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ASSESSMENT OF THE QUALITY OF 'GATE' AREA RAINFALL DATA FROM A NIMBUS-5 RADIOMETER

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FINAL REPORT

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INTRODUCTION

The purpose of the study is to evaluate the quality of rainfall intensity estimates derived from passive microwave measurements by the Electrically Scanned Microwave Radiometer (ESMR-5) aboard the NIMBUS-5 satellite. The microwave measurements used are those coincident with the GARP (Global Atmospheric Research Program) Atlantic Tropical Experiment (GATE). ESMR-5 derived rainfall intensity estimates are compared with hourly averaged GATE radar rainfall measurements. Using the radar measurements as ground truth it is determined that with the transfer curves derived herein the ratio (ESMR-5 derived rain rate)/radar measured rain rate) has a mean of approximately 0.62.

RESEARCH PLAN

The ESMR-5 data set used herein consists of computer printouts of microwave brightness temperature measurements for seventy-nine NIMBUS-5 overpasses coincident with GATE radar rainfall measurements. The following tasks were done in assessing the quality of these data:

1. Collect and verify computer printouts of ESMR-5 GATE coincident data.
2. Convert ESMR-5 brightness temperatures to rain intensity estimates for the two-degree square of the earth's surface centered at (23.5° W, 8.5° N).
3. Compare ESMR-5 derived rain intensity estimates with coincident GATE measurements of rainfall.

METHODOLOGY

1. Data Collection and Preparation

The ESMR-5 data are available on computer tape at Goddard Space Flight Center. Their references are given in Table 1. The printouts indicate brightness temperatures with their latitude-longitude locations and beam positions.

Those data points coincident with GATE are located and plotted on a grid representing the two-degree square centered at (23.5° W, 8.5° N). Beam position, brightness temperature, and scan angle are recorded for each.

GATE radar rainfall data are available on both magnetic tape and microfilm from the GATE World Archives. Also, a GATE Radar Rainfall Atlas is available [2]. Among the data sets contained in the Atlas are tables indicating mean area precipitation rates for various time intervals for the fifteen geographic areas shown in Figure 1 [2]. In this study hourly averaged GATE radar rain data for the entire GATE area (Figure 4) on a grid of 0.25° x 0.25°. Figure 3 indicates the four one-degree square regions into which the two-degree square centered at (23.5° W, 8.5° N) was divided. Mean rainfall intensity estimates for the entire region and for each of the four subregions were computed for both instruments.

2. Conversion of ESMR-5 Brightness Temperatures to Rain Rates

Rain intensity for each data point is determined via a freezing level dependent relation derived from the Wilheit curves [5] shown

in Figure 2. This relation is an interpolation of the 4 km and 5 km curves to correspond to a freezing level of 4.7 km which more closely approximates GATE conditions [1] . The formula for this relation is

$$R = \begin{cases} 0 & \text{, if } 0 \le T \le 185 \\ 0.101T - 18.643, & \text{if } 186 \le T \le 217 \\ 0.116T - 21.962, & \text{if } 218 \le T \le 247 \\ 0.217T - 46.829, & \text{if } 248 \le T \end{cases}$$

where R denotes rain rate and T denotes brightness temperature. Figure 5 indicates how this relation compares with the inverse of the 5 km Wilheit curve.

RESULTS AND CONCLUSIONS

Of the 78 available GATE coincident ESMR-5 sensensings, only 68 could be matched with coincident GATE radar derived rainfall intensity measurements. Using these data, for each matched overpass, mean rain intensity was computed for each of the five regions of the GATE area shown in Figure 3.

Mean rain rate estimates (ESMR-5 and radar) were computed for the entire GATE experiment and for each phase of GATE. For Regions I and 6 of Figure 3, 7-day and 14-day means were computed. In each instance the ratio (ESMR-5 rainfall)/(radar rainfall) was computed.

The ratio (ESMR-5 rainfall)/(radar rainfall) has a mean of approximately 0.62. Figures 6-9 indicate relative frequencies of various rain rates for ESMR-5 and radar.

The following is a listing of the results.

PHASE I

REGION	ESMR-5	RADAR	RATIO
I	.19	.39	.49
II	.1	.46	.22
III	.22	.64	.34
IV	.29	1.04	.29
G	.2	.3	.32

MEAN OF RATIO .33
STANDARD DEVIATION OF RATIO .1

PHASE II

REGION	ESMR-5	RADAR	RATIO
I	.35	.27	1.30
II	.38	.14	2.71
III	.38	.32	1.20
IV	.53	.93	.57
G	.41	.41	1.00

MEAN OF RATIO 1.16
STANDARD DEVIATION OF RATIO .81

PHASE III

REGION	ESMR-5	RADAR	RATIO
I	.28	.52	.54
II	.36	.53	.68
III	.17	.66	.26
IV	.09	.54	.17
G	.22	.56	.39

MEAN OF RATIO .41
STANDARD DEVIATION OF RATIO .21

GATE

REGION	ESMR-5	RADAR	RATIO
I	.27	.39	.69
II	.28	.38	.74
III	.23	.54	.43
IV	.24	.84	.29
G	.26	.53	.49

MEAN OF RATIO .53
STANDARD DEVIATION OF RATION .19

SEVEN DAY MEANS REGION I

PERIOD	ESMR-5	RADAR	RATIO
1	.04	.12	.33
2	.2	.40	.50
3	.27	.54	.50
4	.36	.49	.73
5	.55	.34	1.62
6	.10	.24	.42
7	.42	.69	.61
8	.31	.61	.51

