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**Field Strengths of Some VLF
Transmissions and Atmospheric Noise
Measured in Asia
June 1963 Through March 1964**

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U.S. NAVAL RESEARCH LABORATORY
Washington, D.C.

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ABSTRACT
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The Naval Research Laboratory is conducting an investigation of very-low-frequency (VLF) radio wave propagation at great distances and over a long period of time. The statistical relationship of the field strength of various VLF transmissions and atmospheric noise and the signal-to-noise ratios with the time of day and season of the year is being investigated. Between December 1958 and March 1964 the subject propagation data was recorded at the following sites: Hammerfest, Bodø and Varhaug, Norway; Rome, Italy; Haifa, Israel; and Karachi, West Pakistan.

This is the fifteenth and last in a series of quarterly reports, covering the nineteenth through the twenty-second quarters since the program began. The only station in operation during this period was Karachi, which was closed about the first of April, 1964.

AUTHORIZATION

NRL Problem F01-39
BUSHIPS Problem S-1888
SR 008-01-01-7028

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FIELD STRENGTHS OF SOME VLF
TRANSMISSIONS AND ATMOSPHERIC NOISE
MEASURED IN ASIA
JUNE, 1963 THROUGH MARCH, 1964

INTRODUCTION

The Naval Research Laboratory is conducting an investigation of very-low-frequency (VLF) radio wave propagation at great distances and over a long period of time. For this investigation, the field strengths of various VLF transmissions and atmospheric noise were continuously recorded at several sites on the coasts of Europe and the Near East from December 1958 through March 1964. Extension of the project to the spring of 1964 was primarily intended for obtaining coverage data on the Navy's VLF transmitting facility at Cutler, Maine which commenced operation in January 1961.

The routine output data was published in installments covering each quarter of the year, grouped according to the seasons. This series of reports did not contain an analysis of the data. Analysis and correlation of the data with various geophysical phenomena will be the subject of other reports. This is the fifteenth and last in the series of these installments and covers the nineteenth through the twenty-second quarters, June, 1963 through March, 1964 when the Karachi station was closed. References 1 and 2 covered two and four quarters, respectively.

TRANSMISSION PATHS

During the period covered in this report, field strengths of VLF transmissions and atmospheric noise were recorded at Karachi, Pakistan. The precise location of this, and all other recording sites, is given in Table 1. The locations of the U. S. Navy VLF transmitters are given in Table 2.

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TABLE I

Locations of Data Recording Stations and Periods of Operation

<u>Station</u>	<u>Location</u>		<u>Period of Operation</u>
	Latitude	Longitude	
Bodø	67° 16.5' N	14° 21.4' E	Dec 1958 - Sep 1960
Varhaug	58° 37.5' N	5° 37.8' E	Dec 1958 - Mar 1962
Rome	41° 51' N	12° 40' E	Dec 1958 - Aug 1960
Hammerfest	70° 39' N	23° 37' E	Jun 1959 - Dec 1959 Mar 1961 - Mar 1963
Haifa	32° 48' N	35° 2' E	Jun 1959 - May 1962
Karachi	24° 54' N	67° 2' E	Jun 1961 - Mar 1964

TABLE 2

Locations of U. S. Navy VLF Transmitters

<u>Station</u>	<u>Location</u>	
	Latitude	Longitude
NSS	38° 59.1' N	76° 27.2' W
NPG	48° 12' N	121° 55' W
NPM	21° 25.5' N	158° 9.7' W
NDT	34° 58.3' N	137° 1.3' E
NAA	44° 38.9' N	67° 16.9' W
NBA	9° 3.3' N	70° 38.9' W

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DATA RECORDING AND PROCESSING METHODS

All field strength data reported herein were recorded using a 10-foot, vertical, monopole (whip) antenna. One such antenna is installed at each data recording station. A broadband antenna coupler is used to couple the antenna to AN/URM-139 and AN/URM-6 field strength meters which drive Esterline-Angus strip chart recorders. The whip antenna system is calibrated periodically using a loop antenna.

The U. S. Navy transmitters "locked key" for three minutes and, immediately preceding or following, are "off" for three minutes once each hour. It is during these periods that the subject data were recorded.

Atmospheric noise

The atmospheric noise field strengths reported are average values recorded once each hour during the three minute "off" period of the transmitters discussed above. The AN/URM-139 equipments have a nominal noise bandwidth of 41 cps while the noise bandwidth of the AN/URM-6 equipment varies between about 100 and 200 cps depending upon the frequency to which it is tuned. All atmospheric noise field strengths have been normalized to a bandwidth of 100 cps.

Signal Field Strengths

The signal field strengths given in this report are average values over the three minute "locked key" period recorded once each hour, and normalized to a radiated power of one kilowatt. The signal field strengths are calculated from the measurements of the average signal plus noise and the average noise made during the locked-key and off periods of the transmitters. The radiated power during each locked-key period is determined from a measurement of the average transmitting antenna current during each period and the average radiation resistance of the antenna. The radiation resistance values used for each transmitter are given in Table 3. The radiation resistance of each transmitting station is periodically measured and the value appropriately changed if necessary. Although the radiation resistance of NPG appears to have a seasonal dependency, an average value is used throughout

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the year since the effect on the radiated power is slight.

TABLE 3

AVERAGE RADIATION RESISTANCE FOR VLF TRANSMITTERS

Station	Frequency kc	Radiation Resistance ohms
NAA	14.7	0.078
*NAA	18.6	0.121
NBA	18.0	0.069
NPG	18.6	0.079
*NPG	24.0	0.149
NPM	19.8	0.072
NSS	22.3	0.134

*Frequency changes were made in August, 1963.

Signal-to-Noise Ratios

The signal to atmospheric noise ratios for each hourly locked-key and off period reported are the ratios of the locked-key field strengths normalized to a radiated power of one kilowatt, to the average atmospheric noise field strengths normalized to a 100 cps bandwidth.

Transmitter Radiated Power

As previously stated, the field strengths of all transmissions reported herein have been normalized to a radiated power of one kilowatt. The radiated power during each field strength measurement is calculated by squaring the average transmitting antenna current measured during each locked-key period and multiplying by the average value of radiation resistance (Table 3). To determine the various propagation effects, it is necessary to normalize the data to a constant radiated power. However, for planning communication circuits

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and determining the reliability of the circuits, it is necessary to know the radiated power capability of each transmitting facility.

In Table 4 the average radiated power for each transmitter for each month is given along with the number of hourly periods during which the locked-key test was not transmitted. For approximately six hours each week, NPG operates with only half of its transmitting system for routine maintenance. Although these periods have been referred to as "half-power" transmissions, the reduction in radiated power during such operation is considerably more than 3 db. These "half-system" transmitting periods were not used in determining the average radiated power from NPG because normally the signal is undetectable at all the data recording stations during these periods. The NAA transmitter also operates periodically from half of the system at a reduction in radiated power of approximately 3db. Since these "half power" transmissions can be received at all of the data recording stations, they are not omitted in computing the monthly average radiated power, as is the case with NPG. In Table 4 the monthly average radiated power is computed separately for the full and "half power" transmissions.

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TABLE 4

MONTHLY AVERAGE RADIATED POWER

STATION	FREQ KC	MONTH YEAR	AVERAGE RADIATED POWER DB ABOVE		NUMBER OF LOCKED-KEY PERIODS					
			KW*	1 KW*	FULL POWER	HALF POWER OMITTED				
NAA	17.7	Jun 63	901.4	408.5	29.5	26.1	564	110	46	
		Jul	901.3	413.4	29.5	26.2	561	57	126	
		Aug	817.7	391.9	29.1	25.9	66	533	145	
		Sep	818.0	392.2	29.1	25.9	323	68	329	
		Oct	818.0	385.2	29.1	25.9	14	323	407	
		Nov		391.9	25.9	0	344	376		
	Dec	18.6	Dec	747.5	392.5	28.7	25.9	289	63	392
			Jan 64	750.2	390.0	28.8	25.9	327	32	385
			Feb	818.0	392.0	29.1	25.9	386	36	374
			Mar	818.2	387.9	29.1	25.9	303	48	393
			Dec 63	16.4		12.2		579	0	165
			Mar 64	16.4		12.2		669	0	75
NPS	20.0	Dec 63	226.7		23.5		593	4	147	
		Jan 64	221.1		23.4		562	4	178	

* First Column Indicates Average Power During Full Power Locked Keys
 Second Column Indicates Average Power During Half Power Locked Keys

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RESULTS

The data are reported in several forms as follows:

1. The mean plus and minus one standard deviation for the signal and the atmospheric noise field strengths and the signal-to-noise ratios for each hour of one day for a period of one month.

2. The mean for the signal field strengths and the signal-to-noise ratios for each hour of the day over approximately ten day periods of each month.

3. The probability distribution of the signal and the atmospheric noise field strengths and the signal-to-noise ratios for a period of one month.

NOTE: The probability distribution presented in the signal and noise data, separately, are not time correlated. That is, a high signal level did not necessarily occur simultaneously with a high noise level. Therefore, these two sets of data cannot be used for determining the signal-to-noise probability distribution. Graphs showing the true, signal-to-noise probability distribution are presented, however.

In processing the data included in this report, atmospheric noise field strengths are computed only for the hours during which a signal field strength is computed from a recorded locked key transmission. Ideally this occurs once an hour, every hour. Priority traffic and scheduled maintenance at the transmitter and emergency maintenance at the transmitting and receiving sites thwart efforts to attain the ideal situation. The actual number of recorded, locked key transmissions is indicated above each hourly plot on the monthly signal-to-noise ratio curves. These numbers apply to the signal and atmospheric noise field strengths as well as the signal-to-noise ratio calculations.

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During the period covered by this report, only the NAA transmissions provided sufficient data each month to warrant reporting. As was indicated in Table 3, NAA and NPG made frequency shifts in August, 1963. NAA went from 14.7 kc to 18.6 kc and NPG from 18.6 kc to 24.0 kc. No NPG 18.6 kc data is reported herein.

Additional information about atmospheric noise at many locations around the world and for the same period covered by this report may be found in references 4, 5, and 6.

Figures 1 and 2 may be removed from the report and used for interpolation of the appropriate graph scales.

In March 1962 new antenna couplers were installed at the Hammerfest and Karachi sites. The method used for determining the antenna factor with the new coupler was different than the method used with the old coupler by a factor of 6 db. Unfortunately this change was not incorporated in the computer program. As a consequence, all of the signal and noise field strengths from those stations are in error from that date. The correction factors are noted on the affected curves. The signal-to-noise ratio curves are, obviously, not affected. This had previously been reported in reference 3.

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TABLE 5

FIGURE NUMBER INDEX OF THE INCLUDED DATA

	NAA 14.7 kc	NAA 18.6 kc	NBA 18.0 kc	NPG 24.0 kc
June, 1963	3 - 9			
July	10 - 16			
August		17 - 23		
September		24 - 30		
October		31 - 37		
November		38 - 44		
December		45 - 51	52 - 58	59 - 65
January, 1964		66 - 72		73 - 79
February		80 - 86		
March		87 - 93	94 - 98	

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REFERENCES

1. NRL Memo Report 1478 - 5 December 1963, by W. E. Garner, F. J. Rhoads, E. J. Elwood, III and R. L. Schauer.
2. NRL Memo Report 1595 - 2 March 1965, by W. E. Garner, F. J. Rhoads, R. L. Schauer.
3. NRL Memo Report 1571 - 29 October 1964, by W. E. Garner, F. J. Rhoads, and R. L. Schauer.
4. "Quarterly Radio Noise Data - June, July August, 1963" by W. Q. Crichlow, R. T. Disney, and M. A. Jenkins, National Bureau of Standards Technical Note No. 18-19 dated 21 August 1964.
5. "Quarterly Radio Noise Data - September, October, November, 1963" by W. Q. Crichlow, R. T. Disney, and M. A. Jenkins, National Bureau of Standards Technical Note No. 18-20 dated 23 October 1964.
6. "Quarterly Radio Noise Data - December, January, February, 1963-64" by W. Q. Crichlow, R. T. Disney, and M. A. Jenkins, National Bureau of Standards Technical Note No. 18-21 dated 25 January 1965.

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NORMALIZATIONS

The Field Strengths Of All Transmissions Are Normalized To A Radiated Power (P_r) Of One Kilowatt.

Atmospheric Noise Field Strengths Are Normalized To A Bandwidth of 100 Cycles Per Second.

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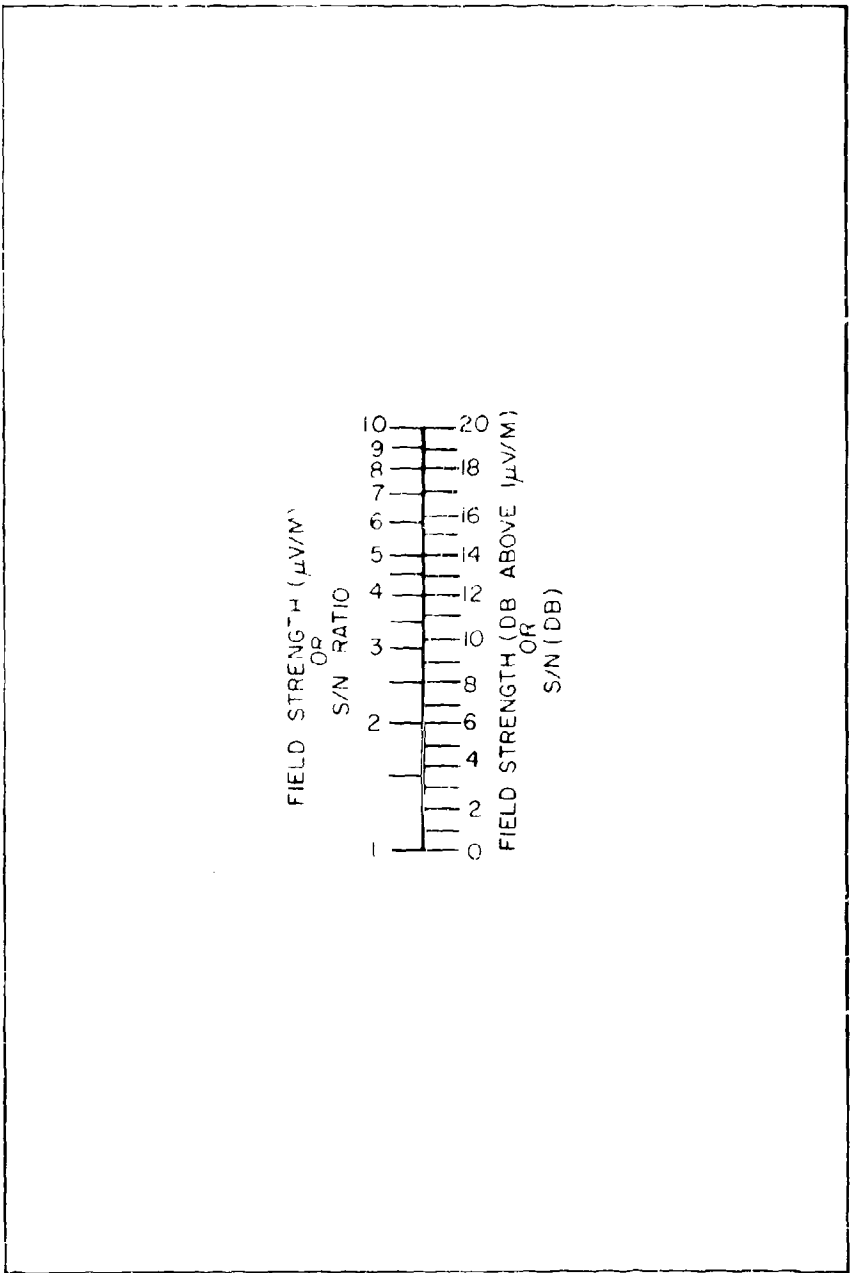


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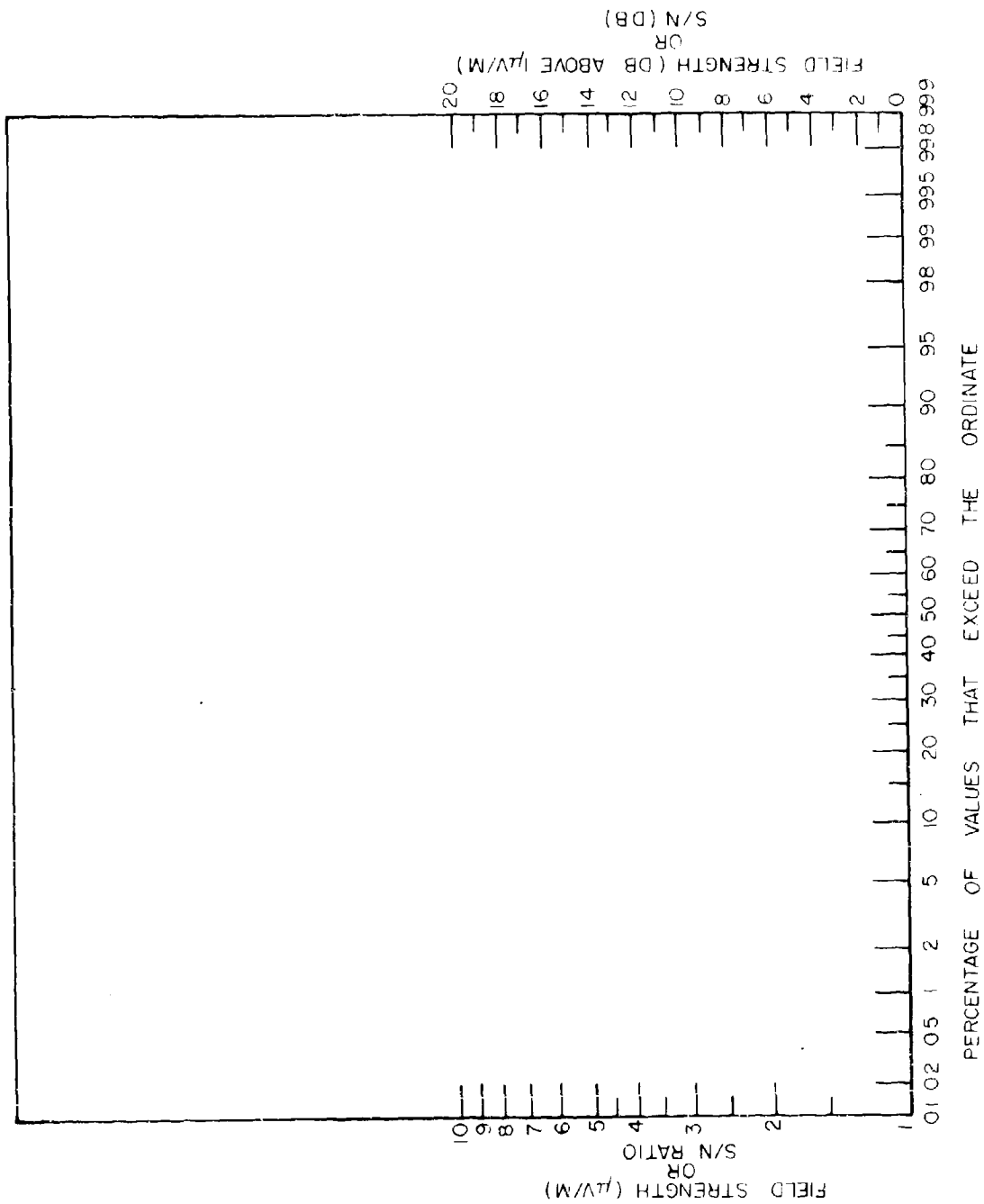


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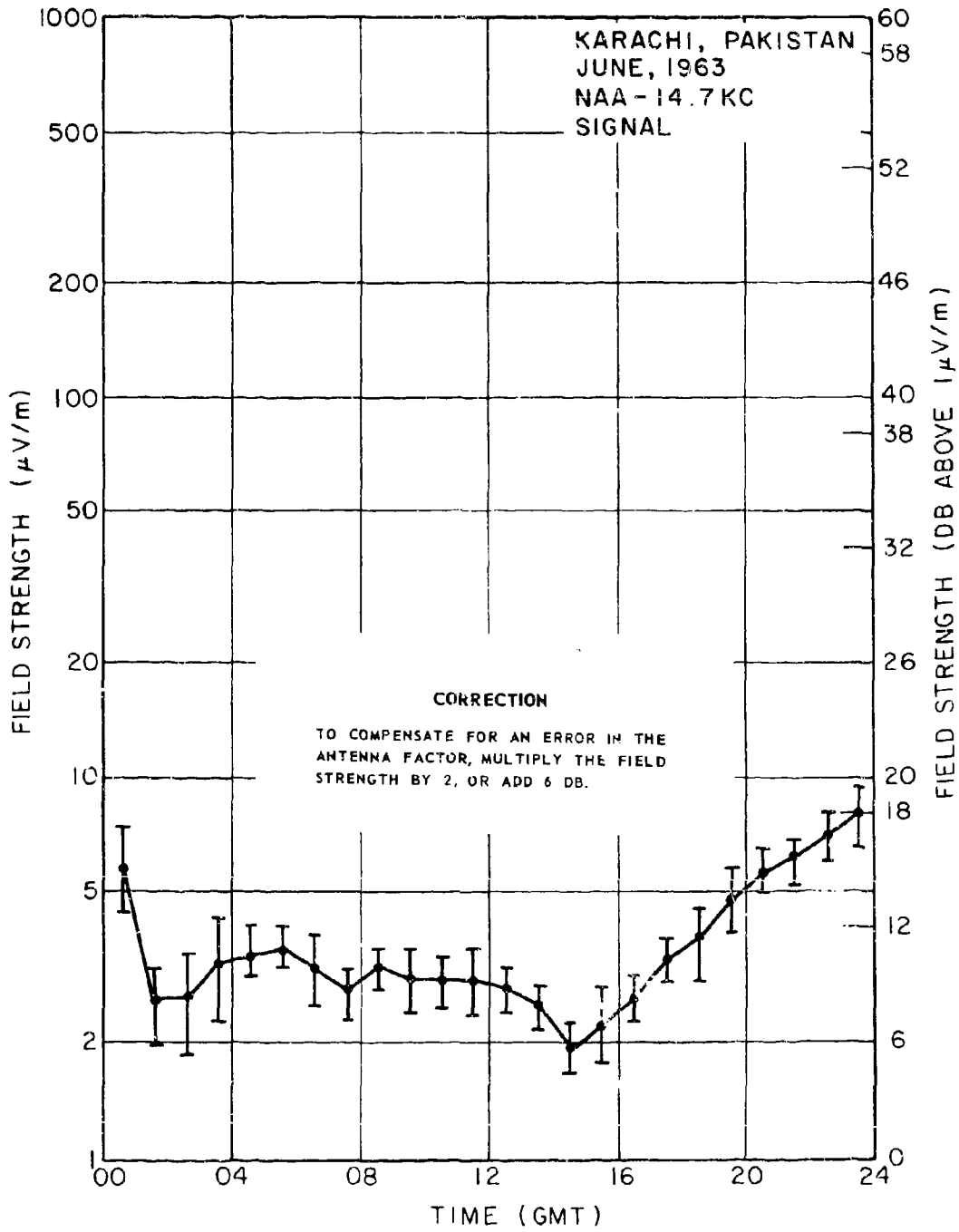


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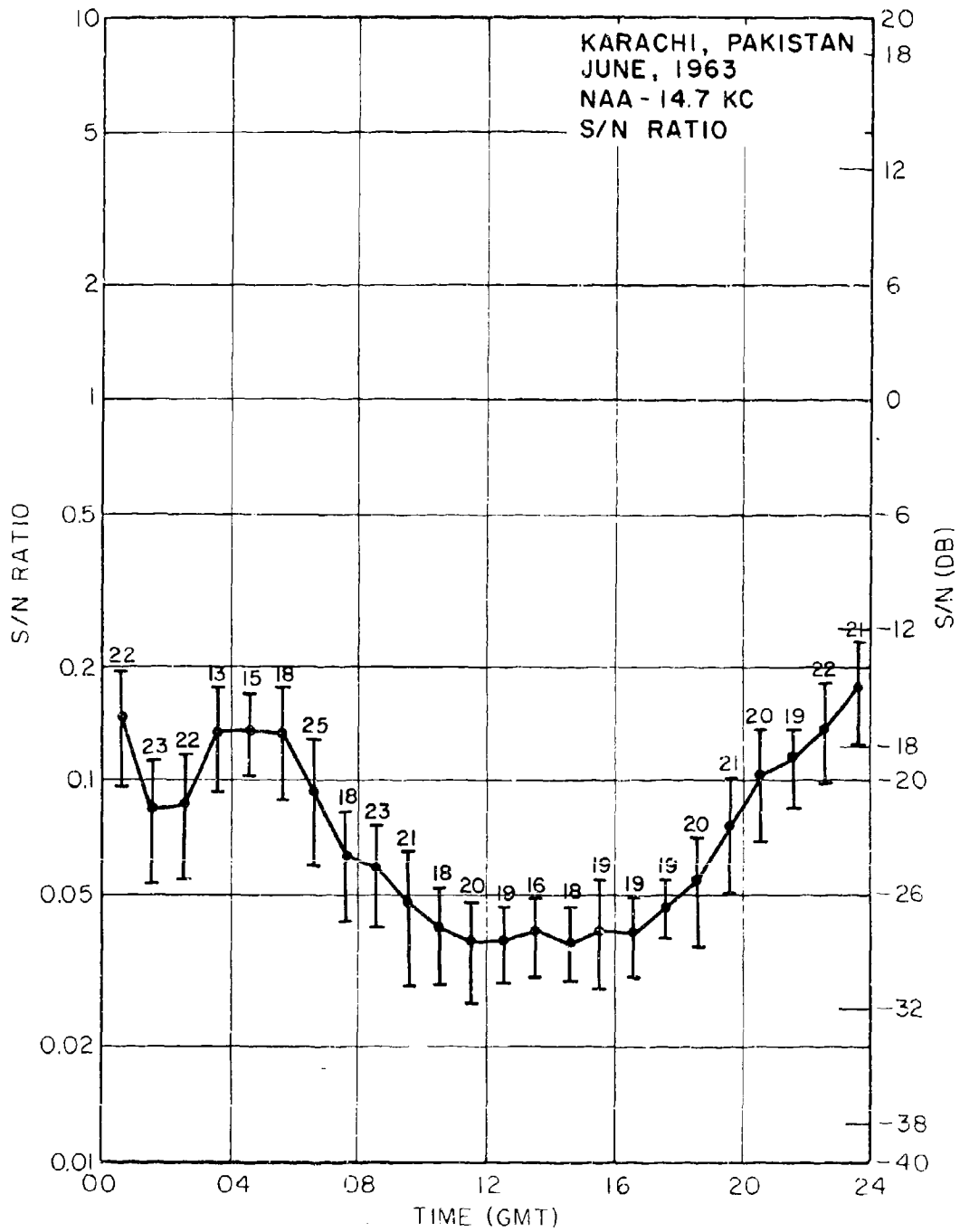


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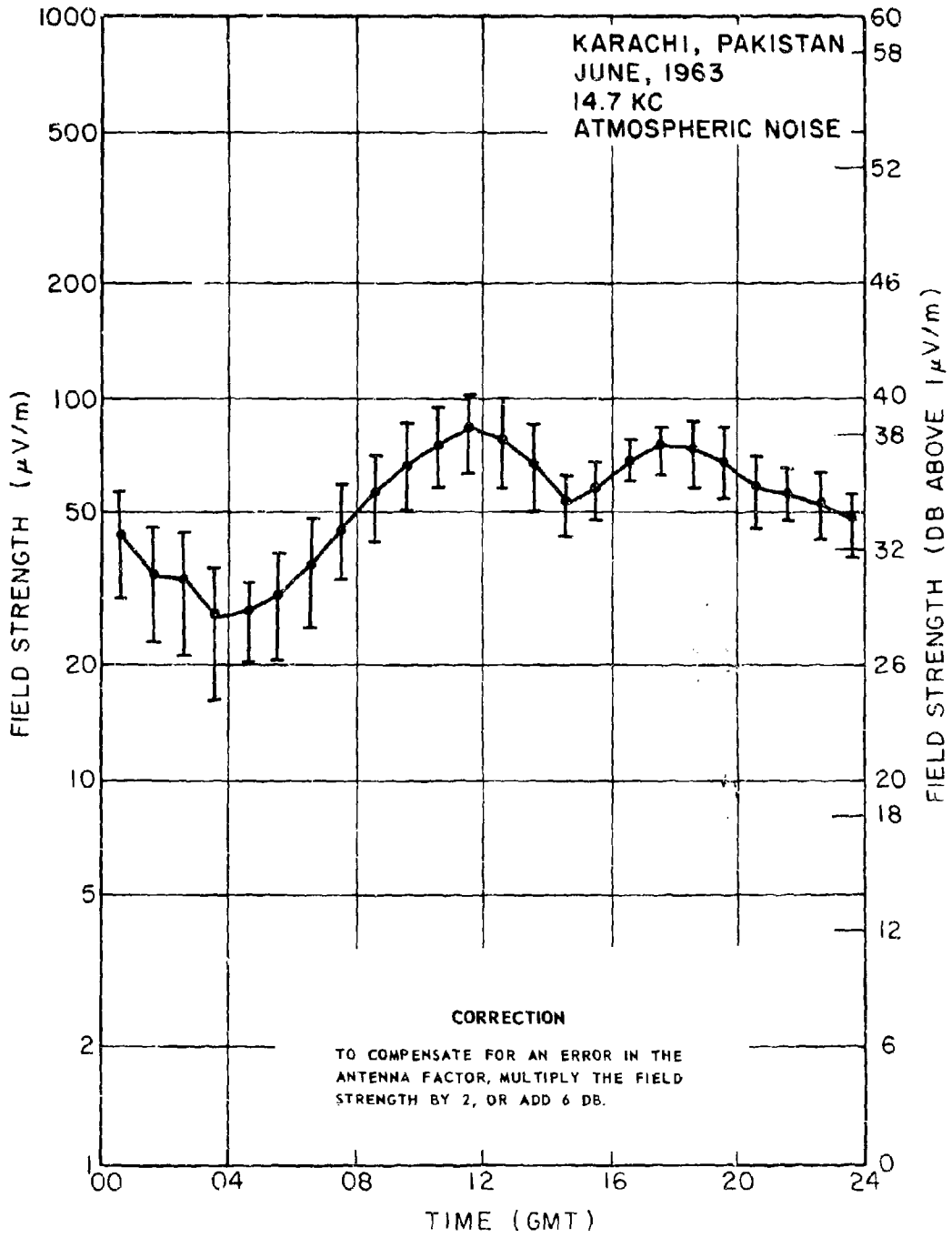


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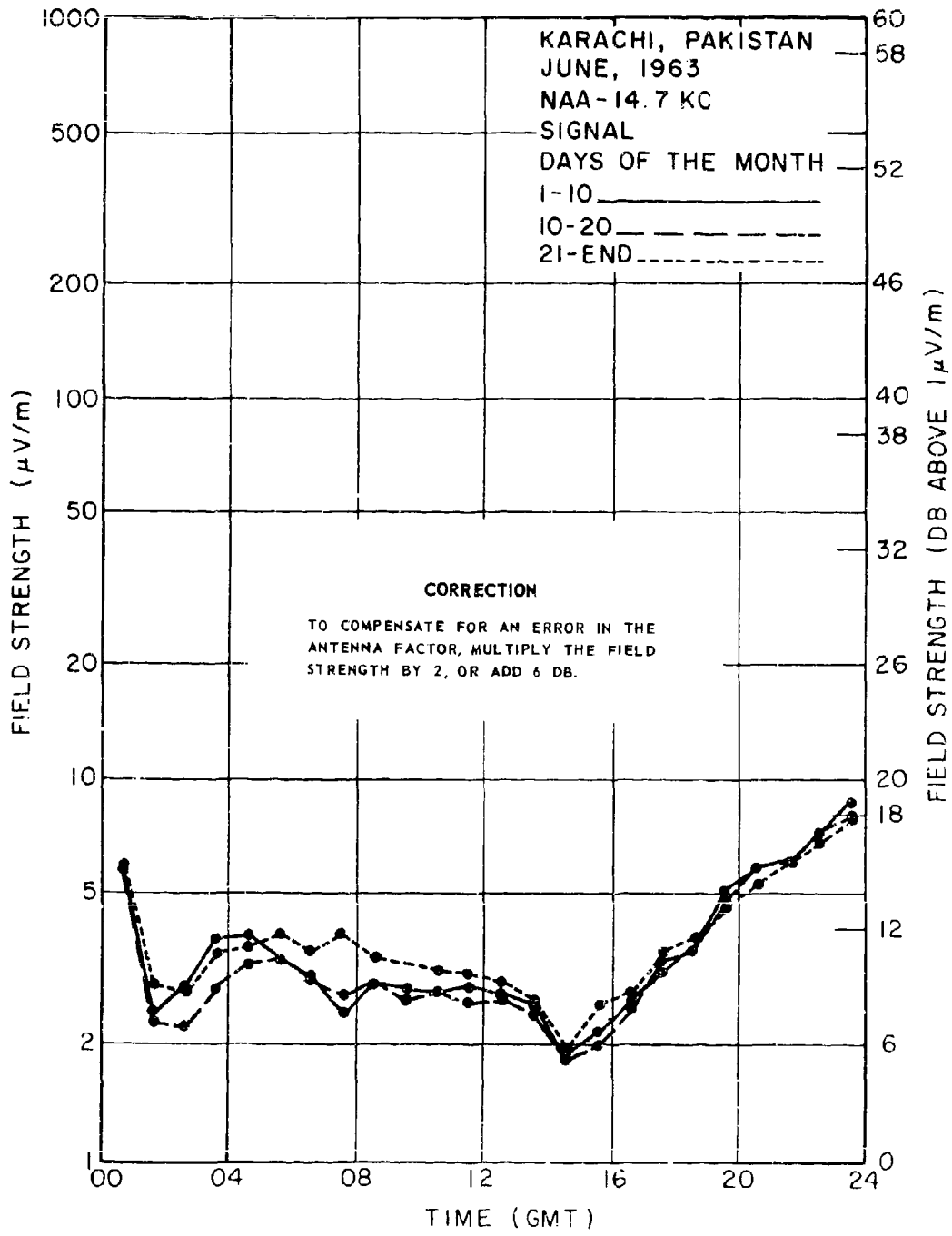


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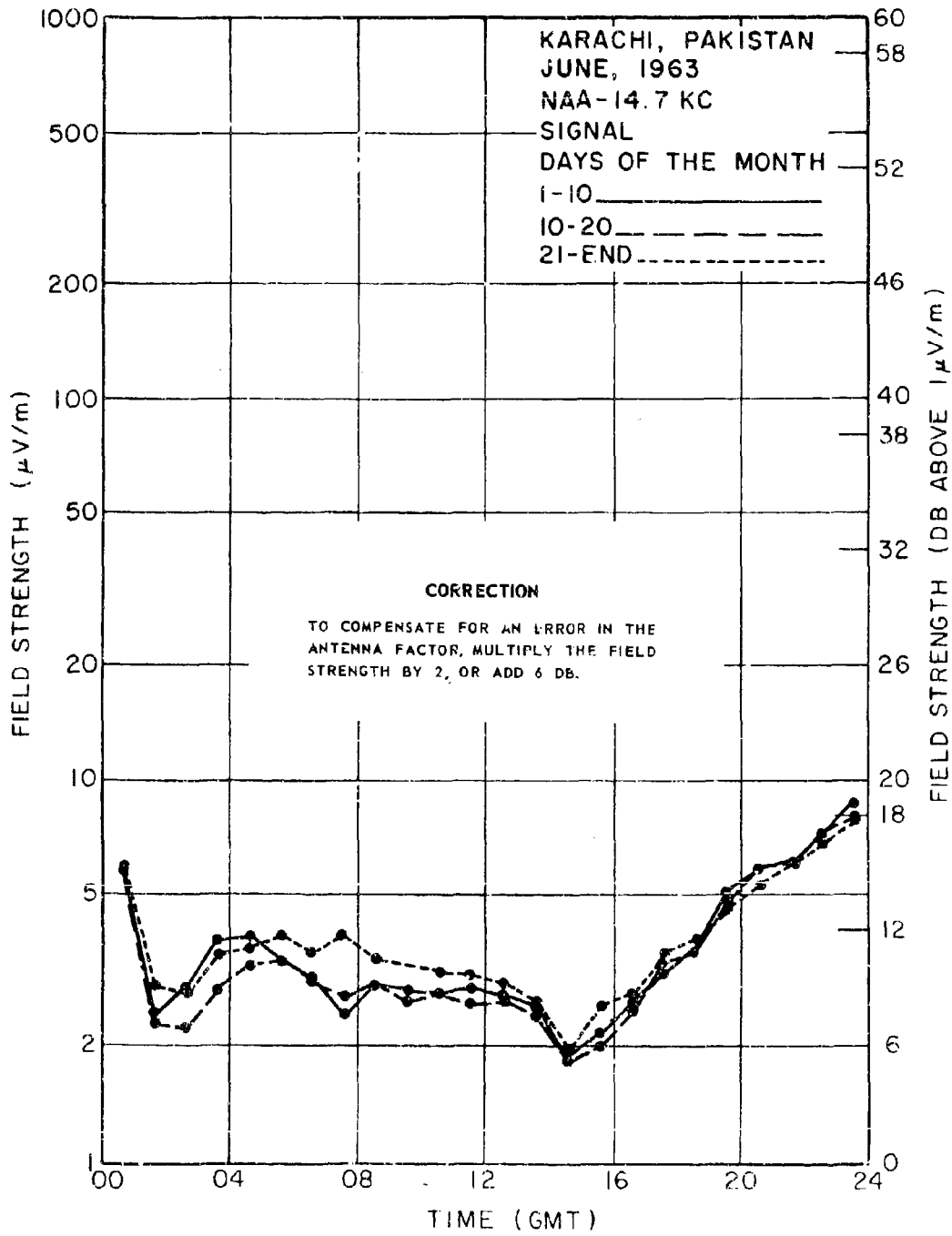


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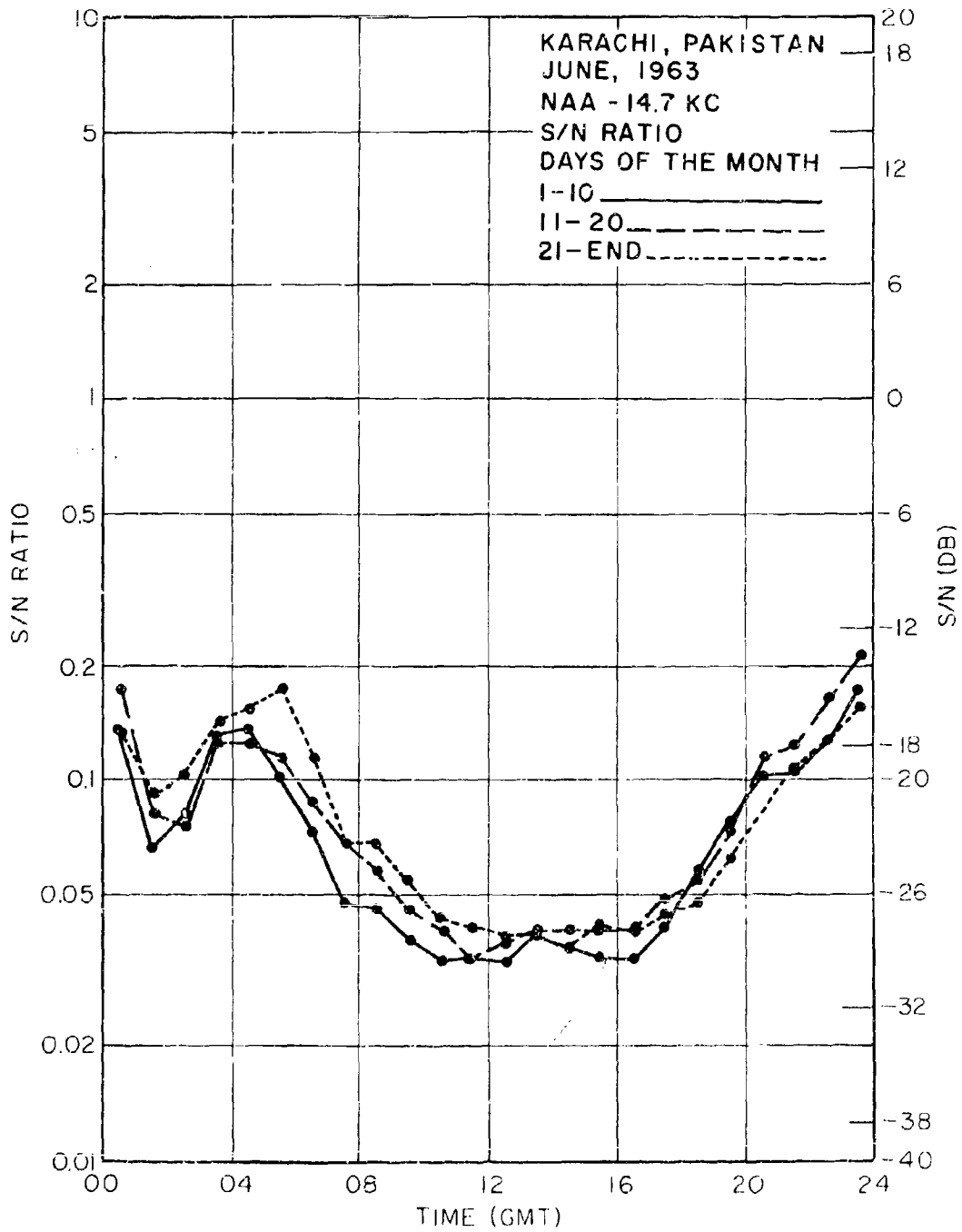


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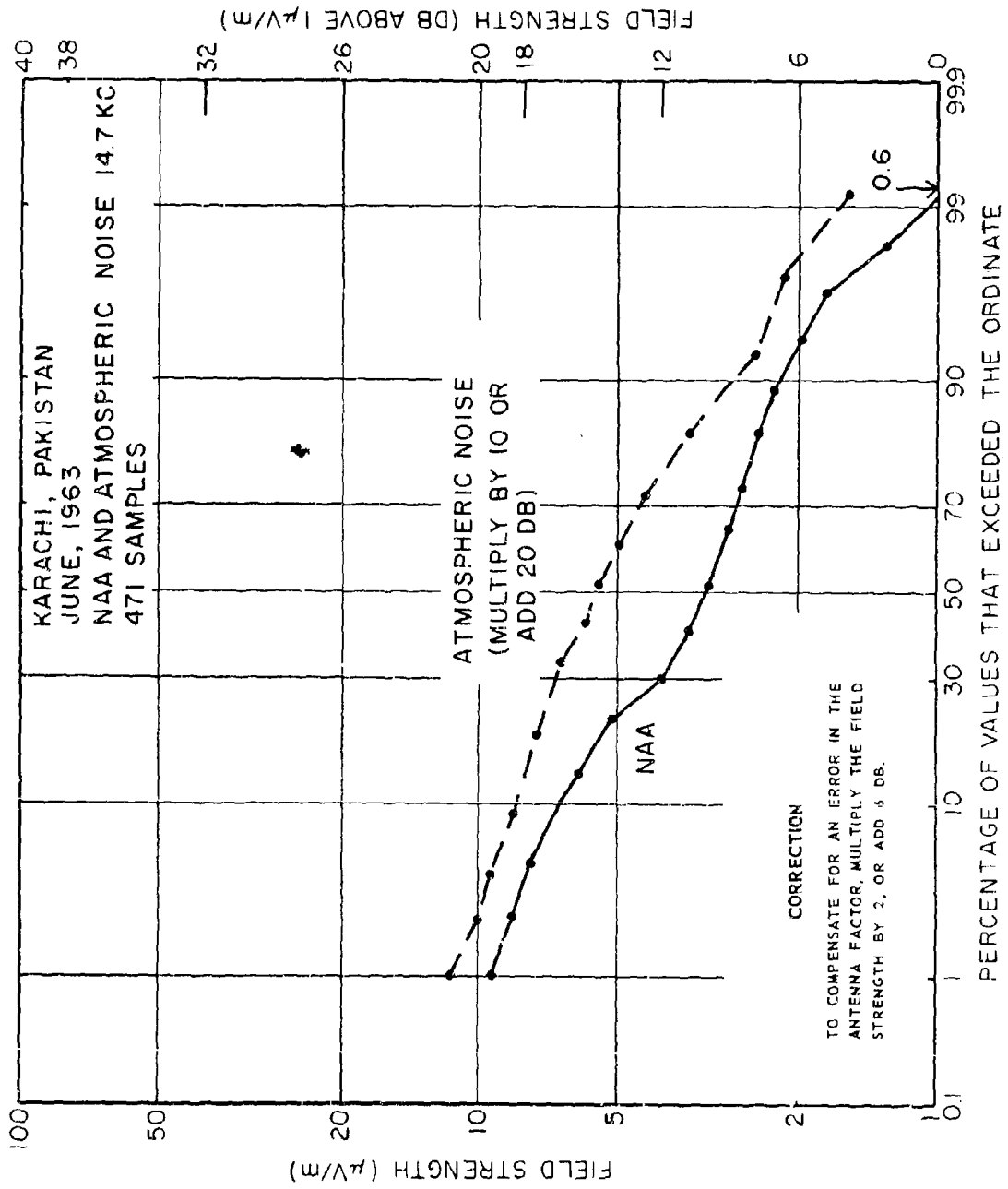


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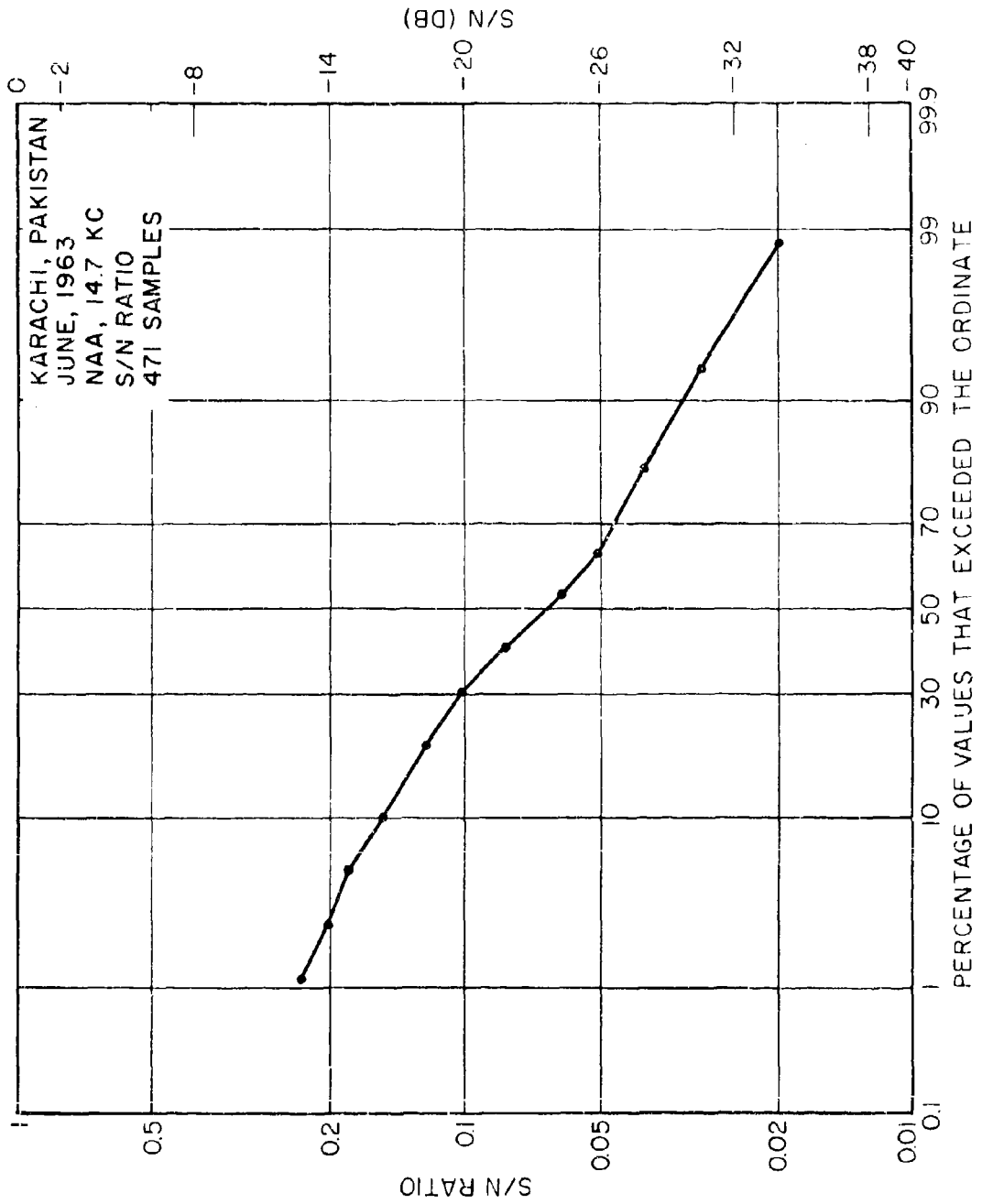


