```
      ENDIF
C******* TEMPERATURE ***************
      IF(NFLAG.EQ.3) THEN
        DO 802 I=1,NCASE
822       WRITE(*,14)I,TCT(I)
14        FORMAT(' Temperature for case # ',I1,' (C) (',F7.2,') ')
          READ(*,10) IVAL
          IF(IVAL.EQ.' ') GOTO 802
          READ(IVAL,8,ERR=822) TCT(I)
802     CONTINUE
        ENDIF
C**********  HUMIDITY  *****************
        IF(NFLAG.EQ.2)THEN
          DO 803 I=1,NCASE
823         WRITE(*,15)I,RHT(I)
15          FORMAT(' Rel. Hum. for case # ',I1,' (%) (',F6.2,') ')
            READ(*,10) IVAL
            IF(IVAL.EQ.' ') GOTO 803
            READ(IVAL,8,ERR=823) RHT(I)
803       CONTINUE
          ENDIF
          ENDIF
C********** DROP. CONC. ******************
          IF(IFLAG.EQ.1)THEN
            DO 804 I=1,NCASE
            IF(RHT(I).GE.99.9)THEN
834          WRITE(*,22)I,WT(I)
22           FORMAT(' Drop. Conc. for case # ',I1,' (g/m3) (',F6.2,') ')
             READ(*,10)IVAL
             IF(IVAL.EQ.' ')GOTO 804
             READ(IVAL,8,ERR=834) WT(I)
             GOTO 804
             ENDIF
C
C*********** HAZE MODEL [2] **************
             IF(RHT(I).LT.80.) GOTO 804
844          WRITE(*,23)I,WA(I)
23       FORMAT(' Aerosol conc. at 80% RH for case # ',
     +             I1,' (mg/m3) (',f6.2,') ')
             READ(*,10)IVAL
             IF(IVAL.EQ.' ')GOTO 824
             READ(IVAL,8,ERR=844) WA(I)
C
824           IF(WA(I).EQ.0.) GOTO 804
             WRITE(*,16)I,HZ(I)
16           FORMAT(' Haze Model for case # ',I1,/,
     +        ' (A-RURAL,B-Urban,C-Maritime,D-C+strong Wind) (',A1,') ')
             READ(*,10)IVAL
          IF(IVAL.EQ.' ') THEN
             HZ(I)=HZ(I)
             ELSEIF((IVAL.EQ.'A').OR.(IVAL.EQ.'B').OR.(IVAL.EQ.'C').OR.
     +         (IVAL.EQ.'D')) THEN
             HZ(I)=IVAL
             ELSE
              GOTO 824
             ENDIF
              IF(HZ(I).EQ.'A') THEN
               C1=117.
               C2=1.87
              ELSEIF(HZ(I).EQ.'B')THEN
               C1=128.
               C2=2.41
              ELSEIF(HZ(I).EQ.'C')THEN
               C1=183.
               C2=5.13
              ELSEIF(HZ(I).EQ.'D')THEN
               C1=197.
