INITIAL RESULTS OF THE GLOBAL THERMOSPHERIC MAPPING STUDY (GTMS)

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The Global Thermospheric Mapping Study (GTMS) is a multi-technique experimental study of the thermosphere designed to map simultaneously its spatial and temporal morphology with a thoroughness and diversity of measurement techniques heretofore unachieved. Three-day campaigns at the summer and winter solstices are planned to study the seasonal variations in thermospheric structure. The GTMS is designed around the Incoherent Scatter Radar Chain in the western hemisphere. The European incoherent scatter radars and the worldwide communities of Fabry Perot interferometers, meteor wind radars, partial reflection drifts radars, MST radars, and satellite probes are included to extend the spatial coverage and types of measurements available. Theoretical and modeling support in the areas of thermospheric and ionospheric structure, tides, and electric fields are included to aid in program planning and data interpretation.

The initial GTMS campaign was conducted on 26-28 June 1984, during a period of sharply declining solar activity. Solar activity was low on the three observation days (F10.7 = 97, 98, 96) and magnetic conditions were unsettled to active (A = 10, 12, 20). All six incoherent scatter radar facilities collected data. Each collected F region data day and night while Saint Santin and Millstone Hill additionally collected E region data during daylight hours. Initial results from Sondrestrom and Millstone Hill are presented. Good quality Fabry Perot data were collected at Fritz Peak and San Jose dos Campos. Weather conditions produced poor results at Arequipa and Arecibo. Initial results from Fritz Peak are presented. Mesosphere/lower-thermosphere observations were conducted under the ATMAP organization. The magnetometer chains also were operational during this campaign. Initial TGCM predictions have been made for assumed solar-geophysical conditions, and selected results are presented.

Sondrestrom ionospheric results show a decrease in electron density from June 26 to 27 to 28, isolated periods of ion frictional heating during the nights throughout the field of view, and strong ionospheric convection velocity reversals well beyond midnight. Neutral wind results show a major period of enhanced northward velocity in response to strong heating to the south of the radar on June 28, the most disturbed of the three days.

Millstone Hill ionospheric results show lower densities on June 27 than on June 26 but higher densities on June 28. Frictional heating effects and velocity reversals are restricted to the most northerly observations. Millstone Hill neutral atmosphere results show a higher temperature and atomic oxygen density over a wide latitude range on June 28 than on the previous two days, with particularly strong effects at lower latitudes. These are believed to be the first incoherent scatter radar determinations of the latitudinal variation of the neutral atomic oxygen density.

Fritz Peak Fabry Perot data show a strong latitudinal gradient in neutral temperature, with temperatures 5 degrees in latitude to the north of the station exceeding those to the south by 200 K. Early on the morning of June 28 the Fabry Perot winds showed a sudden and strong shift toward the equator with the winds to the north exceeding 300 m/s but the winds to the south attaining a speed of only 130 m/s.

TGCM simulations were made to predict the global steady-state behavior of thermospheric temperature, winds, density, and composition for pre-assumed values for solar flux (F10.7 = 120– somewhat high) and magnetic activity (Ap = 4 – somewhat low). A cross-tail magnetospheric potential and an auroral particle input of 2 ergs/cm**2/sec were included but tides were not. These simulations predict a strong summer-solstice neutral temperature gradient over North America with a temperature maximum over Greenland. Meridional wind predictions over Sondrestrom show a strong diurnal flow with poleward velocities of 170 m/s during the day and equatorward velocities of 300 m/s at night. A large quantity of such results are available from the simulations.

As more data are received and analyzed, composite maps of global upper atmospheric and ionospheric structure will be compiled and compared with models and simulations which will be updated as pertinent information on solar/geophysical inputs becomes available. Magnetometer data will be used to estimate global Joule heating rates to act as inputs to the models. The models will rely to various degrees on inputs from the measurements and on feedback from other models as thermospheric, ionospheric, and electrodynamic properties of the upper atmosphere all are interdependent.

A second GTMS campaign will be conducted on 15-17 January 1985. Optical coverage, especially at high northern latitudes near the Radar Chain, should be much improved during this period.

The GTMS data-taking campaigns will be followed by a Workshop at MIT on 17-19 July 1985. In addition to the GTMS solstice campaigns, the Workshop will include the Equinox Transition campaign, a radar/optical campaign coordinated by AFGL in September 1984, designed to observe the summer-winter thermosphere circulation transition and the competition between high-latitude and sub-solar forcing in controlling circulation structure. Consideration will be given to presenting these results at an AGU session in December 1985 or at an NCAR/URSI Radar Workshop on coordinated radar campaigns.

GTMS - EXPERIMENTAL ORGANIZATION

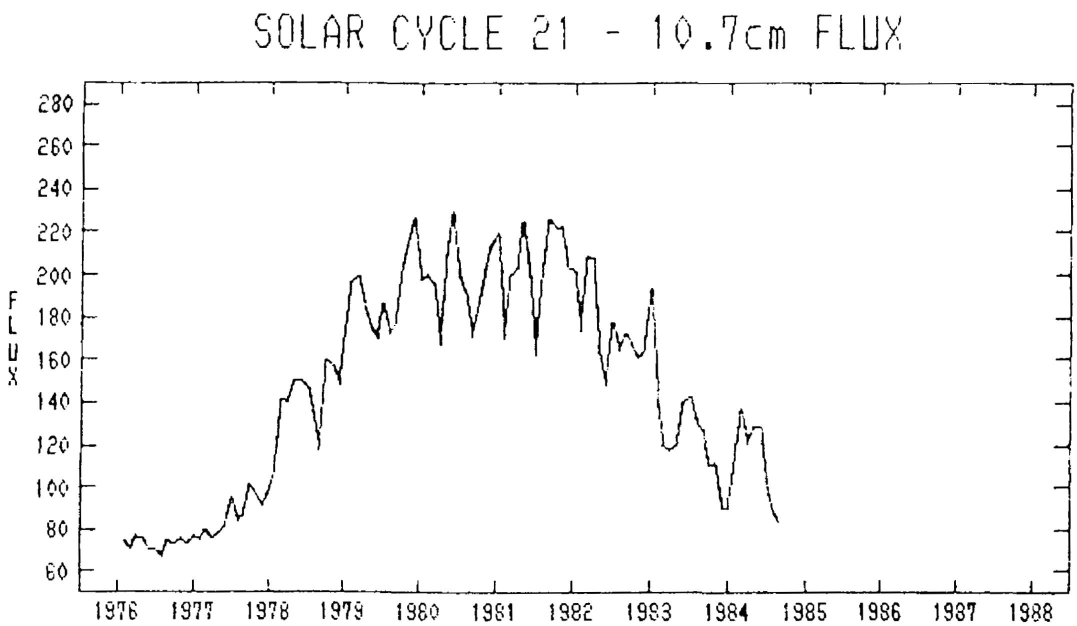
OVERALL COORDINATION - MILLSTONE HILL (W. OLIVER, J. SALAH)

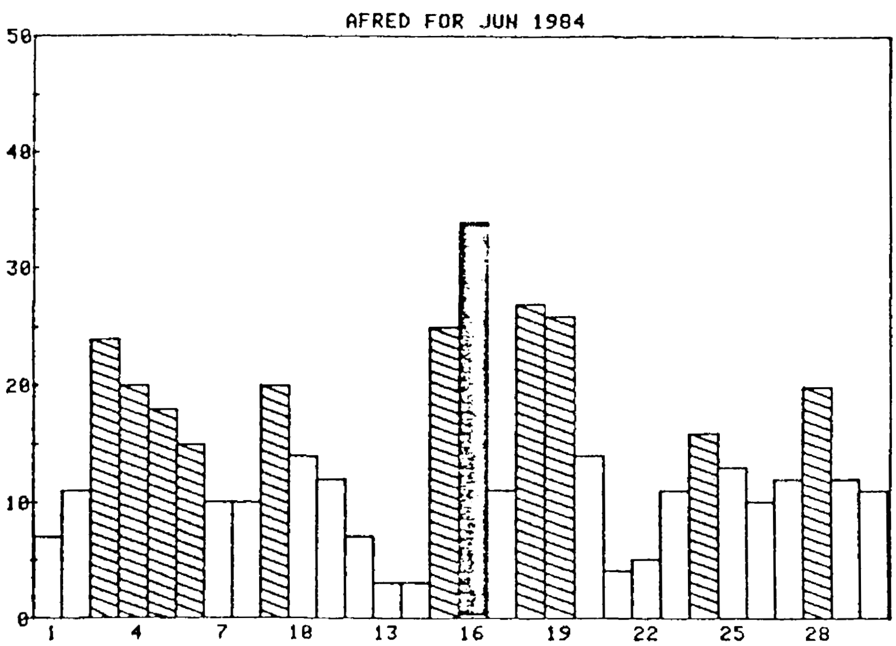
TECHNIQUE COORDINATORS -

INCOHERENT SCATTER RADARS	W. OLIVER
SONDRE STROMFJORD	V. WICKWAR
MILLSTONE HILL	W. OLIVER
ARECIBO, JICAMARCA	W. SWARTZ
EISCAT, SAINT SANTIN	D. ALCAYDE
FABRY PEROT INTERFEROMETERS	J. MERIWETHER
METEOR RADARS	R. ROPER (GLOBMET)
PARTIAL REFLECTION RADARS	J. FORBES (ATMAP)
MST RADARS	J. FORBES (ATMAP)
SATELLITE PROBES	A. HEDIN