MEAN OF RATIO .65
STANDARD DEVIATION OF RATIO .41

SEVEN DAY MEANS REGION G

PERIOD	ESMR-5	RADAR	RATIO
1	.19	.70	.27
2	.21	.63	.33
3	.20	.61	.33
4	.41	.48	.85
5	.55	.48	1.15
6	.14	.52	.27
7	.28	.54	.52
8	.14	.50	.28

MEAN OF RATIO .50
STANDARD DEVIATION OF RATIO .33

FOURTEEN DAY MEANS REGION I

PERIOD	ESMR-5	RADAR	RATIO
1	.12	.26	.46
2	.32	.51	.63
3	.32	.29	1.10
4	.37	.65	.57

MEAN OF RATIO .69
STANDARD DEVIATION OF RATIO .28

FOURTEEN DAY MEANS REGION G

PERIOD	ESMR-5	RADAR	RATIO
1	.2	.66	.30
2	.31	.55	.56
3	.34	.50	.68
4	.2	.51	.41

MEAN OF RATIO .49
STANDARD DEVIATION OF RATIO .17

REFERENCES

[1] Austin, P. and S. Geotis; 1978: 'Evaluation of the Quality of Precipitation Data from a Satellite-Borne Radiometer', Final Report under NASA Grant NSG 5024.

[2] Hudlow, M. D. and V. L. Patterson; 1979: Gate Radar Rainfall Atlas, Center for Environmental Assessment Services, NOAA, Washington, D. C.

[3] Wilheit, T. T.; 1972: 'The Electrically Scanning Microwave Radiometer (ESMR) Experiment', The Nimbus-5 Users Guide, NASA Goddard Space Flight Center, Greenbelt, Maryland.

[4] Wilheit, T. T., A. T. C. Chang, M. S. V. Rao, E. B. Rogers, and J. S. Theon; 1977: 'A Satellite Technique for Quantitative Mapping Rainfall Rate Over Oceans', Journal of Applied Meteorology, 16, 551-560.

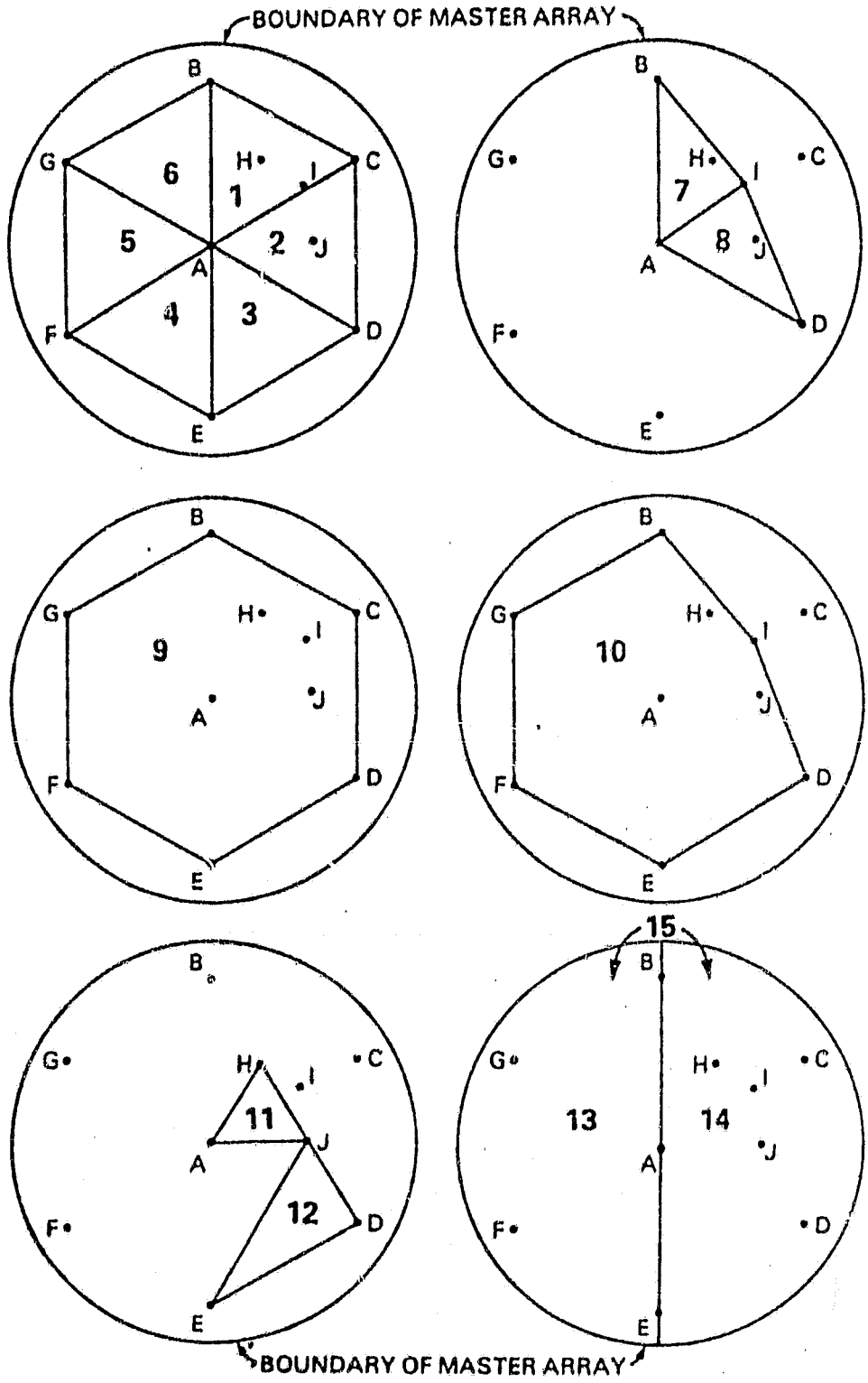


Figure 1. Key giving geometric areas corresponding to the area numbers appearing above the columns of the daily rainfall tabulations. Letters designate ship positions.