               C2=5.83
              ELSE
               GOTO 824
              ENDIF
              WT(I)=WA(I)*((C1-RHT(I))/(C2*(100.-RHT(I))))*(1.E-3)
804       CONTINUE
          ELSE
          WRITE(*,17)
17        FORMAT('  CASE ',3X,' PRES. ',3X,' TEMP. ',3X,'  HUM. ',5X,
     +      ' DROP. ','     RAIN  ')
          DO 805 I=1,NCASE
          WRITE(*,18) I, PBT(I),TCT(I),RHT(I),WT(I),RR(I)
18        FORMAT(3X,I2,2X,5(3X,F7.2))
805       CONTINUE
          ENDIF
900       CONTINUE
C********  RAIN RATE  ************************
          IF(IFLAG.EQ.1)THEN
          DO 902 I=1,NCASE
922       WRITE(*,21)I,RR(I)
21        FORMAT(' Rain Rate for case # ',I1,' (mm/hr) (',F7.2,') ')
          READ(*,10)IVAL
          IF(IVAL.EQ.' ') GOTO 902
          READ(IVAL,8,ERR=922) RR(I)
902       CONTINUE
          ENDIF
1000      CONTINUE
          RETURN
          END
C-----------------------------------------------------------------------
          SUBROUTINE SAVETABL(IFLAG)
       COMMON /ANS1/ D(12,501,10),ATT(501,10),DISP(501,10)
       REAL No,Bo
       COMMON /ANS/ FREQA(501),No(10),Bo(10),EV(10)
       COMMON /AIR/ NCASE,PBT(10),TCt(10),RHt(10),Wt(10),R(10)
         COMMON /RAIN/ RR(10),WA(10)
         COMMON /HAZE/ HZ(10)
       COMMON /FREQS/ FMIN,FMAX,STEP,NF
         CHARACTER*1 HZ,IVAL
         CHARACTER*20 SAVE
         INTEGER*2 DFLAG,HFLAG
C
C    IFLAG = 0 MEANS PRINT TO CONSOLE
C    IFLAG = 1                FILE
C    IFLAG = 2        PRINT SUMMARY TO CONSOLE
C
          DFLAG=0
          HFLAG=0
          IF(IFLAG.EQ.2)THEN
          OPEN(1,FILE='CON')
          GOTO 110
          ENDIF
C
```

```
      WRITE(*,*)'Press C for Complex Refractivity output '
      WRITE(*,*)'or ENTER for normal output '
      READ(*,101)IVAL
      IF((IVAL.EQ.'C').OR.(IVAL.EQ.'c'))THEN
      FFLAG=1
      ELSE
      FFLAG=0
      ENDIF
C
      WRITE(*,*)'Press D to supress dispersion data '
      WRITE(*,*)'Press H to print only the input information'
      WRITE(*,*)'Press ENTER for a normal printout'
      WRITE(*,*)
      READ(*,101)IVAL
101   FORMAT(A1)
      IF((IVAL.EQ.'D').OR.(IVAL.EQ.'d'))THEN
      DFLAG=1
      ELSEIF((IVAL.EQ.'H').OR.(IVAL.EQ.'h'))THEN
      HFLAG=1
      ELSE
      DFLAG=0
      HFLAG=0
      ENDIF
C
      IF (FFLAG.EQ.1)THEN
       CALL SAVREF(IFLAG,DFLAG,HFLAG)
       RETURN
      ENDIF
C
110   CONTINUE
C
      IF (IFLAG.EQ.1)THEN
      WRITE(*,*)'Enter a DOS filename (PRN for a printout): '
      READ(*,12) SAVE
12    FORMAT(A20)
      IF(SAVE.EQ.'PRN')THEN
      OPEN(1,FILE=SAVE,ERR=900)
      ELSE
      OPEN(1,FILE=SAVE,STATUS='NEW',ERR=900)
      ENDIF
      ELSEIF(IFLAG.EQ.0)THEN
      OPEN(1,FILE='CON')
      ELSE
      ENDIF
C
1     FORMAT(//)
C
      WRITE(1,175)
175   FORMAT(8X,'FREQUENCY PROFILES OF ATTENUATION AND DELAY RATES')
      WRITE(1,*)
      WRITE(1,*)'INPUT ',
     +' Valid Parameter ranges indicated by [ ]):'
      WRITE(1,*)
C
      WRITE(1,6)
