Combined Release and Radiation Effects Satellite (CRRES)

High Energy Electron Fluxmeter (HEEF)
and
Proton Telescope (PROTEL)

The HEEF and PROTEL databases have been generated by the US Air Force Research Laboratory (AFRL), Space Vehicles Directorate (AFRL/VS)

16 October 2001

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CRRES HEEF and PROTEL Databases

The Combined Release and Radiation Effects Satellite (CRRES) was launched on 25 July 1990 and returned data up through 11 October 1991. The CRRES orbit was 350 km x 36000 km, 18^{o} inclination, with an orbital period of ~10 hours. Data from the Air Force High Energy Electron Fluxmeter (HEEF) and Proton Telescope (PROTEL) are organized into two primary databases per instrument, with separate files for each orbit. The CRRES magnetometer data were used for the determination of local pitch angles. One database (with the file extension '.min') provides 1-minute average local pitch angle distributions at the satellite's local spatial coordinates. A second database (with the file extension '.pad') is derived from the first, and provides pitch angle distributions mapped to the equator as a function of the McIlwain L parameter (also referred to simply as L-shell or L). The McIlwain L used for sorting the data was calculated using the combined IGRF85 and Olson-Pfitzer quiet magnetic field [1].

There are several orbits for which no data files exists for one of the following various reasons: (a) the spacecraft spin rate was decreasing from its initial rate to its final spin rate of ~2 rpm, (b) there were no magnetometer data to permit pitch angle identification and binning, (c) particle data existed but were flagged as bad, or (d) particle data were not available. These orbits are listed in sections I (HEEF) and II (PROTEL). There is also an interval of orbits for which a subset of PROTEL channels are bad and should be avoided. These are also mentioned in section II.

The HEEF instrument is briefly described in section I, followed by a description of its '.min' (section IA) and '.pad' (section IB) files. The PROTEL instrument is briefly described in section II, followed by a description of its '.min' (section IIA) and '.pad' (section IIB) files.

I. High Energy Electron Fluxmeter (HEEF)

The HEEF electron telescope design includes two solid state detectors (SSDs),a bismuth germanate (BGO) crystal scintillator, and an anti-coincidence plastic scintillator surrounding the BGO crystal. Normal HEEF operation requires a triple coincidence between the two SSD's and the BGO, and an anti-coincidence with the plastic scintillator (to veto particles which exit the BGO without depositing all of their energy). Assuming a particle trajectory triggers the particle identification logic, the energy deposition signature (in the SSDs and BGO) will determine the particle specie (electron, proton) and energy.

For each SSD, two energy deposition windows (W1,W2) are defined by the energy thresholds S0, S1, and S2 (W1=S0-S1, W2=S0-S2). For the BGO crystal, there are 11 energy deposition thresholds which define 10 channel windows. Because of uncertainties in the lowest energy channel, that channel has been omitted from the database. An electron passing through HEEF which produces a pulse within a front SSD energy window (W1F or W2F), a back SSD window (W1B or W2B), and a BGO window, is assigned to the appropriate differential energy channel. A trajectory which deposits energy exceeding the thresholds in the front SSD (S1F or S2F) or the back SSD (S1B or S2B) can be used to determine an appropriate integral energy channel. In regions where there are no energetic protons, it is possible to use the (S1F-S2F) and (S1B-S2B) integral flux differences to provide two electron differential energy channels (0.65 and 0.95 MeV). A more detailed instrument description is provided by elsewhere [2]. The final set of mid-channel energies (MeV), determined following a temperature correction mentioned below, are as follows:

1 - 0.65	7 - 3.15	12 - >0.80 (S2F)	16 - >1.05 (S2B)
2 - 0.95	8 - 3.75	13 - >0.50 (S1F)	17 - >0.85 (S1B)
3 - 1.60	9 - 4.55	14 - >0.30 (W1F)	18 - >0.75 (W1B)
4 - 2.00	10 - 5.75	15 - >0.30 (W2F)	19 - >0.75 (W2B)
5 - 2.35	11 - 7.50		
6 - 2.75			

Channels 3-11 are directly measured differential energy channels [$(cm^2$ sec sr keV$)^{-1}$] and channels 12-19 are integral energy channels [$(cm^2$ sec sr$)^{-1}$]. Channels 1 and 2 are differential channels computed from integral channels (12,13) and (16,17), respectively. One note of caution: although the energies are given in MeV, the energy unit used in the differential flux is keV.

