APPENDIX B

PRINTOUT OF MPM-N PROGRAM FOR VERSION A
(Frequency Profiles)

The computer program MPM-N is written in FORTRAN 77 with extensive comments to run on IBM-XT/AT + 8087/80287 coprocessor, or equivalent, microcomputers.

Program MPM-N is available on 5 1/4" diskettes, either in double (360 kbyte) or quadruple (1.2 Mbyte) density. Requests may be addressed to NTIA/ITS.S3, 325 Broadway, Boulder, CO 80303-3328 (ATTN: Dr. H. Liebe). Please provide the necessary disks.

ID for FORTRAN 77 (IBM Professional 8-bit compiler) version (disk No. 1):

MPM1	FOR	45675	7-16-87	-N/A Frequency Profiles
MPM2	FOR	29762	7-08-87	-N/B Humidity Profiles
MPM3	FOR	24564	6-11-87	-N/C Pressure Profiles
OXYGEN	DAT	3267	7-13-87	Line Data
WATER	DAT	1166	10-23-86	Tables
5 File(s)		254976 bytes free		

ID for EXECUTABLE version (disk No. 2):

MPM1	EXE	354565	7-08-87	-N/A Frequency Profiles
OXYGEN	DAT	3267	7-13-87	Line Data
WATER	DAT	1166	10-23-86	Tables
3 File(s)		1024 bytes free		

The executable code length for MPM2 and 3 is 402 and 356 kbyte, respectively.

```
C       PROGRAM MPM-N
C       AUGUST 1987
C-----------------------------------------------------------------------
C       COMPLEX RADIO REFRACTIVITY OF ATMOSPHERIC AIR (1 TO 1000 GHz).
C       Hans J. Liebe
C       Institute for Telecommunication Sciences
C       NTIA/ITS.S3
C       325 BROADWAY
C       Boulder, CO  80303
C
C       Adapted for IBM-PC Professional FORTRAN  by:
C               John Stricklen   (1-303-497-3195, FTS 320-3195)
C
C       Contents:
C       A. FREQUENCY PROFILES
C       B. HUMIDITY  PROFILES
C       C. PRESSURES PROFILES OF MOIST AIR
C-----------------------------------------------------------------------
C                       A. FREQUENCY PROFILES
C-----------------------------------------------------------------------
C  Program MPM-N/A calculates frequency profiles of the complex radio
C  refractivity N of ATMOSPHERIC AIR over a frequency range f=1 to
C  1000 GHz. The output is expressed in Real part of N and
C  Imaginary part of N and specific rates of power attenuation A
C  (Im. of N) and propagation delay B (Re. of N).
C
C                         OUTPUT:
C        *  Real part of refractivity        N' (f)  in   ppm
C        *  Imaginary part of refractivity   N''(f)  in   ppm
C        *  Nondispersive Refractivity       No      in   ppm
C  or
C        *  Attenuation                      A(f)    in   dB/km
C        *  Dispersive Delay                 B(f)    in   ps/km
C        *  Refractive Delay                 Bo      in   ps/km
C
C
C  Frequency range, moist air, rain conditions (specified by five
C  meterological variables P=p+e, T, RH, wA or w, RR), and haze model
C  code (A, B, C, or D) are the required input information to be
C  entered from the keyboard.
C
C                         INPUT:                          Valid Range:
C        *  Frequency range     f1, f2    in GHz          1 to 1000
C             and step size        df     in GHz          >= 1.E-05
C                                                         (max. 500 freqs.)
C        *  Barometric pressure    P       in kPa         0.0  to 120
C        *  Temperature            T       in  C          -50 to 50
C        *  Relative humidity      RH      in  %          0 to 100
C            [absolute humidity is calculated as v(RH,T) in g/m3
C                                             or e(RH,T) in kPa.]
C
C        *  Haze model (RH = 80 to 99.9%):
C            code A(rural), B(urban), C(maritime), and D(C +strong wind)
C            plus hygroscopic aerosol reference
C            concentration      wA(80%RH) in mg/m3     0 to 1
C        *  Suspended water droplet
C            concentration         w      in g/m3      0 to 10
C        *  Rain Rate             RR      in mm/hr     0 to 200
C
C  COMMENTS:
C  The computation of attenuation A and delay B is described in
C  References [1] to [3].