Table 1. ESMR-5 GATE DATA

Day	Time Span	Tape-File
179	0107-0117	L9697-17
179	1252-1300	L9679-1
180	1207-1215	L9679-9
181	1309-1315	L9679-17
182	1223-1232	L5308-10
183	0142-0153	L2441-4
183	1325-1332	L5308-18
184	0054-0105	L5308-24
186	0110-0119	L5326-20
186	1256-1304	L5228-3
187	0027-0035	L5228-8
187	1210-1218	L5228-14
188	1313-1319	L5225-4
188	0130-0137	L5228-22
189	1227-1238	L5225-7
190	0145-0157	L5225-13
193	0117-0125	L1599-20
193	1300-1307	L5327-2
194	0033-0040	L5327-14
194	1213-1223	L5327-11
195	1316-1324	L5360-4
196	0048-0055	L5360-11
196	1230-1237	L5360-16
197	0150-0157	L5360-22
197	0005-0012	L5360-23
197	1332-1340	L5359-6
209	0140-0150	L5269-4
209	1325-1332	L5269-10
210	0053-0103	L5269-16
210	1237-1245	L5269-21
211	0008-0017	L5349-6
211	0157-0204	L5349-4
211	1340-1349	L5349-10
212	0110-0119	L5349-16
212	1255-1304	L5349-21
222	0047-0054	L5362-4
222	1230-1237	L5362-15
223	0149-0156	L5362-7
224	1245-1253	L5368-9
225	0021-0026	L5368-17
227	0035-0041	L5381-10
227	1216-1224	L5381-15
242	0143-0150	L5399-11
242	1325-1333	L5399-16
243	0100-0108	L5399-22
243	1241-1248	L6861-4
244	0013-0021	L6861-12
244	0200-0209	L6861-11
244	1154-1202	L6861-17
244	1344-1350	L6861-18
245	1257-1304	L6896-3
246	1210-1219	L6896-16
247	0133-0139	L9661-1
247	1313-1321	L9661-6
248	0043-0053	L9661-18
248	1228-1235	L9661-16
249	0147-0155	L5255-6
249	1330-1337	L5255-4
250	1243-1252	L5255-18
251	0015-0023	L5276-1

Table 1 (continued)

Day	Time Span	Tape-File
251	0203-0210	L5276-2
251	1159-1205	L5276-6
252	0116-0125	L5276-14
252	1300-1308	L5276-20
253	0032-0040	L5343-9
253	1215-1223	L5343-3
254	1316-1324	L5343-15
255	1232-1240	L6842-3
256	1333-1340	L6842-14
257	1250-1258	L6872-6
258	1202-1210	L6872-13
259	0123-0129	L6872-21
259	1305-1311	L9649-3
260	0037-0044	L9649-10
260	1219-1228	L9649-15
261	0138-0145	L5268-17
261	1321-1327	L5268-3
262	0053-0100	L5268-9
262	1235-1243	L5268-15

