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Comparisons of 76 Hz Vertical Electric and Horizontal Magnetic Field Strengths Received in Connecticut

Peter R. Bannister
Submarine Electromagnetic Systems Department

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Naval Underwater Systems Center
Newport, Rhode Island / New London, Connecticut

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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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LIST OF ABBREVIATIONS

ELF	Extremely Low Frequency
EW	East-West
GMT	Greenwich Mean Time
NUSC	Naval Underwater Systems Center
SNR	Signal-to-Noise Ratio
SRTP	Sunrise Transition Period
SSTP	Sunset Transition Period
STIU	Signal Timing and Interface Unit
WTF	Wisconsin Test Facility

COMPARISONS OF 76 HZ VERTICAL ELECTRIC AND HORIZONTAL
MAGNETIC FIELD STRENGTHS RECEIVED IN CONNECTICUT

INTRODUCTION

Since June 1970, we have made extremely low frequency (ELF) measurements of the transverse-horizontal magnetic field strength (H_H) received in Connecticut.¹⁻¹⁵ On several occasions, we have also measured the vertical electric field strength (E_V). The AN/BSR-1 ELF receivers are located at the Naval Underwater Systems Center (NUSC), at New London, CT. The whip receiving antenna is also located at NUSC, while the loop receiving antenna is located at Fishers Island, NY (about 10 km from New London). The receiver and loop 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 far field (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 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 degrees east of north, while the electrical axis of the EW antenna is 114 degrees east of north. The WTF array can be steered electrically toward any particular location and its radiated power is approximately 1 W.

In this report we will discuss the results of selected whip measurements taken during the 5-month period of November 1977 to March 1978. We will also compare them (in both amplitude and relative phase) with simultaneous loop measurements during both normal and disturbed propagation conditions.

VERTICAL WHIP ANTENNA

The vertical whip antenna can be used at ELF to measure the vertical electric field strength component (E_V) produced by the WTF antenna array. It consists of an elevated conductor in the form of a long thin vertical cylinder mounted on an insulating base above a ground plane. In practice, a physical length of 1 to 2 m is quite sufficient to deliver an atmospheric noise voltage at the preamplifier that is large compared with the self-noise of the preamplifier. However, the antenna capacitance is typically only a few tens of picofarads and so, at ELF, the antenna input reactance can be hundreds of megohms. A preamplifier with a very high input impedance is therefore needed.

Absolute calibration of magnetic field sensors for ELF is generally much easier than absolute calibration of electric field sensors. By building single coils, or coil systems, one can calculate magnetic fields from current measurements, knowledge of the source configuration, and distance to the sensor. Precise calibration of the whip antenna requires care, first in

establishing an accurately known incident field to illuminate the antenna and second in measuring the capacitances of the equivalent circuit. Clayton et al.¹⁶ describe a procedure using two vertical whip antennas, one to transmit and the other to receive, and a special capacitance measuring procedure. They were able to measure the antenna parameters with an accuracy of plus or minus one percent. (For further information on the use and calibration of loop and whip antennas at ELF, see Burrows¹⁷ and Polk¹⁸.)

In calm, dry weather, the whip antenna is a reliable and simple antenna. However, if the base insulator of the antenna gets wet or dirty, the resulting electrical leakage path to ground places a shunt of unknown and varying impedance across the antenna. This can cause marked changes in the sensitivity of the antenna. In addition, the impact of particles of snow or ice on the electrode of the antenna can cause a "precipitation static" noise voltage to appear across the antenna terminals. This is because the antenna is electrically charged, by the steady naturally occurring electrical bias field, to a potential different from that of the hydrometers. Therefore, each time one of them makes contact with the antenna electrode, a transfer of charge takes place, causing a transient in the antenna voltage. Also, if the wind blows, the resulting vibration in the antenna causes an irregular variation with time of the antenna capacitance. This capacitance change, together with the more-or-less constant charge induced on the electrode by the fair weather field, results in a corresponding change in the antenna voltage. Since the fair weather field is about 100 V/m¹⁹ and can be much bigger when thunderstorm activity threatens, the resulting noise voltage due to changing capacitance can be larger than the atmospheric noise voltage.¹⁷

This "parameter noise," together with the precipitation noise and leakage across the base insulator, seriously detracts from the utility of the whip antenna. However, accurate field strength measurements can still be made if sufficient care is taken in calibration and maintenance, and the whip use is restricted to fairly calm, dry weather.

For measurement distances greater than 0.85 Mm at 76 Hz²⁰, the E_v and H_ϕ fields produced by the WTF antenna array are related by

$$\frac{E_v}{H_\phi} \approx 120\pi (c/v), \quad (1)$$

where c is the velocity of light and v is the earth-ionosphere waveguide phase velocity.

The average 75 Hz band phase velocity ratio (c/v) inferred from propagation measurements taken over various paths from 1966 to 1982 was ~ 1.25 during the day and ~ 1.09 at night.²¹ Therefore, on the average

$$20 \log E_v \approx 20 \log H_\phi + 53.5 \text{ dB} \quad (2)$$

during the day,

$$20 \log E_v = 20 \log H_\phi + 52.9 \text{ dB} \quad (3)$$

during the transition periods, and

$$20 \log E_v = 20 \log H_\phi + 52.3 \text{ dB} \quad (4)$$

at night.

Figure 1 is a sample comparison of the measured whip and equivalent loop field strengths. Here we see that because the average ratio of E_v to H_ϕ is 1.2 dB greater (53.5 - 52.3) during the day than at night, the equivalent loop daily peak-to-trough variation will be less than measured on the whip.

NOVEMBER 1977 - MARCH 1978 CONNECTICUT WHIP MEASUREMENTS

During this time period, reliable field strength data were obtained on 60 days at the Connecticut site. The daily plots of signal strength (both amplitude and relative phase) versus Greenwich Mean Time (GMT) (in 30-minute increments) are presented in Appendices A (November), B (December), C (January), D (February), and E (March). The Connecticut whip daily field strength averages are presented in Tables A-1 (November), B-1 (December), C-1 (January), D-1 (February), and E-1 (March). The data are separated into four time periods, which are representative of nighttime, sunrise transition period (SRTP), daytime, and sunset transition period (SSTP) propagation conditions. From 8 to 17 March, the WTF antenna array phasing angle (ψ) was 201 degrees. During the rest of the whip measurement period, ψ was 291 degrees. (The Connecticut field strengths for $\psi = 291$ degrees should be 1 dB higher than those for $\psi = 201$ degrees). Throughout the 1977-78 measurement period, the WTF transmitting frequency was 76 ± 4 Hz.

Presented in Table 1 are the 1977-78 whip average monthly field strengths while a comparison of the measured and equivalent loop field strengths are presented in Table 2. (All data are normalized to a WTF antenna current of 300 A, and an array phasing angle of 291 degrees.) Referring to Table 2, we see that during pure daytime and nighttime propagation conditions, the average field strengths measured on the whip (i.e., equivalent loop) and loop antennas are almost identical (in both amplitude and relative phase). On the other hand, the SRTP whip field strengths are consistently higher (by about 0.5 dB) than the SRTP loop field strengths.

Both the whip and loop average night-to-day relative phase variation ($\Delta\phi$) was 22.5 degrees. This corresponds to an average difference in the night-to-day relative phase velocity ratio ($\Delta(c/v)$) of 0.15, i.e., if the daytime value of c/v was 1.25, then the nighttime value would equal 1.10.

DAILY PLOTS OF WHIP VERSUS LOOP FIELD STRENGTH

By comparing the daily plots of whip (Appendices A through E) and loop^{8,13,15} field strengths versus GMT, we see that the Connecticut vertical electric field strength behavior is usually very similar to the transverse-horizontal magnetic field strength behavior (in both amplitude and relative phase) during both normal and disturbed propagation conditions. (Some specific examples will be presented in this section.)

On several occasions, we have also measured the radial-horizontal magnetic field strength (H_ρ) produced by the WTF. During normal propagation conditions, the Connecticut H_ρ amplitude behavior is usually similar to the H_ϕ amplitude behavior, while the H_ρ night-to-day relative phase variation ($\Delta\phi$) is usually greater than the H_ϕ $\Delta\phi$ variation. During disturbed propagation conditions, the H_ρ and H_ϕ daily plots (versus GMT) are usually dissimilar (in both amplitude and relative phase).²²

Presented in Figure 2 through 18 are some specific comparisons of daily plots of E_v and H_ϕ field strengths during various propagation conditions. For each 30-minute sample plotted, the post-detection signal-to-noise ratio (SNR) measured on both the whip and loop antennas was greater than 20 dB. From these plots, we see that the Connecticut E_v and H_ϕ behavior is usually very similar (in both amplitude and relative phase).

For the 2-year period of August 1976 to September 1978, H_ϕ 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.¹⁵

Amplitude peak-to-trough variations of 5 dB, or greater, occurred during 11 of the 24 H_ϕ measurement days during March 1978. In particular, they occurred during 8 days in a row (11 through 18 March).¹³ Referring to Figures 13 through 18, we see that similar behavior was observed in the vertical electric field measurements.

Presented in Table 3 is a comparison of the 12 to 17 March 1978 whip and loop average field strengths during the minimum nighttime field strength period of 0500 to 0800 GMT. From this table, we see that for this 6-day disturbed propagation period, the average minimum nighttime field strengths measured on the whip and loop are identical (-148.5 dBA/m).

CONCLUSION

In this report, we have presented the results of 60 days of selected whip antenna measurements taken during the 5-month period of November 1977 to March 1978. We have shown that the Connecticut vertical electric field strength behavior is usually very similar to the transverse-horizontal magnetic field strength behavior (in both amplitude and relative phase) during both normal and disturbed propagation conditions.

During pure daytime and nighttime propagation conditions, the 1977-78 average field strengths measured on the whip (i.e., equivalent loop) and loop antennas are almost identical. On the other hand, the SRTP whip field strengths are consistently higher (by about 0.5 dB) than the SRTP loop field strengths.

Both the whip and loop average night-to-day relative phase variation ($\Delta\phi$) was 22.5 degrees. This corresponds to an average difference in the night-to-day relative velocity ratio ($\Delta(c/v)$) of 0.15 (i.e., if the daytime value of c/v was 1.25, then the nighttime value would equal 1.10).

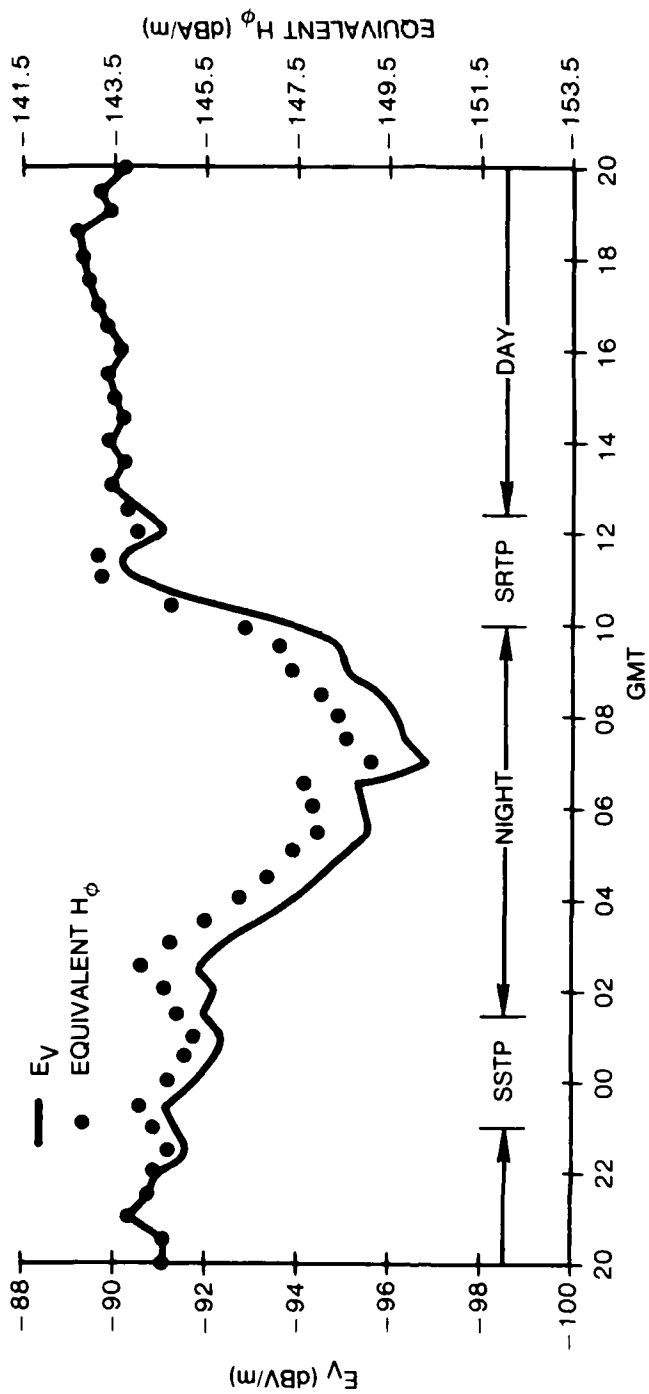


Figure 1. Sample Comparison of Measured Whip and Equivalent Loop Field Strengths

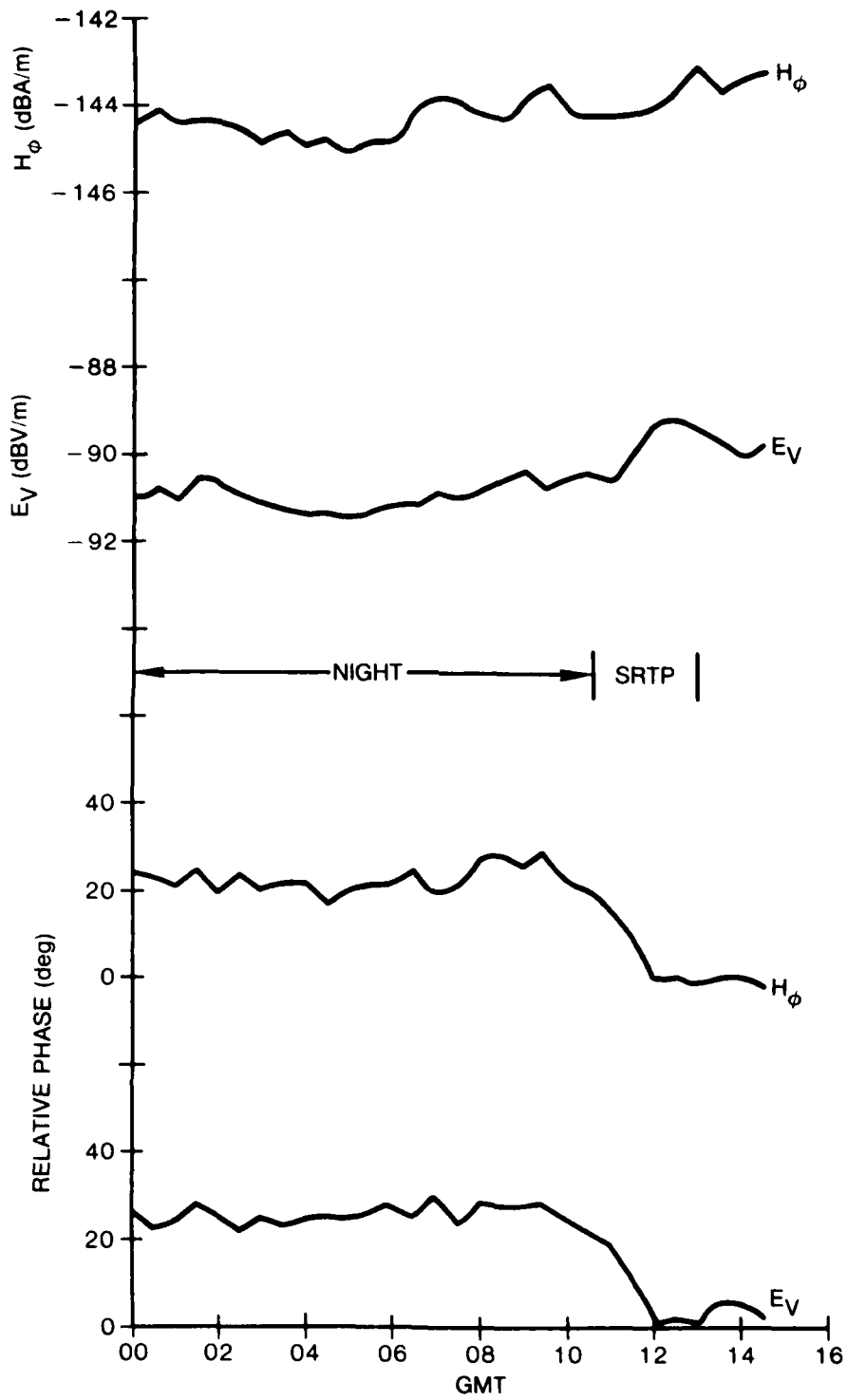


Figure 2. Comparison of Whip and Loop Field Strengths, 1 November 1977 ($\psi = 291$ deg)

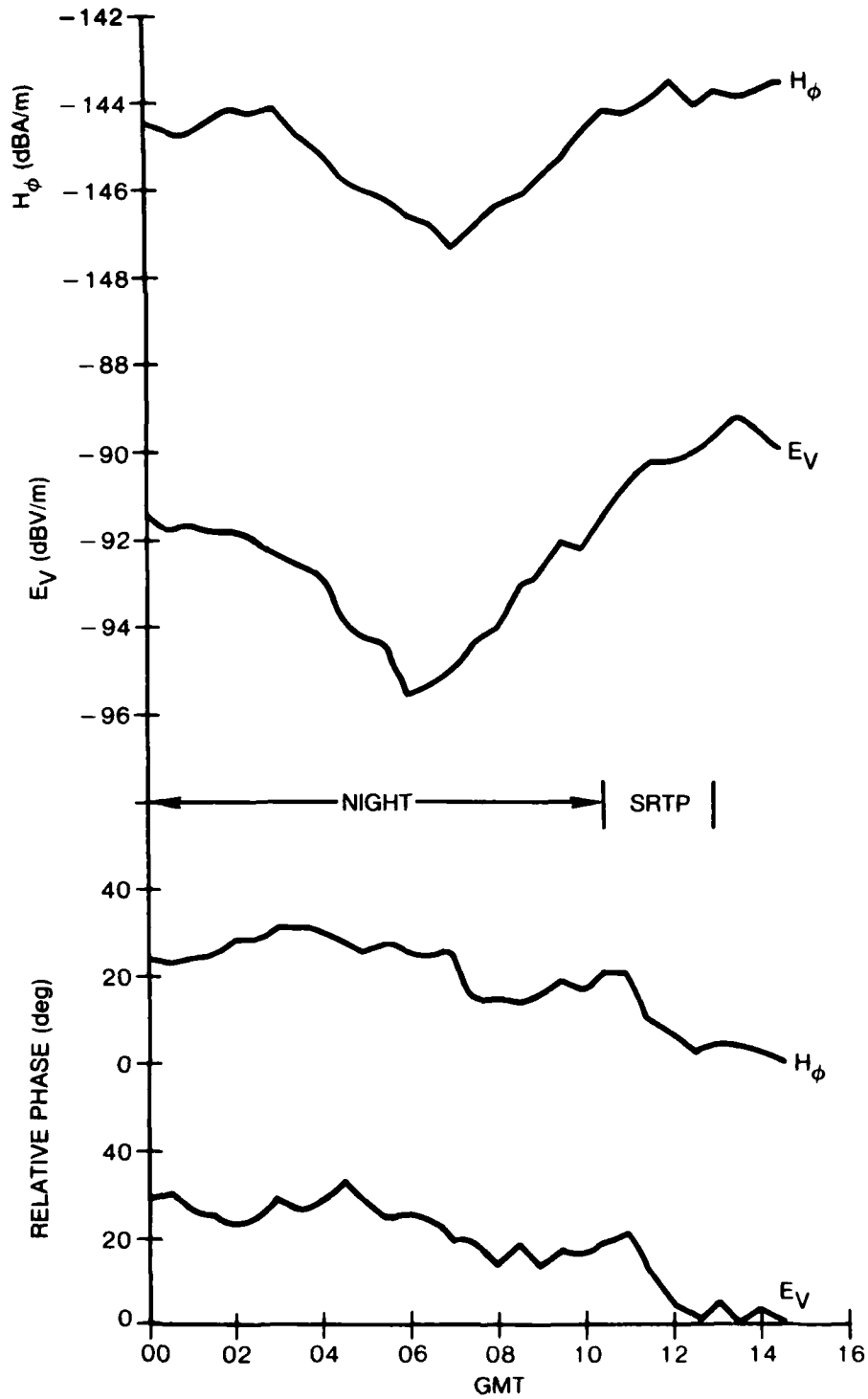


Figure 3. Comparison of Whip and Loop Field Strengths, 2 November 1977 ($\psi = 291$ deg)

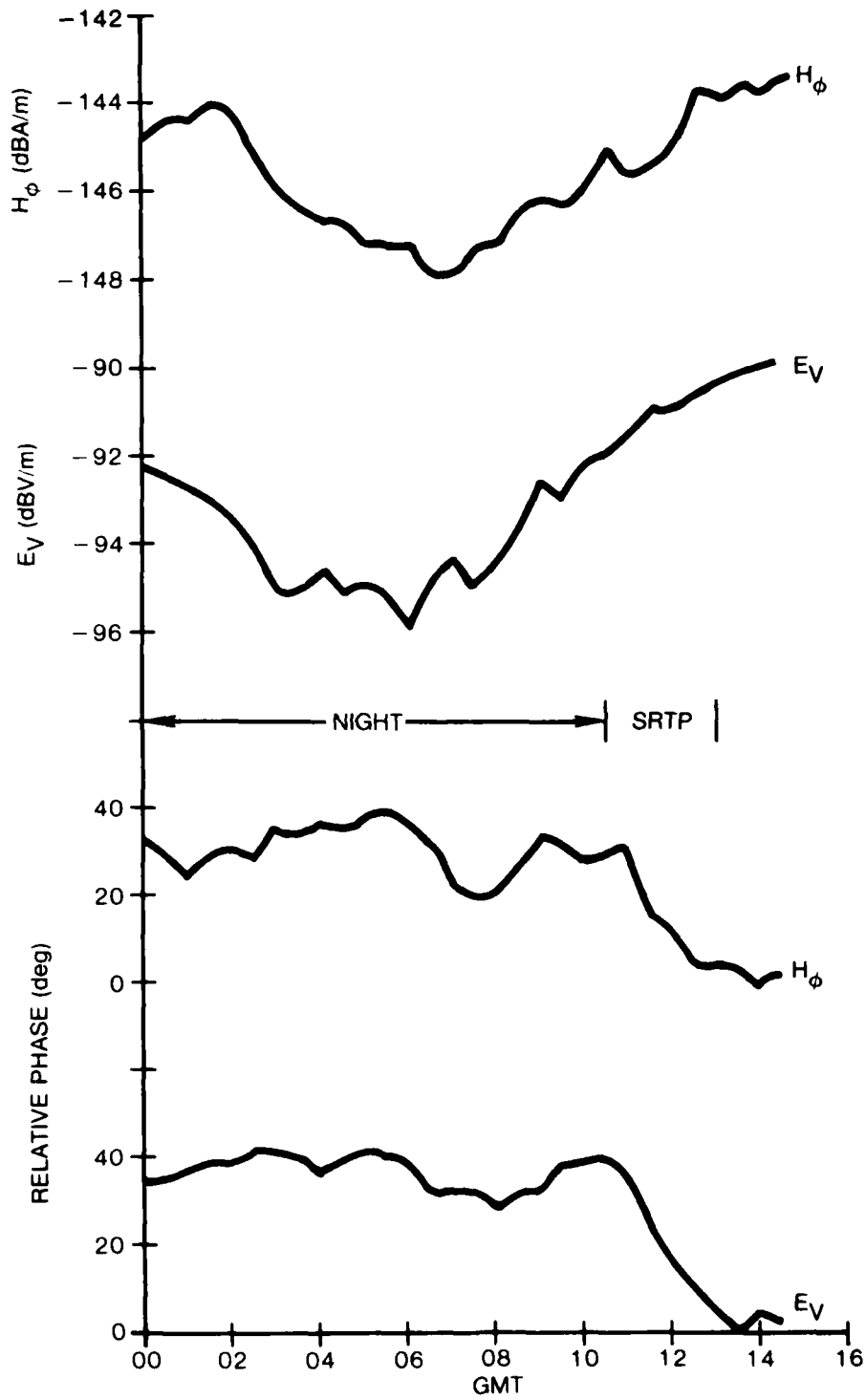


Figure 4. Comparison of Whip and Loop Field Strengths, 9 November 1977 ($\psi = 291$ deg)