C
C  MOLECULAR effects due to oxygen, nitrogen, and water vapor
C  are considered as detailed in [1].
C
C  This MPM version has been corrected for typesetting errors in [1]
C  and revised to include:
C  (a) an improved water vapor continuum spectrum and a haze model
C      reported in [2];
C  (b) an improved model for liquid water dielectric properties and
C      RAYLEIGH absorption and phase delay by suspended water droplets
C      (radii < 50 microns) such as haze, fog, and clouds [3];
C  (c) a rain attenuation model by Olsen, et.al. [4], as well as
C      dispersive delay due to rain approximated from results reported by
C      Zuffery [5];
C  (d) new line data for the 183 GHz water vapor line [6];
C  (e) a VW shape cutoff, setting F"=0 for f > (vo +40 x widths)  [7];
C  (f) a new set of overlap correction coefficients A5 [8];
C  (g) an improved water vapor saturation pressure equation based on
C      degrees Celsius [9] (see comments in program);
C  (h) an approximation for Zeeman (O2) and Doppler (H2O) line broadening [10].
C
C    REFERENCES:  [1] H.J. Liebe,"An updated model for millimeter wave
C                     propagation in moist air", Radio Science, vol. 20
C                     no. 5, pp. 1069-1089, 1985.
C
C                 [2] H.J. Liebe,"A contribution to modeling atmospheric
C                     mm-wave properties", FREQUENZ (J. Telecom.), vol.
C                     41 , no. 1/2, pp. 31-36, 1987.
C
C                 [3] H.J. Liebe, T. Manabe, and J.P. Stricklen,
C                     "Millimeter-wave attenuation and delay for a fog event",
C                     IEEE Digest: 12th Int. Conf. Infrared and Millimeter
C                     Waves, Orlando, FL, December, 1987.
C
C                 [4] R. L. Olsen, D. V. Rogers, and D. B. Hodge,
C                     "The aRb relation in the calculation of rain
C                     attenuation", IEEE Trans. Ant. Prop., vol. AP-26,
C                     no. 2, pp. 318-329, 1978.
C
C                 [5] C.H. Zuffery, "A study of rain effects on EM waves
C                     in the 1-600 GHz range", MS-THesis, Dept.
C                     Electrical Eng., University of Colorado, Boulder,
C                     CO 80309, Feb., 1972.
C
C                 [6] A. Bauer, M. Godon, and B. Duterage, "Self- and
C                     air-broadened linewidth of the 183 GHz absorption
C                     in water vapor", J. Quant. Spectrosc. Radiat.
C                     Transf., vol. 32, no. 2, pp. 167-175, 1985.
C
C                 [7] R. J. Hill, "Absorption by the tails of the oxygen
C                     microwave resonances at atmospheric pressures", IEEE
C                     Trans. AP-35, no.2, pp. 198-204, 1987.
C
C                 [8] P. W. Rosenkranz, "Interference coefficients for
C                     overlapping oxygen lines in air", J. Quant. Spectr.
C                     Rad. Transf., in review, 1987.
C
C                 [9] W. Boegel, "Neue Naeherungsgleichungen fuer den
C                     Saettigungsdruck des Wasserdampfes, DFVLR Bericht
C                     DLR-FB 77-52, 1977.
C
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C
C               [10] H. J. Liebe and G. B. Gimmestad, "Calculation of
C                    clear air EHF refractivity", Radio Sci., vol. 13,
C                    no. 2, pp. 245-251, 1978.
C-----------------------------------------------------------------------
C
C******* LIST OF VARIABLES *********
C
C       FMIN    Minimum Frequency
C       FMAX    Maximum frequency
C       STEP    Step Size between frequencies.
C       NF      No. of frequencies.
C       NCASE   No. of cases.
C       PBT(10) Pressures
C       TCT(10) Temperatures.
C       RHT(10) Rel. Humidities
C       WT(10)  Droplet concentrations.
C       RR(10)  Rain Rate
C       HZ(10) Haze growth models.