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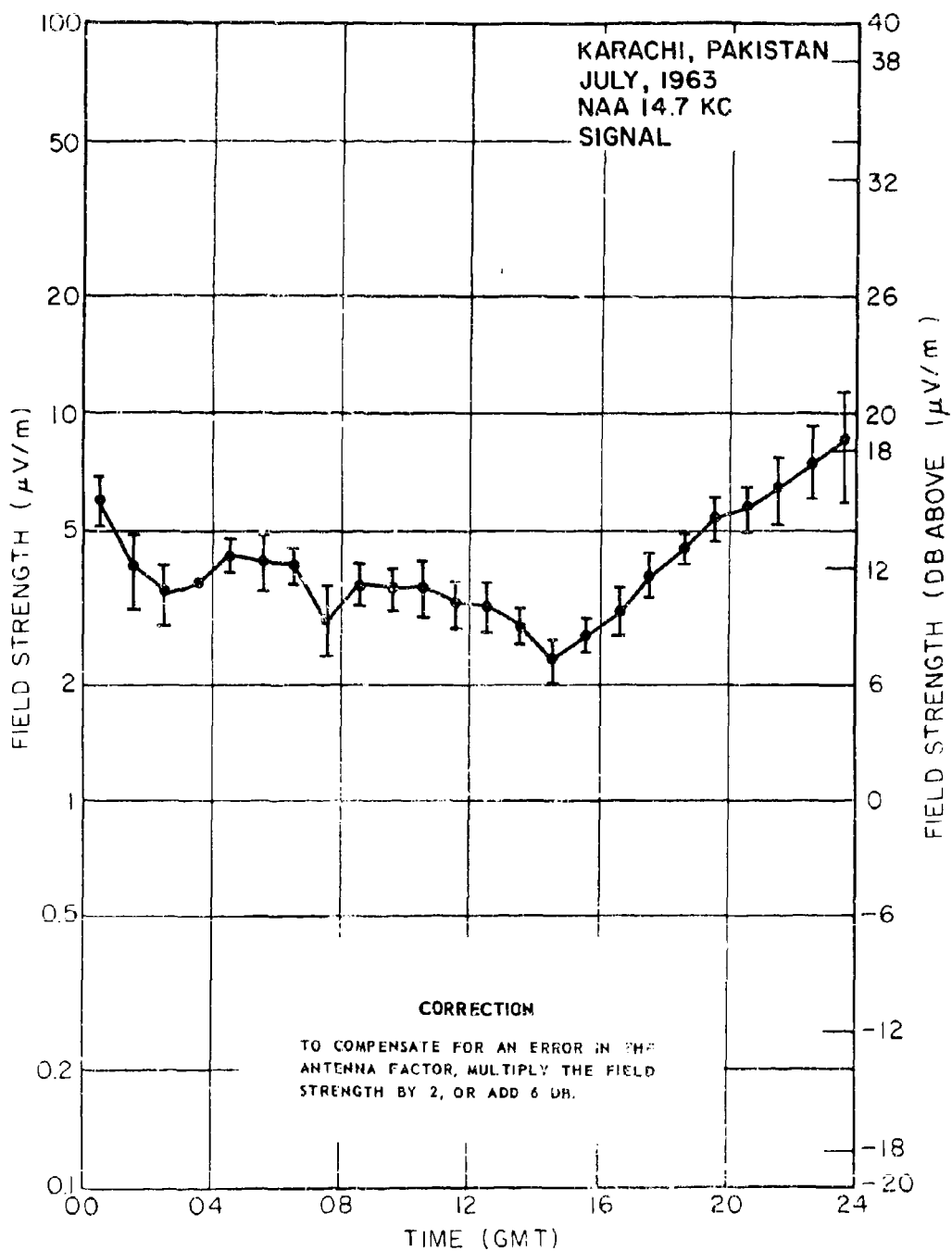


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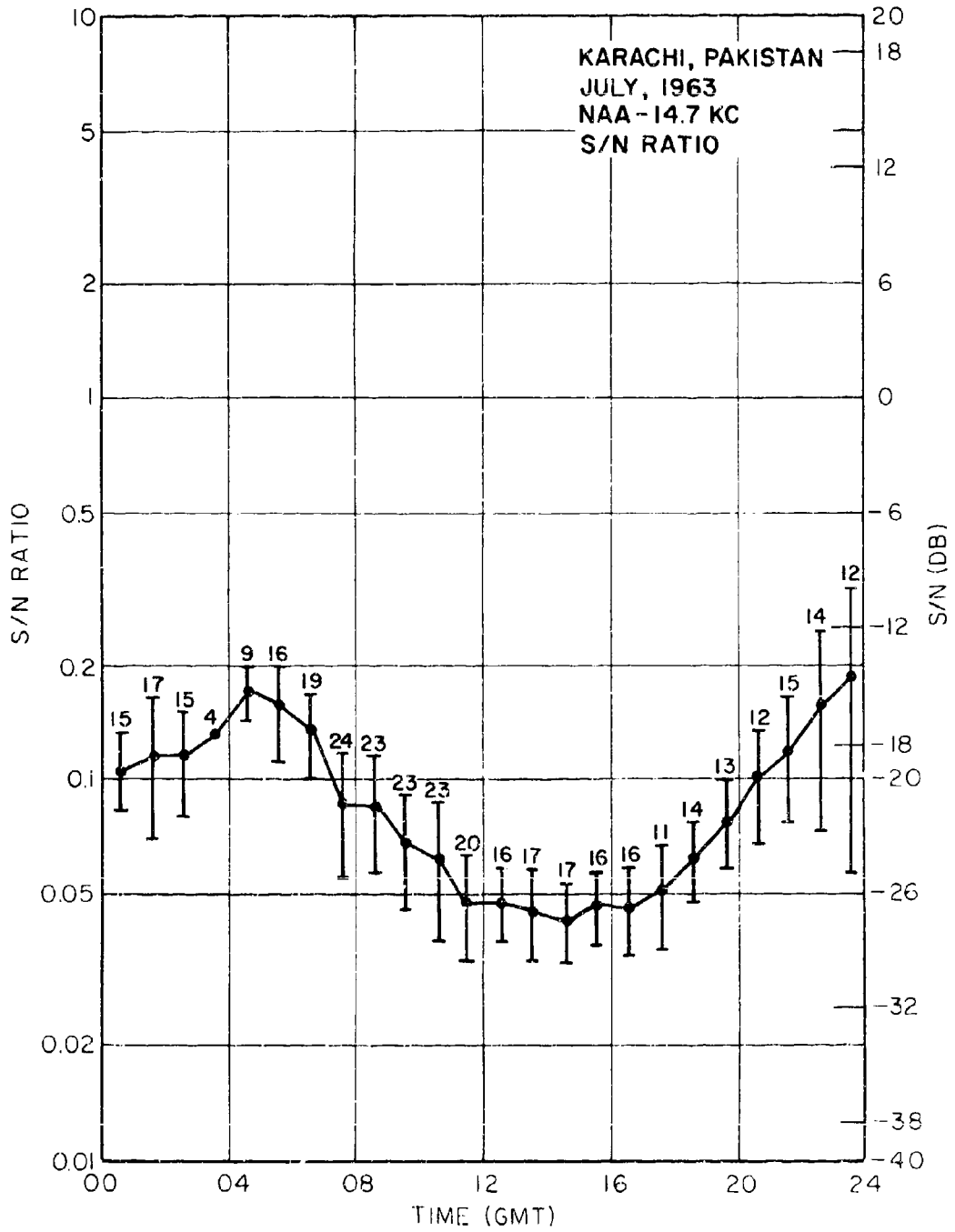


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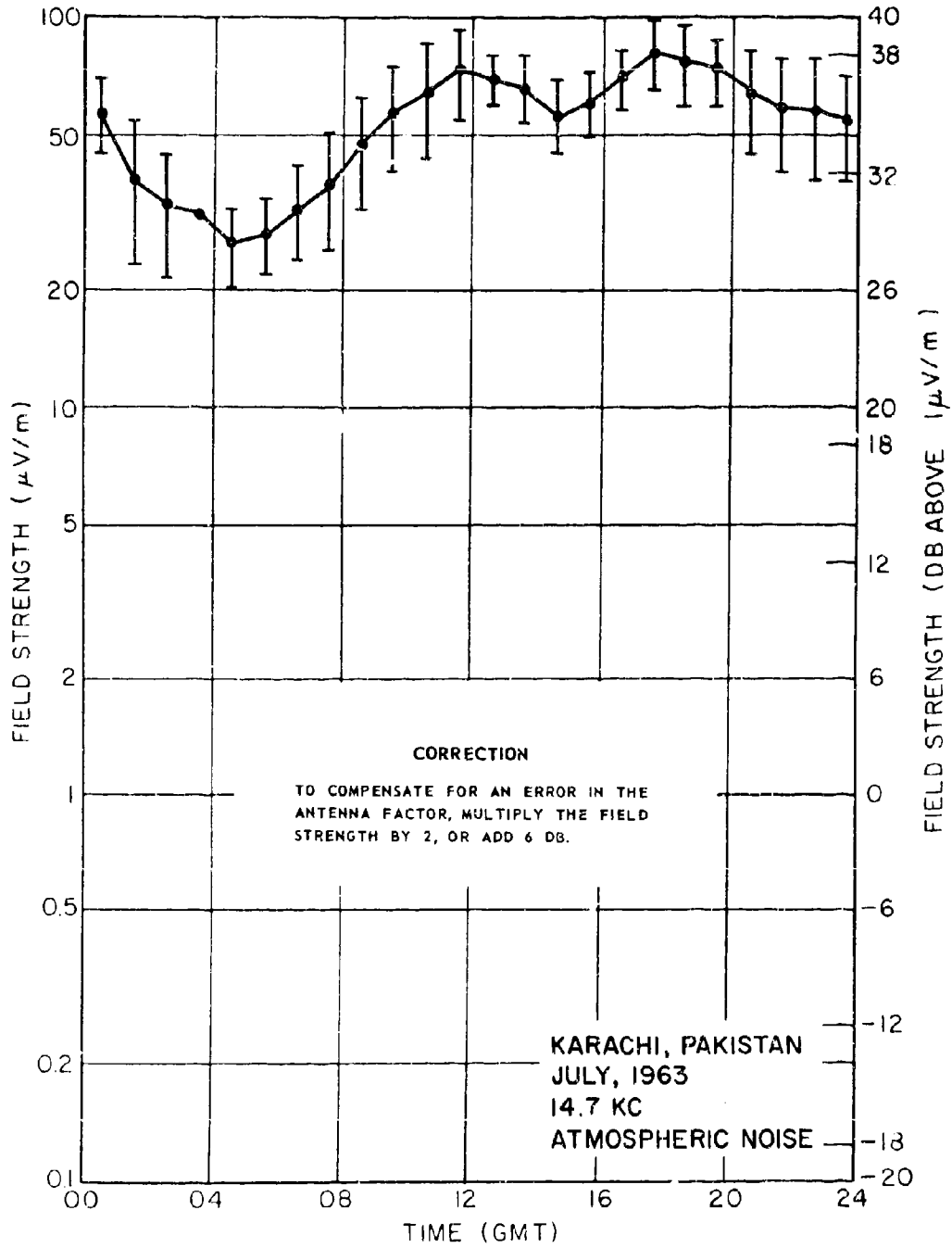


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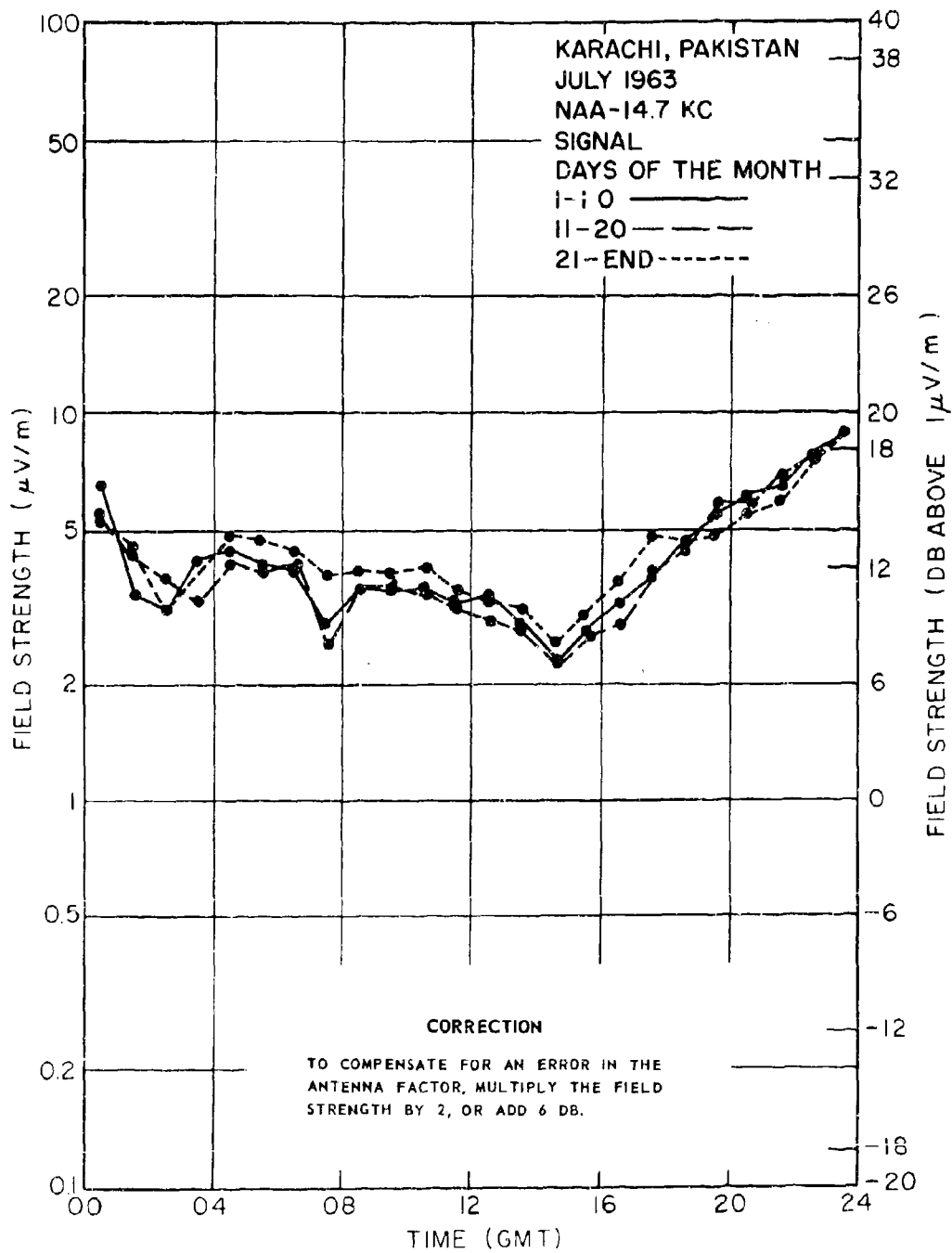


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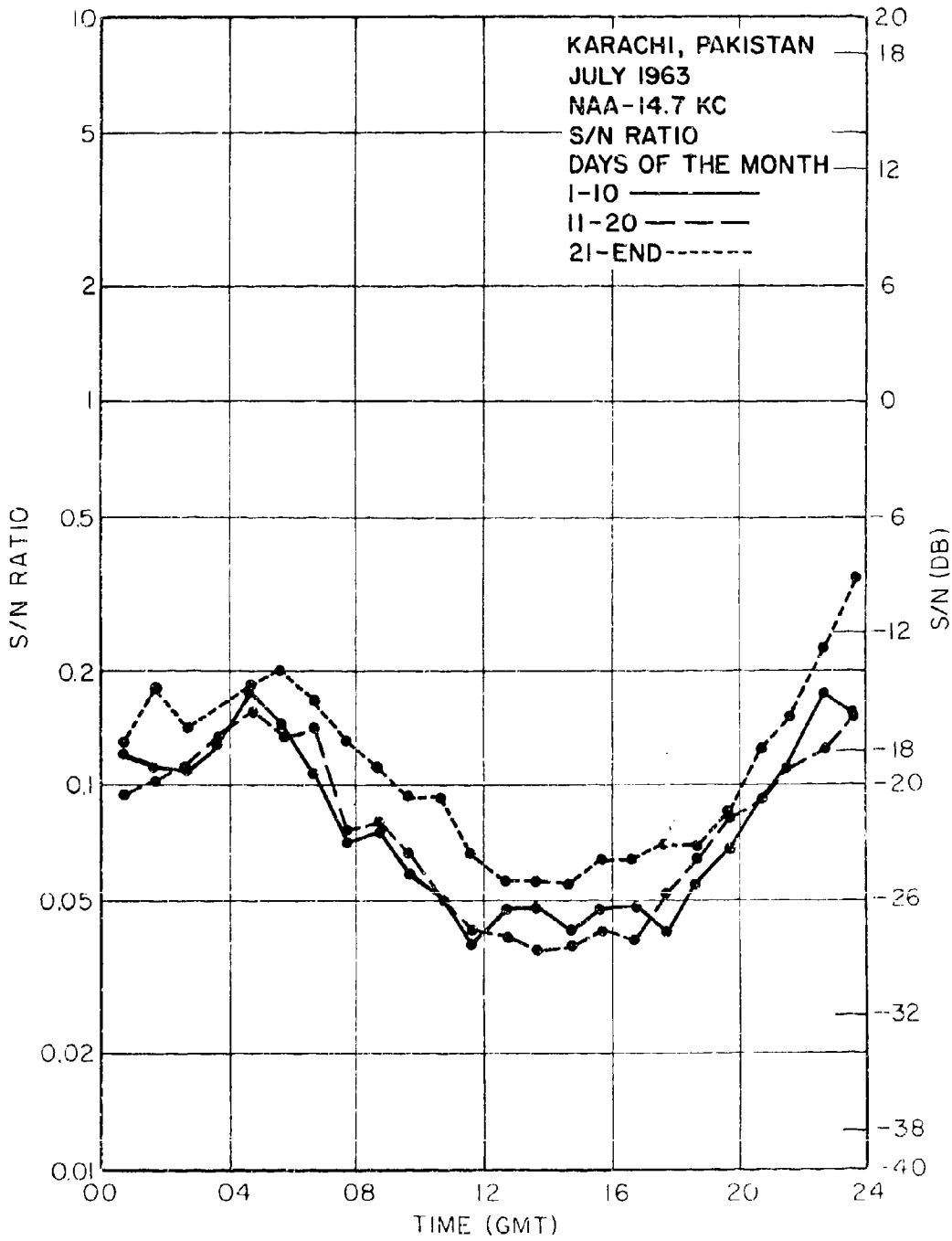


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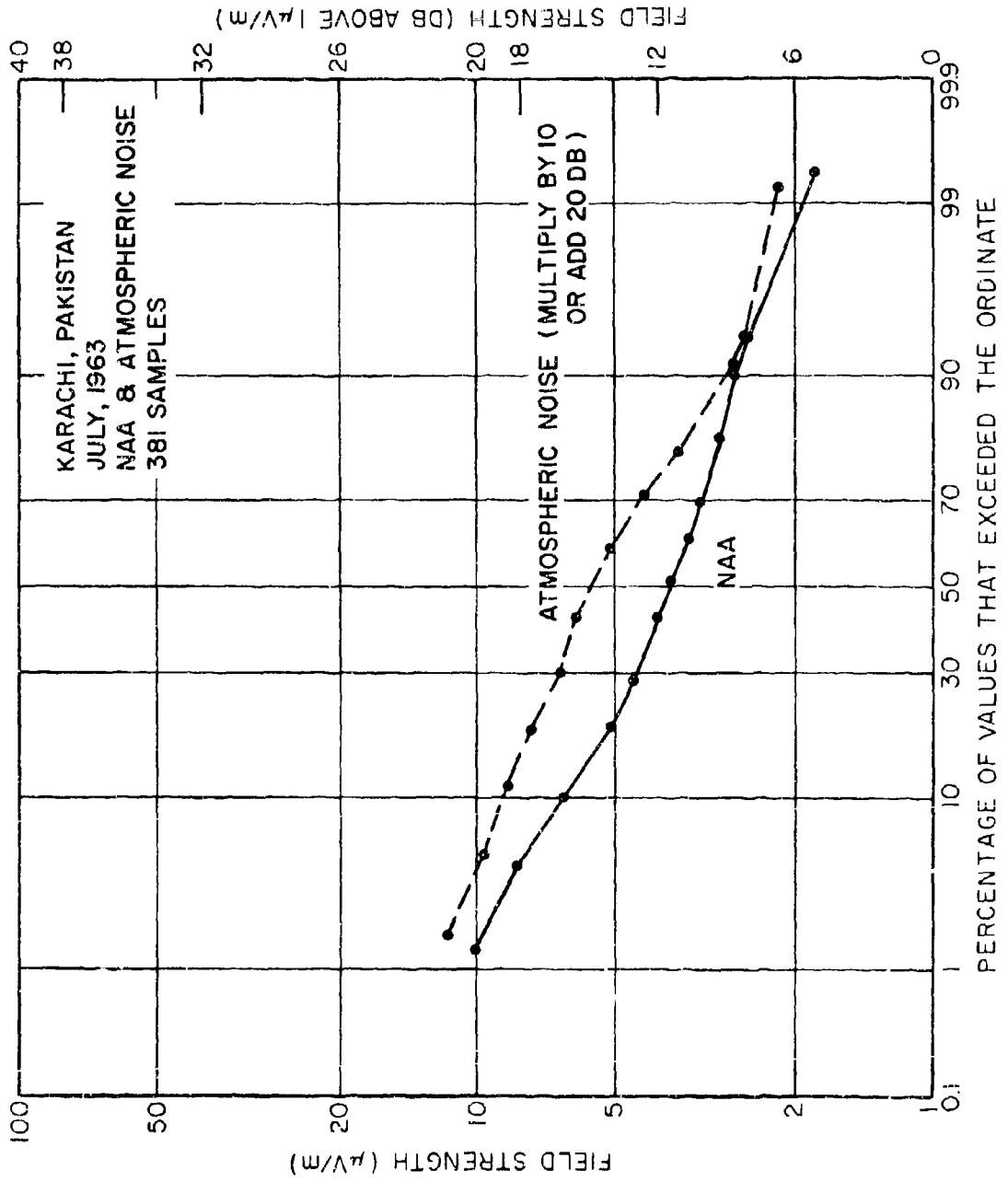


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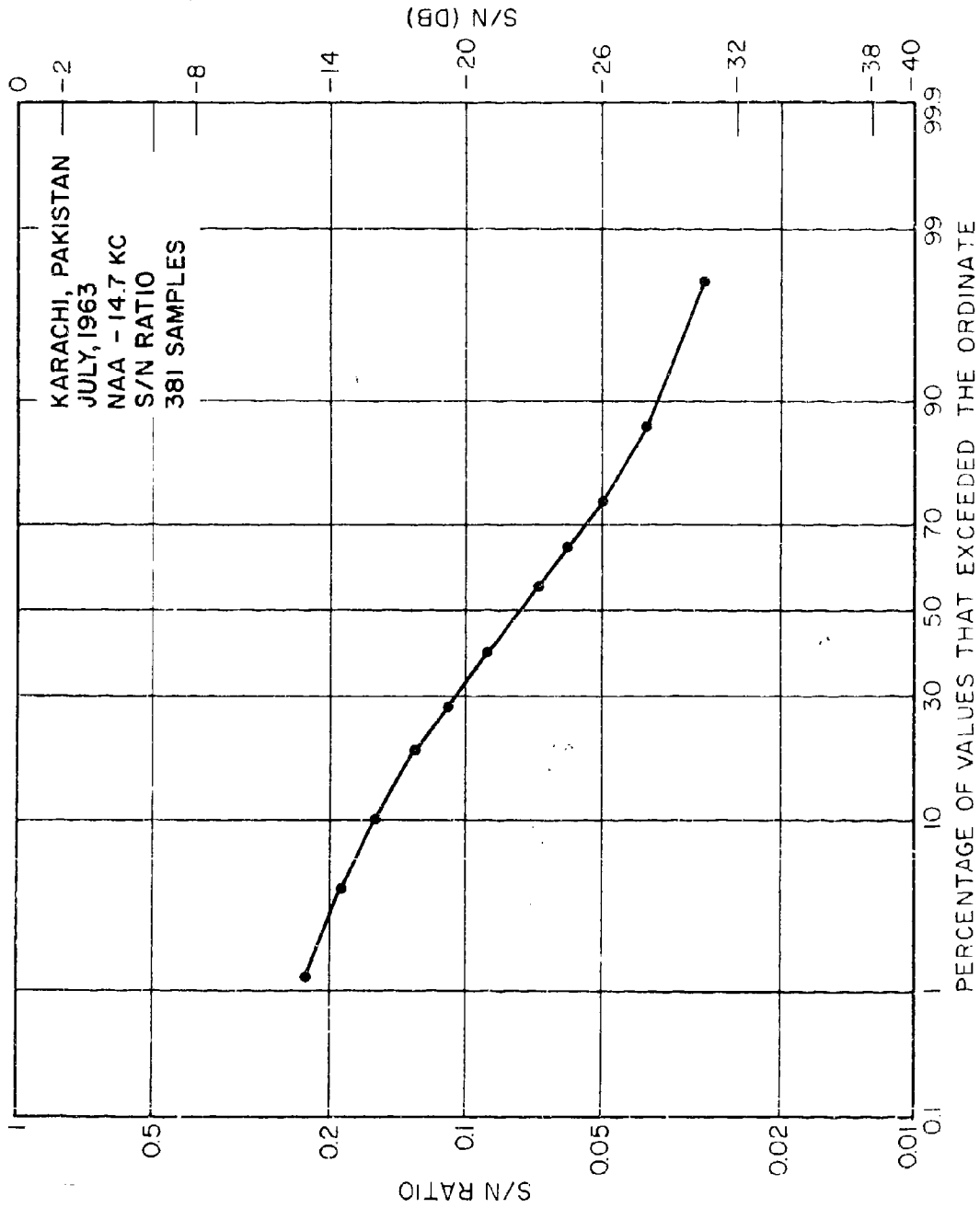


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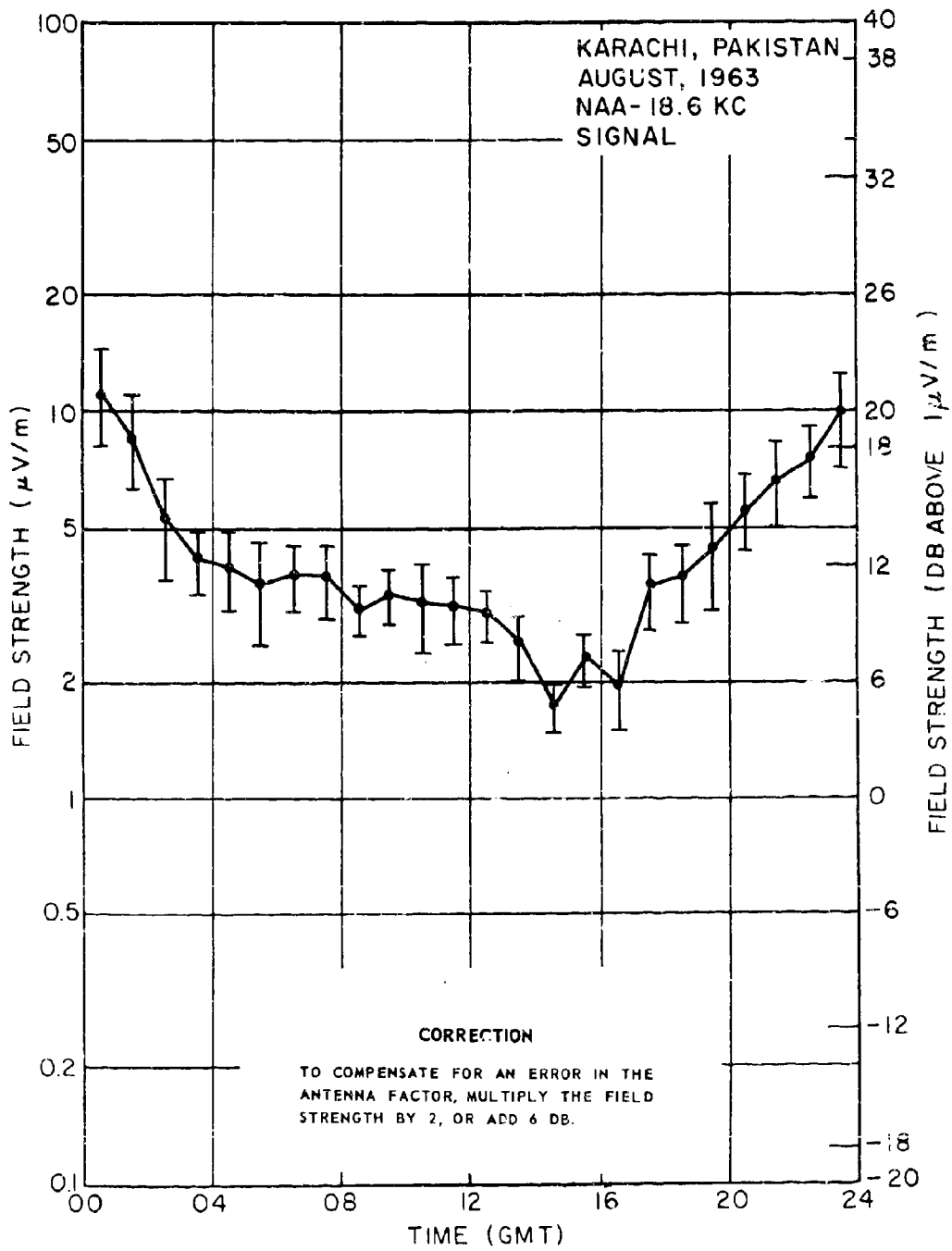


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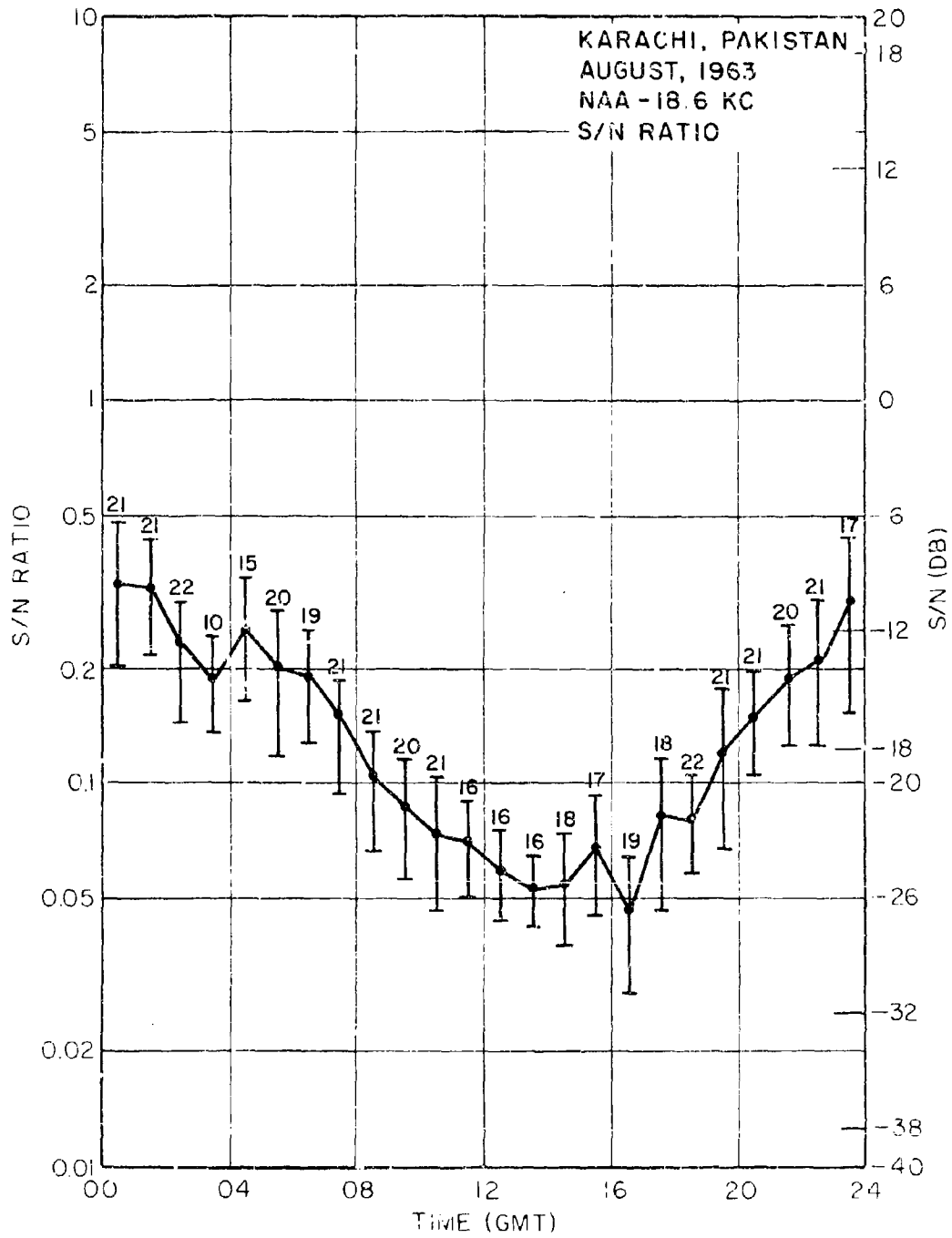


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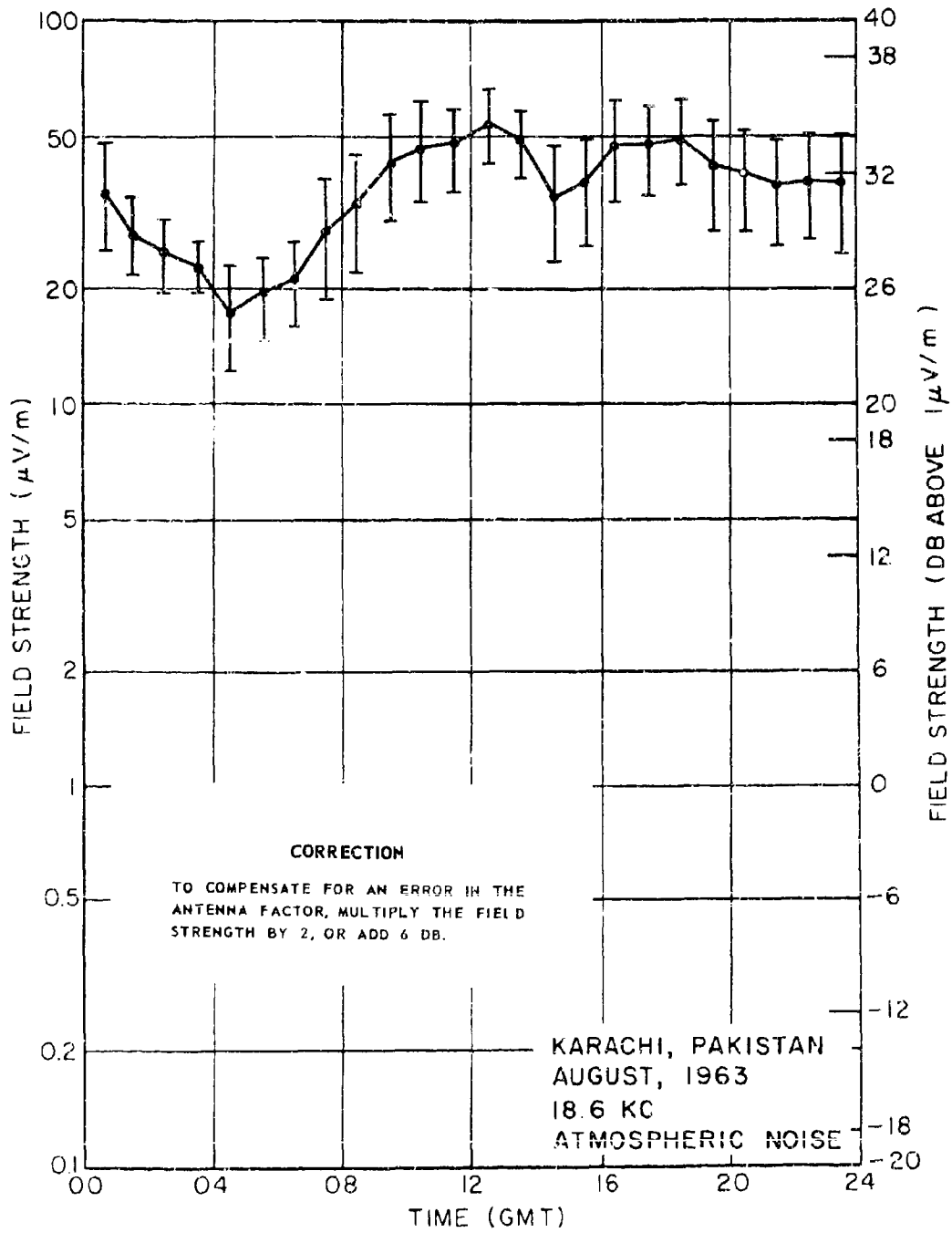


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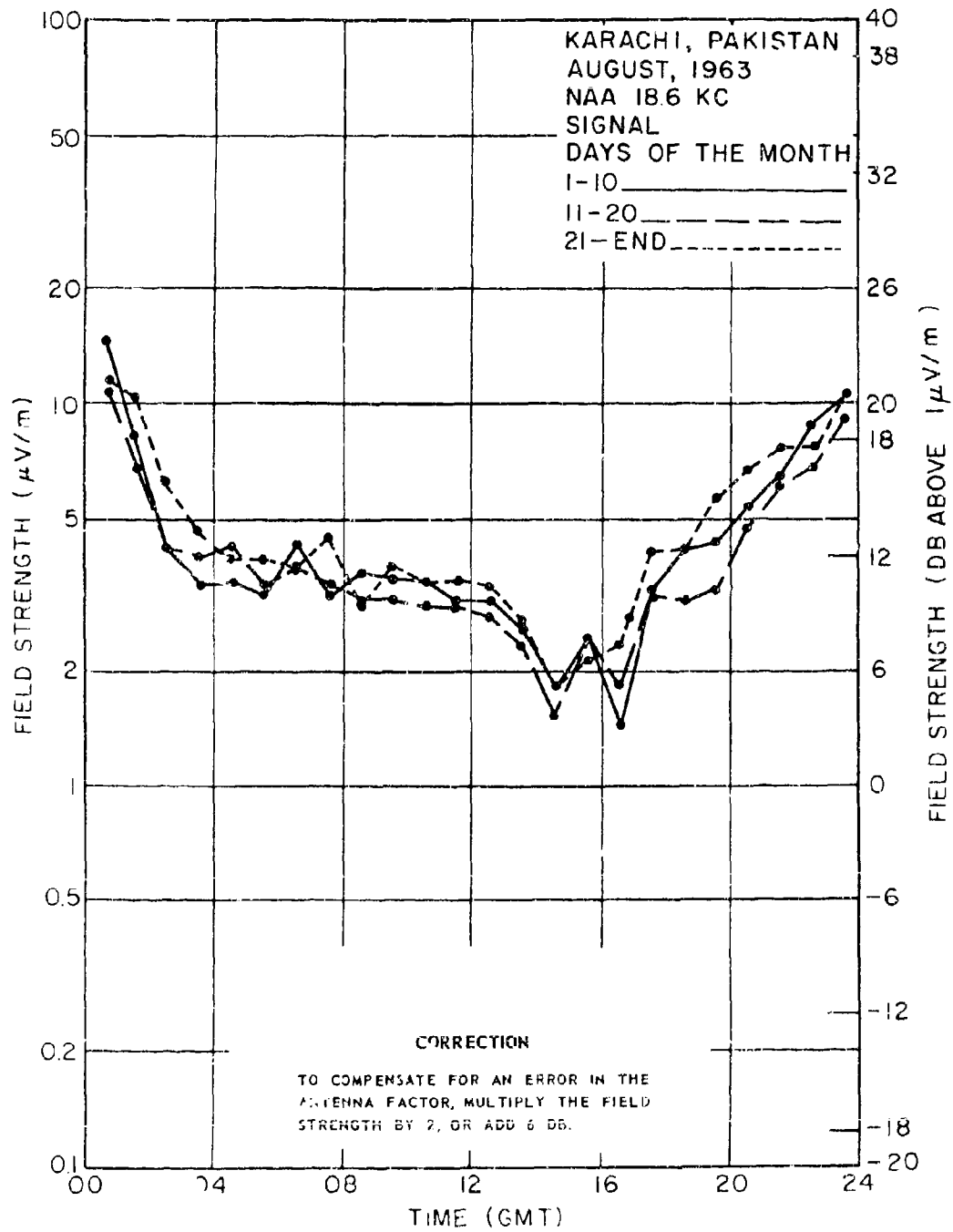


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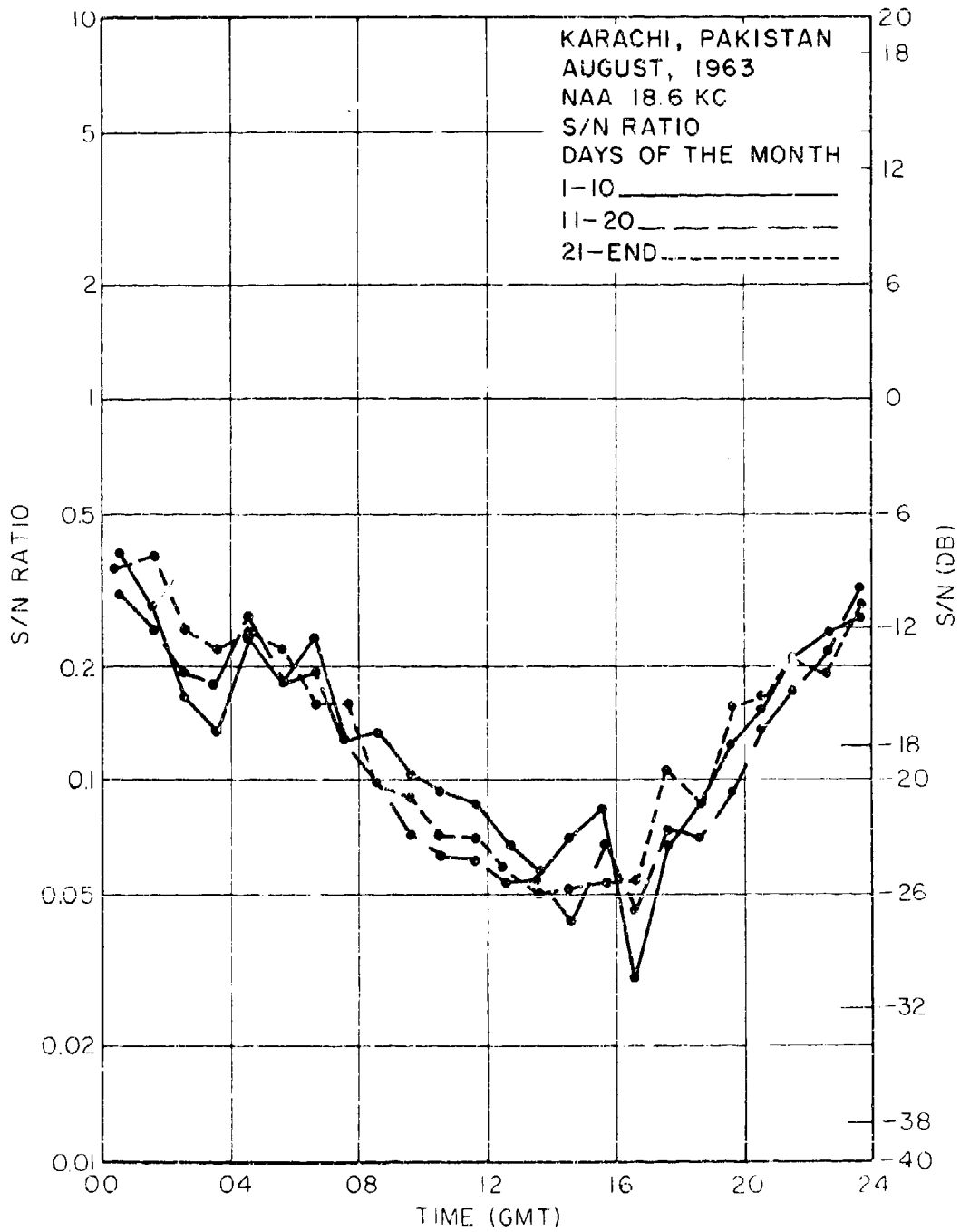


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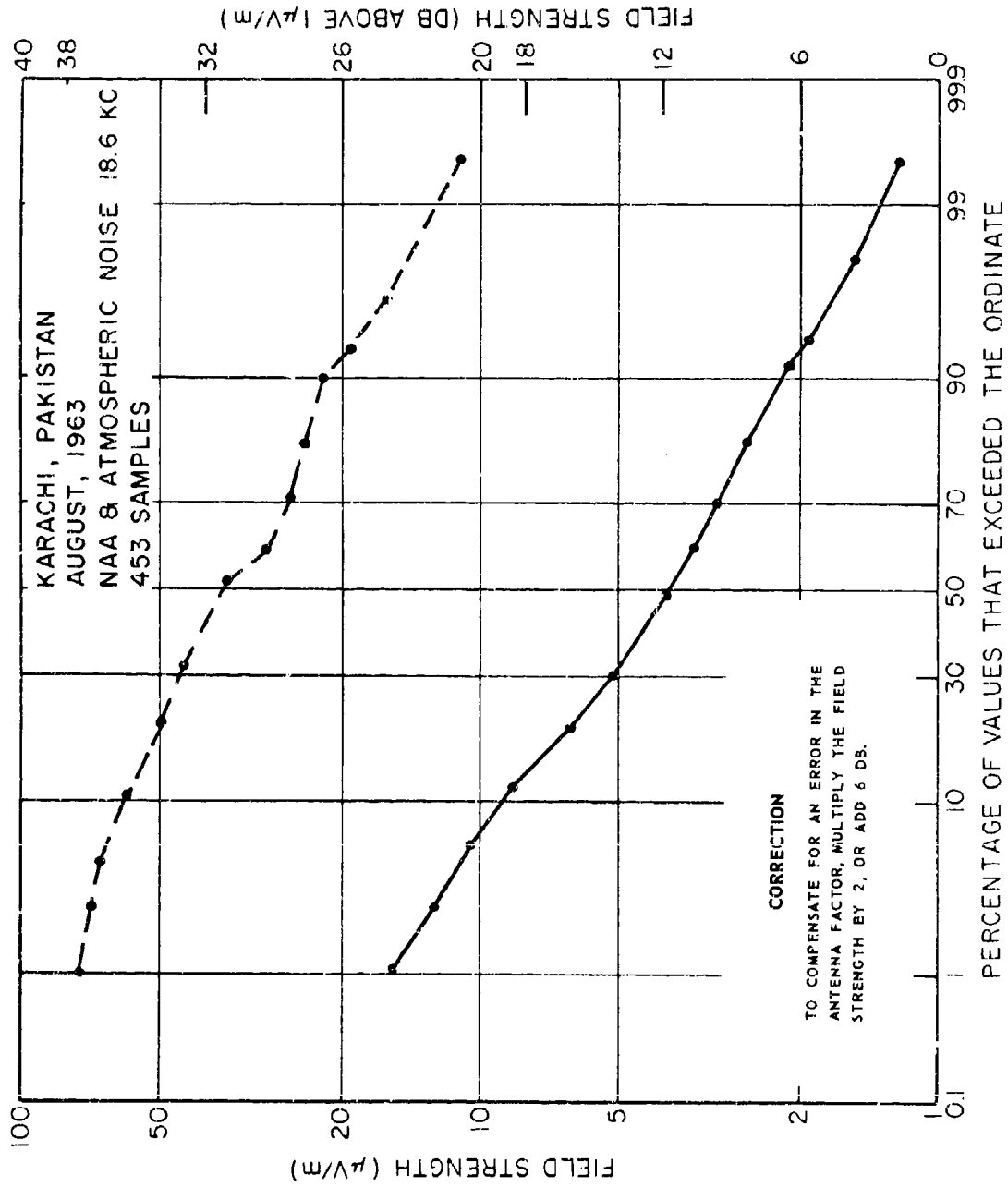


