POLAR CAP BOUNDARY LAYER ELF/VLF WAVES

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We will demonstrate that these boundary layer waves are continuously present on auroral zone magnetic field lines at all local times. The wave intensities and latitudinal location dependences on interplanetary parameters have been statistically determined and will be discussed. The high time resolution wave features at different local times and under different interplanetary (B_z, ram pressure, etc.) and geomagnetic (AE, D_{ST}) conditions will be analyzed.

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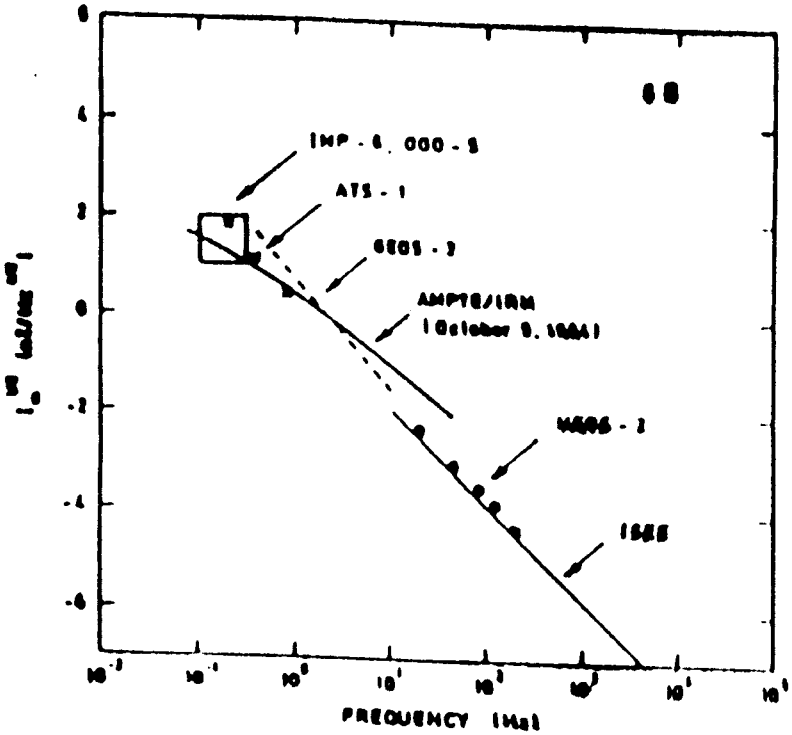
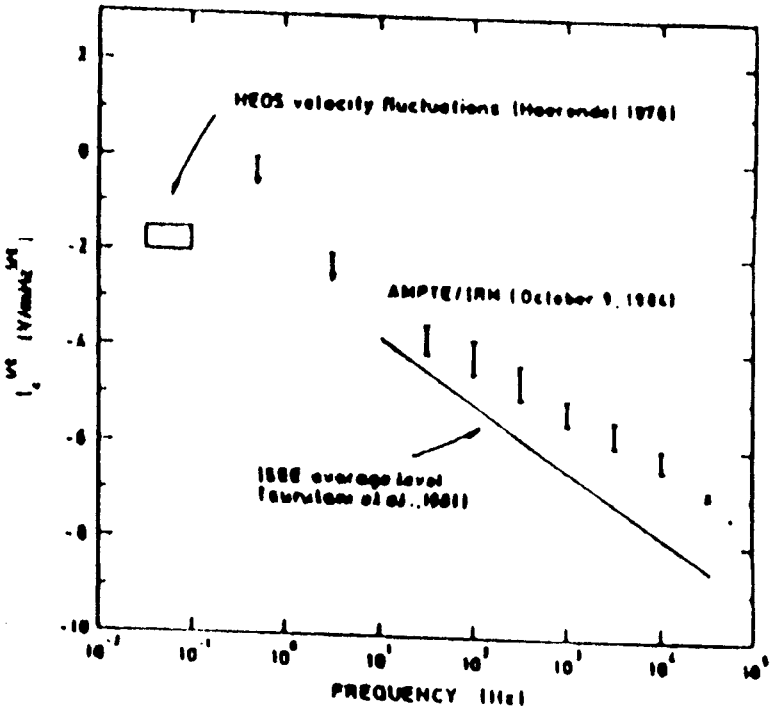
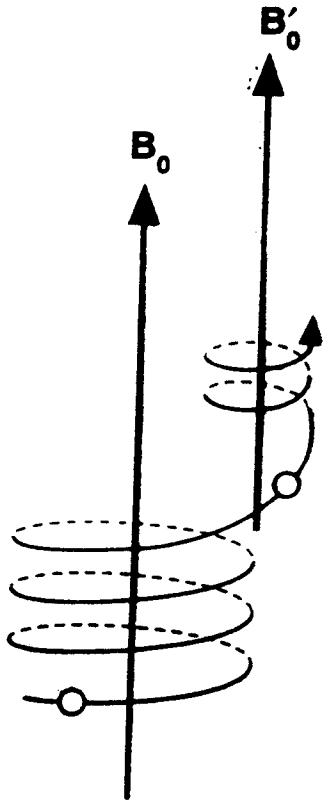
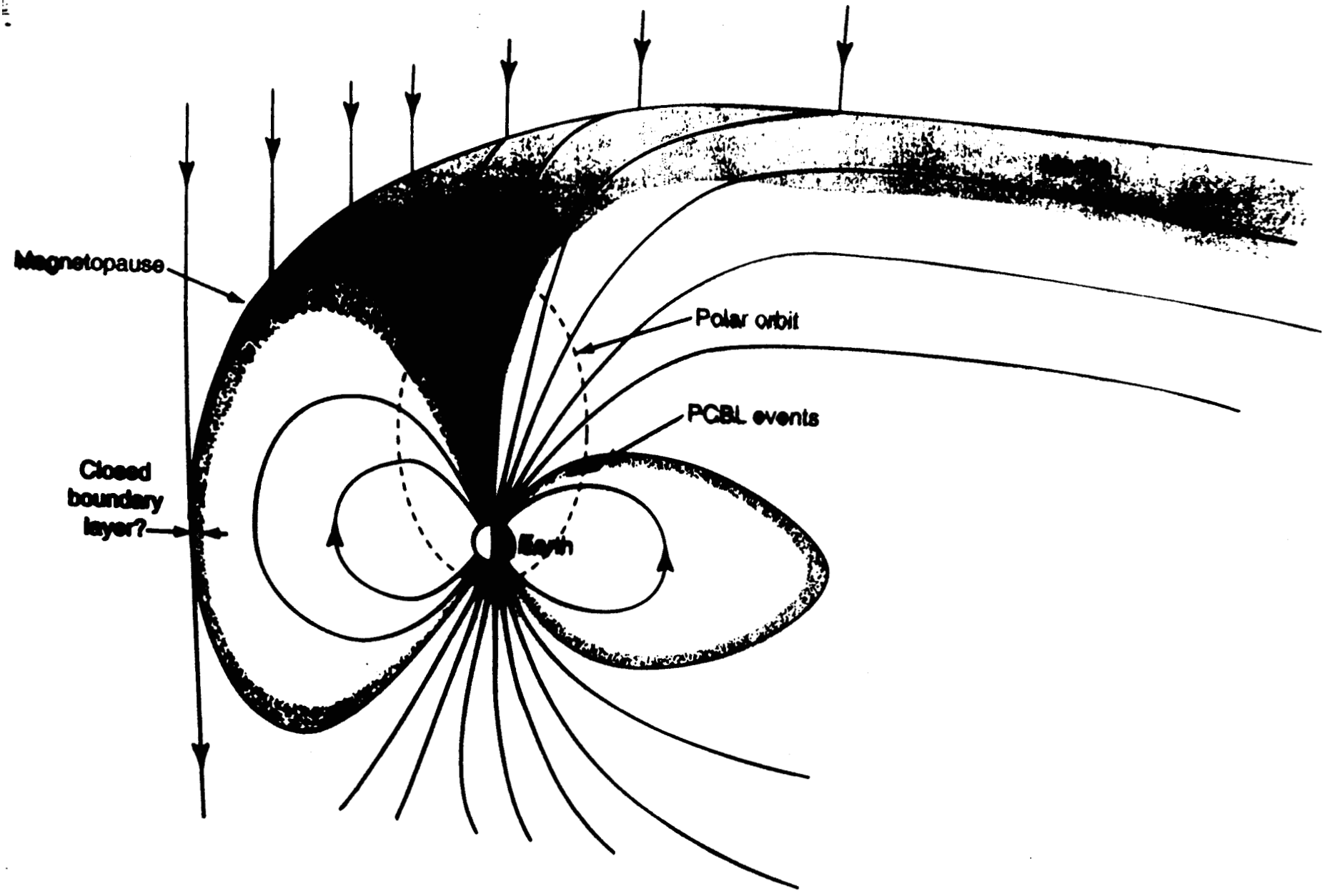
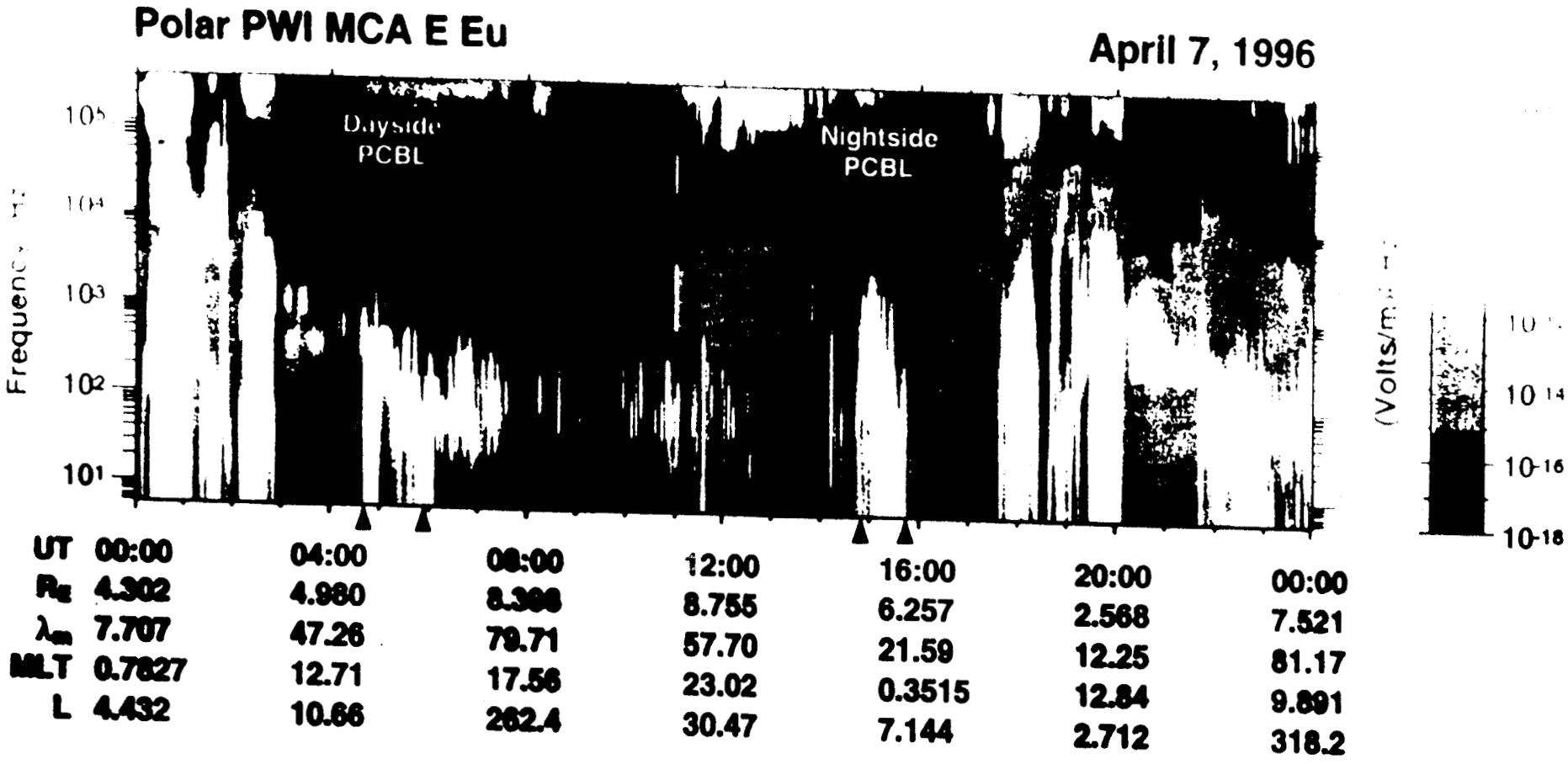
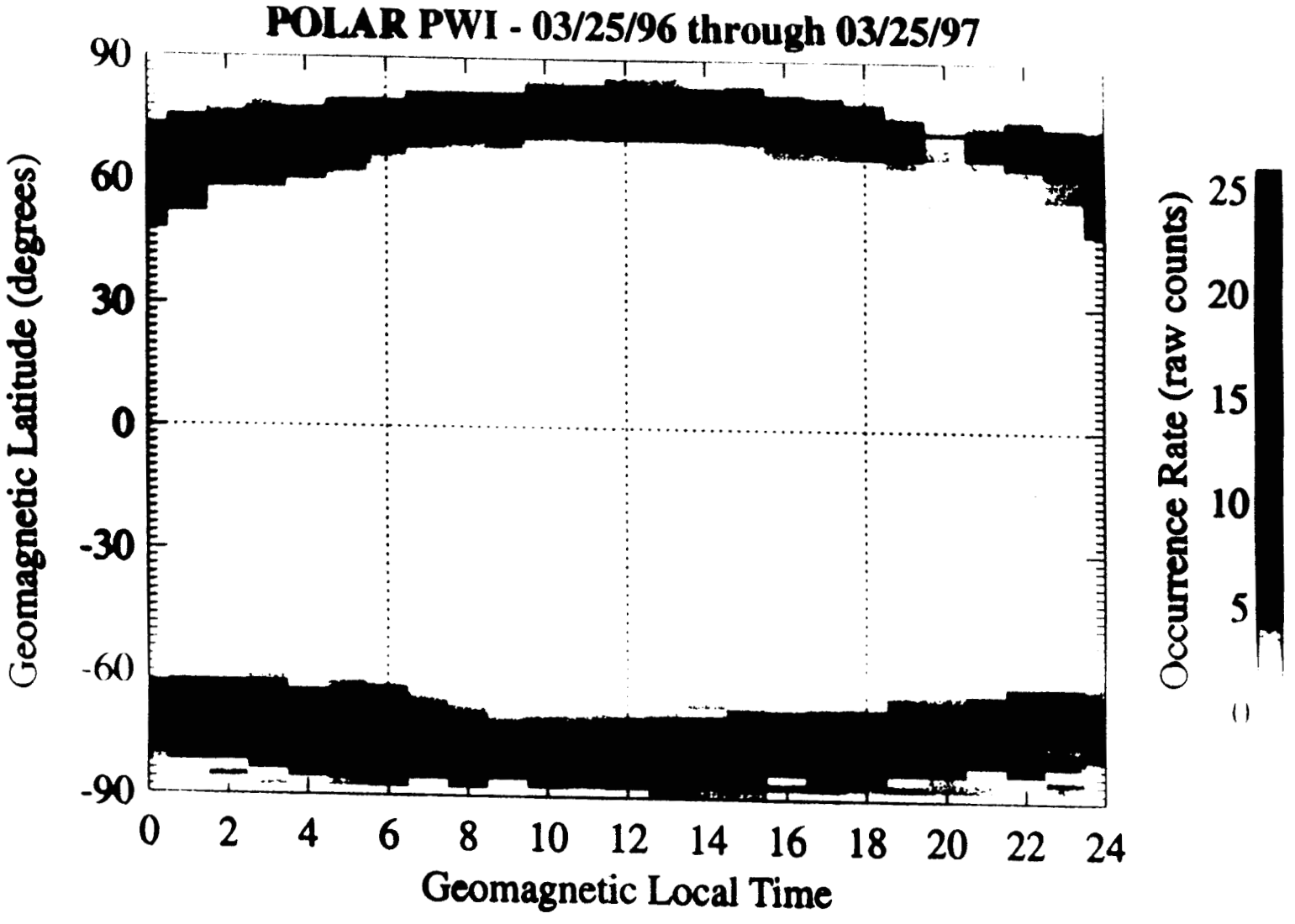

