SAINT MARY'S UNIVERSITY

"VHF/UHF Signal Statistics as Functions of Polarization and Frequency over a Long Salt-Water Path"

by

W. P. Lonc, Principal Investigator

Physics Department

HALIFAX, NOVA SCOTIA

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Physics Department
Saint Mary's University
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B3H 3C3

Work performed under Contract Serial #OST83-00023
and DSS File #21ST. 36001-3-3064

Final Report for the Period
April 1, 1983 to March 31 1984

Summary of work performed under this contract.

1. Data continued to be collected on 147.950, 147.995, and 431.950 MHz on a continuous basis, and on 147.930, 224.950, and 1296 MHz on an occasional basis.

2. All the data acquired since 1981 was reappraised.

3. Signal-level information was obtained for every second hour of a 24-hour day and for every second day of a month from all data acquired since 1981.

4. Time-distribution information was obtained for every second day of a month from all data acquired since 1981.

5. A digital data-logging system was installed to monitor 147.950 and 431.950 MHz.

6. The receiver system at Seaview was relocated to Saint Mary's University.

7. Antennas and associated equipment to provide "slanted" linear polarization on 147.930, 224.950, and 431.900 MHz were installed on Sable Island.

8. At the request of the Coast Guard, Tower #1 was dismantled, and the antennas relocated on Tower #2.

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PREFACE

This Report gives an updated account of the results obtained from observations in the VHF and UHF bands on the Sable-to-Seaview and the Sable-to-Halifax paths. These results supersede any earlier reports on this project, and consist not only of observations made by Saint Mary's University (SMU), but also some observations made by Maritime Tel and Tel (MTT) in their research on the Sable-to-Canso Straits path.

In general, the Report considers data obtained over the past three years. In particular, a reappraisal of all the data obtained over the past three years necessitated discounting some of the data, mainly because of faulty calibration. In the case of the observations on 431.950 MHz, it turned out that the data for 1982 was seriously ambiguous (observations on this frequency began towards the end of 1981).

A brief summary of the methods and definitions used in this Report is given in Chapter 1. Chapters 2 and 3 contain relatively detailed data (mainly in the form of graphs) from the Sable-to-Halifax (147.950 MHz) and Sable-to-Seaview (147.995 MHZ) paths respectively, while Chapter 4 presents similar data on the Sable-to-Halifax path on 431.950 MHz. Chapter 5 presents some miscellaneous results on diversity experiments (mainly consisting of data obtained by MTT); some preliminary data on differential attenuation between vertical and horizontal components on the Sable-to-Halifax path, and some preliminary data pertaining to 1296 MHz. Chapter 6 provides a summary of the data presented in the foregoing chapters. The Appendices contain a variety of supporting data and related information.

Acknowledgement: The author gratefully acknowledges permission from MIT to include some of their data in this Report. This data will be so identified as it appears in the Report. The author also wishes to thank Dr. J. H. Whitteker for permission to use some path-loss calculations and graphs produced at C.R.C.

1. Introduction

This Report is the fourth in a series pertaining to VHF and UHF path-loss measurements made by Saint Mary's University (SMU) for the Communications Research Centre (CRC) of the Department of Communications (DOC). There are two paths studied in this project: one, from Sable Island, Nova Scotia to the Canso Straits area of Nova Scotia; the other, from Sable Island to Halifax, Nova Scotia. A general view of the Canadian East coast, showing the relative postition of Sable Island, is given in Figure 1-1. A more detailed view of the area, showing the location of the sites mentioned in this Report, is given in Figure 1-2.

Appropriate path-loss data in the VHF and UHF parts of the spectrum for a long salt-water path are of interest in the construction of propagation models for this kind of path. These models are required for the determination of interference and service range of maritime and off-shore stations using VHF and UHF communications links.

VHF and UHF path-loss measurements were carried out by operating and monitoring appropriate transmitters on Sable Island, and corresponding receivers and recorders on mainland Nova Scotia. The data was mainly in analog form (associated with strip-chart recordings) and was obtained on a continuous basis.

The objective of this particular Report is to report on the data obtained over the past year and also to combine the observations made on the two paths over the past several years. This will also include a reappraisal of the entire set of data. In fact, on the basis of this reappraisal, it was found necessary to discount some of the data obtained earlier. The result of this reappraisal is that there is one full year (1983) of reliable data for

431.950 MHz, and just over two full years (consisting of 1983 in its entirety, and portions of 1981 and 1982) for 147.950 and 147.995 MHz.

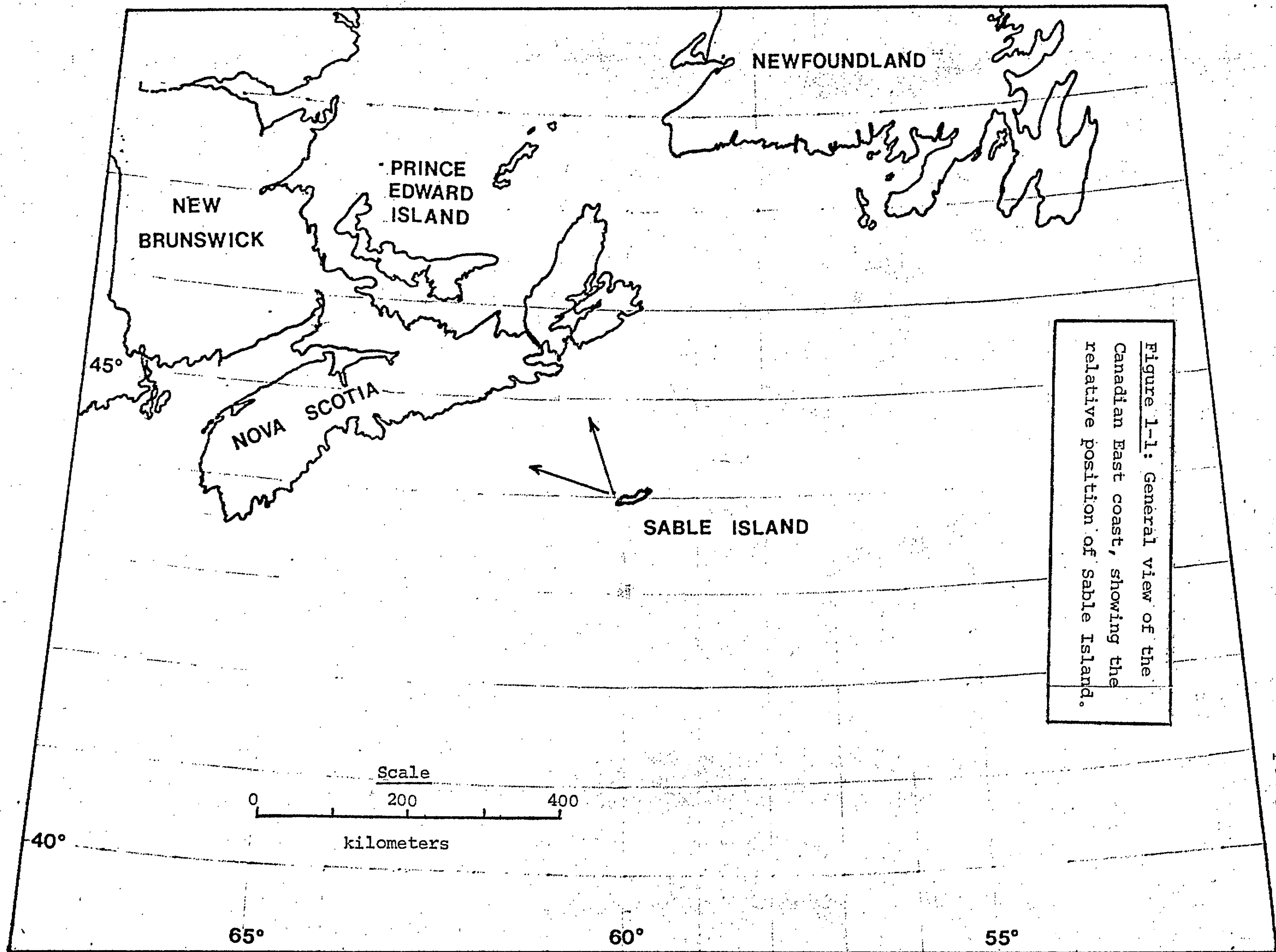
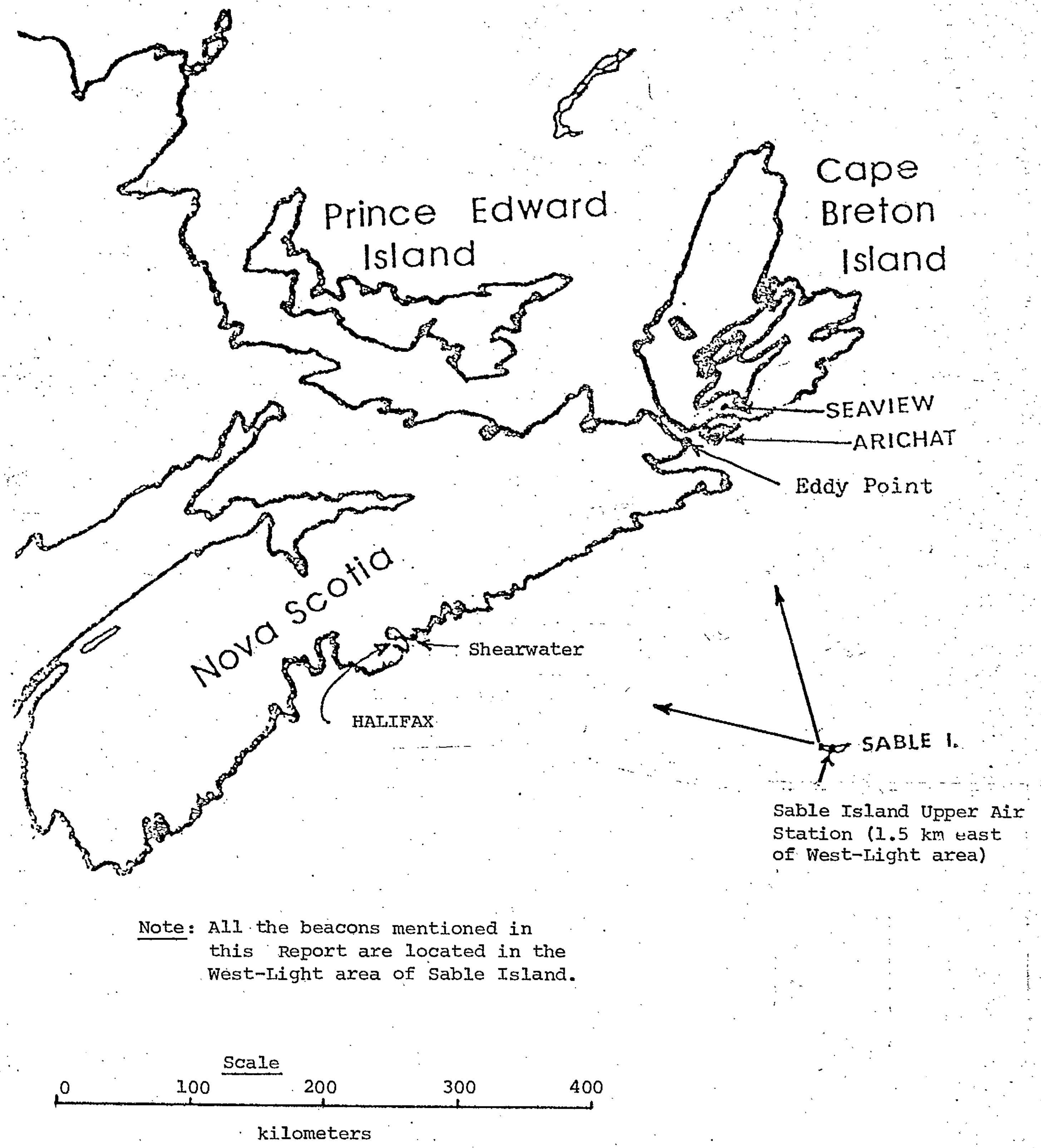


Figure 1-1: General view of the Canadian East coast, showing the relative position of Sable Island.

Figure 1-2: Nova Scotia off-shore area, showing locations of sites mentioned in this Report.



Note: All the beacons mentioned in this Report are located in the West-Light area of Sable Island.

2. Path-loss definitions.

A. Expected path-loss: This quantity is calculated on the basis of NBS-101, Chap.9, where it is called a "long-term median basic transmission loss due to forward scatter" and is reproduced here for convenience (less two terms which are considered to be insignificant):

$$\text{path-loss(db)} = 30 \log f - 20 \log d + F(\theta d) + H_o ,$$

where

f is the frequency in MHz,

d is the sea-level arc distance in kilometers,

$F(\theta d)$ is the attenuation factor,

and

H_o is is the frequency-gain function.

This quantity is taken to be identical with the long-term power fading value associated with a 50% probability that the ordinate is exceeded, as defined in Chapter 10 of NBS-101; the long-term power fading for the 1% and 10% probability levels were also calculated on the basis of this chapter.

B. Observed path-loss: This quantity is calculated from the observed signal-strength data and the appropriate system parameters, using the relationship:

$$\text{Path-loss(db)} = P(TX) - P(RX) - G(TX) - G(RX) + L(RX) + L(TX),$$

where

P(TX) is the the transmitter output,

P(RX) is the power level at the receiver input,

G(TX) and G(RX) are the isotropic antenna gains at the transmitter and receiver respectively,

and

L(TX) and L(RX) are the line losses at the transmitter and receiver respectively.
All these quantities are in db.

Two sets of path-loss determinations were made, one of them corresponding to a daily average (24 hours) of the signal level, and the other corresponding to a daily time-distribution of the signal level.

In the first set, the signal level was determined every two hours from the chart-recording, and then the daily average $\overline{V}$ was calculated on the basis of the expression:

$$\overline{V} = \sum_{n=1}^{12} V_n/12 \qquad (uV)$$

where V_n is the signal level at the n-th hour.

These daily averages then provided the basis for calculating a monthly average (using only every other day of the month). The monthly averages, in turn, provided the basis for calculating an annual average. An example of the monthly averages is given in Figure 2-1.

In the second set, every other day of the month was analysed to determine the percent-time spent above a given signal level. In most cases, four such signal levels were drawn on the chart, and a determination was made for each level. This produced a daily time-distribution of observed signal-level, in terms of "percent time spent above the ordinate". A monthly time-distribution was then obtained by combining all the time-distributions for the month (usually 15 per month); the year's time-distribution was obtained in a similar manner. An example of a year's time-distribution is given in Figure 2-6.

The yearly time-distributions provided not only a median value of the path-loss for the year (defined as the path-loss at the 50% point), but also an average value for the path-loss. This average value was obtained by means of a graphical integration of the time-distribution curves, utilizing the path-loss value at the mid-point of each 10%-interval. The final value of the average path-loss was obtained by averaging the values obtained by the two sets.

Chapter 2: Sable-to-Halifax (147.950 MHz).

The monthly variations in path-loss for the mid-point of each month are given for each year (1981 to 1983) in Figures 2-1, 2-2, and 2-3 respectively. No data is available for the first three months of 1981 and for April, May, and November of 1982. The average of the data for the three years is shown in Figure 2-4. An empirically determined best-fit sinusoid is fitted to the data and shown in Figure 2-5. It is quite apparent that there is a seasonal variation in the path-loss.

The time-distribution of the path-loss for each year is given in Figures 2-6, 2-7, and 2-8 respectively. The average of the data for the three years is shown in Figure 2-9. The observed time-distribution agrees well with the expected time-distribution (as calculated on the basis of NBS-101).

The monthly variations in path-loss are compared with monthly variations in mean "path temperature" for each year in Figures 2-10, 2-11, and 2-12 respectively. The average for the data (i.e. path-loss and temperature) is shown in Figure 2-13. The mean "path temperature" is defined in this Report as the mean of the mean surface temperatures at each end of the path. In this case, the surface temperatures pertain to Sable Island and Shearwater.

Diurnal (24-hour day) variations in path-loss for the extremum months of the year (i.e., February and August) are averaged over three years for August and two years for February. The data indicates that, during February (at which time the path-loss is a maximum for the year), the variation over the 24-hour day is very small or even zero, although there appears to be a small decrease in path-loss at about 0200 hours. This data is shown in Figure 2-16.

Figure 2-1: Monthly variations in path-loss at 147.950 MHz for 1981. Data is not available for the months of January to March, inclusive. The figure includes the average and median values of "expected" path-loss, calculated on the basis of NBS-101. Average and median values of "observed" path-loss for the year were not calculated.

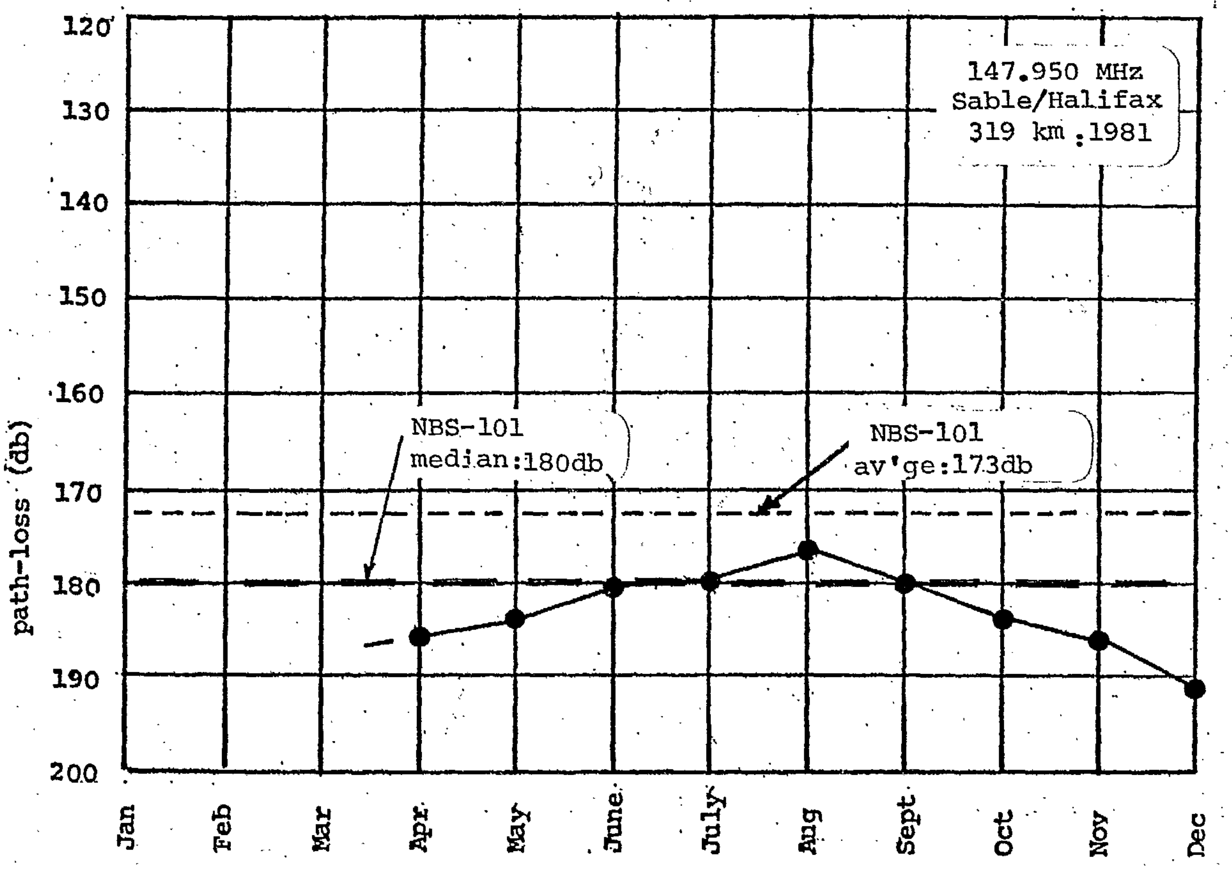
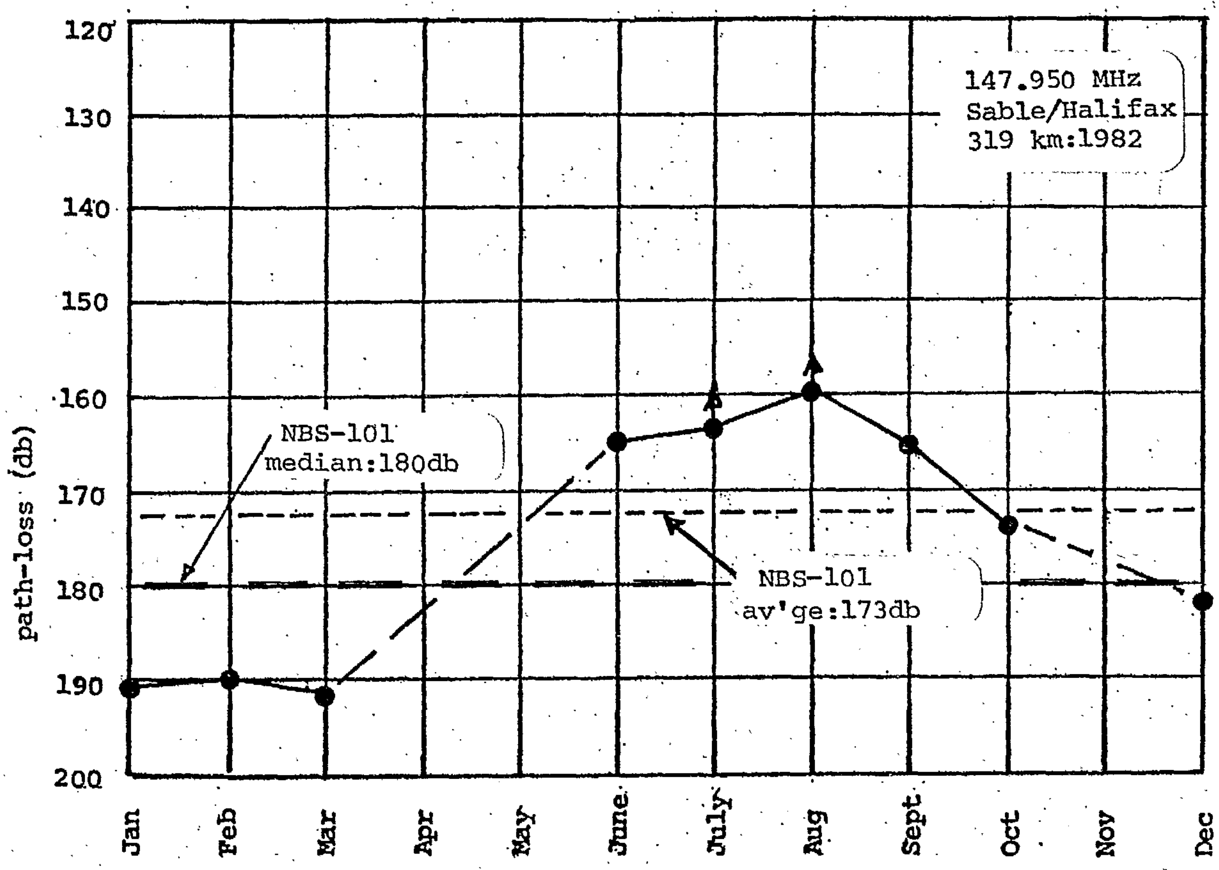
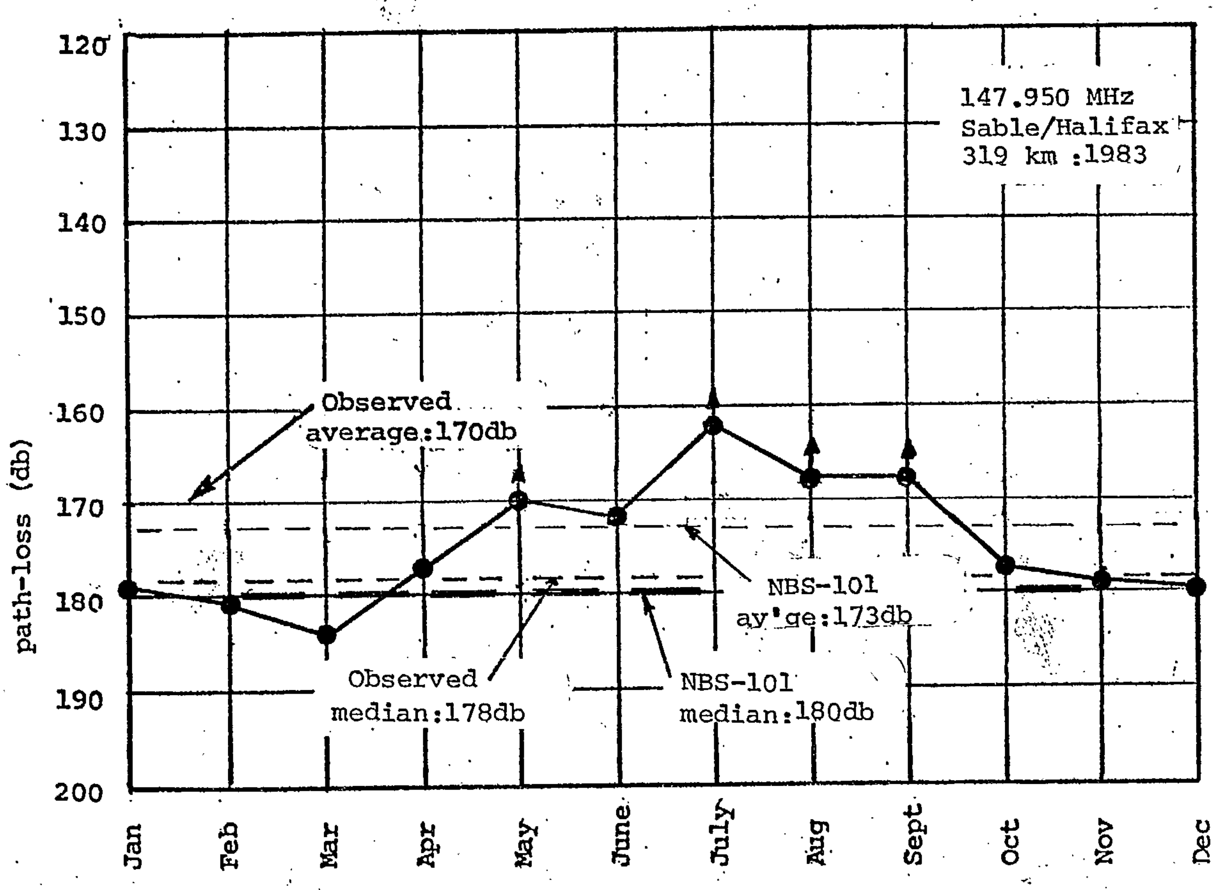


Figure 2-2: Monthly variations in path-loss at 147.950 MHz for 1982. Data is not available for the months of April, May, and November. The figure includes the average and median values of "expected" path-loss, calculated on the basis of NBS-101. Average and median values of "observed" path-loss for the year were not calculated.



Note: The arrows indicate that the path-loss is actually smaller, but the amount is not known.

Figure 2-3: Monthly variations in path-loss at 147.950 MHz for 1983. The figure includes the average and median values of "expected" path-loss, calculated on the basis of NBS-101, as well as the "observed" values of path-loss.



Note: The arrows indicate that the path-loss is actually smaller, but the amount is not known.

Figure 2-4: Monthly variations in path-loss at 147.950 MHz. This figure includes the relevant system-parameters used in calculating the expected path-loss on the basis of NBS-101. Towards the end of 1983, in the course of some maintenance work on the beacon, it was discovered that a connector was noticeably lossy (approximately 5 db at the time of inspection). Since the connector was wet at the time of inspection, it could be assumed that there would be times when the connector was dry and therefore much less lossy. Hence, for the purposes of this Report, it was assumed that the connector (which had been installed exactly one year earlier) contributed an average loss of 3 db during 1983. The line representing the observed average path-loss has an arrow associated with it to indicate the fact that the path-loss is somewhat smaller than indicated, but to an unknown extent.