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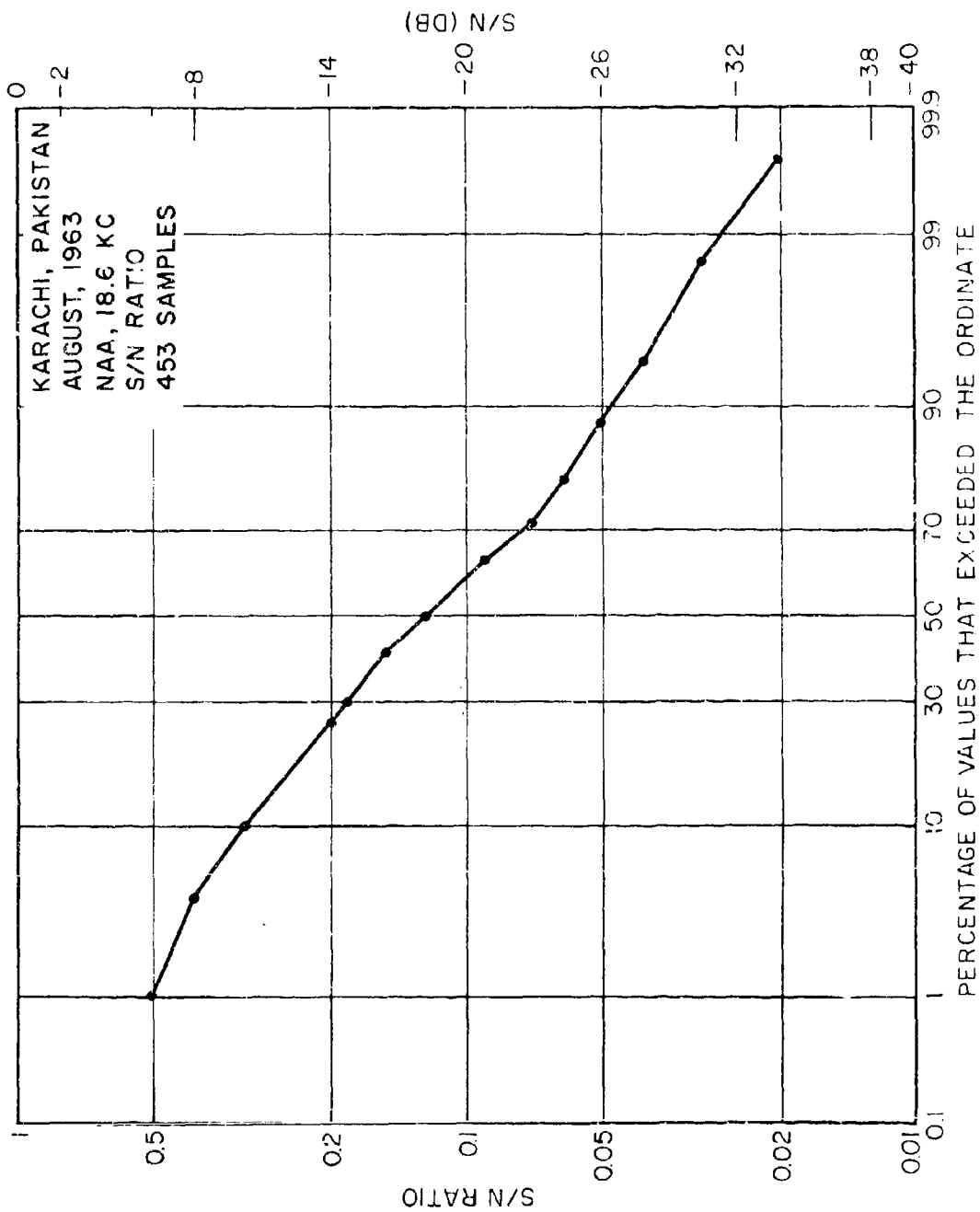


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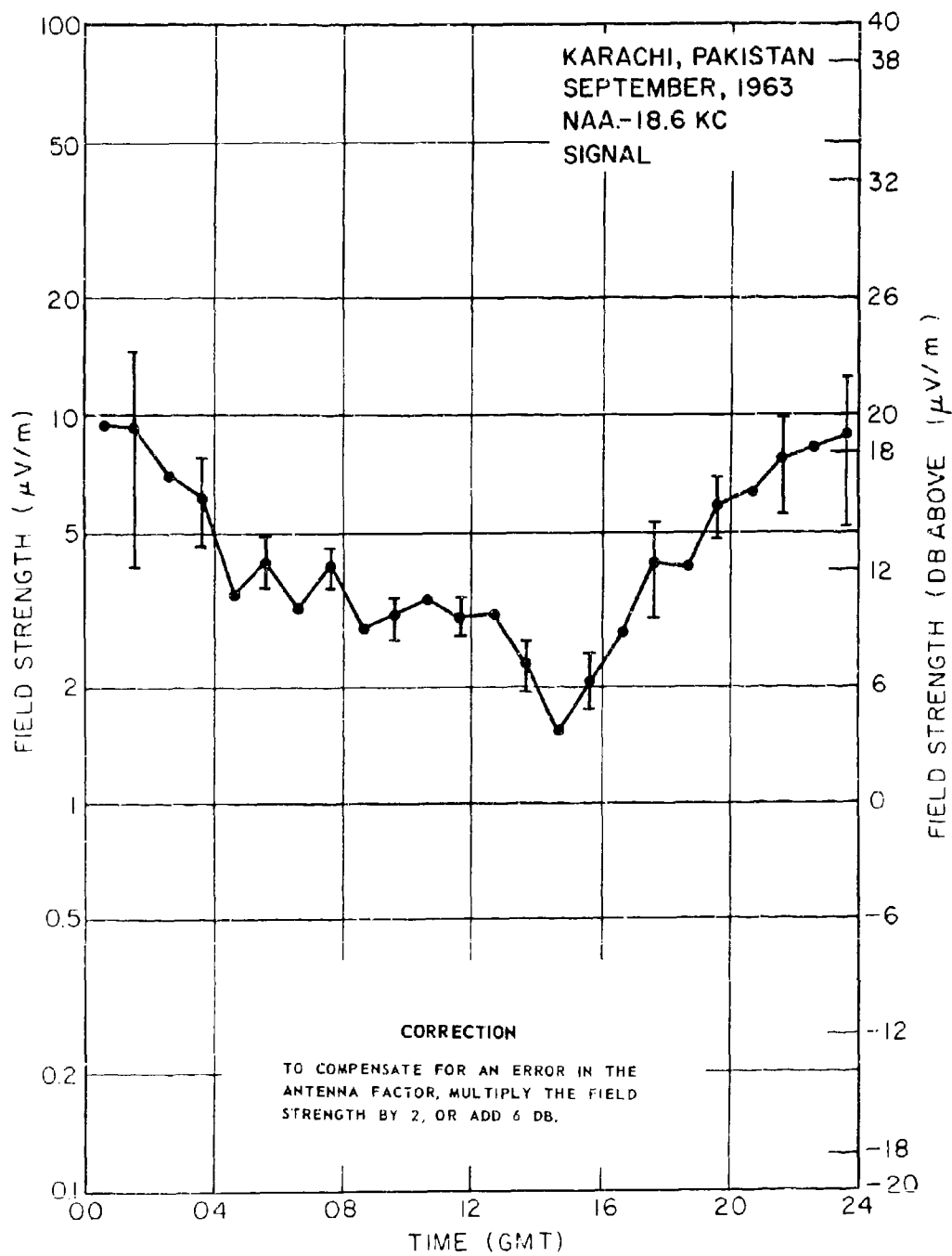


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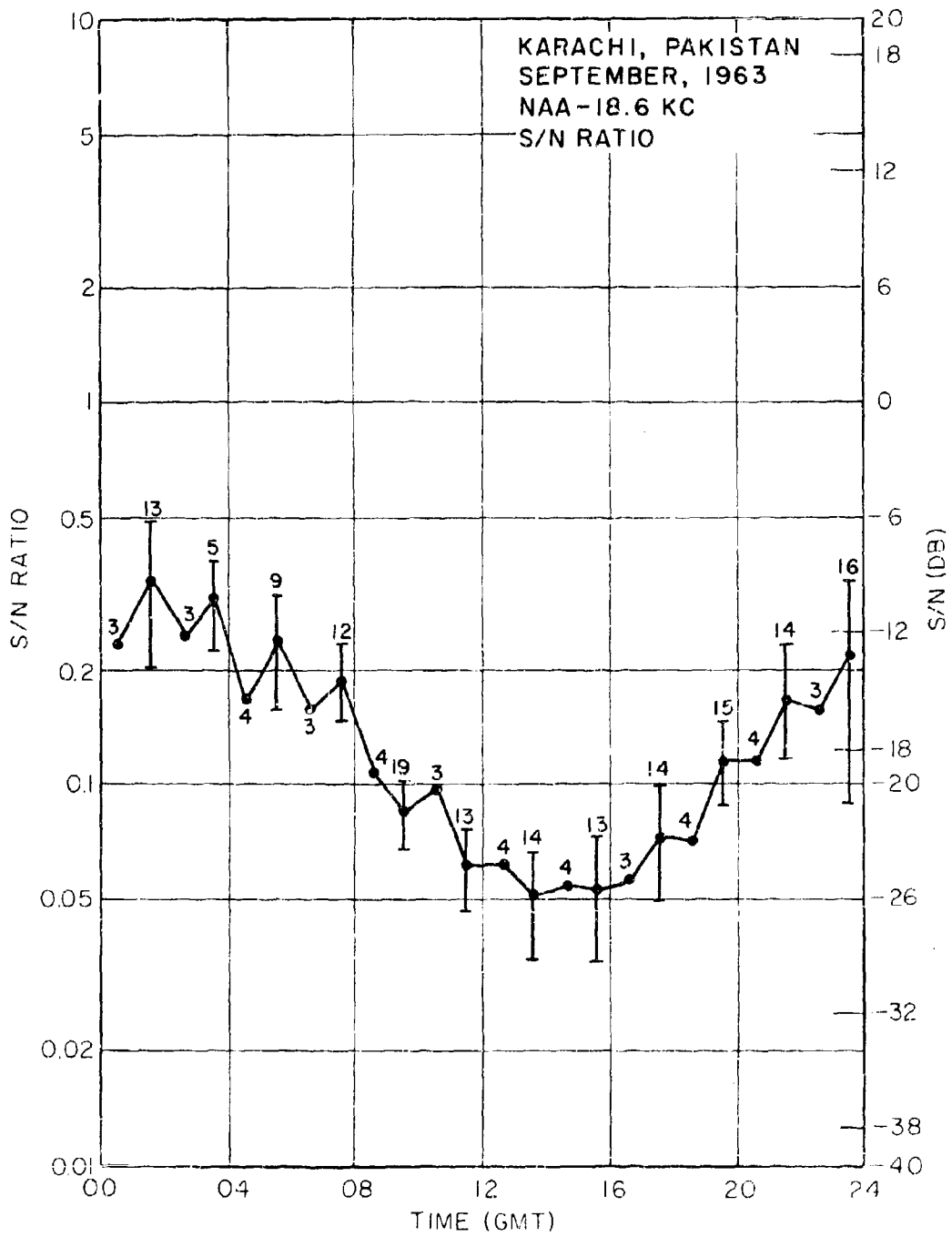


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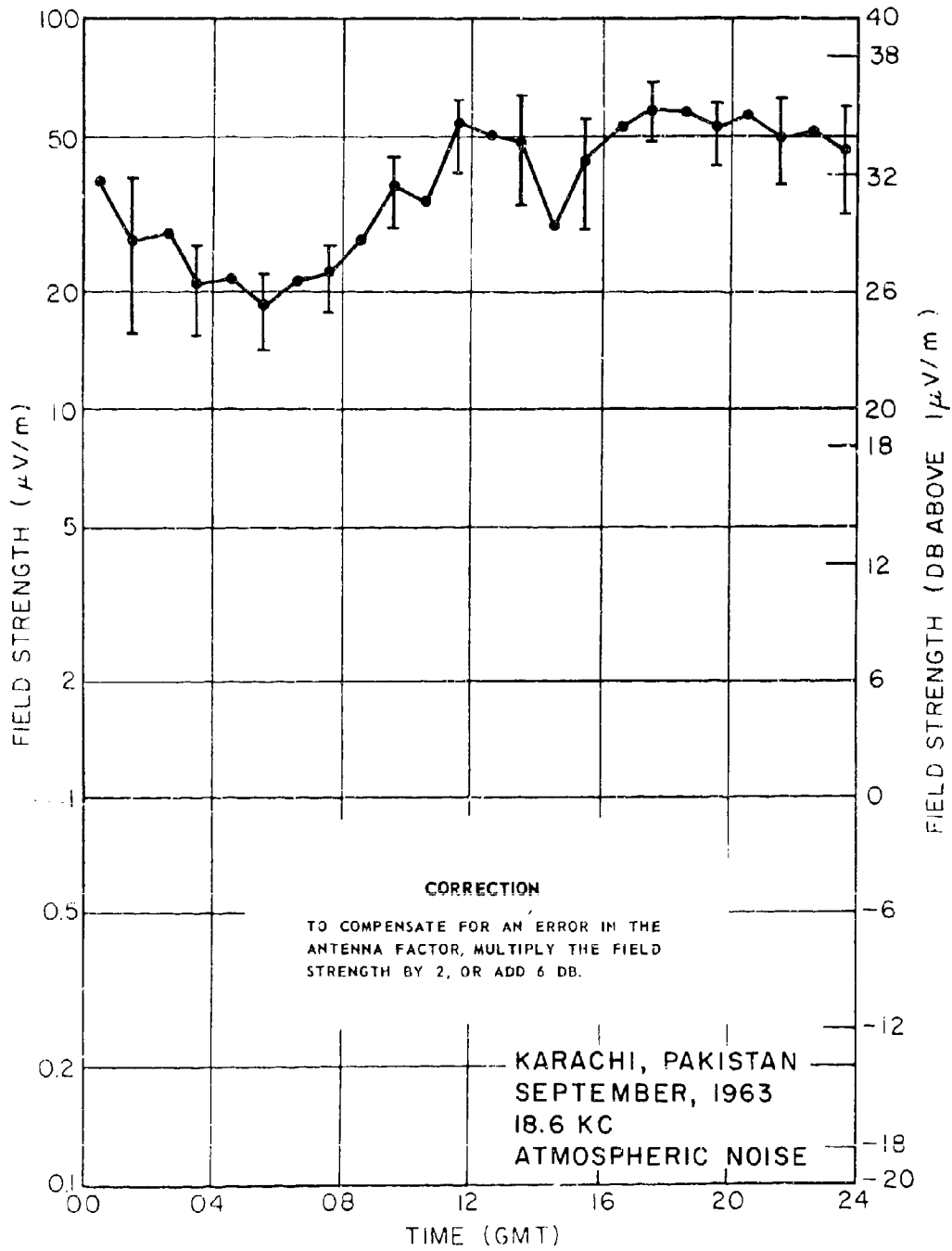


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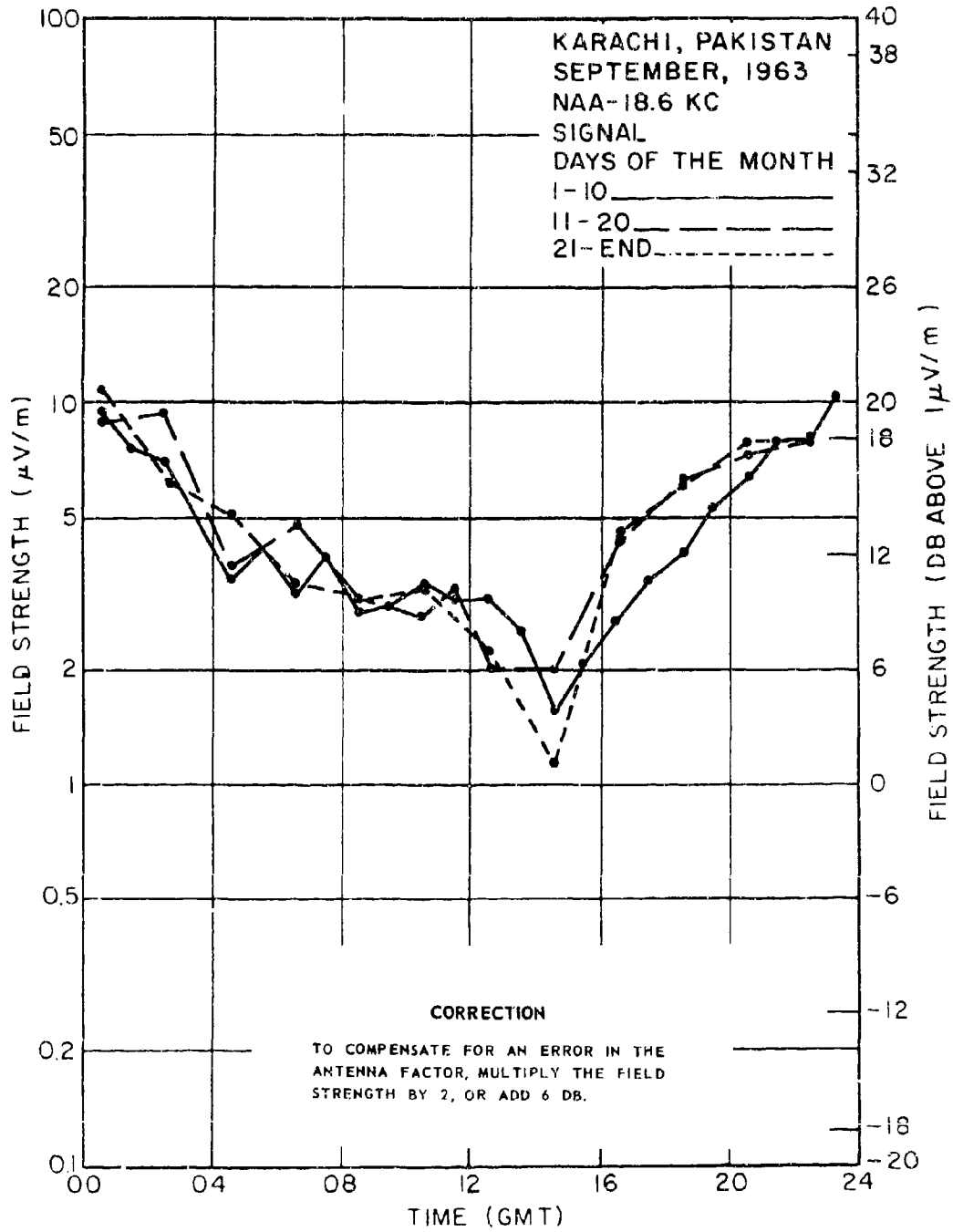


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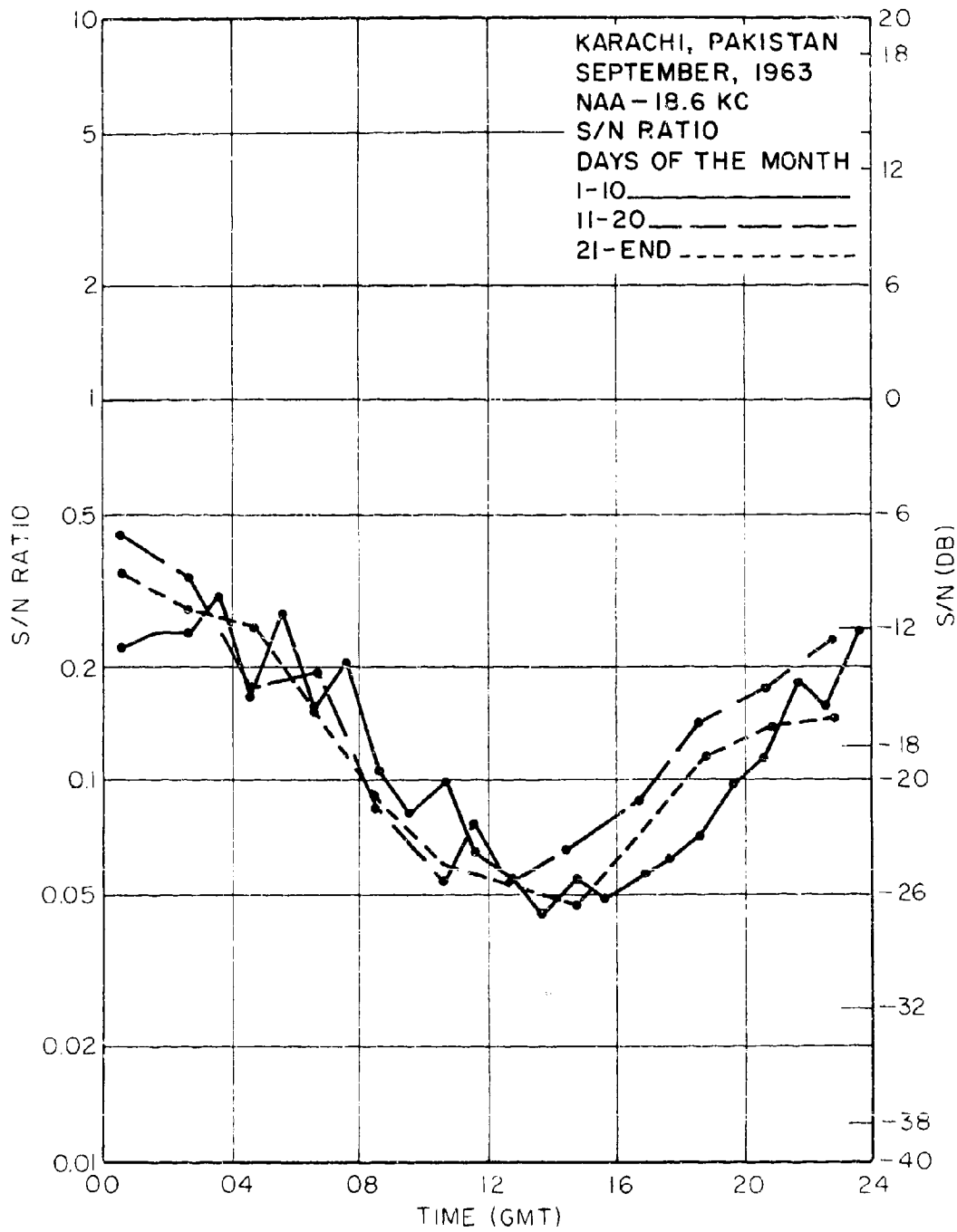


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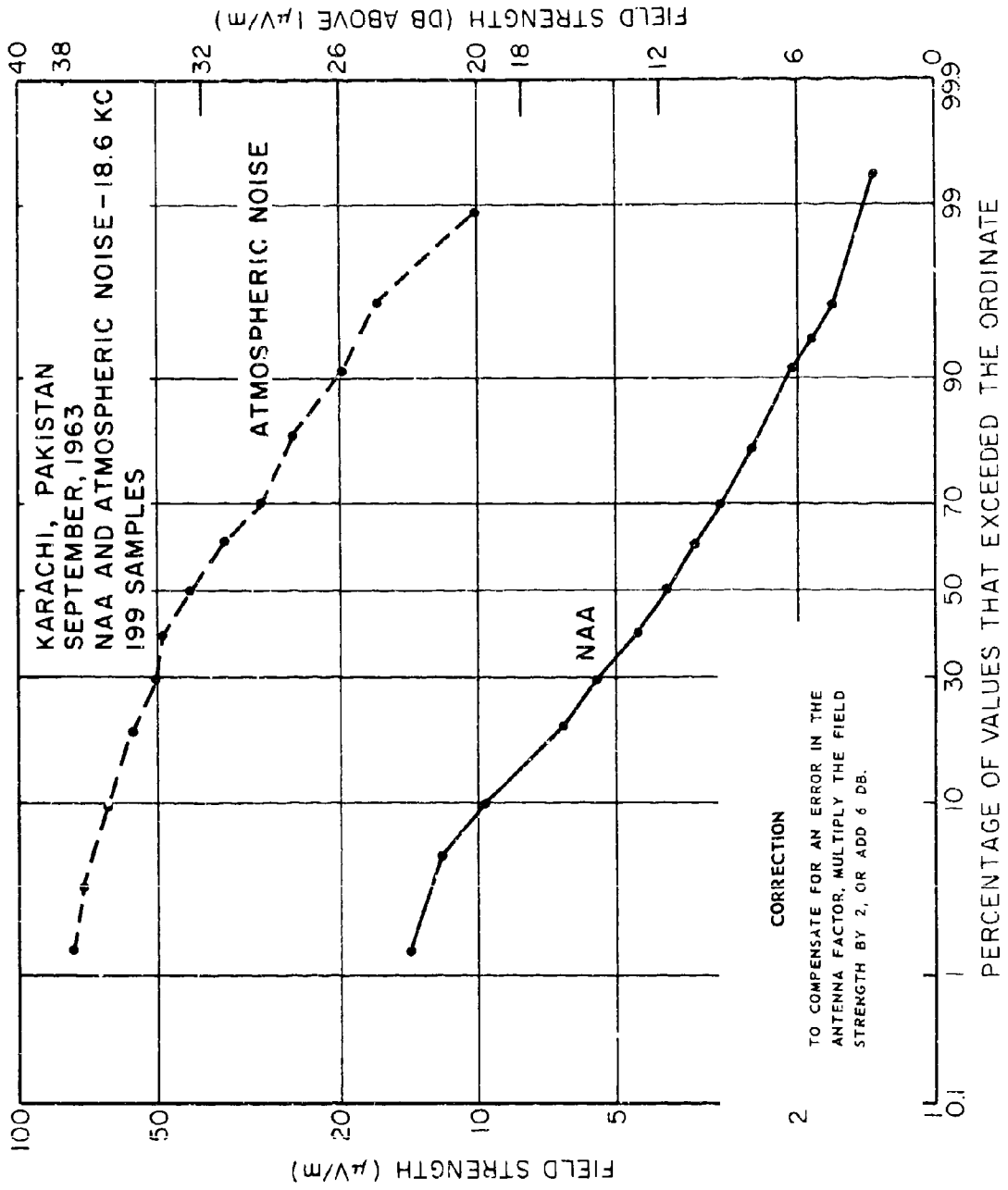


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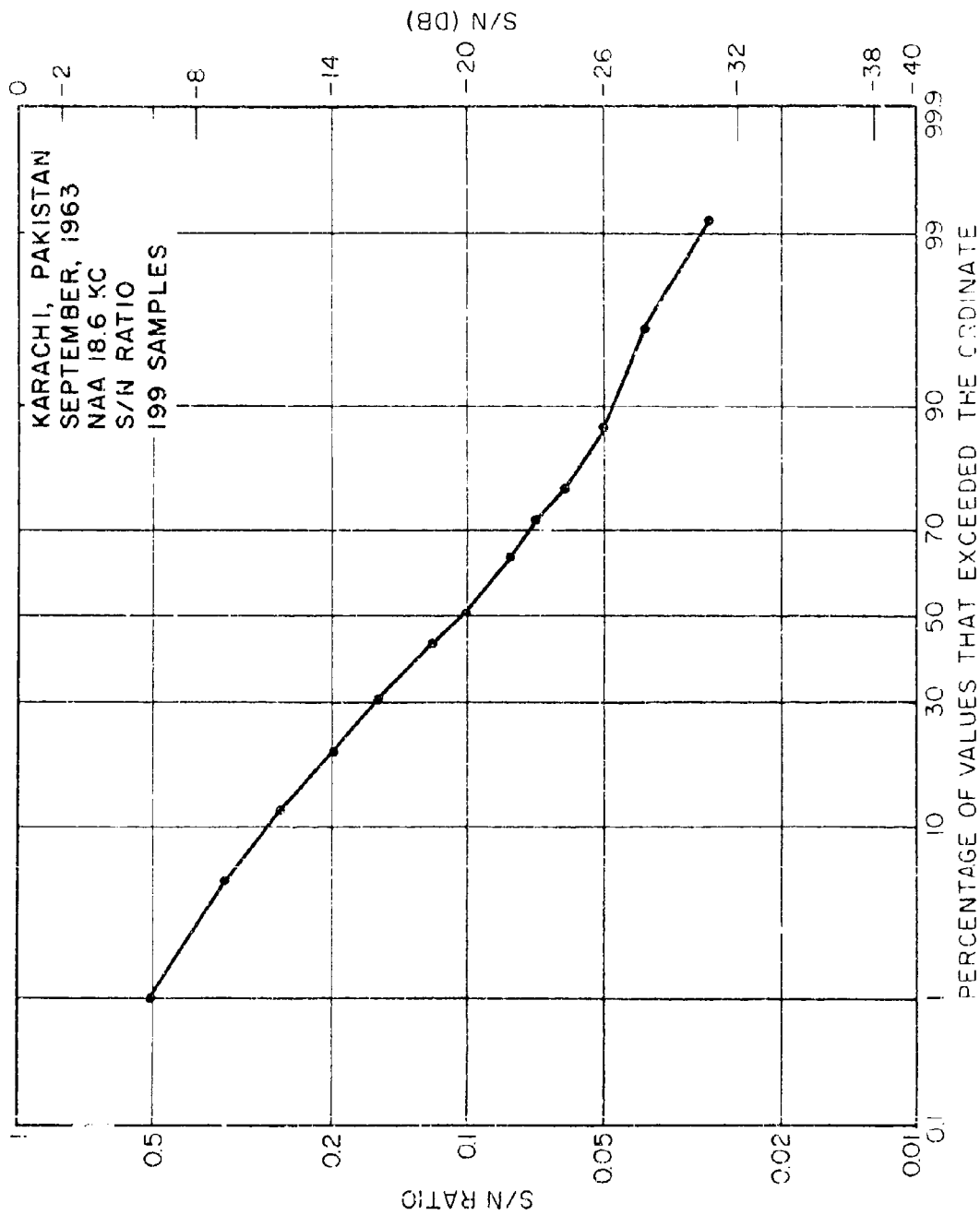


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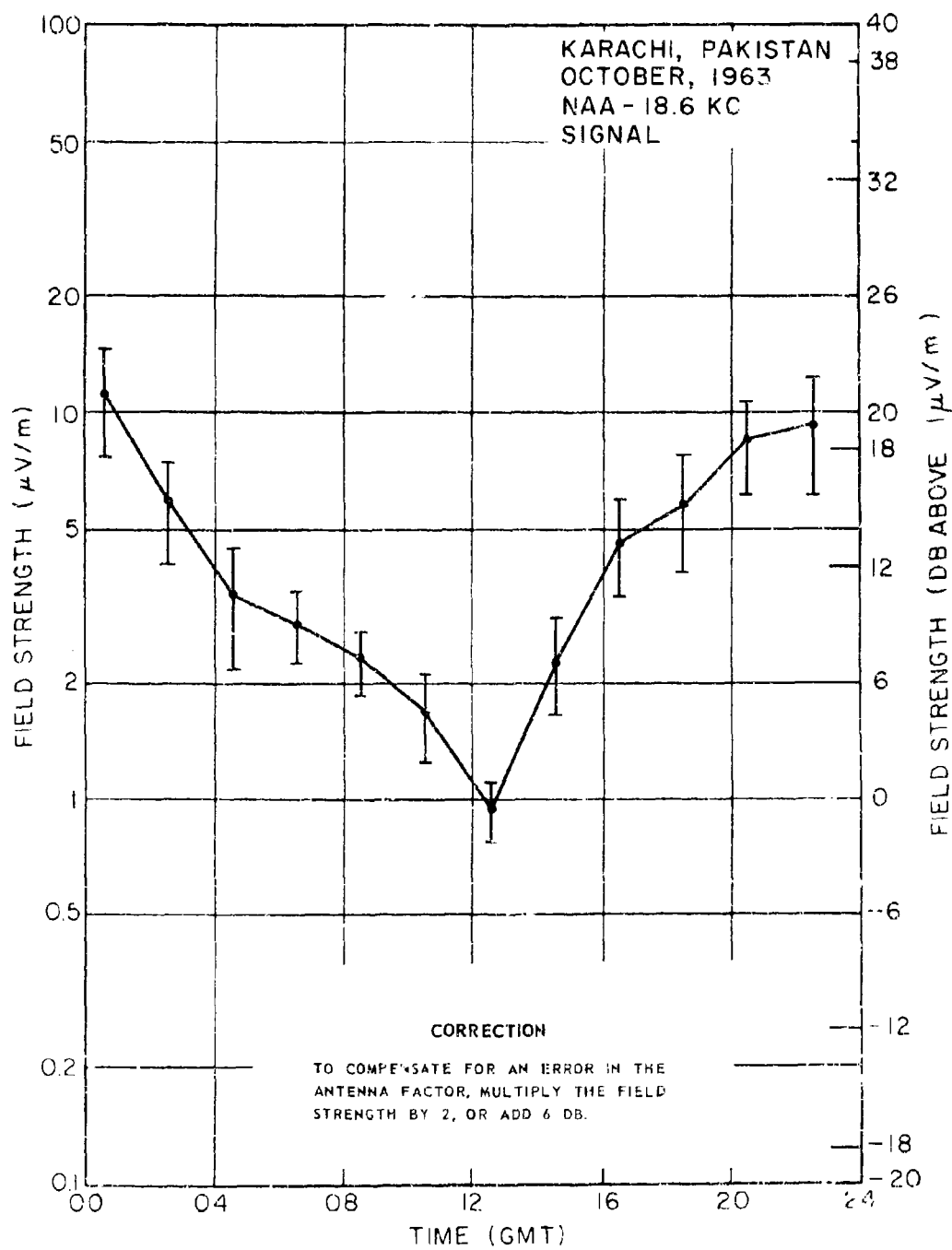


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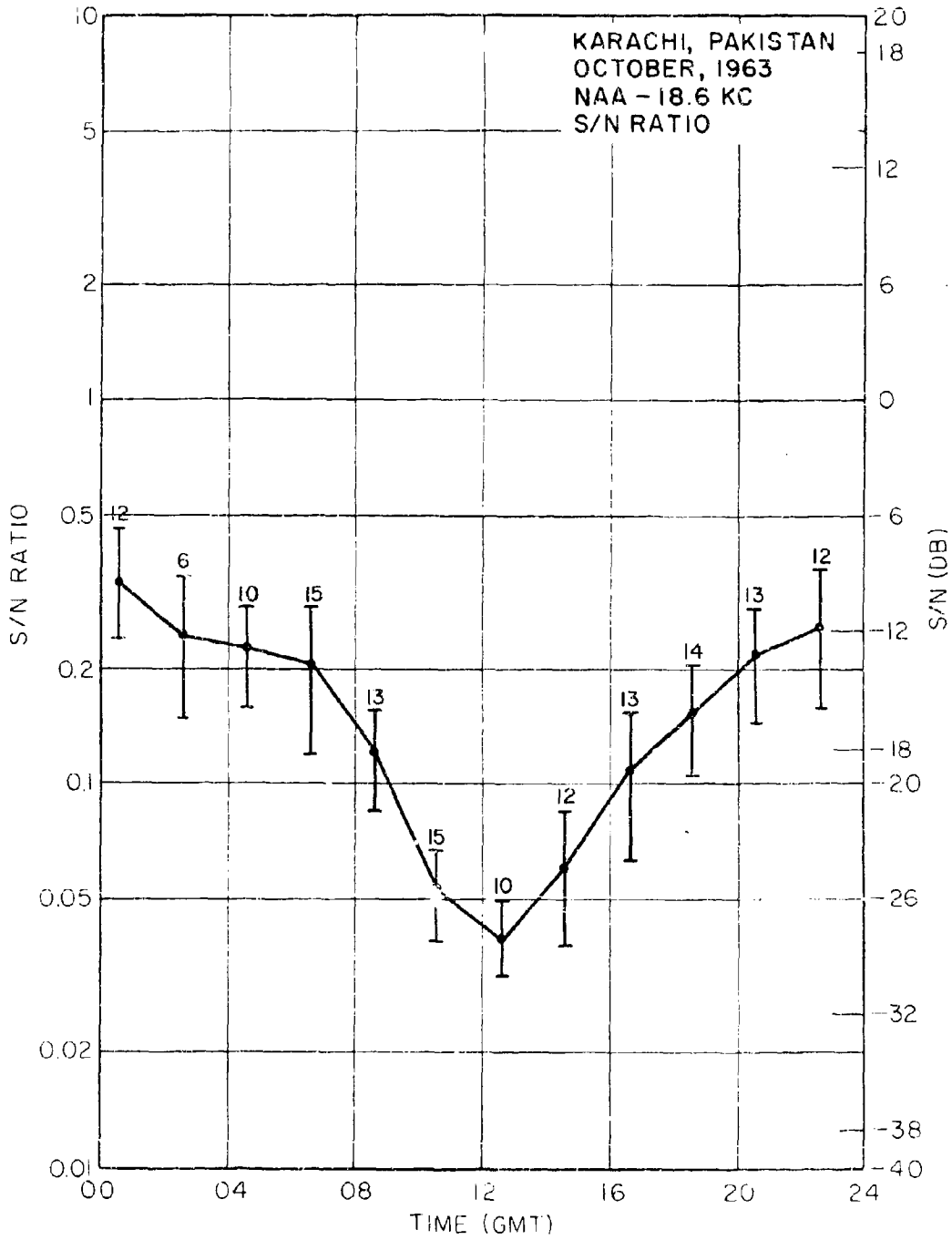


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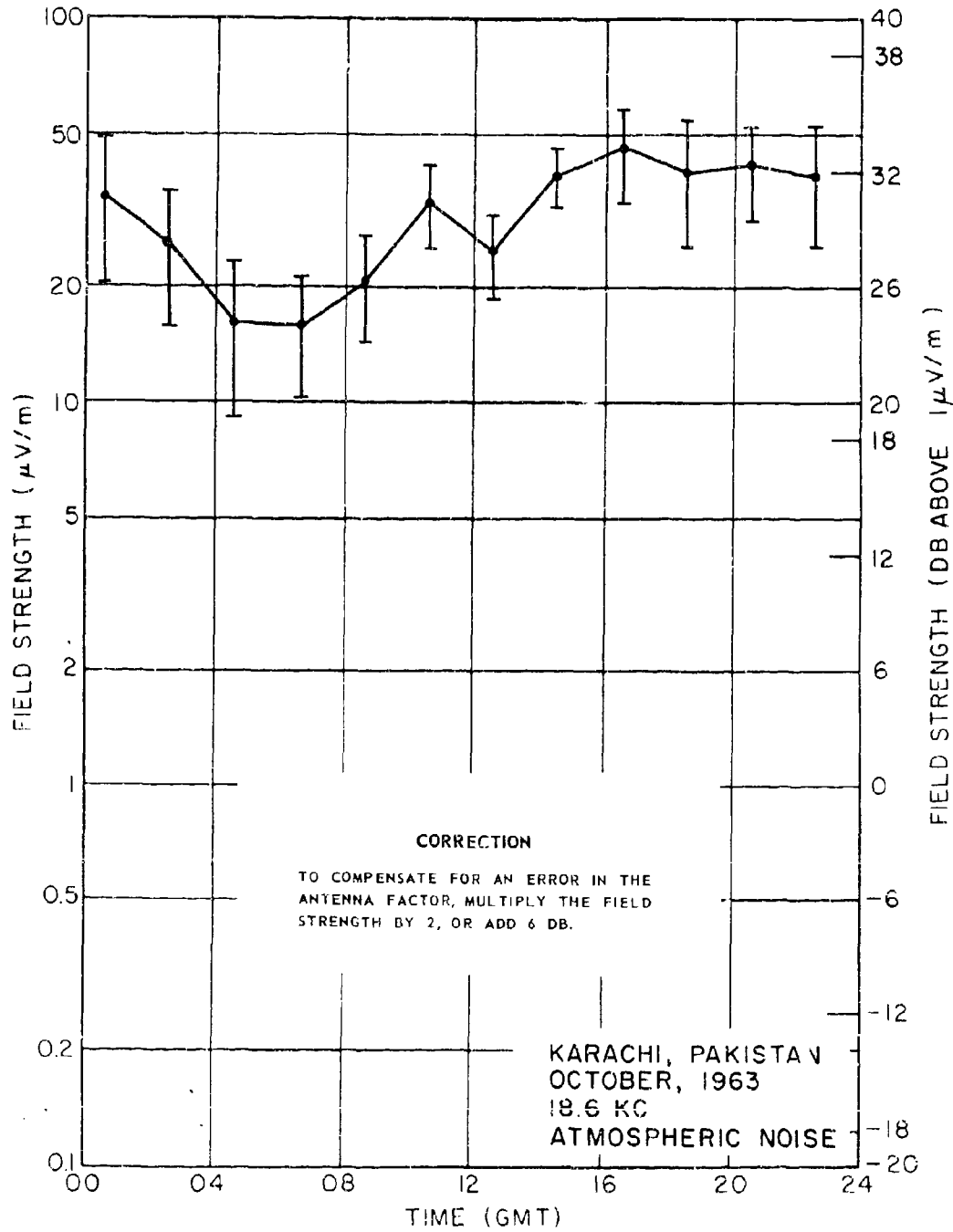


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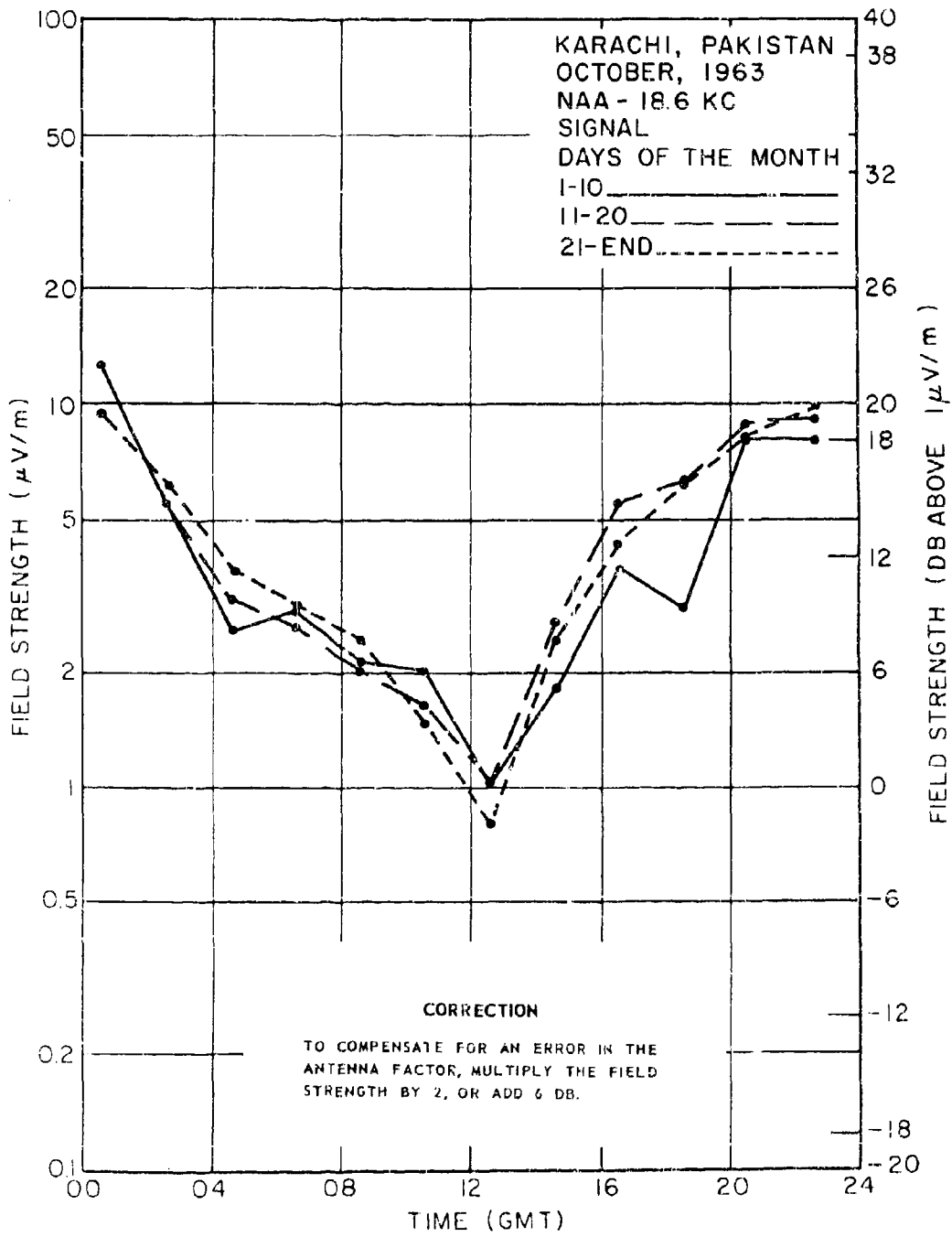


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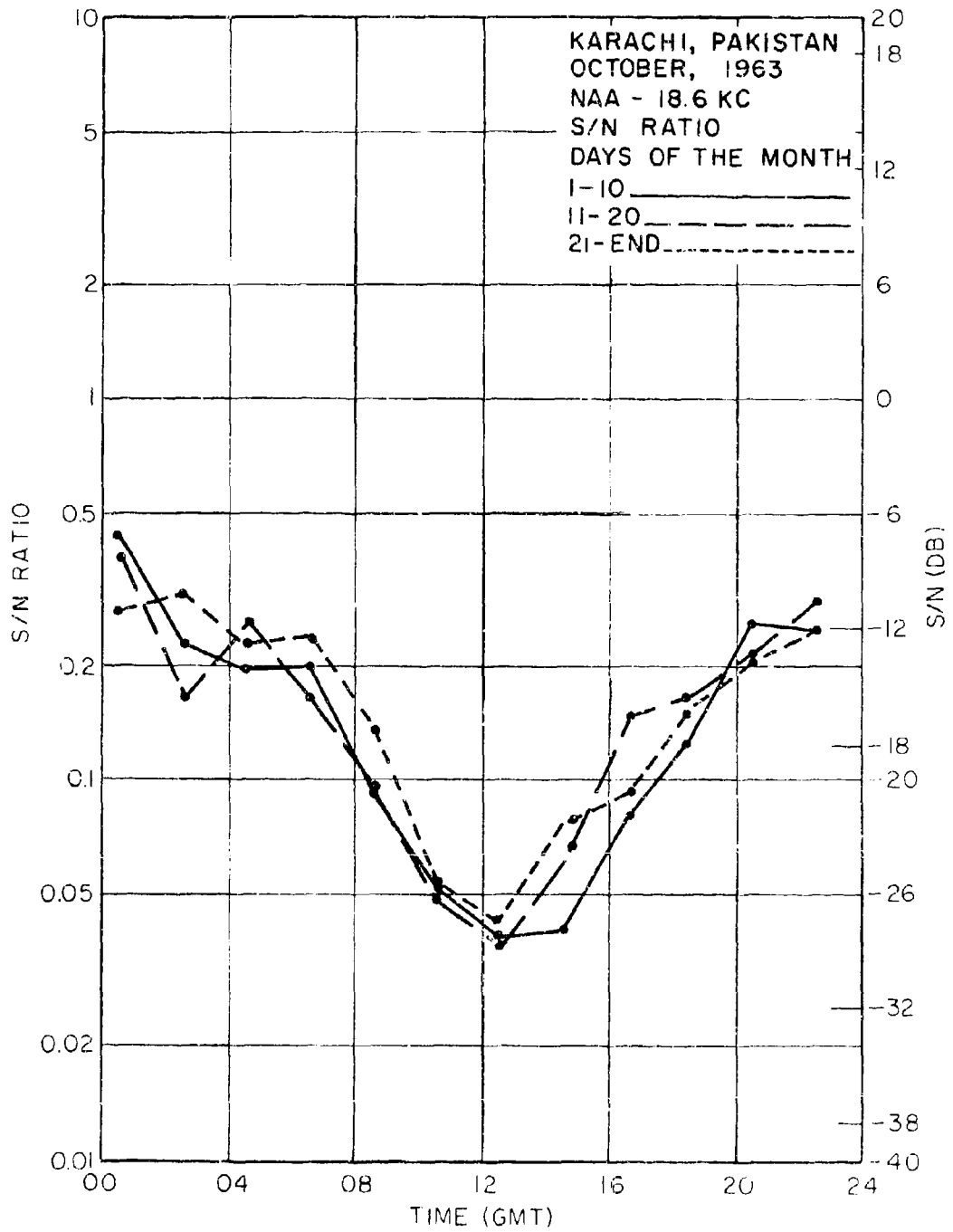