C***********************************************************************
C       MAIN PROGRAM
C***********************************************************************
C
        COMMON /AIR/ NCASE,PBT(10),TCT(10),RHT(10),WT(10),R(10)
        COMMON /FREQS/ FMIN,FMAX,STEP,NF
        COMMON /RAIN/ RR(10),WA(10)
        COMMON /ANS1/ D(12,501,10),ATT(501,10),DISP(501,10)
        COMMON /ANS/ FREQA(501),No(10),Bo(10),EV(10)
        COMMON /O2line/ FOO2(48),A(6,48)
        COMMON /H2O/ F0water(30),B(3,30)
        COMMON /HAZE/ HZ(10)
        CHARACTER*1 HZ
C
C***********************************************************************
C
        WRITE(*,1101)
1101    FORMAT(//////////)
        WRITE(*,2)
2       FORMAT(80(1H*),/,5X,' Executing PARAMETRIC ATTENUATION and ',
     + 'DISPERSIVE DELAY Program',/,80(1H*))
        WRITE(*,4)
4       FORMAT(///)
C
C ****** INITIALIZE ALL DATA VALUES ***************
C
C         OXYGEN LINE DATA
        CALL OXYDA1
C         WATER VAPOR LINE DATA
        CALL VAPDA1
        NCASE=1
        FMIN=10.
        FMAX=100.
        STEP=10.
C  STANDARD SEA LEVEL CONDITIONS FOR PRESSURE, TEMP., AND HUMIDITY
        DO 3 I=1,10
        PBT(I)=101.3
        TCT(I)=15.0
        RHT(I)=50.
        HZ(I)=' '
3       CONTINUE
C
C*****************************************************
C
10      CALL MENU(IMENU)
        IF (IMENU.EQ.1) THEN
          CALL INSTR
        ELSE IF (IMENU.EQ.2) THEN
          CALL EDITSUMM(1)
        ELSE IF (IMENU.EQ.3) THEN
          CALL SAVETABL(2)
        ELSE IF (IMENU.EQ.4) THEN
          CALL COMPUTE(NCASE)
        ELSE IF (IMENU.EQ.5) THEN
          CALL SAVETABL(0)
        ELSE IF (IMENU.EQ.6) THEN
          CALL SAVETABL(1)
        ELSE IF (IMENU.EQ.7) THEN
          WRITE(*,*)'Quitting Program... Normal termination.'
        GOTO 20
        ELSE
          WRITE(*,*)'NOT a valid menu option.'
        ENDIF
        GOTO 10
20      STOP
        END
C-----------------------------------------------------------------------
        SUBROUTINE INSTR
        WRITE(*,1)
1       FORMAT(///)
        WRITE(*,*)'The menu options are:'
        WRITE(*,*)'1)  Instructions'
        WRITE(*,*)'2)  Edit Data'
        WRITE(*,*)'3)  Summary of current data'
        WRITE(*,*)'4)  Process Data'
        WRITE(*,*)'5)  Print Results'
        WRITE(*,*)'6)  Save results to Disk'
        WRITE(*,*)'7)  Quit'
        WRITE(*,*)
        WRITE(*,*)'1)  You have found the instruction set.'
        WRITE(*,*)
        WRITE(*,*)'2)  The input data includes the frequency range and'
        WRITE(*,*)'    step, the parameter that you wish to vary, the'
        WRITE(*,*)'    number of cases and the values of pressure,'
        WRITE(*,*)'    temperature, relative humidity, and rain rate.'
        WRITE(*,*)'    For RH = 80 to 99.9%, a haze model predicts for'
        WRITE(*,*)'    four cases (A=rural, B=urban, C=maritime, and'
        WRITE(*,*)'    D=C+strong wind) the shrinking and swelling by'
        WRITE(*,*)'    hygroscopic aersol concentrations specified at'
        WRITE(*,*)'    80% RH.  At 100% RH a suspended water droplet'
        WRITE(*,*)'    concentration can be added to simulate fog or'
        WRITE(*,*)'    cloud conditions.'
        WRITE(*,*)
        WRITE(*,*)'    The value that appears in parentheses () is the'
        WRITE(*,*)'    default value and will be used if you simply '
        WRITE(*,*)'    press the RETURN key.  To enter a new value'
        WRITE(*,*)'    type the value and press the RETURN key.'