Though this telescope design led to a very "clean" measurement of electrons, the count rates were quite low (maximum of ~100/s for the lowest energy BGO channel, and < ~10/s for the higher energy channels), resulting in significant statistical scatter in the data (particularly notable in the pitch angle distributions for the higher energy channels during "quiet" periods).

Corrections applied to the HEEF data are briefly mentioned below (A detailed discussion is found in an AFRL technical report [3] available from AFRL upon request.) :

1. Temperature correction: There was an unanticipated requirement to shut off one of the heaters in the satellite compartment where HEEF was located, causing the temperature to drop from 2^o C to -12^o C over the course of the mission. Unfortunately, the BGO crystal response is strongly temperature dependent. Laboratory modeling was performed on a second 'backup' HEEF to determine the necessary temperature corrections (a factor up to ~50).

2. Dead-time corrections: Because of the finite temporal response of the system, the counting logic was 'paralyzed' under very intense (~100 keV) electron fluxes, requiring a correction factor up to ~10 (largest in the front SSD integral energy channels).

The data set is restricted to L >= 2.5 because fluxes within the inner belt are contaminated by energetic protons. The integral channels are unreliable within and below the slot region because of low count rates. The differential channels (0.65 MeV and 0.95 MeV) derived from the integral channels are undefined because they often compute to negative flux values.

The HEEF flux data have been cross-calibrated with CRRES dosimeter flux data. Fully corrected HEEF differential spectra were convolved with dosimeter geometric factors to predict dosimeter count rates which agreed with observed count rates to within a factor of 2 [3].

The following orbits are missing from the database:

ORBIT#	COMMENTS
001 - 014	Satellite spin decreasing
163 - 164	No Magnetometer data
231 - 236	Data flagged as bad
272	No Magnetometer data
366 - 409	No Magnetometer data
555	No HEEF data
842 - 843	No HEEF data

IA. HEEF one minute averaged pitch angle data files (*.min)

Input for creating this database is the raw data at 0.512 s time resolution. At 1-minute increments, the high resolution data is sorted and averaged into 5^o local pitch angle bins (19 bins ranging from 0^o to 90^o). The resulting average count rates are corrected for deadtime and temperature effects, and then converted to flux units. Each 1-minute record is tagged with two sets of 8 ephemeris values - the first set is associated with the beginning of the 1-minute interval, the second with the averaged UT.

There is one file per orbit, with the naming convention: 'd04xxxx.min'. The 'd04' refers to 'data(d) from the HEEF(04) instrument, and 'xxxx' is the orbit number ('0015' is orbit 15). The range of orbits is 15 to

1067. The '.min' extension designates the database type. The files are binary and were created as direct access files using a FORTRAN 77 compiler on a non-DEC UNIX machine (SGI) so the byte order in each word may need to be reversed if transporting to a DEC machine or a PC. The records are a fixed length of 2232 bytes. The last 2 bytes are zero filled. Some systems require that you define a record length in 4-byte words. This makes the record length compatible with 4-byte words. This is easily read with other program languages since there are no control words etc., added to the end of records or the file itself. The record structure is described below:

RECORD # 1 consists of a HEADER. The values in the header are as follows:

VALUE 1: ORBIT number - 4 byte integer (10-1067)
VALUE 2: YEAR number - 4 byte integer, should be 90 or 91
VALUE 3: DAY number - 4 byte integer, day of year at start of orbit (1-365)
VALUE 4: BSEC - 4 byte integer, UT at beginning of orbit file. (0-86399)
VALUE 5: ESEC - 4 byte integer, UT at end of orbit file . (1-~115000)
VALUE 6: IBR - 4 byte integer, Beginning Record of data (always 2)
VALUE 7: IER - 4 byte integer, Ending Record of data (approx. 500 for L >= 2.5)
VALUE 8-26: ENERGY - 4 byte REAL, 19 mid-channel energies (MeV)
VALUE 27-558: ZEROS, 532- 4 BYTE ZEROS

