloudless days in Mexico during 1969-71 North and South of Tropic of Cancer, and also as a function of the longitude. Note that there are practically equal number of localities north and south of the Tropic of Cancer.*

in each zone. The figures inside correspond to the number of places in each zone (see Table 1). This histogram indicates that northern Mexico has the highest number of cloudless days.

Another histogram that of *clear sky* and *longitude* is shown in Figure 3. The same data used in Figure 2 has been divided in six zones five degrees wide in longitude. Thus Figure 3 shows the average percentage of clear sky in each zone. Inside the histogram are given the number of entries on which the averages are taken. This histogram indicates that western Mexico has the highest number of cloudless days.

Next, we have combined latitude and longitude in Figure 4. The data have been divided first in two parts, North and South of the tropic of Cancer, and second, each side in zones ten degrees wide in longitude. The results are illustrated graphically in Figure 4. This histogram, as expected, clearly indicates that it is the Northwest of Mexico that has the highest number of cloudless days.

Figure 5 shows the Mexican Republic with the average percentages of cloudless days in each Mexican State. Once again the Northwest shows the highest averages.

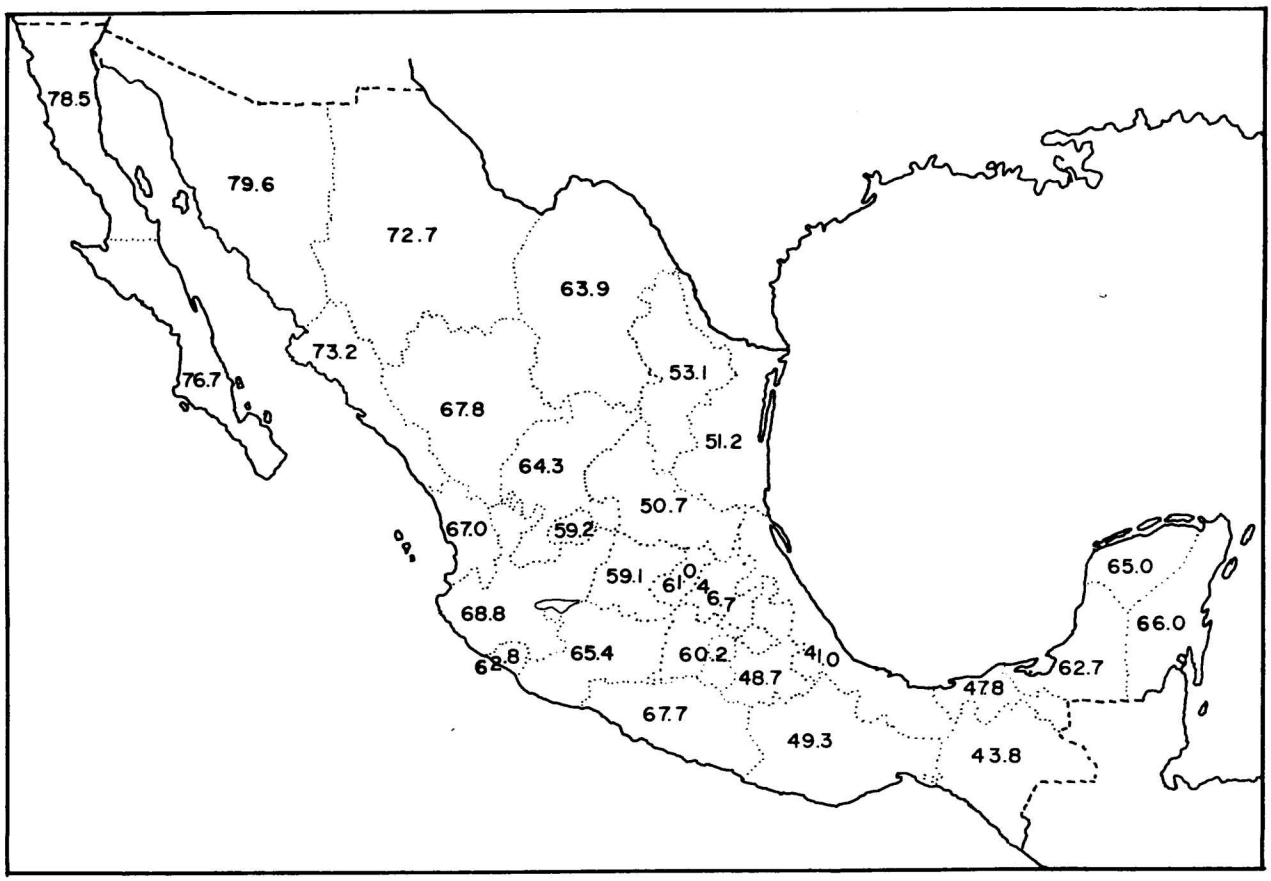

Fig. 5. *The Mexican Republic showing the three years average percentage by State.*

The whole data obtained through the meteorological satellites refer to daylight. However, the majority of the astronomical observations are carried out during the night. To correlate cloudless days with cloudless nights we have chosen the Observatorio Astronómico Nacional at San Pedro Mártir, B. C. N. (see Table 1, fifth row) which is located in the Northwest of Mexico. It is interesting to mention that this astronomical site was selected taking into account the data obtained with the Satellite Tiros of NASA (cf. Mendoza 1971, 1973) up to 1968. At this observatory record of cloudiness is kept every night. We have complete data for 1971. Figure 6 shows the monthly averages of cloudiness for this year at this place, both day (white) and night (black). This histogram indicates that day and night averages are approximately equal (76.8 *versus* 79.0%).

