#650

MI-91C / MI-91D
INTERNATIONAL REFERENCE IONSPHERE ON
TAPE/IRI9-86

No New I.D. Number

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1. INTRODUCTION:

The documentation for this data set was originally on paper, kept in NSSDC's Data Set Catalogs (DSCs). The paper documentation in the Data Set Catalogs have been made into digital images, and then collected into a single PDF file for each Data Set Catalog. The inventory information in these DSCs is current as of July 1, 2004. This inventory information is now no longer maintained in the DSCs, but is now managed in the inventory part of the NSSDC information system. The information existing in the DSCs is now not needed for locating the data files, but we did not remove that inventory information.

The offline tape datasets have now been migrated from the original magnetic tape to Archival Information Packages (AIP's).

A prior restoration may have been done on data sets, if a requestor of this data set has questions; they should send an inquiry to the request office to see if additional information exists.

2. ERRATA/CHANGE LOG:

NOTE: Changes are made in a text box, and will show up that way when displayed on screen with a PDF reader.

When printing, special settings may be required to make the text box appear on the printed output.

Version	Date	Person	Page	Description of Change
01				
02				

3 LINKS TO RELEVANT INFORMATION IN THE ONLINE NSSDC INFORMATION SYSTEM:

http://nssdc.gsfc.nasa.gov/nmc/

[NOTE: This link will take you to the main page of the NSSDC Master Catalog. There you will be able to perform searches to find additional information]

4. CATALOG MATERIALS:

a. Associated Documents To find associated documents you will need to know the document ID number and then click here.
http://nssdcftp.gsfc.nasa.gov/miscellaneous/documents/

b. Core Catalog Materials

REQ. AGENT	RAND NO.	ACQ. AGENT
SAR	V0331	DKB
SAR	V0338	DKB

MI-91C
MI-91D

INTERNATIONAL REFERENCE IONSPHERE

ON TAPE/IRI9-86

No New I.D. Numbers

THIS DATA SET CATALOG CONSISTS OF TWO MAGNETIC TAPES. THE TAPES ARE 9-TRACK, 1600 BPI, AND ARE WRITTEN IN ASCII. THE MI-91C TAPE WAS CREATED ON A PDP 11/70 COMPUTER, AND THE MI-91D TAPE WAS CREATED ON THE VAX 11/780 COMPUTER. THE D AND C NUMBERS ARE AS FOLLOWS:

MI-91C

D#	C#	FILES
D-74058	C-26071	5

MI-91D

D#	C#	FILES
D-74126	C-26130	~~15~~ 21

NSSDC
NATIONAL SPACE SCIENCE DATA CENTER

NEWS

Published Quarterly by the NSSDC

Vol. 2, No. 3, September 1986

IRI continued

Several IRI reports have been published including tables, graphs, and computer programs. IRI is distributed from NSSDC on one magnetic tape (unlabeled, ASCII, 9-track, 1600 BPI) containing the FORTRAN source code, CCIR coefficient sets, and examples for test purposes. The program produces IRI profiles of the electron density, the electron and ion temperature, and the percentage of 0^+, H^+, He^+, $N0^+$ and 0^+_2 ions for a given location (geographic or geomagnetic), time (universal or local), season (day of year or month), and solar activity level (mean sunspot number or 10.7-cm solar radio flux).

IRI is used in research facilities all over the world with applications ranging from ionospheric research to radio astronomy and satellite orbit control. African, Asian, and South American nations with relatively young science programs and limited computer resources have welcomed the opportunity to participate in and benefit from this international project.

To get a copy of the IRI programs and coefficient sets on tape or via SPAN, contact Dieter Bilitza, (301) 286-9536, SPAN address: NSSDCA::Bilitza.

Dieter Bilitza

Newest Ionosphere Model Available

The newest version of the International Reference Ionosphere (IRI-86) was presented at the Committee on Space Research (COSPAR) meeting in Toulouse, France, this July and is now available from NSSDC. Dieter Bilitza, who joined the NSSDC/SAR science team last year, is a member of the IRI panel and was actively involved in improving IRI for the 1986 edition. He is in charge of the master copy of the IRI tape and recently implemented the Toulouse decisions in the IRI programs. The following article reviews the status and goals of the IRI project.

The gaseous envelope that surrounds our planet can be divided into two regions at about 80 km altitude. The turbulent and neutral gas mixture of the lower region sets the stage for the meteorological processes. This part fills only 1/50,000 of the total gas volume, but it contains 10^5 times more gas than the rest. In the upper region, the solar irradiation produces a partially ionized plasma composed mainly of atomic oxygen ions. Above 1000 km altitude light ions (H^+, He^+) become dominant; at lower altitudes heavy ions (NO^+, O^+_2) play an important role. Electron number densities are in the range 10^{10} to 10^{12} m^{-3} and electron temperatures increase from about 300 K at the lower boundary to up to 4000 K at higher altitudes. The plasma-related nomenclature distinguishes the "ionosphere" as below 1000 km altitude and the "protonosphere" as above that altitude.

The International Reference Ionosphere is the standard model for the Earth's ionosphere recommended by COSPAR and the International Union of Radio Science (URSI). COSPAR and URSI are the two organizations that represent ionospheric science in the International Council of Scientific Unions (ICSU).

Responding to numerous requests from within the ionospheric science community and other disciplines, in the late sixties URSI and COSPAR set up a joint working group to filter the growing ionospheric data base into an easily accessible reference standard. At several IRI workshops over the past 15 years, modeling efforts and data selection have been discussed, culminating in continuously improved versions of IRI (named IRI-1 to IRI-9). Guidelines and final approval of new versions are the responsibility of the IRI steering committee, which over the years has read like a "Who's Who" in ionospheric physics.

The global perspective of IRI is obvious from the range of countries of contributing scientists. They include the United States, Soviet Union, India, Japan, Federal Republic of Germany, German Democratic Republic, Bulgaria, France, Czechoslovakia, United Kingdom, Australia, Austria, Argentina, and Brazil.

IRI is relying on measurements only, avoiding the ambiguity of evolving theoretical understanding. Where different techniques produced conflicting results, a data hierarchy had to be established. Luckily, most of the earlier discrepancies between ground-based and in situ measurements have been resolved. Considerable uncertainty still exists in the determination of D region (below 100 km) electron density and ion composition.

IRI describes the global and temporal mean behavior of the undisturbed ionosphere in nonauroral latitudes. Beyond these limitations, the highly variable ionosphere still evades the confinement of descriptive models. Data entries to IRI-9 include:

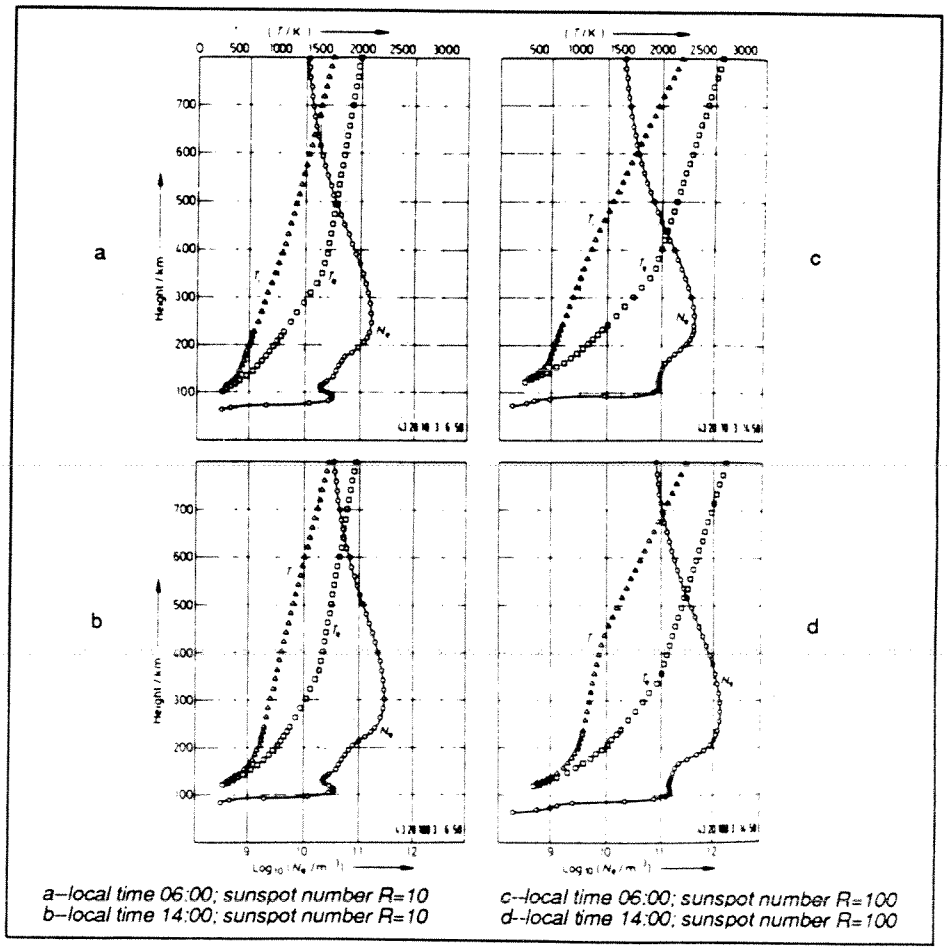
Ground-Based

- Ionosonde measurements from more than 100 stations over more than 20 years compiled in the official CCIR (Comite Consultatif International des Radio Communications) maps for the F region electron density peak.
- Incoherent scatter radar measurements from Jicamarca, Peru; Arecibo, Puerto Rico; Millstone Hill, Massachusetts; St. Santin, France; and Malvern, United Kingdom.
- Absorption measurements have been used for indirect checking of IRI.

In Situ

- Alouette, Ariel (topside sounder), AEROS, AE-C (Langmuir probe, retarding potential analyzer).
- Rocket measurements from the United States, Soviet Union, India, and United Kingdom.

continued on page 8



A selection of IRI-79 profiles of electron density (curves through circles) and plasma temperature (electron temperature, squares; ion temperature, triangles). All for March; longtitude 20° E., latitude 43° N. (modip 50°).

B 36911-000A

Radio Science, Volume 21, Number 3, Pages 343-346, May-June 1986

International reference ionosphere: Recent developments

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(Received July 22, 1985; revised August 19, 1985; accepted August 27, 1985.)

An introduction to the history and intentions of the International Reference Ionosphere (IRI) is given and future plans are outlined. The description of the topside electron density profile in the IRI is based on Bent's summary of topside sounder measurements, mainly Alouette. Instead of Bent's tabular form, the IRI has the advantage of an analytical description. Our comparison with AEROS satellite data shows that the IRI model is inaccurate in its description of the latitudinal behavior of the electron density in the topside ionosphere close to the magnetic equator. An improved IRI formula is proposed that closely follows the experimental data. The present IRI is restricted to solar activities reached during the last solar cycle 20. Measurements during the present solar cycle indicate a saturation effect for very high solar activities.

INTRODUCTION

The International Reference Ionosphere (IRI) was established at the end of the 1960's as a joint project of URSI (subcommission 6.4) and COSPAR (task group on the IRI) under the chairmanship of K. Rawer. The intention was and is to produce a reliable standard model of the most important ionospheric parameters (electron density, electron and ion temperature, and ion composition) similar to the COSPAR neutral atmosphere model CIRA.
Guide-lines were determined by the steering committee which over the years included S. A. Bowhill (United States), K. Champion (United States), A. Danilov (U.S.S.R.), K. I. Maeda (Japan), A. P. Mitra (India), M. J. Rycroft (United Kingdom), T. Taubenheim (German Democratic Republic), to name only some.

The IRI represents the global and temporal mean behavior of the undisturbed ionosphere as it is know from ground-based and in situ measurements over the time range 1950-1975. The restrictions are as follows: (1) mean values; the actual values can deviate by up to 25%; for the electron density a quasi-actual profile can be produced when measured F peak values are available; (2) no auroral latitudes; (3) no irregularities (e.g., spread F, magnetic storms); (4) solar sunspot number (12-months running mean) below 130 due to time span of the data sources. Considering our present state of data resources, beyond the above limitations only rather localized empirical modelling is reasonable.

Several IRI workshops during the COSPAR and URSI general assemblies brought together scientists from different countries and different data background. The main issues discussed during these meetings were (1) data hierarchy, where different measurements produced conflicting results a weighting procedure had to be

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agreed upon (e.g., lower ionosphere electron density (COSPAR, 1972)); (2) comparisons between IRI and new data sources; (3) improvements proposed for IRI.

A first edition of the IRI was published as red URSI booklet (60 pages) in 1978 [Rawer et al., 1978] and an improved first edition as a WDC-A report in 1981 [Lincoln and Conkright, 1981].

The IRI is distributed on tapes containing the FORTRAN main program and subroutines, the CCIR coefficients for generating the CCIR predicted F peak values, and some examples for test purposes. The program produces IRI profiles of electron density, CIRA (1972) neutral temperature, electron and ion temperature, percentage of O^+, H^+, He^+, NO^+ and O_2 ions, for given location: geographic or geomagnetic; time: local time, universal time or solar zenith angle; season: month or day of year; solar activity: mean value of solar sunspot number or 10.7 cm solar radio flux (F10.7, Covington index).

The IRI is now used in over 30 research facilities all over the world. Besides ionospheric research, IRI applications range from radio astronomy to satellite orbit control.

FUTURE PLANS CONCERNING THE IRI ELECTRON DENSITY REPRESENTATION

At the URSI IRI workshop in Florence in 1984 a new descriptive scheme for the electron density profiles was accepted. It makes use of Epstein functions which provide smooth transitions between height regions with different electron density gradient (the first member of this function family is the so-called step function). This analytic description was introduced to ionospheric wave propagation studies by Booker [1977] and was elaborated for application to the IRI by Rawer [1984]. It comprises linear parameters (amplitudes) which can be used to satisfy certain constraints (e.g., F, E peak) and nonlinear parameters which are geometric in nature and can be interpreted as transition heights and thicknesses. Given the global and temporal behavior of these nonlinear parameters, the whole electron density profile can then be contructed using the CCIR E and F peak models.

This approach is already applied for the topside ionosphere where three Epstein functions are combined. The IRI is presently restricted to altitudes below 1000 km. Extension to plasmaspheric heights can be reached with an additional Epstein member (two additional parameters) as soon as the data sources allow a reasonable description of these parameters with magnetic field geometry.

For the middle ionosphere, four members are needed. The corresponding parameters would be altitude and density at the E valley and at the F_1 ledge (or at an intermediate profile point to guarantee reliable bottomside thicknesses).

For the lower ionosphere three members should be sufficient. The highly variable shape in this region allows so far only limited predictability.

PROPOSED IMPROVEMENTS FOR THE TOPSIDE ELECTRON DENSITY MODEL

The IRI describes the normalized electron density profile which then can be combined with the F_2 peak altitude and density either measured or predicted by the International Radio Consultative Committee (CCIR).

The present IRI severely underestimates the ionospheric electron content near the magnetic equator. This was noted by McNamara [1984] in his global comparisons between Faraday measurements and IRI predictions. The discrepancies are not due to errors in the predicted values for f_oF_2, as his comparison with ionosonde measurements shows. His investigation indicates that the IRI F_2 layer is too thin to reproduce the observed content. Theoretically determined profiles based on the study of Anderson and Klobuchar [1983] exceed the IRI predictions above and below the F_2 peak. Our comparison between mean values of electron density measured aboard AEROS-A and -B and IRI densities in Figure 1 confirms this shortcoming of the IRI. We find that close to the magnetic equator the IRI underestimates the satellite measurements at altitudes high above the F_2 peak, whereas close to the peak a satisfying degree of agreement is found. The present IRI topside profile is based on a data compilation by Bent and Llewellyn [1970] composed of Alouette and some Ariel

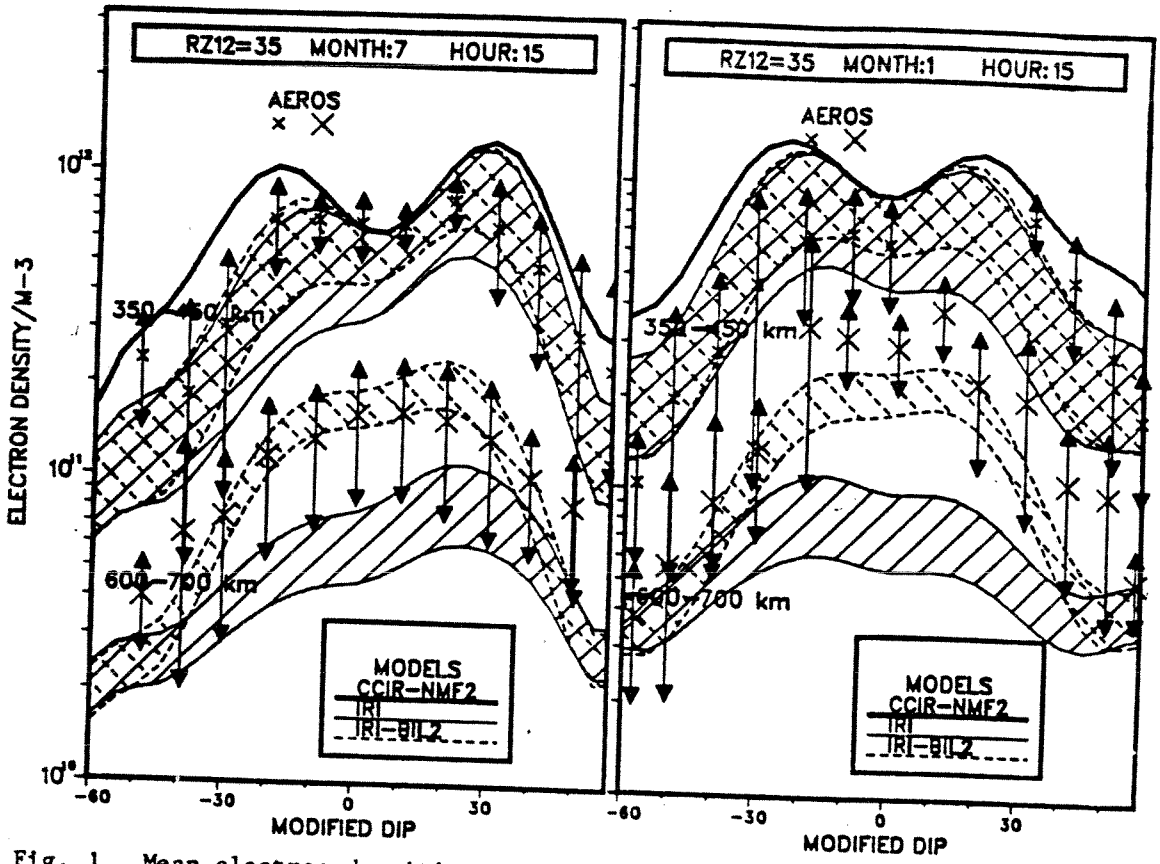

Fig. 1. Mean electron densities measured aboard the AEROS satellites (local time 1400-1600 LT) and IRI predictions for summer and winter conditions (broken line shows improved model; MODIP is modified dip latitude: tan (MODIP)=DIP/[cos(latitude)]$^{1/2}$

3 data. They used a rather crude latitudinal grid (geomagnetic latitude 0°-30°, 30°-60°, 60°-90°) that explains part of the poor prediction quality near the equator.

Figure 1 shows also an improved version of the IRI topside model that is close to the AEROS values. This improvement was reached by substituting the present latitudinal dependence of the relevant IRI paramter ETA: $-0.0070305 \cos^2(\emptyset)$ by $-0.08*E/(1+E)^2$; $E=\exp(-\emptyset/15°)$ and $\emptyset$ is the geomagnetic latitude. Our correction slightly decreases the mentioned electron content discrepancy. For a more profound improvement the profile shape close to the peak has to be reconsidered.

The high solar activites reached during this solar cycle provide the chance of examining the variation of electron density with solar activity above the present IRI validity level. The work by Benkova et al. [1984] presented at the IRI workshop in Stara Zagora, Bulgaria, in 1983 indicates a saturation effect at very high solar activities. Their data collection of mid-latitude rocket, incoherent scatter and satellite measurements over the F10.7 range 80 to 280 shows almost no variation in the relative electron density profile shape above F10.7=150. This has to be further investigated with data from the time span 1979-1982. However, incorporation in the IRI is only meaningful after the CCIR model for the peak values has been updated to these higher solar activities.

Acknowledgments. This contribution was possible through the financial support by Deutsche Forschungsgemeinschaft and by the European Space Agency under contract 5375/83/D.

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Rawer, K., S. Ramakrishnan, and D. Bilitza, International Reference Ionosphere 1978, report, URSI, Brussels, 1978.

D. Bilitza, Goddard Space Flight Center Code 633, Greenbelt, MD 20771.

IRI reports:

World Data Center A for Solar-Terrestrial Physics, Reports UAG-82 (1981) and UAG-90 (1984)

Advances in Space Research, Pergamon Press, Volumes 2/10 (1982), 4/1 (1984), 5/7 (1985), 5/10 (1985)

DESCRIPTION OF MAGNETIC TAPE IRI9-86

This tape contains the the INTERNATIONAL REFERENCE IONOSPHERE (IRI) as presented at the COSPAR meeting in Toulouse July 1986.

NSSDC-Id MI-91C

DATE: December 28, 1986.

COMPUTER: PDP 11/70

FORMAT: 9 track, 1600 BPI, unlabelled, ASCII, 5 files

CONTENT:	(1) FORTRAN-4 IRI main program (driver)	IRIMP9.FOR
	(2) FORTRAN-4 IRI subroutines, functions	IRIFU9.FOR
	(3) FORTRAN-4 IRI special driver	IRIMP0.FOR
	(4) Examples produced with IRIMP9+IRIFU9	IRIEXA.DAT
	(5) CCIR coefficient sets (ASCII)	CCIR.DAT

BLOCKING:	(1) 19 blocks of 40 records of 80 bytes	IRIMP9.FOR
	(2) 28 blocks of 40 records of 80 bytes	IRIFU9.FOR
	(3) 16 blocks of 40 records of 80 bytes	IRIMP0.FOR
	(4) 16 blocks of 20 records of 122 bytes	IRIEXA.DAT
	(5) 215 blocks of 20 records of 122 bytes	CCIR.DAT

EXPLANATION:

(1,2) IRIMP9+IRIFU9 produces altitude profiles of electron density, electron and ion temperature and ion composition (O+,H+,He+,O2+,NO+) for given location (geographic or geomagnetic), solar activity (Rz12), month and local (or universal) time.

(2,3) IRIMP0+IRIFU9 produces temperature and density profiles in (geographic or geomagnetic) latitude or longitude or solar activity or month or local time or universal time at a give altitude. It can also produce these profiles for the peak altitudes and densities (F2, F1, E, D).

(4) IRIEXA contains the IRIMP9-outputs from channels AGNR and KONSOL for several examples.

(5) The CCIR set of coefficients is divided in twelve monthly sets of 2*13*76=1976 coefficients for the F2 critical frequency foF2 plus 2*9*49=882 coefficients for the propagation factor M3000. Each monthly set is written in the FORTRAN-format '1X,8E15.8,1X' that is the format expected in subroutine CCIRCA of IRIFU9. The data file CCIR should be assigned to unit 10.

SOURCE: Dieter Bilitza, GSFC/NSSDC code 633, Greenbelt, MD 20771, tel. (301) 286-9536
SPAN: NSSDCA::[BILITZA]

REFERENCES:

K. Rawer, S. Ramakrishnan and D. Bilitza, IRI 1978, 75p(ages), Report, International Union of Radio Science (URSI), Brussels, 1978.

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Volume 2/10, The Upper Atmosphere of the Earth and Planets, 183-260, 1982.
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Volume 5/7, Models of the Atmosphere and Ionosphere, 1-114, 1985.
Volume 5/10, IRI - Status 1985/86, 131p, 1985.

D. Bilitza, IRI: Recent Develpoments, Radio Sci. 21, 343, 1986.

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C*****************************************************************
C********* INTERNATIONAL REFERENCE IONOSPHERE (IRI). *************
C*****************************************************************
C**************** IRIMP9, AUGUST 1986 ****************************
C****************   DRIVER PROGRAM    ****************************
C*****************************************************************
C*** THIS PROGRAM PRODUCES HEIGHT PROFILES OF                   ***
C***      ELECTRON DENSITY                                      ***
C***      NORMALISED ELECTRON DENSITY (TO F-MAXIMUM)            ***
C***      NEUTRAL TEMPERATURE (CIRA 72)                         ***
C***      ELECTRON TEMPERATURE                                  ***
C***      ION TEMPERATURE                                       ***
C***      ELECTRON TO ION TEMPERATURE RATIO                     ***
C***      RELATIVE PRECENTAGE DENSITIES OF THE IONS             ***
C***           ATOMIC OXYGEN, HYDROGEN, HELIUM,                 ***
C***           MOLECULAR OXYGEN AND NITROGEN OXYD (NO+)         ***
C*****************************************************************
C*** FOR SPECIFIED                                              ***
C***      GEOG. OR GEOM. LATITUDE AND LONGITUDE                 ***
C***      ZURICH SUNSPOT NUMBER (12-MONTH-RUNNING MEAN)         ***
C***      MONTH-NUMBER                                          ***
C***      LOCAL OR UNIVERSAL TIME                               ***
C*****************************************************************
C*** THE ALTITUDE LIMITS ARE:     LOWER          UPPER         ***
C***     ELECTRON DENSITY      60(DAY)/80 KM    1000 KM         ***
C***     TEMPERATURES             120 KM        3000 KM         ***
C***     ION DENSITIES            100 KM        1000 KM         ***
C*****************************************************************
C*     --------------------ADDRESSES-----------------------      *
C*     I  PROF. K. RAWER              DR. D. BILITZA        I    *
C*     I  HERRENSTR. 43               GSFC/NSSDC CODE 633   I    *
C*     I  D-7801 MARCH                GREENBELT MD 20771    I    *
C*     I  F.R.G.                      USA                   I    *
C*     ----------------------------------------------------      *
C*****************************************************************
C*****************************************************************
C*****************************************************************
C*********       ALL ANGLES ARE IN DEGREE          **************
C*********       ALL DENSITIES ARE IN M-3          **************
C*********       ALL ALTITUDES ARE IN KM           **************
C*********     ALL TEMPERATURES ARE IN KELVIN      **************
C*********     ALL TIMES ARE IN DECIMAL HOURS      **************
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C*****************************************************************
C*******************  OPTIONS  ***********************************
C*****************************************************************
C* FOR HMF2=0.0 THE CCIR VALUES FOR FOF2 AND HMF2                *
C* ARE TAKEN BY USE OF THE CCIR-TAPE FOR FOF2 AND M3000.         *
C* THE USER SHOULD ADAPT PROCEDURE CCIRCA TO HIS OWN CCIR-TAPE.  *
C*****************************************************************
C* HOUR        IS LOCAL TIME OR UNIVERSAL TIME + 25              *
C* XHI         CAN BE INPUT OR OUTPUT. IF YOU WANT CALCULATION   *
C*             SET XHI LESS 0.                                   *
C* KOBE        0  (=1 SPECIAL OUTPUT ON UNIVAC)                  *
C* JF(11)      ARE SWITCHES (1=YES,0=NO) TO CHOOSE YOUR PARAMETERS*
C*             (NE,NE/NMF2,TN,TE,TI,TE/TI,O+,H+,HE+,O2+,NO+      *
C* JMAG        =0 MEANS GEOGRAFIC  =1 GEOMAGNETIC LATITUDE       *
C*             AND LONGITUDE.                                    *
C*****************************************************************
C* NE(...)     =0 AE-C AND AEROS MODELS ARE USED FOR ELECTRON    *
C*             TEMPERATURE OTHERWISE THE ANTI-CORRELATION-MODEL  *
C*             IS USED WITH THE GIVEN ELECTRON DENSITY VALUES    *
C*****************************************************************
C*****************************************************************
C* THIS VERSION DIFFERS FROM IRIF08 BY CONTAINING:               *
C* - RESTRICTION OF RZ12/COVM TO VALUES BELOW 145/185            *
C* - CORRECTED HARMONIZED BENT                                   *
C* - NEW ELECTRON TEMPERATURE MODEL                              *
C* - NEWER FOE NIGHT-TIME                                        *
C*****************************************************************
C*****************************************************************
      INTEGER EGNR,AGNR,DAYNR,DDO,DO2,SEASON
      REAL LATI,LONGI,MO2,MO,MODIP,NMF2,MAGBR,
     &  NMF1,NME,NMD,NEI,MM,MLAT,MLONG,NOBO2
      DIMENSION F(3),BOF(32),OUTF(11),RIF(4),XSM(4),HOA(3),AH(4),
     &  JF(11),DDO(4),DO2(2),MM(5),SIPL(2),XNAR(3),ATE(7),TEA(6),
     &  PF10(12),PF30(12),HO(4),MO2(3),MO(5),E(4),SIPH(2),SH(3),
     &  PF20(4),HO2(2),CTNN(3),PG10(80),PG20(32),PG30(80),CTN(3),
     &  XDELS(4),DNDS(4),DTI(4),DTE(5),AHH(7),STTE(6)
      LOGICAL EXT,SCHALT,NIGHT,F1REG
      COMMON/BLOCK1/HMF2,NMF2,HMF1/BLOCK2/B0,B1,C1,HZ,T,HST,STR
     &  /BLOCK3/HDX,HME,NME,HMD,NMD,HEF,D1,XKK,FP30,FP3U,FP1,FP2
     &  /BLOCK5/ZX,TNX,ATN,CTN/BLOCK6/NIGHT,E/BLOTE/AHH,ATE1,
     &  STTE,DTE/CONST/UMR
     &  /BLOCK8/HS,TNHS,XSM,MM,DTI,MXSM/BLO10/BETA,ETA,DELTA,ZETA
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     &  57.,76.,102.,100.,120.,110.,107.,103.,76.,86./,
     &  HOA/300.,400.,600./,DTI/10.,10.,20.,20./,
     &  XDELS/3*5.,10./,DNDS/.016,.01,2*.016/,
     &  AHH/120.,0.,300.,400.,600.,1400.,3000./,
     &  DTE/5.,5.,10.,20.,20./,DDO/9,5,5,50/,DO2/5,5/
      DATA JMAG,LATI,LONGI,R,MONTH,HOUR,XHI,AH,SH,HMF2,FOF2,XNAR
     &  /0,45.1,293.5,100.,10,12.50,-100.0,50,150,500,1000,5,10,
     &   50,298.2,2.346E+11,2.567E+11,1.673E+11,0.0/,JF/3*1,4*0,
     &  4*1/,ILOC,ITIME,ISEL,IALT,IPEAK,ITENE/6*1/
      UMR=ATAN(1.0)*4./180.
      ALOG2=ALOG(2.)
C
C FIRST SPECIFY YOUR COMPUTERS CHANNEL NUMBERS ....................
C EGNR=INPUT, MONITO=MONITOR OUTPUT...............................
C FOR THE CCIR-TAPE CHANNEL 10 IS USED............................
C
      EGNR=5
      MONITO=6
      WRITE(MONITO,5100)
5100  FORMAT('1>>>>>> ENTER YOUR CHANNEL-NR FOR OUTPUT(AGNR)',
     &  ' AND MESSAGES(KONSOL)'/,' DID YOU ASSIGN CCIR.DAT TO',
     &  ' UNIT 10?'/
     &         ' EXAMPLE TO ILLUSTRATE FORMATTED INPUT:'/
     &         ' 15  6')
      READ(EGNR,5101) AGNR,KONSOL
5101  FORMAT(I2,I3)
3329  IF(ILOC.EQ.0) GOTO 5500
      WRITE(MONITO,5000) JMAG,LATI,LONGI
5000  FORMAT(1X/////1X,73('*')/
     &  ' **** INTERNATIONAL REFERENCE IONSPHERE: VERSION IRIF09 ',
     &         '(APRIL 1986) ****'/1X,73('*')///
     &  ' >>>>>> GEOG.(0) OR GEOM.(1) LATITUDE AND LONGITUDE'/
     &         1X,I1,2F6.1)
      READ(EGNR,5001) JMAG,LATI,LONGI
5001  FORMAT(I1,F6.1,F6.1)
5500  IF(ITIME.EQ.0) GOTO 5501
      WRITE(MONITO,5010) R,MONTH,HOUR,XHI
5010  FORMAT(1X//' >>>>>> SOLAR SUNSPOT NUMBER (RZ12),MONTH,',
     &  ' HOUR(DECIMAL),SOLAR',
```

```
     &         ' ZENITH ANGLE (XHI)'/' HOUR IS LOCAL TIME OR UNIVERSAL TIME ',
     &         'PLUS 25.00'/' XHI WILL BE CALCULATED IF YOU SET XHI=-100.0'/
     &         1X,F5.1,I3,F6.2,F7.1)
      READ(EGNR,5011) R,MONTH,HOUR,AXHI
5011  FORMAT(F5.1,I3,F6.2,F7.1)
5501  IF(ISEL.EQ.0) GOTO 5502
      WRITE(MONITO,5030) KOBE,JF
5030  FORMAT(1X//' >>>>>> DUMMY(0), PARAMETER SELECTION YES(1)',
     &  ' NO(0)'/' >>>>>> NE, NE/NMF2,TN,TE,TI,TE/TI,O+,H+,HE+,',
     &  'O2+,NO+'/' NE=2 PRODUCES IRI-8 PROFILE'/1X,I1,1X,11I1)
      READ(EGNR,5031) KOBE,JF
5031  FORMAT(I1,1X,11I1)
      INECH=JF(1)+JF(2)
      KOMB=JF(3)+JF(4)+JF(5)+JF(6)
      IOND=JF(7)+JF(8)+JF(9)+JF(10)+JF(11)
5502  IF(IALT.EQ.0) GOTO 5503
      WRITE(MONITO,5040) AH,SH
5040  FORMAT(1X//' >>>>>> ALTITUDE RANGES(KM): RANGE BONDARIES(4)',
     &  ' AND STEP WIDTHS(3)'/
     &         ' EXAMPLE: 50,55 ... 145,150,160 ... 490,500,550 ... 950,1000'/
     &         1X,F6.1,3F7.1,2X,3F6.1)
      READ(EGNR,5041) AH,SH
5041  FORMAT(F6.1,3F7.1,2X,3F6.1)
5503  IF((INECH.LT.1).OR.(IPEAK.LT.1)) GOTO 5200
      WRITE(MONITO,5050) NMF2,HMF2
5050  FORMAT(1X//' >>>>>> F-PEAK DENSITY(NMF2/M-3) AND ALTITUDE',
     &  '(HMF2/KM)'/' FOF2/MHZ CAN BE GIVEN INSTEAD OF NMF2'/
     &         ' CCIR-FOF2 AND M3000 ARE USED WHEN HMF2=0.'/
     &         1X,1PE8.2,0PF6.1)
      READ(EGNR,5051) FOF2,HMF2
5051  FORMAT(E8.2,F6.1)
5200  IF((KOMB.LT.1).OR.(ITENE.LT.1)) GOTO 5300
      WRITE(MONITO,5060) XNAR
5060  FORMAT(1X//' >>>>>> OPTION TO USE TE-NE-MODEL AT 300,400,600KM',
     &  ' ALTITUDE'/' NE(300), NE(400), NE(600) IN M-3  ',
     &  '(=0  MODEL NOT USED)'/1X,1PE8.2,1X,E8.2,1X,E8.2)
      READ(EGNR,5061) XNAR
5061  FORMAT(E8.2,1X,E8.2,1X,E8.2)
5300  REWIND 10
C
C CALCULATION OF MEAN F10.7CM SOLAR RADIO FLUX (COV)..................
C CALCULATION OF RESTRICTED SOLAR ACTIVITIES (RG,COVG)................
```

```
C
      COV=63.75+R*(0.728+R*0.00089)
      RG=R
      COVG=COV
      IF(R.GT.150.) RG=150.
      IF(COV.GT.193.) COVG=193.
C
C CALCULATION OF GEOG. OR GEOM. COORDINATES IN DEG.....................
C CALCULATION OF MAGNETIC INCLINATION (DIP), DECLINATION (DEC)........
C   DIP LATITUDE (MAGBR) AND MODIFIED DIP (MODIP). ALL IN DEGREE......
C
      IF(JMAG.LE.0) GOTO 888
      MLAT=LATI
      MLONG=LONGI
888   CALL GGM(JMAG,LONGI,LATI,MLONG,MLAT)
      HMEAN=(AH(1)+AH(4))/2.
      IF(HMEAN.GT.325.) HMEAN=300.
      ABSLAT=ABS(LATI)
      CALL FIELDG(LATI,LONGI,HMEAN,XMA,YMA,ZMA,BET,DIP,DEC,MODIP)
      MAGBR=ATAN(0.5*TAN(DIP*UMR))/UMR
C
C CALCULATION OF SEASON (SUMMER=2, WINTER=4)...........................
C CALCULATION OF DAY OF YEAR AND SUN DECLINATION.......................
C
      DAYNR=INT(MONTH*30.42-15.21)
      SUNDEC=-0.40915*COS(.0172142063*(DAYNR+8.))
      SEASON=INT(MONTH/3.0)
      IF(SEASON.LT.1) SEASON=4
      IF(LATI.GT.0.0) GOTO 5592
      SEASON=SEASON-2
      IF(SEASON.LT.1) SEASON=SEASON+4
C
C CALCULATION OF SOLAR ZENITH ANGLE (XHI/DEG)..........................
C NOON VALUE (XHINON)..................................................
C
5592  IF(HOUR.GT.24.) GOTO 2389
      UT=HOUR-LONGI/15.
      IF(UT.LT.0.) UT=UT+24.
      GOTO 2918
2389  UT=HOUR-25.
      HOUR=UT+LONGI/15.
      IF(HOUR.GT.24.) HOUR=HOUR-24.
```

```
2918  Z1=SIN(SUNDEC)*SIN(LATI*UMR)
      Z2=COS(SUNDEC)*COS(LATI*UMR)
      IF(ABS(Z2).GT.0.0) GOTO 120
      SAX=24.0
      IF(Z1.GE.0.0) SAX=0.0
      GOTO 140
120   IF(ABS(Z1/Z2).LE.1.0) GOTO 510
      SAX=24.0
      IF((Z1+Z2).GE.0.0) SAX=0.0
      GOTO 140
510   SAX=12.0-ACOS(-Z1/Z2)/(UMR*15.0)
140   SUX=24.0-SAX
      XLSTA=15.0*(HOUR-12.0)
      COSXHI=Z1+Z2*COS(XLSTA*UMR)
      XHI=ACOS(COSXHI)/UMR
      XHINON=ACOS(Z1+Z2)/UMR
      IF(XHINON.LE.89.0) GOTO 5579
      WRITE(KONSOL,5569) XHINON
5569  FORMAT(1X,'!!!!! YOUR NOON ZENITH ANGLE IS',F7.1,
     &  '; RE-ADJUSTED TO 89.0 !!!!!')
      XHINON=89.0
5579  IF(AXHI.LT.-90.) GOTO 503
      IF(ABS(XHI-AXHI).GT.5.) WRITE(AGNR,2329) AXHI,XHI
2329  FORMAT(1X,'!!! XHI-CHOSEN=',F5.1,' XHI-CALC.=',F5.1,' !!!')
      XHI=AXHI
      COSXHI=COS(XHI*UMR)
503   NIGHT=.FALSE.
      IF((HOUR.GT.SUX).OR.(HOUR.LT.SAX)) NIGHT=.TRUE.
      SUNDEC=SUNDEC/UMR
C
C CALCULATION OF ELECTRON DENSITY PARAMETERS................
C
      HNEA=65.
      IF(NIGHT) HNEA=80.
      HNEE=2000.
      IF(INECH.LT.1) GOTO 4933
      DELA=4.32
      IF(ABS(MODIP).GE.18.) DELA=1.0+EXP(-(ABS(MODIP)-30.0)/10.0)
      DELL=1+EXP(-(ABSLAT-20.)/10.)
C!!!!!!! F-REGION PARAMETERS AND E-PEAK !!!!!!!!!!!!!!!!!!!!!!!!!!
      FOE=FOEEDI(COV,XHI,XHINON,LATI)
      IF(HMF2.GT.0.0) GOTO 501
```

```
      CALL F2OUT(MODIP,LATI,LONGI,RG,MONTH,UT,FOF2,XM3000)
      HMF2=HMF2ED(MAGBR,RG,FOF2/FOE,XM3000)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C FOR CHING-CHIU-VERSION THE LAST STATMENT HAS TO BE REPLACED BY
C     CALL IONDEM(R,MLAT,MLONG,DIP,LATI,HOUR,MONTH,FOF2,HMF2)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
501   IF(FOF2.GT.100.0) FOF2=SQRT(FOF2/1.24E10)
      NMF2=1.24E10*FOF2*FOF2
      COS2=COS(MLAT*UMR)
      COS2=COS2*COS2
      FLU=(COVG-40.0)/30.0
      ETA1=-0.0070305*COS2
      IF(JF(1).EQ.2) GOTO 5566
        EX=EXP(-MLAT/15.)
        EX1=EX+1
        EPIN=4.*EX/(EX1*EX1)
      ETA1=-0.02*EPIN
5566  ETA=0.058798+ETA1+FLU*(-0.014065+0.0069724*COS2)+
     &(0.0024287+0.0042810*COS2-0.00015280*FOF2)*FOF2
      ZETA=0.078922-0.0046702*COS2+FLU*(-0.019132+0.0076545*COS2)+
     &(0.0032513+0.0060290*COS2-0.00020872*FOF2)*FOF2
      BETA=-128.03+20.253*COS2+FLU*(-8.0755-0.65896*COS2)+(0.44041
     &+0.71458*COS2-0.042966*FOF2)*FOF2
      Z=EXP(94.45/BETA)
      Z1=Z+1
      Z2=Z/(BETA*Z1*Z1)
      DELTA=(ETA/Z1-ZETA/2.0)/(ETA*Z2+ZETA/400.0)
1501  B1=3.0
C!!!!!!! INTERPOLATION FOR BO OUT OF ARRAY BOF !!!!!!!!!!!!!!!!!!!!!
      DO 7033 ISR=1,2
      DO 7034 ISL=1,2
      I=(ISR-1)*8+(ISL-1)*16+SEASON*2
7034  SIPH(ISL)=HPOL(HOUR,BOF(I-1),BOF(I),SAX,SUX)
7033  SIPL(ISR)=SIPH(1)+(SIPH(2)-SIPH(1))/DELA
      BO=SIPL(1)+(SIPL(2)-SIPL(1))/90.*(R-10.)
C!!!!!!! F1-REGION PARAMETERS !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      F1REG=.FALSE.
      HMF1=0.
      NMF1=0.
      C1=0.
      XHI0=49.84733+0.349504*ABSLAT
      XHI100=38.96113+0.509932*ABSLAT
```

```
      XHIM=(XHI0+(XHI100-XHI0)*R/100.0)
      IF((XHI.GT.XHIM).OR.NIGHT.OR.(SEASON.EQ.4)) GOTO 150
      F1REG=.TRUE.
      C1=.09+.11/DELA
      FOF1=FOF1ED(MAGBR,R,COSXHI)
      NMF1=1.24E10*FOF1*FOF1
C!!!!!! PARAMETER FOR E AND VALLEY-REGION !!!!!!!!!!!!!!!!!!!!
150   NME=1.24E10*FOE*FOE
      HME=105.0
      XDEL=XDELS(SEASON)/DELA
      DNDHBR=DNDS(SEASON)/DELA
      HDEEP=HPOL(HOUR,10.5/DELA,28.,SAX,SUX)
      WIDTH=HPOL(HOUR,17.8/DELA,45.+22./DELA,SAX,SUX)
      DEPTH=HPOL(HOUR,XDEL,81.,SAX,SUX)
      DLNDH=HPOL(HOUR,DNDHBR,.06,SAX,SUX)
      IF(DEPTH.LT.1.0) GOTO 600
      IF(NIGHT) DEPTH=-DEPTH
      CALL TAL(HDEEP,DEPTH,WIDTH,DLNDH,EXT,E)
      IF(.NOT.EXT) GOTO 667
      WRITE(KONSOL,650)
650   FORMAT(1X,'*NE* E-REGION VALLEY CAN NOT BE MODELLED')
600   WIDTH=.0
667   HEF=HME+WIDTH
C!!!!!!!D-REGION PARAMETER!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      NMD=XMDED(XHI,R,4.0E8)
      HMD=HPOL(HOUR,81.0,88.0,SAX,SUX)
      F(1)=HPOL(HOUR,0.02+0.03/DELA,0.05,SAX,SUX)
      F(2)=HPOL(HOUR,4.6,4.5,SAX,SUX)
      F(3)=HPOL(HOUR,-11.5,-4.0,SAX,SUX)
      FP1=F(1)
      FP2=-FP1*FP1/2.0
      FP30=(-F(2)*FP2-FP1+1.0/F(2))/(F(2)*F(2))
      FP3U=(-F(3)*FP2-FP1-1.0/F(3))/(F(3)*F(3))
      HDX=HMD+F(2)
      X=HDX-HMD
      XDX=NMD*EXP(X*(FP1+X*(FP2+X*FP30)))
      DXDX=XDX*(FP1+X*(2.0*FP2+X*3.0*FP30))
      X=HME-HDX
      XKK=-DXDX*X/(XDX*ALOG(XDX/NME))
      D1=DXDX/(XDX*XKK*X**(XKK-1.0))
C
C SEARCH FOR HMF1 AND HST.................................
```

```
C
3801  IF(F1REG) GOTO 924
      HMF1=HMF2
      GOTO 380
924   H=10.0
133   H=H+10.0
      IF(H.GT.(HMF2-HEF)) GOTO 135
      CALL REGFA1(HMF2-H,HMF2,1.0,NMF1,XE2,SCHALT,HMF1)
      IF(SCHALT) GOTO 133
      GOTO 137
135   WRITE(KONSOL,11)
11    FORMAT(1X,'*NE* HMF1 IS NOT EVALUATED BY THE FUNCTION XE2')
3985  IF (HMF2-HEF.GE.B0) GOTO 922
      BOX=(HMF2-HEF)/1.1
      IF(BOX.LT.10.0) GOTO 922
      WRITE(KONSOL,923) B0,BOX
923   FORMAT(6X,'CORR.: B0(OLD)=',F5.1,' B0(NEW)=',F5.1)
      B0=BOX
      GOTO 924
922   B1X=B1+.5
      IF(B1X.GT.4) GOTO 7398
      WRITE(KONSOL,902) B1,B1X
902   FORMAT(6X,'CORR.: B1(OLD)=',F4.1,' B1(NEW)=',F4.1)
      B1=B1X
      GOTO 924
7398  WRITE(KONSOL,9269)
9269  FORMAT(1X,'CORR.: NO F1 REGION, B1=3, C1=0.0')
      HMF1=0.
      NMF1=0.
      C1=0.0
      B1=3.
      F1REG=.FALSE.
      GOTO 380
137   IF(HMF1.GT.HEF) GOTO 380
      WRITE(KONSOL,9)
9     FORMAT(1X,'*NE* UPPER E-VALLEY LIMIT(HEF) ABOVE HMF1')
      IF((HMF2-HEF.LT.B0).OR.(B1.LT.4)) GOTO 3985
      WRITE(KONSOL,9853)
9853  FORMAT(1X,'CORR.: NO F1 REGION, B1=3, C1=0.0')
      HMF1=0.
      NMF1=0.
      C1=0.0
```

```
      B1=3.
      F1REG=.FALSE.
C!!!!!!! NE3(HST)=NME !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
380   H=-3.
125   H=H+3.0
      IF(H.GT.(HMF1-HEF)) GOTO 900
      CALL REGFA1(HEF+H,HMF1,1.0,NME,XE3,SCHALT,HST)
      STR=HST
      IF(SCHALT) GOTO 125
      GOTO 360
900   WRITE(KONSOL,100)
100   FORMAT(1X,'*NE* HST IS NOT EVALUATED BY THE FUNCTION XE3')
      IF (HMF2-HEF.GE.B0) GOTO 9221
      BOX=(HMF2-HEF)/1.1
      IF(BOX.LT.10.0) GOTO 9221
      WRITE(KONSOL,9231) B0,BOX
9231  FORMAT(6X,'CORR.: B0(OLD)=',F5.1,' B0(NEW)=',F5.1)
      B0=BOX
      GOTO 3801
9221  B1X=B1+.5
      IF(B1X.GT.5) GOTO 7391
      WRITE(KONSOL,9021) B1,B1X
9021  FORMAT(6X,'CORR.: B1(OLD)=',F4.1,' B1(NEW)=',F4.1)
      B1=B1X
      GOTO 3801
7391  B1=3.
      HZ=HEF+.75*(HMF1-HEF)
      WRITE(KONSOL,901) HZ,HEF
901   FORMAT(6X,'CORR.: LIN. APP. BETWEEN HZ=',F5.1,
     &  ' AND HEF=',F5.1)
      XNEHZ=XE(HZ)
      T=(XNEHZ-NME)/(HZ-HEF)
      HST=-333.
      GOTO 6153
360   HZ=(HST+HMF1)/2.0
      D=HZ-HST
      T=D*D/(HZ-HEF-D)
6153  IF(.NOT.F1REG) HMF1=0.
C
C CALCULATION OF NEUTRAL TEMPERATURE PARAMETER...........
C
4933  HTA=120.0
```