RECORD #IBR to #IER (defined in record 1 header above)

VALUE 1-8: 4 byte reals, Ephemeris at beginning of one-minute average.
VALUE 1: UT
VALUE 2: X km (ECI), ECI = Earth Centered Inertial coord. system
VALUE 3: Y km (ECI)
VALUE 4: Z km (ECI)
VALUE 5: SMLAT (Solar Magnetic Latitude)
VALUE 6: SMLT (Solar Magnetic Local Time)
VALUE 7: L-SHELL
VALUE 8: B/B0 - Model
VALUE 9-16: 4 byte reals, Ephemeris for average UT
VALUE 17-377: FLUX(19,19) 4 byte real, 19 channels by 19 pitch angles.
VALUE 17: FLUX(1,1)
VALUE 18: FLUX(2,1)
. . .
VALUE 377: FLUX(19,19)
VALUE 378-738: NOBS(19,19) 2 byte integer, Number of observations in the average FLUX
VALUE 739: DUMMY 2 byte integer

NOTES:

A. ECI = Earth Centered Inertial coord. system
B. Magnetic coordinates computed using IGRF85 + Olson-Pfitzer quiet static model (1974)
C. L-shell is the McIlwain L-parameter. The single value of L given here is computed for the case of locally mirroring particles (90^o at the spacecraft location).
D. If there is no data for the 1-minute interval, all the ephemeris values are set to -1.
E. The last record of every file (# IER) has no data. It provides ephemeris for the end of the one minute average for the previous record.
F. The pitch angle bins are: $1(0^o)$, $2(5^o)$ ... $19(90^o)$, where the angle is the middle of the pitch angle bin.
G. A FLUX value of ZERO is a valid FLUX if the corresponding NOBS value is greater than ZERO.

For further clarification, the following FORTRAN code is provided to create a listing of flux for each data record for a given channel. This should be a useful starting point for reading the files.

```
C  HEEF - One minute average sorted by local pitch angle
C  Input file = 'd04xxxx.min' ; Output file = 'd04xxxx.lis''

      PROGRAM READ_MIN

      REAL*4 EPHEMA(8),EPHEMB(8),FLUX(19,19),ENERGY(19)
      INTEGER*2 NOBF(19,19),IDUM
      INTEGER*4 IORBIT,IYEAR,IDAY,IBSEC,IESEC,IBR,IER
      CHARACTER*11 INFILE,OUTFILE
      DATA inFILE/'d04xxxx.min'/

      PRINT*,'ENTER ORBIT NUMBER:'
      READ(*,*)JORBIT
      PRINT*,'ENTER CHANNEL NUMBER:(1-19)'
      READ(*,*)ICH

      WRITE(INFILE(4:7),'(I4.4)')JORBIT
      OUTFILE=INFILE(1:8)//'lis'

      OPEN(1,FILE=inFILE,ACCESS='DIRECT',RECL=558,ERR=100)
      OPEN(2,FILE=OUTFILE)

C HEADER FILE
      READ(1,REC=1)IORBIT,IYEAR,IDAY,IBSEC,IESEC,IBR,IER,ENERGY

      WRITE(2,21) IYEAR,IDAY,ENERGY(ICH)
 21   FORMAT(' YEAR=',I4,' DAY=',I4,' ENERGY=',F5.2,' MEV')

      WRITE(2,22)IORBIT,IBSEC,IESEC,IER
 22   FORMAT(' ORBIT=',I4,' BSEC=',I6,' ESEC=',I6,' NO. RECORDS=',
     +        I4)

      DO 10 NREC=ibr,ier
       WRITE(2,*)
       READ(1,REC=NREC,ERR=100)EPHEMB,EPHEMA,FLUX,NOBF,IDUM
       WRITE(2,23)EPHEMB
 23    FORMAT(' BEG EPHEM. ',4F9.1,4F8.3)
       write(2,24)EPHEMA
 24    FORMAT(' AVE EPHEM. ',4F9.1,4F8.3)

       WRITE(2,25)
 25    FORMAT(/,' Pitch Angle   Flux      Obs')

       DO 20 IPA=1,19
        WRITE(2,26)IPA*5-5,FLUX(ICH,IPA),NOBF(ICH,IPA)
 20    CONTINUE

 26    FORMAT(I8,4X,E10.4,i8)

 10   CONTINUE

 100  CONTINUE
      END
```