It should be pointed out first, when dealing with weather that practically there are no two places alike; second, the three years' average percentage given in Tables 2 and 3 are formed with values that often differ by more than 10%; and third, the night data correspond to the average of the whole night while the daylight data only to the time in which the pictures were taken.

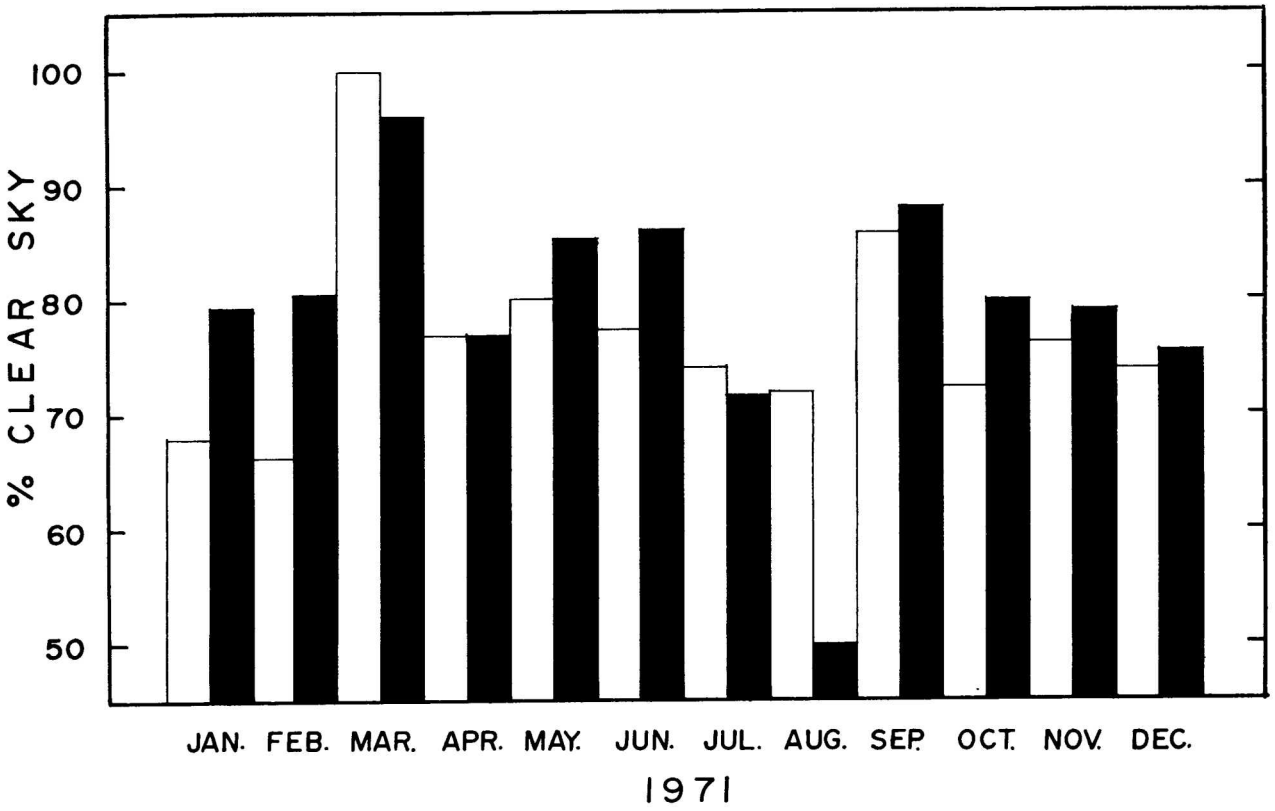

Fig. 6. *A histogram showing the 1971 monthly averages for daylight (white) and night (black). Note the similarity between the two sets of data*

Studies made at the Observatorio Astronómico Nacional (cf. Mendoza 1971, 1973) from 1968 to 1972 indicate that this astronomical site is one of three areas in the world having a minimum number of cloudy nights. The other two are a region along the West coast of Africa and an area in Chile a few degrees North of La Serena.

The present analysis should be extended to a longer period of time to have more reliable results. Night and daylight comparisons also should be made in more places.

IV. Conclusions

We have made a study based on more than 1000 photographs obtained through meteorological satellites. The main results are:

i) The Mexican sites with the highest number of cloudless days are located in the Northwest of Mexico.

ii) Most likely the quality of the sky in these places is the same on the average during daylight and night.

iii) The Northwest of Mexico probably also contains the best place on the whole planet. It is to say, that with a minimum number of cloudy nights per year.

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