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ANALYSIS OF LOW LATITUDE SKYWAVE MEASUREMENTS IN THE MEDIUM FREQUENCY BAND

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SUMMARY

Skywave field strengths of the two Central American medium frequency broadcast stations were recorded, each at a separate United States location. Readings were recorded on paths having geographical midpoint latitudes of 21.5° and 25.5° North, for fifteen months. Recordings showed readings from 8 to 12.4 dB above those in Figures 1a and 2, Section 73.190 of the FCC Rules. Nighttime levels stabilized two to three hours after sunset at the receiving locations.

INTRODUCTION

The FCC Rules regulating medium frequency broadcasting in the 540-1600 kc/s band cover skywave propagation on these frequencies based on field strength measurements made throughout the United States. These are shown in Figures 1, 1a, and 2 of Section 73.190 of the FCC Rules. In Figure 2 the relationship between field strength and distance of propagation is defined as a function of the geographical latitude of the transmission path midpoint for latitudes from 35 to 50 degrees North, covering practically the entire North American continent. Since the publication of these curves there has been a great increase in both North and South America of the number of medium frequency broadcast stations and their radiated power, increasing the potentiality of mutual interference. Lacking suitable low latitude propagation data these problems are currently being handled on the basis of the curves shown in Figures 1a and 2. The Commission recognizes that estimates based on these figures could err appreciably, and therefore exhibits a continuing interest in the acquisition of low latitude propagation data. Accordingly, a very limited field strength recording program of either South or Central America medium frequency broadcasting was initiated at two of the Commission's monitoring stations. Frequency lists were searched, and the majority of stations in these areas discarded because of the difficult reception problems presented. Finally two Central American stations were chosen: BHBS, British Honduras, broadcasting on 834 kc/s; and TGUX, Guatemala City, Guatemala, on 1020 kc/s. The Commission's monitoring station at Powder Springs, Georgia, was selected to receive BHBS; and the monitoring station at Kingsville, Texas, to receive TGUX. Measurements were made from March, 1964 through May, 1965, and are summarized in this report.

METHODS OF FIELD STRENGTH RECORDING AND DATA ANALYSIS

Esterline-Angus moving chart recorders were used to register the skywave signals at both receiving locations. It was determined that adequate accuracy could be achieved by sampling the signal 30 times per hour instead of continuous recording. A switching arrangement, activated by a synchronous clock motor, turned on the receiver for five seconds at two minute intervals to permit the pen to reach full deflection. The current supplied the recording meter was a function of the receiver AGC voltage. Accordingly, the meter marked deflections approximately proportional to the logarithm of the RF receiver voltage for all five-second samples. The recorder charts were analyzed by an electronic analyzer that automatically counted the number of signals exceeding the several calibration levels within the range of signal variation. (Ref. 1).

POWDER SPRINGS MEASUREMENTS

Station BHBS employs a non-directional antenna system consisting of a 300 foot vertical steel radiator and a ground network of 120 radials, each 300 feet long. The unattenuated field at one mile was estimated to be 180 millivolts per meter per kilowatt. Antenna power input was estimated at 13.9 kilowatts. The distance between Belize and Powder Springs is 1190 miles, with the path midpoint approximately 25.5° North. The central portion of the path constituting about 50% of the total is over the Gulf of Mexico, the remaining land segments extending approximately equally to both the transmitter and receiver sites. The receiver utilized a fifty-foot vertical antenna with an effective height of 0.22 meters. These dimensions resulted from measuring the field strength of a nearby broadcasting station while simultaneously recording the receiver voltage input level. The antenna was then replaced by a signal generator and the output required for the same reading recorded. This output, in microvolts, divided by the measured field strength in microvolts per meter, determined the effective antenna height.

KINGSVILLE MEASUREMENTS

Station TGUX broadcasts on 1020 kc/s, using a non-directional antenna. Information on the ground radial system was not available. Transmitter power output was 5 kilowatts. The station's unattenuated field at one mile was estimated to be 186 millivolts per meter per kilowatt. Guatemala City is 1025 miles from Kingsville, at a bearing of 149°. The path midpoint latitude is approximately 21.5° North.

