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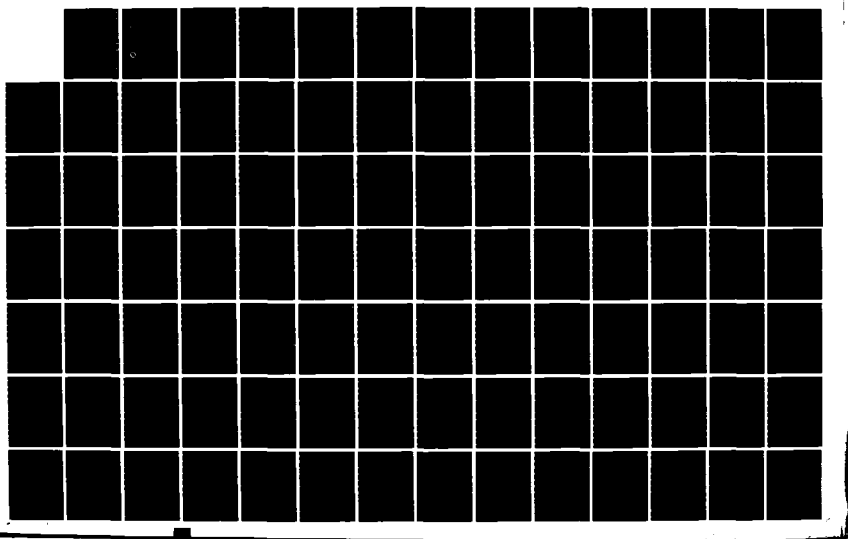

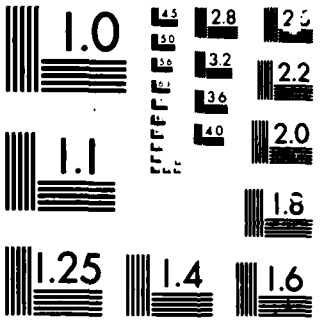

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Connecticut ELF Field-Strength Measurements, August to December 1977 and July to September 1978

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Preface

This report was prepared under NUSC Project No. A59007, "ELF Propagation RDT&E" (U), Principal Investigator, P. R. Bannister (Code 3411), Navy Program Element No. 11401N and Project No. XD792, Space and Naval Warfare Systems Command (SPAWARSYSCOM), Capt. R. Koontz (Code PDW 110-3), Program Manager ELF Communications.

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From August 1976 to September 1978, extremely low frequency (ELF) field-strength measurements were taken continuously in Connecticut. The results of measurements taken from August to December 1977 and from July to September 1978 are discussed in this report. The principal result is that, for the 2 year period of August 1976 to September 1978, amplitude peak-to-trough variations of 5 dB, or greater, were observed 25 percent of the time.

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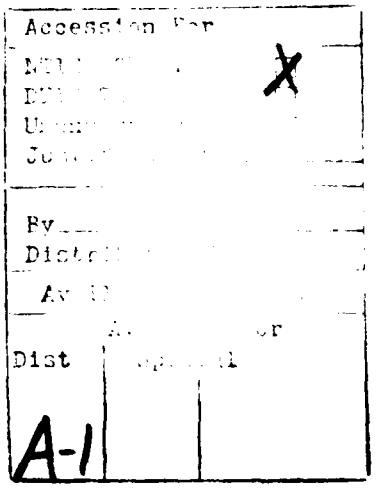

GLOSSARY OF ABBREVIATIONS

ELF	Extremely low frequency
EW	East-west
GMT	Greenwich Mean Time
NS	North-south
NUSC	Naval Underwater Systems Center
SRTP	Sunrise transition period
SSTP	Sunset transition period
STIU	Signal timing and interface unit
TEM	Transverse electromagnetic
VLF	Very low frequency
WTF	Wisconsin Test Facility

CONNECTICUT ELF FIELD-STRENGTH MEASUREMENTS, AUGUST TO DECEMBER 1977 AND JULY TO SEPTEMBER 1978

INTRODUCTION

Since June 1970, we have made extremely low frequency (ELF) measurements of the transverse horizontal magnetic field strength, H_ϕ, received in Connecticut.[1-15] The local measurement site from June 1970 to October 1971 was in the Nehantic State Forest, East Lyme, CT. From October 1971 through November 1975, it was located in Hammonassett State Park, Madison, CT. Since July 1976, the ELF receiver has been located at the Naval Underwater Systems Center (NUSC), at New London, CT. The loop receiving antenna is now located at Fishers Island, NY, about 10 km from New London. The receiver and receiving antenna are connected by means of a microwave link from Fishers Island to New London. The AN/BSR-1 receiver is composed of an AN/UYK-20 minicomputer, a signal-timing and interface unit (STIU), a rubidium frequency time standard, two magnetic-tape recorders, and a preamplifier.

The transmission source for these farfield (1.6-Mm range) measurements is the U.S. Navy's ELF Wisconsin Test Facility (WTF), located in the Chequamegon National Forest in north-central Wisconsin, about 8 km south of the village of Clam Lake. The WTF consists of two 22.5-km antennas. One antenna is located approximately in the north-south (NS) direction and one antenna is located approximately in the east-west (EW) direction. Each antenna is grounded at both ends. At 76 Hz, the electrical axis of the NS antenna is 14 deg east of north, while the electrical axis of the EW antenna is 114 deg east of north. The WTF array can be steered electrically toward any particular location and its radiated power is approximately 1 W.

This report is the last in a series[8-14] dealing with Connecticut H_ϕ measurements during 1977 and 1978. Here, we will discuss the results of the August to December 1977 and July to September 1978 measurements, which were taken to investigate further the diurnal and seasonal ELF propagation variations. Future reports will discuss Connecticut H_ϕ measurements taken from 1982 to 1984 as well as selected vertical electric field, E_V, and radial magnetic field, H_ρ, measurements.

AUGUST 1977 MEASUREMENTS

During August 1977, data were obtained on 16 days at the Connecticut site. The daily plots of signal strength (both amplitude and relative phase) versus Greenwich Mean Time (GMT), in 30-min increments, are presented in appendix A. The data are broken into four time periods that are representative of nighttime, sunrise transition period (SRTP), daytime, and sunset transition period (SSTP) propagation conditions. From 13 to 17 August, the WTF antenna array-phasing angle, ψ, was 21 deg. During the rest of the month, ψ was 291 deg. The transmitting frequency was 76 ±4 Hz.

Listed in table 1* are the August 1977 Connecticut daily field-strength averages. For a WTF antenna array-phasing angle of 291 deg, the average Connecticut field strength should equal -143.3 dBA/m during the day, -144.4 dBA/m during the transition periods, and -145.5 dBA/m at night.[7] For ψ = 21 deg, the values should be 0.7 dB lower. Referring to table 1 and to the figures in appendix A, we see that, with the exception of levels for the minimum nighttime field-strength period, the average field-strength levels are about as expected.

The average August night-to-day relative-phase variation, $\Delta\phi$, was 23.3 deg, which corresponds to an average difference in the night-to-day relative-phase velocity ratio, $\Delta(c/v)$, of 0.16 (i.e., if the daytime value of c/v was 1.25, the nighttime value should equal 1.09). Amplitude peak-to-trough variations of 5 dB, or greater, occurred during 6 of the 16 measurement days (7, 8, 9, 11, 28, and 30 August). The largest variations (7.5 to 8.5 dB) occurred on 7 and 8 August. These variations are illustrated in figure 1* and appendix A.

Referring to figure 1, we see that, on both 7 and 8 August, the field strength steadily decreased 7.5 to 8.5 dB from the beginning of the SSTP to 0730, then steadily increased 6 to 7 dB from 0730 to the beginning of the daytime measurement period (~1200). On 9 August, the SSTP field strength decreased 2 dB, then increased 3 dB. The field strength, then, rapidly decreased 6 dB during the nighttime period of 0200 to 0600 and steadily increased 6 dB from 0600 to 1200.

SEPTEMBER 1977 MEASUREMENTS

During September 1977, data were obtained on 16 days at the Connecticut site. The daily plots of signal strength (both amplitude and relative phase) versus GMT, in 30-min increments, are presented in appendix B. During September, the WTF antenna array-phasing angle was 291 deg and the transmitting frequency was 76 ±4 Hz.

Listed in table 2 are the September 1977 daily field-strength averages. For a WTF antenna array-phasing angle of 291 deg, the average Connecticut field strength should equal -143.3 dBA/m during the day, -144.4 dBA/m during the transition periods, and -145.5 dBA/m at night.[7] Referring to table 2 and to the figures in appendix B, we see that, with the exception of levels for the nighttime minimum field-strength period, the average field-strength levels are about as expected.

The average September night-to-day relative-phase variation was 22.3 deg, which corresponds to a $\Delta(c/v)$ value of approximately 0.15. Amplitude peak-to-trough variations of 5 dB, or greater, occurred during 10 of the 16 days that included a nighttime measurement period (2, 3, 4, 7, 8, 9, 14, 17, 25, and 26 September). The largest variations (8 to 9 dB) occurred on 2 and 3 September. These variations are illustrated in figure 2 and in appendix B.

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*All tables have been placed together, followed by all figures, at the end of this report or in the applicable appendix.

As was mentioned in a previous report,[13] for the 1-yr period of August 1976 to July 1977, 5 dB, or greater, signal-strength fades occurred during 26 percent of the measurement days that included a nighttime measurement period. The most frequent nighttime fading (45 to 50 percent) occurred during March and September. During March 1978, 5 dB, or greater, signal-strength fades again occurred during 45 to 50 percent of the measurement days.[14] Referring to table 2, we see that, during September 1977, the percentage of deep-fade occurrence was even greater (62.5 percent).

Presented in figure 2 is a comparison of the 2, 3, and 16 September field strengths. Here, we see that, on 16 September, the nighttime field strength varied by only about 1 dB. However, during both 2 and 3 September, the field strengths steadily decreased by 7 to 8 dB during the SSTP and nighttime measurement periods (with the exception of a 2 to 3 dB increase, and subsequent decrease, around 0500 to 0700). The field strength then rapidly increased by approximately 8 dB during the SRTP.

OCTOBER 1977 MEASUREMENTS

During October 1977, data were obtained for 29 days at the Connecticut site. The daily plots of signal strength (both amplitude and relative phase) versus GMT are presented in appendix B of NUSC TR 6773.[11] The WTF antenna array-phasing angle was 291 deg from 2 through 17 October and 21 deg from 18 through 30 October. The transmitting frequency was 76 ±4 Hz.

Amplitude peak-to-trough variations of 5 dB, or greater, occurred during 7 of the first 11 October measurement days (2, 3, 4, 8, 9, 10, and 12 October). The largest variation (approximately 9 dB) occurred on 12 October. However, from 13 October until the end of October, there were zero days where the amplitude peak-to-trough variation was 5 dB or greater.[11]

The late-October measurement period is highlighted by the "Halloween effect." This effect has been observed for the past 7 consecutive years (1970 to 1976) during the period of 27 October to 1 November.[6,7] It is marked by an average drop in the ELF nighttime field strengths of 2 to 6 dB relative to the preceding or following nights.

Since the 26 to 28 October 1977 period was characterized by the greatest amount of magnetic-storm activity during October, we expected that the "Halloween effect" would be substantial. However, this year the effect reversed itself. During 26, 28, 29, and 30 October and 1 November, the average nighttime field strength was 1 to 1.5 dB higher than normal, and the average night-to-day relative-phase variation was 5 to 10 deg lower than normal.[11]

These two factors imply a decrease in the 26 October to 1 November 1977 nighttime reflection height of roughly 10 km. Because particle precipitation into the D region tends to increase ionization, making the ionosphere more "daylike" by lowering the effective reflection height and improving excitation, the 26 October to 1 November nighttime field-strength increases are as expected.

NOVEMBER 1977 MEASUREMENTS

During November 1977, data were obtained on 28 days at the Connecticut site. The daily plots of signal strength (both amplitude and relative phase) versus GMT, in 30-min increments, are presented in appendix C. From 1 to 9 November, the WTF antenna array-phasing angle, ψ, was 291 deg. During the rest of the month, ψ was 21 deg. The transmitting frequency was 76 ±4 Hz.

Listed in table 3 are the November 1977 Connecticut daily field-strength averages. For a WTF antenna array-phasing angle of 291 deg, the average Connecticut field strength should equal -143.3 dBA/m during the day, -144.4 dBA/m during the transition periods, and -145.5 dBA/m at night.[7] For ψ = 21 deg, the values should be 0.7 dB lower. Referring to table 3, we see that the average-daytime field strengths are about as expected, while the average transition-period and nighttime field strengths are about 0.5 dB higher.

The average November night-to-day relative-phase variation was 22.9 deg, which corresponds to a $\Delta(c/v)$ value of approximately 0.16. Amplitude peak-to-trough variations of 5 dB, or greater, occurred during zero of the 28 measurement days that included a nighttime measurement period. In fact, from 13 October until the end of November, there were zero days (out of the 47 measured) where the amplitude peak-to-trough variation was 5 dB or greater.

The largest amplitude peak-to-trough variation during this time period (~4.5 dB) occurred on 9 November. Presented in figure 3 is a comparison of the 1 and 9 November field strengths (both amplitude and relative phase). Here, we see that, during 1 November, the nighttime field strength was 1 to 1.5 dB higher than expected while the nighttime relative-phase variation was approximately 10 deg.

During 9 November, the field strength steadily decreased by 4 dB during the nighttime period of 0200 to 0700, then increased 4 to 4.5 dB from 0700 to the beginning of the daytime measurement period (1300). Meanwhile, the nighttime relative phase increased 15 deg from 0100 to 0530, decreased 20 deg from 0530 to 0800, increased 10 deg by 0900, then leveled off. The relative phase then decreased to its normal daytime level by the end of the SRTP (1300).

DECEMBER 1977 MEASUREMENTS

During December 1977, data were obtained on 27 days at the Connecticut site. The daily plots of signal strength (both amplitude and relative phase) versus GMT, in 30-min increments, are presented in appendix D. During December, the WTF antenna array-phasing angle was 291 deg and the transmitting frequency was 76 ±4 Hz.

Listed in table 4 are the December 1977 daily field-strength averages. Referring to table 4 and to the figures in appendix D, we see that, with the exception of levels for the nighttime minimum field-strength period, the average field-strength levels are about as expected.

The average December night-to-day relative-phase variation was 23.2 deg, which corresponds to a $\Delta(c/v)$ value of approximately 0.16. Amplitude peak-to-trough variations of 5 dB, or greater, occurred during 6 of the 27 days that included a nighttime measurement period (2, 3, 11, 12, 14, and 22 December). The largest variation (6 dB) occurred on 22 December. These variations are illustrated in figure 4 and appendix D.

Presented in figure 4 is a comparison of the 9, 12, and 22 December field strengths. During 9 December, the nighttime field strength was 1 to 3 dB lower than expected throughout the nighttime measurement period. During 12 December, the nighttime field strength steadily increased 2 dB from midnight to 0330, rapidly decreased 5 dB from 0330 to 0500, and steadily increased 4 dB by the end of the nighttime measurement period (1100).

During 22 December, the nighttime field strength rapidly decreased 4 dB from 0230 to 0400, then rapidly increased 4 dB from 0400 to 0630. Then, it decreased 1 dB from 0630 to 0700 and steadily increased 3 dB from 0700 to 1100.

JULY 1978 MEASUREMENTS

During July 1978, the WTF transmitted only during the daytime period of 1100 to 1500. Signal-strength data were obtained on 17 days at the Connecticut site. The WTF antenna array-phasing angle was 291 deg and the transmitting frequency was 76 ±4 Hz.

The daily plots of signal strength versus GMT, in 30-min increments, are presented in figure 5, while the daily field-strength averages are listed in table 5. From these, we see that the July 1978 daytime field-strength levels are about as expected.

AUGUST AND SEPTEMBER 1978 MEASUREMENTS

During the period of 21 August to 20 September 1978, data were obtained on 27 days at the Connecticut site. The daily plots of signal strength (both amplitude and relative phase) versus GMT, in 30-min increments, are presented in appendix E for August and in appendix F for September. From 21 August to 1 September, the WTF antenna array-phasing angle, ψ, was 291 deg. From 2 to 7 September, ψ was 20 deg and, during the rest of September, it was 110 deg. The transmitting frequency was 76 ±4 Hz.

Listed in tables 6 and 7 are the August and September 1978, respectively, Connecticut daily field-strength averages. For a WTF antenna array-phasing angle of 291 deg, the average Connecticut field strength should equal -143.3 dBA/m during the day, -144.4 dBA/m during the transition periods, and -145.5 dBA/m at night.[7] For ψ = 20 deg, the values should be 0.7 dB lower while, for ψ = 110 deg, the values should be 1.8 dB lower. Referring to tables 6 and 7, we see that the August and September daytime and August transition-period and nighttime field strengths are about as expected. However, the September transition-period and nighttime field strengths are 0.5 to 1.0 dB higher.

The average night-to-day relative-phase variation, $\Delta\phi$, was 21.4 deg from 21 to 31 August, 12.7 deg from 1 to 6 September, and 21.7 deg from 7 to 20 September. The corresponding $\Delta(c/v)$ values are 0.15, 0.09, and 0.15, respectively.

Amplitude peak-to-trough variations of 5 dB, or greater, occurred during only 1 of the 27 measurement days that included a nighttime measurement period, 13 September (see appendix F). This is in direct contrast to the 1973 to 1977 results where 5 dB, or greater, amplitude peak-to-trough variations occurred during 35 out of the 63 September measurement days (i.e., 56 percent of the time).[7,13]

The late August and early September 1978 period was characterized by substantial magnetic-storm activity. In the past, several ELF nighttime disturbances (both increases and decreases) have occurred during the several days following magnetic storms, when similar but less-pronounced behavior is found to coincide with phase disturbances on very low frequency (VLF) paths across the northern United States.[16]

Presented in figure 6 is a comparison of the 21 to 31 August and 1 to 6 September 1978 average field strengths (both amplitude and relative phase). Here, we see that the 1 to 6 September average-nighttime field strengths were about 1 dB higher and the average night-to-day relative-phase variation was approximately 10 deg lower.

These two factors imply a decrease in the 1 to 6 September nighttime reflection height of roughly 10 km. Because particle precipitation into the D region tends to increase ionization, making the ionosphere more "daylike" by lowering the effective reflection height and improving excitation, the 1 to 6 September 1978 nighttime field-strength increases are as expected.

DISCUSSION

During the last several years, we have made a substantial number of horizontal magnetic field-strength measurements in Connecticut. We definitely noticed that ELF nighttime propagation is much more variable than ELF daytime propagation. Two prime candidates for the cause of these nighttime variations are particle precipitation and the presence of a nocturnal sporadic E layer.[15-17] An alternative explanation is standing-wave or diffraction patterns caused by the interaction of the transverse electromagnetic (TEM) mode with the polar-cap boundary.[18]

Listed in table 8 are the number of August 1976 to September 1978 Connecticut measurement days that included a nighttime measurement period where the daily amplitude peak-to-trough variation was 5 dB, or greater. The monthly percentage of these days, relative to the total number of measurement days, also is shown in table 8 and plotted in figure 7.

Referring to table 8 and figure 7, we see that, for the 2-yr period of August 1976 to September 1977, 5 dB, or greater, signal-strength fades occurred during 25 percent of the measurement days. The most-frequent nighttime fading occurred during the late-winter/early-spring (January through

April) and late-summer/early-fall (August through October) periods. The least-frequent nighttime fading occurred during June and November.

CONCLUSIONS

The horizontal magnetic field-strength measurements taken in Connecticut from August to December 1977 and July to September 1978 have demonstrated, again, that the short-term sample-to-sample variability of ELF nighttime propagation is much greater than the short-term sample-to-sample variability of ELF daytime propagation.

For the 2-yr period of August 1976 to September 1978, amplitude peak-to-trough variations of 5 dB, or, greater, were observed 25 percent of the time. The most-frequent nighttime fading occurred during the late-winter/early-spring (January through April) and late-summer/early-fall (August through October) periods. The least-frequent nighttime fading occurred during June and November.

Table 1. August 1977 Connecticut Daily Field-Strength Averages

Date	ψ (deg)	Day H_ϕ (dBA/m)	SSTP H_ϕ (dBA/m)	Night H_ϕ (dBA/m)	SRTP H_ϕ (dBA/m)	$\Delta\phi$ (deg)	Peak/ Trough $\geq$ 5 dB
8/1	291	-143.2	-143.8	-145.0	-143.3	23.5	No
8/4	291	-143.1	-144.2	-144.8	-143.4	23.1	No
8/5	291	-143.4	-144.7	-145.7	-143.8	22.0	No
8/7*	291	-142.5	-143.1	-146.4	-145.1	25.4	Yes
8/8*	291	-143.8	-143.4	-147.8	-146.4	27.9	Yes
8/9	291	-145.3	-145.8	-147.5	-146.9	19.4	Yes
8/11	291	-143.3	-145.1	-146.6	-145.1	26.9	Yes
8/12	291	-143.7	-145.7	-146.3	-145.7	24.7	No
8/13	21	-144.0	-144.2	-145.7	-145.4	27.4	No
8/14	21	-144.4	-145.2	-146.4	-144.9	18.9	No
8/15	21	-144.5	-145.6	-145.9	-146.0	$\approx$22	No
8/16	21	-144.2	-144.8	-146.8	-145.2	22.5	No
8/17	21	-143.9	-144.7	-145.8	-144.8	19.9	No
8/28	291	-143.2	-144.5	-146.0	-144.6	$\approx$25	Yes
8/29	291	-142.8	-143.4	-145.0	-144.0	27.2	No
8/30	291	-143.3	-143.9	-144.7	-144.4	28.4	Yes
Average	291	-143.4	-144.3	-145.9	-144.7	24.5	6/16 (37.5%)
Average	21	-144.2	-144.9	-146.1	-145.2	22.1	
Average	291†	-143.4	-144.3	-145.7	-144.6	23.3	

*Vertical electric field measurements.
†Normalized to 291 deg.

Table 2. September 1977 Connecticut Daily Field-Strength Averages (ψ = 291 deg)

Date	Day H_ϕ (dBA/m)	SSTP H_ϕ (dBA/m)	Night H_ϕ (dBA/m)	SRTP H_ϕ (dBA/m)	$\Delta\phi$ (deg)	Peak/ Trough $\geq$ 5 dB
9/2	-143.1	-144.5	-147.9	-146.1	29.3	Yes
9/3	-143.8	-144.3	-147.5	-149.0	25.9	Yes
9/4	-	-145.6	-147.4(7)	-	-	Yes
9/7	-143.1	-143.7	-145.5	-143.9	24.8	Yes
9/8	-143.0	-143.9	-145.3	-143.8	17.5	Yes
9/9	-143.1	-143.6	-145.4	-144.8	24.3	Yes
9/14	-143.2	-143.8	-145.2	-143.7	18.9	Yes
9/15	-143.0	-143.5	-145.0	-143.8	22.1	No
9/16	-142.7	-143.0	-144.3	-143.5	21.1	No
9/17	-142.6	-143.5	-145.3	-143.7	25.6	Yes
9/21	-143.5	-145.0	-145.0	-142.8	24.1	No
9/22	-142.9	-143.7	-144.8	-143.4	-	No
9/23	-142.1	-142.5	-144.3	-143.6	-	No
9/24	-142.8	-143.7	-144.3	-144.4	19.2	No
9/25	-143.0	-144.6	-145.5	-144.4	18.2	Yes
9/26	-142.7	-143.4	-145.1	-144.0	18.8	Yes
Average	-143.0	-143.8	-145.5	-144.3	22.3	10/16 (62.5%)

Table 3. November 1977 Connecticut Daily Field-Strength Averages

Date	SSTP H_ϕ (dBA/m)	Night H_ϕ (dBA/m)	SRTP H_ϕ (dBA/m)	Day H_ϕ (dBA/m)	$\Delta\phi$ (deg)	ψ (deg)	Peak/ Trough $\geq$ 5 dB
11/1	-	-144.3	-144.0	-143.3	23.4	291	No
11/2	-143.6	-145.4	-144.0	-143.8	20.8	291	No
11/3	-143.2	-145.3	-143.5	-143.5	19.3	291	No
11/4	-	-145.2	-144.5	-143.5	16.7	291	No
11/5	-143.5	-144.7	-143.8	-143.6	24.9	291	No
11/6	-143.8	-145.2	-144.1	-143.0	24.2	291	No
11/7	-143.2	-145.3	-144.4	-143.2	29.8	291	No
11/8	-144.3	-145.6	-143.9	-143.2	24.1	291	No
11/9	-144.3	-146.1	-144.8	-143.5	28.9	291	No
Average	-143.7	-145.2	-144.1	-143.4	23.6	291	
11/11	-145.2	-145.8	-145.0	-143.7	21.6	21	No
11/12	-145.1	-145.6	-145.6	-143.7	19.0	21	No
11/13	-144.5	-146.0	-145.1	-144.0	21.7	21	No
11/14	-144.0	-146.0	-145.0	-143.9	17.0	21	No
11/15	-144.4	-145.5	-144.8	-144.1	16.7	21	No
11/16	-144.3	-145.4	-144.6	-144.0	15.4	21	No

Table 3. (Cont'd) November 1977 Connecticut Daily Field-Strength Averages

Date	SSTP H_ϕ (dBA/m)	Night H_ϕ (dBA/m)	SRTP H_ϕ (dBA/m)	Day H_ϕ (dBA/m)	$\Delta\phi$ (deg)	ψ (deg)	Peak/ Trough $\geq$ 5 dB
11/17	-144.3	-145.4	-	-	-	21	No
11/19	-144.4	-145.4	-144.8	-143.8	21.0	21	No
11/20	-144.4	-145.1	-145.0	-143.8	22.0	21	No
11/21	-144.2	-145.9	-144.9	-143.8	19.1	21	No
11/22	-144.1	-145.5	-145.5	-144.2	31.3	21	No
11/23	-144.5	-145.7	-145.0	-143.6	26.4	21	No
11/24	-144.4	-145.4	-144.5	-142.9	27.2	21	No
11/25	-144.0	-145.3	-144.2	-143.8	26.3	21	No
11/26	-144.3	-145.5	-144.4	-143.4	28.3	21	No
11/27	-143.4	-144.7	-144.6	-143.2	24.2	21	No
11/28	-144.7	-145.5	-144.5	-143.5	20.8	21	No
11/29	-145.1	-145.1	-145.1	-143.4	23.2	21	No
11/30	-144.4	-145.3	-144.8	-143.4	18.5	21	No
Average	-144.4	-145.5	-144.8	-143.7	22.2	21	0/28 (0.00%)
Average	-143.7	-145.0	-144.1	-143.2	22.9	291*	

*Normalized to 291 deg.

Table 4. December 1977 Connecticut Daily Field-Strength Averages (ψ = 291 deg)

Date	SSTP H_ϕ (dBA/m)	Night H_ϕ (dBA/m)	SRTP H_ϕ (dBA/m)	Day H_ϕ (dBA/m)	$\Delta\phi$ (deg)	Peak/ Trough $\geq$ 5 dB
12/1	-144.6	-145.4	-145.0	-143.6	25.5	No
12/2	-	-146.1	-143.9	-142.8	25.0	Yes
12/3	-	-145.3	-142.3	-142.5	15.0	Yes
12/4	-	-144.0	-143.4	-142.9	16.7	No
12/5	-	-144.2	-143.3	-142.6	20.8	No
12/6	-	-144.5	-144.2	-143.5	20.1	No
12/7	-	-144.9	-144.3	-143.6	20.9	No
12/8	-145.5	-144.8	-144.0	-143.6(15)	-	No
12/9	-	-147.2	-	-	-	No
12/10	-143.9	-145.3	-144.5	-143.4	24.9	No
12/11	-143.9	-145.5	-143.4	-142.8	22.3	Yes
12/12	-144.5	-144.7	-143.2	-143.1	18.8	Yes
12/13	-143.6	-144.8	-143.8	-143.2(13)	18.1	No
12/14	-143.6	-145.6	-144.2	-143.2	22.9	Yes
12/15	-144.1	-145.3	-145.0	-143.5(15)	23.7	No
12/16	-145.0	-146.1	-144.8	-143.3	24.5	No
12/17	-144.0	-146.2	-145.1	-143.7	27.5	No
12/18	-144.4	-145.6	-144.3	-142.9	22.5	No
12/19	-144.4	-145.6	-144.3	-143.0	25.4	No
12/20	-144.5	-145.6	-144.1	-143.3	28.5	No
12/21	-143.6	-145.3	-144.2	-143.4	32.3	No
12/22	-144.4	-146.1	-144.9	-143.8	27.5	Yes
12/23	-143.9	-145.3	-144.3	-143.6	23.7	No
12/24	-144.5	-145.8	-144.9	-143.6	26.6	No
12/25	-144.3	-145.6	-	-	22.5	No
12/29	-144.2	-145.7	-145.3	-143.9	18.7	No
12/30	-144.5	-146.1	-144.9	-143.8	24.9	No
Average	-144.2	-145.4	-144.2	-143.3	23.2	6/27 (22.2%)

Table 5. July 1978 Connecticut Daily Field-Strength Averages (ψ = 291 deg)

Date	H_ϕ (dBA/m)
7/8	-143.6
7/9	-143.4
7/10	-143.3
7/11	-143.3
7/12	-143.4
7/13	-143.1
7/14	-142.8
7/15	-143.3
7/16	-143.6
7/17	-143.5
7/18	-143.2
7/19	-143.1
7/20	-143.0
7/21	-143.0
7/25	-143.7
7/27	-143.6
7/28	-143.0
Average	-143.3

Table 6. August 1978 Connecticut Daily Field-Strength Averages (ψ = 291 deg)

Date	SSTP H_ϕ (dBA/m)	Night H_ϕ (dBA/m)	SRTP H_ϕ (dBA/m)	Day H_ϕ (dBA/m)	$\Delta\phi$ (deg)	Peak/ Trough $\geq$ 5 dB
8/21	-145.1	-145.9	-145.0	-143.3	26.4	No
8/22	-144.5	-145.5	-144.9	-143.3	26.5	No
8/23	-	-	-	-143.4	31.9	-
8/24	-144.5	-145.4	-144.8	-143.4	26.0	No
8/25	-144.3	-146.0	-	-	28.7	No
8/26	-144.3	-145.5	-144.5	-144.3(7)	20.9	No
8/28	-	-	-	-142.9	15.4	-
8/29	-143.6	-144.8	-143.8	-143.2	11.8	No
8/30	-144.1	-144.7	-144.0	-143.1	14.5	No
8/31	-144.3	-145.0	-143.9	-143.3	12.1	No
Average	-144.3	-145.3	-144.4	-143.3	21.4	0/8 (0.00%)

Table 7. September 1978 Connecticut Daily Field-Strength Averages

Date	ψ (deg)	SSTP H_ϕ (dBA/m)	Night H_ϕ (dBA/m)	SRTP H_ϕ (dBA/m)	Day H_ϕ (dBA/m)	$\Delta\phi$ (deg)	Peak/ Trough $\geq$ 5 dB
9/1	291	-145.0	-144.8	-144.4	-143.6	8.8	No
9/2	20	-144.4	-145.1	-144.4	-144.0	14.0	No
9/3	20	-144.3	-145.4	-144.8	-143.8	10.1	No
9/4	20	-144.5	-144.8	-144.3	-143.6	12.1	No
9/5	20	-144.8	-144.9	-144.6	-144.0	10.7	No
9/6	20	-144.6	-145.2	-144.6	-143.8	12.0	No
9/7	20	-144.9	-145.2	-	-	17.5	-
9/7	110	-	-146.0	-145.8	-145.3	22.7	No
9/8	110	-145.7	-146.7	-146.5	-145.3	17.9	No
9/9	110	-145.9	-146.5	-146.0	-146.0	18.1	No
9/10	110	-146.0	-146.3	-145.0	-145.2	22.2	No
9/11	110	-146.0	-146.2	-146.1	-145.5	19.3	No
9/13	110	-145.4	-146.9	-146.0	-145.2	-	Yes
9/14	110	-145.5	-146.8	-146.0	-145.1	22.8	No
9/15	110	-145.6	-146.2	-145.9	-145.0	17.3	No
9/16	110	-145.6	-146.0	-145.1	-144.7	18.8	No
9/17	110	-146.1	-146.7	-145.4	-144.9	-	No
9/18	110	-145.7	-146.6	-145.8	-145.1	29.1	No
9/19	110	-146.0	-146.9	-145.9	-145.0	29.2	No
9/20	110	-146.3	-146.9	-145.1	-144.8	21.0	No
Average	20	-144.6	-145.1	-144.5	-143.8	12.7	1/19 (5.3%)
Average	110	-145.8	-146.5	-145.7	-145.1	21.7	
Average	291*	-144.0	-144.6	-143.9	-143.2	18.0	

*Normalized to 291 deg.

Table 8. Number of 1976 to 1978 Connecticut Measurement Days (That Included a Nighttime Measurement Period) Where the Daily Amplitude Peak-to-Trough Variation Was $\geq$ 5 dB

Month	Number of Days	Total Number of Measurement Days	Percent
January	13	42	31
February	16	47	34
March	25	53	47
April	15	52	29
May	11	54	20
June	1	34	3
July	4	19	21
August	9	35	26
September	20	55	36
October	13	54	24
November	0	53	0
December	8	54	15
Total*	135	542	25

*Total for 2-yr period of August 1976 through September 1978.