```
      HTE=2000.0
      HTNA=90.0
      TNA=183.0
      ZX=125.0
      Z1=XLSTA
      HDEL=ZX-HTNA
      HD2=HDEL*HDEL
      TUN=TUNCAL(COV,LATI,SUNDEC,Z1)
      TNX=371.6678+0.0518806*TUN-294.3505*EXP(-0.00216222*TUN)
      ATN=0.63662*(TUN-TNX)
      TDEL=TNX-TNA
      CTN(1)=1.9*TDEL/HDEL
      CTN(3)=3.0*TDEL/(HD2*HD2)
      CTN(2)=CTN(3)*1.333333*HDEL-CTN(1)/HD2
C
C CALCULATION OF ELECTRON TEMPERATURE PARAMETER................
C
881   CONTINUE
C !!!!!!!!!! TE(120KM)=TN(120KM) !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      ATE(1)=TN(AHH(1),TNX,ATN,CTN)
C !!!!!!!!!! TE-MAXIMUM (JICAMARCA,ARECIBO) !!!!!!!!!!!!!!!!!!!!
      HM=60.*EXP(-(MLAT/22.41)**2)+210.
      AHH(2)=HPOL(HOUR,HM,150.,SAX,SUX)
      TM=800.*EXP(-(MLAT/33.)**2)+1500.
C !!!!!!!!!! TE(300,400KM)=TE-AE-C !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
C !!!!!!!!!! TE(1400,3000KM)=TE-ISIS !!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      IS=SEASON-SEASON/3*2
      CALL TEBA(MAGBR,HOUR,IS,TEA)
      ATE(2)=HPOL(HOUR,TM,TEA(5),SAX,SUX)
      ATE(3)=TEA(1)
      ATE(4)=TEA(2)
      ATE(6)=TEA(3)
      ATE(7)=TEA(4)
C !!!!!!!!!! TE(600KM)=TE-AEROS !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      ETT=EXP(-MLAT/11.35)
      TET=2900.-5600.*ETT/((ETT+1)**2.)
      TEN=839.+1161./(1.+EXP(-(ABS(MLAT)-45.)/5.))
      ATE(5)=HPOL(HOUR,TET,TEN,SAX,SUX)
C !!!!!!!!!! OPTION TO USE TE-NE-RELATION !!!!!!!!!!!!!!!!!!!!!!
C !!!!!!!!!! AT 300, 400 OR 600 KM  !!!!!!!!!!!!!!!!!!!!!!!!!!!!
      DO 3395 I=1,3
3395  IF(XNAR(I).GT.0.) ATE(I+2)=TEDE(HOA(I),XNAR(I),-COV)
```

```
C !!!!!!!!!! TE'S ARE CORRECTED !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
C !!!!!!!!!! ALSO TE > TN ENFORCED !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      TNAHH2=TN(AHH(2),TNX,ATN,CTN)
      IF(ATE(2).LT.TNAHH2) ATE(2)=TNAHH2
      STTE1=(ATE(2)-ATE(1))/(AHH(2)-AHH(1))
      DO 1901 I=2,6
       TNAHHI=TN(AHH(I+1),TNX,ATN,CTN)
       IF(ATE(I+1).LT.TNAHHI) ATE(I+1)=TNAHHI
       STTE2=(ATE(I+1)-ATE(I))/(AHH(I+1)-AHH(I))
       ATE(I)=ATE(I)-(STTE2-STTE1)*DTE(I-1)*ALOG2
1901  STTE1=STTE2
C !!!!!!!!!! GRADIENTS ARE CALCULATED WITH !!!!!!!!!!!!!!!!!!!!
C !!!!!!!!!! CORRECTED REGION BOUNDARIES !!!!!!!!!!!!!!!!!!!!!!
      DO 1902 I=1,6
1902  STTE(I)=(ATE(I+1)-ATE(I))/(AHH(I+1)-AHH(I))
      ATE1=ATE(1)
C
C CALCULATION OF ION TEMPERATURE PARAMETERS....................
C
887   CONTINUE
C !!!!!!!!!! TI(430KM,DAY)=TI-AEROS !!!!!!!!!!!!!!!!!!!!!!!!!!!
      XSM(1)=430.0
      Z1=EXP(-0.09*MLAT)
      TID1=1240.0-1400.0*Z1/((1.0+Z1)*(1.0+Z1))
      MM(2)=HPOL(HOUR,3.0,0.0,SAX,SUX)
C !!!!!!!!!! TN < TI < TE !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      TED1=TEA(6)+90.
      TND1=TUNCAL(COV,LATI,SUNDEC,0.0)
      IF(TED1.LT.TND1) TED1=TND1
      IF(TID1.GT.TED1) TID1=TED1
      IF(TID1.LT.TND1) TID1=TND1
C !!!!!!!!!! TI(430KM,NIGHT)=TI-AEROS !!!!!!!!!!!!!!!!!!!!!!!!!!
      Z1=ABS(MLAT)
      Z2=Z1*(0.47+Z1*0.024)*UMR
      Z3=COS(Z2)
      TIN1=1200.0-300.0*SIGN(1.0,Z3)*SQRT(ABS(Z3))
C !!!!!!!!!! TN < TI < TE !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      TEN1=TEA(5)
      TNN1=TUNCAL(COV,LATI,SUNDEC,180.0)
      IF(TEN1.LT.TNN1) TEN1=TNN1
      IF(TIN1.GT.TEA(5)) TIN1=TEA(5)
      IF(TIN1.LT.TNN1) TIN1=TNN1
```

```
C !!!!!!!!!! TI(430KM,LT) FROM STEP FUNCTION !!!!!!!!!!!!!!!!!!
      TI1=TIN1
      IF(TID1.GT.TIN1) TI1=HPOL(HOUR,TID1,TIN1,SAX,SUX)
C !!!!!!!!!! TANGENT ON TN DETERMINES HS !!!!!!!!!!!!!!!!!!!!!!
      CALL REGFA1(130.0,500.0,0.1,TI1,TEDER,SCHALT,HS)
      IF(SCHALT) HS=200.
      TNHS=TN(HS,TNX,ATN,CTN)
      MM(1)=DTNDH(HS,ATN,CTN)
      IF(SCHALT) MM(1)=(TI1-TNHS)/(XSM(1)-HS)
      MXSM=2
C !!!!!!!!!! XTETI ALTITTUDE WHERE TE=TI !!!!!!!!!!!!!!!!!!!!!!
2391  XTTS=500.
      X=500.
2390    X=X+XTTS
      IF(X.GE.AHH(7)) GOTO 240
      TEX=ELTE(X)
      TIX=TI(X)
      IF(TIX.LT.TEX) GOTO 2390
      X=X-XTTS
      XTTS=XTTS/10.
      IF(XTTS.GT.0.1) GOTO 2390
      XTETI=X+XTTS*5.
C !!!!!!!!!! TI=TE ABOVE XTETI !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      MXSM=3
      MM(3)=STTE(6)
      XSM(2)=XTETI
      IF(XTETI.GT.AHH(6)) GOTO 240
      MXSM=4
      MM(3)=STTE(5)
      MM(4)=STTE(6)
      XSM(3)=AHH(6)
      IF(XTETI.GT.AHH(5)) GOTO 240
      MXSM=5
      DTI(1)=5.
      DTI(2)=5.
      MM(3)=STTE(4)
      MM(4)=STTE(5)
      MM(5)=STTE(6)
      XSM(3)=AHH(5)
      XSM(4)=AHH(6)
C
C INPUT OF THE ION DENSITY PARAMETER ARRAYS PF10,PF20 AND PF30......
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```
C
240   IF(IOND.LT.1) GOTO 141
      RIF(1)=2.
      IF(ABSLAT.LT.30.0) RIF(1)=1.
      RIF(2)=2.
      IF(COV.LT.100.0) RIF(2)=1.
      RIF(3)=SEASON
      IF(SEASON.EQ.1) RIF(3)=3.
      RIF(4)=1.
      IF(NIGHT) RIF(4)=2.
      CALL KOEFP1(PG10)
      CALL KOEFP2 (PG20)
      CALL KOEFP3 (PG30)
      CALL SUFE (PG10,RIF,12,PF10)
      CALL SUFE(PG20,RIF,4,PF20)
      CALL SUFE(PG30,RIF,12,PF30)
C
C CALCULATION OF ION DENSITY PARAMETER..................
C
      HNIA=100.
      HNIE=2000.
      ZZZ1=0.0
      IF(XHI.LE.90.0) ZZZ1=COSXHI
      HFIXO=300.0
      IF((RIF(2).EQ.2.).AND.(RIF(3).EQ.2.)) HFIXO=249.0
      MO(1)=EPSTEP(PF10(1),PF10(2),PF10(3),PF10(4),ZZZ1)
      MO(2)=EPSTEP(PF10(5),PF10(6),PF10(7),PF10(8),ZZZ1)
      MO(3)=0.0
      HO(1)=EPSTEP(PF10(9),PF10(10),PF10(11),PF10(12),ZZZ1)
      HO(4)=PF20(1)
      MO(4)=PF20(2)
      MO(5)=PF20(3)
7100  HO(2)=290.0
      IF((RIF(2).EQ.2.).AND.(RIF(3).EQ.2.)) HO(2)=237.0
      HO(3)=(4.60517-MO(5)*(HO(4)-PF20(4)))/MO(4)+HO(4)
      IF(HO(2).LT.HO(3)) GOTO 7101
      MO(4)=MO(4)-0.001
      GOTO 7100
7101  Z2=5.0
      X=HO(2)
      Z1=0.0
7102  X=X+Z2
```

```
      Y=RPID(X,HFIXO,98.0,4,MO,DDO,HO)
      IF(Y.LE.Z1) GOTO 7103
      Z1=Y
      GOTO 7102
7103  IF(Z2.LE.1.0) GOTO 7104
      X=X-Z2
      Z2=1.0
      GOTO 7102
7104  HOO=X-0.5
      DO 7105 I=2,4,2
      L=I/2
      HO2(L)=PF3O(1+I)+PF3O(2+I)*ZZZ1
7105  MO2(L+1)=PF3O(7+I)+PF3O(8+I)*ZZZ1
      MO2(1)=PF3O(7)+PF3O(8)*ZZZ1
7106  Y=RPID(HOO,PF3O(1),PF3O(2),2,MO2,DO2,HO2)
      IF(Y.LE.0.1) GOTO 1899
      MO2(3)=MO2(3)-0.02
      GOTO 7106
C!!!!!!! RATIO OF NO+ TO O2+ DENSITY AT O+ MAXIMUM IS USED !!!!!!
C!!!!!!! FOR NO+ CALCULATION ABOVE THE O+ MAXIMUM (HOO) !!!!!!!!!
1899  Z1B= RPID (HOO,HFIXO,98.0,4,MO,DDO,HO)
      Z2B= RPID (HOO,PF3O(1),PF3O(2),2,MO2,DO2,HO2)
      NOBO2= (100.0-Z1B-Z2B)/Z2B
      IF(Z2B.LT.1.) NOBO2=0.0
C
C OUTPUT ON THE SPECIFIED DEVICE.................................
C
141   IF(JMAG.EQ.0) GOTO 7055
      WRITE(AGNR,7052) MLAT,MLONG,R,MONTH,HOUR
      WRITE(AGNR,7062) LATI,LONGI,COV,DAYNR
      GOTO 7065
7055  WRITE(AGNR,7054) LATI,LONGI,R,MONTH,HOUR
      WRITE(AGNR,7064) MLAT,MLONG,COV,DAYNR
7065  WRITE(AGNR,7060) DIP,MAGBR,MODIP,DEC
      WRITE(AGNR,7066) XHI,SAX,SUX,SUNDEC
      WRITE(AGNR,7070) NMF2,NMF1,NME,NMD
      WRITE(AGNR,7080) HMF2,HMF1,HME,HMD
      WRITE(AGNR,7091)
7052  FORMAT ('1','INPUT:'/1X,'MLAT=',F5.1,2X,'MLON=',F5.1,
     &  2X,'R=',F4.0,'  MONTH=',I2,'  HOUR=',F5.2)
7054  FORMAT ('1','INPUT:'/1X,'LATI=',F5.1,2X,'LONG=',F5.1,
     &  2X,'R=',F4.0,'  MONTH=',I2,'  HOUR=',F5.2)
```

```
7062  FORMAT (1X/' CALCULATED VALUES:'/1X,
     &  'LATI=',F5.1,' LONG=',F5.1,'   COV=',F5.1,' DAY=',I3)
7064  FORMAT (1X/' CALCULATED VALUES:'/1X,
     &  'MLAT=',F5.1,' MLON=',F5.1,'   COV=',F5.1,' DAY=',I3)
7060  FORMAT(1X,
     &  'DIP =',F5.1,' DIPL=',F5.1,' MODIP=',F5.1,' DEC=',F5.1)
7066  FORMAT(1X,'XHI =',F5.1,' SUNRISE/SET(LT):',F4.1,'/',F4.1,
     &  ' SUN-DEC=',F5.1)
7070  FORMAT(1X,'NMF2=',1PE8.2,2X,'NMF1=',E8.2,3X,
     &  'NME=',E8.2,1X,'NMD=',E8.2)
7080  FORMAT(1X,'HMF2=',F5.1,5X,'HMF1=',F5.1,6X,'HME=',F5.1,
     &  4X,'HMD=',F5.1)
7091  FORMAT(1X/51X,'RELATIVE PRECENTAGE DENSITY'/1X,' H(KM)',3X,
     &  'NE(M-3)',2X,'NE/NMF2 TN(K) TE(K) TI(K)  TE/TI',3X,
     &  'O+   H+  HE+  O2+  NO+')
      MMM=INT((AH(2)-AH(1))/SH(1)+1.4)+INT((AH(3)-AH(2))/SH(2)+
     &  .4)+INT((AH(4)-AH(3))/SH(3)+.4)
      IF(KOBE.EQ.1)
     &  WRITE(12,*) LATI,LONGI,MLAT,MLONG,DIP,MODIP,MAGBR,XHI,
     &  SUNDEC,R,COV,MONTH,HOUR,SAX,SUX,NMF2,NMF1,NME,NMD,HMF2,
     &  HMF1,HME,HMD,MMM
C
C CALCULATION FOR THE REQUIRED HEIGHT RANGE.......................
C
      IF(.NOT.F1REG) HMF1=HZ
      X=AH(1)
      IKL=1
300   DO 7397 KI=1,11
7397  OUTF(KI)=-1.6
      OUTF(1)=-1.
      OUTF(2)=-1.
      OUTF(6)=-1.
      IF((INECH.LT.0).OR.(X.LT.HNEA)) GOTO 330
      NEI=XE(X)
      IF(JF(1).GT.0) OUTF(1)=NEI
      IF(JF(2).GT.0) OUTF(2)=NEI/NMF2
330   IF(KOMB.LT.1) GOTO 7108
      IF((X.GT.HTE).OR.(X.LT.HTA)) GOTO 7108
      TNH=TN(X,TNX,ATN,CTN)
      TIH=TNH
      IF(X.GE.HS) TIH=TI(X)
      TEH=ELTE(X)
```

```
      IF(JF(3).GT.0) OUTF(3)=TNH
      IF(JF(4).GT.0) OUTF(4)=TEH
      IF(JF(5).GT.0) OUTF(5)=TIH
      IF(JF(6).GT.0) OUTF(6)=TEH/TIH
7108  IF(IOND.LT.1) GOTO 7118
      IF((X.GT.HNIE).OR.(X.LT.HNIA)) GOTO 7118
      Z1=RPID(X,HFIXO,98.0,4,MO,DDO,HO)
      Z2=RPID(X,PF3O(1),PF3O(2),2,MO2,DO2,HO2)
      IF(JF(7).GT.0) OUTF(7)=Z1
      IF((JF(8).GT.0).OR.(JF(9).GT.0))
     & CALL RDHHE(X,HOO,Z1,Z2,NOBO2,10.,OUTF(8),OUTF(9))
      IF(JF(10).GT.0) OUTF(10)=Z2
      IF(JF(11).GT.0) OUTF(11)=RDNO(X,HOO,Z2,Z1,NOBO2)
7118  IF(KOBE.EQ.0)
     & WRITE(AGNR,7117) X,OUTF(1),OUTF(2),IFIX(OUTF(3)+.5),
     &  IFIX(OUTF(4)+.5),IFIX(OUTF(5)+.5),OUTF(6),
     &  IFIX(OUTF(7)+.5),IFIX(OUTF(8)+.5),IFIX(OUTF(9)+.5),
     &  IFIX(OUTF(10)+.5),IFIX(OUTF(11)+.5)
      IF(KOBE.EQ.1)
     & WRITE(12,*) X,OUTF(1),OUTF(3),OUTF(4),OUTF(5),
     &  OUTF(7),OUTF(8),OUTF(9),OUTF(10),OUTF(11)
7117  FORMAT(1X,F6.1,2X,1PE9.2,1X,0PF7.4,3I6,F7.2,5I5,F7.2)
      X=X+SH(IKL)
      IF(X.LE.AH(IKL+1)) GOTO 300
      IF(IKL.GT.2) GOTO 4599
      IKL=IKL+1
      X=X-SH(IKL-1)+SH(IKL)
      GOTO 300
4599  WRITE(AGNR,7097)
7097  FORMAT(1X/' NOTE: -1 MEANS NO MODEL VALUE AVAILABLE'
     &        /'           OR PARAMETER WAS NOT REQUESTED')
      IF(AH(4).GT.1000.) WRITE(AGNR,7096)
7096   FORMAT(1X,'NOTE: ABOVE 1000 KM THE MODEL VALUES ARE ',
     &  'EXTRAPOLATIONS')
      IF(ABS(MLAT).GT.60.0) WRITE(AGNR,7099)
7099   FORMAT(1X,'NOTE: IRI IS DESIGNED FOR NON-AURORAL ',
     &  'LATITUDES')
      WRITE(MONITO,5600)
5600  FORMAT(1X//' **** DO YOU WANT TO CONTINUE:',
     &  ' YES(1) NO(0)'/' 1')
      READ(EGNR,5601) IALL
      IF(IALL.EQ.0) GOTO 3330
```

```
      WRITE(MONITO,5602) ILOC,ITIME,ISEL,IALT,IPEAK,ITENE
5602  FORMAT(1X//' **** WHICH PARAMETER DO YOU WANT TO ',
     & 'CHANGE?'/' **** LOCATION,TIME,SELECTION,ALTITUDES,',
     & 'F-PEAK,TE-NE-OPTION'/6I2)
      READ(EGNR,5601) ILOC,ITIME,ISEL,IALT,IPEAK,ITENE
5601  FORMAT(I1,5I2)
      JMAG=0
      HMF2=0.0
      GOTO 3329
3330  CONTINUE
      STOP
      END
```

```
C*************************************************************
C********** INTERNATIONAL REFERENCE IONOSPHERE ****************
C*************************************************************
C****************  IRIFU9, AUGUST 1986  **********************
C**************** FUNCTIONS,SUBROUTINES **********************
C*************************************************************
C*************************************************************
C***  -------------------ADDRESSES-----------------------  ***
C***  I  PROF. K. RAWER              DR. D. BILITZA       I  ***
C***  I  HERRENSTR. 43               GSFC CODE 633        I  ***
C***  I  7801 MARCH 1                GREENBELT MD 20771   I  ***
C***  I  F.R.G.                      USA                  I  ***
C***  I                              TEL. (301)286-9536   I  ***
C***  ---------------------------------------------------  ***
C*************************************************************
C*************************************************************
C
C*************************************************************
C** SUBROUTINE CCIRCA READS THE CCIR-COEFFICIENT SET WITH:   **
C**            READ(10) FOF2,M3000                           **
C** MAKE SURE THAT THE BINARY FILE CCIR.DAT IS ASSIGNED      **
C** OR CHANGE THE ABOVE STATEMENT AS INDICATED IN CCIRCA IF  **
C** YOU ARE USING THE ASCC-CODED CCIR-SET.                   **
C*************************************************************
C
C
C*************************************************************
C*************** ELECTRON DENSITY ****************************
C*************************************************************
C
      FUNCTION XE1(H)
C REPRESENTING ELECTRON DENSITY(M-3) IN THE TOPSIDE IONOSPHERE
C (H=HMF2....1000 KM) BY HARMONIZED BENT-MODEL ADMITTING
C VARIABILITY OFGLOBAL PARAMETER ETA,ZETA,BETA,DELTA WITH
C GEOM. LATITUDE, SMOOTHED SOLAR FLUX AND CRITICAL FREQUENCY
C (SEE MAIN PROGRAM).
C [REF.:K.RAWER,S.RAMAKRISHNAN,1978]
      REAL NMF2
      COMMON/BLOCK1/HMF2,NMF2,HMF1/BLO10/BETA,ETA,DELTA,ZETA
      DXDH=(1000.-HMF2)/700.
      X=(H-HMF2)/DXDH+300.0-DELTA
      E1=EXP((X-394.5)/BETA)
```

```
      E2=EXP((X-300.0)/100.)
      Y=DXDH*(BETA*ETA*ALOG((1.+E1)/(1.+EXP((-94.5-DELTA)/BETA)))
     &+ZETA*(100.*ALOG((1.+E2)/(1.+EXP(-DELTA/100.)))-X+300.-DELTA))
      XE1=NMF2*EXP(-Y)
      RETURN
      END
C
      FUNCTION DXE1N(H)
C LOGARITHMIC DERIVATIVE OF FUNCTION XE1 (KM-1).
      REAL NMF2
      COMMON/BLOCK1/HMF2,NMF2,HMF1/BLO10/BETA,ETA,DELTA,ZETA
      X=(H-HMF2)/(1000.0-HMF2)*700.0+300.0-DELTA
      DXE1N=(ZETA*(1.-1./(1.+EXP((300.-X)/100.)))-
     &ETA*1./(1.+EXP((394.5-X)/BETA)))
      RETURN
      END
C
      REAL FUNCTION XE2(H)
C ELECTRON DENSITY FOR THE BOTTOMSIDE F-REGION (HMF1...HMF2).
      REAL NMF2
      COMMON/BLOCK1/HMF2,NMF2,HMF1/BLOCK2/B0,B1,C1,HZ,T,HST,STR
      X=(HMF2-H)/B0
      XE2=NMF2*EXP(-X**B1)/COSH(X)
      RETURN
      END
C
      REAL FUNCTION XE3(H)
C ELECTRON DENSITY FOR THE F1-LAYER (HZ.....HMF1).
      REAL NMF2
      COMMON/BLOCK1/HMF2,NMF2,HMF1/BLOCK2/B0,B1,C1,HZ,T,HST,STR
      XE3=XE2(H)+NMF2*C1*SQRT(ABS(HMF1-H)/B0)
      RETURN
      END
C
      REAL FUNCTION XE4(H)
C ELECTRON DENSITY FOR THE INDERMEDIUM REGION (HEF..HZ).
      COMMON/BLOCK2/B0,B1,C1,HZ,T,HST,STR/BLOCK3/HDX,HME,
     &  XME,HMD,XMD,HEF,D1,XKK,FP30,FP3U,FP1,FP2
      IF(HST.LT.0.) GOTO 100
      XE4=XE3(HZ+T/2.0-SIGN(1.0,T)*SQRT(T*(HZ-H+T/4.0)))
      RETURN
100   XE4=XME+T*(H-HEF)
```

```
      RETURN
      END
C
      REAL FUNCTION XE5(H)
C ELECTRON DENSITY FOR THE E AND VALLEY REGION (HME..HEF).
      LOGICAL NIGHT
      COMMON/BLOCK3/HDX,HME,XNME,HMD,XNMD,HEF,D1,XKK,FP30,
     &  FP3U,FP1,FP2/BLOCK6/NIGHT,E(4)
      T3=H-HME
      T1=T3*T3*(E(1)+T3*(E(2)+T3*(E(3)+T3*E(4))))
      IF(NIGHT) GOTO 100
      XE5=XNME*(1+T1)
      RETURN
100   XE5=XNME*EXP(T1)
      RETURN
      END
C
      REAL FUNCTION XE6(H)
C ELECTRON DENSITY FOR THE D REGION (HA...HME).
      COMMON/BLOCK3/HDX,HME,XNME,HMD,XNMD,HEF,D1,XKK,FP30,
     &  FP3U,FP1,FP2
      IF(H.GT.HDX) GOTO 100
      Z=H-HMD
      FP3=FP3U
      IF(Z.GT.0.0) FP3=FP30
      XE6=XNMD*EXP(Z*(FP1+Z*(FP2+Z*FP3)))
      RETURN
100   Z=HME-H
      XE6=XNME*EXP(-D1*Z**XKK)
      RETURN
      END
C
      REAL FUNCTION XE(H)
C ELECTRON DENSITY BEETWEEN HA(KM) AND 1000 KM
C SUMMARIZING PROCEDURES  NE1....6;
      COMMON/BLOCK1/HMF2,XNMF2,HMF1/BLOCK2/B0,B1,C1,HZ,T,
     &  HST,STR/BLOCK3/HDX,HME,XNME,HMD,XNMD,HEF,D1,XKK,
     &  FP30,FP3U,FP1,FP2
      IF(H.LT.HMF2) GOTO 100
      XE=XE1(H)
      RETURN
100   IF(H.LT.HMF1) GOTO 300
```

```
      XE=XE2(H)
      RETURN
300   IF(H.LT.HZ) GOTO 400
      XE=XE3(H)
      RETURN
400   IF(H.LT.HEF) GOTO 500
      XE=XE4(H)
      RETURN
500   IF(H.LT.HME) GOTO 600
      XE=XE5(H)
      RETURN
600   XE=XE6(H)
      RETURN
      END
C
C*************************************************************
C***************** ELECTRON TEMPERATURE ********************
C*************************************************************
C
      FUNCTION DTEDH(H,F2,HMAX,D,HO,DTNDH,A)
C D.BILITZA 1978, CALCULATES THE HEIGHT DERIVATIVE
C ELECTRON TEMPERATURE PROFILE AFTER PROCEDURE TE
      IF(H.LT.HO) GOTO 100
      Y=EXP(-0.03*(H-HMAX))
      F=1.0+Y
      DTEDH=D-F2*0.03*Y*(1.0-Y)/(F*F*F)
      RETURN
100   DTEDH=DTNDH+A
      RETURN
      END
C
      SUBROUTINE TELAT(PHI,A,B,XN,P1,P2,C,F1,F2)
C D. BILITZA 1978, CALCULATES THE PARAMETERS F1 AND F2
C NEEDED IN THE ELECTRON TEMPERATURE MODEL PROCEDURE TE,
C BOTH DEPENDING ON GEOMAGNETIC LATITUDE (PHI)
      COMMON/CONST/UMR
      XPHI=ABS(PHI)
      F=(P1+P2*XPHI)*XPHI
      F=F*UMR
      Y=COS(F)
      F1=A-B*SIGN(1.0,Y)*ABS(Y)**XN
      Y=EXP(-0.1*XPHI)
```

```
      F=1.0+Y
      F2=C*Y/(F*F)
      RETURN
      END
C
      FUNCTION TE(H,F1,F2,HMAX,D,HHO,TNH,HTA,A)
C D. BILITZA 1978. ELECTRON TEMPERATURE PROFILE
C IN THE  HEIGHT RANGE 120-1000 KM. F1,F2 ARE LATITUDE DEPENDENT AND
C ARE GIVEN BY TELAT. HMAX IS THE HEIGHT OF A POSSIBLE MAXIMUM
C D THE TEMPERATURE HEIGHT GRADIENT, HO THE INTERSECTION HEIGHT
C BELOW WHICH THE PROFILE IS BUILT TO APPROACH THE CIRA 72 TEMP.
C TNA AT HTA . A TNH ARE COEFFICIENTS OF THE FITTING FUNCTION
      IF(H.LT.HHO) GOTO 10
      Y=EXP(-0.03*(H-HMAX))
      F=1.0+Y
      TE=F1+F2*Y/(F*F)+D*(H-700.0)
      RETURN
10    TE=TNH+A*(H-HTA)
      RETURN
      END
C
      SUBROUTINE TEBA(DIPL,SLT,IS,TE)
C CALCULATES ELECTRON TEMPERATURES TE(1) TO TE(4) AT ALTITUDES
C 300, 400, 1400 AND 3000 KM FOR DIP-LATITUDE DIPL/DEG AND
C LOCAL SOLAR TIME SLT/H USING THE BRACE-THEIS-MODELS (J. ATMOS.
C TERR. PHYS. 43, 1317, 1981); IS=1 EQUINOX, IS=2 SUMMER.
C ALSO CALCULATED ARE THE TEMPERATURES AT 300 KM ALTITUDE FOR
C MIDNIGHT (TE(5)) AND AT 400 KM AT NOON (TE(6)).
      DIMENSION C(4,2,81),A(82),TE(6)
      COMMON/CONST/UMR
      DATA (C(1,1,J),J=1,81)/
     &.3100E1,-.3215E-2,.2440E+0,-.4613E-3,-.1711E-1,.2605E-1,
     &-.9546E-1,.1794E-1,.1270E-1,.2791E-1,.1536E-1,-.6629E-2,
     &-.3616E-2,.1229E-1,.4147E-3,.1447E-2,-.4453E-3,-.1853,
     &-.1245E-1,-.3675E-1,.4965E-2,.5460E-2,.8117E-2,-.1002E-1,
     &.5466E-3,-.3087E-1,-.3435E-2,-.1107E-3,.2199E-2,.4115E-3,
     &.6061E-3,.2916E-3,-.6584E-1,.4729E-2,-.1523E-2,.6689E-3,
     &.1031E-2,.5398E-3,-.1924E-2,-.4565E-1,.7244E-2,-.8543E-4,
     &.1052E-2,-.6696E-3,-.7492E-3,.4405E-1,.3047E-2,.2858E-2,
     &-.1465E-3,.1195E-2,-.1024E-3,.4582E-1,.8749E-3,.3011E-3,
     &.4473E-3,-.2782E-3,.4911E-1,-.1016E-1,.27E-2,-.9304E-3,
     &-.1202E-2,.2210E-1,.2566E-2,-.122E-3,.3987E-3,-.5744E-1,
```

```
&.4408E-2,-.3497E-2,.83E-3,-.3536E-1,-.8813E-2,.2423E-2,
&-.2994E-1,-.1929E-2,-.5268E-3,-.2228E-1,.3385E-2,
&.413E-1,.4876E-2,.2692E-1,.1684E-2/
 DATA (C(1,2,J),J=1,81)/.313654E1,.6796E-2,.181413,.8564E-1,
&-.32856E-1,-.3508E-2,-.1438E-1,-.2454E-1,.2745E-2,.5284E-1,
&.1136E-1,-.1956E-1,-.5805E-2,.2801E-2,-.1211E-2,.4127E-2,
&.2909E-2,-.25751,-.37915E-2,-.136E-1,-.13225E-1,.1202E-1,
&.1256E-1,-.12165E-1,.1326E-1,-.7123E-1,.5793E-3,.1537E-2,
&.6914E-2,-.4173E-2,.1052E-3,-.5765E-3,-.4041E-1,-.1752E-2,
&-.542E-2,-.684E-2,.8921E-3,-.2228E-2,.1428E-2,.6635E-2,-.48045E-2,
&-.1659E-2,-.9341E-3,.223E-3,-.9995E-3,.4285E-1,-.5211E-3,
&-.3293E-2,.179E-2,.6435E-3,-.1891E-3,.3844E-1,.359E-2,-.8139E-3,
&-.1996E-2,.2398E-3,.2938E-1,.761E-2,.347655E-2,.1707E-2,.2769E-3,
&-.157E-1,.983E-3,-.6532E-3,.929E-4,-.2506E-1,.4681E-2,.1461E-2,
&-.3757E-5,-.9728E-2,.2315E-2,.6377E-3,-.1705E-1,.2767E-2,
&-.6992E-3,-.115E-1,-.1644E-2,.3355E-2,-.4326E-2,.2035E-1,.2985E-1/
 DATA (C(2,1,J),J=1,81)/.3136E1,.6498E-2,.2289,.1859E-1,-.3328E-1,
&-.4889E-2,-.3054E-1,-.1773E-1,-.1728E-1,.6555E-1,.1775E-1,
&-.2488E-1,-.9498E-2,.1493E-1,.281E-2,.2406E-2,.5436E-2,-.2115,
&.7007E-2,-.5129E-1,-.7327E-2,.2402E-1,.4772E-2,-.7374E-2,
&-.3835E-3,-.5013E-1,.2866E-2,.2216E-2,.2412E-3,.2094E-2,.122E-2
&,-.1703E-3,-.1082,-.4992E-2,-.4065E-2,.3615E-2,-.2738E-2,
&-.7177E-3,.2173E-3,-.4373E-1,-.375E-2,.5507E-2,-.1567E-2,
&-.1458E-2,-.7397E-3,.7903E-1,.4131E-2,.3714E-2,.1073E-2,
&-.8991E-3,.2976E-3,.2623E-1,.2344E-2,.5608E-3,.4124E-3,.1509E-3,
&.5103E-1,.345E-2,.1283E-2,.7238E-3,-.3464E-4,.1663E-1,-.1644E-2,
&-.71E-3,.5281E-3,-.2729E-1,.3556E-2,-.3391E-2,-.1787E-3,.2154E-2,
&.6476E-2,-.8282E-3,-.2361E-1,.9557E-3,.3205E-3,-.2301E-1,
&-.854E-3,-.1126E-1,-.2323E-2,-.8582E-2,.2683E-1/
 DATA (C(2,2,J),J=1,81)/.3144E1,.8571E-2,.2539,.6937E-1,-.1667E-1,
&.2249E-1,-.4162E-1,.1201E-1,.2435E-1,.5232E-1,.2521E-1,-.199E-1,
&-.7671E-2,.1264E-1,-.1551E-2,-.1928E-2,.3652E-2,-.2019,.5697E-2,
&-.3159E-1,-.1451E-1,.2868E-1,.1377E-1,-.4383E-2,.1172E-1,
&-.5683E-1,.3593E-2,.3571E-2,.3282E-2,.1732E-2,-.4921E-3,-.1165E-2
&,-.1066,-.1892E-1,.357E-2,-.8631E-3,-.1876E-2,-.8414E-4,.2356E-2,
&-.4259E-1,-.322E-2,.4641E-2,.6223E-3,-.168E-2,-.1243E-3,.7393E-1,
&-.3143E-2,-.2362E-2,.1235E-2,-.1551E-2,.2099E-3,.2299E-1,.5301E-2
&,-.4306E-2,-.1303E-2,.7687E-5,.5305E-1,.6642E-2,-.1686E-2,
&.1048E-2,.5958E-3,.4341E-1,-.8819E-4,-.333E-3,-.2158E-3,-.4106E-1
&,.4191E-2,.2045E-2,-.1437E-3,-.1803E-1,-.8072E-3,-.424E-3,
&-.26E-1,-.2329E-2,.5949E-3,-.1371E-1,-.2188E-2,.1788E-1,
&.6405E-3,.5977E-2,.1333E-1/
```

```
      DATA (C(3,1,J),J=1,81)/.3372E1,.1006E-1,.1436,.2023E-2,-.5166E-1,
     &.9606E-2,-.5596E-1,.4914E-3,-.3124E-2,-.4713E-1,-.7371E-2,
     &-.4823E-2,-.2213E-2,.6569E-2,-.1962E-3,.3309E-3,-.3908E-3,
     &-.2836,.7829E-2,.1175E-1,.9919E-3,.6589E-2,.2045E-2,-.7346E-2
     &,-.89E-3,-.347E-1,-.4977E-2,.147E-2,-.2823E-5,.6465E-3,
     &-.1448E-3,.1401E-2,-.8988E-1,-.3293E-4,-.1848E-2,.4439E-3,
     &-.1263E-2,.317E-3,-.6227E-3,.1721E-1,-.199E-2,-.4627E-3,
     &.2897E-5,-.5454E-3,.3385E-3,.8432E-1,-.1951E-2,.1487E-2,
     &.1042E-2,-.4788E-3,-.1276E-3,.2373E-1,.2409E-2,.5263E-3,
     &.1301E-2,-.4177E-3,.3974E-1,.1418E-3,-.1048E-2,-.2982E-3,
     &-.3396E-4,.131E-1,.1413E-2,-.1373E-3,.2638E-3,-.4171E-1,
     &-.5932E-3,-.7523E-3,-.6883E-3,-.2355E-1,.5695E-3,-.2219E-4,
     &-.2301E-1,-.9962E-4,-.6761E-3,.204E-2,-.5479E-3,.2591E-1,
     &-.2425E-2,.1583E-1,.9577E-2/
      DATA (C(3,2,J),J=1,81)/.3367E1,.1038E-1,.1407,.3622E-1,-.3144E-1,
     &.112E-1,-.5674E-1,.3219E-1,.1288E-2,-.5799E-1,-.4609E-2,
     &.3252E-2,-.2859E-3,.1226E-1,-.4539E-2,.1310E-2,-.5603E-3,
     &-.311,-.1268E-2,.1539E-1,.3146E-2,.7787E-2,-.143E-2,-.482E-2
     &,.2924E-2,-.9981E-1,-.7838E-2,-.1663E-3,.4769E-3,.4148E-2,
     &-.1008E-2,-.979E-3,-.9049E-1,-.2994E-2,-.6748E-2,-.9889E-3,
     &.1488E-2,-.1154E-2,-.8412E-4,-.1302E-1,-.4859E-2,-.7172E-3,
     &-.9401E-3,.9101E-3,-.1735E-3,.7055E-1,.6398E-2,-.3103E-2,
     &-.938E-3,-.4E-3,-.1165E-2,.2713E-1,-.1654E-2,.2781E-2,
     &-.5215E-5,.2258E-3,.5022E-1,.95E-2,.4147E-3,.3499E-3,
     &-.6097E-3,.4118E-1,.6556E-2,.3793E-2,-.1226E-3,-.2517E-1,
     &.1491E-3,.1075E-2,.4531E-3,-.9012E-2,.3343E-2,.3431E-2,
     &-.2519E-1,.3793E-4,.5973E-3,-.1423E-1,-.132E-2,-.6048E-2,
     &-.5005E-2,-.115E-1,.2574E-1/
      DATA (C(4,1,J),J=1,81)/.3574E1,.0,.7537E-1,.0,-.8459E-1,
     &0.,-.294E-1,0.,.4547E-1,-.5321E-1,0.,.4328E-2,0.,.6022E-2,
     &.0,-.9168E-3,.0,-.1768,.0,.294E-1,.0,.5902E-3,.0,-.9047E-2,
     &.0,-.6555E-1,.0,-.1033E-2,.0,.1674E-2,.0,.2802E-3,-.6786E-1
     &,.0,.4193E-2,.0,-.6448E-3,.0,.9277E-3,-.1634E-1,.0,-.2531E-2
     &,.0,.193E-4,.0,.528E-1,.0,.2438E-2,.0,-.5292E-3,.0,.1555E-1
     &,.0,-.3259E-2,.0,-.5998E-3,.3168E-1,.0,.2382E-2,.0,-.4078E-3
     &,.2312E-1,.0,.1481E-3,.0,-.1885E-1,.0,.1144E-2,.0,-.9952E-2
     &,.0,-.551E-3,-.202E-1,.0,-.7283E-4,-.1272E-1,.0,.2224E-2,
     &.0,-.251E-2,.2434E-1/
      DATA (C(4,2,J),J=1,81)/.3574E1,-.5639E-2,.7094E-1,
     &-.3347E-1,-.861E-1,-.2877E-1,-.3154E-1,-.2847E-2,.1235E-1,
     &-.5966E-1,-.3236E-2,.3795E-3,-.8634E-3,.3377E-2,-.1071E-3,
     &-.2151E-2,-.4057E-3,-.1783,.126E-1,.2835E-1,-.242E-2,
```

```
     &.3002E-2,-.4684E-2,-.6756E-2,-.7493E-3,-.6147E-1,-.5636E-2
     &,-.1234E-2,-.1613E-2,-.6353E-4,-.2503E-3,-.1729E-3,-.7148E-1
     &,.5326E-2,.4006E-2,.6484E-3,-.1046E-3,-.6034E-3,-.9435E-3,
     &-.2385E-2,.6853E-2,.151E-2,.1319E-2,.9049E-4,-.1999E-3,
     &.3976E-1,.2802E-2,-.103E-2,.5599E-3,-.4791E-3,-.846E-4,
     &.2683E-1,.427E-2,.5911E-3,.2987E-3,-.208E-3,.1396E-1,
     &-.1922E-2,-.1063E-2,.3803E-3,.1343E-3,.1771E-1,-.1038E-2,
     &-.4645E-3,-.2481E-3,-.2251E-1,-.29E-2,-.3977E-3,-.516E-3,
     &-.8079E-2,-.1528E-2,.306E-3,-.1582E-1,-.8536E-3,.1565E-3,
     &-.1252E-1,.2319E-3,.4311E-2,.1024E-2,.1296E-5,.179E-1/
      COLAT=UMR*(90.-DIPL)
      AZ=.2618*SLT
      CALL SPHARM(A,8,8,COLAT,AZ)
      DO 2 K=1,4
      STE=0.
      DO 1 I=1,81
1     STE=STE+A(I)*C(K,IS,I)
2     TE(K)=10.**STE
      DO 4 J=1,2
      STE=0.
      AZ=.2618*(J-1)*12.
      CALL SPHARM(A,8,8,COLAT,AZ)
      DO 3 I=1,81
3     STE=STE+A(I)*C(J,IS,I)
4     TE(J+4)=10.**STE
      RETURN
      END
C
      SUBROUTINE SPHARM(C,L,M,COLAT,AZ)
C CALCULATES THE COEFFICIENTS OF THE SPHERICAL HARMONIC
C EXPANSION THAT WAS USED FOR THE BRACE-THEIS-MODELS.
      DIMENSION C(82)
      C(1)=1.
      K=2
      X=COS(COLAT)
      C(K)=X
      K=K+1
      DO 10 I=2,L
      C(K)=((2*I-1)*X*C(K-1)-(I-1)*C(K-2))/I
10    K=K+1
      Y=SIN(COLAT)
      DO 20 MT=1,M
```

```
      CAZ=COS(MT*AZ)
      SAZ=SIN(MT*AZ)
      C(K)=Y**MT
      K=K+1
      IF(MT.EQ.L) GOTO 16
      C(K)=C(K-1)*X*(2*MT+1)
      K=K+1
      IF((MT+1).EQ.L) GOTO 16
      DO 15 I=2+MT,L
      C(K)=((2*I-1)*X*C(K-1)-(I+MT-1)*C(K-2))/(I-MT)
15    K=K+1
16    N=L-MT+1
      DO 18 I=1,N
      C(K)=C(K-N)*CAZ
      C(K-N)=C(K-N)*SAZ
18    K=K+1
20    CONTINUE
      RETURN
      END
C
      REAL FUNCTION ELTE(H)
C ELECTRON TEMPERATURE PROFILE BASED ON THE TEMPERATURES AT 120
C HMAX,300,400,600,1400,3000 KM ALTITUDE. INBETWEEN CONSTANT
C GRADIENT IS ASSUMED.
      COMMON /BLOTE/AH(7),ATE1,ST(6),D(5)
      SUM=ATE1+ST(1)*(H-AH(1))
      DO 1 I=1,5
      A=H-AH(I+1)
      IF(A/D(I).LT.88.) A=D(I)*ALOG(1.+EXP(A/D(I)))
      B=AH(1)-AH(I+1)
      IF(B/D(I).LT.88.) B=D(I)*ALOG(1.+EXP(B/D(I)))
1     SUM=SUM+(ST(I+1)-ST(I))*(A-B)
      ELTE=SUM
      RETURN
      END
C
      FUNCTION TEDE(H,DEN,COV)
C ELECTRON TEMEPERATURE MODEL AFTER BRACE,THEIS .
C FOR NEG. COV THE MEAN COV-INDEX (3 SOLAR ROT.) IS EXPECTED.
C DEN IS THE ELECTRON DENSITY IN M-3.
      Y=1051.+(17.01*H-2746.)*
     &EXP(-5.122E-4*H+(6.094E-12-3.353E-14*H)*DEN)
```

18

```
      ACOV=ABS(COV)
      YC=1.+(.117+2.02E-3*ACOV)/(1.+EXP(-(ACOV-102.5)/5.))
      IF(COV.LT.0.)
     &YC=1.+(.123+1.69E-3*ACOV)/(1.+EXP(-(ACOV-115.)/10.))
      TEDE=Y*YC
      RETURN
      END
C
C*************************************************************
C**************** NEUTRAL AND ION TEMPERATURE ******************
C*************************************************************
C
      FUNCTION TUNCAL(COV,XLATI,SD,SLSTA)
C CALCULATES THE EXOSPHERIC TEMPERATURE FOR COVINGTON-INDEX
C COV,LATITUDE XLATI,SOLARDEKLINATION SD AND LOCAL SOLAR TIME
C ANGLE SLSTA USING CIRA72-MODEL
      COMMON/CONST/UMR
      TC=379.0+3.24*COV
      ETA=ABS(XLATI-SD)/2.0
      THETA=ABS(XLATI+SD)/2.0
      H1=COS(ETA*UMR)**2.2
      H2=SIN(THETA*UMR)**2.2
      TD=1.0+0.3*H1
      TN=1.0+0.3*H2
      A=(TD-TN)/TN
      TAU=SLSTA-37.0+6.0*SIN((SLSTA+43.0)*UMR)
      X=COS(TAU/2.0*UMR)
      TUNCAL=TC*TN*(1.0+A*SIGN(1.0,X)*ABS(X)**3.0)
      RETURN
      END
C
      REAL FUNCTION TN(X,TTNX,ATN,CCTN)
C NEUTRAL TEMPERATURE
C D. BILITZA, 1978, NEUTRAL TEMPERATURE PROFILE
C APPROXIMATING ROUGHLY CIRA72-MODEL;
      DIMENSION CCTN(3)
      Z=X-125.0
      IF(Z.LE.0.0) GOTO 100
      Y=Z**2.5
      Y=(1.0+(4.5E-6)*Y)*Z
      YY=CCTN(1)/ATN
      Y=YY*Y
```

```
      Y=ATAN(Y)*ATN
      TN=TTNX+Y
      RETURN
100   TN=TTNX+Z*(CCTN(1)+Z*Z*(CCTN(2)+Z*CCTN(3)))
200   RETURN
      END
C
      FUNCTION DTNDH(H,ATN,CCTN)
C DERIVATIVE OF NEUTRAL TEMPERATURE
C D.BILITZA, 1978. APPROXIMATE HEIGHT DERIVATIVE OF NEUTRAL
C CIRA-72 MODEL TEMPERATURE PROFILE
      DIMENSION CCTN(3)
      Z=H-125.0
      IF(Z.GT.0.0) GOTO 100
      DTNDH=CCTN(1)+Z*Z*(3.0*CCTN(2)+Z*4.0*CCTN(3))
      RETURN
100   H1=CCTN(1)/ATN
      H2=Z**2.5
      H3=H1*Z*(1.0+(4.5E-6)*H2)
      DTNDH=ATN/(1.0+H3*H3)*H1*(1.0+(15.75E-6)*H2)
      RETURN
      END
C
      REAL FUNCTION TI(H)
C ION TEMPERATURE FOR HEIGHTS NOT GREATER 1000 KM AND NOT LESS HS
C EXPLANATION SEE FUNCTION RPID.
      REAL MM
      COMMON/BLOCK8/HS,TNHS,XSM(4),MM(5),G(4),M
      SUM=MM(1)*(H-HS)+TNHS
      DO 100 I=1,M-1
      A=H-XSM(I)
      IF(A/G(I).LT.88.) A=G(I)*ALOG(1.0+EXP(A/G(I)))
      B=HS-XSM(I)
      IF(B/G(I).LT.88.) B=G(I)*ALOG(1.0+EXP(B/G(I)))
100   SUM=SUM+(MM(I+1)-MM(I))*(A-B)
      TI=SUM
      RETURN
      END
C
      REAL FUNCTION TEDER(H)
C THIS FUNCTION ALONG WITH PROCEDURE REGFA1 ALLOWS TO FIND
C THE  HEIGHT ABOVE WHICH TN BEGINS TO BE DIFFERENT FROM TI
```