IMP - 8, GOO - 5
ATS - 1
GEOS - 2
AMPTE/IRM
(October 9, 1984)
ISEE
PREQUENCY (Hz)


HEOS velocity fluctuations (Heerendal 1978)
AMPTE/IRM (October 9, 1984)
ISEE average level
(Gurnett et al., 1981)
PREQUENCY (Hz)


B_0'
B_0


Magnetopause
Polar orbit
PCBL events
Closed boundary layer?
Earth


Polar PWI MCA E Eu
April 7, 1996
Dayside PCBL
Nightside PCBL
Frequency
(Volts/m)
UT 00:00 04:00 08:00 12:00 16:00 20:00 00:00
R_E 4.302 4.980 8.398 8.755 6.257 2.568 7.521
λ_m 7.707 47.26 79.71 57.70 21.59 12.25 81.17
MLT 0.7827 12.71 17.56 23.02 0.3515 12.84 9.891
L 4.432 10.66 262.4 30.47 7.144 2.712 318.2


POLAR PWI - 03/25/96 through 03/25/97
Geomagnetic Latitude (degrees)
90
60
30
0
-30
-60
-90
0
2
4
6
8
10
12
14
16
18
20
22
24
Geomagnetic Local Time
Occurrence Rate (raw counts)
25
20
15
10
5
0