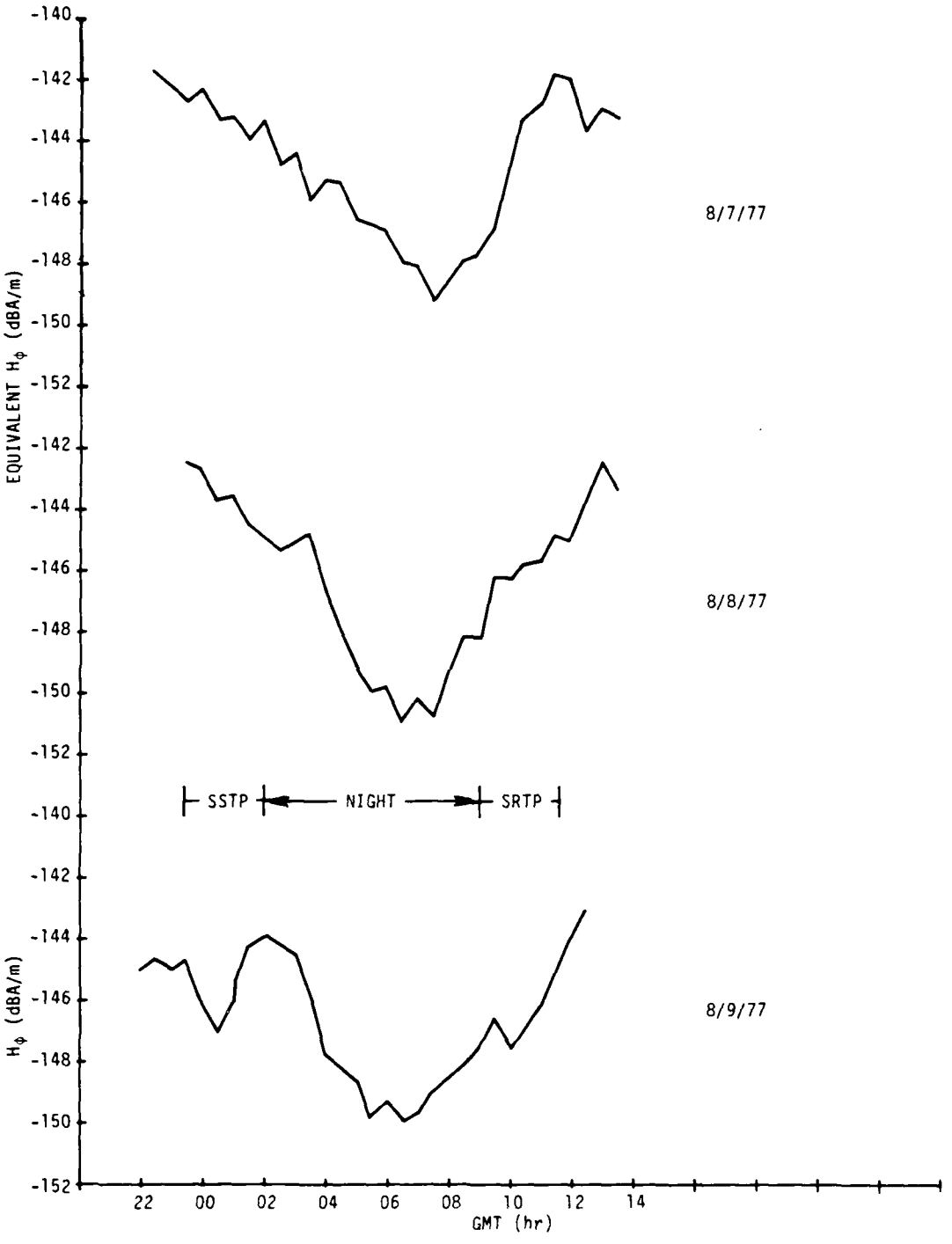

Figure 1. Connecticut Field Strength Versus GMT, 7 Through 9 August 1977

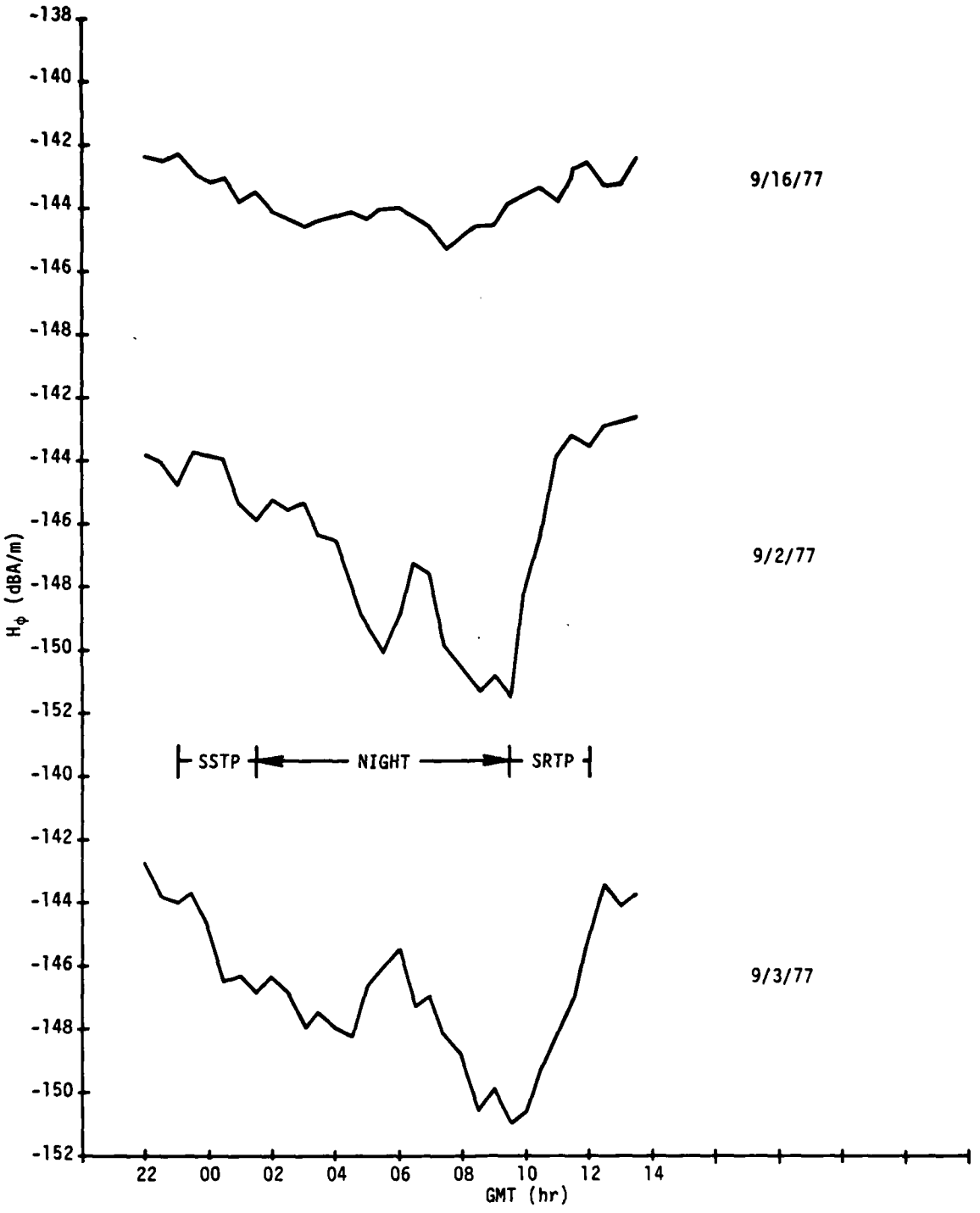

Figure 2. Connecticut Field Strength Versus GMT, 2, 3, and 16 September 1977

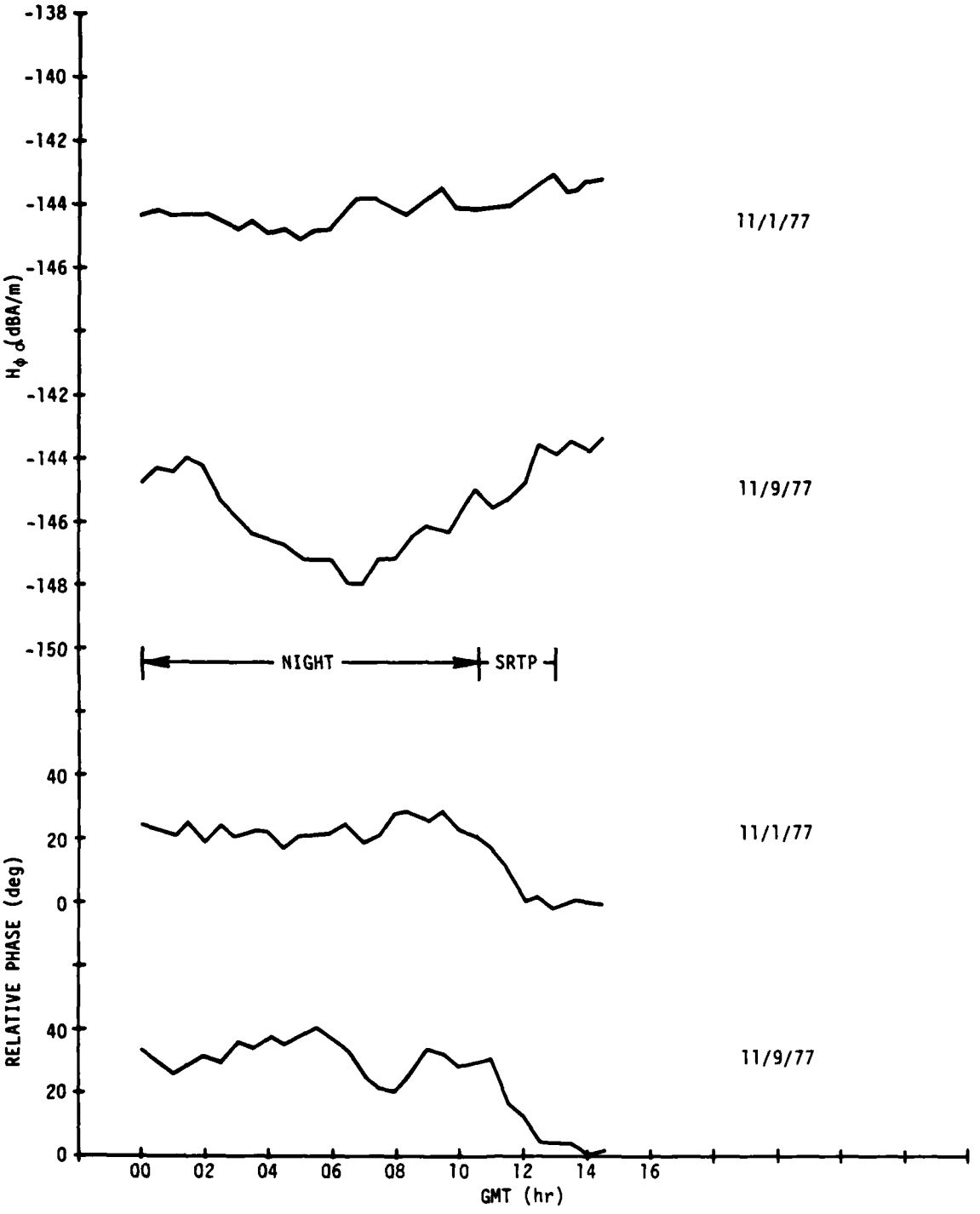

Figure 3. Connecticut Field Strength Versus GMT, 1 and 9 November 1977

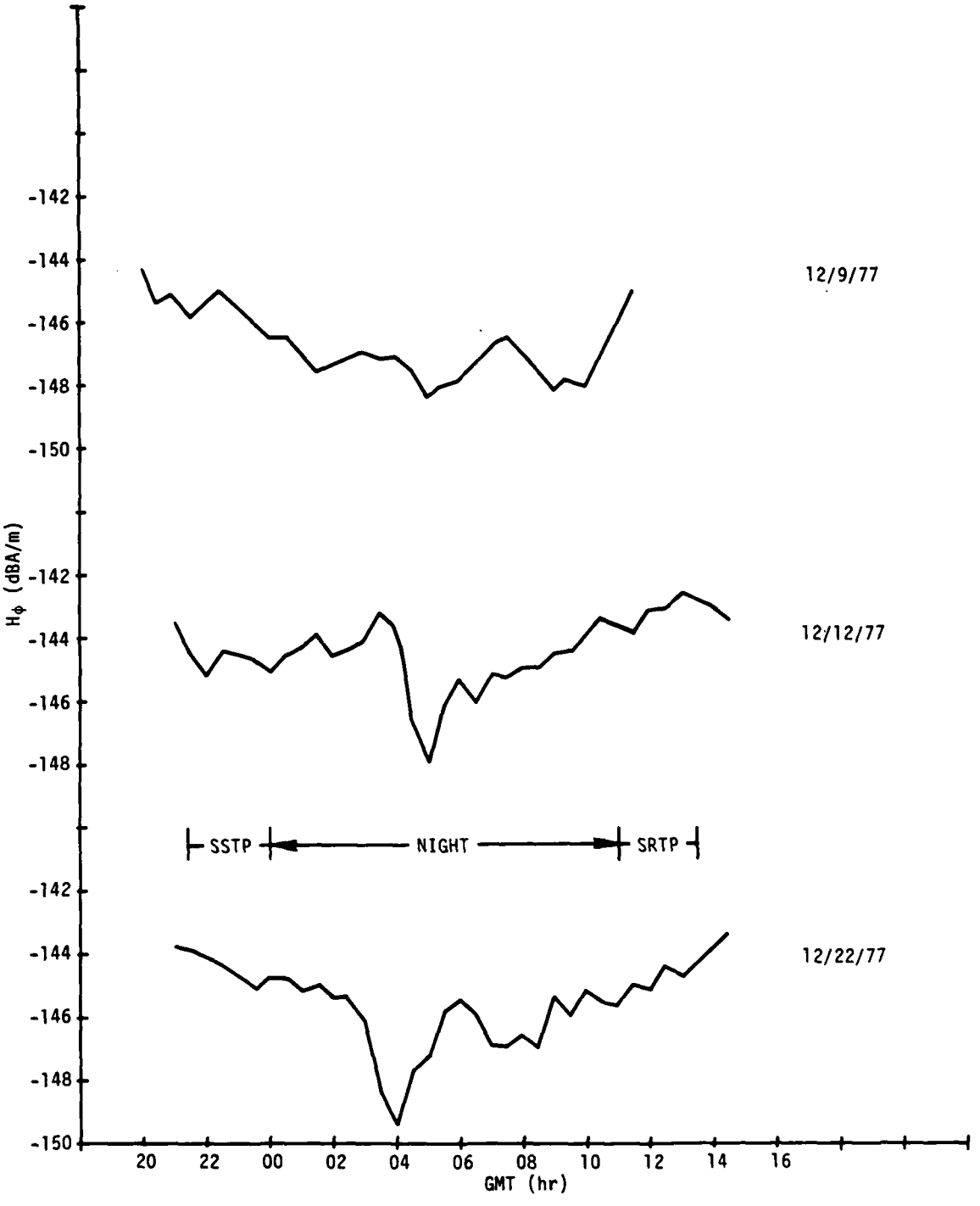

Figure 4. Connecticut Field Strength Versus GMT, 9, 12, and 22 December 1977

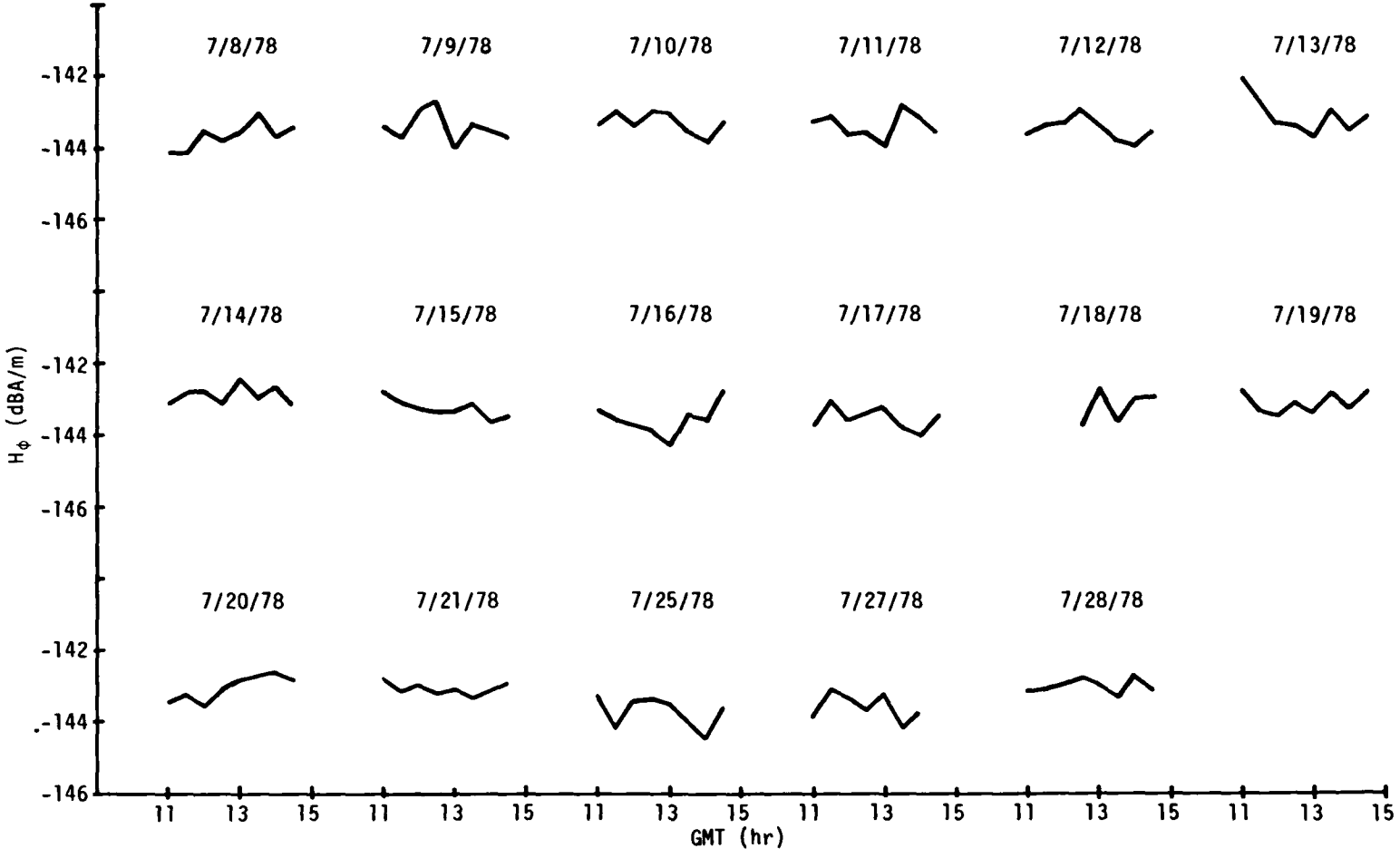

Figure 5. Connecticut Daytime Field Strength Versus GMT, 8 Through 28 July 1978

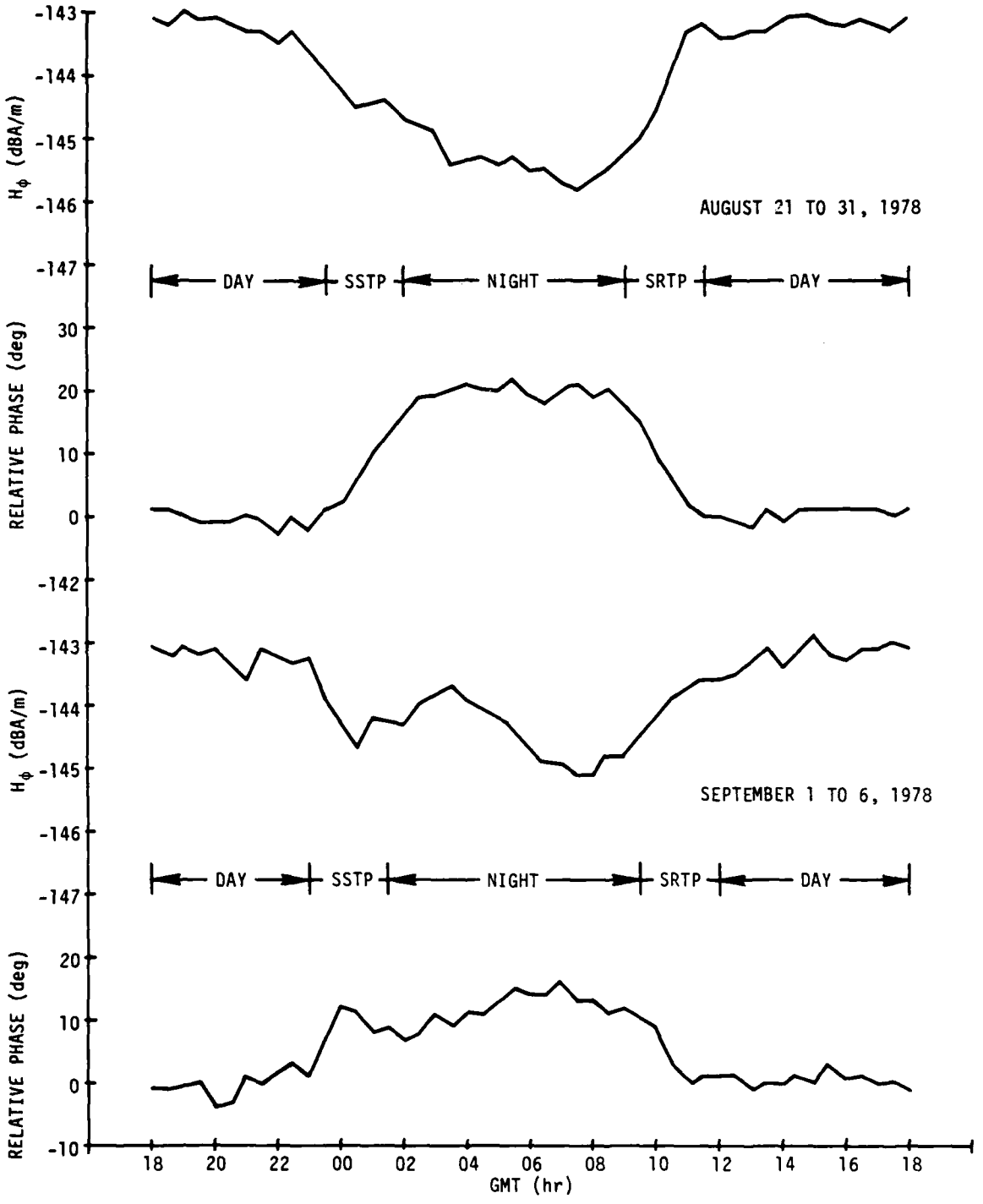

Figure 6. Connecticut Average Field Strengths Versus GMT, 21 August Through 6 September 1978

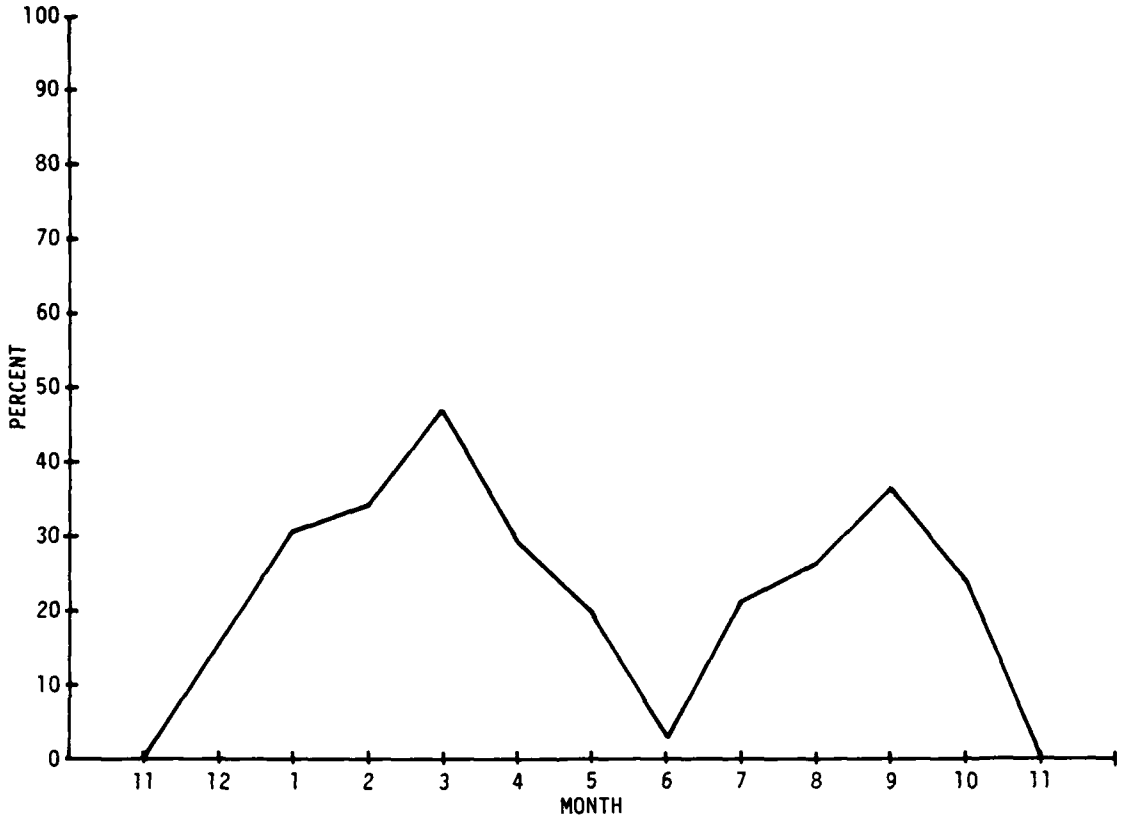

Figure 7. Percent of Measurement Days (August 1976 to September 1978) Where the Daily Amplitude Peak-to-Trough Variation Was $\geq$ 5 dB

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Appendix A

AUGUST 1977 DAILY PLOTS

Daily plots of field strength at the Connecticut site (both amplitude and relative phase) versus GMT, in 30-min increments, for August 1977 are presented in this appendix as figures A-1 through A-8.

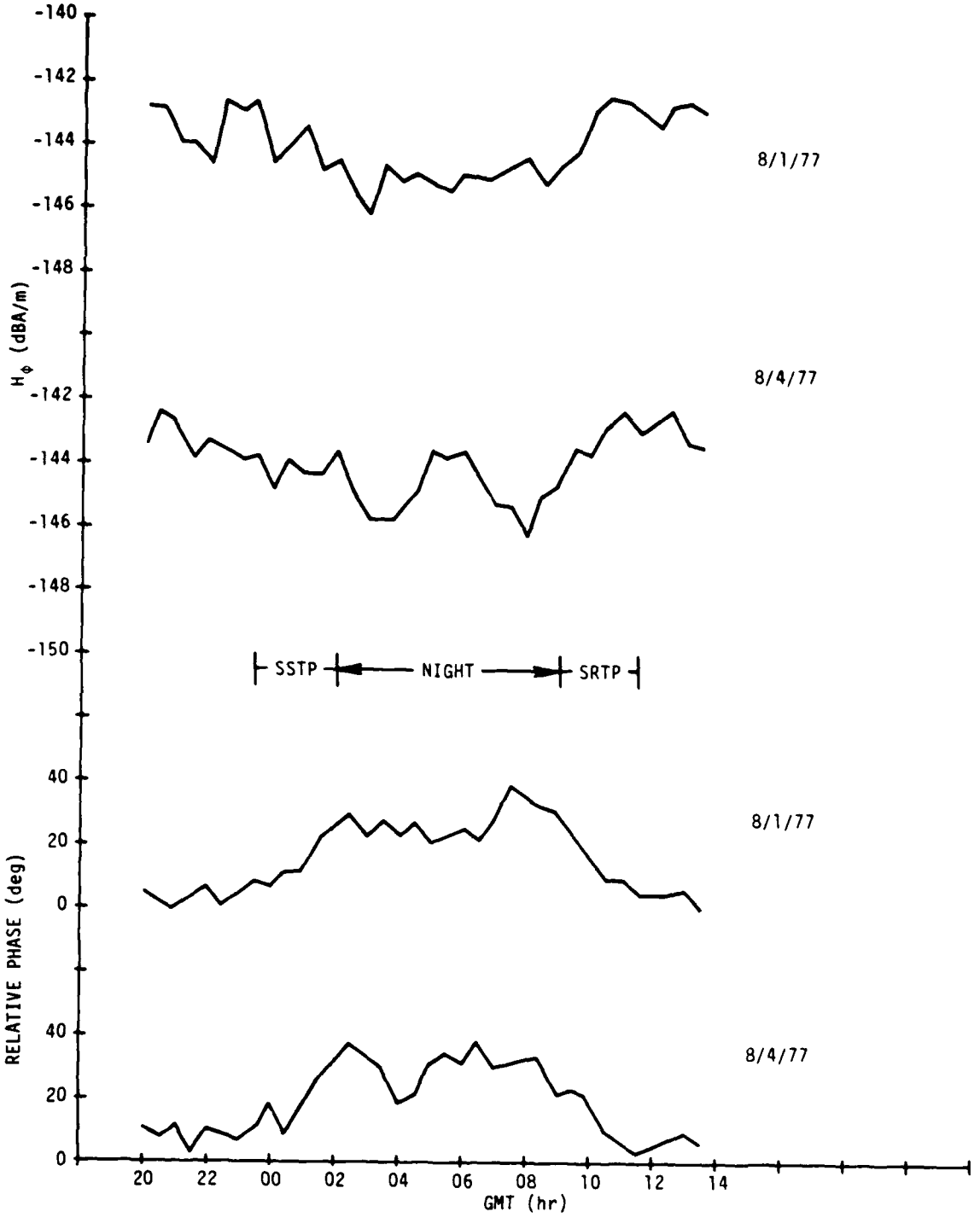

Figure A-1. Connecticut Field Strength Versus GMT, 1 and 4 August 1977 (ψ = 291 deg)

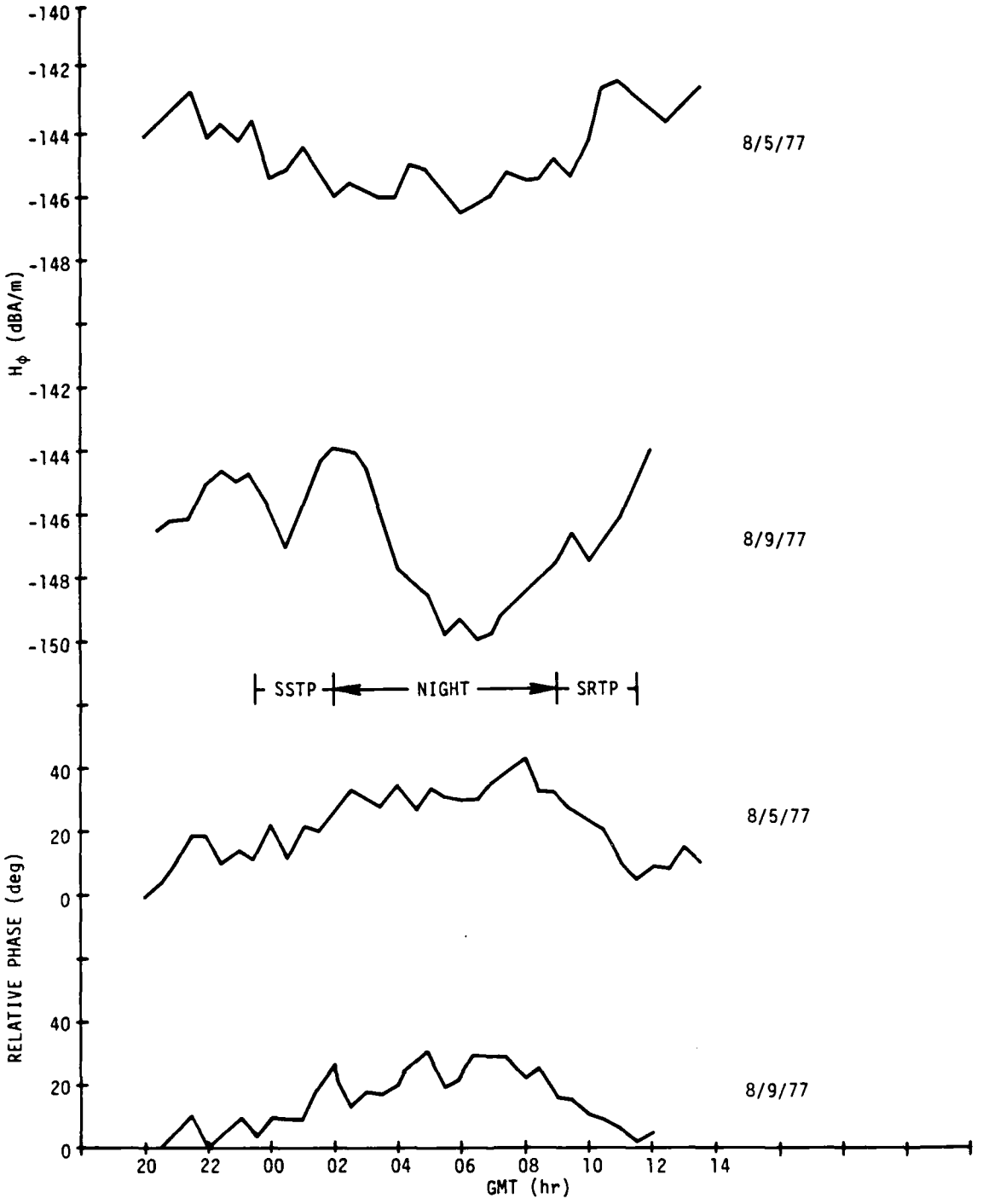

Figure A-2. Connecticut Field Strength Versus GMT, 5 and 9 August 1977 (ψ = 291 deg)