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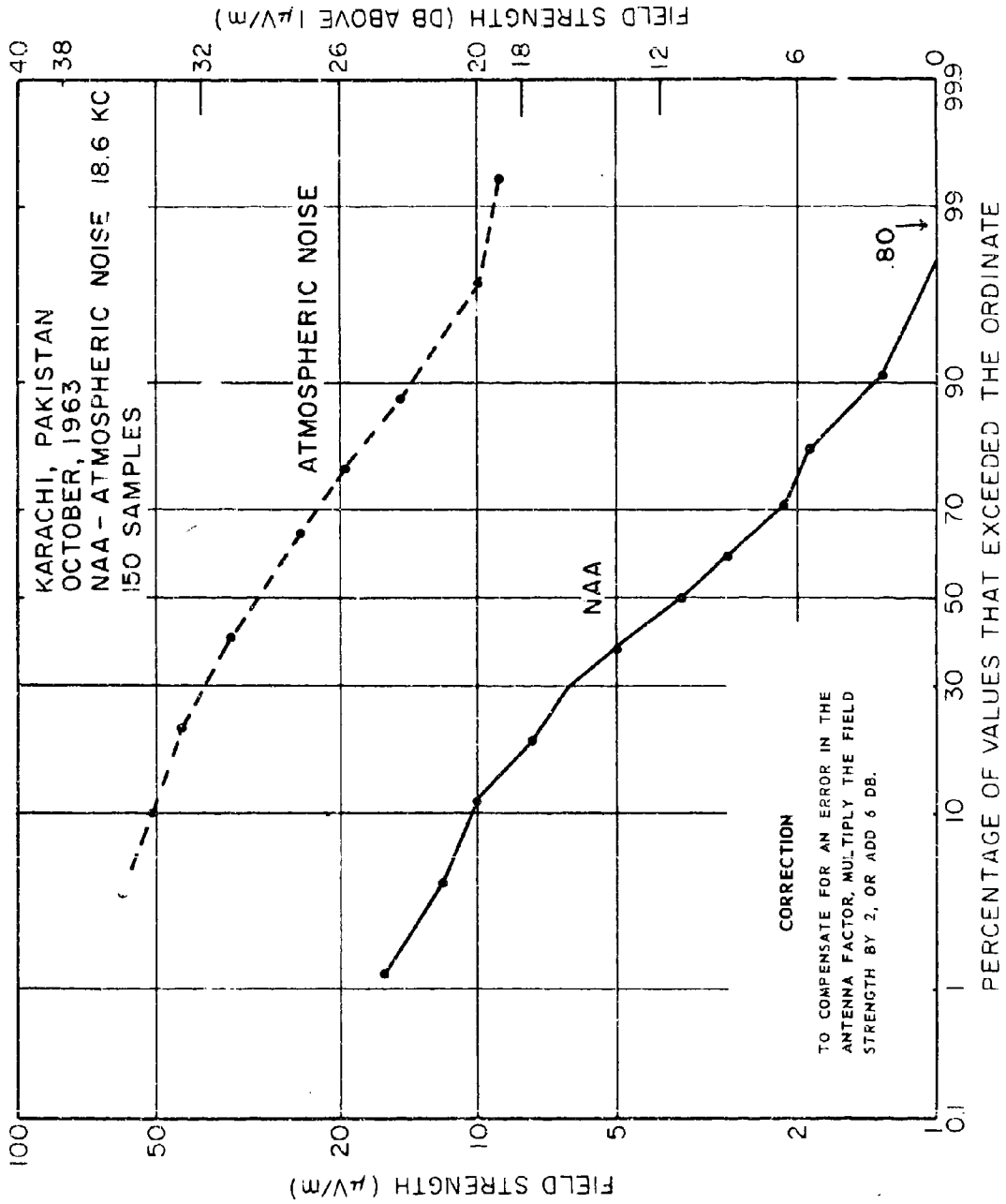


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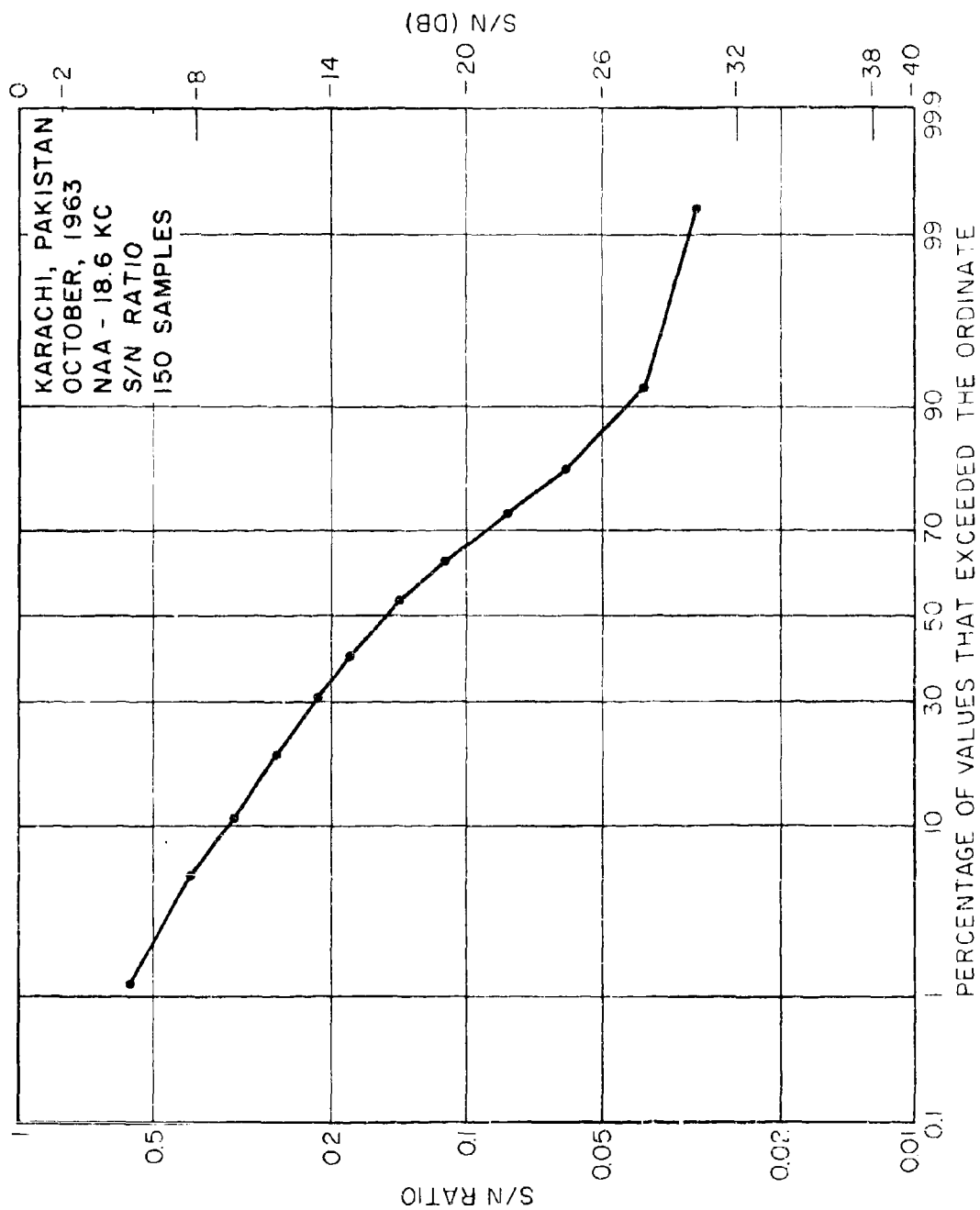


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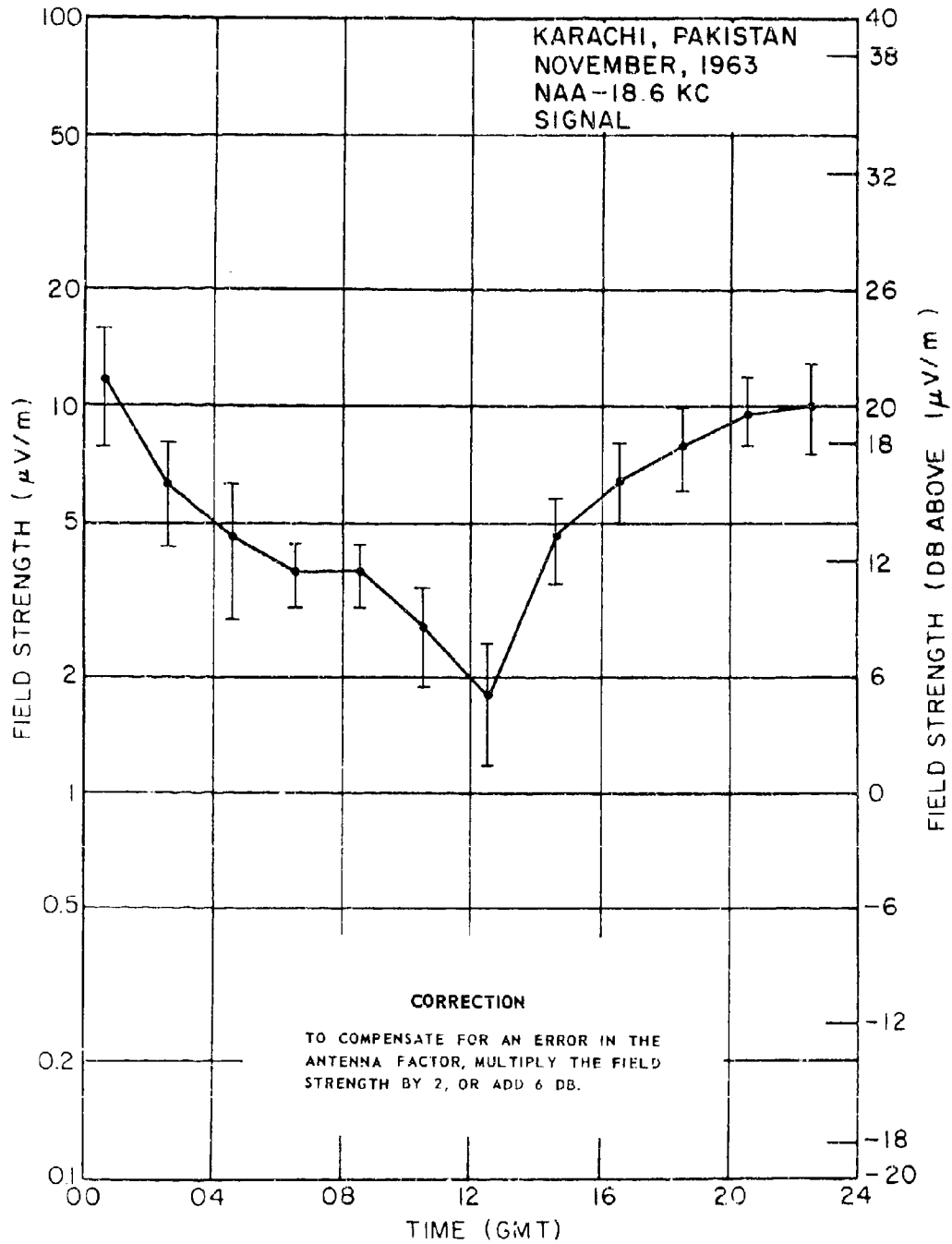


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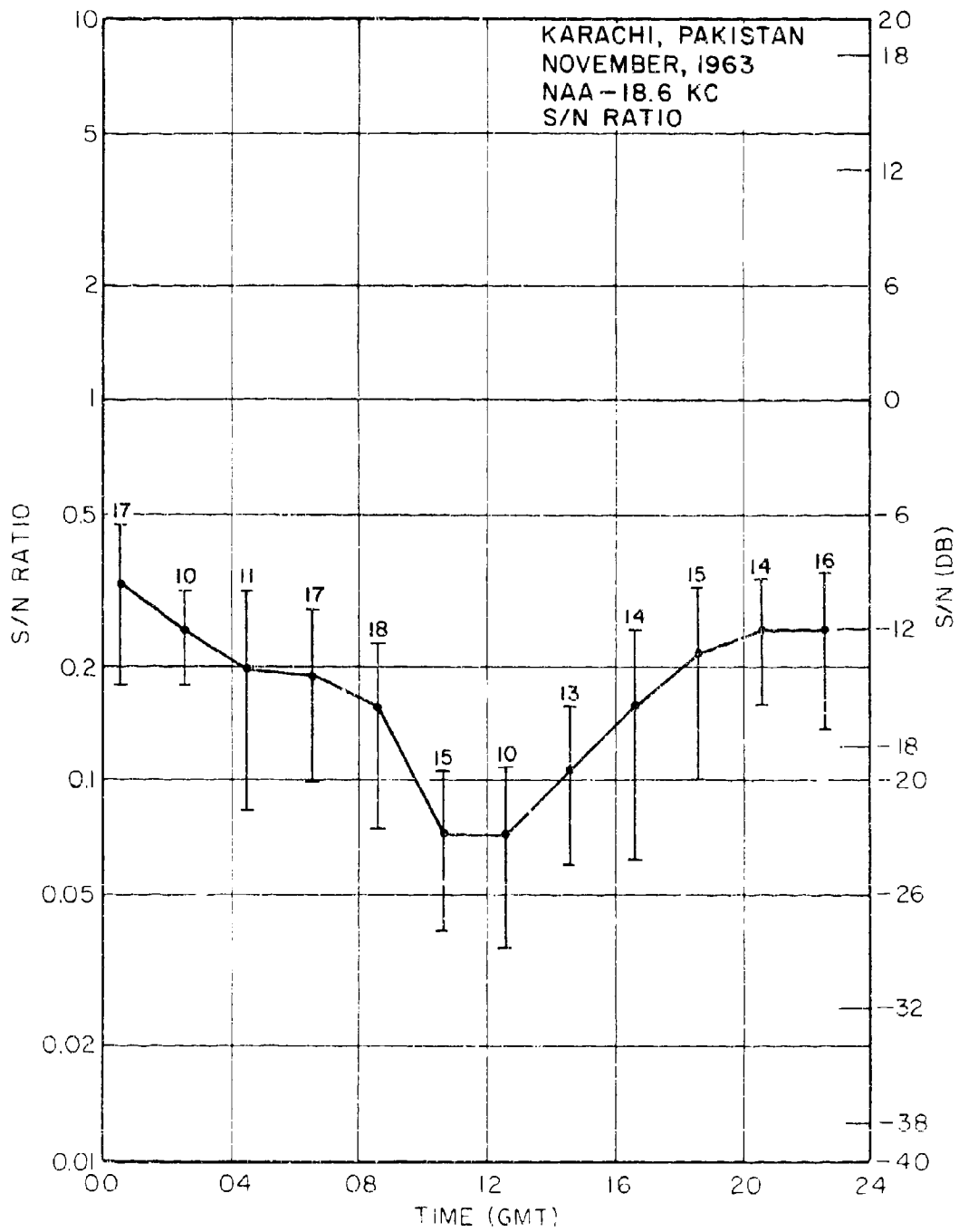


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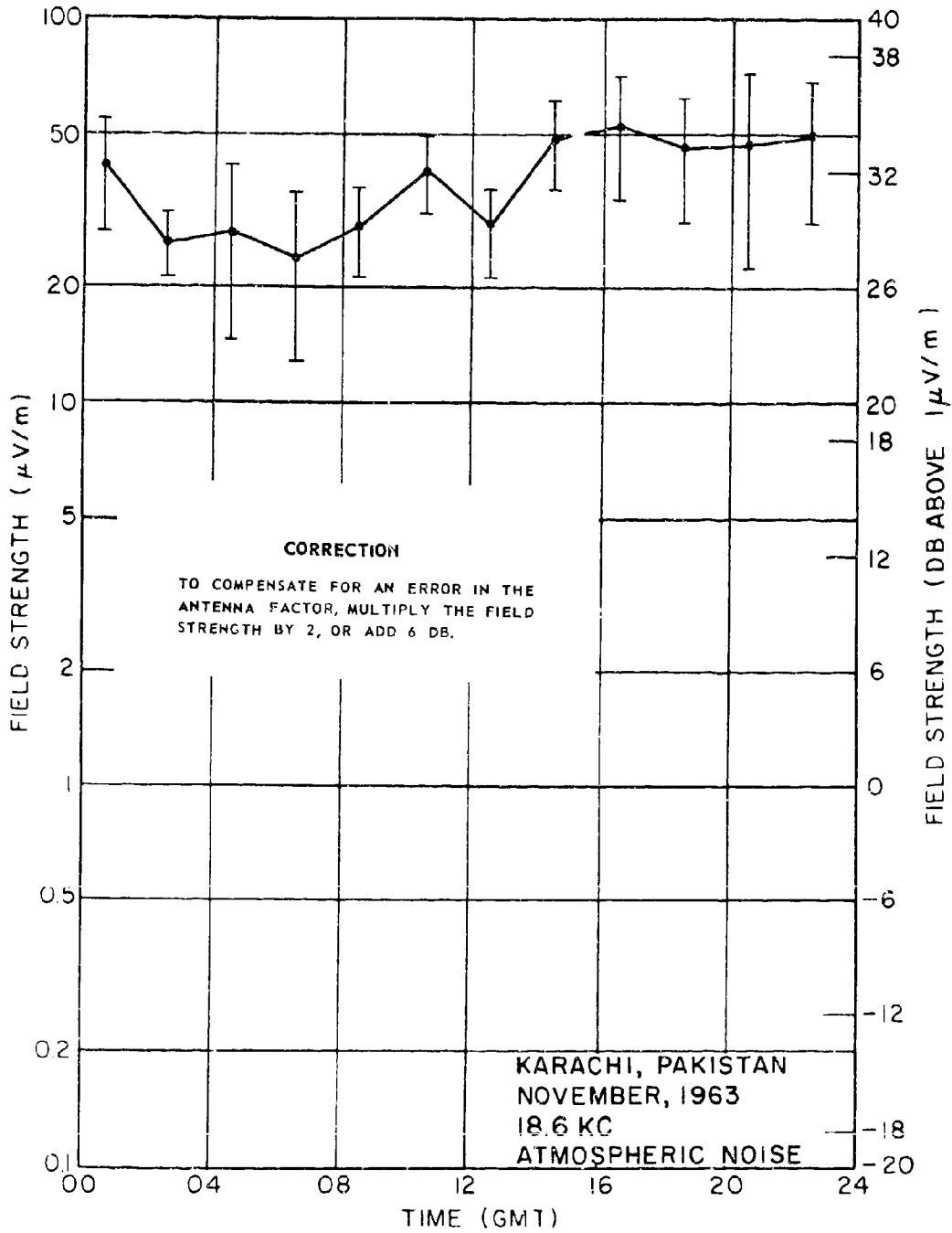


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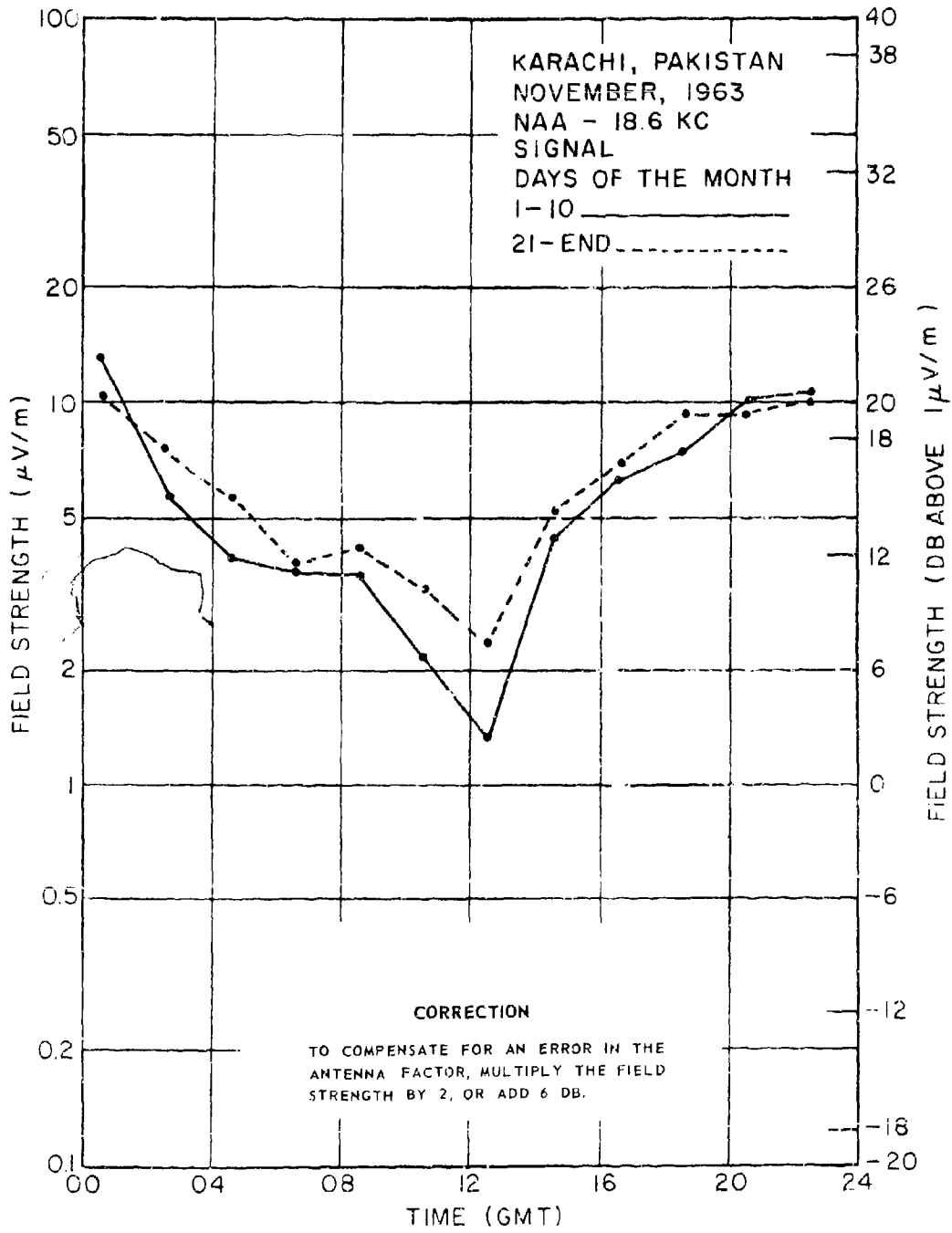


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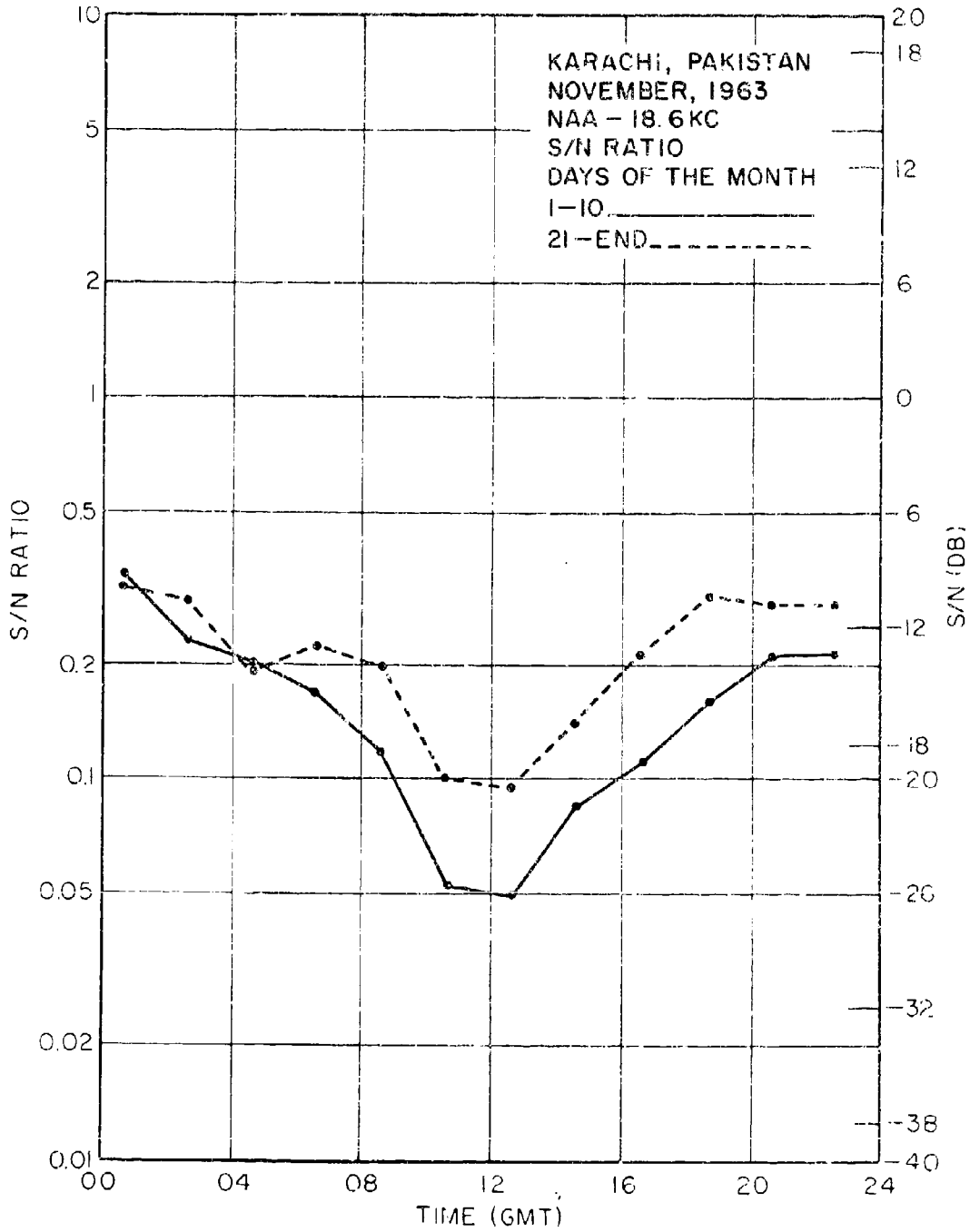


Figure 42

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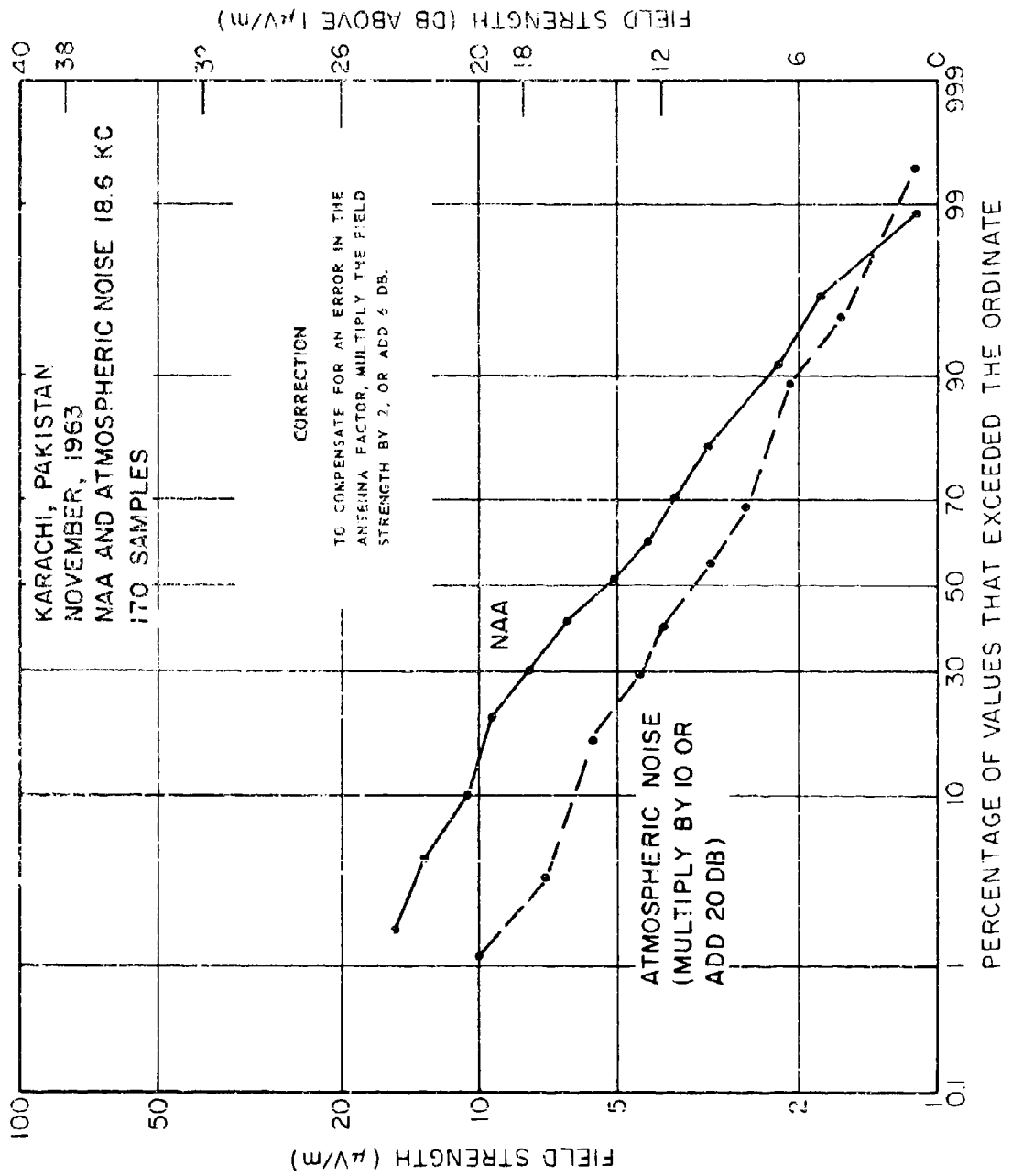


Figure 43

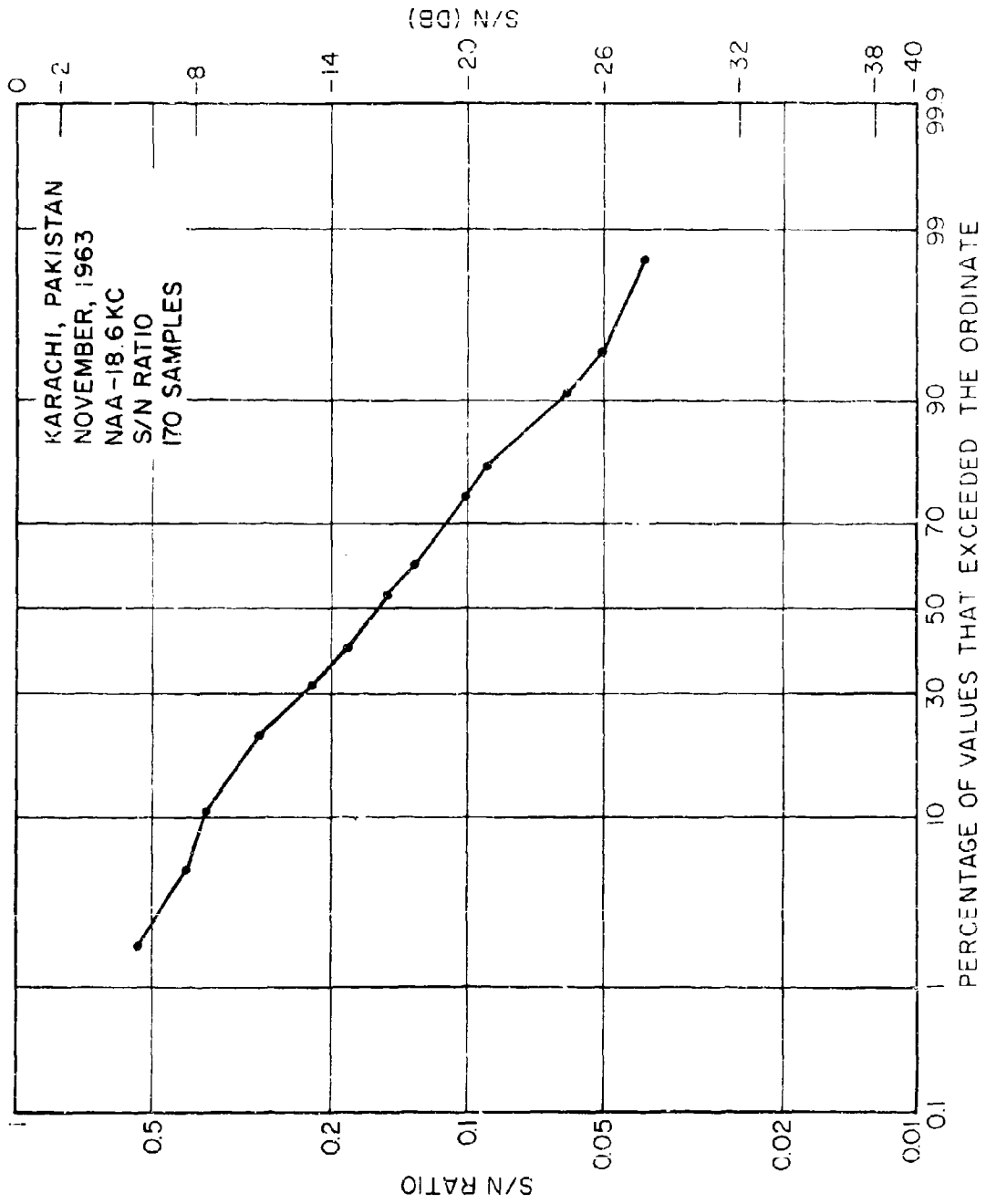


Figure 44

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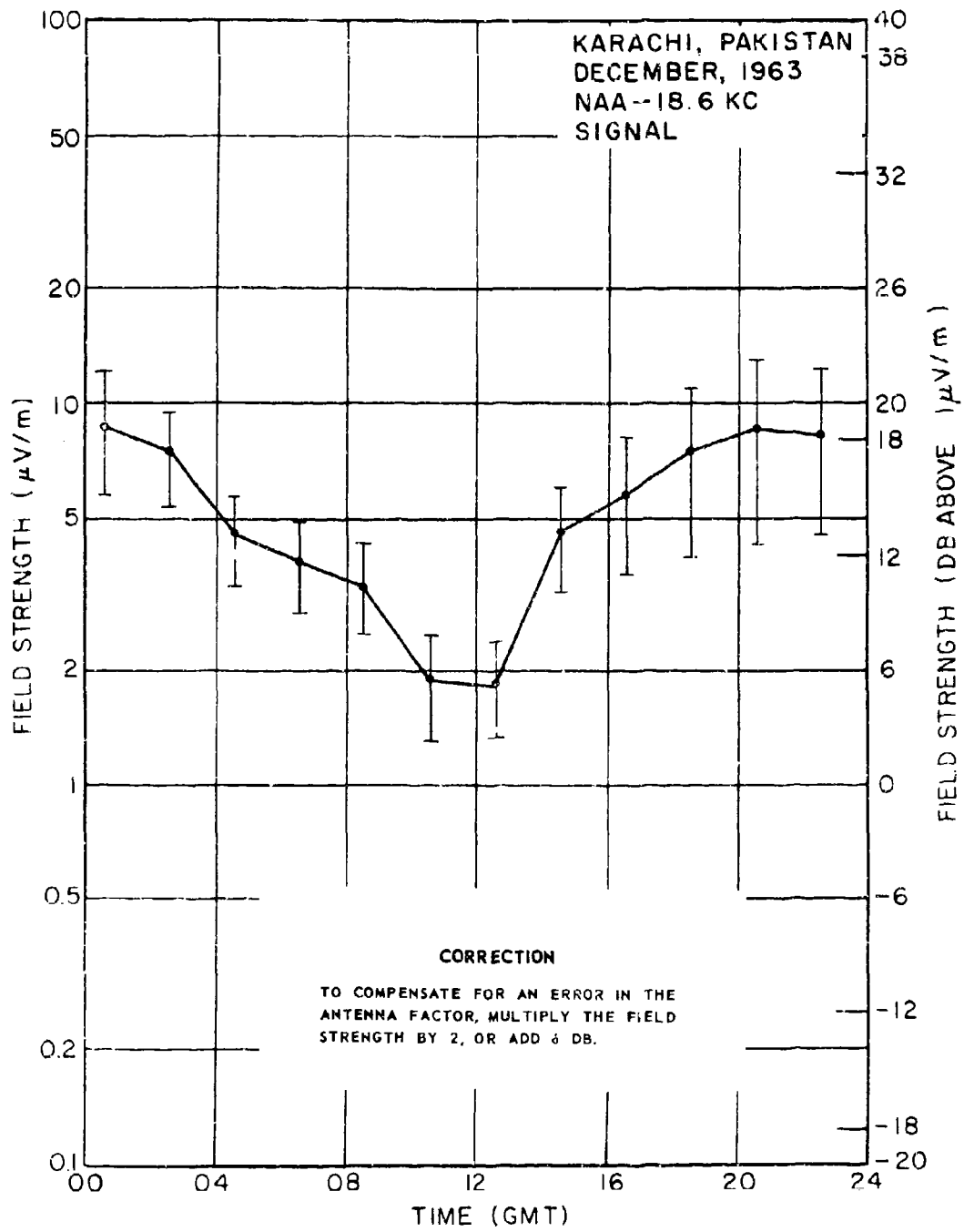


Figure 45

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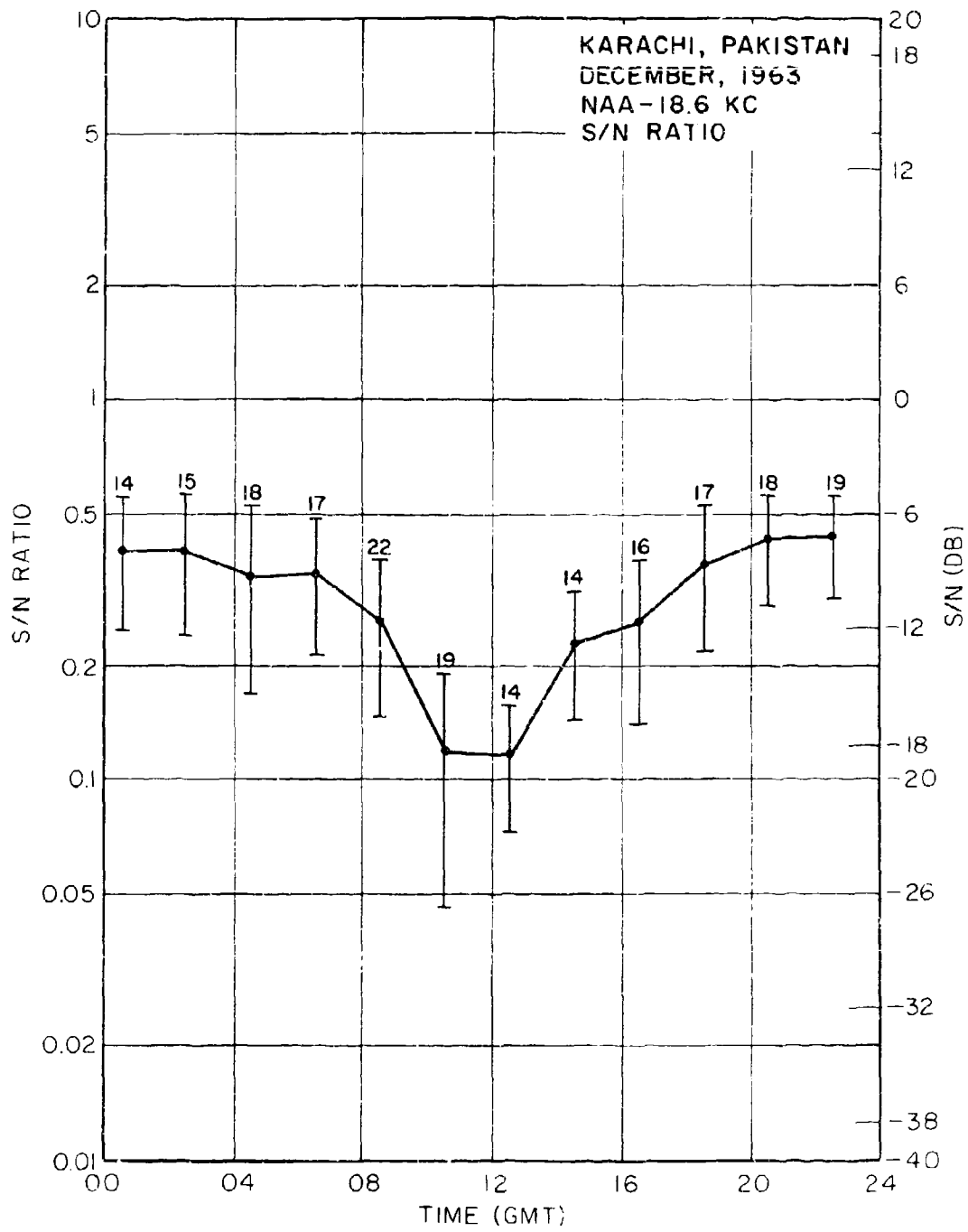


Figure 46

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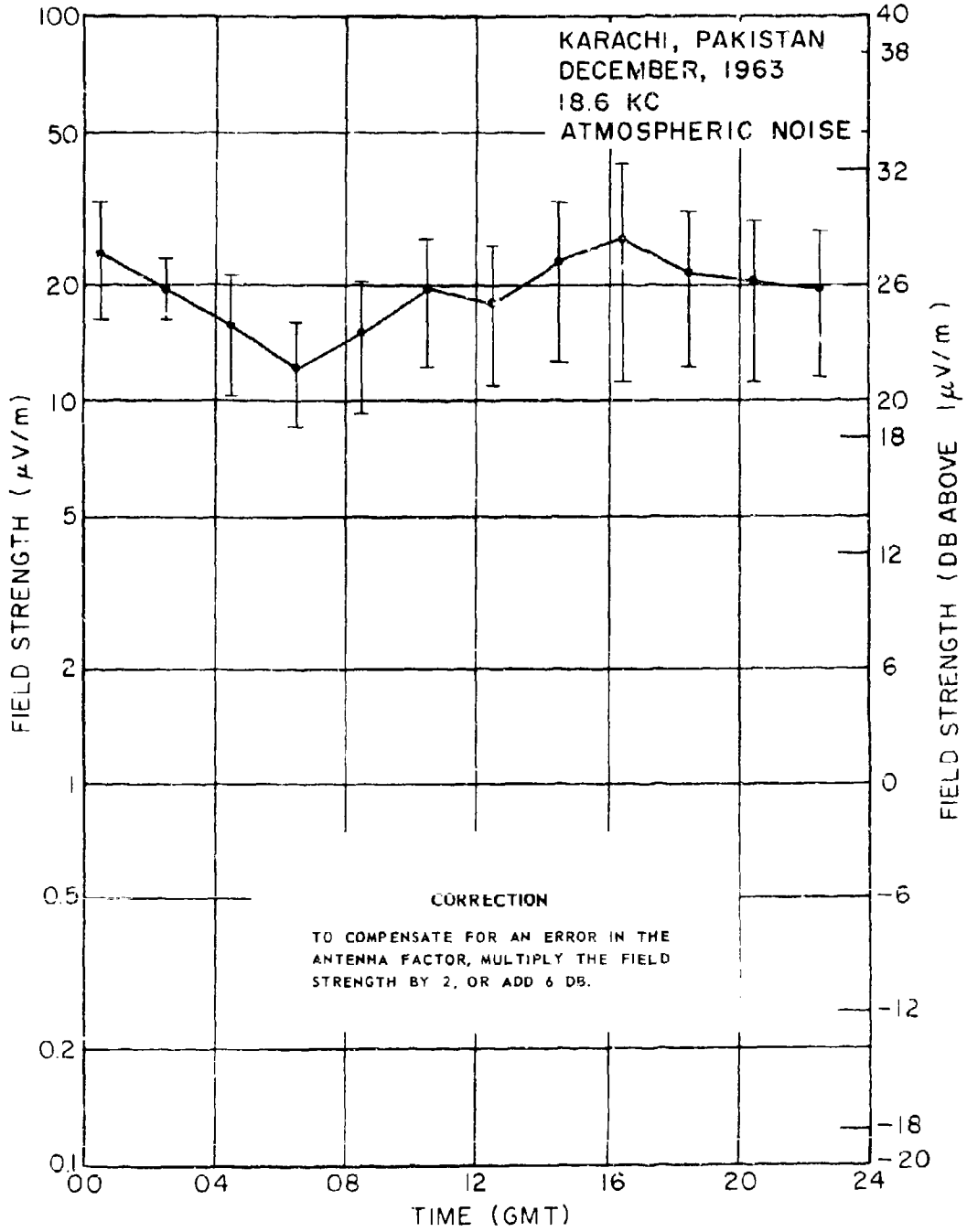


Figure 47

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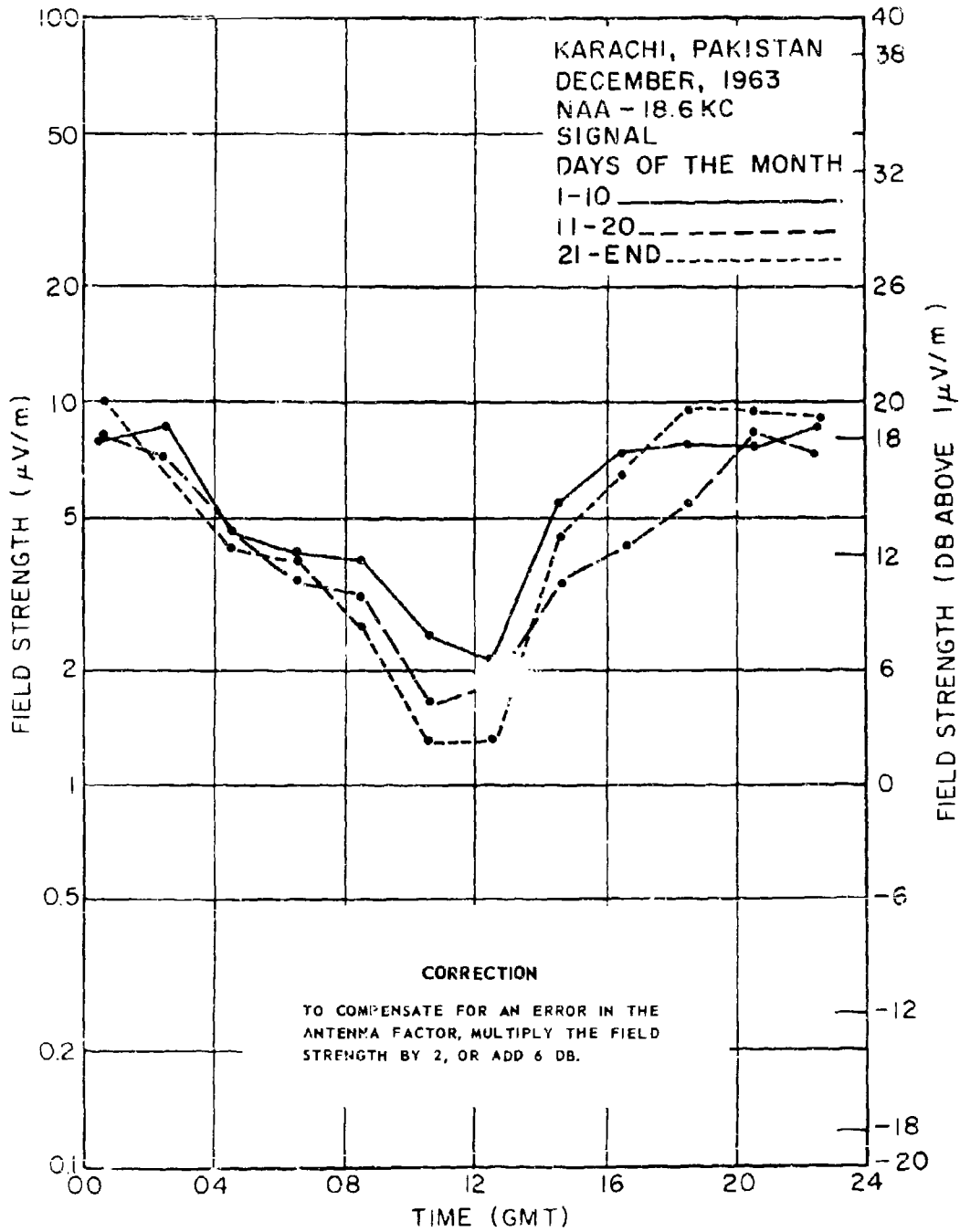