Figure 2-4

Monthly variations in path-loss   f: 147.950 MHz   1981-3

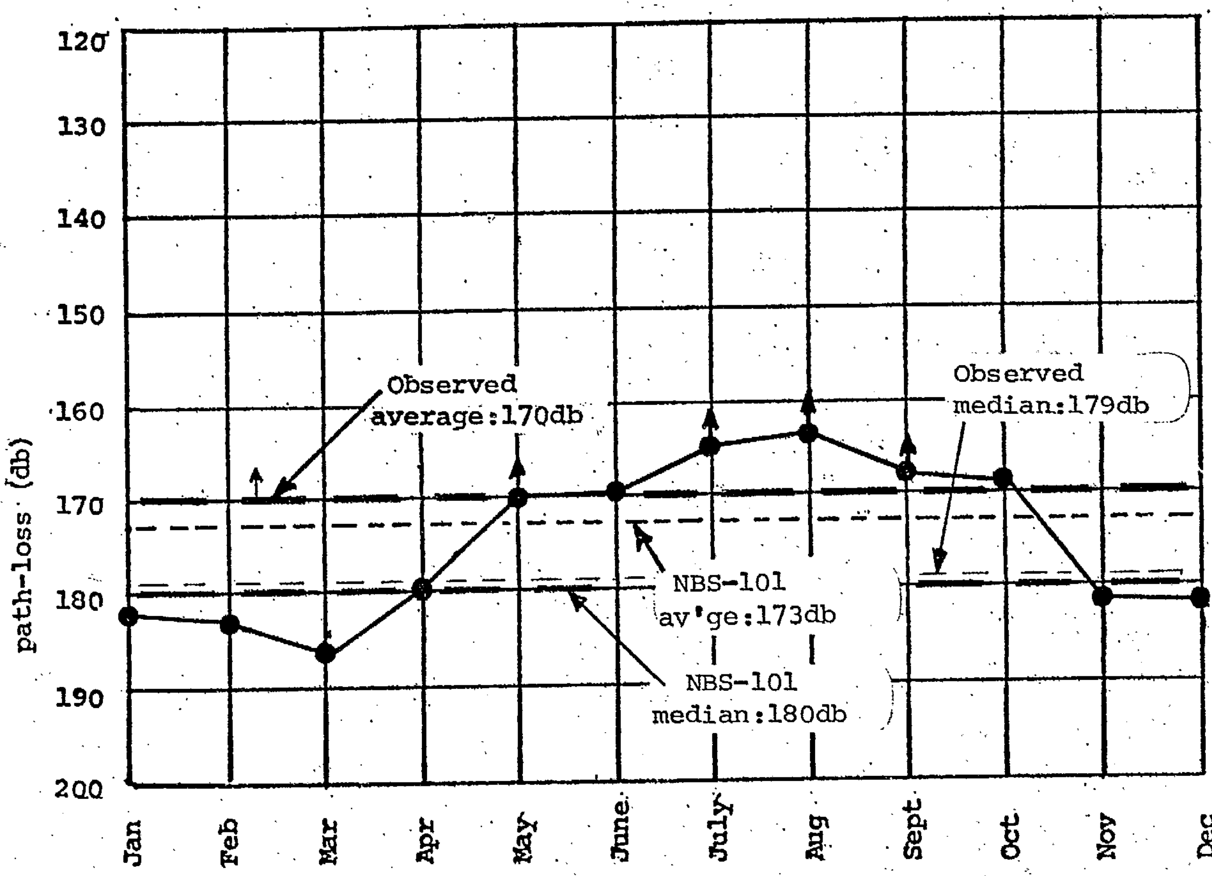
Sable to Halifax (319 km)

System parameters: TX: 10W   ant.gain:11.2dbi   line loss:4.3db

RX: ---   "   "   "   "   " 3.8db

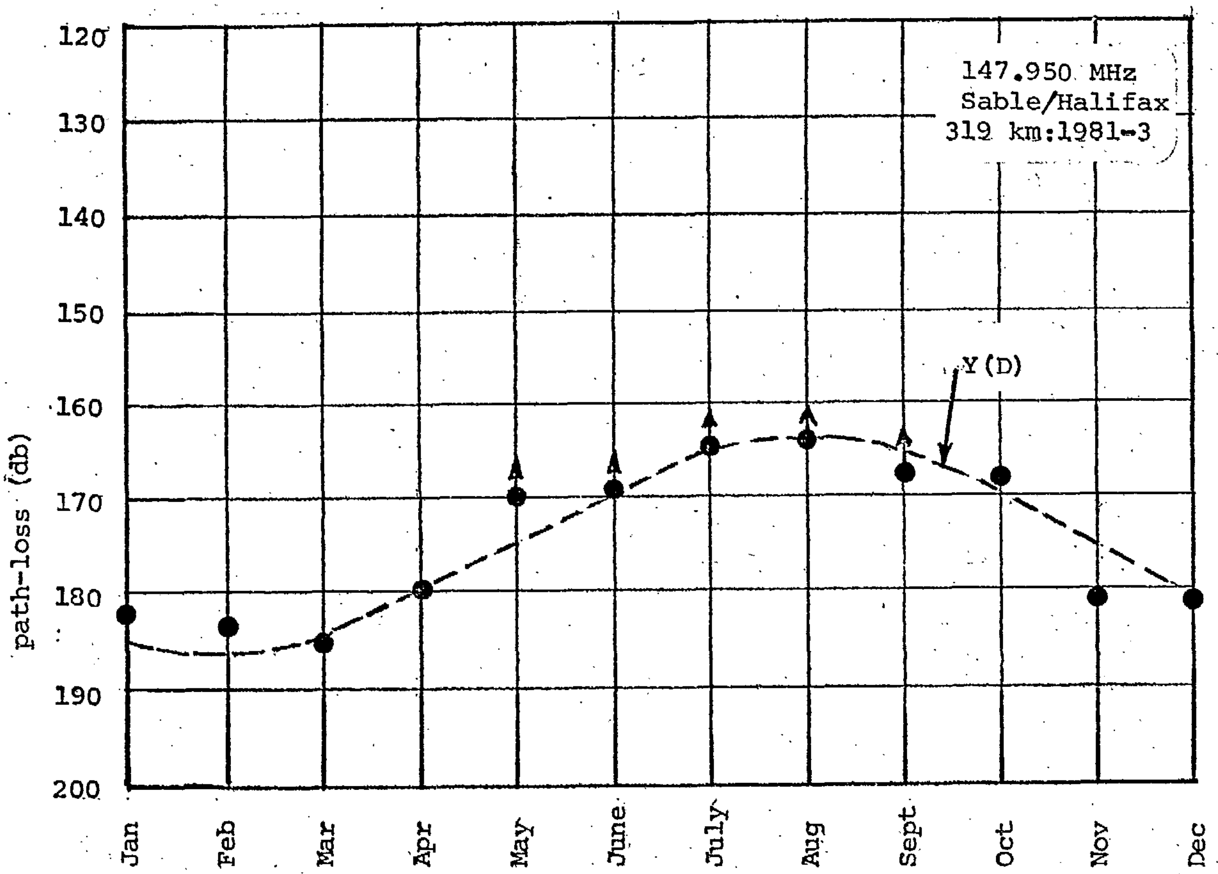
TX antenna 20m above sea-level; RX antenna 60m above sea-level.

Note: During 1983, due to a faulty connector, an additional 3db is added to the TX line loss.



Note: The arrows indicate that the path-loss is actually smaller, but the amount is not known.

Figure 2-5: Monthly variations in path-loss at 147.950 MHz. This figure displays the correlation between the monthly average (averaged over three years) and an empirically determined best-fit sinusoid, designated as Y(D), where Y represents the path-loss for a given day-number D. It is noted that there is agreement between the data points and the sinusoid to within a few db.



Note: The arrows indicate that the path-loss is actually smaller, but the amount is not known.

The function $Y(D) = 175 + 11\cos\left[2\pi(D-44)/365\right]$, where $0 \leq D \leq 365$, is an empirically determined best-fit to the data; D is the number of the day in the year. The observed data is assumed to pertain to the mid-point of each month. For the purposes of this figure, each month has 365/12 days. It is being assumed that the maximum path-loss occurs in mid-February.

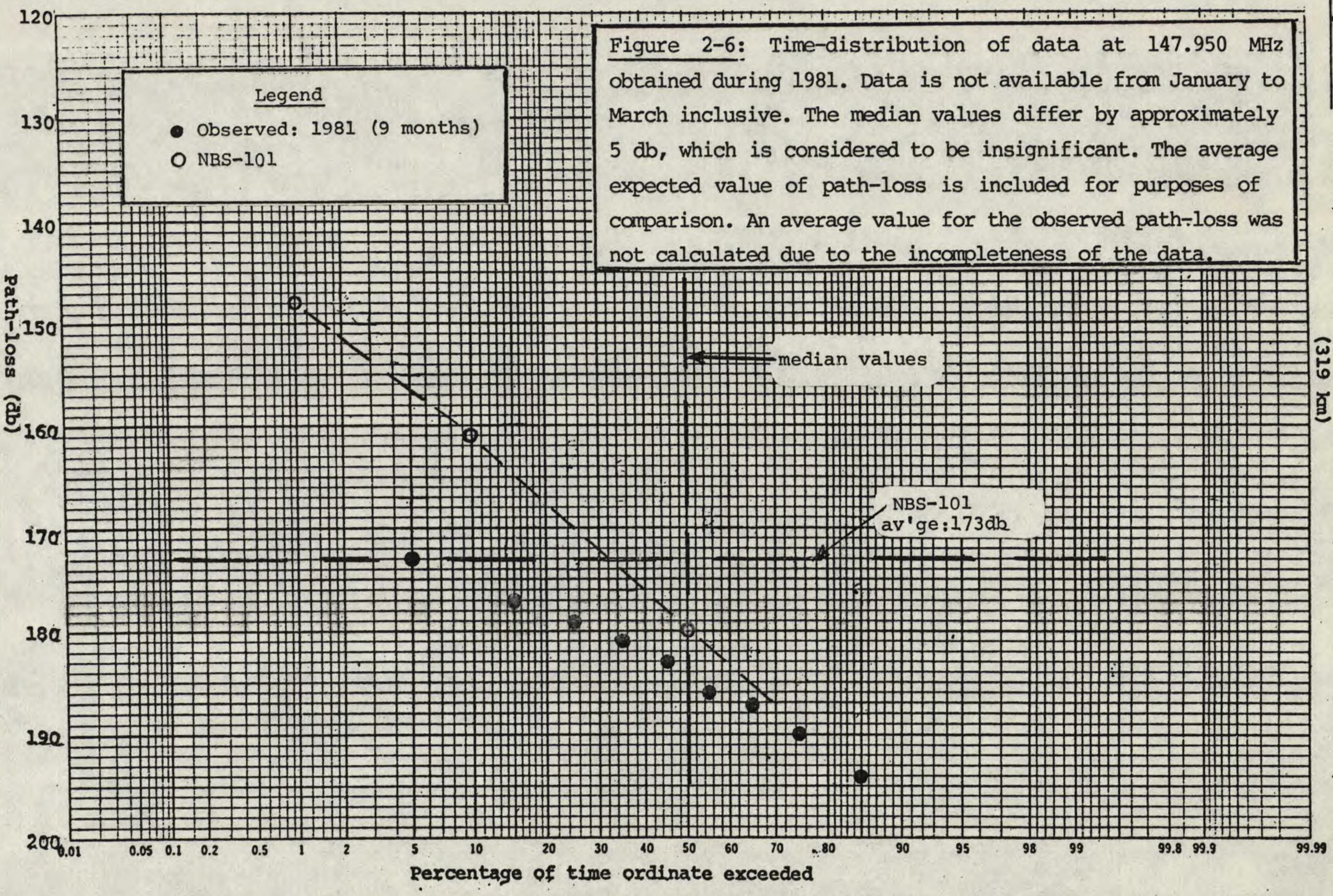


Figure 2-6: Time-distribution of data at 147.950 MHz obtained during 1981. Data is not available from January to March inclusive. The median values differ by approximately 5 db, which is considered to be insignificant. The average expected value of path-loss is included for purposes of comparison. An average value for the observed path-loss was not calculated due to the incompleteness of the data.

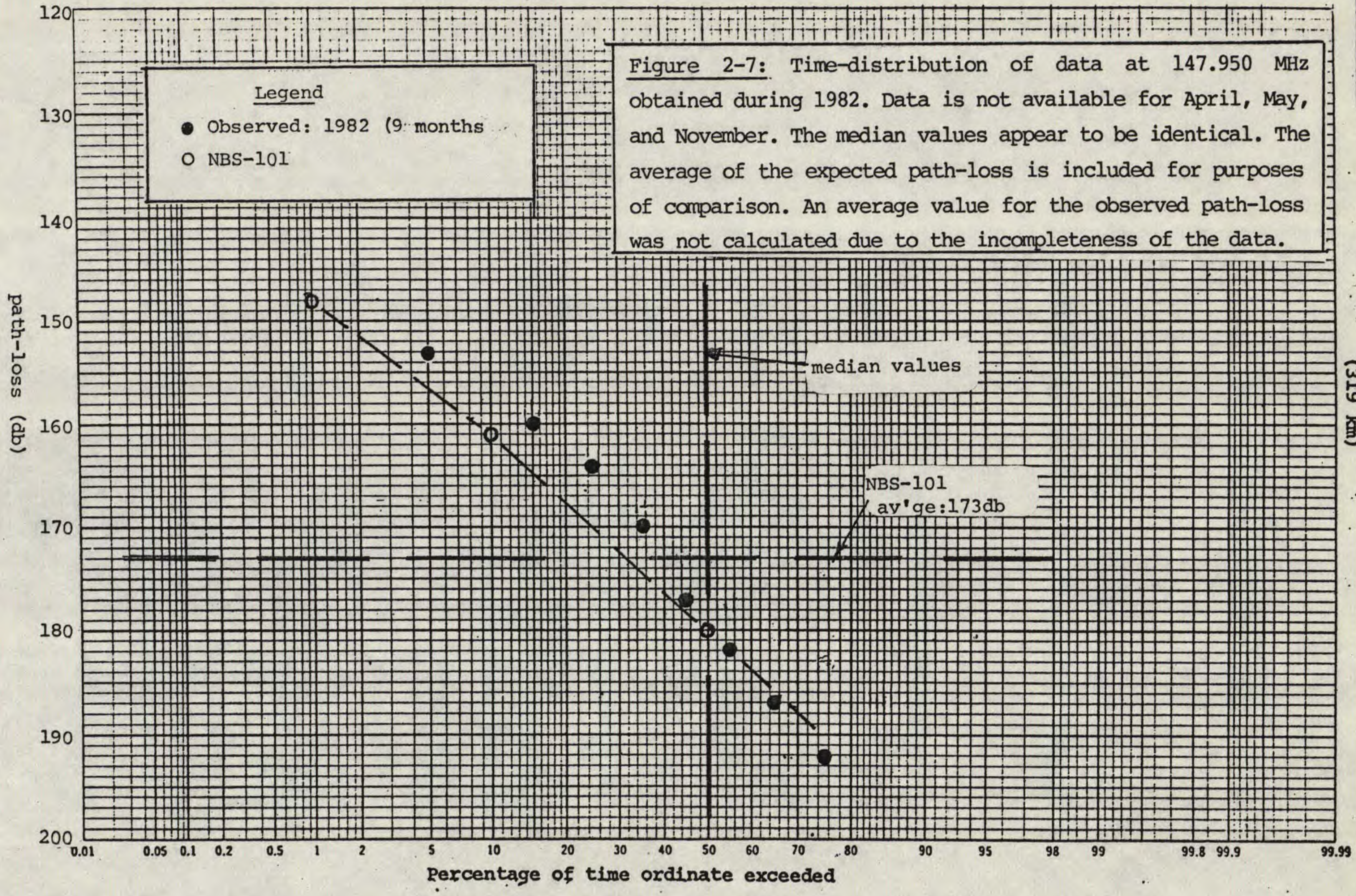


Figure 2-7: Time-distribution of data at 147.950 MHz obtained during 1982. Data is not available for April, May, and November. The median values appear to be identical. The average of the expected path-loss is included for purposes of comparison. An average value for the observed path-loss was not calculated due to the incompleteness of the data.

Figure 2-8

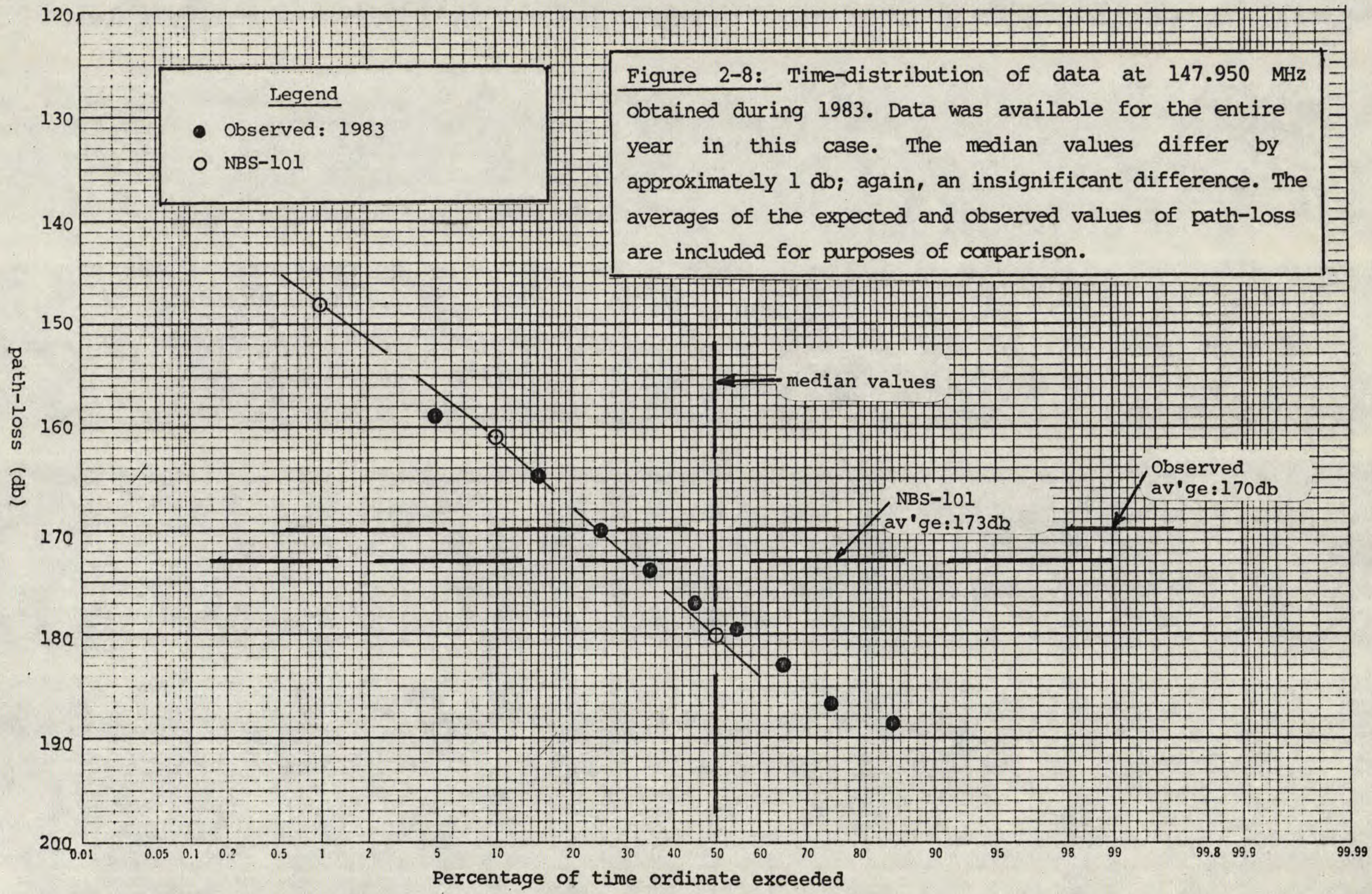


Figure 2-8: Time-distribution of data at 147.950 MHz obtained during 1983. Data was available for the entire year in this case. The median values differ by approximately 1 db; again, an insignificant difference. The averages of the expected and observed values of path-loss are included for purposes of comparison.

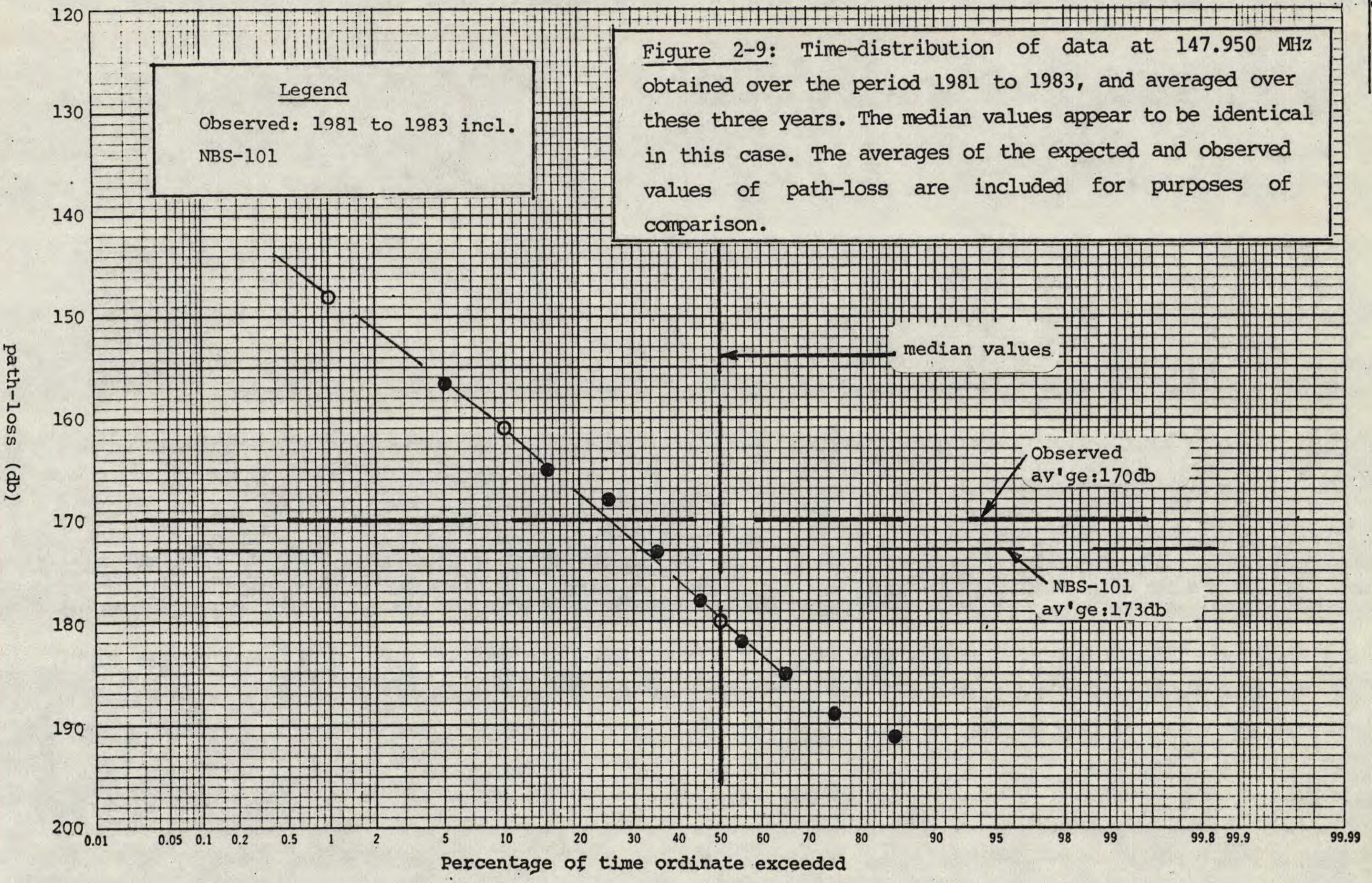


Figure 2-9: Time-distribution of data at 147.950 MHz obtained over the period 1981 to 1983, and averaged over these three years. The median values appear to be identical in this case. The averages of the expected and observed values of path-loss are included for purposes of comparison.

Figure 2-10: Monthly variations in path-loss at 147.950 MHz compared with monthly averages of "path temperature"; both pertain to 1981 only.

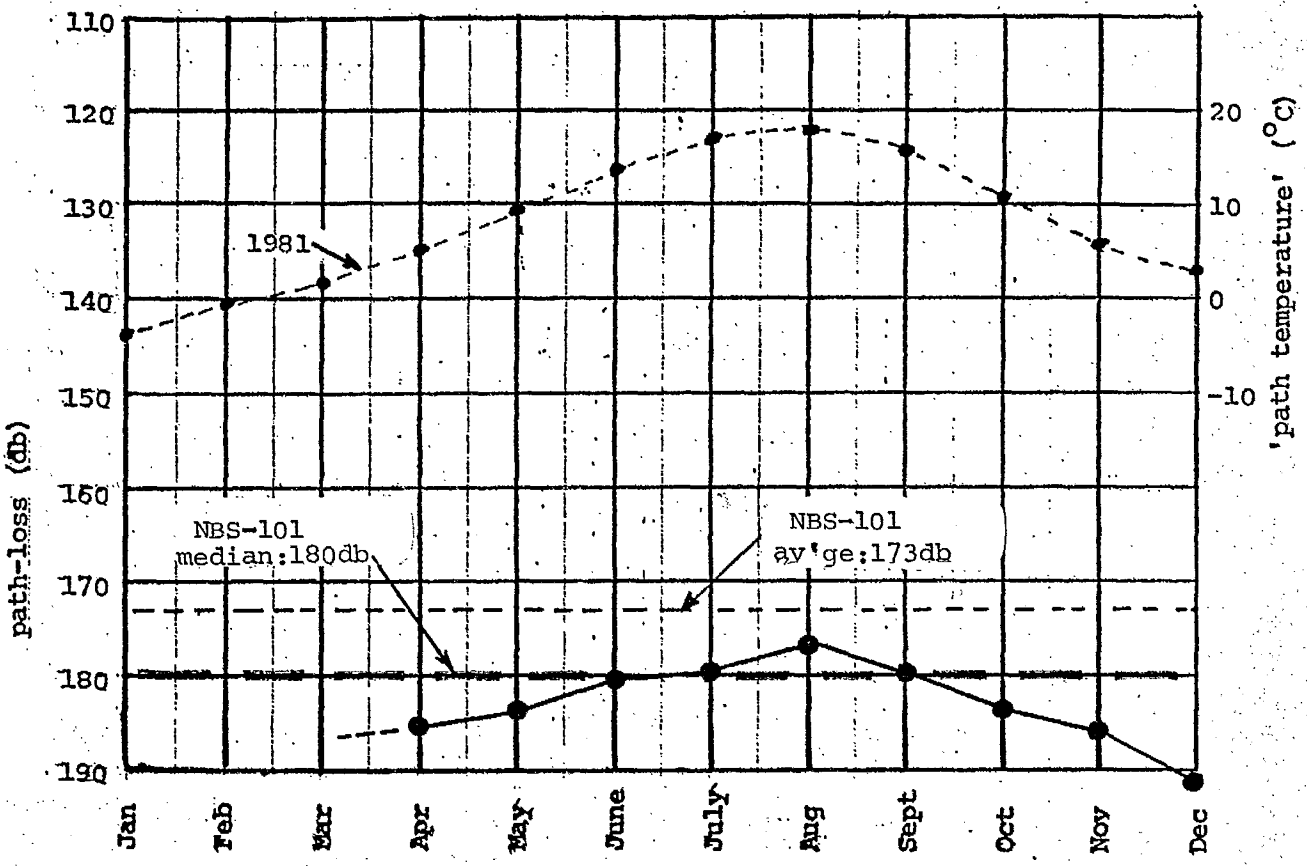
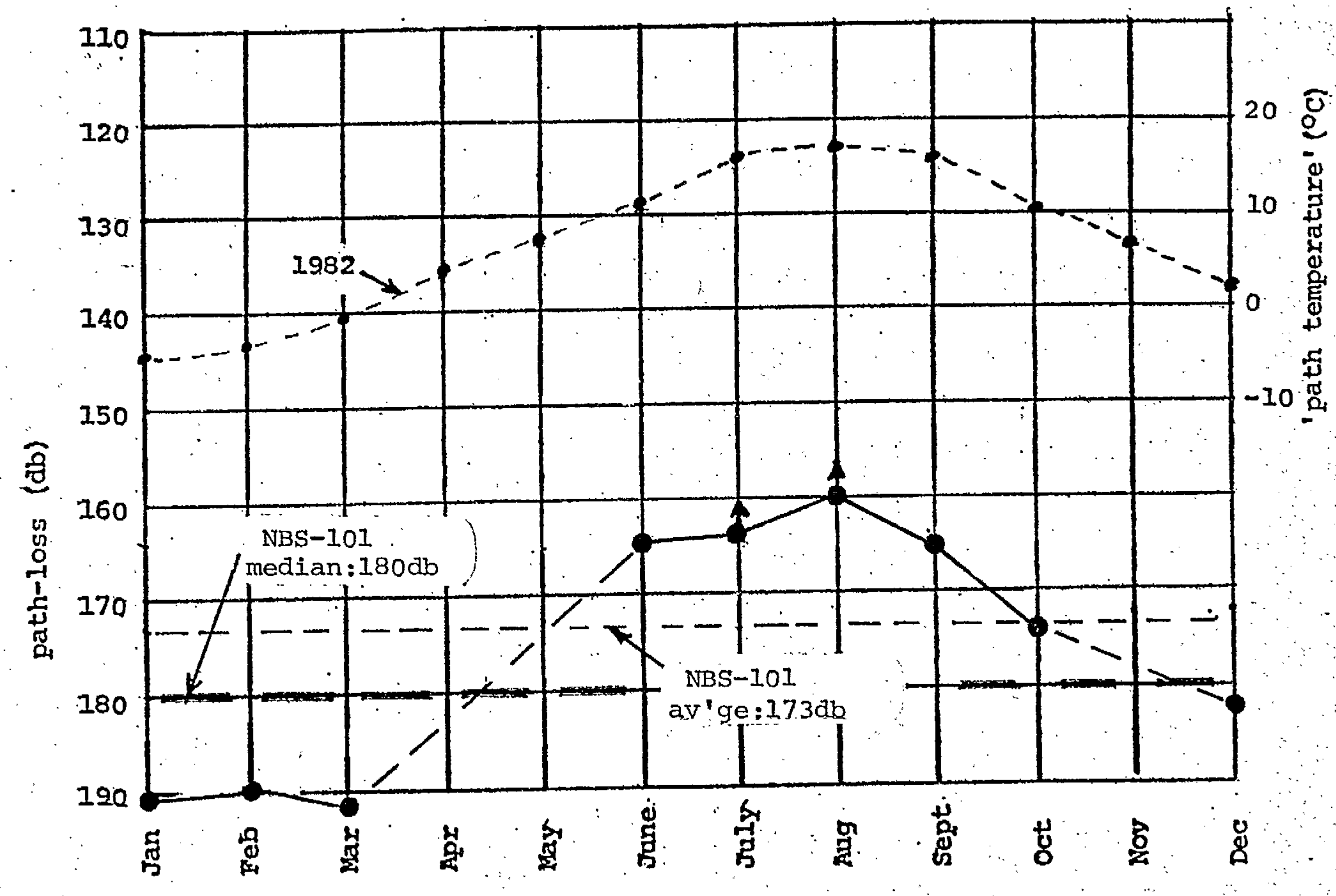
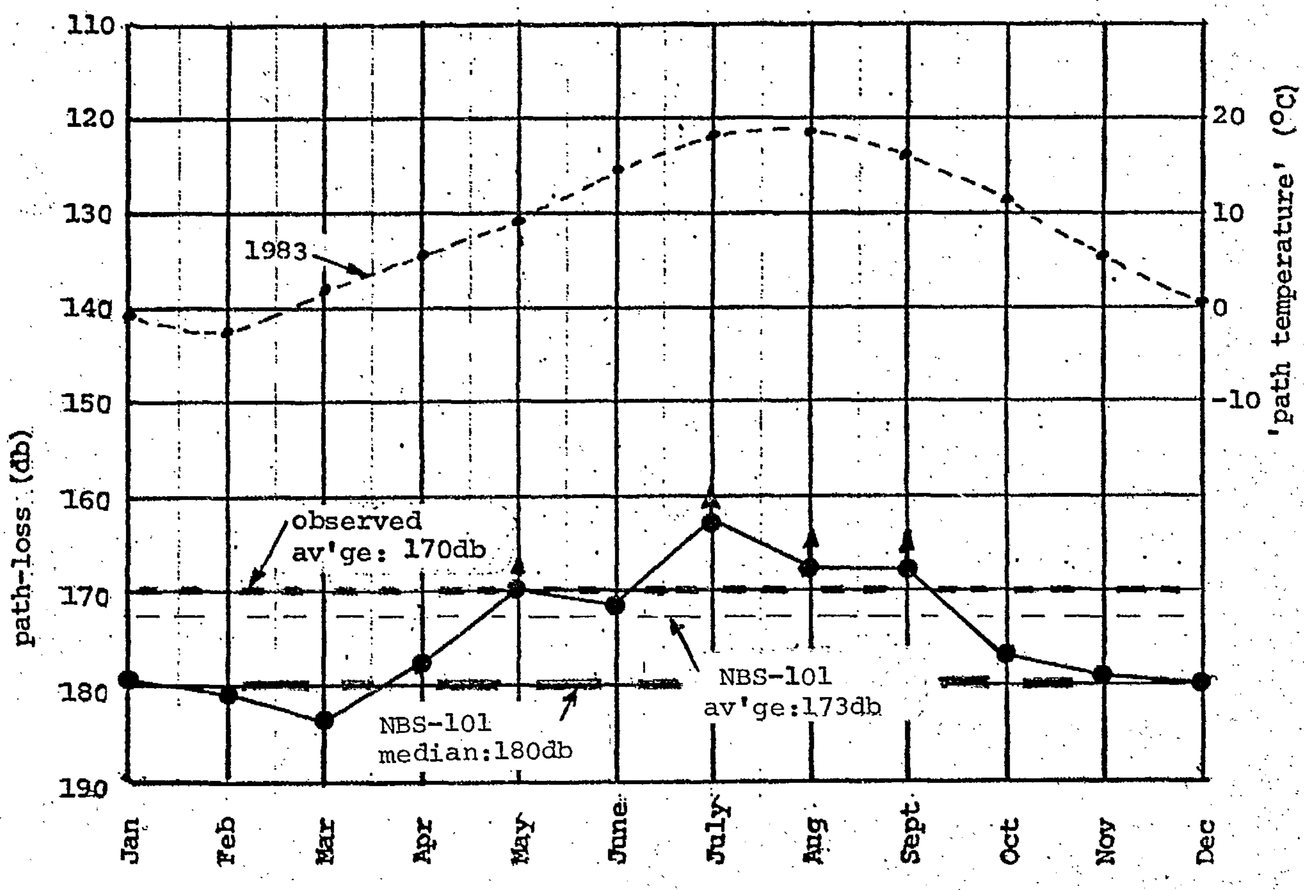


Figure 2-11: Monthly variations in path-loss at 147.950 MHz compared with monthly averages of "path temperature"; both pertain to 1982 only.