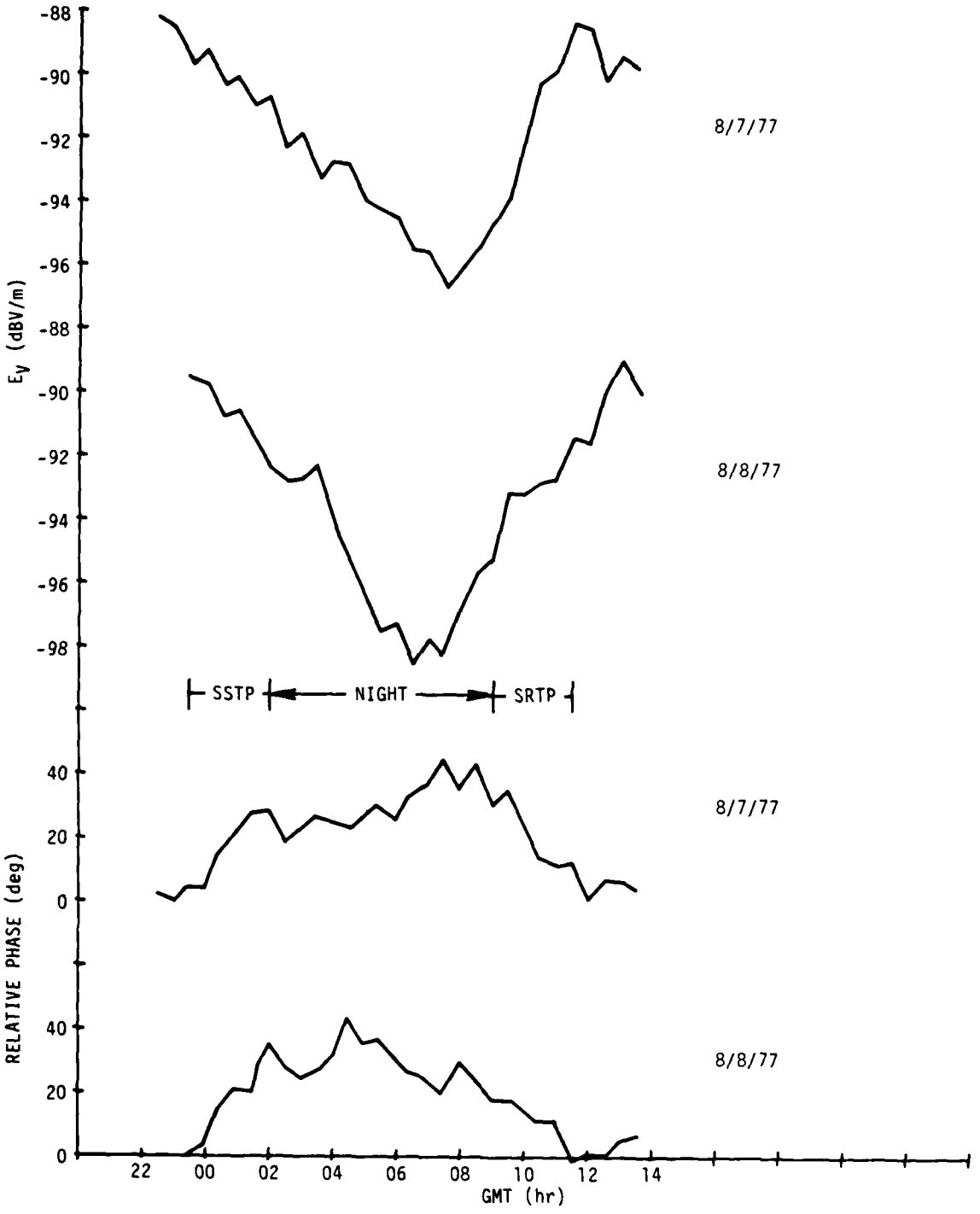

Figure A-3. Connecticut Field Strength Versus GMT, 7 and 8 August 1977 (ψ = 291 deg)

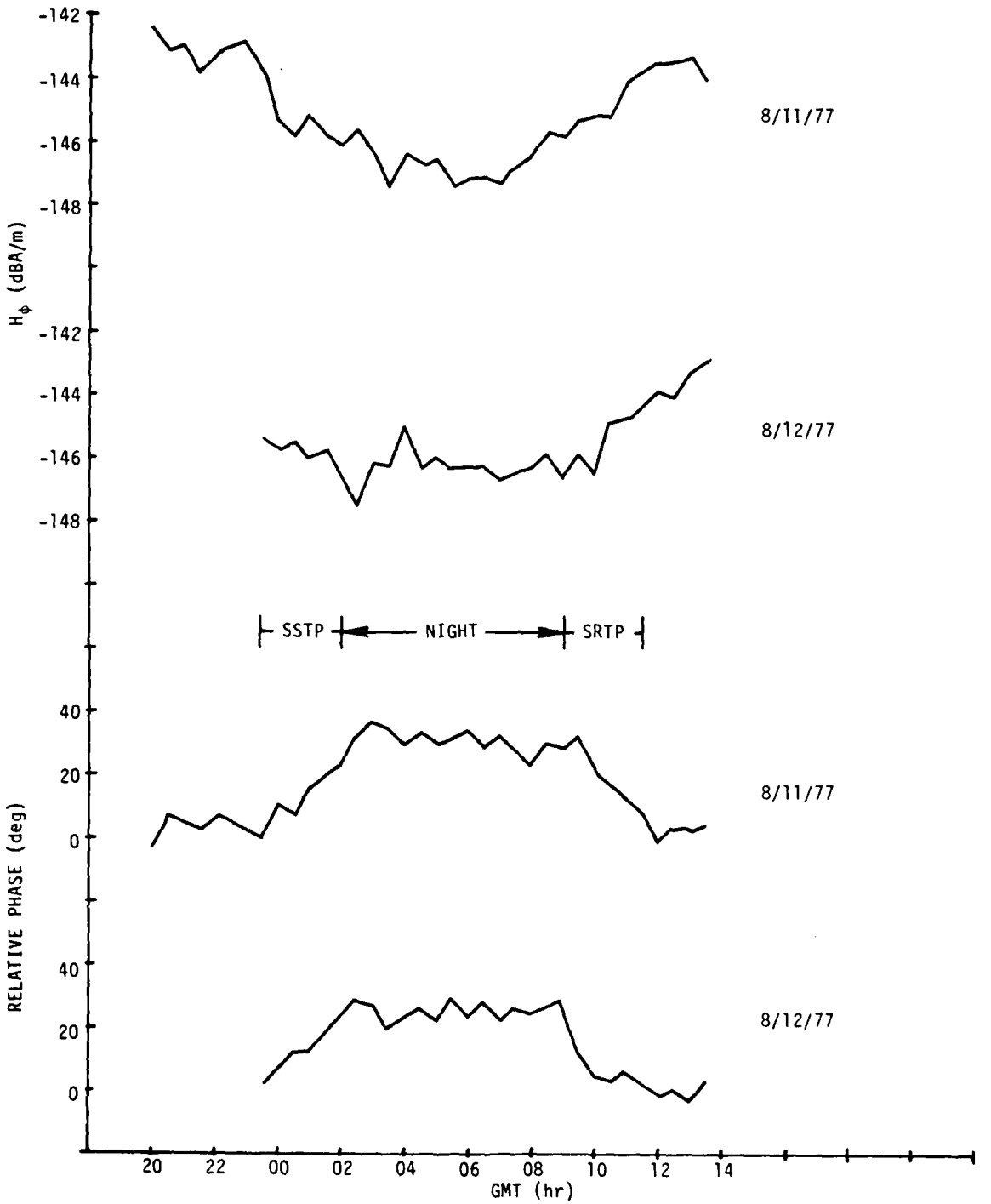

Figure A-4. Connecticut Field Strength Versus GMT, 11 and 12 August 1977 (ψ = 291 deg)

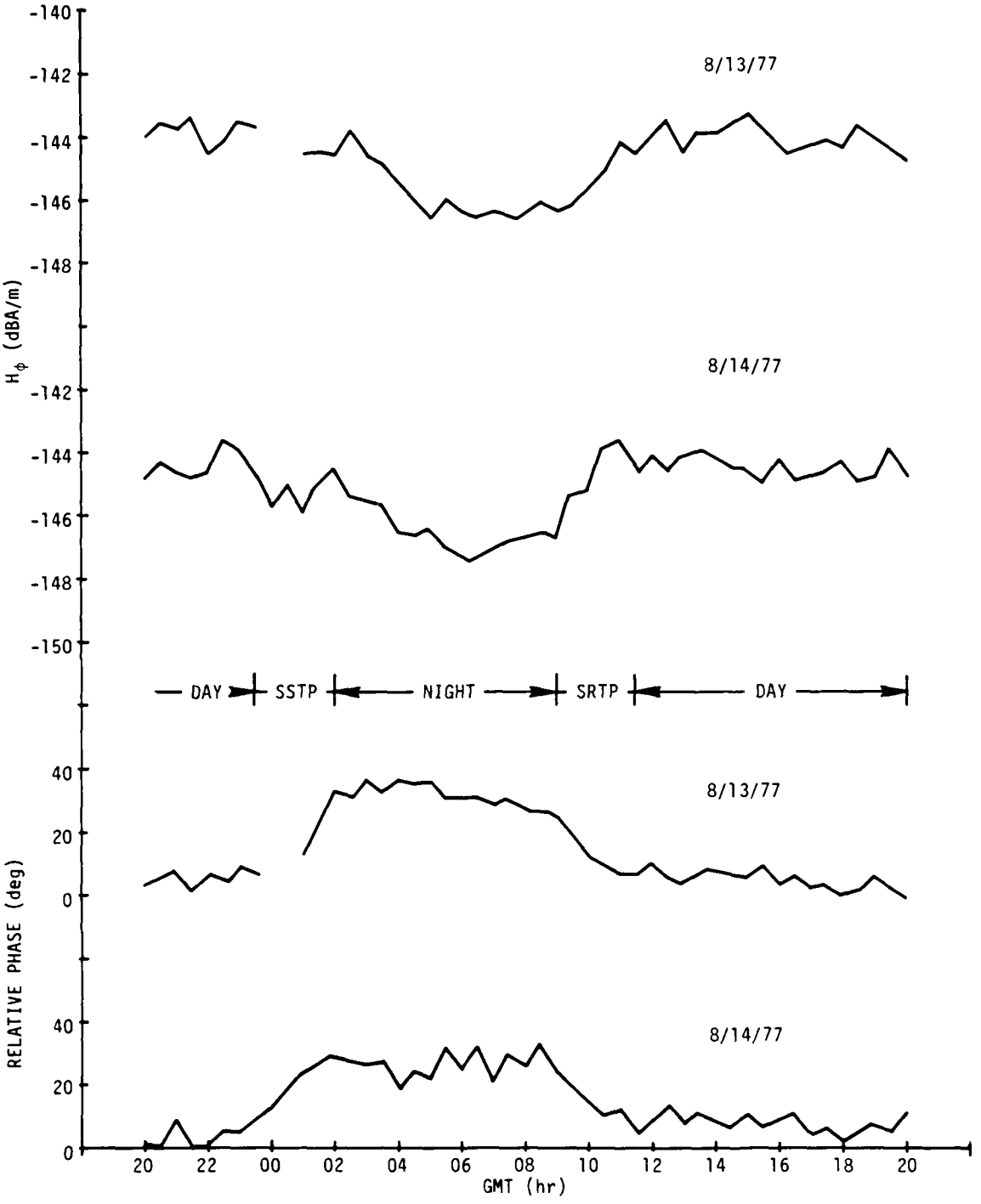

Figure A-5. Connecticut Field Strength Versus GMT, 13 and 14 August 1977 (ψ = 21 deg)

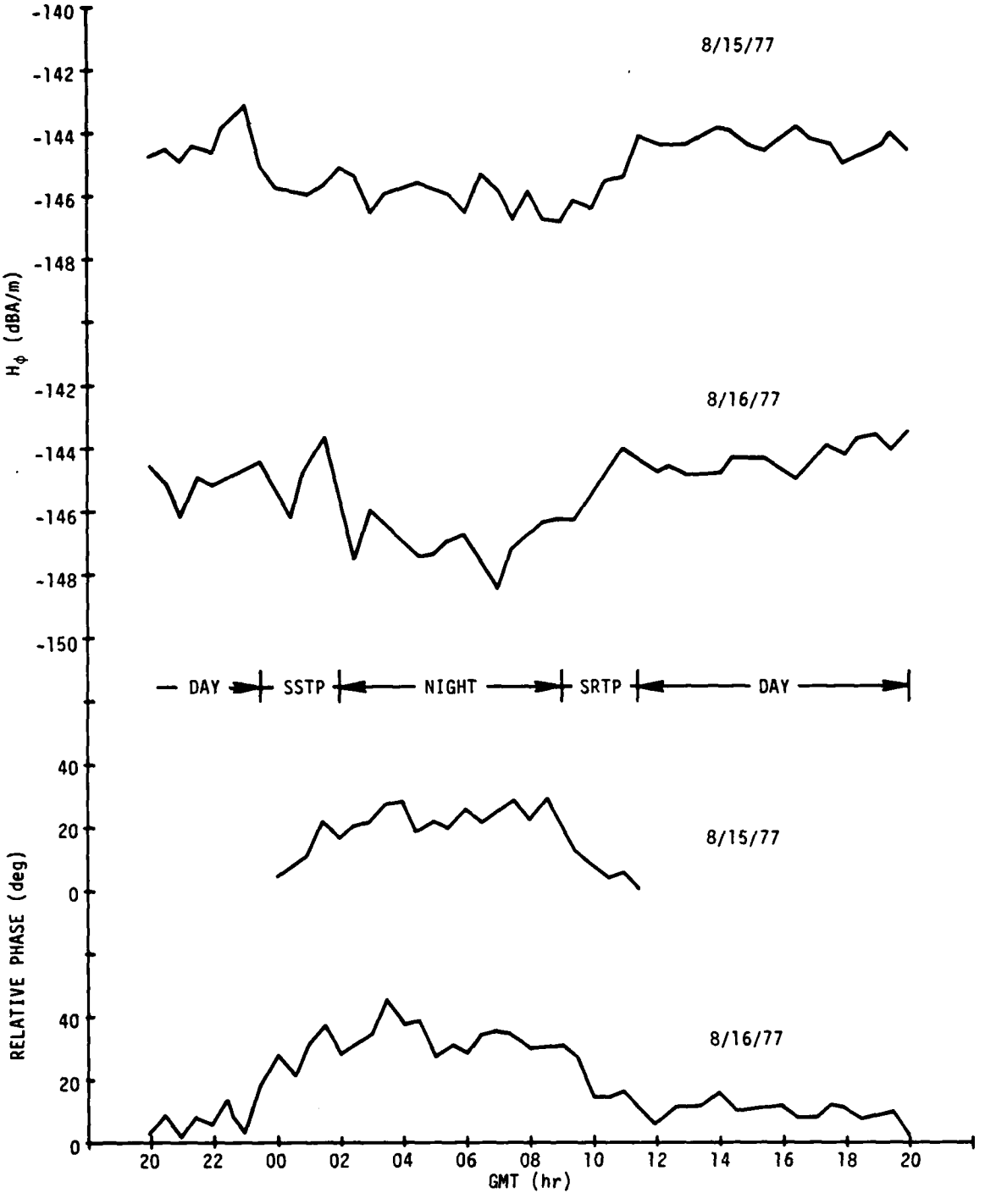

Figure A-6. Connecticut Field Strength Versus GMT, 15 and 16 August 1977 (ψ = 21 deg)

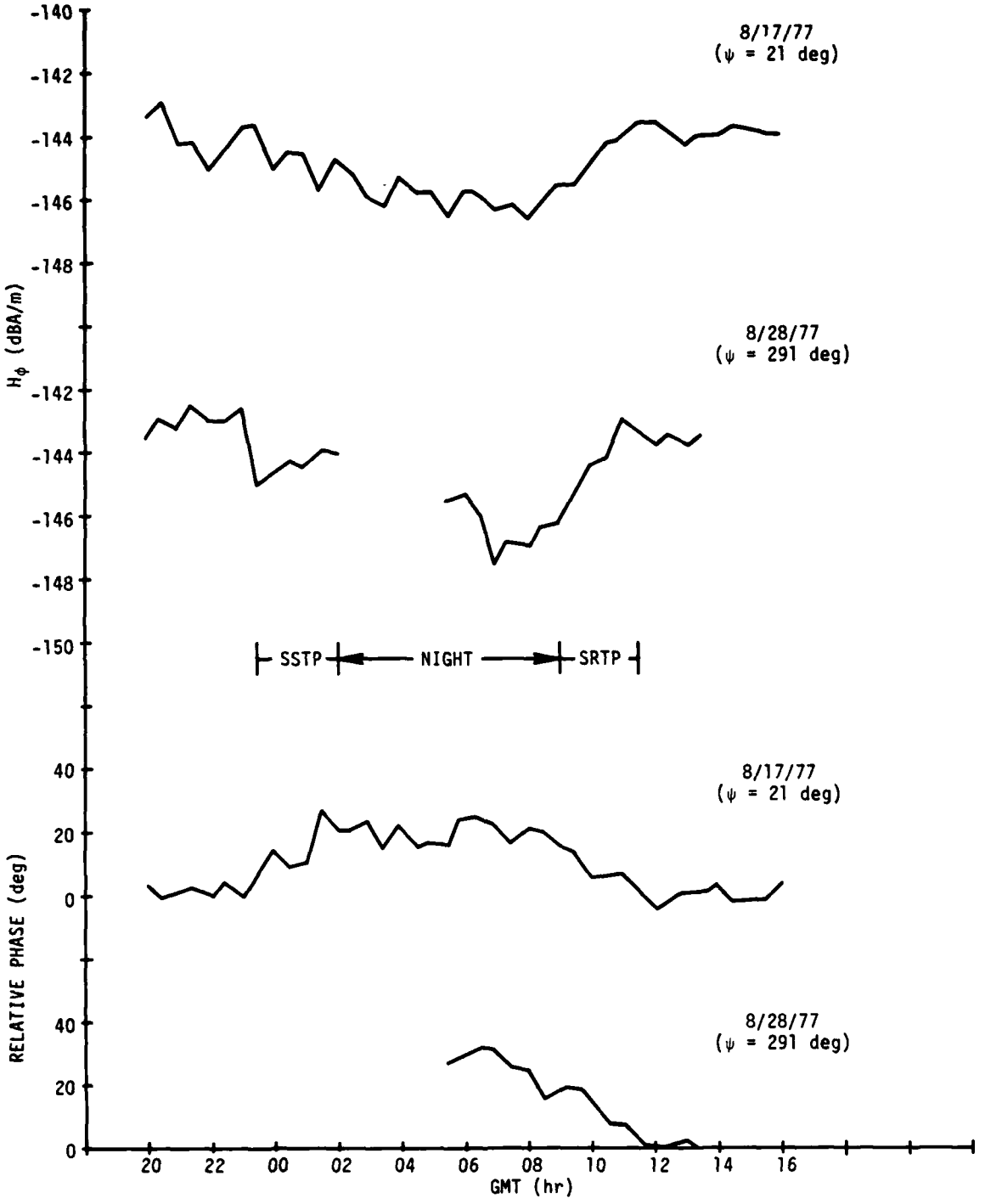

Figure A-7. Connecticut Field Strength Versus GMT, 17 (ψ = 21 deg) and 28 (ψ = 291 deg) August 1977

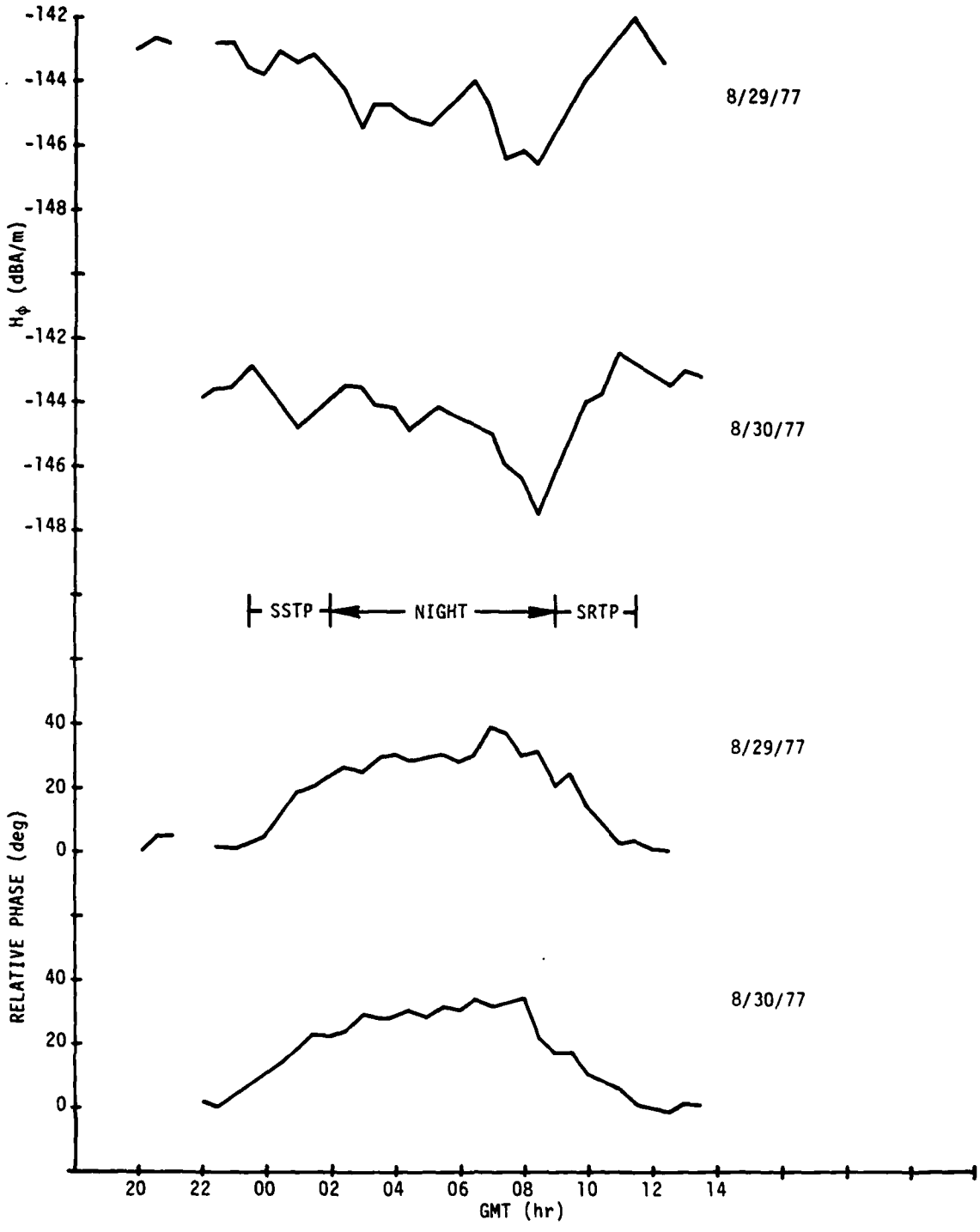

Figure A-8. Connecticut Field Strength Versus GMT, 29 and 30 August 1977 (ψ = 291 deg)

Appendix B

SEPTEMBER 1977 DAILY PLOTS

Daily plots of field strength at the Connecticut site (both amplitude and relative phase) versus GMT, in 30-min increments, for September 1977 are presented in this appendix as figures B-1 through B-7.

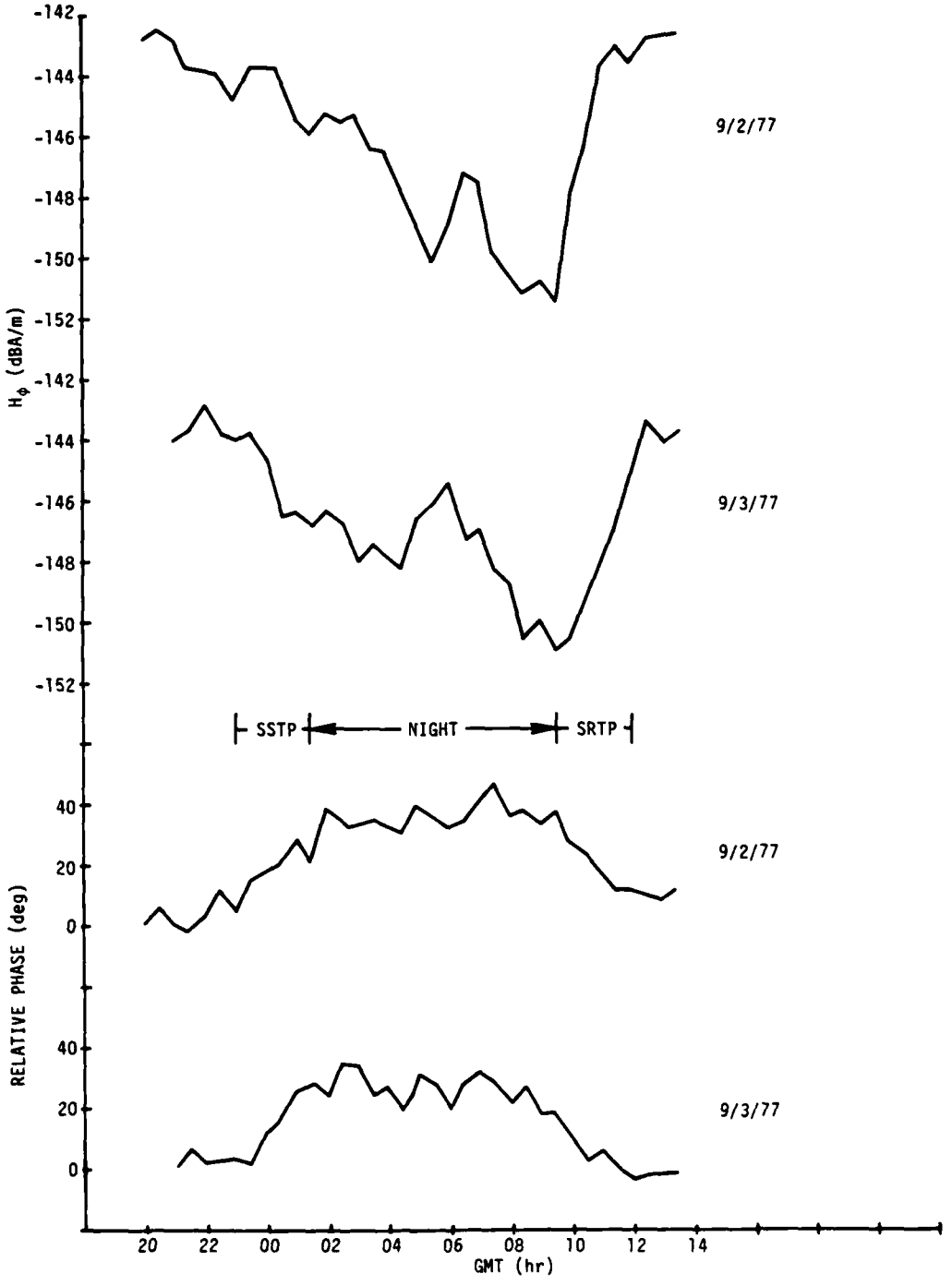

Figure B-1. Connecticut Field Strength Versus GMT, 2 and 3 September 1977 (ψ = 291 deg)

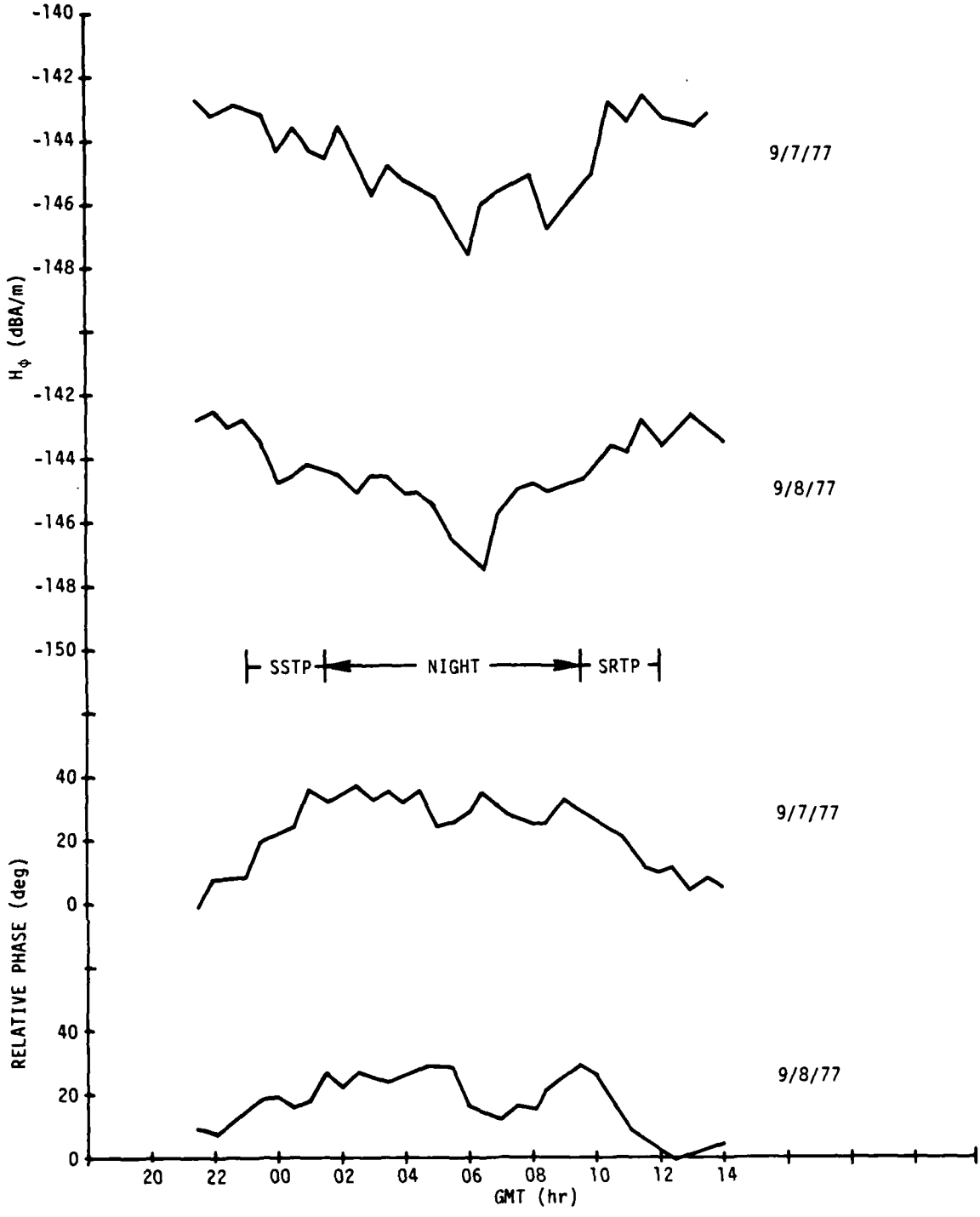

Figure B-2. Connecticut Field Strength Versus GMT, 7 and 8 September 1977 (ψ = 291 deg)

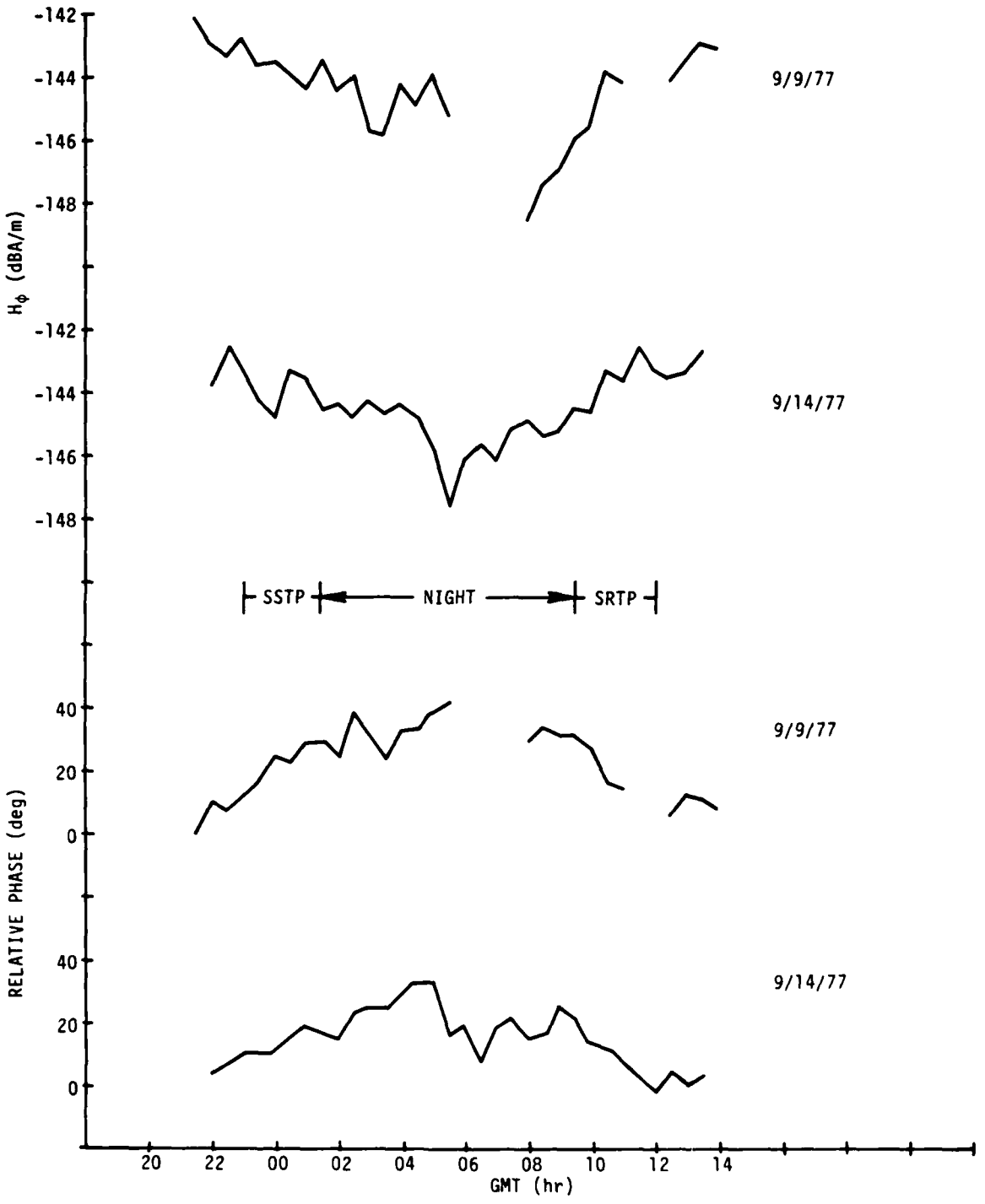

Figure B-3. Connecticut Field Strength Versus GMT, 9 and 14 September 1977 (ψ = 291 deg)