The central portion of the path constituting approximately 70% of the total, is over the Gulf of Mexico, the longest land portion extending in the northwest direction from Guatemala City. The Kingsville receiving terminal is within 35 to 40 miles of the gulf coast. The Kingsville receiver employed a Beverage antenna 1800 feet long, oriented 180° from true North. It was calibrated by comparing a series of fifteen receiver input voltage measurements taken simultaneously with the same number of readings from a field strength meter located approximately 1/3 of the distance from the antenna's receiving end and separated from it by 200 feet. From these readings the average effective antenna height was calculated to be 1.37 meters.

DESCRIPTION OF RESULTS

Figure 1 presents long term distributions of field strengths for both stations over practically identical time periods. Somewhat higher fields were received from TGUX than from BHBS, due possibly to the shorter transmission distance and lower path midpoint latitude.

Figure 2 shows the diurnal variation of both fields exceeded for 10% and 50% of the recording periods. These were compared with the corresponding values obtained from the curves in Figures 1a and 2 of Section 73.190 of the FCC Rules, as shown in Table I. The curve in Figure 1a is based on measurements involving latitudes from 35° to 50° North. The latitude dependent curves in Figure 2 were extrapolated to the respective path midpoint latitudes of 21.5° and 25.5° North. The measured field strength values were taken from Figure 2 of this report for the second hour after average annual sunset when they reach their steady nighttime values. (Sunset occurs at about 6:40 PM at both receiver locations, Ref. 2).

TABLE I

	F(10%), dB above 1 uV/m per kilowatt		F(50%), dB above 1 uV/m per kilowatt	
Station	Measured	FCC Fig. 2	Measured	FCC Fig. 1a
BHBS	43.6	33.0	35.0	22.6
TGUX	44.8	36.8	37.5	27.3

Figure 3 shows the seasonal variations of field strengths of both stations for the entire recording period. No consistent correlation is evident.

CONCLUSIONS

The measured field strengths of both stations consistenely exceeded the corresponding values indicated by Figures 1a and 2 of the FCC Rules. It is reasonable to attribute this difference to the effect of low latitudes on skywave transmission. For the 10% fields these differences ranged from 8 to 10.6 dB, the corresponding range for the 50% fields being 10.2 to 12.4 dB. Admittedly, two propagation paths do not constitute a highly representative sample. Accumulation of more data in tropical latitudes is needed to extend this study.

ACKNOWLEDGMENTS

George V. Waldo of the Chief Engineer's Office initiated this low latitude recording project and provided guidance and advice on the analysis of the data. The actual measurements were made by the FCC Field Engineering Bureau at the Kingsville and Powder Springs Monitoring Stations.

REFERENCES

1. "Analysis of Field Strength Recorder Charts by Automatic Electronic Equipment," George V. Waldo, FCC Report No. TR-6201, May 11, 1962.

2. Section 26 of the Standards of Good Engineering Practice Concerning Standard Broadcast Stations (550-1600 kc/s). Table Containing Average Time of Sunrise and Sunset Based on Local Standard Time in Specified Cities and Localities in the United States. U. S. Government Printing Office, 1948.