6     FORMAT
     +('                              REL.       HAZE     SUSP.    RAIN')
      WRITE(1,7)
7     FORMAT
     +(' CASE   PRES.,P   TEMP.,T   HUM.,RH    MODEL    DROP.,w   RATE',
     + ',R')
      WRITE(1,75)
75    FORMAT
     +('          (kPa)      (C)       (%)',
     +'           (mg/m3)  (g/m3)   (mm/hr)')

      WRITE(1,76)
76    FORMAT
     +(' [1-9] [0.0-110] [+/-50]   [0-100]       [0-1]',
     +'     [0-10]  [0-200]')
C
      WRITE(1,*)
      DO 10 LP=1,NCASE
      WRITE(1,8)LP,PBT(LP),TCT(LP),RHT(LP),HZ(LP),WA(LP),
     +   WT(LP),RR(LP)
8     FORMAT(I3,3(3X,F7.1),7X,A1,': ',F4.2,1X,F7.3,1X,F7.1)
10    CONTINUE
      WRITE(1,*)
      WRITE(1,2) FMIN
2     FORMAT(' Minimum Frequency F1         ',F8.3,' (GHz)')
      WRITE(1,3) FMAX
3     FORMAT(' Maximum Frequency F2 [1000.]',F8.3,' (GHz)')
      WRITE(1,4) STEP
4     FORMAT(' Frequency Step [max 500] dF ',F8.3,' (GHz)')
      WRITE(1,*)
      WRITE(1,*)
C
      IF(IFLAG.EQ.2)RETURN
      IF(HFLAG.EQ.1)RETURN
C
      WRITE(1,45)
45    FORMAT(62(1H-))
      WRITE(1,*)'OUTPUT:'
C
      DO 200 LP=1,NCASE
      WRITE(1,9) LP,No(LP)*3.336
9     FORMAT('   Case Number: ',I2,'  (Refractive delay = '
     +    ,F7.2,' ps/km)')
C
      WRITE(1,16)
16    FORMAT(11X,51(1H-))
      WRITE(1,17)R(LP)
17    FORMAT(15X,'MOIST AIR  (v= ',F5.2,' g/m3)')
      WRITE(1,18)
18    FORMAT(13X,'DRY     WATER      HAZE, FOG')
      WRITE(1,19)
19    FORMAT(13X,'AIR   +  VAPOR    +  CLOUD +    RAIN   ',
     +  ' = TOTAL  ')
      WRITE(1,16)
      WRITE(1,14)
14    FORMAT(' FREQUENCY ',17X,'ATTENUATION (dB/km)')
        IF(DFLAG.EQ.0)THEN
      WRITE(1,15)
15    FORMAT('          ',24X,'DISPERSIVE DELAY (ps/km)')
        ENDIF
        WRITE(1,*)'   (GHz)'
        DO 100 IF=1,NF
        SM1=D(1,IF,LP)+D(2,IF,LP)
        SM2=D(3,IF,LP)+D(4,IF,LP)
        WRITE(1,11)FREQA(IF),SM1,SM2,D(5,IF,LP),D(11,IF,LP),
```

```
     +        ATT(IF,LP)
11     FORMAT(F9.3,2X,F8.2,3(1X,F8.2),2X,F8.2)
       IF(DFLAG.EQ.0)THEN
       WRITE(1,30)D(6,IF,LP)+D(7,IF,LP),D(8,IF,LP)+D(9,IF,LP),
     +             D(10,IF,LP),D(12,IF,LP),DISP(IF,LP)
30     FORMAT(12X,F8.2,4(2X,F8.2))
       ENDIF
100    CONTINUE
       WRITE(1,*)
200    CONTINUE
       CLOSE(1)
       RETURN
900    WRITE(*,13) SAVE
13     FORMAT(' ERROR Opening file: ',A20)
       RETURN
       END
C-----------------------------------------------------------------------
        SUBROUTINE SAVREF(IFLAG,DFLAG,HFLAG)
      COMMON /ANS1/ D(12,501,10),ATT(501,10),DISP(501,10)
      REAL No,Bo
      COMMON /ANS/ FREQA(501),No(10),Bo(10),EV(10)
      COMMON /AIR/ NCASE,PBT(10),TCt(10),RHt(10),Wt(10),R(10)
        COMMON /RAIN/ RR(10),WA(10)
        COMMON /HAZE/ HZ(10)
      COMMON /FREQS/ FMIN,FMAX,STEP,NF
        CHARACTER*1 HZ,IVAL
        CHARACTER*20 SAVE
        INTEGER*2 DFLAG,HFLAG
C
        IF (IFLAG.EQ.1)THEN
        WRITE(*,*)'Enter a DOS filename (PRN for a printout): '
        READ(*,12) SAVE
12      FORMAT(A20)