GTMS - THEORY/MODEL/SIMULATION ORGANIZATION

1 -	THERMOSPHERE SIMULATION (TGCM)	ROBLE ET AL.
2 -	THERMOSPHERE MODEL COMPARISON (E.G., MSIS)	HEDIN ET AL.
3 -	TIDES MODELING/COMPARISON	FORBES ET AL.
4 -	IONOSPHERE SIMULATION	SCHUNK ET AL.
5 -	ELECTRIC FIELD MODELING/COMPARISON	RICHMOND ET AL.
6 -	NE/TE MODEL COMPARISON	BRACE ET AL.
7 -	NE MODEL COMPARISON	CHIU ET AL.


SOLAR CYCLE 21 - 10.7cm FLUX
FLUX
280
260
240
220
200
180
160
140
120
100
80
60
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988


AFRED FOR JUN 1984
50
40
30
20
10
0
1
4
7
10
13
16
19
22
25
28

GTMS - 26-28 JUNE 1984 - SOLAR/GEOPHYSICAL INDICES

MONTHLY AVERAGES

MONTH	F10.7
MARCH	122.0
APRIL	128.7
MAY	128.3
JUNE	100.3
JULY	89.3
AUGUST	83.7
SEPT.	(78.1)

DAILY VALUES

DAY	F10.7	AFR	K-FREDERICKSBURG	K-ANCHORAGE
JUNE 24	100.3	16	5-4-2-2-2-2-2-3	5-6-3-3-2-3-2-3
25	101.3	13	4-3-2-2-2-2-3-3	4-3-3-2-3-3-3-2
26	96.8	10	3-3-3-2-1-1-2-3	3-3-2-3-2-3-2-3
27	98.2	12	4-4-3-2-1-0-2-2	5-4-4-4-3-2-3-2
28	96.2	20	3-3-4-3-3-3-4-4	4-4-5-4-4-6-4-3
29	97.0	12	3-2-2-3-1-3-3-3	4-3-3-3-1-3-3-3
30	97.8	11	3-3-2-2-2-2-3-3	3-4-3-3-4-4-2-3

SITES INVOLVED IN THE GLOBAL THERMOSPHERIC MAPPING STUDY

SITE	STATE/COUNTRY	LAT	LON	EXPERIMENT TYPE
Saint Santin	France	44	2	IS
SOUCY	West Germany	52	10	MST
Bologna	Italy	44	11	MR
EISCAT	Scandanavia	69	19	IS
Kiruna	Sweden	68	20	FP
Kyoto	Japan	35	135	MR
Adelaide	South Australia	-35	138	FP PR
Christchurch	New Zealand	-43	172	PR
Fairbanks	Alaska	64	212	FP
Poker Flat	Alaska	64	212	MST
Calgary	Alberta	51	246	FP
Saskatoon	Saskachewan	52	254	PR
Fritz Peak	Colorado	40	255	FP
Sunset	Colorado	40	255	MST
Urbana	Illinois	40	272	MR MST
Atlanta	Georgia	33	276	MR
Ann Arbor	Michigan	42	277	FP
Laurel Ridge	Pennsylvania	40	281	FP
Jicamarca	Peru	-12	283	IS MST
Millstone Hill	Massachusetts	43	289	IS FP
Arequipa	Peru	-16	289	FP
Durham	New Hampshire	43	289	MR
Arecibo	Puerto Rico	18	294	IS FP MST
Sondrestrom	Greenland	67	309	IS FP
San Jose dos Campos	Brazil	-23	314	FP

LAT: LATitude, + in northern hemisphere, - in southern
LON: east LONgitude
IS: Incoherent Scatter
FP: Fabry Perot interferometer
MR: Meteor wind Radar
PR: Partial Reflection drifts radar
MST: Mesosphere-Stratosphere-Troposphere radar

GTMS - 26-28 JUNE 1984 - IS - EISCAT

DAYS OF OBSERVATION: 26-28 JUNE

OBSERVING SCHEME: CP-3 - WIDE LATITUDE SCAN

CYCLE TIME: 30 MINUTES

MEASURED QUANTITIES - IONOSPHERIC (F REGION)
NE, TE, TI, E FIELD - VS LATITUDE

MEASURED QUANTITIES - NEUTRAL (UPPER THERMOSPHERE)
TEMPERATURE - VS LATITUDE
MERIDIONAL WIND - VS LATITUDE
OXYGEN DENSITY - VS LATITUDE

DATA QUALITY: PRESUMED GOOD

GTMS - 26-28 JUNE 1984 - IS - SAINT SANTIN

DAYS OF OBSERVATION: 26-28 JUNE

OBSERVING SCHEME: VERTICAL TRANSMITTED BEAM (SAINT SANTIN)
3 RECEIVERS SCANNING TRANSMITTED BEAM
(NANCAY, MENDE, MONPAZIER)
(MONPAZIER RESTRICTED TO F REGION ON 28-TH)

CYCLE TIME: DAY - 60 MINUTES
NIGHT - 30 MINUTES

MEASURED QUANTITIES - IONOSPHERIC (LOCAL)
F REGION - NE, TE, TI, E FIELD
E REGION - NE, TE, TI, COLL. FREQ., ION DRIFT

MEASURED QUANTITIES - NEUTRAL (LOCAL)
F REGION - TEMPERATURE
MERIDIONAL WIND
OXYGEN DENSITY (DAY)
E REGION - TEMPERATURE (DAY)
WIND VECTOR (DAY)
N2 DENSITY (DAY)

DATA QUALITY: GOOD

GTMS - 26-28 JUNE 1984 - IS - ARECIBO

DAYS OF OBSERVATION - 26-28 JUNE

OBSERVING SCHEME - CONICAL BEAM SWING
INTERLACED POWER AND SPECTRAL MEASUREMENTS

CYCLE TIME: 16 MINUTES FOR ANTENNA SWING
1-2 MINUTES FOR LINE-OF-SIGHT MEASUREMENTS

MEASURED QUANTITIES - IONOSPHERIC (LOCAL F REGION)
NE, TE, TI, E FIELD

MEASURED QUANTITIES - NEUTRAL (LOCAL UPPER THERMOSPHERE)
TEMPERATURE
MERIDIONAL WIND
OXYGEN DENSITY (DAYTIME)

DATA QUALITY - GOOD

GTMS - 26-28 JUNE 1984 - IS - JICAMARCA

DAYS OF OBSERVATION: FARADAY ROTATION (NE) - 26-28 JUNE
IS SPECTRAL DATA - 27-28 JUNE

OBSERVING SCHEME -
SPLIT BEAM, EAST AND WEST

CYCLE TIME: 5 MINUTES

MEASURED QUANTITIES - IONOSPHERIC (LOCAL F REGION)
NE, TE, TI, E FIELD

MEASURED QUANTITIES - NEUTRAL (LOCAL UPPER THERMOSPHERE)
TEMPERATURE
?? OXYGEN DENSITY (DAYTIME)