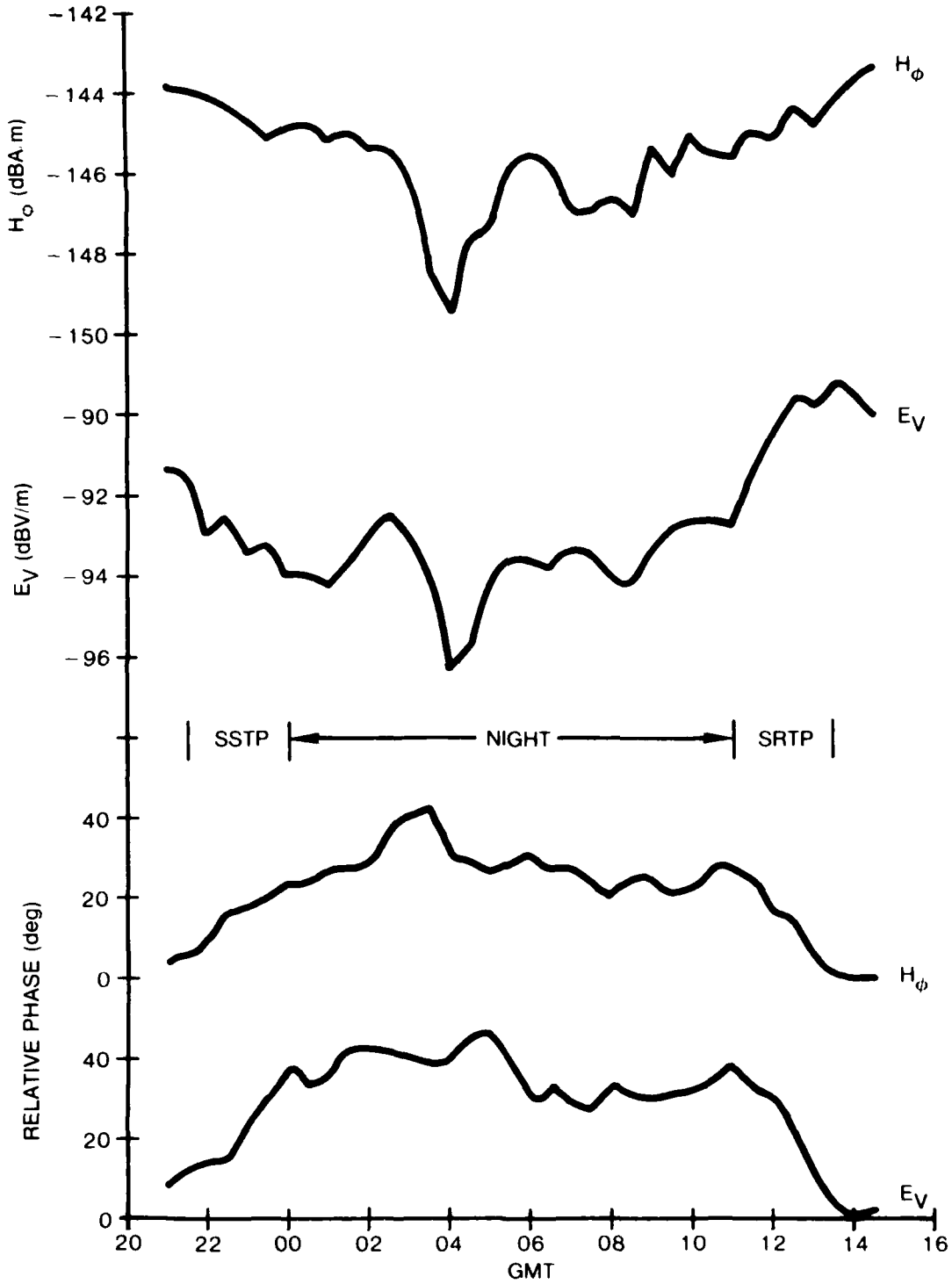


Figure 5. Comparison of Whip and Loop Field Strengths, 21/22 December 1977 ($\psi = 291$ deg)

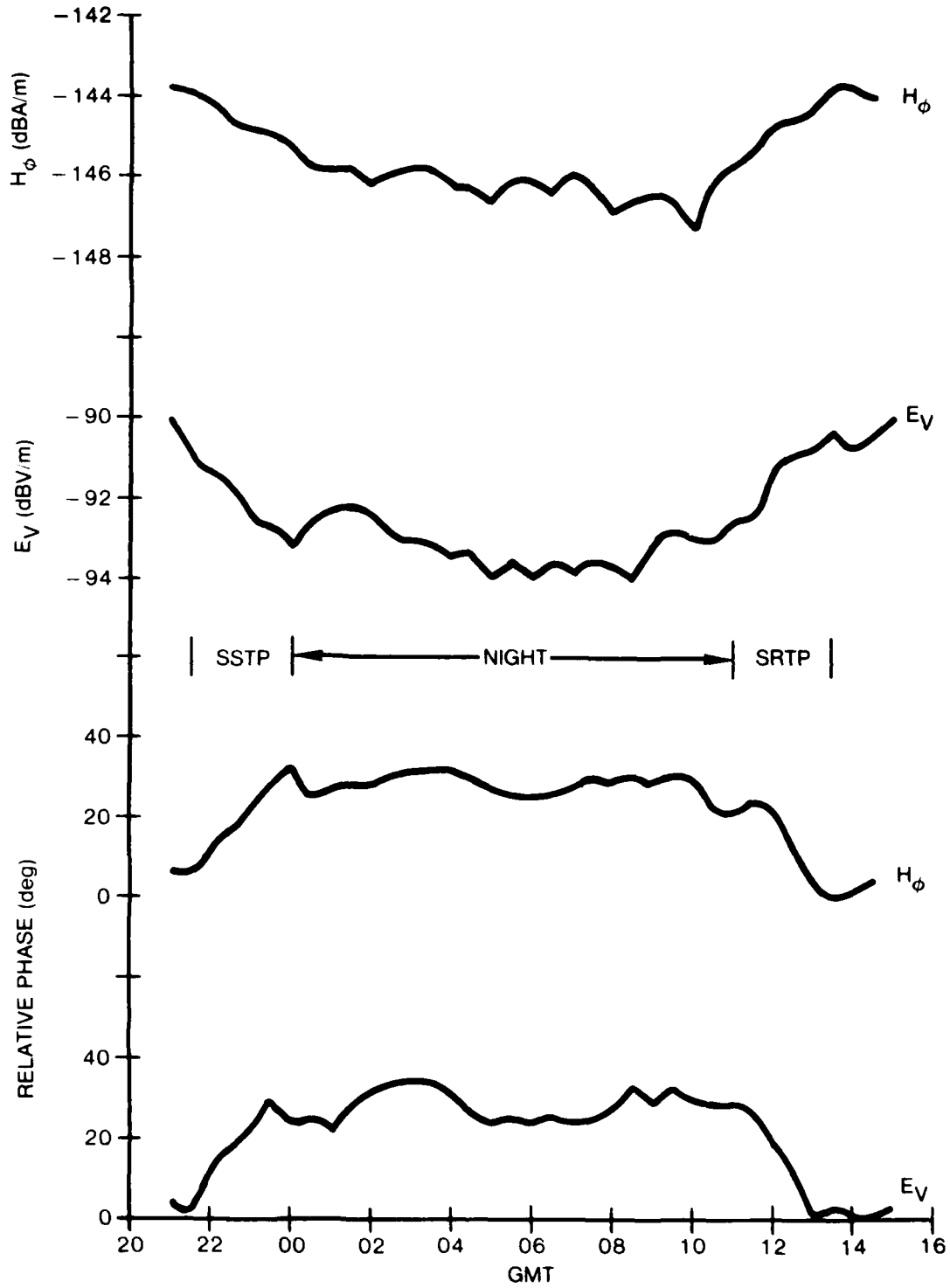


Figure 6. Comparison of Whip and Loop Field Strengths, 29/30 December 1977 ($\psi = 291$ deg)

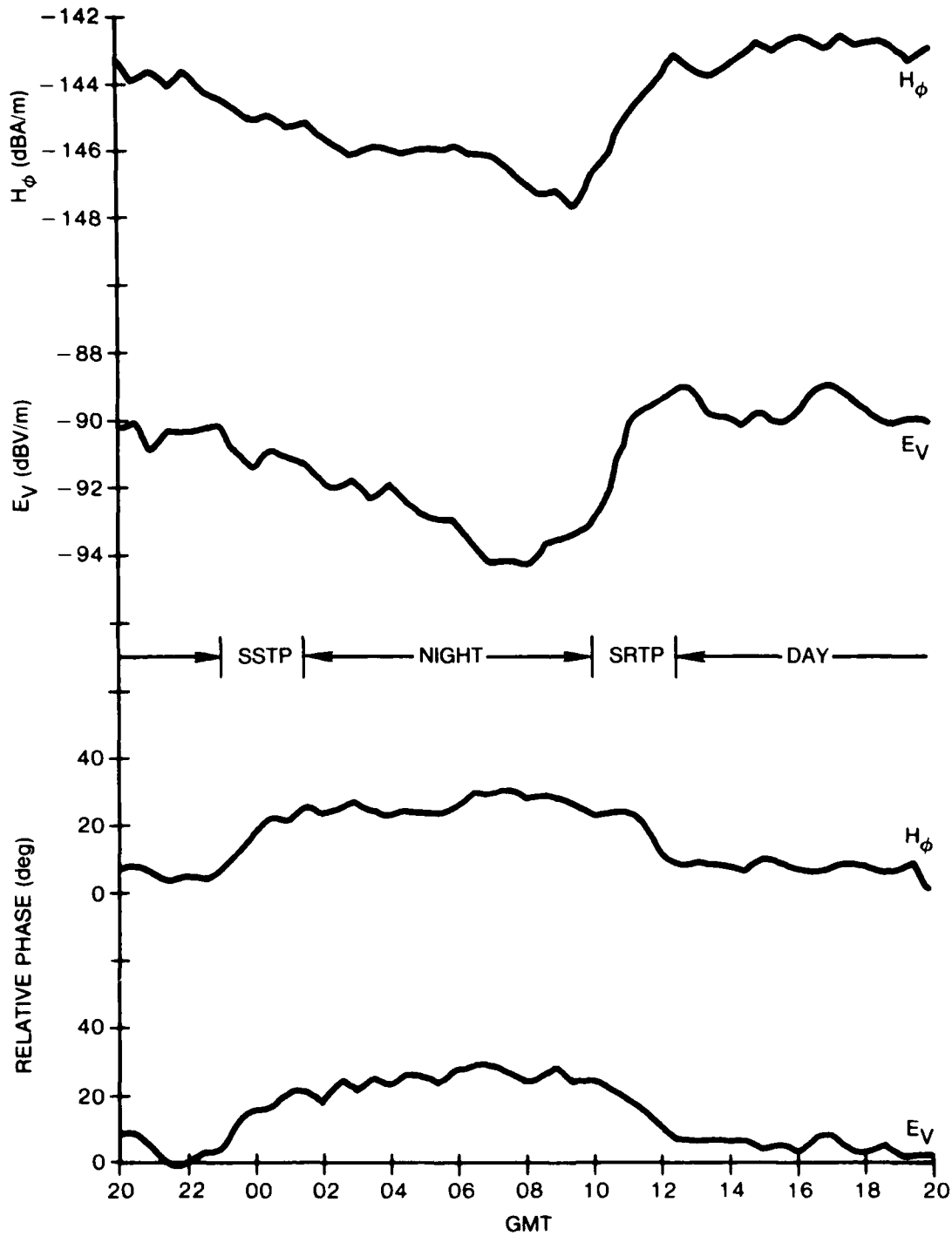


Figure 7. Comparison of whip and Loop Field Strengths, 5/6 March 1978 ($\psi = 291$ deg)

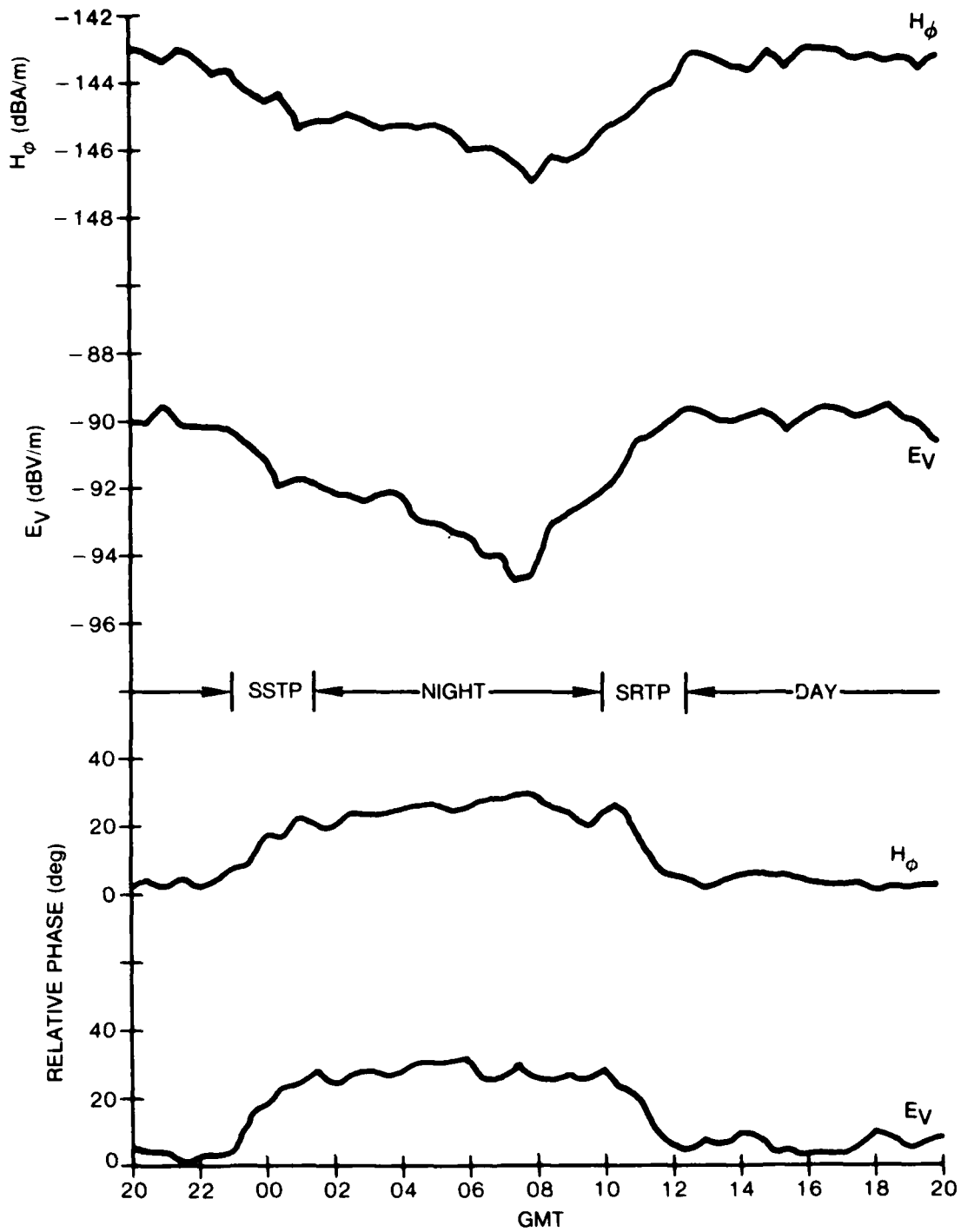


Figure 8. Comparison of Whip and Loop Field Strengths, 6/7 March 1978 ($\psi = 291$ deg)

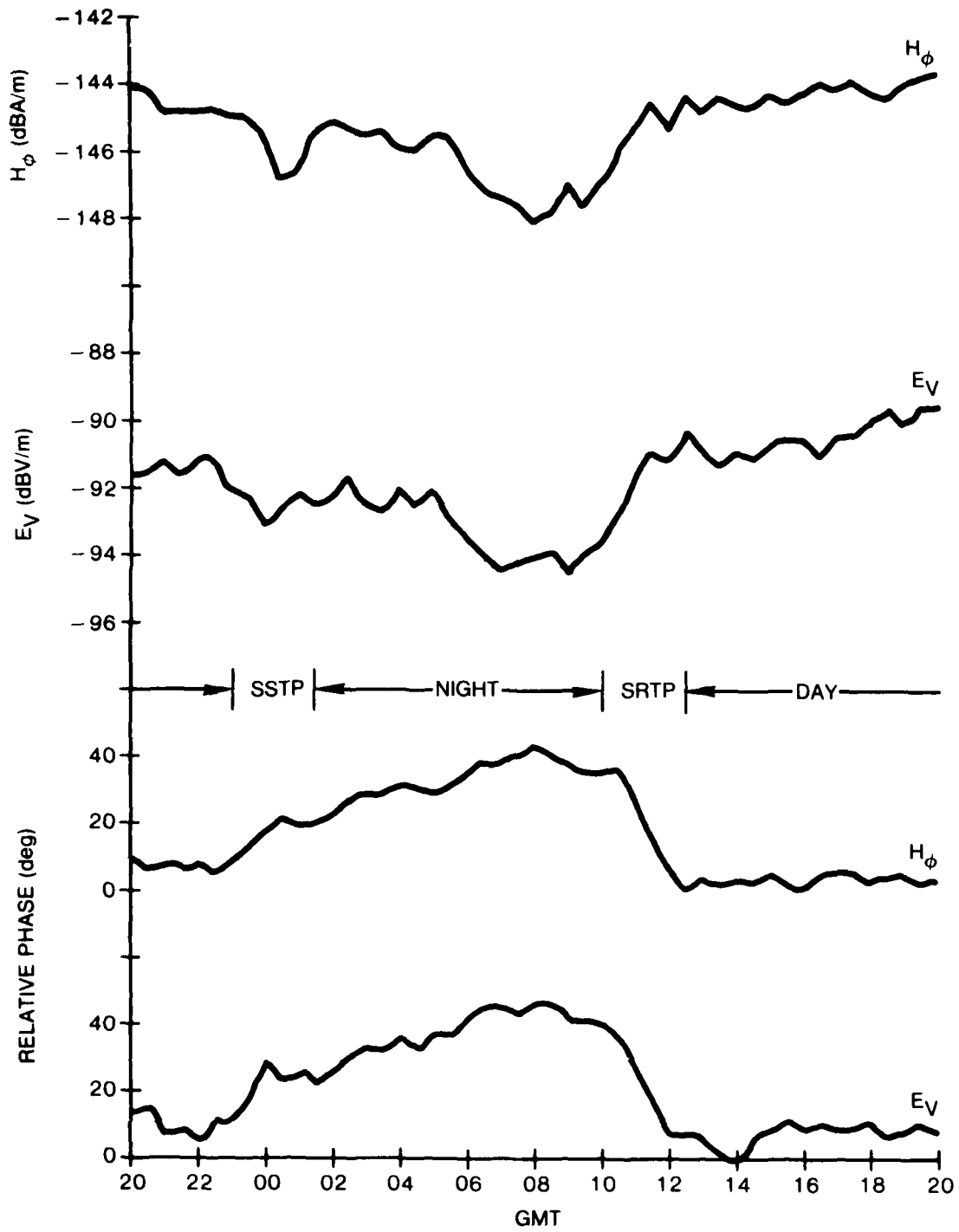


Figure 9. Comparison of Whip and Loop Field Strengths, 7/8 March 1978 ($\psi = 201$ deg)

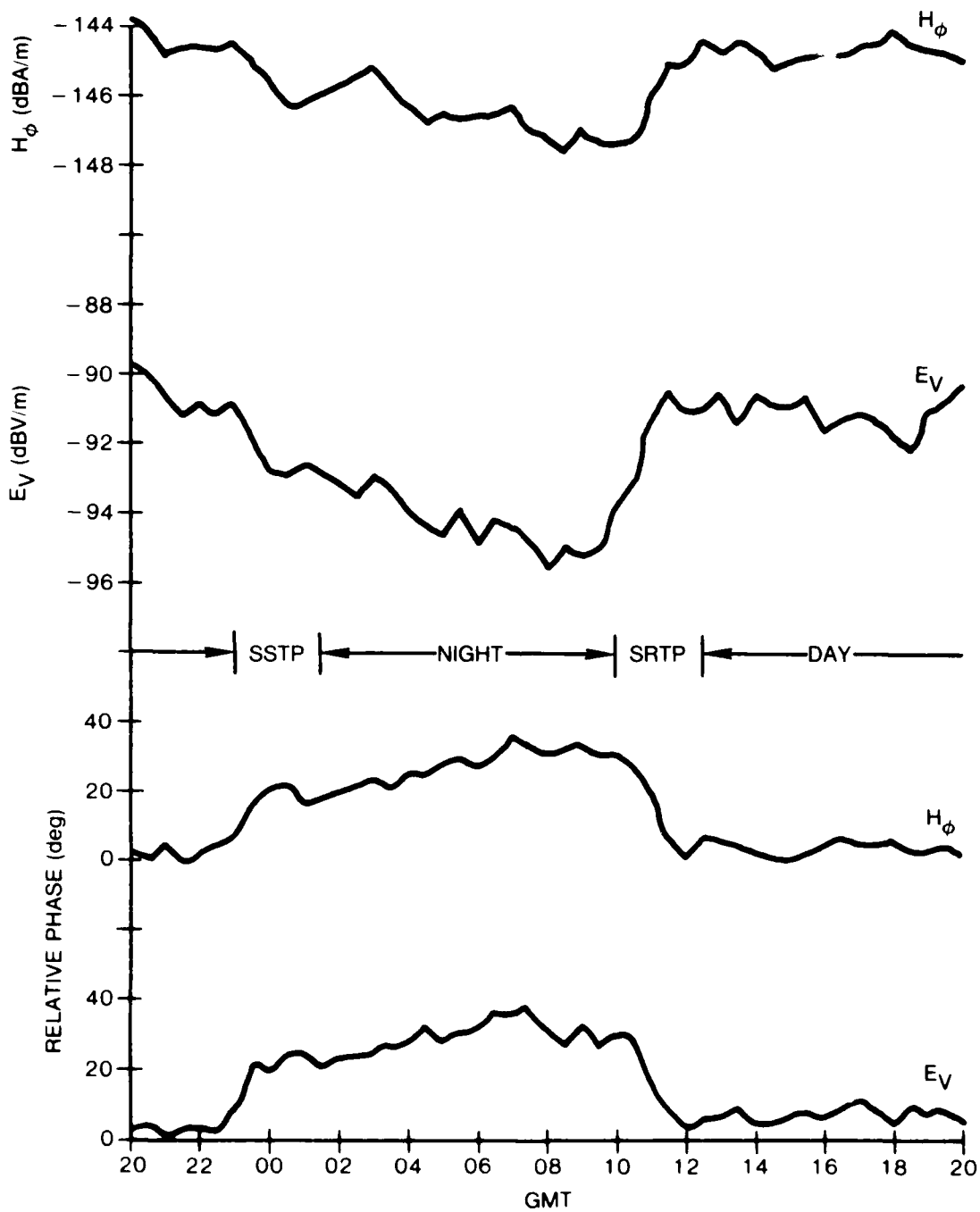


Figure 10. Comparison of Whip and Loop Field Strengths, 8/9 March 1978 ($\psi = 201$ deg)