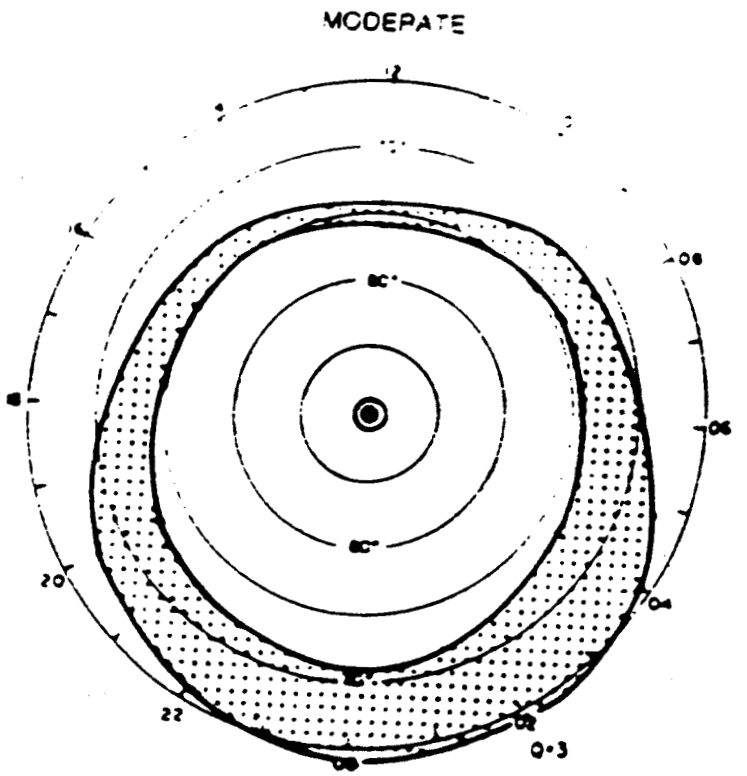
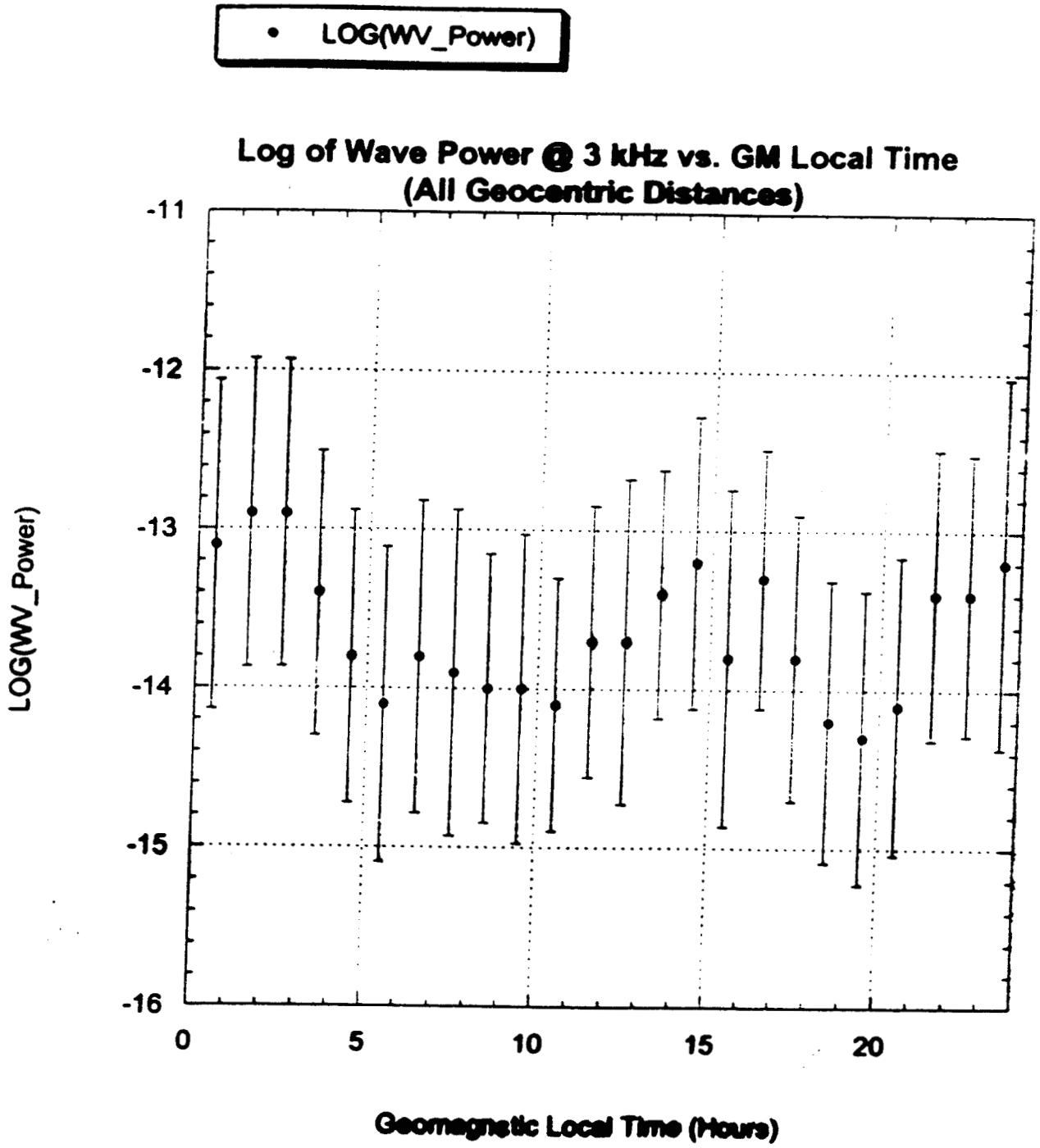
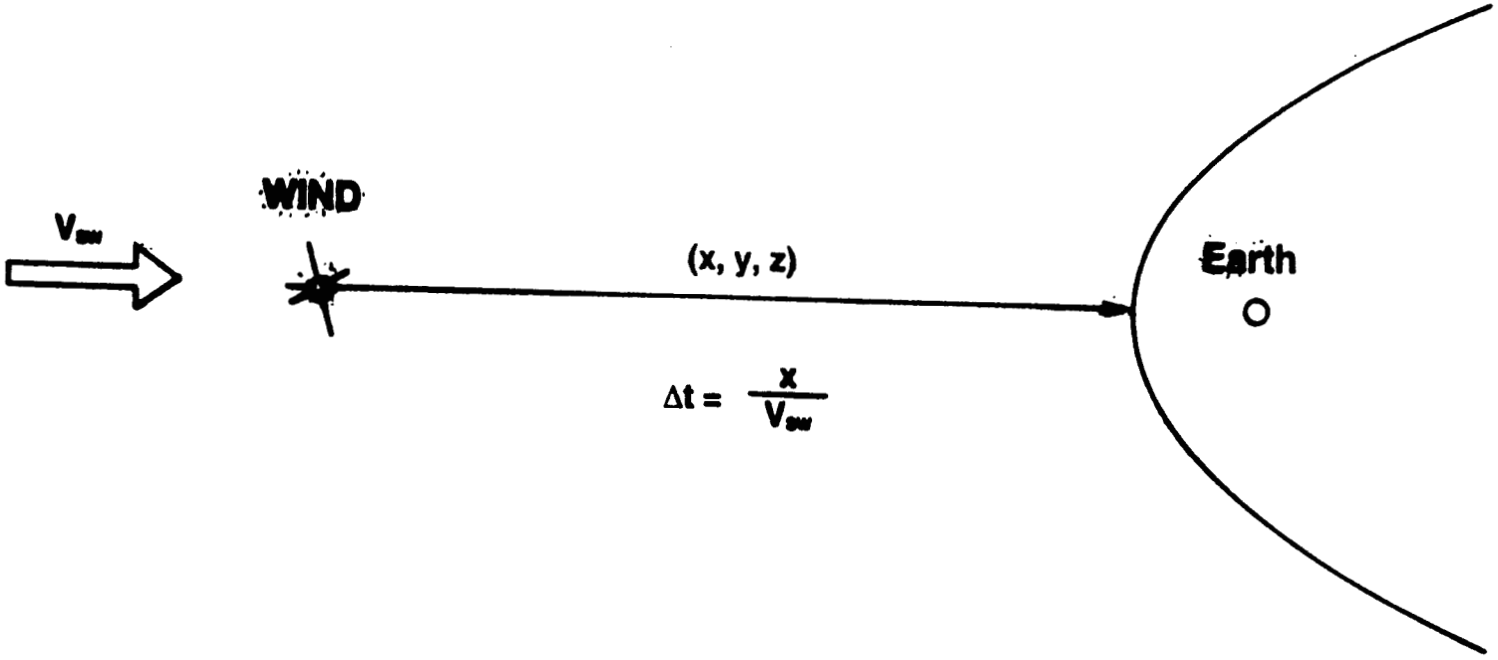
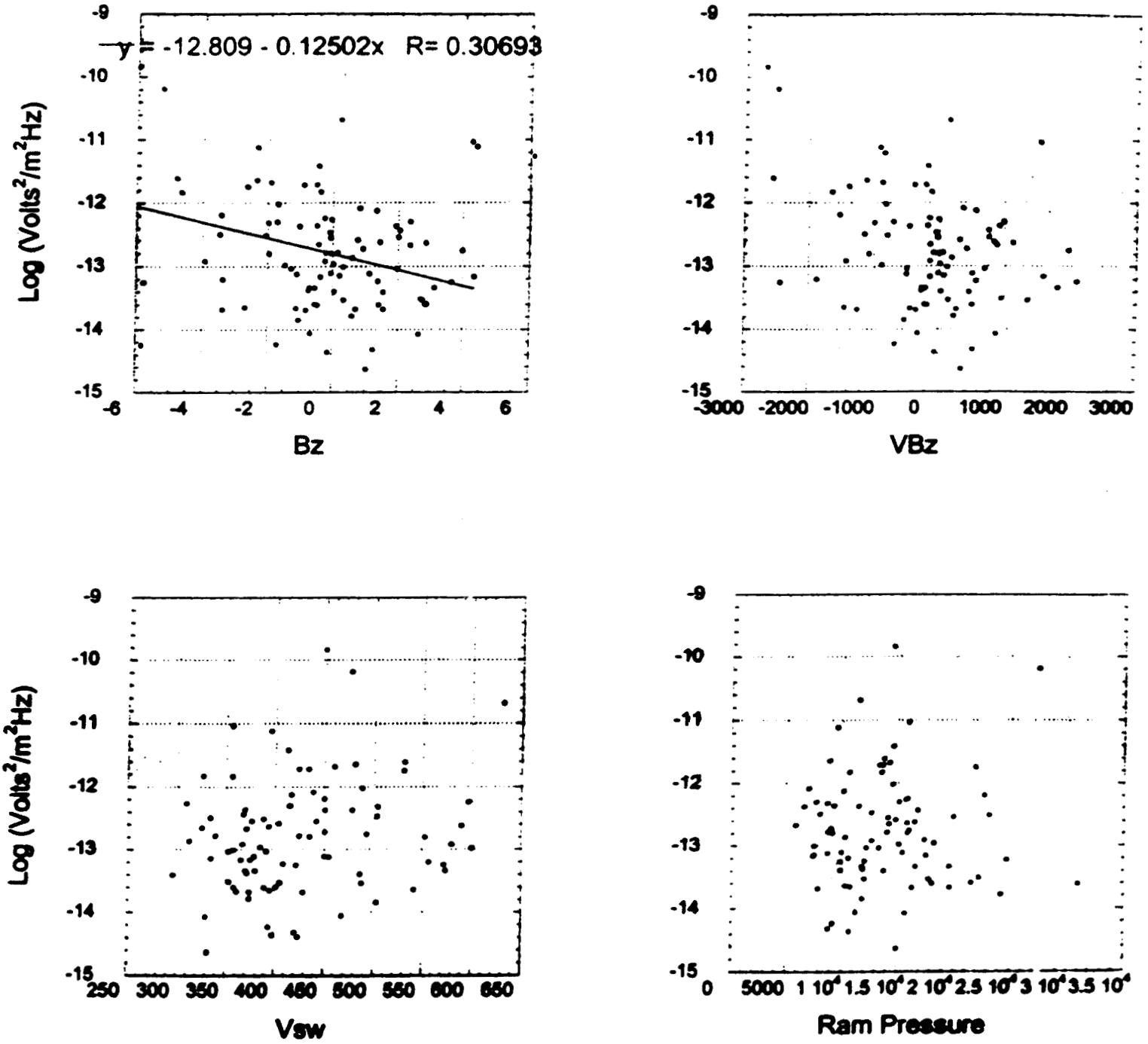