FIGURE 1

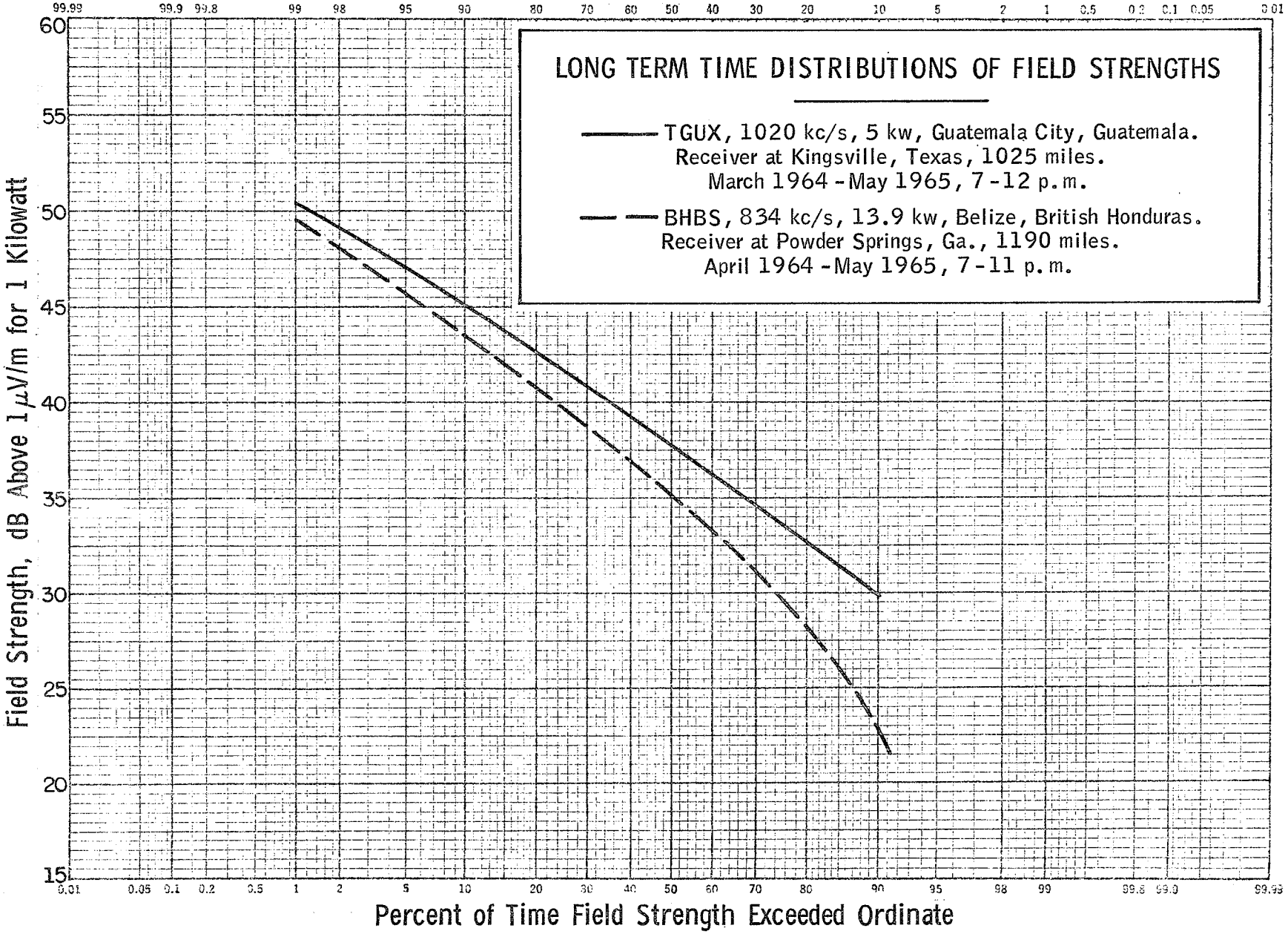

LONG TERM TIME DISTRIBUTIONS OF FIELD STRENGTHS
TGUX, 1020 kc/s, 5 kw, Guatemala City, Guatemala.
Receiver at Kingsville, Texas, 1025 miles.
March 1964 - May 1965, 7 - 12 p.m.
BHBS, 834 kc/s, 13.9 kw, Belize, British Honduras.
Receiver at Powder Springs, Ga., 1190 miles.
April 1964 - May 1965, 7 - 11 p.m.
Field Strength, dB Above 1 μV/m for 1 Kilowatt
60
55
50
45
40
35
30
25
20
15
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99
Percent of Time Field Strength Exceeded Ordinate