Figure 48

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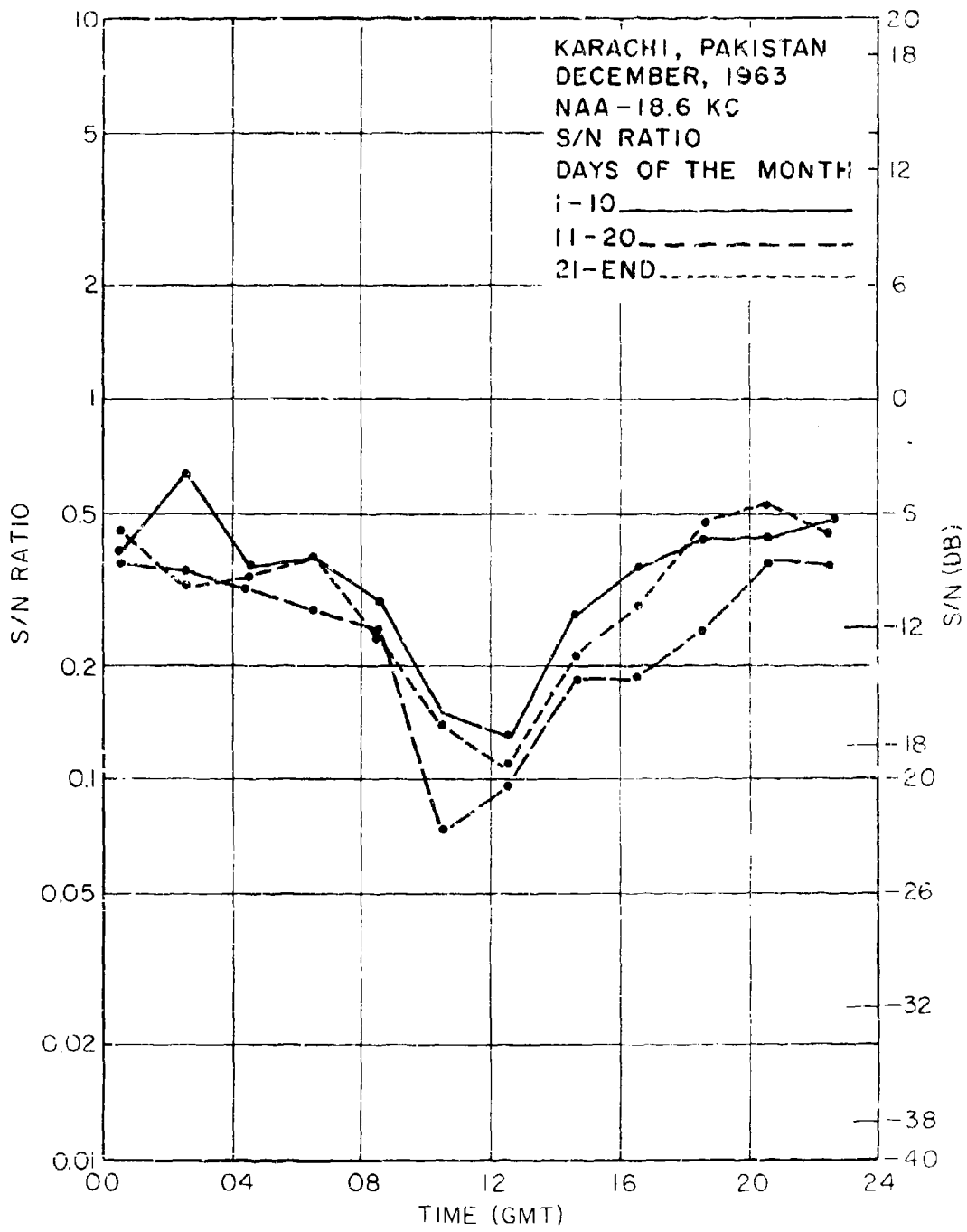


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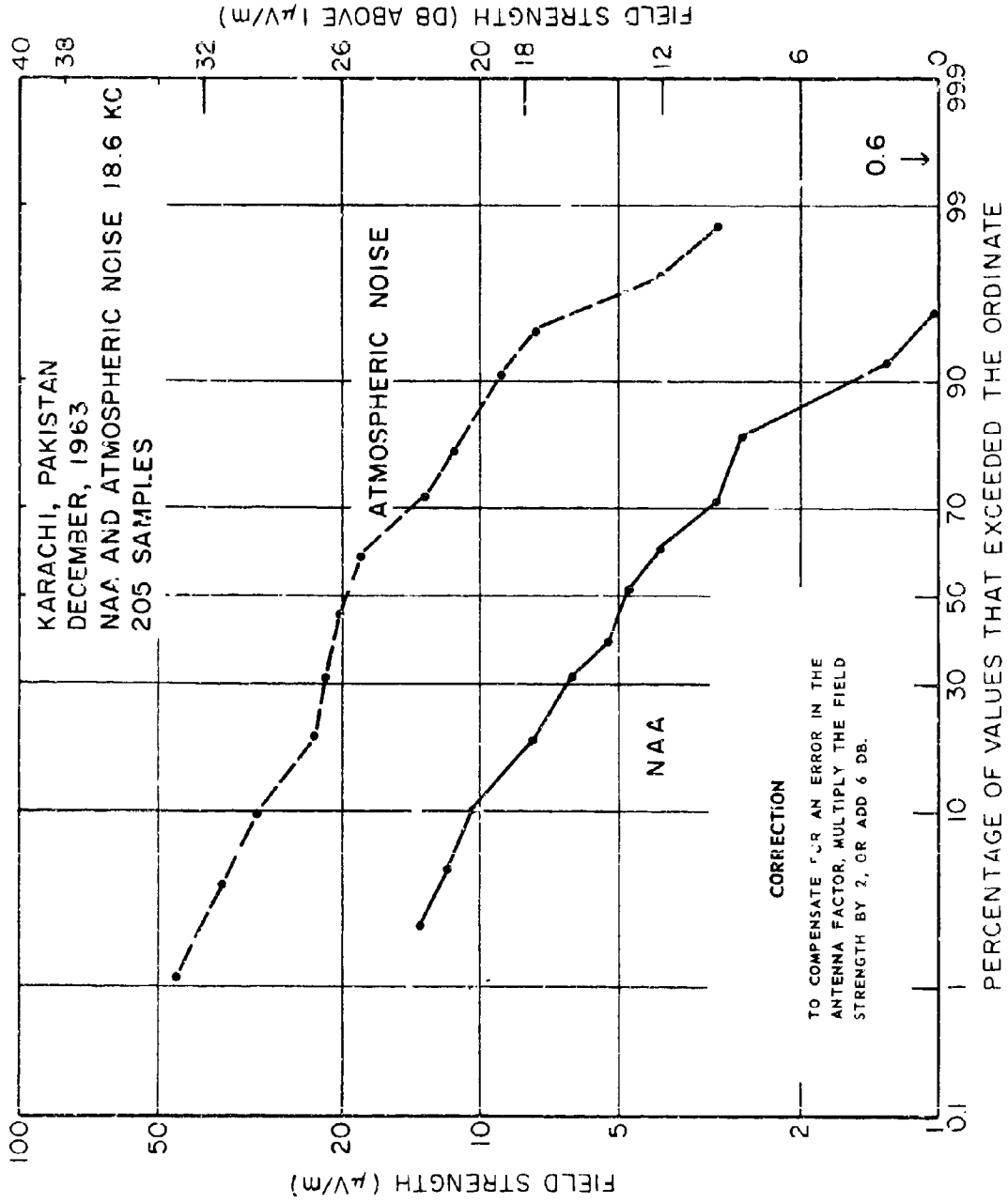


Figure 50

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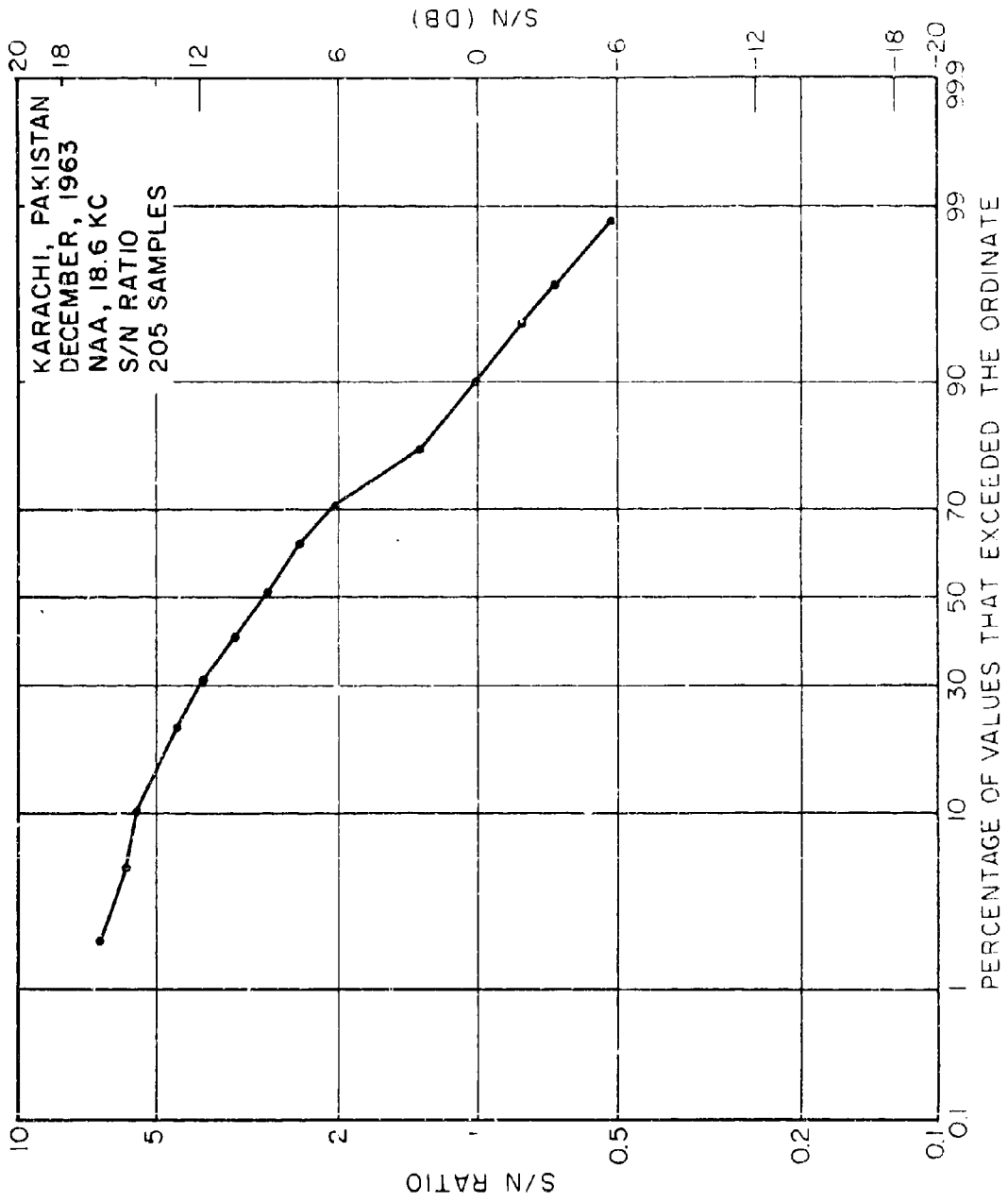


Figure 51

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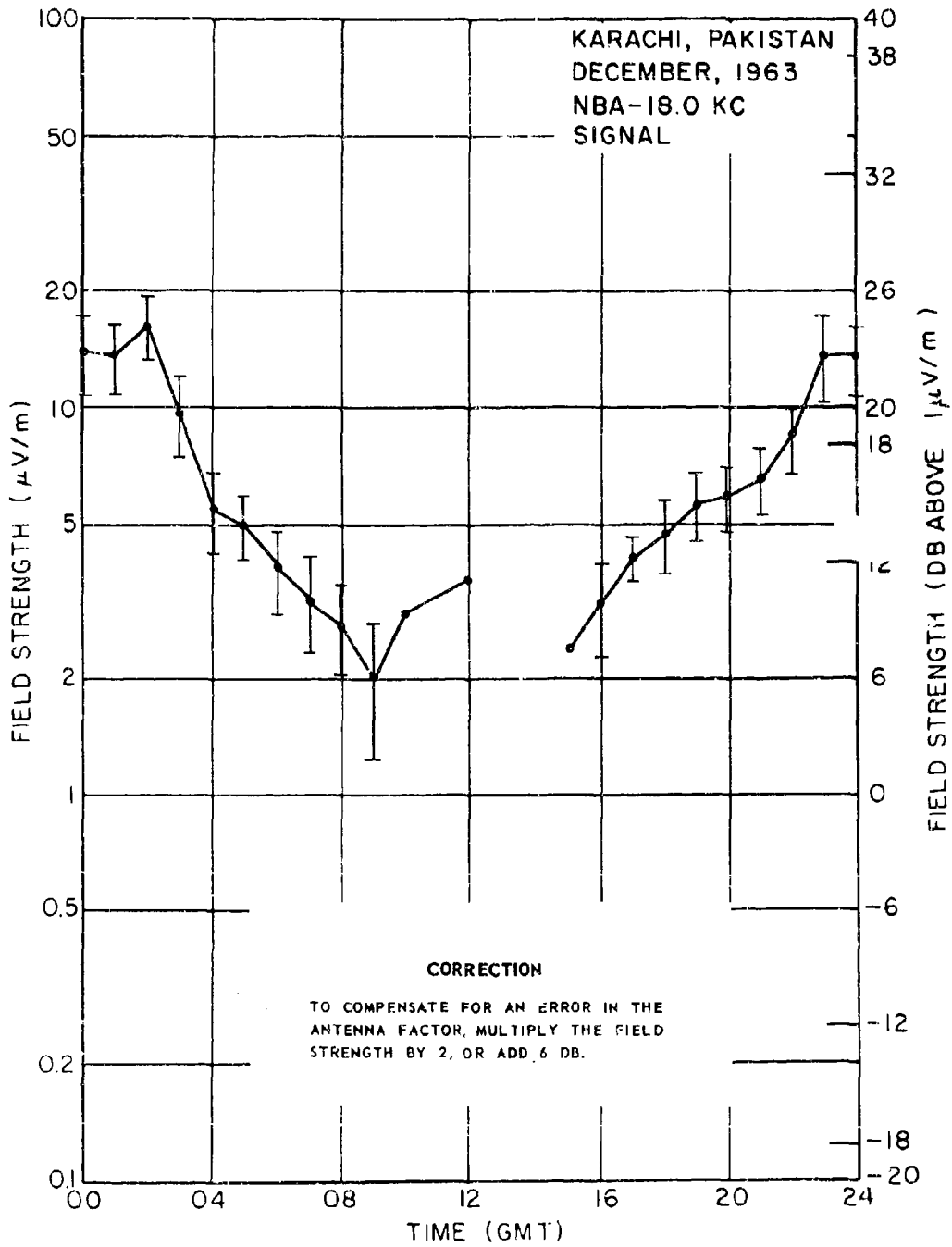


Figure 52

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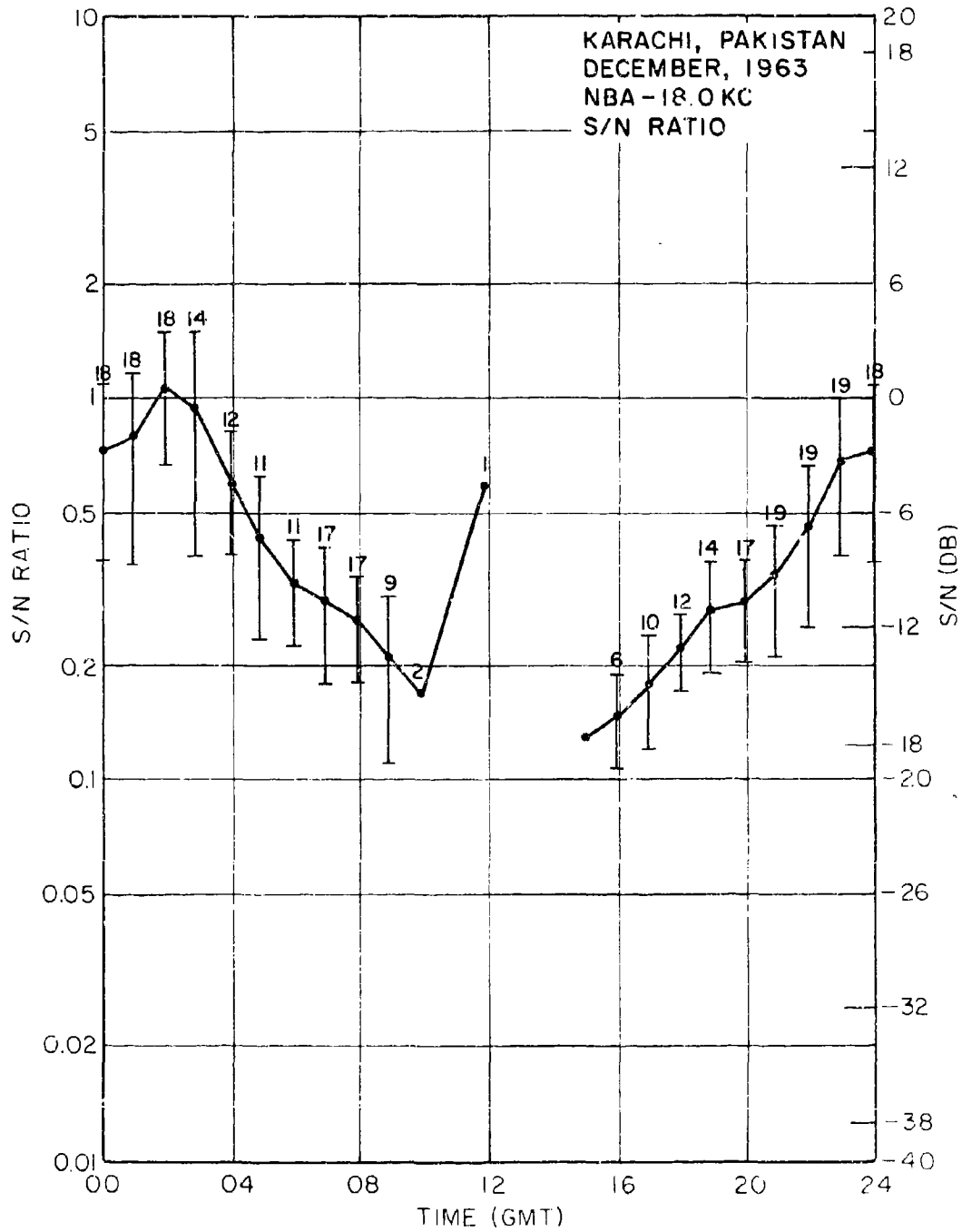


Figure 53

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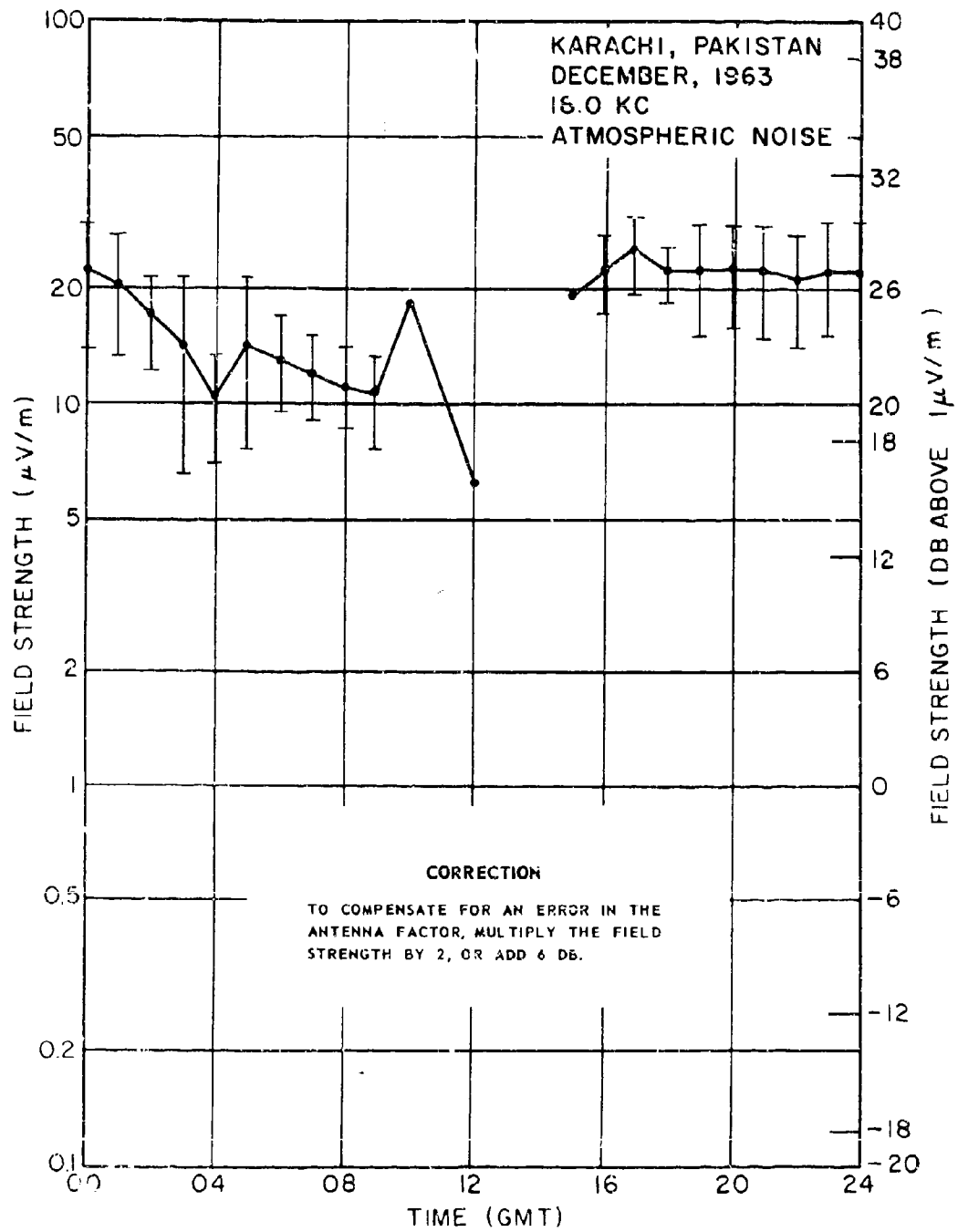


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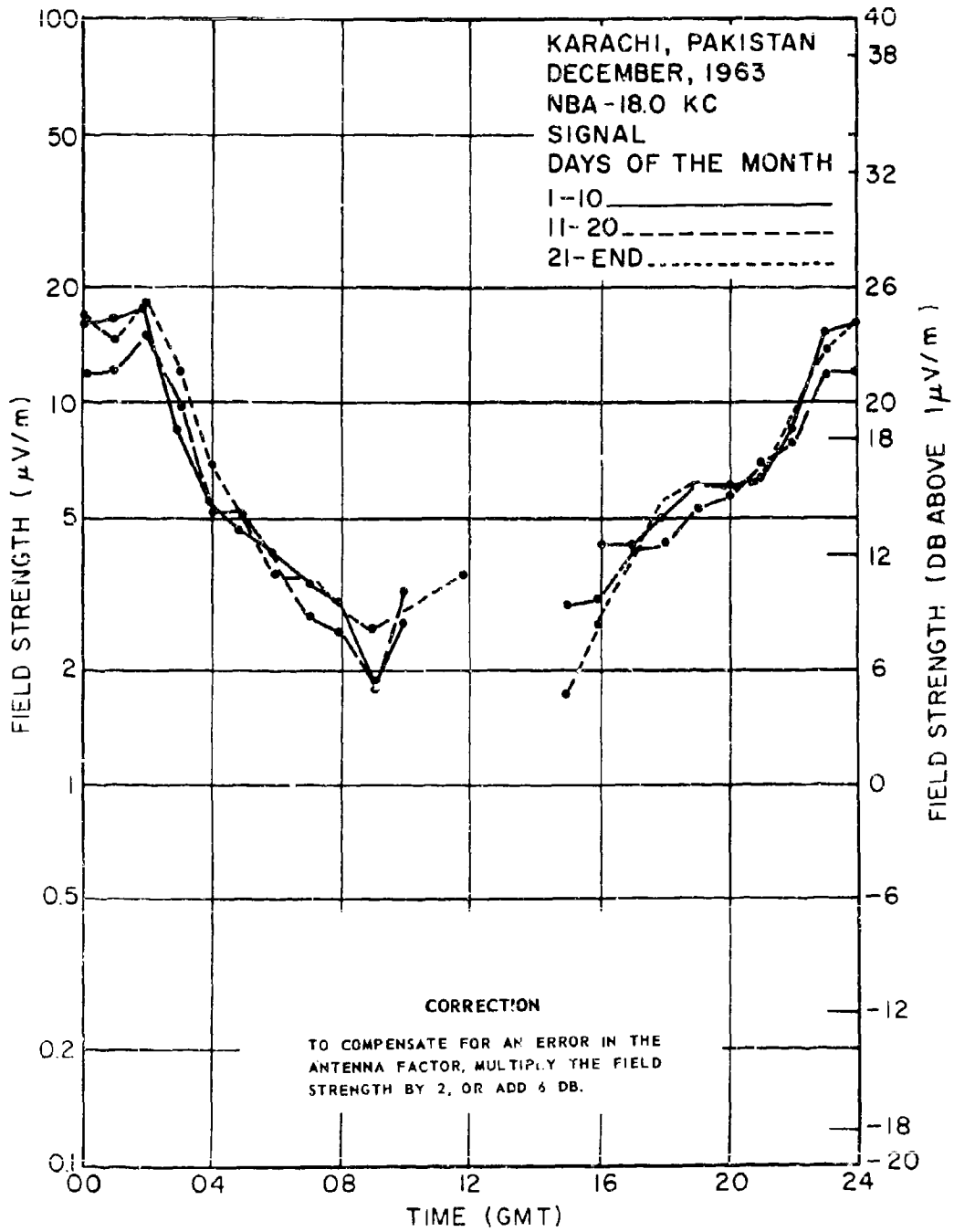


Figure 55

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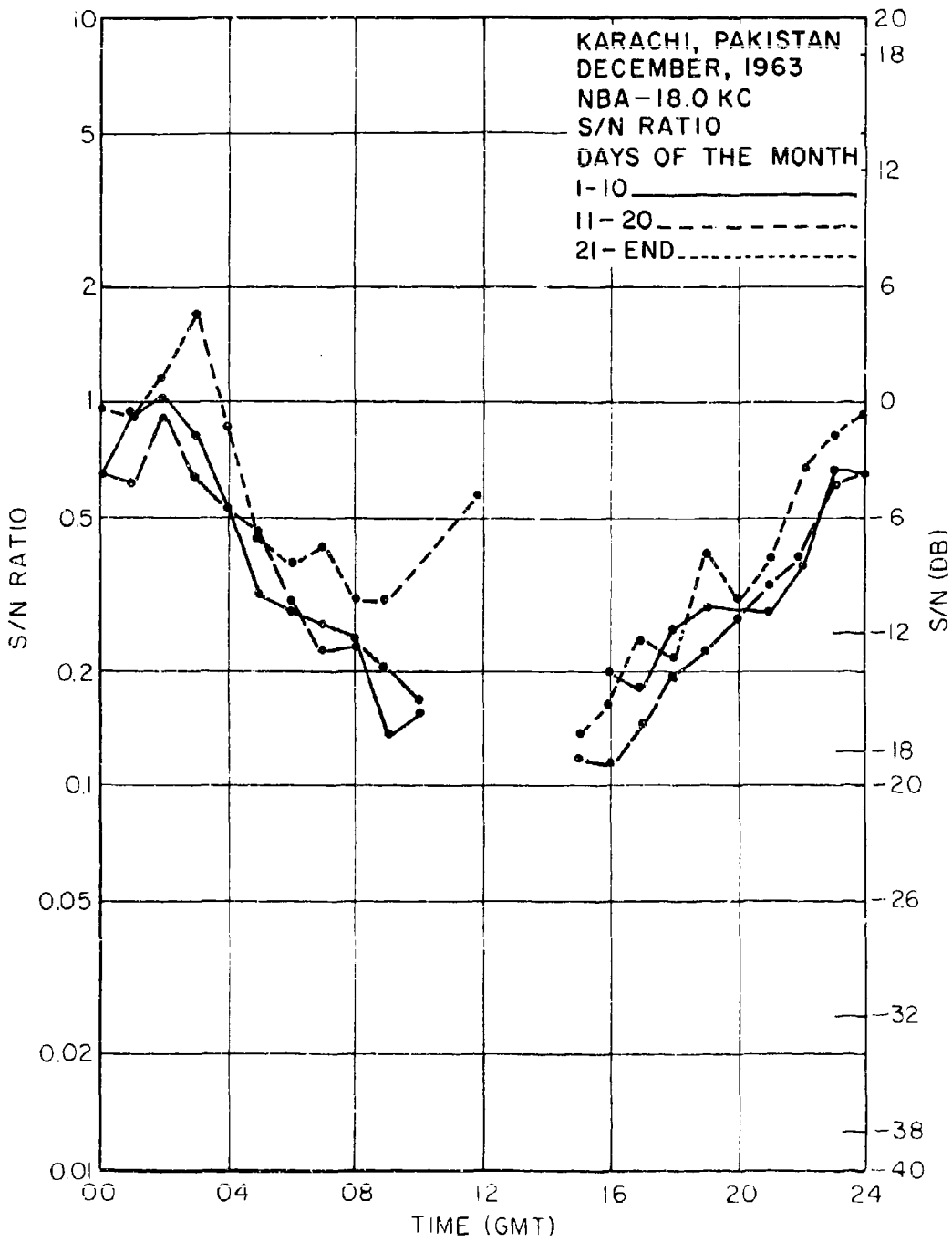


Figure 56

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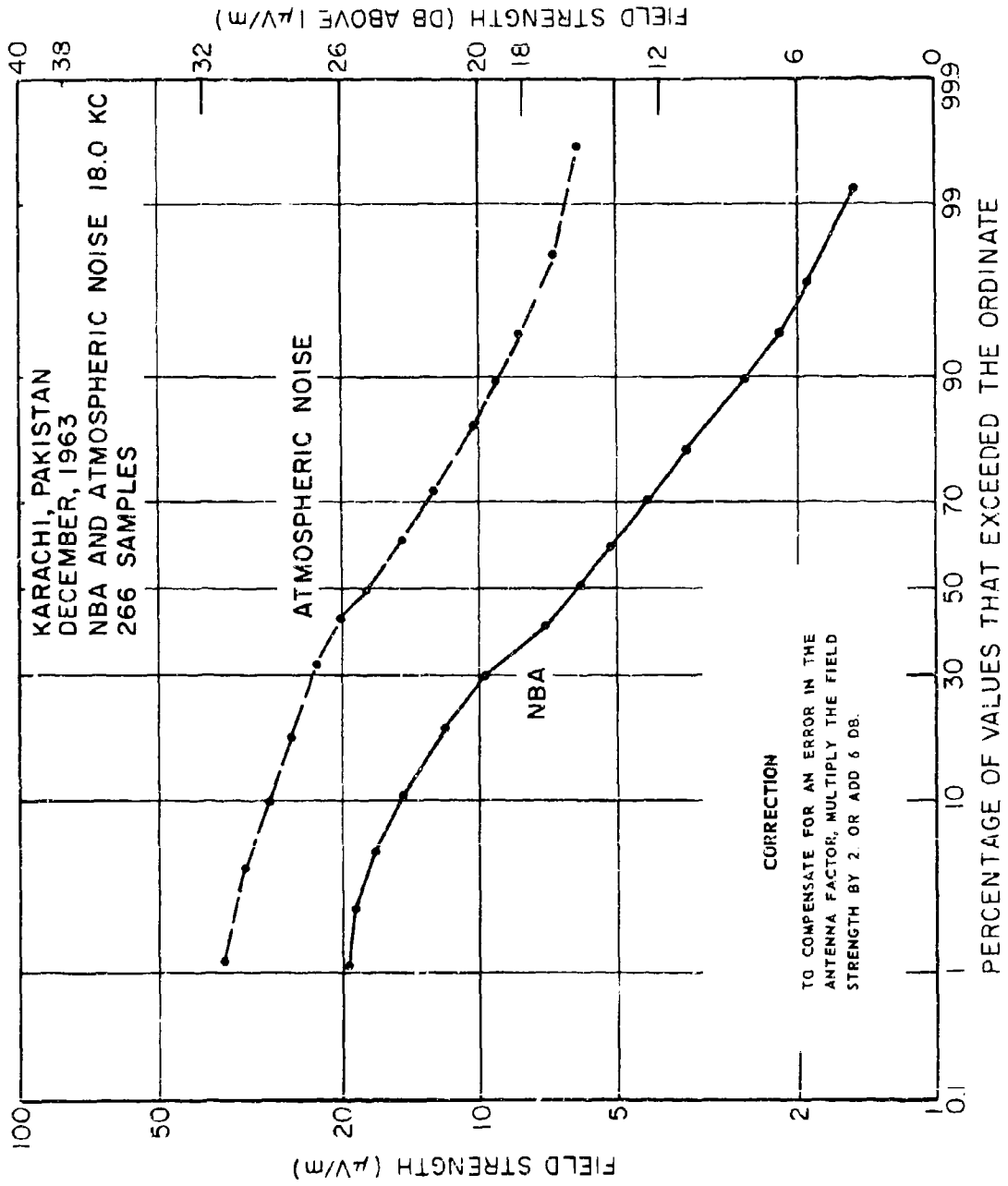


Figure 57

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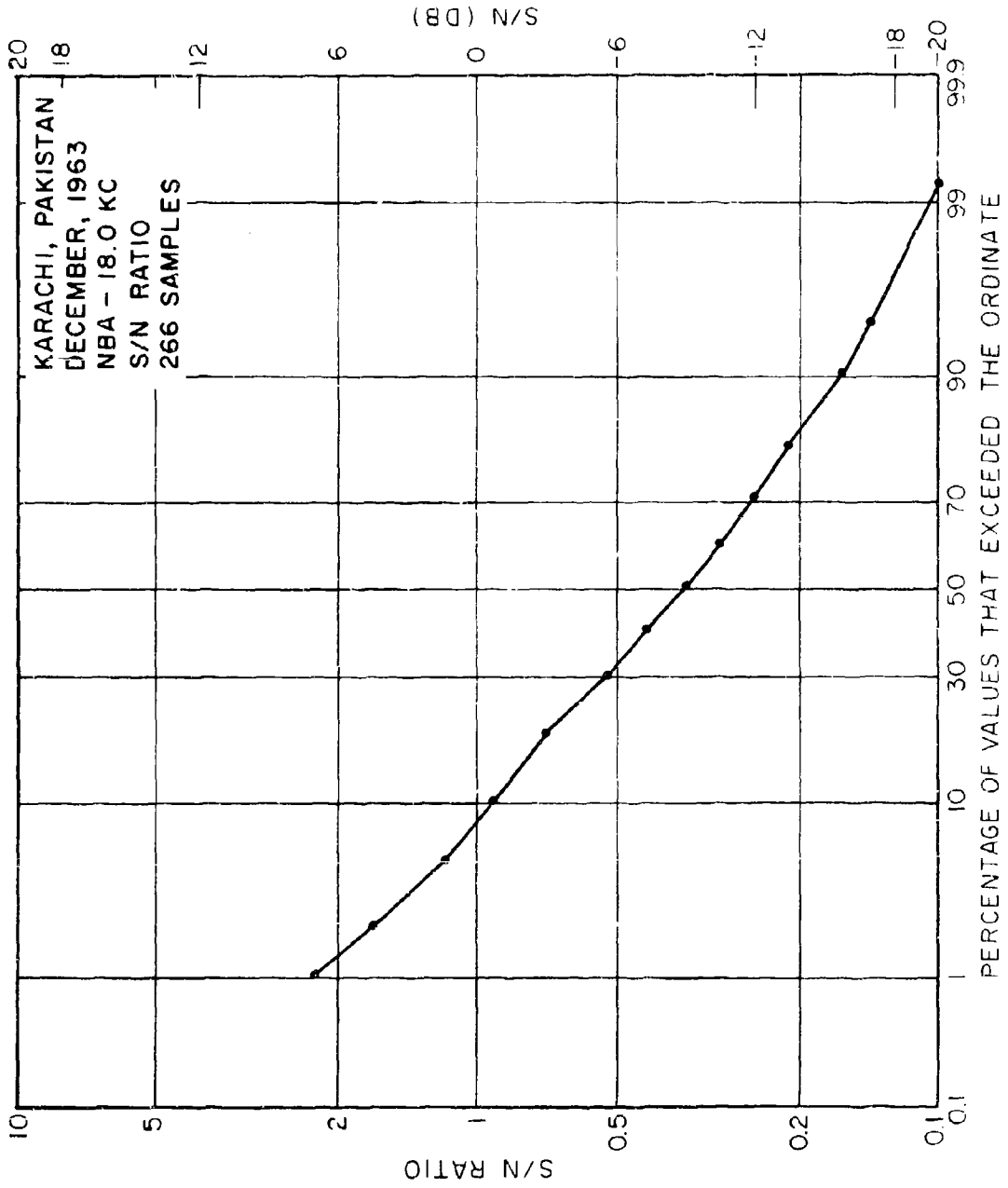


Figure 58

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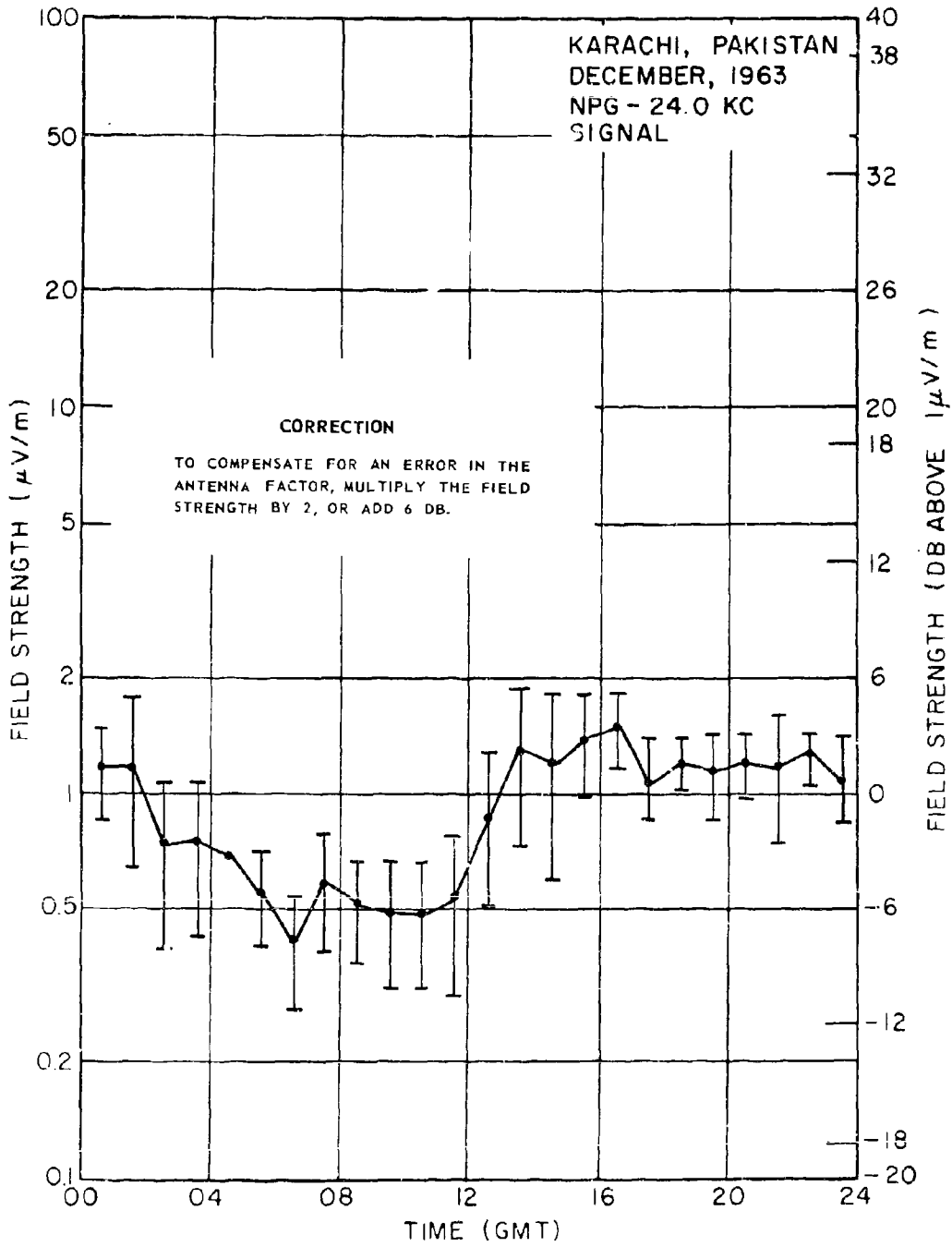


Figure 59

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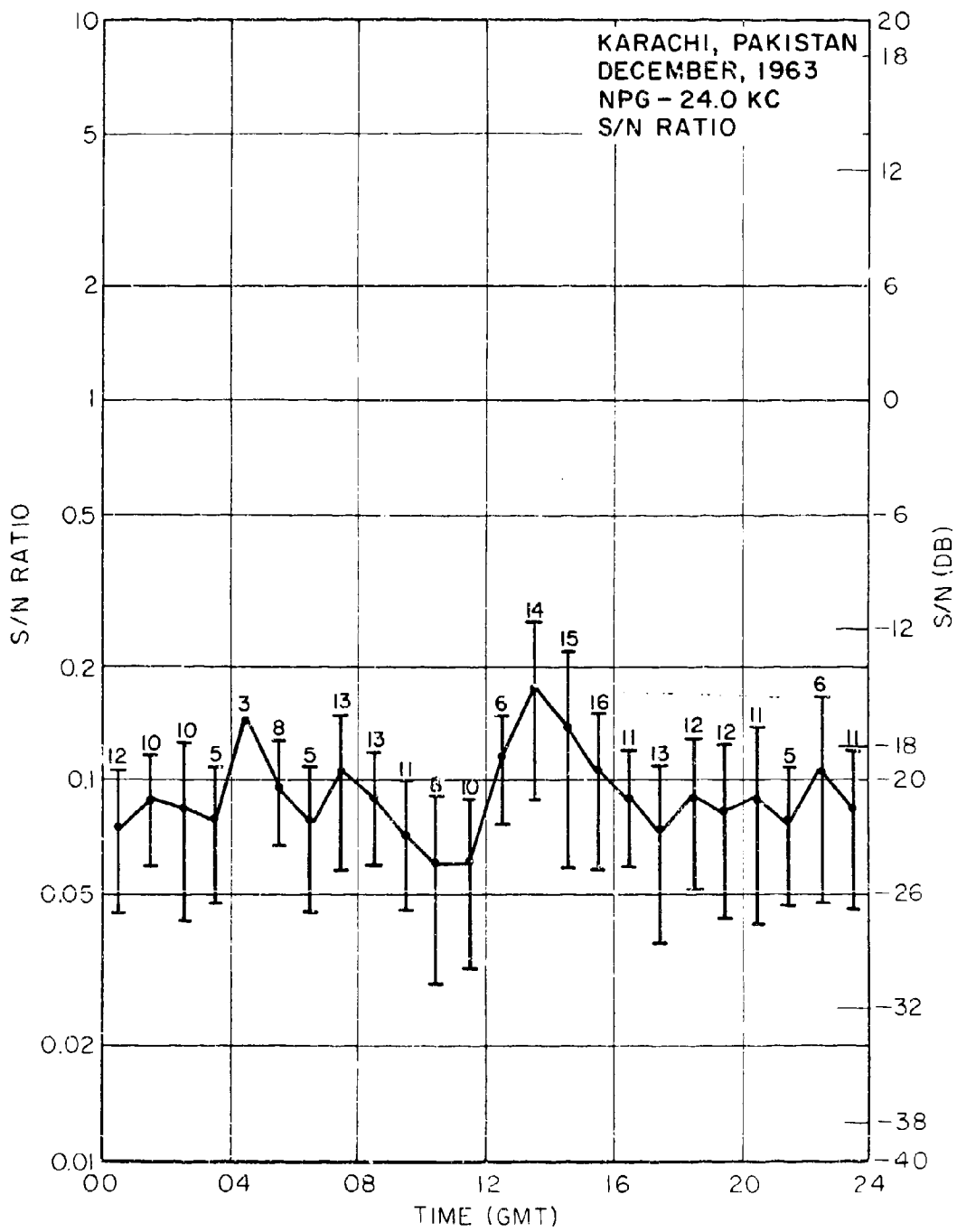


Figure 60

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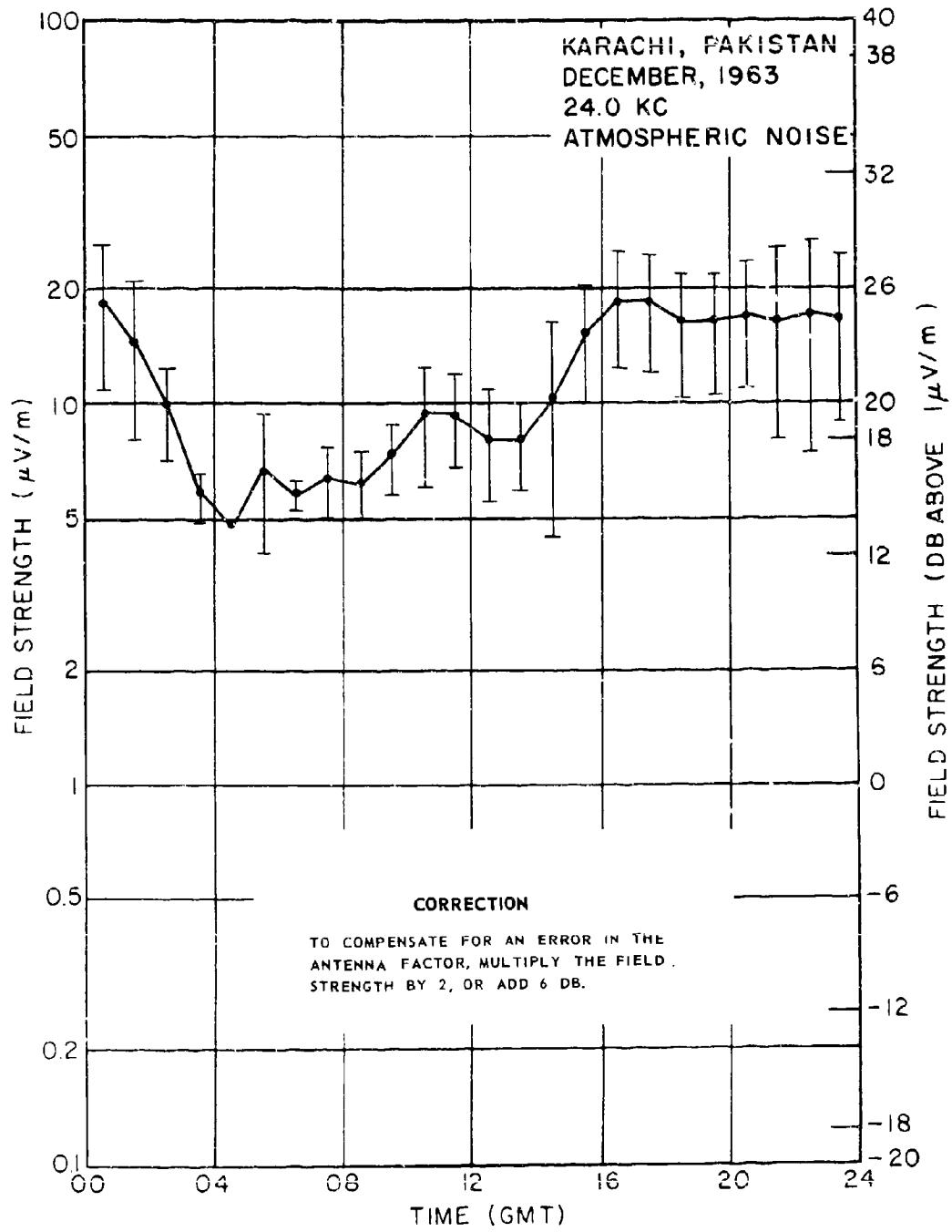