        WRITE(*,*)
        WRITE(*,*)'    The computer will ask you which parameter you'
```

```
      WRITE(*,*)'    wish to vary and you should type P, R, or T'
      WRITE(*,*)'    for Pressure, Relative humidity, or Temperature'
      WRITE(*,*)'    respectively.  The other two parameters will'
      WRITE(*,*)'    be fixed at the same value for every case'
      WRITE(*,*)'    and you will be prompted for these values.'
      WRITE(*,*)'    You will then be prompted for a value of your'
      WRITE(*,*)'    selected parameter for each separate case.'
      WRITE(*,*)'    For every case in which the relative humidity'
      WRITE(*,*)'    is 100% you will be prompted to enter a value'
      WRITE(*,*)'    for the suspended droplet concentration, and '
      WRITE(*,*)'    for cases in which the humidity is above 80%'
      WRITE(*,*)'    you will be asked for a hygroscopic aerosol'
      WRITE(*,*)'    content at 80%.  This is used to calculate the'
      WRITE(*,*)'    water droplet content using the haze growth'
      WRITE(*,*)'    model of [2].'
      WRITE(*,*)
      WRITE(*,*)'    The units on the parameters are:'
      WRITE(*,*)'    Pressure in kPa.  '
      WRITE(*,*)'    Relative Humidity in %'
      WRITE(*,*)'    Temperature in degrees C'
      WRITE(*,*)'    Water Droplet concentration in grams/meter'
      WRITE(*,*)'    cubed'
      WRITE(*,*)'    Rain rate in millimeters per hour'
      WRITE(*,*)'    These are given in the prompt'
      WRITE(*,*)
      WRITE(*,*)'3)  This gives a summary of all the current input'
      WRITE(*,*)'    data.  It is a good idea to request a summary'
      WRITE(*,*)'    after you edit the data to make sure that all'
      WRITE(*,*)'    of the decimals are in the right place etc.'
      WRITE(*,*)
      WRITE(*,*)'4)  This option causes the data to be used to '
      WRITE(*,*)'    generate a table of attenuation and dispersion.'
      WRITE(*,*)'    This must be done every time you change the '
      WRITE(*,*)'    data to update the table.'
      WRITE(*,*)
      WRITE(*,*)'5)  The table of attenuation and dispersion will be'
      WRITE(*,*)'    printed to the console.  To make a hard copy you'
      WRITE(*,*)'    may use the CTRL-PRTSC key or to make a disk'
      WRITE(*,*)'    file you can use the menu option given next'
      WRITE(*,*)'    and print the file.  The output is in tabular'
      WRITE(*,*)'    form with the components of the total'
      WRITE(*,*)'    attenuation and dispersion shown in two lines'
      WRITE(*,*)'    with the attenuation above the dispersion.'
      WRITE(*,*)
      WRITE(*,*)'6)  This saves the results to a file you specify.'
      WRITE(*,*)
      WRITE(*,*)'7)  This stops program execution.'
      WRITE(*,1)
      RETURN
      END
C-------------------------------------------------------------------------


C-------------------------------------------------------------------------
      SUBROUTINE MENU(IMENU)
C
      CHARACTER*1 IVAL
      WRITE(*,1)
1     FORMAT(' Enter the number of the option you wish to choose.,'/,
     +         /,'   1 - Instructions',
     +         /,'   2 - Edit Data',
     +         /,'   3 - Summary of current data',
     +         /,'   4 - Process Data',
     +         /,'   5 - Print Results ',
     +         /,'   6 - Save output to Disk file',
     +         /,'   7 - Quit',//)
C
100   WRITE(*,2)
2     FORMAT(' OPTION ? ')
      READ(*,3) IVAL
3     FORMAT(A1)
      IF((IVAL.EQ.'1').OR.(IVAL.EQ.'2').OR.(IVAL.EQ.'3').OR.
     + (IVAL.EQ.'4').OR.(IVAL.EQ.'5').OR.(IVAL.EQ.'6').OR.(IVAL.EQ.'7'))
     + THEN
      READ(IVAL,4,ERR=100) IMENU
4     FORMAT(I1)
      ELSE
      WRITE(*,*)'Invalid option.'
      GOTO 100
      ENDIF
      RETURN
      END
C-------------------------------------------------------------------------
      SUBROUTINE EDITSUMM(IFLAG)
C  THIS ROUTINE PRINTS SUMMARY AND/OR EDITS THE DATA.