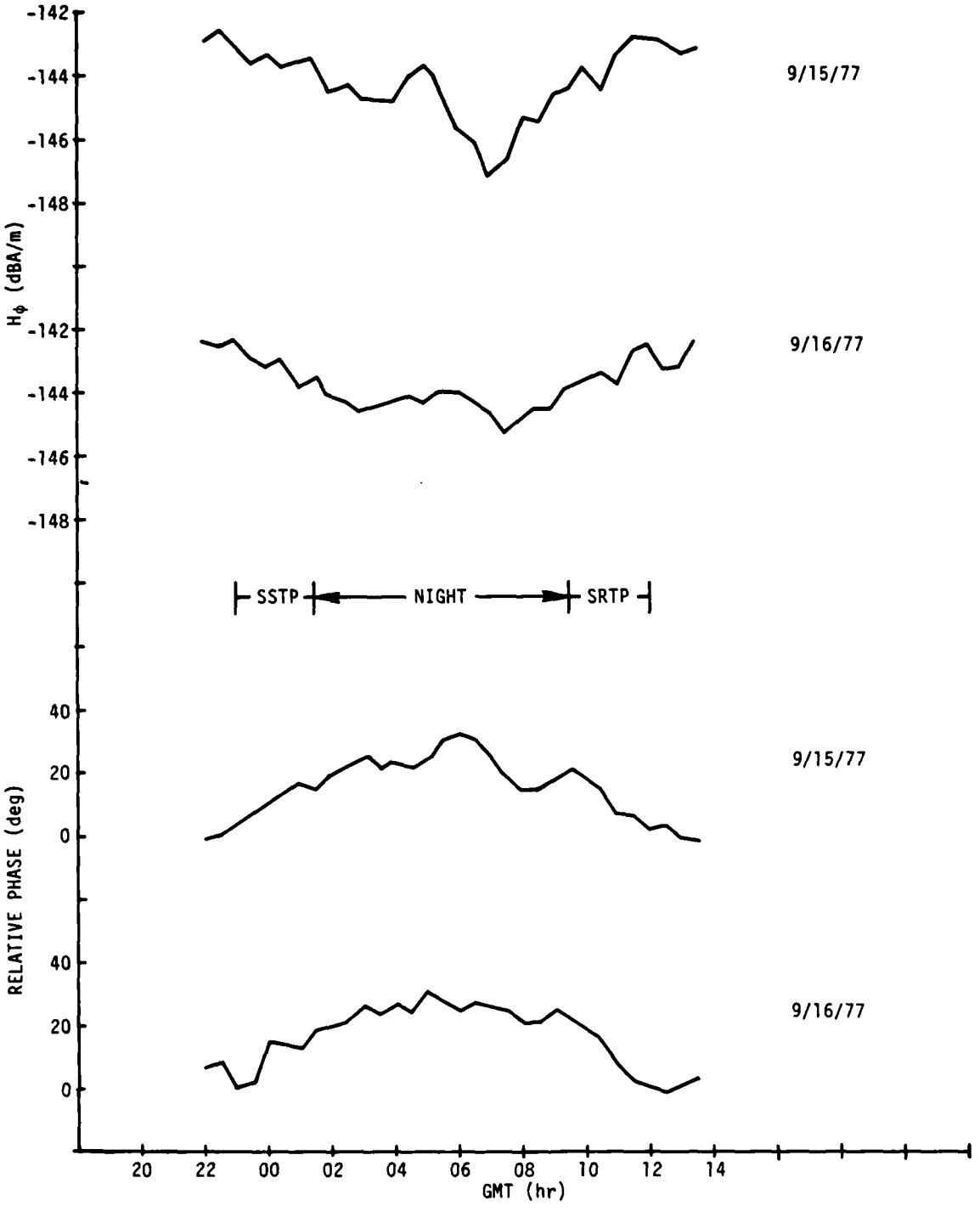

Figure B-4. Connecticut Field Strength Versus GMT, 15 and 16 September 1977 (ψ = 291 deg)

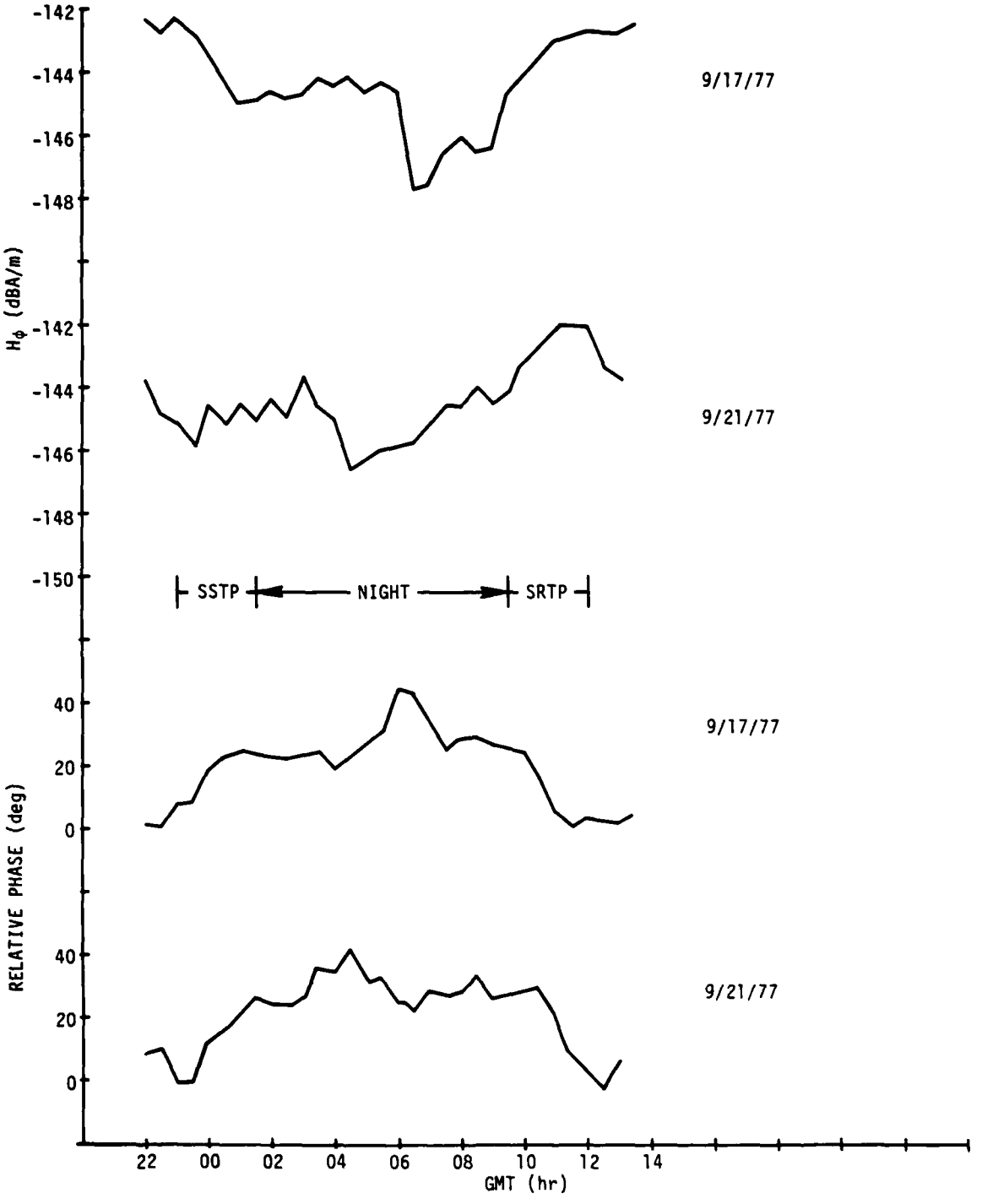

Figure B-5. Connecticut Field Strength Versus GMT, 17 and 21 September 1977 (ψ =. 291 deg)

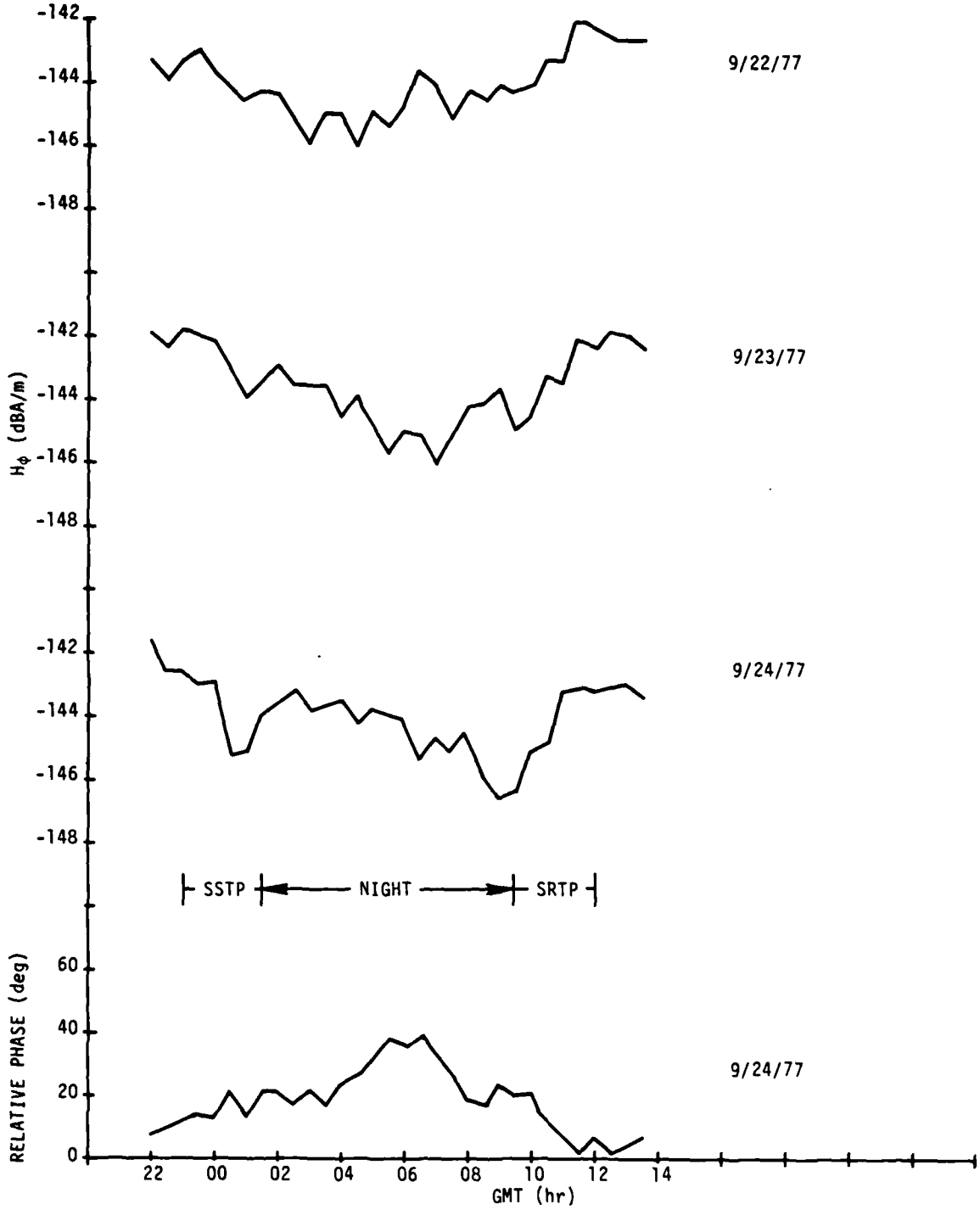

Figure B-6. Connecticut Field Strength Versus GMT, 22, 23, and 24 September 1977 (ψ = 291 deg)

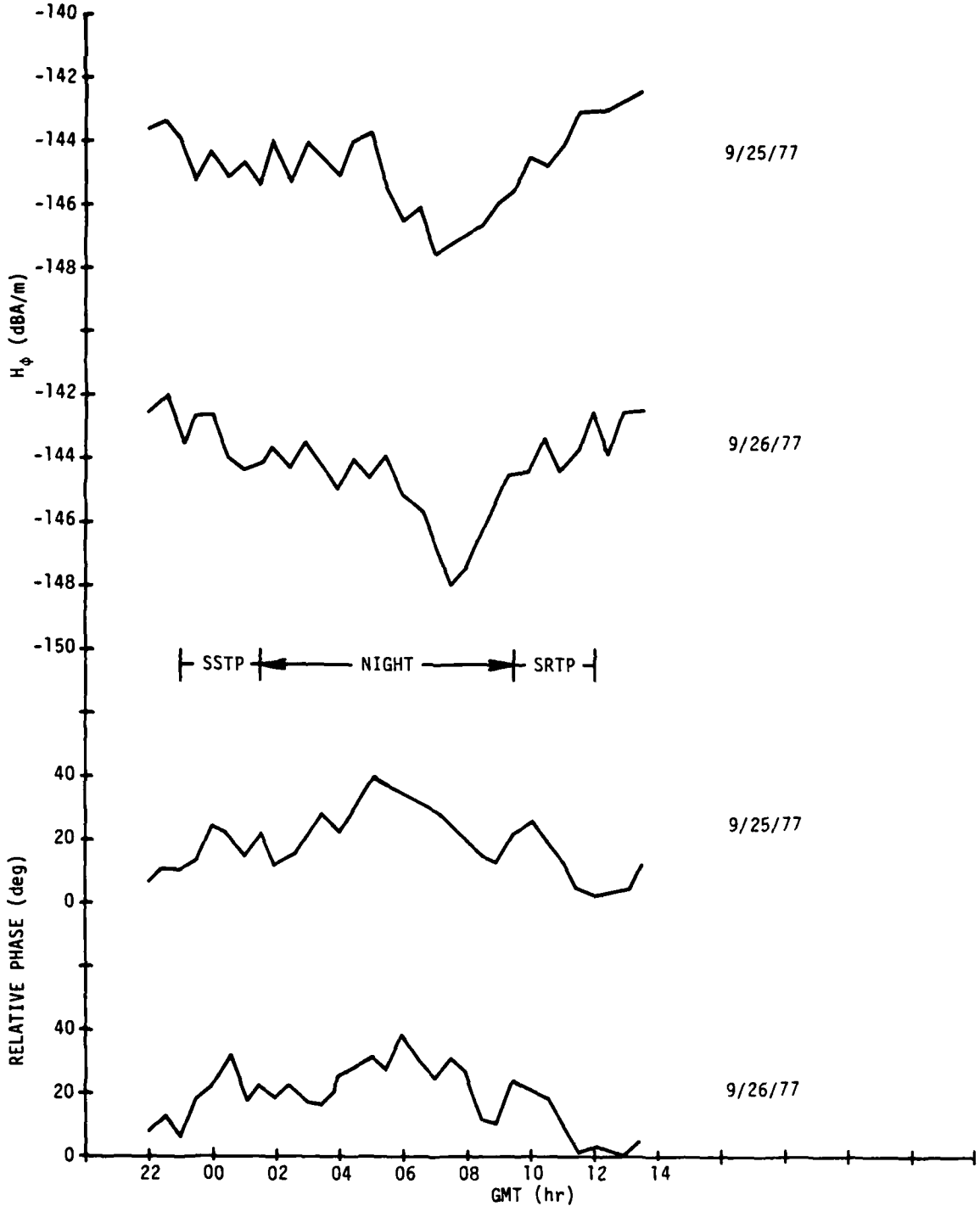

Figure B-7. Connecticut Field Strength Versus GMT, 25 and 26 September 1977 (ψ = 291 deg)

Appendix C

NOVEMBER 1977 DAILY PLOTS

Daily plots of field strength at the Connecticut site (both amplitude and relative phase) versus GMT, in 30-min increments, for November 1977 are presented in this appendix as figures C-1 through C-13.

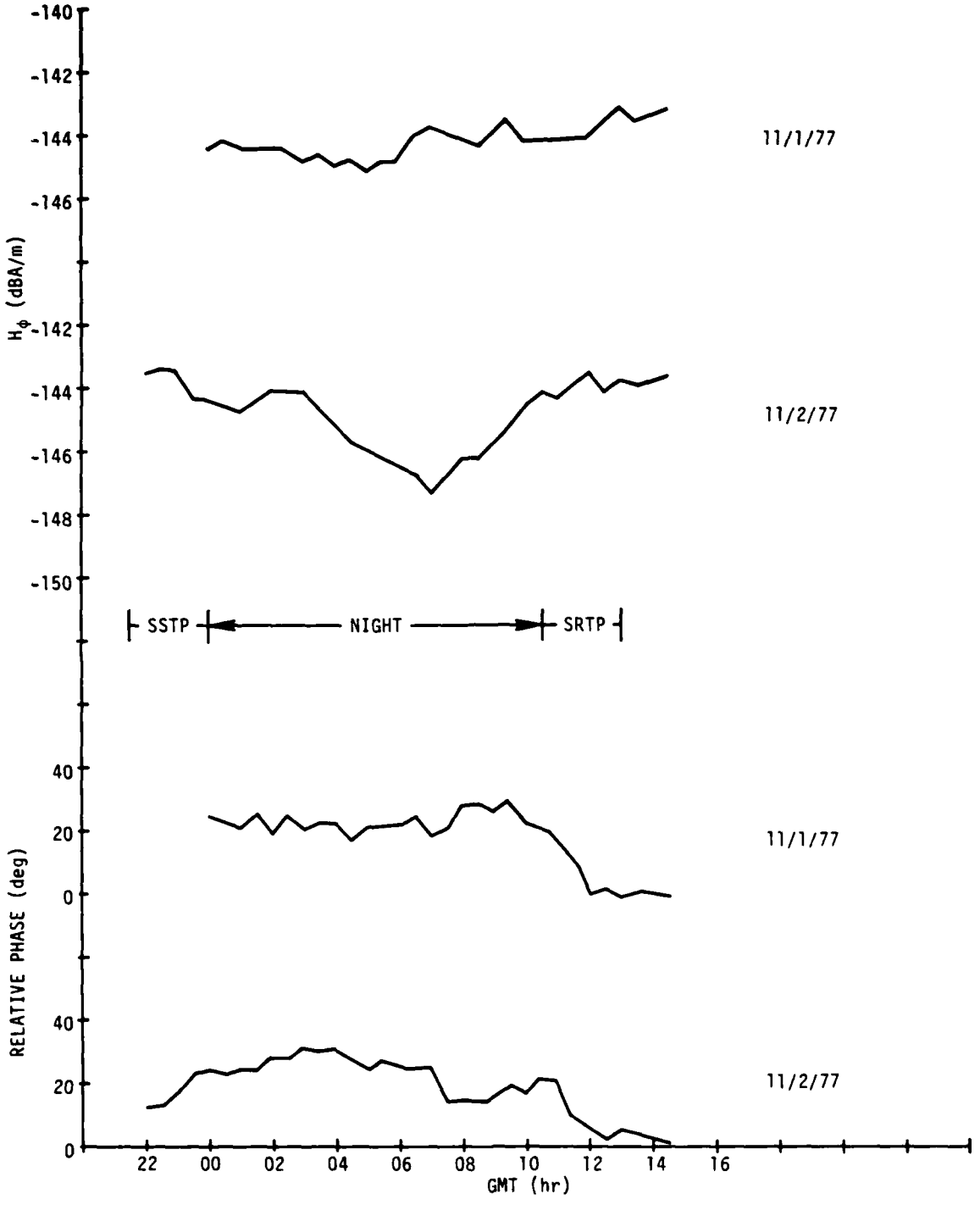

Figure C-1. Connecticut Field Strength Versus GMT, 1 and 2 November 1977 (ψ = 291 deg)

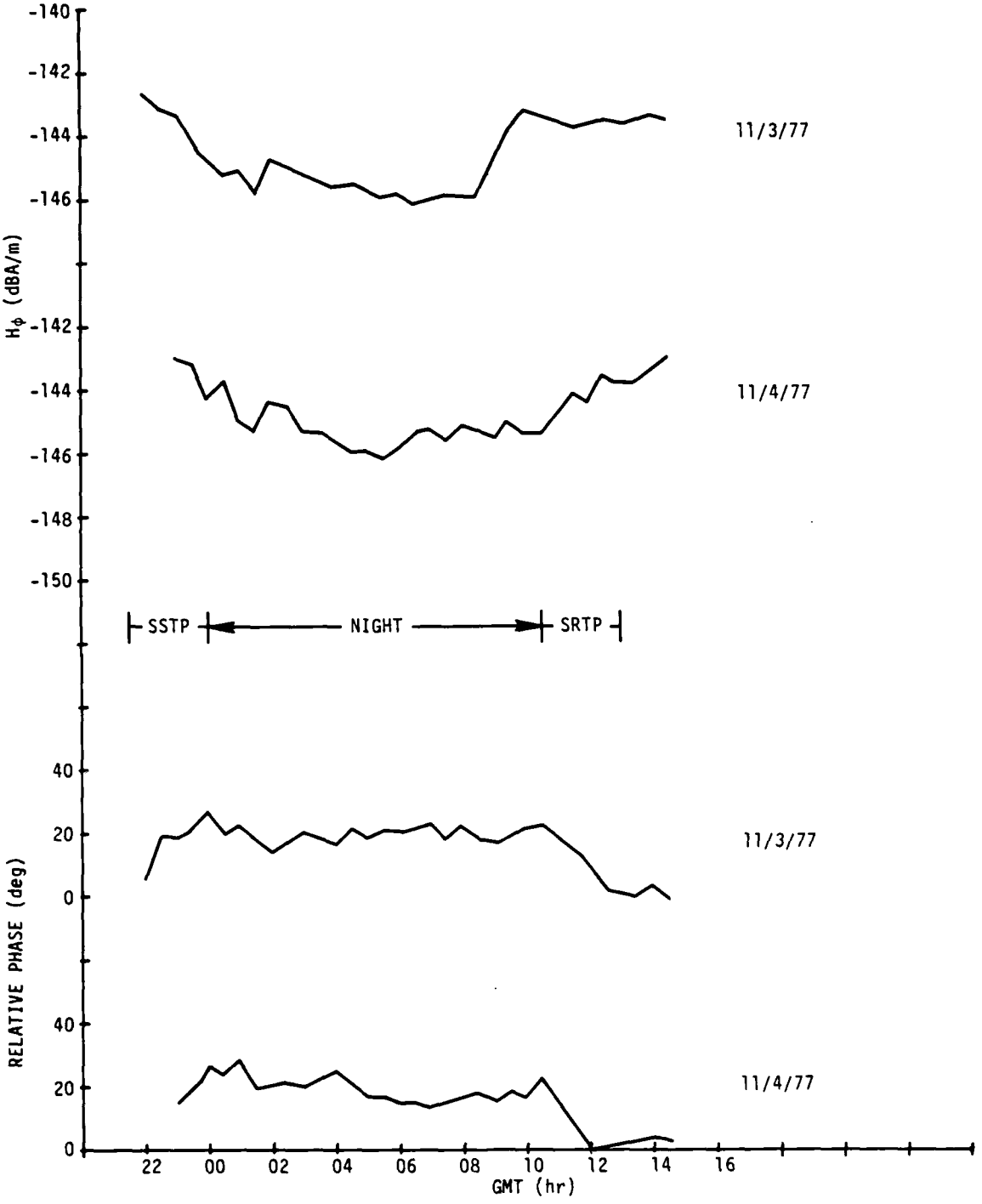

Figure C-2. Connecticut Field Strength Versus GMT, 3 and 4 November 1977 (ψ = 291 deg)

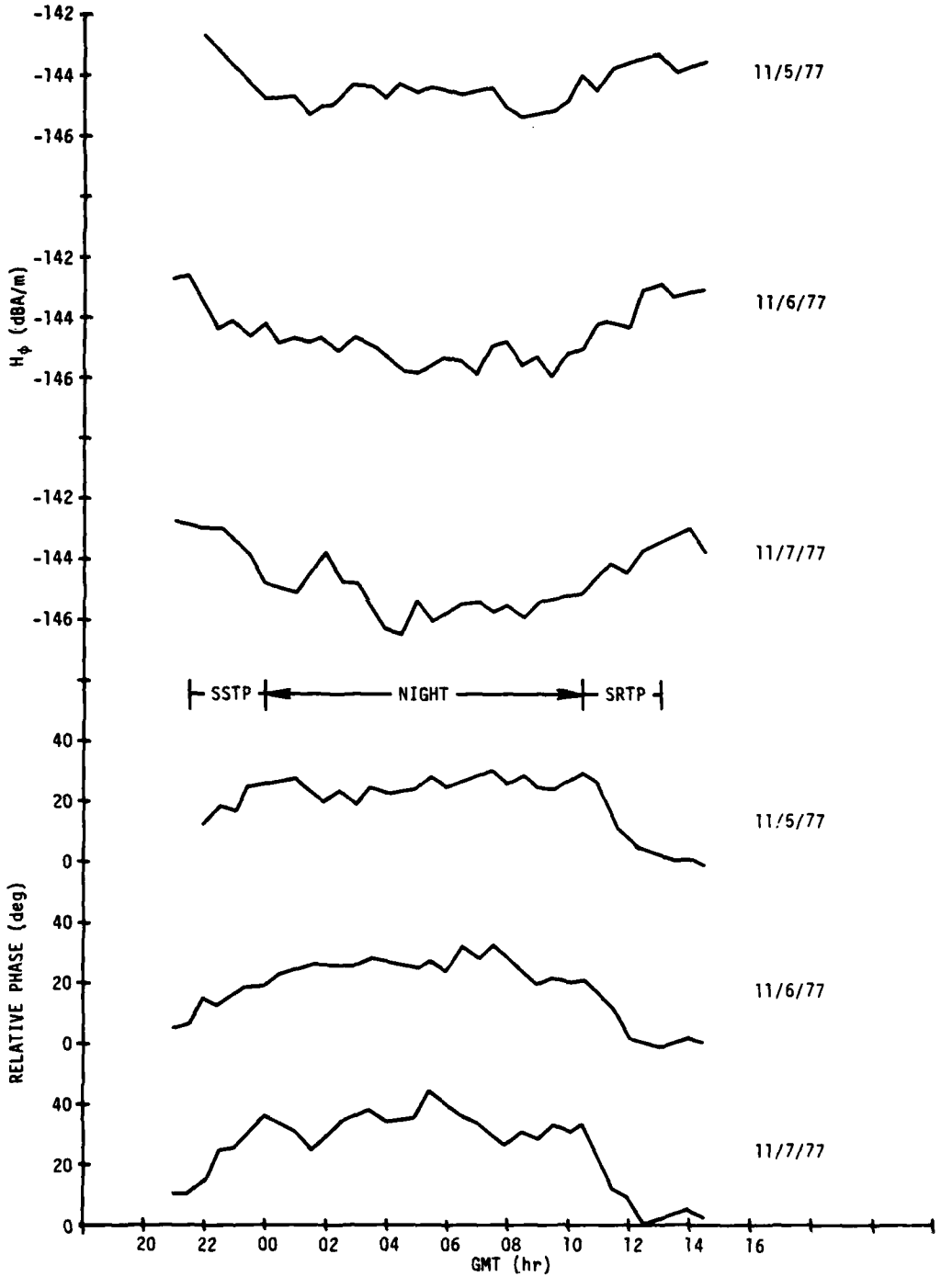

Figure C-3. Connecticut Field Strength Versus GMT, 5, 6, and 7 November 1977 (ψ = 291 deg)

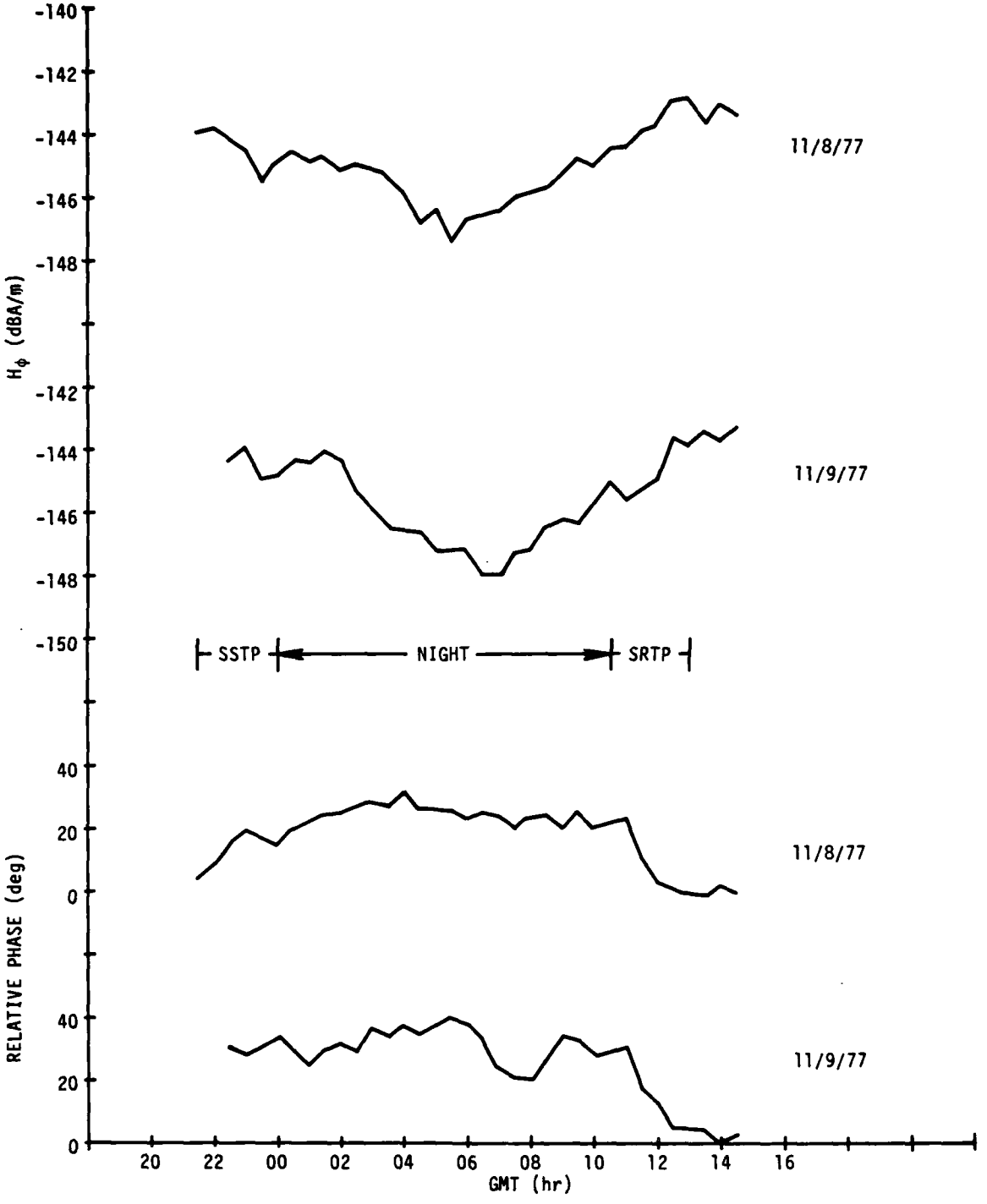

Figure C-4. Connecticut Field Strength Versus GMT, 8 and 9 November 1977 (ψ = 291 deg)