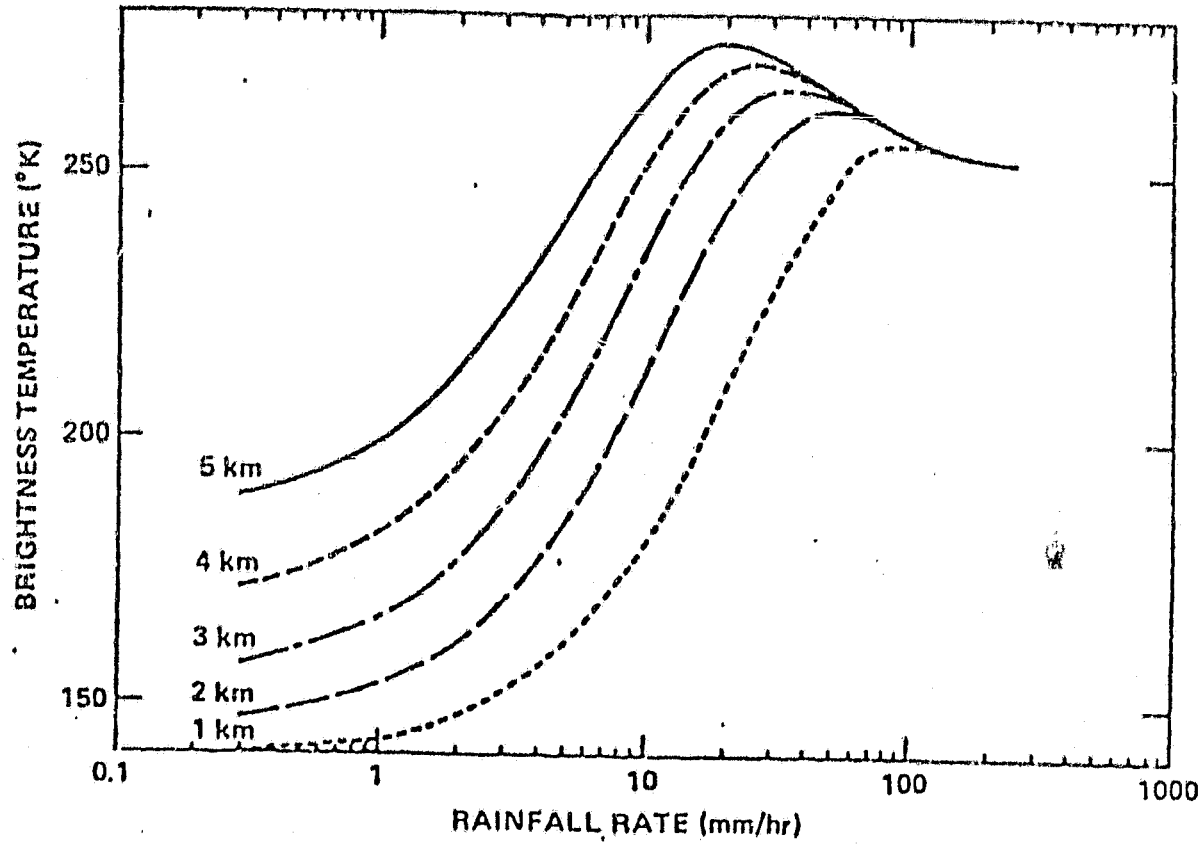


Fig. 1. Calculated brightness temperature at 1.55 cm as a function of rain rate for melting levels of 1, 2, 3, 4 and 5 km (from Wilheit et al, 1977).