```
      COMMON/BLOCK5/ZX,TNX,ATN,CTN(3)/BLOCK8/HS,TNHS,XSM(4),
     &  XMM(5),G(4),M
      TNH=TN(H,TNX,ATN,CTN)
      DTDX=DTNDH(H,ATN,CTN)
      TEDER=DTDX*(XSM(1)-H)+TNH
      RETURN
      END
C
C*************************************************************
C************* ION RELATIVE PRECENTAGE DENSITY *****************
C*************************************************************
C
      REAL FUNCTION RPID (H, HO, NO, M, ST, ID, XS)
C D.BILITZA,1977,THIS ANALYTIC FUNCTION IS USED TO REPRESENT THE
C RELATIVE PRECENTAGE DENSITY OF ATOMAR AND MOLECULAR OXYGEN IONS.
C THE M+1 HEIGHT GRADIENTS ST(M+1) ARE CONNECTED WITH EPSTEIN-
C STEP-FUNCTIONS AT THE STEP HEIGHTS XS(M) WITH TRANSITION
C THICKNESSES ID(M). RPID(HO,HO,NO,....)=NO.
C INSTEAD OF 88.0 YOU CAN USE THE HIGHEST ALLOWED ARGUMENT
C FOR EXP AT YOUR COMPUTER.
      REAL NO
      DIMENSION ID(4), ST(5), XS(4)
      SUM=(H-HO)*ST(1)
      DO 100  I=1,M
      A=H-XS(I)
      XI=FLOAT(ID(I))
      IF (A/XI.LT.88.0) A=XI*ALOG(1.0+EXP(A/XI))
      B=HO-XS(I)
      IF (B/XI.LT.88.0) B=XI*ALOG(1.0+EXP(B/XI))
100   SUM=SUM+(ST(I+1)-ST(I))*(A-B)
      SUM=NO*EXP(SUM)
      RPID=SUM
      RETURN
      END
C
      SUBROUTINE RDHHE (H,HB,RDOH,RDO2H,RNO,PEHE,RDH,RDHE)
C BILITZA,FEB.82,H+ AND HE+ RELATIVE PERECENTAGE DENSITY BELOW
C 1000 KM. THE O+ AND O2+ REL. PER. DENSITIES SHOULD BE GIVEN
C (RDOH,RDO2H). HB IS THE ALTITUDE OF MAXIMAL O+ DENSITY. PEHE
C IS THE PRECENTAGE OF HE+ IONS COMPARED TO ALL LIGHT IONS.
C RNO IS THE RATIO OF NO+ TO O2+DENSITY AT H=HB.
      RDHE=0.0
```

```
      RDH=0.0
      IF(H.LE.HB) GOTO 100
      REST=100.0-RDOH-RDO2H-RNO*RDO2H
      RDH=REST*(1.-PEHE/100.)
      RDHE=REST*PEHE/100.
100   RETURN
      END
C
      REAL FUNCTION RDNO(H,HB,RDO2H,RDOH,RNO)
C D.BILITZA, 1978. NO+ RELATIVE PERCENTAGE DENSITY ABOVE 100KM.
C FOR MORE INFORMATION SEE SUBROUTINE RDHHE.
      IF (H.GT.HB) GOTO 200
      RDNO=100.0-RDO2H-RDOH
      RETURN
200   RDNO=RNO*RDO2H
      RETURN
      END
C
C*************************************************************
C************* PEAK VALUES ELECTRON DENSITY ******************
C*************************************************************
C
      SUBROUTINE F2OUT(XMODIP,XLATI,XLONGI,R,MONTH,UT,
     &                 FOF2,XM3000)
C CALCULATES FOF2/MHZ AND M3000 USING THE CCIR-MAPS.
C INPUT: MODIFIED DIP LATITUDE XMODIP, GEOG. LATITUDE XLATI,
C LONGITUDE XLONGI (ALL IN DEG.), SMOOTHED SUNSPOT NUMBER R,
C MONTH AND UNIVERSAL TIME UT (DEC. HOURS).
C D.BILITZA,JULY 85.
      DIMENSION FF0(988),XM0(441)
      INTEGER QM(7),QF(9)
      DATA QF/11,11,8,4,1,0,0,0,0/,QM/6,7,5,2,1,0,0/
      CALL CCIRCA(R,MONTH,FF0,XM0)
      FOF2=GAMMA1(XMODIP,XLATI,XLONGI,UT,6,QF,9,76,13,988,FF0)
      XM3000=GAMMA1(XMODIP,XLATI,XLONGI,UT,4,QM,7,49,9,441,XM0)
      RETURN
      END
C
      REAL FUNCTION HMF2ED(XMAGBR,R,X,XM3)
C CALCULATES THE PEAK HEIGHT HMF2/KM FOR THE MAGNETIC
C LATITUDE XMAGBR/DEG. AND THE SMOOTHED ZUERICH SUNSPOT
C NUMBER R USING CCIR-M3000 XM3 AND THE RATIO X=FOF2/FOE.
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```
C [REF. D.BILITZA ET AL., TELECOMM.J., 46, 549-553, 1979]
C D.BILITZA,1980.
      F1=(2.32E-3)*R+0.222
      F2=1.2-(1.16E-2)*EXP((2.39E-2)*R)
      F3=0.096*(R-25.0)/150.0
      DELM=F1*(1.0-R/150.0*EXP(-XMAGBR*XMAGBR/1600.0))/(X-F2)+F3
      HMF2ED=1490.0/(XM3+DELM)-176.0
      RETURN
      END
C
      REAL FUNCTION FOF1ED(YLATI,R,COSXHI)
C CALCULATES FOF1/MHZ FOR DIP-LATITUDE YLATI/DEG., SMOOTHED
C ZURICH SUNSPOT NUMBER R AND COSINE OF SOLAR ZENITH ANGLE
C COSXHI.
C [REF: E.D.DUCHARME ET AL., RADIO SCI., 6,369-378, 1971
C AND 8, 837-839, 1973; HOWEVER WITH MAGNETIC INSTEAD OF GEO-
C MAGNETIC LATITUDE,R.EYFRIG,1979]
C D. BILITZA, 1980.
      XLATI=ABS(YLATI)
      F0=4.35+XLATI*(0.0058-(1.2E-4)*XLATI)
      F100=5.348+XLATI*(0.011-(2.3E-4)*XLATI)
      FS=F0+(F100-F0)*R/100.0
      XMUE=0.093+XLATI*(0.0046-(5.4E-5)*XLATI)+(3.0E-4)*R
      FOF1ED=FS*COSXHI**XMUE
      RETURN
      END
C
      REAL FUNCTION FOEEDI(COV,XHI,XHIM,SLATI)
C CALCULATES FOE/MHZ BY THE EDINBURGH-METHOD.
C INPUT: MEAN 10.7CM SOLAR RADIO FLUX (COV), GEOGRAPHIC
C LATITUDE (SLATI/DEG), SOLAR ZENITH ANGLE (XHI/DEG AND
C XHIM/DEG AT NOON).
C [REF.: KOURIS-MUGGELETON, CCIR DOC. 6/3/07 SEPT.73]
C UP-DATED WITH ARECIBO DATA [TROST, J. GEOPHYS. RES.
C 84, 2736, 1979]
C D.BILITZA, AUGUST 1986.
      COMMON/CONST/UMR
      XLATI=ABS(SLATI)
      A=1.0+0.0094*(COV-66.0)
      SL=COS(XLATI*UMR)
      IF(XLATI.LT.32.0) GOTO 100
      SM=0.11-0.49*SL
```

```
      C=92.0+35.0*SL
      GOTO 400
100   SM=-1.93+1.92*SL
      C=23.0+116.0*SL
400   B=COS(XHIM*UMR)**SM
      SP=1.31
      IF(XLATI.GT.12.0) SP=1.2
      XHIC=XHI-3.*ALOG(1.+EXP((XHI-89.98)/3.))
      D=COS(XHIC*UMR)**SP
      R4FOE=A*B*C*D
      SMIN=0.121+0.0015*(COV-60.)
      SMIN=SMIN*SMIN
      IF(R4FOE.LT.SMIN) R4FOE=SMIN
      FOEEDI=R4FOE**0.25
      RETURN
      END
C
      REAL FUNCTION XMDED(XHI,R,YW)
C D. BILITZA, 1978, CALCULATES ELECTRON DENSITY OF D MAXIMUM.
C XHI/DEG. IS SOLAR ZENITH ANGLE, R SMOOTHED ZURICH SUNSPOT NUMBER
C AND YW/M-3 THE ASSUMED CONSTANT NIGHT VALUE.
C [REF.: D.BILITZA, WORLD DATA CENTER A REPORT UAG-82,7,
C        BOULDER,1981]
      COMMON/CONST/UMR
      Y=6.05E8+0.088E8*R
      Z=(-0.1/(ALOG(YW/Y)))**0.3704
      SUXHI=ACOS(Z)
      IF (SUXHI.LT.1.0472) SUXHI=1.0472
      XXHI=XHI*UMR
      IF (XXHI.GT.SUXHI) GOTO 100
      X=COS(XXHI)
      XMDED=Y*EXP(-0.1/X**2.7)
      RETURN
100   XMDED=YW
      RETURN
      END
C
C*************************************************************
C*************** EARTH MAGNETIC FIELD ***********************
C*************************************************************
C
      SUBROUTINE GGM(ART,LONG,LATI,MLONG,MLAT)
```

```
C CALCULATES GEOMAGNETIC LONGITUDE (MLONG) AND LATITUDE (MLAT)
C FROM GEOGRAFIC LONGITUDE (LONG) AND LATITUDE (LATI) FOR ART=0
C AND REVERSE FOR ART=1. ALL ANGLES IN DEGREE.
C LATITUDE:-90 TO 90. LONGITUDE:0 TO 360 EAST.
      INTEGER ART
      REAL MLONG,MLAT,LONG,LATI
      COMMON/CONST/FAKTOR
      ZPI=FAKTOR*360.
      CBG=11.4*FAKTOR
      CI=COS(CBG)
      SI=SIN(CBG)
      IF(ART.EQ.0) GOTO 10
      CBM=COS(MLAT*FAKTOR)
      SBM=SIN(MLAT*FAKTOR)
      CLM=COS(MLONG*FAKTOR)
      SLM=SIN(MLONG*FAKTOR)
      SBG=SBM*CI-CBM*CLM*SI
      LATI=ASIN(SBG)
      CBG=COS(LATI)
      SLG=(CBM*SLM)/CBG
      CLG=(SBM*SI+CBM*CLM*CI)/CBG
      IF(CLG.GT.1.) CLG=1.
      LONG=ACOS(CLG)
      IF(SLG.LT.0.0) LONG=ZPI-ACOS(CLG)
      LATI=LATI/FAKTOR
      LONG=LONG/FAKTOR
      LONG=LONG-69.8
      IF(LONG.LT.0.0) LONG=LONG+360.0
      RETURN
10    YLG=LONG+69.8
      CBG=COS(LATI*FAKTOR)
      SBG=SIN(LATI*FAKTOR)
      CLG=COS(YLG*FAKTOR)
      SLG=SIN(YLG*FAKTOR)
      SBM=SBG*CI+CBG*CLG*SI
      MLAT=ASIN(SBM)
      CBM=COS(MLAT)
      SLM=(CBG*SLG)/CBM
      CLM=(-SBG*SI+CBG*CLG*CI)/CBM
      IF(CLM.GT.1.) CLM=1.
      MLONG=ACOS(CLM)
      IF(SLM.LT..0) MLONG=ZPI-ACOS(CLM)
```

```
      MLAT=MLAT/FAKTOR
      MLONG=MLONG/FAKTOR
      RETURN
      END
C
      SUBROUTINE FIELDG(DLAT,DLONG,ALT,X,Y,Z,F,DIP,DEC,SMODIP)
C THIS IS A SPECIAL VERSION OF THE POGO 68/10 MAGNETIC FIELD
C LEGENDRE MODEL. TRANSFORMATION COEFF. G(144) VALID FOR 1973.
C INPUT: DLAT, DLONG=GEOGRAPHIC COORDINATES/DEG.(-90/90,0/360),
C        ALT=ALTITUDE/KM.
C OUTPUT: F TOTAL FIELD (GAUSS), Z DOWNWARD VERTICAL COMPONENT
C        X,Y COMPONENTS IN THE EQUATORIAL PLANE (X TO ZERO LONGITUDE).
C        DIP INCLINATION ANGLE(DEGREE). SMODIP RAWER'S MODFIED DIP.
C SHEIK,1977.
      DIMENSION H(144),XI(3),G(144),FEL1(72),FEL2(72)
      COMMON/CONST/UMR
      DATA FEL1/0.0, 0.1506723,0.0101742, -0.0286519, 0.0092606,
     & -0.0130846, 0.0089594, -0.0136808,-0.0001508, -0.0093977,
     & 0.0130650, 0.0020520, -0.0121956, -0.0023451, -0.0208555,
     & 0.0068416,-0.0142659, -0.0093322, -0.0021364, -0.0078910,
     & 0.0045586,  0.0128904, -0.0002951, -0.0237245,0.0289493,
     & 0.0074605, -0.0105741, -0.0005116, -0.0105732, -0.0058542,
     &0.0033268, 0.0078164,0.0211234, 0.0099309, 0.0362792,
     &-0.0201070,-0.0046350,-0.0058722,0.0011147,-0.0013949,
     & -0.0108838,  0.0322263, -0.0147390,  0.0031247, 0.0111986,
     & -0.0109394,0.0058112,  0.2739046, -0.0155682, -0.0253272,
     &  0.0163782, 0.0205730,  0.0022081, 0.0112749,-0.0098427,
     & 0.0072705, 0.0195189, -0.0081132, -0.0071889, -0.0579970,
     & -0.0856642, 0.1884260,-0.7391512, 0.1210288, -0.0241888,
     & -0.0052464, -0.0096312, -0.0044834, 0.0201764,  0.0258343,
     &0.0083033,  0.0077187/
      DATA FEL2/0.0586055,0.0102236,-0.0396107,
     & -0.0167860, -0.2019911, -0.5810815,0.0379916,  3.7508268,
     & 1.8133030, -0.0564250, -0.0557352, 0.1335347, -0.0142641,
     & -0.1024618,0.0970994, -0.0751830,-0.1274948, 0.0402073,
     &  0.0386290, 0.1883088,  0.1838960, -0.7848989,0.7591817,
     & -0.9302389,-0.8560960, 0.6633250, -4.6363869, -13.2599277,
     & 0.1002136,  0.0855714,-0.0991981, -0.0765378,-0.0455264,
     &  0.1169326, -0.2604067, 0.1800076, -0.2223685, -0.6347679,
     &0.5334222, -0.3459502,-0.1573697,  0.8589464, 1.7815990,
     &-6.3347645, -3.1513653, -9.9927750,13.3327637, -35.4897308,
     &37.3466339, -0.5257398,  0.0571474, -0.5421217,  0.2404770,
```

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```
     & -0.1747774,-0.3433644, 0.4829708,0.3935944, 0.4885033,
     &  0.8488121, -0.7640999, -1.8884945, 3.2930784,-7.3497229,
     & 0.1672821,-0.2306652, 10.5782146, 12.6031065, 8.6579742,
     & 215.5209961, -27.1419220,22.3405762,1108.6394043/
      K=0
      DO 10 I=1,72
      K=K+1
      G(K)=FEL1(I)
10    G(72+K)=FEL2(I)
      RLAT=DLAT*UMR
      CT=SIN(RLAT)
      ST=COS(RLAT)
      NMAX=11
      D=SQRT(40680925.0-272336.0*CT*CT)
      RLONG=DLONG*UMR
      CP=COS(RLONG)
      SP=SIN(RLONG)
      ZZZ=(ALT+40408589.0/D)*CT/6371.2
      RHO=(ALT+40680925.0/D)*ST/6371.2
      XXX=RHO*CP
      YYY=RHO*SP
      RQ=1.0/(XXX*XXX+YYY*YYY+ZZZ*ZZZ)
      XI(1)=XXX*RQ
      XI(2)=YYY*RQ
      XI(3)=ZZZ*RQ
      IHMAX=NMAX*NMAX+1
      LAST=IHMAX+NMAX+NMAX
      IMAX=NMAX+NMAX-1
      DO 100 I=IHMAX,LAST
100   H(I)=G(I)
      DO 200 K=1,3,2
      I=IMAX
      IH=IHMAX
300   IL=IH-I
      F1=2./(I-K+2.)
      X1=XI(1)*F1
      Y1=XI(2)*F1
      Z1=XI(3)*(F1+F1)
      I=I-2
      IF((I-1).LT.0) GOTO 400
      IF((I-1).EQ.0) GOTO 500
      DO 600 M=3,I,2
```

```
      H(IL+M+1)=G(IL+M+1)+Z1*H(IH+M+1)+X1*(H(IH+M+3)-H(IH+M-1))-
     &Y1*(H(IH+M+2)+H(IH+M-2))
      H(IL+M)=G(IL+M)+Z1*H(IH+M)+X1*(H(IH+M+2)-H(IH+M-2))+
     &Y1*(H(IH+M+3)+H(IH+M-1))
600   CONTINUE
500   H(IL+2)=G(IL+2)+Z1*H(IH+2)+X1*H(IH+4)-Y1*(H(IH+3)+H(IH))
      H(IL+1)=G(IL+1)+Z1*H(IH+1)+Y1*H(IH+4)+X1*(H(IH+3)-H(IH))
400   H(IL)=G(IL)+Z1*H(IH)+2.0*(X1*H(IH+1)+Y1*H(IH+2))
700   IH=IL
      IF(I.GE.K) GOTO 300
200   CONTINUE
      S=0.5*H(1)+2.0*(H(2)*XI(3)+H(3)*XI(1)+H(4)*XI(2))
      XT=(RQ+RQ)*SQRT(RQ)
      X=XT*(H(3)-S*XXX)
      Y=XT*(H(4)-S*YYY)
      Z=XT*(H(2)-S*ZZZ)
      F=SQRT(X*X+Y*Y+Z*Z)
      BRHO=Y*SP+X*CP
      Y=Y*CP-X*SP
      X=Z*ST-BRHO*CT
      Z=-Z*CT-BRHO*ST
      DIP=ASIN(Z/F)
      DEC=ASIN(Y/SQRT(X*X+Y*Y))
      SMODIP=ASIN(DIP/SQRT(DIP*DIP+ST))
      DIP=DIP/UMR
      DEC=DEC/UMR
      SMODIP=SMODIP/UMR
      RETURN
      END
C
C*************************************************************
C*********** INTERPOLATION AND REST ***************************
C*************************************************************
C
      SUBROUTINE REGFA1(X11,X22,EPS,FW,F,SCHALT,X)
C REGULA-FALSI-PROCEDURE TO FIND X WITH F(X)-FW=0. X1,X2 ARE THE
C STARTING VALUES. THE COMUTATION ENDS WHEN THE X-INTERVAL
C HAS BECOME LESS THAN EPS . IF SIGN(F(X1)-FW)= SIGN(F(X2)-FW)
C THEN SCHALT=.TRUE.
      LOGICAL L1,LINKS,K,SCHALT
      SCHALT=.FALSE.
      X1=X11
```

```
      X2=X22
      F1=F(X1)-FW
      F2=F(X2)-FW
      IF(ABS(SIGN(1.0,F1)-SIGN(1.0,F2))-10E-10) 100,110,110
110   K=.FALSE.
      NG=2
200   X=(X1*F2-X2*F1)/(F2-F1)
      GOTO 400
300   L1=LINKS
      IF(LINKS) GOTO 500
      X=X1+FLOAT(NG-1)*(X2-X1)/FLOAT(NG)
      GOTO 400
500   X=X1+(X2-X1)/FLOAT(NG)
400   FX=F(X)-FW
      LINKS=SIGN(1.0,F1)*SIGN(1.0,FX).GT.0
      K=.NOT.K
      IF(LINKS) GOTO 600
      X2=X
      F2=FX
      GOTO 700
600   X1=X
      F1=FX
700   IF(ABS(X2-X1).LE.EPS) GOTO 800
      IF(K) GOTO 300
      IF((LINKS.AND.(.NOT.L1)).OR.(.NOT.LINKS.AND.L1)) NG=2*NG
      GOTO 200
100   X=0.0
      SCHALT=.TRUE.
800   RETURN
      END
C
      SUBROUTINE TAL(SHABR,SDELTA,SHBR,SDTDHO,AUS6,SPT)
C CALCULATES THE COEFFICIENTS SPT FOR THE POLYNOMIAL
C Y(X)=1+SPT(1)*X**2+SPT(2)*X**3+SPT(3)*X**4+SPT(4)*X**5
C TO FIT THE VALLEY IN Y, REPRESENTED BY:
C Y(X=0)=1, THE X VALUE OF THE DEEPEST VALLEY POINT (SHABR),
C THE PRECENTAGE DEPTH (SDELTA), THE WIDTH (SHBR) AND THE
C DERIVATIVE DY/DX AT THE UPPER VALLEY BOUNDRY (SDTDHO).
C IF THERE IS AN UNWANTED ADDITIONAL EXTREMUM IN THE VALLEY
C REGION, THEN AUS6=.TRUE., ELSE AUS6=.FALSE..
C FOR -SDELTA THE COEFF. ARE CALCULATED FOR THE FUNCTION
C Y(X)=EXP(SPT(1)*X**2+...+SPT(4)*X**5).
```

```
      DIMENSION SPT(4)
      LOGICAL AUS6
      Z1=-SDELTA/(100.0*SHABR*SHABR)
      IF(SDELTA.GT.0.) GOTO 500
      SDELTA=-SDELTA
      Z1=ALOG(1.-SDELTA/100.)/(SHABR*SHABR)
500   Z3=SDTDH0/(2.*SHBR)
      Z4=SHABR-SHBR
      SPT(4)=2.0*(Z1*(SHBR-2.0*SHABR)*SHBR+Z3*Z4*SHABR)/
     &  (SHABR*SHBR*Z4*Z4*Z4)
      SPT(3)=Z1*(2.0*SHBR-3.0*SHABR)/(SHABR*Z4*Z4)-
     &  (2.*SHABR+SHBR)*SPT(4)
      SPT(2)=-2.0*Z1/SHABR-2.0*SHABR*SPT(3)-3.0*SHABR*SHABR*SPT(4)
      SPT(1)=Z1-SHABR*(SPT(2)+SHABR*(SPT(3)+SHABR*SPT(4)))
      AUS6=.FALSE.
      B=4.*SPT(3)/(5.*SPT(4))+SHABR
      C=-2.*SPT(1)/(5*SPT(4)*SHABR)
      Z2=B*B/4.-C
      IF(Z2.LT.0.0) GOTO 300
      Z3=SQRT(Z2)
      Z1=B/2.
      Z2=-Z1+Z3
      IF(Z2.GT.0.0.AND.Z2.LT.SHBR) AUS6=.TRUE.
      IF (ABS(Z3).GT.1.E-15) GOTO 400
      Z2=C/Z2
      IF(Z2.GT.0.0.AND.Z2.LT.SHBR) AUS6=.TRUE.
      RETURN
400   Z2=-Z1-Z3
      IF(Z2.GT.0.0.AND.Z2.LT.SHBR) AUS6=.TRUE.
300   RETURN
      END
C
      REAL FUNCTION GAMMA1(SMODIP,SLAT,SLONG,HOUR,IHARM,NQ,
     &  K1,M,MM,M3,SFE)
C CALCULATES GAMMA1=FOF2 OR M3000 USING CCIR NUMERICAL MAP
C COEFFICIENTS SFE(M3) FOR MODIFIED DIP LATITUDE (SMODIP/DEG)
C GEOGRAPHIC LATITUDE (SLAT/DEG) AND LONGITUDE (SLONG/DEG)
C AND UNIVERSIAL TIME (HOUR/DECIMAL HOURS).
C NQ(K1) IS AN INTEGER ARRAY GIVING THE HIGHEST DEGREES IN
C LATITUDE FOR EACH LONGITUDE HARMONIC.
C M=1+NQ1+2(NQ2+1)+2(NQ3+1)+... .
C SHEIKH,4.3.77.
```

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```
      REAL*8 C(12),S(12),COEF(100),SUM
      DIMENSION NQ(K1),XSINX(13),SFE(M3)
      COMMON/CONST/UMR
      HOU=(15.0*HOUR-180.0)*UMR
      S(1)=SIN(HOU)
      C(1)=COS(HOU)
      DO 250 I=2,IHARM
      C(I)=C(1)*C(I-1)-S(1)*S(I-1)
      S(I)=C(1)*S(I-1)+S(1)*C(I-1)
250   CONTINUE
      DO 300 I=1,M
      MI=(I-1)*MM
      COEF(I)=SFE(MI+1)
      DO 300 J=1,IHARM
      COEF(I)=COEF(I)+SFE(MI+2*J)*S(J)+SFE(MI+2*J+1)*C(J)
300   CONTINUE
      SUM=COEF(1)
      SS=SIN(SMODIP*UMR)
      S3=SS
      XSINX(1)=1.0
      INDEX=NQ(1)
      DO 350 J=1,INDEX
      SUM=SUM+COEF(1+J)*SS
      XSINX(J+1)=SS
      SS=SS*S3
350   CONTINUE
      XSINX(NQ(1)+2)=SS
      NP=NQ(1)+1
      SS=COS(SLAT*UMR)
      S3=SS
      DO 400 J=2,K1
      S0=SLONG*(J-1.)*UMR
      S1=COS(S0)
      S2=SIN(S0)
      INDEX=NQ(J)+1
      DO 450 L=1,INDEX
      NP=NP+1
      SUM=SUM+COEF(NP)*XSINX(L)*SS*S1
      NP=NP+1
      SUM=SUM+COEF(NP)*XSINX(L)*SS*S2
450   CONTINUE
      SS=SS*S3
```