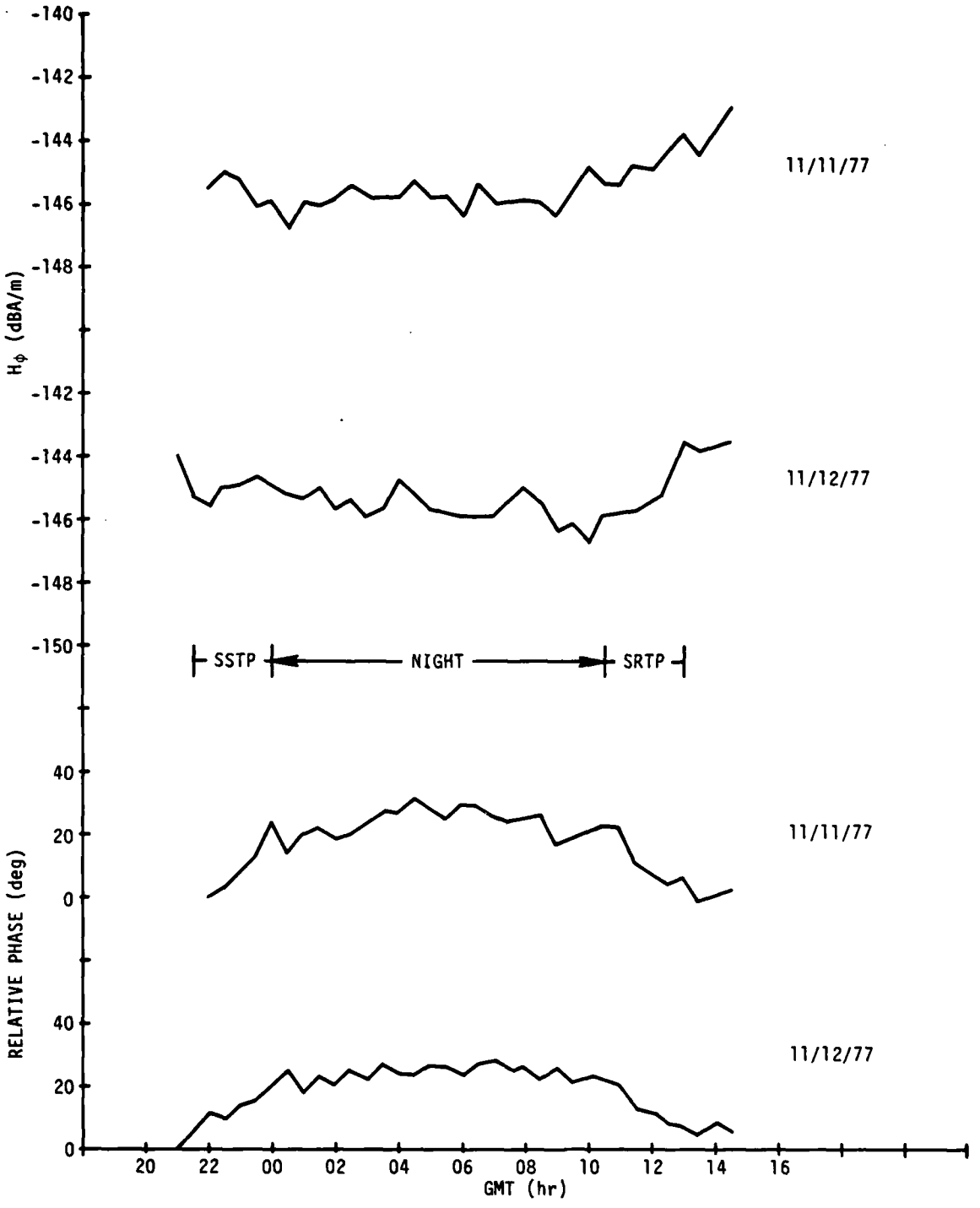

Figure C-5. Connecticut Field Strength Versus GMT, 11 and 12 November 1977 (ψ = 21 deg)

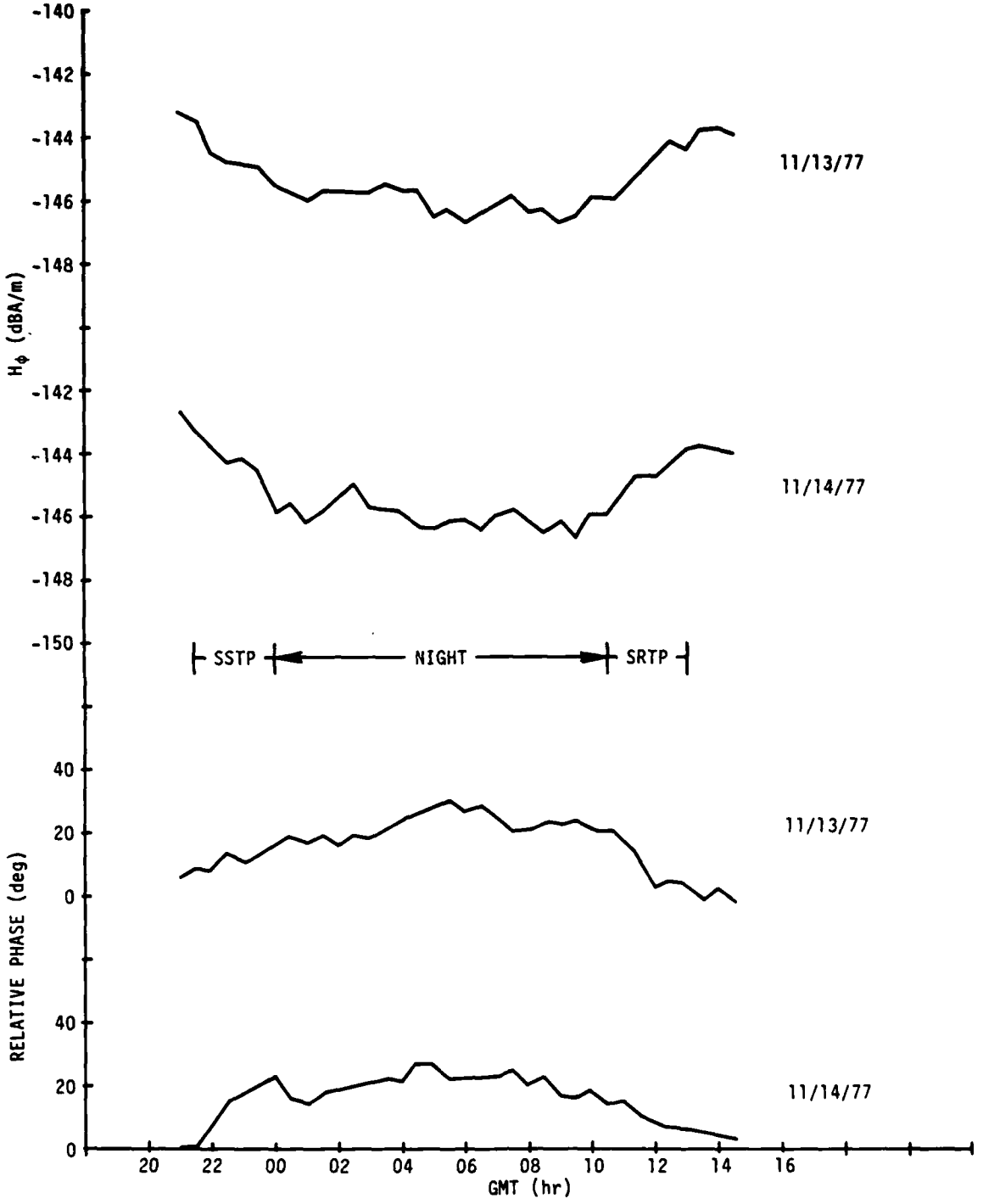

Figure C-6. Connecticut Field Strength Versus GMT, 13 and 14 November 1977 (ψ = 21 deg)

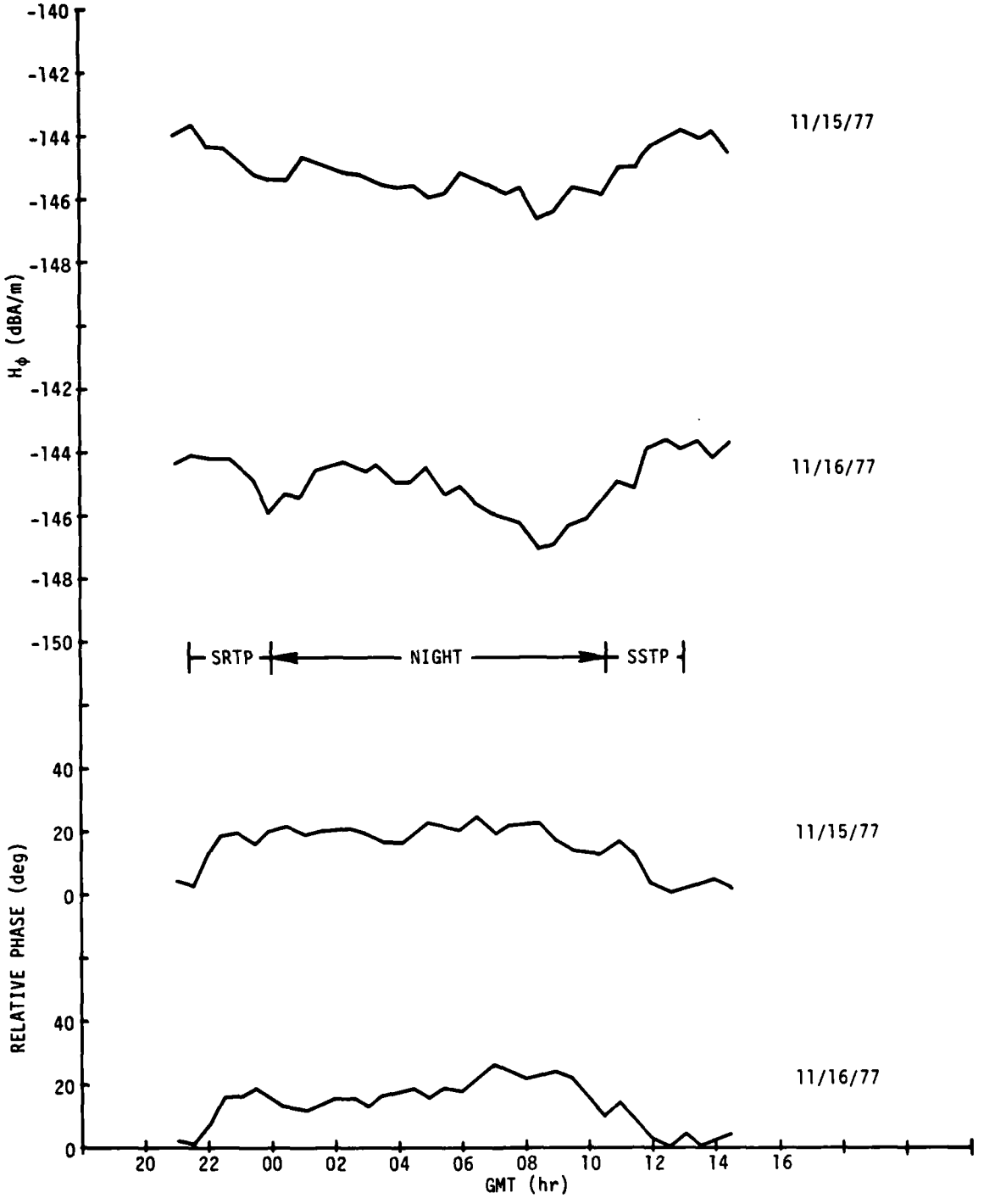

Figure C-7. Connecticut Field Strength Versus GMT, 15 and 16 November 1977 (ψ = 21 deg)

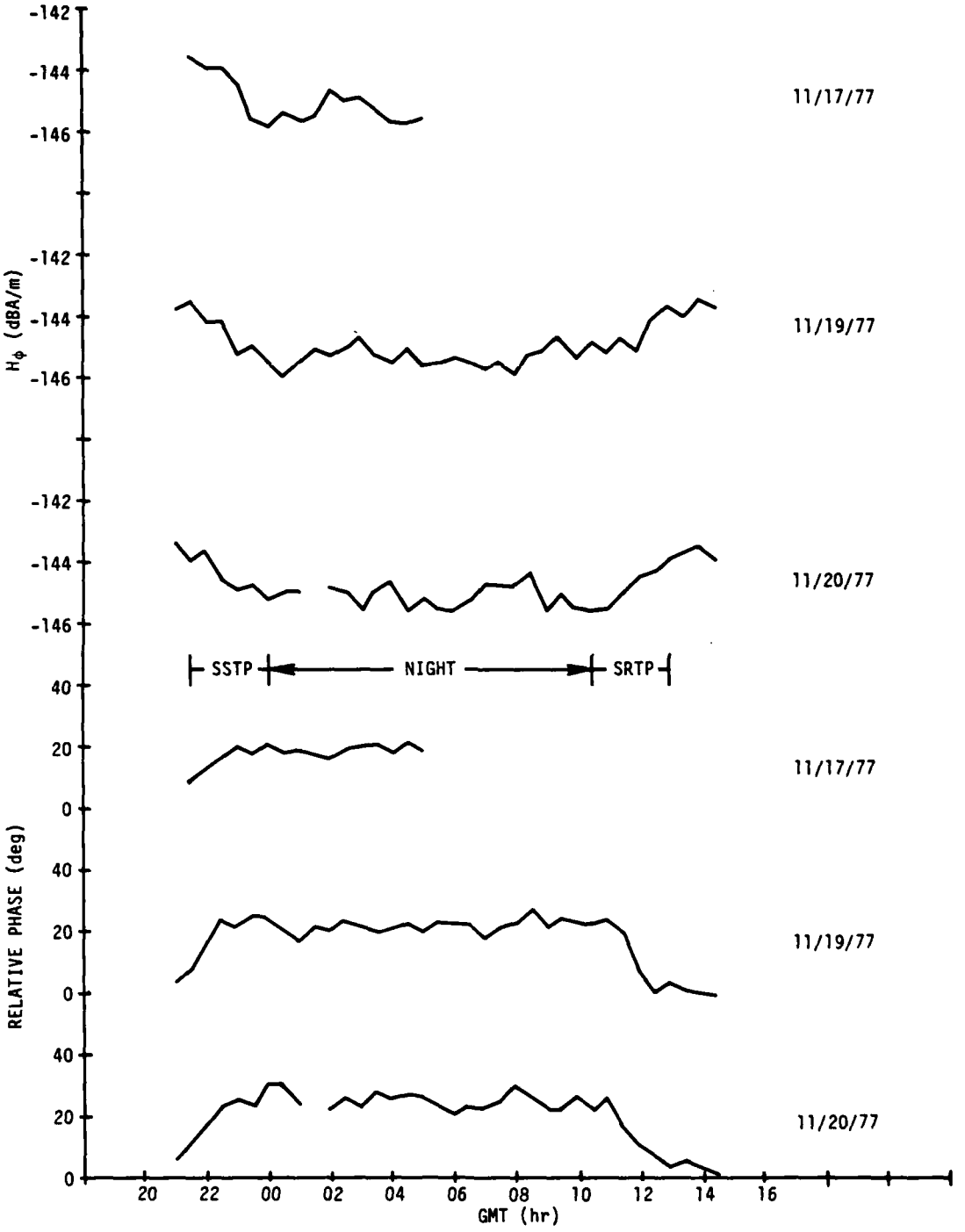

Figure C-8. Connecticut Field Strength Versus GMT, 17, 19, and 20 November 1977 (ψ = 21 deg)

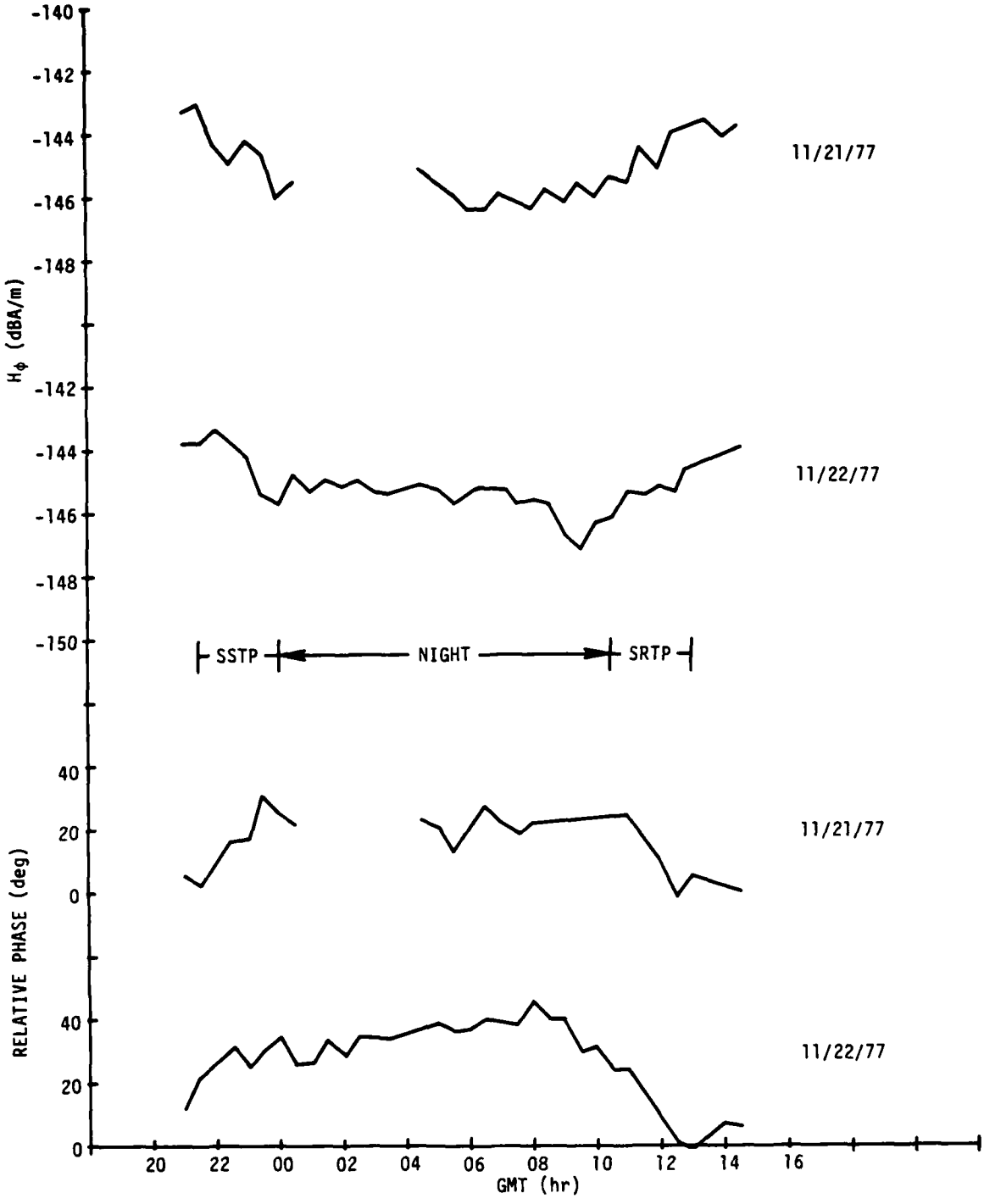

Figure C-9. Connecticut Field Strength Versus GMT, 21 and 22 November 1977 (ψ = 21 deg)

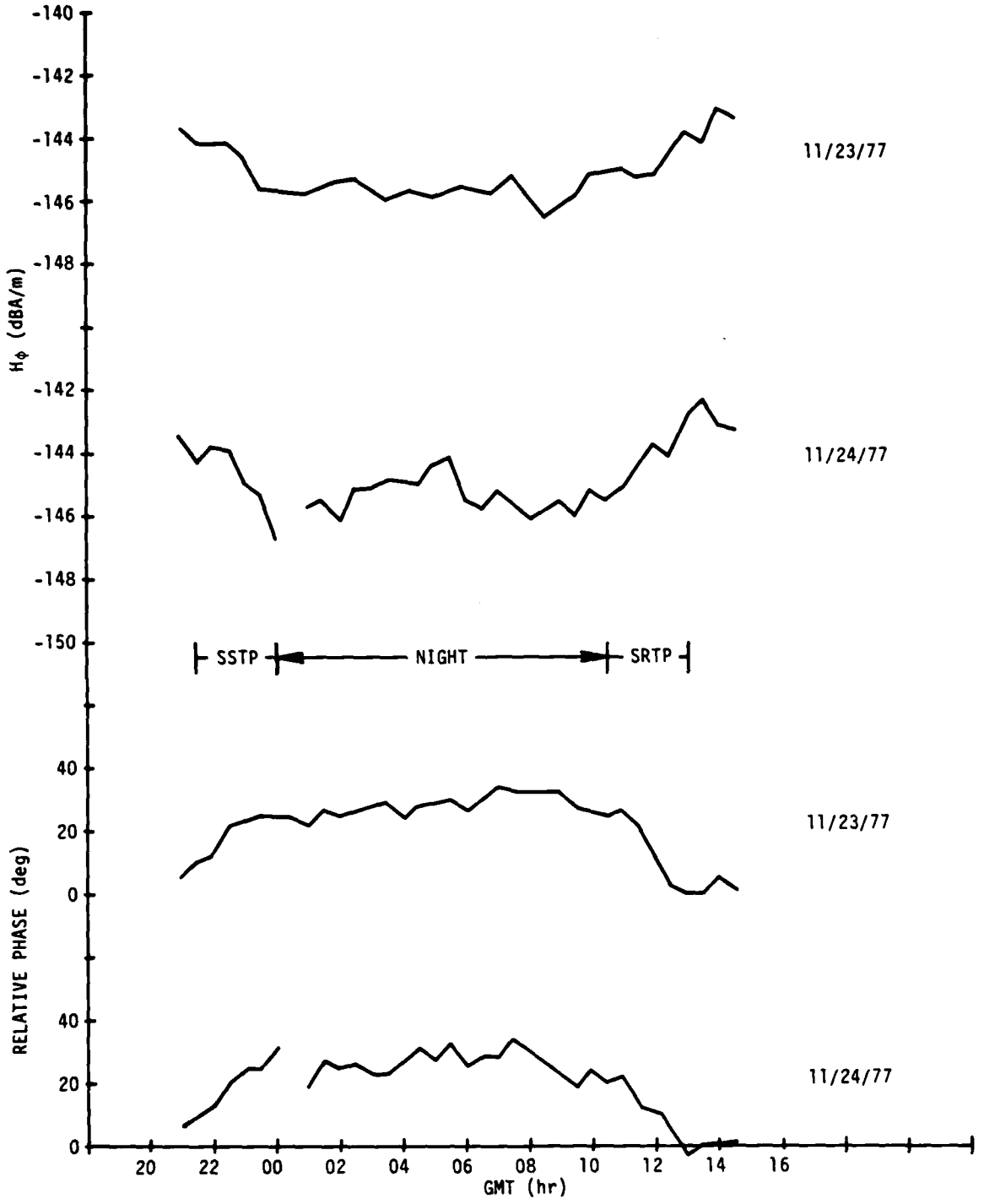

Figure C-10. Connecticut Field Strength Versus GMT, 23 and 24 November 1977 (ψ = 21 deg)

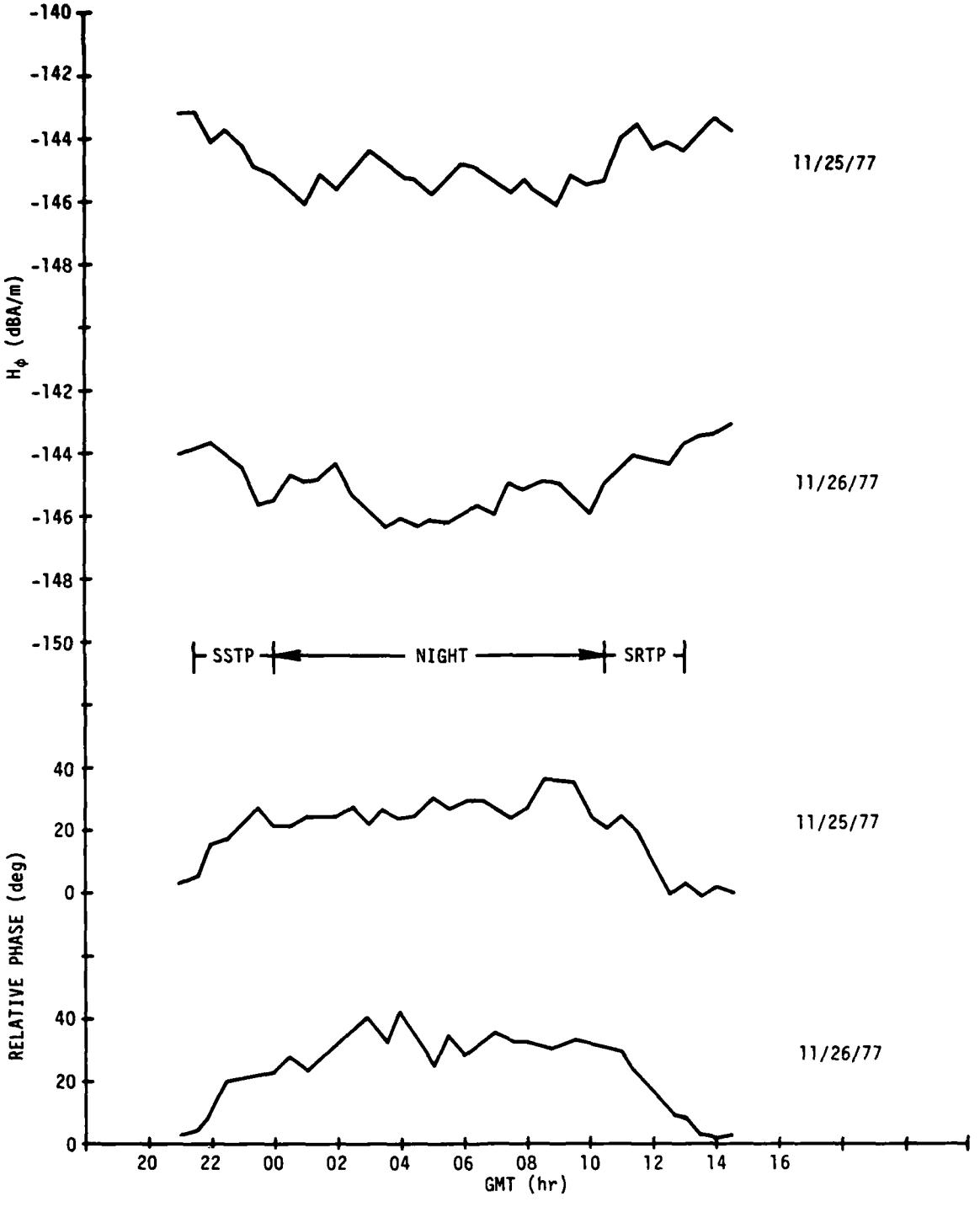

Figure C-11. Connecticut Field Strength Versus GMT, 25 and 26 November 1977 (ψ = 21 deg)

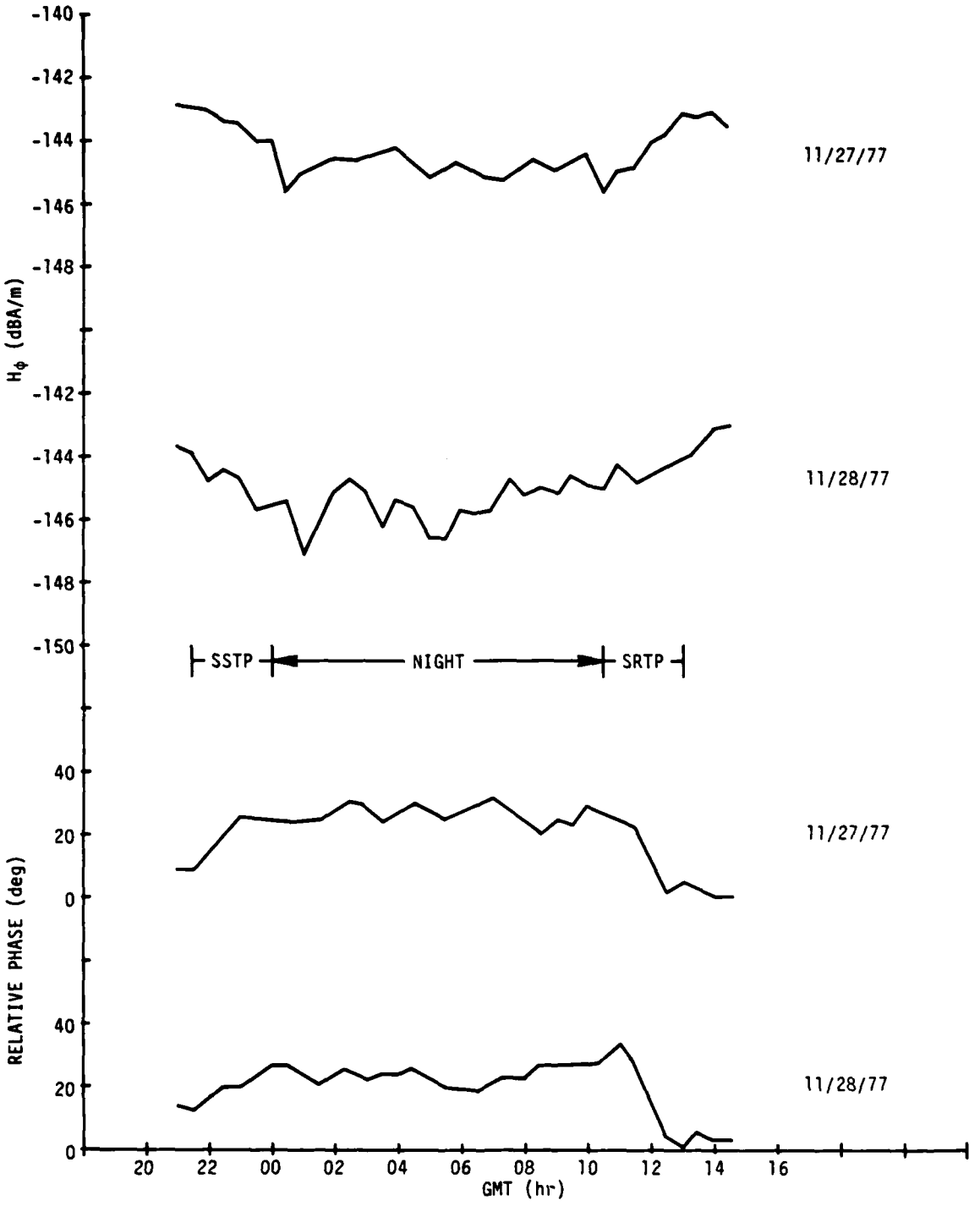

Figure C-12. Connecticut Field Strength Versus GMT, 27 and 28 November 1977 (ψ = 21 deg)

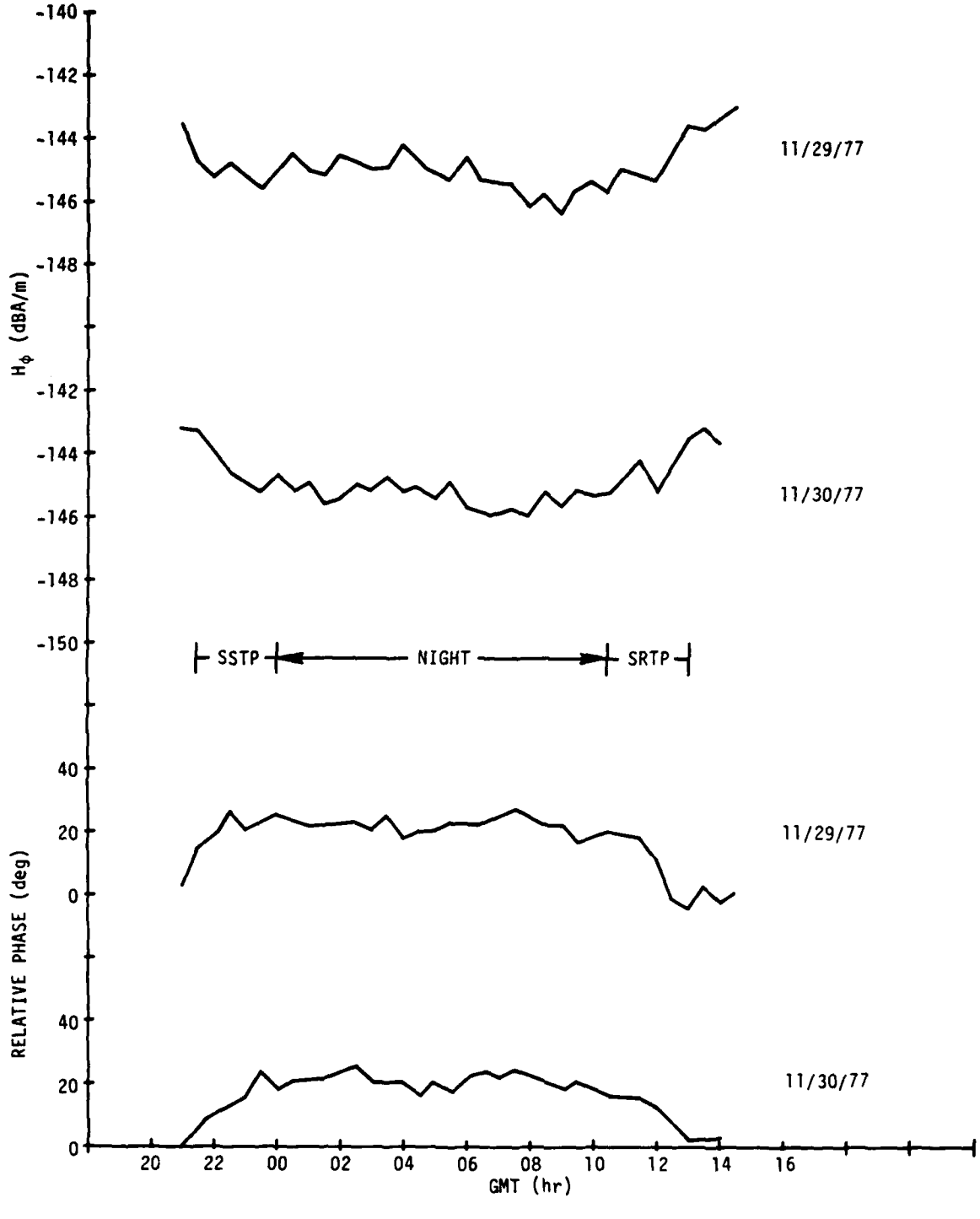

Figure C-13. Connecticut Field Strength Versus GMT, 29 and 30 November 1977 (ψ = 21 deg)

Appendix D

DECEMBER 1977 DAILY PLOTS

Daily plots of field strength at the Connecticut site (both amplitude and relative phase) versus GMT, in 30-min increments, for December 1977 are presented in this appendix as figures D-1 through D-13.