DATA QUALITY: FARADAY ROTATION - GOOD
IS SPECTRAL - UNCERTAIN

GTMS - 26-28 JUNE 1984 - IS - SONDRESTROM

DAYS OF OBSERVATION - 26-28 JUNE

OBSERVING SCHEME -

11-POSITION MEASUREMENT: 5 PAIRS STRADDLING FIELD LINE (FOR E FIELD VS LATITUDE)
1 POSITION UP B FIELD (FOR LOCAL WINDS)

N-S ELEVATION SCAN (SCALAR QUANTITIES VS LATITUDE)

UP B FIELD AFTER 11-POSITION AND ELEVATION SCAN

CYCLE TIME: 22.5 MINUTES (6 MINUTES UP B)

MEASURED QUANTITIES - IONOSPHERIC (F REGION)

NE, TE, TI, E FIELD - VS LATITUDE

MEASURED QUANTITIES - NEUTRAL (UPPER THERMSOPHERE)

TEMPERATURE - VS LATITUDE

MERIDIONAL WIND - LOCAL

?? OXYGEN DENSITY

DATA QUALITY - GOOD

GTMS - 26-28 JUNE 1984 - IS - MILLSTONE HILL

DAYS OF OBSERVATION - 26-28 JUNE

OBSERVING SCHEME -

DOUBLE ELEVATION SCAN: ONE ALONG MILLSTONE MERIDIAN
ONE CANTED 30 DEGREES TO WEST

ZENITH MEASUREMENTS

DAYTIME: ADDED 3-POSITION E REGION MEASUREMENT

CYCLE TIME: NIGHT - 30 MINUTES
DAY - 60 MINUTES

MEASURED QUANTITIES - IONOSPHERIC

F REGION - NE, TE, TI, E FIELD - VS LATITUDE

E REGION - NE, TE, TI, COLL. FREQ., ION DRIFT - LOCAL

MEASURED QUANTITIES - NEUTRAL

F REGION -	TEMPERATURE	- VS LATITUDE	
	MERIDIONAL WIND	- VS LATITUDE	
	OXYGEN DENSITY	- VS LATITUDE	(DAY)
E REGION -	TEMPERATURE	- LOCAL	(DAY)
	WIND VECTOR	- LOCAL	(DAY)
	N2 DENSITY	- LOCAL	(DAY)

DATA QUALITY - GOOD

GTMS - 26-28 JUNE 1984 - FABRY PEROT OBSERVATIONS

6300-A NIGHTTIME OBSERVATIONS

1 - SAO JOSE DOS CAMPOS:
   JUNE 25 - 1850-2330 LT
   JUNE 26/27 - 1900-0430 LT (VERY LOW INTENSITY AFTER 00 LT)
   JUNE 27 - NO OBSERAVTIONS (BAD WEATHER)
   JUNE 28 - NO OBSERVATIONS (BAD WEATHER)
   JULY 01/02 - 1950-0200 LT
   JULY 02/03 - 1830-0400 LT (LOW INTENSITY)
   JULY 03/04 - 1830-0300 LT

2 - AREQUIPA - DATA TAKEN, WEATHER WAS CLOUDY

3 - ARECIBO - DATA TAKEN, SKY WAS HAZY, POOR QUALITY

4 - FRITZ PEAK:
   JUNE 27 - 0300-1100 UT (TEMPERATURE ONLY)
   JUNE 28 - 0300-1100 UT (TEMPERATURE + HORIZONTAL WIND)

5 - LAUREL RIDGE - TAPE RECORDER MALFUNCTION

6 - ANN ARBOR - NO DATA

7 - CALGARY - NO DATA

8 - FAIRBANKS - NO DATA, INOPERATIVE IN SUMMER

9 - SONDRESTROM - NO DATA, INOPERATIVE IN SUMMER

OTHERS ??

GTMS - 26-28 JUNE 1984 - D&E-REGION/MESOSPHERE OBSERVATIONS

1 - ENTIRE ATMAP NETWORK - REPORTS INCOMPLETE
   METEOR RADARS
   PARTIAL REFLECTION DRIFTS RADARS
   MST RADARS

2 - INCOHERENT SCATTER RADARS - DAYTIME ONLY
   MILLSTONE HILL
   SAINT SANTIN

3 - FABRY PEROT INTERFEROMETERS (GREEN LINE) - NO OBSERVATIONS
   (ONLY F REGION RED LINE DATA WERE TAKEN)

GTMS - 26-28 JUNE 1984 - SATELLITE DATA

???

GTMS - 26-28 JUNE 1984 - MAGNETOMETER DATA

MAGNETOMETER CHAINS WERE OPERATING

KAMIDE AND AKASOFU PLAN TO CALCULATE GLOBAL MAPS OF JOULE HEAT PRODUCTION AND IONOSPHERIC CURRENTS

GTMS/EQUINOX-CIRCULATION WORKSHOP

WORKSHOP TO STUDY GLOBAL FEATURES OF THERMOSPHERE STRUCTURE AS OBSERVED DURING:

(1) GTMS SUMMER (JUNE 1984) AND WINTER (JANUARY 1985) SOLSTICE CAMPAIGNS

(2) EQUINOX-CIRCULATION (SEPTEMBER 1984) CAMPAIGN

WORKSHOP DATES/PLACE: 17-19 JULY 1985 AT MIT

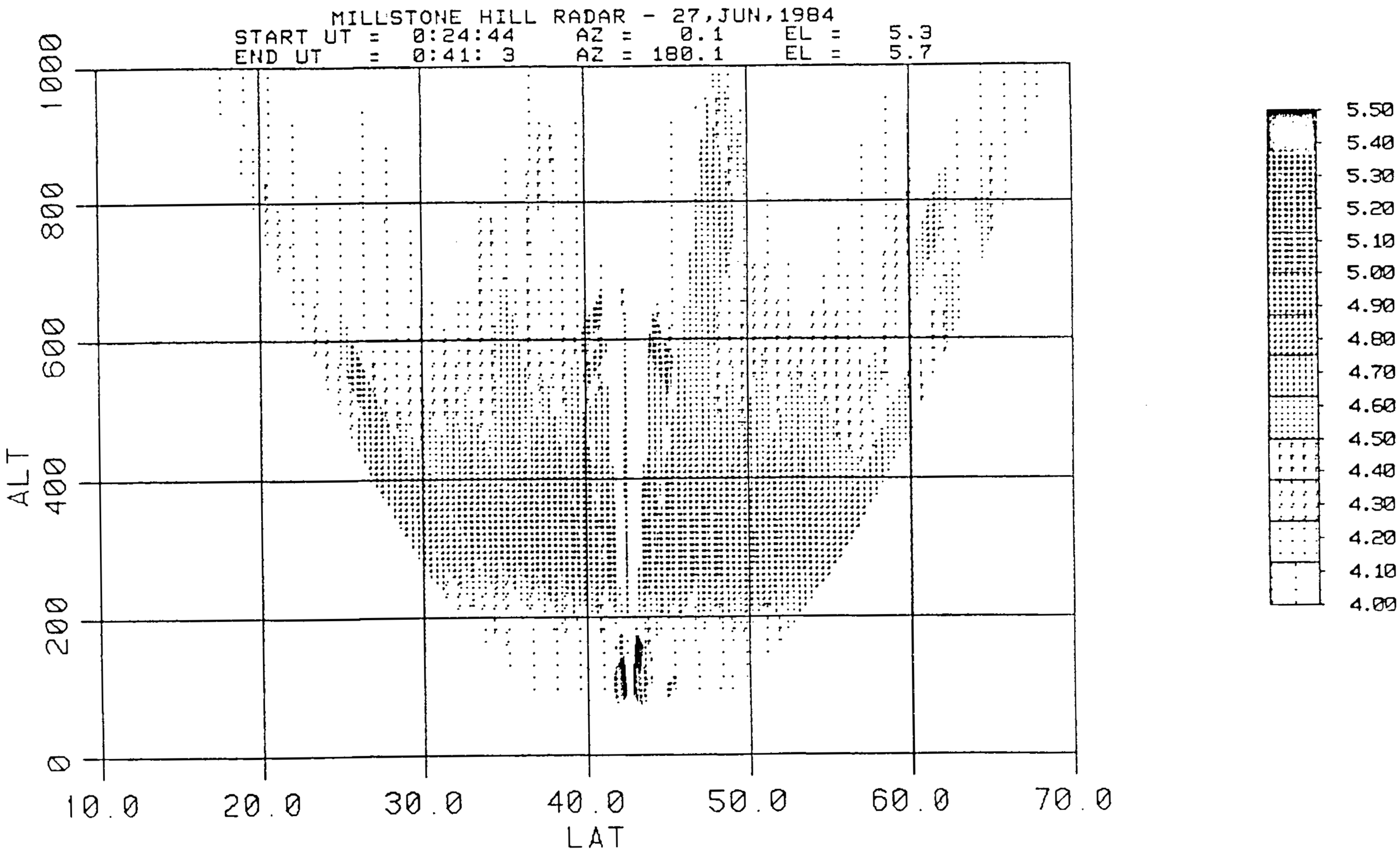
GTMS/EQUINOX-CIRCULATION AGU SESSION

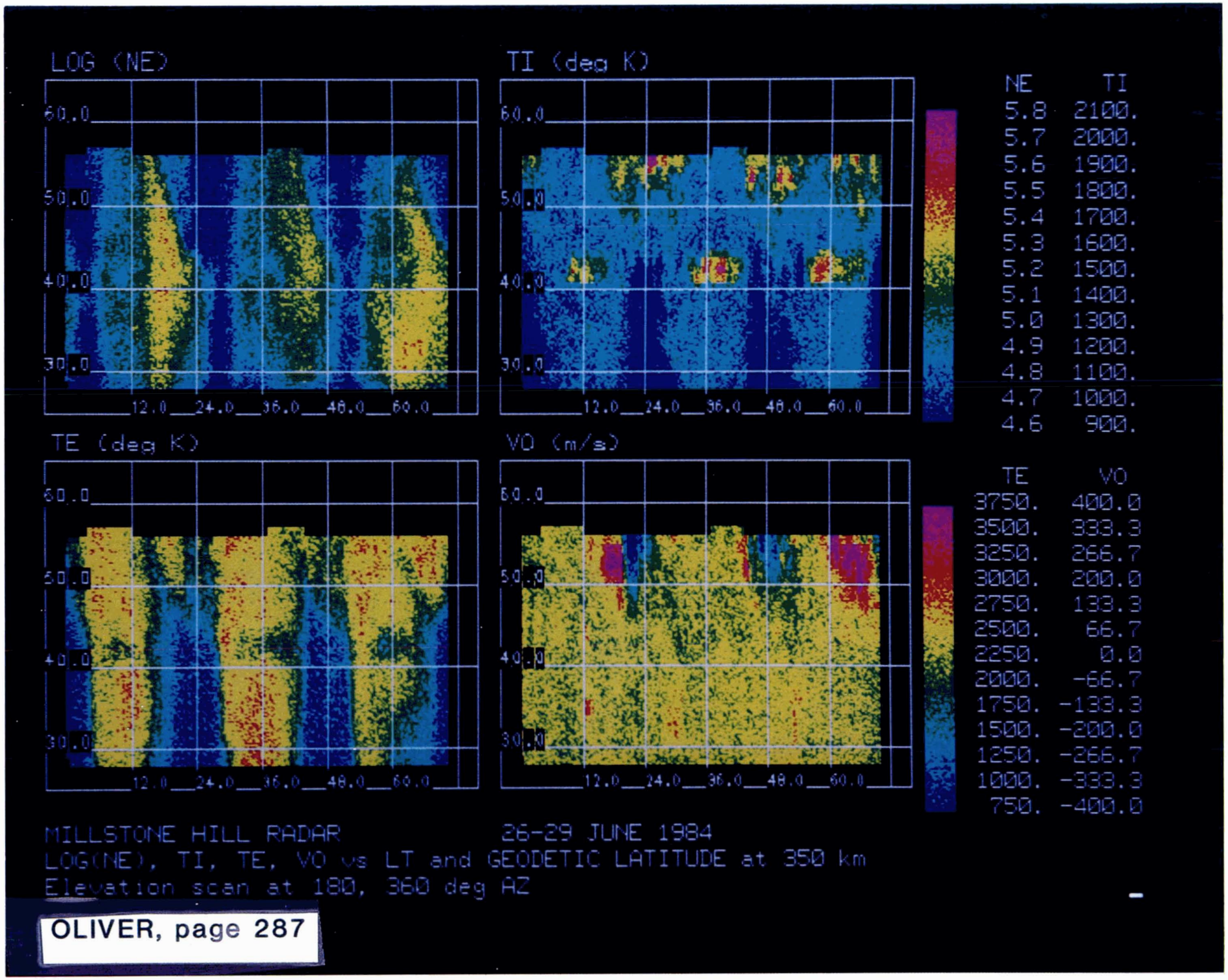
DECEMBER 1985 MEETING IN SAN FRANCISCO

SESSION TO BE PLANNED AT JULY 1985 WORKSHOP

ABSTRACTS DUE IN TO AGU IN SEPTEMBER 1985

Illustration of the latitude-altitude coverage attained by a north-south elevation scan down to about 5 degrees at Millstone Hill. Plotted is the logarithm (base 10) of the electron density (cm**-3).