C
C  IFLAG=1 IS FOR EDIT MODE--ANYTHING ELSE IS A SUMMARY.
C  NFLAG IS INDEX FOR PARAMETER VARIATION
C
      COMMON /AIR/ NCASE,PBT(10),TCT(10),RHT(10),WT(10),R(10)
      COMMON /FREQS/ FMIN,FMAX,STEP,NF
      COMMON /RAIN/ RR(10),WA(10)
      COMMON /HAZE/ HZ(10)
      CHARACTER*1 HZ
      CHARACTER*8 IVAL
C**************************************************
C
10    FORMAT(A8)
C
C  ZERO OUT THE DROPLET CONCENTRATIONS
      IF(IFLAG.EQ.1) THEN
      DO 100 I=1,10
      WT(I)=0.0
      HZ(I)=' '
100   CONTINUE
      ENDIF
200   CONTINUE
C  ******  FREQUENCY DATA  **********************
300   WRITE(*,4) FMIN
4     FORMAT(' Minimum Frequency, GHz (',F7.2,') ')
      IF(IFLAG.EQ.1)THEN
        READ(*,10) IVAL
        IF(IVAL.EQ.' ')THEN
        GOTO 400
        ELSE
        READ(IVAL,8,ERR=300) FMIN
8        FORMAT(F8.0)
        ENDIF
C  CHECK FOR VALID RANGE ON FMIN
      IF((FMIN.GT.0.).AND.(FMIN.LE.1000.)) GOTO 400
      WRITE(*,*)'Minimum Freq. must satisfy 0 < FMIN <= 1000.'
      GOTO 300
```

```
C     LINE DATA FILES    (Table I in [1])
C     (read as separate data files by MPM)
C
C
CCoefficients A5 after Rosenkranz [8], for 118.75 GHz line after Hill [7]
C   FO              A1        A2        A3    A4      A5     A6
C  49.452379        0.12    11.830     8.40   0      6.600   1.7
C  49.962257        0.34    10.720     8.50   0      6.600   1.7
C  50.474238        0.94     9.690     8.60   0      6.600   1.7
C  50.987748        2.46     8.690     8.70   0      6.600   1.7
C  51.503350        6.08     7.740     8.90   0      6.627   1.8
C  52.021409       14.14     6.840     9.20   0      6.347   1.8
C  52.542393       31.02     6.000     9.40   0      6.046   1.8
C  53.066906       64.10     5.220     9.70   0      5.719   1.9
C  53.595748      124.70     4.480    10.00   0      5.400   1.8
C  54.129999      228.00     3.810    10.20   0      5.157   2.0
C  54.671157      391.80     3.190    10.50   0      4.783   1.9
C  55.221365      631.60     2.620    10.79   0      4.339   2.1
C  55.783800      953.50     2.115    11.10   0      4.011   2.1
C  56.264777      548.90     0.010    16.46   0      2.772   0.9
C  56.363387     1344.00     1.655    11.44   0      3.922   2.3
C  56.968180     1763.00     1.255    11.81   0      3.398   2.5
C  57.612481     2141.00     0.910    12.21   0      1.145   3.2
C  58.323874     2386.00     0.621    12.66   0      0.317  -2.5
C  58.446589     1457.00     0.079    14.49   0      6.270   0.8
C  59.164204     2404.00     0.386    13.19   0     -4.119   0.1
C  59.590982     2112.00     0.207    13.60   0      6.766   0.5
C  60.306057     2124.00     0.207    13.82   0     -6.183   0.7
C  60.434775     2461.00     0.386    12.97   0      3.290  -0.4
C  61.150558     2504.00     0.621    12.48   0     -1.591   3.5
C  61.800152     2298.00     0.910    12.07   0     -2.068   2.9
C  62.411212     1933.00     1.255    11.71   0     -4.158   2.3
C  62.486253     1517.00     0.078    14.68   0     -4.068   0.9
C  62.997974     1503.00     1.660    11.39   0     -4.482   2.2
C  63.568515     1087.00     2.110    11.08   0     -4.442   2.0
C  64.127764      733.50     2.620    10.78   0     -4.687   2.0
C  64.678900      463.50     3.190    10.50   0     -5.074   1.8
C  65.224067      274.80     3.810    10.20   0     -5.403   1.9
C  65.764769      153.00     4.480    10.00   0     -5.610   1.8
C  66.302088       80.09     5.220     9.70   0     -5.896   1.8
C  66.836827       39.46     6.000     9.40   0     -6.194   1.7
C  67.369595       18.32     6.840     9.20   0     -6.468   1.8