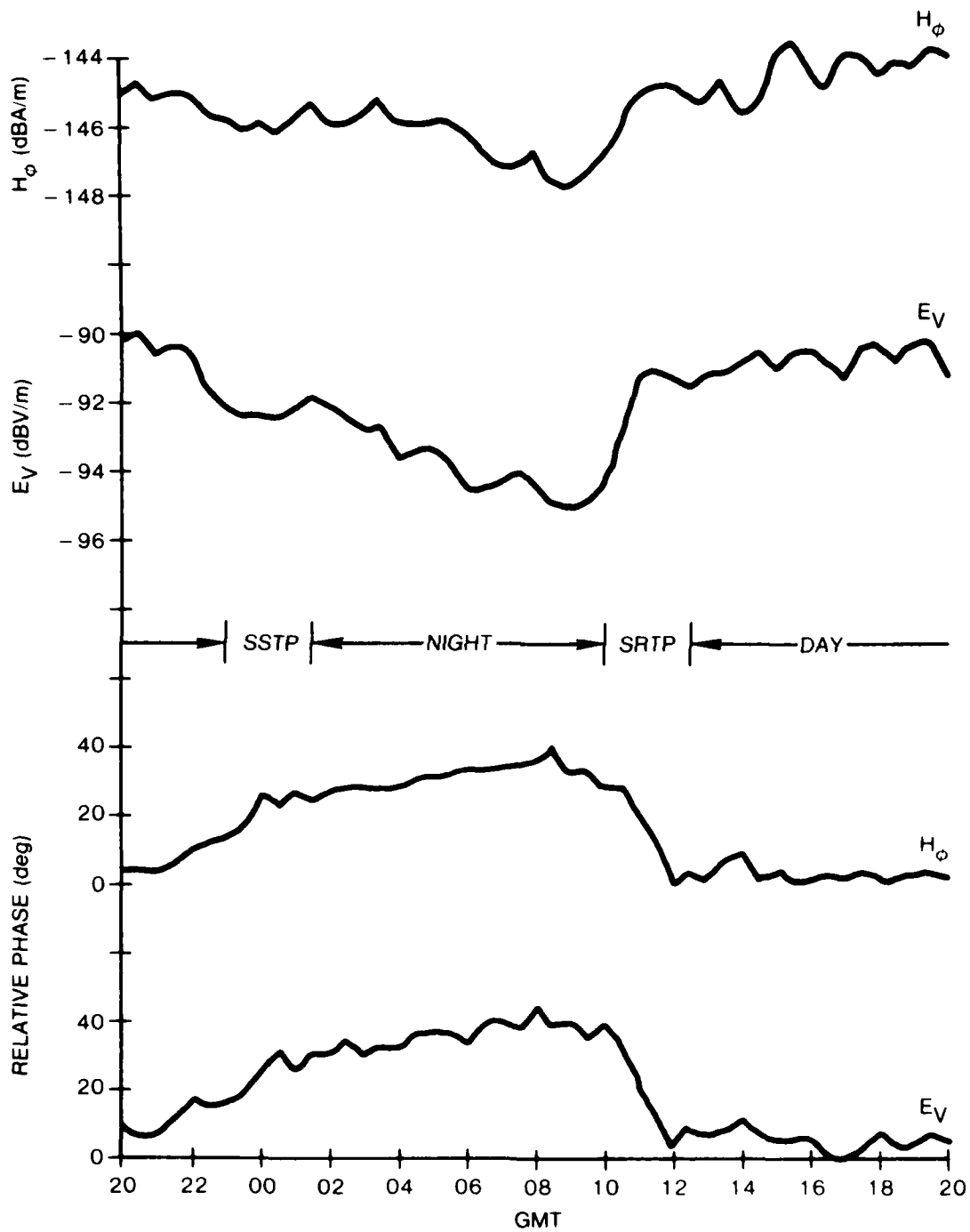


Figure 11. Comparison of Whip and Loop Field Strengths, 9/10 March 1978 ($\psi = 201$ deg)

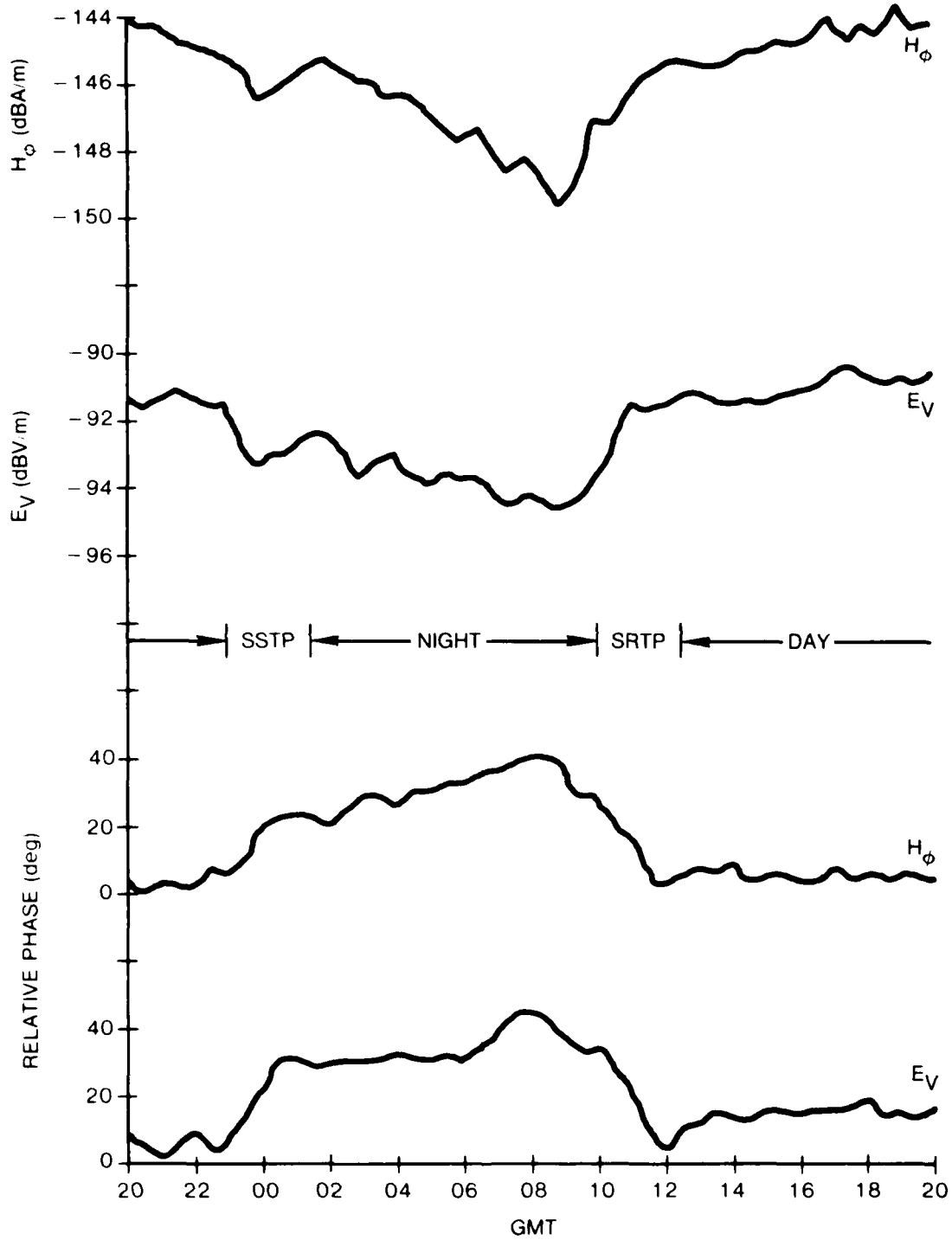


Figure 12. Comparison of Whip and Loop Field Strengths, 10/11 March 1978 ($\psi = 201$ deg)

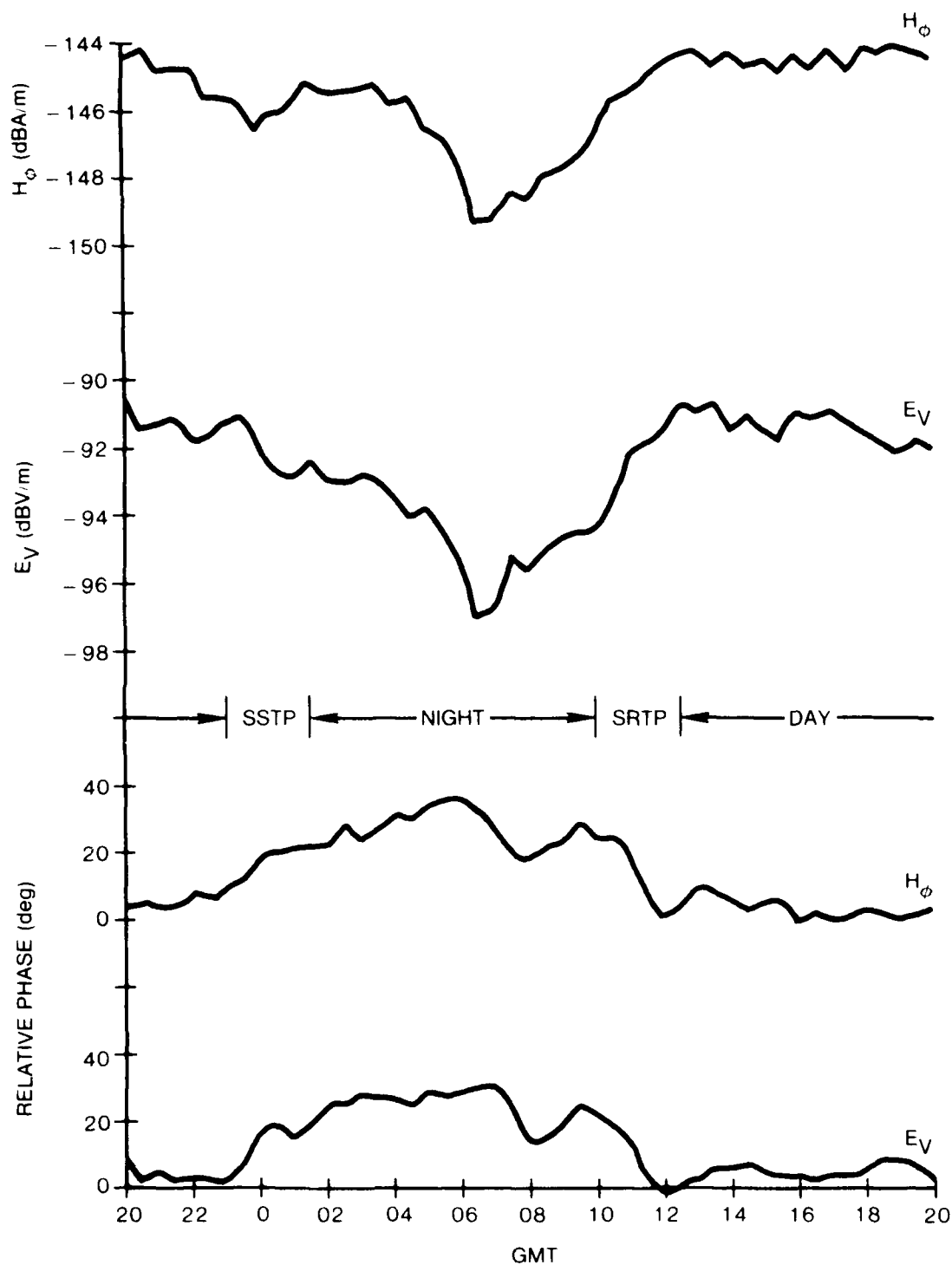


Figure 13. Comparison of Whip and Loop Field Strengths, 11/12 March 1978 ($\Psi = 201$ deg)

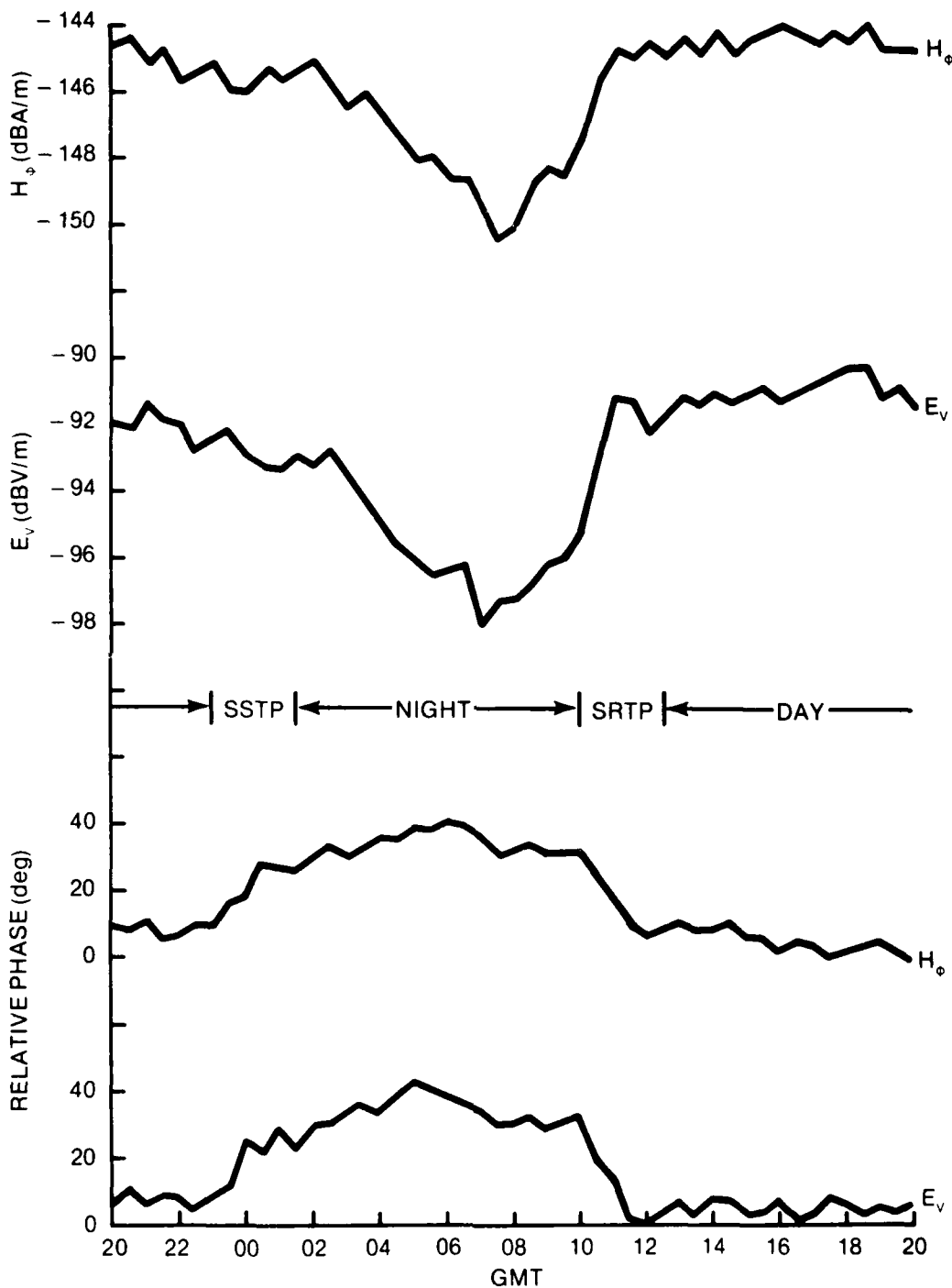


Figure 14. Comparison of Whip and Loop Field Strengths, 13/14 March 1978 ($\psi = 201$ deg)

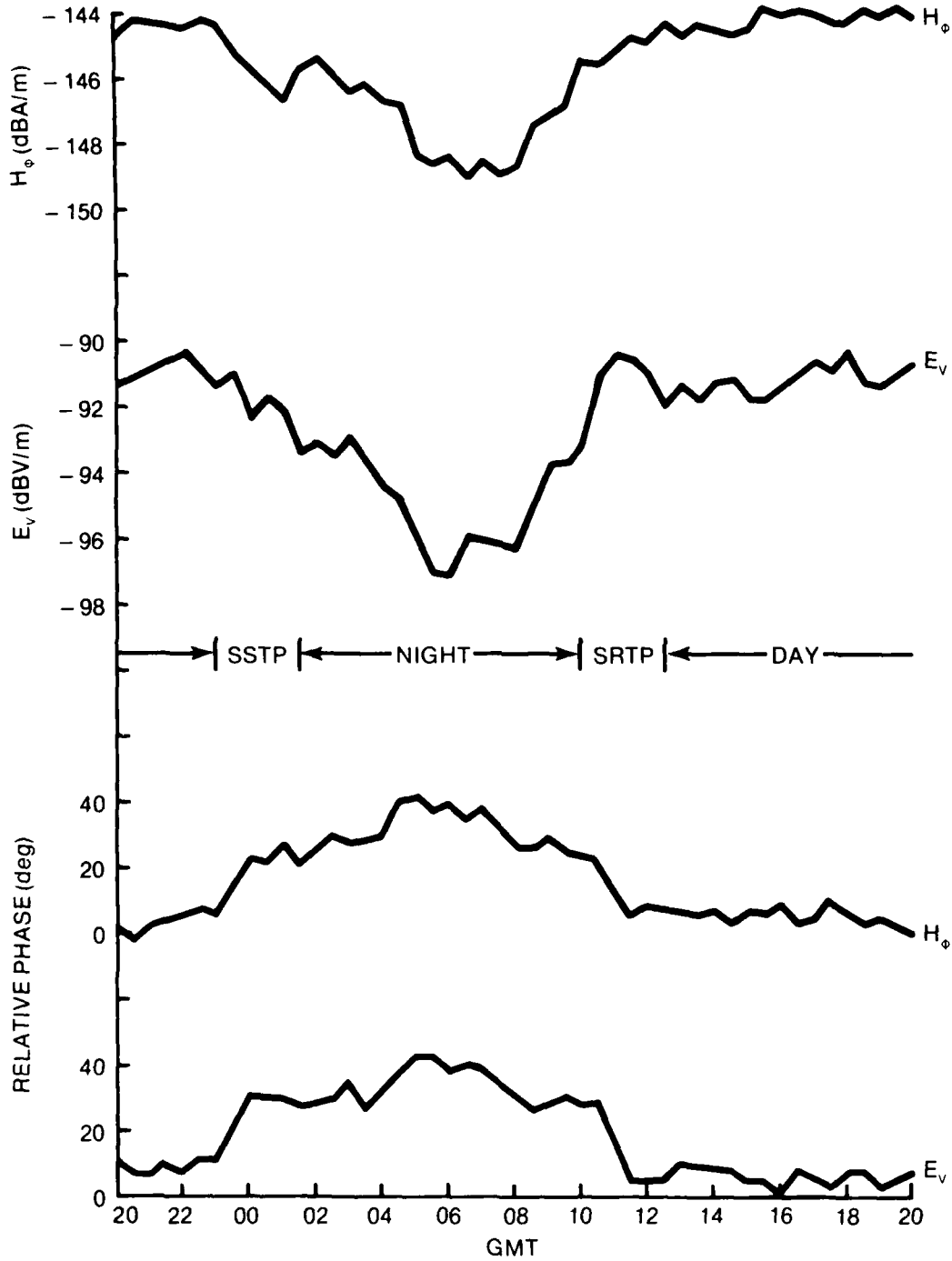


Figure 15. Comparison of Whip and Loop Field Strengths, 13/14 March 1978 ($\psi = 201$ deg)

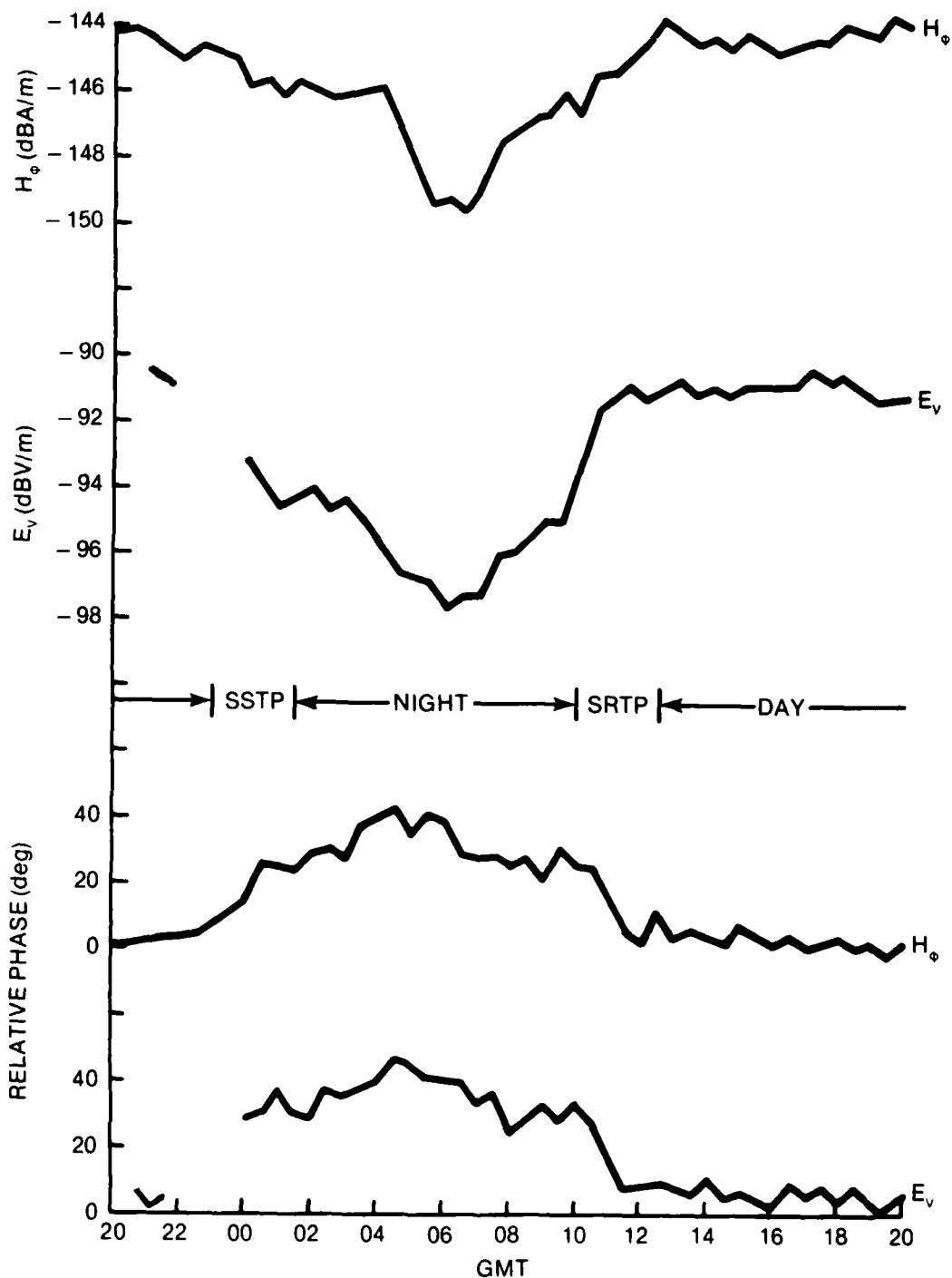


Figure 16. Comparison of Whip and Loop Field Strengths, 14/15 March 1978 ($\psi = 201$ deg)