```
400   CONTINUE
      GAMMA1=SUM
      RETURN
      END
C
      SUBROUTINE CCIRMO(MONTH,F2,FM3)
C THIS SUBROUTINE READS THE CCIR-COEFFICIENT SETS F2(13,76,2) AND
C FM3(9,49,2) FROM UNIT 10 FOR THE DESIRED MONTH.
      DIMENSION F2(13,76,2),FM3(9,49,2)
      DO 10 I=1,MONTH
10    READ(10) F2,FM3
      RETURN
      END
C
      SUBROUTINE CCIRRZ(R,F2,FM3,FOF2,SM3000)
C THIS SUBROUTINE CALCULATES THE
C SOLAR ACTIVITY (RZ12=R) INTERPOLATED ARRAYS FOF2(988=13*76) AND
C SM3000(441=9*49) OUT OF F2 AND FM3.
      DIMENSION FOF2(988),SM3000(441),F2(13,76,2),FM3(9,49,2)
      RR2=R/100.
      RR1=1.-RR2
      DO 20 I=1,76
      DO 20 J=1,13
      K=J+13*(I-1)
20    FOF2(K)=F2(J,I,1)*RR1+F2(J,I,2)*RR2
      DO 30 I=1,49
      DO 30 J=1,9
      K=J+9*(I-1)
30    SM3000(K)=FM3(J,I,1)*RR1+FM3(J,I,2)*RR2
      RETURN
      END
C
      SUBROUTINE CCIRCA(R,MONTH,FOF2,SM3000)
C THIS SUBROUTINE READS THE CCIR-COEFFICIENT SETS F2(13,76,2) AND
C FM3(9,49,2) FROM UNIT 10 FOR THE DESIRED MONTH AND STORES THE
C SOLAR ACTIVITY (RZ12=R) INTERPOLATED ARRAYS FOF2(988=13*76) AND
C SM3000(441=9*49).
      DIMENSION FOF2(988),SM3000(441),F2(13,76,2),FM3(9,49,2)
      DO 10 I=1,MONTH
C ***********************************************************
C THIS IS EXPECTING ASCII-CODED CCIR-COEFFICIENTS, IF YOU
C USE THE BINARY-CODED SET YOU HAVE TO REPLACE THE NEXT
```

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```
C STATEMENT BY:   READ(10) F2,FM3
C ******************************************************
      READ(10,1) F2,FM3
10    CONTINUE
1     FORMAT(1X,8E15.8)
      RR2=R/100.
      RR1=1.-RR2
      DO 20 I=1,76
      DO 20 J=1,13
      K=J+13*(I-1)
20    FOF2(K)=F2(J,I,1)*RR1+F2(J,I,2)*RR2
      DO 30 I=1,49
      DO 30 J=1,9
      K=J+9*(I-1)
30    SM3000(K)=FM3(J,I,1)*RR1+FM3(J,I,2)*RR2
      RETURN
      END
C
      SUBROUTINE  KOEFP1(PG10)
C THIEMANN,1979,COEFFICIENTS PG10 FOR CALCULATING  O+ PROFILES
C BELOW THE F2-MAXIMUM. CHOSEN TO APPROACH DANILOV-
C SEMENOV'S COMPILATION.
      DIMENSION PG10(80)
      REAL FELD (80)
      DATA FELD/-11.0,-11.0,4.0,-11.0,0.08018,
     &0.13027,0.04216,0.25  ,-0.00686,0.00999,
     &5.113,0.1 ,170.0,180.0,0.1175,0.15,-11.0,
     &1.0 ,2.0,-11.0,0.069,0.161,0.254,0.18,0.0161,
     &0.0216,0.03014,0.1,152.0,167.0,0.04916,
     &0.17,-11.0,2.0,2.0,-11.0,0.072,0.092,0.014,0.21,
     &0.01389,0.03863,0.05762,0.12,165.0,168.0,0.008,
     &0.258,-11.0,1.0,3.0,-11.0,0.091,0.088,
     &0.008,0.34,0.0067,0.0195,0.04,0.1,158.0,172.0,
     &0.01,0.24,-11.0,2.0,3.0, -11.0,0.083,0.102,
     &0.045,0.03,0.00127,0.01,0.05,0.09,167.0,185.0,
     &0.015,0.18/
      K=0
      DO 10 I=1,80
      K=K+1
10    PG10(K)=FELD(I)
      RETURN
      END
```

```
C
      SUBROUTINE KOEFP2(PG20)
C THIEMANN,1979,COEFFICIENTS FOR CALCULATION OF O+ PROFILES
C ABOVE THE F2-MAXIMUM (DUMBS,SPENNER:AEROS-COMPILATION)
      DIMENSION PG20(32)
      REAL FELD(32)
      DATA FELD/1.0,-11.0,-11.0,1.0,695.0,-.000781,
     &-.00264,2177.0,1.0,-11.0,-11.0,2.0,570.0,
     &-.002,-.0052,1040.0,2.0,-11.0,-11.0,1.0,695.0,
     &-.000786,-.00165,3367.0,2.0,-11.0,-11.0,2.0,
     &575.0,-.00126,-.00524,1380.0/
      K=0
      DO 10 I=1,32
      K=K+1
10    PG20(K)=FELD(I)
      RETURN
      END
C
      SUBROUTINE  KOEFP3(PG30)
C THIEMANN,1979,COEFFICIENTS FOR CALCULATING O2+ PROFILES.
C CHOSEN AS TO APPROACH DANILOV-SEMENOV'S COMPILATION.
      DIMENSION PG30(80)
      REAL FELD(80)
      DATA FELD/-11.0,1.0,2.0,-11.0,160.0,31.0,130.0,
     &-10.0,198.0,0.0,0.05922,-0.07983,
     &-0.00397,0.00085,-0.00313,0.0,-11.0,2.0,2.0,-11.0,
     &140.0,30.0,130.0,-10.0,
     &190.0,0.0,0.05107,-0.07964,0.00097,-0.01118,-0.02614,
     &-0.09537,
     &-11.0,1.0,3.0,-11.0,140.0,37.0,125.0,0.0,182.0,
     &0.0,0.0307,-0.04968,-0.00248,
     &-0.02451,-0.00313,0.0,-11.0,2.0,3.0,-11.0,
     &140.0,37.0,125.0,0.0,170.0,0.0,
     &0.02806,-0.04716,0.00066,-0.02763,-0.02247,-0.01919,
     &-11.0,-11.0,4.0,-11.0,140.0,45.0,136.0,-9.0,
     &181.0,-26.0,0.02994,-0.04879,
     &-0.01396,0.00089,-0.09929,0.05589/
      K=0
      DO 10 I=1,80
      K=K+1
10    PG30(K)=FELD(I)
      RETURN
```

```
      END
C
      SUBROUTINE SUFE (FIELD,RFE,M,FE)
C SELECTS THE REQUIRED ION DENSITY PARAMETER SET.
C THE INPUT FIELD INCLUDES DIFFERENT SETS OF DIMENSION M EACH
C CARACTERISED BY 4 HEADER NUMBERS. RFE(4) SHOULD CONTAIN THE
C CHOSEN HEADER NUMBERS.FE(M) IS THE CORRESPONDING SET.
      DIMENSION RFE(4),FE(12),FIELD(80),EFE(4)
      K=0
100   DO 101 I=1,4
      K=K+1
101   EFE(I)=FIELD(K)
      DO 111 I=1,M
      K=K+1
111   FE(I)=FIELD(K)
      DO 120 I=1,4
      IF((EFE(I).GT.-10.0).AND.(RFE(I).NE.EFE(I))) GOTO 100
120   CONTINUE
      RETURN
      END
C
      FUNCTION HPOL(XHOUR,TW,XNW,SA,SU)
C PROCEDURE FOR SMOOTH TIME-INTERPOLATION USING EPSTEIN
C STEP FUNCTION OF ONE HOUR WIDTH AT SUNRISE AND SUNSET.
C TW,NW ARE THE DAY AND NIGHT VALUE OF THE PARAMETER TO
C BE INTERPOLATED. SA AND SU ARE TIME OF SUNRISE AND
C SUNSET IN DECIMAL HOURS.
C BILITZA, 1979.
      IF(ABS(SU-SA).GE.24.0) GOTO 100
      HPOL=XNW+(TW-XNW)/(1.0+EXP(-(XHOUR-SA)/1.0))+(XNW-TW)
     &/(1.0+EXP(-(XHOUR-SU)/1.0))
      RETURN
100   HPOL=XNW
      IF(SA.LT.1.0) HPOL=TW
      RETURN
      END
C
      FUNCTION EPSTEP(BE,AB,TH,FIX,COSI)
C EPSTEIN STEP FUNCTION = TRANSITION WITH THICKNESS TH BETWEEN
C BE AND AB CENTERED WHERE VARIABLE COSI EQUALS FIX.
      EPSTEP=AB+(BE-AB)/(1.0+EXP(-(COSI-FIX)/TH))
      RETURN
```

```
      END
```

```
C*****************************************************************
C****************** IRIMPO, OCT 1986 *****************************
C*****************************************************************
C**  SPECIAL IRI DRIVER PROGRAM TO GENERATE IRI PROFILES IN      **
C**  ALTITUDE, GEOGRAPHIC OR GEOMAGNETIC LATITUDE, LONGITUDE,    **
C**  SOLAR ACTIVITY, MONTH, LOCAL OR UNIVERSAL TIME,             **
C**  OR ALTITUDE.                                                **
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C*****************************************************************
C** INPUT: JMAG,LATI,LONG,R,MONTH,HOUR,H,IVAR,ZBEG,ZSTEP,ZEND,   **
C**        ZEND,JNE,JTETI,JNI,JOUT                               **
C**                                                              **
C** JMAG         =0 GEOGRAPHIC, =1 GEOMAGNETIC COORDINATES        **
C** LATI,LONG    GEOG. OR GEOM. LATITUDE AND LONGITUDE IN DEGREES**
C** R            SOLAR SUNSPOT NUMBER 12-MONTHS-RUNNING MEAN      **
C** HOUR         LOCAL TIME IN DECIMAL HOURS                      **
C**              +25  UNIVERSAL TIME                              **
C** H            ALTITUDE IN KM                                   **
C**              =0 GIVES F2,F1,E,D PEAK ALTITUDES (KM) AND       **
C**                 DENSITIES (CM-3)                             **
C** IVAR         =1,2,3,4,5  FOR PROFILE IN LATI, LONG, R, HOUR   **
C**                OR H RESPECTIVELY                             **
C** ZBEG,ZSTEP   BEGIN, STEP AND END VALUE OF PARAMETER CHOSEN    **
C**   ,ZEND          WITH IVAR                                   **
C** JNE          =1(0)   ELECTRON DENSITY (NOT) REQUESTED         **
C** JTETI        =1(0)   TEMPERATURES OF NEUTRALS, IONS AND       **
C**                        ELECTRONS (NOT) REQUESTED             **
C** JNI          =1(0)   RELATIVE ION DENSITIES (NOT) REQUESTED   **
C** JOUT         =0 NORMAL OUTPUT ON PRINTER AND FILE             **
C**              =2 UNFORMATTED OUTPUT                            **
C** JMAG         =2,3 GEOMAGNETIC COORDINATES ARE USED, BUT THE   **
C**                   OUTPUT (X-COORDINATE) WILL BE THE          **
C**                   CALCULATED DIP(2) OR MODIP(3)              **
C*****************************************************************
C***** YOU HAVE TO ADJUST THE INPUT AND OUTPUT FORMATS TO     *****
C***** YOUR COMPUTER ALSO NOTE THAT CONDITIONAL IF IS USED    *****
C***** (IF .... ENDIF). PLEASE ASSIGN CCIR-COEFFICIENT SET    *****
C***** TO UNIT 10 AND LINK IRIMPO WITH IRIFU9.                *****
C*****************************************************************
      INTEGER EGNR,AGNR,DAYNR,DDO,DO2,SEASON
      REAL LATI,LONGI,MO2,MO,MODIP,NMF2,MAGBR,
     &  NMF1,NME,NMD,NEI,MM,MLAT,MLONG,NOBO2
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      DIMENSION BOF(32),RIF(4),XSM(4),HOA(3),F(3),DDO(4),DO2(2),
     &  MM(5),SIPL(2),XNAR(3),ATE(7),TEA(6),PF10(12),PF30(12),
     &  HO(4),HO2(2),MO2(3),MO(5),E(4),SIPH(2),XVAR(6),PF20(4),
     &  CTNN(3),PG10(80),PG20(32),PG30(80),CTN(3),XDELS(4),
     &  DNDS(4),PARF(14),OUTF(9),DTI(4),DTE(5),AHH(7),STTE(6)
      LOGICAL SCHALT,EXT,NIGHT,F1REG
      COMMON/BLOCK1/HMF2,NMF2,HMF1/BLOCK2/B0,B1,C1,HZ,T,HST,STR
     &  /BLOCK3/HDX,HME,NME,HMD,NMD,HEF,D1,XKK,FP30,FP3U,FP1,FP2
     &  /BLOCK5/ZX,TNX,ATN,CTN/BLOCK6/NIGHT,E
     &  /BLOTE/AHH,ATE1,STTE,DTE/CONST/UMR
     &  /BLOCK8/HS,TNHS,XSM,MM,DTI,MXSM
     &  /BLO10/BETA,ETA,DELTA,ZETA
      EXTERNAL XE1,XE2,XE3,XE4,XE5,XE6,TEDER
      DATA BOF/114.,64.,134.,77.,128.,66.,75.,73.,113.,115.,
     &  150.,116.,138.,123.,94.,132.,72.,84.,83.,89.,75.,85.,
     &  57.,76.,102.,100.,120.,110.,107.,103.,76.,86./,
     & HOA/300.,400.,600./,AHH/120.,0.,300.,400.,600.,1400.,
     &  3000./,DTE/5.,5.,10.,20.,20./,DDO/9,5,5,50/,DO2/5,5/,
     & XDELS/3*5.,10./,DNDS/.016,.01,2*.016/,XNAR/3*0.0/,
     & DTI/10.,10.,20.,20./
C
C OPEN OUTPUT FILE IRI.DAT ........................................
C
      OPEN(UNIT=16,NAME='IRI.DAT',TYPE='NEW',FORM='FORMATTED')
      UMR=ATAN(1.)*4./180.
      ALOG2=ALOG(2.)
C
C FIRST SPECIFY YOUR COMPUTERS CHANNEL NUMBERS ....................
C EGNR=INPUT, MONITO=MONITOR OUTPUT ...............................
C FOR THE CCIR-TAPE CHANNEL 10 IS USED ............................
C
      EGNR=5
      MONITO=6
      KONSOL=6
2234  WRITE(6,2122)
2122  FORMAT(1X,'M,K,JMAG,LATI,LONG,R,MONTH,HOUR,H,IVAR,ZBEG,',
     &     'ZSTEP,ZEND,JNE,JTETI,JNI,JOUT'/1X,
     &     '>>>>H=0 PEAKS<<<<>>>>HOUR+25: UNIVERSAL TIME<<<<'
     &     /1X,'>>>>JNE=1 IRI =2 IRI-COV =3 IRI-OLD<<<<')
      READ(5,*) MONITO,KONSOL,JMAG,LATI,LONGI,R,MONTH,HOUR,HEIGHT,
     &     IVAR,ZBEGIN,ZSTEP,ZEND,JNE,JTE,JNI,JOUT
      IF(JMAG.EQ.-1) GOTO 2235
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      LANZ=INT((ZEND-ZBEGIN)/ZSTEP)+1
      IF(JMAG.GT.0) THEN
      MLAT=LATI
      MLONG=LONGI
      ENDIF
      TYPE *,JMAG,LATI,LONGI,R,MONTH,HOUR,HEIGHT,IVAR,ZBEGIN,
     &    ZSTEP,ZEND,JNE,JTE,JNI,JOUT
      IF(JOUT.EQ.0)
     &  WRITE(16,*) JMAG,LATI,LONGI,R,MONTH,HOUR,HEIGHT,IVAR,
     &    ZBEGIN,ZSTEP,ZEND,JNE,JTE,JNI,JOUT
      XVAR(1)=LATI
      XVAR(2)=LONGI
      IF(JMAG.GT.0) THEN
      XVAR(1)=MLAT
      XVAR(2)=MLONG
      ENDIF
      XVAR(3)=R
      XVAR(4)=MONTH
      XVAR(5)=HOUR
      XVAR(6)=HEIGHT
      LFD=0
      XVAR(IVAR)=ZBEGIN-ZSTEP
2123  XVAR(IVAR)=XVAR(IVAR)+ZSTEP
      LFD=LFD+1
      IF(JMAG.GT.0)THEN
      MLAT=XVAR(1)
      MLONG=XVAR(2)
      ELSE
        LATI=XVAR(1)
        LONGI=XVAR(2)
      ENDIF
      R=XVAR(3)
      MONTH=INT(XVAR(4))
      HOUR=XVAR(5)
      HEIGHT=XVAR(6)
      HMEAN=300.
C
C SOLAR ACTIVITY PARAMETERS ..................................
C
      COV=63.75+R*(0.728+R*0.00089)
      RG=R
      COVG=COV
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      IF(JNE.EQ.1) THEN
      IF(R.GT.150.) RG=150.
      IF(COV.GT.193.) COVG=193.
      ENDIF
C
C GEOGRAPHIC AND MAGNETIC PARAMETER ..............................
C
      IF((LFD.EQ.1).OR.(IVAR.LT.3)) THEN
        CALL GGM(JMAG,LONGI,LATI,MLONG,MLAT)
        CALL FIELDG(LATI,LONGI,HMEAN,XMA,YMA,ZMA,BET,DIP,DEC,MODIP)
        MAGBR=ATAN(0.5*TAN(DIP*UMR))/UMR
      ENDIF
      ABSLAT=ABS(LATI)
C
C DAY OF YEAR AND SEASON ........................................
C
      DAYNR=INT(MONTH*30.42-15.21)
      SUNDEC=-0.40915*COS(.0172142063*(DAYNR+8.))
      SEASON=INT(MONTH/3.)
      IF(SEASON.LT.1) SEASON=4
      IF(LATI.GT.0.) GOTO 5592
        SEASON=SEASON-2
      IF(SEASON.LT.1) SEASON=SEASON+4
5592  REWIND(10)
C
C TIME PARAMETER ................................................
C
      IF(HOUR.GT.24.) GOTO 2389
      UT=HOUR-LONGI/15.
      IF(UT.LT.0.0) UT=UT+24.
      GOTO 2918
2389  UT=HOUR-25.
      HOUR=UT+LONGI/15.
        IF(HOUR.GT.24.) HOUR=HOUR-24.
2918  Z1=SIN(SUNDEC)*SIN(LATI*UMR)
      Z2=COS(SUNDEC)*COS(LATI*UMR)
      IF(ABS(Z2).GT.0.0) GOTO 120
      SAX=24.0
      IF(Z1.GE.0.0) SAX=0.0
      GOTO 140
120   IF(ABS(Z1/Z2).LE.1.0) GOTO 510
      SAX=24.0
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      IF((Z1+Z2).GE.0.0) SAX=0.0
      GOTO 140
510   SAX=12.0-ACOS(-Z1/Z2)/(UMR*15.0)
140   SUX=24.0-SAX
      XLSTA=15.0*(HOUR-12.0)
      COSXHI=Z1+Z2*COS(XLSTA*UMR)
      XHI=ACOS(COSXHI)/UMR
      COSXHI=COS(XHI*UMR)
      NIGHT=.FALSE.
      IF((HOUR.GT.SUX).OR.(HOUR.LT.SAX)) NIGHT=.TRUE.
      SUNDEC=SUNDEC/UMR
C
C CALCULATION OF ELECTRON DENSITY PARAMETERS................
C
      HNEA=65.
      IF(NIGHT) HNEA=80.
      HNEE=2000.
      IF(JNE.LT.1) GOTO 4933
      DELA=4.32
      IF(ABS(MODIP).GE.18.) DELA=1.0+EXP(-(ABS(MODIP)-30.0)/10.0)
      DELL=1+EXP(-(ABSLAT-20.)/10.)
C!!!!!!! F-REGION PARAMETERS AND FOE !!!!!!!!!!!!!!!!!!!!!!!!!!
      XHINON=ACOS(Z1+Z2)/UMR
      FOE=FOEEDI(COV,XHI,XHINON,LATI)
      IF(HMF2.GT.0.0) GOTO 501
      CALL F2OUT(MODIP,LATI,LONGI,RG,MONTH,UT,FOF2,XM3000)
      HMF2=HMF2ED(MAGBR,RG,FOF2/FOE,XM3000)
501   IF(FOF2.GT.100.0) FOF2=SQRT(FOF2/1.24E10)
      NMF2=1.24E10*FOF2*FOF2
      COS2=COS(MLAT*UMR)
      COS2=COS2*COS2
      FLU=(COVG-40.0)/30.0
      ETA1=-0.0070305*COS2
      IF(JNE.EQ.3) GOTO 5566
        EX=EXP(-MLAT/15.)
        EX1=EX+1
        EPIN=4.*EX/(EX1*EX1)
      ETA1=-0.02*EPIN
5566  ETA=0.058798+ETA1+FLU*(-0.014065+0.0069724*COS2)+
     &(0.0024287+0.0042810*COS2-0.00015280*FOF2)*FOF2
      ZETA=0.078922-0.0046702*COS2+FLU*(-0.019132+0.0076545*COS2)+
     &(0.0032513+0.0060290*COS2-0.00020872*FOF2)*FOF2
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      BETA=-128.03+20.253*COS2+FLU*(-8.0755-0.65896*COS2)+(0.44041
     &+0.71458*COS2-0.042966*FOF2)*FOF2
      Z=EXP(94.45/BETA)
      Z1=Z+1
      Z2=Z/(BETA*Z1*Z1)
      DELTA=(ETA/Z1-ZETA/2.0)/(ETA*Z2+ZETA/400.0)
      B1=3.0
C!!!!!!! INTERPOLATION FOR BO OUT OF ARRAY BOF !!!!!!!!!!!!!!!!!!!!!
      DO 7033 ISR=1,2
      DO 7034 ISL=1,2
      I=(ISR-1)*8+(ISL-1)*16+SEASON*2
7034  SIPH(ISL)=HPOL(HOUR,BOF(I-1),BOF(I),SAX,SUX)
7033  SIPL(ISR)=SIPH(1)+(SIPH(2)-SIPH(1))/DELA
      BO=SIPL(1)+(SIPL(2)-SIPL(1))/90.*(R-10.)
C!!!!!!! F1-REGION PARAMETERS !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      F1REG=.FALSE.
      HMF1=0.
      NMF1=0.
      C1=0.
      XHIO=49.84733+0.349504*ABSLAT
      XHI100=38.96113+0.509932*ABSLAT
      XHIM=(XHIO+(XHI100-XHIO)*R/100.0)
      IF((XHI.GT.XHIM).OR.NIGHT.OR.(SEASON.EQ.4)) GOTO 150
      F1REG=.TRUE.
      C1=.09+.11/DELA
      FOF1=FOF1ED(MAGBR,R,COSXHI)
      NMF1=1.24E10*FOF1*FOF1
C!!!!!!! PARAMETER FOR E AND VALLEY-REGION !!!!!!!!!!!!!!!!!!!!!!
150   NME=1.24E10*FOE*FOE
      HME=105.0
      XDEL=XDELS(SEASON)/DELA
      DNDHBR=DNDS(SEASON)/DELA
      HDEEP=HPOL(HOUR,10.5/DELA,28.,SAX,SUX)
      WIDTH=HPOL(HOUR,17.8/DELA,45.+22./DELA,SAX,SUX)
      DEPTH=HPOL(HOUR,XDEL,81.,SAX,SUX)
      DLNDH=HPOL(HOUR,DNDHBR,.06,SAX,SUX)
      IF(DEPTH.LT.1.0) GOTO 600
      IF(NIGHT) DEPTH=-DEPTH
      CALL TAL(HDEEP,DEPTH,WIDTH,DLNDH,EXT,E)
      IF(.NOT.EXT) GOTO 667
      WRITE(KONSOL,650)
650   FORMAT(1X,'*NE* E-REGION VALLEY CAN NOT BE MODELLED')
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600   WIDTH=.0
667   HEF=HME+WIDTH
C!!!!!!!D-REGION PARAMETER!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      NMD=XMDED(XHI,R,4.0E8)
      HMD=HPOL(HOUR,81.0,88.0,SAX,SUX)
      F(1)=HPOL(HOUR,0.02+0.03/DELA,0.05,SAX,SUX)
      F(2)=HPOL(HOUR,4.6,4.5,SAX,SUX)
      F(3)=HPOL(HOUR,-11.5,-4.0,SAX,SUX)
      FP1=F(1)
      FP2=-FP1*FP1/2.0
      FP30=(-F(2)*FP2-FP1+1.0/F(2))/(F(2)*F(2))
      FP3U=(-F(3)*FP2-FP1-1.0/F(3))/(F(3)*F(3))
      HDX=HMD+F(2)
      X=HDX-HMD
      XDX=NMD*EXP(X*(FP1+X*(FP2+X*FP30)))
      DXDX=XDX*(FP1+X*(2.0*FP2+X*3.0*FP30))
      X=HME-HDX
      XKK=-DXDX*X/(XDX*ALOG(XDX/NME))
      D1=DXDX/(XDX*XKK*X**(XKK-1.0))
C
C SEARCH FOR HMF1 AND HST.....................................
C
3801  IF(F1REG) GOTO 924
      HMF1=HMF2
      GOTO 380
924   JER=0
      H=10.0
133   H=H+10.0
      IF(H.GT.(HMF2-HEF)) GOTO 135
      CALL REGFA1(HMF2-H,HMF2,1.0,NMF1,XE2,SCHALT,HMF1)
      IF(SCHALT) GOTO 133
      GOTO 137
135   IF(JER.EQ.0) WRITE(KONSOL,11) XVAR(IVAR)
      JER=JER+1
11    FORMAT(1X,'*NE* HMF1 IS NOT EVALUATED BY THE FUNCTION XE2',
     &   F8.1)
3985  IF (HMF2-HEF.GE.B0) GOTO 922
      BOX=(HMF2-HEF)/1.1
      IF(BOX.LT.10.0) GOTO 922
      WRITE(KONSOL,923) B0,BOX
923   FORMAT(6X,'CORR.: B0(OLD)=',F5.1,3X,' B0(NEW)=',F5.1)
      B0=BOX
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      GOTO 924
922   B1X=B1+.5
      IF(B1X.GT.4) GOTO 7398
      WRITE(KONSOL,902) B1
902   FORMAT(6X,'CORR.: B1(OLD)=',F4.1,3X,' B1(NEW)=B1(OLD)+.5')
      B1=B1X
      GOTO 924
7398  WRITE(KONSOL,9269)
9269  FORMAT(1X,'CORR.: NO F1 REGION, B1=3, C1=0.0')
      HMF1=0.
      NMF1=0.
      C1=0.0
      B1=3.
      F1REG=.FALSE.
      GOTO 380
137   IF(HMF1.GT.HEF) GOTO 380
      WRITE(KONSOL,9)
9     FORMAT(1X,'*NE* UPPER E-VALLEY LIMIT(HEF) ABOVE HMF1')
      IF((HMF2-HEF.LT.B0).OR.(B1.LT.4)) GOTO 3985
      WRITE(KONSOL,9853)
9853  FORMAT(1X,'CORR.: NO F1 REGION, B1=3, C1=0.0')
      HMF1=0.
      NMF1=0.
      C1=0.0
      B1=3.
      F1REG=.FALSE.
C!!!!!!! NE3(HST)=NME !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
380   H=-3.
      JER=0
125   H=H+3.0
      IF(H.GT.(HMF1-HEF)) GOTO 900
      CALL REGFA1(HEF+H,HMF1,1.0,NME,XE3,SCHALT,HST)
      STR=HST
      IF(SCHALT) GOTO 125
      GOTO 360
900   IF(JER.EQ.0) WRITE(KONSOL,100) XVAR(IVAR)
100   FORMAT(1X,'*NE* HST IS NOT EVALUATED BY THE FUNCTION XE3',
     &     F8.1)
      JER=JER+1
      IF (HMF2-HEF.GE.B0) GOTO 9221
      B0X=(HMF2-HEF)/1.1
      IF(B0X.LT.10.0) GOTO 9221
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      WRITE(KONSOL,9231) BO,BOX
9231  FORMAT(6X,'CORR.: BO(OLD)=',F5.1,' BO(NEW)=',F5.1)
      BO=BOX
      GOTO 3801
9221  B1X=B1+.5
      IF(B1X.GT.5) GOTO 7391
      WRITE(KONSOL,9021) B1
9021  FORMAT(6X,'CORR.: B1(OLD)=',F4.1,' B1(NEW)=B1(OLD)+.5')
      B1=B1X
      GOTO 3801
7391  B1=3.
      HZ=HEF+.75*(HMF1-HEF)
      WRITE(KONSOL,901) HZ,HEF
901   FORMAT(6X,'CORR.: LIN. APP. BETWEEN HZ=',F5.1,
     &' AND HEF=',F5.1)
      XNEHZ=XE(HZ)
      T=(XNEHZ-NME)/(HZ-HEF)
      HST=-333.
      GOTO 6153
360   HZ=(HST+HMF1)/2.0
      D=HZ-HST
      T=D*D/(HZ-HEF-D)
6153  IF(.NOT.F1REG) HMF1=0.
C
C CALCULATION OF NEUTRAL TEMPERATURE PARAMETER...........
C
4933  HTA=120.0
      HTE=2000.0
      HTNA=90.0
      TNA=183.0
      IF(JTE.EQ.0) GOTO 240
      ZX=125.0
      Z1=XLSTA
      HDEL=ZX-HTNA
      HD2=HDEL*HDEL
      TUN=TUNCAL(COV,LATI,SUNDEC,Z1)
      TNX=371.6678+0.0518806*TUN-294.3505*EXP(-0.00216222*TUN)
      ATN=0.63662*(TUN-TNX)
      TDEL=TNX-TNA
      CTN(1)=1.9*TDEL/HDEL
      CTN(3)=3.0*TDEL/(HD2*HD2)
      CTN(2)=CTN(3)*1.333333*HDEL-CTN(1)/HD2
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C
C CALCULATION OF ELECTRON TEMPERATURE PARAMETER................
C
881    ATE(1)=TN(AHH(1),TNX,ATN,CTN)
       HMM=60.*EXP(-(MLAT/22.41)**2)+210.
       HM=HPOL(HOUR,HMM,150.,SAX,SUX)
       AHH(2)=HM
       TM=800.*EXP(-(MLAT/33.)**2)+1500.
       IS=SEASON-SEASON/3*2
       CALL TEBA(MAGBR,HOUR,IS,TEA)
       ATE(3)=TEA(1)
       ATE(4)=TEA(2)
       ATE(6)=TEA(3)
       ATE(7)=TEA(4)
       ETT=EXP(-MLAT/11.35)
       TET=2900.-5600.*ETT/((ETT+1)**2.)
       TEN=839.+1161./(1.+EXP(-(ABS(MLAT)-45.)/5.))
       ATE(5)=HPOL(HOUR,TET,TEN,SAX,SUX)
       DO 3395 I=1,3
3395   IF(XNAR(I).GT.0.) ATE(I+2)=TEDE(HOA(I),XNAR(I),-COV)
       ATE5=ATE(5)
       ATE(2)=HPOL(HOUR,TM,TEA(5),SAX,SUX)
       ATE2=ATE(2)
       TNATEI=TN(AHH(2),TNX,ATN,CTN)
       IF(ATE(2).LT.TNATEI) ATE(2)=TNATEI
       STTE1=(ATE(2)-ATE(1))/(AHH(2)-AHH(1))
       DO 1901 I=2,6
       TNATEI=TN(AHH(I+1),TNX,ATN,CTN)
       IF(ATE(I+1).LT.TNATEI) ATE(I+1)=TNATEI
        STTE2=(ATE(I+1)-ATE(I))/(AHH(I+1)-AHH(I))
        ATE(I)=ATE(I)-(STTE2-STTE1)*DTE(I-1)*ALOG2
1901   STTE1=STTE2
       DO 1902 I=1,6
1902   STTE(I)=(ATE(I+1)-ATE(I))/(AHH(I+1)-AHH(I))
       ATE1=ATE(1)
C
C CALCULATION OF ION TEMPERATURE PARAMETERS
C
887    XSM(1)=430.0
       MM(2)=HPOL(HOUR,3.0,0.0,SAX,SUX)
       Z1=EXP(-0.09*MLAT)
       Z2=1.+Z1
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      TID1=1240.0-1400.0*Z1/(Z2*Z2)
      TIDD1=TID1
C THE DAYTIME ION TEMPERATURE TID1 SHOULD BE BETWEEN THE NOON NEUTRAL
C TEMPERATURE TND1 AND ELECTRON TEMPERATURE TED1 (=TE(400)+3*30).
      TED1=TEA(6)+90.
      TND1=TUNCAL(COV,LATI,SUNDEC,0.0)
      IF(TED1.LT.TND1) TED1=TND1
      IF(TID1.GT.TED1) TID1=TED1
      IF(TID1.LT.TND1) TID1=TND1
      Z1=ABS(MLAT)
      Z2=COS(Z1*(0.47+Z1*0.024)*UMR)
      TIN1=1200.0-300.0*SIGN(1.0,Z2)*SQRT(ABS(Z2))
      TINN1=TIN1
C THE NIGHTTIME ION TEMPERATURE TIN1 SHOULD BE BETWEEN THE NEUTRAL AND
C ELECTRON MIDNIGHT TEMPERATURE (TNN1, TEA(5)=TE(300)).
      TNN1=TUNCAL(COV,LATI,SUNDEC,180.)
      TEN1=TEA(5)
      IF(TEN1.LT.TNN1) TEN1=TNN1
      IF(TIN1.GT.TEN1) TIN1=TEN1
      IF(TIN1.LT.TNN1) TIN1=TNN1
      TI1=TIN1
      IF(TID1.GT.TIN1) TI1=HPOL(HOUR,TID1,TIN1,SAX,SUX)
C      TE1=ELTE(XSM(1))
C      TN1=TN(XSM(1),TNX,ATN,CTN)
C      IF((TI1.LT.TN1).OR.(TI1.GT.TE1)) TI1=(TE1+TN1)/2.0
      CALL REGFA1(130.0,500.0,0.1,TI1,TEDER,SCHALT,HS)
      IF(SCHALT) HS=200.
      TNHS=TN(HS,TNX,ATN,CTN)
      MM(1)=DTNDH(HS,ATN,CTN)
      IF(SCHALT) MM(1)=(TI1-TNHS)/(XSM(1)-HS)
      MXSM=2
C ION AND ELECTRON TEMPERATURE ARE MERGED AT AN ALTITUDE BETWEEN
C 600 AND 1400 KM.
2391  XTTS=500.
      X=500.
2390    X=X+XTTS
      IF(X.GE.AHH(7)) GOTO 240
      TEX=ELTE(X)
      TIX=TI(X)
      IF(TIX.LT.TEX) GOTO 2390
      X=X-XTTS
      XTTS=XTTS/10.
```

```
      IF(XTTS.GT.0.1) GOTO 2390
      XTETI=X+XTTS*5.
      MXSM=3
      MM(3)=STTE(6)
      XSM(2)=XTETI
      IF(XTETI.GT.AHH(6)) GOTO 240
      MXSM=4
        MM(3)=STTE(5)
      MM(4)=STTE(6)
      XSM(3)=AHH(6)
      IF(XTETI.GT.AHH(5)) GOTO 240
      MXSM=5
      DTI(2)=5.
      DTI(1)=5.
        MM(3)=STTE(4)
      MM(4)=STTE(5)
      MM(5)=STTE(6)
      XSM(3)=AHH(5)
      XSM(4)=AHH(6)
C
C INPUT OF THE ION DENSITY PARAMETER ARRAYS PF10,PF20 AND PF30......
C
240   HNIA=100.
      HNIE=2000.
      IF(JNI.LT.1) GOTO 141
      RIF(1)=2.
      IF(ABSLAT.LT.30.0) RIF(1)=1.
      RIF(2)=2.
      IF(COV.LT.100.0) RIF(2)=1.
      RIF(3)=SEASON
      IF(SEASON.EQ.1) RIF(3)=3.
      RIF(4)=1.
      IF(NIGHT) RIF(4)=2.
      CALL KOEFP1(PG10)
      CALL KOEFP2 (PG20)
      CALL KOEFP3 (PG30)
      CALL SUFE (PG10,RIF,12,PF10)
      CALL SUFE(PG20,RIF,4,PF20)
      CALL SUFE(PG30,RIF,12,PF30)
C
C CALCULATION OF ION DENSITY PARAMETER.................
C
```

```
      ZZZ1=0.0
      IF(XHI.LE.90.0) ZZZ1=COSXHI
      HFIXO=300.0
      IF((RIF(2).EQ.2.).AND.(RIF(3).EQ.2.)) HFIXO=249.0
      MO(1)=EPSTEP(PF10(1),PF10(2),PF10(3),PF10(4),ZZZ1)
      MO(2)=EPSTEP(PF10(5),PF10(6),PF10(7),PF10(8),ZZZ1)
      MO(3)=0.0
      HO(1)=EPSTEP(PF10(9),PF10(10),PF10(11),PF10(12),ZZZ1)
      HO(4)=PF20(1)
      MO(4)=PF20(2)
      MO(5)=PF20(3)
7100  HO(2)=290.0
      IF((RIF(2).EQ.2.).AND.(RIF(3).EQ.2.)) HO(2)=237.0
      HO(3)=(4.60517-MO(5)*(HO(4)-PF20(4)))/MO(4)+HO(4)
      IF(HO(2).LT.HO(3)) GOTO 7101
      MO(4)=MO(4)-0.001
      GOTO 7100
7101  Z2=5.0
      X=HO(2)
      Z1=0.0
7102  X=X+Z2
      Y=RPID(X,HFIXO,98.0,4,MO,DDO,HO)
      IF(Y.LE.Z1) GOTO 7103
      Z1=Y
      GOTO 7102
7103  IF(Z2.LE.1.0) GOTO 7104
      X=X-Z2
      Z2=1.0
      GOTO 7102
7104  HOO=X-0.5
      DO 7105 I=2,4,2
      L=I/2
      HO2(L)=PF30(1+I)+PF30(2+I)*ZZZ1
7105  MO2(L+1)=PF30(7+I)+PF30(8+I)*ZZZ1
      MO2(1)=PF30(7)+PF30(8)*ZZZ1
7106  Y=RPID(HOO,PF30(1),PF30(2),2,MO2,DO2,HO2)
      IF(Y.LE.0.1) GOTO 1899
      MO2(3)=MO2(3)-0.02
      GOTO 7106
C!!!!!!! RATIO OF NO+ TO O2+ DENSITY AT O+ MAXIMUM IS USED !!!!!!
C!!!!!!! FOR NO+ CALCULATION ABOVE THE O+ MAXIMUM (HOO) !!!!!!!!!
1899  Z1B= RPID (HOO,HFIXO,98.0,4,MO,DDO,HO)
```

```
      Z2B= RPID (HOO,PF3O(1),PF3O(2),2,MO2,DO2,HO2)
      NOBO2= (100.0-Z1B-Z2B)/Z2B
      IF(Z2B.LT.1.) NOBO2=0.0
C
C OUTPUT ON THE SPECIFIED DEVICE...............................
C
141   CONTINUE
      IF(.NOT.F1REG) HMF1=HZ
      XCOR=XVAR(IVAR)
      IF(JMAG.EQ.2) XCOR=DIP
      IF(JMAG.EQ.3) XCOR=MODIP
      IF((IVAR.EQ.5).AND.(XCOR.GT.24.)) XCOR=XCOR-25.
      IF(HEIGHT.LT.1.0) THEN
       WRITE(16,7829) XCOR,INT(HMF2+.5),INT(HMF1+.5),INT(HME+.5),
     &    INT(HMD+.5),INT(NMF2/1.E6+.5),INT(NMF1/1.E6+.5),
     &    INT(NME/1.E6+.5),INT(NMD/1.E6+.5)
       WRITE(6,7829) XCOR,INT(HMF2+.5),INT(HMF1+.5),INT(HME+.5),
     &    INT(HMD+.5),INT(NMF2/1.E6+.5),INT(NMF1/1.E6+.5),
     &    INT(NME/1.E6+.5),INT(NMD/1.E6+.5)
7829   FORMAT(1X,F7.1,2X,4I4,2X,4I7)
       GOTO 2135
      ENDIF
      X=HEIGHT
      LHEI=1
7819    DO 7056 J=1,9
7056  OUTF(J)=0.
      IF(JNE.GT.0) OUTF(1)=XE(X)/1.E6
        IF((X.GE.HTA).AND.(JTE.GT.0)) THEN
        TNH=TN(X,TNX,ATN,CTN)
        TIH=TNH
        IF(X.GT.HS) TIH=TI(X)
          OUTF(2)=TNH
        OUTF(3)=TIH
          OUTF(4)=ELTE(X)
        ENDIF
        IF((X.GE.HNIA).AND.(JNI.GT.0)) THEN
        Z1=RPID(X,HFIXO,98.,4,MO,DDO,HO)
        Z2=RPID(X,PF3O(1),PF3O(2),2,MO2,DO2,HO2)
        CALL RDHHE(X,HOO,Z1,Z2,NOBO2,10.,Z4,Z5)
        OUTF(5)=Z1
        OUTF(6)=Z4
        OUTF(7)=Z5
```

```
        OUTF(8)=Z2
        OUTF(9)=RDNO(X,HOO,Z2,Z1,NOBO2)
      ENDIF
      IF(IVAR.EQ.6) XCOR=X
      IF(JOUT.EQ.0) THEN
         WRITE(16,7546) XCOR,INT(OUTF(1)+.5),INT(OUTF(2)+.5),
     &    INT(OUTF(3)+.5),INT(OUTF(4)+.5),INT(OUTF(5)+.5),
     &    INT(OUTF(6)+.5),INT(OUTF(7)+.5),INT(OUTF(8)+.5),
     &    INT(OUTF(9)+.5)
         WRITE(6,7546) XCOR,INT(OUTF(1)+.5),INT(OUTF(2)+.5),
     &    INT(OUTF(3)+.5),INT(OUTF(4)+.5),INT(OUTF(5)+.5),
     &    INT(OUTF(6)+.5),INT(OUTF(7)+.5),INT(OUTF(8)+.5),
     &    INT(OUTF(9)+.5)
         ENDIF
7546  FORMAT(1X,F7.1,2X,I7,2X,3I5,2X,5I5)
      IF(JOUT.EQ.1) WRITE(6,7547) INT(XCOR+.5),INT(OUTF(2)+.5),
     &    INT(OUTF(3)+.5),INT(OUTF(4)+.5),INT(OUTF(3)-OUTF(2)+.5),
     &    INT(OUTF(4)-OUTF(3)+.5),INT(HM+.5),INT(TEA(1)-ATE2+.5),
     &    INT(TEA(1)+.5),INT(TEA(2)-TEA(1)+.5),INT(ATE5-TEA(2)+.5),
     &    INT(TEA(3)-ATE5+.5),INT(TEA(4)-TEA(3)+.5),
     &    INT(TIDD1+.5),INT(TINN1+.5),INT(XTETI+.5)
7547  FORMAT(1X,I4,6I5,2I4,I5,2I4,5I5)
      IF(JTNN.EQ.2) WRITE(16,*) XCOR,(OUTF(J),J=1,4),HM,ATE2,
     &    TEA(1),TEA(2),ATE5,TEA(3),TEA(4),ATE,TIDD1,TINN1,TI1
2135  IF(IVAR.EQ.6) THEN
      X=X+ZSTEP
      LHEI=LHEI+1
      IF(LHEI.LE.LANZ) GOTO 7819
      HMF2=0.0
      GOTO 2234
      ENDIF
      HMF2=0.0
      IF(LFD.LT.LANZ) GOTO 2123
      GOTO 2234
2235  CONTINUE
      STOP
      END
```

```
 *NE* HST IS NOT EVALUATED BY THE FUNCTION XE3
      CORR.: B1(OLD)= 3.0 B1(NEW)= 3.5
 *NE* HST IS NOT EVALUATED BY THE FUNCTION XE3
      CORR.: B1(OLD)= 3.5 B1(NEW)= 4.0
 *NE* HST IS NOT EVALUATED BY THE FUNCTION XE3
      CORR.: B1(OLD)= 4.0 B1(NEW)= 4.5
 *NE* HST IS NOT EVALUATED BY THE FUNCTION XE3
      CORR.: B1(OLD)= 4.5 B1(NEW)= 5.0
 *NE* HST IS NOT EVALUATED BY THE FUNCTION XE3
      CORR.: LIN. APP. BETWEEN HZ=163.9 AND HEF=122.1
1INPUT:
 LATI= 45.1  LONG=293.5  R=100.  MONTH=10  HOUR=12.50

 CALCULATED VALUES:
 MLAT= 56.5 MLON=  4.2   COV=145.4 DAY=288
 DIP = 72.3 DIPL= 57.5 MODIP= 56.4 DEC=-19.0
 XHI = 54.3 SUNRISE/SET(LT): 6.6/17.4 SUN-DEC= -8.8
 NMF2=1.26E+12  NMF1=2.70E+11   NME=1.36E+11 NMD=9.68E+08
 HMF2=288.7     HMF1=177.8      HME=105.0    HMD= 81.1
```

							RELATIVE PRECENTAGE DENSITY				
H(KM)	NE(M-3)	NE/NMF2	TN(K)	TE(K)	TI(K)	TE/TI	O+	H+	HE+	O2+	NO+
50.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
55.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
60.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
65.0	1.44E+08	0.0001	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
70.0	3.76E+08	0.0003	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
75.0	6.63E+08	0.0005	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
80.0	9.18E+08	0.0007	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
85.0	1.90E+09	0.0015	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
90.0	1.91E+10	0.0152	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
95.0	7.16E+10	0.0569	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
100.0	1.24E+11	0.0985	-1	-1	-1	-1.00	0	0	0	46	53
105.0	1.36E+11	0.1084	-1	-1	-1	-1.00	0	0	0	46	53
110.0	1.32E+11	0.1050	-1	-1	-1	-1.00	1	0	0	46	53
115.0	1.29E+11	0.1025	-1	-1	-1	-1.00	1	0	0	46	53
120.0	1.33E+11	0.1054	336	336	336	1.00	2	0	0	46	53
125.0	1.44E+11	0.1146	394	404	394	1.03	3	0	0	44	53
130.0	1.58E+11	0.1252	451	472	451	1.05	4	0	0	42	54
135.0	1.71E+11	0.1359	506	541	506	1.07	6	0	0	40	54
140.0	1.84E+11	0.1465	557	609	557	1.09	9	0	0	37	54
145.0	1.98E+11	0.1571	604	677	604	1.12	13	0	0	34	53

150.0	2.11E+11	0.1678	647	745	647	1.15	18	0	0	32	50
160.0	2.38E+11	0.1891	718	882	718	1.23	36	0	0	27	38
170.0	2.74E+11	0.2175	774	1018	774	1.32	57	0	0	20	23
180.0	3.03E+11	0.2407	819	1155	819	1.41	73	0	0	13	14
190.0	4.16E+11	0.3306	855	1291	855	1.51	82	0	0	8	10
200.0	5.44E+11	0.4319	884	1424	884	1.61	86	0	0	5	9
210.0	6.79E+11	0.5392	908	1544	908	1.70	88	0	0	3	9
220.0	8.13E+11	0.6456	929	1641	929	1.77	90	0	0	2	9
230.0	9.37E+11	0.7445	946	1726	946	1.83	91	0	0	1	8
240.0	1.04E+12	0.8301	960	1809	961	1.88	92	0	0	1	7
250.0	1.13E+12	0.8988	971	1891	975	1.94	93	0	0	0	6
260.0	1.19E+12	0.9487	981	1973	990	1.99	94	0	0	0	5
270.0	1.23E+12	0.9804	989	2056	1005	2.04	96	0	0	0	4
280.0	1.25E+12	0.9963	996	2138	1020	2.10	97	0	0	0	3
290.0	1.26E+12	0.9999	1002	2218	1035	2.14	98	0	0	0	2
300.0	1.25E+12	0.9960	1007	2291	1050	2.18	98	0	0	0	2
310.0	1.24E+12	0.9859	1011	2349	1065	2.21	98	0	0	0	2
320.0	1.22E+12	0.9700	1014	2399	1080	2.22	98	0	0	0	2
330.0	1.19E+12	0.9488	1017	2448	1095	2.24	98	0	0	0	2
340.0	1.16E+12	0.9230	1019	2496	1110	2.25	98	2	0	0	0
350.0	1.12E+12	0.8933	1021	2544	1125	2.26	98	2	0	0	0
360.0	1.08E+12	0.8603	1023	2592	1140	2.27	98	2	0	0	0
370.0	1.04E+12	0.8248	1025	2639	1155	2.29	98	2	0	0	0
380.0	9.91E+11	0.7875	1026	2684	1170	2.29	98	2	0	0	0
390.0	9.43E+11	0.7492	1027	2724	1185	2.30	98	2	0	0	0
400.0	8.94E+11	0.7104	1028	2755	1200	2.30	98	2	0	0	0
410.0	8.45E+11	0.6717	1029	2775	1216	2.28	98	2	0	0	0
420.0	7.97E+11	0.6335	1030	2787	1234	2.26	98	2	0	0	0
430.0	7.51E+11	0.5963	1030	2793	1254	2.23	98	2	0	0	0
440.0	7.05E+11	0.5604	1031	2798	1278	2.19	98	2	0	0	0
450.0	6.62E+11	0.5260	1031	2801	1305	2.15	98	2	0	0	0
460.0	6.21E+11	0.4932	1032	2805	1334	2.10	97	3	0	0	0
470.0	5.82E+11	0.4623	1032	2808	1363	2.06	96	3	0	0	0
480.0	5.45E+11	0.4332	1033	2811	1393	2.02	95	4	0	0	0
490.0	5.11E+11	0.4059	1033	2814	1422	1.98	95	5	1	0	0
500.0	4.79E+11	0.3806	1033	2817	1452	1.94	94	6	1	0	0
600.0	2.67E+11	0.2123	1035	2855	1749	1.63	86	12	1	0	0
700.0	1.77E+11	0.1402	1035	2925	2046	1.43	78	20	2	0	0
800.0	1.37E+11	0.1086	1036	3003	2343	1.28	67	29	3	0	0
900.0	1.18E+11	0.0938	1036	3080	2640	1.17	57	38	4	0	0
1000.0	1.09E+11	0.0866	1036	3157	2937	1.07	49	46	5	0	0

NOTE: -1 MEANS NO MODEL VALUE AVAILABLE
OR PARAMETER WAS NOT REQUESTED

1INPUT:
MLAT= 30.0 MLON= 2.4 R= 35. MONTH= 7 HOUR=16.00

CALCULATED VALUES:
LATI= 18.6 LONG=292.4 COV= 90.3 DAY=197
DIP = 50.1 DIPL= 30.9 MODIP= 41.9 DEC= -7.7
XHI = 56.1 SUNRISE/SET(LT): 5.5/18.5 SUN-DEC= 21.7
NMF2=8.19E+11 NMF1=0.00E+00 NME=1.12E+11 NMD=5.64E+08
HMF2=292.3 HMF1= 0.0 HME=105.0 HMD= 81.5

							RELATIVE PRECENTAGE DENSITY				
H(KM)	NE(M-3)	NE/NMF2	TN(K)	TE(K)	TI(K)	TE/TI	O+	H+	HE+	O2+	NO+
60.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
65.0	5.15E+07	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
70.0	1.86E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
75.0	3.73E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
80.0	5.26E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
85.0	9.25E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
90.0	1.01E+10	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
95.0	4.68E+10	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
100.0	9.59E+10	-1.0000	-1	-1	-1	-1.00	0	-1	-1	25	75
105.0	1.12E+11	-1.0000	-1	-1	-1	-1.00	0	-1	-1	26	73
110.0	1.05E+11	-1.0000	-1	-1	-1	-1.00	0	-1	-1	28	71
115.0	1.01E+11	-1.0000	-1	-1	-1	-1.00	0	-1	-1	30	69
120.0	1.08E+11	-1.0000	318	318	318	-1.00	1	-1	-1	32	67
140.0	1.48E+11	-1.0000	512	641	512	-1.00	3	-1	-1	33	64
160.0	2.02E+11	-1.0000	639	963	639	-1.00	10	-1	-1	31	59
180.0	2.72E+11	-1.0000	712	1286	712	-1.00	16	-1	-1	29	55
200.0	3.63E+11	-1.0000	757	1602	757	-1.00	23	-1	-1	21	56
220.0	4.82E+11	-1.0000	786	1769	789	-1.00	32	-1	-1	7	61
240.0	6.35E+11	-1.0000	807	1647	822	-1.00	44	-1	-1	2	54
260.0	7.56E+11	-1.0000	821	1491	854	-1.00	61	-1	-1	1	38
280.0	8.12E+11	-1.0000	830	1336	887	-1.00	84	-1	-1	0	16
300.0	8.16E+11	-1.0000	837	1215	919	-1.00	98	-1	-1	0	2
320.0	7.85E+11	-1.0000	842	1238	951	-1.00	97	-1	-1	0	0
340.0	7.25E+11	-1.0000	845	1296	984	-1.00	93	-1	-1	0	0
360.0	6.47E+11	-1.0000	848	1356	1016	-1.00	90	-1	-1	0	0
380.0	5.62E+11	-1.0000	850	1417	1049	-1.00	87	-1	-1	0	0
400.0	4.79E+11	-1.0000	851	1488	1082	-1.00	84	-1	-1	0	0
500.0	1.96E+11	-1.0000	854	1972	1324	-1.00	70	-1	-1	0	0

600.0	9.61E+10	-1.0000	855	2424	1601	-1.00	58	-1	-1	0	0

NOTE: -1 MEANS NO MODEL VALUE AVAILABLE
OR PARAMETER WAS NOT REQUESTED

1INPUT:
LATI=-12.0 LONG=283.1 R= 10. MONTH= 1 HOUR=11.00

CALCULATED VALUES:
MLAT= -0.7 MLON=353.1 COV= 71.1 DAY= 15
DIP = 2.7 DIPL= 1.4 MODIP= 2.8 DEC= 4.7
XHI = 17.3 SUNRISE/SET(LT): 5.7/18.3 SUN-DEC=-21.6
NMF2=6.29E+11 NMF1=2.44E+11 NME=1.44E+11 NMD=6.19E+08
HMF2=357.1 HMF1=253.8 HME=105.0 HMD= 81.0

							RELATIVE PRECENTAGE DENSITY				
H(KM)	NE(M-3)	NE/NMF2	TN(K)	TE(K)	TI(K)	TE/TI	O+	H+	HE+	O2+	NO+
60.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
65.0	6.28E+07	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
70.0	2.47E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
75.0	4.72E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
80.0	6.01E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
85.0	1.20E+09	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
90.0	1.46E+10	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
95.0	6.51E+10	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
100.0	1.26E+11	-1.0000	-1	-1	-1	-1.00	0	-1	-1	50	50
105.0	1.44E+11	-1.0000	-1	-1	-1	-1.00	0	-1	-1	46	54
110.0	1.45E+11	-1.0000	-1	-1	-1	-1.00	0	-1	-1	42	57
115.0	1.46E+11	-1.0000	-1	-1	-1	-1.00	1	-1	-1	39	60
120.0	1.47E+11	-1.0000	305	305	305	-1.00	1	-1	-1	37	62
140.0	1.51E+11	-1.0000	479	590	479	-1.00	4	-1	-1	33	63
160.0	1.56E+11	-1.0000	585	876	585	-1.00	10	-1	-1	31	59
180.0	1.61E+11	-1.0000	641	1161	641	-1.00	17	-1	-1	29	55
200.0	1.68E+11	-1.0000	675	1446	675	-1.00	23	-1	-1	21	56
220.0	1.77E+11	-1.0000	697	1731	697	-1.00	32	-1	-1	7	61
240.0	1.98E+11	-1.0000	712	2015	716	-1.00	44	-1	-1	2	54
260.0	2.85E+11	-1.0000	723	2265	734	-1.00	61	-1	-1	1	38
280.0	4.05E+11	-1.0000	730	2035	752	-1.00	84	-1	-1	0	16
300.0	5.11E+11	-1.0000	735	1468	771	-1.00	98	-1	-1	0	2
320.0	5.84E+11	-1.0000	738	1280	789	-1.00	97	-1	-1	0	0
340.0	6.21E+11	-1.0000	741	1193	807	-1.00	93	-1	-1	0	0
360.0	6.30E+11	-1.0000	743	1109	826	-1.00	90	-1	-1	0	0
380.0	6.24E+11	-1.0000	744	1032	844	-1.00	87	-1	-1	0	0

400.0	5.94E+11	-1.0000	745	987	863	-1.00	84	-1	-1	0	0
500.0	3.52E+11	-1.0000	747	1217	1098	-1.00	70	-1	-1	0	0
600.0	2.17E+11	-1.0000	748	1495	1397	-1.00	58	-1	-1	0	0

```
 NOTE: -1 MEANS NO MODEL VALUE AVAILABLE
          OR PARAMETER WAS NOT REQUESTED
 *NE* HST IS NOT EVALUATED BY THE FUNCTION XE3
      CORR.: B1(OLD)= 3.0 B1(NEW)= 3.5
 *NE* HST IS NOT EVALUATED BY THE FUNCTION XE3
      CORR.: B1(OLD)= 3.5 B1(NEW)= 4.0
 *NE* HST IS NOT EVALUATED BY THE FUNCTION XE3
      CORR.: B1(OLD)= 4.0 B1(NEW)= 4.5
 *NE* HST IS NOT EVALUATED BY THE FUNCTION XE3
      CORR.: B1(OLD)= 4.5 B1(NEW)= 5.0
 *NE* HST IS NOT EVALUATED BY THE FUNCTION XE3
      CORR.: LIN. APP. BETWEEN HZ=261.8 AND HEF=155.0
1INPUT:
 LATI=-12.0  LONG=283.1  R=100.  MONTH= 7  HOUR= 0.00

 CALCULATED VALUES:
 MLAT= -0.7 MLON=353.1   COV=145.4 DAY=197
 DIP =  2.7 DIPL=  1.4 MODIP=  2.8 DEC=  4.7
 XHI =170.3 SUNRISE/SET(LT): 6.3/17.7 SUN-DEC= 21.7
 NMF2=5.60E+11  NMF1=0.00E+00   NME=3.09E+09 NMD=4.00E+08
 HMF2=297.5     HMF1=  0.0      HME=105.0    HMD= 88.0
```

							RELATIVE PRECENTAGE DENSITY				
H(KM)	NE(M-3)	NE/NMF2	TN(K)	TE(K)	TI(K)	TE/TI	O+	H+	HE+	O2+	NO+
60.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
65.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
70.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
75.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
80.0	5.32E+05	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
85.0	2.47E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
90.0	4.73E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
95.0	2.47E+09	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
100.0	3.08E+09	-1.0000	-1	-1	-1	-1.00	0	-1	-1	18	82
105.0	3.09E+09	-1.0000	-1	-1	-1	-1.00	0	-1	-1	20	80
110.0	2.65E+09	-1.0000	-1	-1	-1	-1.00	0	-1	-1	24	76
115.0	1.84E+09	-1.0000	-1	-1	-1	-1.00	0	-1	-1	27	73
120.0	1.17E+09	-1.0000	317	317	317	-1.00	0	-1	-1	32	68
140.0	7.56E+08	-1.0000	508	633	508	-1.00	1	-1	-1	45	54

160.0	2.74E+10	-1.0000	632	800	632	-1.00	7	-1	-1	37	56
180.0	1.25E+11	-1.0000	702	812	702	-1.00	43	-1	-1	22	35
200.0	2.22E+11	-1.0000	745	814	745	-1.00	79	-1	-1	4	17
220.0	3.19E+11	-1.0000	774	816	774	-1.00	89	-1	-1	1	10
240.0	4.17E+11	-1.0000	794	818	794	-1.00	93	-1	-1	0	7
260.0	5.14E+11	-1.0000	807	820	807	-1.00	96	-1	-1	0	4
280.0	5.52E+11	-1.0000	816	822	816	-1.00	99	-1	-1	0	1
300.0	5.61E+11	-1.0000	823	824	823	-1.00	98	-1	-1	0	0
320.0	5.57E+11	-1.0000	828	827	829	-1.00	86	-1	-1	0	0
340.0	5.36E+11	-1.0000	831	830	835	-1.00	73	-1	-1	0	0
360.0	5.02E+11	-1.0000	833	832	841	-1.00	62	-1	-1	0	0
380.0	4.61E+11	-1.0000	835	835	847	-1.00	53	-1	-1	0	0
400.0	4.16E+11	-1.0000	836	837	853	-1.00	45	-1	-1	0	0
500.0	2.34E+11	-1.0000	840	838	862	-1.00	21	-1	-1	0	0
600.0	1.47E+11	-1.0000	841	841	863	-1.00	11	-1	-1	0	0

NOTE: -1 MEANS NO MODEL VALUE AVAILABLE
OR PARAMETER WAS NOT REQUESTED

1INPUT:
MLAT= 61.0 MLON=290.0 R= 35. MONTH= 6 HOUR=12.00

CALCULATED VALUES:
LATI= 55.5 LONG=236.6 COV= 90.3 DAY=167
DIP = 75.5 DIPL= 62.6 MODIP= 60.3 DEC= 25.8
XHI = 32.3 SUNRISE/SET(LT): 3.4/20.6 SUN-DEC= 23.2
NMF2=2.96E+11 NMF1=2.42E+11 NME=1.33E+11 NMD=7.80E+08
HMF2=224.9 HMF1=180.2 HME=105.0 HMD= 81.0

							RELATIVE PRECENTAGE DENSITY				
H(KM)	NE(M-3)	NE/NMF2	TN(K)	TE(K)	TI(K)	TE/TI	O+	H+	HE+	O2+	NO+
60.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
65.0	1.23E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
70.0	3.08E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
75.0	5.36E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
80.0	7.42E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
85.0	1.57E+09	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
90.0	1.62E+10	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
95.0	6.44E+10	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
100.0	1.18E+11	-1.0000	-1	-1	-1	-1.00	0	-1	-1	42	58
105.0	1.33E+11	-1.0000	-1	-1	-1	-1.00	0	-1	-1	40	59
110.0	1.30E+11	-1.0000	-1	-1	-1	-1.00	0	-1	-1	39	61
115.0	1.27E+11	-1.0000	-1	-1	-1	-1.00	1	-1	-1	37	62

120.0	1.31E+11	-1.0000	317	317	317	-1.00	1	-1	-1	36	63
140.0	1.59E+11	-1.0000	508	587	508	-1.00	4	-1	-1	33	63
160.0	2.01E+11	-1.0000	633	857	633	-1.00	10	-1	-1	31	59
180.0	2.42E+11	-1.0000	703	1127	703	-1.00	16	-1	-1	29	55
200.0	2.81E+11	-1.0000	747	1396	758	-1.00	23	-1	-1	23	54
220.0	2.95E+11	-1.0000	775	1653	812	-1.00	32	-1	-1	11	57
240.0	2.93E+11	-1.0000	795	1898	866	-1.00	44	-1	-1	4	51
260.0	2.83E+11	-1.0000	809	2142	921	-1.00	61	-1	-1	2	37
280.0	2.65E+11	-1.0000	818	2385	975	-1.00	83	-1	-1	1	16
300.0	2.43E+11	-1.0000	825	2591	1030	-1.00	98	-1	-1	0	2
320.0	2.18E+11	-1.0000	829	2647	1084	-1.00	99	-1	-1	0	1
340.0	1.92E+11	-1.0000	833	2665	1138	-1.00	99	-1	-1	0	1
360.0	1.67E+11	-1.0000	835	2682	1193	-1.00	99	-1	-1	0	0
380.0	1.44E+11	-1.0000	837	2699	1247	-1.00	99	-1	-1	0	0
400.0	1.24E+11	-1.0000	838	2716	1302	-1.00	99	-1	-1	0	0
500.0	5.80E+10	-1.0000	841	2794	1593	-1.00	95	-1	-1	0	0
600.0	3.22E+10	-1.0000	842	2874	1893	-1.00	87	-1	-1	0	0

NOTE: -1 MEANS NO MODEL VALUE AVAILABLE
OR PARAMETER WAS NOT REQUESTED
NOTE: IRI IS DESIGNED FOR NON-AURORAL LATITUDES
1INPUT:
LATI= 18.5 LONG=293.2 R= 50. MONTH= 3 HOUR= 6.00

CALCULATED VALUES:
MLAT= 29.9 MLON= 3.3 COV=102.4 DAY= 76
DIP = 49.9 DIPL= 30.7 MODIP= 41.8 DEC= -8.2
XHI = 90.9 SUNRISE/SET(LT): 6.1/17.9 SUN-DEC= -2.9
NMF2=2.46E+11 NMF1=0.00E+00 NME=1.99E+10 NMD=4.00E+08
HMF2=277.8 HMF1= 0.0 HME=105.0 HMD= 84.6

							RELATIVE PRECENTAGE DENSITY				
H(KM)	NE(M-3)	NE/NMF2	TN(K)	TE(K)	TI(K)	TE/TI	O+	H+	HE+	O2+	NO+
60.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
65.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
70.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
75.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
80.0	2.77E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
85.0	4.07E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
90.0	1.71E+09	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
95.0	9.93E+09	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
100.0	1.84E+10	-1.0000	-1	-1	-1	-1.00	0	-1	-1	18	82

105.0	1.99E+10	-1.0000	-1	-1	-1	-1.00	0	-1	-1	21	79
110.0	1.73E+10	-1.0000	-1	-1	-1	-1.00	0	-1	-1	24	76
115.0	1.36E+10	-1.0000	-1	-1	-1	-1.00	0	-1	-1	27	73
120.0	1.16E+10	-1.0000	303	303	303	-1.00	0	-1	-1	31	69
140.0	1.75E+10	-1.0000	472	604	472	-1.00	1	-1	-1	37	62
160.0	3.50E+10	-1.0000	573	904	573	-1.00	4	-1	-1	36	60
180.0	6.21E+10	-1.0000	627	1182	627	-1.00	18	-1	-1	20	63
200.0	1.03E+11	-1.0000	658	1301	658	-1.00	40	-1	-1	6	54
220.0	1.57E+11	-1.0000	679	1352	682	-1.00	54	-1	-1	2	44
240.0	2.10E+11	-1.0000	693	1401	706	-1.00	65	-1	-1	0	34
260.0	2.39E+11	-1.0000	703	1450	730	-1.00	78	-1	-1	0	22
280.0	2.46E+11	-1.0000	710	1498	754	-1.00	92	-1	-1	0	8
300.0	2.41E+11	-1.0000	714	1560	778	-1.00	98	-1	-1	0	0
320.0	2.29E+11	-1.0000	718	1671	801	-1.00	86	-1	-1	0	0
340.0	2.11E+11	-1.0000	720	1795	825	-1.00	74	-1	-1	0	0
360.0	1.91E+11	-1.0000	722	1917	849	-1.00	63	-1	-1	0	0
380.0	1.69E+11	-1.0000	723	2032	873	-1.00	54	-1	-1	0	0
400.0	1.48E+11	-1.0000	724	2106	897	-1.00	46	-1	-1	0	0
500.0	7.33E+10	-1.0000	726	1909	1034	-1.00	21	-1	-1	0	0
600.0	4.21E+10	-1.0000	727	1702	1179	-1.00	11	-1	-1	0	0

NOTE: -1 MEANS NO MODEL VALUE AVAILABLE
OR PARAMETER WAS NOT REQUESTED

DESCRIPTION OF MAGNETIC TAPE IRI9-86-VAX

NSSDC-Id MI-91D

NAME(short): IRI on VAX/VMS tape

(long): International Reference Ionosphere on labeled (IRI986) tape (VAX/VMS)

DATE: December 28, 1986.

COMPUTER: VAX 11/780, created in VAX/VMS with COPY

FORMAT: 9 track, 1600 BPI, labeled (IRI986), ASCII, 21 files, 261 blocks

SOURCE: Dieter Bilitza, GSFC/NSSDC code 633, Greenbelt, MD 20771, tel. (301) 286-9536
SPAN: NSSDCA::[BILITZA]

CONTENT:

standard IRI programs, 3 files		blocks
(1) FORTRAN-4 IRI main program (driver)	IRIMP9.FOR	15
(2) FORTRAN-4 IRI subroutines, functions	IRIFU9.FOR	28
(3) CCIR coefficient sets (binary)	CCIR.DAT	72
interactive driver, 14 files		
(4) FORTRAN-77 IRI main program (driver)	IRINEW.FOR	18
(5) FORTRAN-77 IRI subroutines, functions	IRIFUN.LIB	26
(6) User Manual for IRINEW with example	IRINEW.DOC	20
(7) CCIR coeff. set for Jan (binary)	CCIR11.BIN	6
... ...	...	
(18) CCIR coeff. set for Dec (binary)	CCIR22.BIN	6
Test examples for IRINEW, 3 files		
(19) input parameters for several examples	INPUT.IRI	1
(20) output of IRINEW for examples (1)	OUTEXA.IRI	5
(21) messages during computation	KONEXA.IRI	4

INSTRUCTION: The 21 files can be COPYed in VAX/VMS

BRIEF DESCRIPTION:

This labeled (IRI986), ASCII coded, 1600 BPI tape contains the programs, subroutines and coefficient sets of the INTERNATIONAL REFERENCE IONOSPHERE 1986 (IRI-86) as presented at the COSPAR meeting in Toulouse, France July 1986.

IRI is the empirical reference model of ionospheric densities and temperatures (electrons and ions) recommended by COSPAR and URSI. It was established in an international collaboration starting in the late sixties. IRI is up-dated bi-yearly to incorporate newly available measurements.

This tape was created in VAX/VMS with COPY and contains 21 files: the Fortran source codes for (1) the standard IRI driver program IRIMP9, (2) the IRI library IRIFU9 and (3) the CCIR coefficients for foF2 and M3000 in the format that is used in subroutine CCIRCA of IRIFU9. The CCIR set of coefficients is divided in twelve monthly sets of 2*13*76=1976 coefficients for the F2 critical frequency foF2 plus 2*9*49=882 coefficients for the propagation factor M3000. This file is binary and should be assigned to unit 10.

(4) The interactive driver program IRINEW with (5) the corresponding library of subroutines IRIFUN, (6) a documentation file for IRINEW with user manual and example, (7) ... (18) the binary CCIR coefficients sets for each month from January to December, and finally several examples for IRINEW including (19) user input, (20) program output, (21) konsol

messages during computation.

IRIMP9 produces altitude profiles of electron density, electron and ion temperature and ion composition (O+, H+, He+, O2+, NO+) for chosen latitude and longitude (geodetic or geomagnetic), solar activity (12-months-running mean of solar sunspot number), month and local (or universal) time. Selection flags allow to calculate and print only those densities/temperatures that are wanted. IRINEW produces density and temperature profiles in latitude or longitude or solar activity or month or time or altitude; it can also produce these profiles for the D, E and F peaks. This interactive module is described in detail in the documentation file.