Figure 3. Subdivisions of the two-degree square region centered at (23.5° W, 8.5° N). The letter G denotes the entire region.

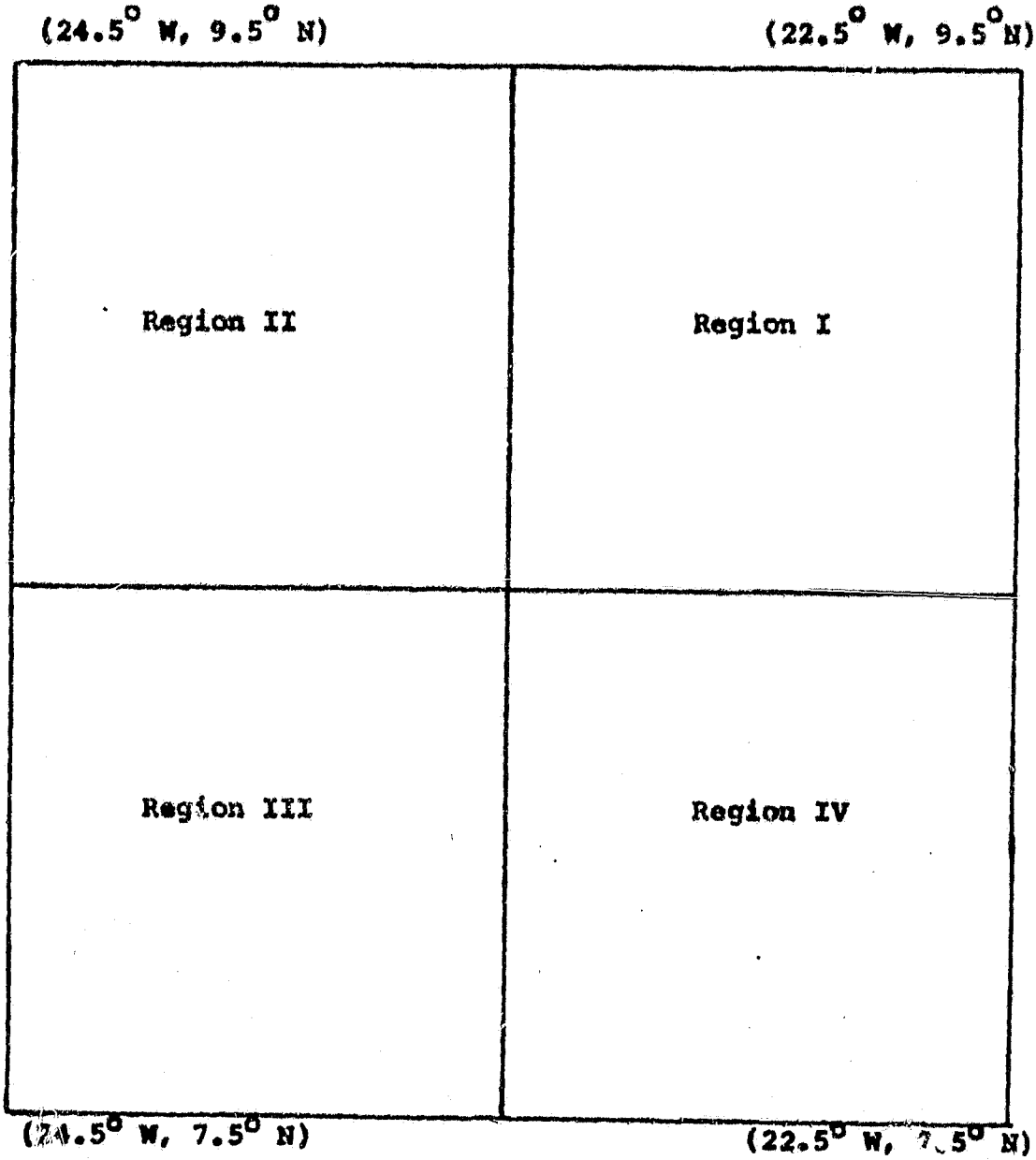
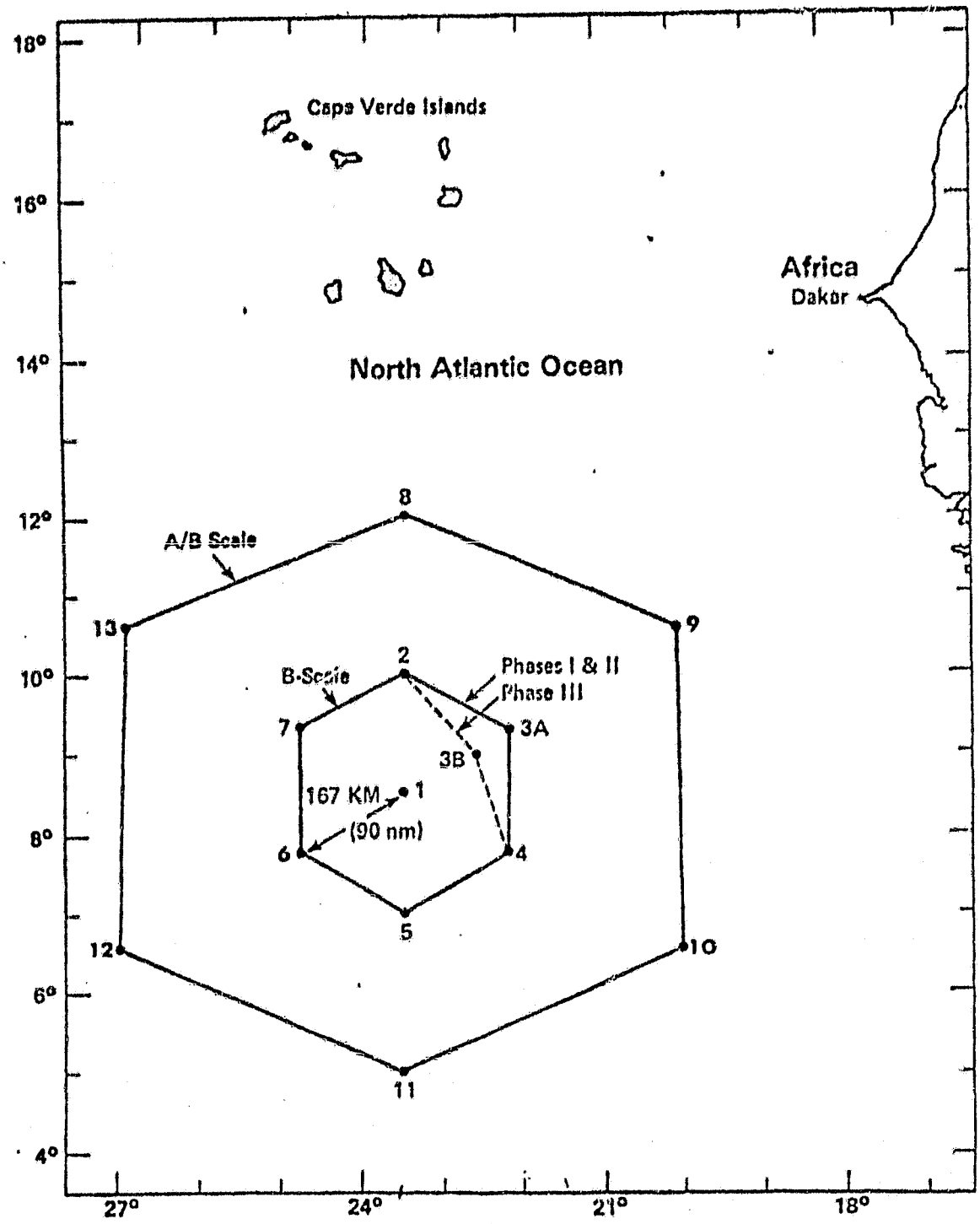