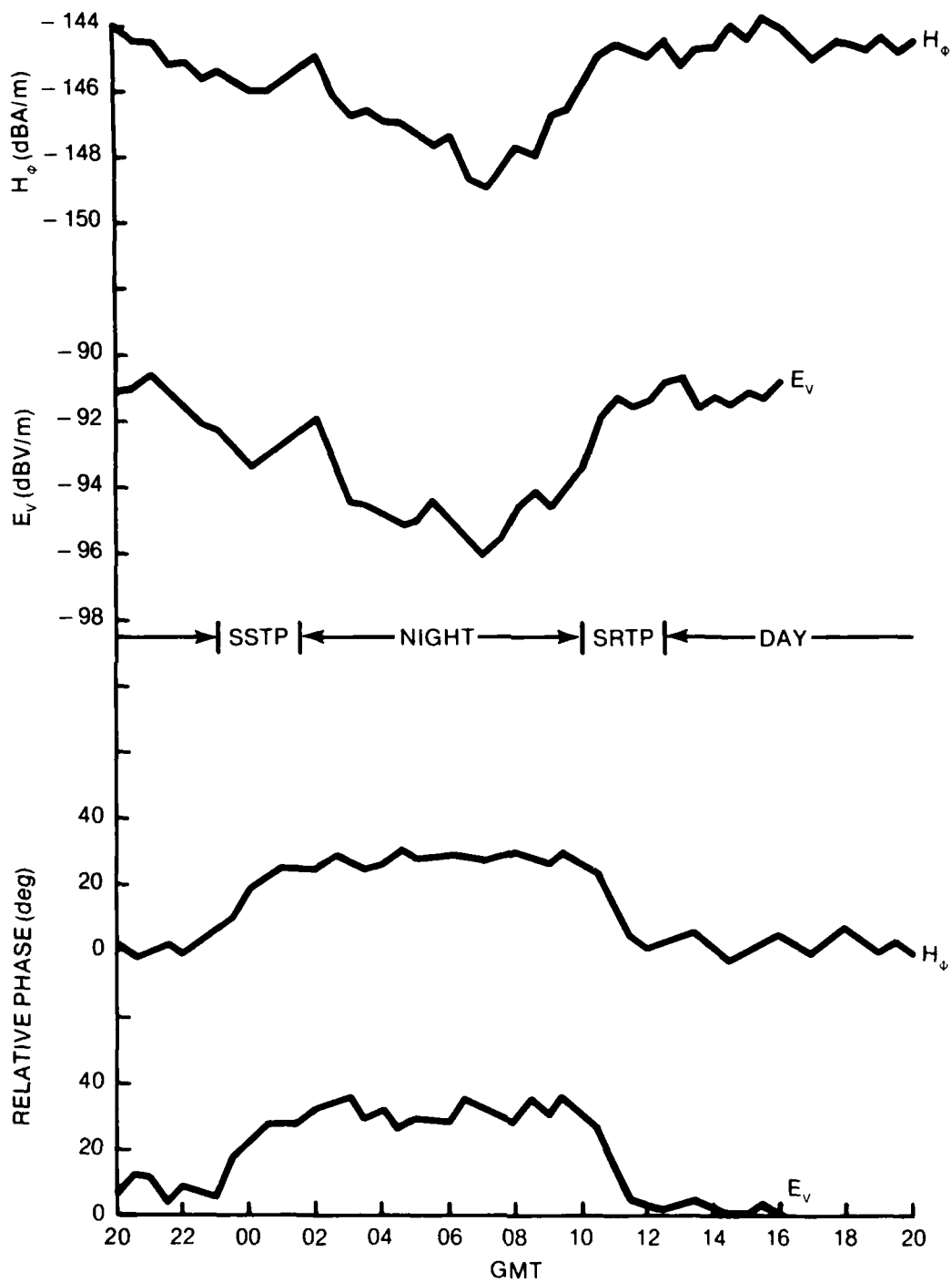


Figure 17. Comparison of Whip and Loop Field Strengths, 15/16 March 1978 ($\psi = 201$ deg)

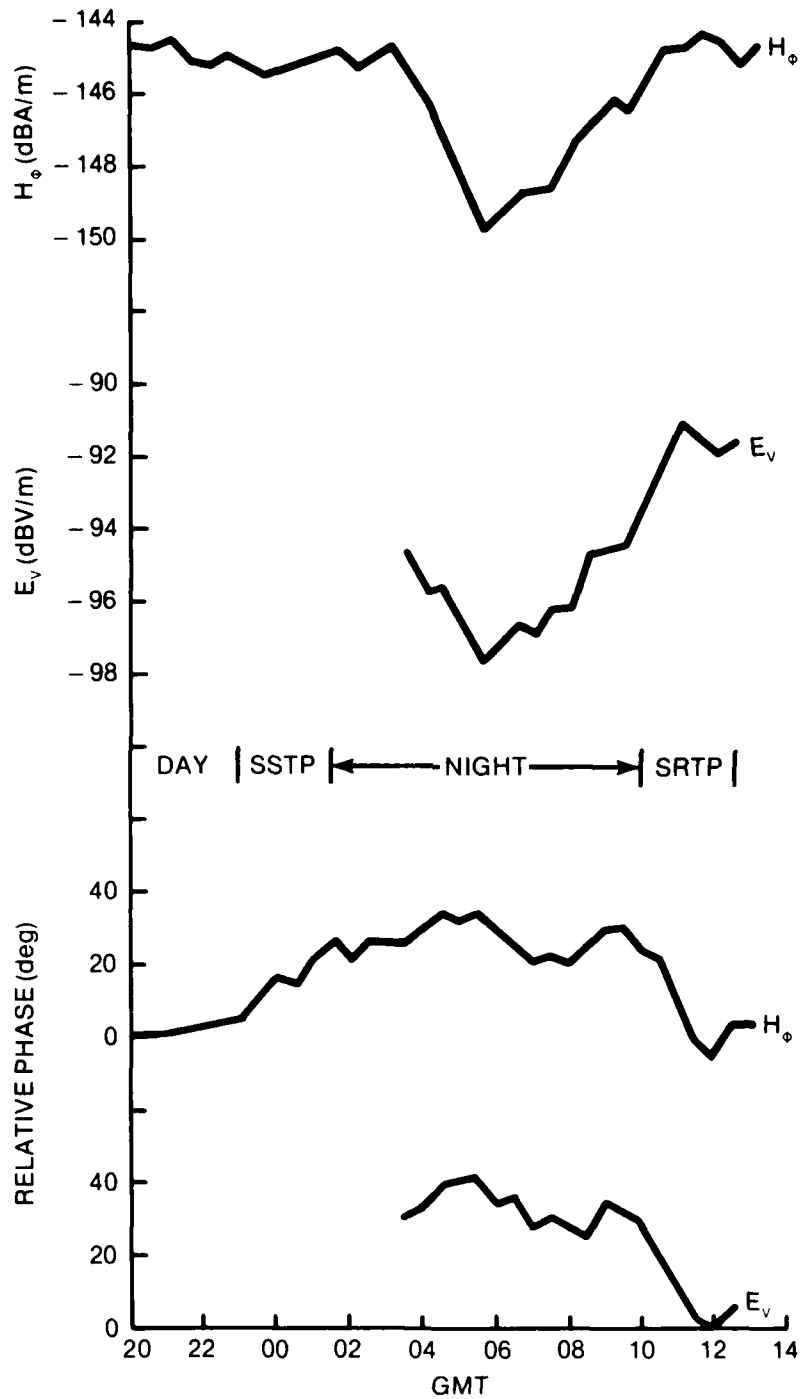


Figure 18. Comparison of whip and Loop Field Strengths, 16/17 March 1978 ($\psi = 201$ deg)

Table 1. 1977-78 Conn. whip Average Field Strengths*

Date	SSTP E_v (dBV/m)	Night E_v (dBV/m)	SRTP E_v (dBV/m)	Day E_v (dBV/m)	Approx. $\Delta\theta$ (deg)
November 1977	-90.7	-92.7	-90.6	-89.8	28.0
December 1977	-92.0	-93.6	-91.5	-90.1	25.0
January 1978	-90.8	-92.6	-91.0	-89.9	20.0
February 1978	-91.0	-92.7	-90.8	-89.7	16.7
March 1-7, 1978	-91.1	-92.9	-90.8	-89.8	19.2
March 8-17, 1978	-91.3	-93.5	-91.0	-89.9	26.5
1977-78 Average	-91.1	-93.0	-90.9	-89.8	22.5

* All data normalized to $I = 300A$ and $\psi = 291$ deg

Table 2. Comparison of Whip and Loop Average Field Strengths*

Date	Field Strength Component	SSTP H_{ϕ} (dBA/m)	Night H_{ϕ} (dBA/m)	SRTP H_{ϕ} (dBA/m)	Day H_{ϕ} (dBA/m)	Approx. $\Delta\phi$ (deg)
November 1977	Equiv. H_{ϕ}	-143.6	-145.0	-143.5	-143.3	28.0
	Meas. H_{ϕ}	-143.7	-145.2	-144.1	-143.4	24.5
December 1977	Equiv. H_{ϕ}	-144.9	-145.9	-144.4	-143.6	25.0
	Meas. H_{ϕ}	-144.3	-145.8	-144.8	-143.7	24.0
January 1978	Equiv. H_{ϕ}	-143.8	-145.1	-144.0	-143.4	20.0
	Meas. H_{ϕ}	-----	-----	-----	-----	-----
February 1978	Equiv. H_{ϕ}	-144.1	-145.4	-143.9	-143.2	16.7
	Meas. H_{ϕ}	-143.9	-145.5	-144.3	-143.0	17.5
March 1-7, 1978	Equiv. H_{ϕ}	-144.1	-145.4	-143.8	-143.3	19.2
	Meas. H_{ϕ}	-144.3	-145.7	-144.7	-143.3	19.3
March 8-17, 1978	Equiv. H_{ϕ}	-144.1	-145.6	-143.8	-143.4	26.5
	Meas. H_{ϕ}	-144.6	-145.8	-144.4	-143.5	26.4
1977-78 Average	Equiv. H_{ϕ}	-144.1	-145.4	-143.9	-143.3	22.5
	Meas. H_{ϕ}	-144.1	-145.6	-144.4	-143.3	22.5

* All data normalized to $I = 300A$ and $\psi = 291$ deg.

Table 3. Comparison of Whip and Loop Average Field Strengths During Minimum Nighttime Field Strength Period (0500-0800 GMT).*

Date	Meas. E_y (dBV/m)	Equiv. H_{ϕ} (dBA/m)	Meas. H_{ϕ} (dBA/m)
3/12/78	-95.5	-147.8	-148.0
3/13	-96.7	-149.0	-148.8
3/14	-96.4	-148.7	-148.6
3/15	-96.9	-149.2	-148.8
3/16	-95.2	-147.5	-147.9
3/17	-96.8	-149.1	-148.9
Average	-96.2	-148.5	-148.5

* $\psi = 201$ deg

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APPENDIX A

CONNECTICUT DAILY DATA, NOVEMBER 1977

Daily plots of Connecticut whip field strength averages and whip field strength averages versus GMT for November 1977 are given in Table A-1 and Figures A-1 through A-4, respectively.

Table A-1. November 1977 Conn. Whip Daily Field Strength Averages
 ($\psi = 291$ deg)

Date	SSTP E_V (dBV/m)	Ni ght E_V (dBV/m)	SRTP E_V (dBV/m)	Day E_V (dBV/m)	Approx. $\Delta\phi$ (deg)
11/1	-----	-91.0	-89.8	-89.7	21.5
11/2	-----	-93.0	-90.4	-89.5	21.5
11/3	-----	-92.2	-90.7	-90.4	23.0
11/4-11/5	-91.9	-92.9	-91.6	-90.5	29.0
11/5-11/6	-90.5	-92.9	-90.9	-89.6	31.0
11/6-11/7	-89.8	-93.0	-90.7	-89.3	36.5
11/8	-----	-93.2	-90.3	-89.5	27.0
11/9	-----	-94.0	-91.1	-90.0	33.5
Average	-90.7	-92.7	-90.6	-89.8	28.0

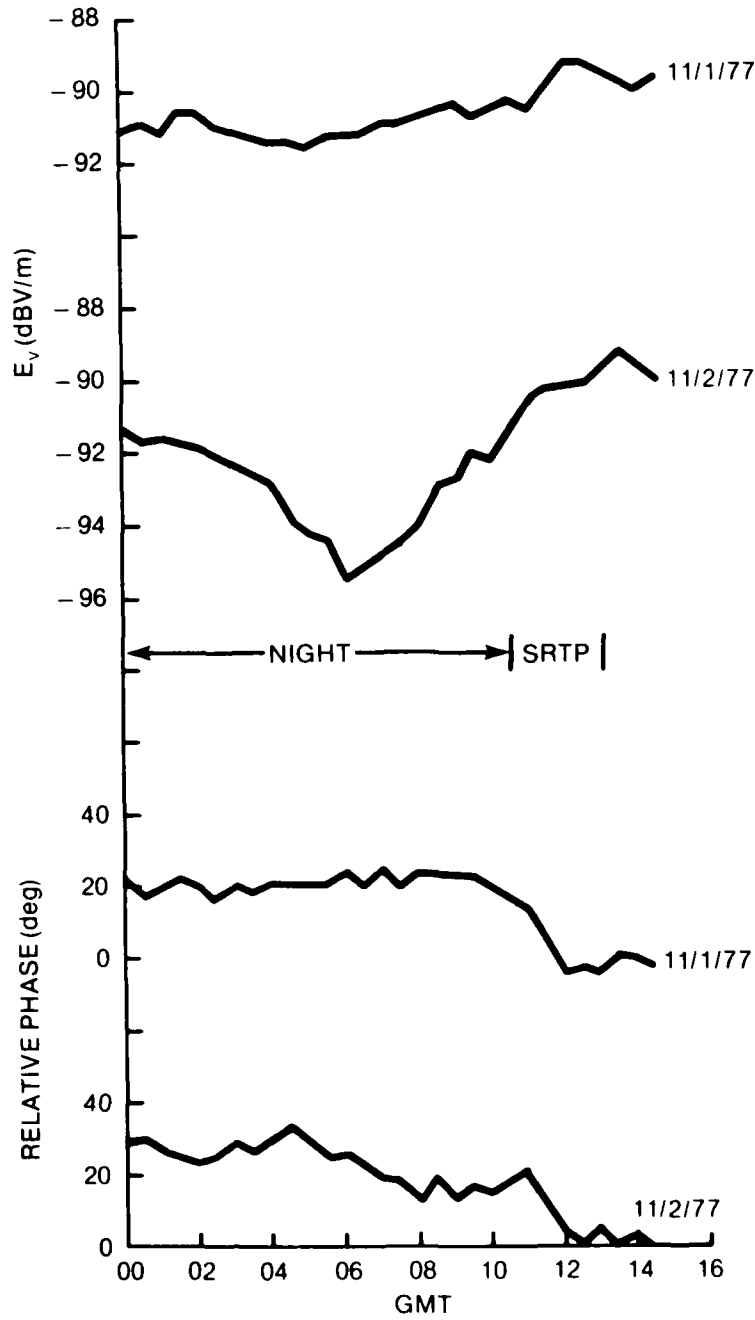


Figure A-1. Connecticut Whip Field Strength Versus GMT, 1 and 2 November 1977 ($\psi = 291$ deg)

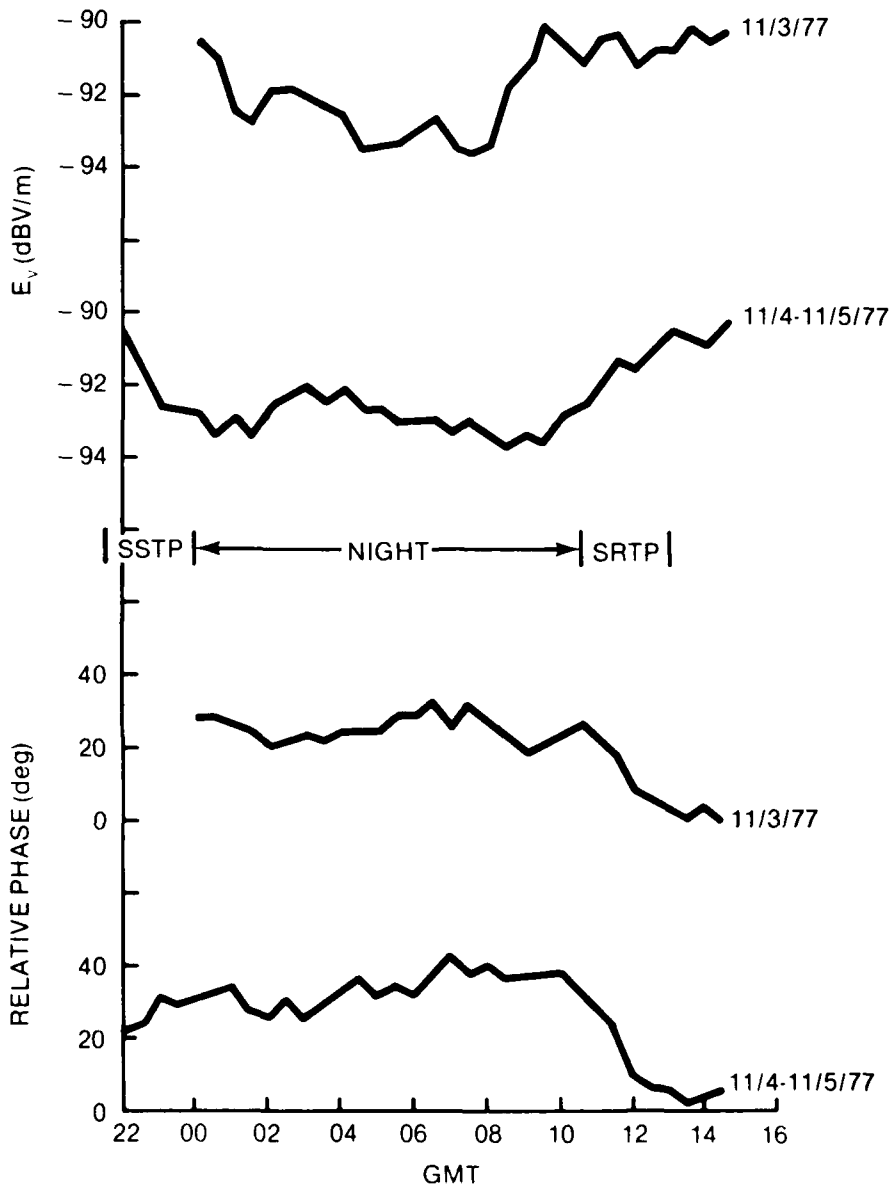


Figure A-2. Connecticut Whip Field Strength Versus GMT, 3 and 4/5 November 1977 ($\psi = 291$ deg)

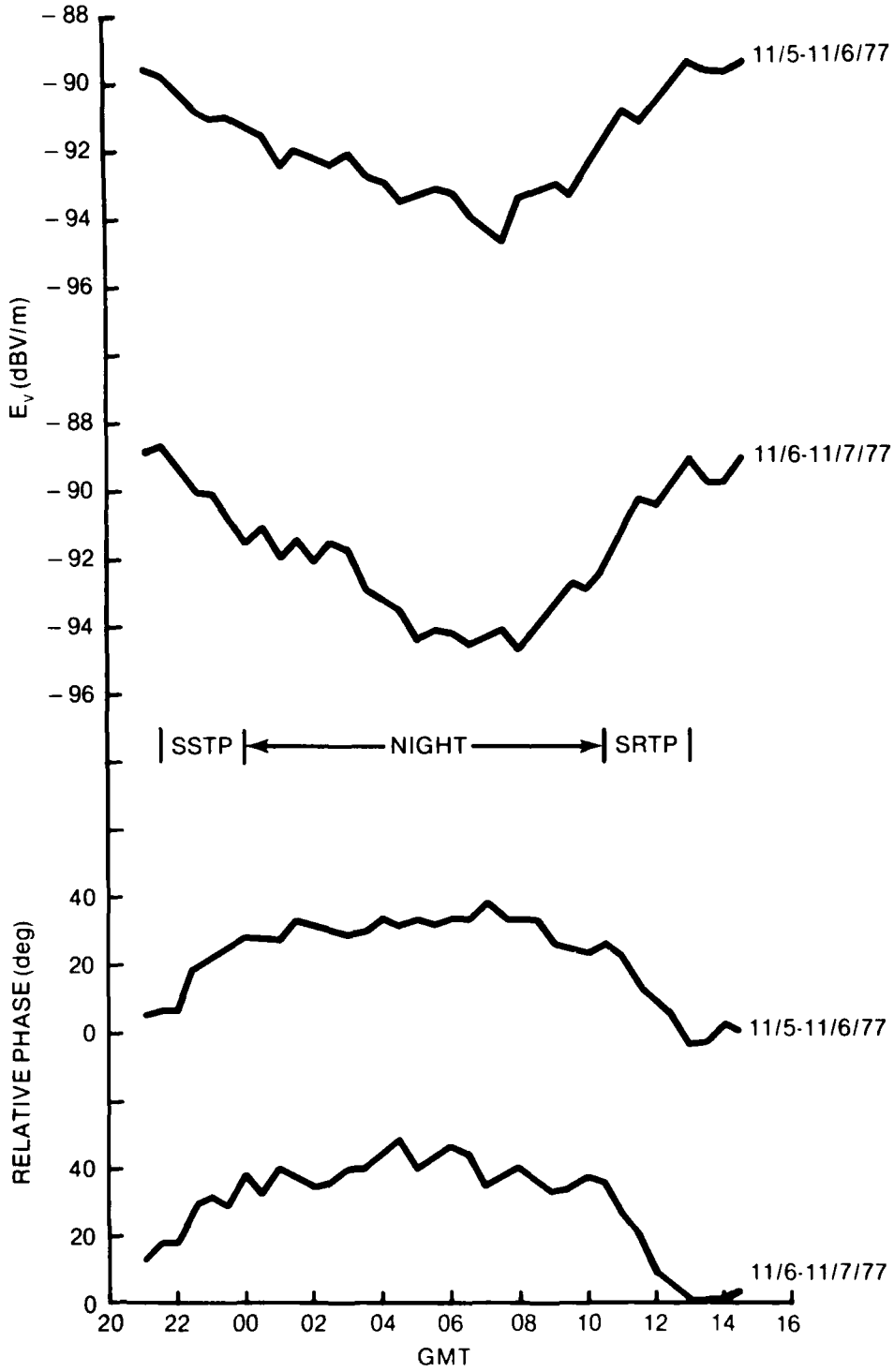


Figure A-3. Connecticut Whip Field Strength Versus GMT, 5/6 and 6/7 November 1977 ($\psi = 291$ deg)

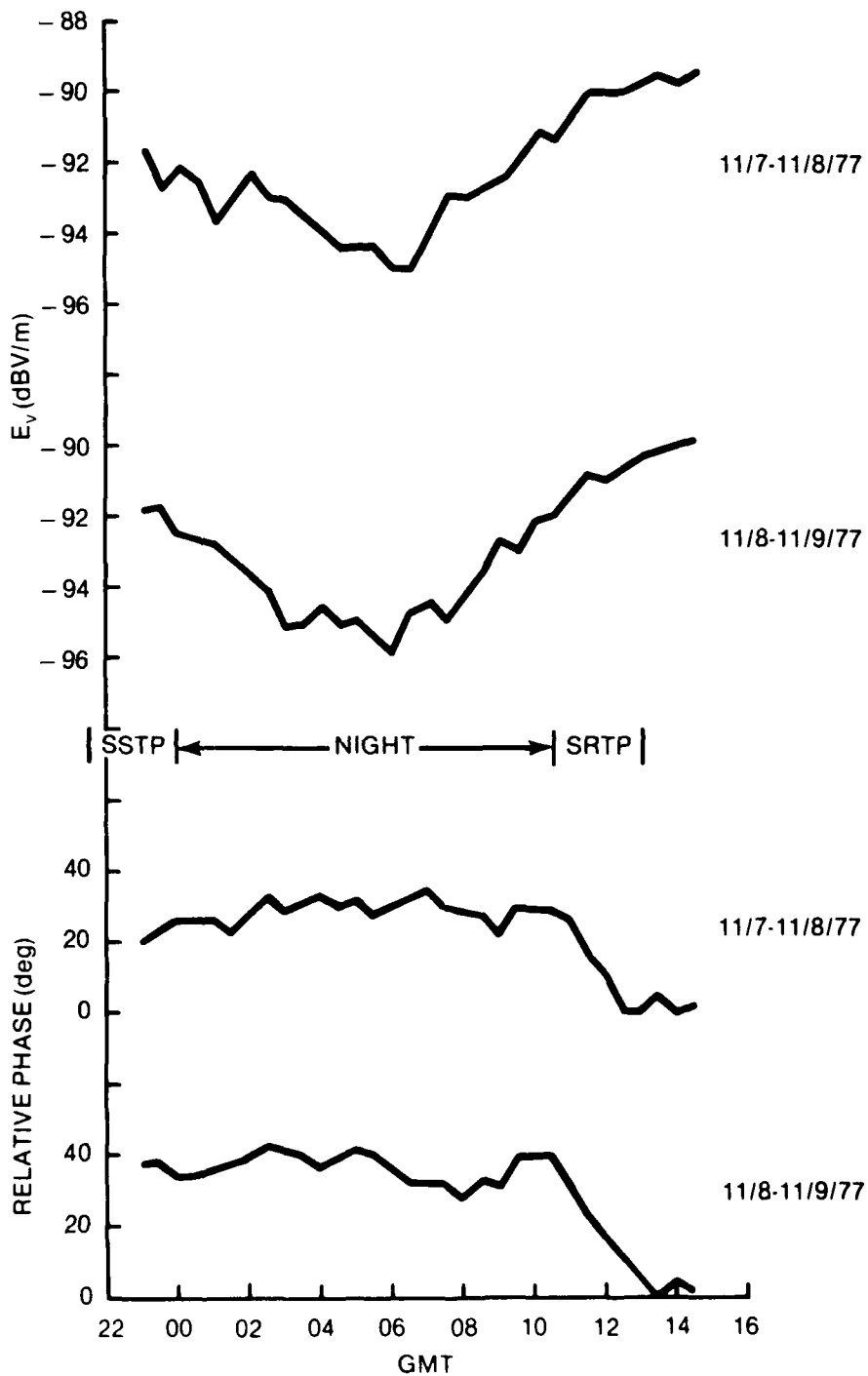


Figure A-4. Connecticut Whip Field Strength Versus GMT, 7/8 and 8/9 November 1977 ($\psi = 291$ deg)

APPENDIX B

CONNECTICUT DAILY DATA, DECEMBER 1977

Daily plots of Connecticut whip field strength averages and whip field strength averages versus GMT for December 1977 are given in Table B-1 and Figures B-1 through B-4, respectively.