IB. HEEF pitch angle dependent L-shell data files (*.pad)

Input for this data set is the 1-minute average database described in section IA which has been sorted into 5^o local pitch angle bins. For every 1-minute interval (with average UT and local spatial coordinates), the 19 pitch angles are assigned a McIlwain L from a previously generated look-up table. The L's in the look-up table were computed using a combined IGRF85 and Olson-Pfitzer quiet static magnetic field model [1]. The local pitch angle distribution is then mapped to the equator, assuming the conservation of the first adiabatic invariant, into 0.05 wide L bins. Data determined to be in the loss-cone are excluded. This procedure is applied to both leg one (first half of orbit) and leg two (second half of the orbit).

There is one file per orbit, with the naming convention: 'd04xxxx.pad'. The 'd04' refers to 'data(d) from the HEEF(04) instrument, and 'xxxx' is the orbit number ('0015' is orbit 15). The range of orbits is 15 to 1067. The '.pad' extension designates the database type. The files are binary and were created as direct access files using a FORTRAN 77 compiler on a non-DEC UNIX machine (SGI) so the byte order in each word may need to be reversed if transporting to a DEC machine or a PC. The records are a fixed length of 2176 bytes. The last 2 bytes are zero filled. Some systems require that you define a record length in 4-byte words. This makes the record length compatible with 4-byte words. This format is easily read with other program languages since there are no control words, etc., added to the end of records or the file itself. The record structure is described below:

RECORD # 1 consists of a HEADER. The values in the header are as follows:
- VALUE 1: ORBIT number - 4-byte integer (15-1067)
- VALUE 2: YEAR number - 4-byte integer, should be 90 or 91
- VALUE 3: DAY number - 4-byte integer, day of year at start of orbit (1-365)
- VALUE 4: NREC - 4-byte integer, number of data records after the header record, (<260)
- VALUE 5: MAXBIN - 4-byte integer, MAXBIN*.05+2.45 = Max L-shell
- VALUE 6-24: ENERGY - 4-byte REAL, 19 mid-channel energies (MeV)
- VALUE 25-544: ZEROS, 520- 4-BYTE ZEROS.

RECORD # 2 to NREC+1.
- VALUE 1: LEG number - 2-byte integer, 1 for first half of orbit, 2 for second half of orbit.
- VALUE 2: LSH number - 2-byte integer, represents the beginning of the 1/20th of an L-shell bin.
  L-shell=LSH*.05+2.45
- VALUE 3: KSEC - 4 byte integer, nearest value of average UT in the LSH bin for that LEG.
- VALUE 4-364: FLUX(19,19) - 4-byte real, 19 channels by 19 pitch angles.
- VALUE 4: FLUX(1,1)
- VALUE 5: FLUX(2,1)
- . . .
- VALUE 364: FLUX(19,19)
- VALUE 365-725: NOBS(19,19) 2-byte integer, Number of observations in the average FLUX
- VALUE 726: DUMMY 2-byte integer

NOTES:

A. UT is from beginning day of orbit, so that if there is a cross-over from one day to the next within a given orbit, KSEC will exceed the total number of seconds in a day (86400). That is, the full range of KSEC can be 0 - ~115,000.