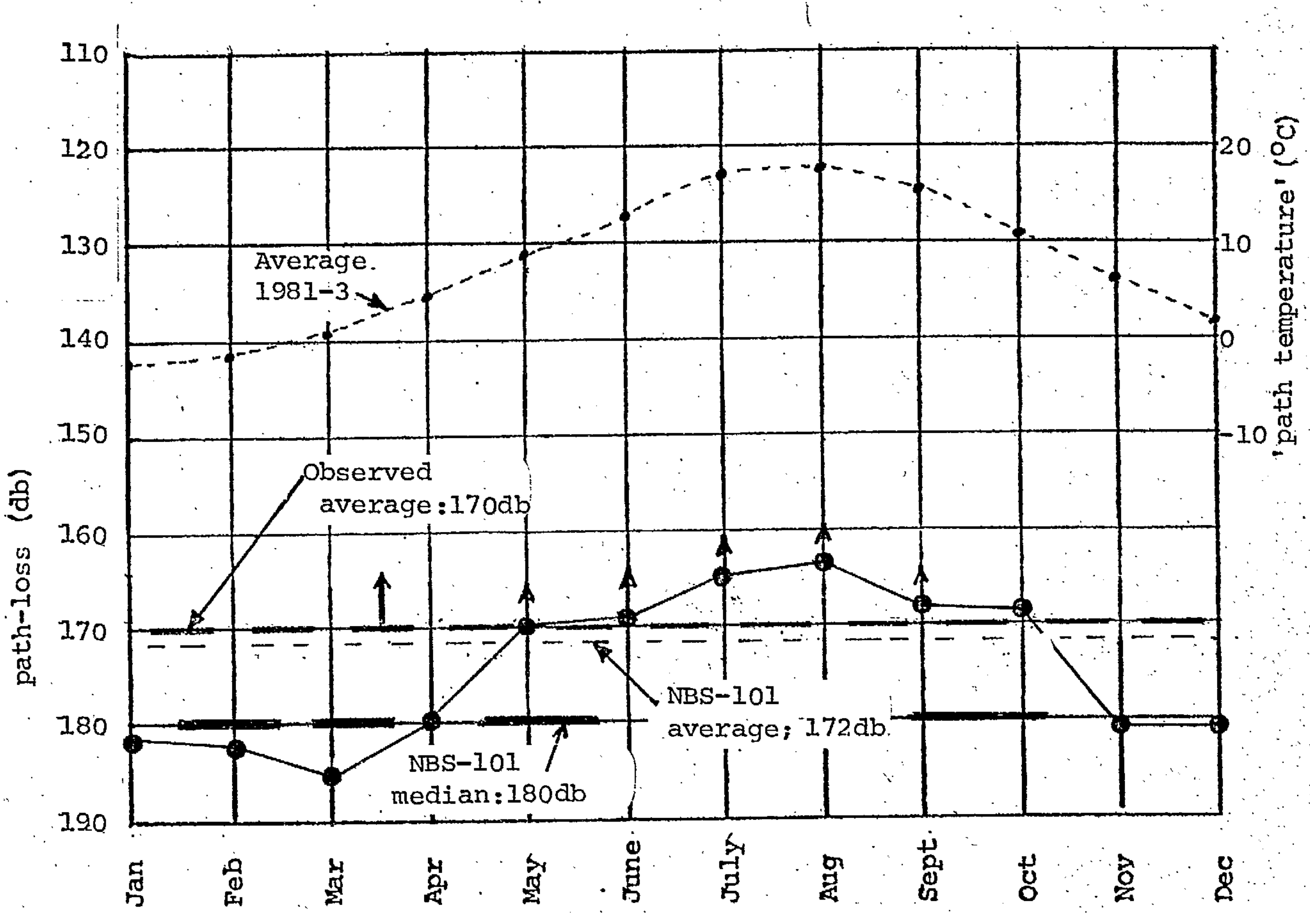
Note: The arrows indicate that the path-loss is actually smaller, but the amount is not known.

Figure 2-12: Monthly variations in path-loss at 147.950 MHz compared with monthly averages of "path temperature"; both pertain to 1983 only.



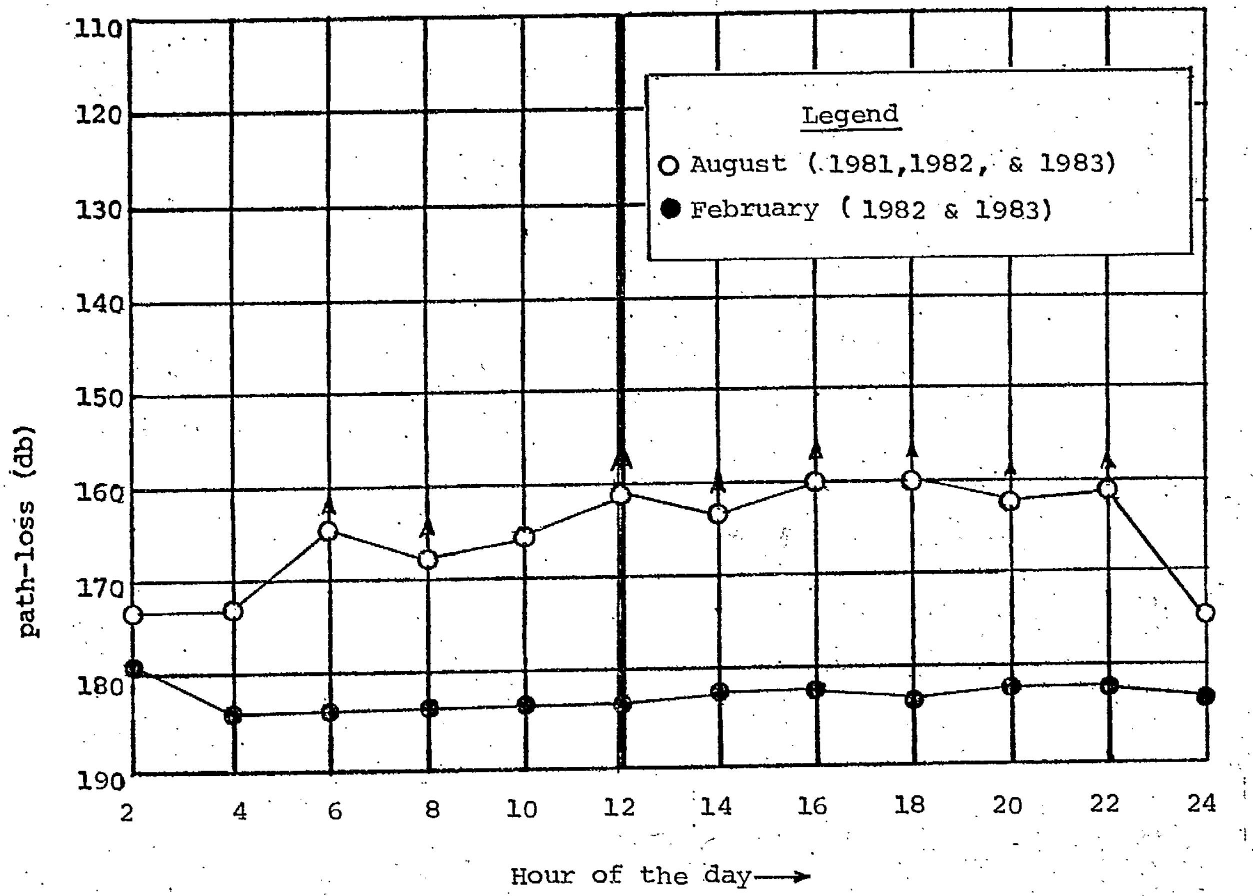
Note: The arrows indicate that the path-loss is actually smaller, but the amount is not known.

Figure 2-13: Monthly variations in path-loss at 147.950 MHz compared with monthly averages of "path temperature"; both quantities are averaged over three years. It is noted that the correlation between the two quantities is such that the seasonal relationship between path-loss and "path temperature" is clear.



Note: The arrows indicate that the path-loss is actually smaller, but the amount is not known.

Figure 2-14: Diurnal (24-hour day) variations in path-loss for the extremum months of the year (February and August), averaged over three years for August and two years for February, for 147.950 MHz.



Note: The arrows indicate that the path-loss is actually smaller, but the amount is not known.

Chapter 3: Sable-to-Seaview (147.995 MHz)

The monthly variations in path-loss for the mid-point of each month are given for each year (1981 to 1983) in Figures 3-1, 3-2, and 3-3 respectively. No data is available for the first four months of 1981, and for June, July, and September to December of 1982. The average for the data for the three years is shown in Figure 3-4. An empirically determined best-fit sinusoid is fitted to the data and shown in Figure 3-5. It is quite apparent that there is a seasonal variation in path-loss.

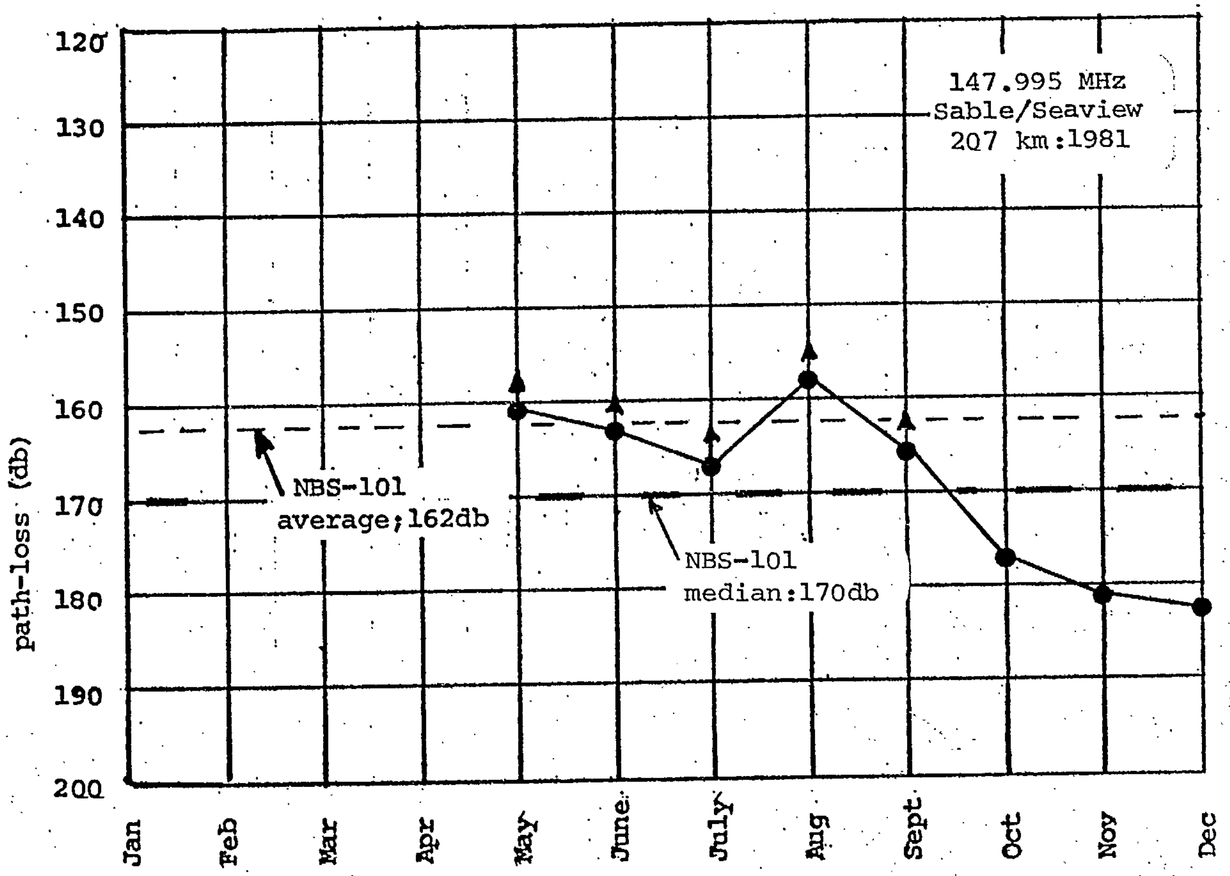
The time-distribution of the path-loss for each year is given in Figures 3-6, 3-7, and 3-8 respectively. The average of the data for the three years is shown in Figure 3-9. The observed time-distribution differs from the expected by approximately 5 db.

The monthly variations in path-loss are compared with monthly variations in mean "path temperature" for each year in Figures 3-10, 3-11, and 3-12 respectively. The average for the data is shown in Figure 3-13. In this case, the surface temperatures pertain to Sable Island and to Eddy Point (Canso Straits area).

Where appropriate, data obtained by M.T.T. for the frequency under discussion is also included. This data was obtained only for the first four months of 1983. Time-distribution data from MTT is found in Appendix C.

Diurnal (24-hour day) variations in path-loss for the extremum months of the year (i.e., February and August) are averaged over two years for both February and August. The data indicates that, during February (at which time the path-loss is a maximum for the year), the variation over the 24-hour day is very small or even zero, although there appears to be a small decrease in path-loss at about 0200 hours. This data is shown in Figure 3-14.

Figure 3-1: Monthly variations in path-loss at 147.995 MHz for 1981. Data is not available for the months of January to April, inclusive. The figure includes the average and median values of "expected" path-loss, calculated on the basis of NBS-101. Average and median values of "observed" path-loss for the year were not calculated.



Note: The arrows indicate that the path-loss is actually smaller, but the amount is not known.

Figure 3-2: Monthly variations in path-loss at 147.995 MHz for 1982. Data is not available for the months of June, July, and September to December, inclusive. The figure includes the average and median values of "expected" path-loss, calculated on the basis of NBS-101. Average and median values of "observed" path-loss for the year were not calculated.

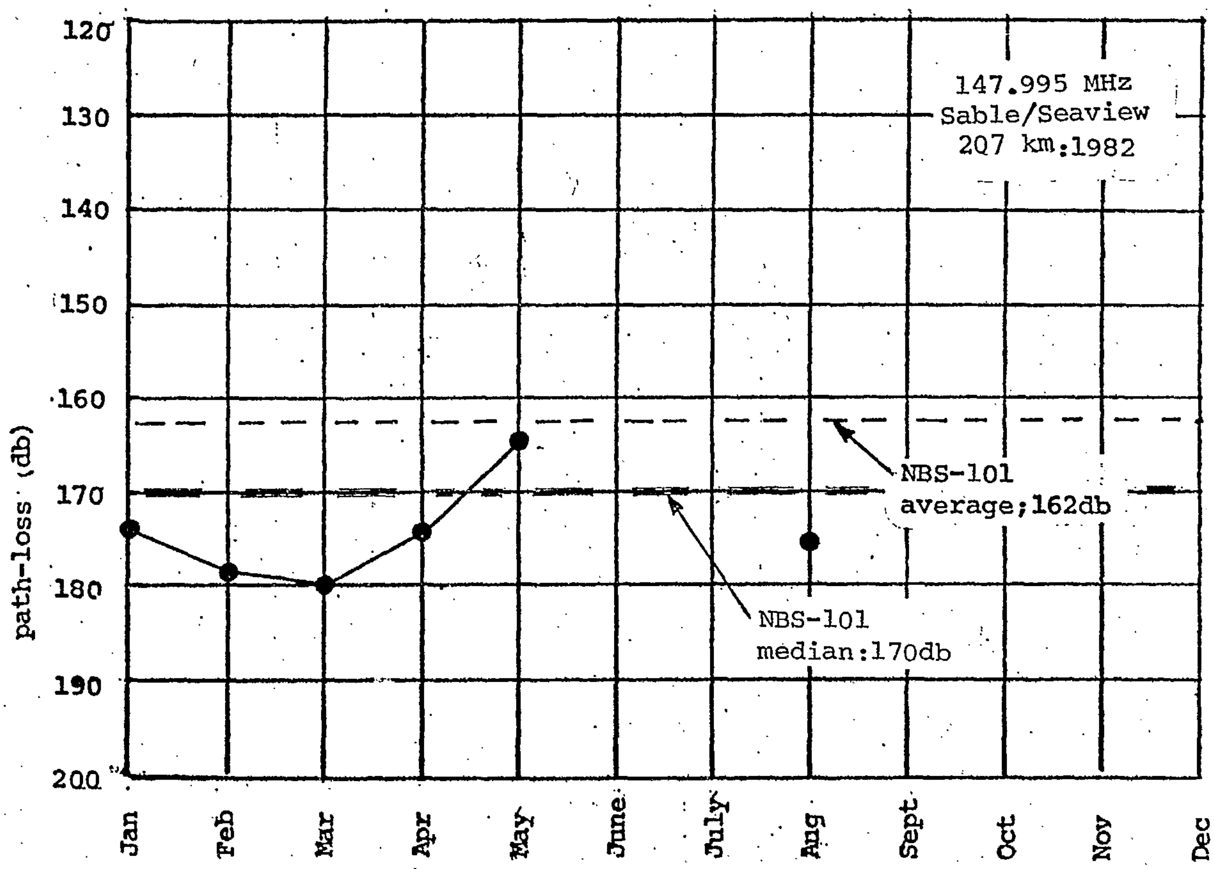
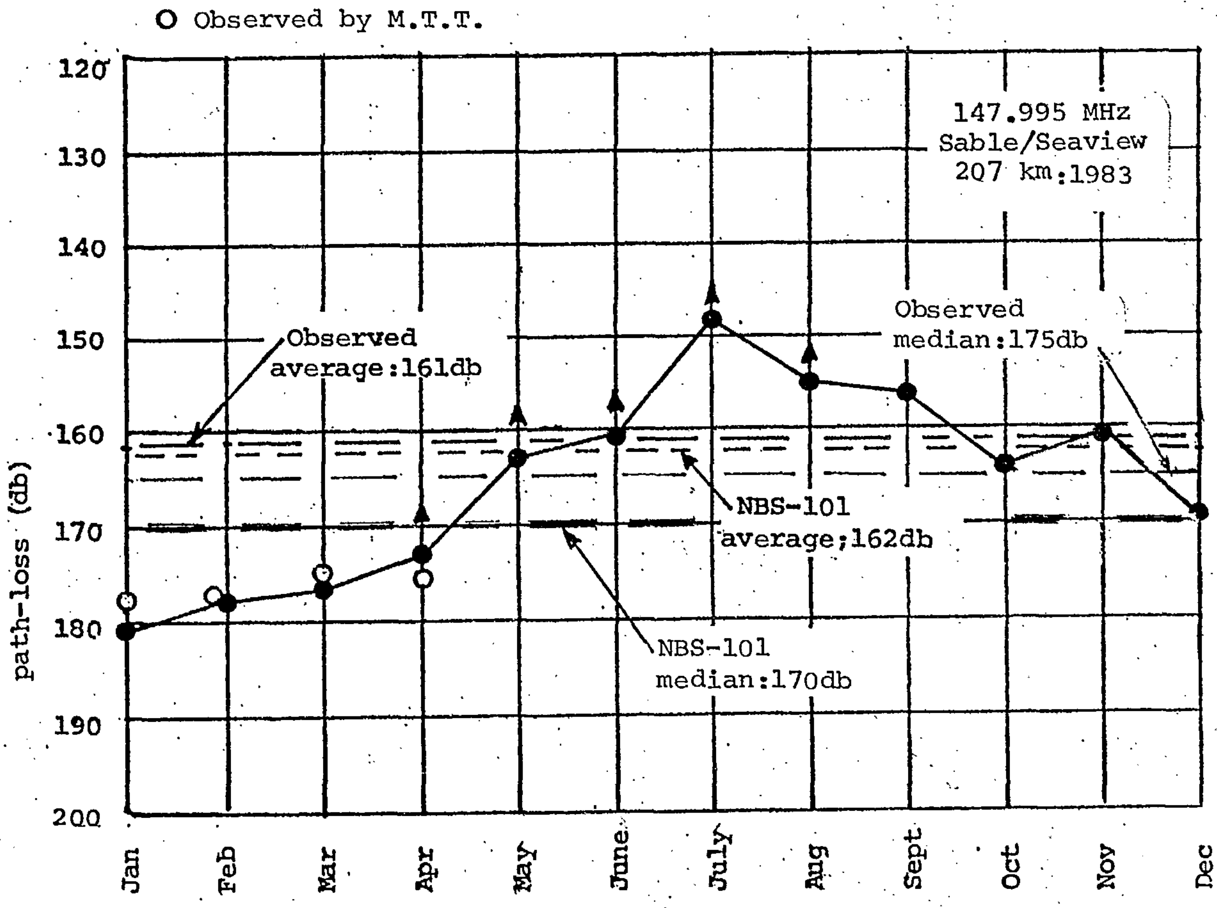


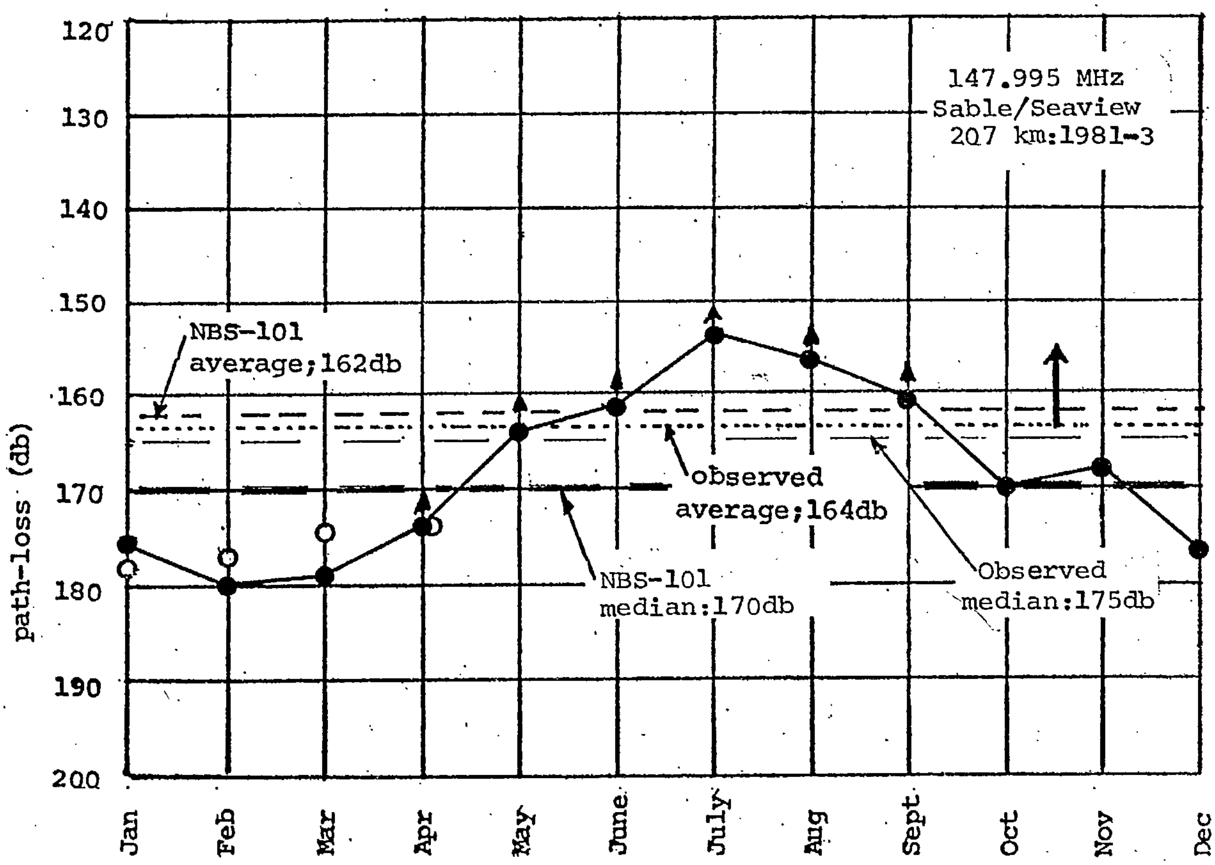
Figure 3-3: Monthly variations in path-loss at 147.995 MHz for 1983. The figure includes the average and median values of "expected" path-loss, calculated on the basis of NBS-101, as well as the "observed" values of path-loss for the year.



Note: The arrows indicate that the path-loss is actually smaller, but the amount is not known.

Figure 3-4: Monthly variations in path-loss at 147.995 MHz. This figure includes the relevant system-parameters used in calculating the expected path-loss on the basis of NBS-101. The line representing the observed average has an arrow associated with it to indicate the fact that the path-loss is somewhat smaller than indicated, but to an unknown extent. The data obtained by MTT (for Jan. to Apr., 1983) is also shown in this figure.

O Observed by M.T.T.



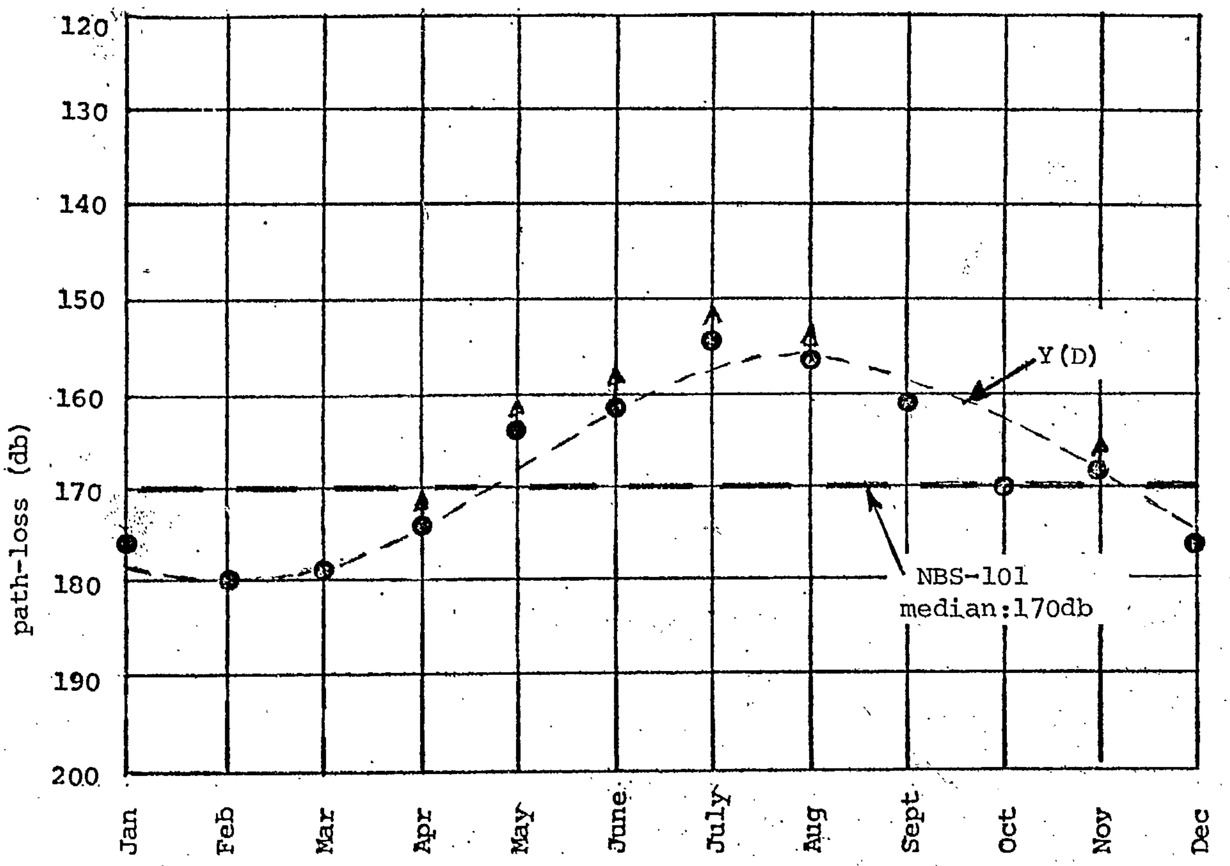
Note: The arrows indicate that the path-loss is actually smaller, but the amount is not known.

System parameters: TX: 15W ant.gain:11.2dbi line loss:4.3db

RX: — " " " " " 3.8db

TX antenna 20m above sea-level RX antenna 77m above sea-level

Figure 3-5: Monthly variations in path-loss at 147.995 MHz. This figure displays the correlation between the monthly average (averaged over three years) and an empirically determined best-fit sinusoid, designated as Y(D), where Y represents the path-loss for a given day-number D. It is noted that the data points agree with the sinusoid to within a few db.



Note: The arrows indicate that the path-loss is actually smaller, but the amount is not known.

The function $Y(D) = 168 + 12\cos\left[2\pi(D-44)/365\right]$, where $0 \leq D \leq 365$, is an empirically determined fit to the data; D is the number of the day of the year. The observed data is assumed to pertain to the mid-point of each month. For the purposes of this figure, each month has 365/12 days. It is being assumed that the maximum path-loss occurs in mid-February.

Figure 3-6: Time-distribution of data at 147.995 MHz obtained during 1981. Data is not available from January to April inclusive. The median values differ by approximately 15 db, which is considered to be probably insignificant on the basis that the data for this year is rather incomplete, and that differences in the order of 10 db or so cannot be ruled out. The average of the expected value of path-loss is included for purposes of comparison. An average value for the observed path-loss was not calculated because of the incompleteness of the data.