Table B-1. December 1977 Conn. Whip Daily Field Strength Averages
 ($\psi = 291$ deg)

Date	SSTP E_V (dBV/m)	Night E_V (dBV/m)	S RTP E_V (dBV/m)	Day E_V (dBV/m)	Approx. $\Delta\phi$ (deg)
12/22	-92.7	-93.7	-90.8	-89.5	34.5
12/23	-91.8	-93.9	-91.6	-90.2	27.0
12/24	-92.0	-94.3	-91.9	-90.2	24.0
12/25-12/26	-92.2	-94.2	-91.6	-90.3	27.5
12/27	-92.0	-93.8	-91.6	-90.7	17.0
12/28	-92.1	-93.3	-91.6	-90.6	18.5
12/29	-91.6	-92.7	-92.0	-89.7	19.5
12/30	-91.8	-93.2	-91.5	-90.2	26.0
12/31	-91.9	-93.5	-----	-89.9	31.0
Average	-92.0	-93.6	-91.5	-90.1	25.0

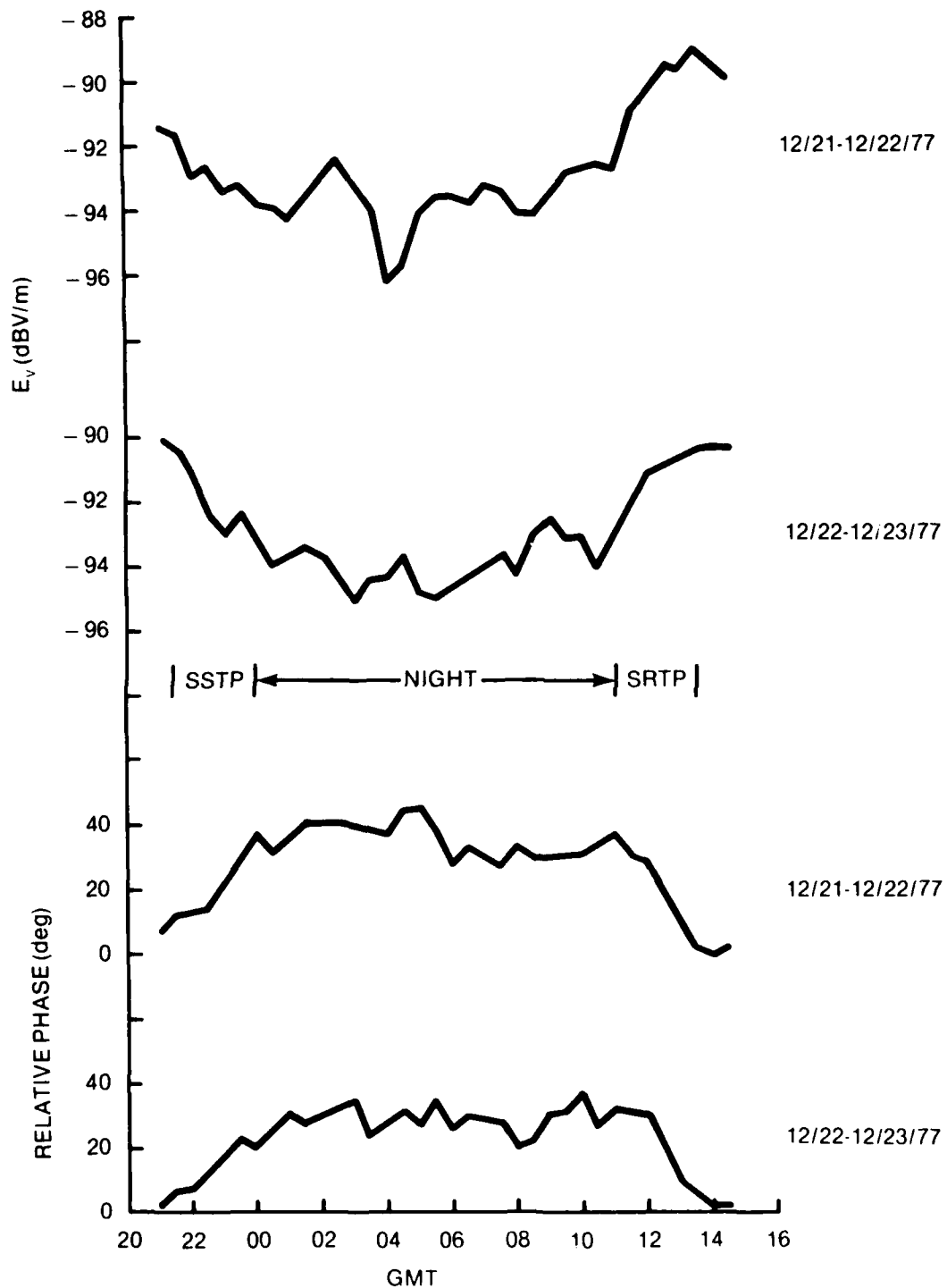


Figure B-1. Connecticut Whip Field Strength Versus GMT, 21/22 and 22/23 December 1977 ($\psi = 291$ deg)

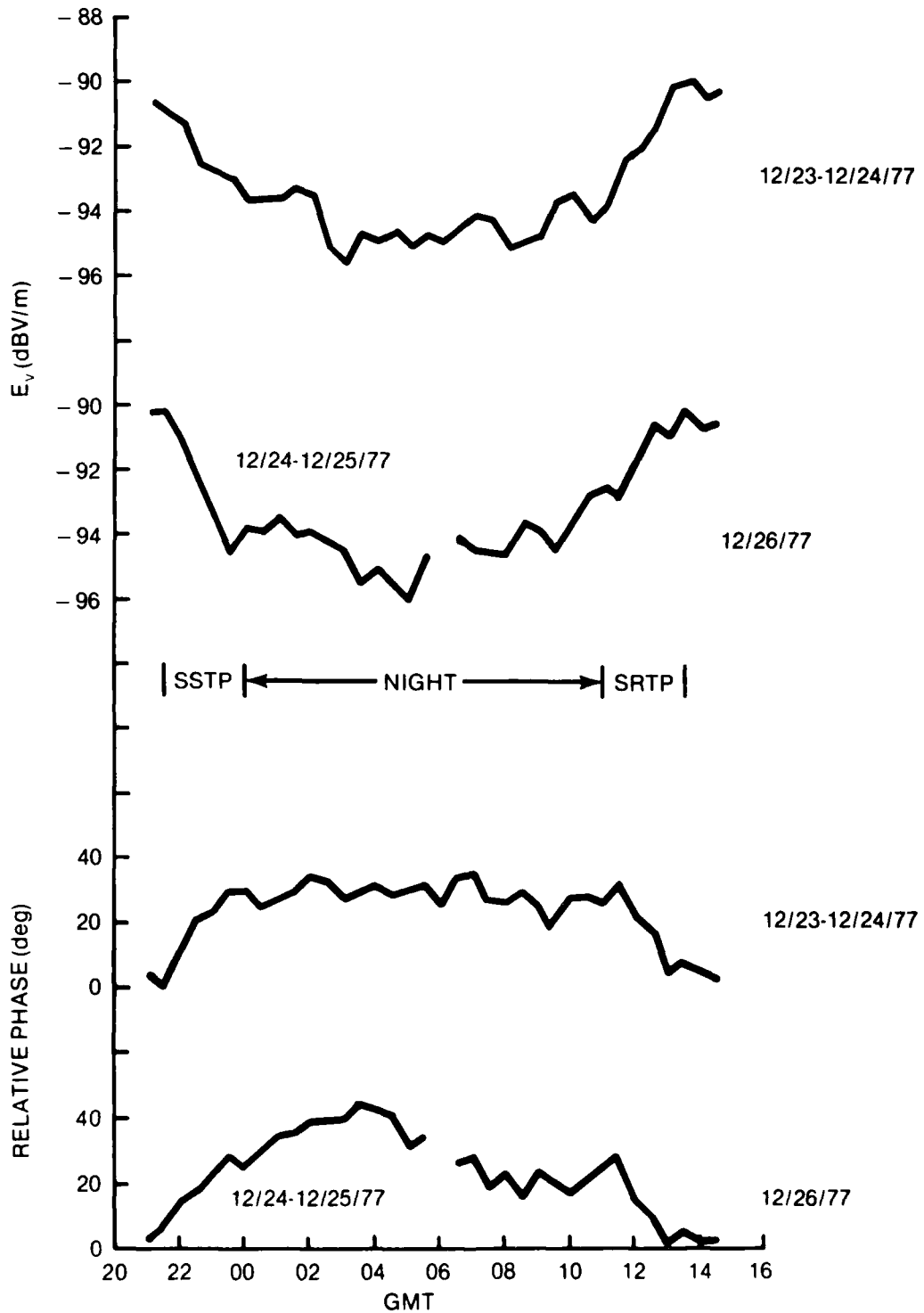


Figure B-2. Connecticut Whip Field Strength Versus GMT, 23/24, 24/25, and 26 December 1977 ($\psi = 291$)

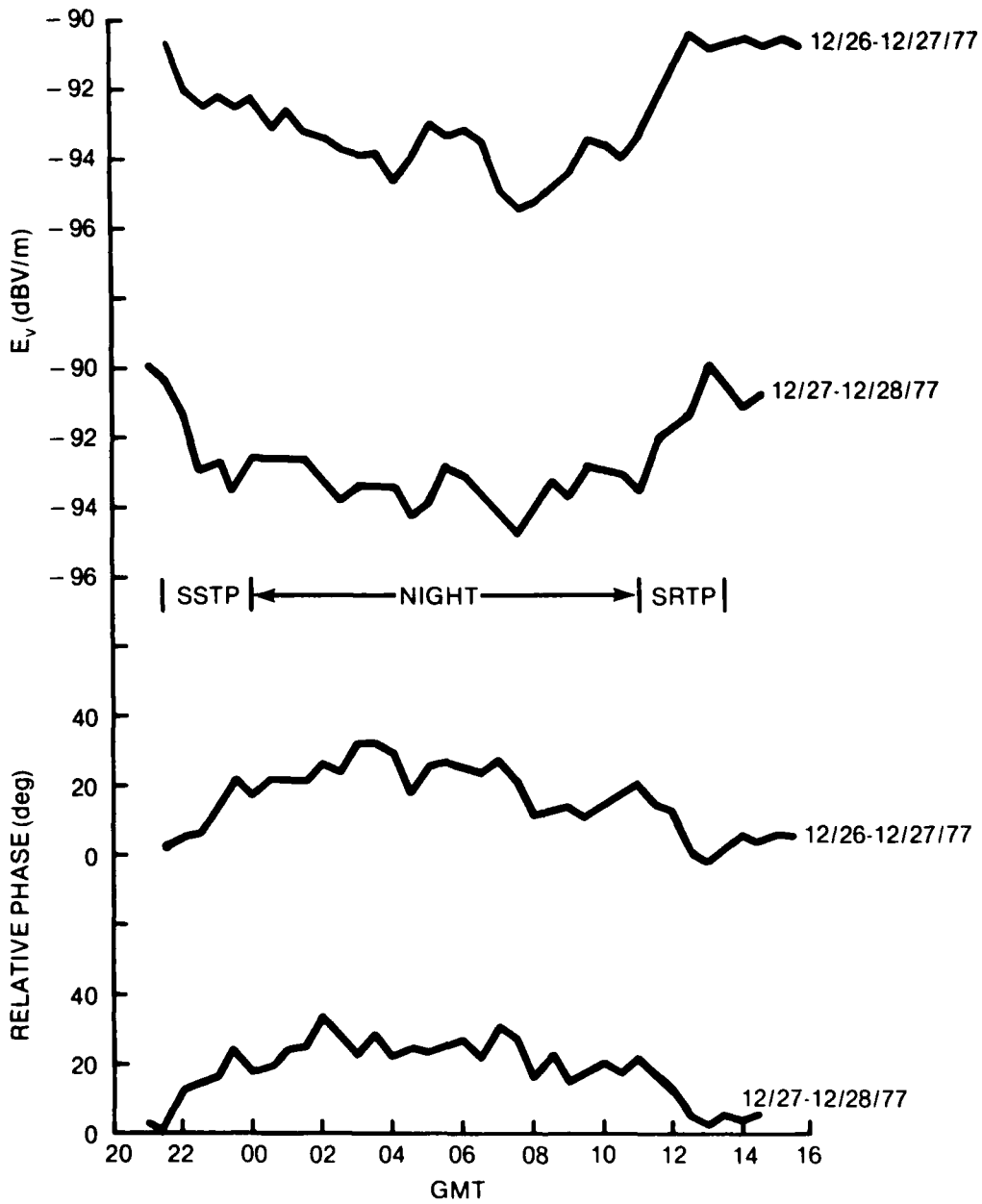


Figure B-3. Connecticut Whip Field Strength Versus GMT, 26/27 and 27/28 December 1977 ($\psi = 291$ deg)

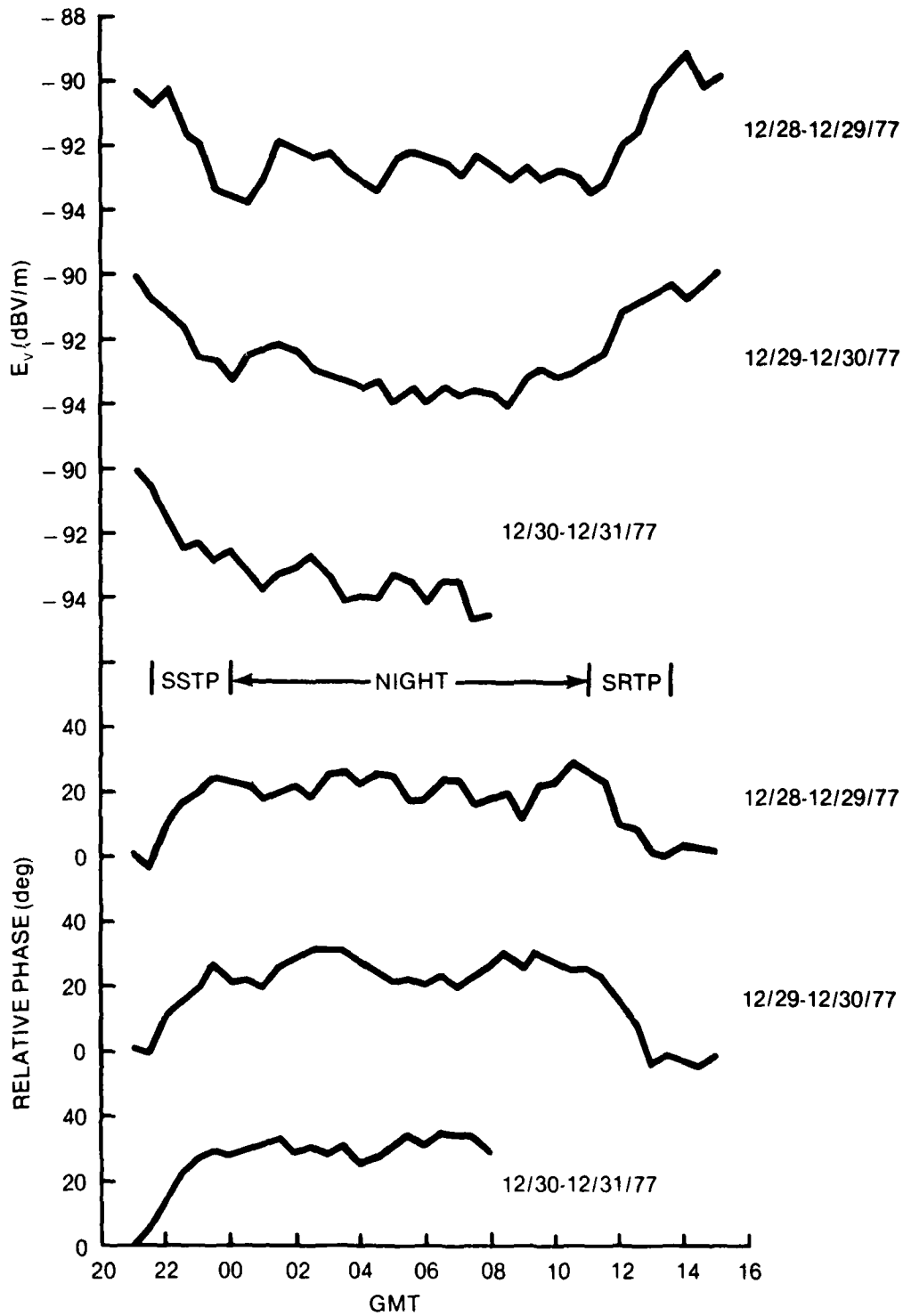


Figure B-4. Connecticut Whip Field Strength Versus GMT, 28/29, 29/30, and 30/31 December 1977 ($\psi = 291$ deg)

APPENDIX C

CONNECTICUT DAILY DATA, JANUARY 1978

Daily plots of Connecticut whip field strength averages and whip field strength averages versus GMT for January 1978 are given in Table C-1 and Figures C-1 through C-5, respectively.

Table C-1. January 1978 Conn. Whip Daily Field Strength Averages
($\psi = 291$ deg)

Date	SSTP E_V (dBV/m)	Night E_V (dBV/m)	SRTP E_V (dBV/m)	Day E_V (dBV/m)	Approx. $\Delta\phi$ (deg)
1/4	-91.2	-93.3	-91.0	-89.9	17.5
1/5	-90.5	-93.2	-91.4	-90.5	14.0
1/6	-91.4	-92.6	-91.2	-89.7	11.0
1/7	-----	-92.2	-90.9	-89.9	12.5
1/8	-90.4	-92.1 (5)	-----	-----	-----
1/10	-91.5 (3)	-92.5	-89.9	-90.5	17.0
1/11	-90.0	-92.0	-91.0	-89.5	17.5
1/12	-90.6	-92.1	-90.8	-90.0	20.5
1/13	-90.9	-92.8	-91.5	-90.7	20.0
1/16	-90.3	-92.6	-90.7	-88.7	28.0
1/17	-91.0	-93.0	-91.3	-89.1	27.5
1/19	-91.5	-92.9	-91.5	-89.8	28.0
1/20	-91.4	-92.6 (10)	-----	-----	-----
1/21	-----	-92.3	-91.3	-90.0	21.0
1/22	-90.6	-93.0	-91.2	-90.2	23.5
1/23	-90.8	-92.7	-90.8	-90.3	24.5
Average	-90.8	-92.6	-91.0	-89.9	20.0

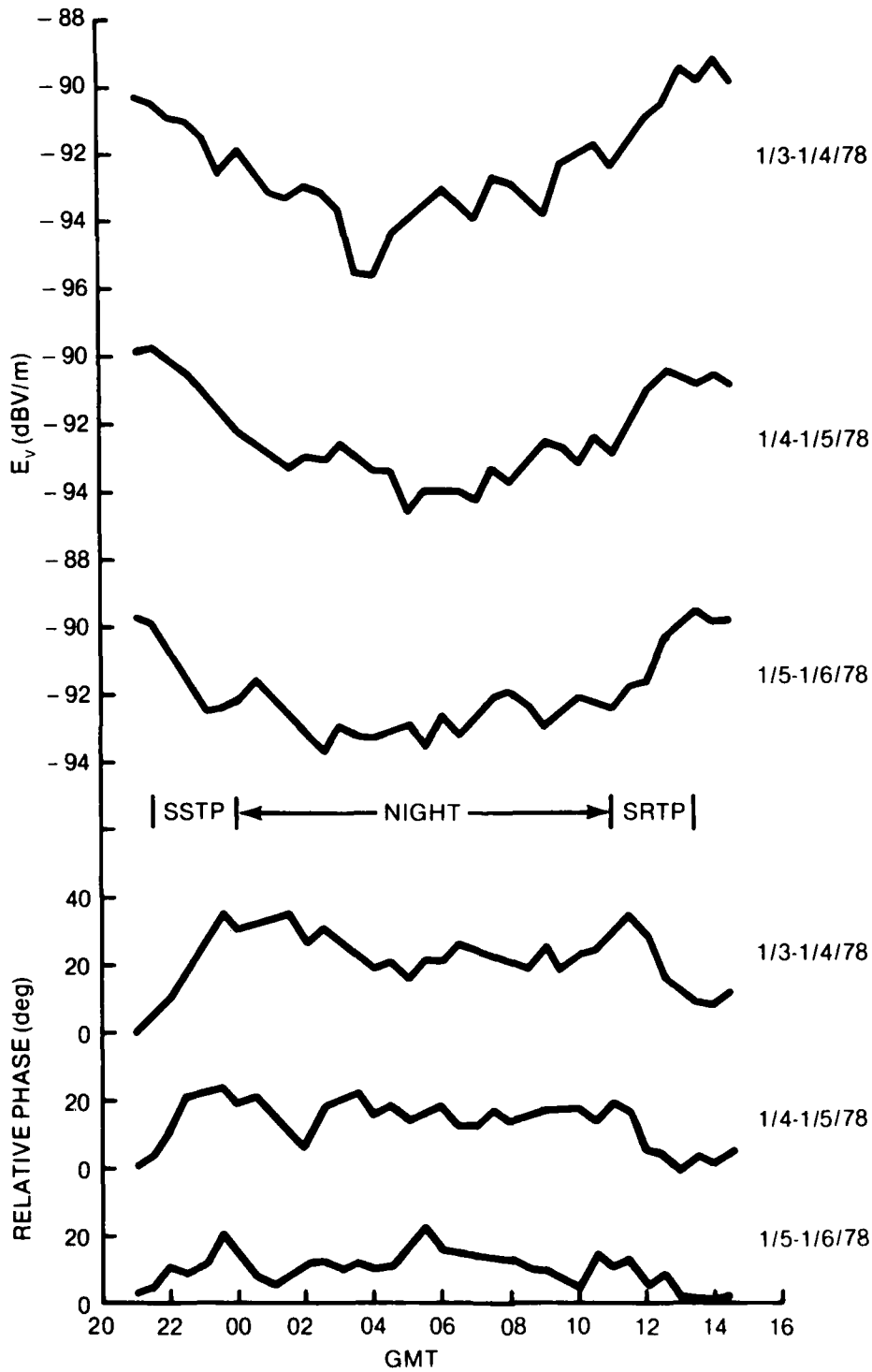


Figure C-1. Connecticut Whip Field Strength Versus GMT, 3/4, 4/5, and 5/6 January 1978 ($\psi = 291$ deg)