B. If there is no data for the 1-minute interval, all the ephemeris values are set to -1.

C. The pitch angle bins are: $1(0^o)$, $2(5^o)$ ... $19(90^o)$, where the angle is the middle of the pitch angle bin.

D. A FLUX value of ZERO is a valid FLUX if the corresponding NOBS value is greater than ZERO.

For further clarification, the following FORTRAN code is provided to create a listing of flux for each data record for a given channel. This should be a useful starting point for reading the files.

```
C  HEEF - One minute average sorted by pitch angle dependent L (derived from *.min files).
C Input file = 'd04xxxx.pad' ; Output file = 'fort.2"
      PROGRAM READ_PAD
      INTEGER*2 NOBF(19,19),KLEG,KSH
      INTEGER*4 IORBIT,ICH,JORBIT,IYEAR,IDAY,NREC,MAXBIN,KSEC
      REAL*4 ENERGY(19),FLUX(19,19)
      CHARACTER*11 INFILE
      DATA INFILE/'d04xxxx.pad'/

      iorbit=600
      ich=5
C
C ORBIT 600 AND CHANNEL=5 ARE HARDWIRED
C
      write(infile(4:7),'(i4.4)')iorbit
C
C NOTE THAT THE RECORD LENGTH IS DEFINED IN 4-BYTE WORDS, I'VE USED
C OTHER UNIX SYSTEMS THAT NEED TO BE IN BYTES.
C
      OPEN(1,FILE=inFILE,ACCESS='DIRECT',RECL=544,ERR=100)

C HEADER

      READ(1,REC=1,err=100)JORBIT,iyear,iday,nrec,maxbin,ENERGY

      WRITE(2,22)JORBIT,IYEAR,IDAY,ENERGY(ICH)
 22   FORMAT(/,' ORBIT=',I4,' YEAR=',I2,' DAY=',I3,' MeV=',F6.2)

      DO 10 iREC=2,nrec+1
       READ(1,REC=iREC,ERR=100)kleg,ksh,ksec,FLUX,NOBF
       SH=KSH*.05+2.45
       WRITE(2,23)KLEG,SH,KSEC
 23    FORMAT(/,' LEG=',I2,' L-SHELL=',F5.2,' UT=',I7,/)
       WRITE(2,24)
 24    FORMAT(' PITCH ANGLE    FLUX   OBS')
       DO 20 IPA=1,19
         WRITE(2,25)IPA*5-5,FLUX(ICH,IPA),NOBF(ICH,IPA)
 25      FORMAT(I8,E13.4,I6)
 20    CONTINUE

 10   CONTINUE

 100  CONTINUE

      END
```

II. Proton Telescope (PROTEL)

The Proton Telescope (PROTEL) was designed to make well calibrated, high resolution measurements of high energy protons from the heart of the inner belts out to geosynchronous altitudes. PROTEL has two detector heads which combine to measure the differential flux [cm^2sec sr MeV$)^{-1}$] spectrum of protons from 1 to 100 MeV in 24 channels with the following mid-channel energies (MeV) :

1 - 1.5	9 - 6.8	17 - 26.3
2 - 2.1	10 - 8.5	18 - 30.9
3 - 2.5	11 - 9.7	19 - 36.3
4 - 2.9	12 - 10.7	20 - 42.3
5 - 3.6	13 - 13.2	21 - 47.5
6 - 4.3	14 - 15.2	22 - 57.0
7 - 5.7	15 - 16.9	23 - 67.5
8 - 8.4	16 - 19.4	24 - 82.9

The low energy head (LEH) has channels 1-8 and covers a range of 1 - 9 Mev. The high energy head (HEH) has the remaining channels 9-24 and covers a range of 6 - 100 Mev. Channel 8 (the highest energy in the LEH) may be ignored because of its overlap of channels 9 and 10 of the HEH. This avoids any discontinuity in the display of the spectra or complicated integration. Channel 14 has been determined to have a significantly lower sensitivity than the other channels and as a result has been left out of any calculations in the PROTEL flux models (CRRESPRO) [4]. The instrument contains silicon solid state detector arrays with both anti-coincidence and multiple coincidence requirements to reduce contamination. A more detailed description of the instrument's proton detection scheme has been published elsewhere [5].

PROTEL showed no response to electrons, including the >10 MeV electrons found in the slot region following the March 1991 storm. However, in calibration measurements made prior to flight, and in computer simulations of the detector, it was found that >100 MeV protons could enter the telescope off-axis and be counted as lower-energy protons. This contamination is important in regions where >100 MeV protons greatly exceed the flux of lower-energy protons, namely, for L < 1.7 at pitch angles near the loss cone. For L < 1.4 the correction can be comparable to or greater than the residual value, and these data should be used with caution. A description of the loss cone subtraction (made on the *.pad files, but not the *.min files) may be found in the literature [4].