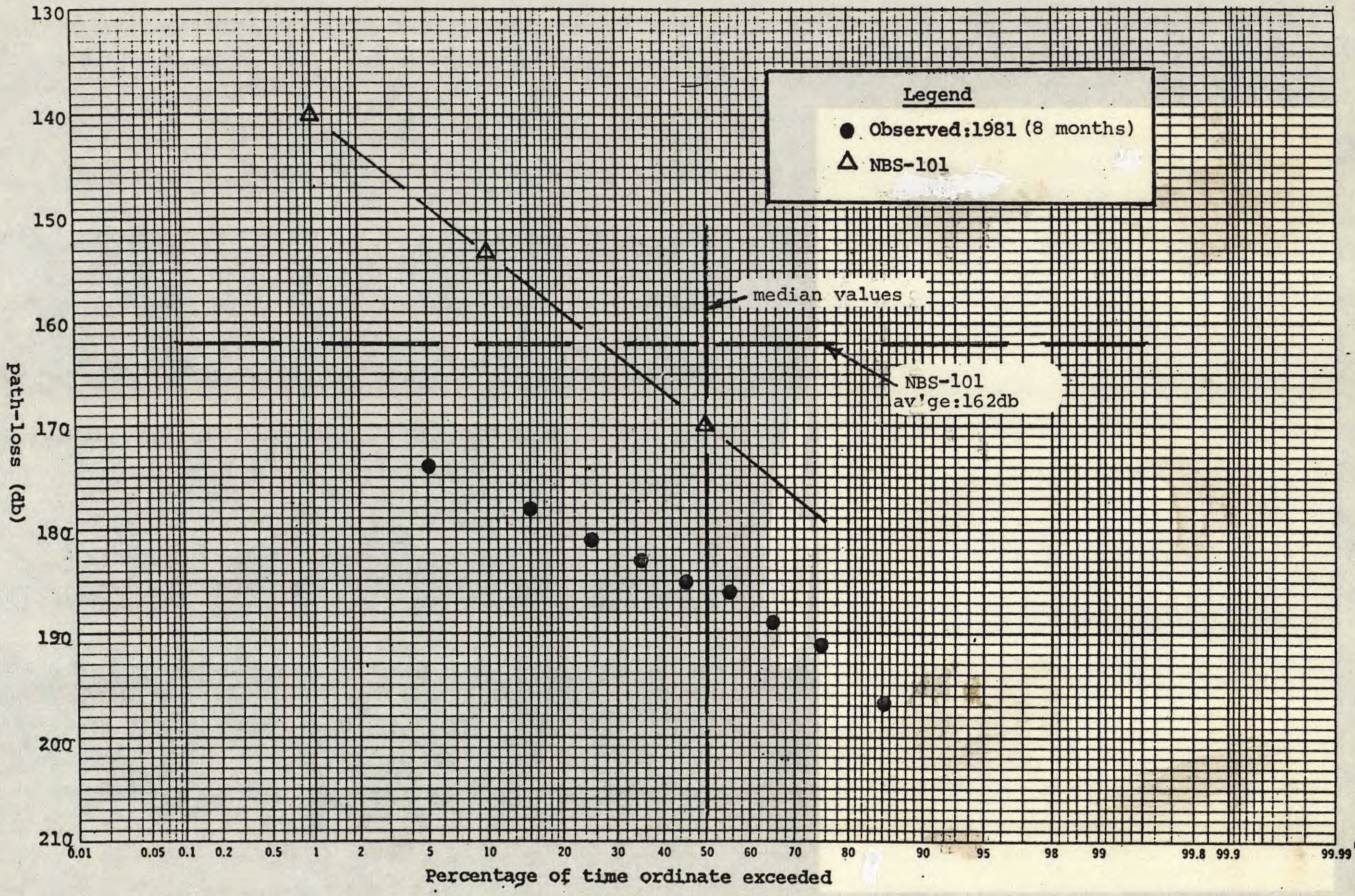


Figure 3-6: Sable to Seaview 147.995 1981

Figure 3-7: Time-distribution of data at 147.995 MHz obtained during 1982. Data is not available for June, July, and September to December inclusive. The median values differ by approximately 9 db. The average value of the expected path-loss is included for purposes of comparison. An average value for the observed path-loss was not calculated because of the incompleteness of the data.

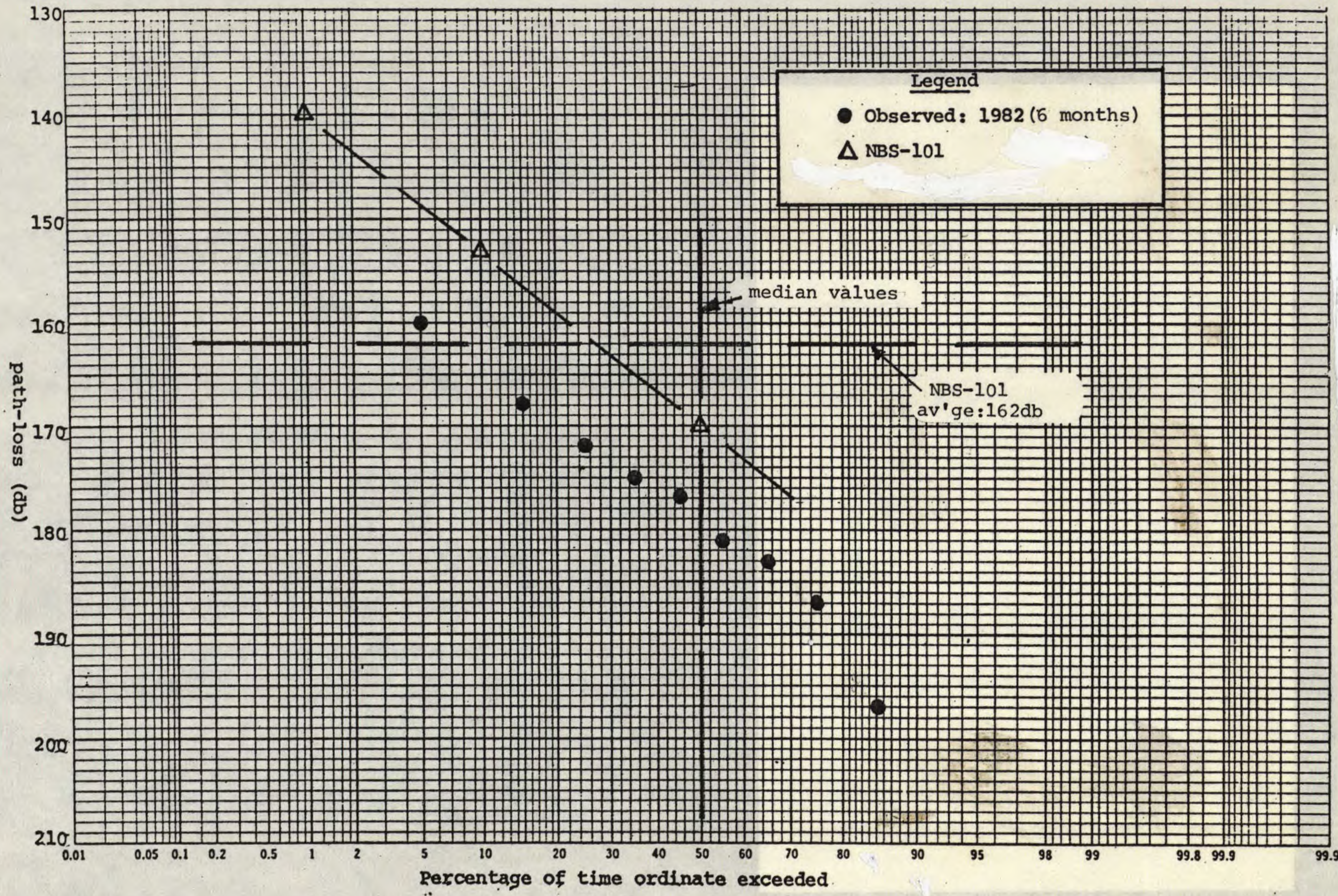


Figure 3-7: Sable to Seaview 147.995 MHz 1982

Figure 3-8: Time-distribution of data at 147.995 MHz obtained during 1983. The median values differ by approximately 4 db. The MIT data is thought to be consistent with both the NBS-101 prediction as well as with the SMU data inasmuch as the MIT data represents path-loss behaviour for the winter season, which is associated with maximum path-loss (see Chapter 6 for further discussion of this). Average values for the expected and observed path-loss are included for purposes of comparison.

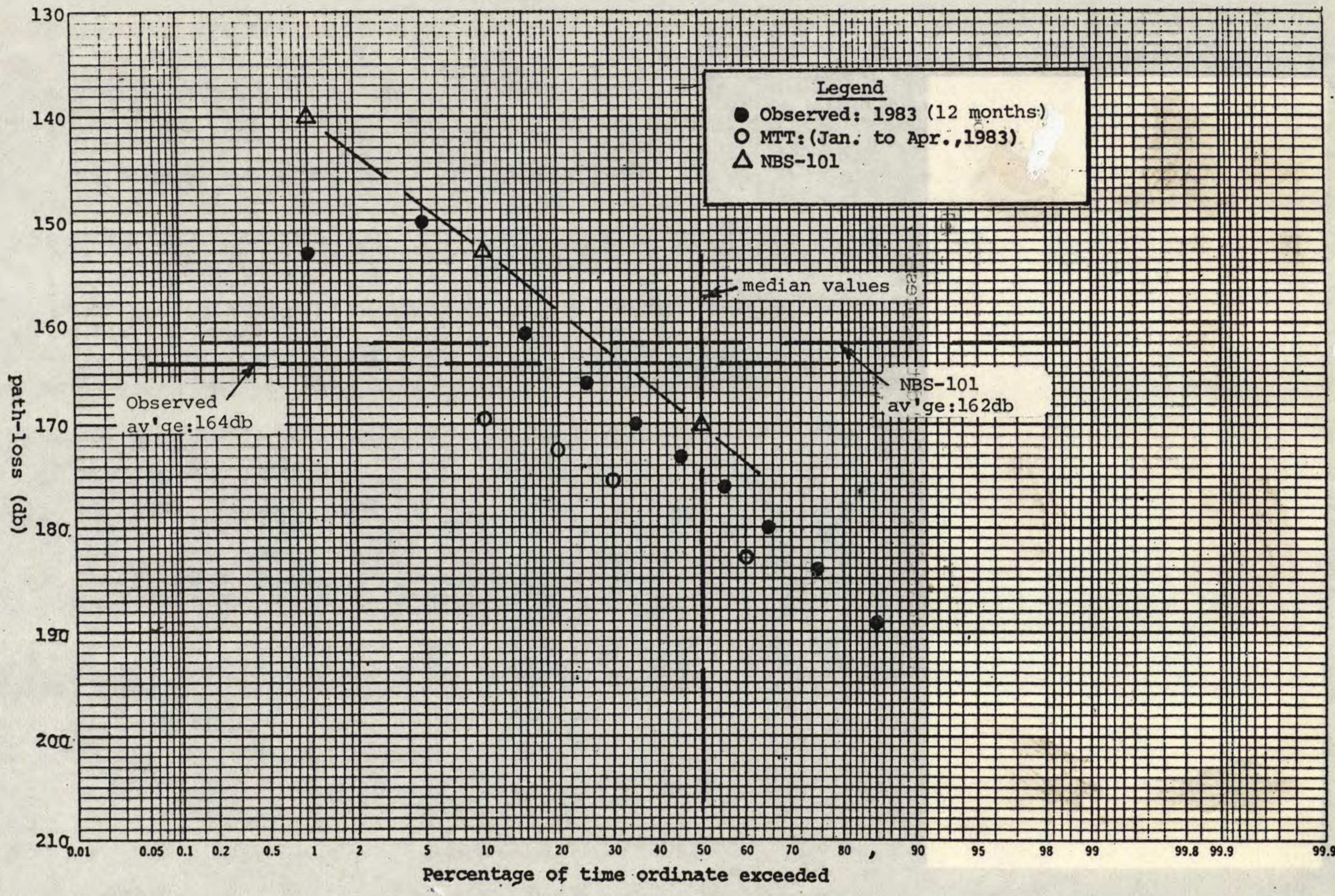


Figure 3-8: Sable to Seaview 147.995 MHz 1983

Figure 3-9: Time-distribution data at 147.995 MHz obtained over the period 1981 to 1983, and averaged over the three years. The median values differ by approximately 5 db. The averages of the expected and the observed values of path-loss are included for purposes of comparison.

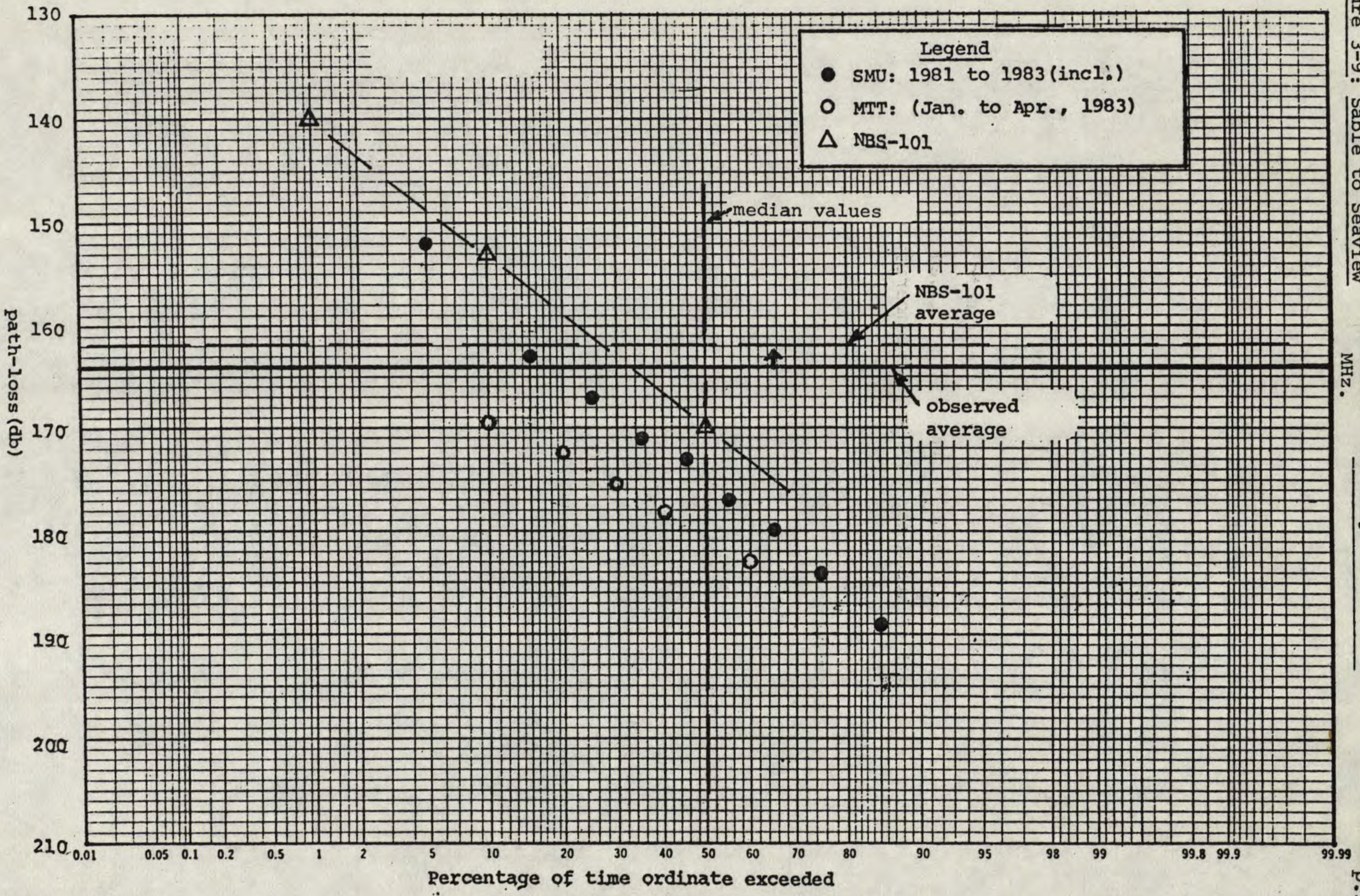
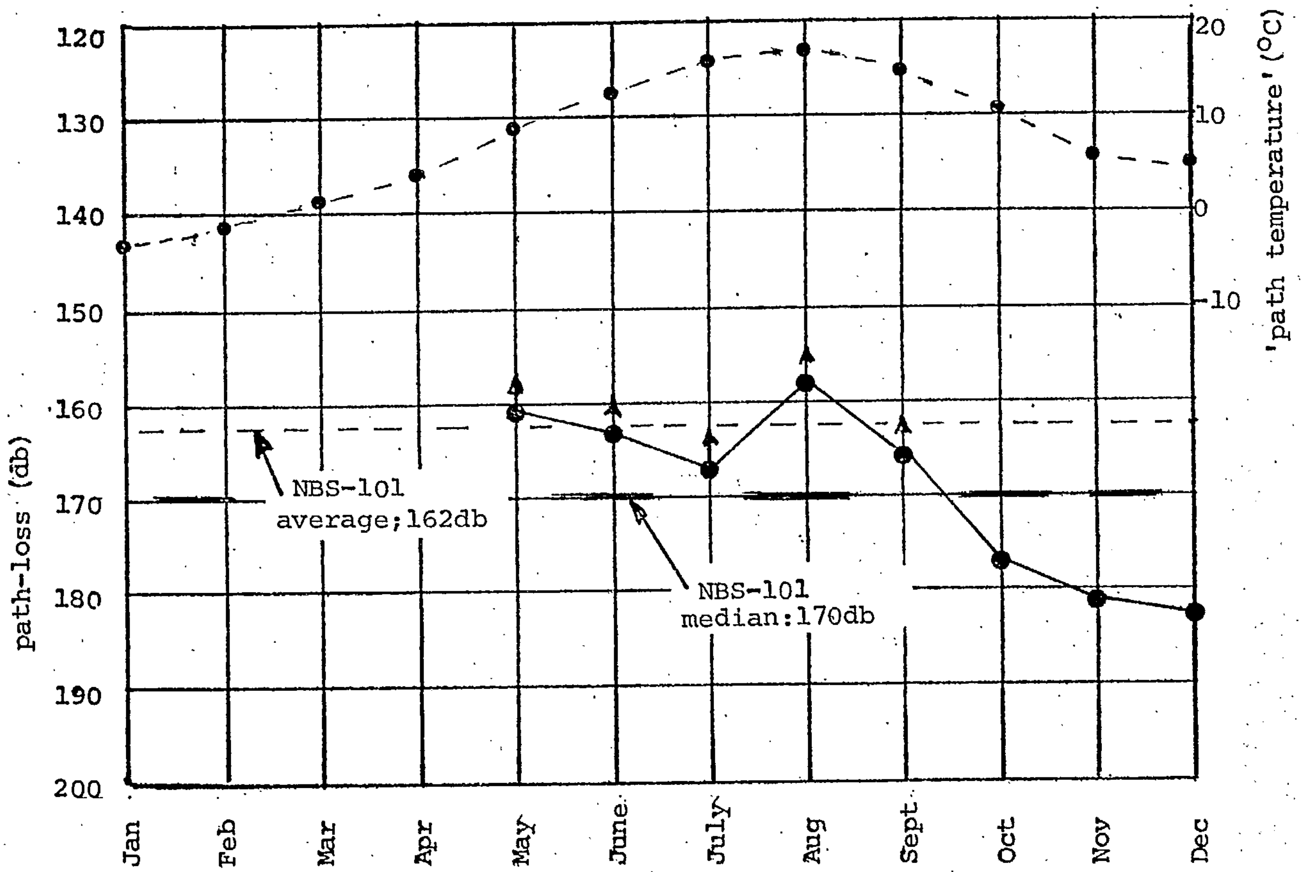


Figure 3-9: Sable to Seaview 147.995 MHz. average for 1981-3

Figure 3-10: Monthly variations in path-loss at 147.995 MHz compared with monthly averages of "path temperature"; both pertain to 1981 only.



Note: The arrows indicate that the path-loss is actually smaller, but the amount is not known.

Figure 3-11: Monthly variations in path-loss at 147.995 MHz compared with monthly averages of "path temperature"; both pertain to 1982 only.

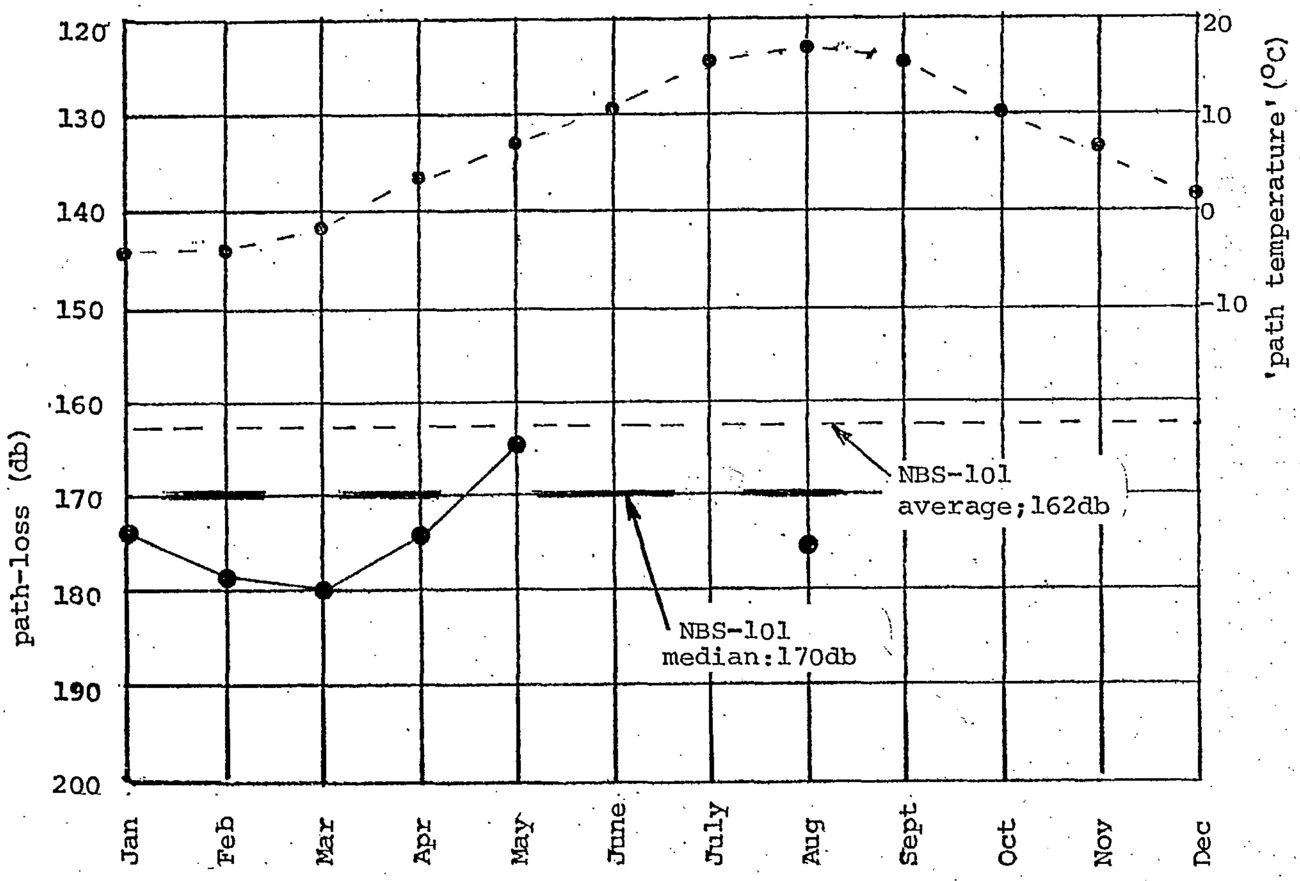
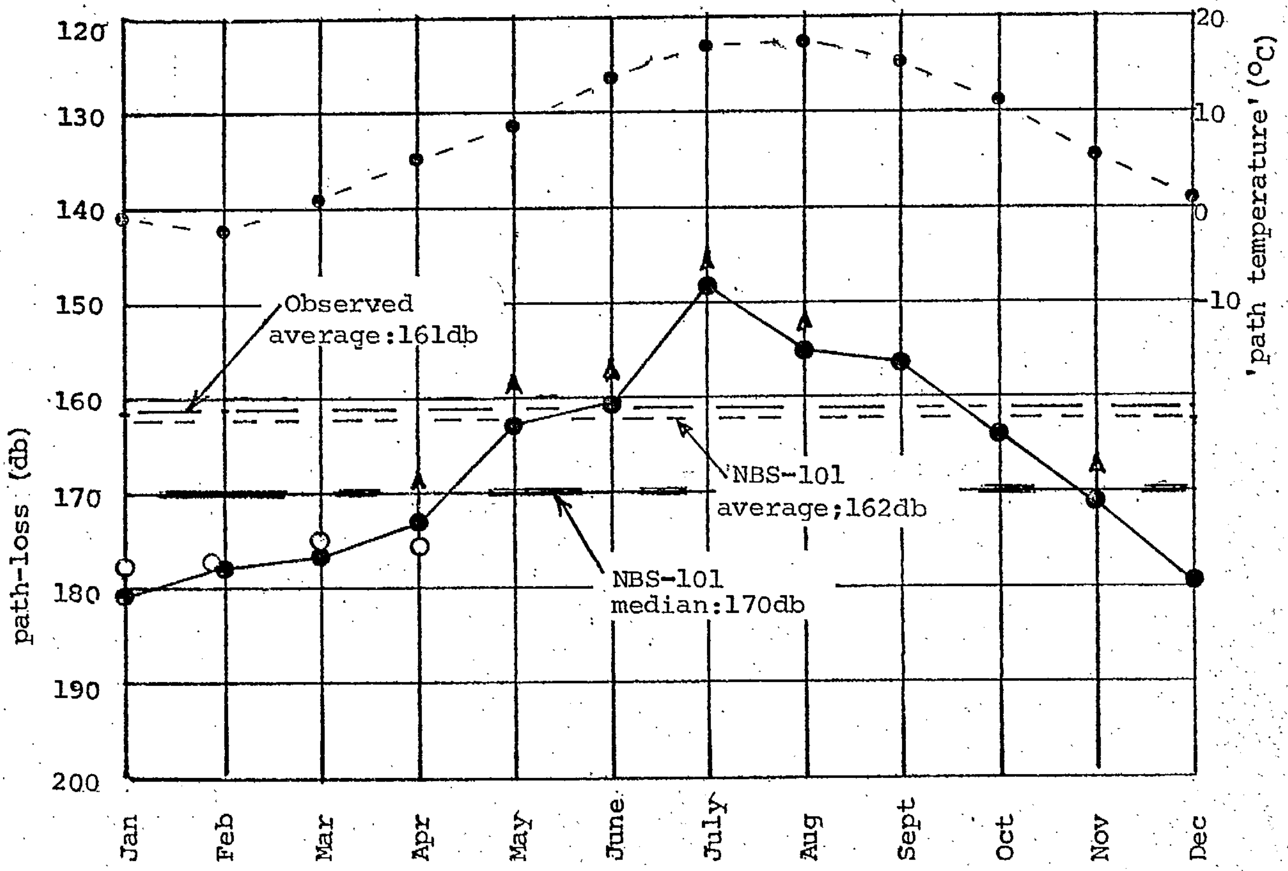
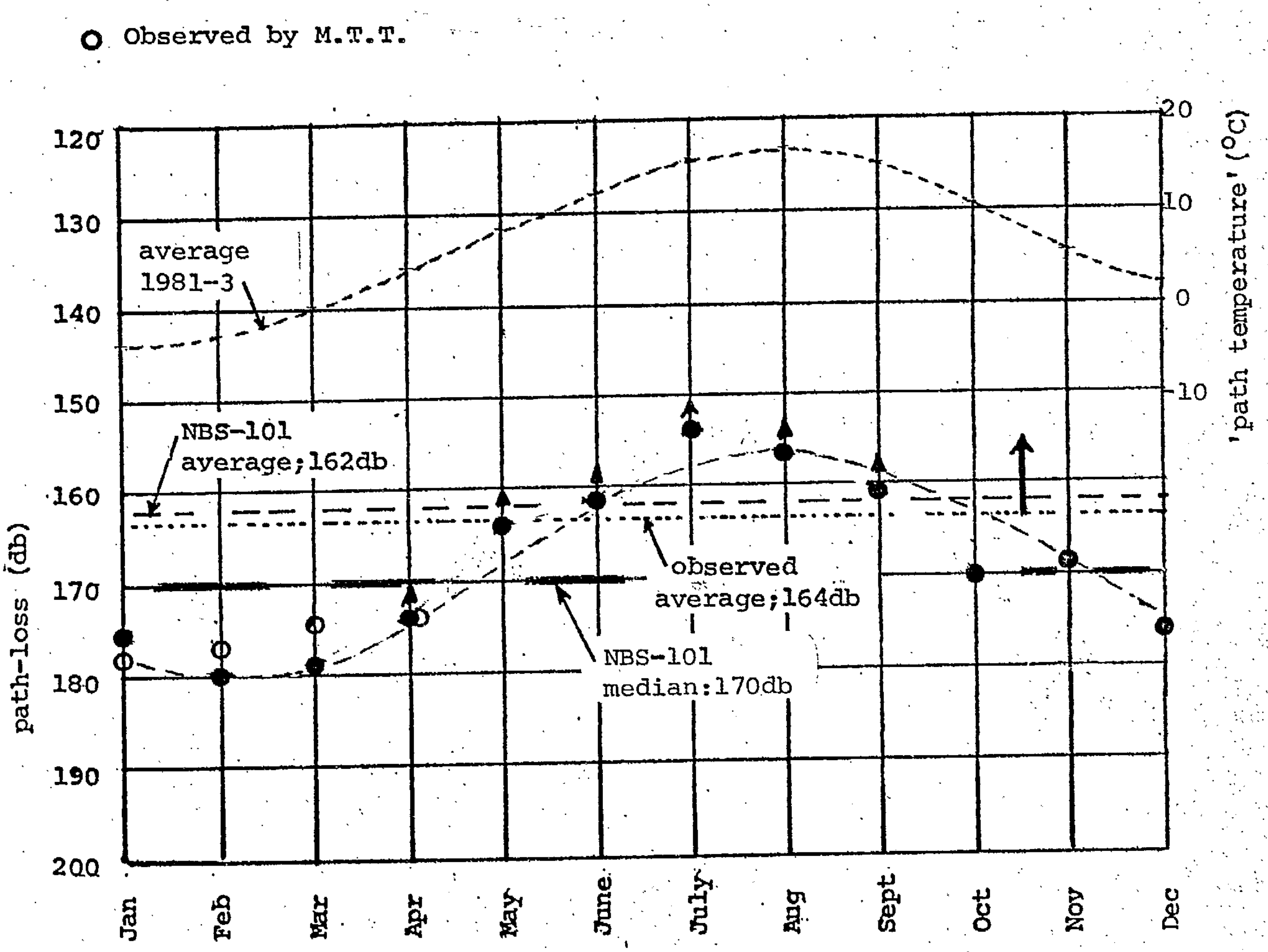


Figure 3-12: Monthly variations in path-loss at 147.995 MHz compared with monthly averages of "path temperature"; both pertain to 1983 only.