C  67.900862        8.01     7.740     8.90   0     -6.718   1.7
C  68.431001        3.30     8.690     8.70   0     -6.70    1.7
C  68.960306        1.28     9.690     8.60   0     -6.60    1.7
C  69.489021        0.47    10.720     8.50   0     -6.60    1.7
C  70.017342        0.16    11.830     8.40   0     -6.60    1.7
C 118.750341      945.00     0.000    16.30   0     -0.134   0.8
C 368.498350       67.90     0.020    19.20   0.6    0       1
C 424.763120      638.00     0.011    19.16   0.6    0       1
C 487.249370      235.00     0.011    19.20   0.6    0       1
C 715.393150       99.60     0.089    18.10   0.6    0       1
C 773.838730      671.00     0.079    18.10   0.6    0       1
C 834.145330      180.00     0.079    18.10   0.6    0       1
C

C
C Width B3 of 183, 325, and 380 GHz lines increased by 10% [6]
C   FO            B1       B2     B3
C  22.235080    0.1090   2.143  27.84
C  67.813960    0.0011   8.730  27.60
C 119.995940    0.0007   8.347  27.00
C 183.310117    2.3000   0.653  31.64
C 321.225644    0.0464   6.156  21.40
C 325.152919    1.5400   1.515  29.70
C 336.187000    0.0010   9.802  26.50
C 380.197372   11.9000   1.018  30.36
C 390.134508    0.0044   7.318  19.00
C 437.346667    0.0637   5.015  13.70
C 439.150812    0.9210   3.561  16.40
C 443.018295    0.1940   5.015  14.40
C 448.001075   10.6000   1.370  23.80
C 470.888947    0.3300   3.561  18.20
C 474.689127    1.2800   2.342  19.80
C 488.491133    0.2530   2.814  24.90
C 503.568532    0.0374   6.693  11.50
C 504.482692    0.0125   6.693  11.90
C 556.936002  510.0000   0.114  30.00
C 620.700807    5.0900   2.150  22.30
C 658.006500    0.2740   7.767  30.00
C 752.033227  250.0000   0.336  28.60
C 841.073593    0.0130   8.113  14.10
C 859.865000    0.1330   7.989  28.60
C 899.407000    0.0550   7.845  28.60
C 902.555000    0.0380   8.360  26.40
C 906.205524    0.1830   5.039  23.40
C 916.171582    8.5600   1.369  25.30
C 970.315022    9.1600   1.842  24.00
C 987.926764  138.0000   0.178  28.60
C
C
C
```

```
C
C*********************************************************************
C                          EXAMPLE FOR A.
C*********************************************************************
C
C        FREQUENCY PROFILES OF ATTENUATION AND DELAY RATES
C
C INPUT  Valid Parameter ranges indicated by [ ]):
C
C                              REL.          HAZE      SUSP.    RAIN
C CASE   PRES.,P    TEMP.,T    HUM.,RH       MODEL     DROP.,w  RATE,R
C        (kPa)      (C)        (%)           (mg/m3)   (g/m3)   (mm/hr)
C [1-9] [0.0-110] [+/-50]    [0-100]       [0-1]     [0-10]   [0-200] MOIST AIR
C                                                                     +
C  1     101.3       15.0       99.5        C: 1.00   0.033     0.0    HAZE
C  2     101.3       15.0      100.0          : 0.00   1.000    10.0    FOG, RAIN
C
C Minimum Frequency F1              0.000 (GHz)
C Maximum Frequency F2 [1000.]1000.000 (GHz)
C Frequency Step [max 500] dF   100.000 (GHz)
C
C
C-------------------------------------------------------------
C OUTPUT:
C   Case Number:  1  (Refractive delay = 1164.49 ps/km)
C            ---------------------------------------------------
C               MOIST AIR  (v= 12.74 g/m3)
C              DRY      WATER      HAZE, FOG
C              AIR   +  VAPOR   +  CLOUD +     RAIN     = TOTAL
C            ---------------------------------------------------
C FREQUENCY                  ATTENUATION (dB/km)
C                              DISPERSIVE DELAY (ps/km)
C
C    (GHz)
C    0.000      0.00      0.00      0.00      0.00      0.00
C                0.00      0.00      0.00      0.00      0.00