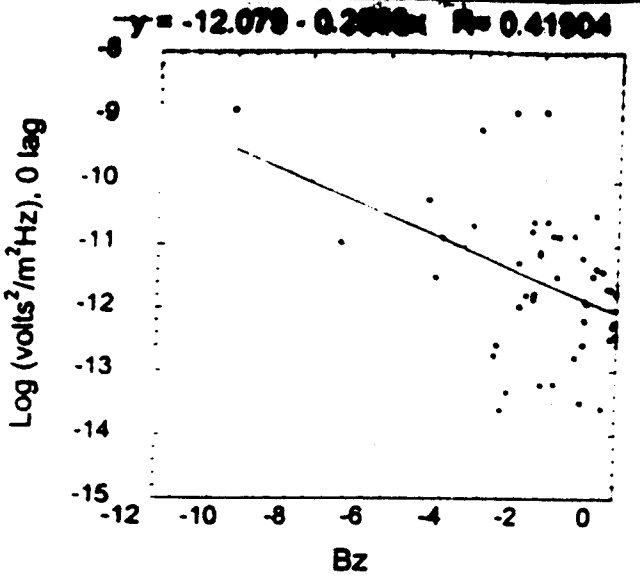
FIG. 14.8. Variation in the size of the auroral oval with activity. The shaded area represents the distribution of maximum auroral activity in the northern hemisphere. Coordinate system is corrected geomagnetic (CG) latitude and CG local time, and noon is at the top. (Adapted from Feldstein and Starkov, 1967.)

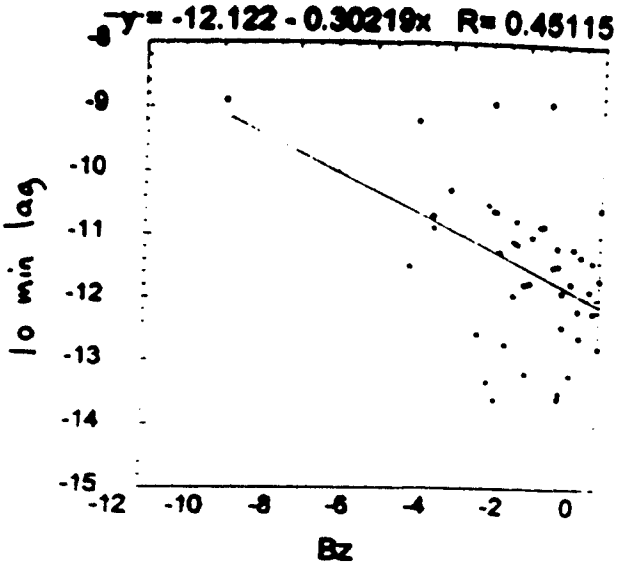

LOG(WV_Power)
Log of Wave Power @ 3 kHz vs. GM Local Time
(All Geocentric Distances)
-11
-12
-13
-14
-15
-16
0
5
10
15
20
LOG(WV_Power)
Geomagnetic Local Time (Hours)