FIGURE 2

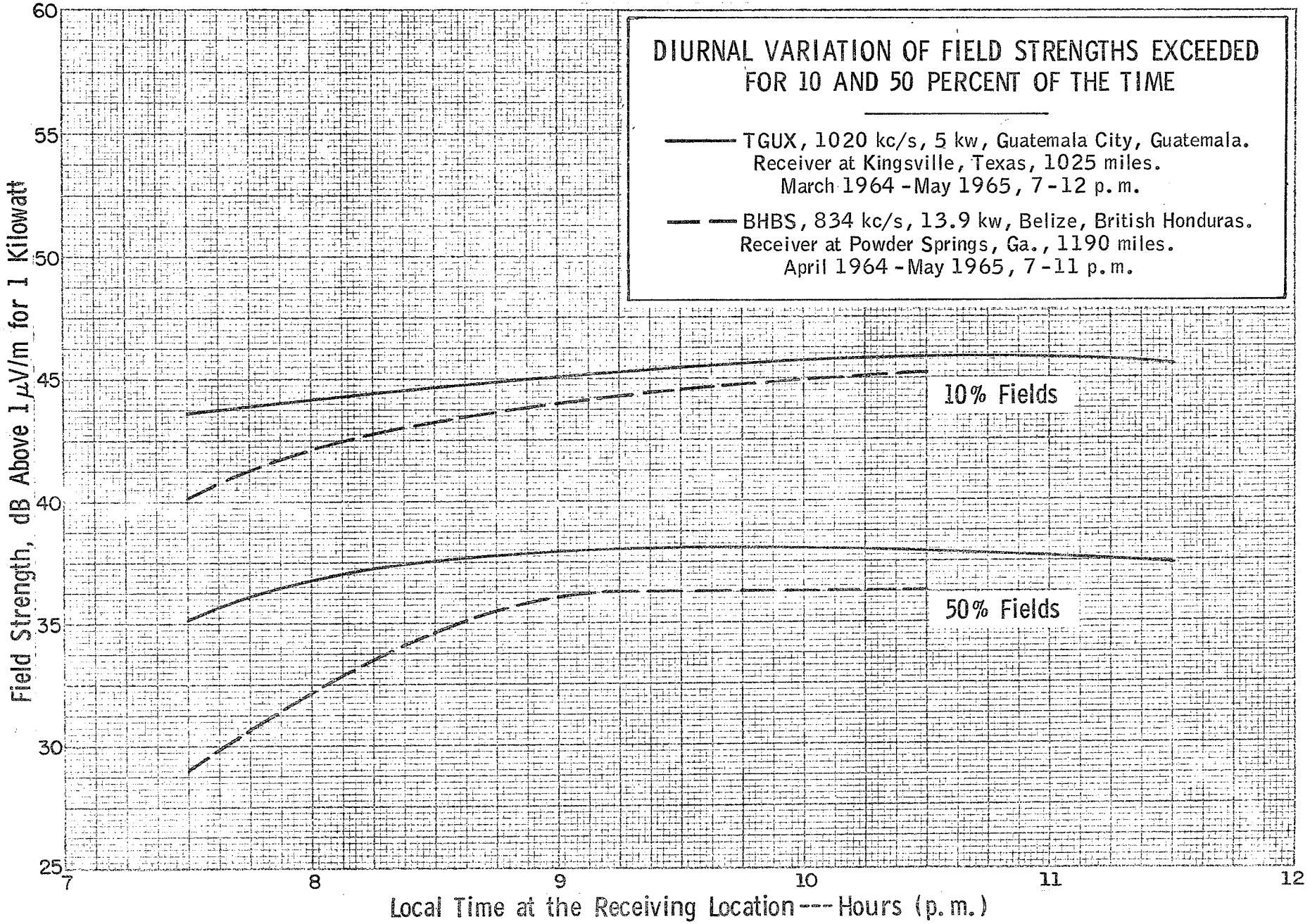
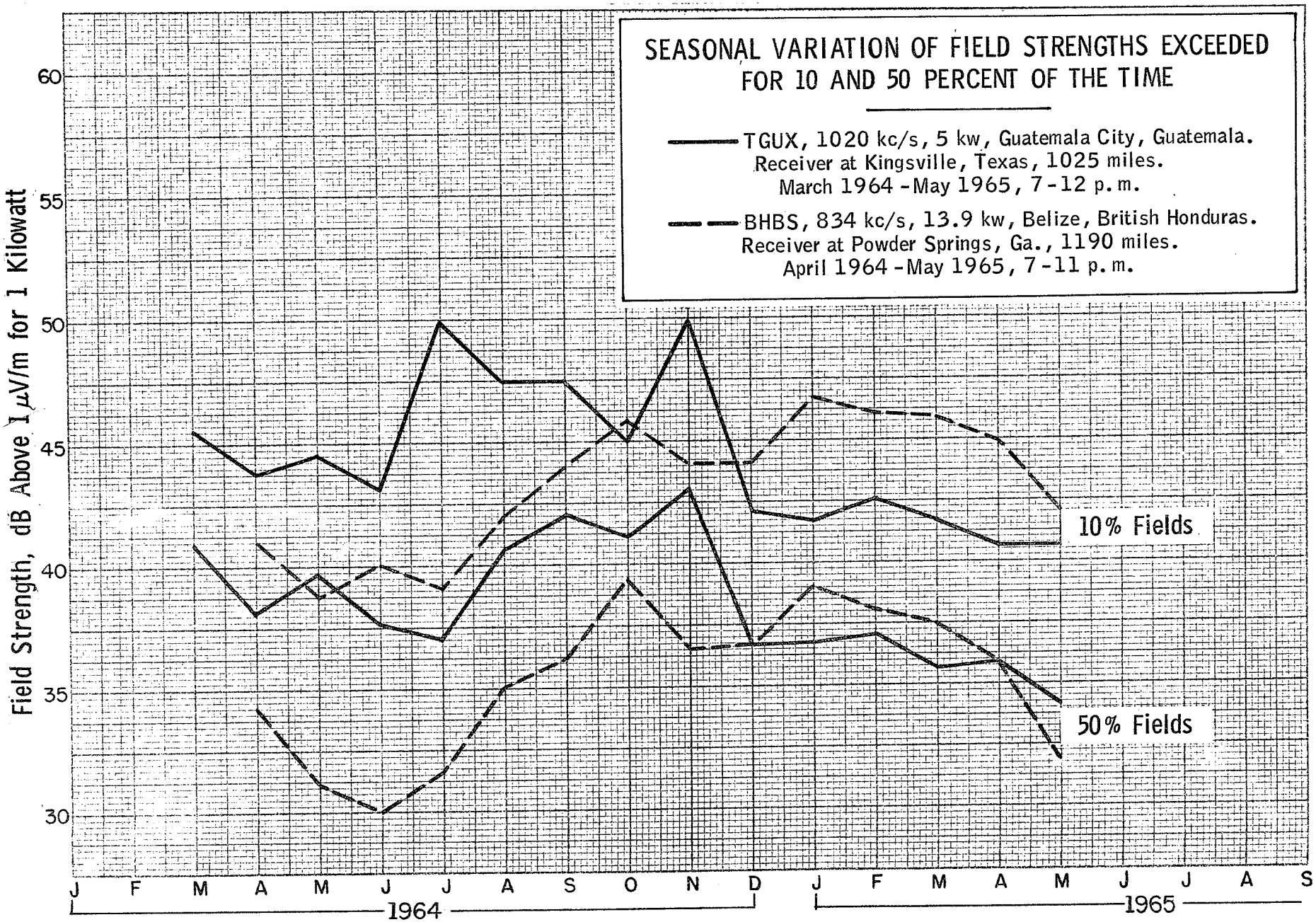