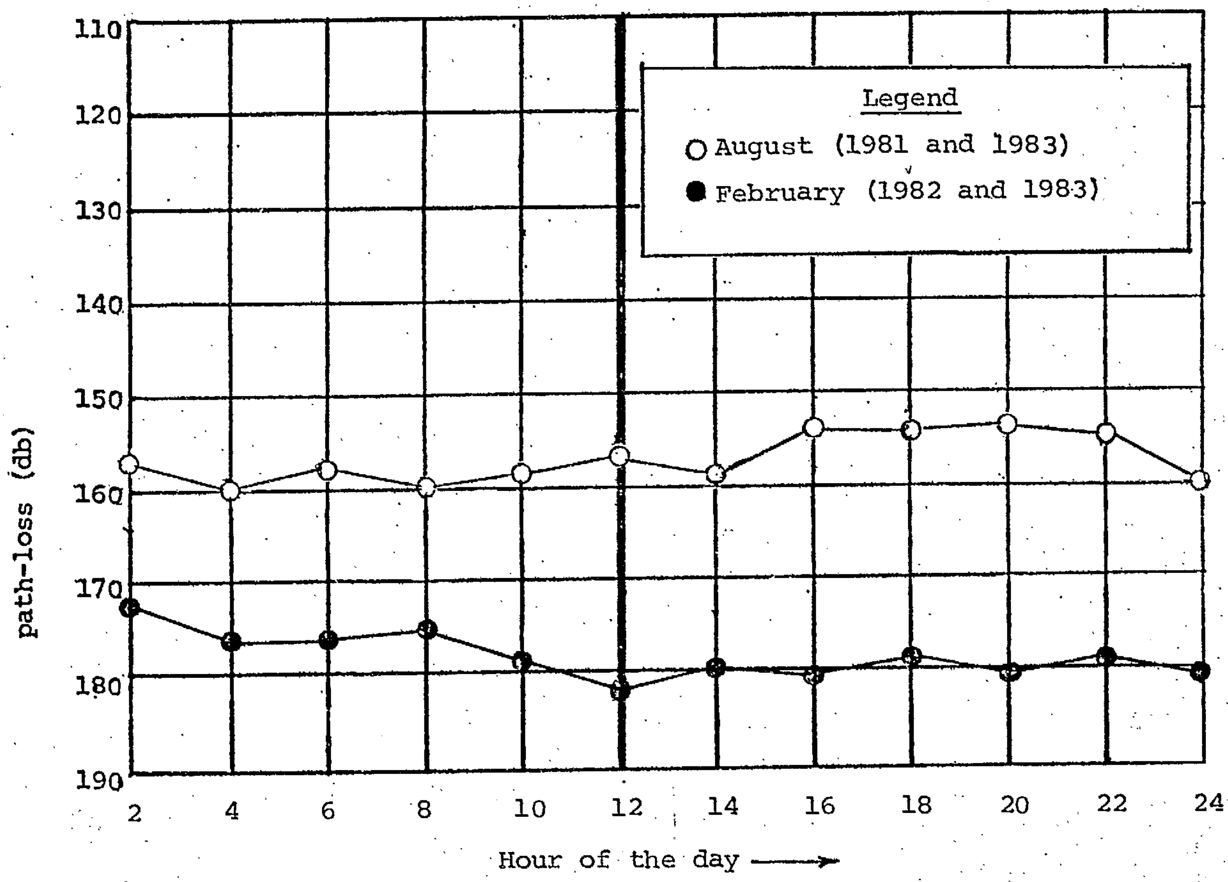
Note: The arrows indicate that the path-loss is actually smaller, but the amount is not known.

Figure 3-13: Monthly variations in path-loss at 147.995 MHz, compared with monthly averages of "path temperature; both quantities are averaged over three years. It is noted that the correlation between the two quantities is such that the seasonal relationship between path-loss and "path temperature" is clear.



Note: The arrows indicate that the path-loss is actually smaller, but the amount is not known.

Figure 3-14: Diurnal (24-hour day) variations in path-loss for extremum months of the year (February and August), averaged over two years, for 147.995 MHz.



Note: The arrows indicate that the path-loss is actually smaller, but the amount is not known.

Chapter 4: Sable-to-Halifax (431.950 MHz)

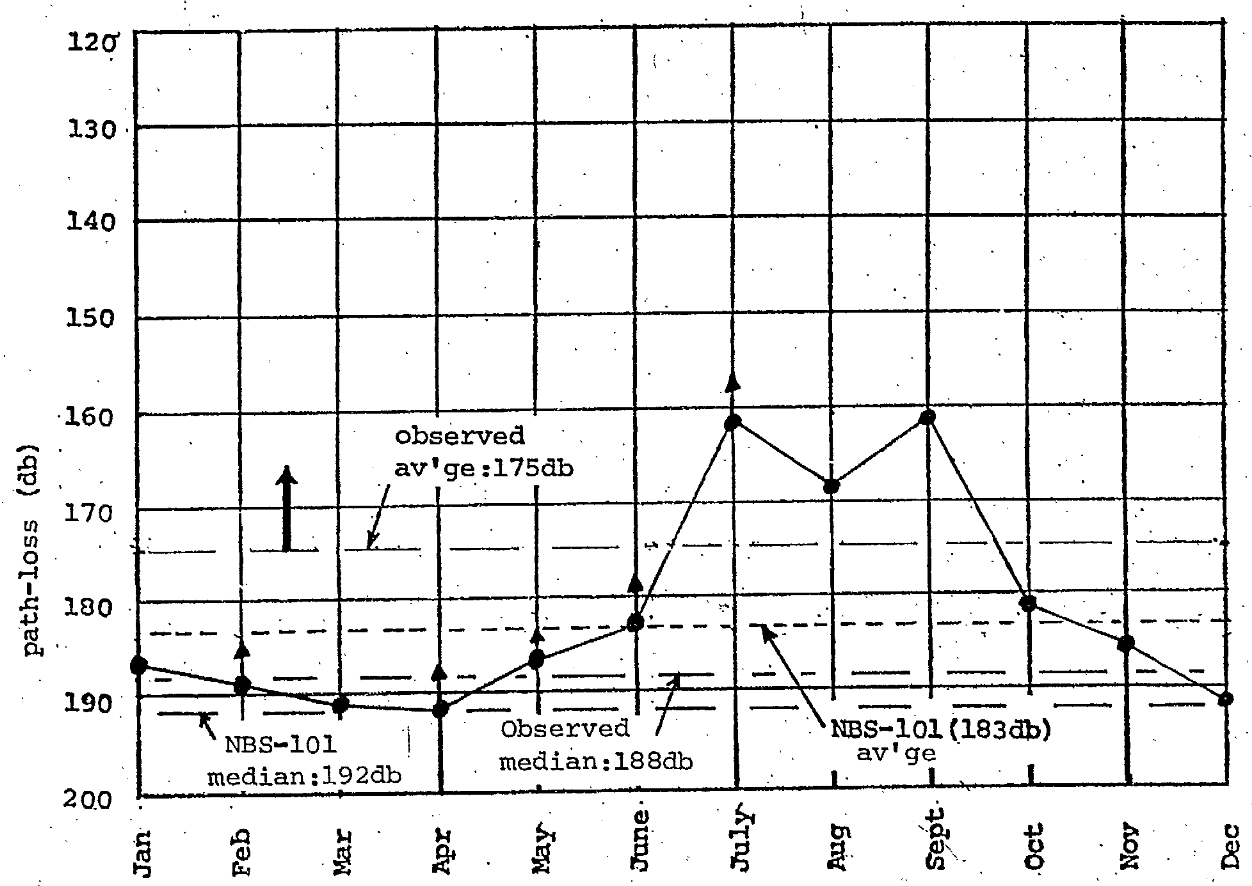
The monthly variations in path-loss for the mid-point of each month are given for 1983 in Figure 4-1. An empirically determined best-fit sinusoid is fitted to the data and shown in Figure 4-2. The data displays a marked seasonal variation.

The time-distribution of the observed path-loss is shown in Figure 4-3, and compared with the expected time-distribution (based on NBS-101). The average values of the observed and expected path-loss are included in the graph to facilitate comparison. The data shows that the median value of the observed time-distribution of the path-loss is approximately 5 db less than the expected. This difference is, however, taken to be insignificant in view of the experimental uncertainties and the scatter in the data. Moreover, the data represents only one full year of observations.

The monthly variations in path-loss are compared with the monthly variations in mean "path temperature" in Figure 4-4, and indicate a definite correlation between the seasonal variation in path-loss and seasonal variation in path-temperature.

Diurnal (24-hour day) variations in path-loss for the extremum months of the year (February and August), for 1983 only, are shown in Figure 4-5. The data indicates that during February (at which time the path-loss is maximum for the year), the variation over the 24-hour day is very small (possibly zero), although there appears to be a small decrease in path-loss at about 0200 hours. However, during August, the variation is quite marked, and also suggests that there is a tendency for the path-loss to be a minimum towards midday.

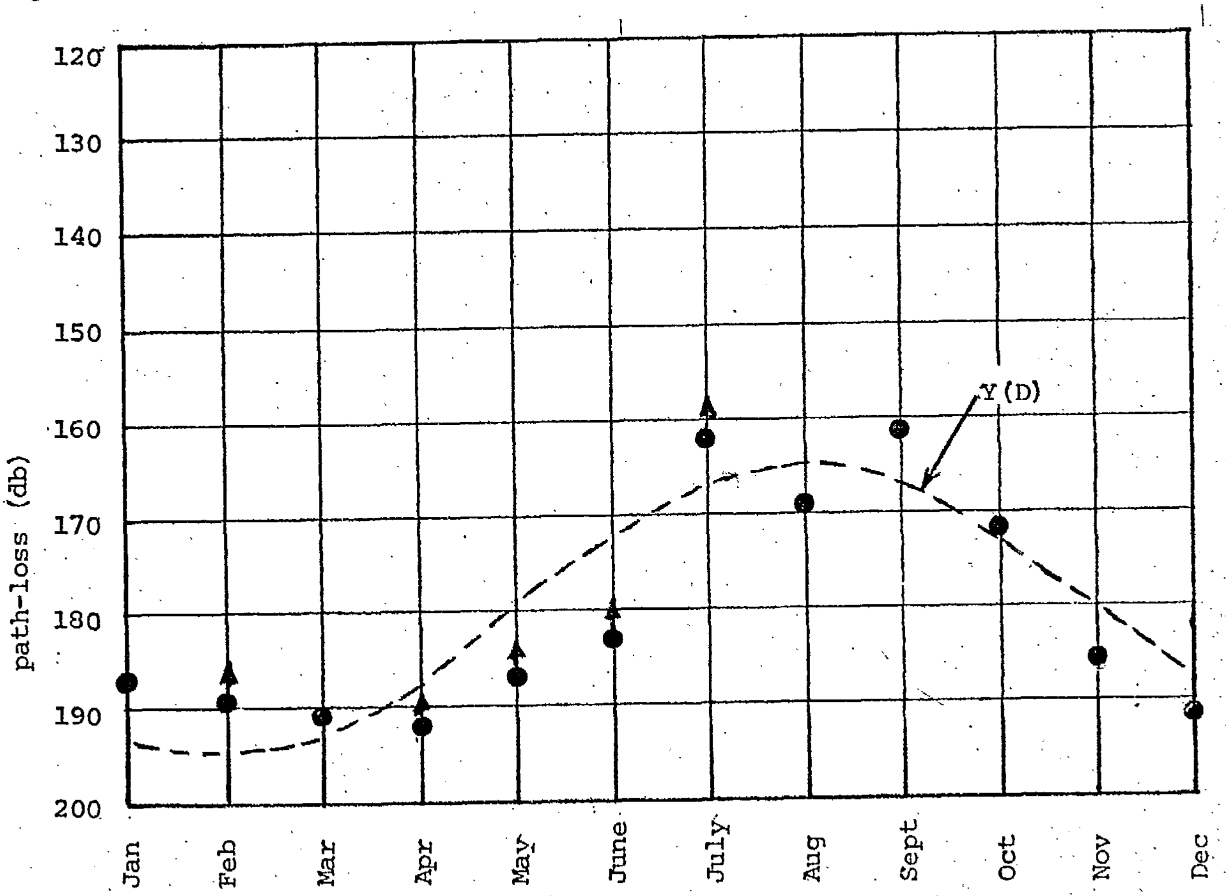
Figure 4-1: Monthly variations in path-loss at 431.950 MHz. This figure includes the relevant system-parameters used in calculating the expected path-loss on the basis of NBS-101. The line representing the observed average has an arrow associated with it to indicate that the path-loss is actually smaller, but the amount is not known.



Note: The arrows indicate that the path-loss is actually smaller, but the amount is not known.

Note: Data obtained (using a data-logger) for Jan./84 indicate a path-loss of 187 db for this month; this agrees with the results for 1983.

Figure 4-2: Monthly variations in path-loss at 431.950 MHz. This figure displays the correlation between the monthly averages (for 1983) and an empirically determined best-fit sinusoid, designated Y(D), where Y represents the path-loss for a given day-number D. It is noted that the data points agree with the sinusoid to within a few db.



Note: The arrows indicate that the path-loss is actually smaller, but the amount is not known.

The function $Y(D) = 180 + 15\cos\left[2\pi(D-44)/356\right]$, where $0 \leq D \leq 365$, is an empirically determined fit to the data; D is the number of the day of the year. The observed data is assumed to pertain to the mid-point of each month. For the purposes of this figure, each month has 365/12 days. It is being assumed that the maxmimum path-loss occurs in mid-February.

Figure 4-3   431.950 MHz   Sable to Halifax(319 km)

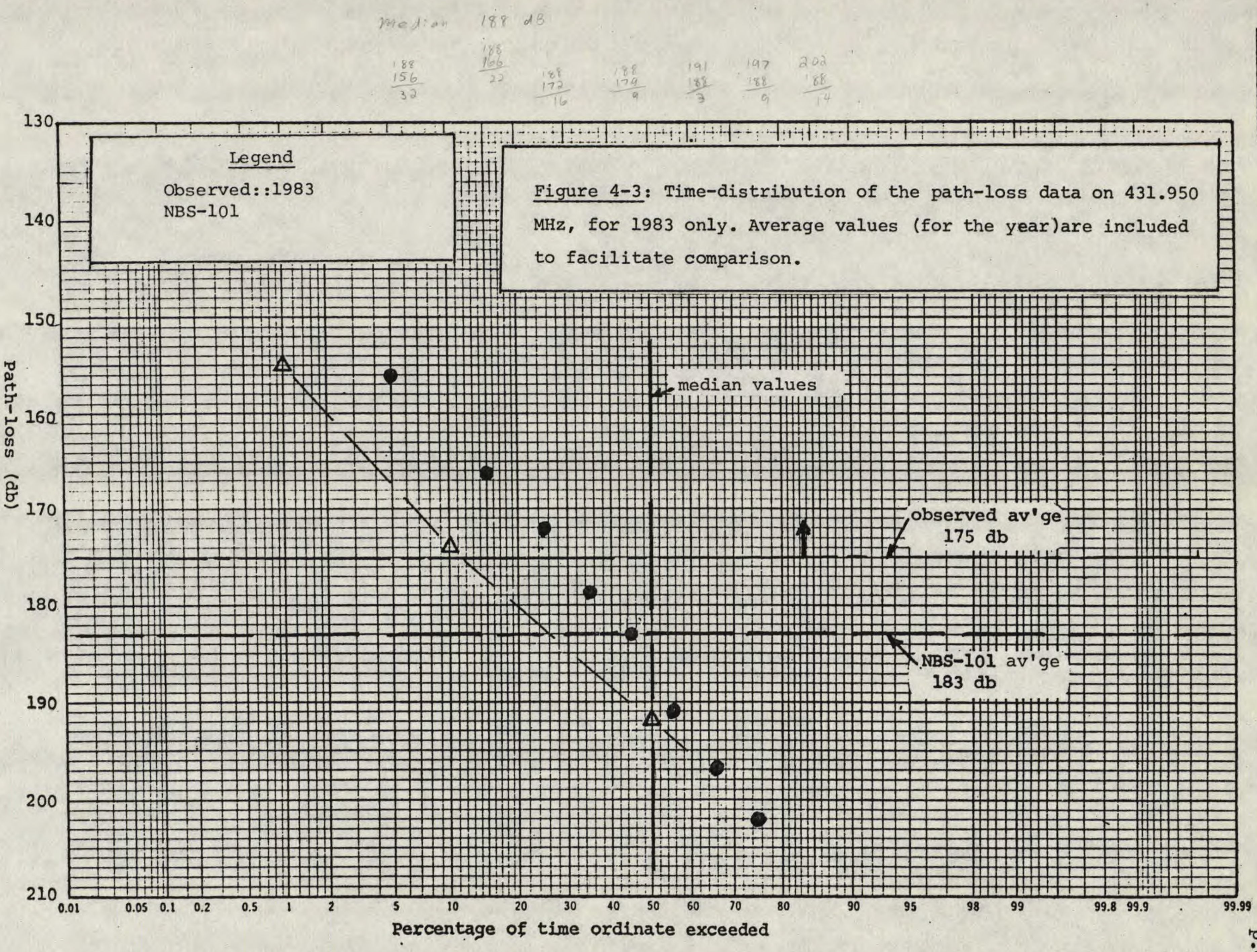


Figure 4-3: Time-distribution of the path-loss data on 431.950 MHz, for 1983 only. Average values (for the year)are included to facilitate comparison.

Figure 4-4 f: 431.950 MHz 1983

Sable to Halifax (319 km)

Comparison of monthly variations in path-loss with monthly variations in 'path temperature' (for 1983 only).

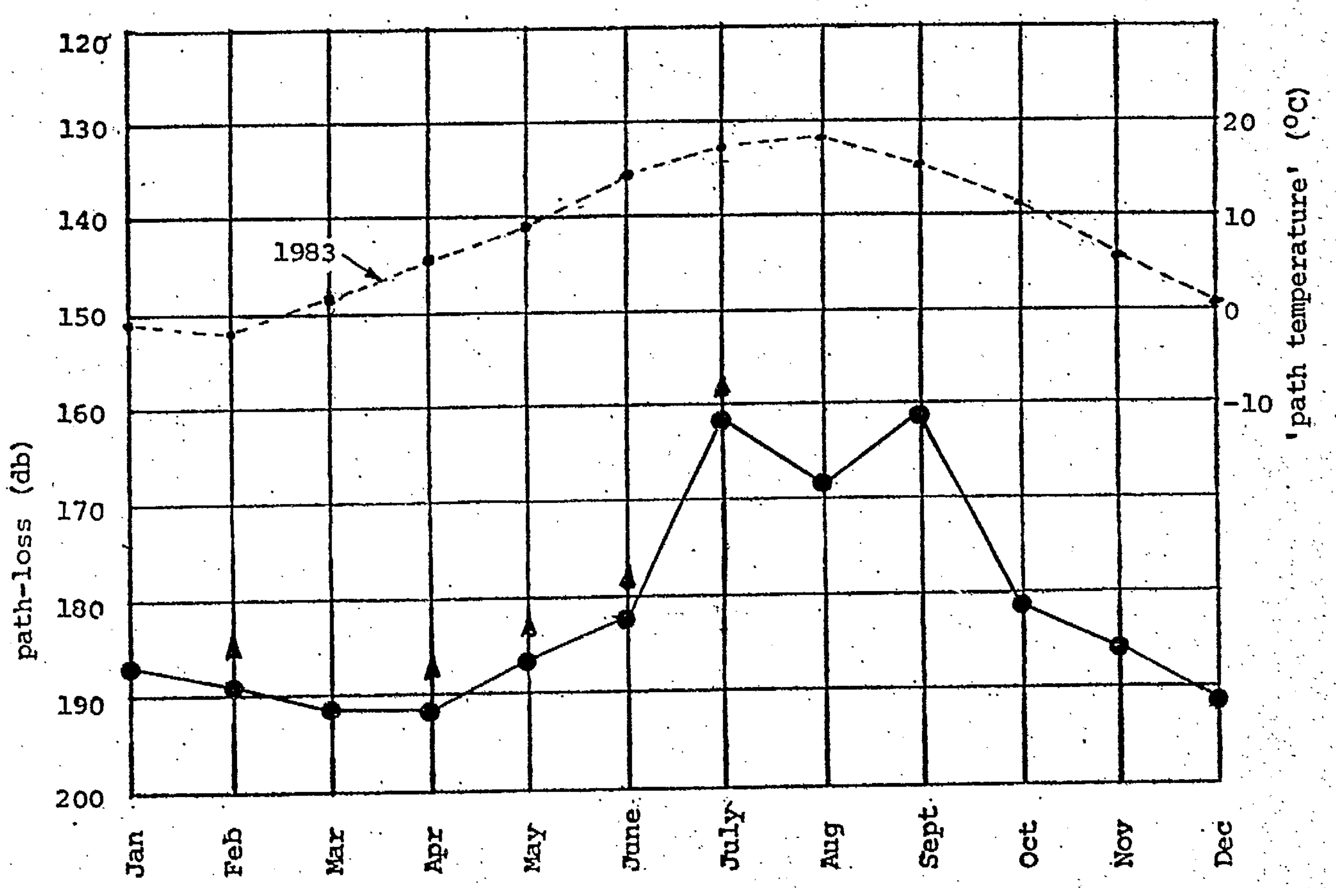
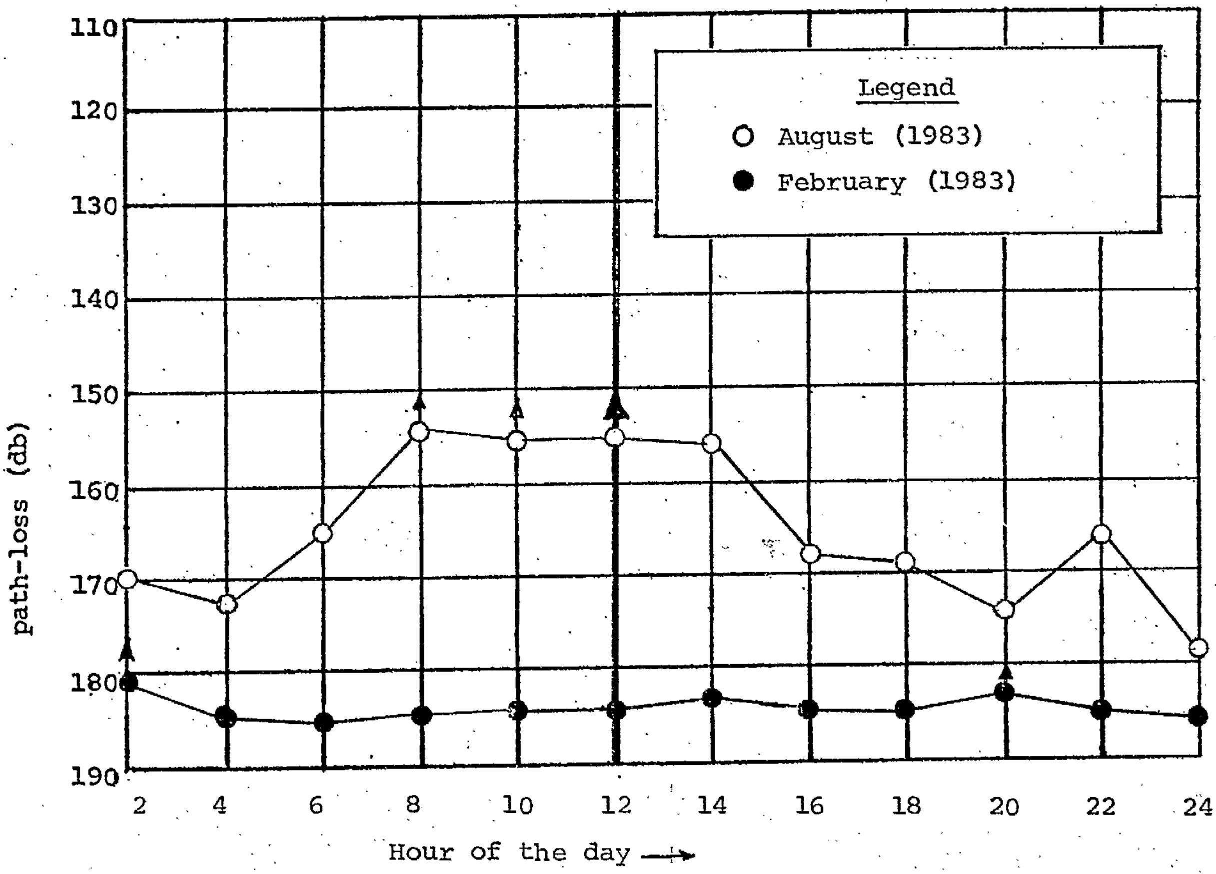


Figure 4-5: Diurnal (24-hour day) variations in the path-loss for the extremum months of the year (February and August), for 1983, at 431.950 MHz.



Note: The arrows indicate that the path-loss is actually smaller, but the amount is not known.

1.Diversity observations.

Some preliminary "diversity" experiments, involving frequency and space separation, were conducted by SMU and reported earlier (Appendices C, E, G, and I, of the Report for 1981-2). These were short-term observations (lasting about 1 hour each), conducted May 8, June 19, September 9, and December 8, of 1981. On the basis of these observations, it was concluded (in that Report) that a multi-channel receiver system, in a diversity configuration, should show a marked decrease in channel outages associated with fast-fading.

However, much more extensive observations were made by MTT on diversity configurations involving six different links in various combinations. The observations were conducted continuously during the first four months of 1983. The results of these observations are shown in Figure 5-1 (reproduced, with permission, from MTT's Report ESP 82-01). It is clear from the MTT data that the observed long-term improvements associated with diversity configurations are rather small--in the order of 1% in most instances.

The difference between the two sets of observations (MTT and SMU) is substantial. Although a seasonal factor might be adduced to account for the difference, it is pointed out, on the one hand, that SMU's observations on December 8, 1981 (which lasted for 51 minutes) indicated that of the 8.6 minutes (total) during which the signal at Seaview was below 0.2 uV, the signal at Arichat was simultaneously below this level for only 1.1 minutes (total) of this time, representing approximately 13% of the total 'outage' time. If a perfectly efficient diversity system had been in place, then 87% of the 8.6 minutes could have been supplied by Arichat, thus reducing the overall outage from 8.6 to some 1.1 minutes, representing a decrease in outage (associated with fast-fading) during the 51 minutes from 17% to some 2.2 %.

On the other hand, the SMU observations represent short-term behaviour, whereas those by MTT represent the long-term. Hence, for the purposes of this Report, which pertains mainly to long-term effects, it would appear that the observations made by MTT represent the dominant phenomenon.

Figure 5-1: Summary of results from diversity observations obtained by MTT.

(from MTT Report #ESP 82-01)
(reproduced with permission)

TABLE 2

DIVERSITY IMPROVED AVAILABILITIES

(for 0.2 uV received signal)

CHANNEL	JANUARY	FEBRUARY	MARCH	APRIL
Arichat VHF #1 (Non-diversity)	94.01%	88.61%	90.55%	96.47%
Arichat VHF #1 with Seaview VHF #1	94.13%	88.98%	91.08%	97.12%
Arichat VHF #1 with Seaview VHF #2	94.30%	88.36%	91.11%	97.31%
Arichat VHF #1 with Seaview VHF #3	94.05%	88.97%	90.75%	96.69%
Arichat VHF #1 with Seaview UHF #1	94.38%	88.83%	92.96%	97.43%
Arichat VHF #1 with Arichat UHF #1	94.03%	88.66%	90.90%	96.93%
Arichat VHF #1 with Canso VHF #1	94.74%	88.72%	92.38%	97.80%
Arichat VHF #1 with Canso UHF #1	95.25%	88.91%	92.00%	97.54%

Arichat VHF#1: 142.605 MHz(vertical)
Seaview VHF#1: 142.605 MHz(")
Seaview VHF#2: 143.395 MHz(")
Seaview VHF#3: 147.995 MHz(horizontal)
Canso VHF#1: 142.605 MHz(vertical)
Seaview UHF#1:419.2125 MHz(")
Arichat UHF#1:419.2125 MHz(")
Canso UHF#1: 419.2125 MHz (")

Note: the terms in parentheses refer to polarization.

2. Polarization effects.

Some preliminary observations have been made over the past year and a half on a possible difference in path-loss for vertically polarized and horizontally polarized radiation. To separate this effect from other --possibly larger--effects, several antennas were installed on Sable Island which were slanted at 45 degrees in such a way that the radiated power would have equal vertical and horizontal components. In this experimental configuration, any polarization-dependent propagation would appear as an apparent rotation of the plane of polarization at the receiving terminal.

In particular, if the analyzing antenna (and this was the case) is adjusted for a null in the receiver (this procedure is convenient when the signal is rather weak and fading rapidly), then the apparent angle of rotation is readily measured. For purposes of preliminary observations, the equipment was capable of an experimental uncertainty of no more than 2 degrees, which is equivalent to a relative change in power of approximately 0.2 db. The frequencies associated with these observations are: 147.930 (formerly 147.900), 224.950, 431.900, and 1296 MHz.

On the basis of only several observations at each of the frequencies, it appears that the vertical component is associated with a path-loss several db larger than is the horizontal, at both 147.930 and 224.950 MHz; at 431.900, the vertical component appears to be attenuated additionally by only 0.5 db or so; and, at 1296, any additional attenuation is less than 0.2 db.

Given the experimental uncertainties associated with this project (estimated to be approximately 3 db) and given the uncertainty associated with the scatter in the path-loss data (assumed to be in the order of 10 db), it is apparent that the effect being discussed here is a relatively minor one, and would quite probably not be detected in any long-term observations of path-loss.

Hence, although it appears that there is some differential path-loss pertaining to linear polarization (vertical or horizontal), it is pointed out--for the purposes of this Report--that the data is quite tentative and that the effect is relatively small.

3. Preliminary data for 1296 MHz.

Semiquantitative observations have been made over the past two years of the signal-level from the 1296 MHz beacon on Sable Island. The bulk of these observations were made by Mr. Elmer Naugler (VE1OD), of Halifax, whose observations extend mainly from June 30, 1983 to January 2, 1984.

In general, it was observed that the beacon could be heard during the summer rather frequently, but only rarely during the winter, agreeing with the seasonal dependence of the path-loss observed at the other frequencies associated with this Report. A tentative estimate of the path-loss yields the value 182 db, which appears to agree with a forward-scattering model for the propagation. This estimate pertains to the mid-summer value; presumably, the mid-winter value would be at least 20 db larger than this.

The data for this frequency is quite preliminary.

Chapter 6: Summary

The monthly averages of path-loss, averaged over three years, for 147.950 and 147.995 MHz, are displayed as graphs in Figure 6-1. The graphs show both observed and expected values for the median path-loss. The observed data shows that the form of the seasonal variation in path-loss is similar for the two paths, with a constant difference of approximately 7 db. Although the agreement between observed and expected median values is closer at 147.950 MHz (Sable to Halifax) than at 147.995 MHz (Sable to Seaview), the difference in both cases is taken to be insignificant, and leads to the conclusion that the long-term median values of path-loss on both paths are in agreement with the calculations based on NBS-101. The same observed data is given in Figure 6-2, where it is compared with average rather than median values. Data obtained by MTT for the first four months of 1983 is also shown in Figures 6-1 and 6-2, and is seen to be in agreement with the other data.

Time-distribution data, averaged over the three years, for the same two frequencies, is shown in Figure 6-3, and is compared with time-distribution behaviour based on NBS-101. For both frequencies, the best-fit line through the data-points is taken to be in agreement with the expected values, leading to the conclusion that the long-term median value of the path-loss on these two paths and at these frequencies is consistent with a forward-scattering model for the propagation.

Moreover, given that the NBS-101 model being used here does not distinguish among polarizations (vertical, horizontal, circular), and given that the data obtained by SMU (using horizontal polarization) and the data obtained by MTT (using vertical polarization) are both taken to be in agreement with the NBS-101, then it is concluded that there is no significant (i.e. not larger than several db) sensitivity to polarization on these paths and at these frequencies.

The monthly average path-loss values, averaged over the three years for the two VHF and one UHF paths studied by SMU, along with the best-fit sinusoids for each, are shown combined in Figure 6-4 to facilitate comparison and interpretation of the data. The combined time-distribution data is shown in Figure 6-5.

The correlation between average monthly path-loss and average monthly path-temperature, indicating the fairly linear relationship between the long-term average monthly path-loss and the long-term average monthly path-temperature, as well as indicating that the slope in each case is approximately 1 db per degree Celsius, is shown in Figure 6-6.