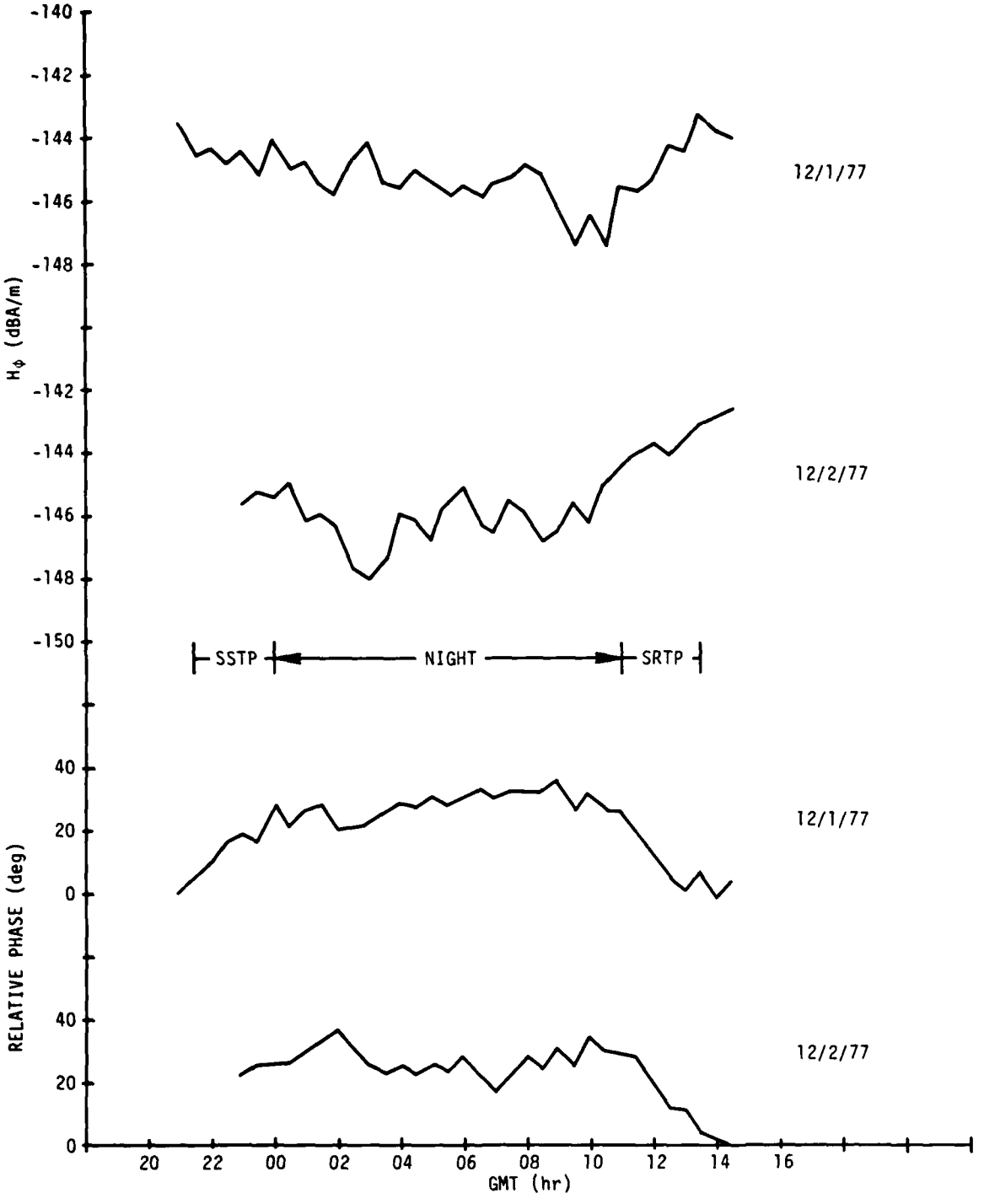

Figure D-1. Connecticut Field Strength Versus GMT, 1 and 2 December 1977 (ψ = 291 deg)

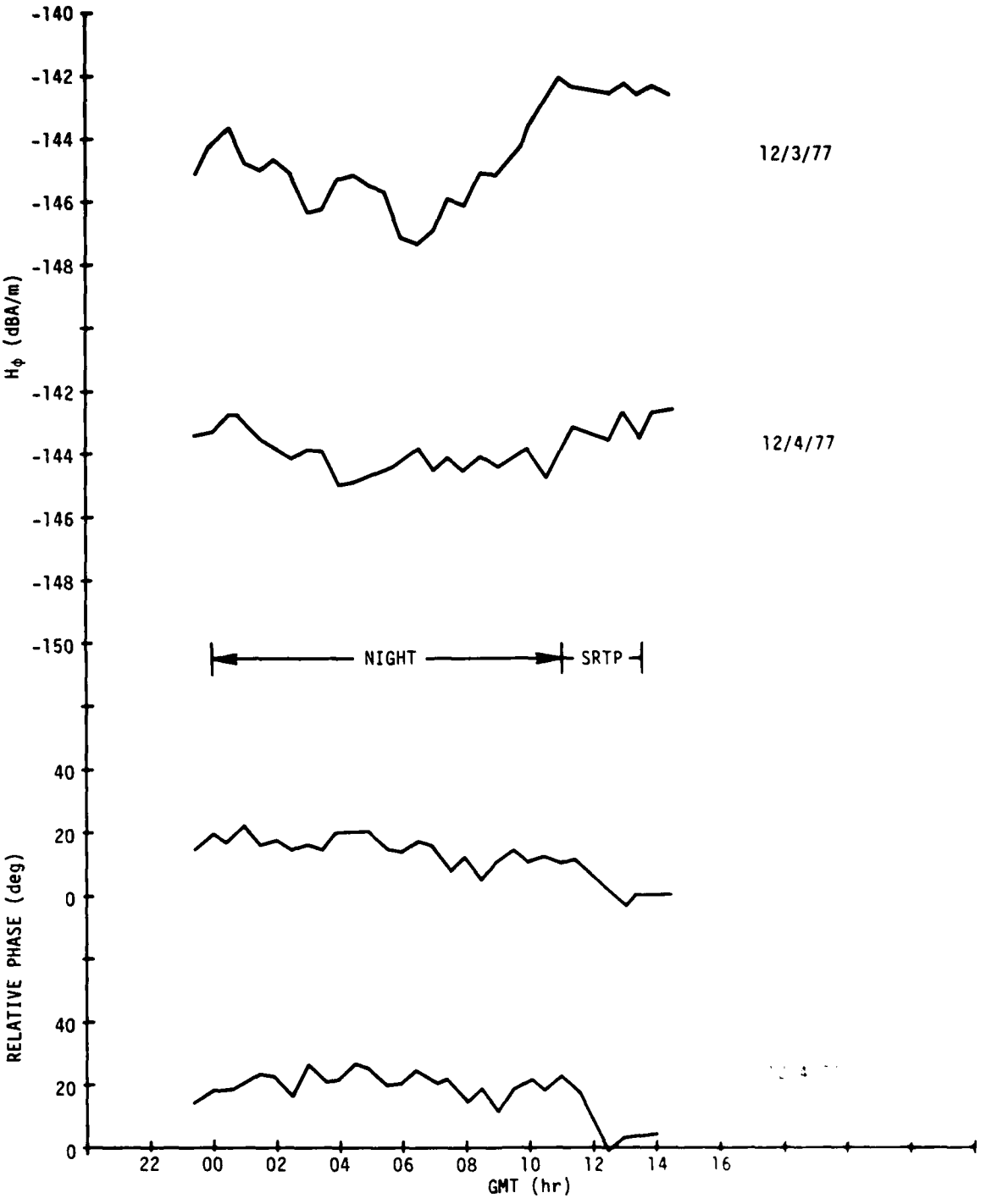

Figure D-2. Connecticut Field Strength Versus GMT, 3 and 4 December 1977 (ψ = 291 deg)

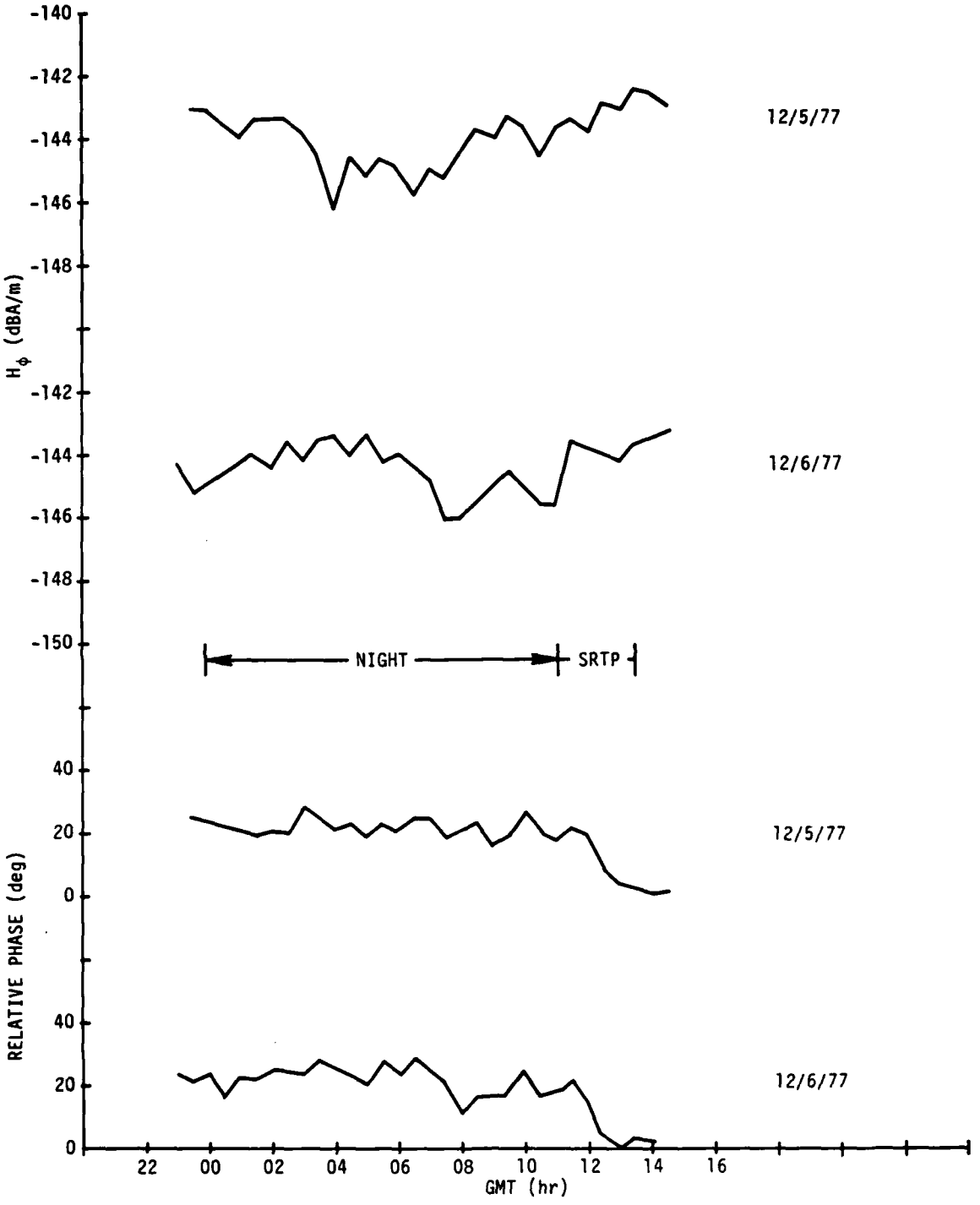

Figure D-3. Connecticut Field Strength Versus GMT, 5 and 6 December 1977 (ψ = 291 deg)

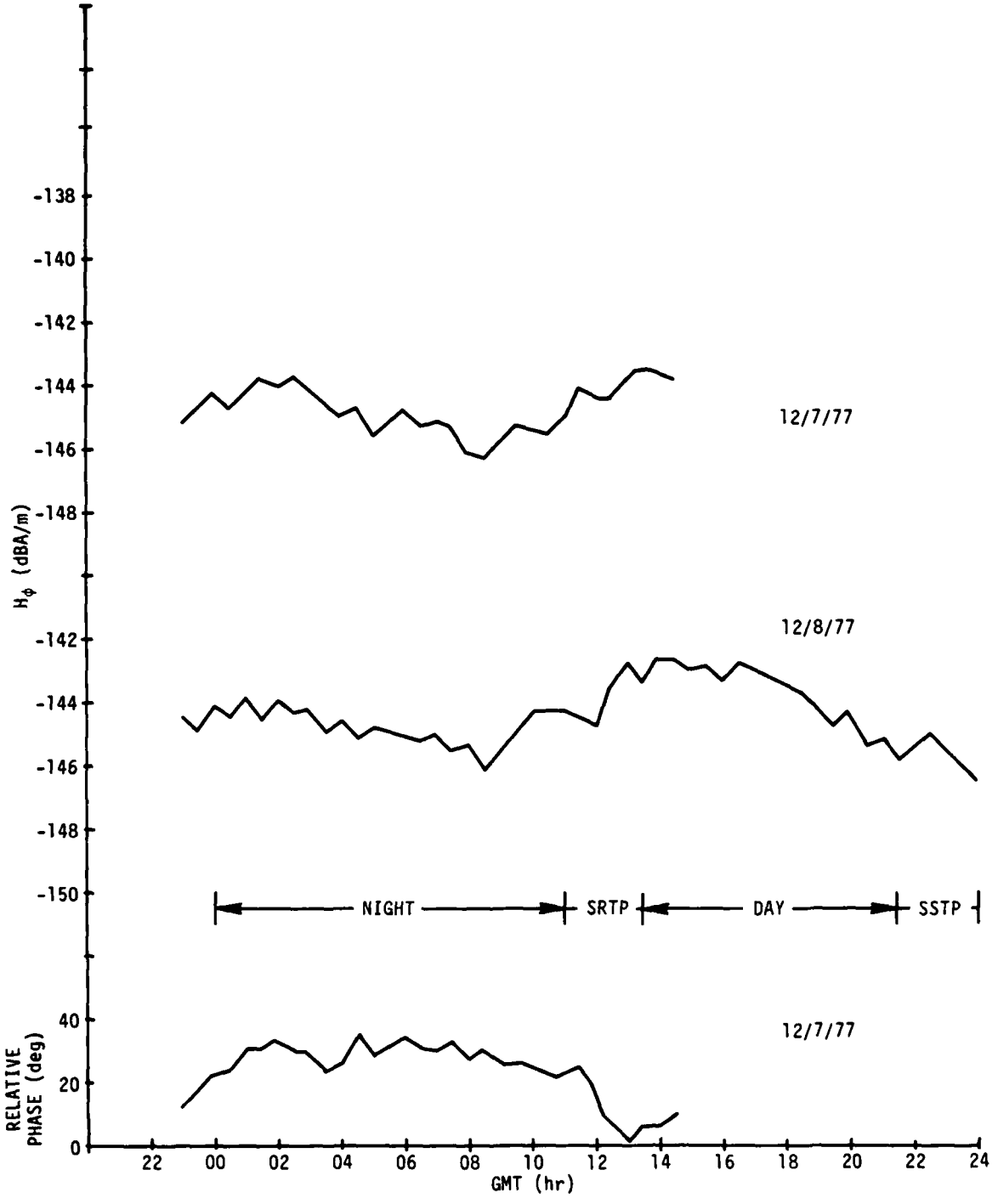

Figure D-4. Connecticut Field Strength Versus GMT, 7 and 8 December 1977 (ψ = 291 deg)

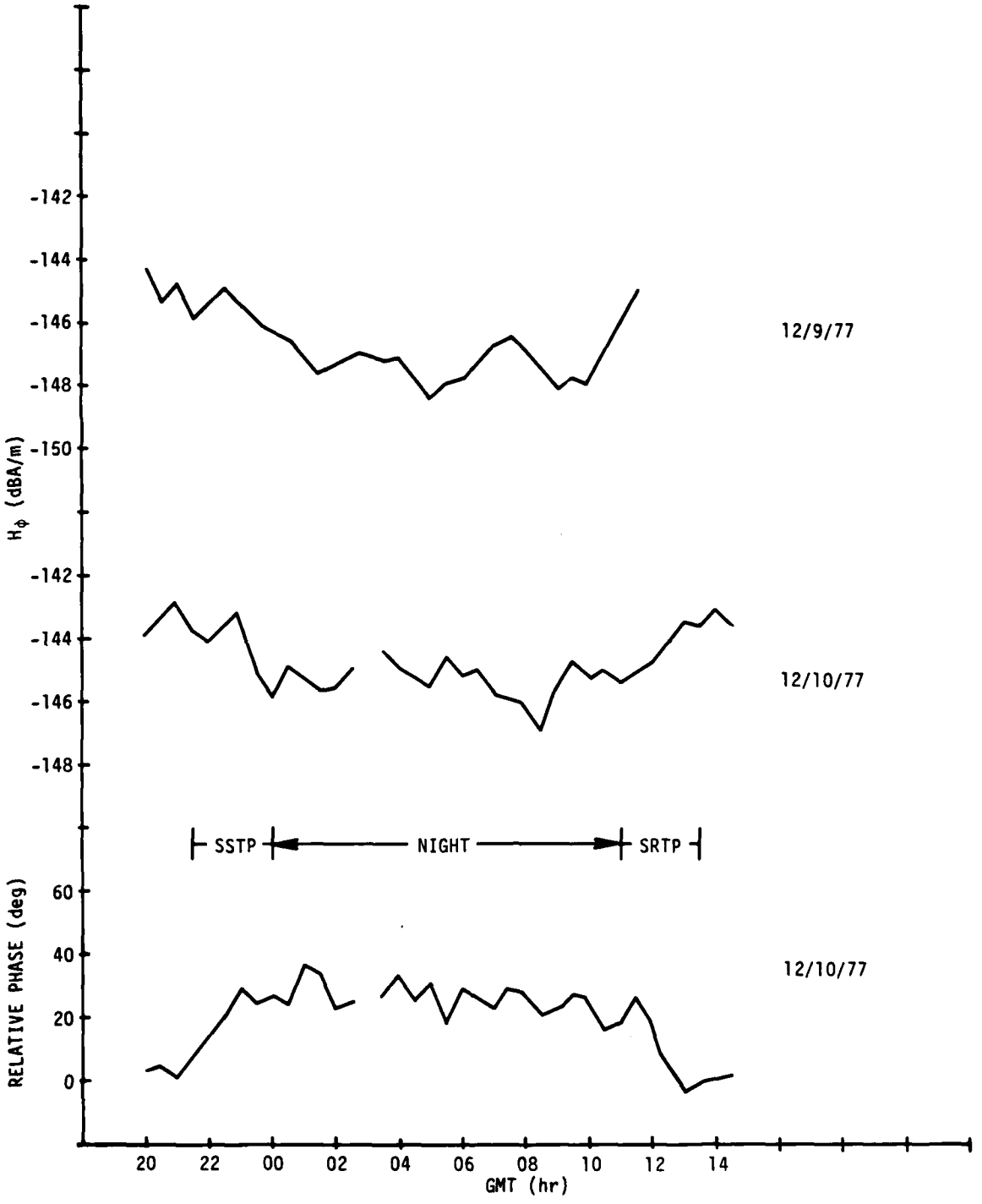

Figure D-5. Connecticut Field Strength Versus GMT, 9 and 10 December 1977 (ψ = 291 deg)

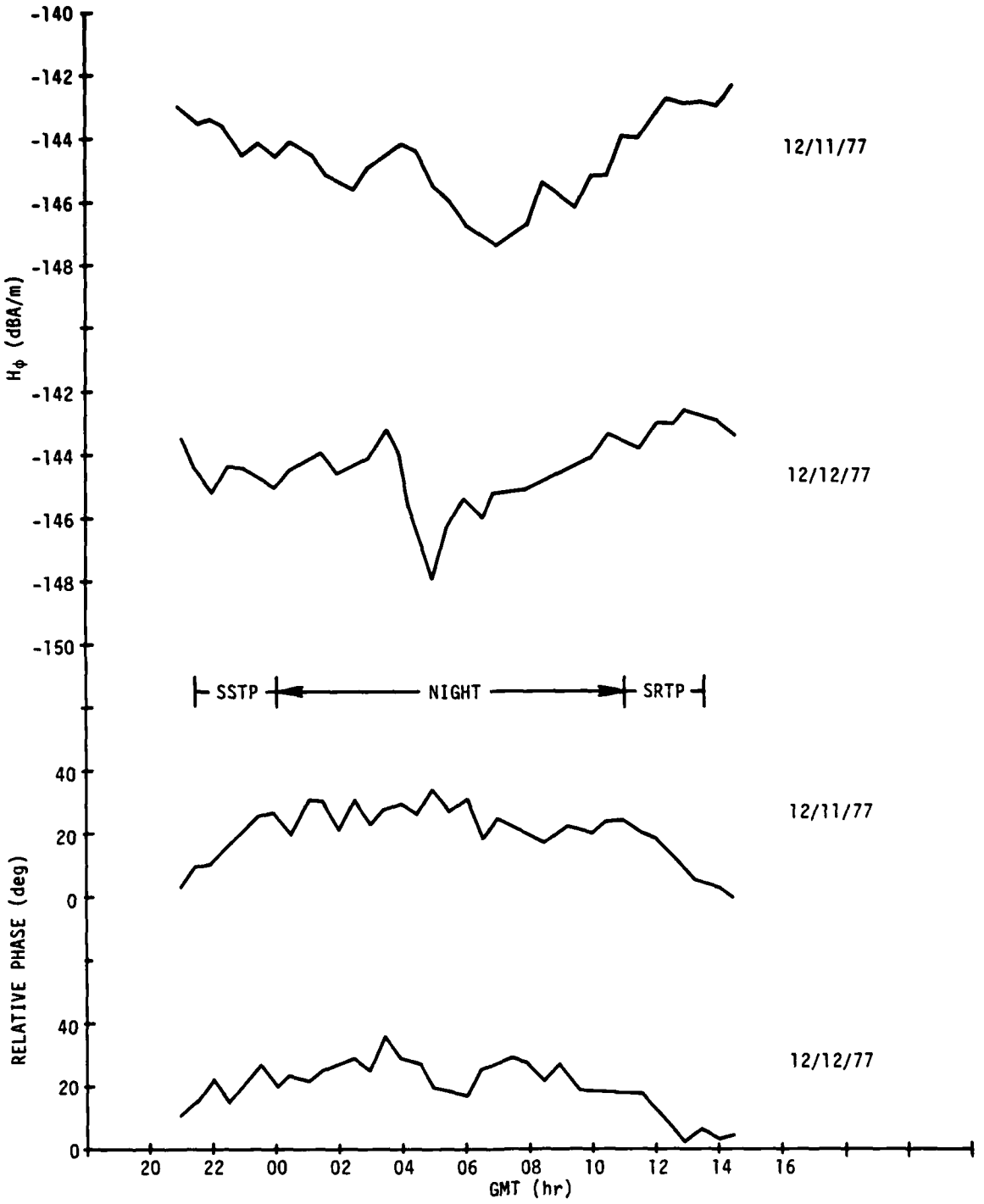

Figure D-6. Connecticut Field Strength Versus GMT, 11 and 12 December 1977 (ψ = 291 deg)

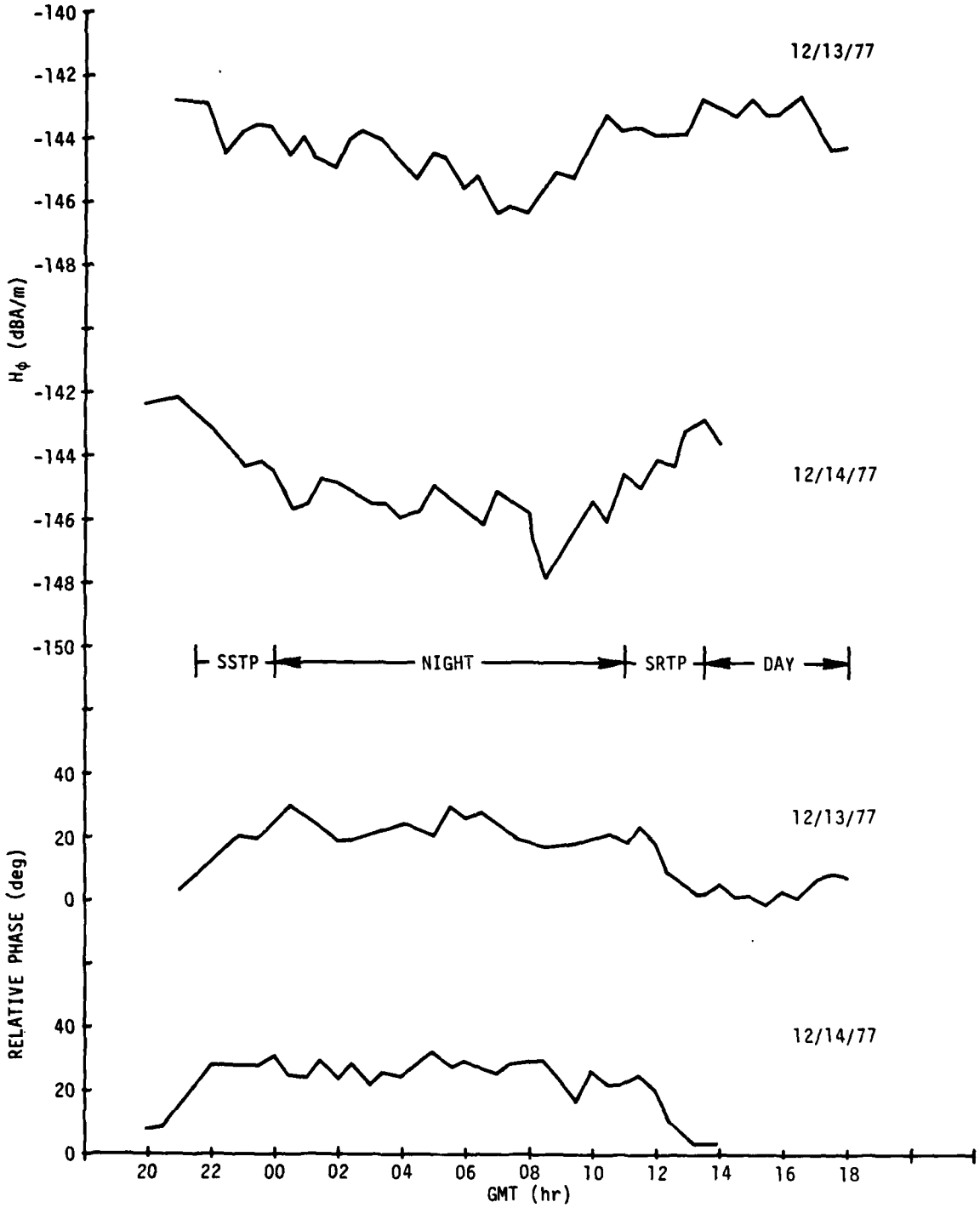

Figure D-7. Connecticut Field Strength Versus GMT, 13 and 14 December 1977 (ψ = 291 deg)

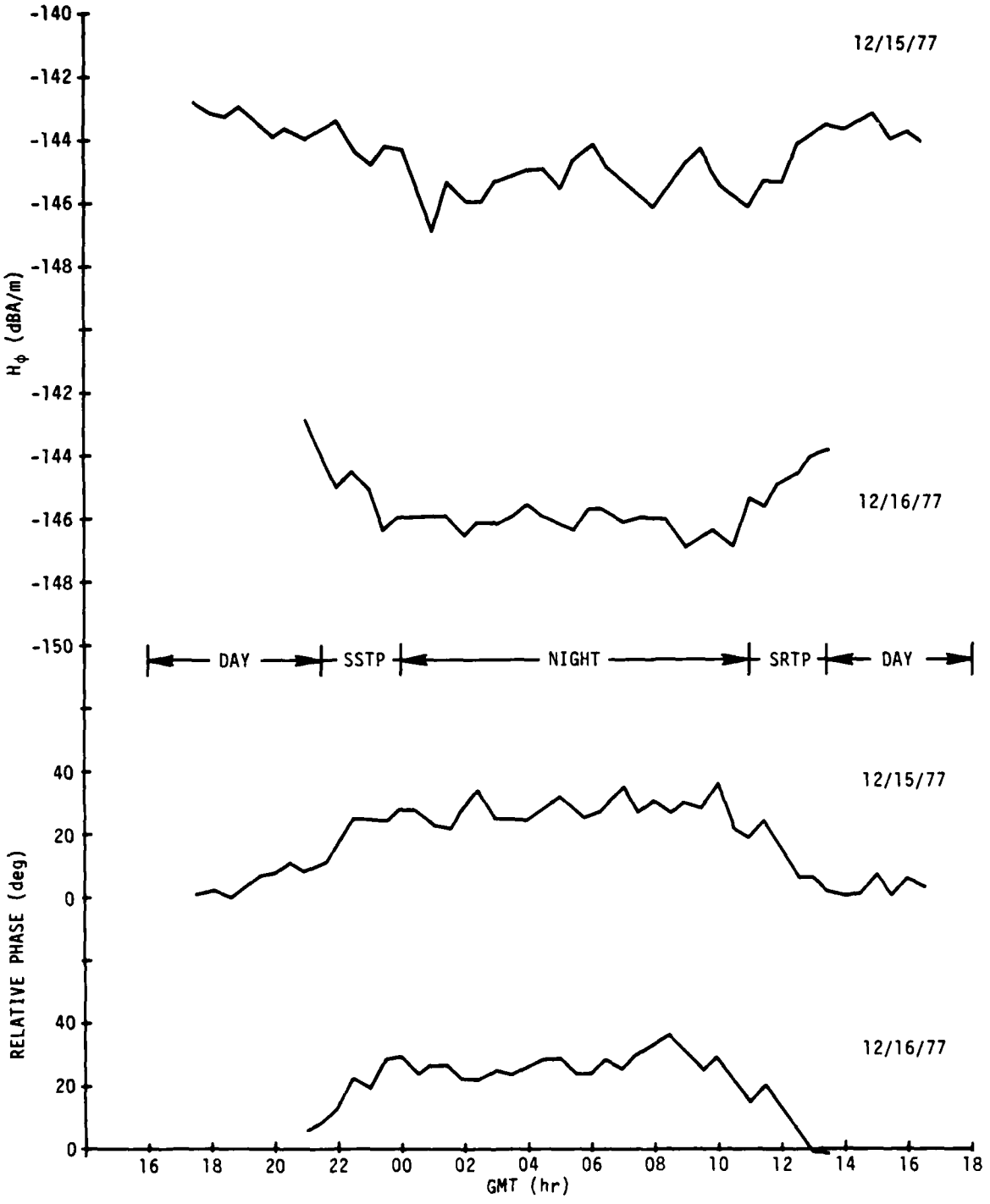

Figure D-8. Connecticut Field Strength Versus GMT, 15 and 16 December 1977 (ψ = 291 deg)

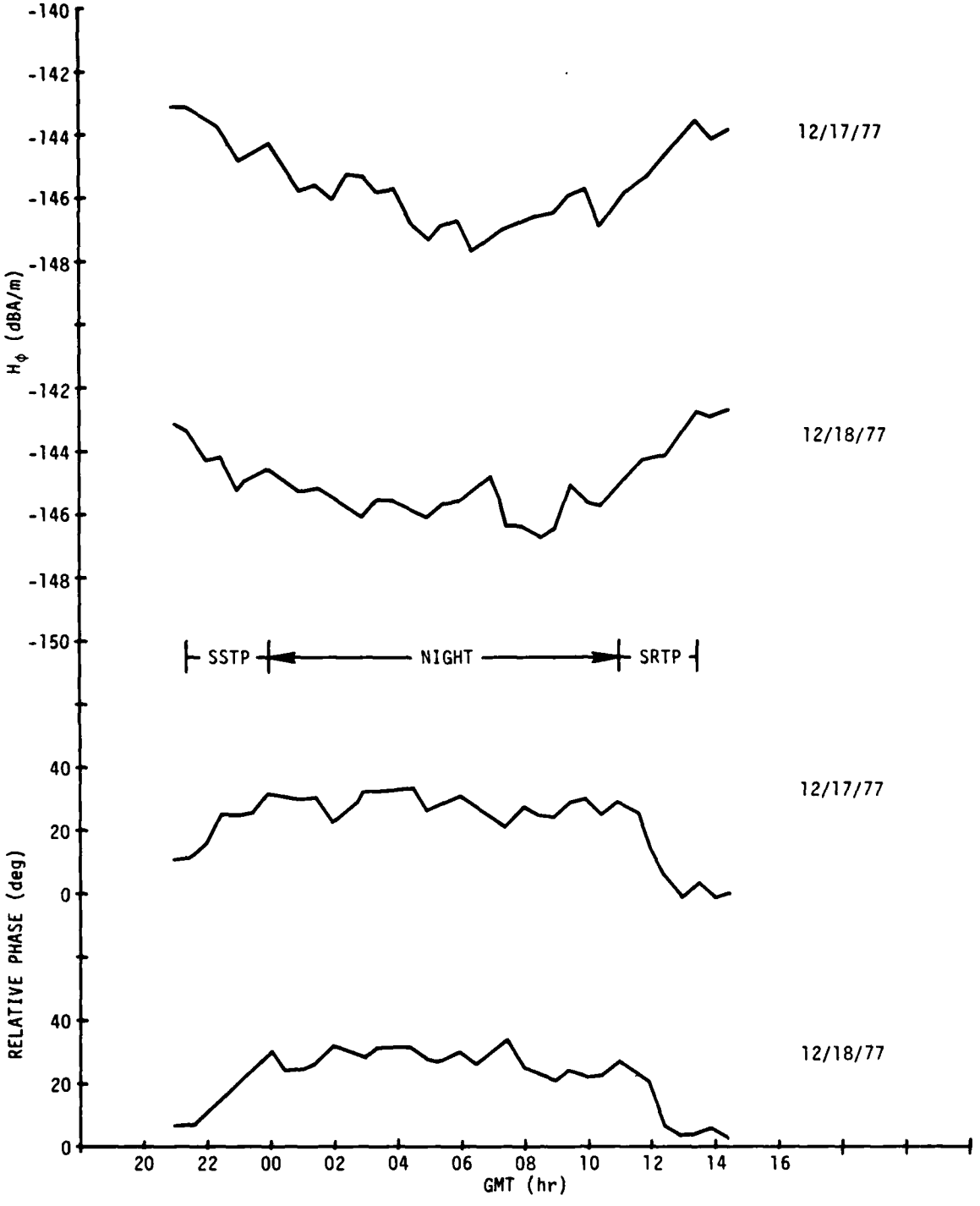

Figure D-9. Connecticut Field Strength Versus GMT, 17 and 18 December 1977 (ψ = 291 deg)