Figure 4 The GATE Area



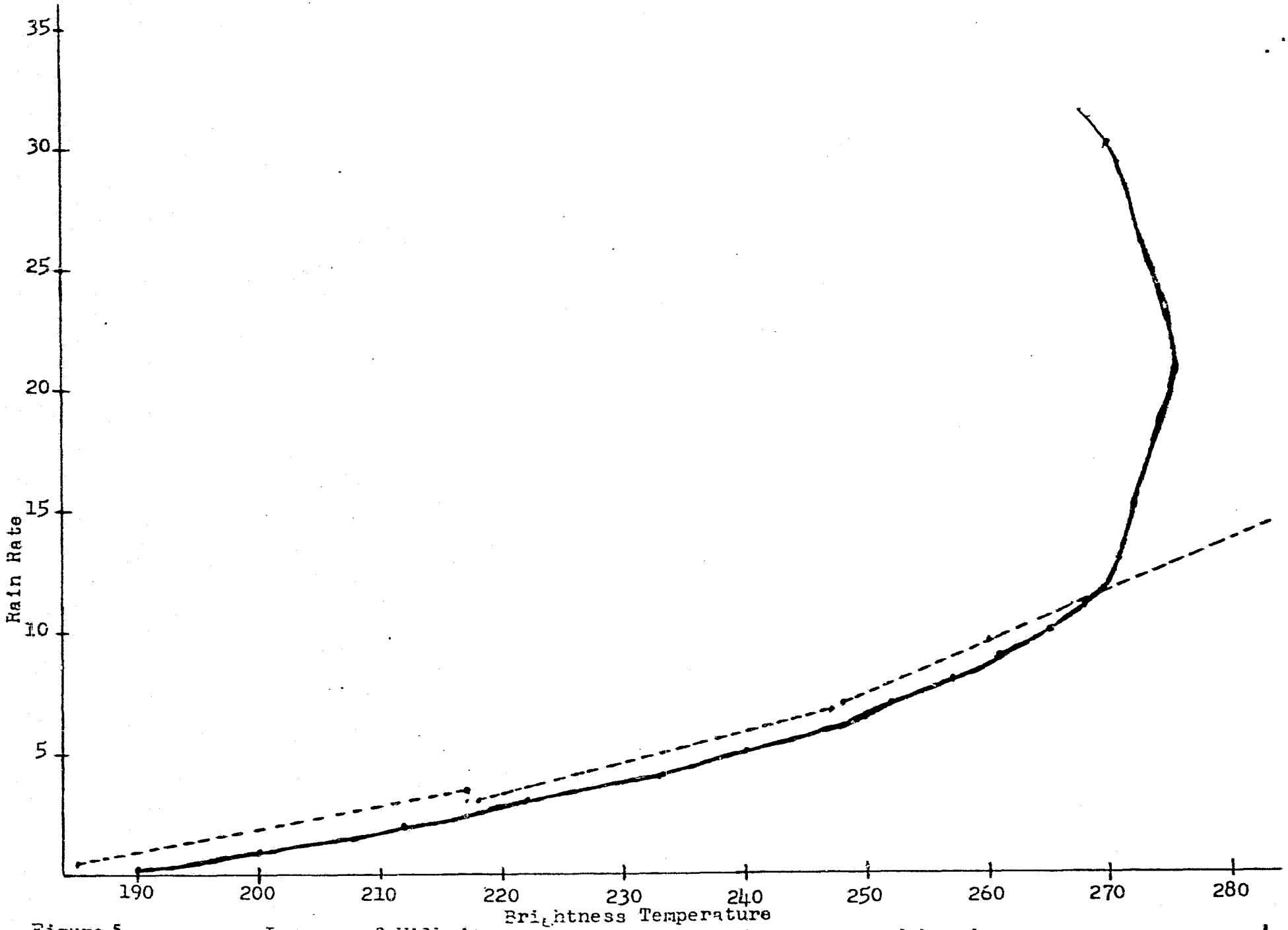


Figure 5. _____ Inverse of Wilheit curve. ----- Transfer curve used herein.

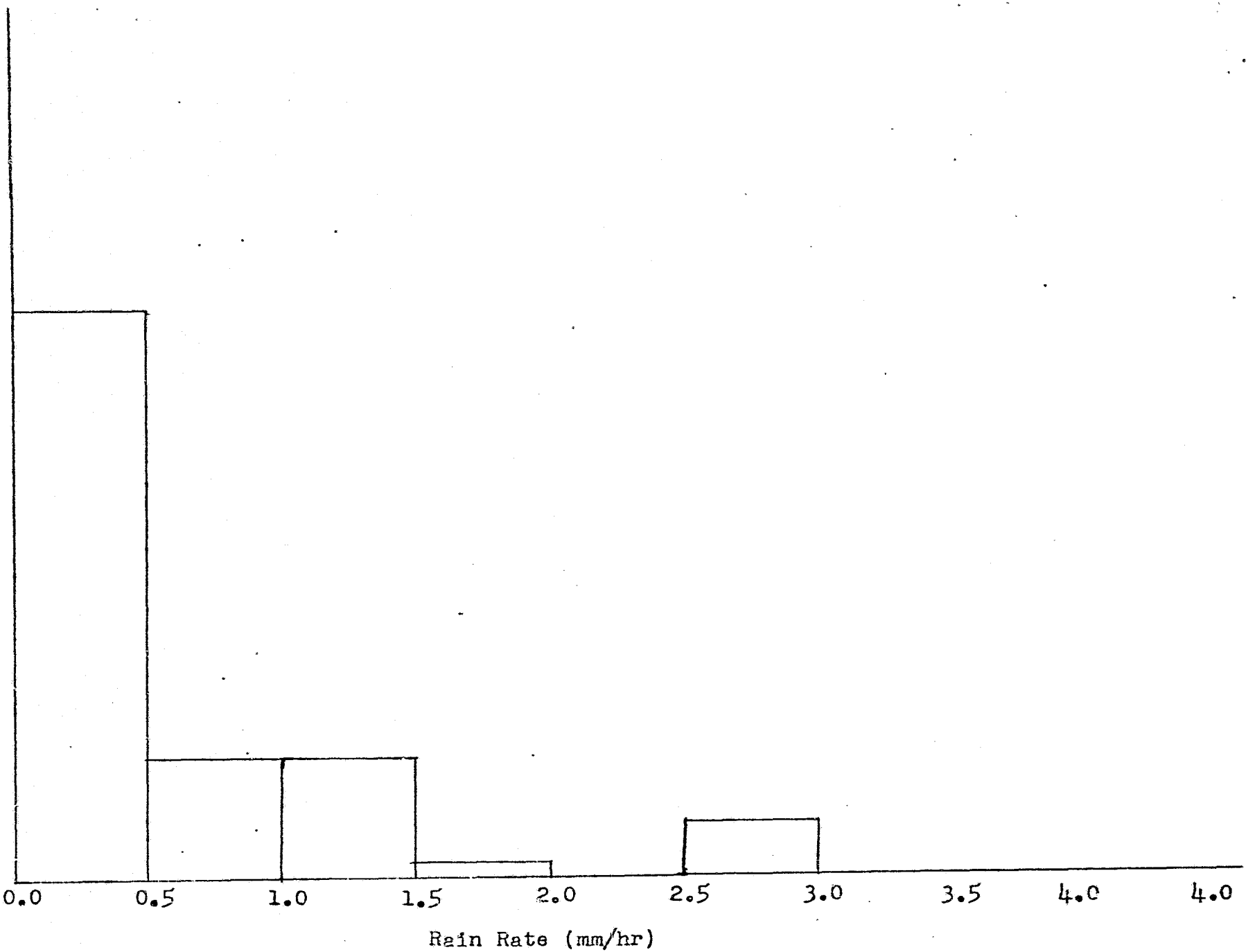


Figure 6. Radar--Region G.