Diurnal (24-hour day) variations in path-loss are shown in Figure 6-7. The data represents the average of all available data from 1981 to 1983 inclusive. Given that the experimental uncertainty is probably 3 db at least, and the relatively large scatter in the data (in the order of 10 db at the least), the results indicate that for February there is no significant diurnal variation, although there appears to be a minimum at 0200 hours for all three frequencies. For August, the results indicate that the diurnal variations for 147.995 MHz (Sable-to-Seaview; 207 km) are also relatively negligible, but that the variations for 147.950 and 431.950 MHz (both are for Sable-to-Halifax; 319 km) appear to be significant. In particular, the results for these two frequencies suggest that there is a tendency for the path-loss to be less during daylight, and that the amplitude of the diurnal variation is larger at 431.950 than at 147.950 MHz.

Figure 6-1: Monthly variations in path-loss, averaged over the period from January 1, 1981 to December 31, 1983, for both VHF links studied by SMU. Both variations display a marked seasonal dependence, with the maximum path-loss occuring around mid-February and the minimum around mid-August. The average median path-loss is shown for the "observed" data (averaged over 3 years). The "expected" median (based on NBS-101) is also shown. The experimental uncertainty in all the data given in this Report is thought to be in the order of 3 db; short-term fluctuations are frequently in the order of 20 to 30 db and more.

At times, the signal level was high enough to drive the recording system off scale, and arrows are used in the figures to indicate that the path-loss is actually smaller, but the amount by which it is smaller is not known.

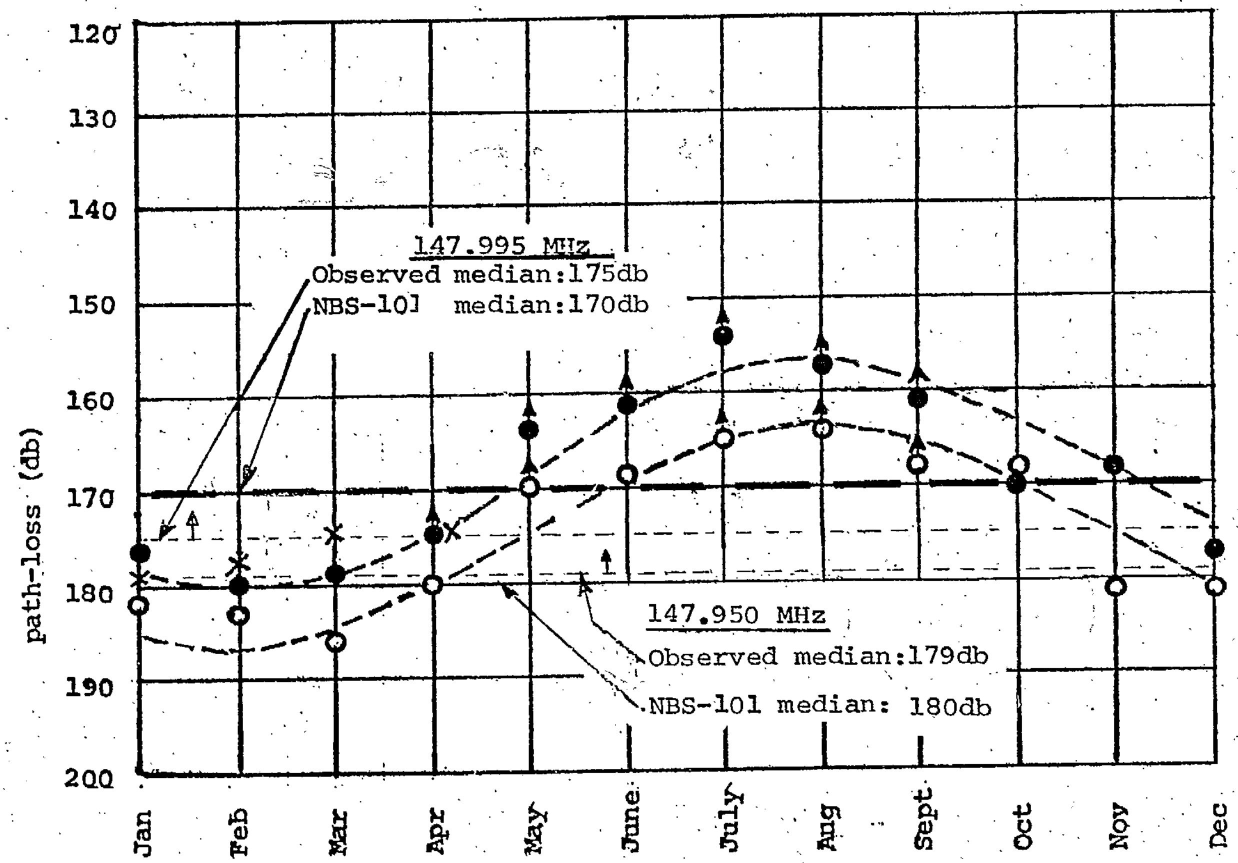
SMU's 147.995 MHz receiver was monitored by MIT in the course of their study of the path-loss between Sable Island and the Canso Straits area; this data is shown for the months of January to April of 1983 (the duration of the MIT study).

Figure 6-1

Monthly variations in path-loss
(compared with median values)

Legend

O 147.950 MHz; Sable to Halifax } observed by S.M.U., 1981-1983.
● 147.995 MHz; Sable to Seaview } observed by S.M.U., 1981-1983.
X 147.995 MHz; observed by M.T.T. (1983)

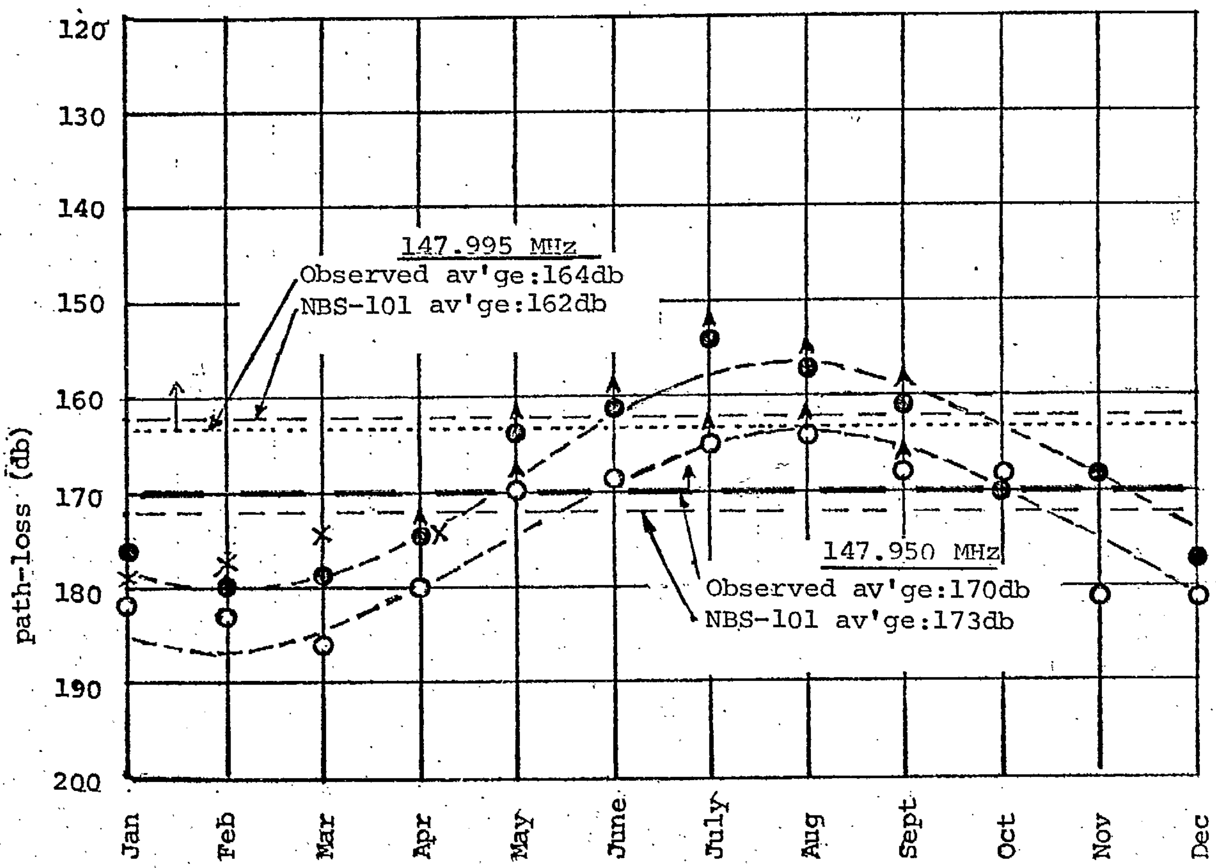


Note: The arrows indicate that the path-loss is actually smaller, but the amount is not known.

Figure 6-2: The same observed data as in Figure 6-1 is shown here, but this data is compared here with the various relevant average values rather than median values.

Legend

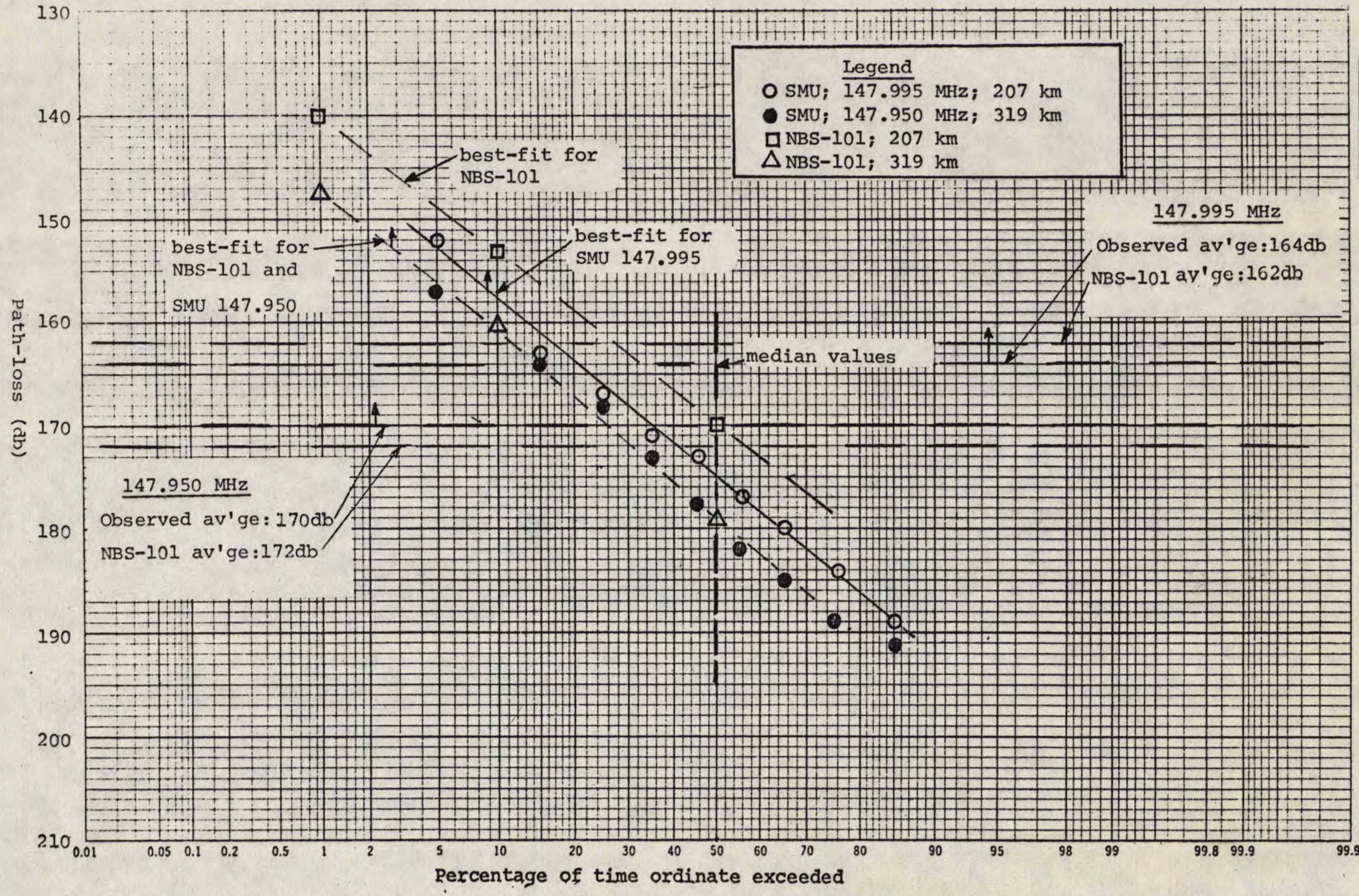
O 147.950 MHz; Sable to Halifax } observed by S.M.U., 1981-1983.
● 147.995 MHz; Sable to Seaview }
X 147.995 MHz; observed by M.T.T. (1983)



Note: The arrows indicate that the path-loss is actually smaller, but the amount is not known.

Figure 6-3: Time-distribution plot of the VHF path-loss data, averaged over the three years. Also shown, for both paths, is the expected distribution, based on NBS-101. It is noticed that the observed behaviour on the Sable-to-Halifax path is in closer agreement with the expected than is the case for the Sable-to-Seaview path. There is no apparent explanation for this difference.

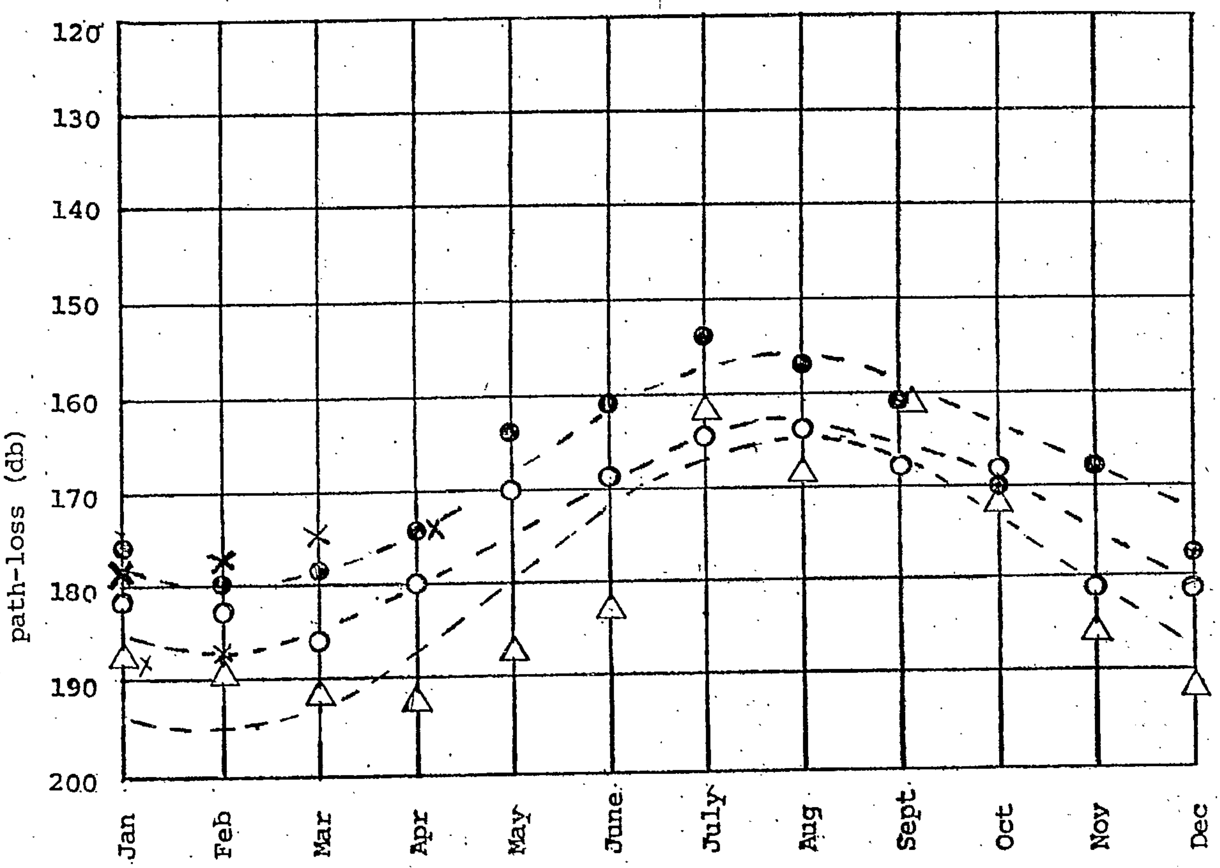
The MTT data shown here is the monthly average of their observations during the first four months of 1983. Since the seasonal variation in the path-loss is approximately 24db (see Figure 6-1), and since the MTT data represents the path-loss for a time of the year when the path-loss is a maximum, then it is concluded that the MTT data is in agreement with the other data.



Legend
SMU; 147.995 MHz; 207 km
SMU; 147.950 MHz; 319 km
NBS-101; 207 km
NBS-101; 319 km
best-fit for NBS-101
best-fit for NBS-101 and SMU 147.950
best-fit for SMU 147.995
147.995 MHz
Observed av'ge:164db
NBS-101 av'ge:162db
median values
147.950 MHz
Observed av'ge:170db
NBS-101 av'ge:172db
Path-loss (db)
130
140
150
160
170
180
190
200
210
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
Percentage of time ordinate exceeded

Figure 6-3

Figure 6-4: Monthly variations in path-loss, averaged over three years for the two VHF and one UHF paths studied by SMU. The empirically determined best-fit sinusoids are included to facilitate comparison.



Legend

● 147.950 MHz; Sable to Halifax(1981-3)

O 147.995 MHz; Sable to Seaview(1981-3)

△ 431.950 MHz; Sable to Halifax(1983)

X 147.995 MHz; Sable to Seaview(Jan. - Apr.,1983); from MTT.

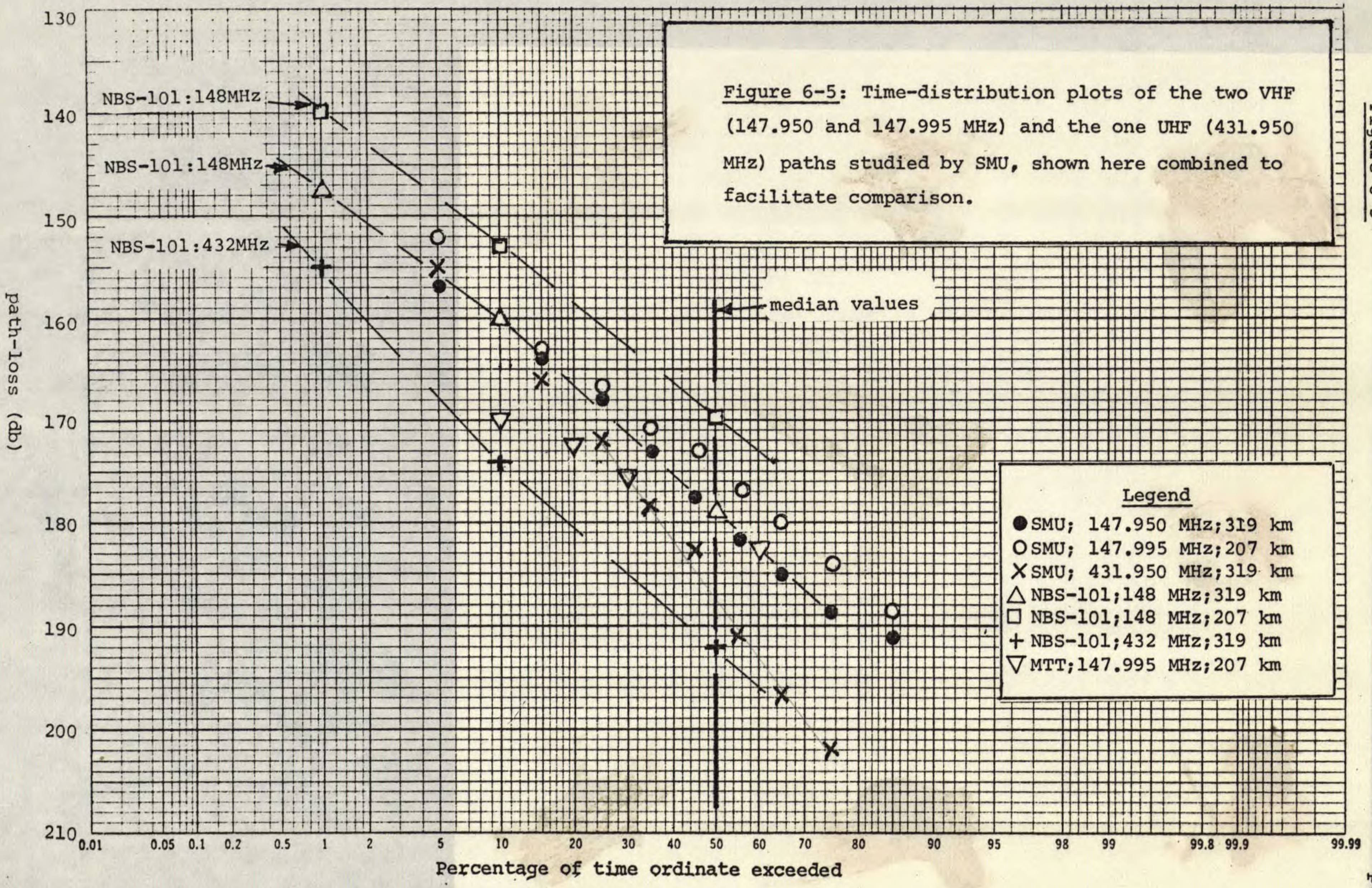


Figure 6-5: Time-distribution plots of the two VHF (147.950 and 147.995 MHz) and the one UHF (431.950 MHz) paths studied by SMU, shown here combined to facilitate comparison.

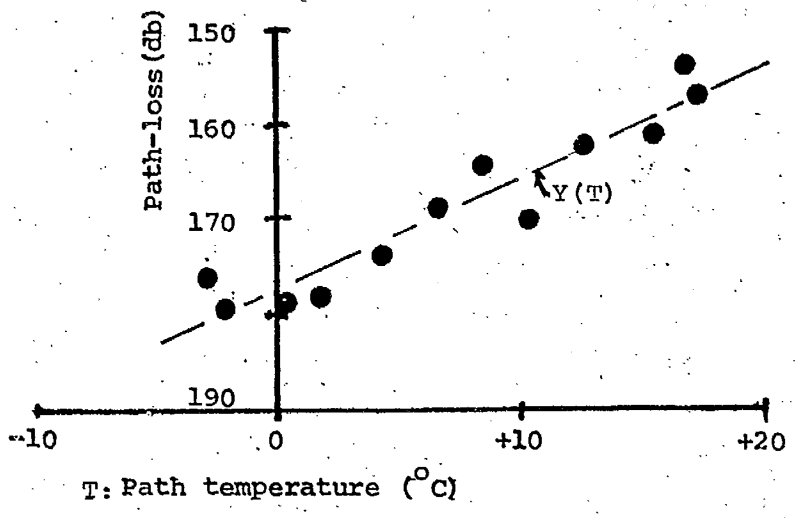
Figure 6-5

Figure 6-6: Dependence of average monthly path-loss on average monthly path-temperature. The two VHF paths (147.950 and 147.995 MHz) as well as the UHF (431.950 MHz) are shown. For the purposes of this Report, the data-points are fitted (least squares method) to a straight line. The two VHF paths are described to within a few db by straight lines, although the UHF path does not correlate with a straight line in as satisfactory a manner. It is noted, however, that the UHF data represents only a one-year sample, whereas the VHF data represents an average over three years; in other words, it is being presumed that a larger sample at UHF would, in fact, correlate satisfactorily with a straight line. It is also noted that the slopes of the best-fit straight lines are approximately identical. Finally, it is noted that the data pertains to long-term averages values only; in other words, there is no observed indication in the data that the relationship between path-loss and path-temperature holds for shorter time scales (eg., for a period of an hour at some arbitaray time of the year).

Figure 6-6

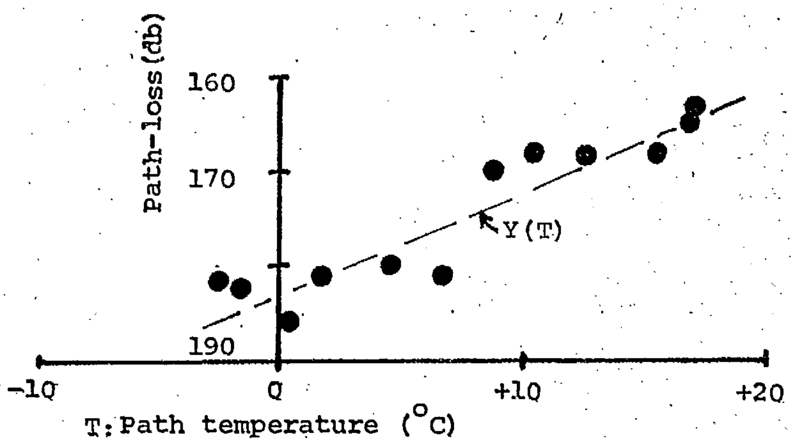
Average monthly path-loss dependence on average monthly path-temperature

First-order approximation



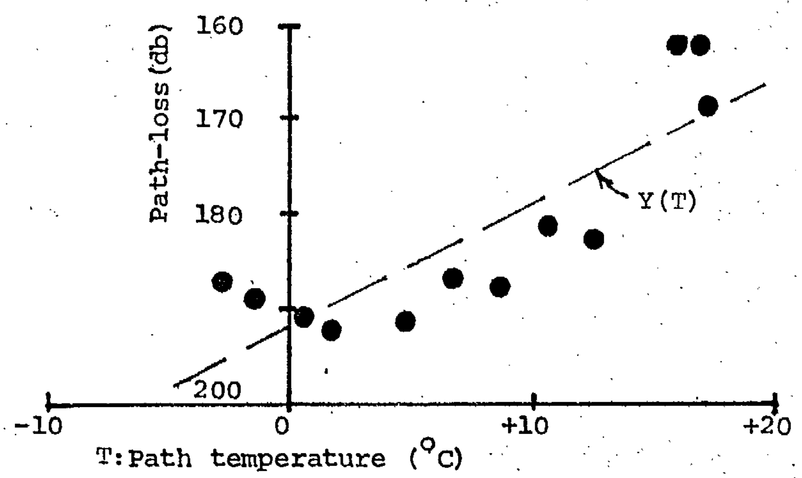
Sable to Seaview (147.995 MHz)
1981-3

$Y(T)=177-1.15T$ db



Sable to Halifax (147.950 MHz)
1981-3

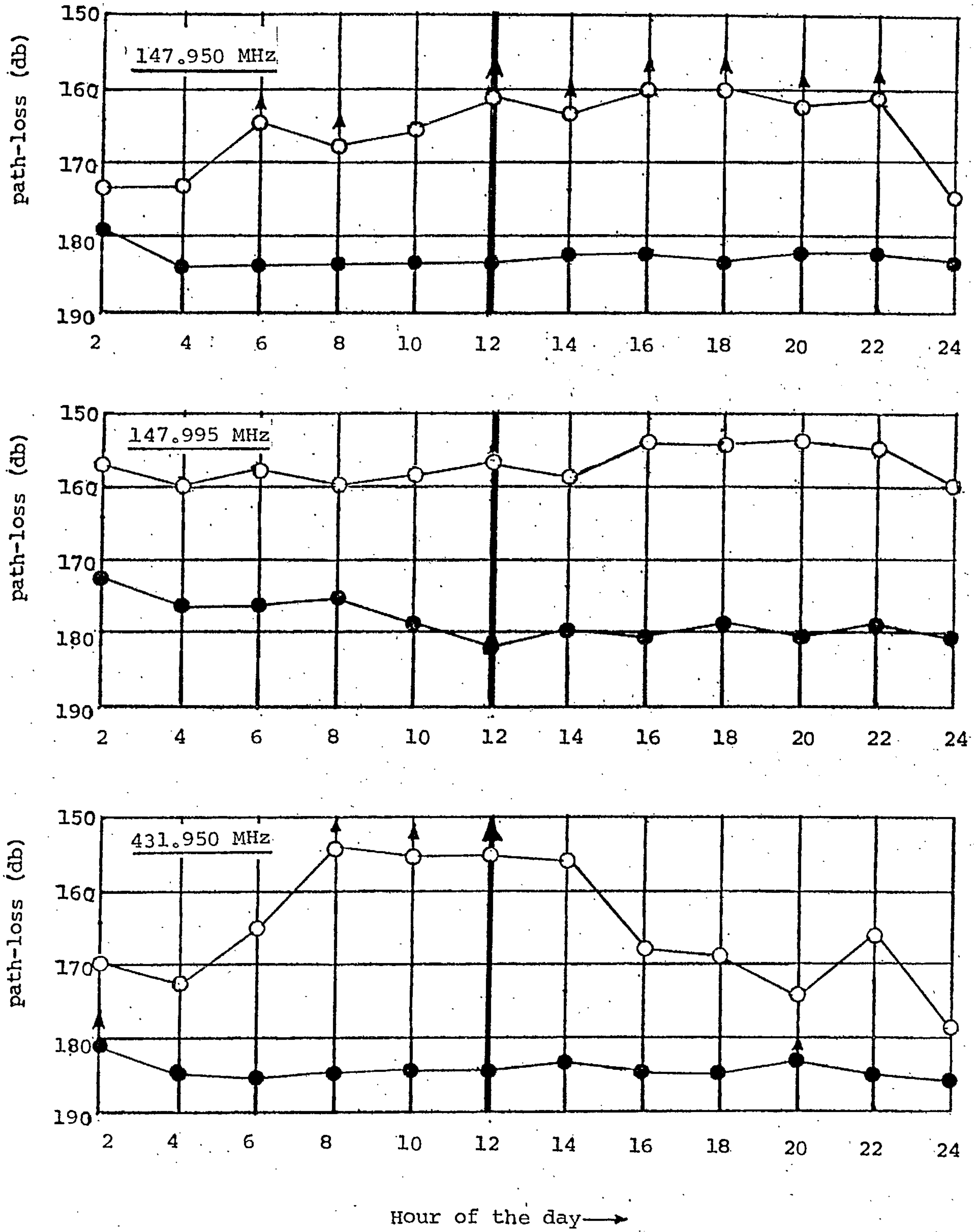
$Y(T)= 182.6-1.03T$ db



Sable to Halifax (431.950 MHz)
1983

$Y(T)= 192-1.28T$ db

Figure 6-7: Diurnal (24-hour day) variations in path-loss for the extremum months (February and August) of the year, for the paths associated with 147.950, 147.995, and 431.950 MHz. The open circles represent average values for August, and the closed circles pertain to February.



Note: The arrows indicate that the path-loss is actually smaller, but the amount is not known.

Conclusions

In general, it is concluded that:

1. The long-term median path-loss for the paths and frequencies discussed in this Report are predicted by the forward-scattering model in NBS-101 to within a few db.

2. The monthly variations in the path-loss display the expected seasonal dependence (i.e. maximum path-loss in mid-winter and minimum in mid-summer).