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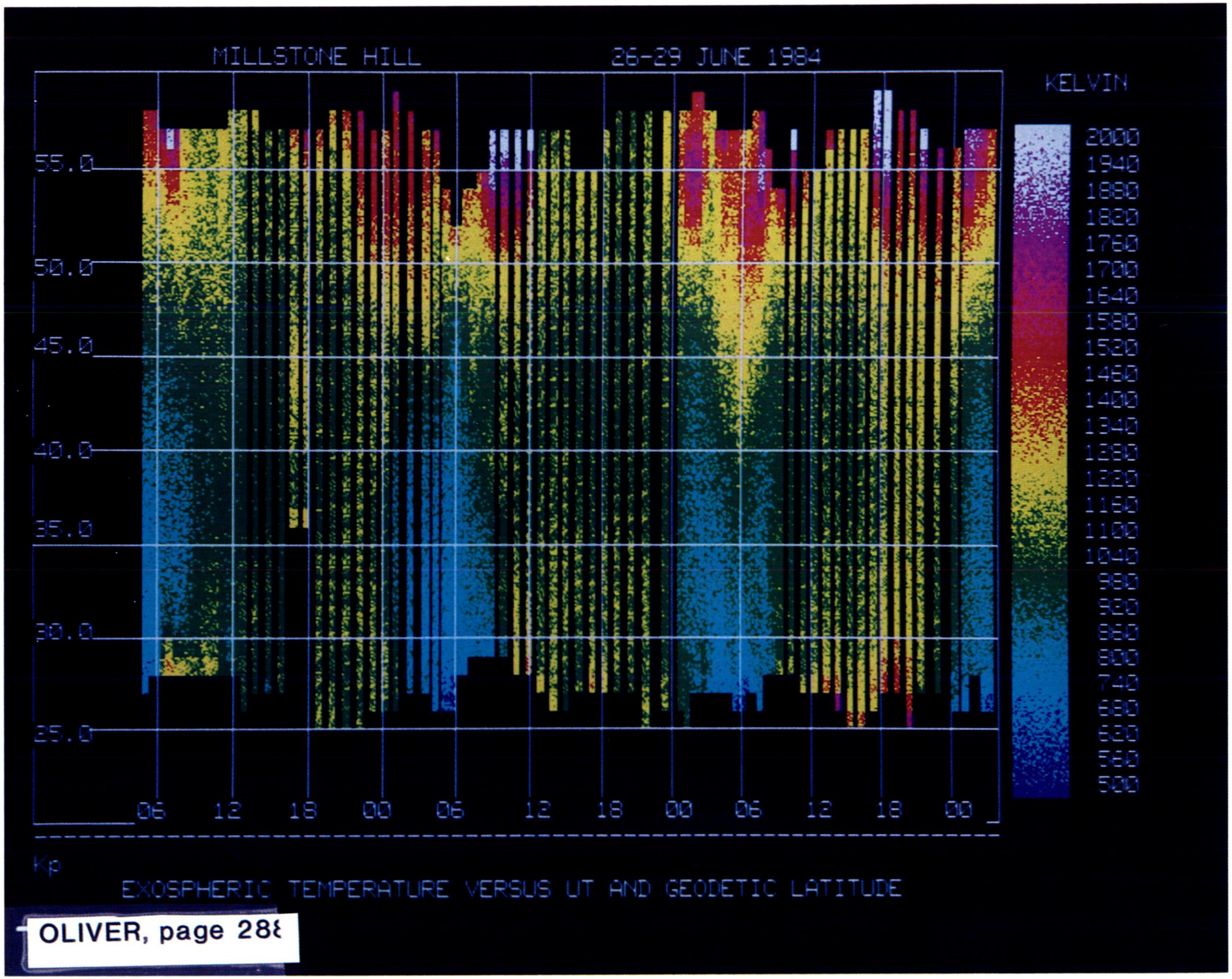
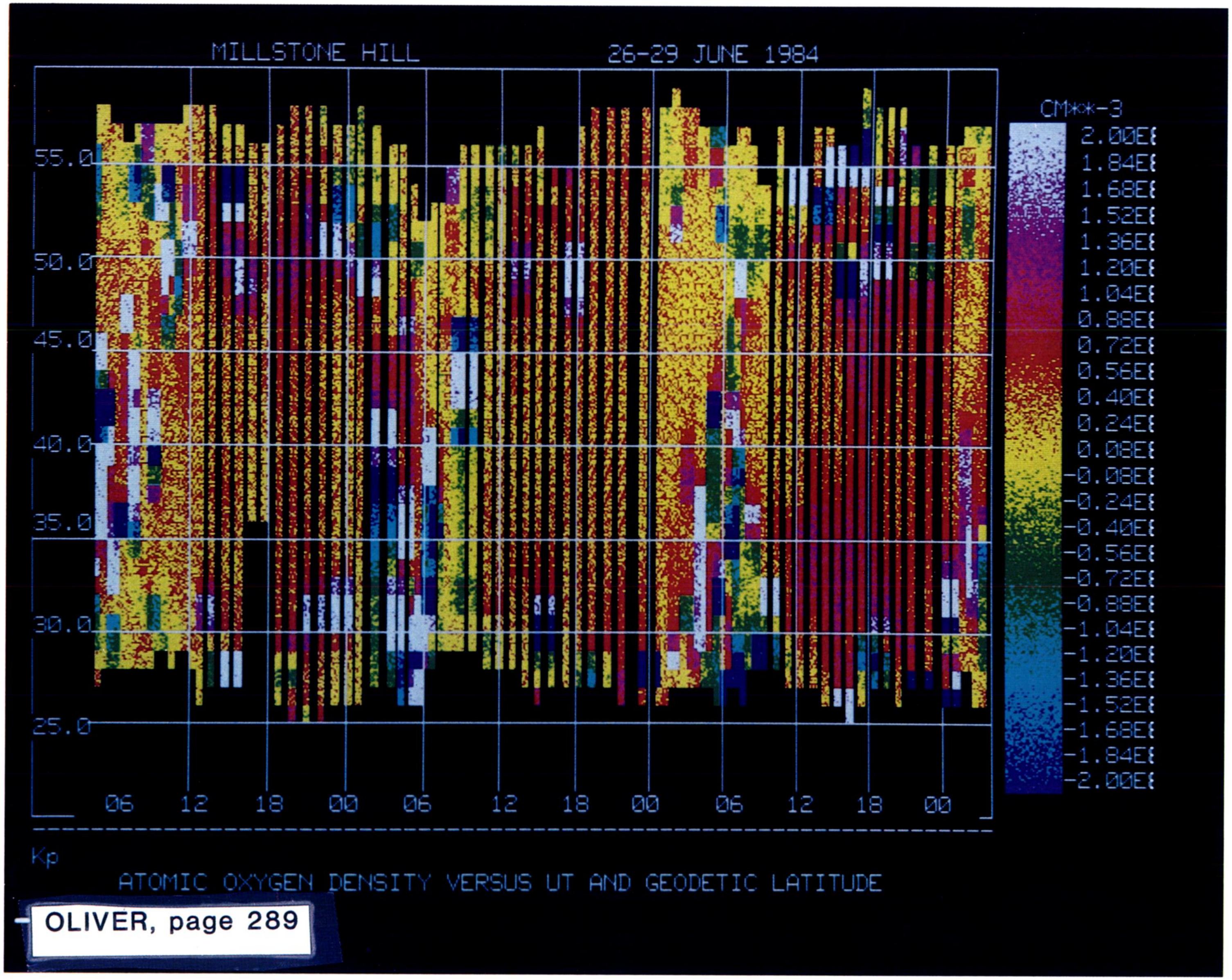
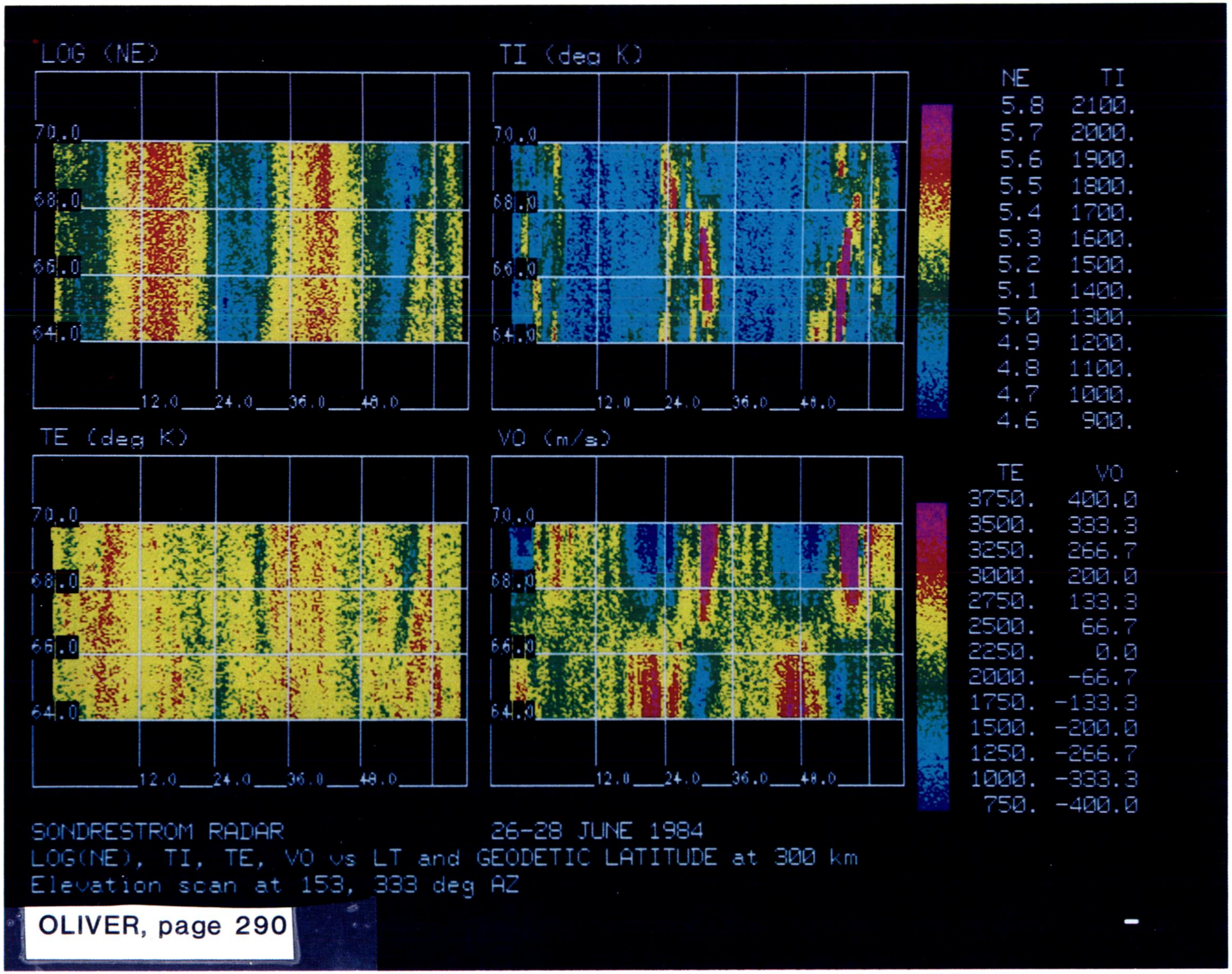
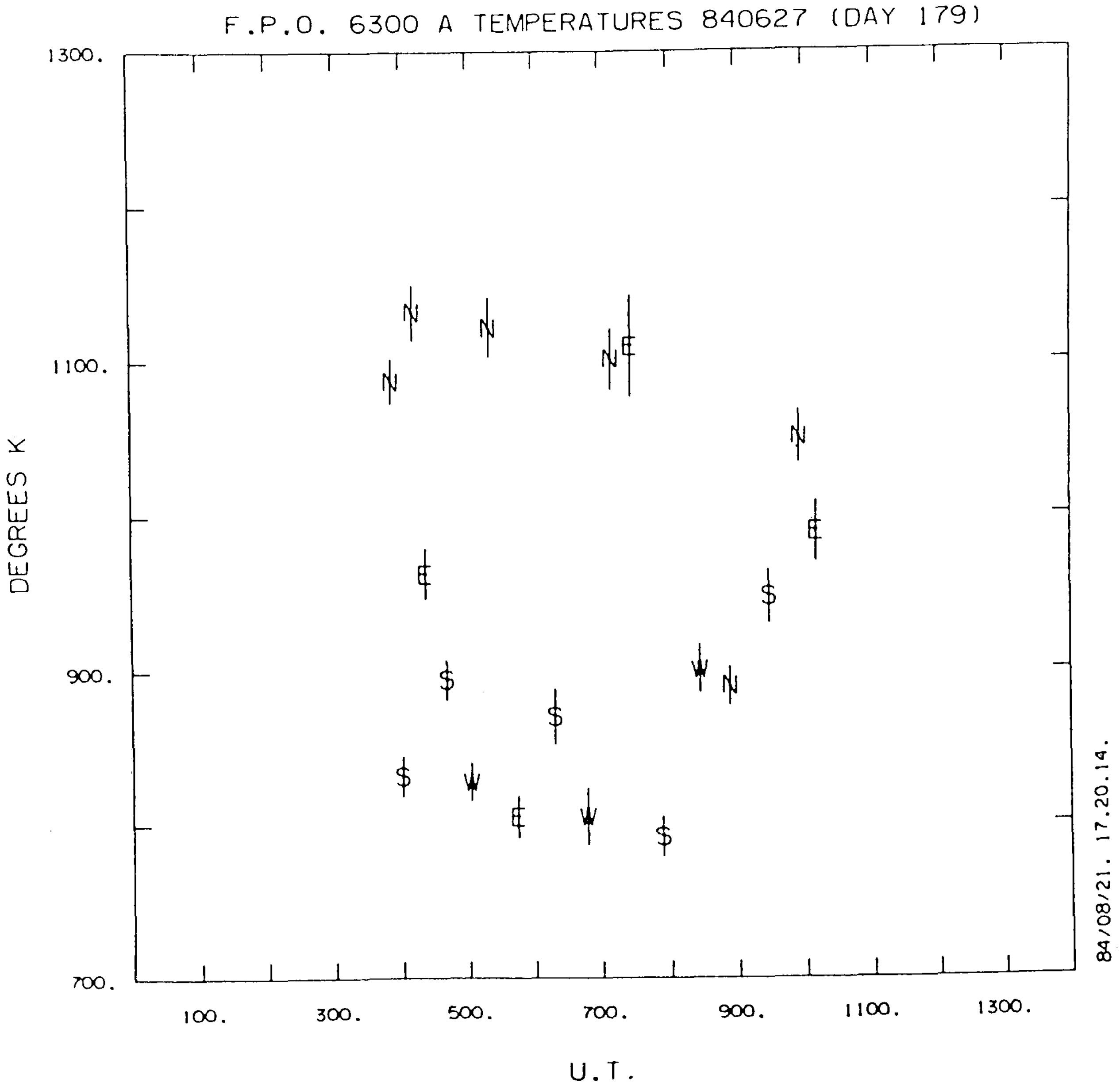