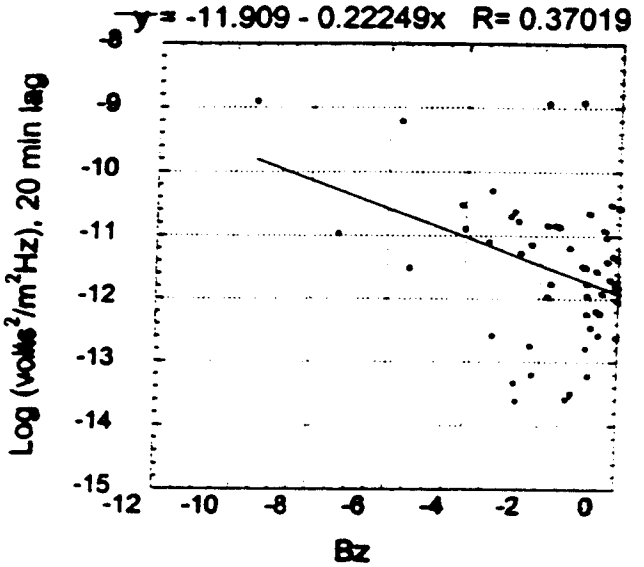

V_{sw}
WIND
(x, y, z)
Earth
$\Delta t = \frac{x}{V_{sw}}$

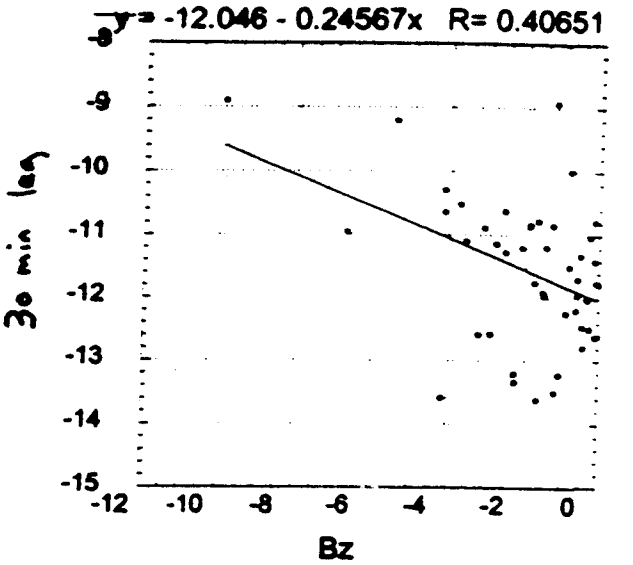
NOON (10-14 MLT) Electric Waves 562 Hz

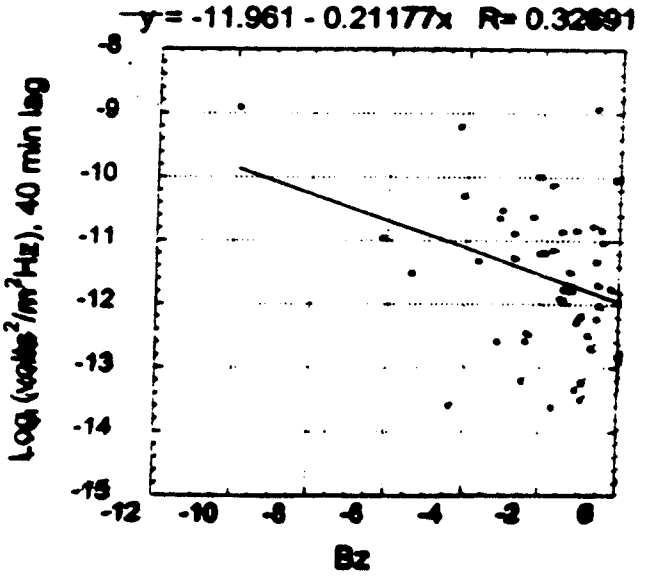


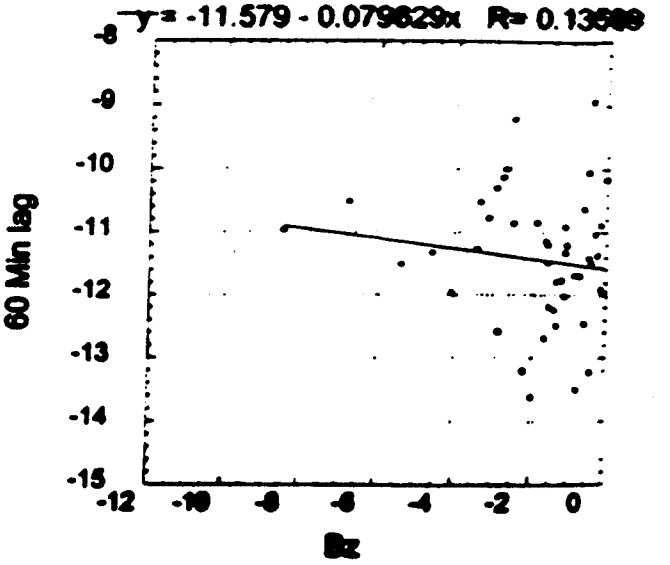

y = -12.079 - 0.2[illegible]x R= 0.41904
Log (volts²/m²Hz), 0 lag
Bz


y = -12.122 - 0.30219x R= 0.45115
10 min lag
Bz