The following orbits are missing from the database:

ORBIT#	COMMENTS
001 - 014	Satellite spin decreasing
026	Bad time tag in PROTEL THDB
163 - 164	No Magnetometer data
272	No Magnetometer data
351	No PROTEL data
366 - 409	No Magnetometer data

For orbits 231-255, the LEH (channels 1-8) was operated in a mode that resulted in bad flux data. The channels have been included to maintain the data structure, but they should be excluded from any study.

IIA. PROTEL one minute averaged pitch angle data files (*.min)

Input for creating this database is the raw data at 1.024 s time resolution. At 1-minute increments, the high resolution data is sorted and averaged into 5^{o} local pitch angle bins (19 bins ranging from 0^{o} to 90^{o}). Spike removal is implemented by passing through the data a second time, throwing out individual count rates within each 1-minute interval which were outside a +/- 3 sigma window for that minute's average value. The resulting average count rates are converted to flux units. Each 1-minute record is tagged with two sets of 8 ephemeris values - the first set is corresponds to the beginning of the 1-minute interval, the second with the interval's average UT. The loss cone subtraction described in section II is not applied to this database of local pitch angle distributions; it is used only for the equatorial pitch angle distribution database described in section IIB.

There is one file per orbit, with the naming convention: 'd08xxxx.min'. The 'd08' refers to 'data(d) from the PROTEL(08) instrument, and 'xxxx' is the orbit number ('0015' is orbit 15). The range of orbits is 15 to 1067. The '.min' extension designates the database type. The files are binary and were created as direct access files using a FORTRAN 77 compiler on a non-DEC UNIX machine (SGI) so the byte order in each word may need to be reversed if transporting to a DEC machine or a PC. The records are a fixed length of 2800 bytes. This is easily read with other program languages since there are control words etc., added to the end of records or the file itself. The record structure is described below:

RECORD # 1 consists of a HEADER. The values in the header are as follows:

VALUE 1: ORBIT number - 4 byte integer (10-1067)
VALUE 2: YEAR number - 4 byte integer, should be 90 or 91
VALUE 3: DAY number - 4 byte integer, day of year at start of orbit (1-365)
VALUE 4: BSEC - 4 byte integer, UT at beginning of orbit. (0-86399)
VALUE 5: ESEC - 4 byte integer, UT at end of orbit. (1-~115000)
VALUE 6: IBR - 4 byte integer, Beginning Record of data (always 2)
VALUE 7: IER - 4 byte integer, Ending Record of data (approx. 595-625)
VALUE 8-31: ENERGY - 4 byte REAL, 24 mid-channel energies (MeV)
VALUE 32-700: ZEROS, 669 - 4 BYTE ZEROS

RECORD #IBR to #IER (defined in record 1 header above)

VALUE 1-8: 4 byte reals, Ephemeris at beginning of one-minute average.
VALUE 1: UT
VALUE 2: X km (ECI), ECI = Earth Centered Inertial coord. system
VALUE 3: Y km (ECI)
VALUE 4: Z km (ECI)
VALUE 5: SMLAT (Solar Magnetic Latitude)
VALUE 6: SMLT (Solar Magnetic Local Time)
VALUE 7: L-SHELL
VALUE 8: B/B0 - Model
VALUE 9-16: 4 byte reals, Ephemeris for average UT
VALUE 17-472: FLUX(24,19) 4 byte real, 24 channels by 19 pitch angles.
VALUE 17: FLUX(1,1)
VALUE 18: FLUX(2,1)
. . .
VALUE 472: FLUX(24,19)
VALUE 473-928: NOBS(24,19) 2 byte integer, Number of observations in the average FLUX
VALUE 739: DUMMY 2 byte integer

NOTES:

A. ECI = Earth Centered Inertial coord. system
B. Magnetic coordinates computed using IGRF85 + Olson-Pfitzer quiet static model (1974)
C. L-shell is the McIlwain L-parameter. The single value of L given here is computed for the case of locally mirroring particles (90^o at the spacecraft location).
D. If there is no data for the 1-minute interval, all the ephemeris values are set to -1.
E. The last record of every file (# IER) has no data. It provides ephemeris for the end of the one minute average for the previous record.
F. The pitch angle bins are: $1(0^o)$, $2(5^o)$ ... $19(90^o)$, where the angle is the middle of the pitch angle bin.
G. A FLUX value of ZERO is a valid FLUX if the corresponding NOBS value is greater than ZERO.