MILLSTONE HILL
26-29 JUNE 1984
KELVIN
2000
1940
1880
1820
1760
1700
1640
1580
1520
1460
1400
1340
1280
1220
1160
1100
1040
980
920
860
800
740
680
620
560
500
55.0
50.0
45.0
40.0
35.0
30.0
25.0
06 12 18 00 06 12 18 00 06 12 18 00
Kp
EXOSPHERIC TEMPERATURE VERSUS UT AND GEODETIC LATITUDE
OLIVER, page 28

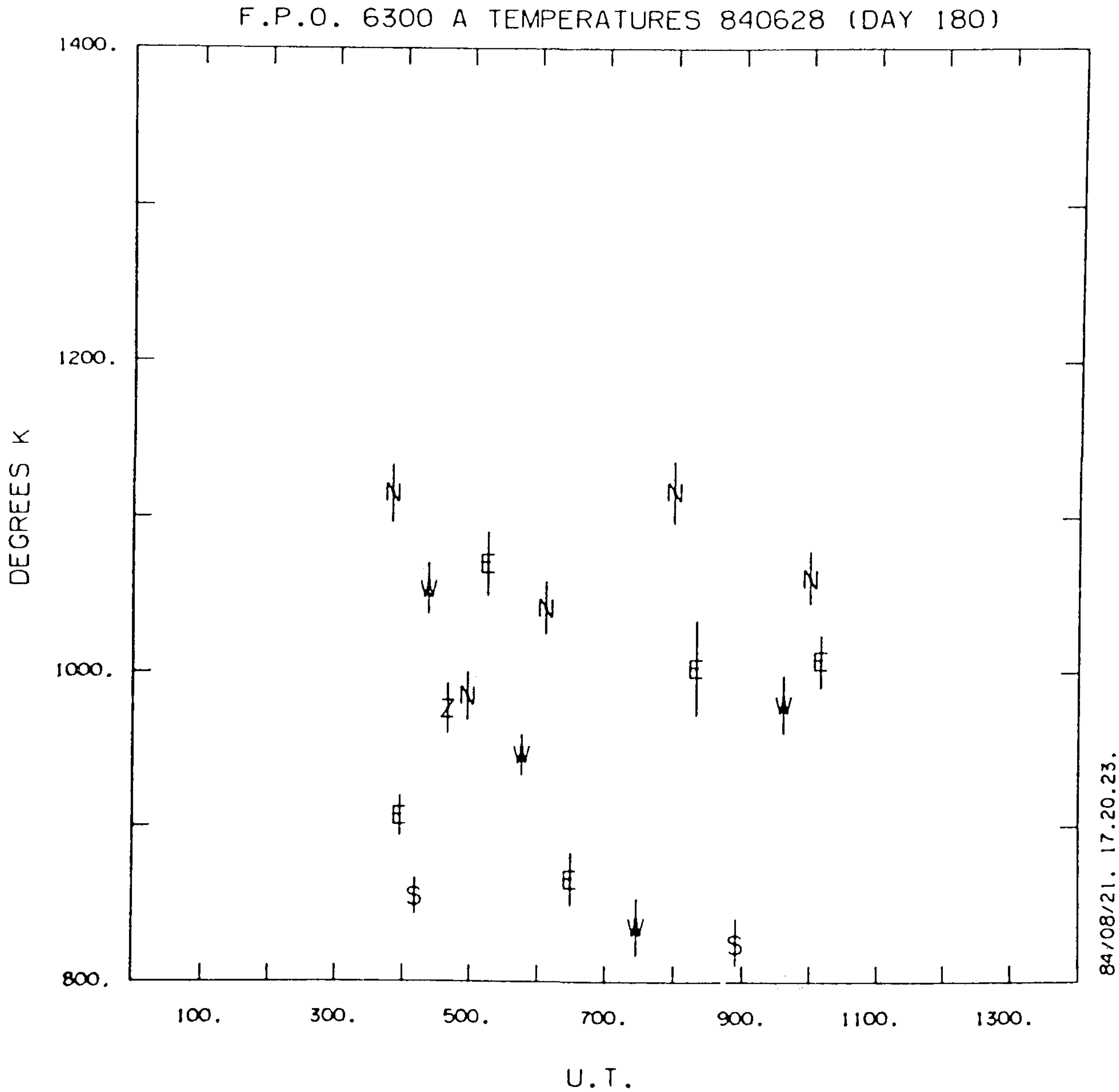

MILLSTONE HILL
26-29 JUNE 1984
CM** -3
2.00E
1.84E
1.68E
1.52E
1.36E
1.20E
1.04E
0.88E
0.72E
0.56E
0.40E
0.24E
0.08E
-0.08E
-0.24E
-0.40E
-0.56E
-0.72E
-0.88E
-1.04E
-1.20E
-1.36E
-1.52E
-1.68E
-1.84E
-2.00E
55.0
50.0
45.0
40.0
35.0
30.0
25.0
06 12 18 00 06 12 18 00 06 12 18 00
Kp
ATOMIC OXYGEN DENSITY VERSUS UT AND GEODETIC LATITUDE
OLIVER, page 289