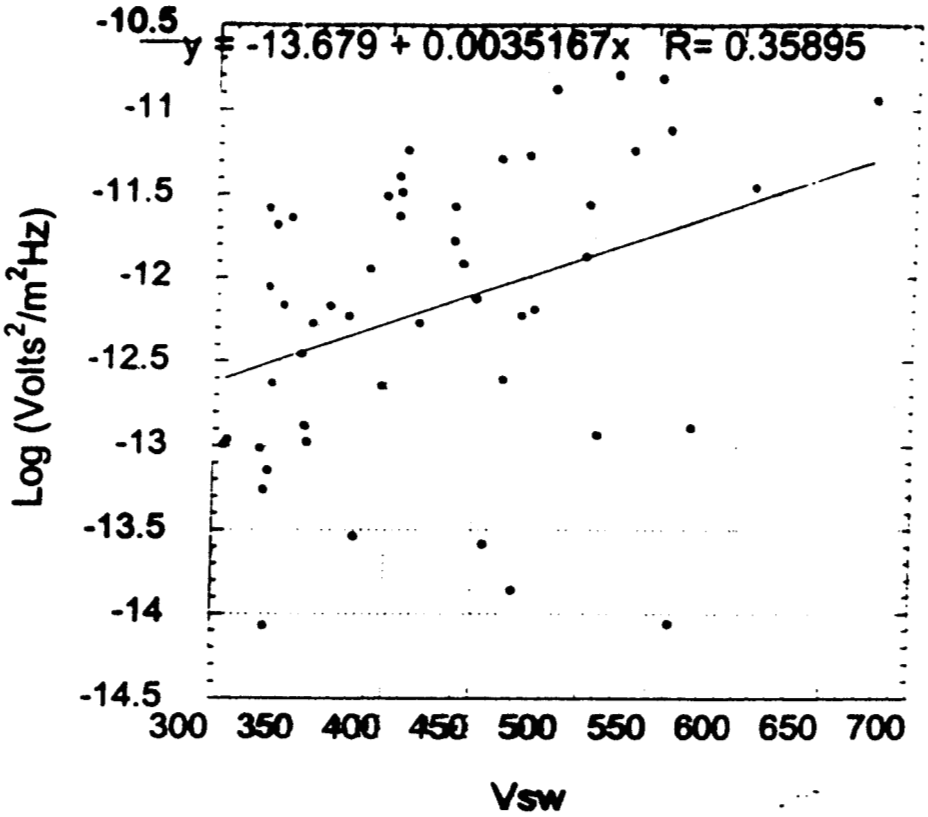

y = -11.909 - 0.22249x R= 0.37019
Log (volts²/m²Hz), 20 min lag
Bz

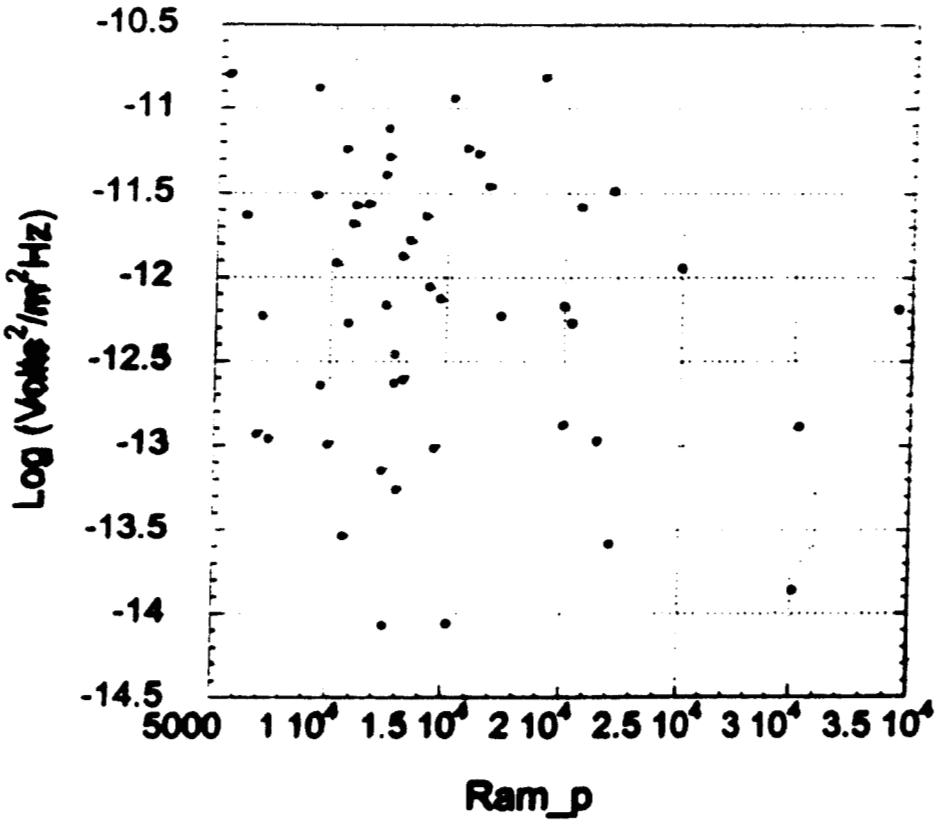

y = -12.046 - 0.24567x R= 0.40651
30 min lag
Bz

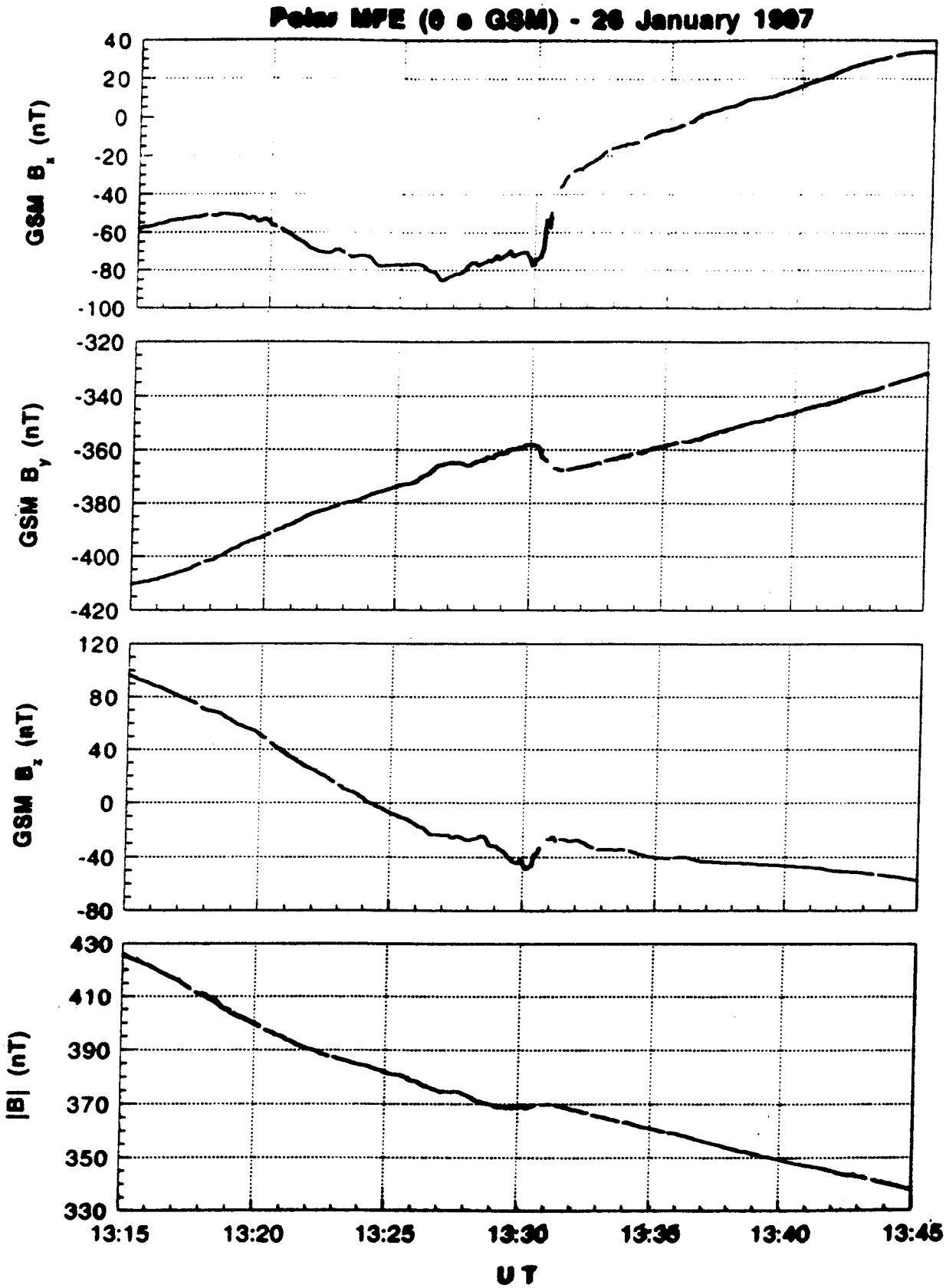

y = -11.961 - 0.21177x R= 0.32691
Log (volts²/m²Hz), 40 min lag
Bz

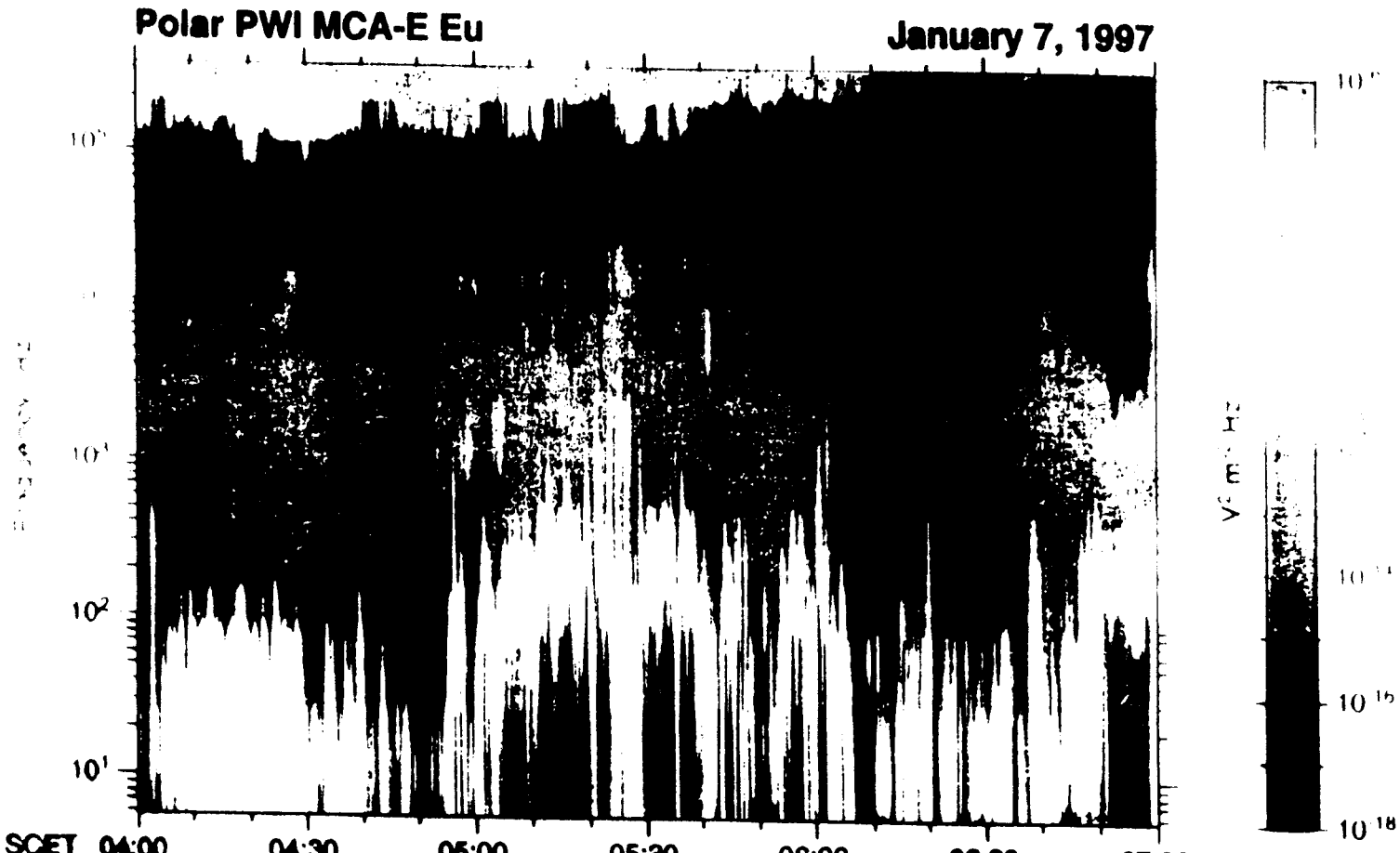

y = -11.579 - 0.079629x R= 0.13[illegible]
60 Min lag
Bz