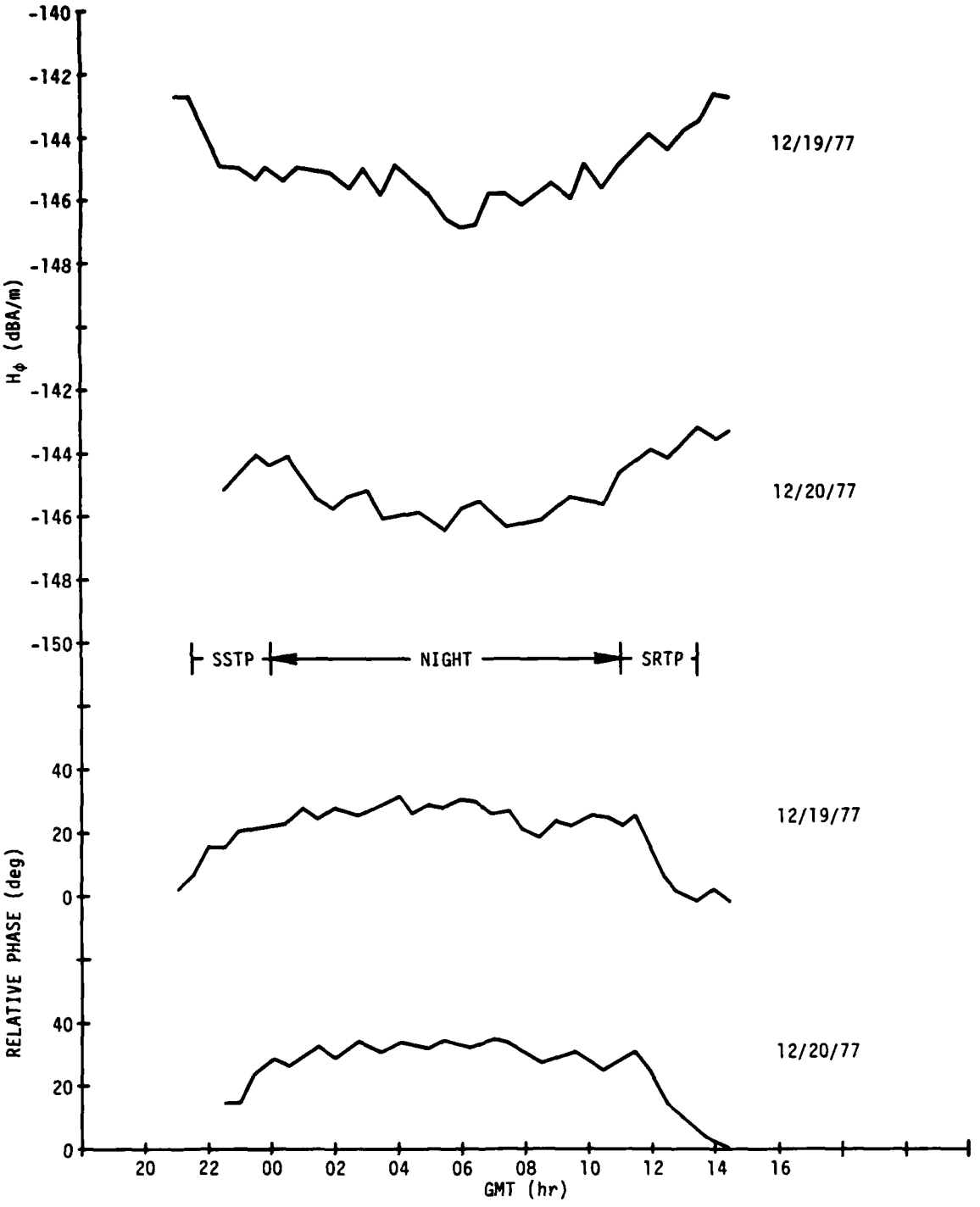

Figure D-10. Connecticut Field Strength Versus GMT, 19 and 20 December 1977 (ψ = 291 deg)

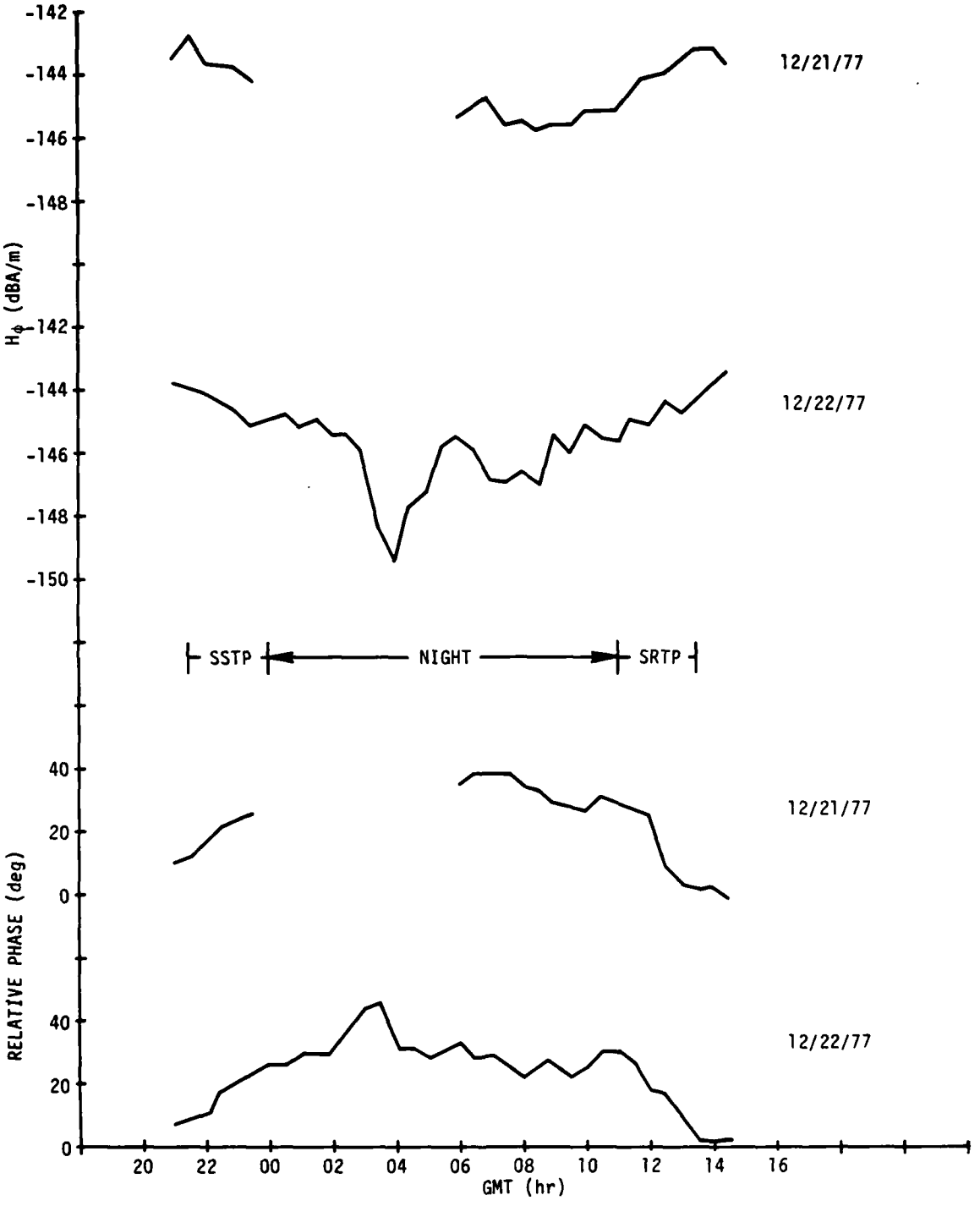

Figure D-11. Connecticut Field Strength Versus GMT, 21 and 22 December 1977 (ψ = 291 deg)

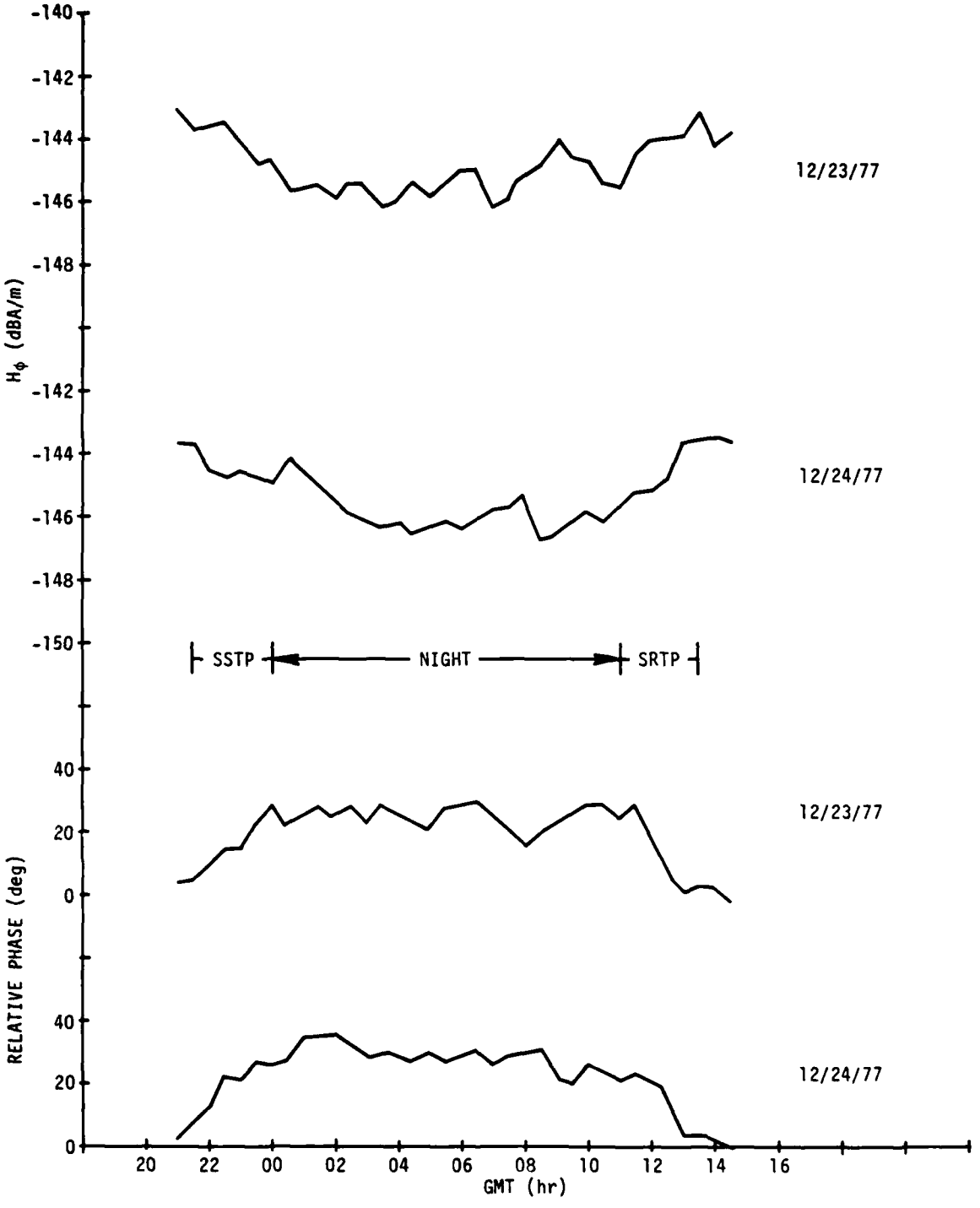

Figure D-12. Connecticut Field Strength Versus GMT, 23 and 24 December 1977 (ψ = 291 deg)

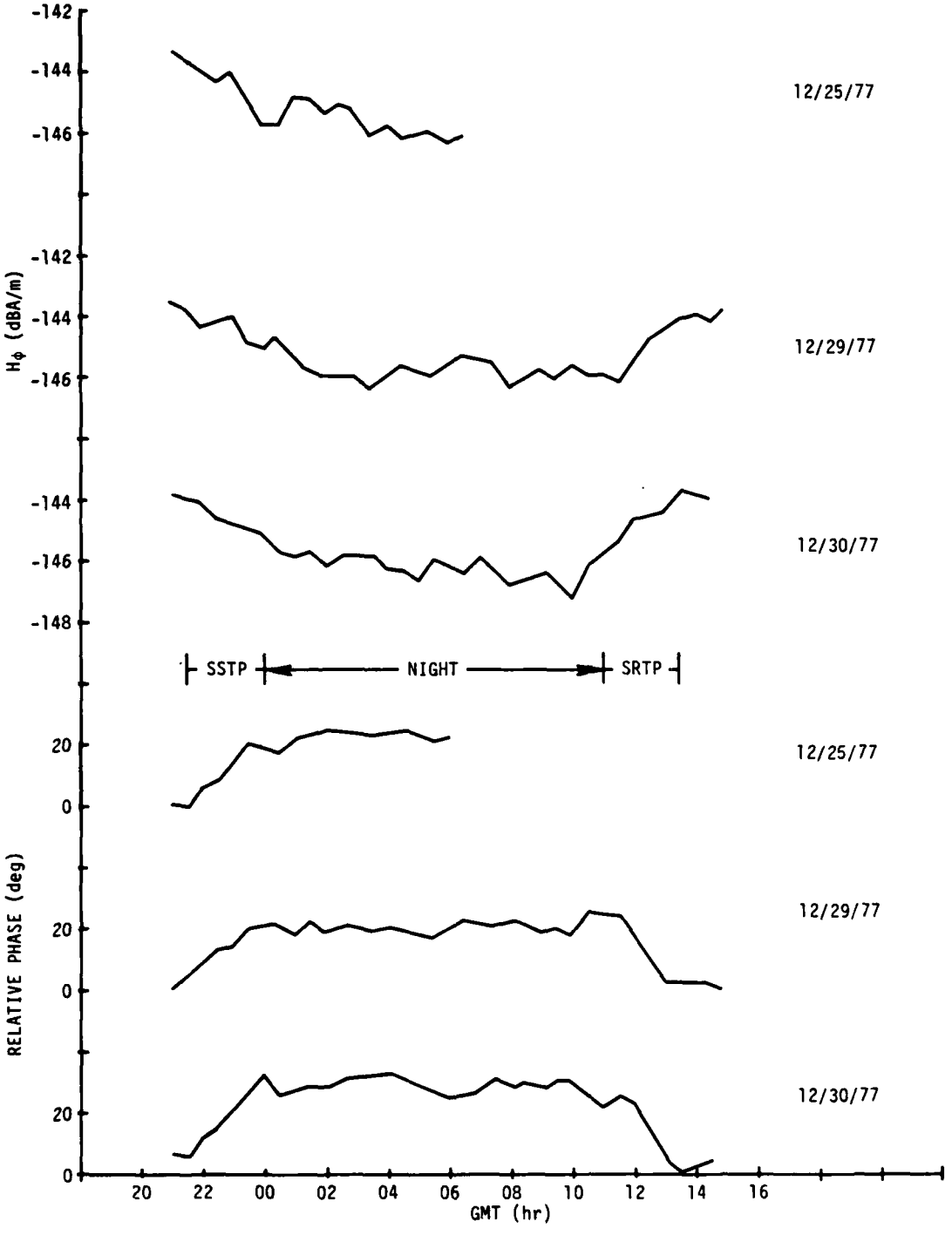

Figure D-13. Connecticut Field Strength Versus GMT, 25, 29, and 30 December 1977 (ψ = 291 deg)

Appendix E

AUGUST 1978 DAILY PLOTS

Daily plots of field strength at the Connecticut site (both amplitude and relative phase) versus GMT, in 30-min increments, for August 1978 are presented in this appendix as figures E-1 through E-4.

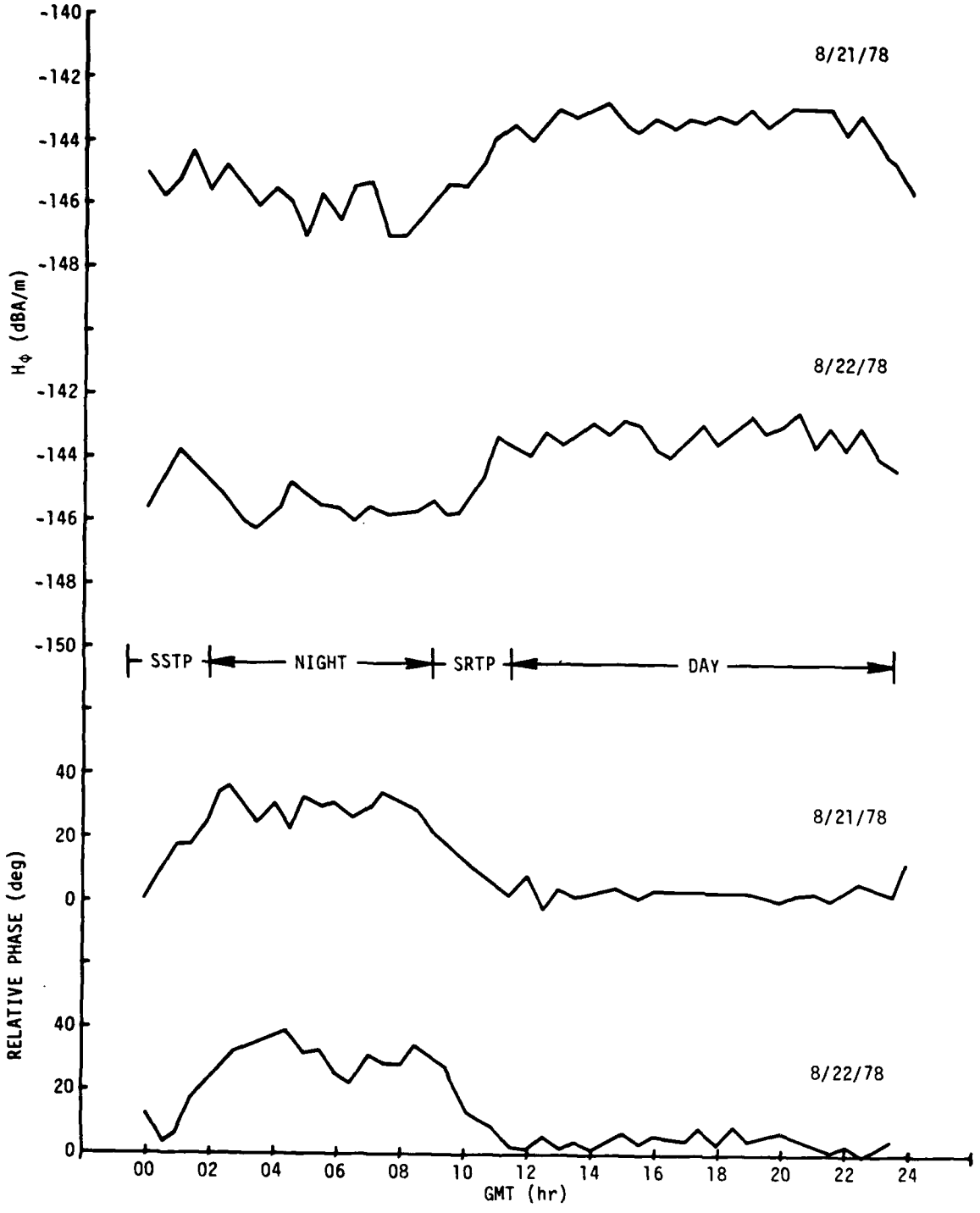

Figure E-1. Connecticut Field Strength Versus GMT, 21 and 22 August 1978 (ψ = 291 deg)

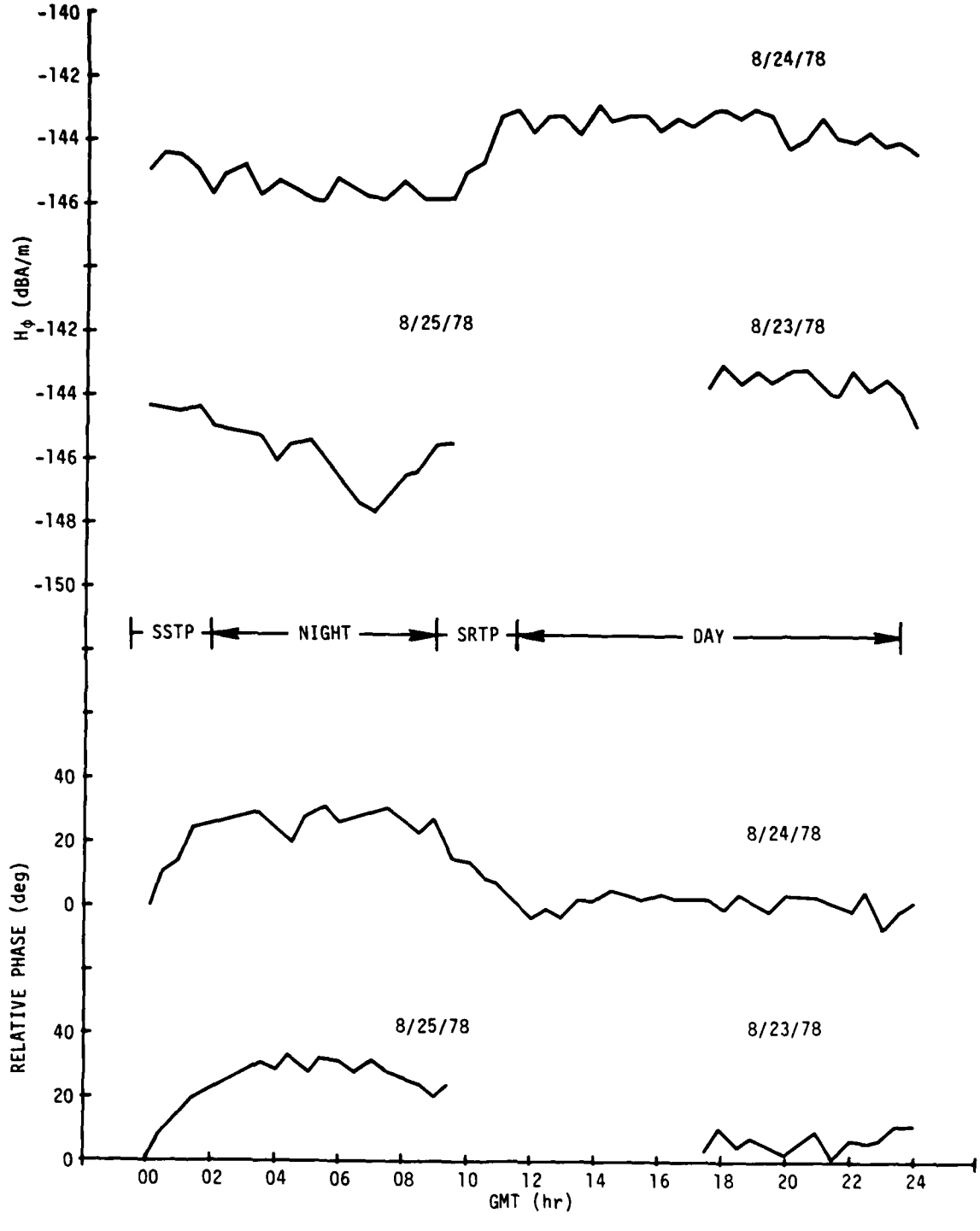

Figure E-2. Connecticut Field Strength Versus GMT, 23, 24, and 25 August 1978 (ψ = 291 deg)

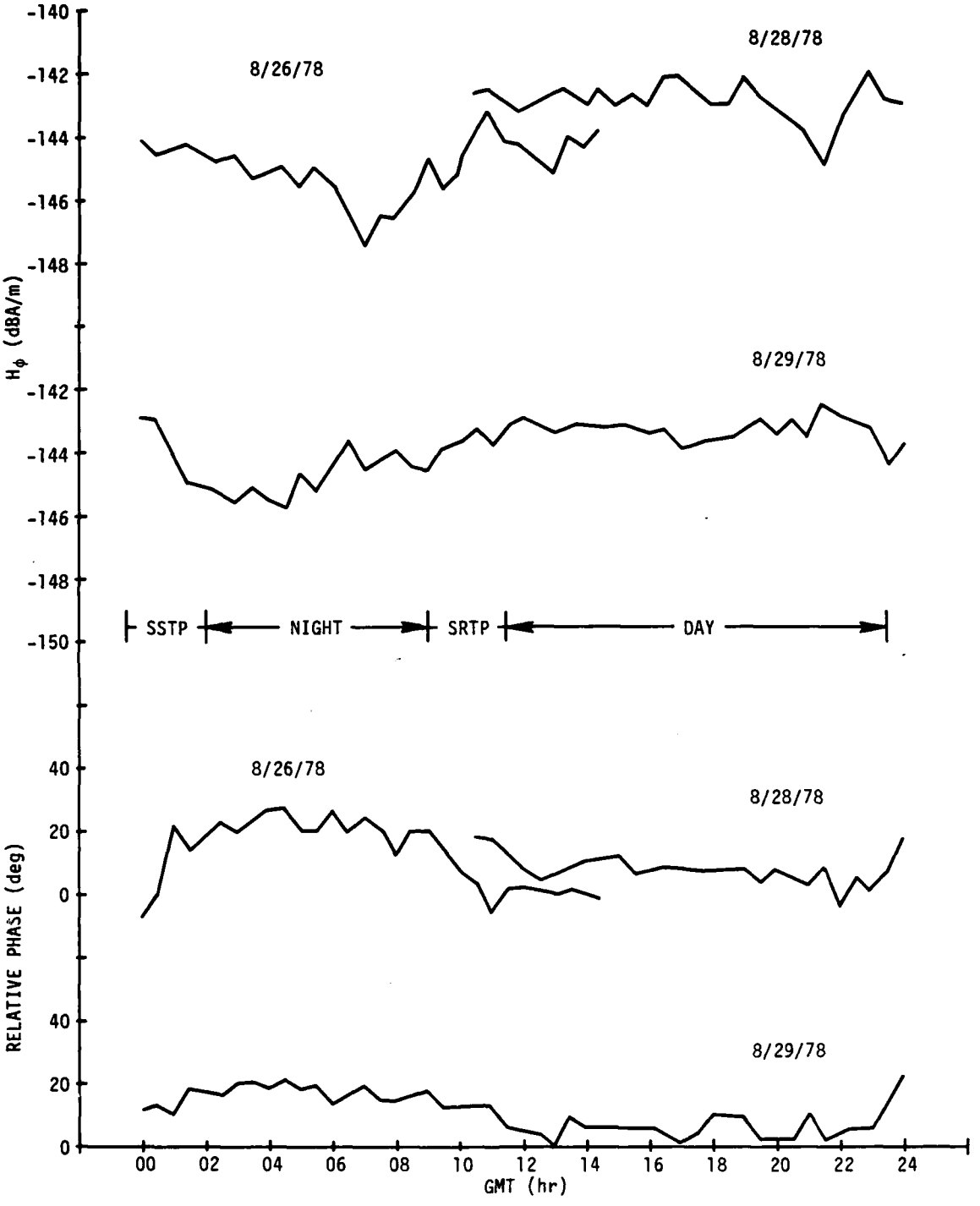

Figure E-3. Connecticut Field Strength Versus GMT, 26, 28, and 29 August 1978 (ψ = 291 deg)

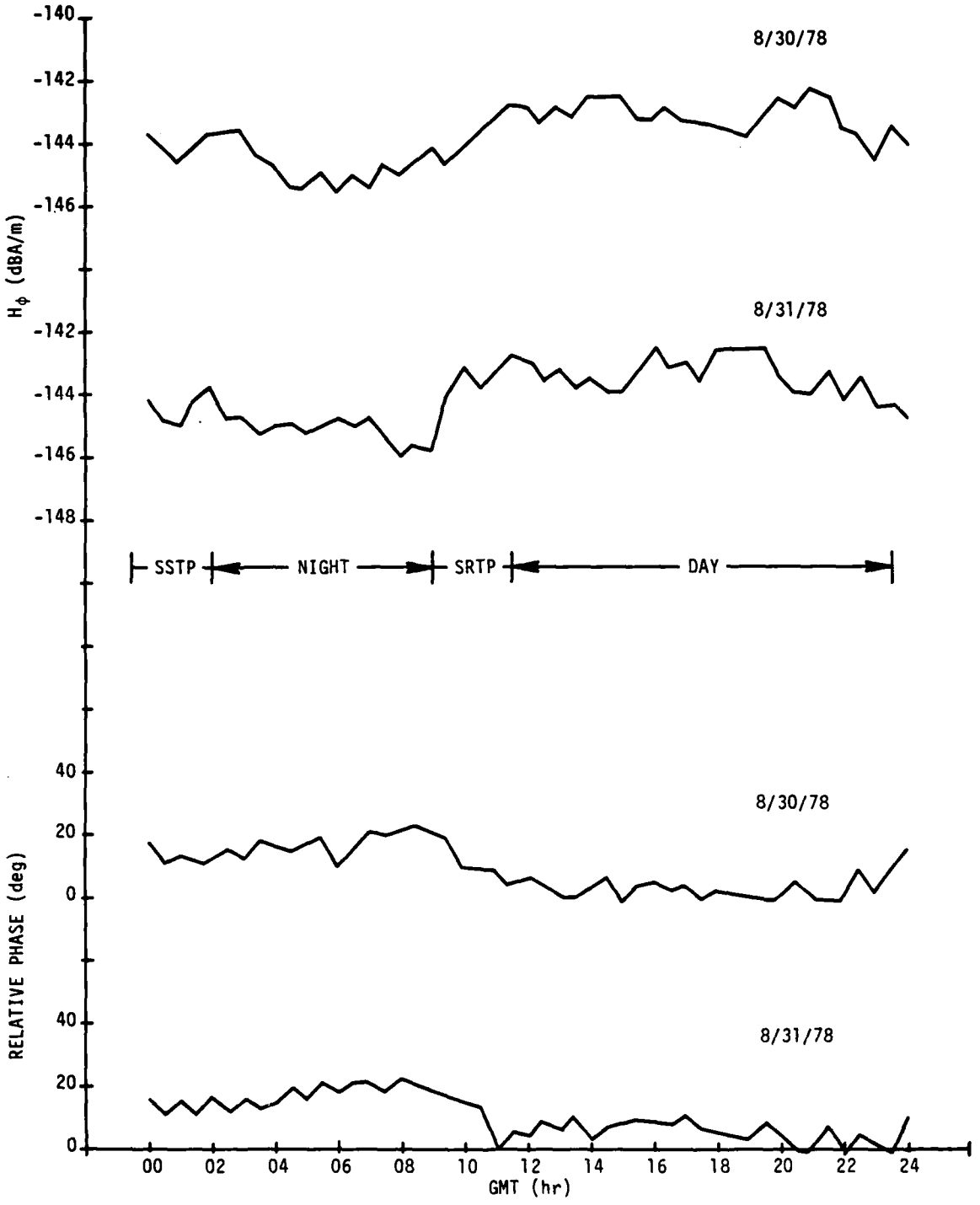

Figure E-4. Connecticut Field Strength Versus GMT, 30 and 31 August 1978 (ψ = 291 deg)

Appendix F

SEPTEMBER 1978 DAILY PLOTS

Daily plots of field strength at the Connecticut site (both amplitude and relative phase) versus GMT, in 30-min increments, for September 1978 are presented in this appendix as figures F-1 through F-9.