Figure 61

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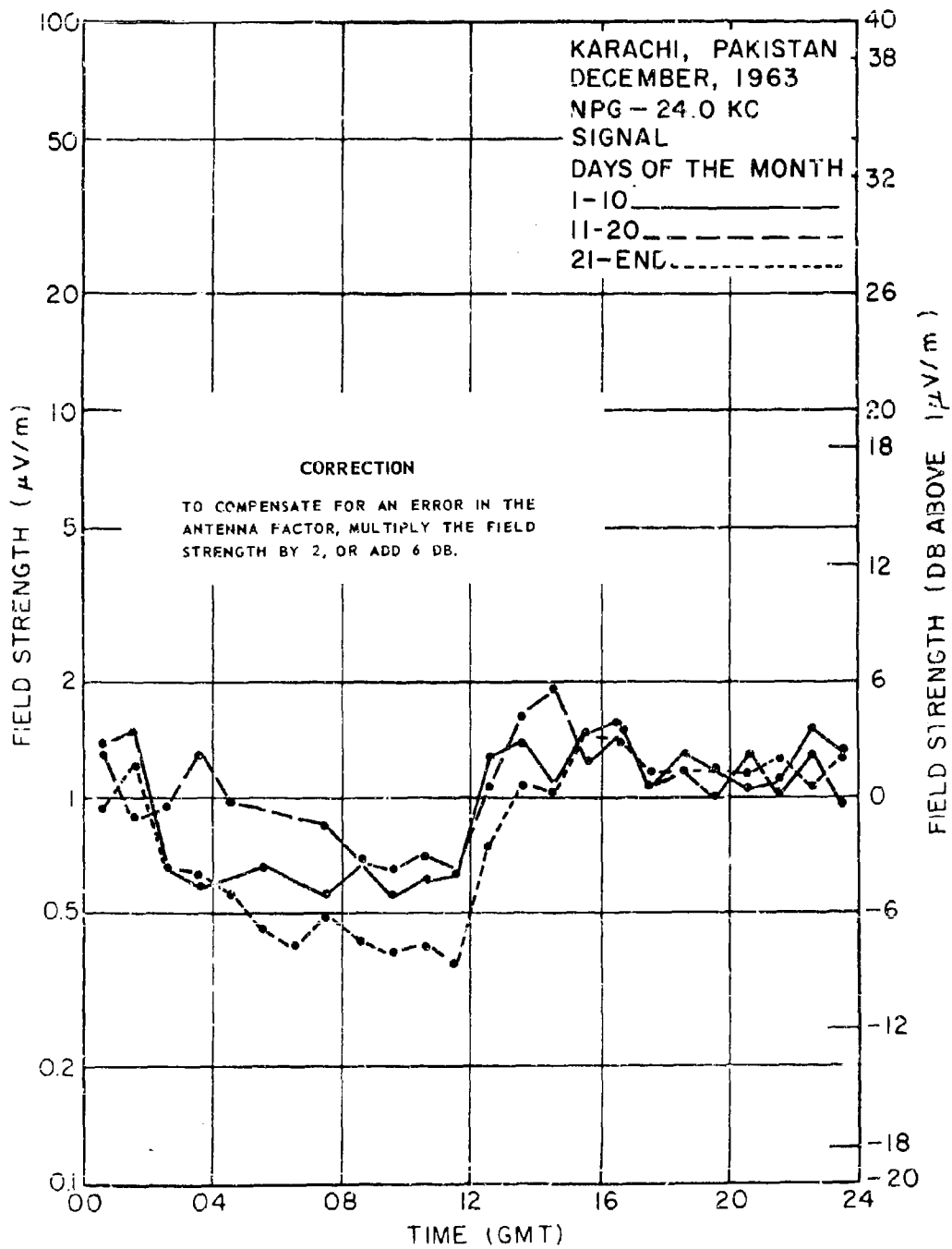


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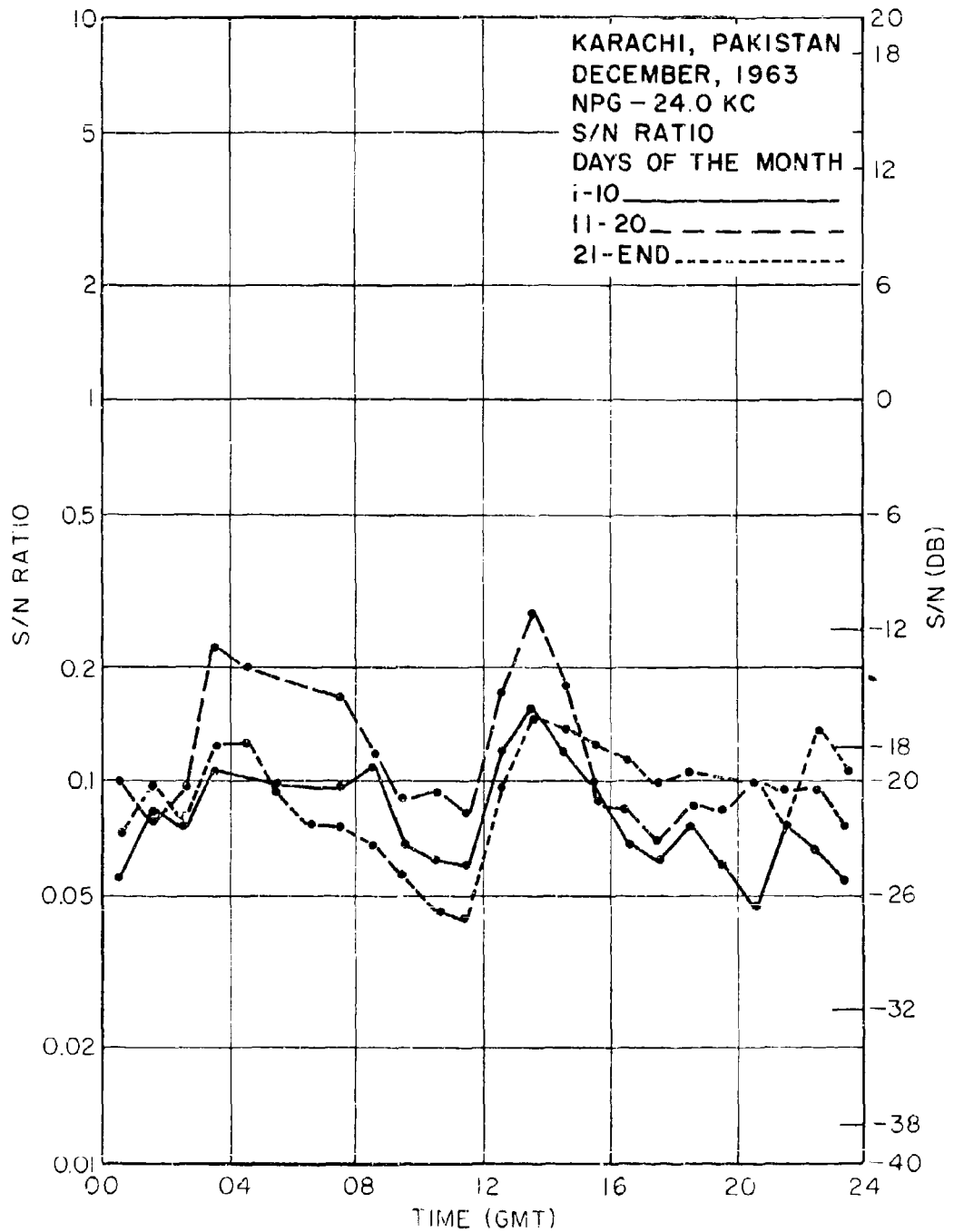


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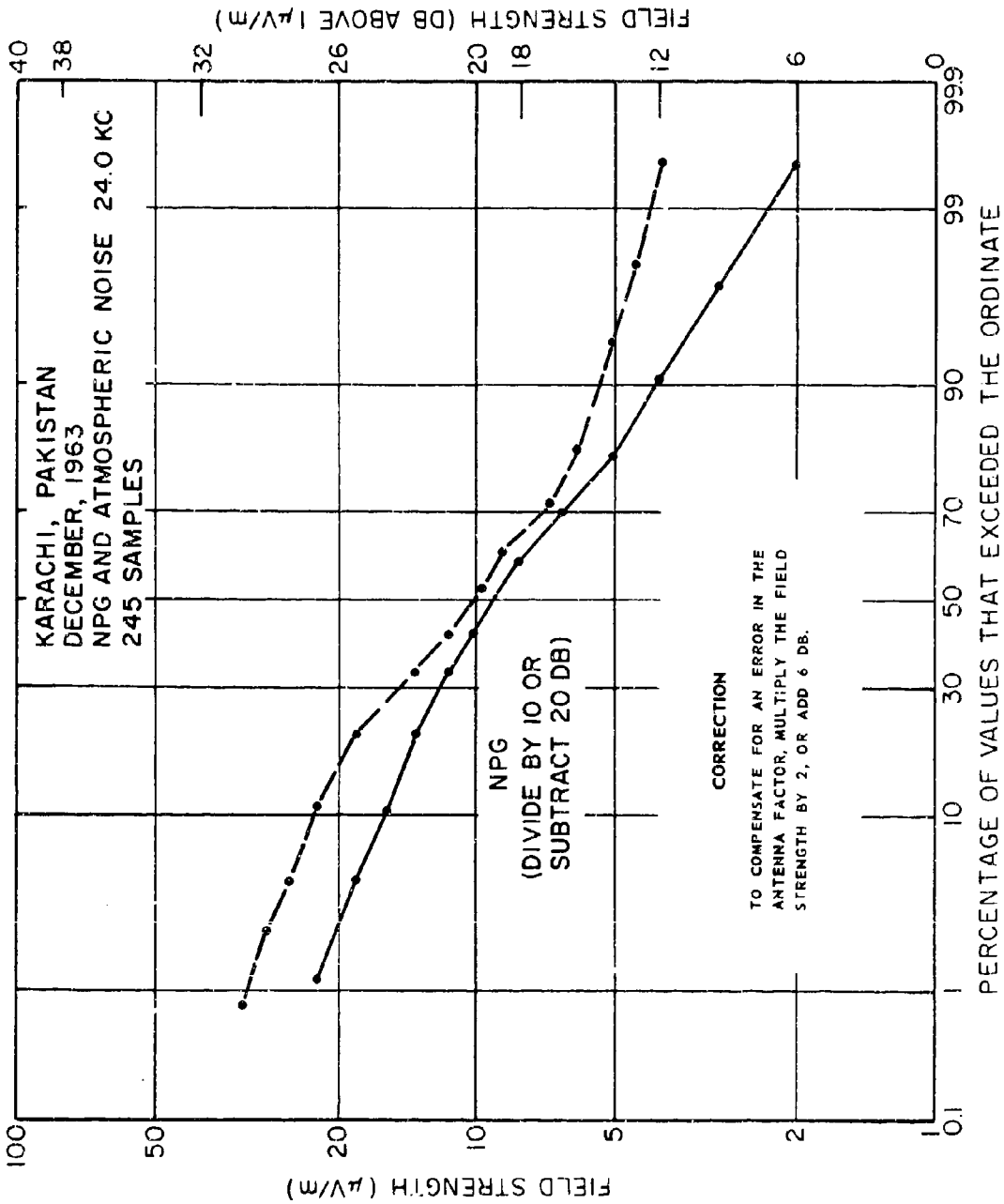


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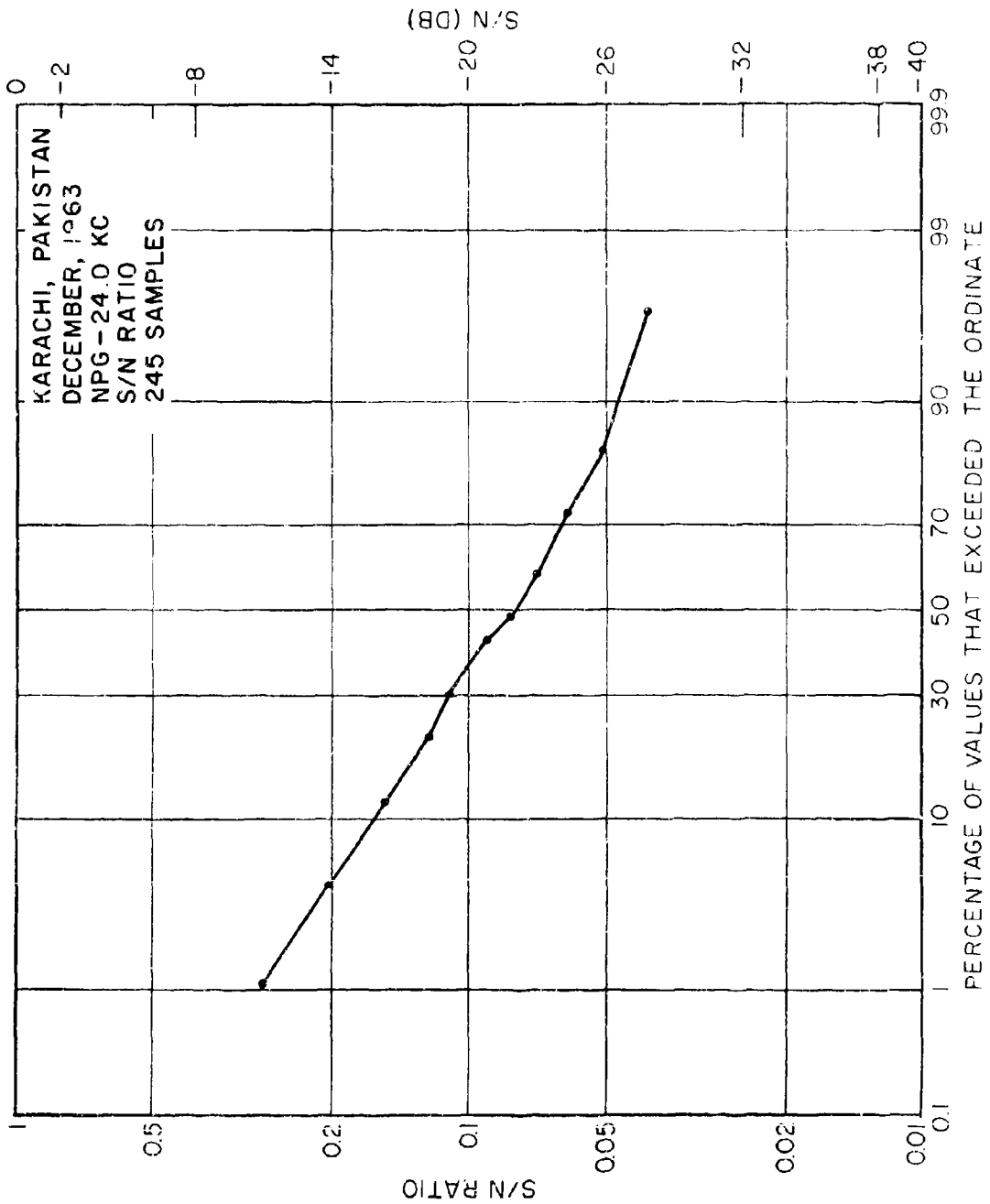


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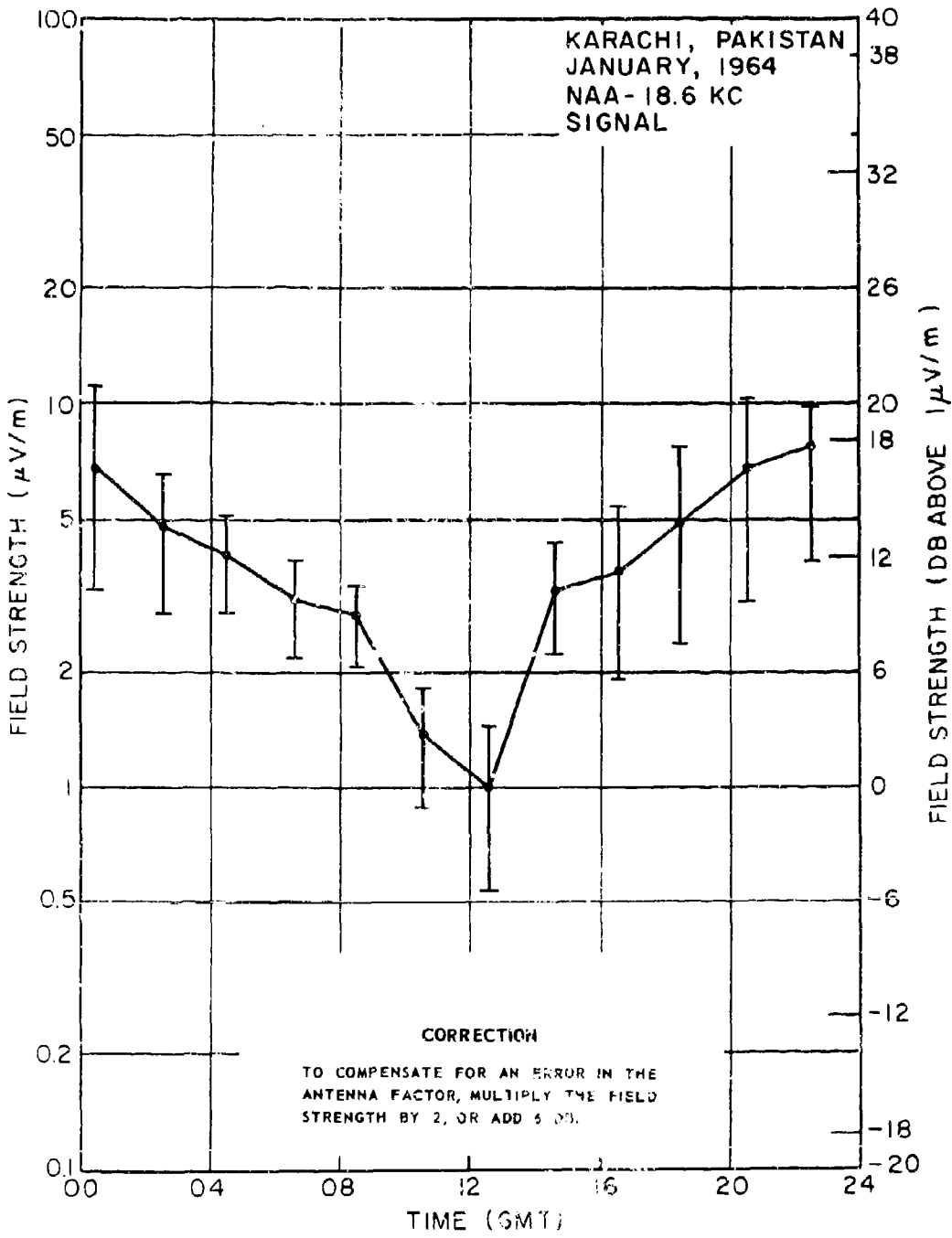


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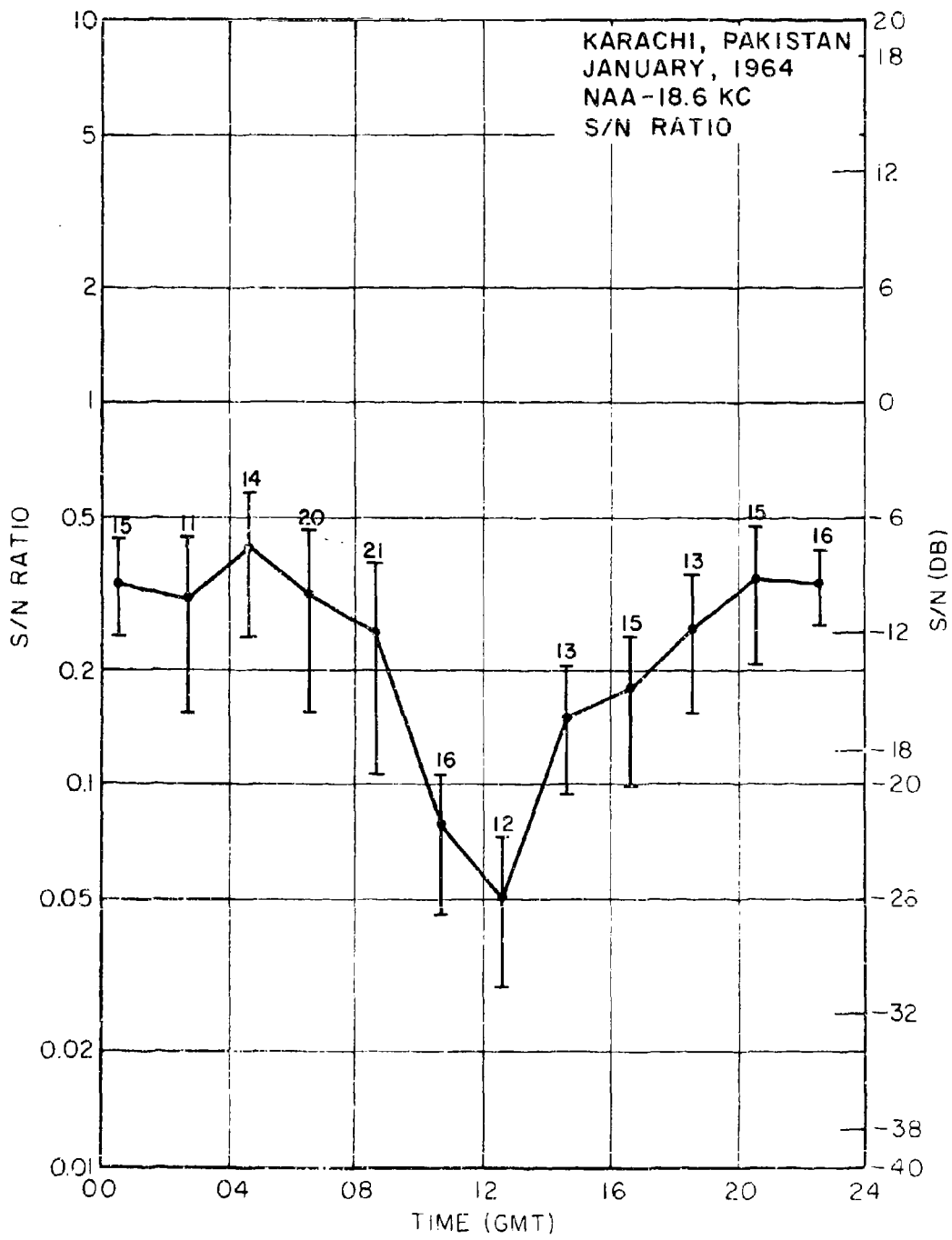


Figure 67

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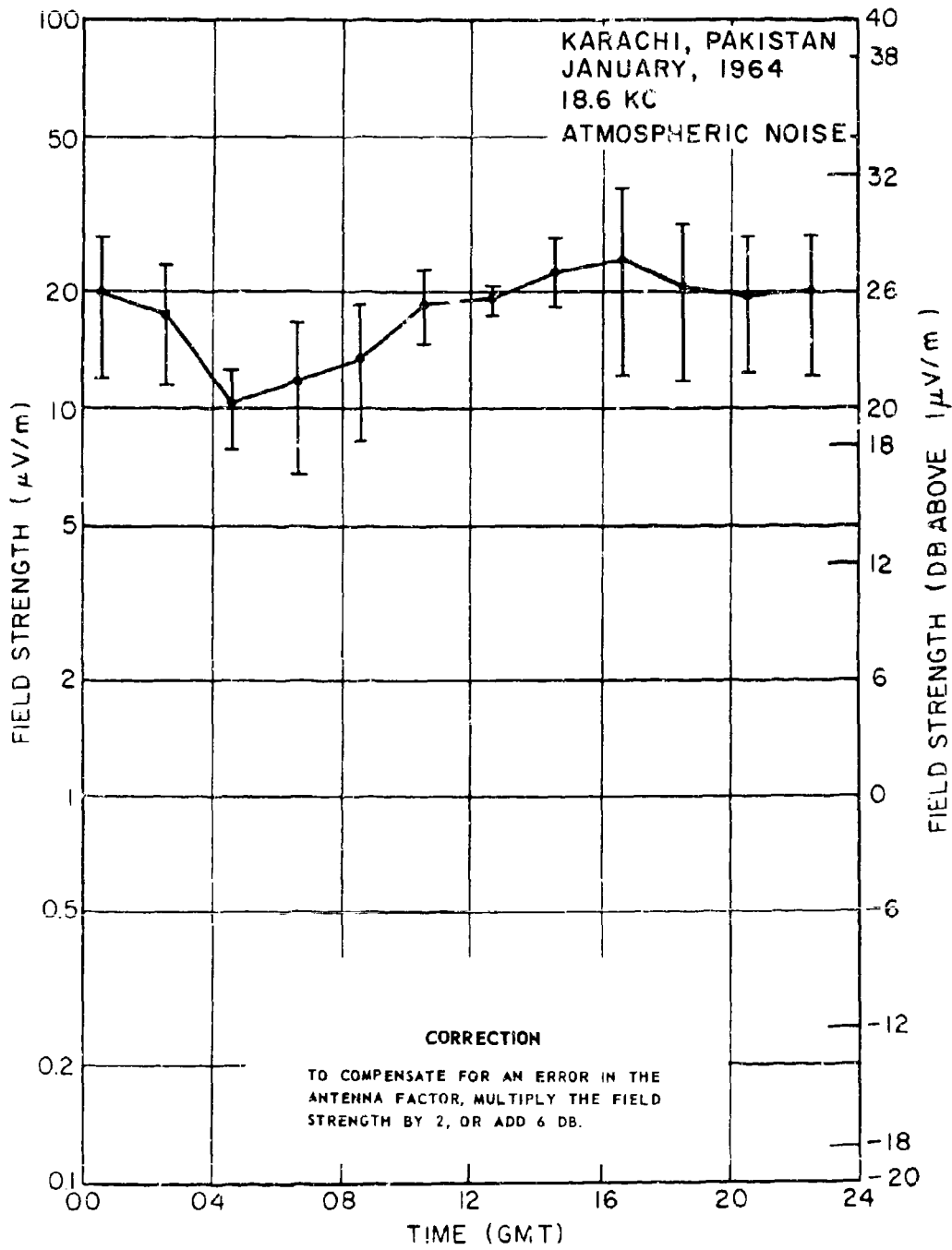


Figure 68

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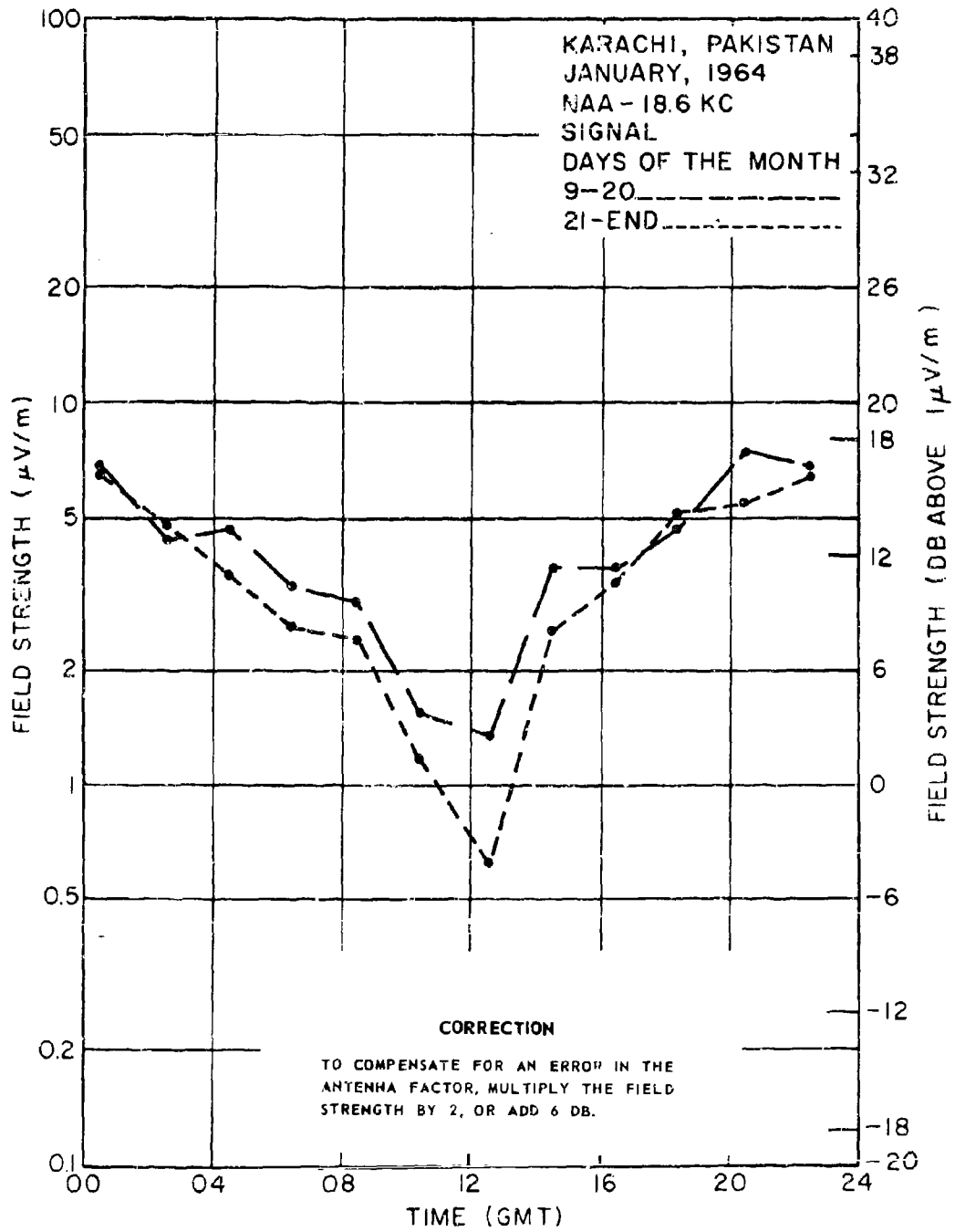


Figure 69

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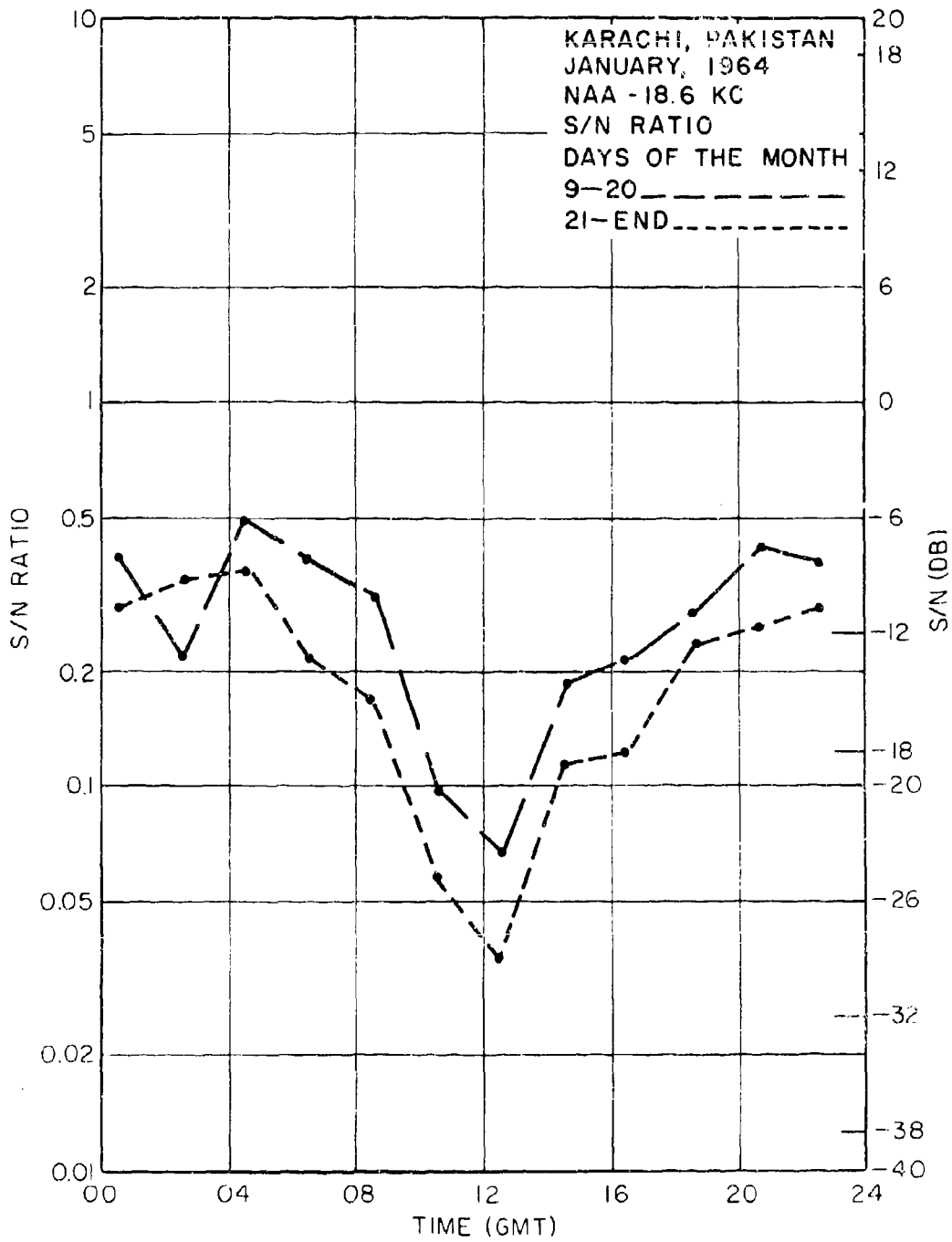


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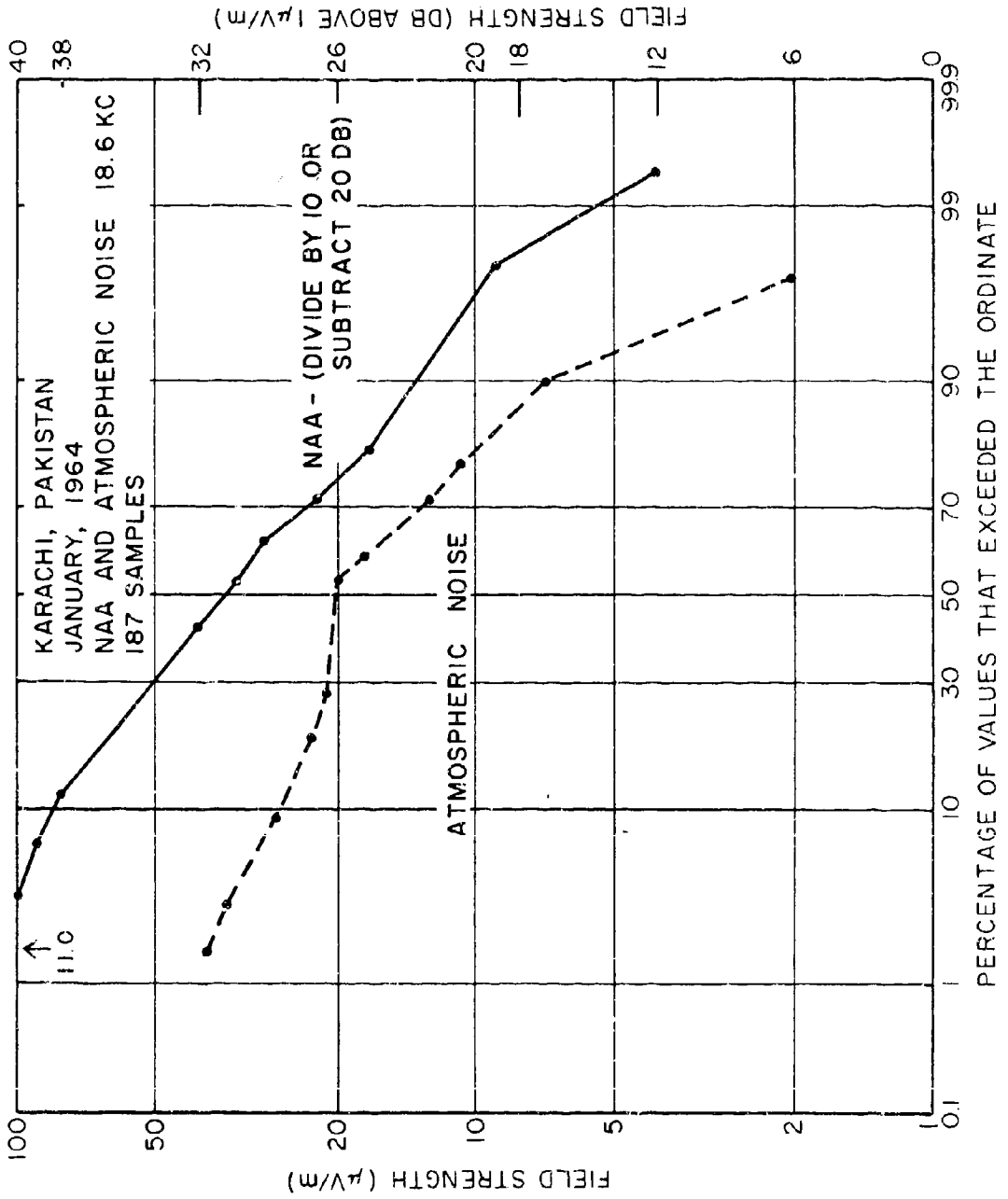


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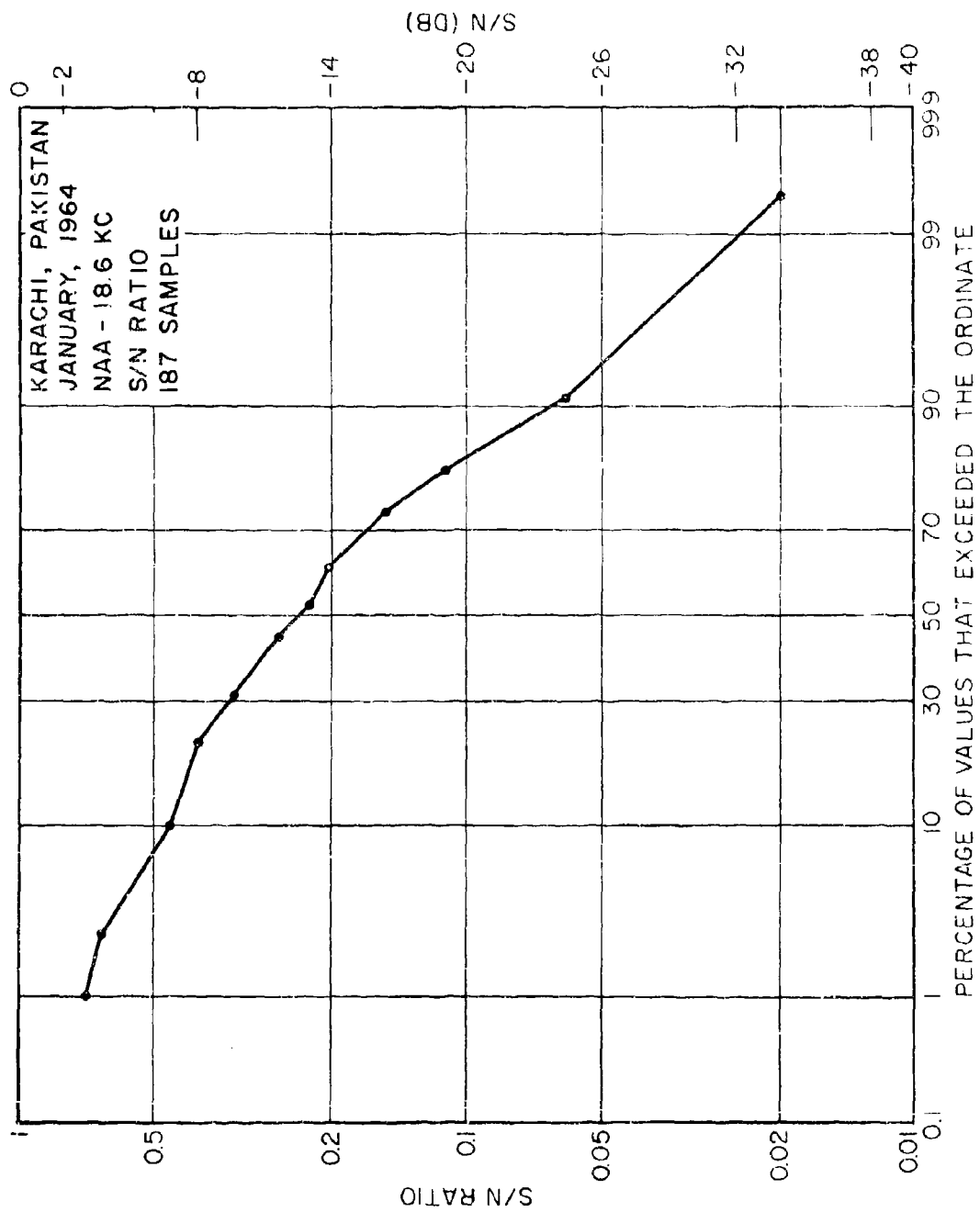


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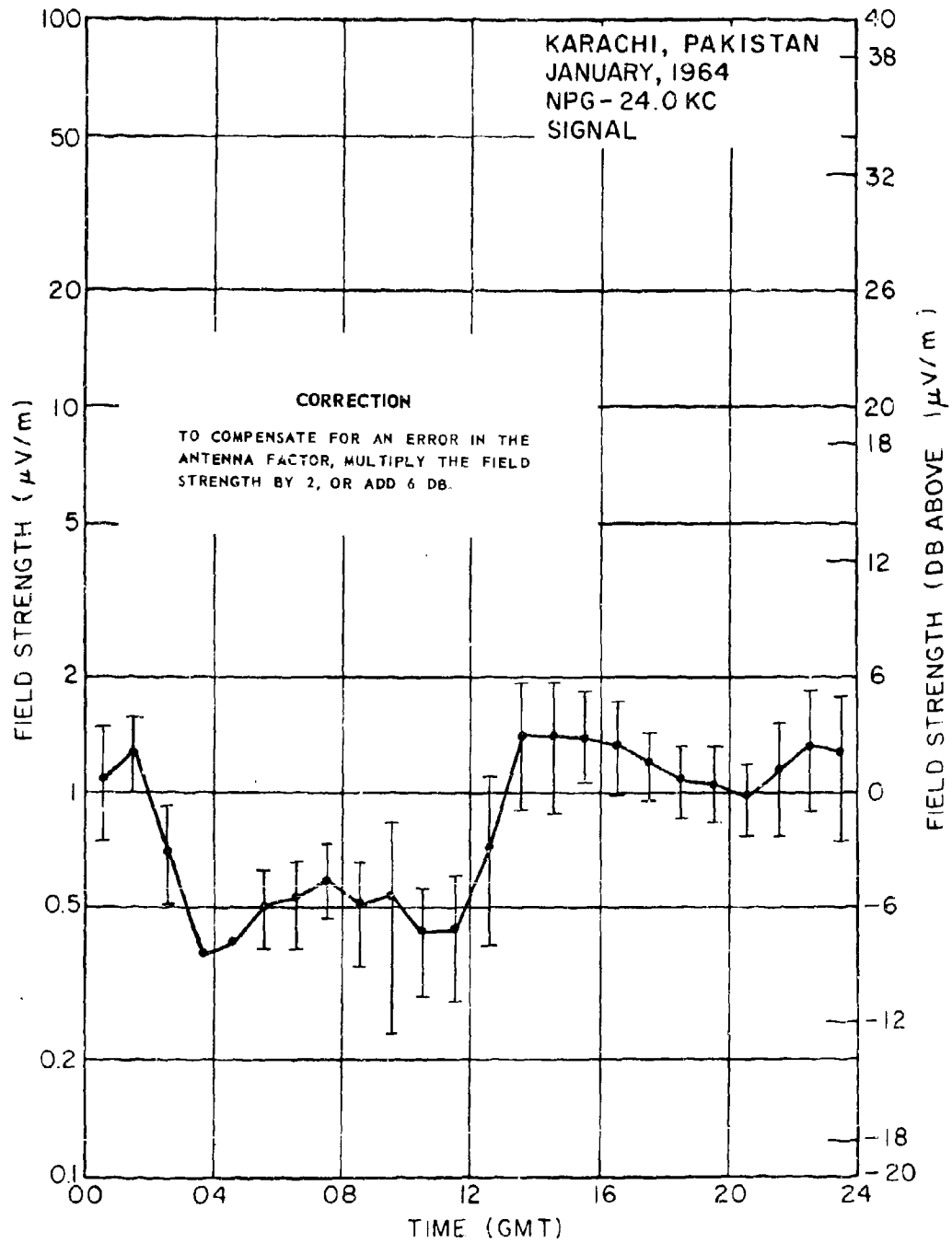


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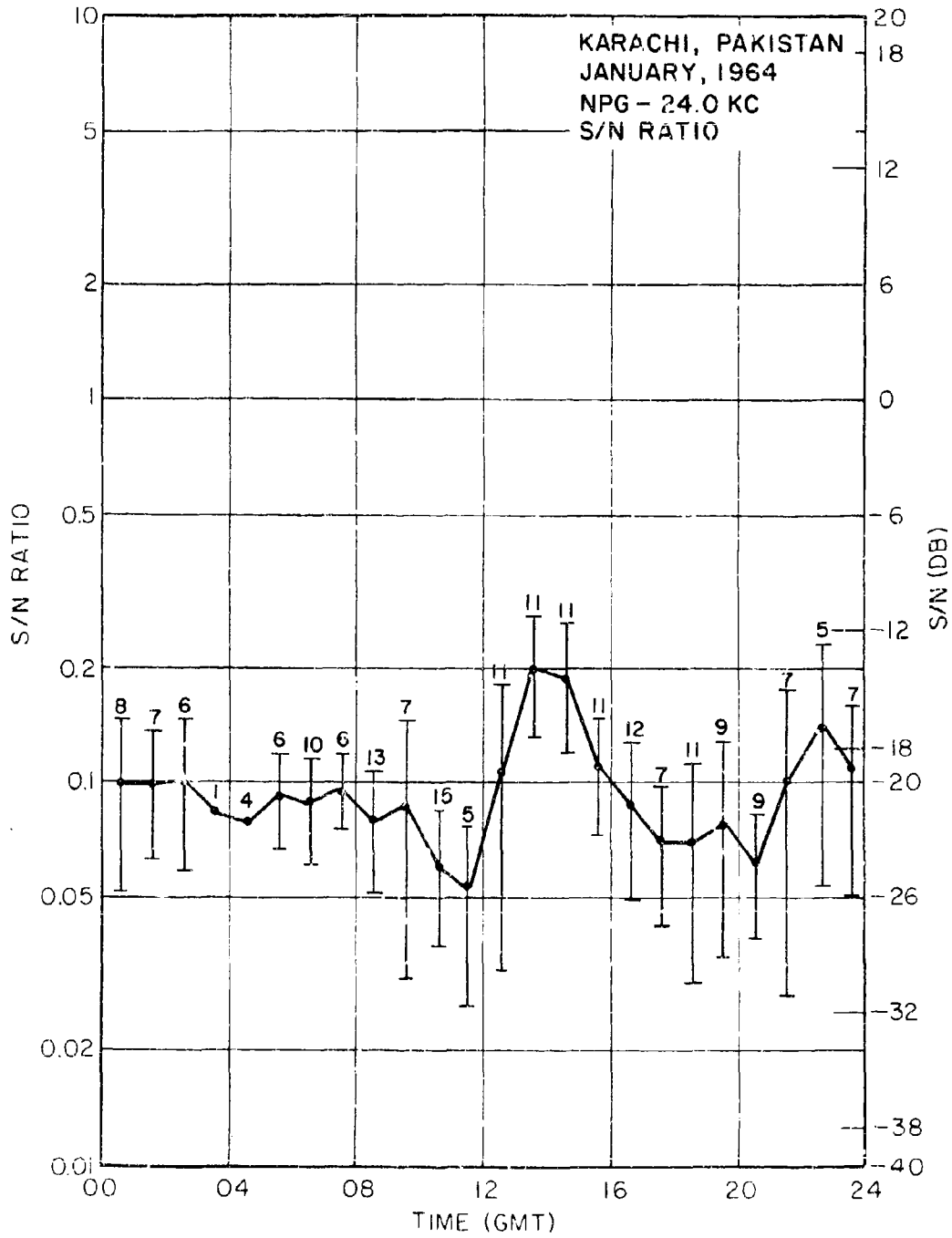