IRI is also available on a unlabeled tape, on a floppy disc or on-line via the Space Plasma Analysis Network (SPAN).

REFERENCES:

K. Rawer, S. Ramakrishnan and D. Bilitza, IRI 1978, 75p(ages), Report, International Union of Radio Science (URSI), Brussels, 1978.

K. Rawer, D. Bilitza and S. Ramakrishnan, Goals and Status of the IRI, Rev. Geophys. Space Phys. 16, 177, 1978.

World Data Center A for Solar-Terrestrial Physics, Boulder, Colorado,
Report UAG-82, IRI 79 (Tables, Figures and Program), 243p, 1981.
Report UAG-90, Experience with and proposed Improvements of IRI 79, 232p, 1984. (available from NGDC, 325 Broadway, Boulder, CO 80303)

Advances in Space Research, Pergamon Press, New York,
Volume 2/10, The Upper Atmosphere of the Earth and Planets, 183-260, 1982.
Volume 4/1, Towards an Improved IRI, 171p, 1984.
Volume 5/7, Models of the Atmosphere and Ionosphere, 1-114, 1985.
Volume 5/10, IRI - Status 1985/86, 131p, 1985.

D. Bilitza, IRI: Recent Developments, Radio Sci. 21, 343, 1986.

```
C*****************************************************************
C********* INTERNATIONAL REFERENCE IONOSPHERE (IRI). *************
C*****************************************************************
C**************** IRIMP9, AUGUST 1986 ****************************
C****************   DRIVER PROGRAM    ****************************
C*****************************************************************
C*** THIS PROGRAM PRODUCES HEIGHT PROFILES OF                   ***
C***      ELECTRON DENSITY                                      ***
C***      NORMALISED ELECTRON DENSITY (TO F-MAXIMUM)            ***
C***      NEUTRAL TEMPERATURE (CIRA 72)                         ***
C***      ELECTRON TEMPERATURE                                  ***
C***      ION TEMPERATURE                                       ***
C***      ELECTRON TO ION TEMPERATURE RATIO                     ***
C***      RELATIVE PRECENTAGE DENSITIES OF THE IONS             ***
C***           ATOMIC OXYGEN, HYDROGEN, HELIUM,                 ***
C***           MOLECULAR OXYGEN AND NITROGEN OXYD (NO+)         ***
C*****************************************************************
C*** FOR SPECIFIED                                              ***
C***      GEOG. OR GEOM. LATITUDE AND LONGITUDE                 ***
C***      ZURICH SUNSPOT NUMBER (12-MONTH-RUNNING MEAN)         ***
C***      MONTH-NUMBER                                          ***
C***      LOCAL OR UNIVERSAL TIME                               ***
C*****************************************************************
C*** THE ALTITUDE LIMITS ARE:     LOWER          UPPER         ***
C***     ELECTRON DENSITY      60(DAY)/80 KM    1000 KM         ***
C***     TEMPERATURES             120 KM        3000 KM         ***
C***     ION DENSITIES            100 KM        1000 KM         ***
C*****************************************************************
C*     --------------------ADDRESSES-----------------------      *
C*     I  PROF. K. RAWER              DR. D. BILITZA        I    *
C*     I  HERRENSTR. 43               GSFC/NSSDC CODE 633   I    *
C*     I  D-7801 MARCH                GREENBELT MD 20771    I    *
C*     I  F.R.G.                      USA                   I    *
C*     ----------------------------------------------------      *
C*****************************************************************
C*****************************************************************
C*****************************************************************
C*********       ALL ANGLES ARE IN DEGREE          **************
C*********       ALL DENSITIES ARE IN M-3          **************
C*********       ALL ALTITUDES ARE IN KM           **************
C*********     ALL TEMPERATURES ARE IN KELVIN      **************
C*********     ALL TIMES ARE IN DECIMAL HOURS      **************
```

```
C*****************************************************************
C*******************  OPTIONS  ***********************************
C*****************************************************************
C* FOR HMF2=0.0 THE CCIR VALUES FOR FOF2 AND HMF2                *
C* ARE TAKEN BY USE OF THE CCIR-TAPE FOR FOF2 AND M3000.         *
C* THE USER SHOULD ADAPT PROCEDURE CCIRCA TO HIS OWN CCIR-TAPE.  *
C*****************************************************************
C* HOUR        IS LOCAL TIME OR UNIVERSAL TIME + 25              *
C* XHI         CAN BE INPUT OR OUTPUT. IF YOU WANT CALCULATION   *
C*             SET XHI LESS 0.                                   *
C* KOBE        0  (=1 SPECIAL OUTPUT ON UNIVAC)                  *
C* JF(11)      ARE SWITCHES (1=YES,0=NO) TO CHOOSE YOUR PARAMETERS*
C*             (NE,NE/NMF2,TN,TE,TI,TE/TI,O+,H+,HE+,O2+,NO+      *
C* JMAG        =0 MEANS GEOGRAFIC  =1 GEOMAGNETIC LATITUDE       *
C*             AND LONGITUDE.                                    *
C*****************************************************************
C* NE(...)     =0 AE-C AND AEROS MODELS ARE USED FOR ELECTRON    *
C*             TEMPERATURE OTHERWISE THE ANTI-CORRELATION-MODEL  *
C*             IS USED WITH THE GIVEN ELECTRON DENSITY VALUES    *
C*****************************************************************
C*****************************************************************
C* THIS VERSION DIFFERS FROM IRIF08 BY CONTAINING:               *
C* - RESTRICTION OF RZ12/COVM TO VALUES BELOW 145/185            *
C* - CORRECTED HARMONIZED BENT                                   *
C* - NEW ELECTRON TEMPERATURE MODEL                              *
C* - NEWER FOE NIGHT-TIME                                        *
C*****************************************************************
C*****************************************************************
      INTEGER EGNR,AGNR,DAYNR,DDO,DO2,SEASON
      REAL LATI,LONGI,MO2,MO,MODIP,NMF2,MAGBR,
     &  NMF1,NME,NMD,NEI,MM,MLAT,MLONG,NOBO2
      DIMENSION F(3),BOF(32),OUTF(11),RIF(4),XSM(4),HOA(3),AH(4),
     &  JF(11),DDO(4),DO2(2),MM(5),SIPL(2),XNAR(3),ATE(7),TEA(6),
     &  PF10(12),PF30(12),HO(4),MO2(3),MO(5),E(4),SIPH(2),SH(3),
     &  PF20(4),HO2(2),CTNN(3),PG10(80),PG20(32),PG30(80),CTN(3),
     &  XDELS(4),DNDS(4),DTI(4),DTE(5),AHH(7),STTE(6)
      LOGICAL EXT,SCHALT,NIGHT,F1REG
      COMMON/BLOCK1/HMF2,NMF2,HMF1/BLOCK2/B0,B1,C1,HZ,T,HST,STR
     &  /BLOCK3/HDX,HME,NME,HMD,NMD,HEF,D1,XKK,FP30,FP3U,FP1,FP2
     &  /BLOCK5/ZX,TNX,ATN,CTN/BLOCK6/NIGHT,E/BLOTE/AHH,ATE1,
     &  STTE,DTE/CONST/UMR
     &  /BLOCK8/HS,TNHS,XSM,MM,DTI,MXSM/BLO10/BETA,ETA,DELTA,ZETA
```

```
      EXTERNAL XE1,XE2,XE3,XE4,XE5,XE6,TEDER
      DATA BOF/114.,64.,134.,77.,128.,66.,75.,73.,113.,115.,
     &  150.,116.,138.,123.,94.,132.,72.,84.,83.,89.,75.,85.,
     &  57.,76.,102.,100.,120.,110.,107.,103.,76.,86./,
     &  HOA/300.,400.,600./,DTI/10.,10.,20.,20./,
     &  XDELS/3*5.,10./,DNDS/.016,.01,2*.016/,
     &  AHH/120.,0.,300.,400.,600.,1400.,3000./,
     &  DTE/5.,5.,10.,20.,20./,DDO/9,5,5,50/,DO2/5,5/
      DATA JMAG,LATI,LONGI,R,MONTH,HOUR,XHI,AH,SH,HMF2,FOF2,XNAR
     &  /0,45.1,293.5,100.,10,12.50,-100.0,50,150,500,1000,5,10,
     &   50,298.2,2.346E+11,2.567E+11,1.673E+11,0.0/,JF/3*1,4*0,
     &  4*1/,ILOC,ITIME,ISEL,IALT,IPEAK,ITENE/6*1/
      UMR=ATAN(1.0)*4./180.
      ALOG2=ALOG(2.)
C
C FIRST SPECIFY YOUR COMPUTERS CHANNEL NUMBERS ....................
C EGNR=INPUT, MONITO=MONITOR OUTPUT...............................
C FOR THE CCIR-TAPE CHANNEL 10 IS USED............................
C
      EGNR=5
      MONITO=6
      WRITE(MONITO,5100)
5100  FORMAT('1>>>>>> ENTER YOUR CHANNEL-NR FOR OUTPUT(AGNR)',
     &  ' AND MESSAGES(KONSOL)'/,' DID YOU ASSIGN CCIR.DAT TO',
     &  ' UNIT 10?'/
     &         ' EXAMPLE TO ILLUSTRATE FORMATTED INPUT:'/
     &         ' 15  6')
      READ(EGNR,5101) AGNR,KONSOL
5101  FORMAT(I2,I3)
3329  IF(ILOC.EQ.0) GOTO 5500
      WRITE(MONITO,5000) JMAG,LATI,LONGI
5000  FORMAT(1X/////1X,73('*')/
     &  ' **** INTERNATIONAL REFERENCE IONSPHERE: VERSION IRIF09 ',
     &         '(APRIL 1986) ****'/1X,73('*')///
     &  ' >>>>>> GEOG.(0) OR GEOM.(1) LATITUDE AND LONGITUDE'/
     &         1X,I1,2F6.1)
      READ(EGNR,5001) JMAG,LATI,LONGI
5001  FORMAT(I1,F6.1,F6.1)
5500  IF(ITIME.EQ.0) GOTO 5501
      WRITE(MONITO,5010) R,MONTH,HOUR,XHI
5010  FORMAT(1X//' >>>>>> SOLAR SUNSPOT NUMBER (RZ12),MONTH,',
     &  ' HOUR(DECIMAL),SOLAR',
```

```
     &         ' ZENITH ANGLE (XHI)'/' HOUR IS LOCAL TIME OR UNIVERSAL TIME ',
     &         'PLUS 25.00'/' XHI WILL BE CALCULATED IF YOU SET XHI=-100.0'/
     &         1X,F5.1,I3,F6.2,F7.1)
      READ(EGNR,5011) R,MONTH,HOUR,AXHI
5011  FORMAT(F5.1,I3,F6.2,F7.1)
5501  IF(ISEL.EQ.0) GOTO 5502
      WRITE(MONITO,5030) KOBE,JF
5030  FORMAT(1X//' >>>>>> DUMMY(0), PARAMETER SELECTION YES(1)',
     &  ' NO(0)'/' >>>>>> NE, NE/NMF2,TN,TE,TI,TE/TI,O+,H+,HE+,',
     &  'O2+,NO+'/' NE=2 PRODUCES IRI-8 PROFILE'/1X,I1,1X,11I1)
      READ(EGNR,5031) KOBE,JF
5031  FORMAT(I1,1X,11I1)
      INECH=JF(1)+JF(2)
      KOMB=JF(3)+JF(4)+JF(5)+JF(6)
      IOND=JF(7)+JF(8)+JF(9)+JF(10)+JF(11)
5502  IF(IALT.EQ.0) GOTO 5503
      WRITE(MONITO,5040) AH,SH
5040  FORMAT(1X//' >>>>>> ALTITUDE RANGES(KM): RANGE BONDARIES(4)',
     &  ' AND STEP WIDTHS(3)'/
     &         ' EXAMPLE: 50,55 ... 145,150,160 ... 490,500,550 ... 950,1000'/
     &         1X,F6.1,3F7.1,2X,3F6.1)
      READ(EGNR,5041) AH,SH
5041  FORMAT(F6.1,3F7.1,2X,3F6.1)
5503  IF((INECH.LT.1).OR.(IPEAK.LT.1)) GOTO 5200
      WRITE(MONITO,5050) NMF2,HMF2
5050  FORMAT(1X//' >>>>>> F-PEAK DENSITY(NMF2/M-3) AND ALTITUDE',
     &  '(HMF2/KM)'/' FOF2/MHZ CAN BE GIVEN INSTEAD OF NMF2'/
     &         ' CCIR-FOF2 AND M3000 ARE USED WHEN HMF2=0.'/
     &         1X,1PE8.2,0PF6.1)
      READ(EGNR,5051) FOF2,HMF2
5051  FORMAT(E8.2,F6.1)
5200  IF((KOMB.LT.1).OR.(ITENE.LT.1)) GOTO 5300
      WRITE(MONITO,5060) XNAR
5060  FORMAT(1X//' >>>>>> OPTION TO USE TE-NE-MODEL AT 300,400,600KM',
     &  ' ALTITUDE'/' NE(300), NE(400), NE(600) IN M-3  ',
     &  '(=0  MODEL NOT USED)'/1X,1PE8.2,1X,E8.2,1X,E8.2)
      READ(EGNR,5061) XNAR
5061  FORMAT(E8.2,1X,E8.2,1X,E8.2)
5300  REWIND 10
C
C CALCULATION OF MEAN F10.7CM SOLAR RADIO FLUX (COV)..................
C CALCULATION OF RESTRICTED SOLAR ACTIVITIES (RG,COVG)................
```

```
C
      COV=63.75+R*(0.728+R*0.00089)
      RG=R
      COVG=COV
      IF(R.GT.150.) RG=150.
      IF(COV.GT.193.) COVG=193.
C
C CALCULATION OF GEOG. OR GEOM. COORDINATES IN DEG.....................
C CALCULATION OF MAGNETIC INCLINATION (DIP), DECLINATION (DEC)........
C   DIP LATITUDE (MAGBR) AND MODIFIED DIP (MODIP). ALL IN DEGREE......
C
      IF(JMAG.LE.0) GOTO 888
      MLAT=LATI
      MLONG=LONGI
888   CALL GGM(JMAG,LONGI,LATI,MLONG,MLAT)
      HMEAN=(AH(1)+AH(4))/2.
      IF(HMEAN.GT.325.) HMEAN=300.
      ABSLAT=ABS(LATI)
      CALL FIELDG(LATI,LONGI,HMEAN,XMA,YMA,ZMA,BET,DIP,DEC,MODIP)
      MAGBR=ATAN(0.5*TAN(DIP*UMR))/UMR
C
C CALCULATION OF SEASON (SUMMER=2, WINTER=4)...........................
C CALCULATION OF DAY OF YEAR AND SUN DECLINATION.......................
C
      DAYNR=INT(MONTH*30.42-15.21)
      SUNDEC=-0.40915*COS(.0172142063*(DAYNR+8.))
      SEASON=INT(MONTH/3.0)
      IF(SEASON.LT.1) SEASON=4
      IF(LATI.GT.0.0) GOTO 5592
      SEASON=SEASON-2
      IF(SEASON.LT.1) SEASON=SEASON+4
C
C CALCULATION OF SOLAR ZENITH ANGLE (XHI/DEG)..........................
C NOON VALUE (XHINON)..................................................
C
5592  IF(HOUR.GT.24.) GOTO 2389
      UT=HOUR-LONGI/15.
      IF(UT.LT.0.) UT=UT+24.
      GOTO 2918
2389  UT=HOUR-25.
      HOUR=UT+LONGI/15.
      IF(HOUR.GT.24.) HOUR=HOUR-24.
```

```
2918  Z1=SIN(SUNDEC)*SIN(LATI*UMR)
      Z2=COS(SUNDEC)*COS(LATI*UMR)
      IF(ABS(Z2).GT.0.0) GOTO 120
      SAX=24.0
      IF(Z1.GE.0.0) SAX=0.0
      GOTO 140
120   IF(ABS(Z1/Z2).LE.1.0) GOTO 510
      SAX=24.0
      IF((Z1+Z2).GE.0.0) SAX=0.0
      GOTO 140
510   SAX=12.0-ACOS(-Z1/Z2)/(UMR*15.0)
140   SUX=24.0-SAX
      XLSTA=15.0*(HOUR-12.0)
      COSXHI=Z1+Z2*COS(XLSTA*UMR)
      XHI=ACOS(COSXHI)/UMR
      XHINON=ACOS(Z1+Z2)/UMR
      IF(XHINON.LE.89.0) GOTO 5579
      WRITE(KONSOL,5569) XHINON
5569  FORMAT(1X,'!!!!! YOUR NOON ZENITH ANGLE IS',F7.1,
     &  '; RE-ADJUSTED TO 89.0 !!!!!')
      XHINON=89.0
5579  IF(AXHI.LT.-90.) GOTO 503
      IF(ABS(XHI-AXHI).GT.5.) WRITE(AGNR,2329) AXHI,XHI
2329  FORMAT(1X,'!!! XHI-CHOSEN=',F5.1,' XHI-CALC.=',F5.1,' !!!')
      XHI=AXHI
      COSXHI=COS(XHI*UMR)
503   NIGHT=.FALSE.
      IF((HOUR.GT.SUX).OR.(HOUR.LT.SAX)) NIGHT=.TRUE.
      SUNDEC=SUNDEC/UMR
C
C CALCULATION OF ELECTRON DENSITY PARAMETERS................
C
      HNEA=65.
      IF(NIGHT) HNEA=80.
      HNEE=2000.
      IF(INECH.LT.1) GOTO 4933
      DELA=4.32
      IF(ABS(MODIP).GE.18.) DELA=1.0+EXP(-(ABS(MODIP)-30.0)/10.0)
      DELL=1+EXP(-(ABSLAT-20.)/10.)
C!!!!!!! F-REGION PARAMETERS AND E-PEAK !!!!!!!!!!!!!!!!!!!!!!!!!
      FOE=FOEEDI(COV,XHI,XHINON,LATI)
      IF(HMF2.GT.0.0) GOTO 501
```

```
      CALL F2OUT(MODIP,LATI,LONGI,RG,MONTH,UT,FOF2,XM3000)
      HMF2=HMF2ED(MAGBR,RG,FOF2/FOE,XM3000)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C FOR CHING-CHIU-VERSION THE LAST STATMENT HAS TO BE REPLACED BY
C     CALL IONDEM(R,MLAT,MLONG,DIP,LATI,HOUR,MONTH,FOF2,HMF2)
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
501   IF(FOF2.GT.100.0) FOF2=SQRT(FOF2/1.24E10)
      NMF2=1.24E10*FOF2*FOF2
      COS2=COS(MLAT*UMR)
      COS2=COS2*COS2
      FLU=(COVG-40.0)/30.0
      ETA1=-0.0070305*COS2
      IF(JF(1).EQ.2) GOTO 5566
        EX=EXP(-MLAT/15.)
        EX1=EX+1
        EPIN=4.*EX/(EX1*EX1)
      ETA1=-0.02*EPIN
5566  ETA=0.058798+ETA1+FLU*(-0.014065+0.0069724*COS2)+
     &(0.0024287+0.0042810*COS2-0.00015280*FOF2)*FOF2
      ZETA=0.078922-0.0046702*COS2+FLU*(-0.019132+0.0076545*COS2)+
     &(0.0032513+0.0060290*COS2-0.00020872*FOF2)*FOF2
      BETA=-128.03+20.253*COS2+FLU*(-8.0755-0.65896*COS2)+(0.44041
     &+0.71458*COS2-0.042966*FOF2)*FOF2
      Z=EXP(94.45/BETA)
      Z1=Z+1
      Z2=Z/(BETA*Z1*Z1)
      DELTA=(ETA/Z1-ZETA/2.0)/(ETA*Z2+ZETA/400.0)
1501  B1=3.0
C!!!!!!! INTERPOLATION FOR B0 OUT OF ARRAY BOF !!!!!!!!!!!!!!!!!!!!!
      DO 7033 ISR=1,2
      DO 7034 ISL=1,2
      I=(ISR-1)*8+(ISL-1)*16+SEASON*2
7034  SIPH(ISL)=HPOL(HOUR,BOF(I-1),BOF(I),SAX,SUX)
7033  SIPL(ISR)=SIPH(1)+(SIPH(2)-SIPH(1))/DELA
      B0=SIPL(1)+(SIPL(2)-SIPL(1))/90.*(R-10.)
C!!!!!!! F1-REGION PARAMETERS !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      F1REG=.FALSE.
      HMF1=0.
      NMF1=0.
      C1=0.
      XHI0=49.84733+0.349504*ABSLAT
      XHI100=38.96113+0.509932*ABSLAT
```

```
      XHIM=(XHI0+(XHI100-XHI0)*R/100.0)
      IF((XHI.GT.XHIM).OR.NIGHT.OR.(SEASON.EQ.4)) GOTO 150
      F1REG=.TRUE.
      C1=.09+.11/DELA
      FOF1=FOF1ED(MAGBR,R,COSXHI)
      NMF1=1.24E10*FOF1*FOF1
C!!!!!!! PARAMETER FOR E AND VALLEY-REGION !!!!!!!!!!!!!!!!!!!!!
150   NME=1.24E10*FOE*FOE
      HME=105.0
      XDEL=XDELS(SEASON)/DELA
      DNDHBR=DNDS(SEASON)/DELA
      HDEEP=HPOL(HOUR,10.5/DELA,28.,SAX,SUX)
      WIDTH=HPOL(HOUR,17.8/DELA,45.+22./DELA,SAX,SUX)
      DEPTH=HPOL(HOUR,XDEL,81.,SAX,SUX)
      DLNDH=HPOL(HOUR,DNDHBR,.06,SAX,SUX)
      IF(DEPTH.LT.1.0) GOTO 600
      IF(NIGHT) DEPTH=-DEPTH
      CALL TAL(HDEEP,DEPTH,WIDTH,DLNDH,EXT,E)
      IF(.NOT.EXT) GOTO 667
      WRITE(KONSOL,650)
650   FORMAT(1X,'*NE* E-REGION VALLEY CAN NOT BE MODELLED')
600   WIDTH=.0
667   HEF=HME+WIDTH
C!!!!!!!D-REGION PARAMETER!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      NMD=XMDED(XHI,R,4.0E8)
      HMD=HPOL(HOUR,81.0,88.0,SAX,SUX)
      F(1)=HPOL(HOUR,0.02+0.03/DELA,0.05,SAX,SUX)
      F(2)=HPOL(HOUR,4.6,4.5,SAX,SUX)
      F(3)=HPOL(HOUR,-11.5,-4.0,SAX,SUX)
      FP1=F(1)
      FP2=-FP1*FP1/2.0
      FP30=(-F(2)*FP2-FP1+1.0/F(2))/(F(2)*F(2))
      FP3U=(-F(3)*FP2-FP1-1.0/F(3))/(F(3)*F(3))
      HDX=HMD+F(2)
      X=HDX-HMD
      XDX=NMD*EXP(X*(FP1+X*(FP2+X*FP30)))
      DXDX=XDX*(FP1+X*(2.0*FP2+X*3.0*FP30))
      X=HME-HDX
      XKK=-DXDX*X/(XDX*ALOG(XDX/NME))
      D1=DXDX/(XDX*XKK*X**(XKK-1.0))
C
C SEARCH FOR HMF1 AND HST.................................
```

```
C
3801  IF(F1REG) GOTO 924
      HMF1=HMF2
      GOTO 380
924   H=10.0
133   H=H+10.0
      IF(H.GT.(HMF2-HEF)) GOTO 135
      CALL REGFA1(HMF2-H,HMF2,1.0,NMF1,XE2,SCHALT,HMF1)
      IF(SCHALT) GOTO 133
      GOTO 137
135   WRITE(KONSOL,11)
11    FORMAT(1X,'*NE* HMF1 IS NOT EVALUATED BY THE FUNCTION XE2')
3985  IF (HMF2-HEF.GE.B0) GOTO 922
      BOX=(HMF2-HEF)/1.1
      IF(BOX.LT.10.0) GOTO 922
      WRITE(KONSOL,923) B0,BOX
923   FORMAT(6X,'CORR.: B0(OLD)=',F5.1,' B0(NEW)=',F5.1)
      B0=BOX
      GOTO 924
922   B1X=B1+.5
      IF(B1X.GT.4) GOTO 7398
      WRITE(KONSOL,902) B1,B1X
902   FORMAT(6X,'CORR.: B1(OLD)=',F4.1,' B1(NEW)=',F4.1)
      B1=B1X
      GOTO 924
7398  WRITE(KONSOL,9269)
9269  FORMAT(1X,'CORR.: NO F1 REGION, B1=3, C1=0.0')
      HMF1=0.
      NMF1=0.
      C1=0.0
      B1=3.
      F1REG=.FALSE.
      GOTO 380
137   IF(HMF1.GT.HEF) GOTO 380
      WRITE(KONSOL,9)
9     FORMAT(1X,'*NE* UPPER E-VALLEY LIMIT(HEF) ABOVE HMF1')
      IF((HMF2-HEF.LT.B0).OR.(B1.LT.4)) GOTO 3985
      WRITE(KONSOL,9853)
9853  FORMAT(1X,'CORR.: NO F1 REGION, B1=3, C1=0.0')
      HMF1=0.
      NMF1=0.
      C1=0.0
```

```
      B1=3.
      F1REG=.FALSE.
C!!!!!!! NE3(HST)=NME !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
380   H=-3.
125   H=H+3.0
      IF(H.GT.(HMF1-HEF)) GOTO 900
      CALL REGFA1(HEF+H,HMF1,1.0,NME,XE3,SCHALT,HST)
      STR=HST
      IF(SCHALT) GOTO 125
      GOTO 360
900   WRITE(KONSOL,100)
100   FORMAT(1X,'*NE* HST IS NOT EVALUATED BY THE FUNCTION XE3')
      IF (HMF2-HEF.GE.B0) GOTO 9221
      B0X=(HMF2-HEF)/1.1
      IF(B0X.LT.10.0) GOTO 9221
      WRITE(KONSOL,9231) B0,B0X
9231  FORMAT(6X,'CORR.: B0(OLD)=',F5.1,' B0(NEW)=',F5.1)
      B0=B0X
      GOTO 3801
9221  B1X=B1+.5
      IF(B1X.GT.5) GOTO 7391
      WRITE(KONSOL,9021) B1,B1X
9021  FORMAT(6X,'CORR.: B1(OLD)=',F4.1,' B1(NEW)=',F4.1)
      B1=B1X
      GOTO 3801
7391  B1=3.
      HZ=HEF+.75*(HMF1-HEF)
      WRITE(KONSOL,901) HZ,HEF
901   FORMAT(6X,'CORR.: LIN. APP. BETWEEN HZ=',F5.1,
     &  ' AND HEF=',F5.1)
      XNEHZ=XE(HZ)
      T=(XNEHZ-NME)/(HZ-HEF)
      HST=-333.
      GOTO 6153
360   HZ=(HST+HMF1)/2.0
      D=HZ-HST
      T=D*D/(HZ-HEF-D)
6153  IF(.NOT.F1REG) HMF1=0.
C
C CALCULATION OF NEUTRAL TEMPERATURE PARAMETER...........
C
4933  HTA=120.0
```

```
      HTE=2000.0
      HTNA=90.0
      TNA=183.0
      ZX=125.0
      Z1=XLSTA
      HDEL=ZX-HTNA
      HD2=HDEL*HDEL
      TUN=TUNCAL(COV,LATI,SUNDEC,Z1)
      TNX=371.6678+0.0518806*TUN-294.3505*EXP(-0.00216222*TUN)
      ATN=0.63662*(TUN-TNX)
      TDEL=TNX-TNA
      CTN(1)=1.9*TDEL/HDEL
      CTN(3)=3.0*TDEL/(HD2*HD2)
      CTN(2)=CTN(3)*1.333333*HDEL-CTN(1)/HD2
C
C CALCULATION OF ELECTRON TEMPERATURE PARAMETER................
C
881   CONTINUE
C !!!!!!!!!! TE(120KM)=TN(120KM) !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      ATE(1)=TN(AHH(1),TNX,ATN,CTN)
C !!!!!!!!!! TE-MAXIMUM (JICAMARCA,ARECIBO) !!!!!!!!!!!!!!!!!!!!
      HM=60.*EXP(-(MLAT/22.41)**2)+210.
      AHH(2)=HPOL(HOUR,HM,150.,SAX,SUX)
      TM=800.*EXP(-(MLAT/33.)**2)+1500.
C !!!!!!!!!! TE(300,400KM)=TE-AE-C !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
C !!!!!!!!!! TE(1400,3000KM)=TE-ISIS !!!!!!!!!!!!!!!!!!!!!!!!!!!!
      IS=SEASON-SEASON/3*2
      CALL TEBA(MAGBR,HOUR,IS,TEA)
      ATE(2)=HPOL(HOUR,TM,TEA(5),SAX,SUX)
      ATE(3)=TEA(1)
      ATE(4)=TEA(2)
      ATE(6)=TEA(3)
      ATE(7)=TEA(4)
C !!!!!!!!!! TE(600KM)=TE-AEROS !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      ETT=EXP(-MLAT/11.35)
      TET=2900.-5600.*ETT/((ETT+1)**2.)
      TEN=839.+1161./(1.+EXP(-(ABS(MLAT)-45.)/5.))
      ATE(5)=HPOL(HOUR,TET,TEN,SAX,SUX)
C !!!!!!!!!! OPTION TO USE TE-NE-RELATION !!!!!!!!!!!!!!!!!!!!!!!
C !!!!!!!!!! AT 300, 400 OR 600 KM  !!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      DO 3395 I=1,3
3395  IF(XNAR(I).GT.0.) ATE(I+2)=TEDE(HOA(I),XNAR(I),-COV)
```

```
C !!!!!!!!!! TE'S ARE CORRECTED !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
C !!!!!!!!!! ALSO TE > TN ENFORCED !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      TNAHH2=TN(AHH(2),TNX,ATN,CTN)
      IF(ATE(2).LT.TNAHH2) ATE(2)=TNAHH2
      STTE1=(ATE(2)-ATE(1))/(AHH(2)-AHH(1))
      DO 1901 I=2,6
       TNAHHI=TN(AHH(I+1),TNX,ATN,CTN)
       IF(ATE(I+1).LT.TNAHHI) ATE(I+1)=TNAHHI
       STTE2=(ATE(I+1)-ATE(I))/(AHH(I+1)-AHH(I))
       ATE(I)=ATE(I)-(STTE2-STTE1)*DTE(I-1)*ALOG2
1901  STTE1=STTE2
C !!!!!!!!!! GRADIENTS ARE CALCULATED WITH !!!!!!!!!!!!!!!!!!!!
C !!!!!!!!!! CORRECTED REGION BOUNDARIES !!!!!!!!!!!!!!!!!!!!!!
      DO 1902 I=1,6
1902  STTE(I)=(ATE(I+1)-ATE(I))/(AHH(I+1)-AHH(I))
      ATE1=ATE(1)
C
C CALCULATION OF ION TEMPERATURE PARAMETERS...................
C
887   CONTINUE
C !!!!!!!!!! TI(430KM,DAY)=TI-AEROS !!!!!!!!!!!!!!!!!!!!!!!!!!!
      XSM(1)=430.0
      Z1=EXP(-0.09*MLAT)
      TID1=1240.0-1400.0*Z1/((1.0+Z1)*(1.0+Z1))
      MM(2)=HPOL(HOUR,3.0,0.0,SAX,SUX)
C !!!!!!!!!! TN < TI < TE !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      TED1=TEA(6)+90.
      TND1=TUNCAL(COV,LATI,SUNDEC,0.0)
      IF(TED1.LT.TND1) TED1=TND1
      IF(TID1.GT.TED1) TID1=TED1
      IF(TID1.LT.TND1) TID1=TND1
C !!!!!!!!!! TI(430KM,NIGHT)=TI-AEROS !!!!!!!!!!!!!!!!!!!!!!!!!!
      Z1=ABS(MLAT)
      Z2=Z1*(0.47+Z1*0.024)*UMR
      Z3=COS(Z2)
      TIN1=1200.0-300.0*SIGN(1.0,Z3)*SQRT(ABS(Z3))
C !!!!!!!!!! TN < TI < TE !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      TEN1=TEA(5)
      TNN1=TUNCAL(COV,LATI,SUNDEC,180.0)
      IF(TEN1.LT.TNN1) TEN1=TNN1
      IF(TIN1.GT.TEA(5)) TIN1=TEA(5)
      IF(TIN1.LT.TNN1) TIN1=TNN1
```

```
C !!!!!!!!!! TI(430KM,LT) FROM STEP FUNCTION !!!!!!!!!!!!!!!!!!
      TI1=TIN1
      IF(TID1.GT.TIN1) TI1=HPOL(HOUR,TID1,TIN1,SAX,SUX)
C !!!!!!!!!! TANGENT ON TN DETERMINES HS !!!!!!!!!!!!!!!!!!!!!!
      CALL REGFA1(130.0,500.0,0.1,TI1,TEDER,SCHALT,HS)
      IF(SCHALT) HS=200.
      TNHS=TN(HS,TNX,ATN,CTN)
      MM(1)=DTNDH(HS,ATN,CTN)
      IF(SCHALT) MM(1)=(TI1-TNHS)/(XSM(1)-HS)
      MXSM=2
C !!!!!!!!!! XTETI ALTITTUDE WHERE TE=TI !!!!!!!!!!!!!!!!!!!!!!
2391  XTTS=500.
      X=500.
2390    X=X+XTTS
      IF(X.GE.AHH(7)) GOTO 240
      TEX=ELTE(X)
      TIX=TI(X)
      IF(TIX.LT.TEX) GOTO 2390
      X=X-XTTS
      XTTS=XTTS/10.
      IF(XTTS.GT.0.1) GOTO 2390
      XTETI=X+XTTS*5.
C !!!!!!!!!! TI=TE ABOVE XTETI !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      MXSM=3
      MM(3)=STTE(6)
      XSM(2)=XTETI
      IF(XTETI.GT.AHH(6)) GOTO 240
      MXSM=4
      MM(3)=STTE(5)
      MM(4)=STTE(6)
      XSM(3)=AHH(6)
      IF(XTETI.GT.AHH(5)) GOTO 240
      MXSM=5
      DTI(1)=5.
      DTI(2)=5.
      MM(3)=STTE(4)
      MM(4)=STTE(5)
      MM(5)=STTE(6)
      XSM(3)=AHH(5)
      XSM(4)=AHH(6)
C
C INPUT OF THE ION DENSITY PARAMETER ARRAYS PF10,PF20 AND PF30......
```

```
C
240   IF(IOND.LT.1) GOTO 141
      RIF(1)=2.
      IF(ABSLAT.LT.30.0) RIF(1)=1.
      RIF(2)=2.
      IF(COV.LT.100.0) RIF(2)=1.
      RIF(3)=SEASON
      IF(SEASON.EQ.1) RIF(3)=3.
      RIF(4)=1.
      IF(NIGHT) RIF(4)=2.
      CALL KOEFP1(PG10)
      CALL KOEFP2 (PG20)
      CALL KOEFP3 (PG30)
      CALL SUFE (PG10,RIF,12,PF10)
      CALL SUFE(PG20,RIF,4,PF20)
      CALL SUFE(PG30,RIF,12,PF30)
C
C CALCULATION OF ION DENSITY PARAMETER.................
C
      HNIA=100.
      HNIE=2000.
      ZZZ1=0.0
      IF(XHI.LE.90.0) ZZZ1=COSXHI
      HFIXO=300.0
      IF((RIF(2).EQ.2.).AND.(RIF(3).EQ.2.)) HFIXO=249.0
      MO(1)=EPSTEP(PF10(1),PF10(2),PF10(3),PF10(4),ZZZ1)
      MO(2)=EPSTEP(PF10(5),PF10(6),PF10(7),PF10(8),ZZZ1)
      MO(3)=0.0
      HO(1)=EPSTEP(PF10(9),PF10(10),PF10(11),PF10(12),ZZZ1)
      HO(4)=PF20(1)
      MO(4)=PF20(2)
      MO(5)=PF20(3)
7100  HO(2)=290.0
      IF((RIF(2).EQ.2.).AND.(RIF(3).EQ.2.)) HO(2)=237.0
      HO(3)=(4.60517-MO(5)*(HO(4)-PF20(4)))/MO(4)+HO(4)
      IF(HO(2).LT.HO(3)) GOTO 7101
      MO(4)=MO(4)-0.001
      GOTO 7100
7101  Z2=5.0
      X=HO(2)
      Z1=0.0
7102  X=X+Z2
```

```
      Y=RPID(X,HFIXO,98.0,4,MO,DDO,HO)
      IF(Y.LE.Z1) GOTO 7103
      Z1=Y
      GOTO 7102
7103  IF(Z2.LE.1.0) GOTO 7104
      X=X-Z2
      Z2=1.0
      GOTO 7102
7104  HOO=X-0.5
      DO 7105 I=2,4,2
      L=I/2
      HO2(L)=PF3O(1+I)+PF3O(2+I)*ZZZ1
7105  MO2(L+1)=PF3O(7+I)+PF3O(8+I)*ZZZ1
      MO2(1)=PF3O(7)+PF3O(8)*ZZZ1
7106  Y=RPID(HOO,PF3O(1),PF3O(2),2,MO2,DO2,HO2)
      IF(Y.LE.0.1) GOTO 1899
      MO2(3)=MO2(3)-0.02
      GOTO 7106
C!!!!!!! RATIO OF NO+ TO O2+ DENSITY AT O+ MAXIMUM IS USED !!!!!!
C!!!!!!! FOR NO+ CALCULATION ABOVE THE O+ MAXIMUM (HOO) !!!!!!!!!
1899  Z1B= RPID (HOO,HFIXO,98.0,4,MO,DDO,HO)
      Z2B= RPID (HOO,PF3O(1),PF3O(2),2,MO2,DO2,HO2)
      NOBO2= (100.0-Z1B-Z2B)/Z2B
      IF(Z2B.LT.1.) NOBO2=0.0
C
C OUTPUT ON THE SPECIFIED DEVICE.................................
C
141   IF(JMAG.EQ.0) GOTO 7055
      WRITE(AGNR,7052) MLAT,MLONG,R,MONTH,HOUR
      WRITE(AGNR,7062) LATI,LONGI,COV,DAYNR
      GOTO 7065
7055  WRITE(AGNR,7054) LATI,LONGI,R,MONTH,HOUR
      WRITE(AGNR,7064) MLAT,MLONG,COV,DAYNR
7065  WRITE(AGNR,7060) DIP,MAGBR,MODIP,DEC
      WRITE(AGNR,7066) XHI,SAX,SUX,SUNDEC
      WRITE(AGNR,7070) NMF2,NMF1,NME,NMD
      WRITE(AGNR,7080) HMF2,HMF1,HME,HMD
      WRITE(AGNR,7091)
7052  FORMAT ('1','INPUT:'/1X,'MLAT=',F5.1,2X,'MLON=',F5.1,
     &  2X,'R=',F4.0,'  MONTH=',I2,'  HOUR=',F5.2)
7054  FORMAT ('1','INPUT:'/1X,'LATI=',F5.1,2X,'LONG=',F5.1,
     &  2X,'R=',F4.0,'  MONTH=',I2,'  HOUR=',F5.2)
```

```
7062  FORMAT (1X/' CALCULATED VALUES:'/1X,
     &  'LATI=',F5.1,' LONG=',F5.1,'   COV=',F5.1,' DAY=',I3)
7064  FORMAT (1X/' CALCULATED VALUES:'/1X,
     &  'MLAT=',F5.1,' MLON=',F5.1,'   COV=',F5.1,' DAY=',I3)
7060  FORMAT(1X,
     &  'DIP =',F5.1,' DIPL=',F5.1,' MODIP=',F5.1,' DEC=',F5.1)
7066  FORMAT(1X,'XHI =',F5.1,' SUNRISE/SET(LT):',F4.1,'/',F4.1,
     &  ' SUN-DEC=',F5.1)
7070  FORMAT(1X,'NMF2=',1PE8.2,2X,'NMF1=',E8.2,3X,
     &  'NME=',E8.2,1X,'NMD=',E8.2)
7080  FORMAT(1X,'HMF2=',F5.1,5X,'HMF1=',F5.1,6X,'HME=',F5.1,
     &  4X,'HMD=',F5.1)
7091  FORMAT(1X/51X,'RELATIVE PRECENTAGE DENSITY'/1X,' H(KM)',3X,
     &  'NE(M-3)',2X,'NE/NMF2 TN(K) TE(K) TI(K)  TE/TI',3X,
     &  'O+   H+  HE+  O2+  NO+')
      MMM=INT((AH(2)-AH(1))/SH(1)+1.4)+INT((AH(3)-AH(2))/SH(2)+
     &  .4)+INT((AH(4)-AH(3))/SH(3)+.4)
      IF(KOBE.EQ.1)
     &  WRITE(12,*) LATI,LONGI,MLAT,MLONG,DIP,MODIP,MAGBR,XHI,
     &  SUNDEC,R,COV,MONTH,HOUR,SAX,SUX,NMF2,NMF1,NME,NMD,HMF2,
     &  HMF1,HME,HMD,MMM
C
C CALCULATION FOR THE REQUIRED HEIGHT RANGE.......................
C
      IF(.NOT.F1REG) HMF1=HZ
      X=AH(1)
      IKL=1
300   DO 7397 KI=1,11
7397  OUTF(KI)=-1.6
      OUTF(1)=-1.
      OUTF(2)=-1.
      OUTF(6)=-1.
      IF((INECH.LT.0).OR.(X.LT.HNEA)) GOTO 330
      NEI=XE(X)
      IF(JF(1).GT.0) OUTF(1)=NEI
      IF(JF(2).GT.0) OUTF(2)=NEI/NMF2
330   IF(KOMB.LT.1) GOTO 7108
      IF((X.GT.HTE).OR.(X.LT.HTA)) GOTO 7108
      TNH=TN(X,TNX,ATN,CTN)
      TIH=TNH
      IF(X.GE.HS) TIH=TI(X)
      TEH=ELTE(X)
```

```
      IF(JF(3).GT.0) OUTF(3)=TNH
      IF(JF(4).GT.0) OUTF(4)=TEH
      IF(JF(5).GT.0) OUTF(5)=TIH
      IF(JF(6).GT.0) OUTF(6)=TEH/TIH
7108  IF(IOND.LT.1) GOTO 7118
      IF((X.GT.HNIE).OR.(X.LT.HNIA)) GOTO 7118
      Z1=RPID(X,HFIXO,98.0,4,MO,DDO,HO)
      Z2=RPID(X,PF3O(1),PF3O(2),2,MO2,DO2,HO2)
      IF(JF(7).GT.0) OUTF(7)=Z1
      IF((JF(8).GT.0).OR.(JF(9).GT.0))
     & CALL RDHHE(X,HOO,Z1,Z2,NOBO2,10.,OUTF(8),OUTF(9))
      IF(JF(10).GT.0) OUTF(10)=Z2
      IF(JF(11).GT.0) OUTF(11)=RDNO(X,HOO,Z2,Z1,NOBO2)
7118  IF(KOBE.EQ.0)
     & WRITE(AGNR,7117) X,OUTF(1),OUTF(2),IFIX(OUTF(3)+.5),
     &  IFIX(OUTF(4)+.5),IFIX(OUTF(5)+.5),OUTF(6),
     &  IFIX(OUTF(7)+.5),IFIX(OUTF(8)+.5),IFIX(OUTF(9)+.5),
     &  IFIX(OUTF(10)+.5),IFIX(OUTF(11)+.5)
      IF(KOBE.EQ.1)
     & WRITE(12,*) X,OUTF(1),OUTF(3),OUTF(4),OUTF(5),
     &  OUTF(7),OUTF(8),OUTF(9),OUTF(10),OUTF(11)
7117  FORMAT(1X,F6.1,2X,1PE9.2,1X,0PF7.4,3I6,F7.2,5I5,F7.2)
      X=X+SH(IKL)
      IF(X.LE.AH(IKL+1)) GOTO 300
      IF(IKL.GT.2) GOTO 4599
      IKL=IKL+1
      X=X-SH(IKL-1)+SH(IKL)
      GOTO 300
4599  WRITE(AGNR,7097)
7097  FORMAT(1X/' NOTE: -1 MEANS NO MODEL VALUE AVAILABLE'
     &         /'          OR PARAMETER WAS NOT REQUESTED')
      IF(AH(4).GT.1000.) WRITE(AGNR,7096)
7096   FORMAT(1X,'NOTE: ABOVE 1000 KM THE MODEL VALUES ARE ',
     &  'EXTRAPOLATIONS')
      IF(ABS(MLAT).GT.60.0) WRITE(AGNR,7099)
7099   FORMAT(1X,'NOTE: IRI IS DESIGNED FOR NON-AURORAL ',
     &  'LATITUDES')
      WRITE(MONITO,5600)
5600  FORMAT(1X//' **** DO YOU WANT TO CONTINUE:',
     &  ' YES(1) NO(0)'/' 1')
      READ(EGNR,5601) IALL
      IF(IALL.EQ.0) GOTO 3330
```

```
      WRITE(MONITO,5602) ILOC,ITIME,ISEL,IALT,IPEAK,ITENE
5602  FORMAT(1X//' **** WHICH PARAMETER DO YOU WANT TO ',
     & 'CHANGE?'/' **** LOCATION,TIME,SELECTION,ALTITUDES,',
     & 'F-PEAK,TE-NE-OPTION'/6I2)
      READ(EGNR,5601) ILOC,ITIME,ISEL,IALT,IPEAK,ITENE
5601  FORMAT(I1,5I2)
      JMAG=0
      HMF2=0.0
      GOTO 3329
3330  CONTINUE
      STOP
      END
```

```
C*************************************************************
C********** INTERNATIONAL REFERENCE IONOSPHERE ****************
C*************************************************************
C****************  IRIFU9, AUGUST 1986  **********************
C**************** FUNCTIONS,SUBROUTINES **********************
C*************************************************************
C*************************************************************
C***  -------------------ADDRESSES-----------------------  ***
C***  I  PROF. K. RAWER              DR. D. BILITZA       I  ***
C***  I  HERRENSTR. 43               GSFC CODE 633        I  ***
C***  I  7801 MARCH 1                GREENBELT MD 20771   I  ***
C***  I  F.R.G.                      USA                  I  ***
C***  I                              TEL. (301)286-9536   I  ***
C***  ----------------------------------------------------  ***
C*************************************************************
C*************************************************************
C
C*************************************************************
C** SUBROUTINE CCIRCA READS THE CCIR-COEFFICIENT SET WITH:   **
C**            READ(10) FOF2,M3000                           **
C** MAKE SURE THAT THE BINARY FILE CCIR.DAT IS ASSIGNED      **
C** OR CHANGE THE ABOVE STATEMENT AS INDICATED IN CCIRCA IF  **
C** YOU ARE USING THE ASCC-CODED CCIR-SET.                   **
C*************************************************************
C
C
C*************************************************************
C*************** ELECTRON DENSITY ****************************
C*************************************************************
C
      FUNCTION XE1(H)
C REPRESENTING ELECTRON DENSITY(M-3) IN THE TOPSIDE IONOSPHERE
C (H=HMF2....1000 KM) BY HARMONIZED BENT-MODEL ADMITTING
C VARIABILITY OFGLOBAL PARAMETER ETA,ZETA,BETA,DELTA WITH
C GEOM. LATITUDE, SMOOTHED SOLAR FLUX AND CRITICAL FREQUENCY
C (SEE MAIN PROGRAM).
C [REF.:K.RAWER,S.RAMAKRISHNAN,1978]
      REAL NMF2
      COMMON/BLOCK1/HMF2,NMF2,HMF1/BLO10/BETA,ETA,DELTA,ZETA
      DXDH=(1000.-HMF2)/700.
      X=(H-HMF2)/DXDH+300.0-DELTA
      E1=EXP((X-394.5)/BETA)
```

```
      E2=EXP((X-300.0)/100.)
      Y=DXDH*(BETA*ETA*ALOG((1.+E1)/(1.+EXP((-94.5-DELTA)/BETA)))
     &+ZETA*(100.*ALOG((1.+E2)/(1.+EXP(-DELTA/100.)))-X+300.-DELTA))
      XE1=NMF2*EXP(-Y)
      RETURN
      END
C
      FUNCTION DXE1N(H)
C LOGARITHMIC DERIVATIVE OF FUNCTION XE1 (KM-1).
      REAL NMF2
      COMMON/BLOCK1/HMF2,NMF2,HMF1/BLO10/BETA,ETA,DELTA,ZETA
      X=(H-HMF2)/(1000.0-HMF2)*700.0+300.0-DELTA
      DXE1N=(ZETA*(1.-1./(1.+EXP((300.-X)/100.)))-
     &ETA*1./(1.+EXP((394.5-X)/BETA)))
      RETURN
      END
C
      REAL FUNCTION XE2(H)
C ELECTRON DENSITY FOR THE BOTTOMSIDE F-REGION (HMF1...HMF2).
      REAL NMF2
      COMMON/BLOCK1/HMF2,NMF2,HMF1/BLOCK2/B0,B1,C1,HZ,T,HST,STR
      X=(HMF2-H)/B0
      XE2=NMF2*EXP(-X**B1)/COSH(X)
      RETURN
      END
C
      REAL FUNCTION XE3(H)
C ELECTRON DENSITY FOR THE F1-LAYER (HZ.....HMF1).
      REAL NMF2
      COMMON/BLOCK1/HMF2,NMF2,HMF1/BLOCK2/B0,B1,C1,HZ,T,HST,STR
      XE3=XE2(H)+NMF2*C1*SQRT(ABS(HMF1-H)/B0)
      RETURN
      END
C
      REAL FUNCTION XE4(H)
C ELECTRON DENSITY FOR THE INDERMEDIUM REGION (HEF..HZ).
      COMMON/BLOCK2/B0,B1,C1,HZ,T,HST,STR/BLOCK3/HDX,HME,
     &  XME,HMD,XMD,HEF,D1,XKK,FP30,FP3U,FP1,FP2
      IF(HST.LT.0.) GOTO 100
      XE4=XE3(HZ+T/2.0-SIGN(1.0,T)*SQRT(T*(HZ-H+T/4.0)))
      RETURN
100   XE4=XME+T*(H-HEF)
```

```
      RETURN
      END
C
      REAL FUNCTION XE5(H)
C ELECTRON DENSITY FOR THE E AND VALLEY REGION (HME..HEF).
      LOGICAL NIGHT
      COMMON/BLOCK3/HDX,HME,XNME,HMD,XNMD,HEF,D1,XKK,FP30,
     &  FP3U,FP1,FP2/BLOCK6/NIGHT,E(4)
      T3=H-HME
      T1=T3*T3*(E(1)+T3*(E(2)+T3*(E(3)+T3*E(4))))
      IF(NIGHT) GOTO 100
      XE5=XNME*(1+T1)
      RETURN
100   XE5=XNME*EXP(T1)
      RETURN
      END
C
      REAL FUNCTION XE6(H)
C ELECTRON DENSITY FOR THE D REGION (HA...HME).
      COMMON/BLOCK3/HDX,HME,XNME,HMD,XNMD,HEF,D1,XKK,FP30,
     &  FP3U,FP1,FP2
      IF(H.GT.HDX) GOTO 100
      Z=H-HMD
      FP3=FP3U
      IF(Z.GT.0.0) FP3=FP30
      XE6=XNMD*EXP(Z*(FP1+Z*(FP2+Z*FP3)))
      RETURN
100   Z=HME-H
      XE6=XNME*EXP(-D1*Z**XKK)
      RETURN
      END
C
      REAL FUNCTION XE(H)
C ELECTRON DENSITY BEETWEEN HA(KM) AND 1000 KM
C SUMMARIZING PROCEDURES  NE1....6;
      COMMON/BLOCK1/HMF2,XNMF2,HMF1/BLOCK2/B0,B1,C1,HZ,T,
     &  HST,STR/BLOCK3/HDX,HME,XNME,HMD,XNMD,HEF,D1,XKK,
     &  FP30,FP3U,FP1,FP2
      IF(H.LT.HMF2) GOTO 100
      XE=XE1(H)
      RETURN
100   IF(H.LT.HMF1) GOTO 300
```

```
      XE=XE2(H)
      RETURN
300   IF(H.LT.HZ) GOTO 400
      XE=XE3(H)
      RETURN
400   IF(H.LT.HEF) GOTO 500
      XE=XE4(H)
      RETURN
500   IF(H.LT.HME) GOTO 600
      XE=XE5(H)
      RETURN
600   XE=XE6(H)
      RETURN
      END
C
C*************************************************************
C***************** ELECTRON TEMPERATURE ********************
C*************************************************************
C
      FUNCTION DTEDH(H,F2,HMAX,D,HO,DTNDH,A)
C D.BILITZA 1978, CALCULATES THE HEIGHT DERIVATIVE
C ELECTRON TEMPERATURE PROFILE AFTER PROCEDURE TE
      IF(H.LT.HO) GOTO 100
      Y=EXP(-0.03*(H-HMAX))
      F=1.0+Y
      DTEDH=D-F2*0.03*Y*(1.0-Y)/(F*F*F)
      RETURN
100   DTEDH=DTNDH+A
      RETURN
      END
C
      SUBROUTINE TELAT(PHI,A,B,XN,P1,P2,C,F1,F2)
C D. BILITZA 1978, CALCULATES THE PARAMETERS F1 AND F2
C NEEDED IN THE ELECTRON TEMPERATURE MODEL PROCEDURE TE,
C BOTH DEPENDING ON GEOMAGNETIC LATITUDE (PHI)
      COMMON/CONST/UMR
      XPHI=ABS(PHI)
      F=(P1+P2*XPHI)*XPHI
      F=F*UMR
      Y=COS(F)
      F1=A-B*SIGN(1.0,Y)*ABS(Y)**XN
      Y=EXP(-0.1*XPHI)
```

```
      F=1.0+Y
      F2=C*Y/(F*F)
      RETURN
      END
C
      FUNCTION TE(H,F1,F2,HMAX,D,HHO,TNH,HTA,A)
C D. BILITZA 1978. ELECTRON TEMPERATURE PROFILE
C IN THE  HEIGHT RANGE 120-1000 KM. F1,F2 ARE LATITUDE DEPENDENT AND
C ARE GIVEN BY TELAT. HMAX IS THE HEIGHT OF A POSSIBLE MAXIMUM
C D THE TEMPERATURE HEIGHT GRADIENT, HO THE INTERSECTION HEIGHT
C BELOW WHICH THE PROFILE IS BUILT TO APPROACH THE CIRA 72 TEMP.
C TNA AT HTA . A TNH ARE COEFFICIENTS OF THE FITTING FUNCTION
      IF(H.LT.HHO) GOTO 10
      Y=EXP(-0.03*(H-HMAX))
      F=1.0+Y
      TE=F1+F2*Y/(F*F)+D*(H-700.0)
      RETURN
10    TE=TNH+A*(H-HTA)
      RETURN
      END
C
      SUBROUTINE TEBA(DIPL,SLT,IS,TE)
C CALCULATES ELECTRON TEMPERATURES TE(1) TO TE(4) AT ALTITUDES
C 300, 400, 1400 AND 3000 KM FOR DIP-LATITUDE DIPL/DEG AND
C LOCAL SOLAR TIME SLT/H USING THE BRACE-THEIS-MODELS (J. ATMOS.
C TERR. PHYS. 43, 1317, 1981); IS=1 EQUINOX, IS=2 SUMMER.
C ALSO CALCULATED ARE THE TEMPERATURES AT 300 KM ALTITUDE FOR
C MIDNIGHT (TE(5)) AND AT 400 KM AT NOON (TE(6)).
      DIMENSION C(4,2,81),A(82),TE(6)
      COMMON/CONST/UMR
      DATA (C(1,1,J),J=1,81)/
     &.3100E1,-.3215E-2,.2440E+0,-.4613E-3,-.1711E-1,.2605E-1,
     &-.9546E-1,.1794E-1,.1270E-1,.2791E-1,.1536E-1,-.6629E-2,
     &-.3616E-2,.1229E-1,.4147E-3,.1447E-2,-.4453E-3,-.1853,
     &-.1245E-1,-.3675E-1,.4965E-2,.5460E-2,.8117E-2,-.1002E-1,
     &.5466E-3,-.3087E-1,-.3435E-2,-.1107E-3,.2199E-2,.4115E-3,
     &.6061E-3,.2916E-3,-.6584E-1,.4729E-2,-.1523E-2,.6689E-3,
     &.1031E-2,.5398E-3,-.1924E-2,-.4565E-1,.7244E-2,-.8543E-4,
     &.1052E-2,-.6696E-3,-.7492E-3,.4405E-1,.3047E-2,.2858E-2,
     &-.1465E-3,.1195E-2,-.1024E-3,.4582E-1,.8749E-3,.3011E-3,
     &.4473E-3,-.2782E-3,.4911E-1,-.1016E-1,.27E-2,-.9304E-3,
     &-.1202E-2,.2210E-1,.2566E-2,-.122E-3,.3987E-3,-.5744E-1,
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&.4408E-2,-.3497E-2,.83E-3,-.3536E-1,-.8813E-2,.2423E-2,
&-.2994E-1,-.1929E-2,-.5268E-3,-.2228E-1,.3385E-2,
&.413E-1,.4876E-2,.2692E-1,.1684E-2/
 DATA (C(1,2,J),J=1,81)/.313654E1,.6796E-2,.181413,.8564E-1,
&-.32856E-1,-.3508E-2,-.1438E-1,-.2454E-1,.2745E-2,.5284E-1,
&.1136E-1,-.1956E-1,-.5805E-2,.2801E-2,-.1211E-2,.4127E-2,
&.2909E-2,-.25751,-.37915E-2,-.136E-1,-.13225E-1,.1202E-1,
&.1256E-1,-.12165E-1,.1326E-1,-.7123E-1,.5793E-3,.1537E-2,
&.6914E-2,-.4173E-2,.1052E-3,-.5765E-3,-.4041E-1,-.1752E-2,
&-.542E-2,-.684E-2,.8921E-3,-.2228E-2,.1428E-2,.6635E-2,-.48045E-2,
&-.1659E-2,-.9341E-3,.223E-3,-.9995E-3,.4285E-1,-.5211E-3,
&-.3293E-2,.179E-2,.6435E-3,-.1891E-3,.3844E-1,.359E-2,-.8139E-3,
&-.1996E-2,.2398E-3,.2938E-1,.761E-2,.347655E-2,.1707E-2,.2769E-3,
&-.157E-1,.983E-3,-.6532E-3,.929E-4,-.2506E-1,.4681E-2,.1461E-2,
&-.3757E-5,-.9728E-2,.2315E-2,.6377E-3,-.1705E-1,.2767E-2,
&-.6992E-3,-.115E-1,-.1644E-2,.3355E-2,-.4326E-2,.2035E-1,.2985E-1/
 DATA (C(2,1,J),J=1,81)/.3136E1,.6498E-2,.2289,.1859E-1,-.3328E-1,
&-.4889E-2,-.3054E-1,-.1773E-1,-.1728E-1,.6555E-1,.1775E-1,
&-.2488E-1,-.9498E-2,.1493E-1,.281E-2,.2406E-2,.5436E-2,-.2115,
&.7007E-2,-.5129E-1,-.7327E-2,.2402E-1,.4772E-2,-.7374E-2,
&-.3835E-3,-.5013E-1,.2866E-2,.2216E-2,.2412E-3,.2094E-2,.122E-2
&,-.1703E-3,-.1082,-.4992E-2,-.4065E-2,.3615E-2,-.2738E-2,
&-.7177E-3,.2173E-3,-.4373E-1,-.375E-2,.5507E-2,-.1567E-2,
&-.1458E-2,-.7397E-3,.7903E-1,.4131E-2,.3714E-2,.1073E-2,
&-.8991E-3,.2976E-3,.2623E-1,.2344E-2,.5608E-3,.4124E-3,.1509E-3,
&.5103E-1,.345E-2,.1283E-2,.7238E-3,-.3464E-4,.1663E-1,-.1644E-2,
&-.71E-3,.5281E-3,-.2729E-1,.3556E-2,-.3391E-2,-.1787E-3,.2154E-2,
&.6476E-2,-.8282E-3,-.2361E-1,.9557E-3,.3205E-3,-.2301E-1,
&-.854E-3,-.1126E-1,-.2323E-2,-.8582E-2,.2683E-1/
 DATA (C(2,2,J),J=1,81)/.3144E1,.8571E-2,.2539,.6937E-1,-.1667E-1,
&.2249E-1,-.4162E-1,.1201E-1,.2435E-1,.5232E-1,.2521E-1,-.199E-1,
&-.7671E-2,.1264E-1,-.1551E-2,-.1928E-2,.3652E-2,-.2019,.5697E-2,
&-.3159E-1,-.1451E-1,.2868E-1,.1377E-1,-.4383E-2,.1172E-1,
&-.5683E-1,.3593E-2,.3571E-2,.3282E-2,.1732E-2,-.4921E-3,-.1165E-2
&,-.1066,-.1892E-1,.357E-2,-.8631E-3,-.1876E-2,-.8414E-4,.2356E-2,
&-.4259E-1,-.322E-2,.4641E-2,.6223E-3,-.168E-2,-.1243E-3,.7393E-1,
&-.3143E-2,-.2362E-2,.1235E-2,-.1551E-2,.2099E-3,.2299E-1,.5301E-2
&,-.4306E-2,-.1303E-2,.7687E-5,.5305E-1,.6642E-2,-.1686E-2,
&.1048E-2,.5958E-3,.4341E-1,-.8819E-4,-.333E-3,-.2158E-3,-.4106E-1
&,.4191E-2,.2045E-2,-.1437E-3,-.1803E-1,-.8072E-3,-.424E-3,
&-.26E-1,-.2329E-2,.5949E-3,-.1371E-1,-.2188E-2,.1788E-1,
&.6405E-3,.5977E-2,.1333E-1/
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```
      DATA (C(3,1,J),J=1,81)/.3372E1,.1006E-1,.1436,.2023E-2,-.5166E-1,
     &.9606E-2,-.5596E-1,.4914E-3,-.3124E-2,-.4713E-1,-.7371E-2,
     &-.4823E-2,-.2213E-2,.6569E-2,-.1962E-3,.3309E-3,-.3908E-3,
     &-.2836,.7829E-2,.1175E-1,.9919E-3,.6589E-2,.2045E-2,-.7346E-2
     &,-.89E-3,-.347E-1,-.4977E-2,.147E-2,-.2823E-5,.6465E-3,
     &-.1448E-3,.1401E-2,-.8988E-1,-.3293E-4,-.1848E-2,.4439E-3,
     &-.1263E-2,.317E-3,-.6227E-3,.1721E-1,-.199E-2,-.4627E-3,
     &.2897E-5,-.5454E-3,.3385E-3,.8432E-1,-.1951E-2,.1487E-2,
     &.1042E-2,-.4788E-3,-.1276E-3,.2373E-1,.2409E-2,.5263E-3,
     &.1301E-2,-.4177E-3,.3974E-1,.1418E-3,-.1048E-2,-.2982E-3,
     &-.3396E-4,.131E-1,.1413E-2,-.1373E-3,.2638E-3,-.4171E-1,
     &-.5932E-3,-.7523E-3,-.6883E-3,-.2355E-1,.5695E-3,-.2219E-4,
     &-.2301E-1,-.9962E-4,-.6761E-3,.204E-2,-.5479E-3,.2591E-1,
     &-.2425E-2,.1583E-1,.9577E-2/
      DATA (C(3,2,J),J=1,81)/.3367E1,.1038E-1,.1407,.3622E-1,-.3144E-1,
     &.112E-1,-.5674E-1,.3219E-1,.1288E-2,-.5799E-1,-.4609E-2,
     &.3252E-2,-.2859E-3,.1226E-1,-.4539E-2,.1310E-2,-.5603E-3,
     &-.311,-.1268E-2,.1539E-1,.3146E-2,.7787E-2,-.143E-2,-.482E-2
     &,.2924E-2,-.9981E-1,-.7838E-2,-.1663E-3,.4769E-3,.4148E-2,
     &-.1008E-2,-.979E-3,-.9049E-1,-.2994E-2,-.6748E-2,-.9889E-3,
     &.1488E-2,-.1154E-2,-.8412E-4,-.1302E-1,-.4859E-2,-.7172E-3,
     &-.9401E-3,.9101E-3,-.1735E-3,.7055E-1,.6398E-2,-.3103E-2,
     &-.938E-3,-.4E-3,-.1165E-2,.2713E-1,-.1654E-2,.2781E-2,
     &-.5215E-5,.2258E-3,.5022E-1,.95E-2,.4147E-3,.3499E-3,
     &-.6097E-3,.4118E-1,.6556E-2,.3793E-2,-.1226E-3,-.2517E-1,
     &.1491E-3,.1075E-2,.4531E-3,-.9012E-2,.3343E-2,.3431E-2,
     &-.2519E-1,.3793E-4,.5973E-3,-.1423E-1,-.132E-2,-.6048E-2,
     &-.5005E-2,-.115E-1,.2574E-1/
      DATA (C(4,1,J),J=1,81)/.3574E1,.0,.7537E-1,.0,-.8459E-1,
     &0.,-.294E-1,0.,.4547E-1,-.5321E-1,0.,.4328E-2,0.,.6022E-2,
     &.0,-.9168E-3,.0,-.1768,.0,.294E-1,.0,.5902E-3,.0,-.9047E-2,
     &.0,-.6555E-1,.0,-.1033E-2,.0,.1674E-2,.0,.2802E-3,-.6786E-1
     &,.0,.4193E-2,.0,-.6448E-3,.0,.9277E-3,-.1634E-1,.0,-.2531E-2
     &,.0,.193E-4,.0,.528E-1,.0,.2438E-2,.0,-.5292E-3,.0,.1555E-1
     &,.0,-.3259E-2,.0,-.5998E-3,.3168E-1,.0,.2382E-2,.0,-.4078E-3
     &,.2312E-1,.0,.1481E-3,.0,-.1885E-1,.0,.1144E-2,.0,-.9952E-2
     &,.0,-.551E-3,-.202E-1,.0,-.7283E-4,-.1272E-1,.0,.2224E-2,
     &.0,-.251E-2,.2434E-1/
      DATA (C(4,2,J),J=1,81)/.3574E1,-.5639E-2,.7094E-1,
     &-.3347E-1,-.861E-1,-.2877E-1,-.3154E-1,-.2847E-2,.1235E-1,
     &-.5966E-1,-.3236E-2,.3795E-3,-.8634E-3,.3377E-2,-.1071E-3,
     &-.2151E-2,-.4057E-3,-.1783,.126E-1,.2835E-1,-.242E-2,
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     &.3002E-2,-.4684E-2,-.6756E-2,-.7493E-3,-.6147E-1,-.5636E-2
     &,-.1234E-2,-.1613E-2,-.6353E-4,-.2503E-3,-.1729E-3,-.7148E-1
     &,.5326E-2,.4006E-2,.6484E-3,-.1046E-3,-.6034E-3,-.9435E-3,
     &-.2385E-2,.6853E-2,.151E-2,.1319E-2,.9049E-4,-.1999E-3,
     &.3976E-1,.2802E-2,-.103E-2,.5599E-3,-.4791E-3,-.846E-4,
     &.2683E-1,.427E-2,.5911E-3,.2987E-3,-.208E-3,.1396E-1,
     &-.1922E-2,-.1063E-2,.3803E-3,.1343E-3,.1771E-1,-.1038E-2,
     &-.4645E-3,-.2481E-3,-.2251E-1,-.29E-2,-.3977E-3,-.516E-3,
     &-.8079E-2,-.1528E-2,.306E-3,-.1582E-1,-.8536E-3,.1565E-3,
     &-.1252E-1,.2319E-3,.4311E-2,.1024E-2,.1296E-5,.179E-1/
      COLAT=UMR*(90.-DIPL)
      AZ=.2618*SLT
      CALL SPHARM(A,8,8,COLAT,AZ)
      DO 2 K=1,4
      STE=0.
      DO 1 I=1,81
1     STE=STE+A(I)*C(K,IS,I)
2     TE(K)=10.**STE
      DO 4 J=1,2
      STE=0.
      AZ=.2618*(J-1)*12.
      CALL SPHARM(A,8,8,COLAT,AZ)
      DO 3 I=1,81
3     STE=STE+A(I)*C(J,IS,I)
4     TE(J+4)=10.**STE
      RETURN
      END
C
      SUBROUTINE SPHARM(C,L,M,COLAT,AZ)
C CALCULATES THE COEFFICIENTS OF THE SPHERICAL HARMONIC
C EXPANSION THAT WAS USED FOR THE BRACE-THEIS-MODELS.
      DIMENSION C(82)
      C(1)=1.
      K=2
      X=COS(COLAT)
      C(K)=X
      K=K+1
      DO 10 I=2,L
      C(K)=((2*I-1)*X*C(K-1)-(I-1)*C(K-2))/I
10    K=K+1
      Y=SIN(COLAT)
      DO 20 MT=1,M
```

```
      CAZ=COS(MT*AZ)
      SAZ=SIN(MT*AZ)
      C(K)=Y**MT
      K=K+1
      IF(MT.EQ.L) GOTO 16
      C(K)=C(K-1)*X*(2*MT+1)
      K=K+1
      IF((MT+1).EQ.L) GOTO 16
      DO 15 I=2+MT,L
      C(K)=((2*I-1)*X*C(K-1)-(I+MT-1)*C(K-2))/(I-MT)
15    K=K+1
16    N=L-MT+1
      DO 18 I=1,N
      C(K)=C(K-N)*CAZ
      C(K-N)=C(K-N)*SAZ
18    K=K+1
20    CONTINUE
      RETURN
      END
C
      REAL FUNCTION ELTE(H)
C ELECTRON TEMPERATURE PROFILE BASED ON THE TEMPERATURES AT 120
C HMAX,300,400,600,1400,3000 KM ALTITUDE. INBETWEEN CONSTANT
C GRADIENT IS ASSUMED.
      COMMON /BLOTE/AH(7),ATE1,ST(6),D(5)
      SUM=ATE1+ST(1)*(H-AH(1))
      DO 1 I=1,5
      A=H-AH(I+1)
      IF(A/D(I).LT.88.) A=D(I)*ALOG(1.+EXP(A/D(I)))
      B=AH(1)-AH(I+1)
      IF(B/D(I).LT.88.) B=D(I)*ALOG(1.+EXP(B/D(I)))
1     SUM=SUM+(ST(I+1)-ST(I))*(A-B)
      ELTE=SUM
      RETURN
      END
C
      FUNCTION TEDE(H,DEN,COV)
C ELECTRON TEMEPERATURE MODEL AFTER BRACE,THEIS .
C FOR NEG. COV THE MEAN COV-INDEX (3 SOLAR ROT.) IS EXPECTED.
C DEN IS THE ELECTRON DENSITY IN M-3.
      Y=1051.+(17.01*H-2746.)*
     &EXP(-5.122E-4*H+(6.094E-12-3.353E-14*H)*DEN)
```

```
      ACOV=ABS(COV)
      YC=1.+(.117+2.02E-3*ACOV)/(1.+EXP(-(ACOV-102.5)/5.))
      IF(COV.LT.0.)
     &YC=1.+(.123+1.69E-3*ACOV)/(1.+EXP(-(ACOV-115.)/10.))
      TEDE=Y*YC
      RETURN
      END
C
C*************************************************************
C**************** NEUTRAL AND ION TEMPERATURE ******************