DIURNAL VARIATION OF FIELD STRENGTHS EXCEEDED FOR 10 AND 50 PERCENT OF THE TIME
TGUX, 1020 kc/s, 5 kw, Guatemala City, Guatemala.
Receiver at Kingsville, Texas, 1025 miles.
March 1964 - May 1965, 7-12 p.m.
BHBS, 834 kc/s, 13.9 kw, Belize, British Honduras.
Receiver at Powder Springs, Ga., 1190 miles.
April 1964 - May 1965, 7-11 p.m.
10% Fields
50% Fields
Field Strength, dB Above 1 μV/m for 1 Kilowatt
60
55
50
45
40
35
30
25
7
8
9
10
11
12
Local Time at the Receiving Location --- Hours (p.m.)

FIGURE 3


SEASONAL VARIATION OF FIELD STRENGTHS EXCEEDED FOR 10 AND 50 PERCENT OF THE TIME
TGUX, 1020 kc/s, 5 kw, Guatemala City, Guatemala.
Receiver at Kingsville, Texas, 1025 miles.
March 1964 - May 1965, 7 - 12 p.m.
BHBS, 834 kc/s, 13.9 kw, Belize, British Honduras.
Receiver at Powder Springs, Ga., 1190 miles.
April 1964 - May 1965, 7 - 11 p.m.
Field Strength, dB Above 1 μV/m for 1 Kilowatt
60
55
50
45
40
35
30
10% Fields
50% Fields
J F M A M J J A S O N D J F M A M J J A S
1964
1965