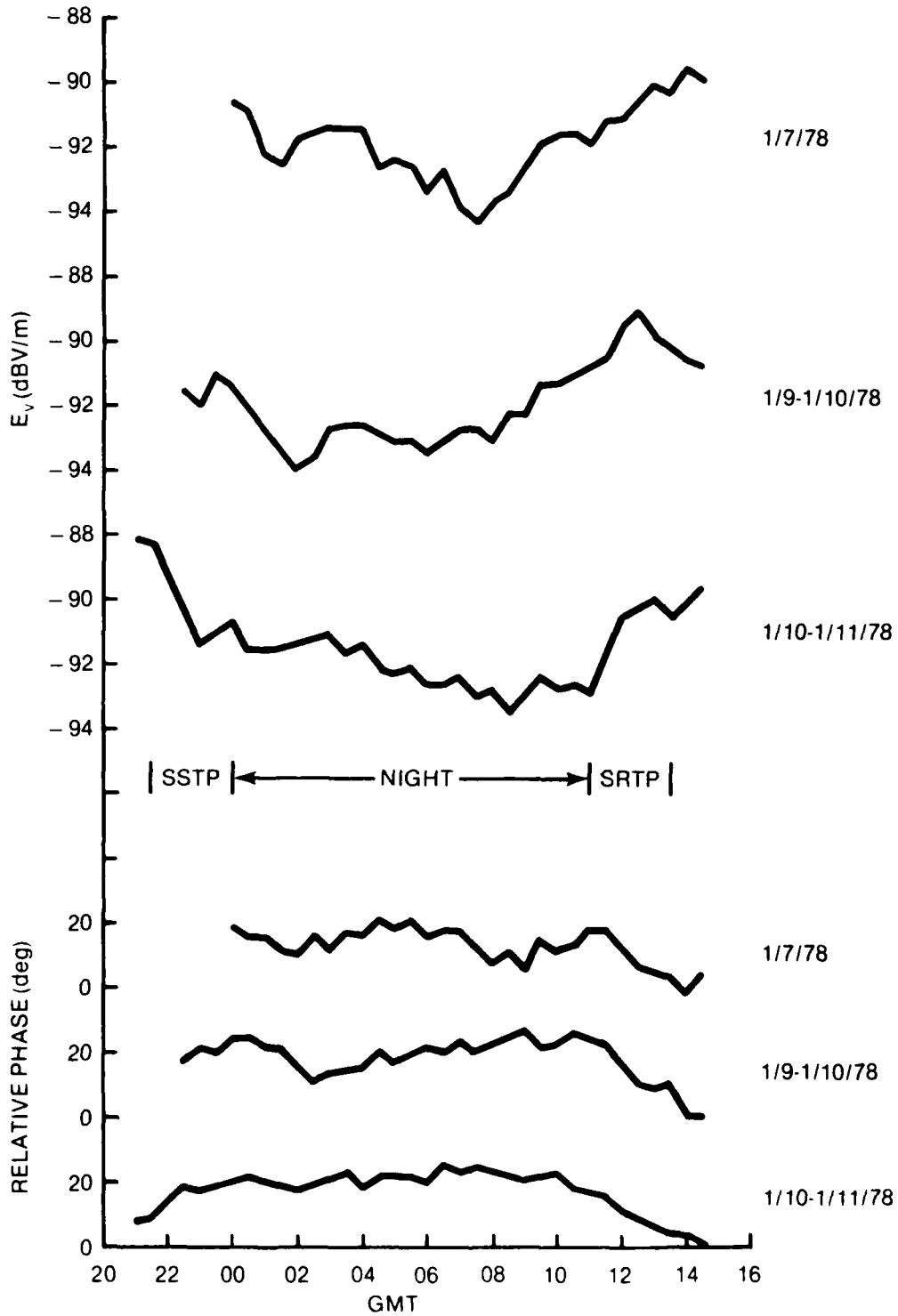


Figure C-2. Connecticut Whip Field Strength Versus GMT, 7, 9/10, and 10/11 January 1978 ($\Psi = 291$ deg)

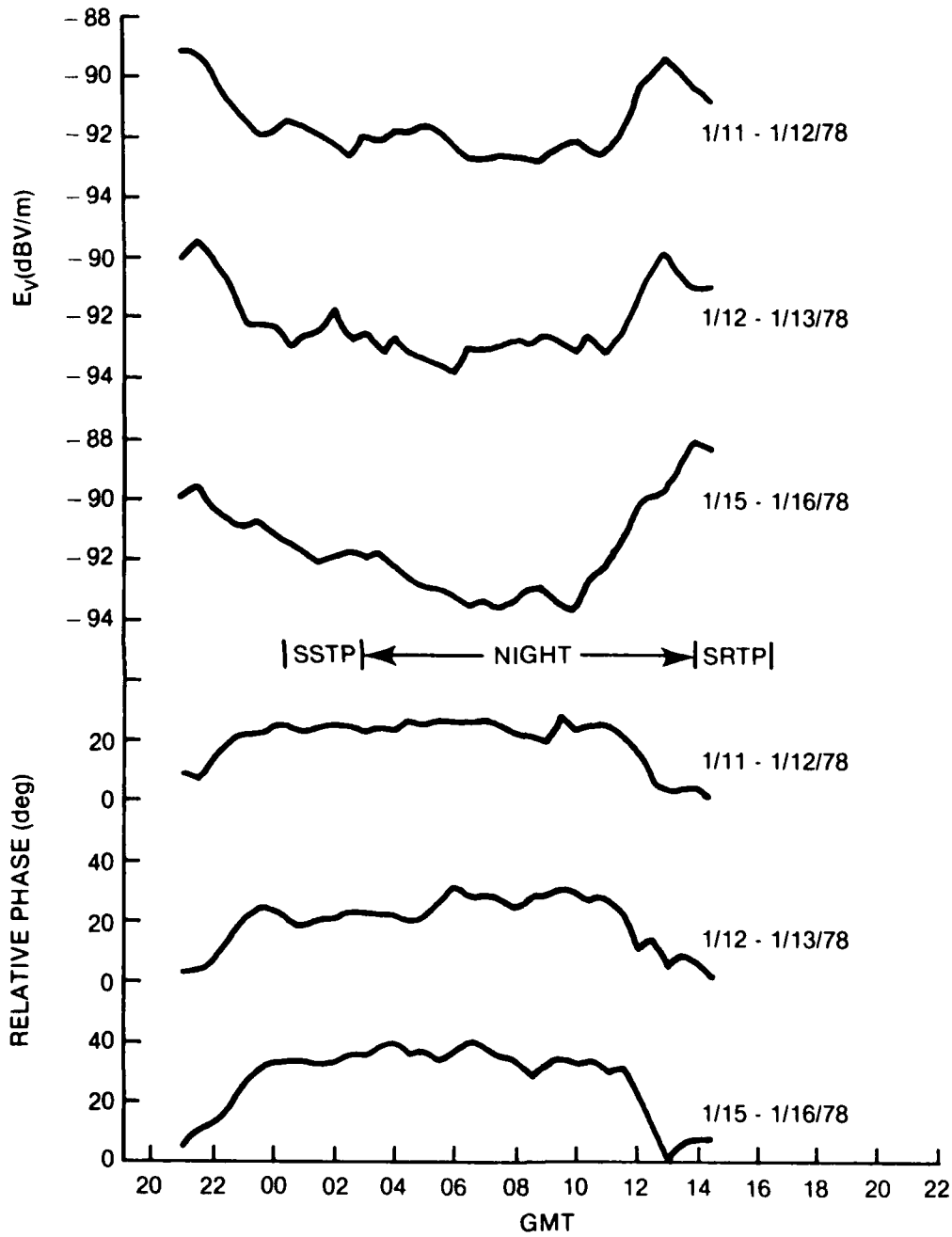


Figure C-3. Connecticut Whip Field Strength Versus GMT, 11/12, 12/13, and 15/16 January 1978 ($\psi = 291$ deg)

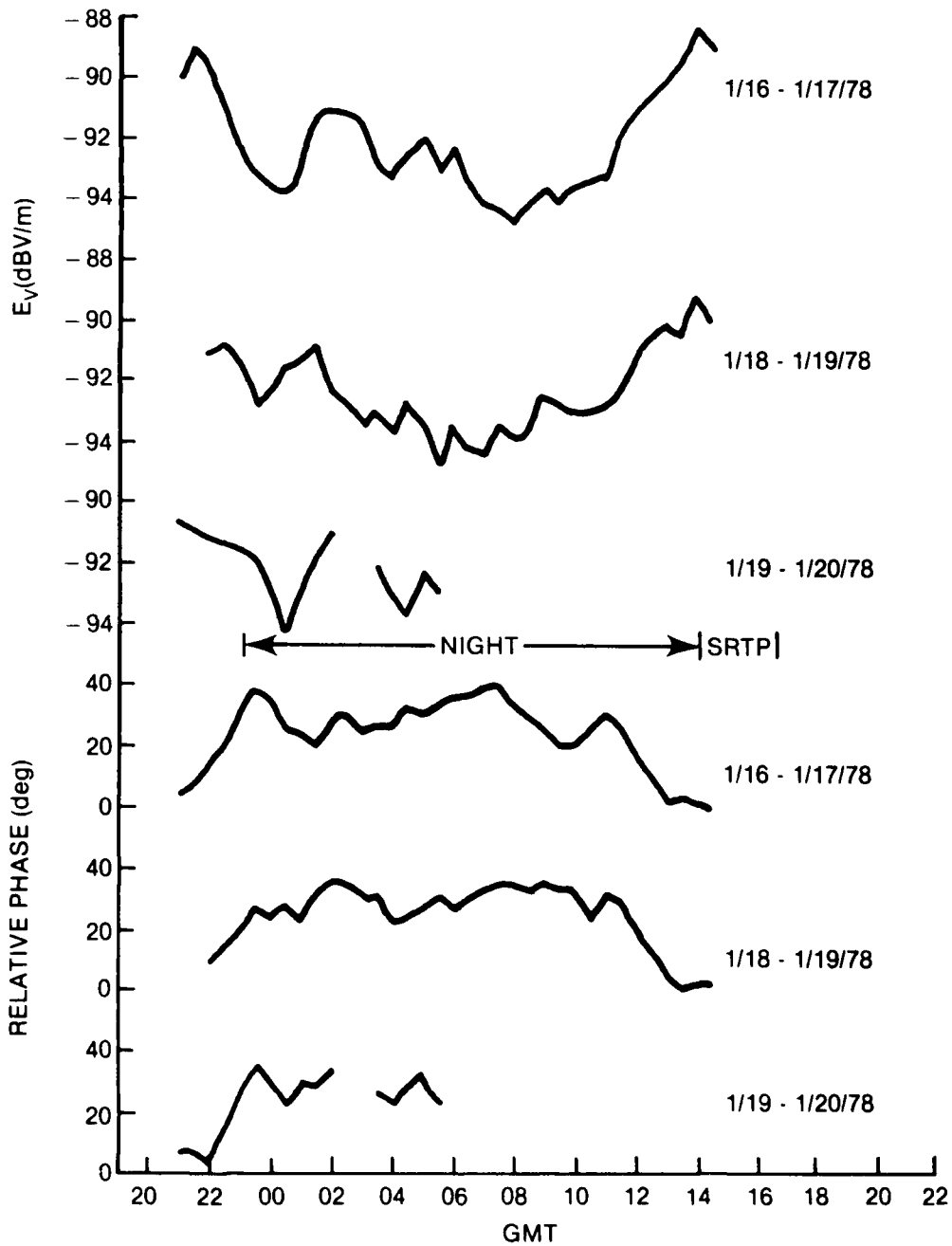


Figure C-4. Connecticut Whip Field Strength Versus GMT, 16/17, 18/19, and 19/20 January 1978 ($\psi = 291$ deg)

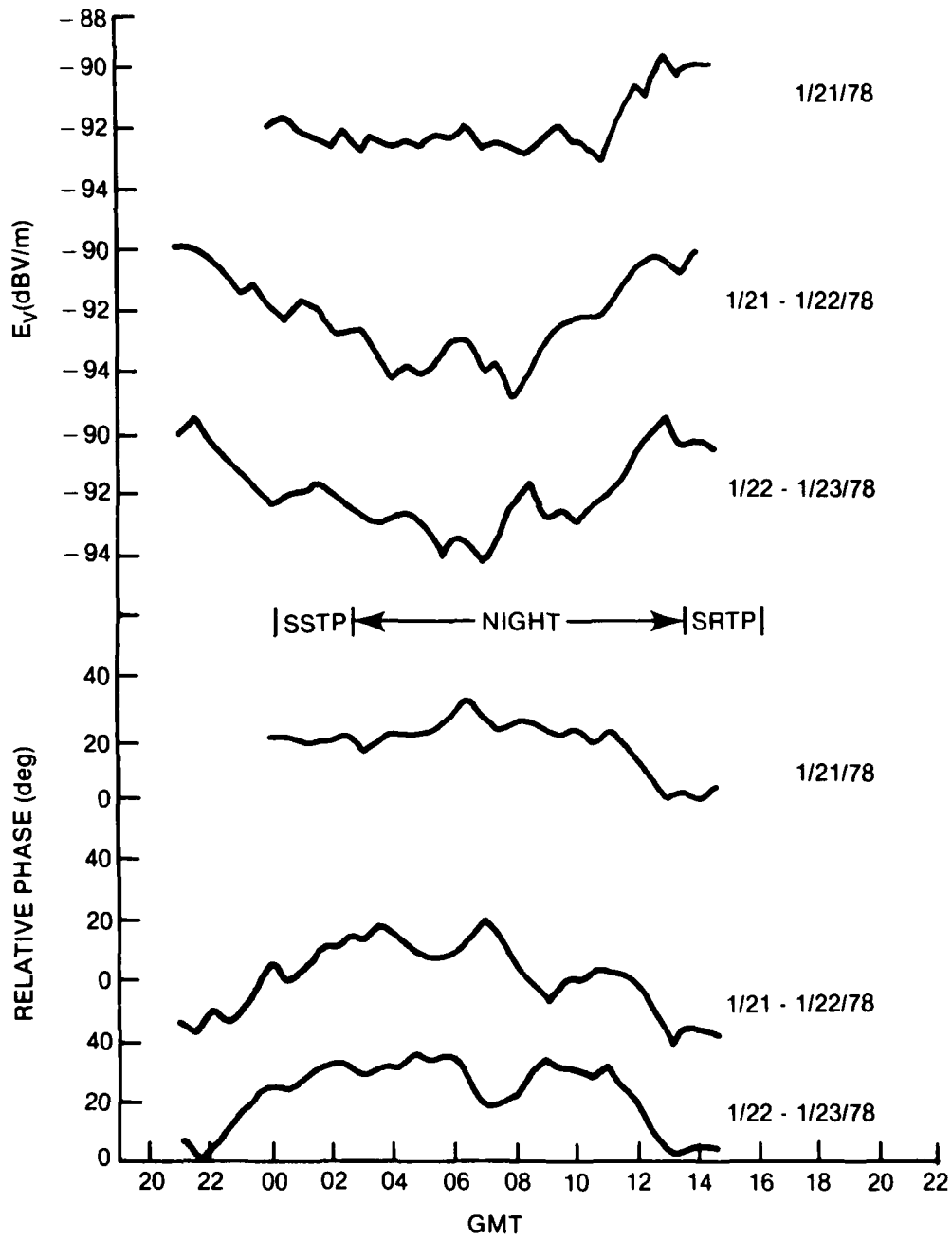


Figure C-5. Connecticut Whip Field Strength Versus GMT, 21, 22, and 23 January 1978 ($\psi = 291$ deg)

APPENDIX D

CONNECTICUT DAILY DATA, FEBRUARY 1978

Daily plots of Connecticut whip field strength averages and whip field strength averages versus GMT for February 1978 are given in Table D-1 and Figures D-1 through D-5, respectively.

Table D-1. February 1978 Conn. Whip Daily Field Strength Averages
 ($\psi = 291$ deg)

Date	SSTP E_v (dBV/m)	Night E_v (dBV/m)	SRTP E_v (dBV/m)	Day E_v (dBV/m)	$\Delta\phi$ (deg)
2/1	-----	-92.9	-91.0	-89.8	16.5
2/2	-90.9	-92.3	-90.2	-89.6	13.8
2/3	-90.6	-92.5	-90.6	-89.5	14.5
2/5	-90.3	-93.0	-90.8	-89.4	18.0
2/6	-90.5	-92.3	-91.4	-90.2	14.8
2/10	-91.3	-92.4	-90.8	-89.8	15.0
2/11	-91.4	-92.6	-90.9	-89.3	20.4
2/12	-91.4	-93.1	-90.9	-90.1	20.2
2/13	-----	-92.9	-90.8	-90.2	14.8
2/15	-92.1	-93.6	-90.5	-89.6	18.7
Average	-91.0	-92.7	-90.8	-89.7	16.7

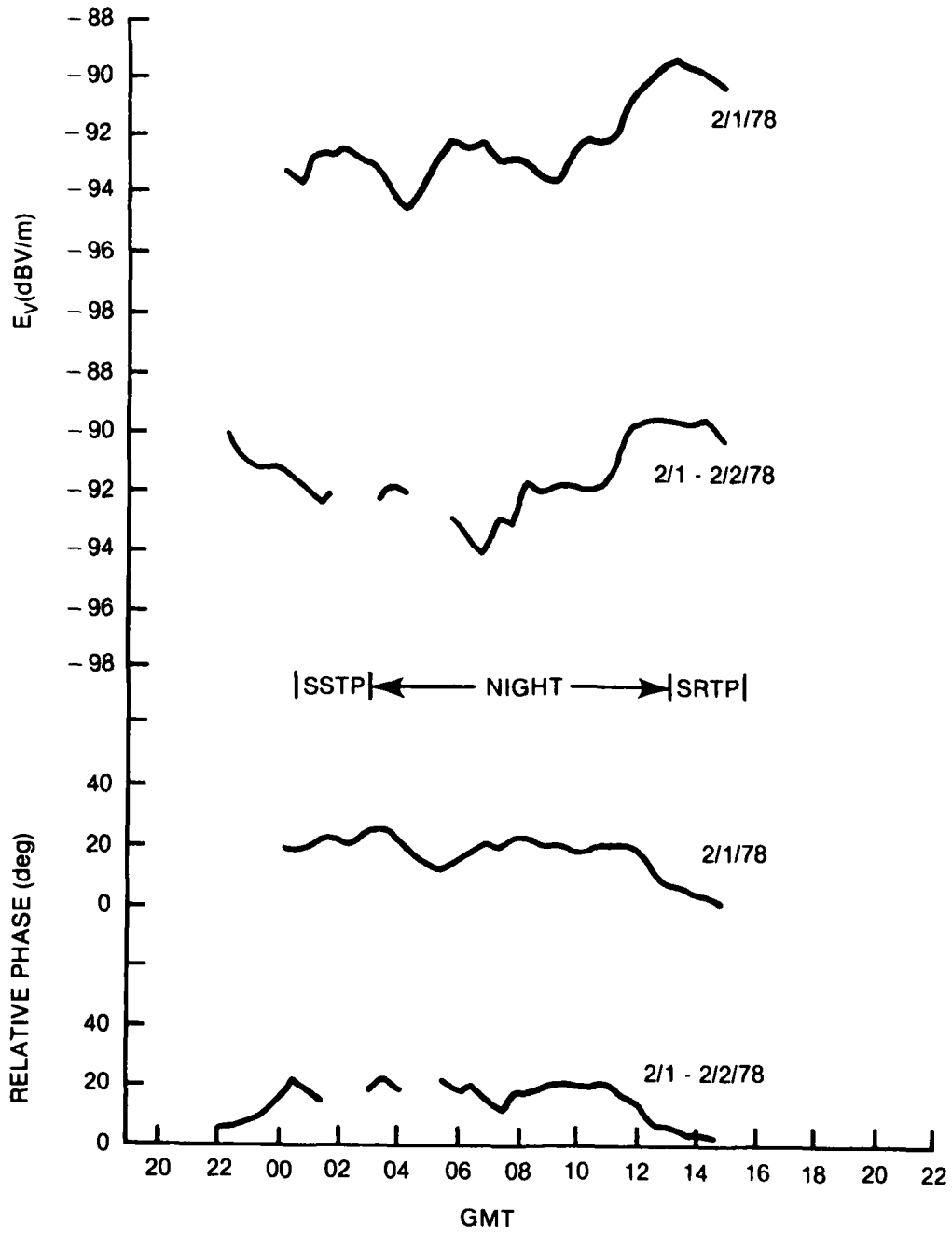


Figure D-1. Connecticut Whip Field Strength Versus GMT, 1 and 2 February 1978 ($\Psi = 291$ deg)

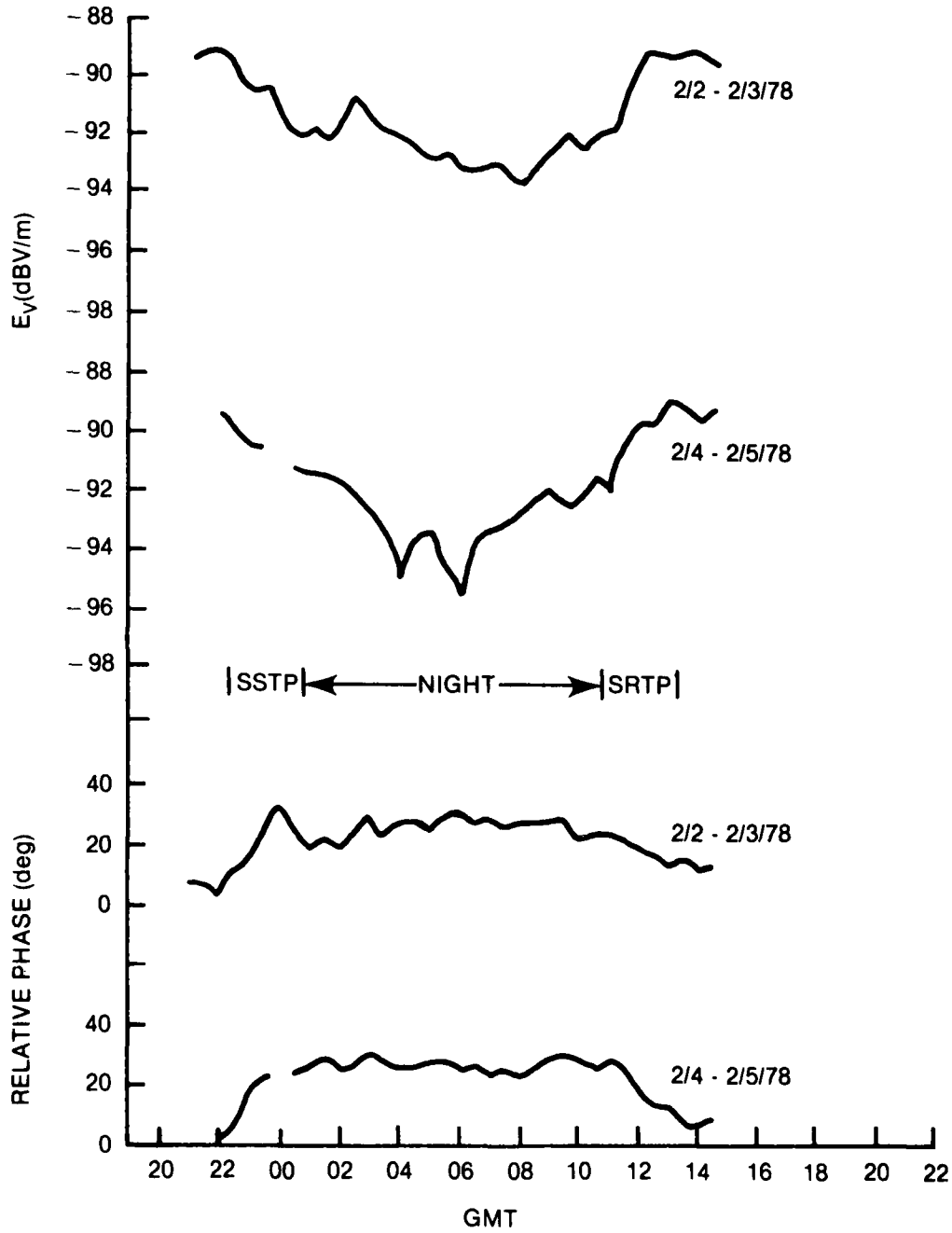


Figure D-2. Connecticut Whip Field Strength Versus GMT, 2/3 and 4/5 February 1978 ($\psi = 291$ deg)