C*************************************************************
C
      FUNCTION TUNCAL(COV,XLATI,SD,SLSTA)
C CALCULATES THE EXOSPHERIC TEMPERATURE FOR COVINGTON-INDEX
C COV,LATITUDE XLATI,SOLARDEKLINATION SD AND LOCAL SOLAR TIME
C ANGLE SLSTA USING CIRA72-MODEL
      COMMON/CONST/UMR
      TC=379.0+3.24*COV
      ETA=ABS(XLATI-SD)/2.0
      THETA=ABS(XLATI+SD)/2.0
      H1=COS(ETA*UMR)**2.2
      H2=SIN(THETA*UMR)**2.2
      TD=1.0+0.3*H1
      TN=1.0+0.3*H2
      A=(TD-TN)/TN
      TAU=SLSTA-37.0+6.0*SIN((SLSTA+43.0)*UMR)
      X=COS(TAU/2.0*UMR)
      TUNCAL=TC*TN*(1.0+A*SIGN(1.0,X)*ABS(X)**3.0)
      RETURN
      END
C
      REAL FUNCTION TN(X,TTNX,ATN,CCTN)
C NEUTRAL TEMPERATURE
C D. BILITZA, 1978, NEUTRAL TEMPERATURE PROFILE
C APPROXIMATING ROUGHLY CIRA72-MODEL;
      DIMENSION CCTN(3)
      Z=X-125.0
      IF(Z.LE.0.0) GOTO 100
      Y=Z**2.5
      Y=(1.0+(4.5E-6)*Y)*Z
      YY=CCTN(1)/ATN
      Y=YY*Y
```

```
      Y=ATAN(Y)*ATN
      TN=TTNX+Y
      RETURN
100   TN=TTNX+Z*(CCTN(1)+Z*Z*(CCTN(2)+Z*CCTN(3)))
200   RETURN
      END
C
      FUNCTION DTNDH(H,ATN,CCTN)
C DERIVATIVE OF NEUTRAL TEMPERATURE
C D.BILITZA, 1978. APPROXIMATE HEIGHT DERIVATIVE OF NEUTRAL
C CIRA-72 MODEL TEMPERATURE PROFILE
      DIMENSION CCTN(3)
      Z=H-125.0
      IF(Z.GT.0.0) GOTO 100
      DTNDH=CCTN(1)+Z*Z*(3.0*CCTN(2)+Z*4.0*CCTN(3))
      RETURN
100   H1=CCTN(1)/ATN
      H2=Z**2.5
      H3=H1*Z*(1.0+(4.5E-6)*H2)
      DTNDH=ATN/(1.0+H3*H3)*H1*(1.0+(15.75E-6)*H2)
      RETURN
      END
C
      REAL FUNCTION TI(H)
C ION TEMPERATURE FOR HEIGHTS NOT GREATER 1000 KM AND NOT LESS HS
C EXPLANATION SEE FUNCTION RPID.
      REAL MM
      COMMON/BLOCK8/HS,TNHS,XSM(4),MM(5),G(4),M
      SUM=MM(1)*(H-HS)+TNHS
      DO 100 I=1,M-1
      A=H-XSM(I)
      IF(A/G(I).LT.88.) A=G(I)*ALOG(1.0+EXP(A/G(I)))
      B=HS-XSM(I)
      IF(B/G(I).LT.88.) B=G(I)*ALOG(1.0+EXP(B/G(I)))
100   SUM=SUM+(MM(I+1)-MM(I))*(A-B)
      TI=SUM
      RETURN
      END
C
      REAL FUNCTION TEDER(H)
C THIS FUNCTION ALONG WITH PROCEDURE REGFA1 ALLOWS TO FIND
C THE  HEIGHT ABOVE WHICH TN BEGINS TO BE DIFFERENT FROM TI
```

```
      COMMON/BLOCK5/ZX,TNX,ATN,CTN(3)/BLOCK8/HS,TNHS,XSM(4),
     &  XMM(5),G(4),M
      TNH=TN(H,TNX,ATN,CTN)
      DTDX=DTNDH(H,ATN,CTN)
      TEDER=DTDX*(XSM(1)-H)+TNH
      RETURN
      END
C
C*************************************************************
C************* ION RELATIVE PRECENTAGE DENSITY *****************
C*************************************************************
C
      REAL FUNCTION RPID (H, HO, NO, M, ST, ID, XS)
C D.BILITZA,1977,THIS ANALYTIC FUNCTION IS USED TO REPRESENT THE
C RELATIVE PRECENTAGE DENSITY OF ATOMAR AND MOLECULAR OXYGEN IONS.
C THE M+1 HEIGHT GRADIENTS ST(M+1) ARE CONNECTED WITH EPSTEIN-
C STEP-FUNCTIONS AT THE STEP HEIGHTS XS(M) WITH TRANSITION
C THICKNESSES ID(M). RPID(HO,HO,NO,....)=NO.
C INSTEAD OF 88.0 YOU CAN USE THE HIGHEST ALLOWED ARGUMENT
C FOR EXP AT YOUR COMPUTER.
      REAL NO
      DIMENSION ID(4), ST(5), XS(4)
      SUM=(H-HO)*ST(1)
      DO 100  I=1,M
      A=H-XS(I)
      XI=FLOAT(ID(I))
      IF (A/XI.LT.88.0) A=XI*ALOG(1.0+EXP(A/XI))
      B=HO-XS(I)
      IF (B/XI.LT.88.0) B=XI*ALOG(1.0+EXP(B/XI))
100   SUM=SUM+(ST(I+1)-ST(I))*(A-B)
      SUM=NO*EXP(SUM)
      RPID=SUM
      RETURN
      END
C
      SUBROUTINE RDHHE (H,HB,RDOH,RDO2H,RNO,PEHE,RDH,RDHE)
C BILITZA,FEB.82,H+ AND HE+ RELATIVE PERECENTAGE DENSITY BELOW
C 1000 KM. THE O+ AND O2+ REL. PER. DENSITIES SHOULD BE GIVEN
C (RDOH,RDO2H). HB IS THE ALTITUDE OF MAXIMAL O+ DENSITY. PEHE
C IS THE PRECENTAGE OF HE+ IONS COMPARED TO ALL LIGHT IONS.
C RNO IS THE RATIO OF NO+ TO O2+DENSITY AT H=HB.
      RDHE=0.0
```

```
      RDH=0.0
      IF(H.LE.HB) GOTO 100
      REST=100.0-RDOH-RDO2H-RNO*RDO2H
      RDH=REST*(1.-PEHE/100.)
      RDHE=REST*PEHE/100.
100   RETURN
      END
C
      REAL FUNCTION RDNO(H,HB,RDO2H,RDOH,RNO)
C D.BILITZA, 1978. NO+ RELATIVE PERCENTAGE DENSITY ABOVE 100KM.
C FOR MORE INFORMATION SEE SUBROUTINE RDHHE.
      IF (H.GT.HB) GOTO 200
      RDNO=100.0-RDO2H-RDOH
      RETURN
200   RDNO=RNO*RDO2H
      RETURN
      END
C
C*************************************************************
C************* PEAK VALUES ELECTRON DENSITY ******************
C*************************************************************
C
      SUBROUTINE F2OUT(XMODIP,XLATI,XLONGI,R,MONTH,UT,
     &                 FOF2,XM3000)
C CALCULATES FOF2/MHZ AND M3000 USING THE CCIR-MAPS.
C INPUT: MODIFIED DIP LATITUDE XMODIP, GEOG. LATITUDE XLATI,
C LONGITUDE XLONGI (ALL IN DEG.), SMOOTHED SUNSPOT NUMBER R,
C MONTH AND UNIVERSAL TIME UT (DEC. HOURS).
C D.BILITZA,JULY 85.
      DIMENSION FF0(988),XM0(441)
      INTEGER QM(7),QF(9)
      DATA QF/11,11,8,4,1,0,0,0,0/,QM/6,7,5,2,1,0,0/
      CALL CCIRCA(R,MONTH,FF0,XM0)
      FOF2=GAMMA1(XMODIP,XLATI,XLONGI,UT,6,QF,9,76,13,988,FF0)
      XM3000=GAMMA1(XMODIP,XLATI,XLONGI,UT,4,QM,7,49,9,441,XM0)
      RETURN
      END
C
      REAL FUNCTION HMF2ED(XMAGBR,R,X,XM3)
C CALCULATES THE PEAK HEIGHT HMF2/KM FOR THE MAGNETIC
C LATITUDE XMAGBR/DEG. AND THE SMOOTHED ZUERICH SUNSPOT
C NUMBER R USING CCIR-M3000 XM3 AND THE RATIO X=FOF2/FOE.
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C [REF. D.BILITZA ET AL., TELECOMM.J., 46, 549-553, 1979]
C D.BILITZA,1980.
      F1=(2.32E-3)*R+0.222
      F2=1.2-(1.16E-2)*EXP((2.39E-2)*R)
      F3=0.096*(R-25.0)/150.0
      DELM=F1*(1.0-R/150.0*EXP(-XMAGBR*XMAGBR/1600.0))/(X-F2)+F3
      HMF2ED=1490.0/(XM3+DELM)-176.0
      RETURN
      END
C
      REAL FUNCTION FOF1ED(YLATI,R,COSXHI)
C CALCULATES FOF1/MHZ FOR DIP-LATITUDE YLATI/DEG., SMOOTHED
C ZURICH SUNSPOT NUMBER R AND COSINE OF SOLAR ZENITH ANGLE
C COSXHI.
C [REF: E.D.DUCHARME ET AL., RADIO SCI., 6,369-378, 1971
C AND 8, 837-839, 1973; HOWEVER WITH MAGNETIC INSTEAD OF GEO-
C MAGNETIC LATITUDE,R.EYFRIG,1979]
C D. BILITZA, 1980.
      XLATI=ABS(YLATI)
      F0=4.35+XLATI*(0.0058-(1.2E-4)*XLATI)
      F100=5.348+XLATI*(0.011-(2.3E-4)*XLATI)
      FS=F0+(F100-F0)*R/100.0
      XMUE=0.093+XLATI*(0.0046-(5.4E-5)*XLATI)+(3.0E-4)*R
      FOF1ED=FS*COSXHI**XMUE
      RETURN
      END
C
      REAL FUNCTION FOEEDI(COV,XHI,XHIM,SLATI)
C CALCULATES FOE/MHZ BY THE EDINBURGH-METHOD.
C INPUT: MEAN 10.7CM SOLAR RADIO FLUX (COV), GEOGRAPHIC
C LATITUDE (SLATI/DEG), SOLAR ZENITH ANGLE (XHI/DEG AND
C XHIM/DEG AT NOON).
C [REF.: KOURIS-MUGGELETON, CCIR DOC. 6/3/07 SEPT.73]
C UP-DATED WITH ARECIBO DATA [TROST, J. GEOPHYS. RES.
C 84, 2736, 1979]
C D.BILITZA, AUGUST 1986.
      COMMON/CONST/UMR
      XLATI=ABS(SLATI)
      A=1.0+0.0094*(COV-66.0)
      SL=COS(XLATI*UMR)
      IF(XLATI.LT.32.0) GOTO 100
      SM=0.11-0.49*SL
```

```
      C=92.0+35.0*SL
      GOTO 400
100   SM=-1.93+1.92*SL
      C=23.0+116.0*SL
400   B=COS(XHIM*UMR)**SM
      SP=1.31
      IF(XLATI.GT.12.0) SP=1.2
      XHIC=XHI-3.*ALOG(1.+EXP((XHI-89.98)/3.))
      D=COS(XHIC*UMR)**SP
      R4FOE=A*B*C*D
      SMIN=0.121+0.0015*(COV-60.)
      SMIN=SMIN*SMIN
      IF(R4FOE.LT.SMIN) R4FOE=SMIN
      FOEEDI=R4FOE**0.25
      RETURN
      END
C
      REAL FUNCTION XMDED(XHI,R,YW)
C D. BILITZA, 1978, CALCULATES ELECTRON DENSITY OF D MAXIMUM.
C XHI/DEG. IS SOLAR ZENITH ANGLE, R SMOOTHED ZURICH SUNSPOT NUMBER
C AND YW/M-3 THE ASSUMED CONSTANT NIGHT VALUE.
C [REF.: D.BILITZA, WORLD DATA CENTER A REPORT UAG-82,7,
C        BOULDER,1981]
      COMMON/CONST/UMR
      Y=6.05E8+0.088E8*R
      Z=(-0.1/(ALOG(YW/Y)))**0.3704
      SUXHI=ACOS(Z)
      IF (SUXHI.LT.1.0472) SUXHI=1.0472
      XXHI=XHI*UMR
      IF (XXHI.GT.SUXHI) GOTO 100
      X=COS(XXHI)
      XMDED=Y*EXP(-0.1/X**2.7)
      RETURN
100   XMDED=YW
      RETURN
      END
C
C*************************************************************
C*************** EARTH MAGNETIC FIELD ************************
C*************************************************************
C
      SUBROUTINE GGM(ART,LONG,LATI,MLONG,MLAT)
```

```
C CALCULATES GEOMAGNETIC LONGITUDE (MLONG) AND LATITUDE (MLAT)
C FROM GEOGRAFIC LONGITUDE (LONG) AND LATITUDE (LATI) FOR ART=0
C AND REVERSE FOR ART=1. ALL ANGLES IN DEGREE.
C LATITUDE:-90 TO 90. LONGITUDE:0 TO 360 EAST.
      INTEGER ART
      REAL MLONG,MLAT,LONG,LATI
      COMMON/CONST/FAKTOR
      ZPI=FAKTOR*360.
      CBG=11.4*FAKTOR
      CI=COS(CBG)
      SI=SIN(CBG)
      IF(ART.EQ.0) GOTO 10
      CBM=COS(MLAT*FAKTOR)
      SBM=SIN(MLAT*FAKTOR)
      CLM=COS(MLONG*FAKTOR)
      SLM=SIN(MLONG*FAKTOR)
      SBG=SBM*CI-CBM*CLM*SI
      LATI=ASIN(SBG)
      CBG=COS(LATI)
      SLG=(CBM*SLM)/CBG
      CLG=(SBM*SI+CBM*CLM*CI)/CBG
      IF(CLG.GT.1.) CLG=1.
      LONG=ACOS(CLG)
      IF(SLG.LT.0.0) LONG=ZPI-ACOS(CLG)
      LATI=LATI/FAKTOR
      LONG=LONG/FAKTOR
      LONG=LONG-69.8
      IF(LONG.LT.0.0) LONG=LONG+360.0
      RETURN
10    YLG=LONG+69.8
      CBG=COS(LATI*FAKTOR)
      SBG=SIN(LATI*FAKTOR)
      CLG=COS(YLG*FAKTOR)
      SLG=SIN(YLG*FAKTOR)
      SBM=SBG*CI+CBG*CLG*SI
      MLAT=ASIN(SBM)
      CBM=COS(MLAT)
      SLM=(CBG*SLG)/CBM
      CLM=(-SBG*SI+CBG*CLG*CI)/CBM
      IF(CLM.GT.1.) CLM=1.
      MLONG=ACOS(CLM)
      IF(SLM.LT..0) MLONG=ZPI-ACOS(CLM)
```

```
      MLAT=MLAT/FAKTOR
      MLONG=MLONG/FAKTOR
      RETURN
      END
C
      SUBROUTINE FIELDG(DLAT,DLONG,ALT,X,Y,Z,F,DIP,DEC,SMODIP)
C THIS IS A SPECIAL VERSION OF THE POGO 68/10 MAGNETIC FIELD
C LEGENDRE MODEL. TRANSFORMATION COEFF. G(144) VALID FOR 1973.
C INPUT: DLAT, DLONG=GEOGRAPHIC COORDINATES/DEG.(-90/90,0/360),
C        ALT=ALTITUDE/KM.
C OUTPUT: F TOTAL FIELD (GAUSS), Z DOWNWARD VERTICAL COMPONENT
C        X,Y COMPONENTS IN THE EQUATORIAL PLANE (X TO ZERO LONGITUDE).
C        DIP INCLINATION ANGLE(DEGREE). SMODIP RAWER'S MODFIED DIP.
C SHEIK,1977.
      DIMENSION H(144),XI(3),G(144),FEL1(72),FEL2(72)
      COMMON/CONST/UMR
      DATA FEL1/0.0, 0.1506723,0.0101742, -0.0286519, 0.0092606,
     & -0.0130846, 0.0089594, -0.0136808,-0.0001508, -0.0093977,
     & 0.0130650, 0.0020520, -0.0121956, -0.0023451, -0.0208555,
     & 0.0068416,-0.0142659, -0.0093322, -0.0021364, -0.0078910,
     & 0.0045586,  0.0128904, -0.0002951, -0.0237245,0.0289493,
     & 0.0074605, -0.0105741, -0.0005116, -0.0105732, -0.0058542,
     &0.0033268, 0.0078164,0.0211234, 0.0099309, 0.0362792,
     &-0.0201070,-0.0046350,-0.0058722,0.0011147,-0.0013949,
     & -0.0108838,  0.0322263, -0.0147390,  0.0031247, 0.0111986,
     & -0.0109394,0.0058112,  0.2739046, -0.0155682, -0.0253272,
     &  0.0163782, 0.0205730,  0.0022081, 0.0112749,-0.0098427,
     & 0.0072705, 0.0195189, -0.0081132, -0.0071889, -0.0579970,
     & -0.0856642, 0.1884260,-0.7391512, 0.1210288, -0.0241888,
     & -0.0052464, -0.0096312, -0.0044834, 0.0201764,  0.0258343,
     &0.0083033,  0.0077187/
      DATA FEL2/0.0586055,0.0102236,-0.0396107,
     & -0.0167860, -0.2019911, -0.5810815,0.0379916,  3.7508268,
     & 1.8133030, -0.0564250, -0.0557352, 0.1335347, -0.0142641,
     & -0.1024618,0.0970994, -0.0751830,-0.1274948, 0.0402073,
     &  0.0386290, 0.1883088,  0.1838960, -0.7848989,0.7591817,
     & -0.9302389,-0.8560960, 0.6633250, -4.6363869, -13.2599277,
     & 0.1002136,  0.0855714,-0.0991981, -0.0765378,-0.0455264,
     &  0.1169326, -0.2604067, 0.1800076, -0.2223685, -0.6347679,
     &0.5334222, -0.3459502,-0.1573697,  0.8589464, 1.7815990,
     &-6.3347645, -3.1513653, -9.9927750,13.3327637, -35.4897308,
     &37.3466339, -0.5257398,  0.0571474, -0.5421217,  0.2404770,
```

```
     & -0.1747774,-0.3433644, 0.4829708,0.3935944, 0.4885033,
     &  0.8488121, -0.7640999, -1.8884945, 3.2930784,-7.3497229,
     & 0.1672821,-0.2306652, 10.5782146, 12.6031065, 8.6579742,
     & 215.5209961, -27.1419220,22.3405762,1108.6394043/
      K=0
      DO 10 I=1,72
      K=K+1
      G(K)=FEL1(I)
10    G(72+K)=FEL2(I)
      RLAT=DLAT*UMR
      CT=SIN(RLAT)
      ST=COS(RLAT)
      NMAX=11
      D=SQRT(40680925.0-272336.0*CT*CT)
      RLONG=DLONG*UMR
      CP=COS(RLONG)
      SP=SIN(RLONG)
      ZZZ=(ALT+40408589.0/D)*CT/6371.2
      RHO=(ALT+40680925.0/D)*ST/6371.2
      XXX=RHO*CP
      YYY=RHO*SP
      RQ=1.0/(XXX*XXX+YYY*YYY+ZZZ*ZZZ)
      XI(1)=XXX*RQ
      XI(2)=YYY*RQ
      XI(3)=ZZZ*RQ
      IHMAX=NMAX*NMAX+1
      LAST=IHMAX+NMAX+NMAX
      IMAX=NMAX+NMAX-1
      DO 100 I=IHMAX,LAST
100   H(I)=G(I)
      DO 200 K=1,3,2
      I=IMAX
      IH=IHMAX
300   IL=IH-I
      F1=2./(I-K+2.)
      X1=XI(1)*F1
      Y1=XI(2)*F1
      Z1=XI(3)*(F1+F1)
      I=I-2
      IF((I-1).LT.0) GOTO 400
      IF((I-1).EQ.0) GOTO 500
      DO 600 M=3,I,2
```

```
      H(IL+M+1)=G(IL+M+1)+Z1*H(IH+M+1)+X1*(H(IH+M+3)-H(IH+M-1))-
     &Y1*(H(IH+M+2)+H(IH+M-2))
      H(IL+M)=G(IL+M)+Z1*H(IH+M)+X1*(H(IH+M+2)-H(IH+M-2))+
     &Y1*(H(IH+M+3)+H(IH+M-1))
600   CONTINUE
500   H(IL+2)=G(IL+2)+Z1*H(IH+2)+X1*H(IH+4)-Y1*(H(IH+3)+H(IH))
      H(IL+1)=G(IL+1)+Z1*H(IH+1)+Y1*H(IH+4)+X1*(H(IH+3)-H(IH))
400   H(IL)=G(IL)+Z1*H(IH)+2.0*(X1*H(IH+1)+Y1*H(IH+2))
700   IH=IL
      IF(I.GE.K) GOTO 300
200   CONTINUE
      S=0.5*H(1)+2.0*(H(2)*XI(3)+H(3)*XI(1)+H(4)*XI(2))
      XT=(RQ+RQ)*SQRT(RQ)
      X=XT*(H(3)-S*XXX)
      Y=XT*(H(4)-S*YYY)
      Z=XT*(H(2)-S*ZZZ)
      F=SQRT(X*X+Y*Y+Z*Z)
      BRHO=Y*SP+X*CP
      Y=Y*CP-X*SP
      X=Z*ST-BRHO*CT
      Z=-Z*CT-BRHO*ST
      DIP=ASIN(Z/F)
      DEC=ASIN(Y/SQRT(X*X+Y*Y))
      SMODIP=ASIN(DIP/SQRT(DIP*DIP+ST))
      DIP=DIP/UMR
      DEC=DEC/UMR
      SMODIP=SMODIP/UMR
      RETURN
      END
C
C*************************************************************
C*********** INTERPOLATION AND REST ***************************
C*************************************************************
C
      SUBROUTINE REGFA1(X11,X22,EPS,FW,F,SCHALT,X)
C REGULA-FALSI-PROCEDURE TO FIND X WITH F(X)-FW=0. X1,X2 ARE THE
C STARTING VALUES. THE COMUTATION ENDS WHEN THE X-INTERVAL
C HAS BECOME LESS THAN EPS . IF SIGN(F(X1)-FW)= SIGN(F(X2)-FW)
C THEN SCHALT=.TRUE.
      LOGICAL L1,LINKS,K,SCHALT
      SCHALT=.FALSE.
      X1=X11
```

```
      X2=X22
      F1=F(X1)-FW
      F2=F(X2)-FW
      IF(ABS(SIGN(1.0,F1)-SIGN(1.0,F2))-10E-10) 100,110,110
110   K=.FALSE.
      NG=2
200   X=(X1*F2-X2*F1)/(F2-F1)
      GOTO 400
300   L1=LINKS
      IF(LINKS) GOTO 500
      X=X1+FLOAT(NG-1)*(X2-X1)/FLOAT(NG)
      GOTO 400
500   X=X1+(X2-X1)/FLOAT(NG)
400   FX=F(X)-FW
      LINKS=SIGN(1.0,F1)*SIGN(1.0,FX).GT.0
      K=.NOT.K
      IF(LINKS) GOTO 600
      X2=X
      F2=FX
      GOTO 700
600   X1=X
      F1=FX
700   IF(ABS(X2-X1).LE.EPS) GOTO 800
      IF(K) GOTO 300
      IF((LINKS.AND.(.NOT.L1)).OR.(.NOT.LINKS.AND.L1)) NG=2*NG
      GOTO 200
100   X=0.0
      SCHALT=.TRUE.
800   RETURN
      END
C
      SUBROUTINE TAL(SHABR,SDELTA,SHBR,SDTDHO,AUS6,SPT)
C CALCULATES THE COEFFICIENTS SPT FOR THE POLYNOMIAL
C Y(X)=1+SPT(1)*X**2+SPT(2)*X**3+SPT(3)*X**4+SPT(4)*X**5
C TO FIT THE VALLEY IN Y, REPRESENTED BY:
C Y(X=0)=1, THE X VALUE OF THE DEEPEST VALLEY POINT (SHABR),
C THE PRECENTAGE DEPTH (SDELTA), THE WIDTH (SHBR) AND THE
C DERIVATIVE DY/DX AT THE UPPER VALLEY BOUNDRY (SDTDHO).
C IF THERE IS AN UNWANTED ADDITIONAL EXTREMUM IN THE VALLEY
C REGION, THEN AUS6=.TRUE., ELSE AUS6=.FALSE..
C FOR -SDELTA THE COEFF. ARE CALCULATED FOR THE FUNCTION
C Y(X)=EXP(SPT(1)*X**2+...+SPT(4)*X**5).
```

```
      DIMENSION SPT(4)
      LOGICAL AUS6
      Z1=-SDELTA/(100.0*SHABR*SHABR)
      IF(SDELTA.GT.0.) GOTO 500
      SDELTA=-SDELTA
      Z1=ALOG(1.-SDELTA/100.)/(SHABR*SHABR)
500   Z3=SDTDH0/(2.*SHBR)
      Z4=SHABR-SHBR
      SPT(4)=2.0*(Z1*(SHBR-2.0*SHABR)*SHBR+Z3*Z4*SHABR)/
     &  (SHABR*SHBR*Z4*Z4*Z4)
      SPT(3)=Z1*(2.0*SHBR-3.0*SHABR)/(SHABR*Z4*Z4)-
     &  (2.*SHABR+SHBR)*SPT(4)
      SPT(2)=-2.0*Z1/SHABR-2.0*SHABR*SPT(3)-3.0*SHABR*SHABR*SPT(4)
      SPT(1)=Z1-SHABR*(SPT(2)+SHABR*(SPT(3)+SHABR*SPT(4)))
      AUS6=.FALSE.
      B=4.*SPT(3)/(5.*SPT(4))+SHABR
      C=-2.*SPT(1)/(5*SPT(4)*SHABR)
      Z2=B*B/4.-C
      IF(Z2.LT.0.0) GOTO 300
      Z3=SQRT(Z2)
      Z1=B/2.
      Z2=-Z1+Z3
      IF(Z2.GT.0.0.AND.Z2.LT.SHBR) AUS6=.TRUE.
      IF (ABS(Z3).GT.1.E-15) GOTO 400
      Z2=C/Z2
      IF(Z2.GT.0.0.AND.Z2.LT.SHBR) AUS6=.TRUE.
      RETURN
400   Z2=-Z1-Z3
      IF(Z2.GT.0.0.AND.Z2.LT.SHBR) AUS6=.TRUE.
300   RETURN
      END
C
      REAL FUNCTION GAMMA1(SMODIP,SLAT,SLONG,HOUR,IHARM,NQ,
     &  K1,M,MM,M3,SFE)
C CALCULATES GAMMA1=FOF2 OR M3000 USING CCIR NUMERICAL MAP
C COEFFICIENTS SFE(M3) FOR MODIFIED DIP LATITUDE (SMODIP/DEG)
C GEOGRAPHIC LATITUDE (SLAT/DEG) AND LONGITUDE (SLONG/DEG)
C AND UNIVERSIAL TIME (HOUR/DECIMAL HOURS).
C NQ(K1) IS AN INTEGER ARRAY GIVING THE HIGHEST DEGREES IN
C LATITUDE FOR EACH LONGITUDE HARMONIC.
C M=1+NQ1+2(NQ2+1)+2(NQ3+1)+... .
C SHEIKH,4.3.77.
```

```
      REAL*8 C(12),S(12),COEF(100),SUM
      DIMENSION NQ(K1),XSINX(13),SFE(M3)
      COMMON/CONST/UMR
      HOU=(15.0*HOUR-180.0)*UMR
      S(1)=SIN(HOU)
      C(1)=COS(HOU)
      DO 250 I=2,IHARM
      C(I)=C(1)*C(I-1)-S(1)*S(I-1)
      S(I)=C(1)*S(I-1)+S(1)*C(I-1)
250   CONTINUE
      DO 300 I=1,M
      MI=(I-1)*MM
      COEF(I)=SFE(MI+1)
      DO 300 J=1,IHARM
      COEF(I)=COEF(I)+SFE(MI+2*J)*S(J)+SFE(MI+2*J+1)*C(J)
300   CONTINUE
      SUM=COEF(1)
      SS=SIN(SMODIP*UMR)
      S3=SS
      XSINX(1)=1.0
      INDEX=NQ(1)
      DO 350 J=1,INDEX
      SUM=SUM+COEF(1+J)*SS
      XSINX(J+1)=SS
      SS=SS*S3
350   CONTINUE
      XSINX(NQ(1)+2)=SS
      NP=NQ(1)+1
      SS=COS(SLAT*UMR)
      S3=SS
      DO 400 J=2,K1
      S0=SLONG*(J-1.)*UMR
      S1=COS(S0)
      S2=SIN(S0)
      INDEX=NQ(J)+1
      DO 450 L=1,INDEX
      NP=NP+1
      SUM=SUM+COEF(NP)*XSINX(L)*SS*S1
      NP=NP+1
      SUM=SUM+COEF(NP)*XSINX(L)*SS*S2
450   CONTINUE
      SS=SS*S3
```

```
400   CONTINUE
      GAMMA1=SUM
      RETURN
      END
C
      SUBROUTINE CCIRMO(MONTH,F2,FM3)
C THIS SUBROUTINE READS THE CCIR-COEFFICIENT SETS F2(13,76,2) AND
C FM3(9,49,2) FROM UNIT 10 FOR THE DESIRED MONTH.
      DIMENSION F2(13,76,2),FM3(9,49,2)
      DO 10 I=1,MONTH
10    READ(10) F2,FM3
      RETURN
      END
C
      SUBROUTINE CCIRRZ(R,F2,FM3,FOF2,SM3000)
C THIS SUBROUTINE CALCULATES THE
C SOLAR ACTIVITY (RZ12=R) INTERPOLATED ARRAYS FOF2(988=13*76) AND
C SM3000(441=9*49) OUT OF F2 AND FM3.
      DIMENSION FOF2(988),SM3000(441),F2(13,76,2),FM3(9,49,2)
      RR2=R/100.
      RR1=1.-RR2
      DO 20 I=1,76
      DO 20 J=1,13
      K=J+13*(I-1)
20    FOF2(K)=F2(J,I,1)*RR1+F2(J,I,2)*RR2
      DO 30 I=1,49
      DO 30 J=1,9
      K=J+9*(I-1)
30    SM3000(K)=FM3(J,I,1)*RR1+FM3(J,I,2)*RR2
      RETURN
      END
C
      SUBROUTINE CCIRCA(R,MONTH,FOF2,SM3000)
C THIS SUBROUTINE READS THE CCIR-COEFFICIENT SETS F2(13,76,2) AND
C FM3(9,49,2) FROM UNIT 10 FOR THE DESIRED MONTH AND STORES THE
C SOLAR ACTIVITY (RZ12=R) INTERPOLATED ARRAYS FOF2(988=13*76) AND
C SM3000(441=9*49).
      DIMENSION FOF2(988),SM3000(441),F2(13,76,2),FM3(9,49,2)
      DO 10 I=1,MONTH
C ********************************************************
C THIS IS EXPECTING ASCII-CODED CCIR-COEFFICIENTS, IF YOU
C USE THE BINARY-CODED SET YOU HAVE TO REPLACE THE NEXT
```

```
C STATEMENT BY:   READ(10) F2,FM3
C ******************************************************
      READ(10,1) F2,FM3
10    CONTINUE
1     FORMAT(1X,8E15.8)
      RR2=R/100.
      RR1=1.-RR2
      DO 20 I=1,76
      DO 20 J=1,13
      K=J+13*(I-1)
20    FOF2(K)=F2(J,I,1)*RR1+F2(J,I,2)*RR2
      DO 30 I=1,49
      DO 30 J=1,9
      K=J+9*(I-1)
30    SM3000(K)=FM3(J,I,1)*RR1+FM3(J,I,2)*RR2
      RETURN
      END
C
      SUBROUTINE  KOEFP1(PG10)
C THIEMANN,1979,COEFFICIENTS PG10 FOR CALCULATING  O+ PROFILES
C BELOW THE F2-MAXIMUM. CHOSEN TO APPROACH DANILOV-
C SEMENOV'S COMPILATION.
      DIMENSION PG10(80)
      REAL FELD (80)
      DATA FELD/-11.0,-11.0,4.0,-11.0,0.08018,
     &0.13027,0.04216,0.25  ,-0.00686,0.00999,
     &5.113,0.1 ,170.0,180.0,0.1175,0.15,-11.0,
     &1.0 ,2.0,-11.0,0.069,0.161,0.254,0.18,0.0161,
     &0.0216,0.03014,0.1,152.0,167.0,0.04916,
     &0.17,-11.0,2.0,2.0,-11.0,0.072,0.092,0.014,0.21,
     &0.01389,0.03863,0.05762,0.12,165.0,168.0,0.008,
     &0.258,-11.0,1.0,3.0,-11.0,0.091,0.088,
     &0.008,0.34,0.0067,0.0195,0.04,0.1,158.0,172.0,
     &0.01,0.24,-11.0,2.0,3.0, -11.0,0.083,0.102,
     &0.045,0.03,0.00127,0.01,0.05,0.09,167.0,185.0,
     &0.015,0.18/
      K=0
      DO 10 I=1,80
      K=K+1
10    PG10(K)=FELD(I)
      RETURN
      END
```

```
C
      SUBROUTINE KOEFP2(PG20)
C THIEMANN,1979,COEFFICIENTS FOR CALCULATION OF O+ PROFILES
C ABOVE THE F2-MAXIMUM (DUMBS,SPENNER:AEROS-COMPILATION)
      DIMENSION PG20(32)
      REAL FELD(32)
      DATA FELD/1.0,-11.0,-11.0,1.0,695.0,-.000781,
     &-.00264,2177.0,1.0,-11.0,-11.0,2.0,570.0,
     &-.002,-.0052,1040.0,2.0,-11.0,-11.0,1.0,695.0,
     &-.000786,-.00165,3367.0,2.0,-11.0,-11.0,2.0,
     &575.0,-.00126,-.00524,1380.0/
      K=0
      DO 10 I=1,32
      K=K+1
10    PG20(K)=FELD(I)
      RETURN
      END
C
      SUBROUTINE  KOEFP3(PG30)
C THIEMANN,1979,COEFFICIENTS FOR CALCULATING O2+ PROFILES.
C CHOSEN AS TO APPROACH DANILOV-SEMENOV'S COMPILATION.
      DIMENSION PG30(80)
      REAL FELD(80)
      DATA FELD/-11.0,1.0,2.0,-11.0,160.0,31.0,130.0,
     &-10.0,198.0,0.0,0.05922,-0.07983,
     &-0.00397,0.00085,-0.00313,0.0,-11.0,2.0,2.0,-11.0,
     &140.0,30.0,130.0,-10.0,
     &190.0,0.0,0.05107,-0.07964,0.00097,-0.01118,-0.02614,
     &-0.09537,
     &-11.0,1.0,3.0,-11.0,140.0,37.0,125.0,0.0,182.0,
     &0.0,0.0307,-0.04968,-0.00248,
     &-0.02451,-0.00313,0.0,-11.0,2.0,3.0,-11.0,
     &140.0,37.0,125.0,0.0,170.0,0.0,
     &0.02806,-0.04716,0.00066,-0.02763,-0.02247,-0.01919,
     &-11.0,-11.0,4.0,-11.0,140.0,45.0,136.0,-9.0,
     &181.0,-26.0,0.02994,-0.04879,
     &-0.01396,0.00089,-0.09929,0.05589/
      K=0
      DO 10 I=1,80
      K=K+1
10    PG30(K)=FELD(I)
      RETURN
```

```
      END
C
      SUBROUTINE SUFE (FIELD,RFE,M,FE)
C SELECTS THE REQUIRED ION DENSITY PARAMETER SET.
C THE INPUT FIELD INCLUDES DIFFERENT SETS OF DIMENSION M EACH
C CARACTERISED BY 4 HEADER NUMBERS. RFE(4) SHOULD CONTAIN THE
C CHOSEN HEADER NUMBERS.FE(M) IS THE CORRESPONDING SET.
      DIMENSION RFE(4),FE(12),FIELD(80),EFE(4)
      K=0
100   DO 101 I=1,4
      K=K+1
101   EFE(I)=FIELD(K)
      DO 111 I=1,M
      K=K+1
111   FE(I)=FIELD(K)
      DO 120 I=1,4
      IF((EFE(I).GT.-10.0).AND.(RFE(I).NE.EFE(I))) GOTO 100
120   CONTINUE
      RETURN
      END
C
      FUNCTION HPOL(XHOUR,TW,XNW,SA,SU)
C PROCEDURE FOR SMOOTH TIME-INTERPOLATION USING EPSTEIN
C STEP FUNCTION OF ONE HOUR WIDTH AT SUNRISE AND SUNSET.
C TW,NW ARE THE DAY AND NIGHT VALUE OF THE PARAMETER TO
C BE INTERPOLATED. SA AND SU ARE TIME OF SUNRISE AND
C SUNSET IN DECIMAL HOURS.
C BILITZA, 1979.
      IF(ABS(SU-SA).GE.24.0) GOTO 100
      HPOL=XNW+(TW-XNW)/(1.0+EXP(-(XHOUR-SA)/1.0))+(XNW-TW)
     &/(1.0+EXP(-(XHOUR-SU)/1.0))
      RETURN
100   HPOL=XNW
      IF(SA.LT.1.0) HPOL=TW
      RETURN
      END
C
      FUNCTION EPSTEP(BE,AB,TH,FIX,COSI)
C EPSTEIN STEP FUNCTION = TRANSITION WITH THICKNESS TH BETWEEN
C BE AND AB CENTERED WHERE VARIABLE COSI EQUALS FIX.
      EPSTEP=AB+(BE-AB)/(1.0+EXP(-(COSI-FIX)/TH))
      RETURN
```

```
      END
```

```
C*****************************************************************
C****************** IRIMPO, OCT 1986 ****************************
C*****************************************************************
C**  SPECIAL IRI DRIVER PROGRAM TO GENERATE IRI PROFILES IN     **
C**  ALTITUDE, GEOGRAPHIC OR GEOMAGNETIC LATITUDE, LONGITUDE,   **
C**  SOLAR ACTIVITY, MONTH, LOCAL OR UNIVERSAL TIME,            **
C**  OR ALTITUDE.                                               **
C**  D.BILITZA, GSFC/NSSDC,CODE 633, GREENBELT, MD 20771, USA   **
C*****************************************************************
C** INPUT: JMAG,LATI,LONG,R,MONTH,HOUR,H,IVAR,ZBEG,ZSTEP,ZEND,  **
C**        ZEND,JNE,JTETI,JNI,JOUT                              **
C**                                                             **
C** JMAG         =0 GEOGRAPHIC, =1 GEOMAGNETIC COORDINATES      **
C** LATI,LONG    GEOG. OR GEOM. LATITUDE AND LONGITUDE IN DEGREES**
C** R            SOLAR SUNSPOT NUMBER 12-MONTHS-RUNNING MEAN    **
C** HOUR         LOCAL TIME IN DECIMAL HOURS                    **
C**              +25  UNIVERSAL TIME                            **
C** H            ALTITUDE IN KM                                 **
C**              =0 GIVES F2,F1,E,D PEAK ALTITUDES (KM) AND     **
C**                 DENSITIES (CM-3)                            **
C** IVAR         =1,2,3,4,5  FOR PROFILE IN LATI, LONG, R, HOUR **
C**                OR H RESPECTIVELY                            **
C** ZBEG,ZSTEP   BEGIN, STEP AND END VALUE OF PARAMETER CHOSEN  **
C**   ,ZEND          WITH IVAR                                  **
C** JNE          =1(0)   ELECTRON DENSITY (NOT) REQUESTED       **
C** JTETI        =1(0)   TEMPERATURES OF NEUTRALS, IONS AND     **
C**                        ELECTRONS (NOT) REQUESTED            **
C** JNI          =1(0)   RELATIVE ION DENSITIES (NOT) REQUESTED **
C** JOUT         =0 NORMAL OUTPUT ON PRINTER AND FILE           **
C**              =2 UNFORMATTED OUTPUT                          **
C** JMAG         =2,3 GEOMAGNETIC COORDINATES ARE USED, BUT THE **
C**                   OUTPUT (X-COORDINATE) WILL BE THE         **
C**                   CALCULATED DIP(2) OR MODIP(3)             **
C*****************************************************************
C***** YOU HAVE TO ADJUST THE INPUT AND OUTPUT FORMATS TO    *****
C***** YOUR COMPUTER ALSO NOTE THAT CONDITIONAL IF IS USED   *****
C***** (IF .... ENDIF). PLEASE ASSIGN CCIR-COEFFICIENT SET   *****
C***** TO UNIT 10 AND LINK IRIMPO WITH IRIFU9.               *****
C*****************************************************************
      INTEGER EGNR,AGNR,DAYNR,DDO,DO2,SEASON
      REAL LATI,LONGI,MO2,MO,MODIP,NMF2,MAGBR,
     &  NMF1,NME,NMD,NEI,MM,MLAT,MLONG,NOBO2
```

```
      DIMENSION BOF(32),RIF(4),XSM(4),HOA(3),F(3),DDO(4),DO2(2),
     &  MM(5),SIPL(2),XNAR(3),ATE(7),TEA(6),PF10(12),PF30(12),
     &  HO(4),HO2(2),MO2(3),MO(5),E(4),SIPH(2),XVAR(6),PF20(4),
     &  CTNN(3),PG10(80),PG20(32),PG30(80),CTN(3),XDELS(4),
     &  DNDS(4),PARF(14),OUTF(9),DTI(4),DTE(5),AHH(7),STTE(6)
      LOGICAL SCHALT,EXT,NIGHT,F1REG
      COMMON/BLOCK1/HMF2,NMF2,HMF1/BLOCK2/B0,B1,C1,HZ,T,HST,STR
     &  /BLOCK3/HDX,HME,NME,HMD,NMD,HEF,D1,XKK,FP30,FP3U,FP1,FP2
     &  /BLOCK5/ZX,TNX,ATN,CTN/BLOCK6/NIGHT,E
     &  /BLOTE/AHH,ATE1,STTE,DTE/CONST/UMR
     &  /BLOCK8/HS,TNHS,XSM,MM,DTI,MXSM
     &  /BLO10/BETA,ETA,DELTA,ZETA
      EXTERNAL XE1,XE2,XE3,XE4,XE5,XE6,TEDER
      DATA BOF/114.,64.,134.,77.,128.,66.,75.,73.,113.,115.,
     &  150.,116.,138.,123.,94.,132.,72.,84.,83.,89.,75.,85.,
     &  57.,76.,102.,100.,120.,110.,107.,103.,76.,86./,
     & HOA/300.,400.,600./,AHH/120.,0.,300.,400.,600.,1400.,
     &  3000./,DTE/5.,5.,10.,20.,20./,DDO/9,5,5,50/,DO2/5,5/,
     & XDELS/3*5.,10./,DNDS/.016,.01,2*.016/,XNAR/3*0.0/,
     & DTI/10.,10.,20.,20./
C
C OPEN OUTPUT FILE IRI.DAT ......................................
C
      OPEN(UNIT=16,NAME='IRI.DAT',TYPE='NEW',FORM='FORMATTED')
      UMR=ATAN(1.)*4./180.
      ALOG2=ALOG(2.)
C
C FIRST SPECIFY YOUR COMPUTERS CHANNEL NUMBERS ...................
C EGNR=INPUT, MONITO=MONITOR OUTPUT ..............................
C FOR THE CCIR-TAPE CHANNEL 10 IS USED ...........................
C
      EGNR=5
      MONITO=6
      KONSOL=6
2234  WRITE(6,2122)
2122  FORMAT(1X,'M,K,JMAG,LATI,LONG,R,MONTH,HOUR,H,IVAR,ZBEG,',
     &    'ZSTEP,ZEND,JNE,JTETI,JNI,JOUT'/1X,
     &    '>>>>H=0 PEAKS<<<<>>>>HOUR+25: UNIVERSAL TIME<<<<'
     &    /1X,'>>>>JNE=1 IRI =2 IRI-COV =3 IRI-OLD<<<<')
      READ(5,*) MONITO,KONSOL,JMAG,LATI,LONGI,R,MONTH,HOUR,HEIGHT,
     &    IVAR,ZBEGIN,ZSTEP,ZEND,JNE,JTE,JNI,JOUT
      IF(JMAG.EQ.-1) GOTO 2235
```

```
      LANZ=INT((ZEND-ZBEGIN)/ZSTEP)+1
      IF(JMAG.GT.0) THEN
      MLAT=LATI
      MLONG=LONGI
      ENDIF
      TYPE *,JMAG,LATI,LONGI,R,MONTH,HOUR,HEIGHT,IVAR,ZBEGIN,
     &    ZSTEP,ZEND,JNE,JTE,JNI,JOUT
      IF(JOUT.EQ.0)
     &  WRITE(16,*) JMAG,LATI,LONGI,R,MONTH,HOUR,HEIGHT,IVAR,
     &    ZBEGIN,ZSTEP,ZEND,JNE,JTE,JNI,JOUT
      XVAR(1)=LATI
      XVAR(2)=LONGI
      IF(JMAG.GT.0) THEN
      XVAR(1)=MLAT
      XVAR(2)=MLONG
      ENDIF
      XVAR(3)=R
      XVAR(4)=MONTH
      XVAR(5)=HOUR
      XVAR(6)=HEIGHT
      LFD=0
      XVAR(IVAR)=ZBEGIN-ZSTEP
2123  XVAR(IVAR)=XVAR(IVAR)+ZSTEP
      LFD=LFD+1
      IF(JMAG.GT.0)THEN
      MLAT=XVAR(1)
      MLONG=XVAR(2)
      ELSE
        LATI=XVAR(1)
        LONGI=XVAR(2)
      ENDIF
      R=XVAR(3)
      MONTH=INT(XVAR(4))
      HOUR=XVAR(5)
      HEIGHT=XVAR(6)
      HMEAN=300.
C
C SOLAR ACTIVITY PARAMETERS ..................................
C
      COV=63.75+R*(0.728+R*0.00089)
      RG=R
      COVG=COV
```

```
      IF(JNE.EQ.1) THEN
      IF(R.GT.150.) RG=150.
      IF(COV.GT.193.) COVG=193.
      ENDIF
C
C GEOGRAPHIC AND MAGNETIC PARAMETER ...............................
C
      IF((LFD.EQ.1).OR.(IVAR.LT.3)) THEN
        CALL GGM(JMAG,LONGI,LATI,MLONG,MLAT)
        CALL FIELDG(LATI,LONGI,HMEAN,XMA,YMA,ZMA,BET,DIP,DEC,MODIP)
        MAGBR=ATAN(0.5*TAN(DIP*UMR))/UMR
      ENDIF
      ABSLAT=ABS(LATI)
C
C DAY OF YEAR AND SEASON ......................................
C
      DAYNR=INT(MONTH*30.42-15.21)
      SUNDEC=-0.40915*COS(.0172142063*(DAYNR+8.))
      SEASON=INT(MONTH/3.)
      IF(SEASON.LT.1) SEASON=4
      IF(LATI.GT.0.) GOTO 5592
        SEASON=SEASON-2
      IF(SEASON.LT.1) SEASON=SEASON+4
5592  REWIND(10)
C
C TIME PARAMETER ..............................................
C
      IF(HOUR.GT.24.) GOTO 2389
      UT=HOUR-LONGI/15.
      IF(UT.LT.0.0) UT=UT+24.
      GOTO 2918
2389  UT=HOUR-25.
      HOUR=UT+LONGI/15.
        IF(HOUR.GT.24.) HOUR=HOUR-24.
2918  Z1=SIN(SUNDEC)*SIN(LATI*UMR)
      Z2=COS(SUNDEC)*COS(LATI*UMR)
      IF(ABS(Z2).GT.0.0) GOTO 120
      SAX=24.0
      IF(Z1.GE.0.0) SAX=0.0
      GOTO 140
120   IF(ABS(Z1/Z2).LE.1.0) GOTO 510
      SAX=24.0
```

```
      IF((Z1+Z2).GE.0.0) SAX=0.0
      GOTO 140
510   SAX=12.0-ACOS(-Z1/Z2)/(UMR*15.0)
140   SUX=24.0-SAX
      XLSTA=15.0*(HOUR-12.0)
      COSXHI=Z1+Z2*COS(XLSTA*UMR)
      XHI=ACOS(COSXHI)/UMR
      COSXHI=COS(XHI*UMR)
      NIGHT=.FALSE.
      IF((HOUR.GT.SUX).OR.(HOUR.LT.SAX)) NIGHT=.TRUE.
      SUNDEC=SUNDEC/UMR
C
C CALCULATION OF ELECTRON DENSITY PARAMETERS................
C
      HNEA=65.
      IF(NIGHT) HNEA=80.
      HNEE=2000.
      IF(JNE.LT.1) GOTO 4933
      DELA=4.32
      IF(ABS(MODIP).GE.18.) DELA=1.0+EXP(-(ABS(MODIP)-30.0)/10.0)
      DELL=1+EXP(-(ABSLAT-20.)/10.)
C!!!!!!! F-REGION PARAMETERS AND FOE !!!!!!!!!!!!!!!!!!!!!!!!!!
      XHINON=ACOS(Z1+Z2)/UMR
      FOE=FOEEDI(COV,XHI,XHINON,LATI)
      IF(HMF2.GT.0.0) GOTO 501
      CALL F2OUT(MODIP,LATI,LONGI,RG,MONTH,UT,FOF2,XM3000)
      HMF2=HMF2ED(MAGBR,RG,FOF2/FOE,XM3000)
501   IF(FOF2.GT.100.0) FOF2=SQRT(FOF2/1.24E10)
      NMF2=1.24E10*FOF2*FOF2
      COS2=COS(MLAT*UMR)
      COS2=COS2*COS2
      FLU=(COVG-40.0)/30.0
      ETA1=-0.0070305*COS2
      IF(JNE.EQ.3) GOTO 5566
        EX=EXP(-MLAT/15.)
        EX1=EX+1
        EPIN=4.*EX/(EX1*EX1)
      ETA1=-0.02*EPIN
5566  ETA=0.058798+ETA1+FLU*(-0.014065+0.0069724*COS2)+
     &(0.0024287+0.0042810*COS2-0.00015280*FOF2)*FOF2
      ZETA=0.078922-0.0046702*COS2+FLU*(-0.019132+0.0076545*COS2)+
     &(0.0032513+0.0060290*COS2-0.00020872*FOF2)*FOF2
```

```
      BETA=-128.03+20.253*COS2+FLU*(-8.0755-0.65896*COS2)+(0.44041
     &+0.71458*COS2-0.042966*FOF2)*FOF2
      Z=EXP(94.45/BETA)
      Z1=Z+1
      Z2=Z/(BETA*Z1*Z1)
      DELTA=(ETA/Z1-ZETA/2.0)/(ETA*Z2+ZETA/400.0)
      B1=3.0
C!!!!!!! INTERPOLATION FOR BO OUT OF ARRAY BOF !!!!!!!!!!!!!!!!!!!!
      DO 7033 ISR=1,2
      DO 7034 ISL=1,2
      I=(ISR-1)*8+(ISL-1)*16+SEASON*2
7034  SIPH(ISL)=HPOL(HOUR,BOF(I-1),BOF(I),SAX,SUX)
7033  SIPL(ISR)=SIPH(1)+(SIPH(2)-SIPH(1))/DELA
      BO=SIPL(1)+(SIPL(2)-SIPL(1))/90.*(R-10.)
C!!!!!!! F1-REGION PARAMETERS !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      F1REG=.FALSE.
      HMF1=0.
      NMF1=0.
      C1=0.
      XHIO=49.84733+0.349504*ABSLAT
      XHI100=38.96113+0.509932*ABSLAT
      XHIM=(XHIO+(XHI100-XHIO)*R/100.0)
      IF((XHI.GT.XHIM).OR.NIGHT.OR.(SEASON.EQ.4)) GOTO 150
      F1REG=.TRUE.
      C1=.09+.11/DELA
      FOF1=FOF1ED(MAGBR,R,COSXHI)
      NMF1=1.24E10*FOF1*FOF1
C!!!!!!! PARAMETER FOR E AND VALLEY-REGION !!!!!!!!!!!!!!!!!!!!!
150   NME=1.24E10*FOE*FOE
      HME=105.0
      XDEL=XDELS(SEASON)/DELA
      DNDHBR=DNDS(SEASON)/DELA
      HDEEP=HPOL(HOUR,10.5/DELA,28.,SAX,SUX)
      WIDTH=HPOL(HOUR,17.8/DELA,45.+22./DELA,SAX,SUX)
      DEPTH=HPOL(HOUR,XDEL,81.,SAX,SUX)
      DLNDH=HPOL(HOUR,DNDHBR,.06,SAX,SUX)
      IF(DEPTH.LT.1.0) GOTO 600
      IF(NIGHT) DEPTH=-DEPTH
      CALL TAL(HDEEP,DEPTH,WIDTH,DLNDH,EXT,E)
      IF(.NOT.EXT) GOTO 667
      WRITE(KONSOL,650)
650   FORMAT(1X,'*NE* E-REGION VALLEY CAN NOT BE MODELLED')
```

```
600   WIDTH=.0
667   HEF=HME+WIDTH
C!!!!!!!D-REGION PARAMETER!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
      NMD=XMDED(XHI,R,4.0E8)
      HMD=HPOL(HOUR,81.0,88.0,SAX,SUX)
      F(1)=HPOL(HOUR,0.02+0.03/DELA,0.05,SAX,SUX)
      F(2)=HPOL(HOUR,4.6,4.5,SAX,SUX)
      F(3)=HPOL(HOUR,-11.5,-4.0,SAX,SUX)
      FP1=F(1)
      FP2=-FP1*FP1/2.0
      FP30=(-F(2)*FP2-FP1+1.0/F(2))/(F(2)*F(2))
      FP3U=(-F(3)*FP2-FP1-1.0/F(3))/(F(3)*F(3))
      HDX=HMD+F(2)
      X=HDX-HMD
      XDX=NMD*EXP(X*(FP1+X*(FP2+X*FP30)))
      DXDX=XDX*(FP1+X*(2.0*FP2+X*3.0*FP30))
      X=HME-HDX
      XKK=-DXDX*X/(XDX*ALOG(XDX/NME))
      D1=DXDX/(XDX*XKK*X**(XKK-1.0))
C
C SEARCH FOR HMF1 AND HST.....................................
C
3801  IF(F1REG) GOTO 924
      HMF1=HMF2
      GOTO 380
924   JER=0
      H=10.0
133   H=H+10.0
      IF(H.GT.(HMF2-HEF)) GOTO 135
      CALL REGFA1(HMF2-H,HMF2,1.0,NMF1,XE2,SCHALT,HMF1)
      IF(SCHALT) GOTO 133
      GOTO 137
135   IF(JER.EQ.0) WRITE(KONSOL,11) XVAR(IVAR)
      JER=JER+1
11    FORMAT(1X,'*NE* HMF1 IS NOT EVALUATED BY THE FUNCTION XE2',
     &   F8.1)
3985  IF (HMF2-HEF.GE.B0) GOTO 922
      BOX=(HMF2-HEF)/1.1
      IF(BOX.LT.10.0) GOTO 922
      WRITE(KONSOL,923) B0,BOX
923   FORMAT(6X,'CORR.: B0(OLD)=',F5.1,3X,' B0(NEW)=',F5.1)
      B0=BOX
```

```
      GOTO 924
922   B1X=B1+.5
      IF(B1X.GT.4) GOTO 7398
      WRITE(KONSOL,902) B1
902   FORMAT(6X,'CORR.: B1(OLD)=',F4.1,3X,' B1(NEW)=B1(OLD)+.5')
      B1=B1X
      GOTO 924
7398  WRITE(KONSOL,9269)
9269  FORMAT(1X,'CORR.: NO F1 REGION, B1=3, C1=0.0')
      HMF1=0.
      NMF1=0.
      C1=0.0
      B1=3.
      F1REG=.FALSE.
      GOTO 380
137   IF(HMF1.GT.HEF) GOTO 380
      WRITE(KONSOL,9)
9     FORMAT(1X,'*NE* UPPER E-VALLEY LIMIT(HEF) ABOVE HMF1')
      IF((HMF2-HEF.LT.B0).OR.(B1.LT.4)) GOTO 3985
      WRITE(KONSOL,9853)
9853  FORMAT(1X,'CORR.: NO F1 REGION, B1=3, C1=0.0')
      HMF1=0.
      NMF1=0.
      C1=0.0
      B1=3.
      F1REG=.FALSE.
C!!!!!!! NE3(HST)=NME !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
380   H=-3.
      JER=0
125   H=H+3.0
      IF(H.GT.(HMF1-HEF)) GOTO 900
      CALL REGFA1(HEF+H,HMF1,1.0,NME,XE3,SCHALT,HST)
      STR=HST
      IF(SCHALT) GOTO 125
      GOTO 360
900   IF(JER.EQ.0) WRITE(KONSOL,100) XVAR(IVAR)
100   FORMAT(1X,'*NE* HST IS NOT EVALUATED BY THE FUNCTION XE3',
     &    F8.1)
      JER=JER+1
      IF (HMF2-HEF.GE.B0) GOTO 9221
      BOX=(HMF2-HEF)/1.1
      IF(BOX.LT.10.0) GOTO 9221
```

```
      WRITE(KONSOL,9231) B0,B0X
9231  FORMAT(6X,'CORR.: B0(OLD)=',F5.1,' B0(NEW)=',F5.1)
      B0=B0X
      GOTO 3801
9221  B1X=B1+.5
      IF(B1X.GT.5) GOTO 7391
      WRITE(KONSOL,9021) B1
9021  FORMAT(6X,'CORR.: B1(OLD)=',F4.1,' B1(NEW)=B1(OLD)+.5')
      B1=B1X
      GOTO 3801
7391  B1=3.
      HZ=HEF+.75*(HMF1-HEF)
      WRITE(KONSOL,901) HZ,HEF
901   FORMAT(6X,'CORR.: LIN. APP. BETWEEN HZ=',F5.1,
     &' AND HEF=',F5.1)
      XNEHZ=XE(HZ)
      T=(XNEHZ-NME)/(HZ-HEF)
      HST=-333.
      GOTO 6153
360   HZ=(HST+HMF1)/2.0
      D=HZ-HST
      T=D*D/(HZ-HEF-D)
6153  IF(.NOT.F1REG) HMF1=0.
C
C CALCULATION OF NEUTRAL TEMPERATURE PARAMETER...........
C
4933  HTA=120.0
      HTE=2000.0
      HTNA=90.0
      TNA=183.0
      IF(JTE.EQ.0) GOTO 240
      ZX=125.0
      Z1=XLSTA
      HDEL=ZX-HTNA
      HD2=HDEL*HDEL
      TUN=TUNCAL(COV,LATI,SUNDEC,Z1)
      TNX=371.6678+0.0518806*TUN-294.3505*EXP(-0.00216222*TUN)
      ATN=0.63662*(TUN-TNX)
      TDEL=TNX-TNA
      CTN(1)=1.9*TDEL/HDEL
      CTN(3)=3.0*TDEL/(HD2*HD2)
      CTN(2)=CTN(3)*1.333333*HDEL-CTN(1)/HD2
```

```
C
C CALCULATION OF ELECTRON TEMPERATURE PARAMETER...............
C
881    ATE(1)=TN(AHH(1),TNX,ATN,CTN)
       HMM=60.*EXP(-(MLAT/22.41)**2)+210.
       HM=HPOL(HOUR,HMM,150.,SAX,SUX)
       AHH(2)=HM
       TM=800.*EXP(-(MLAT/33.)**2)+1500.
       IS=SEASON-SEASON/3*2
       CALL TEBA(MAGBR,HOUR,IS,TEA)
       ATE(3)=TEA(1)
       ATE(4)=TEA(2)
       ATE(6)=TEA(3)
       ATE(7)=TEA(4)
       ETT=EXP(-MLAT/11.35)
       TET=2900.-5600.*ETT/((ETT+1)**2.)
       TEN=839.+1161./(1.+EXP(-(ABS(MLAT)-45.)/5.))
       ATE(5)=HPOL(HOUR,TET,TEN,SAX,SUX)
       DO 3395 I=1,3
3395   IF(XNAR(I).GT.0.) ATE(I+2)=TEDE(HOA(I),XNAR(I),-COV)
       ATE5=ATE(5)
       ATE(2)=HPOL(HOUR,TM,TEA(5),SAX,SUX)
       ATE2=ATE(2)
       TNATEI=TN(AHH(2),TNX,ATN,CTN)
       IF(ATE(2).LT.TNATEI) ATE(2)=TNATEI
       STTE1=(ATE(2)-ATE(1))/(AHH(2)-AHH(1))
       DO 1901 I=2,6
       TNATEI=TN(AHH(I+1),TNX,ATN,CTN)
       IF(ATE(I+1).LT.TNATEI) ATE(I+1)=TNATEI
        STTE2=(ATE(I+1)-ATE(I))/(AHH(I+1)-AHH(I))
        ATE(I)=ATE(I)-(STTE2-STTE1)*DTE(I-1)*ALOG2
1901   STTE1=STTE2
       DO 1902 I=1,6
1902   STTE(I)=(ATE(I+1)-ATE(I))/(AHH(I+1)-AHH(I))
       ATE1=ATE(1)
C
C CALCULATION OF ION TEMPERATURE PARAMETERS
C
887    XSM(1)=430.0
       MM(2)=HPOL(HOUR,3.0,0.0,SAX,SUX)
       Z1=EXP(-0.09*MLAT)
       Z2=1.+Z1
```

```
      TID1=1240.0-1400.0*Z1/(Z2*Z2)
      TIDD1=TID1
C THE DAYTIME ION TEMPERATURE TID1 SHOULD BE BETWEEN THE NOON NEUTRAL
C TEMPERATURE TND1 AND ELECTRON TEMPERATURE TED1 (=TE(400)+3*30).
      TED1=TEA(6)+90.
      TND1=TUNCAL(COV,LATI,SUNDEC,0.0)
      IF(TED1.LT.TND1) TED1=TND1
      IF(TID1.GT.TED1) TID1=TED1
      IF(TID1.LT.TND1) TID1=TND1
      Z1=ABS(MLAT)
      Z2=COS(Z1*(0.47+Z1*0.024)*UMR)
      TIN1=1200.0-300.0*SIGN(1.0,Z2)*SQRT(ABS(Z2))
      TINN1=TIN1
C THE NIGHTTIME ION TEMPERATURE TIN1 SHOULD BE BETWEEN THE NEUTRAL AND
C ELECTRON MIDNIGHT TEMPERATURE (TNN1, TEA(5)=TE(300)).
      TNN1=TUNCAL(COV,LATI,SUNDEC,180.)
      TEN1=TEA(5)
      IF(TEN1.LT.TNN1) TEN1=TNN1
      IF(TIN1.GT.TEN1) TIN1=TEN1
      IF(TIN1.LT.TNN1) TIN1=TNN1
      TI1=TIN1
      IF(TID1.GT.TIN1) TI1=HPOL(HOUR,TID1,TIN1,SAX,SUX)
C      TE1=ELTE(XSM(1))
C      TN1=TN(XSM(1),TNX,ATN,CTN)
C      IF((TI1.LT.TN1).OR.(TI1.GT.TE1)) TI1=(TE1+TN1)/2.0
      CALL REGFA1(130.0,500.0,0.1,TI1,TEDER,SCHALT,HS)
      IF(SCHALT) HS=200.
      TNHS=TN(HS,TNX,ATN,CTN)
      MM(1)=DTNDH(HS,ATN,CTN)
      IF(SCHALT) MM(1)=(TI1-TNHS)/(XSM(1)-HS)
      MXSM=2
C ION AND ELECTRON TEMPERATURE ARE MERGED AT AN ALTITUDE BETWEEN
C 600 AND 1400 KM.
2391  XTTS=500.
      X=500.
2390    X=X+XTTS
      IF(X.GE.AHH(7)) GOTO 240
      TEX=ELTE(X)
      TIX=TI(X)
      IF(TIX.LT.TEX) GOTO 2390
      X=X-XTTS
      XTTS=XTTS/10.
```

```
      IF(XTTS.GT.0.1) GOTO 2390
      XTETI=X+XTTS*5.
      MXSM=3
      MM(3)=STTE(6)
      XSM(2)=XTETI
      IF(XTETI.GT.AHH(6)) GOTO 240
      MXSM=4
        MM(3)=STTE(5)
      MM(4)=STTE(6)
      XSM(3)=AHH(6)
      IF(XTETI.GT.AHH(5)) GOTO 240
      MXSM=5
      DTI(2)=5.
      DTI(1)=5.
        MM(3)=STTE(4)
      MM(4)=STTE(5)
      MM(5)=STTE(6)
      XSM(3)=AHH(5)
      XSM(4)=AHH(6)
C
C INPUT OF THE ION DENSITY PARAMETER ARRAYS PF10,PF20 AND PF30......
C
240   HNIA=100.
      HNIE=2000.
      IF(JNI.LT.1) GOTO 141
      RIF(1)=2.
      IF(ABSLAT.LT.30.0) RIF(1)=1.
      RIF(2)=2.
      IF(COV.LT.100.0) RIF(2)=1.
      RIF(3)=SEASON
      IF(SEASON.EQ.1) RIF(3)=3.
      RIF(4)=1.
      IF(NIGHT) RIF(4)=2.
      CALL KOEFP1(PG10)
      CALL KOEFP2 (PG20)
      CALL KOEFP3 (PG30)
      CALL SUFE (PG10,RIF,12,PF10)
      CALL SUFE(PG20,RIF,4,PF20)
      CALL SUFE(PG30,RIF,12,PF30)
C
C CALCULATION OF ION DENSITY PARAMETER.................
C
```

```
      ZZZ1=0.0
      IF(XHI.LE.90.0) ZZZ1=COSXHI
      HFIXO=300.0
      IF((RIF(2).EQ.2.).AND.(RIF(3).EQ.2.)) HFIXO=249.0
      MO(1)=EPSTEP(PF10(1),PF10(2),PF10(3),PF10(4),ZZZ1)
      MO(2)=EPSTEP(PF10(5),PF10(6),PF10(7),PF10(8),ZZZ1)
      MO(3)=0.0
      HO(1)=EPSTEP(PF10(9),PF10(10),PF10(11),PF10(12),ZZZ1)
      HO(4)=PF20(1)
      MO(4)=PF20(2)
      MO(5)=PF20(3)
7100  HO(2)=290.0
      IF((RIF(2).EQ.2.).AND.(RIF(3).EQ.2.)) HO(2)=237.0
      HO(3)=(4.60517-MO(5)*(HO(4)-PF20(4)))/MO(4)+HO(4)
      IF(HO(2).LT.HO(3)) GOTO 7101
      MO(4)=MO(4)-0.001
      GOTO 7100
7101  Z2=5.0
      X=HO(2)
      Z1=0.0
7102  X=X+Z2
      Y=RPID(X,HFIXO,98.0,4,MO,DDO,HO)
      IF(Y.LE.Z1) GOTO 7103
      Z1=Y
      GOTO 7102
7103  IF(Z2.LE.1.0) GOTO 7104
      X=X-Z2
      Z2=1.0
      GOTO 7102
7104  HOO=X-0.5
      DO 7105 I=2,4,2
      L=I/2
      HO2(L)=PF30(1+I)+PF30(2+I)*ZZZ1
7105  MO2(L+1)=PF30(7+I)+PF30(8+I)*ZZZ1
      MO2(1)=PF30(7)+PF30(8)*ZZZ1
7106  Y=RPID(HOO,PF30(1),PF30(2),2,MO2,DO2,HO2)
      IF(Y.LE.0.1) GOTO 1899
      MO2(3)=MO2(3)-0.02
      GOTO 7106
C!!!!!!! RATIO OF NO+ TO O2+ DENSITY AT O+ MAXIMUM IS USED !!!!!!
C!!!!!!! FOR NO+ CALCULATION ABOVE THE O+ MAXIMUM (HOO) !!!!!!!!!
1899  Z1B= RPID (HOO,HFIXO,98.0,4,MO,DDO,HO)
```

```
      Z2B= RPID (HOO,PF3O(1),PF3O(2),2,MO2,DO2,HO2)
      NOBO2= (100.0-Z1B-Z2B)/Z2B
      IF(Z2B.LT.1.) NOBO2=0.0
C
C OUTPUT ON THE SPECIFIED DEVICE...............................
C
141   CONTINUE
      IF(.NOT.F1REG) HMF1=HZ
      XCOR=XVAR(IVAR)
      IF(JMAG.EQ.2) XCOR=DIP
      IF(JMAG.EQ.3) XCOR=MODIP
      IF((IVAR.EQ.5).AND.(XCOR.GT.24.)) XCOR=XCOR-25.
      IF(HEIGHT.LT.1.0) THEN
       WRITE(16,7829) XCOR,INT(HMF2+.5),INT(HMF1+.5),INT(HME+.5),
     &    INT(HMD+.5),INT(NMF2/1.E6+.5),INT(NMF1/1.E6+.5),
     &    INT(NME/1.E6+.5),INT(NMD/1.E6+.5)
       WRITE(6,7829) XCOR,INT(HMF2+.5),INT(HMF1+.5),INT(HME+.5),
     &    INT(HMD+.5),INT(NMF2/1.E6+.5),INT(NMF1/1.E6+.5),
     &    INT(NME/1.E6+.5),INT(NMD/1.E6+.5)
7829   FORMAT(1X,F7.1,2X,4I4,2X,4I7)
       GOTO 2135
      ENDIF
      X=HEIGHT
      LHEI=1
7819    DO 7056 J=1,9
7056  OUTF(J)=0.
      IF(JNE.GT.0) OUTF(1)=XE(X)/1.E6
        IF((X.GE.HTA).AND.(JTE.GT.0)) THEN
        TNH=TN(X,TNX,ATN,CTN)
        TIH=TNH
        IF(X.GT.HS) TIH=TI(X)
          OUTF(2)=TNH
        OUTF(3)=TIH
          OUTF(4)=ELTE(X)
        ENDIF
        IF((X.GE.HNIA).AND.(JNI.GT.0)) THEN
        Z1=RPID(X,HFIXO,98.,4,MO,DDO,HO)
        Z2=RPID(X,PF3O(1),PF3O(2),2,MO2,DO2,HO2)
        CALL RDHHE(X,HOO,Z1,Z2,NOBO2,10.,Z4,Z5)
        OUTF(5)=Z1
        OUTF(6)=Z4
        OUTF(7)=Z5
```

```
        OUTF(8)=Z2
        OUTF(9)=RDNO(X,HOO,Z2,Z1,NOBO2)
      ENDIF
      IF(IVAR.EQ.6) XCOR=X
      IF(JOUT.EQ.0) THEN
         WRITE(16,7546) XCOR,INT(OUTF(1)+.5),INT(OUTF(2)+.5),
     &    INT(OUTF(3)+.5),INT(OUTF(4)+.5),INT(OUTF(5)+.5),
     &    INT(OUTF(6)+.5),INT(OUTF(7)+.5),INT(OUTF(8)+.5),
     &    INT(OUTF(9)+.5)
         WRITE(6,7546) XCOR,INT(OUTF(1)+.5),INT(OUTF(2)+.5),
     &    INT(OUTF(3)+.5),INT(OUTF(4)+.5),INT(OUTF(5)+.5),
     &    INT(OUTF(6)+.5),INT(OUTF(7)+.5),INT(OUTF(8)+.5),
     &    INT(OUTF(9)+.5)
         ENDIF
7546  FORMAT(1X,F7.1,2X,I7,2X,3I5,2X,5I5)
      IF(JOUT.EQ.1) WRITE(6,7547) INT(XCOR+.5),INT(OUTF(2)+.5),
     &    INT(OUTF(3)+.5),INT(OUTF(4)+.5),INT(OUTF(3)-OUTF(2)+.5),
     &    INT(OUTF(4)-OUTF(3)+.5),INT(HM+.5),INT(TEA(1)-ATE2+.5),
     &    INT(TEA(1)+.5),INT(TEA(2)-TEA(1)+.5),INT(ATE5-TEA(2)+.5),
     &    INT(TEA(3)-ATE5+.5),INT(TEA(4)-TEA(3)+.5),
     &    INT(TIDD1+.5),INT(TINN1+.5),INT(XTETI+.5)
7547  FORMAT(1X,I4,6I5,2I4,I5,2I4,5I5)
      IF(JTNN.EQ.2) WRITE(16,*) XCOR,(OUTF(J),J=1,4),HM,ATE2,
     &    TEA(1),TEA(2),ATE5,TEA(3),TEA(4),ATE,TIDD1,TINN1,TI1
2135  IF(IVAR.EQ.6) THEN
      X=X+ZSTEP
      LHEI=LHEI+1
      IF(LHEI.LE.LANZ) GOTO 7819
      HMF2=0.0
      GOTO 2234
      ENDIF
      HMF2=0.0
      IF(LFD.LT.LANZ) GOTO 2123
      GOTO 2234
2235  CONTINUE
      STOP
      END
```

```
 *NE* HST IS NOT EVALUATED BY THE FUNCTION XE3
      CORR.: B1(OLD)= 3.0 B1(NEW)= 3.5
 *NE* HST IS NOT EVALUATED BY THE FUNCTION XE3
      CORR.: B1(OLD)= 3.5 B1(NEW)= 4.0
 *NE* HST IS NOT EVALUATED BY THE FUNCTION XE3
      CORR.: B1(OLD)= 4.0 B1(NEW)= 4.5
 *NE* HST IS NOT EVALUATED BY THE FUNCTION XE3
      CORR.: B1(OLD)= 4.5 B1(NEW)= 5.0
 *NE* HST IS NOT EVALUATED BY THE FUNCTION XE3
      CORR.: LIN. APP. BETWEEN HZ=163.9 AND HEF=122.1
1INPUT:
 LATI= 45.1  LONG=293.5  R=100.  MONTH=10  HOUR=12.50

 CALCULATED VALUES:
 MLAT= 56.5 MLON=  4.2   COV=145.4 DAY=288
 DIP = 72.3 DIPL= 57.5 MODIP= 56.4 DEC=-19.0
 XHI = 54.3 SUNRISE/SET(LT): 6.6/17.4 SUN-DEC= -8.8
 NMF2=1.26E+12  NMF1=2.70E+11   NME=1.36E+11 NMD=9.68E+08
 HMF2=288.7     HMF1=177.8      HME=105.0    HMD= 81.1
```