For further clarification, the following FORTRAN code is provided to create a listing of flux for each data record for a given channel. This should be a useful starting point for reading the files.

```
C  PROTEL - One minute average sorted by local pitch angle
C Input file = 'd08xxxx.min' ; Output file = 'd08xxxx.lis"
C
      PROGRAM READ_MIN
      REAL*4 EPHEMA(8),EPHEMB(8),FLUX(24,19),ENERGY(24)
      INTEGER*2 NOBF(24,19)
      INTEGER*4 IORBIT,IYEAR,IDAY,IBSEC,IESEC,IBR,IER
      CHARACTER*11 INFILE,OUTFILE
      DATA inFILE/'d08xxxx.min'/

      PRINT*,'ENTER ORBIT NUMBER:'
      READ(*,*)JORBIT
      PRINT*,'ENTER CHANNEL NUMBER:(1-24)'
      READ(*,*)ICH

      WRITE(INFILE(4:7),'(I4.4)')JORBIT
      OUTFILE=INFILE(1:8)//'lis'

      OPEN(1,FILE=inFILE,ACCESS='DIRECT',RECL=700,ERR=100)
      OPEN(2,FILE=OUTFILE)

C HEADER FILE
      READ(1,REC=1)IORBIT,IYEAR,IDAY,IBSEC,IESEC,IBR,IER,ENERGY

      WRITE(2,21) IYEAR,IDAY,ENERGY(ICH)
 21   FORMAT(' YEAR=',I4,' DAY=',I4,' ENERGY=',F5.2,' MEV')

      WRITE(2,22)IORBIT,IBSEC,IESEC,IER
 22   FORMAT(' ORBIT=',I4,' BSEC=',I6,' ESEC=',I6,' NO. RECORDS=',
     +        I4)

      DO 10 NREC=ibr,ier
       WRITE(2,*)
       READ(1,REC=NREC,ERR=100)EPHEMB,EPHEMA,FLUX,NOBF
       WRITE(2,23)EPHEMB
 23    FORMAT(' BEG EPHEM. ',4F9.1,4F8.3)
       write(2,24)EPHEMA
 24    FORMAT(' AVE EPHEM. ',4F9.1,4F8.3)

       WRITE(2,25)
 25    FORMAT(/,' Pitch Angle   Flux      Obs')

       DO 20 IPA=1,19
        WRITE(2,26)IPA*5-5,FLUX(ICH,IPA),NOBF(ICH,IPA)
 20    CONTINUE
 26    FORMAT(I8,4X,E10.4,i8)

 10   CONTINUE

 100  CONTINUE

      END
```

IIB. PROTEL pitch angle dependent L-shell data files (*.pad)

Input for this data set is the 1-minute average database described in section IIA which has been sorted into 5^{o} local pitch angle bins. For every 1-minute interval (with average UT and local spatial coordinates), the 19 pitch angles are assigned a McIlwain L from a previously generated look-up table. The L's in the look-up table were computed using a combined IGRF85 and Olson-Pfitzer quiet static magnetic field model [1]. The local pitch angle distribution is then mapped to the equator, assuming the conservation of the first adiabatic invariant, into 0.05 wide L bins. The loss cone subtraction mentioned in section II is performed on the equatorial pitch angle distribution. This equatorial mapping procedure is applied to both leg one (first half of orbit) and leg two (second half of the orbit).

There is one file per orbit, with the naming convention: 'd08xxxx.pad'. The 'd08' refers to 'data(d) from the PROTEL(08) instrument, and 'xxxx' is the orbit number ('0015' is orbit 15). The range of orbits is 15 to 1067. The '.pad' extension designates the database type. The files are binary and were created as direct access files using a FORTRAN 77 compiler on a non-DEC UNIX machine (SGI) so the byte order in each word may need to be reversed if transporting to a DEC machine or a PC. The records are a fixed length of 2744 bytes. This format is easily read with other program languages since there are no control words, etc., added to the end of records or the file itself. The record structure is described below:

RECORD # 1 consists of a HEADER. The values in the header are as follows:

- VALUE 1: ORBIT number - 4-byte integer (15-1067)
- VALUE 2: YEAR number - 4-byte integer, should be 90 or 91
- VALUE 3: DAY number - 4-byte integer, day of year at start of orbit (1-365)
- VALUE 4: NREC - 4-byte integer, number of data records after the header record, (<320)
- VALUE 5: MAXBIN - 4-byte integer, MAXBIN*.05+.95 = Max L-shell
- VALUE 6-29: ENERGY - 4-byte REAL, 24 mid-channel energies (MeV)
- VALUE 30-686: ZEROS, 657 4-BYTE ZEROS.