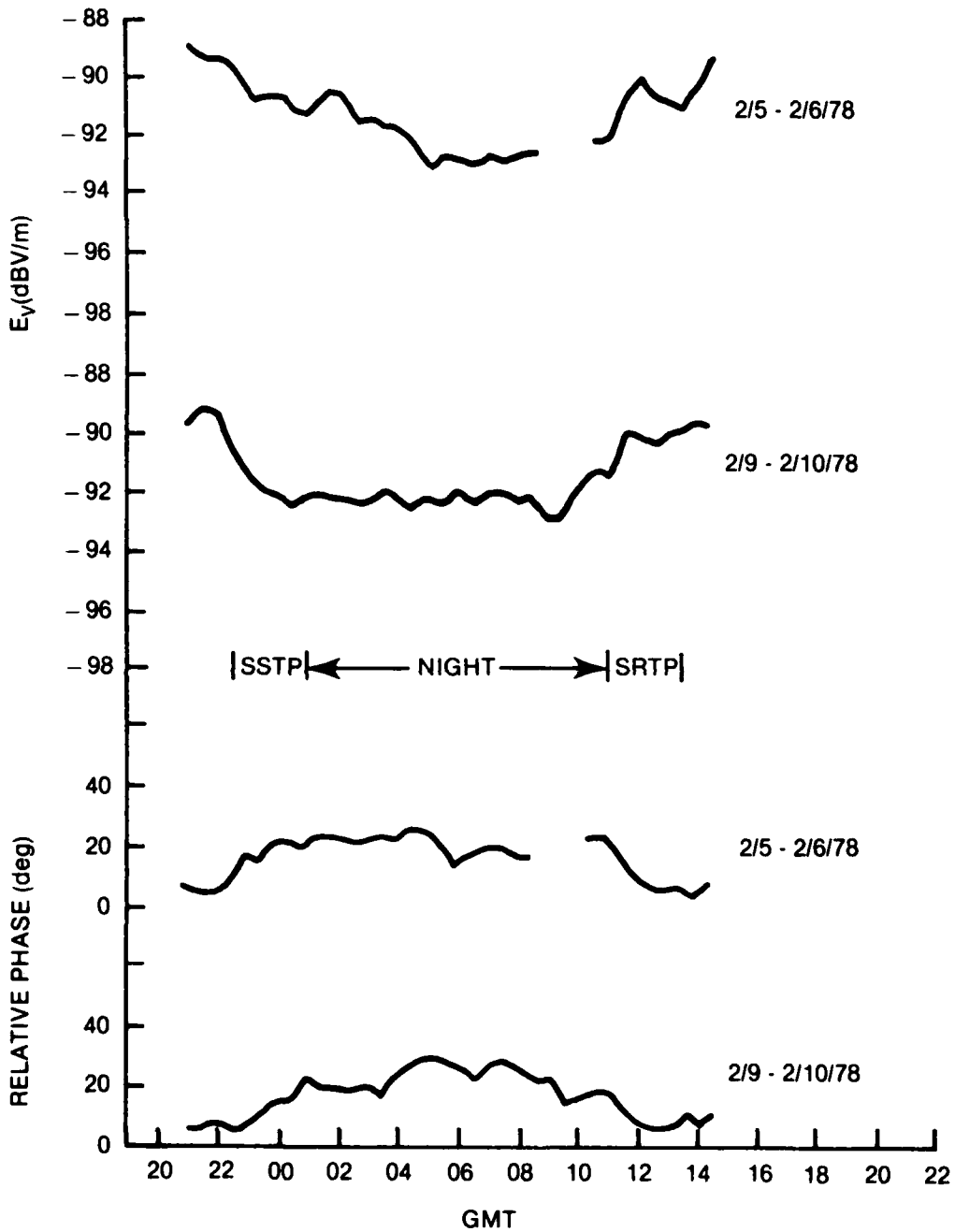


Figure D-3. Connecticut Whip Field Strength Versus GMT, 5/6 and 9/10 February 1978 ($\psi = 291$ deg)

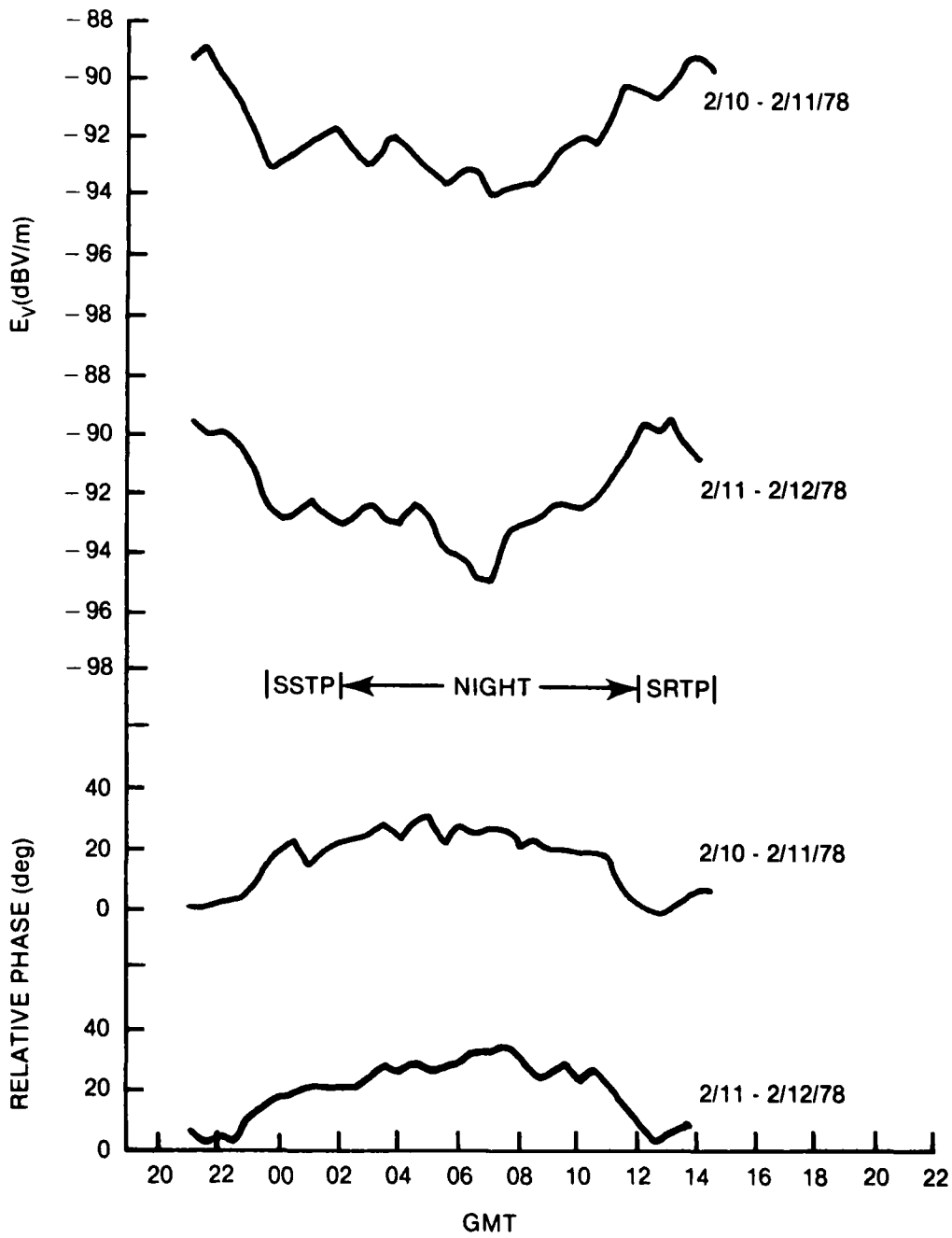


Figure D-4. Connecticut Whip Field Strength Versus GMT, 10/11 and 11/12 February 1978 ($\psi = 291$ deg)

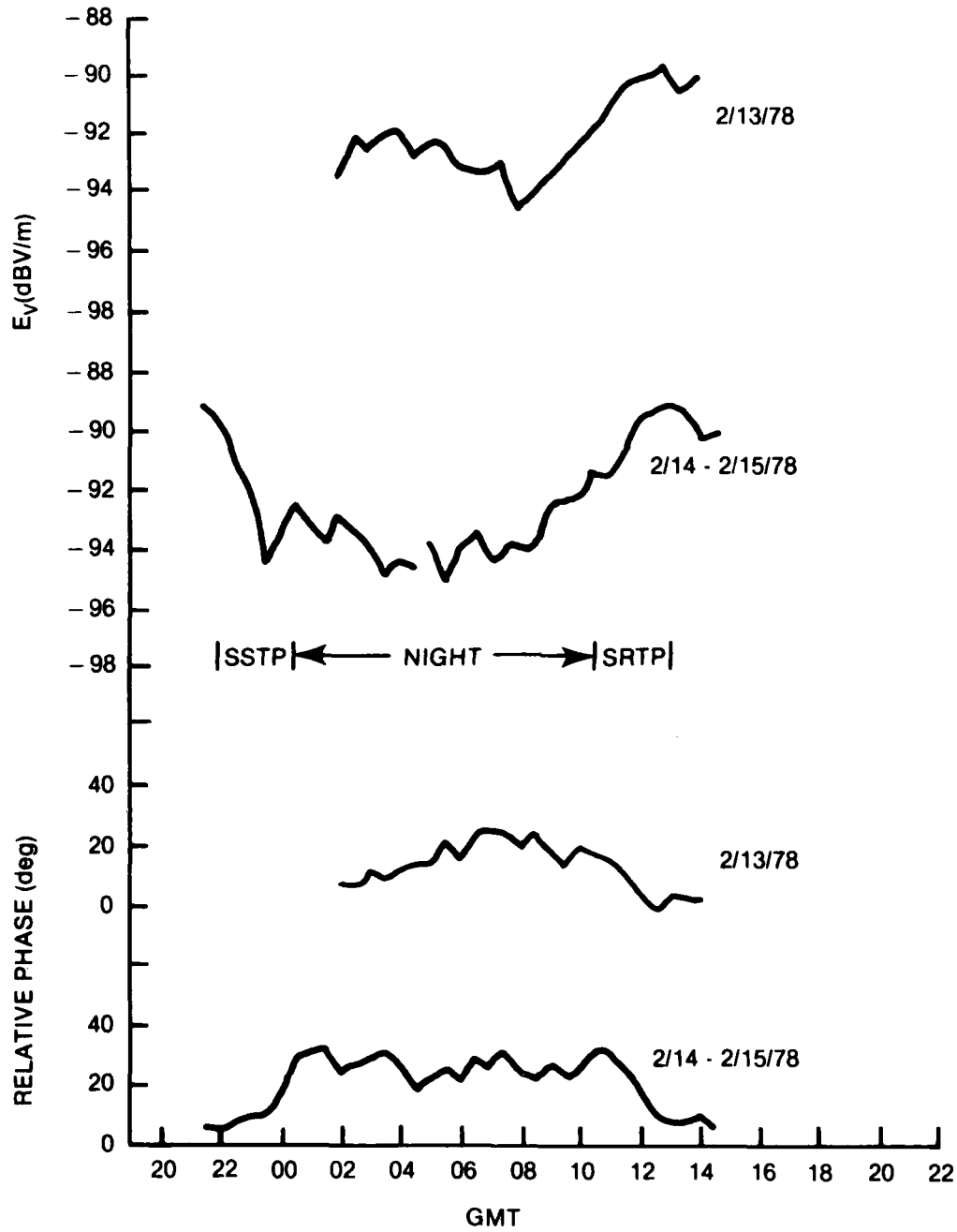


Figure D-5. Connecticut Whip Field Strength Versus GMT, 13 and 14/15 February 1978 ($\psi = 291$ deg)

APPENDIX E

CONNECTICUT DAILY DATA, MARCH 1978

Daily plots of Connecticut whip field strength averages and whip field strength averages versus GMT for March 1978 are given in Table E-1 and Figures E-1 through E-9, respectively.

Table E-1. March 1978 Connecticut Whip Daily Field Strength Averages

Date	ψ (deg)	SSTP E_V (dBV/m)	Night E_V (dBV/m)	SRTP E_V (dBV/m)	Day E_V (dBV/m)	Relative Phase (deg)
3/1	291	-90.2	-91.6	-90.5	-89.6	18.3
3/2	291	-92.3	-93.2	-91.4	-89.9	16.3
3/3	291	-91.1	-93.3	-90.4	-89.9	16.6
3/4	291	-----	-93.8	-91.4	-90.0	18.2
3/5	291	-91.5	-92.6	-90.7	-89.9	22.3
3/6	291	-90.9	-92.9	-90.7	-89.7	21.1
3/7	291	-91.1	-93.0	-90.9	-89.9	21.7
3/1-3/7 Average	291	-91.1	-92.9	-90.8	-89.8	19.2
3/8	201	-92.4	-93.2	-91.8	-90.5	30.2
3/9	201	-92.2	-94.1	-92.0	-90.9	22.1
3/10	201	-92.2	-93.6	-92.2	-90.9	30.9
3/11	201	-92.4	-93.6	-92.2	-91.0	20.1
3/12	201	-91.9	-94.3	-92.7	-91.5	20.0
3/13	201	-92.7	-95.5	-92.5	-90.8	28.6
3/14	201	-91.6	-94.8	-91.2	-91.1	26.8
3/15	201	-----	-95.8	-91.7	-90.9	29.6
3/16	201	-92.7	-94.2	-91.8	-91.0	29.3
3/17	201	-----	-95.9	-91.9	-----	27.2
3/8-3/17 Average	201	-92.3	-94.5	-92.0	-90.9	26.5

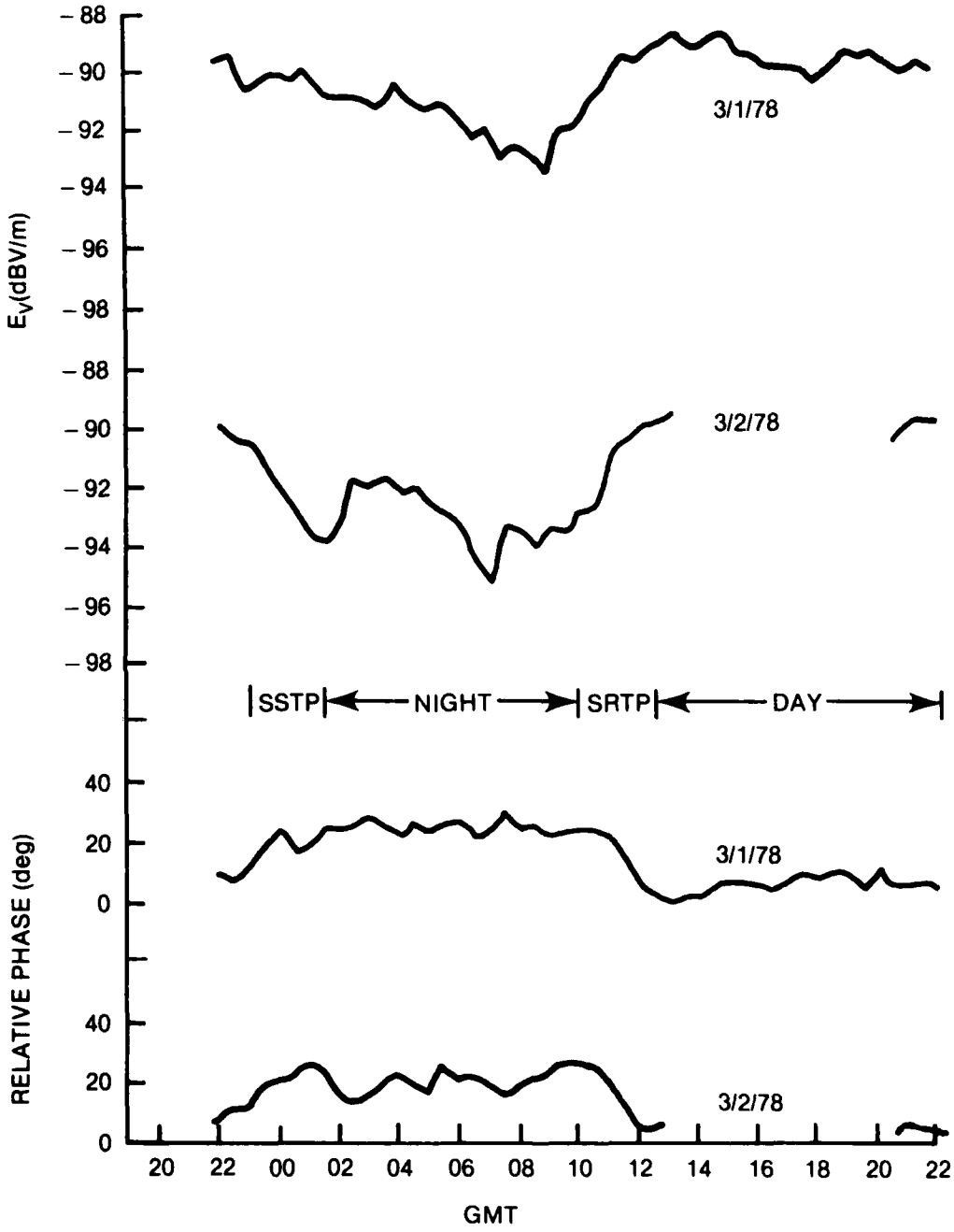


Figure E-1. Connecticut Whip Field Strength Versus GMT, 1 and 2 March 1978 ($\Psi = 291$ deg)

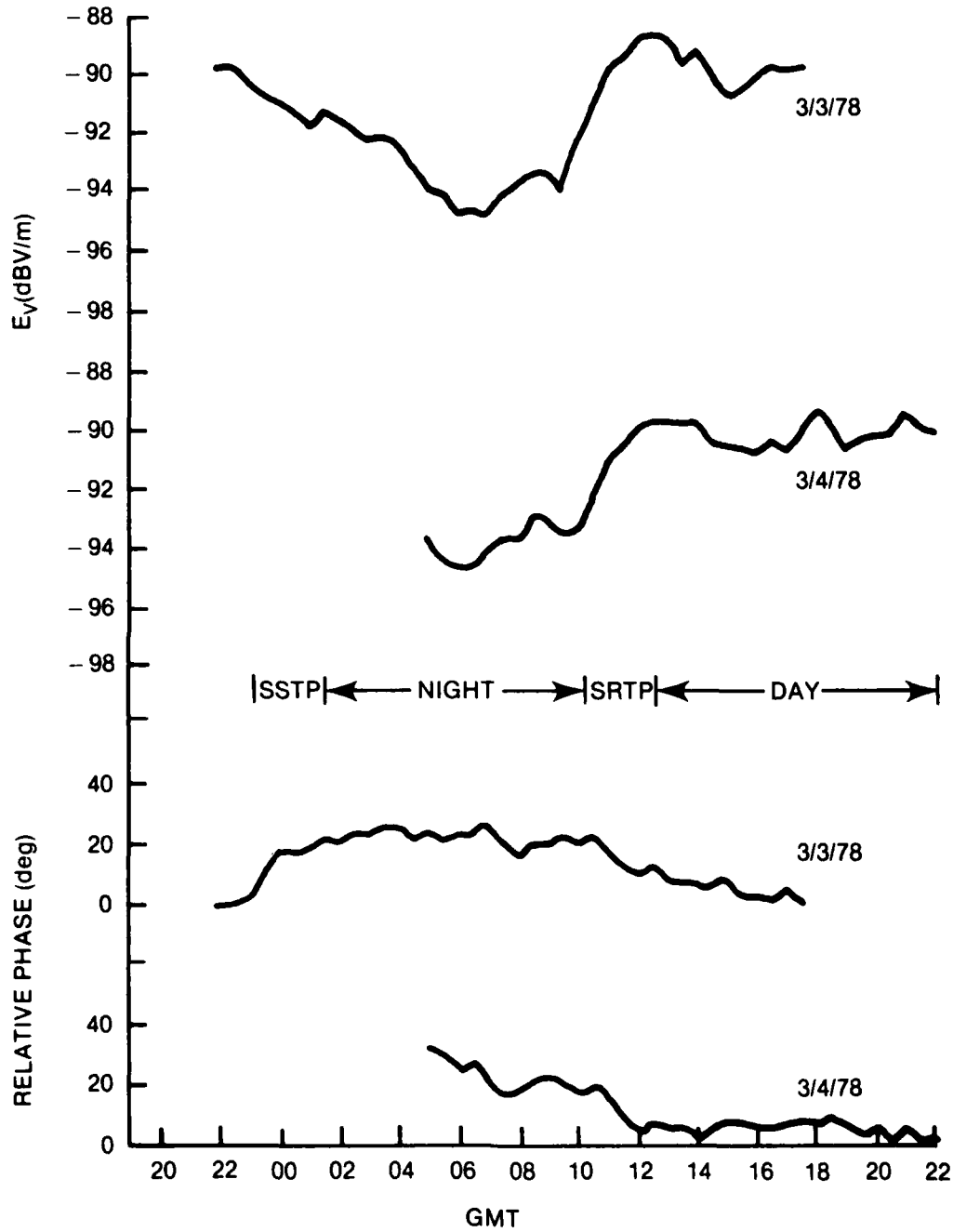


Figure E-2. Connecticut Whip Field Strength Versus GMT, 3 and 4 March 1978 ($\psi = 291$ deg)

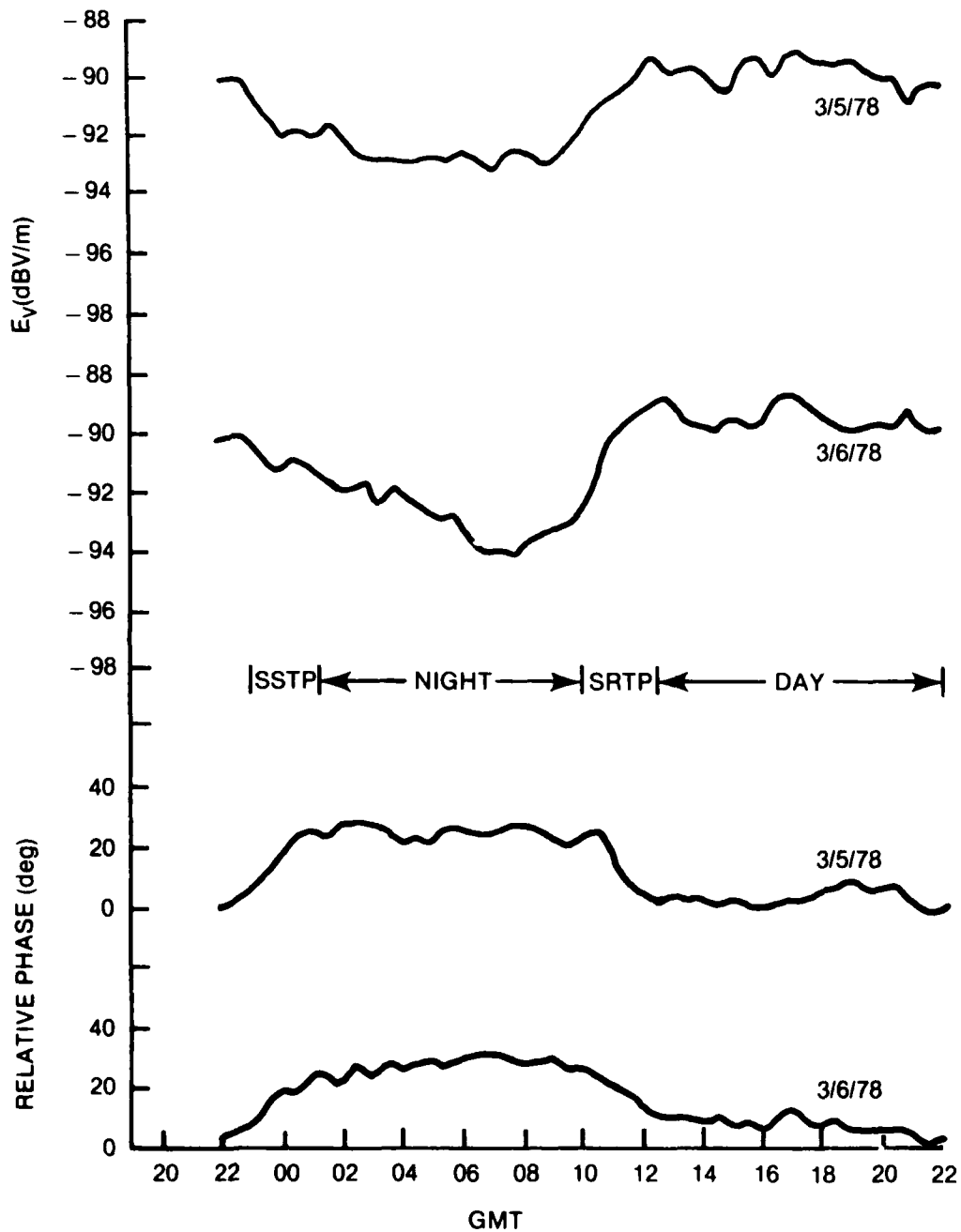


Figure E-3. Connecticut Whip Field Strength Versus GMT, 5 and 6 March 1978 ($\psi = 291$ deg)