3. Differential path-loss (i.e. dependence of path-loss on polarization) appears to be in the order of 3 db or so for VHF, and less than this for UHF. (Note: this is a highly tentative conclusion).

4. Prospects for long-term improvements based on diversity configurations, involving two-element frequency and/or space diversity schemes, appear to be quite negligible.

5. Diurnal (24-hour day) variations for the extremum months (February and August) indicate that the variations (if any) during February are less than 2 or 3 db for all frequencies, but that during August, the variations can be significant.

Figure A-1: Print-out of calculations pertaining to the Sable-to-Mainland paths on 148 MHz, for the indicated system-parameters. (from C.R.C.)

```
EDIT LONC
EDIT B03 HERE
*TY
     1.000 TX:*SABLE                    *LAT:   .00000  LONG:    .00000
     2.000 RX:*MAINLAND                 *LAT:   .00000  LONG:    .00000
     3.000
     4.000 COVERAGE:*RADL*      DISPLAY: *BOTH*
     5.000 PREDICT: *SIG *      PLOT DEV:*TEK *
     6.000 METHOD:  *DETL*      H/D PLOT:*NO  *
     7.000 PROFILE: *USER*      DIAGNOST:*NO  *
     8.000 PATH:    *TERR*
     9.000
    10.000 VARIABLES:    FIRST    LAST  INCREMENT
    11.000 AZIMUTH        .000    .000    .000
    12.000 DISTANCE     20.000 319.000  05.000
    13.000 FREQUENCY     148.0   148.0   148.0
    14.000 TX ANTENNA    30.00   30.00   30.00 }
    15.000 RX ANTENNA    50.00   50.00   50.00 } above sea-level
    16.000
    17.000 POLARIZATION:*H*
    18.000 TIME SIGNAL EXCEEDED: 50.000%        MONTH: 0 HOUR: 0
    19.000
    20.000 POWER:                  15.00 WATTS
    21.000 LINE LOSS:            TX  4.3 DB       RX  3.8 DB
    22.000 RX:       BANDWIDTH      .000 KHZ             .0 DB NOISE FIG
    23.000
    24.000 *K* FACTOR:             1.333
    25.000 GROUND:*SEA *   COND    5.000     PERM  80.000
    26.000
    27.000                           TX                RX
    28.000 CLUTTER:              *NONE *     *    **NONE *    *    *
    29.000 LOS TO CLUTTER         1000.0            1000.0
    30.000 HT ABOVE ANT               .0                .0
    31.000 DEPTH ALONG LOS            .0                .0
    32.000 EXT ACROSS LOS             .0                .0
    33.000
    34.000 USER-SPECIFIED CONTOURS;               NUMBER:  0
    35.000
    36.000 RX ANTENNA GAIN:          11.2 dbi
    37.000 TX ANTENNA AZIMUTH/GAIN(DB);           NUMBER:  1
    38.000       .0  11.2 dbi
    39.000
    40.000 INTERDECILE HEIGHT RANGE (METRES):            .0
    41.000 SITE ELEVATIONS:   TX-1000.0         RX-1000.0
    42.000 TERRAIN PROFILE, DIST/ELEV:
    43.000     .00      .0
    43.100    5.00      .0
    43.300   10.00      .1
    44.000  330.00      .0
    45.000                END OF FILE
    46.000 NOTE:  THE 'LINE LOSSES' ARE MADE UP OF 3 DB FOR THE ASSUMED
    47.000 50% ANTENNA EFFICIENCY, PLUS AN ASSUMED LINE LOSS FOR 160 FT
    48.000 OF 1/2" HELIAX AT SABLE AND 100 FT OF THE SAME ON THE MAINLAND
*   EOF HIT AFTER 48.000
*
```

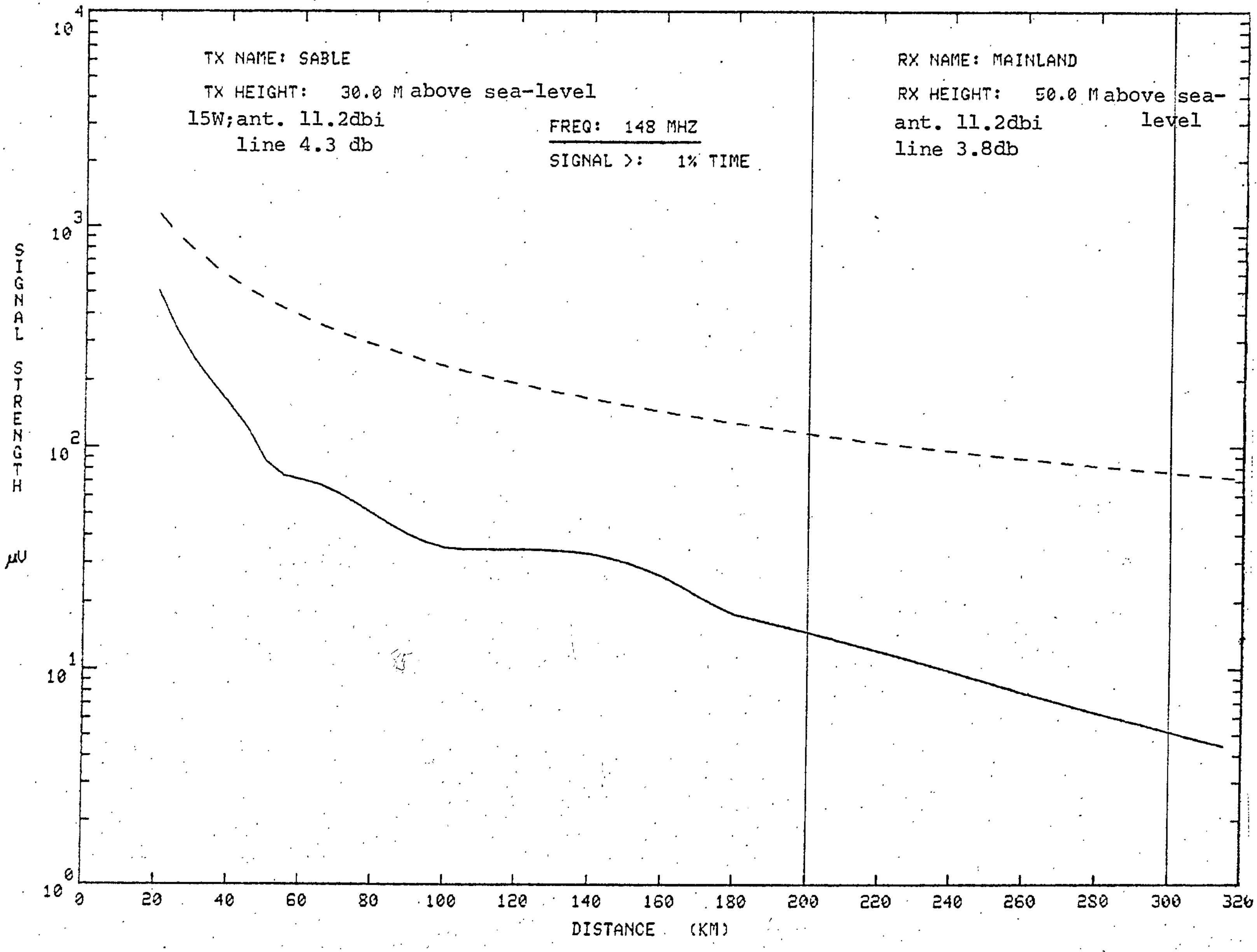


Figure A-2: Plot of calculations based on the system-parameters in Figure A-1, for a 1% probability that the ordinate is exceeded.

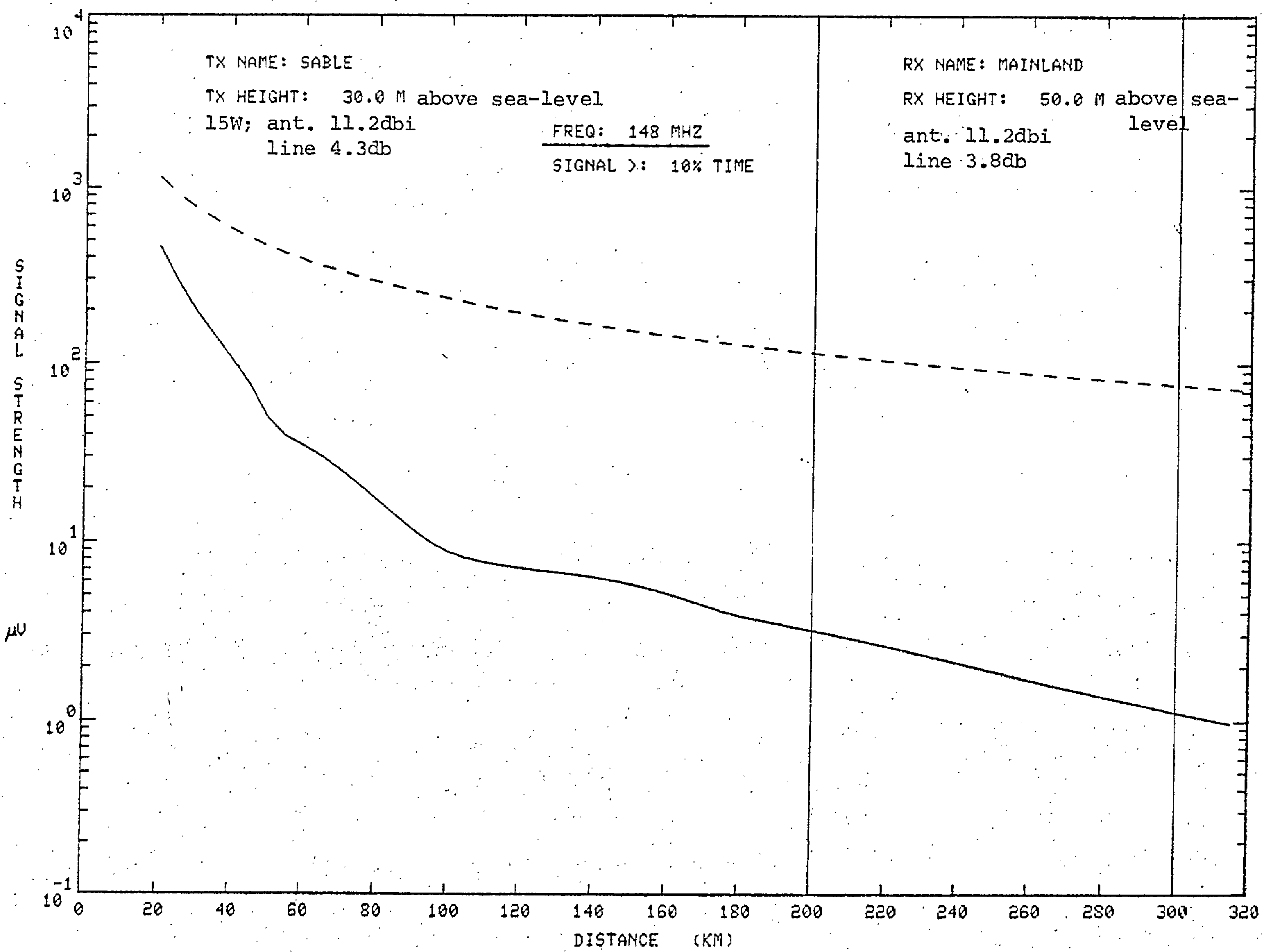


Figure A-3: Plot of calculations based on the system-parameters in Figure A-1, for a 10% probability that the ordinate is exceeded.

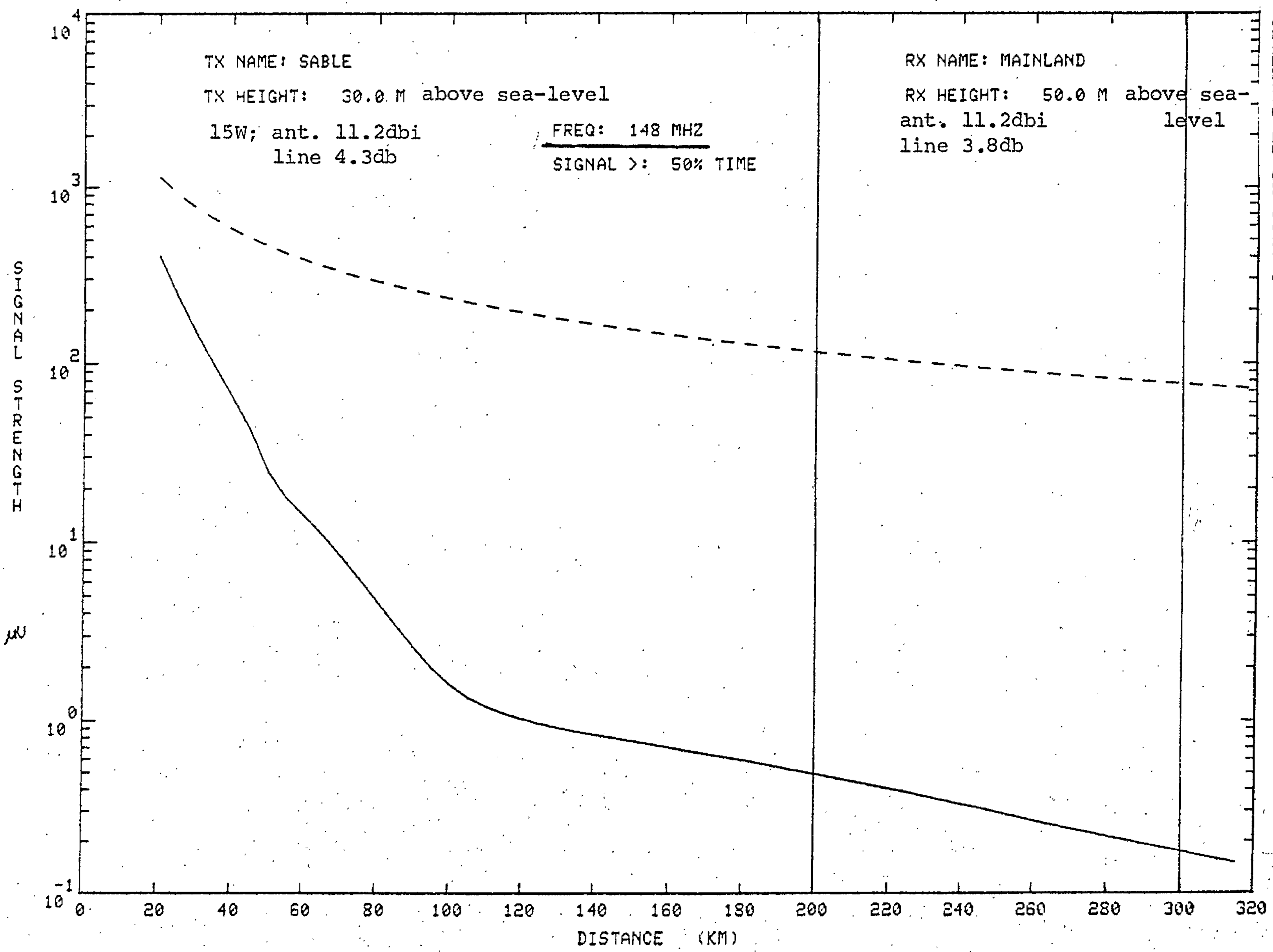


Figure A-4: Plot of calculations based on the system-parameters in Figure A-1, for a 50% probability that the ordinate is exceeded.

Figure A-5: Printout of calculations pertaining to the Sable-to-mainland paths on 148 MHz, for the indicated system-parameters. (from C.R.C.)

```
EDIT LONC148
EDIT B03 HERE
*TY
     1.000 TX:*SABLE                  *LAT:   .00000  LONG:    .00000
     2.000 RX:*MAINLAND               *LAT:   .00000  LONG:    .00000
     3.000
     4.000 COVERAGE:*RADL*      DISPLAY: *BOTH*
     5.000 PREDICT: *SIG *      PLOT DEV:*TEK *
     6.000 METHOD:  *DETL*      H/D PLOT:*NO  *
     7.000 PROFILE: *USER*      DIAGNOST:*NO  *
     8.000 PATH:    *TERR*
     9.000
    10.000 VARIABLES:    FIRST    LAST   INCREMENT
    11.000 AZIMUTH        .000     .000     .000
    12.000 DISTANCE     20.000  319.000   05.000
    13.000 FREQUENCY     148.0    148.0    148.0
    14.000 TX ANTENNA    20.00    20.00    20.00 } above sea-level
    15.000 RX ANTENNA    77.00    77.00    77.00 }
    16.000
    17.000 POLARIZATION:*H*
    18.000 TIME SIGNAL EXCEEDED: 50.000%        MONTH: 0 HOUR: 0
    19.000
    20.000 POWER:                     15.00 WATTS
    21.000 LINE LOSS:              TX  4.3 DB        RX  3.8 DB
    22.000 RX:        BANDWIDTH       .000 KHZ              .0 DB NOISE FIG
    23.000
    24.000 *K* FACTOR:                1.333
    25.000 GROUND:*SEA *    COND     5.000     PERM  80.000
    26.000
    27.000                              TX                RX
    28.000 CLUTTER:              *NONE *    *    **NONE *    *    *
    29.000 LOS TO CLUTTER          1000.0            1000.0
    30.000 HT ABOVE ANT                .0                .0
    31.000 DEPTH ALONG LOS             .0                .0
    32.000 EXT ACROSS LOS              .0                .0
    33.000
    34.000 USER-SPECIFIED CONTOURS;                NUMBER:   0
    35.000
    36.000 RX ANTENNA GAIN:           11.2 dbi
    37.000 TX ANTENNA AZIMUTH/GAIN(DB);            NUMBER:   1
    38.000       .0  11.2  dbi
    39.000
    40.000 INTERDECILE HEIGHT RANGE (METRES):                .0
    41.000 SITE ELEVATIONS:   TX-1000.0        RX-1000.0
    42.000 TERRAIN PROFILE, DIST/ELEV:
    43.000     .00       .0
    43.100    5.00       .0
    43.300   10.00       .1
    44.000  330.00       .0
    45.000                      END OF FILE
    46.000 NOTE:  THE 'LINE LOSSES' ARE MADE UP OF 3 DB FOR THE ASSUMED
    47.000 50% ANTENNA EFFICIENCY, PLUS AN ASSUMED LINE LOSS FOR 160 FT
    48.000 OF 1/2" HELIAX AT SABLE AND 100 FT OF THE SAME ON THE MAINLAND.
*   EOF hit after 48.000
*
```

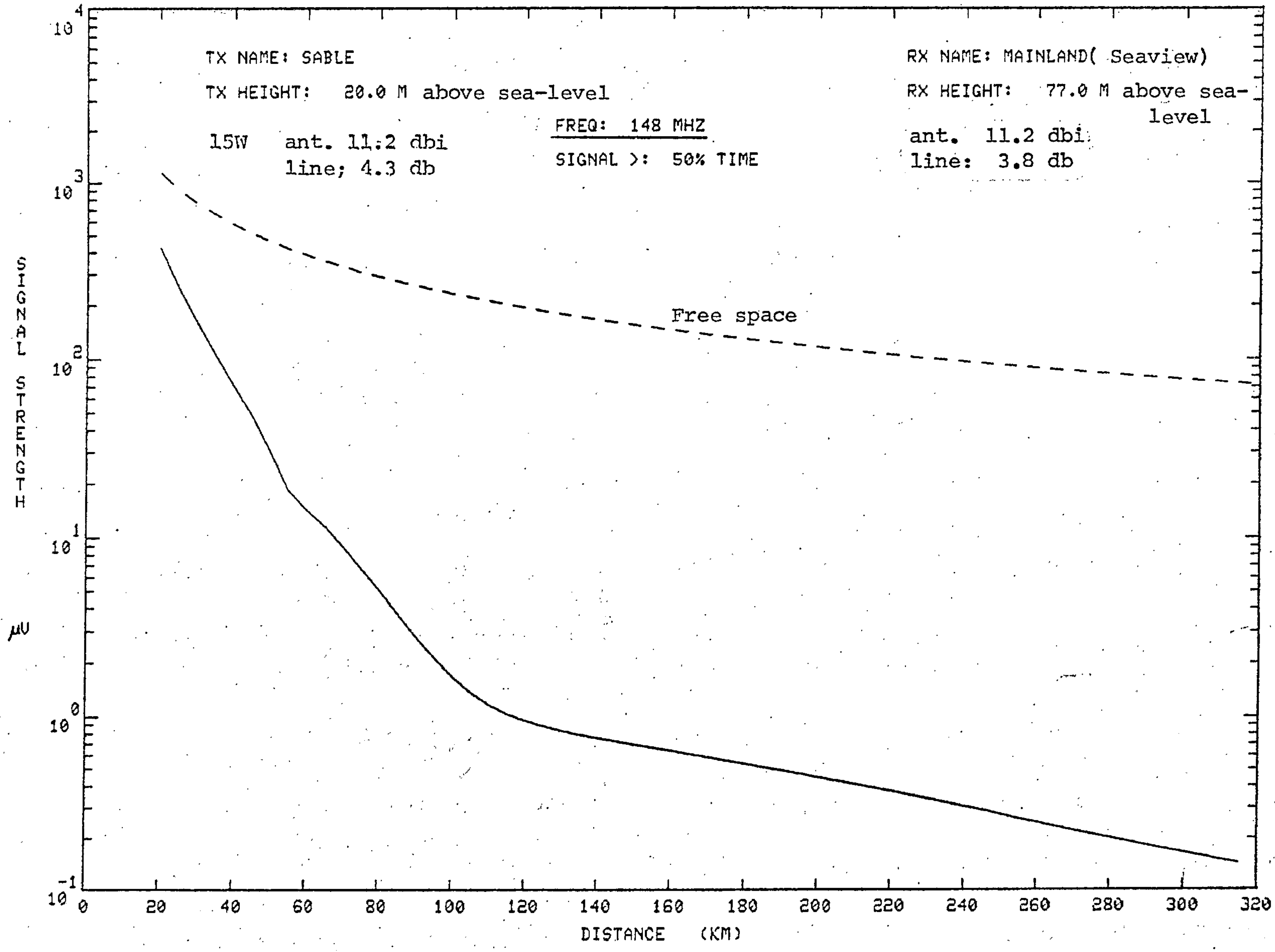


Figure A-6: Plot of calculations based on the system-parameters in Figure A-5, for a 50% probability that the ordinate is exceeded.

Figure A-7: Printout of calculations pertaining to the Sable to mainland path on 431.950 MHz, for the indicated system-parameters. (from C.R.C.)

```
EDIT LONC
EDIT BO3 HERE
*TY
     1.000 TX:*SABLE                   *LAT:  .00000  LONG:    .00000
     2.000 RX:*MAINLAND                *LAT:  .00000  LONG:    .00000
     3.000
     4.000 COVERAGE:*RADL*      DISPLAY: *BOTH*
     5.000 PREDICT: *SIG *      PLOT DEV:*TEK *
     6.000 METHOD:  *DETL*      H/D PLOT:*NO  *
     7.000 PROFILE: *USER*      DIAGNOST:*NO  *
     8.000 PATH:    *TERR*
     9.000
    10.000 VARIABLES:    FIRST    LAST   INCREMENT
    11.000 AZIMUTH         .000     .000     .000
    12.000 DISTANCE      20.000  319.000   05.000
    13.000 FREQUENCY      432.0    432.0    432.0
    14.000 TX ANTENNA     30.00    30.00    30.00 } above sea-level
    15.000 RX ANTENNA     50.00    50.00    50.00 }
    16.000
    17.000 POLARIZATION:*H*
    18.000 TIME SIGNAL EXCEEDED: 50.000%        MONTH: 0 HOUR: 0
    19.000
    20.000 POWER:                        15.00 WATTS
    21.000 LINE LOSS:                TX   5.6 DB       RX  4.6 DB
    22.000 RX:         BANDWIDTH         .000 KHZ            .0 DB NOISE FIG
    23.000
    24.000 *K* FACTOR:                  1.333
    25.000 GROUND:*SEA *    COND       5.000     PERM  80.000
    26.000
    27.000                               TX                  RX
    28.000 CLUTTER:                *NONE *     *   **NONE *     *    *
    29.000 LOS TO CLUTTER             1000.0             1000.0
    30.000 HT ABOVE ANT                   .0                 .0
    31.000 DEPTH ALONG LOS                .0                 .0
    32.000 EXT ACROSS LOS                 .0                 .0
    33.000
    34.000 USER-SPECIFIED CONTOURS:               NUMBER:    0
    35.000
    36.000 RX ANTENNA GAIN:              20.2 dbi
    37.000 TX ANTENNA AZIMUTH/GAIN(DB):           NUMBER:    1
    38.000          .0  20.2 dbi
    39.000
    40.000 INTERDECILE HEIGHT RANGE (METRES):                .0
    41.000 SITE ELEVATIONS:    TX-1000.0       RX-1000.0
    42.000 TERRAIN PROFILE, DIST/ELEV:
    43.000      .00       .0
    43.100     5.00       .0
    43.300    10.00       .1
    44.000   330.00       .0
    45.000                      END OF FILE
    46.000 NOTE:  THE 'LINE LOSSES' ARE MADE UP OF 3 DB FOR THE ASSUMED
    47.000 50% ANTENNA EFFICIENCY, PLUS AN ASSUMED LINE LOSS FOR 160 FT
    48.000 OF 1/2" HELIAX AT SABLE AND 100 FT OF THE SAME ON THE MAINLAND
*   EOF hit after 48.000
*
```

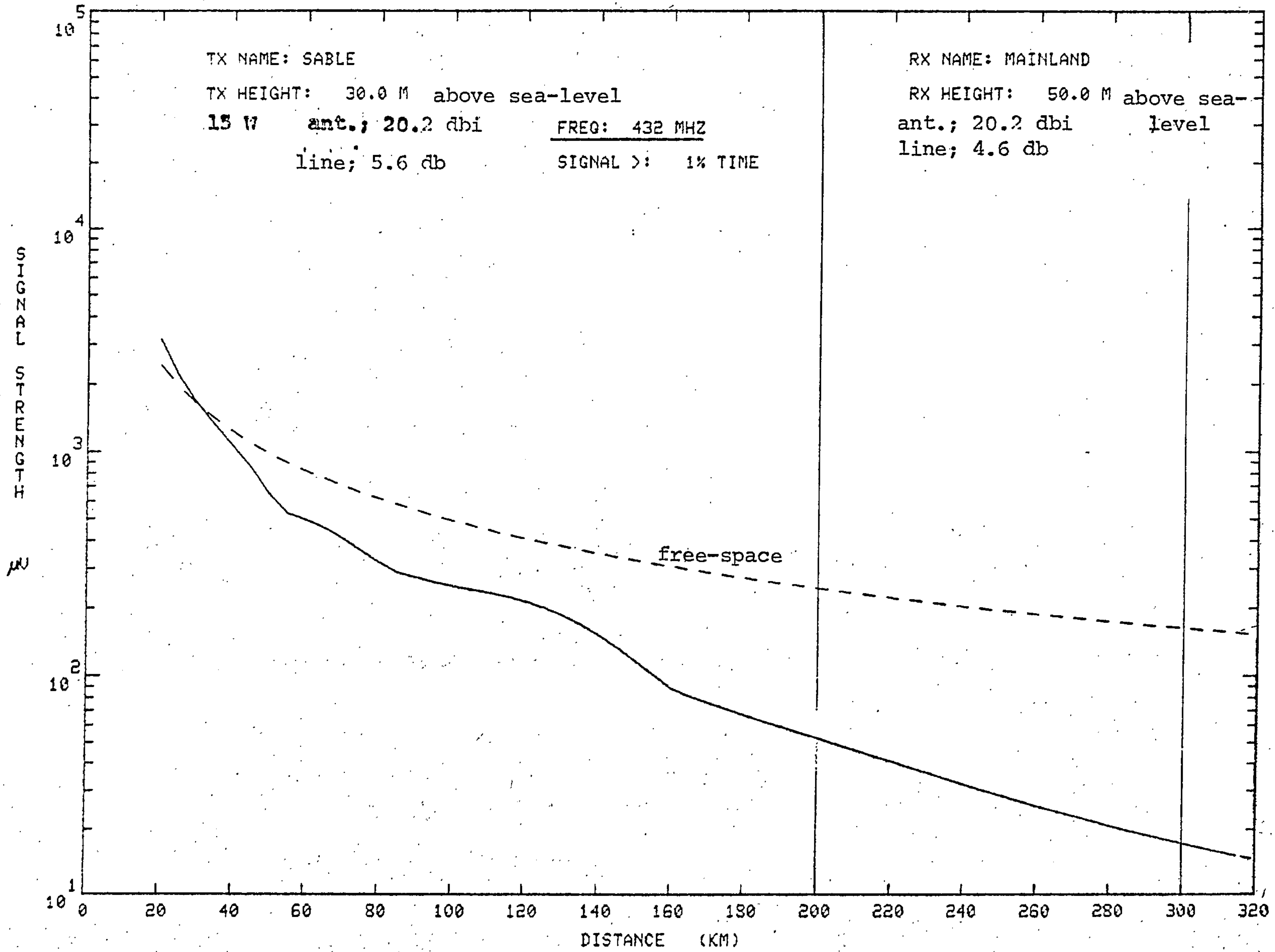


Figure A-8: Plot of calculations based on the system-parameters in Figure A-7, for a 1% probability that the ordinate is exceeded.

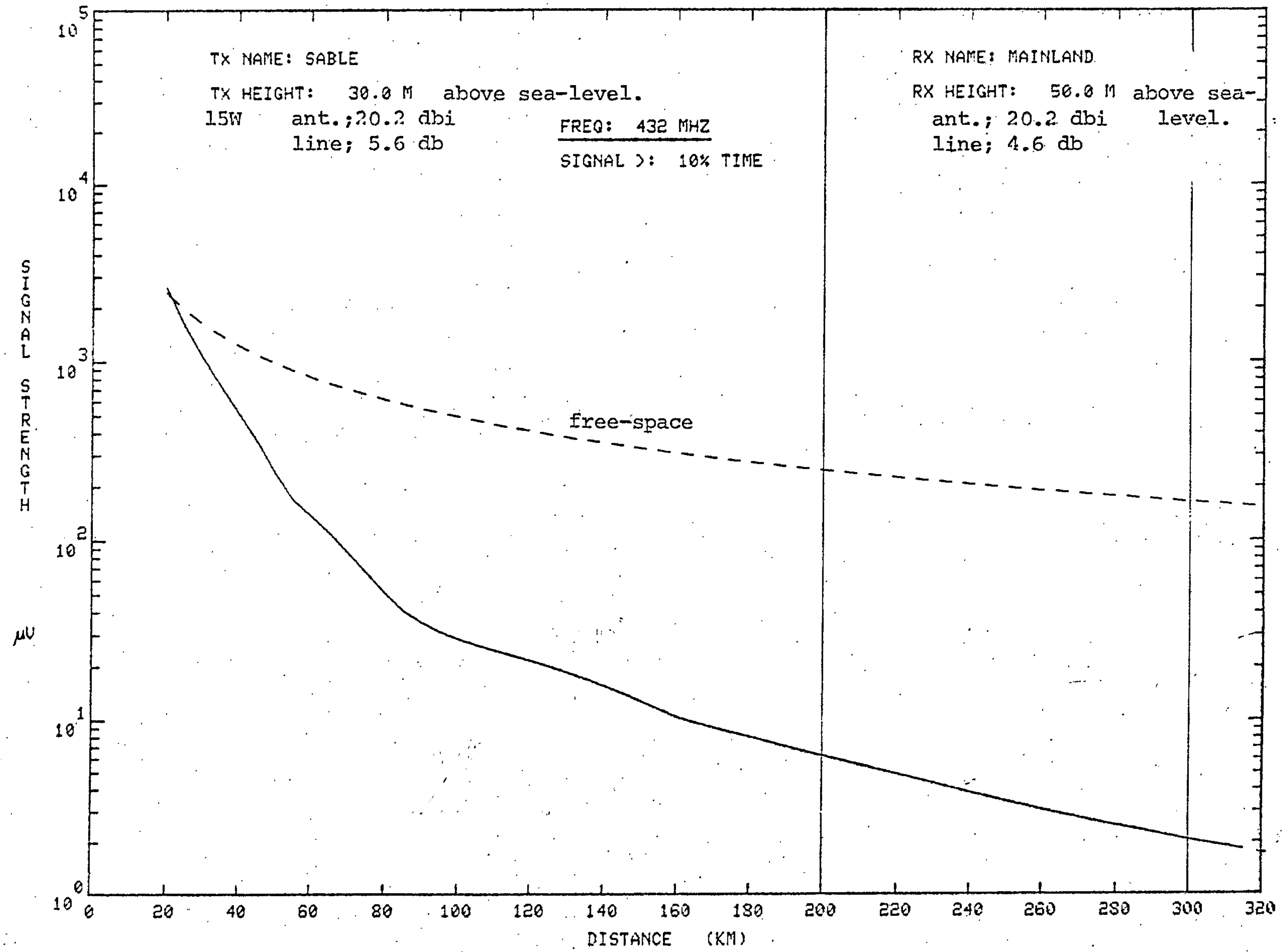


Figure A-9: Plot of calculations based on the system-parameters in Figure A-7, for a 10% probability that the ordinate is exceeded.