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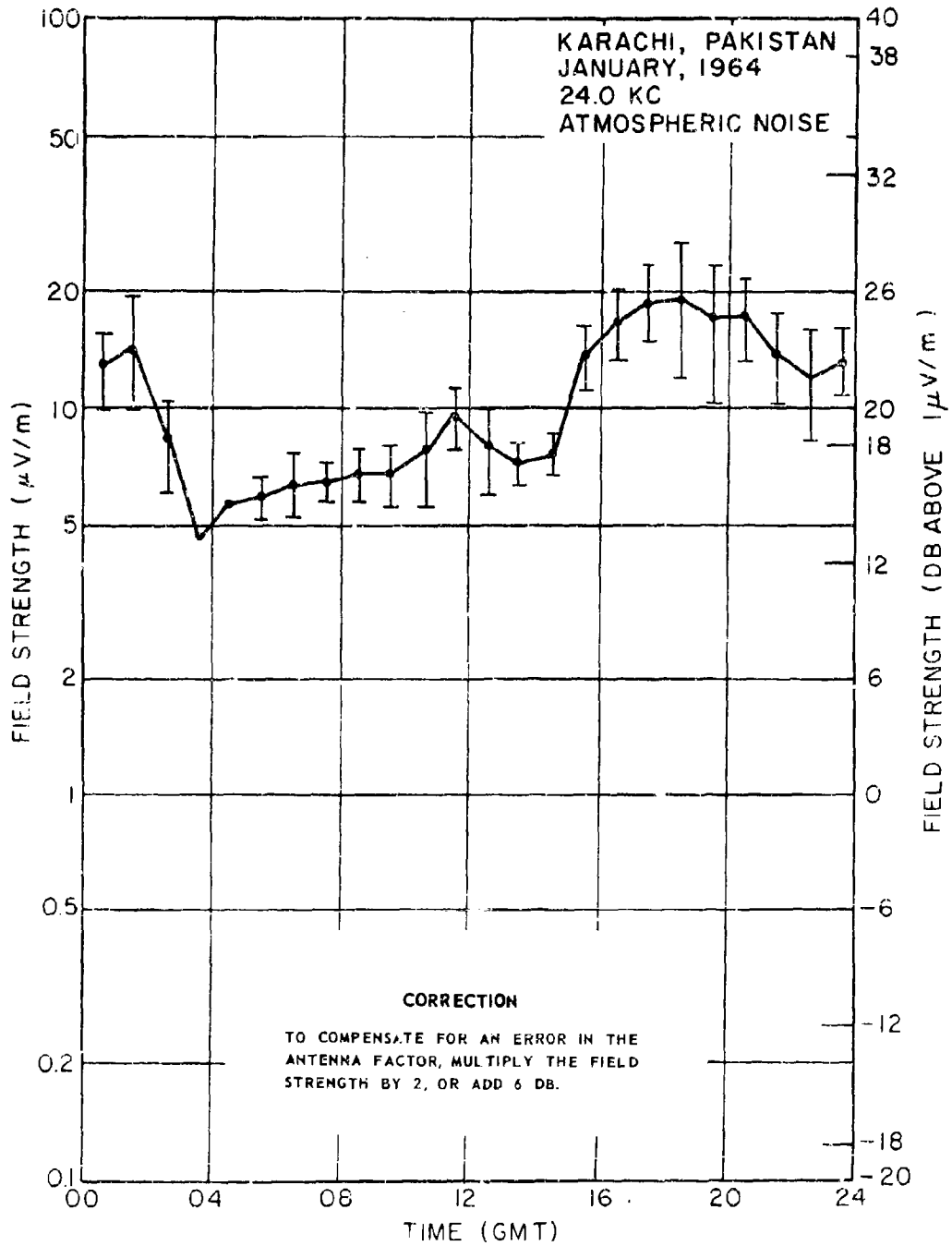


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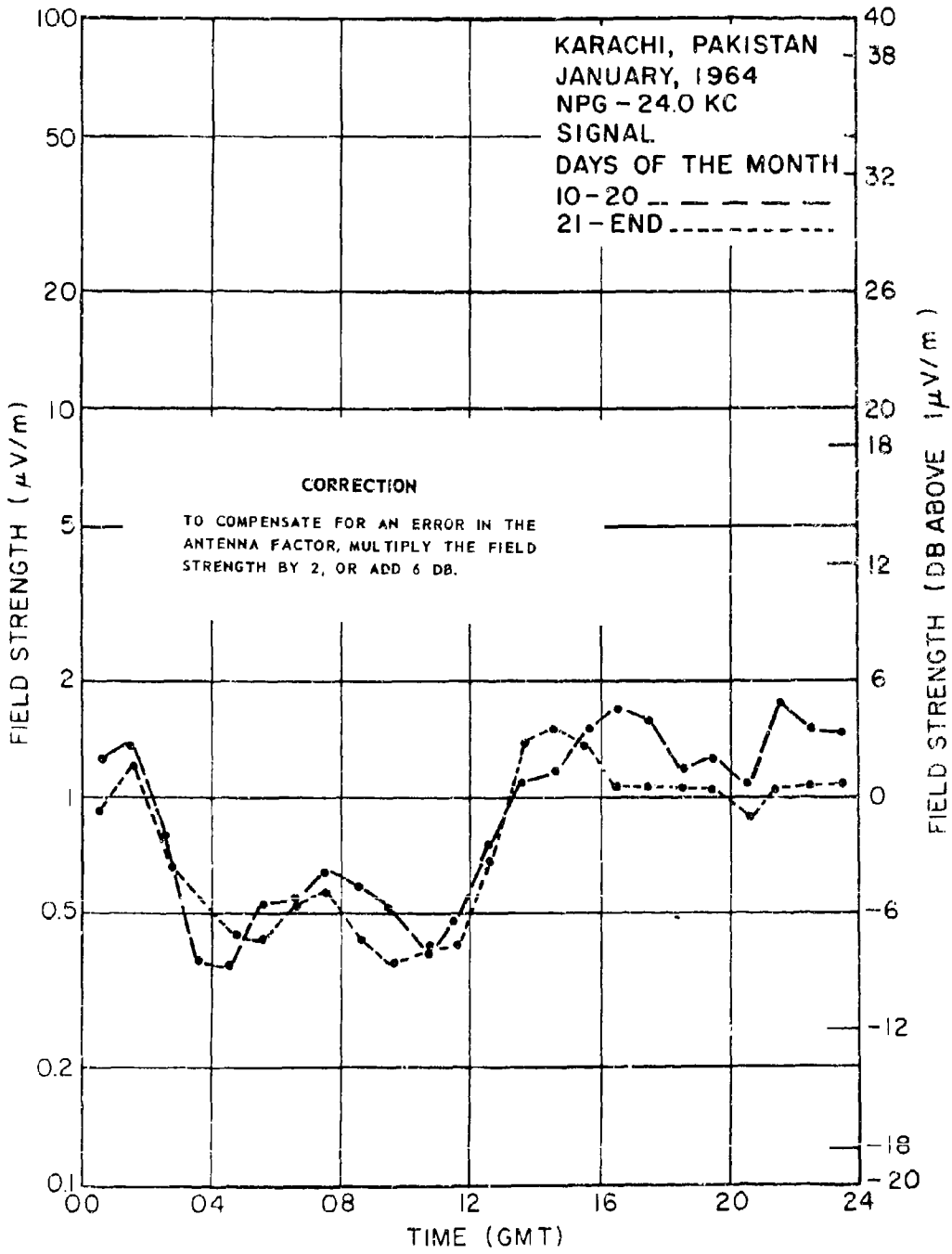


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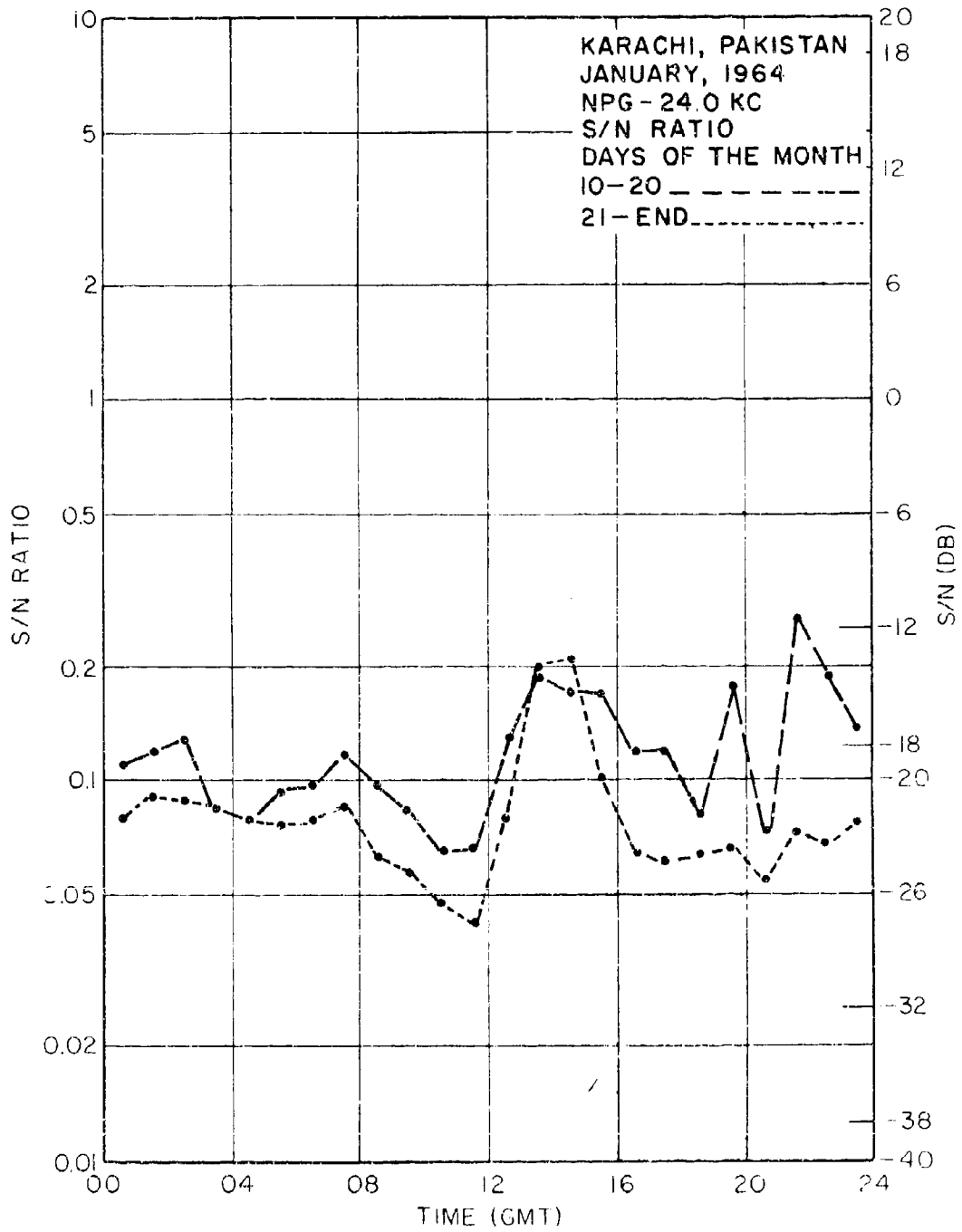


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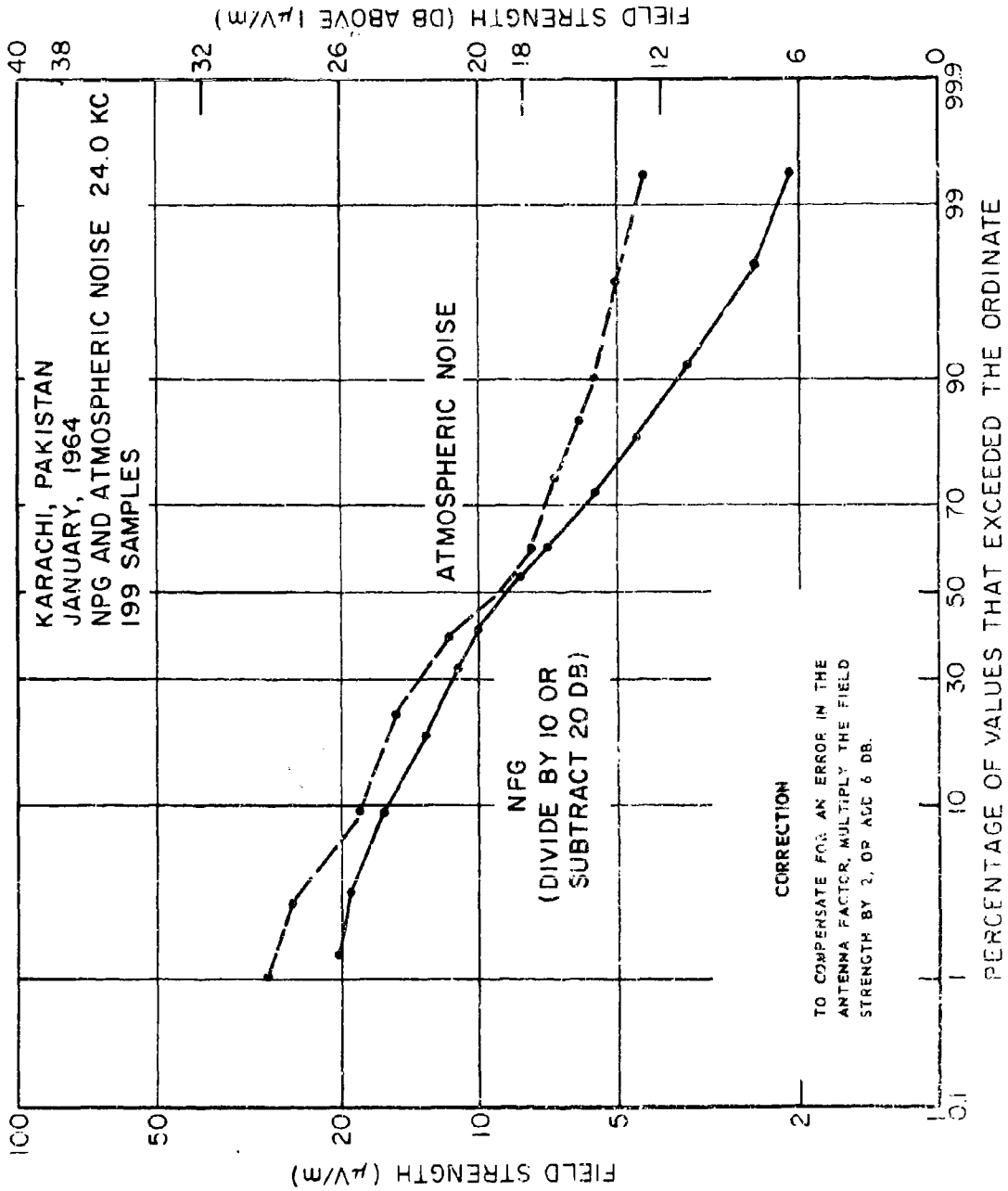


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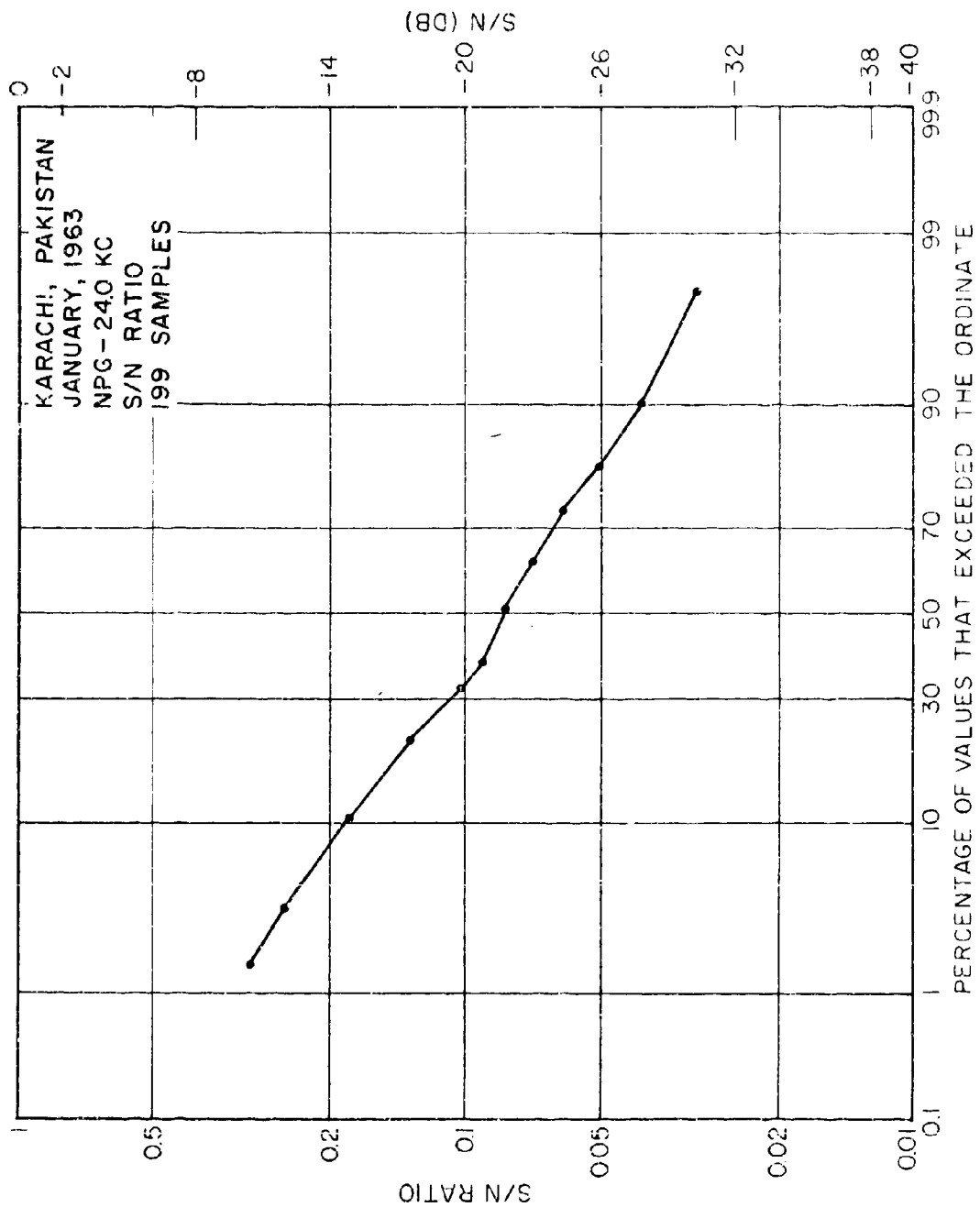


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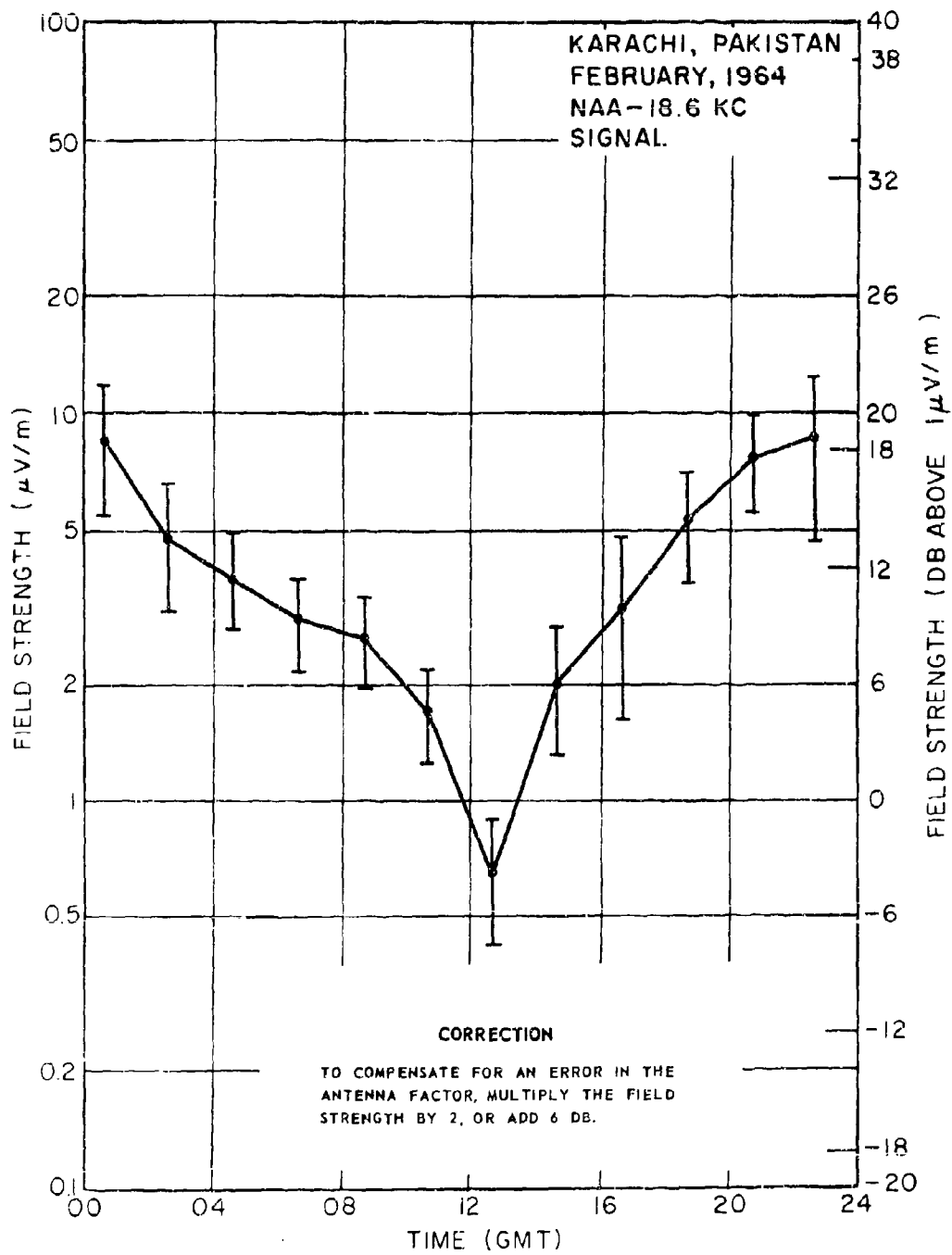


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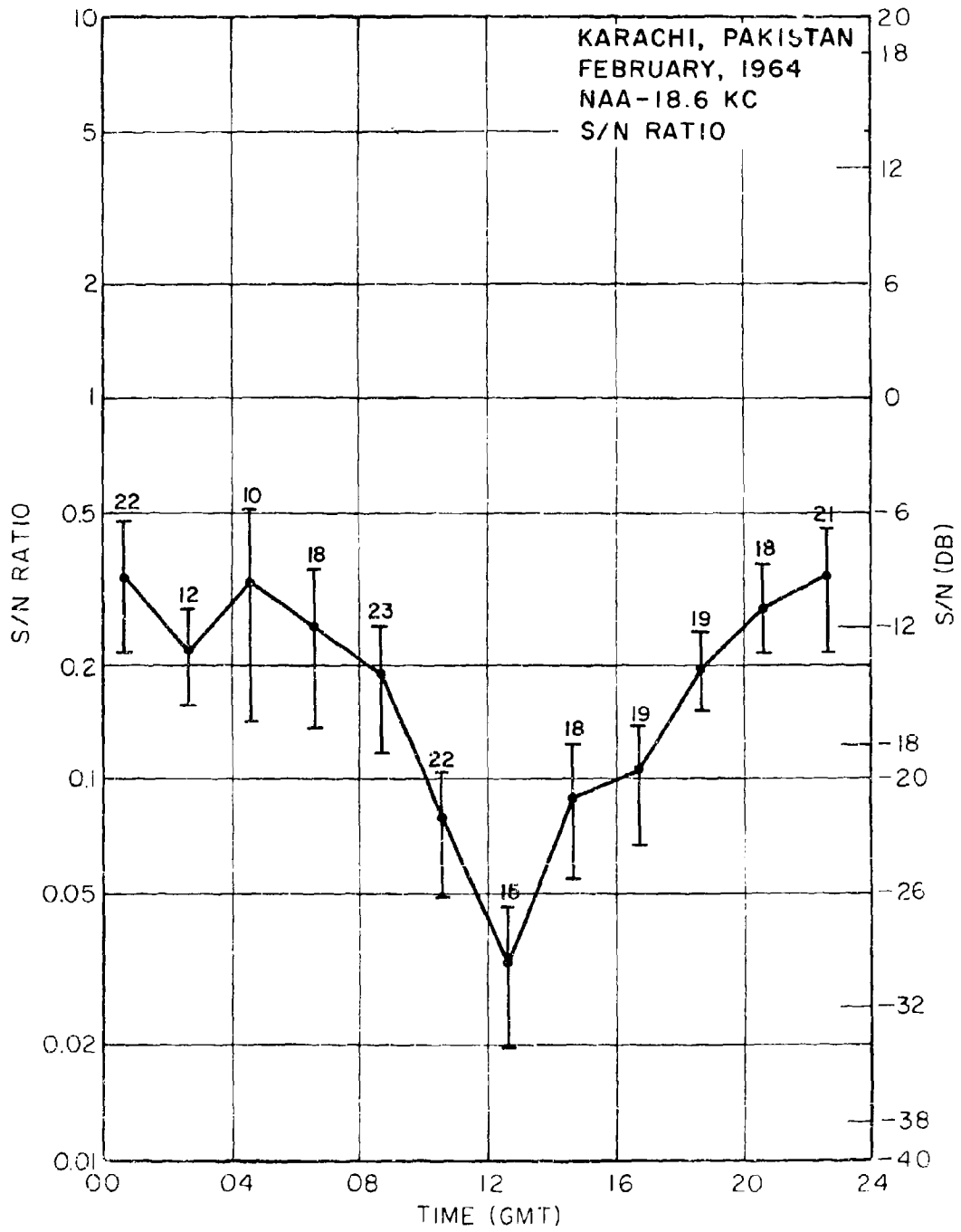


Figure 81

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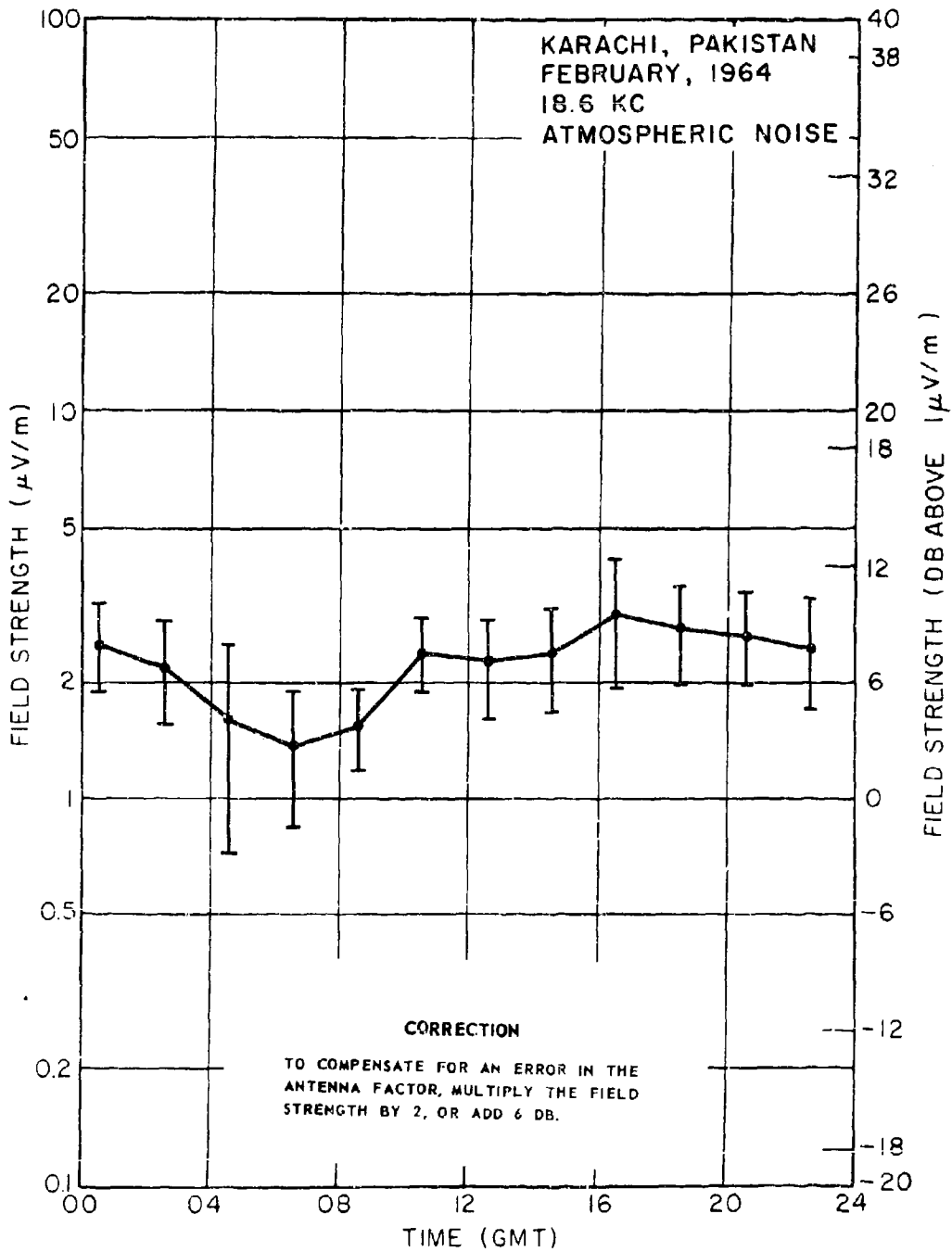


Figure 82

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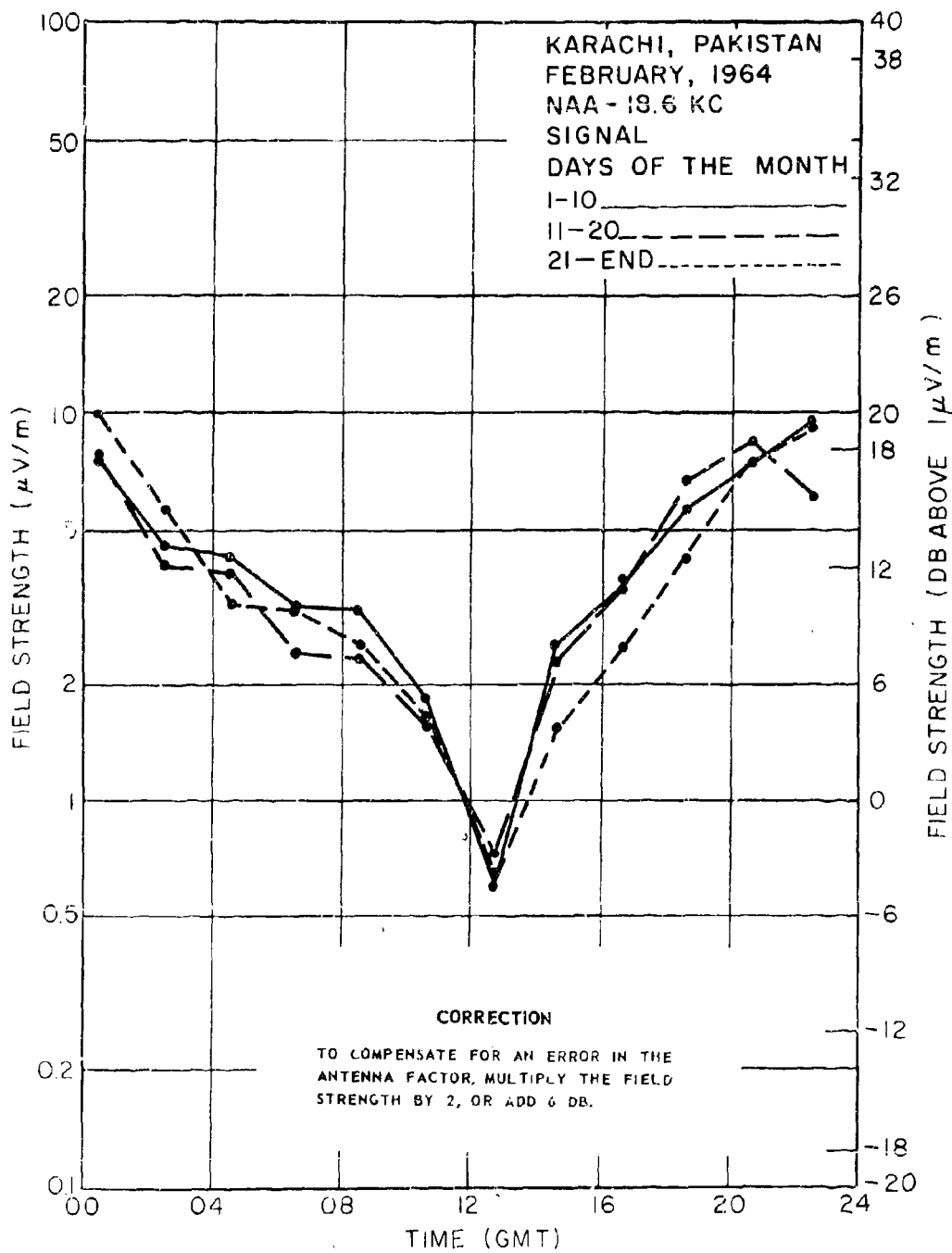


Figure 83

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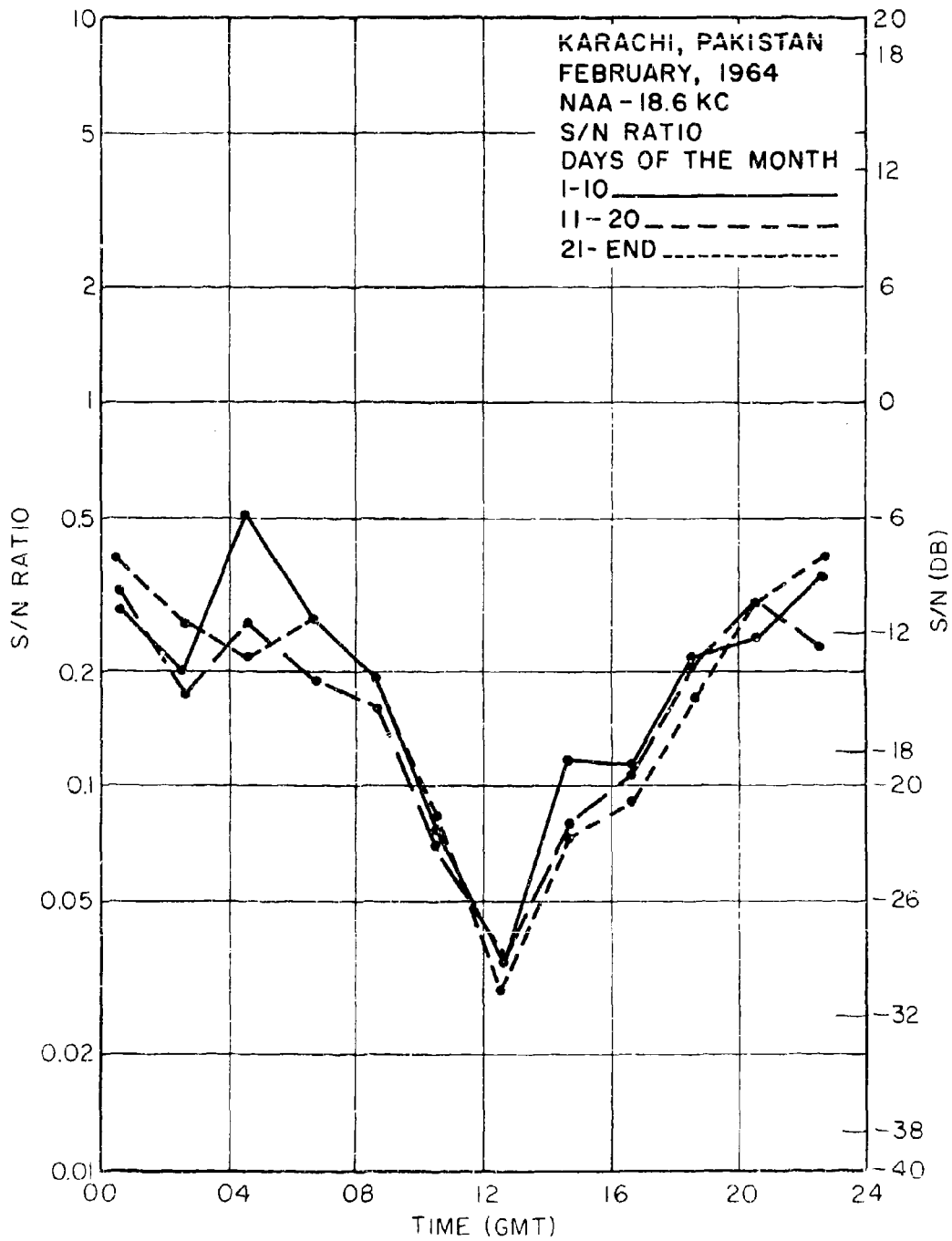


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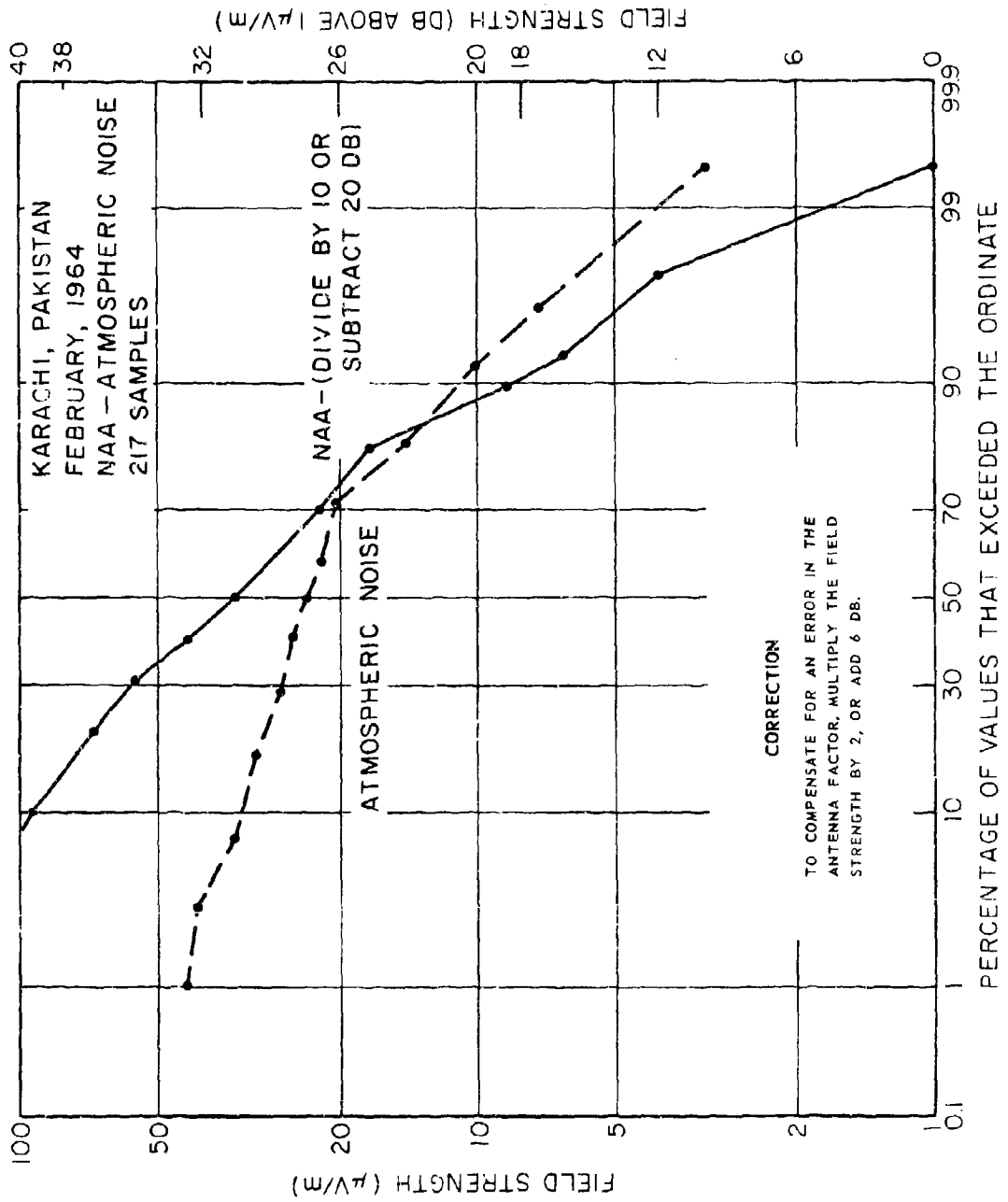


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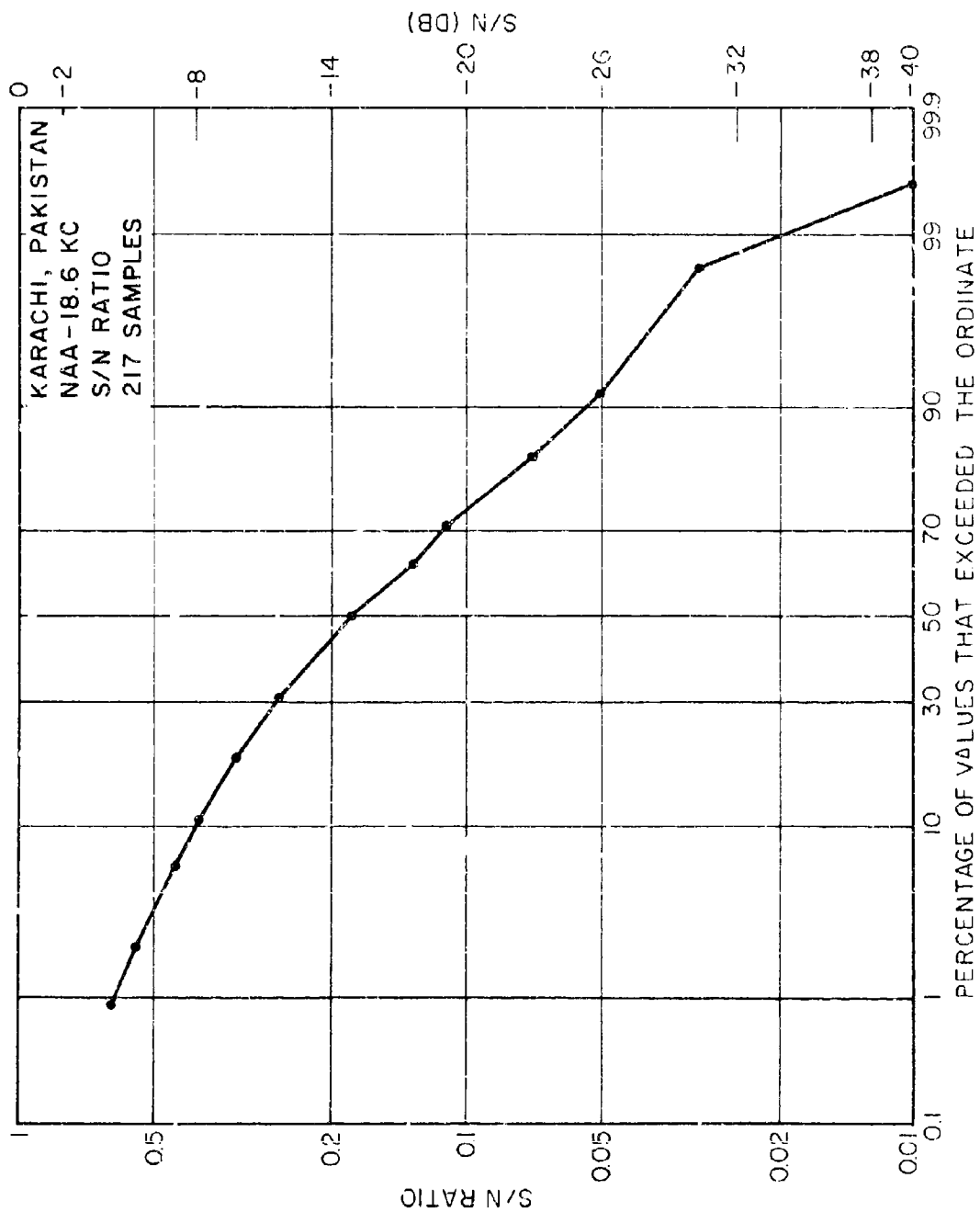


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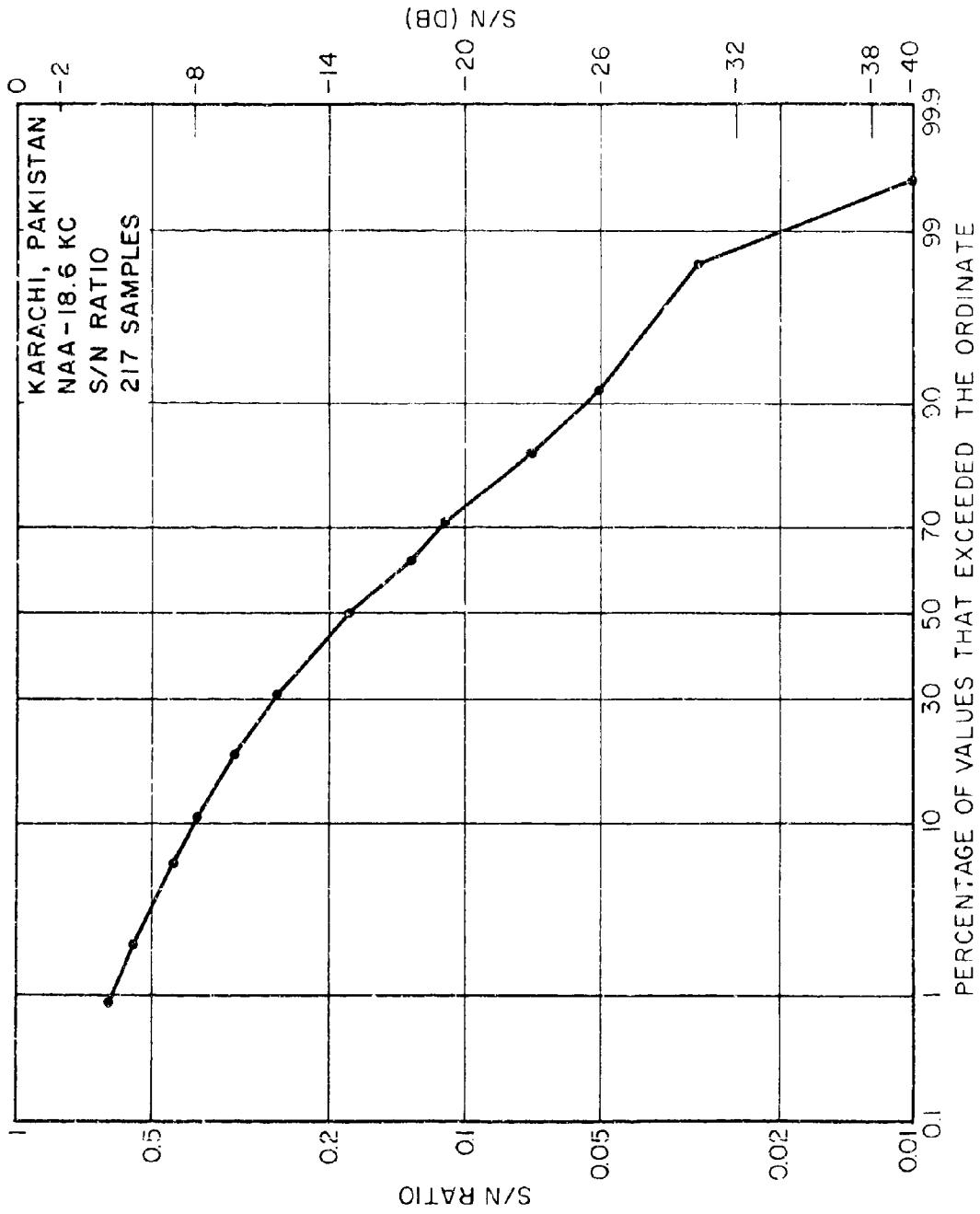