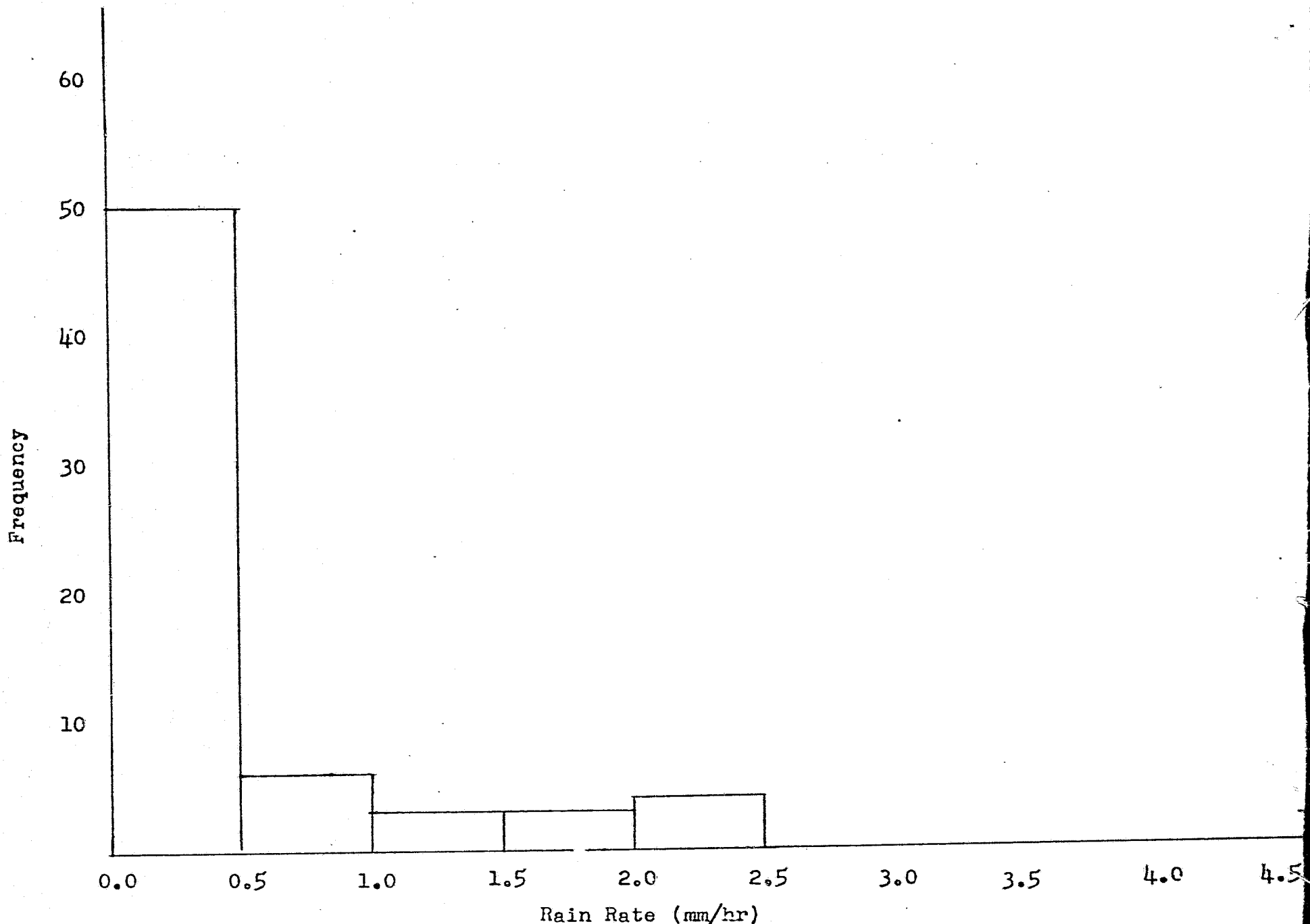


Figure 7. Radar--Region I.