RECORD # 2 to NREC+1.

- VALUE 1: LEG number - 2-byte integer, 1 for first half of orbit, 2 for second half of orbit.
- VALUE 2: LSH number - 2-byte integer, represents the beginning of the 1/20th of an L-shell bin.
- VALUE 3: KSEC - 4 byte integer, nearest value of average UT in the LSH bin for that LEG.
- VALUE 4-459: FLUX(24,19) - 4-byte real, 24 channels by 19 pitch angles.
- VALUE 4: FLUX(1,1)
- VALUE 5: FLUX(2,1)
- . .
- VALUE 459: FLUX(24,19)
- VALUE 460-915: NOBS(24,19) 2-byte integer, Number of observations in the average FLUX

NOTES:

A. UT is from beginning day of orbit, so that if there is a cross-over from one day to the next within a given orbit, KSEC will exceed the total number of seconds in a day (86400). That is, the full range of KSEC can be 0 - ~115,000.

B. The pitch angle bins are: 1(0^{o}), 2(5^{o}) ... 19(90^{o}), where the angle is the middle of the pitch angle bin.

C.FLUX channels 1-24 are differential flux [(cm^{2} sec sr MeV)$^{-1}$].

D. A FLUX value of ZERO is a valid FLUX if the corresponding NOBS value is greater than ZERO.

For further clarification, the following FORTRAN code is provided to create a listing of flux for each data record for a given channel.   This should be a useful starting point for reading the files.

```
C Input file = 'd08xxxx.pad' ; Output file = 'fort.2'
C  PROTEL - One minute average sorted by pitch angle dependent L (derived from *.min files)
C
      PROGRAM READ_PAD
      INTEGER*2 NOBF(24,19),KLEG,KSH
      INTEGER*4 IORBIT,ICH,JORBIT,IYEAR,IDAY,NREC,MAXBIN,KSEC
      REAL*4 ENERGY(24),FLUX(24,19)
      CHARACTER*11 INFILE
      DATA INFILE/'d08xxxx.pad'/

      iorbit=600
      ich=5
C
C ORBIT 600 AND CHANNEL=5 ARE HARDWIRED
C
      write(infile(4:7),'(i4.4)')iorbit
C
C NOTE THAT THE RECORD LENGTH IS DEFINED IN 4-BYTE WORDS, I'VE USED
C OTHER UNIX SYSTEMS THAT NEED TO BE IN BYTES.
C
      OPEN(1,FILE=inFILE,ACCESS='DIRECT',RECL=686,ERR=100)

C HEADER

      READ(1,REC=1,err=100)JORBIT,iyear,iday,nrec,maxbin,ENERGY

      WRITE(2,22)JORBIT,IYEAR,IDAY,ENERGY(ICH)
 22   FORMAT(/,' ORBIT=',I4,' YEAR=',I2,' DAY=',I3,' MeV=',F6.2)

      DO 10 iREC=2,nrec+1
       READ(1,REC=iREC,ERR=100)kleg,ksh,ksec,FLUX,NOBF
       SH=KSH*.05+.95
       WRITE(2,23)KLEG,SH,KSEC
 23    FORMAT(/,' LEG=',I2,' L-SHELL=',F5.2,' UT=',I7,/)
       WRITE(2,24)
 24    FORMAT(' PITCH ANGLE    FLUX   OBS')
       DO 20 IPA=1,19
         WRITE(2,25)IPA*5-5,FLUX(ICH,IPA),NOBF(ICH,IPA)
 25      FORMAT(I8,E13.4,I6)
 20    CONTINUE

 10   CONTINUE

 100  CONTINUE

      END
```

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