LOG (NE)
TI (deg K)
TE (deg K)
VO (m/s)
70.0
68.0
66.0
64.0
12.0
24.0
36.0
48.0
NE TI
5.8 2100.
5.7 2000.
5.6 1900.
5.5 1800.
5.4 1700.
5.3 1600.
5.2 1500.
5.1 1400.
5.0 1300.
4.9 1200.
4.8 1100.
4.7 1000.
4.6 900.
TE VO
3750. 400.0
3500. 333.3
3250. 266.7
3000. 200.0
2750. 133.3
2500. 66.7
2250. 0.0
2000. -66.7
1750. -133.3
1500. -200.0
1250. -266.7
1000. -333.3
750. -400.0
SONDRESTROM RADAR 26-28 JUNE 1984
LOG(NE), TI, TE, VO vs LT and GEODETIC LATITUDE at 300 km
Elevation scan at 153, 333 deg AZ
OLIVER, page 290

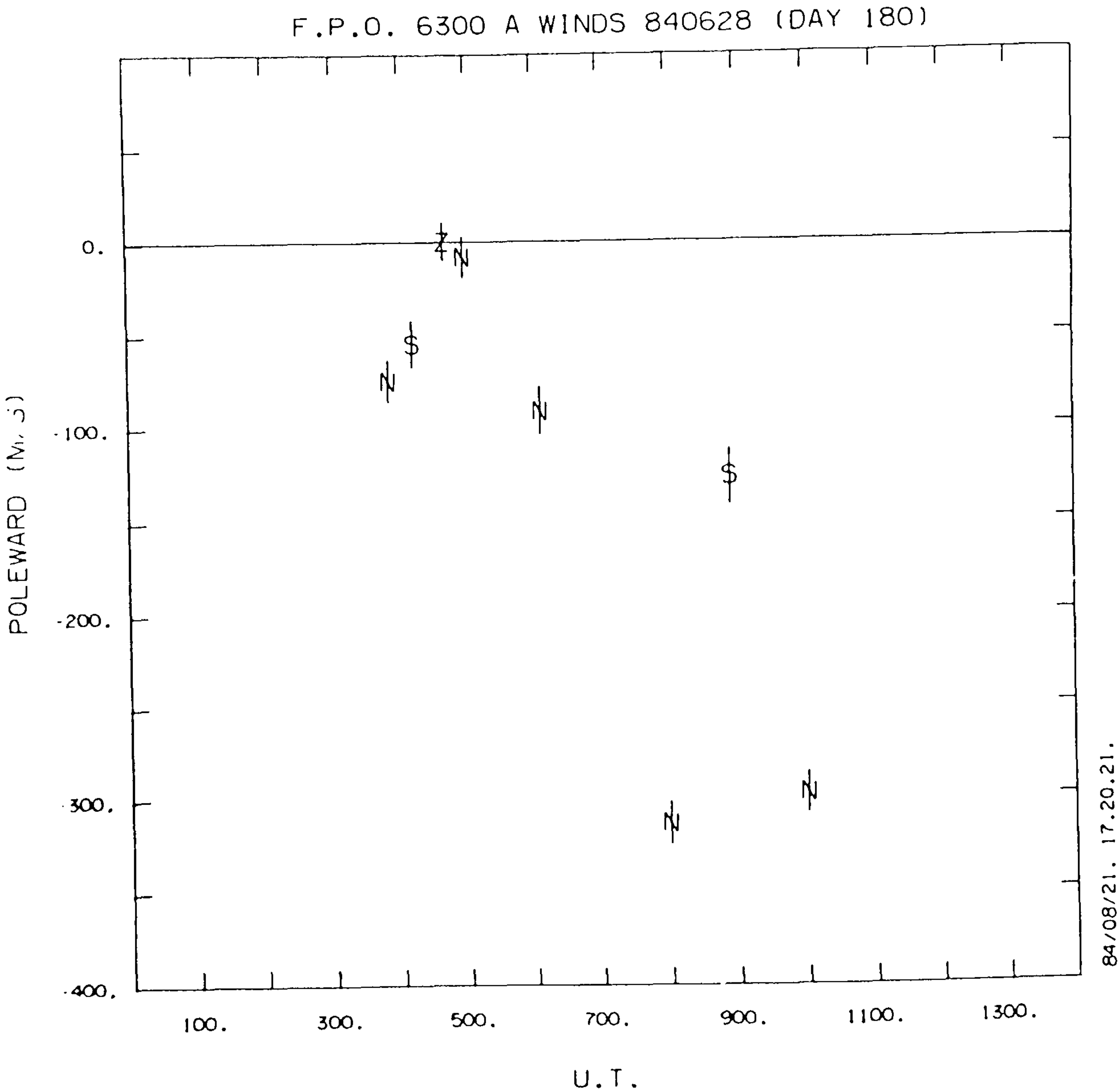
Thermospheric temperatures measured in four directions from Fritz Peak during the night of 26/27 June 1984.



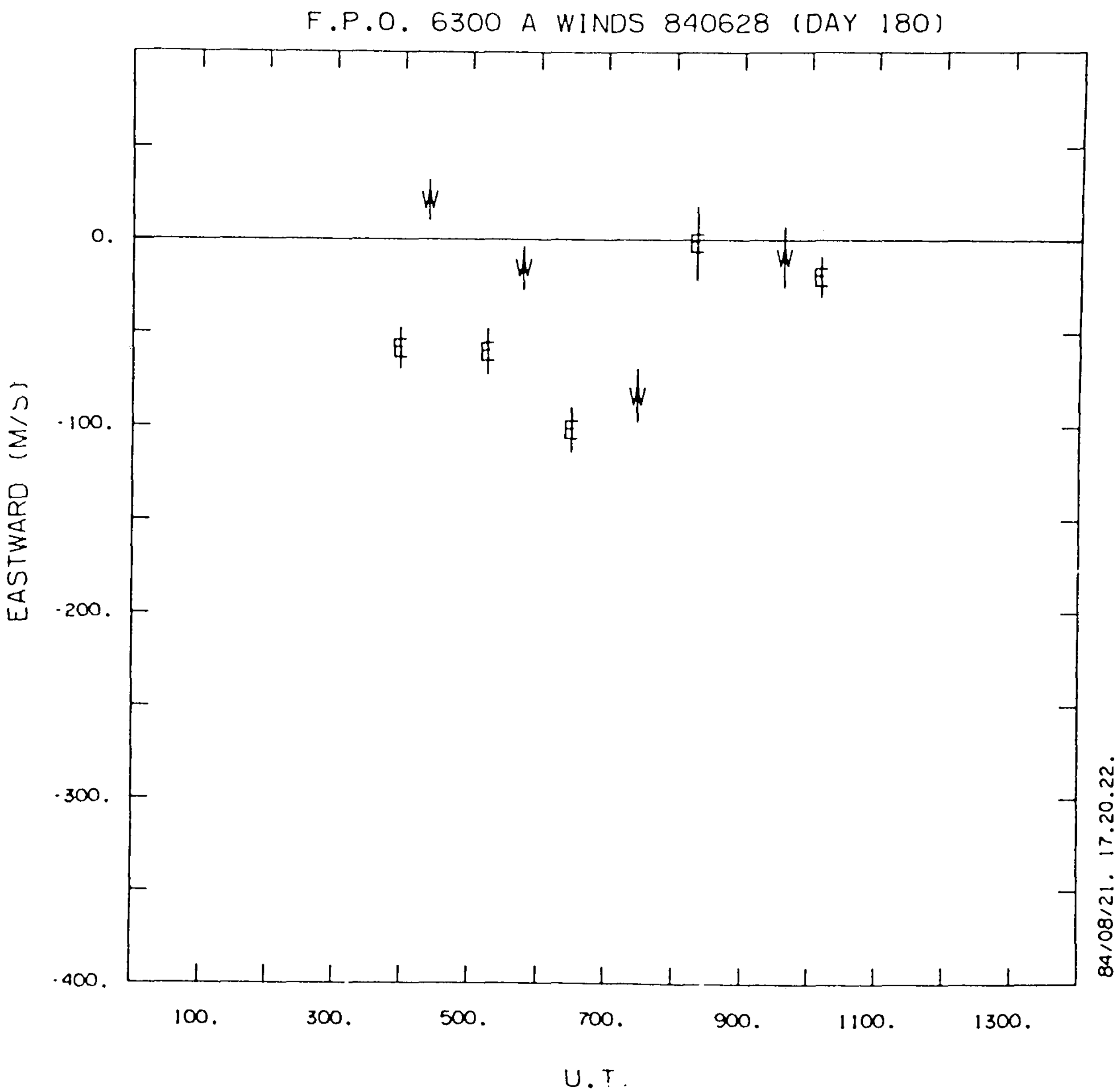
Thermospheric temperatures measured in four directions from Fritz Peak during the night of 27/28 June 1984.