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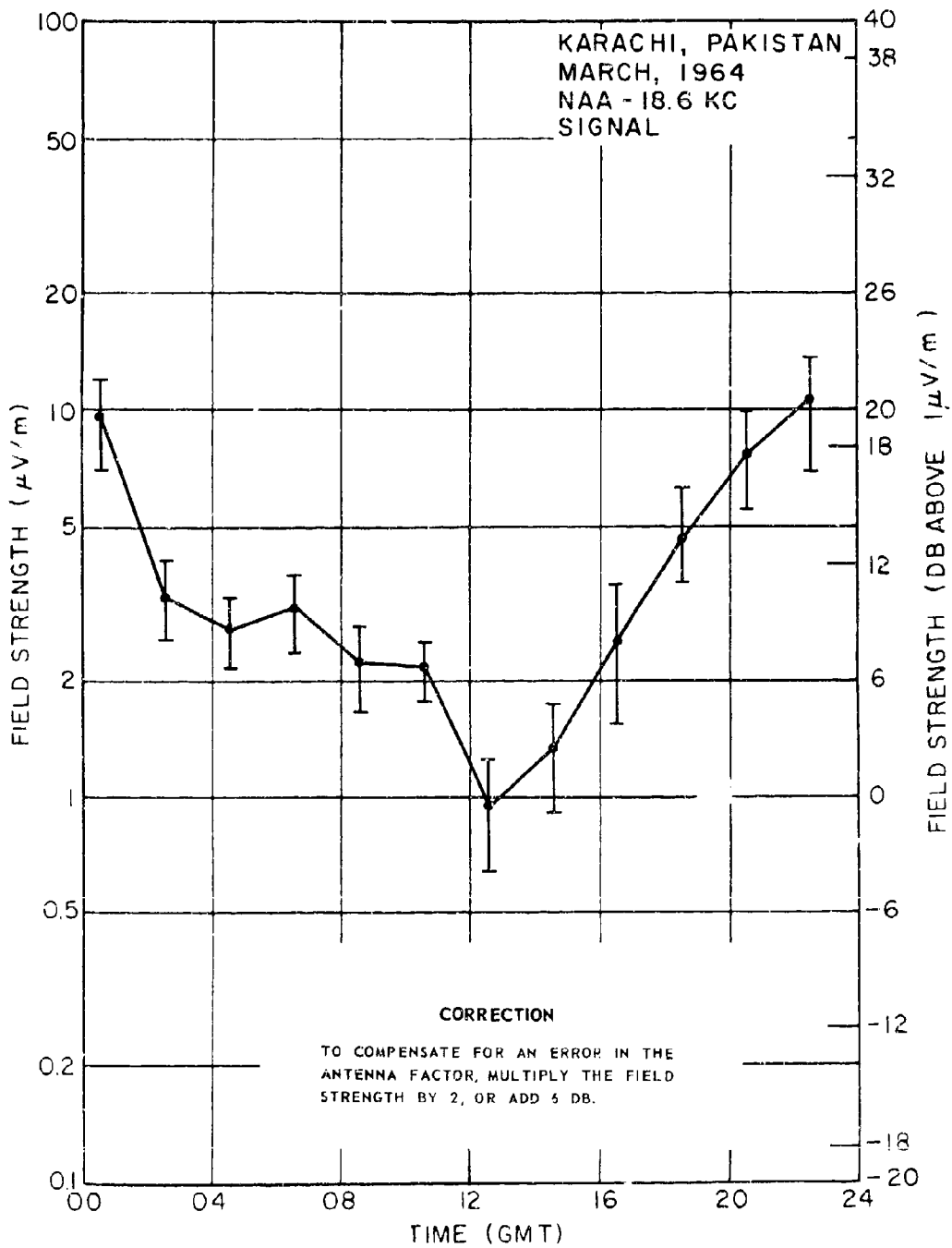


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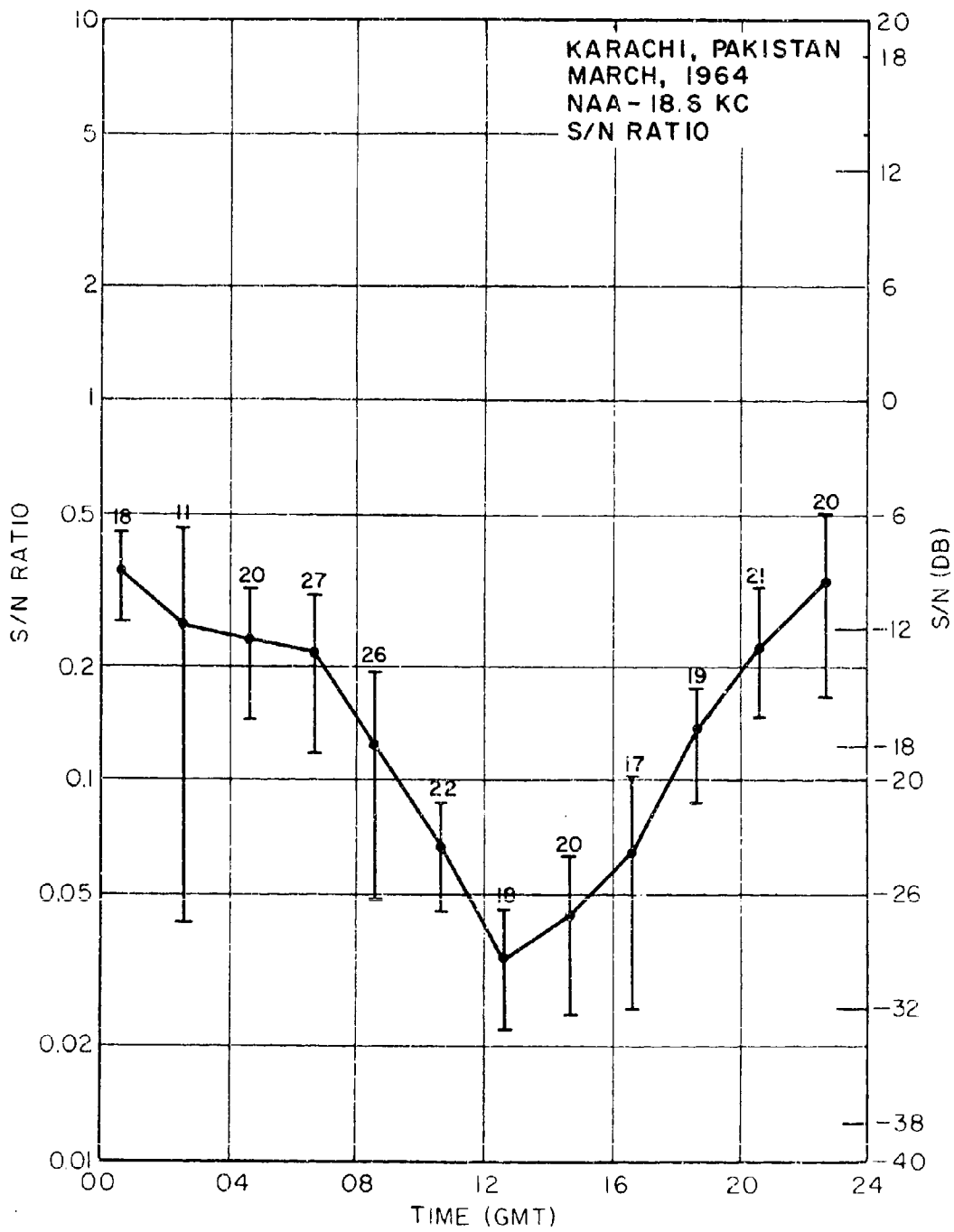


Figure 88

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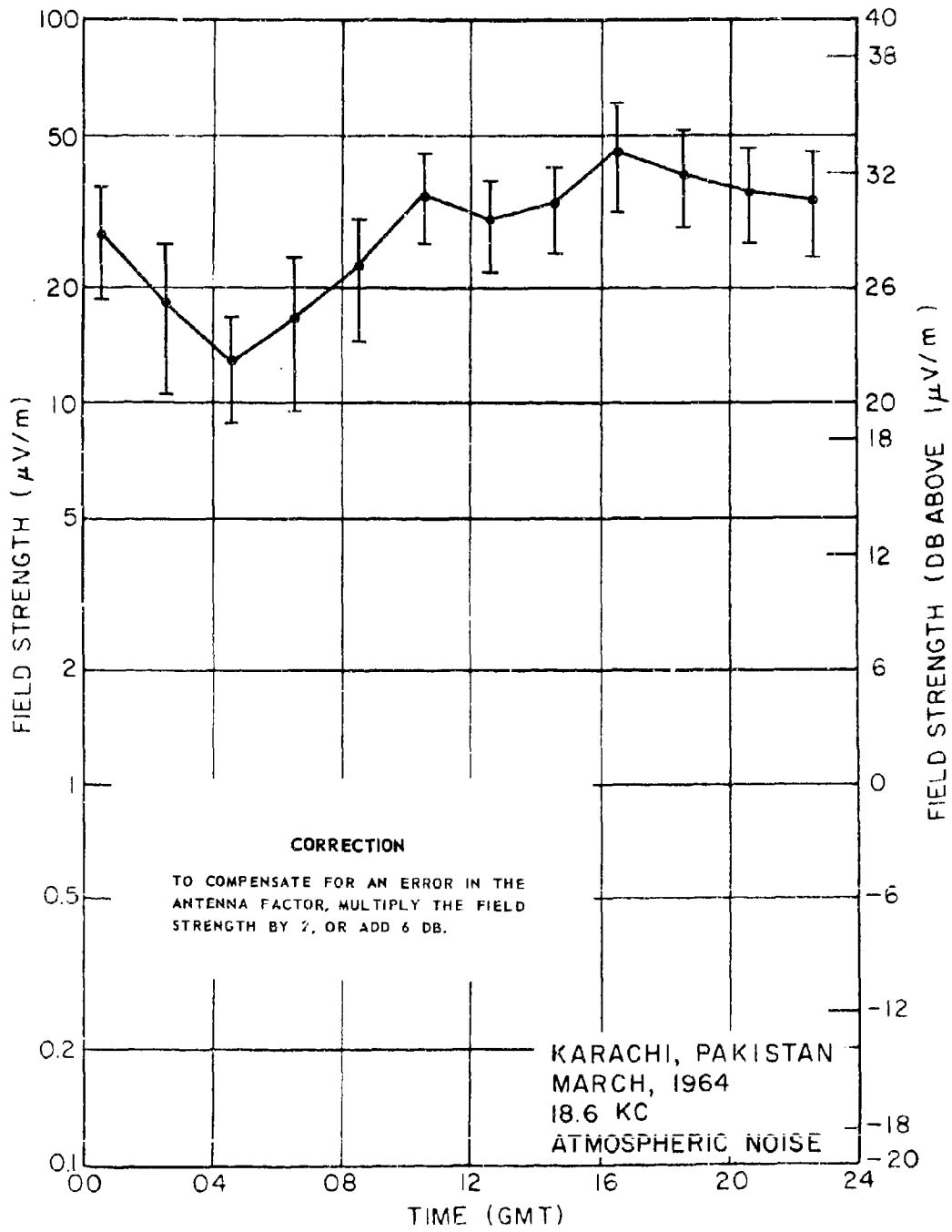


Figure 89

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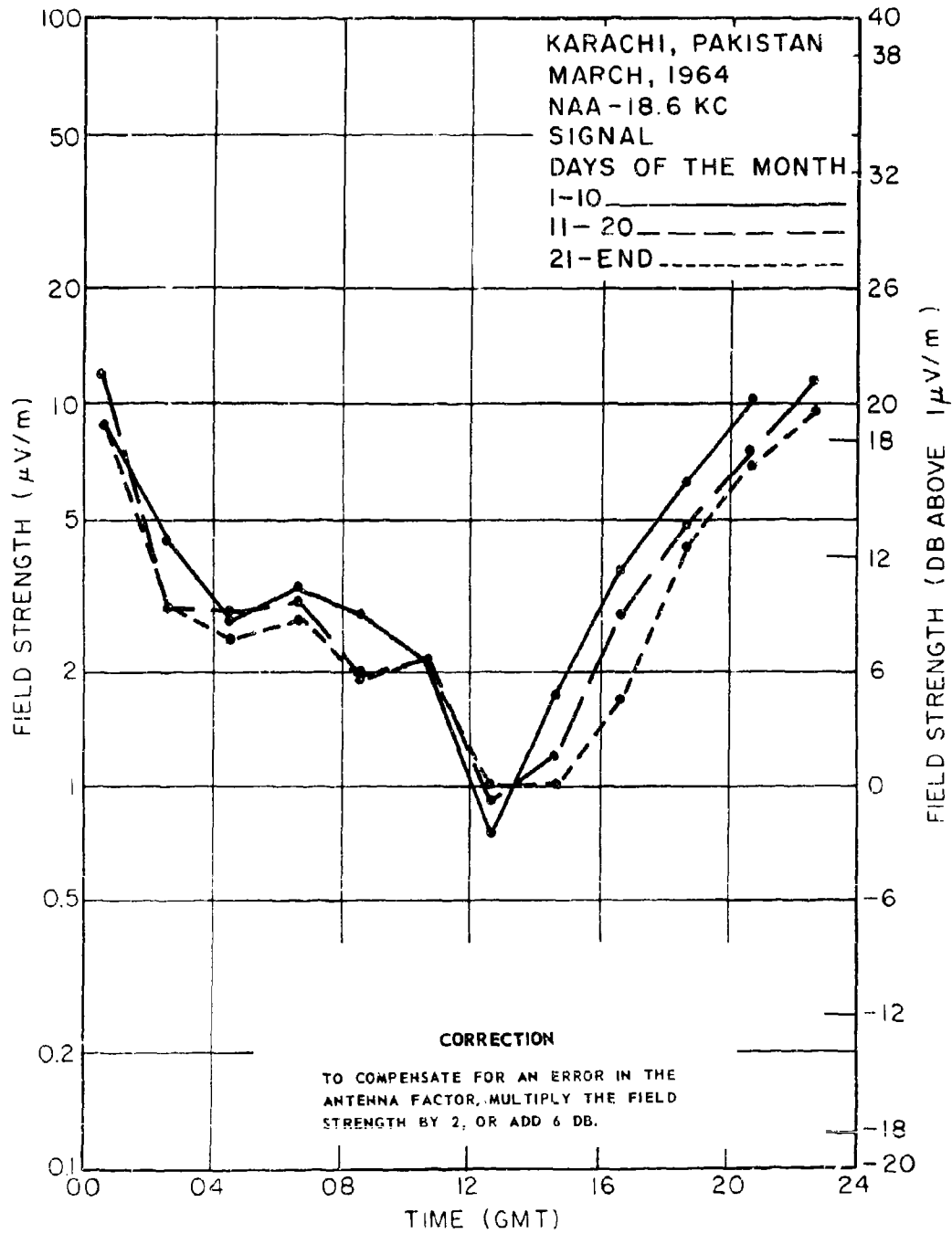


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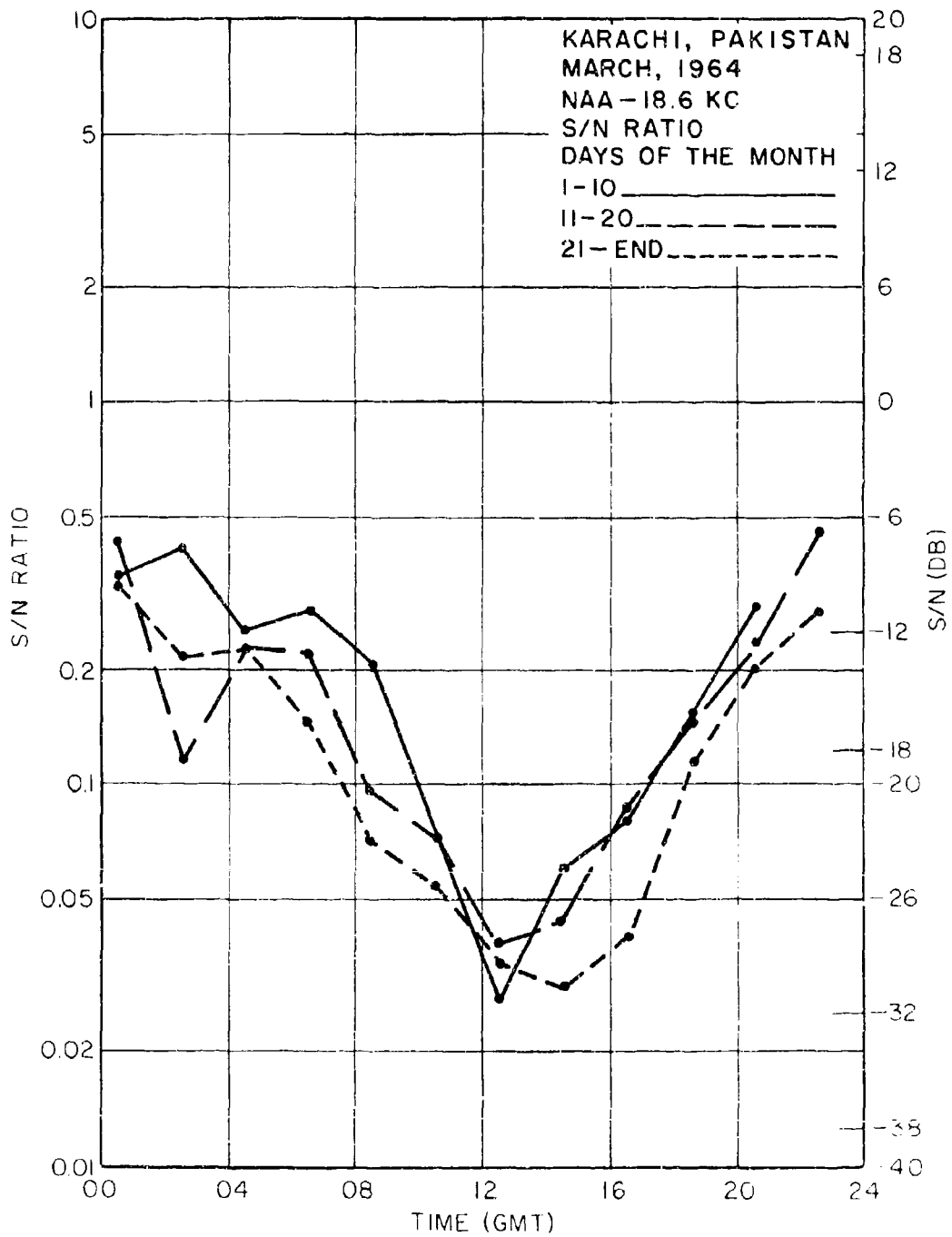


Figure 91

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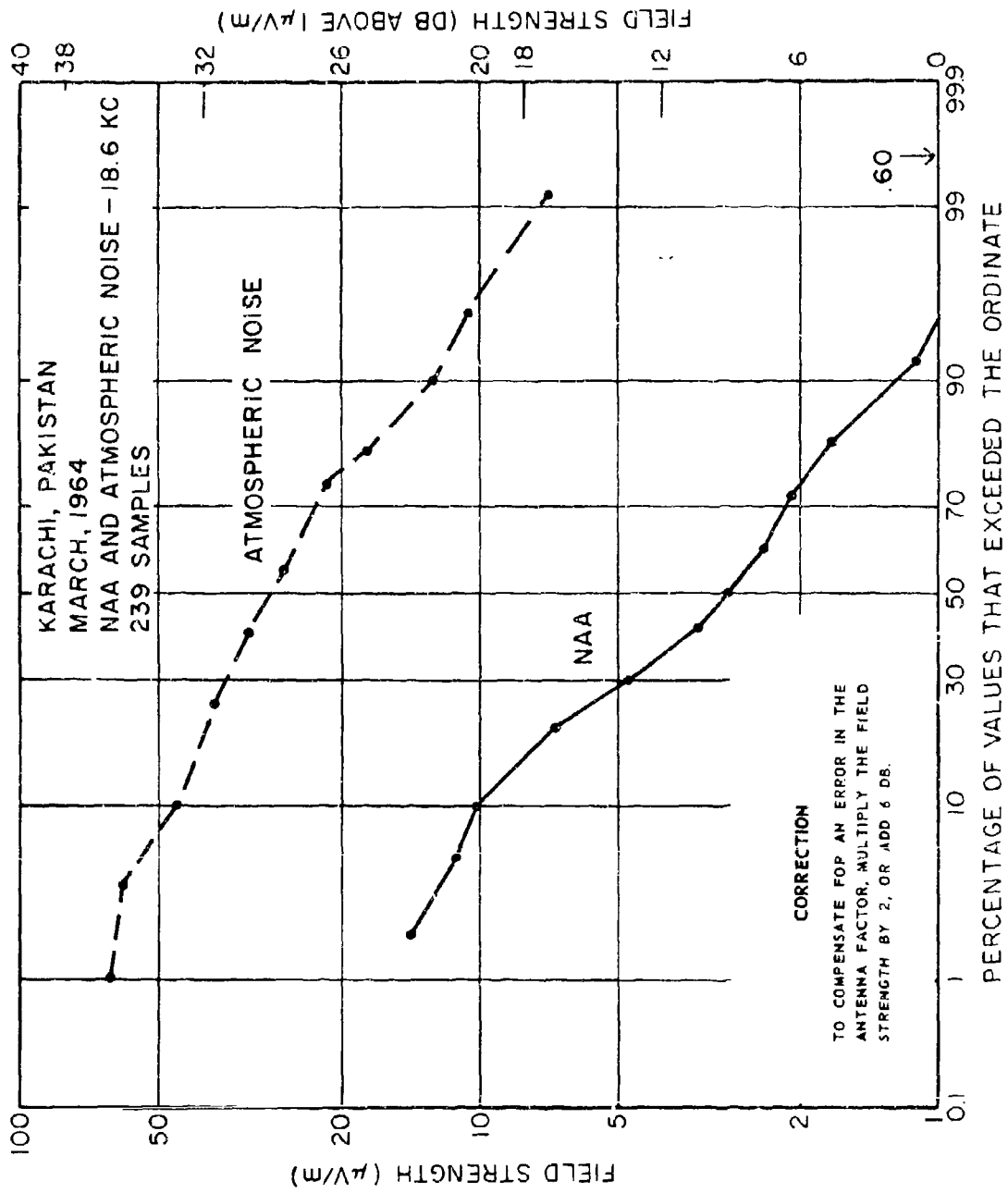


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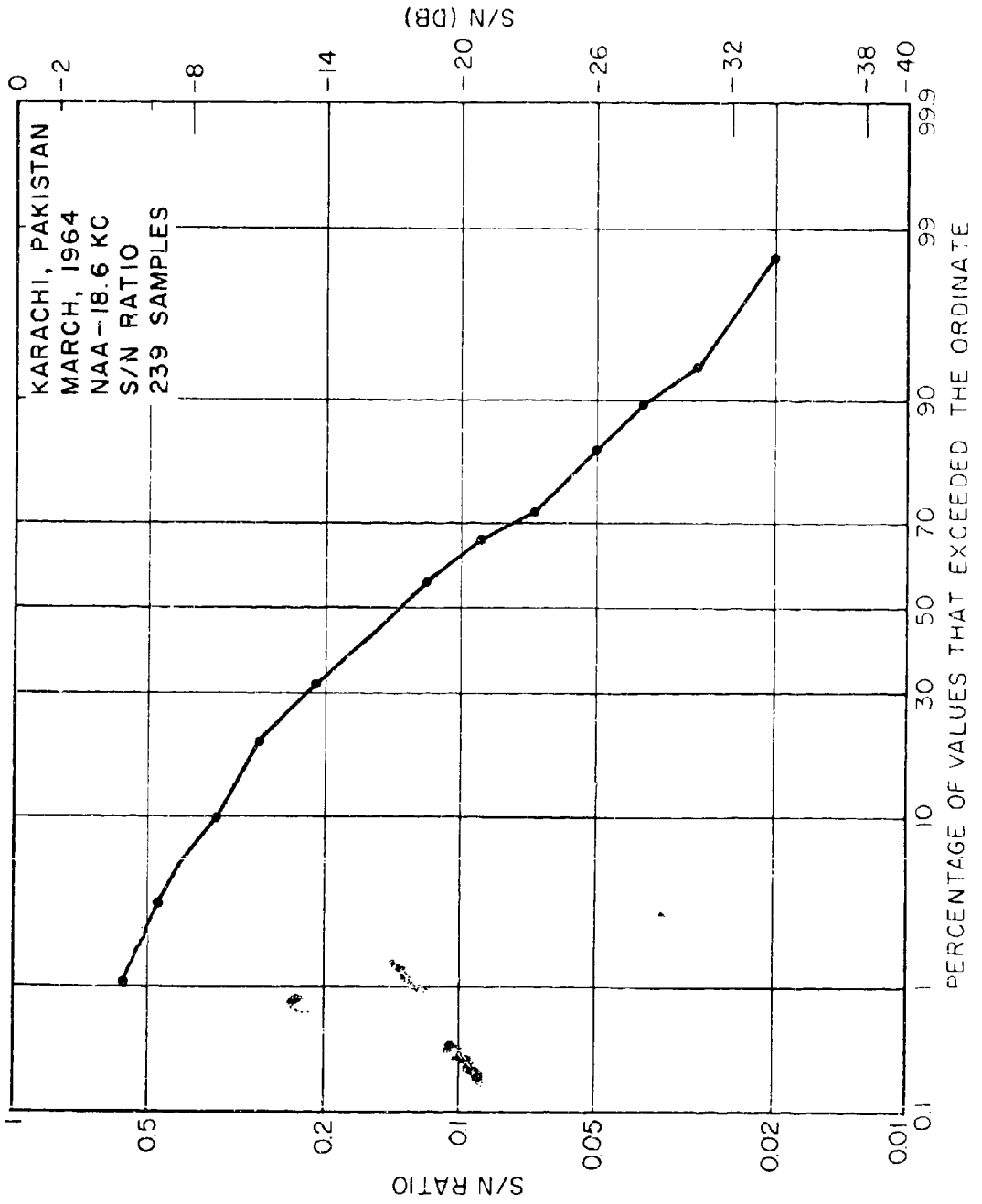


Figure 93

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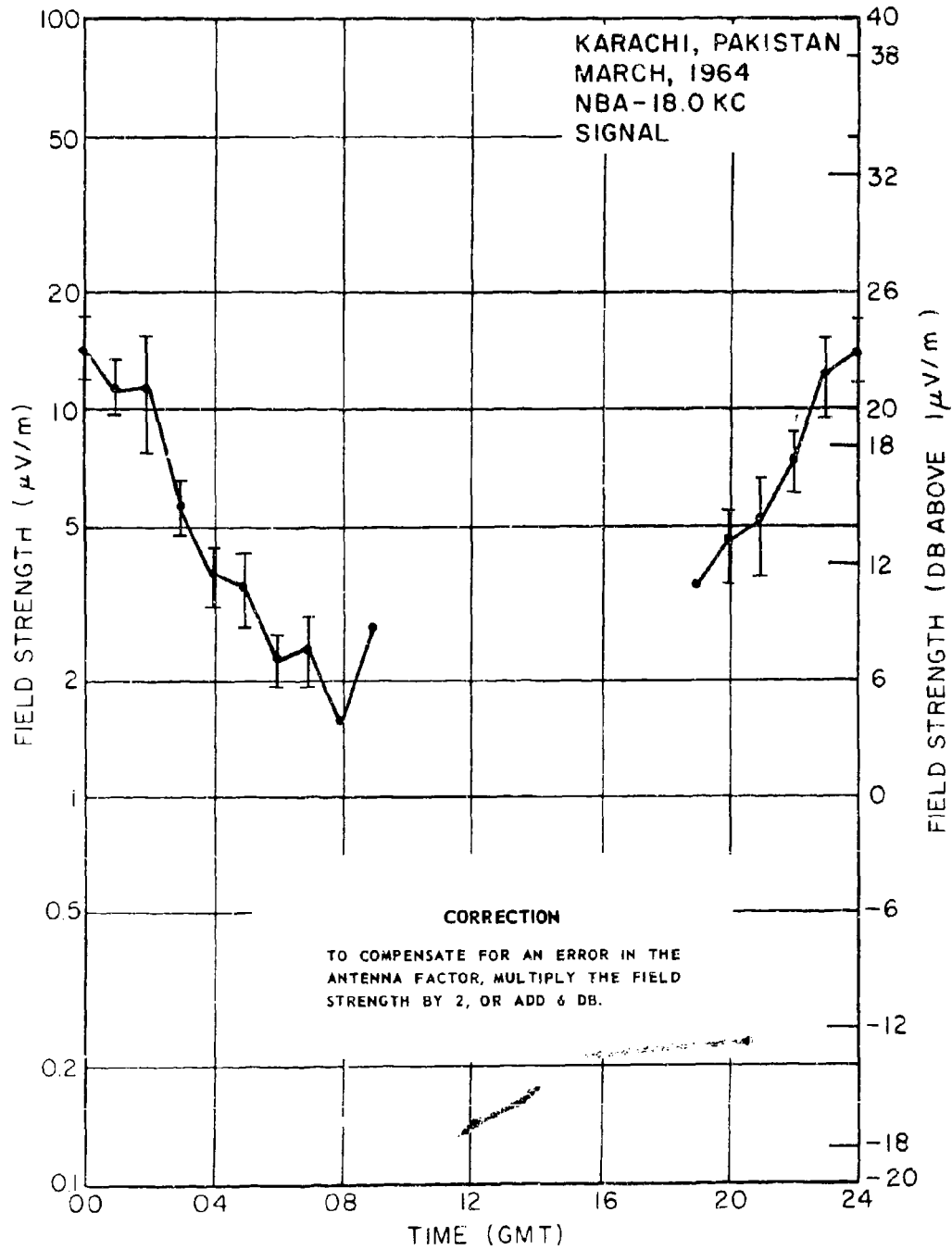


Figure 94

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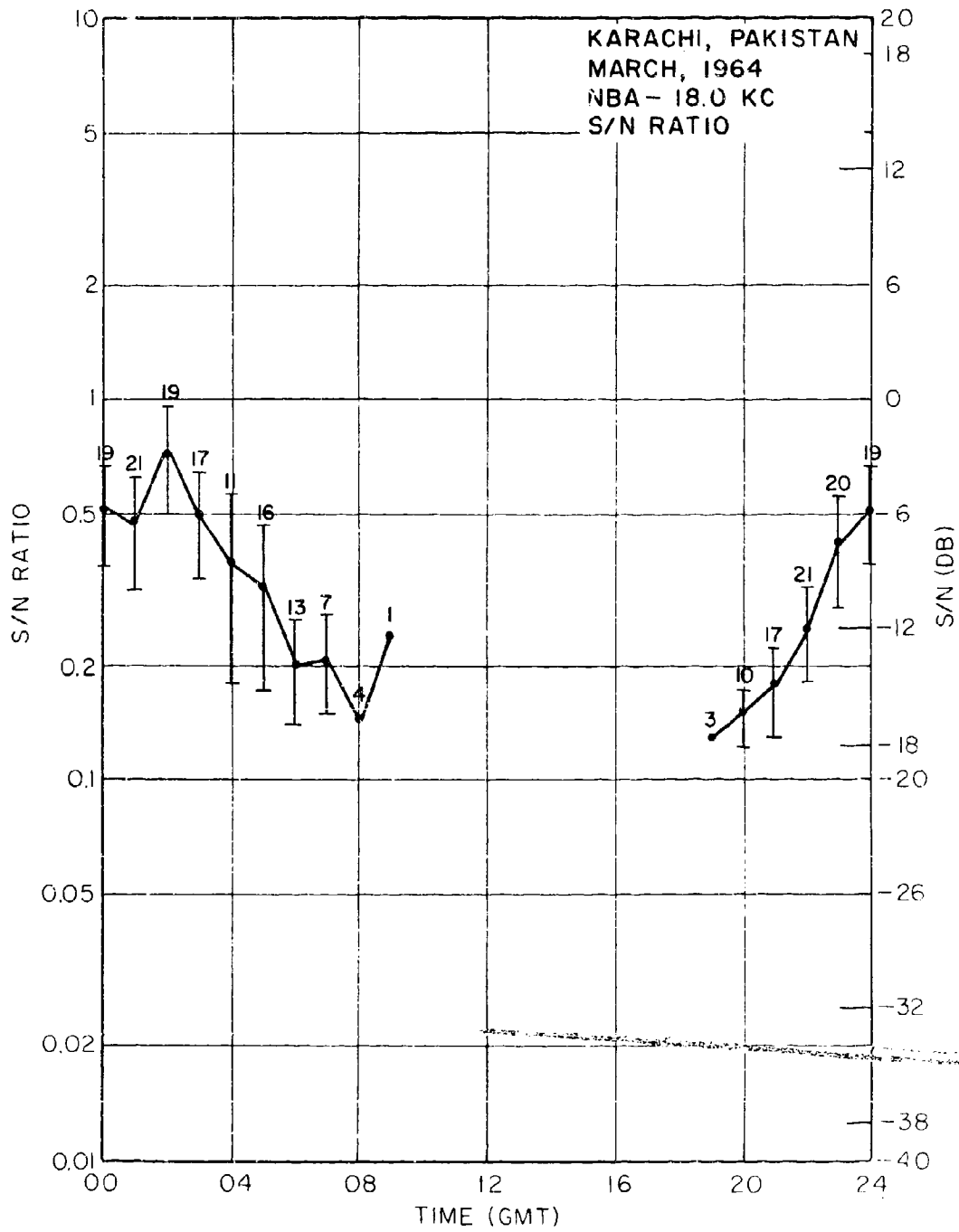


Figure 95

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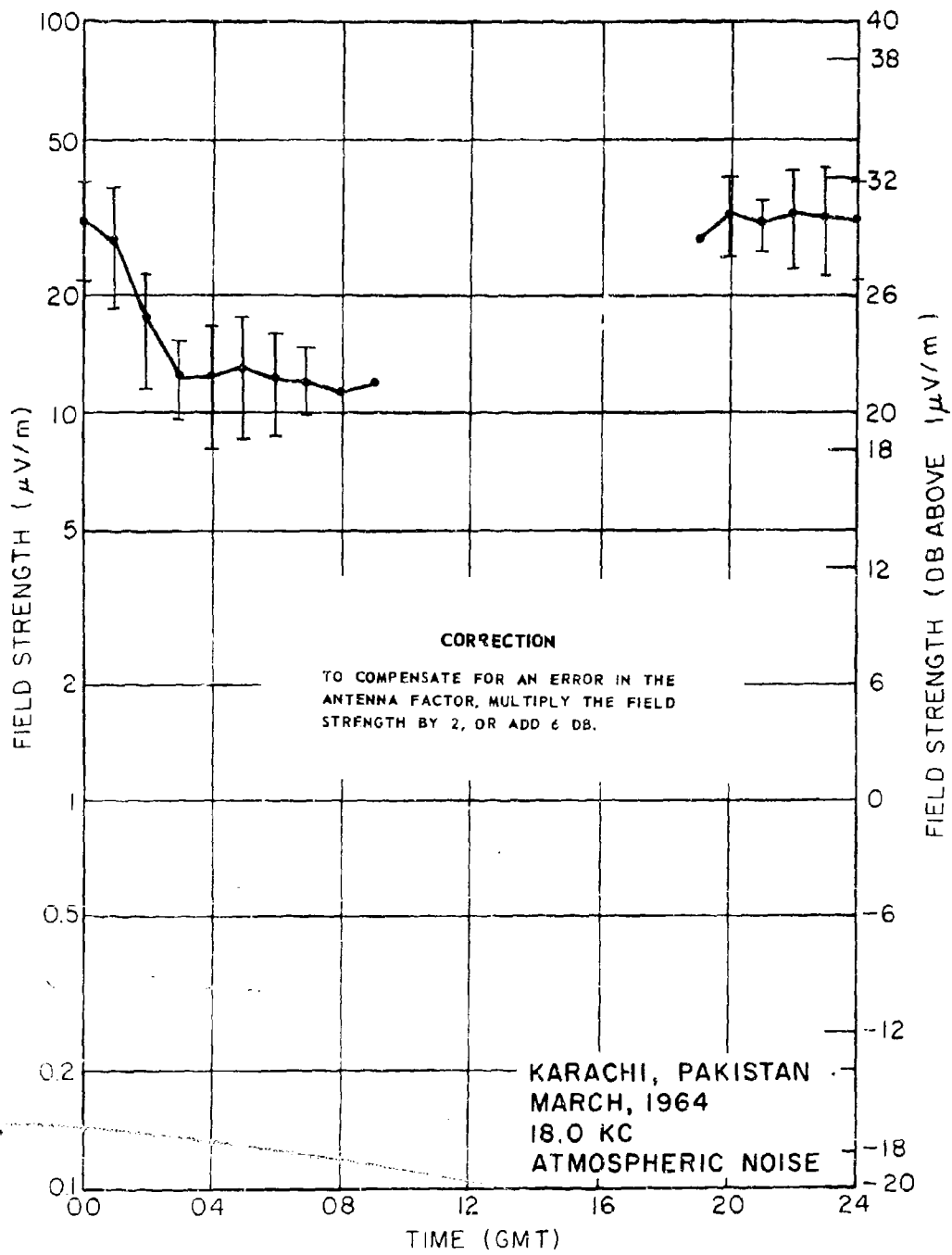


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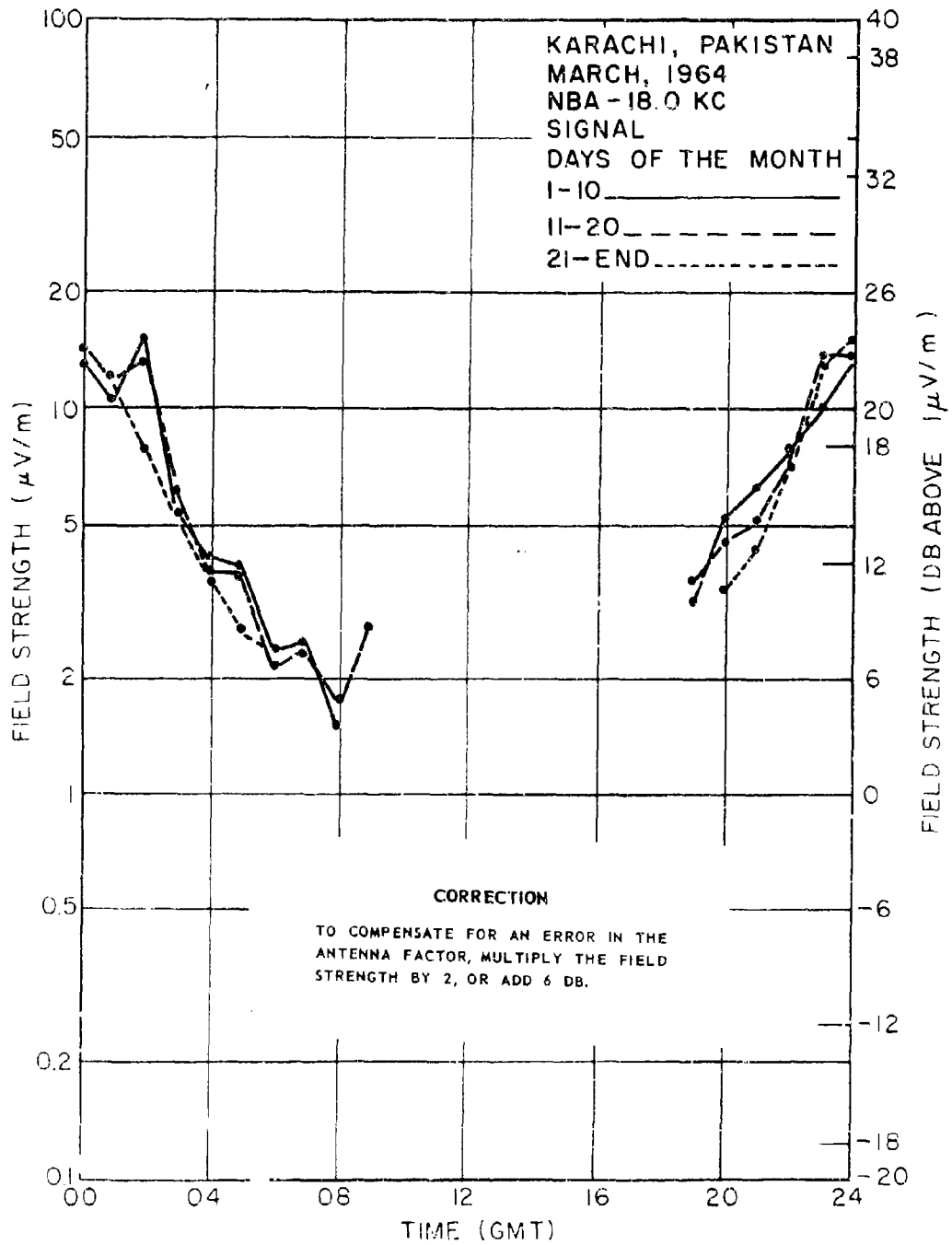


Figure 97

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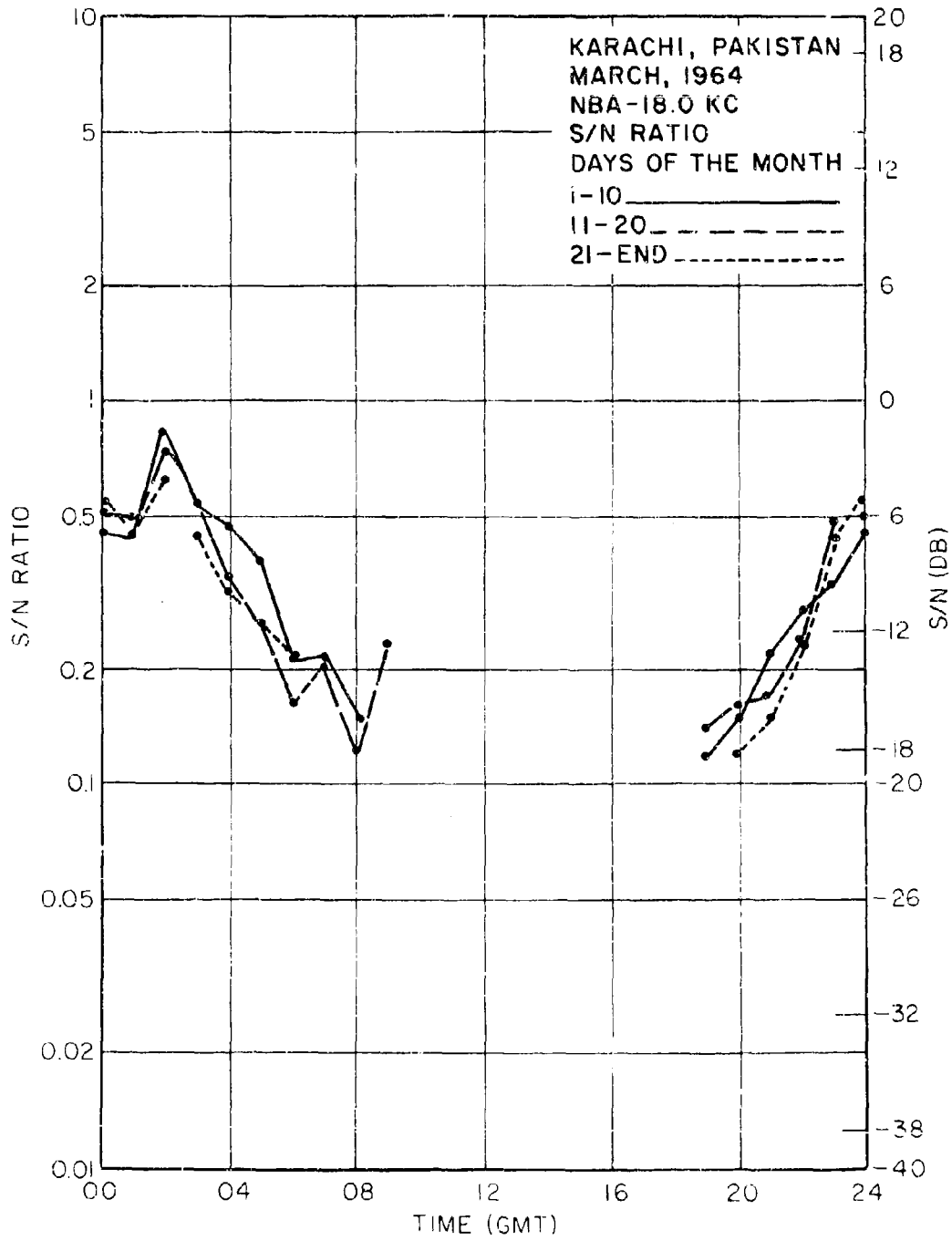


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Technical Library
Research Reports Section

DATE: June 19, 2002
FROM: Mary Templeman, Code 5227
TO: Code 5300 Paul Hughes
CC: Tina Smailwood, Code 1221.1 *f2 6/21/02*
SUBJ: Review of NRL Reports

Dear Sir/Madam:

1. Please review NRL MR -1184, MR-1193, MR-1417, MR-1571, MR-1595, MR-1635, and MR-1667 for:

- Possible Distribution Statement
 Possible Change in Classification

Thank you,

Mary Templeman

Mary Templeman
(202)767-3425
maryt@library.nrl.navy.mil

The subject report can be:

- Changed to Distribution A (Unlimited)
 Changed to Classification Unclassified
 Other:

Paul K. Hughes II *6/21/02*
Signature Date

-- 1 OF 1
-- 1 - AD NUMBER: 366153
-- 2 - FIELDS AND GROUPS: 20/14
-- 3 - ENTRY CLASSIFICATION: UNCLASSIFIED
-- 5 - CORPORATE AUTHOR: NAVAL RESEARCH LAB WASHINGTON D C
-- 6 - UNCLASSIFIED TITLE: FIELD STRENGTHS OF SOME VLF TRANSMISSIONS
-- AND ATMOSPHERIC NOISE MEASURED IN ASIA, JUNE 1963 THROUGH MARCH
-- 1964.
-- 8 - TITLE CLASSIFICATION: UNCLASSIFIED
-- 9 - DESCRIPTIVE NOTE: QUARTERLY REPT. NO. 15, JUN 63-MAR 64,
--10 - PERSONAL AUTHORS: GARNER,W. E.;RHOADS,F. J.;SCHAUER,R. L.;
--11 - REPORT DATE: 13 JUL 1965
--12 - PAGINATION: XXXXXX MEDIA COST: \$ 7.00 PRICE CODE: AA
--14 - REPORT NUMBER: NRL-MR-1635
--16 - PROJECT NUMBER: SR008 01 01 7028
--20 - REPORT CLASSIFICATION: ~~CONFIDENTIAL~~
--23 - DESCRIPTORS: (*RADIO TRANSMISSION, VERY LOW FREQUENCY), RADIO
-- WAVES, IONOSPHERIC PROPAGATION, ATTENUATION, NOISE(RADIO), SIGNAL-
-- TO-NOISE RATIO, MEASUREMENT, EXPERIMENTAL DATA, TABLES(DATA), ASIA
--24 - DESCRIPTOR CLASSIFICATION: UNCLASSIFIED
--29 - INITIAL INVENTORY: 20
▪ --30 - ANNOTATION: FIELD STRENGTHS OF SOME VLF TRANSMISSIONS AND
-- ATMOSPHERIC NOISE MEASURED IN ASIA JUNE 1963 THROUGH MARCH 1964.
-
--32 - REGRADE CATEGORY: C
--33 - LIMITATION CODES: 9
--34 - SOURCE SERIES: 15
--35 - SOURCE CODE: 251950
--36 - ITEM LOCATION: DTIC
--38 - DECLASSIFICATION DATE: OADR
--40 - GEOPOLITICAL CODE: 1100
--41 - TYPE CODE: N
--43 - IAC DOCUMENT TYPE:

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