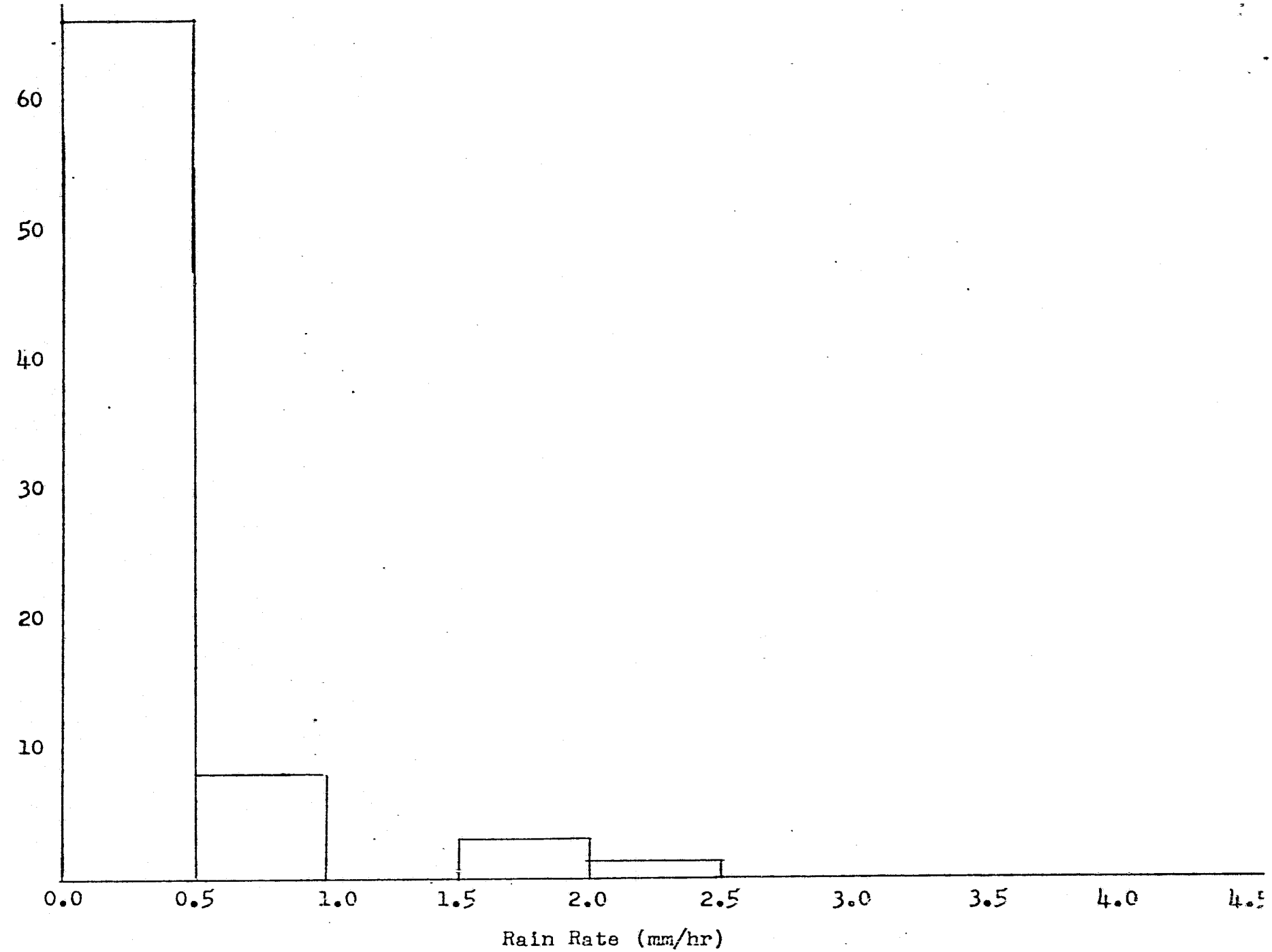


Figure 8. ESMR-5 Region G.

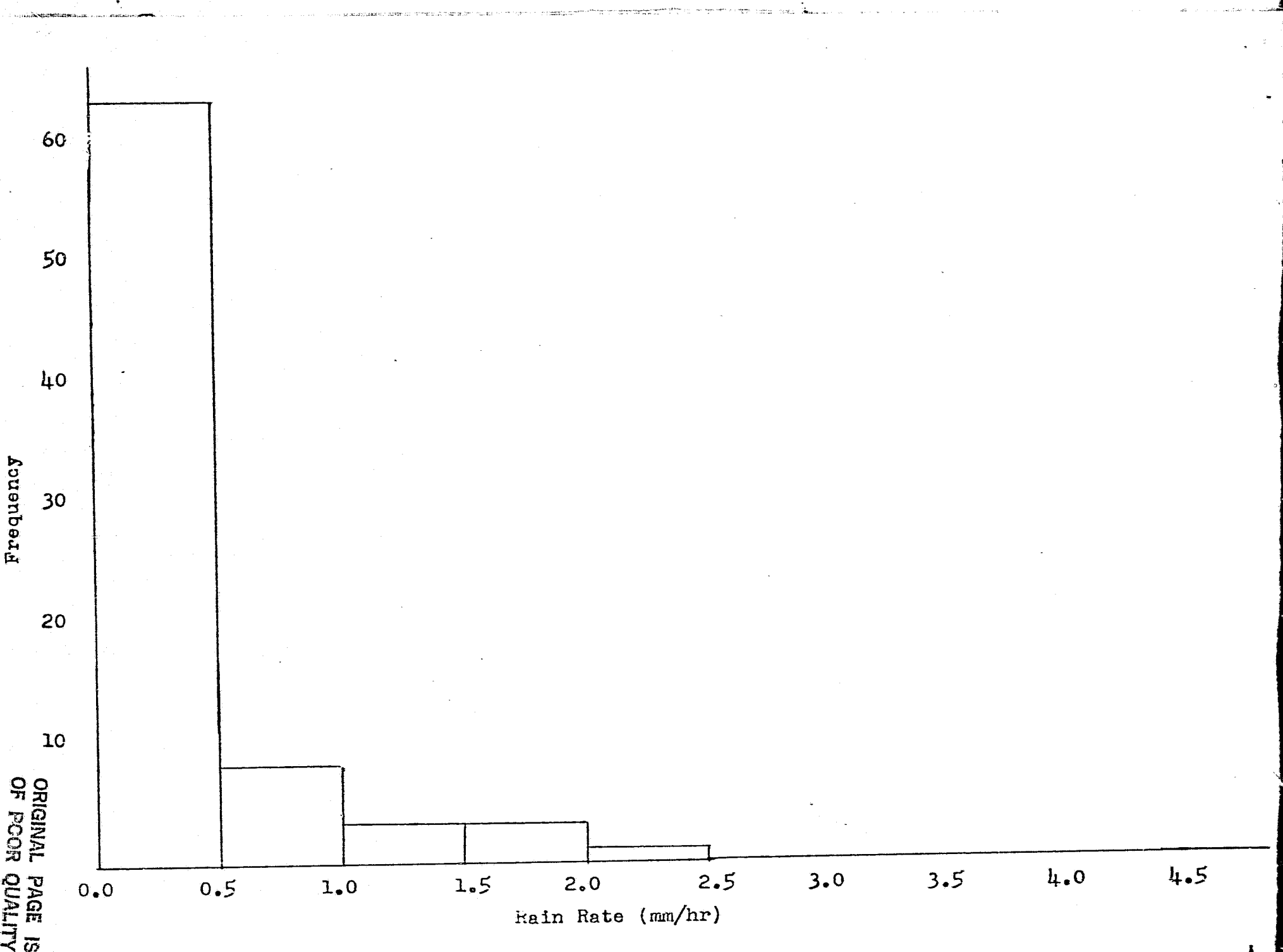


Figure 9. ESMR-5 Region I.