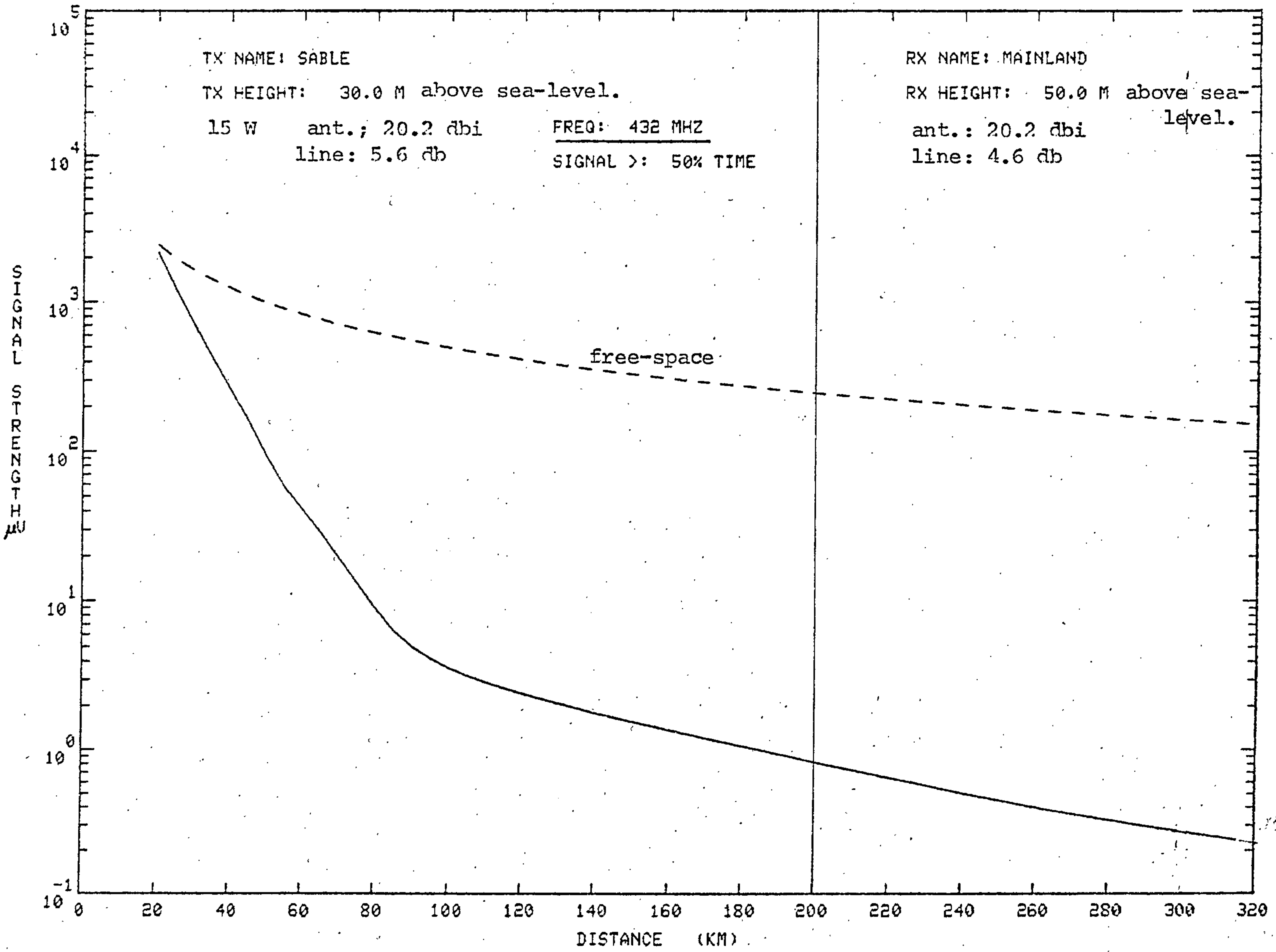


Figure A-10: Plot of calculations based on the system-parameters in Figure A-7, for a 50% probability that the ordinate is exceeded.

Figure A-11: Printout of calculations pertaining to the Sable-to-mainland path on 431.950 MHz, for the indicated system-parameters. (from C.R.C.)

```
EDIT LONC432
*TY
    1.000 TX:*SABLE                  *LAT:  .00000  LONG:   .00000
    2.000 RX:*MAINLAND               *LAT:  .00000  LONG:   .00000
    3.000
    4.000 COVERAGE:*RADL*     DISPLAY: *BOTH*
    5.000 PREDICT: *SIG *     PLOT DEV:*TEK *
    6.000 METHOD:  *DETL*     H/D PLOT:*NO  *
    7.000 PROFILE: *USER*     DIAGNOST:*NO  *
    8.000 PATH:    *TERR*
    9.000
   10.000 VARIABLES:   FIRST    LAST   INCREMENT
   11.000 AZIMUTH        .000     .000     .000
   12.000 DISTANCE     20.000  319.000   05.000
   13.000 FREQUENCY     432.0    432.0    432.0
   14.000 TX ANTENNA    30.00    30.00    30.00 } above sea-level
   15.000 RX ANTENNA    60.00    60.00    60.00 }
   16.000
   17.000 POLARIZATION:*H*
   18.000 TIME SIGNAL EXCEEDED: 50.000%       MONTH: 0 HOUR: 0
   19.000
   20.000 POWER:                      10.00 WATTS
   21.000 LINE LOSS:               TX  5.6 DB       RX  4.6 DB
   22.000 RX:       BANDWIDTH        .000 KHZ            .0 DB NOISE FIG
   23.000
   24.000 *K* FACTOR:                1.333
   25.000 GROUND:*SEA *   COND       5.000     PERM  80.000
   26.000
   27.000                             TX                RX
   28.000 CLUTTER:              *NONE *    *    **NONE *    *    *
   29.000 LOS TO CLUTTER          1000.0            1000.0
   30.000 HT ABOVE ANT                .0                .0
   31.000 DEPTH ALONG LOS             .0                .0
   32.000 EXT ACROSS LOS              .0                .0
   33.000
   34.000 USER-SPECIFIED CONTOURS:           NUMBER:  0
   35.000
   36.000 RX ANTENNA GAIN:           18.0 dbi
   37.000 TX ANTENNA AZIMUTH/GAIN(DB):       NUMBER:  1
   38.000       .0  18.0 dbi
   39.000
   40.000 INTERDECILE HEIGHT RANGE (METRES):          .0
   41.000 SITE ELEVATIONS:   TX-1000.0        RX-1000.0
   42.000 TERRAIN PROFILE, DIST/ELEV:
   43.000     .00      .0
   43.100    5.00      .0
   43.300   10.00      .1
   44.000  330.00      .0
   45.000                        END OF FILE
   46.000 NOTE:  THE 'LINE LOSSES' ARE MADE UP OF 3 DB FOR THE ASSUMED
   47.000 50% ANTENNA EFFICIENCY, PLUS AN ASSUMED LINE LOSS FOR 160 FT
   48.000 OF 1/2" HELIAX AT SABLE AND 100 FT OF THE SAME ON THE MAINLAND.
*   EOF hit after 48.000
*
```

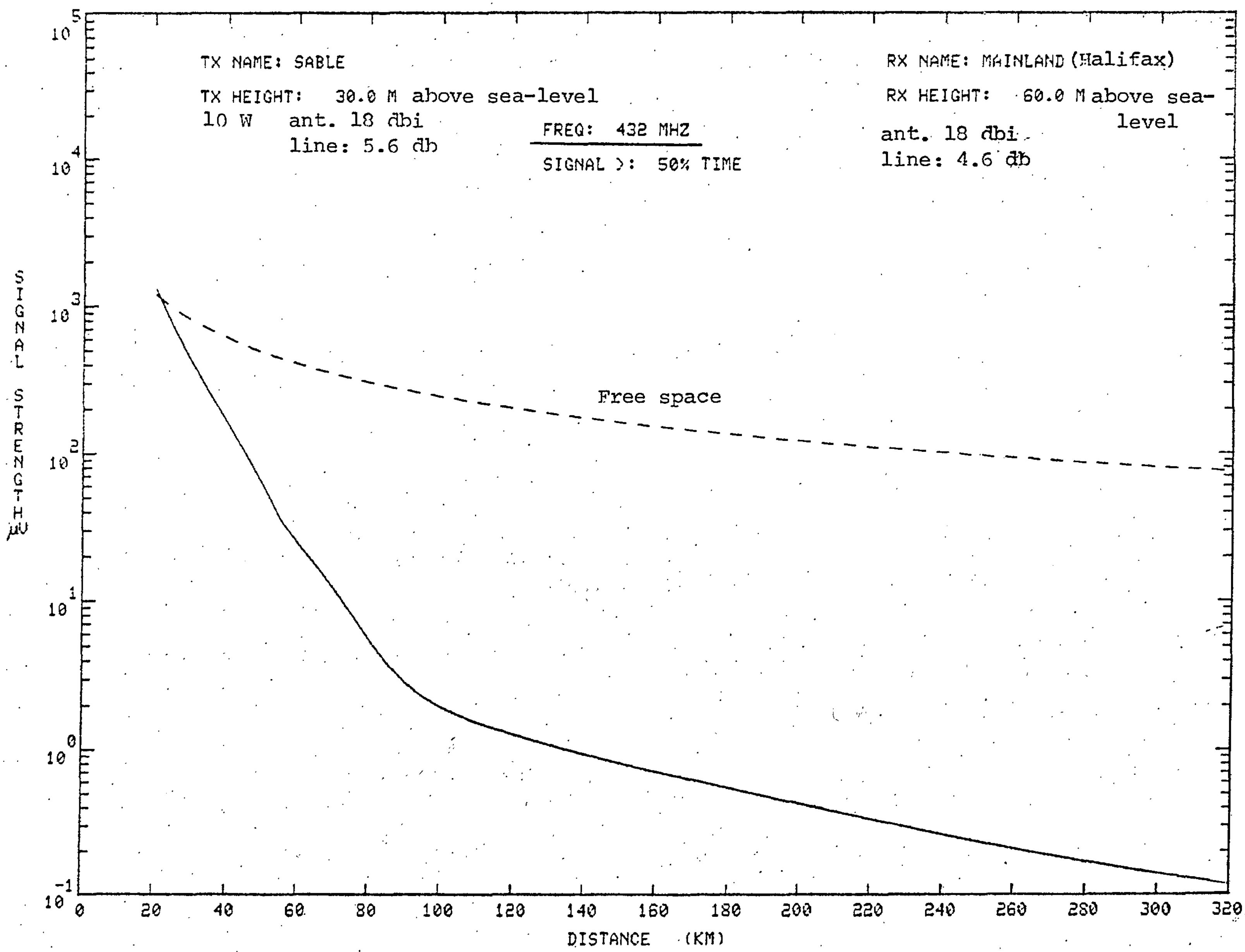


Figure A-12: Plot of calculations based on the system-parameters in Figure A-11, for a 50% probability that the ordinate is exceeded.

Figure B-1: Coordinates, elevations, and great-circle distances pertaining to the various sites. (from C.R.C.)

COORDINATES FOR SABLE ISLAND PROPAGATION PATHS

Antenna site on Sable Island

Geographic	43 45 00 N		60 03 00 W
UTM	zone 21	255.1 km E,	4868.8 km N
Elevation of ground:	3 m? 5 m?		

Halifax SMU

Geographic	44 37 50 N		63 35 00 W
UTM	zone 20	453.8 km E,	4942.0 km N
Elevation of ground:	29 m		

Seaview

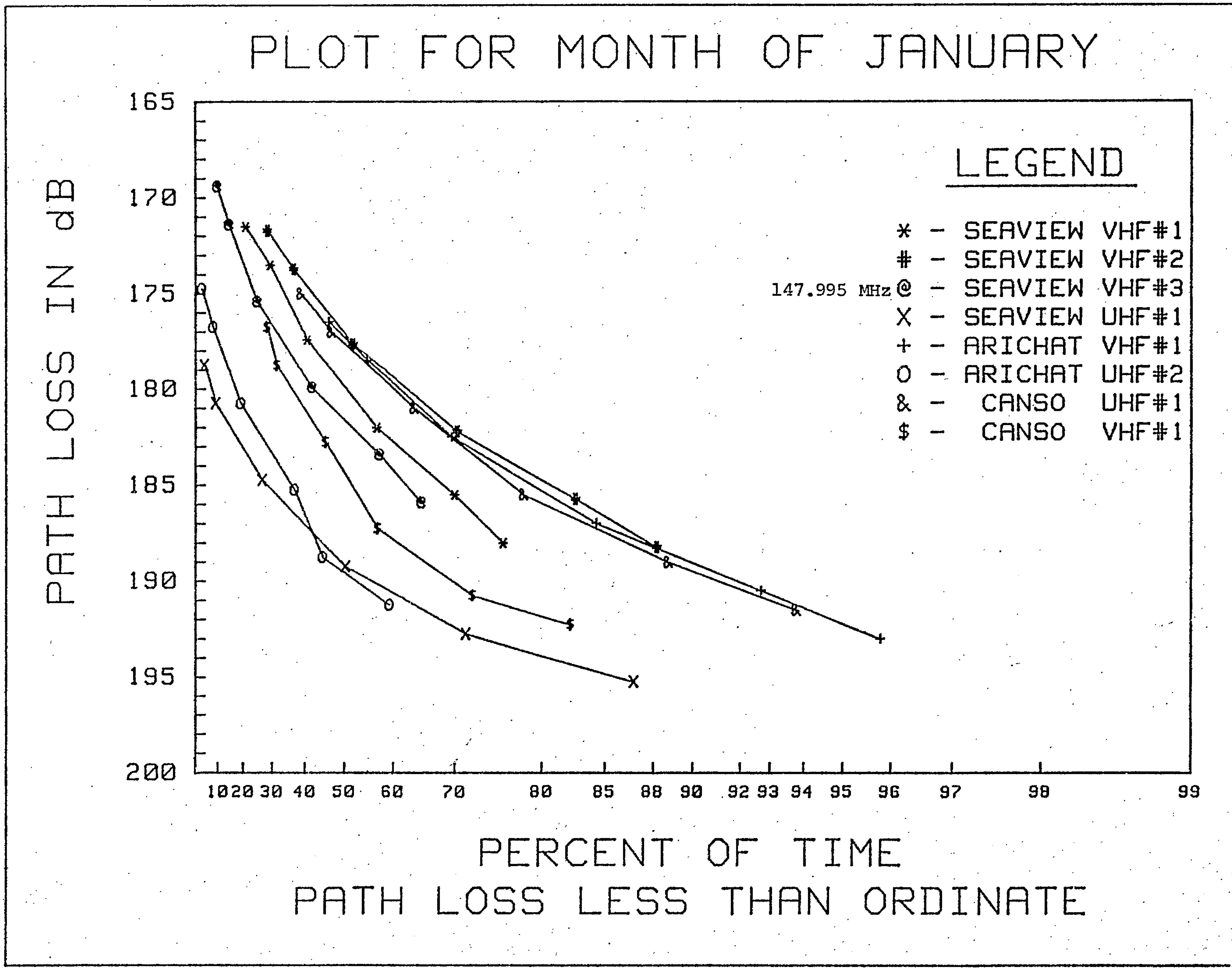
Geographic	45 41 00 N		60 57 50 W
UTM	zone 20	658.5 km E,	5060.5 km N
Elevation of ground:	62 m		

Arichat

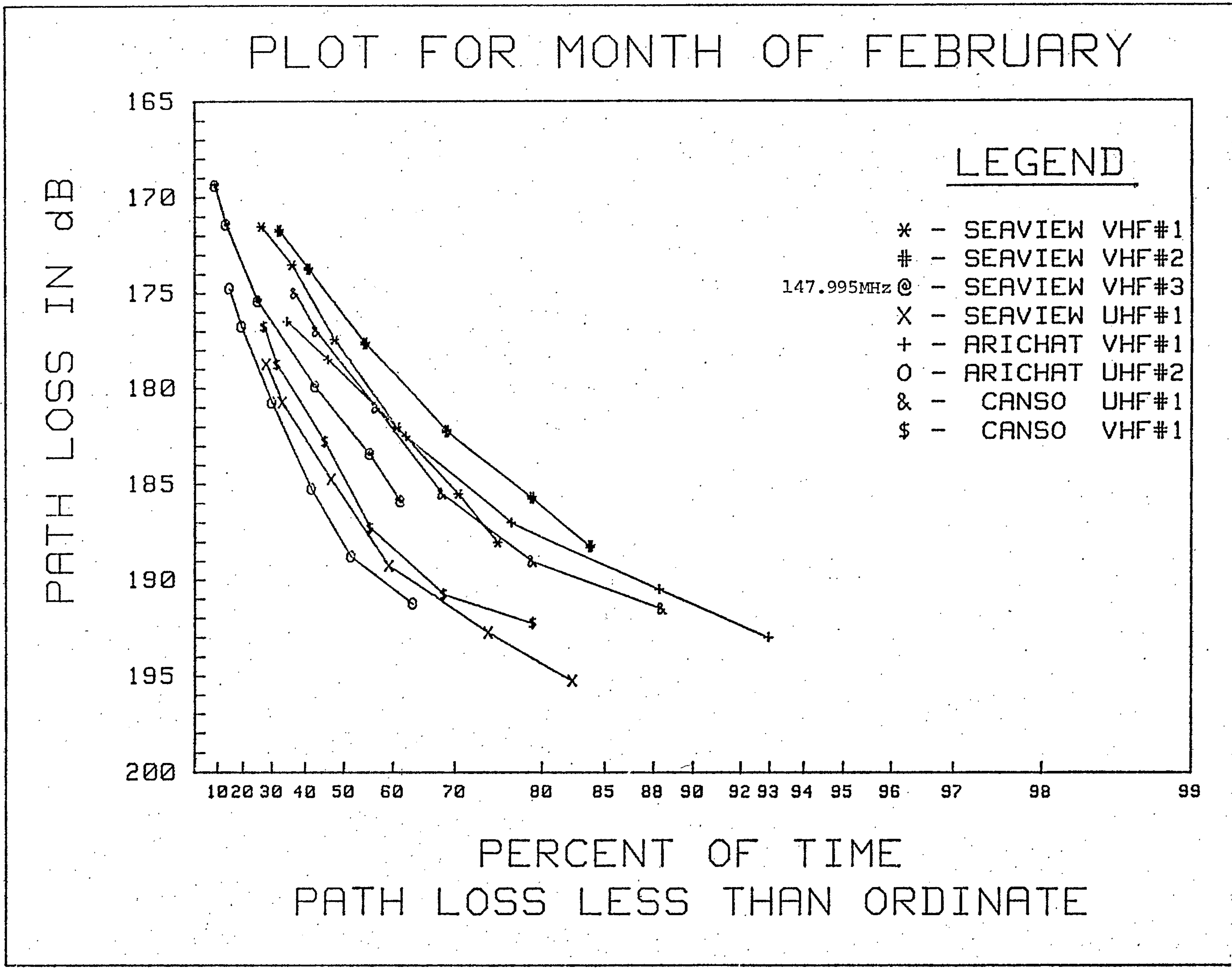
Geographic	45 31 00 N		61 00 50 W
UTM	zone 20	655.0 km E,	5041.9 km N
Elevation of ground:	27 m		

Great-Circle paths, from coordinates given above:

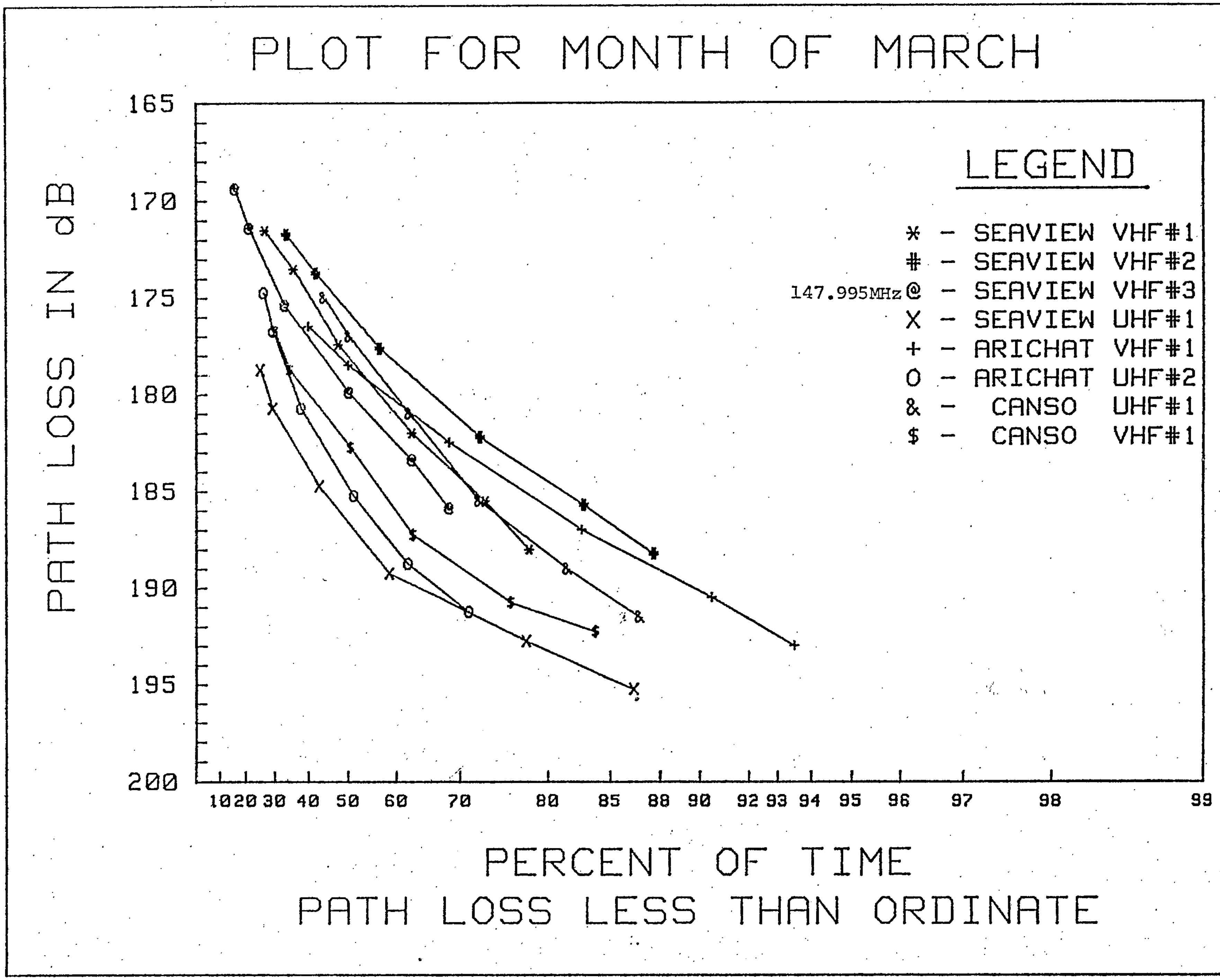
	GC Distance	Azimuth from mainland	Azimuth from Sable
Halifax SMU	292 km	104°	-73°
Seaview	207 km	159°	-20°
Arichat	192 km	156°	-23°

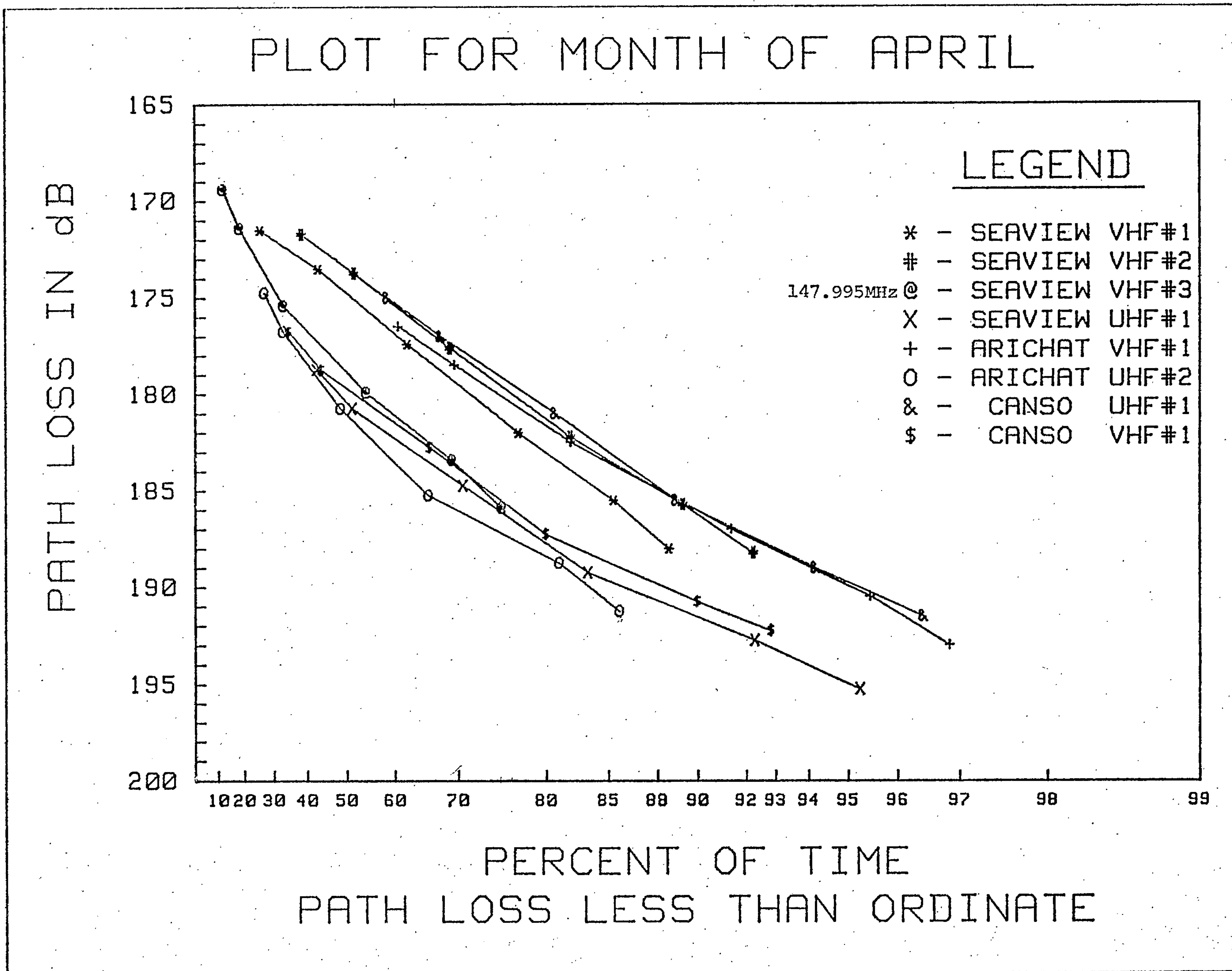


PLOT FOR MONTH OF JANUARY
LEGEND
* - SEAVIEW VHF#1
# - SEAVIEW VHF#2
147.995 MHz @ - SEAVIEW VHF#3
X - SEAVIEW UHF#1
+ - ARICHAT VHF#1
O - ARICHAT UHF#2
& - CANSO UHF#1
$ - CANSO VHF#1
PATH LOSS IN dB
165
170
175
180
185
190
195
200
10 20 30 40 50 60 70 80 85 88 90 92 93 94 95 96 97 98 99
PERCENT OF TIME
PATH LOSS LESS THAN ORDINATE


PLOT FOR MONTH OF FEBRUARY
PATH LOSS IN dB
165
170
175
180
185
190
195
200
LEGEND
* - SEAVIEW VHF#1
# - SEAVIEW VHF#2
147.995MHz @ - SEAVIEW VHF#3
X - SEAVIEW UHF#1
+ - ARICHAT VHF#1
O - ARICHAT UHF#2
& - CANSO UHF#1
$ - CANSO VHF#1
10 20 30 40 50 60 70 80 85 88 90 92 93 94 95 96 97 98 99
PERCENT OF TIME
PATH LOSS LESS THAN ORDINATE

P.C-2


PLOT FOR MONTH OF MARCH
PATH LOSS IN dB
165
170
175
180
185
190
195
200
LEGEND
* - SEAVIEW VHF#1
# - SEAVIEW VHF#2
147.995MHz @ - SEAVIEW VHF#3
X - SEAVIEW UHF#1
+ - ARICHAT VHF#1
O - ARICHAT UHF#2
& - CANSO UHF#1
$ - CANSO VHF#1
10 20 30 40 50 60 70 80 85 88 90 92 93 94 95 96 97 98 99
PERCENT OF TIME
PATH LOSS LESS THAN ORDINATE


PLOT FOR MONTH OF APRIL
PATH LOSS IN dB
165
170
175
180
185
190
195
200
LEGEND
* - SEAVIEW VHF#1
# - SEAVIEW VHF#2
147.995MHz @ - SEAVIEW VHF#3
X - SEAVIEW UHF#1
+ - ARICHAT VHF#1
O - ARICHAT UHF#2
& - CANSO UHF#1
$ - CANSO VHF#1
10 20 30 40 50 60 70 80 85 88 90 92 93 94 95 96 97 98 99
PERCENT OF TIME
PATH LOSS LESS THAN ORDINATE

DATE DUE
DATE DE RETOUR

APR AVR - 9 1985			
APR AVR 17 1985			
FEB FEV 19 1992			
OCT 22 2003			

LOWE-MARTIN No. 1137