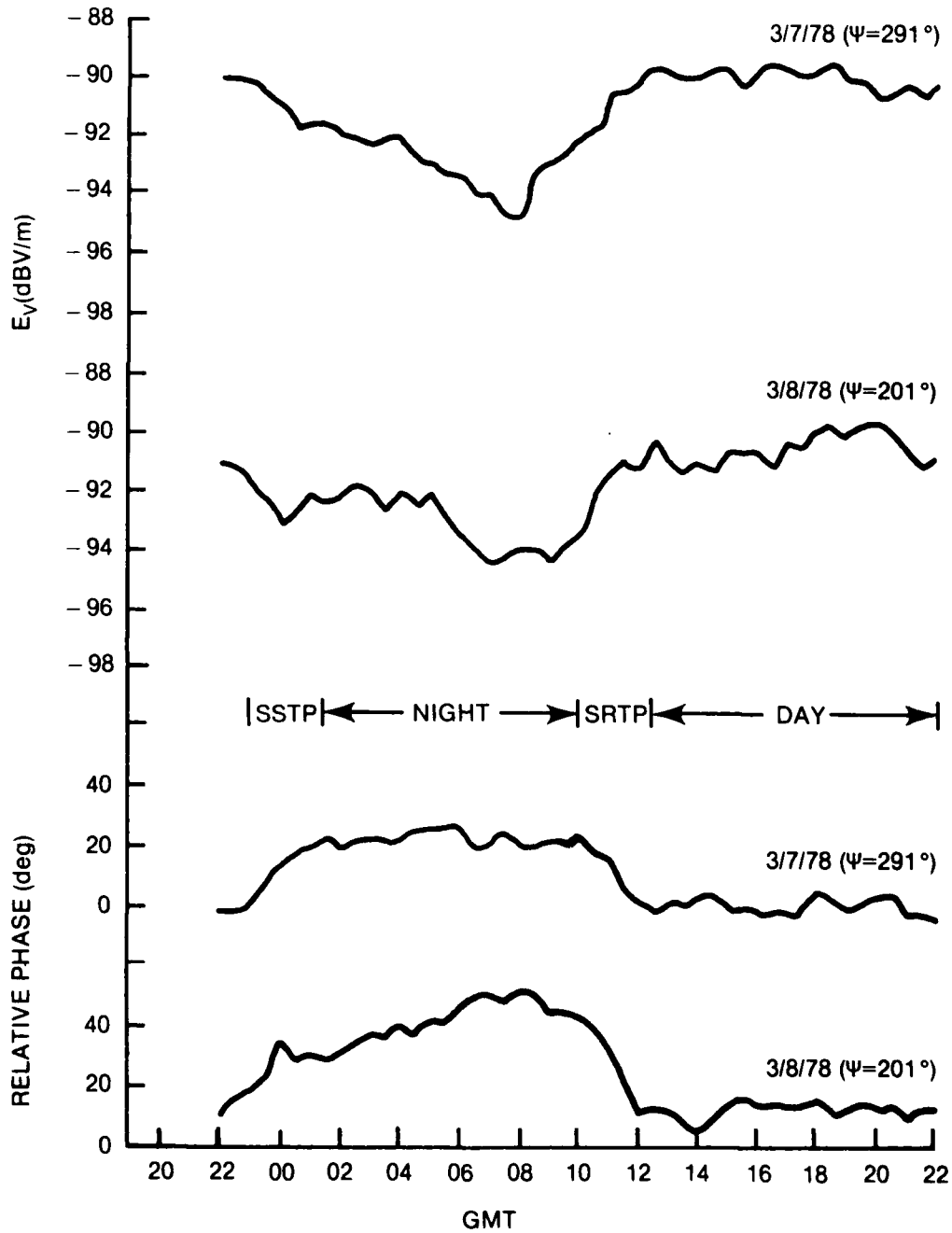


Figure E-4. Connecticut Whip Field Strength Versus GMT, 7 ($\psi = 291$ deg) and 8 ($\psi = 201$ deg) March 1978

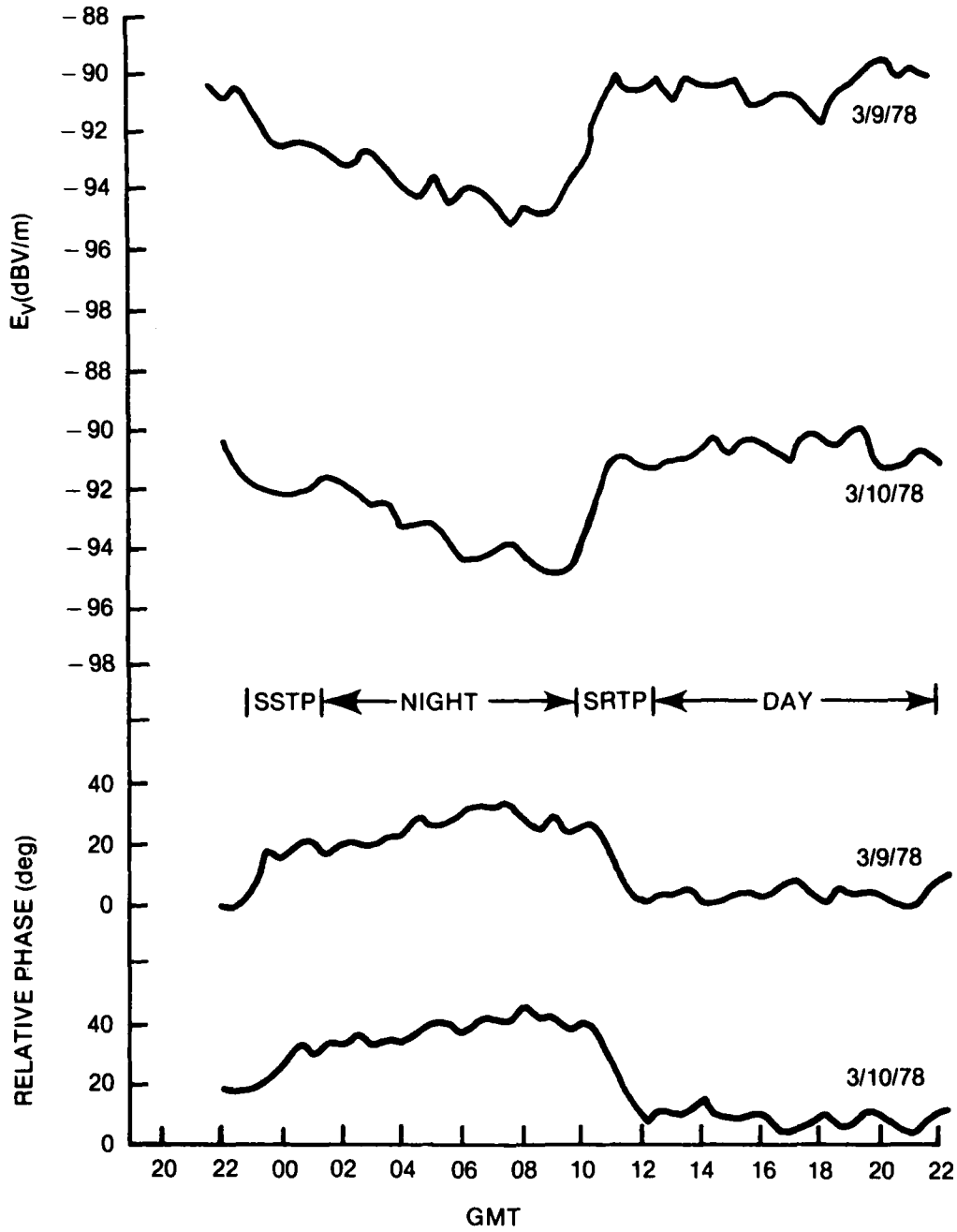


Figure E-5. Connecticut Whip Field Strength Versus GMT, 9 and 10 March 1978 ($\Psi = 201$ deg)

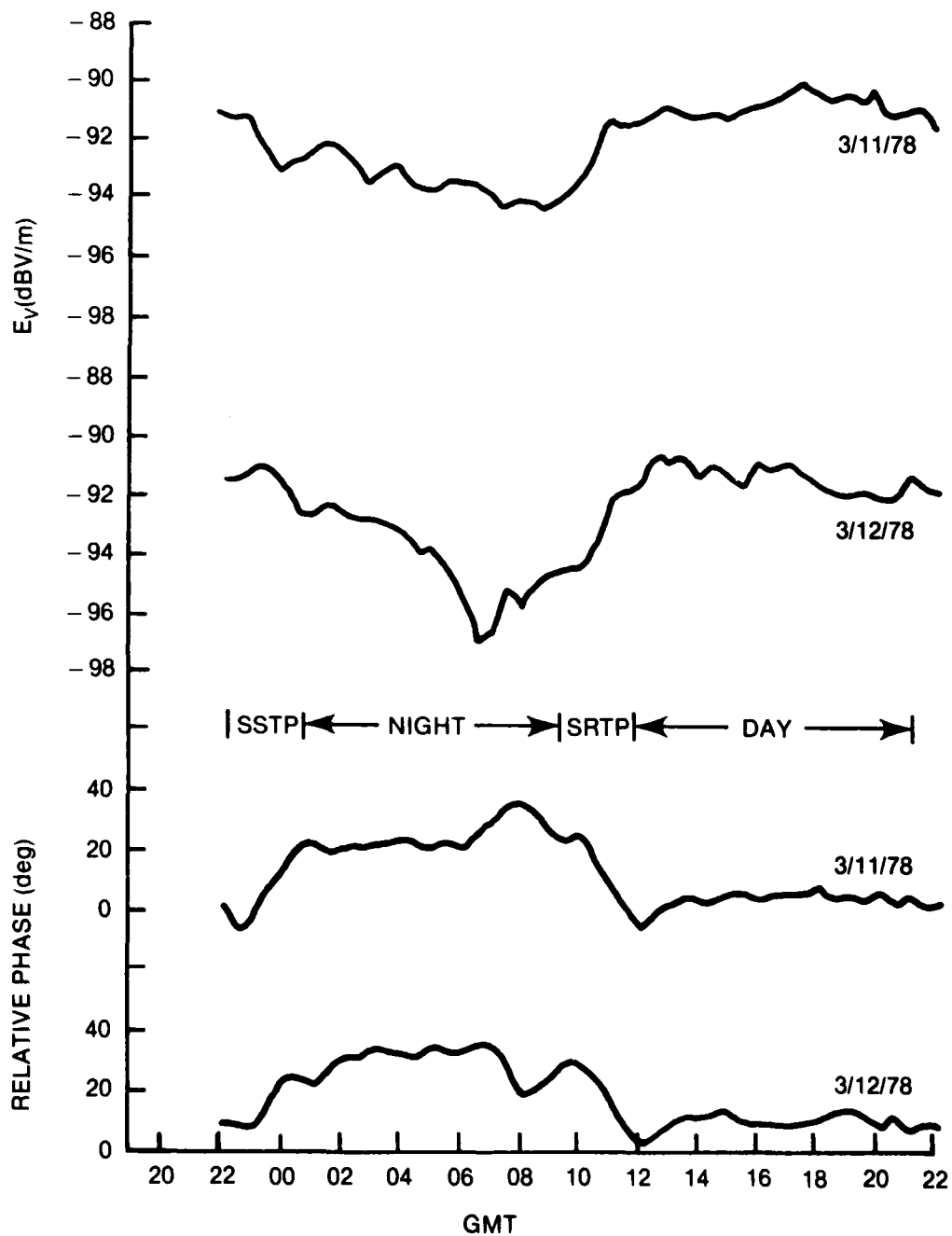


Figure E-6. Connecticut Whip Field Strength Versus GMT, 11 and 12 March 1978 ($\psi = 201$ deg)

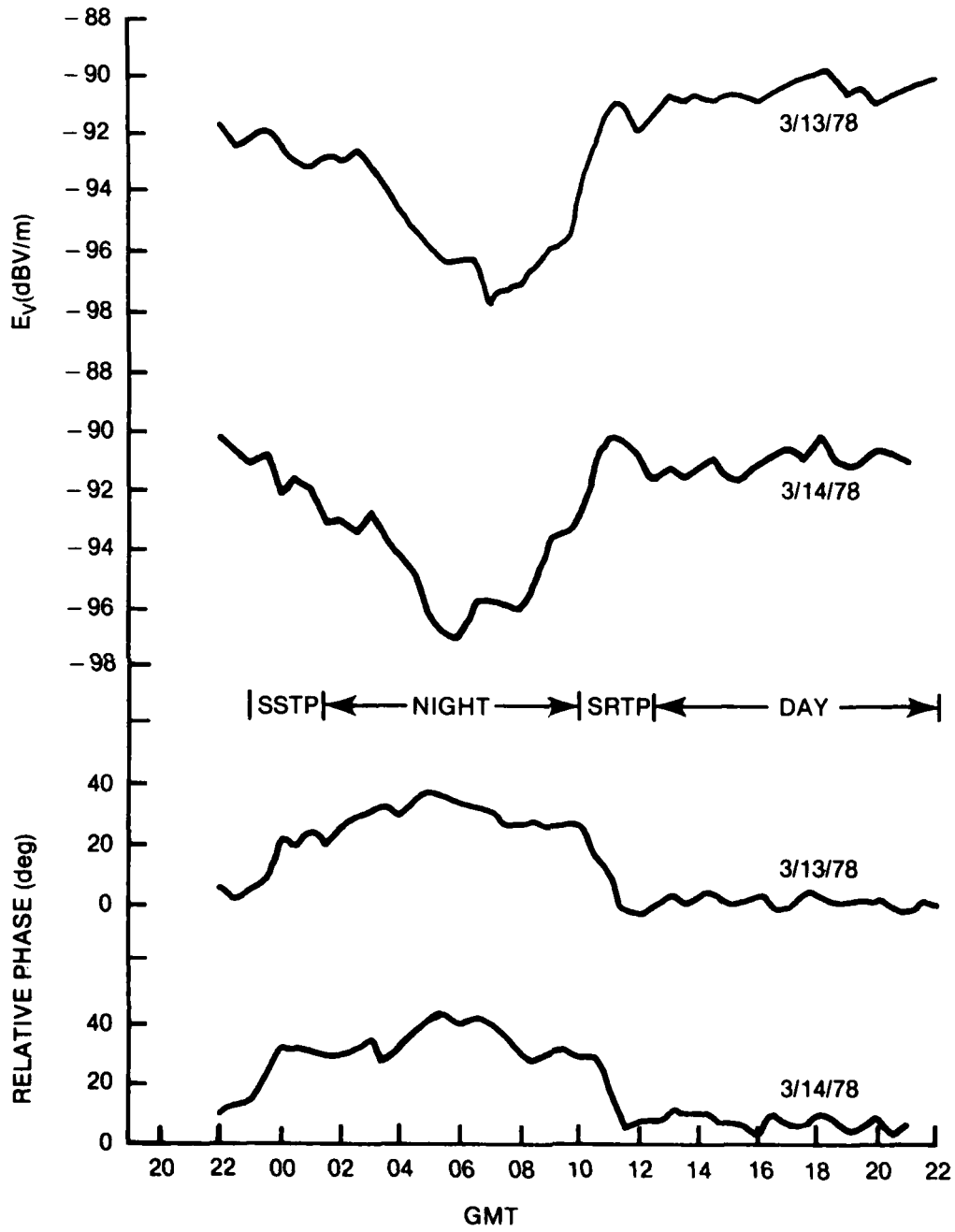


Figure E-7. Connecticut whip Field Strength Versus GMT, 13 and 14 March 1978 ($\psi = 201$ deg)

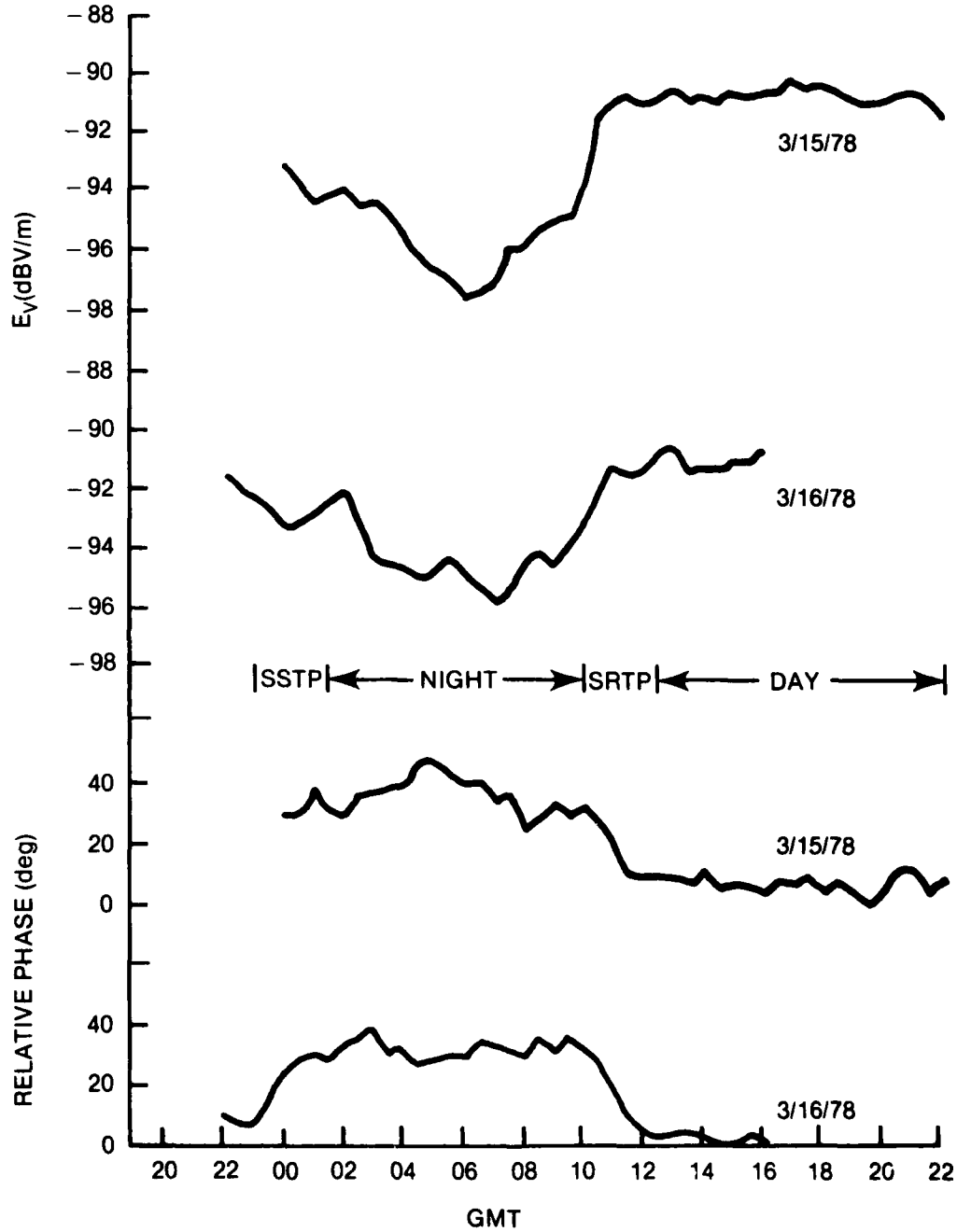


Figure E-8. Connecticut whip Field Strength Versus GMT, 15 and 16 March 1978 ($\psi = 201$ deg)

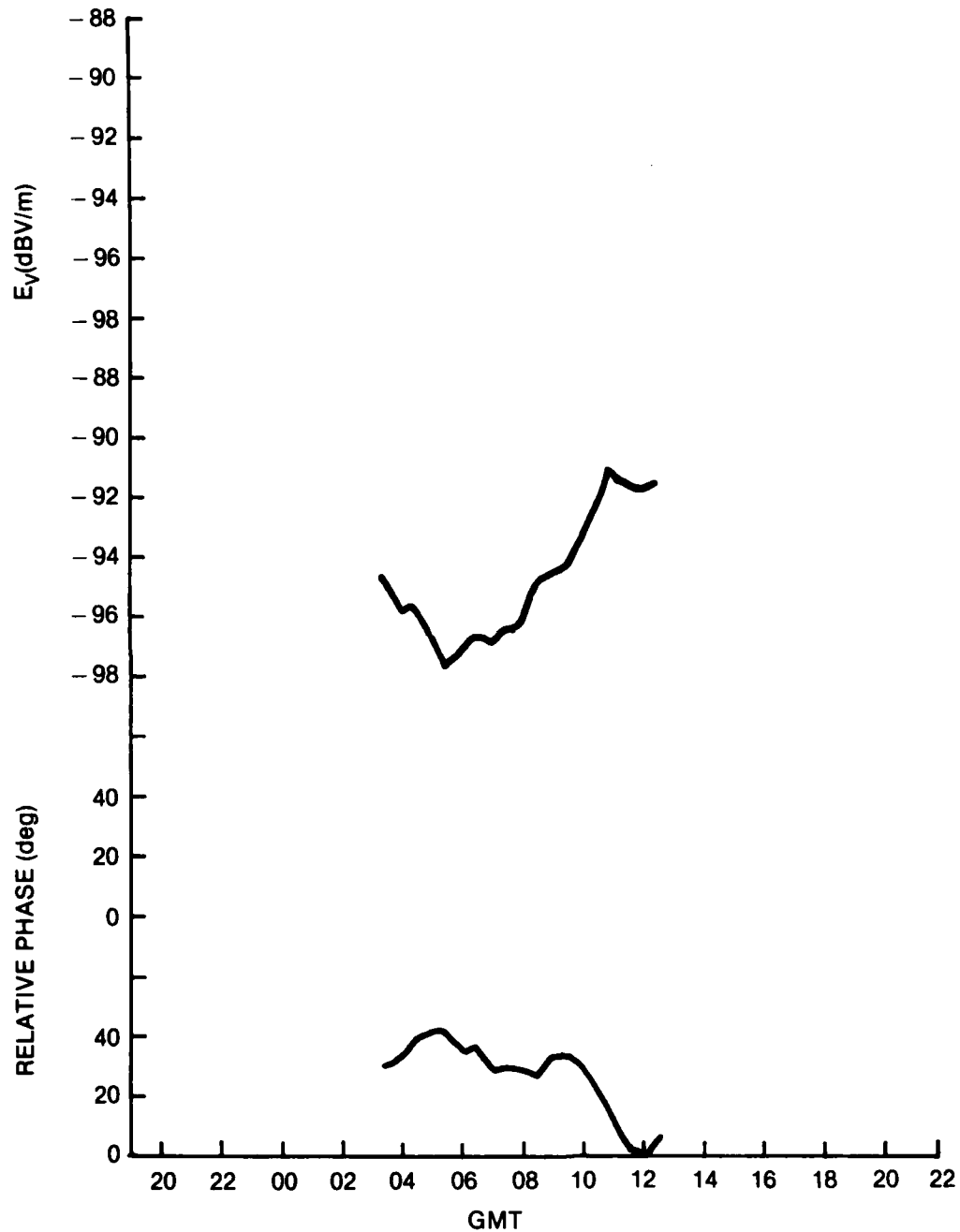


Figure E-9. Connecticut Whip Field Strength Versus GMT, 17 March 1978 ($\psi = 201$ deg)

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