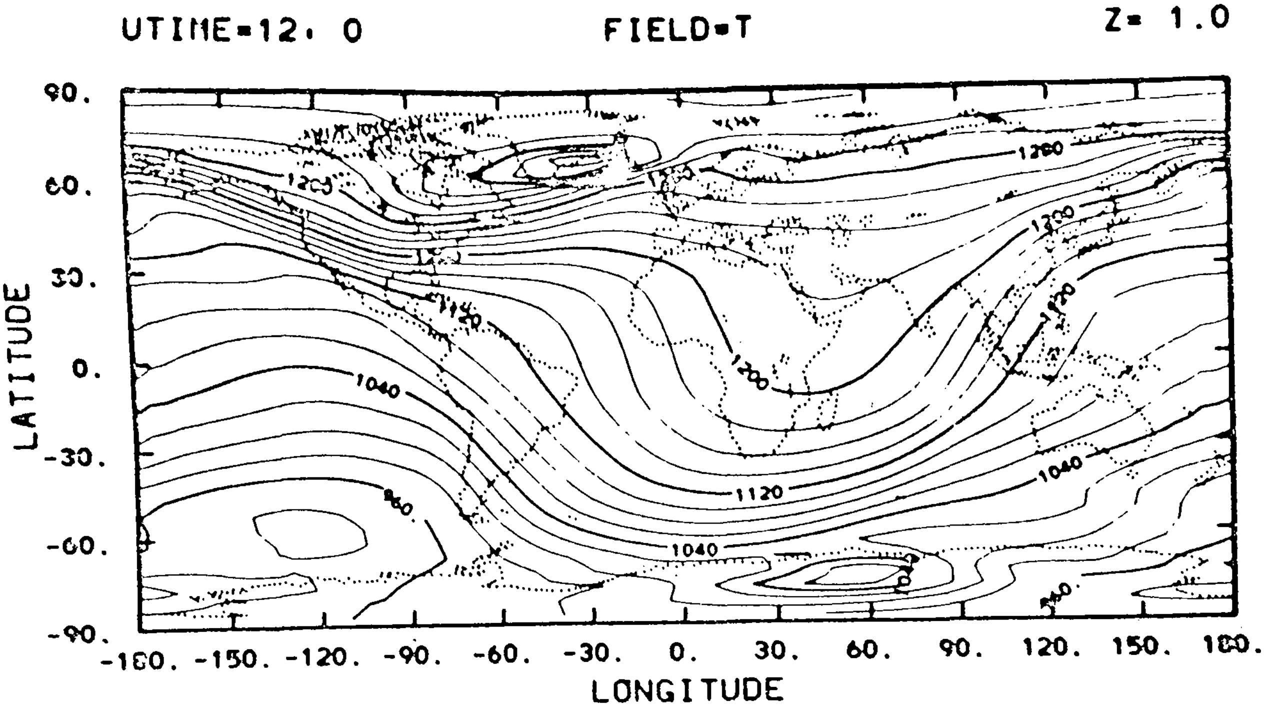


Thermospheric meridional winds measured in four directions from Fritz Peak during the night of 27/28 June 1984.

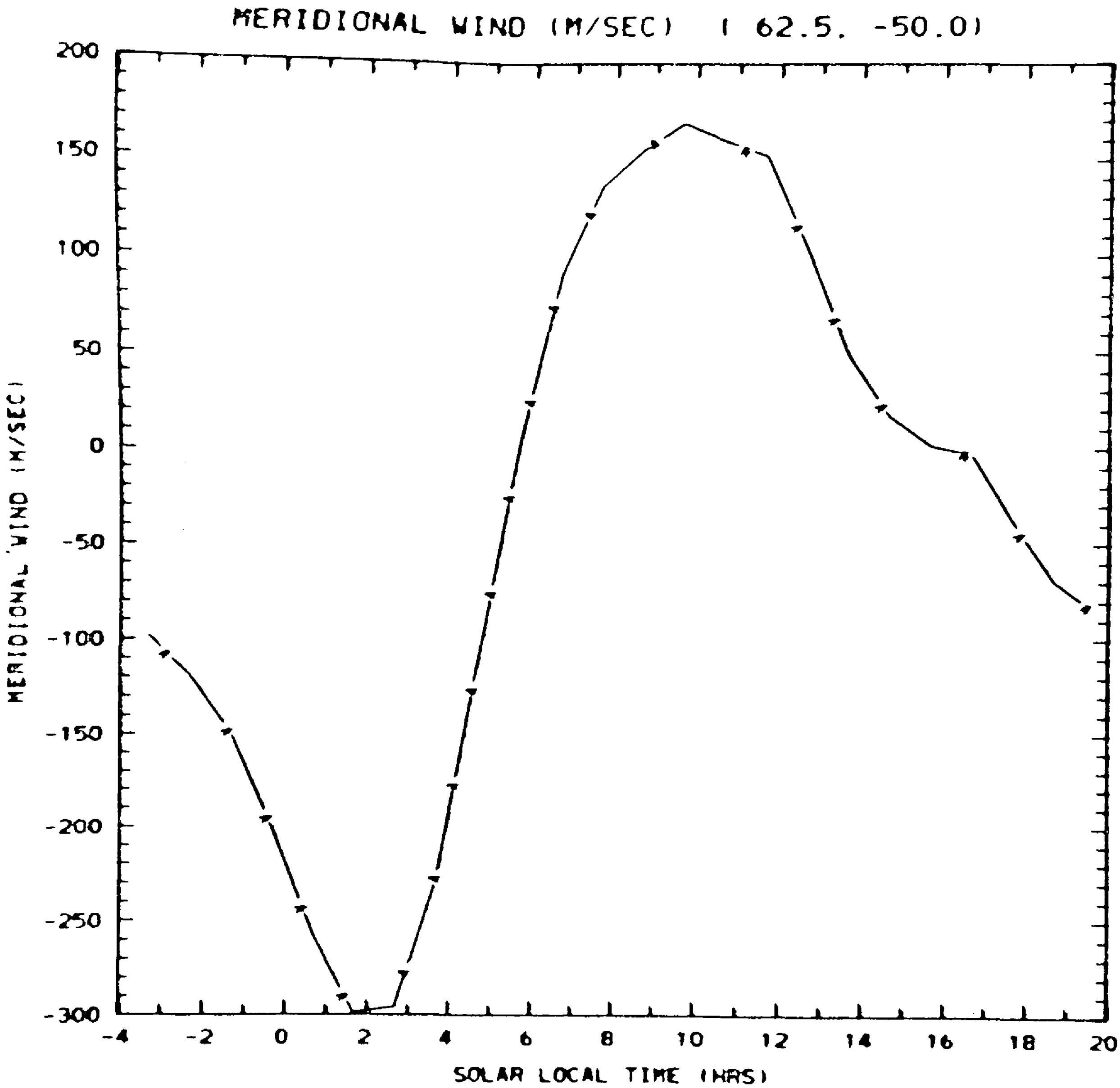


Thermospheric zonal winds measured in four directions from Fritz Peak during the evening of 27/28 June 1984.





TGCM simulation of the global temperature field at UT=12 hours at an altitude of about 300 km.



TGCM simulation of the steady-state meridional wind flow at F region altitudes above Sondre Stromfjord during 26-28 June 1984.