							RELATIVE PRECENTAGE DENSITY				
H(KM)	NE(M-3)	NE/NMF2	TN(K)	TE(K)	TI(K)	TE/TI	O+	H+	HE+	O2+	NO+
50.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
55.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
60.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
65.0	1.44E+08	0.0001	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
70.0	3.76E+08	0.0003	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
75.0	6.63E+08	0.0005	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
80.0	9.18E+08	0.0007	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
85.0	1.90E+09	0.0015	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
90.0	1.91E+10	0.0152	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
95.0	7.16E+10	0.0569	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
100.0	1.24E+11	0.0985	-1	-1	-1	-1.00	0	0	0	46	53
105.0	1.36E+11	0.1084	-1	-1	-1	-1.00	0	0	0	46	53
110.0	1.32E+11	0.1050	-1	-1	-1	-1.00	1	0	0	46	53
115.0	1.29E+11	0.1025	-1	-1	-1	-1.00	1	0	0	46	53
120.0	1.33E+11	0.1054	336	336	336	1.00	2	0	0	46	53
125.0	1.44E+11	0.1146	394	404	394	1.03	3	0	0	44	53
130.0	1.58E+11	0.1252	451	472	451	1.05	4	0	0	42	54
135.0	1.71E+11	0.1359	506	541	506	1.07	6	0	0	40	54
140.0	1.84E+11	0.1465	557	609	557	1.09	9	0	0	37	54
145.0	1.98E+11	0.1571	604	677	604	1.12	13	0	0	34	53