C
C  100.000      0.03      0.82      0.14      0.00      0.99
C               -0.73      1.06     -0.02      0.00      0.32
C
C  200.000      0.02      5.40      0.34      0.00      5.76
C               -0.57      3.55     -0.03      0.00      2.95
C
C  300.000      0.03      9.44      0.51      0.00      9.98
C               -0.54     11.69     -0.04      0.00     11.11
C
C  400.000      0.06     34.82      0.65      0.00     35.53
C               -0.52     20.53     -0.05      0.00     19.96
C
C  500.000      0.09    106.65      0.80      0.00    107.54
C               -0.54     63.86     -0.05      0.00     63.27
C
C  600.000      0.09    244.65      0.93      0.00    245.67
C               -0.53    -57.07     -0.06      0.00    -57.65
C
C  700.000      0.12    128.10      1.04      0.00    129.27
C               -0.52     22.80     -0.06      0.00     22.22
C
C  800.000      0.17    161.71      1.15      0.00    163.03
C               -0.54    -21.09     -0.06      0.00    -21.69
C
C  900.000      0.17    129.49      1.24      0.00    130.89
C               -0.53     23.76     -0.07      0.00     23.16
C
C 1000.000      0.19   1091.46      1.32      0.00   1092.96
C               -0.53    -44.61     -0.07      0.00    -45.21
C
C
C   Case Number:  2  (Refractive delay = 1169.10 ps/km)
C            ---------------------------------------------------
C               MOIST AIR  (v= 12.81 g/m3)
C              DRY      WATER      HAZE, FOG
C              AIR   +  VAPOR   +  CLOUD +     RAIN     = TOTAL
C            ---------------------------------------------------
C FREQUENCY                  ATTENUATION (dB/km)
C                              DISPERSIVE DELAY (ps/km)
C
C    (GHz)
C    0.000      0.00      0.00      0.00      0.00      0.00
C                0.00      0.00      0.00      0.00      0.00
C
C  100.000      0.03      0.83      4.41      5.77     11.04
C               -0.73      1.07     -0.46      0.00     -0.12
C
C  200.000      0.02      5.44     10.50      6.92     22.87
C               -0.57      3.56     -1.00      0.00      2.00
C
C  300.000      0.03      9.50     15.52      6.56     31.61
C               -0.54     11.75     -1.30      0.00      9.90
C
C  400.000      0.06     35.02     20.11      6.31     61.50
C               -0.52     20.64     -1.50      0.00     18.61
C
C  500.000      0.09    107.25     24.43      6.13    137.91
C               -0.54     64.18     -1.65      0.00     61.99
C
C  600.000      0.09    246.00     28.44      5.99    280.52
C               -0.53    -57.35     -1.77      0.00    -59.66
C
C  700.000      0.12    128.84     32.07      5.87    166.90
C               -0.52     22.92     -1.88      0.00     20.52
C
C  800.000      0.17    162.65     35.28      5.76    203.86
C               -0.54    -21.20     -1.96      0.00    -23.70
C
C  900.000      0.17    130.27     38.08      5.67    174.19
C               -0.53     23.88     -2.04      0.00     21.31
C
C 1000.000      0.19   1097.36     40.50      5.60   1143.64
C               -0.53    -44.84     -2.10      0.00    -47.46
C
C
C*********************************************************************
C
```

```
        ENDIF
400     WRITE(*,5) FMAX
5       FORMAT(' Maximum Frequency, GHz (',F7.2,') ')
        IF(IFLAG.EQ.1)THEN
          READ(*,10) IVAL
           IF(IVAL.EQ.' ')THEN
           GOTO 500
           ELSE
           READ(IVAL,8,ERR=400) FMAX
           ENDIF
C   CHECK FOR VALID RANGE ON FMAX
        IF((FMAX.GE.FMIN).AND.(FMAX.LE.1000.)) GOTO 500
        WRITE(*,*)'Maximum Freq. must satisfy FMIN <= FMAX <= 1000.'