Dusk (16-20 MLT) Electric Waves 562 Hz

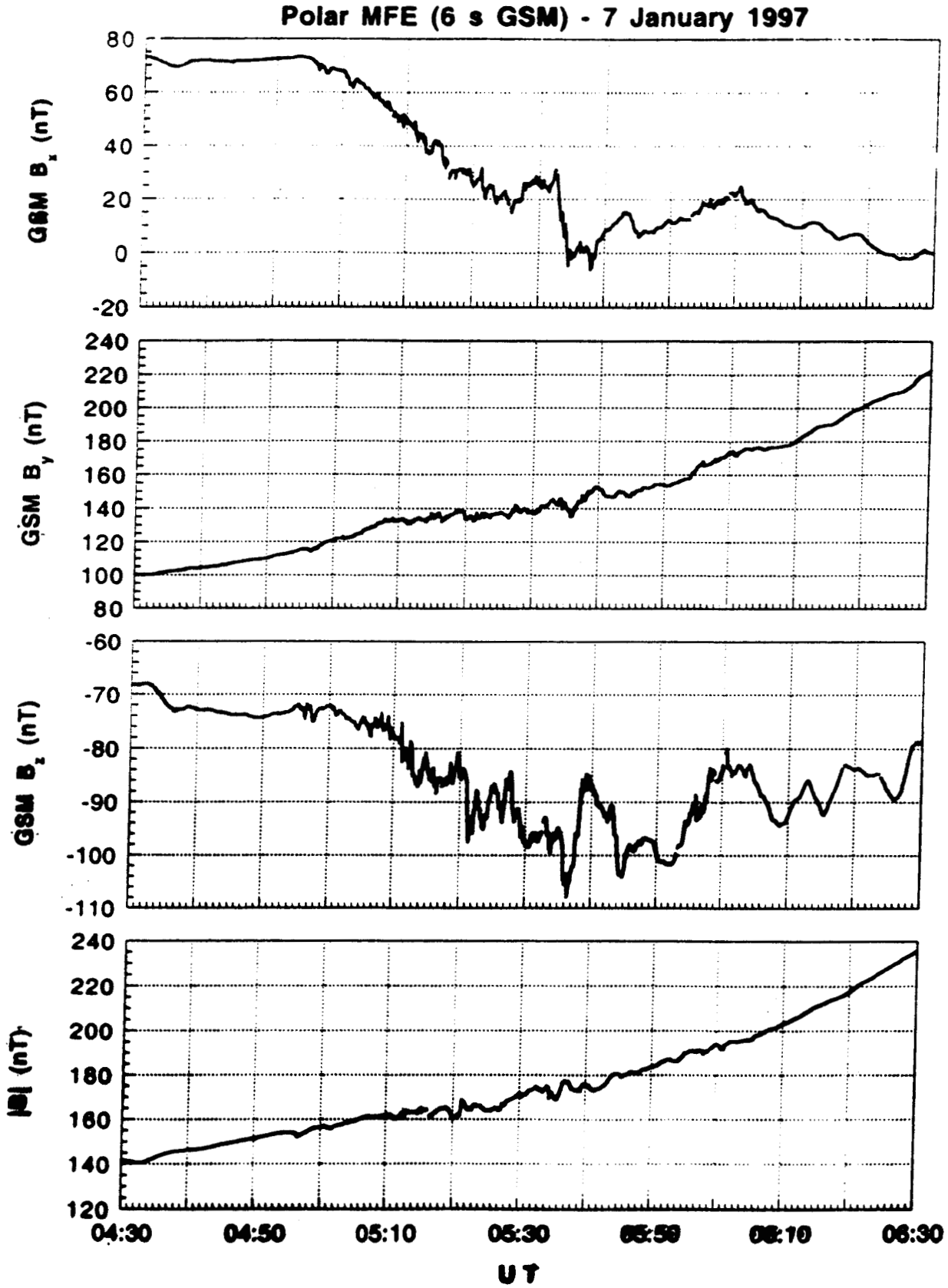


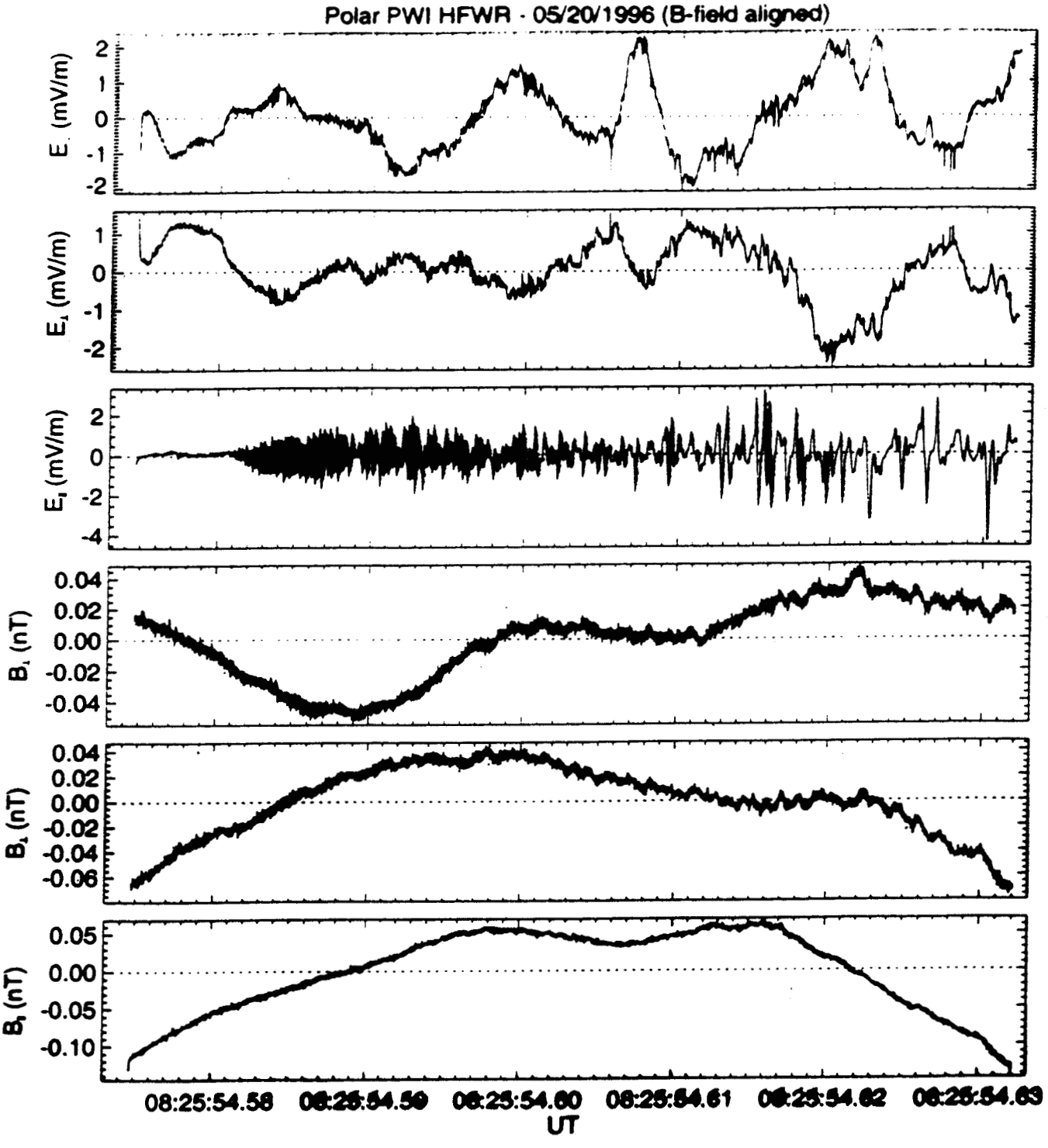


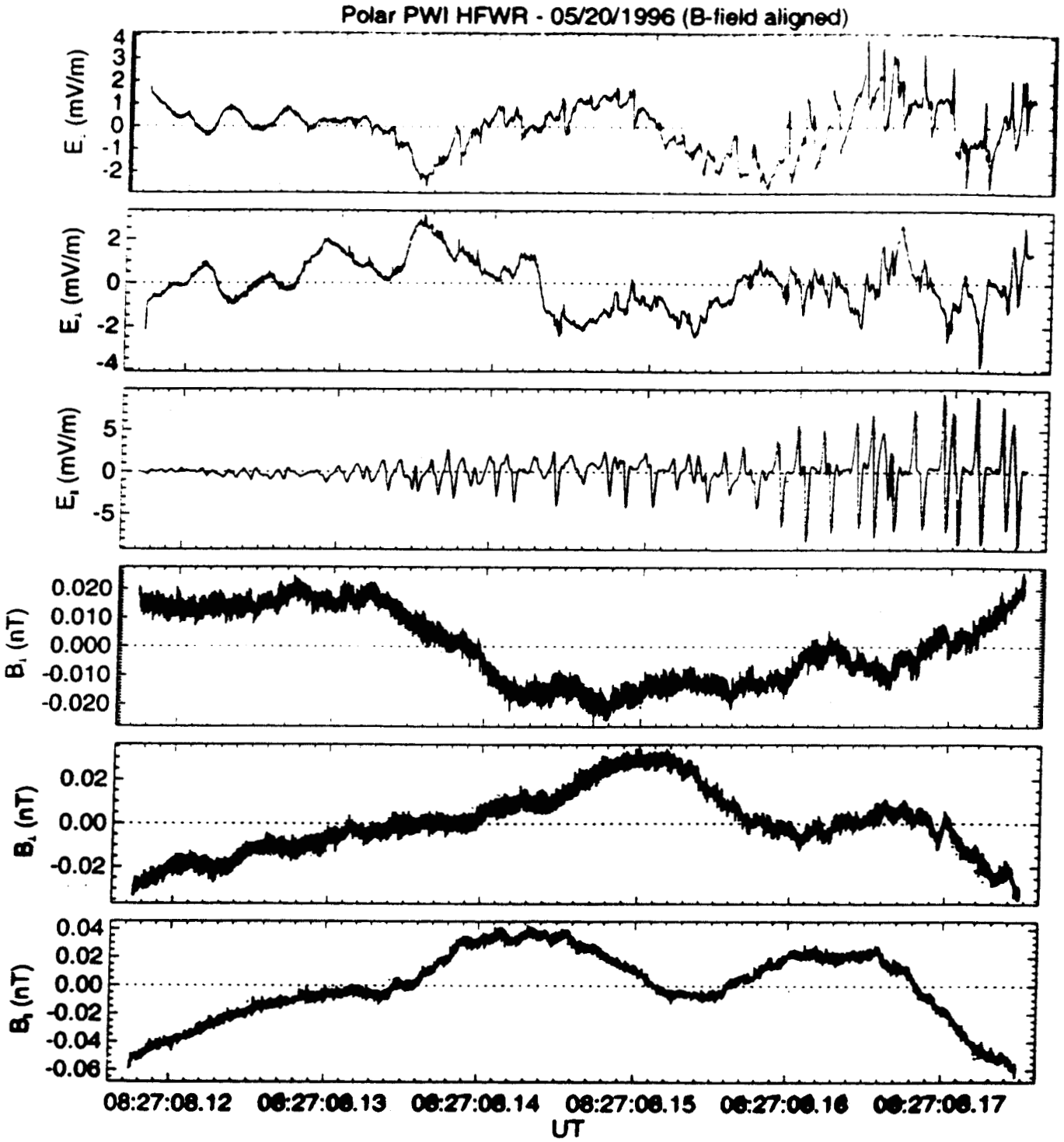

Polar MFE (0 s GSM) - 26 January 1997
GSM B_x (nT)
40
20
0
-20
-40
-60
-80
-100
GSM B_y (nT)
-320
-340
-360
-380
-400
-420
GSM B_z (nT)
120
80
40
0
-40
-80
|B| (nT)
430
410
390
370
350
330
13:15
13:20
13:25
13:30
13:35
13:40
13:45
UT