150.0	2.11E+11	0.1678	647	745	647	1.15	18	0	0	32	50
160.0	2.38E+11	0.1891	718	882	718	1.23	36	0	0	27	38
170.0	2.74E+11	0.2175	774	1018	774	1.32	57	0	0	20	23
180.0	3.03E+11	0.2407	819	1155	819	1.41	73	0	0	13	14
190.0	4.16E+11	0.3306	855	1291	855	1.51	82	0	0	8	10
200.0	5.44E+11	0.4319	884	1424	884	1.61	86	0	0	5	9
210.0	6.79E+11	0.5392	908	1544	908	1.70	88	0	0	3	9
220.0	8.13E+11	0.6456	929	1641	929	1.77	90	0	0	2	9
230.0	9.37E+11	0.7445	946	1726	946	1.83	91	0	0	1	8
240.0	1.04E+12	0.8301	960	1809	961	1.88	92	0	0	1	7
250.0	1.13E+12	0.8988	971	1891	975	1.94	93	0	0	0	6
260.0	1.19E+12	0.9487	981	1973	990	1.99	94	0	0	0	5
270.0	1.23E+12	0.9804	989	2056	1005	2.04	96	0	0	0	4
280.0	1.25E+12	0.9963	996	2138	1020	2.10	97	0	0	0	3
290.0	1.26E+12	0.9999	1002	2218	1035	2.14	98	0	0	0	2
300.0	1.25E+12	0.9960	1007	2291	1050	2.18	98	0	0	0	2
310.0	1.24E+12	0.9859	1011	2349	1065	2.21	98	0	0	0	2
320.0	1.22E+12	0.9700	1014	2399	1080	2.22	98	0	0	0	2
330.0	1.19E+12	0.9488	1017	2448	1095	2.24	98	0	0	0	2
340.0	1.16E+12	0.9230	1019	2496	1110	2.25	98	2	0	0	0
350.0	1.12E+12	0.8933	1021	2544	1125	2.26	98	2	0	0	0
360.0	1.08E+12	0.8603	1023	2592	1140	2.27	98	2	0	0	0
370.0	1.04E+12	0.8248	1025	2639	1155	2.29	98	2	0	0	0
380.0	9.91E+11	0.7875	1026	2684	1170	2.29	98	2	0	0	0
390.0	9.43E+11	0.7492	1027	2724	1185	2.30	98	2	0	0	0
400.0	8.94E+11	0.7104	1028	2755	1200	2.30	98	2	0	0	0
410.0	8.45E+11	0.6717	1029	2775	1216	2.28	98	2	0	0	0
420.0	7.97E+11	0.6335	1030	2787	1234	2.26	98	2	0	0	0
430.0	7.51E+11	0.5963	1030	2793	1254	2.23	98	2	0	0	0
440.0	7.05E+11	0.5604	1031	2798	1278	2.19	98	2	0	0	0
450.0	6.62E+11	0.5260	1031	2801	1305	2.15	98	2	0	0	0
460.0	6.21E+11	0.4932	1032	2805	1334	2.10	97	3	0	0	0
470.0	5.82E+11	0.4623	1032	2808	1363	2.06	96	3	0	0	0
480.0	5.45E+11	0.4332	1033	2811	1393	2.02	95	4	0	0	0
490.0	5.11E+11	0.4059	1033	2814	1422	1.98	95	5	1	0	0
500.0	4.79E+11	0.3806	1033	2817	1452	1.94	94	6	1	0	0
600.0	2.67E+11	0.2123	1035	2855	1749	1.63	86	12	1	0	0
700.0	1.77E+11	0.1402	1035	2925	2046	1.43	78	20	2	0	0
800.0	1.37E+11	0.1086	1036	3003	2343	1.28	67	29	3	0	0
900.0	1.18E+11	0.0938	1036	3080	2640	1.17	57	38	4	0	0
1000.0	1.09E+11	0.0866	1036	3157	2937	1.07	49	46	5	0	0

NOTE: -1 MEANS NO MODEL VALUE AVAILABLE
OR PARAMETER WAS NOT REQUESTED

1INPUT:
MLAT= 30.0 MLON= 2.4 R= 35. MONTH= 7 HOUR=16.00

CALCULATED VALUES:
LATI= 18.6 LONG=292.4 COV= 90.3 DAY=197
DIP = 50.1 DIPL= 30.9 MODIP= 41.9 DEC= -7.7
XHI = 56.1 SUNRISE/SET(LT): 5.5/18.5 SUN-DEC= 21.7
NMF2=8.19E+11 NMF1=0.00E+00 NME=1.12E+11 NMD=5.64E+08
HMF2=292.3 HMF1= 0.0 HME=105.0 HMD= 81.5

							RELATIVE PRECENTAGE DENSITY				
H(KM)	NE(M-3)	NE/NMF2	TN(K)	TE(K)	TI(K)	TE/TI	O+	H+	HE+	O2+	NO+
60.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
65.0	5.15E+07	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
70.0	1.86E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
75.0	3.73E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
80.0	5.26E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
85.0	9.25E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
90.0	1.01E+10	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
95.0	4.68E+10	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
100.0	9.59E+10	-1.0000	-1	-1	-1	-1.00	0	-1	-1	25	75
105.0	1.12E+11	-1.0000	-1	-1	-1	-1.00	0	-1	-1	26	73
110.0	1.05E+11	-1.0000	-1	-1	-1	-1.00	0	-1	-1	28	71
115.0	1.01E+11	-1.0000	-1	-1	-1	-1.00	0	-1	-1	30	69
120.0	1.08E+11	-1.0000	318	318	318	-1.00	1	-1	-1	32	67
140.0	1.48E+11	-1.0000	512	641	512	-1.00	3	-1	-1	33	64
160.0	2.02E+11	-1.0000	639	963	639	-1.00	10	-1	-1	31	59
180.0	2.72E+11	-1.0000	712	1286	712	-1.00	16	-1	-1	29	55
200.0	3.63E+11	-1.0000	757	1602	757	-1.00	23	-1	-1	21	56
220.0	4.82E+11	-1.0000	786	1769	789	-1.00	32	-1	-1	7	61
240.0	6.35E+11	-1.0000	807	1647	822	-1.00	44	-1	-1	2	54
260.0	7.56E+11	-1.0000	821	1491	854	-1.00	61	-1	-1	1	38
280.0	8.12E+11	-1.0000	830	1336	887	-1.00	84	-1	-1	0	16
300.0	8.16E+11	-1.0000	837	1215	919	-1.00	98	-1	-1	0	2
320.0	7.85E+11	-1.0000	842	1238	951	-1.00	97	-1	-1	0	0
340.0	7.25E+11	-1.0000	845	1296	984	-1.00	93	-1	-1	0	0
360.0	6.47E+11	-1.0000	848	1356	1016	-1.00	90	-1	-1	0	0
380.0	5.62E+11	-1.0000	850	1417	1049	-1.00	87	-1	-1	0	0
400.0	4.79E+11	-1.0000	851	1488	1082	-1.00	84	-1	-1	0	0
500.0	1.96E+11	-1.0000	854	1972	1324	-1.00	70	-1	-1	0	0

600.0	9.61E+10	-1.0000	855	2424	1601	-1.00	58	-1	-1	0	0

NOTE: -1 MEANS NO MODEL VALUE AVAILABLE
OR PARAMETER WAS NOT REQUESTED

1INPUT:
LATI=-12.0 LONG=283.1 R= 10. MONTH= 1 HOUR=11.00

CALCULATED VALUES:
MLAT= -0.7 MLON=353.1 COV= 71.1 DAY= 15
DIP = 2.7 DIPL= 1.4 MODIP= 2.8 DEC= 4.7
XHI = 17.3 SUNRISE/SET(LT): 5.7/18.3 SUN-DEC=-21.6
NMF2=6.29E+11 NMF1=2.44E+11 NME=1.44E+11 NMD=6.19E+08
HMF2=357.1 HMF1=253.8 HME=105.0 HMD= 81.0

							RELATIVE PRECENTAGE DENSITY				
H(KM)	NE(M-3)	NE/NMF2	TN(K)	TE(K)	TI(K)	TE/TI	O+	H+	HE+	O2+	NO+
60.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
65.0	6.28E+07	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
70.0	2.47E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
75.0	4.72E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
80.0	6.01E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
85.0	1.20E+09	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
90.0	1.46E+10	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
95.0	6.51E+10	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
100.0	1.26E+11	-1.0000	-1	-1	-1	-1.00	0	-1	-1	50	50
105.0	1.44E+11	-1.0000	-1	-1	-1	-1.00	0	-1	-1	46	54
110.0	1.45E+11	-1.0000	-1	-1	-1	-1.00	0	-1	-1	42	57
115.0	1.46E+11	-1.0000	-1	-1	-1	-1.00	1	-1	-1	39	60
120.0	1.47E+11	-1.0000	305	305	305	-1.00	1	-1	-1	37	62
140.0	1.51E+11	-1.0000	479	590	479	-1.00	4	-1	-1	33	63
160.0	1.56E+11	-1.0000	585	876	585	-1.00	10	-1	-1	31	59
180.0	1.61E+11	-1.0000	641	1161	641	-1.00	17	-1	-1	29	55
200.0	1.68E+11	-1.0000	675	1446	675	-1.00	23	-1	-1	21	56
220.0	1.77E+11	-1.0000	697	1731	697	-1.00	32	-1	-1	7	61
240.0	1.98E+11	-1.0000	712	2015	716	-1.00	44	-1	-1	2	54
260.0	2.85E+11	-1.0000	723	2265	734	-1.00	61	-1	-1	1	38
280.0	4.05E+11	-1.0000	730	2035	752	-1.00	84	-1	-1	0	16
300.0	5.11E+11	-1.0000	735	1468	771	-1.00	98	-1	-1	0	2
320.0	5.84E+11	-1.0000	738	1280	789	-1.00	97	-1	-1	0	0
340.0	6.21E+11	-1.0000	741	1193	807	-1.00	93	-1	-1	0	0
360.0	6.30E+11	-1.0000	743	1109	826	-1.00	90	-1	-1	0	0
380.0	6.24E+11	-1.0000	744	1032	844	-1.00	87	-1	-1	0	0

400.0	5.94E+11	-1.0000	745	987	863	-1.00	84	-1	-1	0	0
500.0	3.52E+11	-1.0000	747	1217	1098	-1.00	70	-1	-1	0	0
600.0	2.17E+11	-1.0000	748	1495	1397	-1.00	58	-1	-1	0	0

```
NOTE: -1 MEANS NO MODEL VALUE AVAILABLE
         OR PARAMETER WAS NOT REQUESTED
*NE* HST IS NOT EVALUATED BY THE FUNCTION XE3
     CORR.: B1(OLD)= 3.0 B1(NEW)= 3.5
*NE* HST IS NOT EVALUATED BY THE FUNCTION XE3
     CORR.: B1(OLD)= 3.5 B1(NEW)= 4.0
*NE* HST IS NOT EVALUATED BY THE FUNCTION XE3
     CORR.: B1(OLD)= 4.0 B1(NEW)= 4.5
*NE* HST IS NOT EVALUATED BY THE FUNCTION XE3
     CORR.: B1(OLD)= 4.5 B1(NEW)= 5.0
*NE* HST IS NOT EVALUATED BY THE FUNCTION XE3
     CORR.: LIN. APP. BETWEEN HZ=261.8 AND HEF=155.0
1INPUT:
LATI=-12.0  LONG=283.1  R=100.  MONTH= 7  HOUR= 0.00

CALCULATED VALUES:
MLAT= -0.7 MLON=353.1   COV=145.4 DAY=197
DIP =  2.7 DIPL=  1.4 MODIP=  2.8 DEC=  4.7
XHI =170.3 SUNRISE/SET(LT): 6.3/17.7 SUN-DEC= 21.7
NMF2=5.60E+11  NMF1=0.00E+00   NME=3.09E+09 NMD=4.00E+08
HMF2=297.5     HMF1=  0.0      HME=105.0    HMD= 88.0
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							RELATIVE PRECENTAGE DENSITY				
H(KM)	NE(M-3)	NE/NMF2	TN(K)	TE(K)	TI(K)	TE/TI	O+	H+	HE+	O2+	NO+
60.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
65.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
70.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
75.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
80.0	5.32E+05	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
85.0	2.47E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
90.0	4.73E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
95.0	2.47E+09	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
100.0	3.08E+09	-1.0000	-1	-1	-1	-1.00	0	-1	-1	18	82
105.0	3.09E+09	-1.0000	-1	-1	-1	-1.00	0	-1	-1	20	80
110.0	2.65E+09	-1.0000	-1	-1	-1	-1.00	0	-1	-1	24	76
115.0	1.84E+09	-1.0000	-1	-1	-1	-1.00	0	-1	-1	27	73
120.0	1.17E+09	-1.0000	317	317	317	-1.00	0	-1	-1	32	68
140.0	7.56E+08	-1.0000	508	633	508	-1.00	1	-1	-1	45	54

160.0	2.74E+10	-1.0000	632	800	632	-1.00	7	-1	-1	37	56
180.0	1.25E+11	-1.0000	702	812	702	-1.00	43	-1	-1	22	35
200.0	2.22E+11	-1.0000	745	814	745	-1.00	79	-1	-1	4	17
220.0	3.19E+11	-1.0000	774	816	774	-1.00	89	-1	-1	1	10
240.0	4.17E+11	-1.0000	794	818	794	-1.00	93	-1	-1	0	7
260.0	5.14E+11	-1.0000	807	820	807	-1.00	96	-1	-1	0	4
280.0	5.52E+11	-1.0000	816	822	816	-1.00	99	-1	-1	0	1
300.0	5.61E+11	-1.0000	823	824	823	-1.00	98	-1	-1	0	0
320.0	5.57E+11	-1.0000	828	827	829	-1.00	86	-1	-1	0	0
340.0	5.36E+11	-1.0000	831	830	835	-1.00	73	-1	-1	0	0
360.0	5.02E+11	-1.0000	833	832	841	-1.00	62	-1	-1	0	0
380.0	4.61E+11	-1.0000	835	835	847	-1.00	53	-1	-1	0	0
400.0	4.16E+11	-1.0000	836	837	853	-1.00	45	-1	-1	0	0
500.0	2.34E+11	-1.0000	840	838	862	-1.00	21	-1	-1	0	0
600.0	1.47E+11	-1.0000	841	841	863	-1.00	11	-1	-1	0	0

NOTE: -1 MEANS NO MODEL VALUE AVAILABLE
OR PARAMETER WAS NOT REQUESTED

1INPUT:
MLAT= 61.0 MLON=290.0 R= 35. MONTH= 6 HOUR=12.00

CALCULATED VALUES:
LATI= 55.5 LONG=236.6 COV= 90.3 DAY=167
DIP = 75.5 DIPL= 62.6 MODIP= 60.3 DEC= 25.8
XHI = 32.3 SUNRISE/SET(LT): 3.4/20.6 SUN-DEC= 23.2
NMF2=2.96E+11 NMF1=2.42E+11 NME=1.33E+11 NMD=7.80E+08
HMF2=224.9 HMF1=180.2 HME=105.0 HMD= 81.0

							RELATIVE PRECENTAGE DENSITY				
H(KM)	NE(M-3)	NE/NMF2	TN(K)	TE(K)	TI(K)	TE/TI	O+	H+	HE+	O2+	NO+
60.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
65.0	1.23E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
70.0	3.08E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
75.0	5.36E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
80.0	7.42E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
85.0	1.57E+09	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
90.0	1.62E+10	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
95.0	6.44E+10	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
100.0	1.18E+11	-1.0000	-1	-1	-1	-1.00	0	-1	-1	42	58
105.0	1.33E+11	-1.0000	-1	-1	-1	-1.00	0	-1	-1	40	59
110.0	1.30E+11	-1.0000	-1	-1	-1	-1.00	0	-1	-1	39	61
115.0	1.27E+11	-1.0000	-1	-1	-1	-1.00	1	-1	-1	37	62

120.0	1.31E+11	-1.0000	317	317	317	-1.00	1	-1	-1	36	63
140.0	1.59E+11	-1.0000	508	587	508	-1.00	4	-1	-1	33	63
160.0	2.01E+11	-1.0000	633	857	633	-1.00	10	-1	-1	31	59
180.0	2.42E+11	-1.0000	703	1127	703	-1.00	16	-1	-1	29	55
200.0	2.81E+11	-1.0000	747	1396	758	-1.00	23	-1	-1	23	54
220.0	2.95E+11	-1.0000	775	1653	812	-1.00	32	-1	-1	11	57
240.0	2.93E+11	-1.0000	795	1898	866	-1.00	44	-1	-1	4	51
260.0	2.83E+11	-1.0000	809	2142	921	-1.00	61	-1	-1	2	37
280.0	2.65E+11	-1.0000	818	2385	975	-1.00	83	-1	-1	1	16
300.0	2.43E+11	-1.0000	825	2591	1030	-1.00	98	-1	-1	0	2
320.0	2.18E+11	-1.0000	829	2647	1084	-1.00	99	-1	-1	0	1
340.0	1.92E+11	-1.0000	833	2665	1138	-1.00	99	-1	-1	0	1
360.0	1.67E+11	-1.0000	835	2682	1193	-1.00	99	-1	-1	0	0
380.0	1.44E+11	-1.0000	837	2699	1247	-1.00	99	-1	-1	0	0
400.0	1.24E+11	-1.0000	838	2716	1302	-1.00	99	-1	-1	0	0
500.0	5.80E+10	-1.0000	841	2794	1593	-1.00	95	-1	-1	0	0
600.0	3.22E+10	-1.0000	842	2874	1893	-1.00	87	-1	-1	0	0

NOTE: -1 MEANS NO MODEL VALUE AVAILABLE
OR PARAMETER WAS NOT REQUESTED
NOTE: IRI IS DESIGNED FOR NON-AURORAL LATITUDES
1INPUT:
LATI= 18.5 LONG=293.2 R= 50. MONTH= 3 HOUR= 6.00

CALCULATED VALUES:
MLAT= 29.9 MLON= 3.3 COV=102.4 DAY= 76
DIP = 49.9 DIPL= 30.7 MODIP= 41.8 DEC= -8.2
XHI = 90.9 SUNRISE/SET(LT): 6.1/17.9 SUN-DEC= -2.9
NMF2=2.46E+11 NMF1=0.00E+00 NME=1.99E+10 NMD=4.00E+08
HMF2=277.8 HMF1= 0.0 HME=105.0 HMD= 84.6

							RELATIVE PRECENTAGE DENSITY				
H(KM)	NE(M-3)	NE/NMF2	TN(K)	TE(K)	TI(K)	TE/TI	O+	H+	HE+	O2+	NO+
60.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
65.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
70.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
75.0	-1.00E+00	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
80.0	2.77E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
85.0	4.07E+08	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
90.0	1.71E+09	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
95.0	9.93E+09	-1.0000	-1	-1	-1	-1.00	-1	-1	-1	-1	-1
100.0	1.84E+10	-1.0000	-1	-1	-1	-1.00	0	-1	-1	18	82

105.0	1.99E+10	-1.0000	-1	-1	-1	-1.00	0	-1	-1	21	79
110.0	1.73E+10	-1.0000	-1	-1	-1	-1.00	0	-1	-1	24	76
115.0	1.36E+10	-1.0000	-1	-1	-1	-1.00	0	-1	-1	27	73
120.0	1.16E+10	-1.0000	303	303	303	-1.00	0	-1	-1	31	69
140.0	1.75E+10	-1.0000	472	604	472	-1.00	1	-1	-1	37	62
160.0	3.50E+10	-1.0000	573	904	573	-1.00	4	-1	-1	36	60
180.0	6.21E+10	-1.0000	627	1182	627	-1.00	18	-1	-1	20	63
200.0	1.03E+11	-1.0000	658	1301	658	-1.00	40	-1	-1	6	54
220.0	1.57E+11	-1.0000	679	1352	682	-1.00	54	-1	-1	2	44
240.0	2.10E+11	-1.0000	693	1401	706	-1.00	65	-1	-1	0	34
260.0	2.39E+11	-1.0000	703	1450	730	-1.00	78	-1	-1	0	22
280.0	2.46E+11	-1.0000	710	1498	754	-1.00	92	-1	-1	0	8
300.0	2.41E+11	-1.0000	714	1560	778	-1.00	98	-1	-1	0	0
320.0	2.29E+11	-1.0000	718	1671	801	-1.00	86	-1	-1	0	0
340.0	2.11E+11	-1.0000	720	1795	825	-1.00	74	-1	-1	0	0
360.0	1.91E+11	-1.0000	722	1917	849	-1.00	63	-1	-1	0	0
380.0	1.69E+11	-1.0000	723	2032	873	-1.00	54	-1	-1	0	0
400.0	1.48E+11	-1.0000	724	2106	897	-1.00	46	-1	-1	0	0
500.0	7.33E+10	-1.0000	726	1909	1034	-1.00	21	-1	-1	0	0
600.0	4.21E+10	-1.0000	727	1702	1179	-1.00	11	-1	-1	0	0

NOTE: -1 MEANS NO MODEL VALUE AVAILABLE
OR PARAMETER WAS NOT REQUESTED

```
LECTRON DENSITY ****************************                    C*************************************
*************************                    C
                                 FUNCTION XE1(H)
      C REPRESENTING ELECTRON DENSITY(M-3) IN THE TOPSIDE IONOSPHERE                    C (H=HMF2....1
000 KM) BY HARMONIZED BENT-MODEL ADMITTING                          C VARIABILITY OFGLOBAL PARAMETER
ETA,ZETA,BETA,DELTA WITH                          C GEOM. LATITUDE, SMOOTHED SOLAR FLUX AND CRITICAL F
REQUENCY                    C (SEE MAIN PROGRAM).
        C [REF.:K.RAWER,S.RAMAKRISHNAN,1978]                                                REAL
 NMF2                                                                COMMON/BLOCK1/HMF2,NMF2
,HMF1/BLO10/BETA,ETA,DELTA,ZETA                          DXDH=(1000.-HMF2)/700.


 TAPE NO.   1              FILE NO.   3
 RECORD   1                LENGTH   3200
C*****************************************************************                C*******************
 IRIMP0, OCT 1986 ******************************                C*************************************
****************************                C**  SPECIAL IRI DRIVER PROGRAM TO GENERATE IRI PROFILES
IN     **                C**  ALTITUDE, GEOGRAPHIC OR GEOMAGNETIC LATITUDE, LONGITUDE,   **
    C**  SOLAR ACTIVITY, MONTH, LOCAL OR UNIVERSAL TIME,                **                C**  OR ALTITUD
E.                                                **                C**  D.BILITZA, GSFC/NSSDC,CODE 63
3, GREENBELT, MD 20771, USA   **                C*****************************************************
*************                C** INPUT: JMAG,LATI,LONG,R,MONTH,HOUR,H,IVAR,ZBEG,ZSTEP,ZEND,  **
        C**          ZEND,JNE,JTETI,JNI,JOUT                                **                C**
                                                **                C** JMAG          =0 GEOGRAPHIC,
 =1 GEOMAGNETIC COORDINATES        **                C** LATI,LONG   GEOG. OR GEOM. LATITUDE AND LONGI
TUDE IN DEGREES**                C** R                SOLAR SUNSPOT NUMBER 12-MONTHS-RUNNING MEAN      **
            C** HOUR          LOCAL TIME IN DECIMAL HOURS                **                C**
          +25  UNIVERSAL TIME                                **                C** H              ALTITUDE I
N KM                                **                C**                =0 GIVES F2,F1,E,D PEAK ALTIT
UDES (KM) AND       **                C**                DENSITIES (CM-3)
**                C** IVAR          =1,2,3,4,5  FOR PROFILE IN LATI, LONG, R, HOUR  **                C**
                OR H RESPECTIVELY                                **                C** ZBEG,ZSTEP  BEGIN,
 STEP AND END VALUE OF PARAMETER CHOSEN   **                C**    ,ZEND          WITH IVAR
                    **                C** JNE          =1(0)   ELECTRON DENSITY (NOT) REQUESTED
    **                C** JTETI        =1(0)   TEMPERATURES OF NEUTRALS, IONS AND      **
 C**                ELECTRONS (NOT) REQUESTED                **                C** JNI          =1
(0)   RELATIVE ION DENSITIES (NOT) REQUESTED  **                C** JOUT         =0 NORMAL OUTPUT ON P
RINTER AND FILE                **                C**                =2 UNFORMATTED OUTPUT
        **                C** JMAG         =2,3 GEOMAGNETIC COORDINATES ARE USED, BUT THE  **
      C**                OUTPUT (X-COORDINATE) WILL BE THE                **                C**
        CALCULATED DIP(2) OR MODIP(3)                **                C*********************************
*********************************                C***** YOU HAVE TO ADJUST THE INPUT AND OUTPUT FORMA
TS TO    *****                C***** YOUR COMPUTER ALSO NOTE THAT CONDITIONAL IF IS USED   *****
          C***** (IF .... ENDIF). PLEASE ASSIGN CCIR-COEFFICIENT SET    *****                C***** TO
UNIT 10 AND LINK IRIMP0 WITH IRIFU9.                *****                C*****************************
*************************************                INTEGER EGNR,AGNR,DAYNR,DD0,DO2,SEASON


 TAPE NO.   1              FILE NO.   4
 RECORD   1                LENGTH   2440
 *NE* HST IS NOT EVALUATED BY THE FUNCTION XE3
                    CORR.: B1(OLD)= 3.0 B1(NEW)= 3.5
                                *NE* HST IS NOT EVALUATED BY THE FUNCTION XE3
                                                CORR.: B1(OLD)= 3.5 B1(N
EW)= 4.0                                                                *NE* H
ST IS NOT EVALUATED BY THE FUNCTION XE3
                    CORR.: B1(OLD)= 4.0 B1(NEW)= 4.5
                                *NE* HST IS NOT EVALUATED BY THE FUNCTION XE3
                                                CORR.: B1(OLD)= 4.5 B1(NEW)= 5.
0                                                               *NE* HST IS N
OT EVALUATED BY THE FUNCTION XE3
                CORR.: LIN. APP. BETWEEN HZ=163.9 AND HEF=122.1
                            1INPUT:
                                                LATI= 45.1  LONG=293.5  R=100.  MONTH=10  H
```

MI-91D
[International Reference Ionosphere on Tape]
IRI9-86
D-74126, C-26130

```
$NOP
$NOP ********** SOUT58A **********
$EXE TPLIST BS

INPUT PARAMETERS ARE:  AS SR=1=1 15 1 1

 TAPE NO.   1              FILE NO.   1
 RECORD   1                LENGTH   80
VOL1IRI986                                                                  3

 TAPE NO.   1              FILE NO.   2
 RECORD   1                LENGTH   2048
0070C*********************************************************************0070C********* INTERNATIONAL
REFERENCE IONOSPHERE (IRI). **************0070C*************************************************************
************0070C**************** IRIMP9, AUGUST 1986 ******************************0070C************
****   DRIVER PROGRAM    ****************************0070C*******************************************
*************************0070C*** THIS PROGRAM PRODUCES HEIGHT PROFILES OF                    ***0070C
***      ELECTRON DENSITY                                    ***0070C***      NORMALISED ELECTRON
DENSITY (TO F-MAXIMUM)            ***0070C***      NEUTRAL TEMPERATURE (CIRA 72)
   ***0070C***      ELECTRON TEMPERATURE                                  ***0070C***      ION TEMP
ERATURE                                   ***0070C***      ELECTRON TO ION TEMPERATURE RATIO
              ***0070C***      RELATIVE PRECENTAGE DENSITIES OF THE IONS                ***0070C***
          ATOMIC OXYGEN, HYDROGEN, HELIUM,                ***0070C***            MOLECULAR OXYGEN AND
 NITROGEN OXYD (NO+)          ***0070C*****************************************************************
**0070C*** FOR SPECIFIED                                          ***0070C***      GEOG. OR GEOM
. LATITUDE AND LONGITUDE                  ***0070C***      ZURICH SUNSPOT NUMBER (12-MONTH-RUNNING ME
AN)          ***0070C***      MONTH-NUMBER                                      ***0070C***      L
OCAL OR UNIVERSAL TIME                                  ***0070C*****************************************
*************************0070C*** THE ALTITUDE LIMITS ARE:      LOWER            UPPER          ***007
0C***      ELECTRON DENSITY      60(DAY)/80 KM      1000 KM          ***0070C***      TEMPERATURES
       120 KM          3000 KM          ***0070C***      ION DENSITIES              100 KM          1000 KM
      ***0070C*****************************************************************0070C*      ---------
-------------ADDRESSES-------------------------*^^^^^^^^^^^^^^^^^^^^

 TAPE NO.   1              FILE NO.   3
 RECORD   1                LENGTH   80
EOF1IRIMP9.FOR        IRI986000100010000173 86364 87096 000015DECFILE11A

 TAPE NO.   1              FILE NO.   4
 RECORD   1                LENGTH   80
HDR1IRIFU9.FOR        IRI986000100020000167 86324 87096 000000DECFILE11A

 TAPE NO.   1              FILE NO.   5
 RECORD   1                LENGTH   2048
0069C*************************************************************  0069C********** INTERNATIONAL
REFERENCE IONOSPHERE ****************  0069C*****************************************************
*******  0069C****************  IRIFU9, AUGUST 1986  ************************  0067C****************
FUNCTIONS,SUBROUTINES ************************0069C*****************************************************
***************  0069C*****************************************************************  0067C***  ----
----------------ADDRESSES-------------------------  ***0067C***  I  PROF. K. RAWER                DR. D.
BILITZA        I  ***0067C***  I  HERRENSTR. 43                GSFC CODE 633        I  ***0067C***  I
 7801 MARCH 1              GREENBELT MD 20771   I  ***0067C***  I  F.R.G.                          USA
                    I  ***0069C***  I                                TEL. (301)286-9536   I  ***  0067C*
**  ---------------------------------------------------------  ***0069C*********************************
****************************  0069C*****************************************************************
 0005C0067C*****************************************************************0067C** SUBROUTINE CCIRCA
READS THE CCIR-COEFFICIENT SET WITH:   **0067C**              READ(10) FOF2,M3000
      **0067C** MAKE SURE THAT THE BINARY FILE CCIR.DAT IS ASSIGNED      **0067C** OR CHANGE THE A
BOVE STATEMENT AS INDICATED IN CCIRCA IF  **0067C** YOU ARE USING THE ASCC-CODED CCIR-SET.
         **0067C*****************************************************************0005C0013C          00
69C*************************************************************   0069C*************** ELECTRON DE
NSITY ****************************   0069C*****************************************************************
****   0005C0029       FUNCTION XE1(H)     0069C REPRESENTING ELECTRON DENSITY(M-3) IN THE TOPSIDE IO
NOSPHERE   0061C (H=HMF2....1000 KM) BY HARMONIZED BENT-MODEL ADMITTING 0069C VARIABILITY OFGLOBAL
```

MI-91C
International Reference
Ionosphere on Tape 1
IRI9-86
D-74058, C-26071

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$NOP
$NOP ********* SOUT57A ********
$EXE TPLIST RS

INPUT PARAMETERS ARE:  AS SR=1=1 5 1 1

 TAPE NO.   1              FILE NO.   1
 RECORD   1                LENGTH   3200
C*************************************************************              C********* INTERNAT
IONAL REFERENCE IONOSPHERE (IRI). **************              C*****************************************
****************************              C***************** IRIMP9, AUGUST 1986 ********************
*********              C*****************   DRIVER PROGRAM    ****************************
   C*****************************************************************              C*** THIS PROGR
AM PRODUCES HEIGHT PROFILES OF                    ***                C***      ELECTRON DENSITY
                                  ***                C***      NORMALISED ELECTRON DENSITY (TO F-MAXIMUM)
          ***                C***      NEUTRAL TEMPERATURE (CIRA 72)                    ***
        C***      ELECTRON TEMPERATURE                                    ***                C***      I
ON TEMPERATURE                                    ***                C***      ELECTRON TO ION TEMP
ERATURE RATIO                     ***                C***      RELATIVE PRECENTAGE DENSITIES OF THE IO
NS            ***                C***          ATOMIC OXYGEN, HYDROGEN, HELIUM,                    ***
            C***            MOLECULAR OXYGEN AND NITROGEN OXYD (NO+)          ***                C******
*****************************************************************              C*** FOR SPECIFIED
                                  ***                C***      GEOG. OR GEOM. LATITUDE AND LONGITU
DE                ***                C***      ZURICH SUNSPOT NUMBER (12-MONTH-RUNNING MEAN)          *
**                C***      MONTH-NUMBER                                    ***                C**
*      LOCAL OR UNIVERSAL TIME                                    ***                C**********************
*********************************************              C*** THE ALTITUDE LIMITS ARE:      LOWER
        UPPER          ***                C***      ELECTRON DENSITY      60(DAY)/80 KM      1000 KM
   ***                C***      TEMPERATURES              120 KM          3000 KM          ***
  C***      ION DENSITIES              100 KM          1000 KM          ***                C*****************
*************************************************              C*      ----------------------ADDRESSES-
                    *              C*      I  PROF. K. RAWER                    DR. D. BILITZA
   I      *              C*      I  HERRENSTR. 43                    GSFC/NSSDC CODE 633  I      *
     C*      I  D-7801 MARCH                    GREENBELT MD 20771    I      *                C*      I  F.R.
G.                    USA                    I      *                C*      ----------------------------
----------------------------      *              C*****************************************************
***************              C*****************************************************************
          C*****************************************************************              C*********
       ALL ANGLES ARE IN DEGREE              ***************              C*********       ALL DENSITIE
S ARE IN M-3              ***************              C*********       ALL ALTITUDES ARE IN KM
   ***************

 TAPE NO.   1              FILE NO.   2
 RECORD   1                LENGTH   3200
C*************************************************************              C********** INTERNA
TIONAL REFERENCE IONOSPHERE ****************              C*****************************************
***************************              C***************** IRIEU9, AUGUST 1986 ******************
******              C***************** FUNCTIONS,SUBROUTINES ************************
   C*****************************************************************              C***************
*************************************************              C***      ----------------------ADDRESSES
--------------------------      ***              C***      I  PROF. K. RAWER                    DR. D. BILITZA
    I      ***              C***      I  HERRENSTR. 43                    GSFC CODE 633          I      ***
       C***      I  7801 MARCH 1                    GREENBELT MD 20771    I      ***                C***      I  F.
R.G.                    USA                    I      ***                C***      I
      TEL. (301)286-9536    I      ***              C***      ---------------------------------------------
---------      ***              C*****************************************************************
          C*****************************************************************              C
                                                                              C***************************
*************************************              C** SUBROUTINE CCIRCA READS THE CCIR-COEFFICI
ENT SET WITH:    **              C**              READ(10) FOF2,M3000                    **
              C** MAKE SURE THAT THE BINARY FILE CCIR.DAT IS ASSIGNED      **              C**
  OR CHANGE THE ABOVE STATEMENT AS INDICATED IN CCIRCA IF    **              C** YOU ARE USING THE
ASCC-CODED CCIR-SET.              **              C*****************************************
**********************              C
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 CALCULATED VALUES:
                                MLAT= 56.5 MLON=   4.2    COV=145.4 DAY=288
                                                   DIP  = 72.3 DIPL= 57.5 MODIP= 56.4 DEC=-19.0
                                                                          XHI  = 54.3 SUNRISE/SET(LT):
 6.6/17.4 SUN-DEC= -8.8                                                                          NMF2
=1.26E+12  NMF1=2.70E+11    NME=1.36E+11 NMD=9.68E+08
                    HMF2=288.7      HMF1=177.8       HME=105.0     HMD= 81.1



 TAPE NO.   1                FILE NO.   5
 RECORD   1                  LENGTH   2440
  0.52396593E+01-0.56523629E-01-0.18704617E-01 0.12128915E-01 0.79412190E-02-0.10031431E-01 0.21567
261E-01-0.68602660E-02    0.37022342E-02 0.78359339E-02 0.63161603E-02-0.10695397E-01 0.29390149E-01
 0.93325400E+00-0.28997503E-01 0.10946778E+00  -0.30769527E+00-0.37993383E+00-0.23273268E+00 0.8948
0691E-01 0.33896305E-01 0.32839003E+00-0.81993349E-01-0.14348941E+00  -0.27823284E-01 0.11266428E-0
1 0.80531130E+01 0.13981724E+01 0.47361958E+00-0.11388183E+00 0.77816737E+00-0.17388150E+00   0.290
99104E+00 0.29059123E-01-0.37210885E+00-0.11191850E+00-0.43733008E-01 0.12193082E+00-0.32639468E+00
-0.13390853E+02   0.62355526E+00 0.24597554E+01 0.44970918E+01 0.85659552E+01 0.40355296E+01-0.7923
1381E+00-0.67203265E+00-0.47442737E+01    0.21074810E+01 0.33913586E+01-0.10161761E+00-0.69574153E+0
0-0.32273560E+02-0.56248417E+01-0.58702965E+01-0.43174982E+01  -0.32914643E+01 0.14731911E+01-0.841
57687E+00-0.18629679E+00 0.36630037E+01-0.49589828E+00 0.42669845E+00-0.39217409E+00    0.15235479E+
01-0.10364820E+08-0.17449905E+02-0.18375044E+02-0.16429411E+02-0.42843178E+02-0.18512333E+02 0.2995
4524E+01    0.44427662E+01 0.22331482E+02-0.11312363E+02-0.17385393E+02 0.13743354E+01 0.49287653E+0
1 0.35317551E+02 0.78040113E+01    0.22017223E+02 0.19007372E+02 0.51486945E+01-0.32355106E+01-0.702
89177E+00-0.18949838E-01-0.10833933E+02 0.30533838E+01  -0.15614654E+01 0.34174812E+00-0.33425496E+
01 0.10955015E+03 0.64495300E+02 0.39307384E+02 0.21447481E+02 0.88321732E+02   0.36022030E+02-0.49
279366E+01-0.11266347E+02-0.45660416E+02 0.24368761E+02 0.36402855E+02-0.37914002E+01-0.12354781E+0
2  -0.15069658E+02-0.54928751E+01-0.30891773E+02-0.26297506E+02-0.28576374E+01 0.23907247E+01 0.271
61193E+01 0.10669554E+01    0.12239296E+02-0.43662004E+01 0.20293267E+01 0.21851628E+00 0.34469433E+
01-0.18371085E+03-0.78854736E+02-0.32724571E+02  -0.86944246E+01-0.80539780E+02-0.31638607E+02 0.32
864110E+01 0.12187758E+02 0.42042595E+02-0.23398046E+02-0.33907742E+02    0.42148323E+01 0.12834593E
+02 0.22537875E+01 0.19722799E+01 0.14214872E+02 0.11752549E+02 0.97573824E-01-0.41853258E+00  -0.1
4487737E+01-0.91950291E+00-0.47050514E+01 0.19138944E+01-0.85748482E+00-0.30080923E+00-0.13293968E+
01 0.86102806E+02    0.31215933E+02 0.92085867E+01-0.52750909E+00 0.26795364E+02 0.10308076E+02-0.60
259044E+00-0.47401175E+01-0.14323977E+02    0.83509979E+01 0.11643826E+02-0.16808408E+01-0.47212696E
+01 0.53214836E-02 0.17079000E+01 0.16235816E+01 0.33274181E-01

 ***** JOB DONE.
 $WEO LPS


 $$
 $ASS IN TB1
 $EXE IRDURC RS
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  TAPE NO.   1                FILE NO.   6
  RECORD   1                  LENGTH   80
EOF1IRIFU9.FOR        IRI986000100002000167 86324 87096 000028DECFILE11A

  TAPE NO.   1                FILE NO.   7
  RECORD   1                  LENGTH   80
HDR1IRIMP0.FOR        IRI986000100003000217 86324 87071 000000DECFILE11A

  TAPE NO.   1                FILE NO.   8
  RECORD   1                  LENGTH   2048
0070C*****************************************************************0070C****************** IRIMP
0, OCT 1986 ***************************0070C*****************************************************
************0070C**  SPECIAL IRI DRIVER PROGRAM TO GENERATE IRI PROFILES IN     **0071C**  ALTITUDE
, GEOGRAPHIC OR GEOMAGNETIC LATITUDE, LONGITUDE,   ** 0070C**  SOLAR ACTIVITY, MONTH, LOCAL OR UNIV
ERSAL TIME,              **0070C**  OR ALTITUDE,                                              **0070
C**  D.BILITZA, GSFC/NSSDC,CODE 633, GREENBELT, MD 20771, USA    **0070C****************************
************************************0070C**  INPUT: JMAG,LATI,LONG,R,MONTH,HOUR,H,IVAR,ZBEG,ZSTEP,Z
END,  **0070C**          ZEND,JNE,JTETI,JNI,JOUT                          **0070C**
                                                **0070C** JMAG          =0 GEOGRAPHIC, =1 GEOMAGNETIC
COORDINATES        **0070C** LATI,LONG   GEOG. OR GEOM. LATITUDE AND LONGITUDE IN DEGREES**0070C** R
            SOLAR SUNSPOT NUMBER 12-MONTHS-RUNNING MEAN      **0070C** HOUR          LOCAL TIME IN DECI
MAL HOURS                  **0070C**                  +25  UNIVERSAL TIME
 **0070C** H               ALTITUDE IN KM                                **0070C**                =0 GIV
ES F2,F1,E,D PEAK ALTITUDES (KM) AND       **0070C**                  DENSITIES (CM-3)
              **0071C** IVAR          =1,2,3,4,5  FOR PROFILE IN LATI, LONG, R, HOUR  ** 0070C**
          OR H RESPECTIVELY                                **0070C** ZBEG,ZSTEP  BEGIN, STEP AND END VA
LUE OF PARAMETER CHOSEN   **0070C**   ,ZEND          WITH IVAR                                      **0
070C** JNE          =1(0)   ELECTRON DENSITY (NOT) REQUESTED          **0070C** JTETI        =1(0)   TE
MPERATURES OF NEUTRALS, IONS AND       **0070C**                          ELECTRONS (NOT) REQUESTED
          **0070C** JNI          =1(0)   RELATIVE ION DENSITIES (NOT) REQUESTED  **0070C** JOUT
   =0 NORMAL OUTPUT ON PRINTER AND FILE                **0000000000000000

  TAPE NO.   1                FILE NO.   9
  RECORD   1                  LENGTH   80
EOF1IRIMP0.FOR        IRI986000100003000217 86324 87071 000011DECFILE11A

  TAPE NO.   1                FILE NO.   10
  RECORD   1                  LENGTH   80
HDR1IRIEXA.DAT        IRI986000100004000104 86364 87096 000000DECFILE11A

  TAPE NO.   1                FILE NO.   11
  RECORD   1                  LENGTH   2048
0050 *NE* HST IS NOT EVALUATED BY THE FUNCTION XE30042       CORR.: B1(OLD)= 3.0 B1(NEW)= 3.50050 *N
E* HST IS NOT EVALUATED BY THE FUNCTION XE30042       CORR.: B1(OLD)= 3.5 B1(NEW)= 4.00050 *NE* HST
IS NOT EVALUATED BY THE FUNCTION XE30042       CORR.: B1(OLD)= 4.0 B1(NEW)= 4.50050 *NE* HST IS NOT
EVALUATED BY THE FUNCTION XE30042       CORR.: B1(OLD)= 4.5 B1(NEW)= 5.00050 *NE* HST IS NOT EVALUAT
ED BY THE FUNCTION XE30057       CORR.: LIN. APP. BETWEEN HZ=163.9 AND HEF=122.100111INPUT:0057 LATI
= 45.1  LONG=293.5  R=100.  MONTH=10  HOUR=12.5000040023 CALCULATED VALUES:0046 MLAT= 56.5 MLON=  4
.2   COV=145.4 DAY=2880048 DIP = 72.3 DIPL= 57.5 MODIP= 56.4 DEC=-19.00055 XHI = 54.3 SUNRISE/SET(L
T): 6.6/17.4 SUN-DEC= -8.80061 NMF2=1.26E+12  NMF1=2.70E+11   NME=1.36E+11 NMD=9.68E+080058 HMF2=28
3.7      HMF1=177.8       HME=105.0     HMD= 81.100040082
        RELATIVE PRECENTAGE DENSITY0080  H(KM)   NE(M-3)  NE/NMF2 TN(K) TE(K) TI(K)  TE/TI    O+    H+
 HE+  O2+  NO+0080   50.0  -1.00E+00 -1.0000    -1     -1     -1  -1.00    -1    -1    -1    -1   -10080
  55.0  -1.00E+00 -1.0000    -1     -1     -1  -1.00    -1    -1    -1    -1   -10080   60.0  -1.00E+00 -
1.0000    -1     -1     -1  -1.00    -1    -1    -1    -1   -10080   65.0   1.44E+08  0.0001    -1     -1
    -1  -1.00    -1    -1    -1    -1   -10080   70.0   3.76E+08  0.0003    -1     -1     -1  -1.00    -1
  -1    -1    -1   -10080   75.0   6.63E+08  0.0005    -1     -1     -1  -1.00    -1    -1    -1    -1   -10
080   80.0   9.18E+08  0.0007    -1     -1     -1  -1.00    -1    -1    -1   -10080   85.0   1.90E+
09  0.0015    -1     -1     -1  -1.00    -1    -1    -1    -1   -10080   90.0   1.91E+10  0.0152    -1
  -1    -1  -1.00    -1    -1    -1    -1   -10080   95.0   7.16E+10  0.0569    -1     -1     -1  -1.00
-1    -1    -1    -1   -10080  100.0   1.24E+11  0.0985    -1     -1     -1  -1.00    0     0     0    46
  530080  105.0   1.36E+11  0.1084    -1     -1     -1  -1.00    0     0     0    46   530080  110.0   1.
32E+11  0.1050    -1     -1     -1  -1.00    1     0     0    46   530000

  TAPE NO.   1                FILE NO.   12
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EOF1IRIEXA.DAT        IRI986000100040000104 86364 87096 000011DECFILE11A

 TAPE NO.   1              FILE NO.   13
 RECORD   1                LENGTH   80
HDR1CCIR.DAT          IRI986000100050000102 86115 87071 000000DECFILE11A

 TAPE NO.   1              FILE NO.   14
 RECORD   1                LENGTH   2048
2048  %AJ g

 A
 +



EA @L
@6X@
c

@%
hC

D
B ~UC
?

U

 TAPE NO.   1              FILE NO.   15
 RECORD   1                LENGTH   80
EOF1CCIR.DAT          IRI986000100050000102 86115 87071 000072DECFILE11A

***** JOB DONE.
$WEO LPS



$$
$ASS IN TB1
```