        GOTO 400
        ENDIF
500     WRITE(*,6) STEP
6       FORMAT(' Frequency Step, GHz (',F7.2,') ')
        IF(IFLAG.EQ.1)THEN
          READ(*,10) IVAL
           IF(IVAL.EQ.' ')THEN
           GOTO 600
           ELSE
           READ(IVAL,8,ERR=500) STEP
           IF(STEP.EQ.0.) THEN
                IF(FMAX-FMIN.EQ.0) THEN
                 STEP=1.
                 GOTO 511
                ENDIF
            WRITE(*,*)' STEP must be greater than 0'
            GOTO 500
            ENDIF
           ENDIF
C   CHECK FOR VALID # OF FREQS. (MAX=501)
511     FF=(FMAX-FMIN)/STEP+1
        IF(FF.GT.501) THEN
        WRITE(*,7) (FMAX-FMIN)/502
7       FORMAT(' Minimum STEP for given freq. range is ',F7.2)
        GOTO 500
        ENDIF
        NF=INT(FF)
        ENDIF
C   ******** PARAMETER VARIATION  ***********
600     CONTINUE
        IF(IFLAG.NE.1) GOTO 700
        WRITE(*,*)'Which param. would you like to vary (P, R, T) ? '
        READ(*,10)IVAL
        IF(IVAL.EQ.'P'.OR.IVAL.EQ.'p') THEN
         NFLAG=1
         GOTO 700
        ELSEIF(IVAL.EQ.'R'.OR.IVAL.EQ.'r')THEN
          NFLAG=2
          GOTO 700
         ELSEIF(IVAL.EQ.'T'.OR.IVAL.EQ.'t')THEN
          NFLAG=3
          GOTO 700
         ELSE
          GOTO 600
         ENDIF
C   ******* NUMBER OF CASES  ****************
700     CONTINUE
        P=PBT(1)
        RH=RHT(1)
        T=TCT(1)
         WRITE(*,11) NCASE
11      FORMAT(' No. of Cases (',I2,')  ')
        IF(IFLAG.NE.1)GOTO 800
         READ(*,10)IVAL
         IF(IVAL.EQ.' ')THEN
          GOTO 800
          ELSE
          READ(IVAL,12,ERR=700) NCASE
12      FORMAT(I1)
        IF(NCASE.GE.10) THEN
        WRITE(*,*)'NO. of Cases must be less than 10.'
        GOTO 700
        ENDIF
        ENDIF
C   *****  PRESSURE, TEMPS, RH, DROP CONC. *********
800     CONTINUE
        IF(IFLAG.EQ.1) THEN
        IF(NFLAG.NE.1) THEN
          WRITE(*,9) P
9         FORMAT(' Pressure for all cases (kPa) (',F7.2,') ')
          READ(*,10) IVAL
           IF(IVAL.EQ.' ') GOTO 830
          READ(IVAL,8,ERR=800) P
           DO 831 I=1,10
831        PBT(I)=P
           GOTO 830
        ENDIF
830     IF(NFLAG.NE.2)THEN
          WRITE(*,19) RH
19        FORMAT(' Rel. Humidity for all cases (%) (',F7.2,') ')
          READ(*,10) IVAL
           IF(IVAL.EQ.' ') GOTO 840
          READ(IVAL,8,ERR=800) RH
           DO 832 I=1,10
832        RHT(I)=RH
           GOTO 840
        ENDIF
840     IF(NFLAG.NE.3)THEN
          WRITE(*,20) T
20        FORMAT(' Temperature for all cases (C) (',F7.2,') ')
          READ(*,10) IVAL
           IF(IVAL.EQ.' ') GOTO 850
          READ(IVAL,8,ERR=800) T
           DO 833 I=1,10
833        TCT(I)=T
           GOTO 850
        ENDIF
850     CONTINUE
C******  PRESSURE  ***************
        IF(NFLAG.EQ.1)THEN
          DO 801 I=1,NCASE
821         WRITE(*,13)I,PBT(I)
13          FORMAT(' Pressure for case # ',I1,' (kPa) (',F7.2,') ')
            READ(*,10) IVAL
            IF(IVAL.EQ.' ') GOTO 801
            READ(IVAL,8,ERR=821) PBT(I)
801     CONTINUE
```