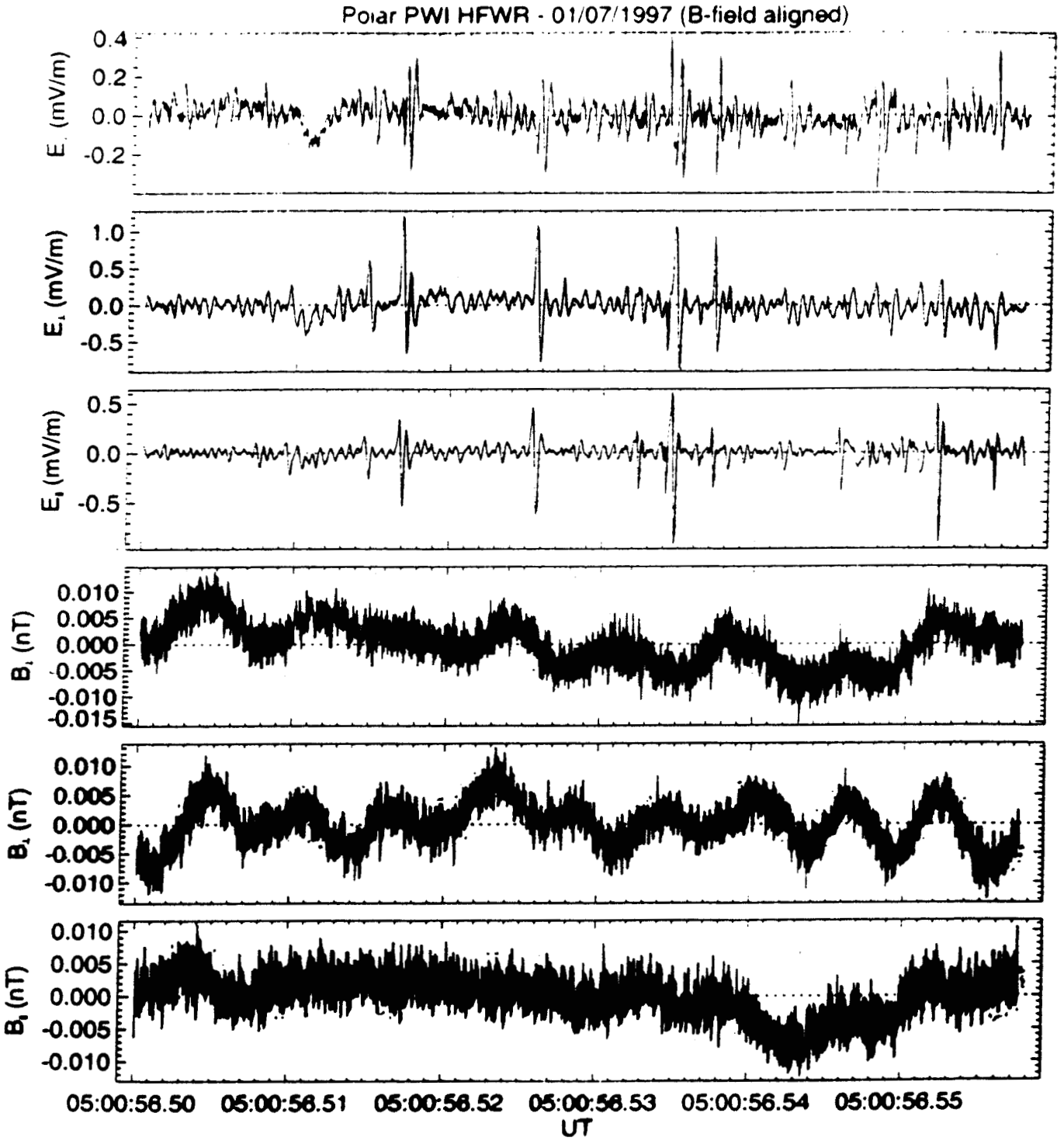


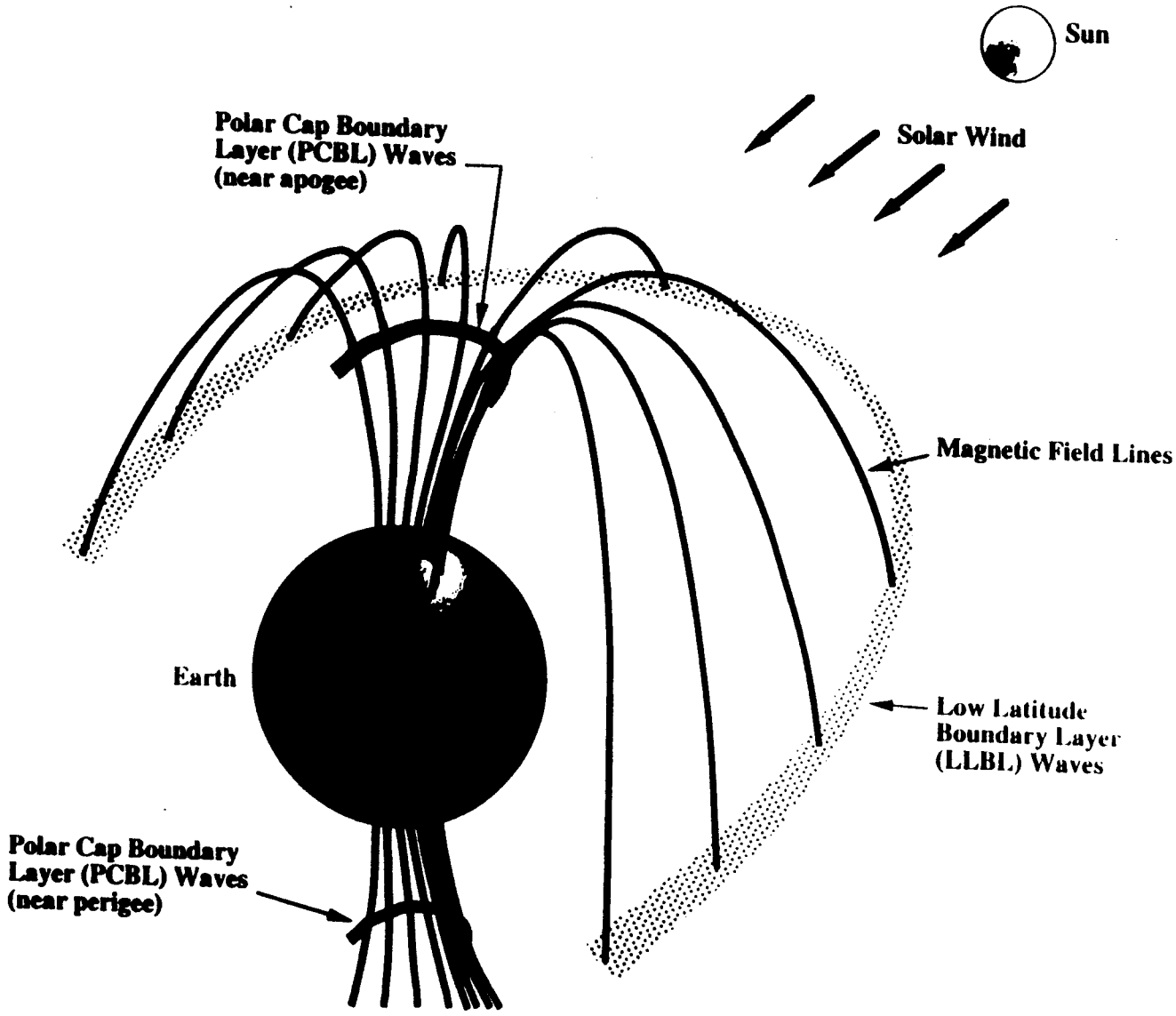
SCET	04:00	04:30	05:00	05:30	06:00	06:30	07:00
R_E	7.94	7.63	7.26	6.83	6.35	5.80	5.18
λ_m	58.99	56.54	53.80	50.64	46.84	42.11	35.96
MLT	6.93	6.95	6.96	6.94	6.91	6.86	6.80
L	29.88	25.08	20.81	17.01	13.61	10.60	7.98


Polar MFE (6 s GSM) - 7 January 1997
GSM B_x (nT)
80
60
40
20
0
-20
GSM B_y (nT)
240
220
200
180
160
140
120
100
80
GSM B_z (nT)
-60
-70
-80
-90
-100
-110
|B| (nT)
240
220
200
180
160
140
120
04:30
04:50
05:10
05:30
05:50
06:10
06:30
UT


Polar PWI HFWR - 05/20/1996 (B-field aligned)
E (mV/m)
E⊥ (mV/m)
E∥ (mV/m)
B⊥ (nT)
B⊥ (nT)
B∥ (nT)
08:25:54.58
08:25:54.59
08:25:54.60
08:25:54.61
08:25:54.62
08:25:54.63
UT


Polar PWI HFWR - 05/20/1996 (B-field aligned)
E∥ (mV/m)
E⊥ (mV/m)
E⊥ (mV/m)
B∥ (nT)
B⊥ (nT)
B⊥ (nT)
08:27:08.12
08:27:08.13
08:27:08.14
08:27:08.15
08:27:08.16
08:27:08.17
UT


Polar PWI HFWR - 01/07/1997 (B-field aligned)
E (mV/m)
0.4
0.2
0.0
-0.2
E∥ (mV/m)
1.0
0.5
0.0
-0.5
E⊥ (mV/m)
0.5
0.0
-0.5
B∥ (nT)
0.010
0.005
0.000
-0.005
-0.010
-0.015
B⊥ (nT)
0.010
0.005
0.000
-0.005
-0.010
B⊥ (nT)
0.010
0.005
0.000
-0.005
-0.010
05:00:56.50
05:00:56.51
05:00:56.52
05:00:56.53
05:00:56.54
05:00:56.55
UT


Sun
Solar Wind
Polar Cap Boundary
Layer (PCBL) Waves
(near apogee)
Magnetic Field Lines
Earth
Low Latitude
Boundary Layer
(LLBL) Waves
Polar Cap Boundary
Layer (PCBL) Waves
(near perigee)

CONCLUSIONS

PCBL Waves

- Global, auroral zone phenomenon.
- Dayside waves enhanced when IMF B_Z <0, nightside enhanced when substorms occurring.
- Strongly related to field-aligned currents.

SUMMARY

~200 Hz Electromagnetic Waves

- Counter-streaming ~25 KeV electrons
  - ~ 45 KeV ion beams
  - ~ 1 keV ion beams generating left-hand mode waves with subsequent mode conversion

1 to 2 kHz Electromagnetic Waves

- 1 keV electron beams

5 kHz Electromagnetic Waves

- ~100 eV electron beams

Bipolar, monopolar electrostatic pulses.

- electron holes

A NEW VIEW OF THE BOUNDARY LAYER

- The PCBL and LLBL regions are dominated by ionospheric plasma.

- The near-ionosphere electric fields generate the particle beams that generate the PCBL/LLBL plasma waves.

- The LLBL plasma waves lead to cross-field diffusion of magnetospheric plasma into the magnetosheath and magnetospheric/solar wind plasma into the magnetosphere, e.g., it is a "viscous" interaction layer.