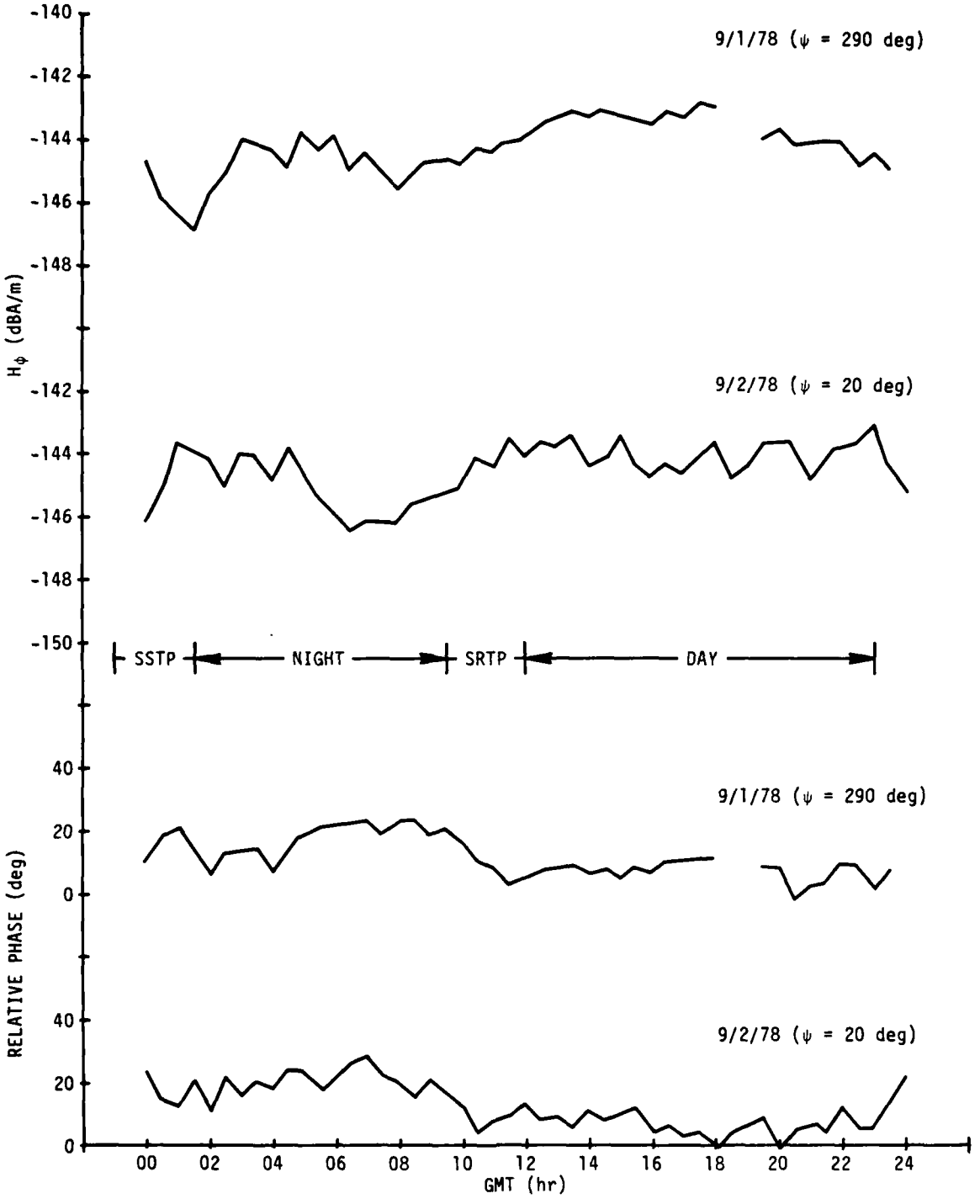

Figure F-1. Connecticut Field Strength Versus GMT, 1 (ψ = 290 deg) and 2 (ψ = 20 deg) September 1978

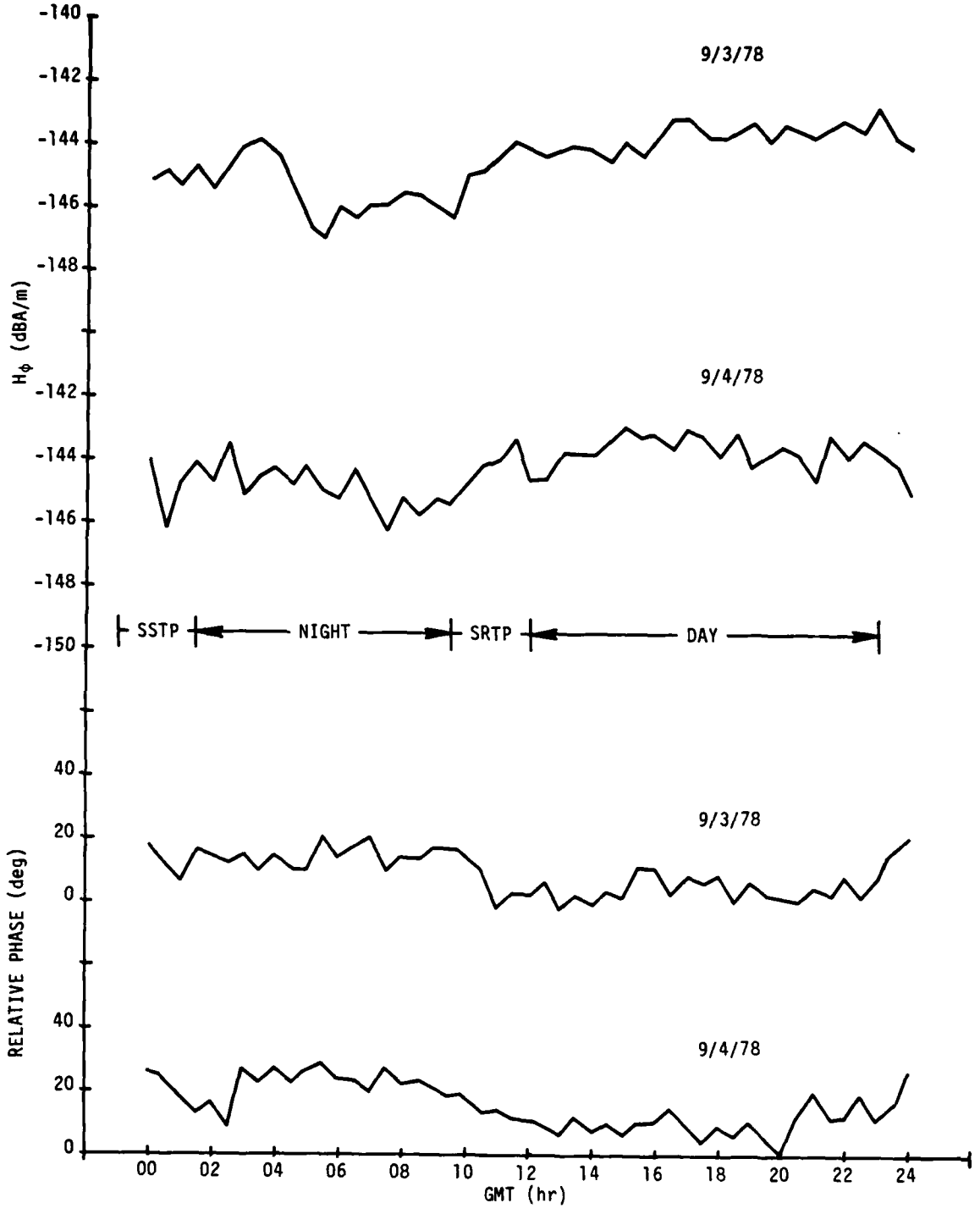

Figure F-2. Connecticut Field Strength Versus GMT, 3 and 4 September 1978 (ψ = 20 deg)

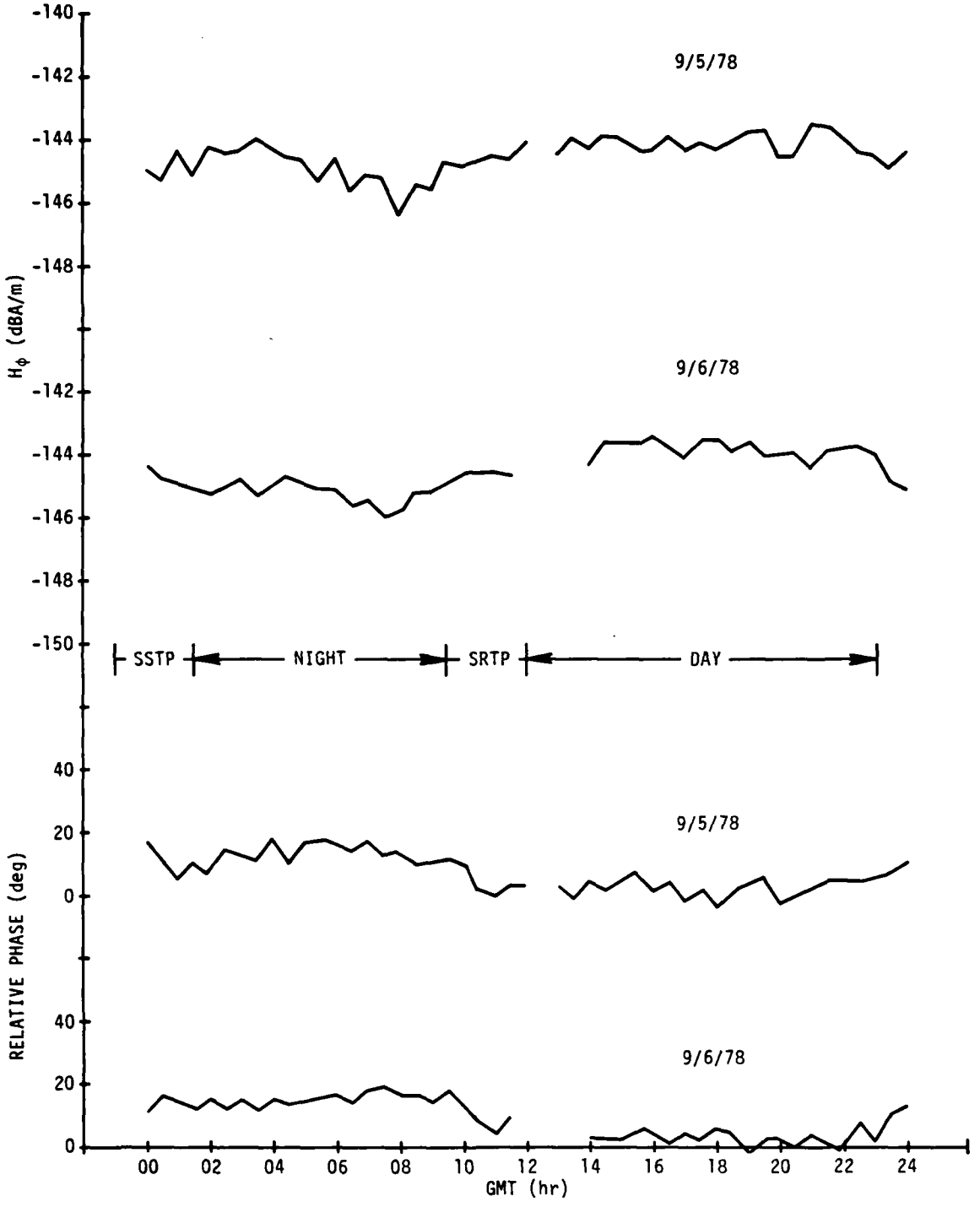

Figure F-3. Connecticut Field Strength Versus GMT, 5 and 6 September 1978 (ψ = 20 deg)

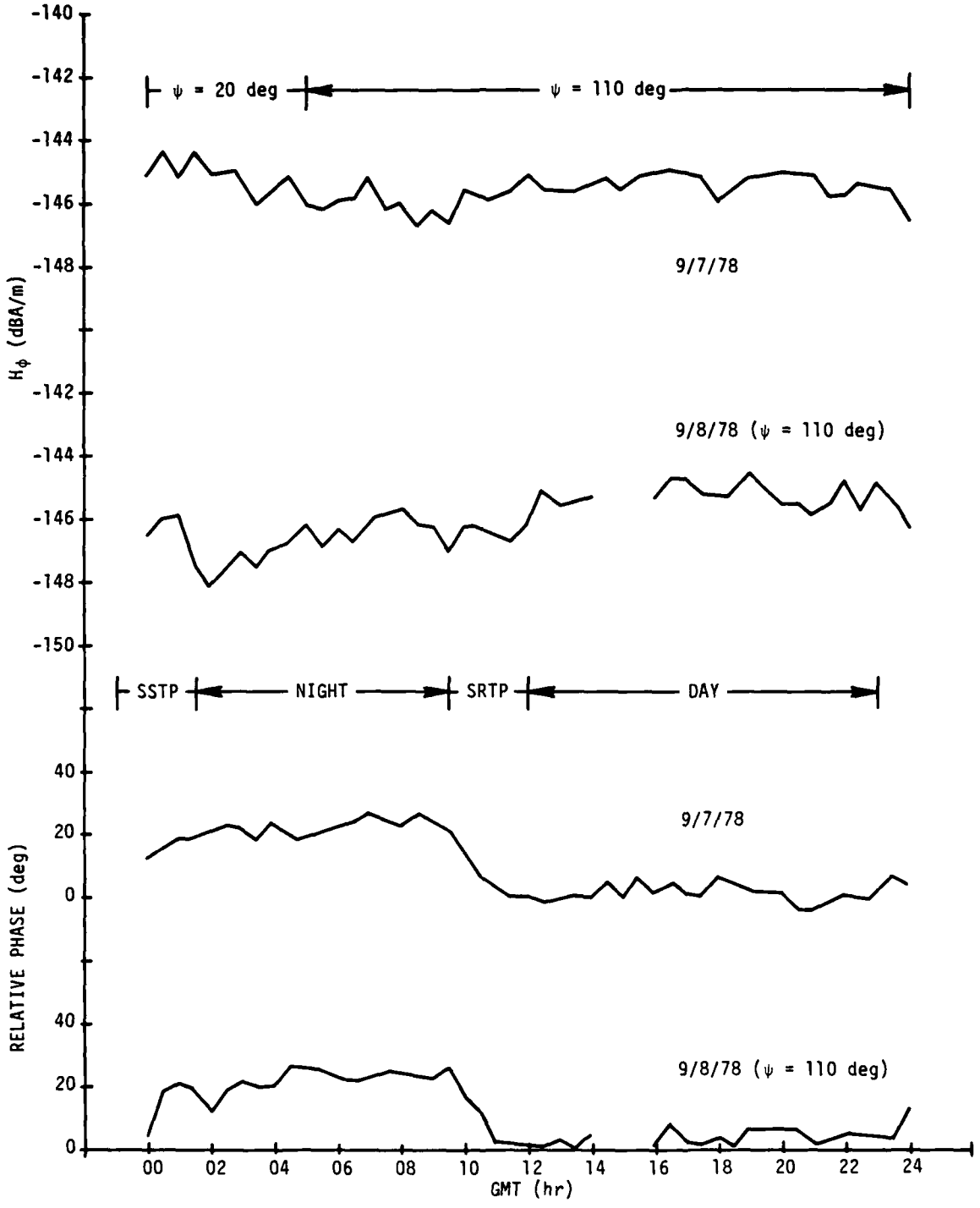

Figure F-4. Connecticut Field Strength Versus GMT, 7 and 8 September 1978 (ψ = 20 and 110 deg)

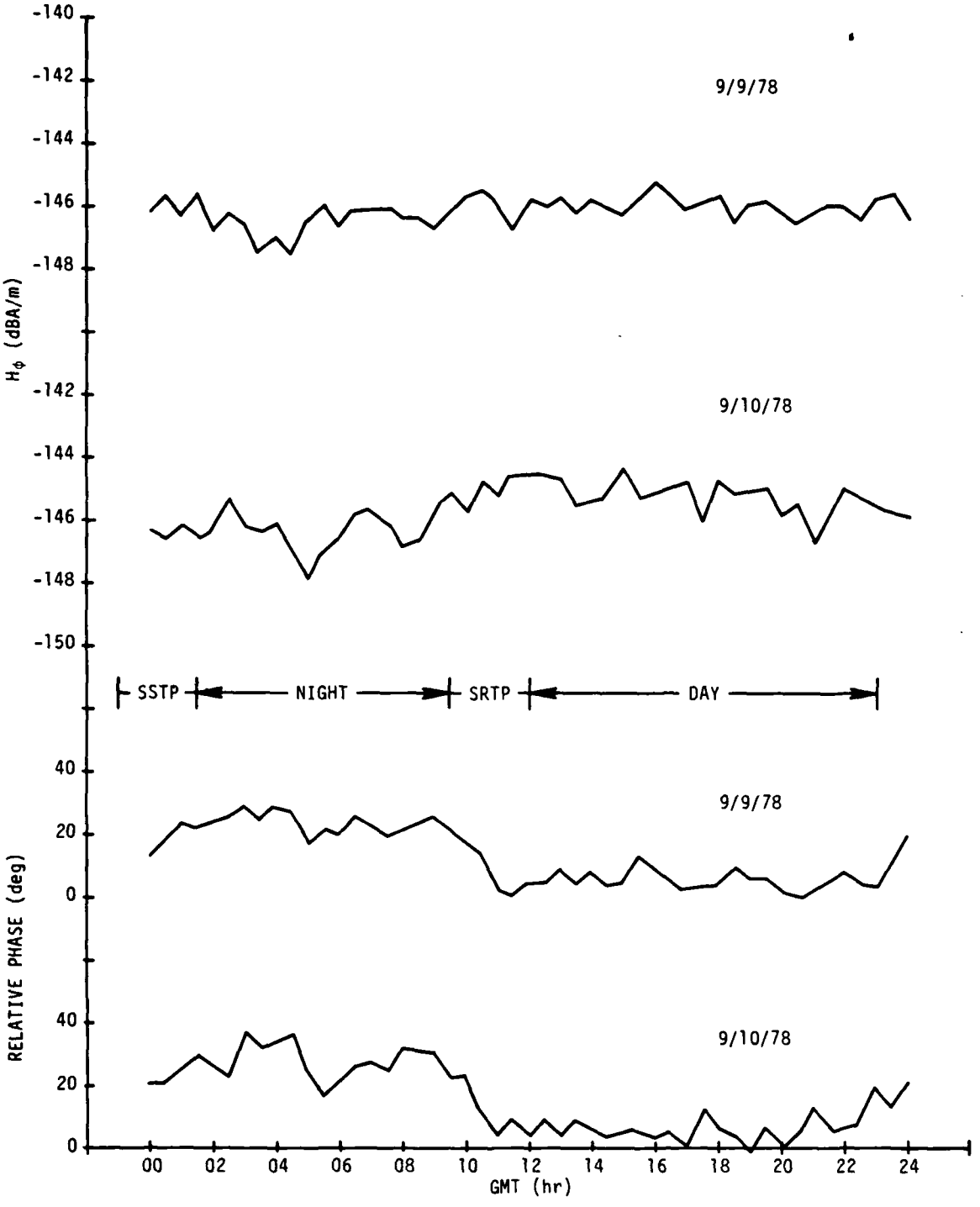

Figure F-5. Connecticut Field Strength Versus GMT, 9 and 10 September 1978 (ψ = 110 deg)

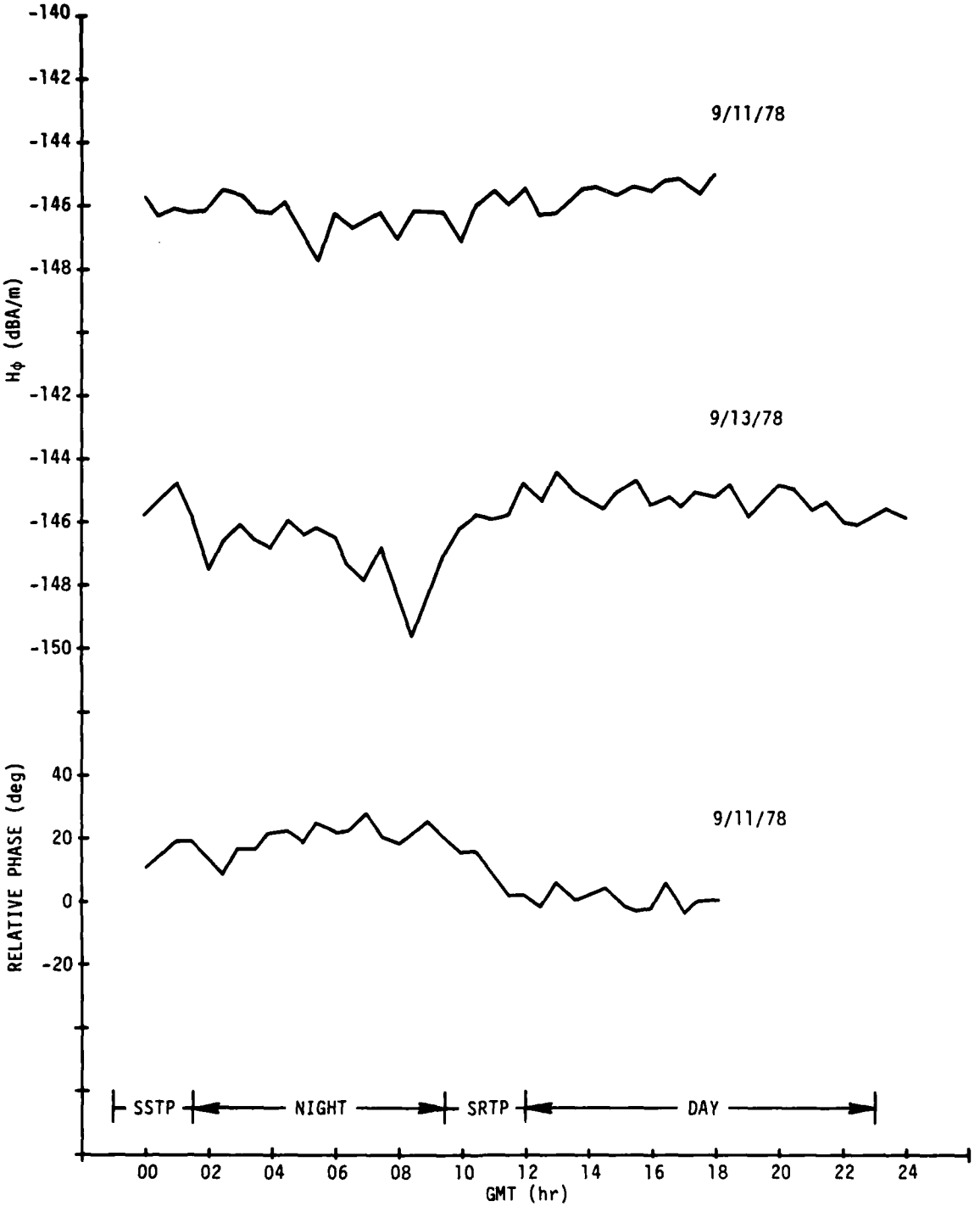

Figure F-6. Connecticut Field Strength Versus GMT, 11 and 13 September 1978 (ψ = 110 deg)

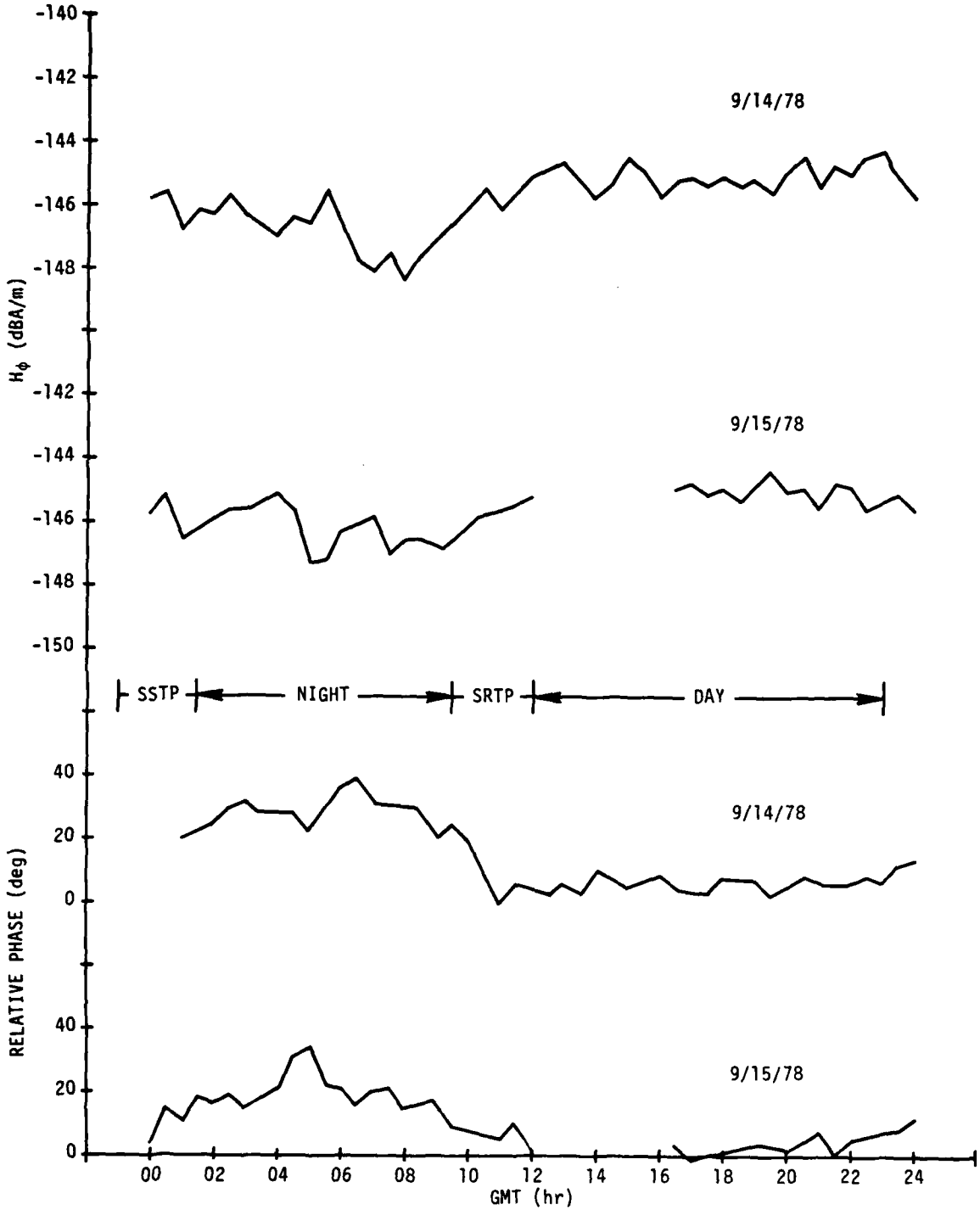

Figure F-7. Connecticut Field Strength Versus GMT, 14 and 15 September 1978 (ψ = 110 deg)

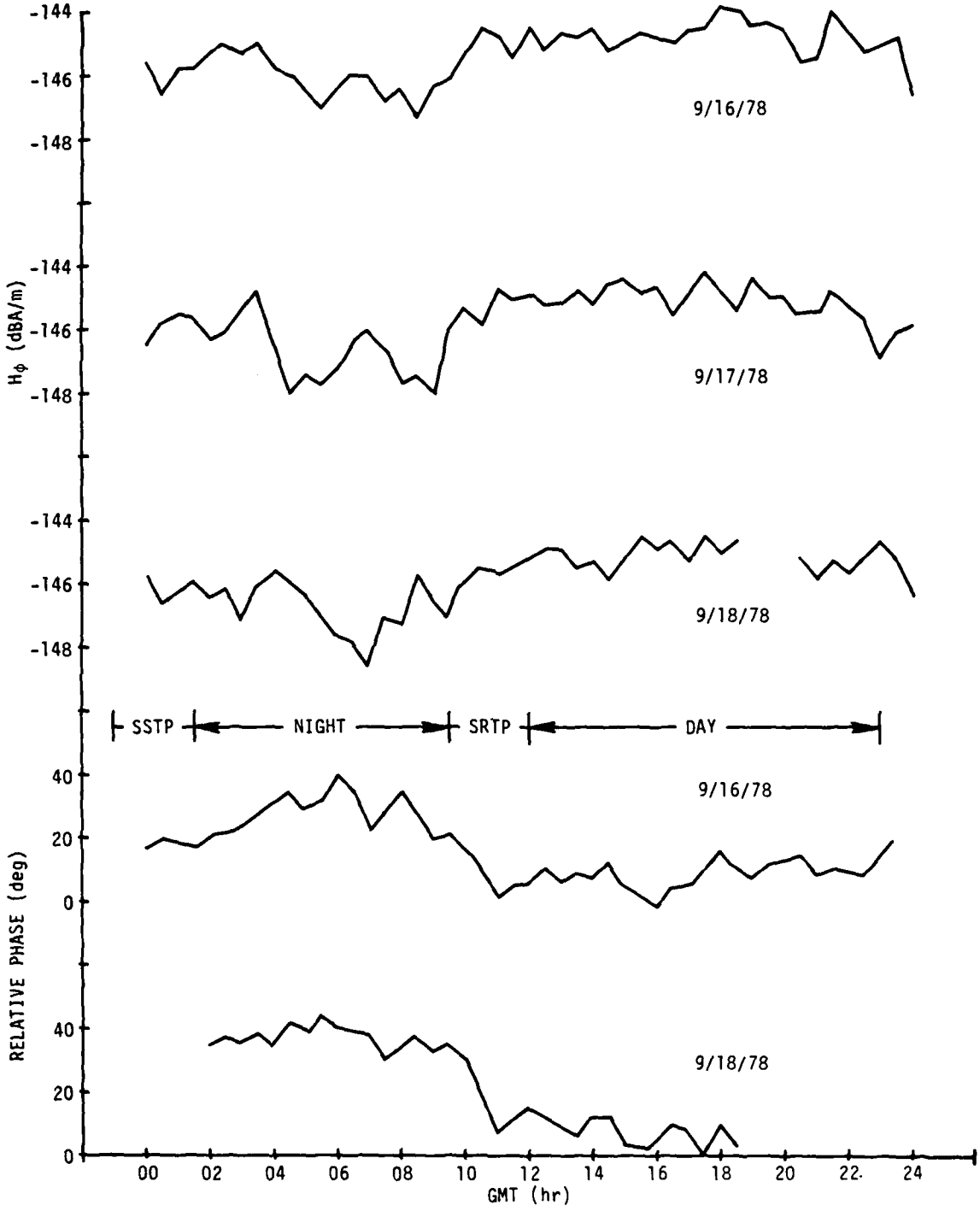

Figure F-8. Connecticut Field Strength Versus GMT, 16, 17, and 18 September 1978 (ψ = 110 deg)

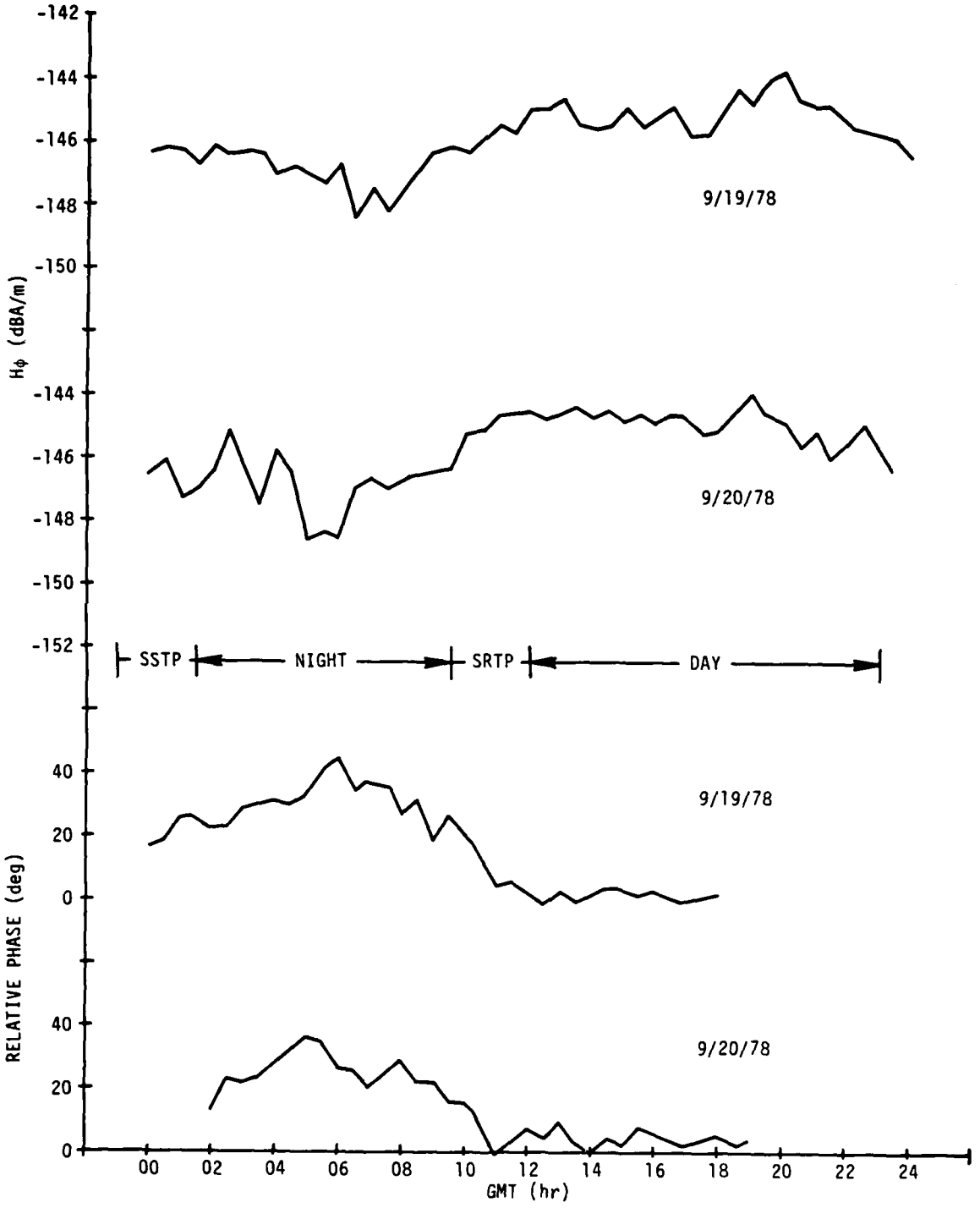

Figure F-9. Connecticut Field Strength Versus GMT, 19 and 20 September 1978 (ψ = 110 deg)

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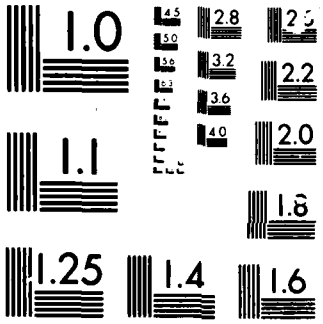
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