        IF(SAVE.EQ.'PRN')THEN
        OPEN(1,FILE=SAVE,ERR=900)
        ELSE
        OPEN(1,FILE=SAVE,STATUS='NEW',ERR=900)
        ENDIF
        ELSEIF(IFLAG.EQ.0)THEN
        OPEN(1,FILE='CON')
        ELSE
        ENDIF
C
1       FORMAT(//)
C
        WRITE(1,175)
175     FORMAT(8X,'FREQUENCY PROFILES OF ATMOSPHERIC COMPLEX',
      + ' REFRACTIVITY')
        WRITE(1,*)
        WRITE(1,*)'INPUT ',
      + ' Valid Parameter ranges indicated by [ ]):'
        WRITE(1,*)
C
        WRITE(1,6)
6       FORMAT
      +('                              REL.        HAZE      SUSP.    RAIN')
        WRITE(1,7)
7       FORMAT
      +(' CASE   PRES.,P   TEMP.,T   HUM.,RH     MODEL    DROP.,w   RATE',
      + ',R')
```

```
        WRITE(1,75)
75      FORMAT
      +('          (kPa)        (C)        (%)',
      +'           (mg/m3)   (g/m3)   (mm/hr)')

        WRITE(1,76)
76      FORMAT
      +(' [1-9] [0.0-110] [+/-50]   [0-100]        [0-1]',
      +'    [0-10]  [0-200]')
C
        WRITE(1,*)
        DO 10 LP=1,NCASE
        WRITE(1,8)LP,PBT(LP),TCT(LP),RHT(LP),HZ(LP),WA(LP),
      +   WT(LP),RR(LP)
8       FORMAT(I3,3(3X,F7.1),7X,A1,': ',F4.2,1X,F7.3,1X,F7.1)
10      CONTINUE
        WRITE(1,*)
        WRITE(1,2) FMIN
2       FORMAT(' Minimum Frequency F1          ',F8.3,' (GHz)')
        WRITE(1,3) FMAX
3       FORMAT(' Maximum Frequency F2 [1000.]',F8.3,' (GHz)')
        WRITE(1,4) STEP
4       FORMAT(' Frequency Step [max 500] dF ',F8.3,' (GHz)')
        WRITE(1,*)
        WRITE(1,*)
C
        IF(IFLAG.EQ.2)RETURN
        IF(HFLAG.EQ.1)RETURN
C
        WRITE(1,45)
45      FORMAT(62(1H-))
        WRITE(1,*)'OUTPUT:'
C
        DO 200 LP=1,NCASE
        WRITE(1,9) LP,No(LP)
9       FORMAT('   Case Number: ',I2,'   (No = ',F7.2,' ppm)')
C
      WRITE(1,16)
16    FORMAT(11X,66(1H-))
      WRITE(1,17)R(LP)
17    FORMAT(15X,'    MOIST AIR  (v= ',F5.2,' g/m3)')
      WRITE(1,18)
18    FORMAT(13X,' DRY          WATER        HAZE, FOG')
      WRITE(1,19)
19    FORMAT(13X,' AIR    +    VAPOR    +    CLOUD +       RAIN    ',
     + ' = TOTAL   ')
      WRITE(1,16)
      WRITE(1,14)
14    FORMAT(' FREQUENCY ',22X,'IMAGINARY PART (ppm)')
        IF(DFLAG.EQ.0)THEN
      WRITE(1,15)
15    FORMAT('           ',31X,'REAL PART (ppm)')
        ENDIF
        WRITE(1,*)'    (GHz)'
        DO 100 IF=1,NF
        SM1=(D(1,IF,LP)+D(2,IF,LP))/(.182*FREQA(IF))
        SM2=(D(3,IF,LP)+D(4,IF,LP))/(.182*FREQA(IF))
        SM3=D(5,IF,LP)/(.182*FREQA(IF))
        SM4=D(11,IF,LP)/(.182*FREQA(IF))
        WRITE(1,11)FREQA(IF),SM1,SM2,SM3,SM4,
```

```
     +          ATT(IF,LP)/(.182*FREQA(IF))
11         FORMAT(F9.3,5(3X,E9.3))
           IF(DFLAG.EQ.0)THEN
           SM1=(D(6,IF,LP)+D(7,IF,LP))/3.336
           SM2=(D(8,IF,LP)+D(9,IF,LP))/3.336
           WRITE(1,30)SM1,SM2,D(10,IF,LP)/3.336,D(12,IF,LP)/3.336,
     +       DISP(IF,LP)/3.336
30         FORMAT(12X,5(3X,E9.3))
           ENDIF
100        CONTINUE
           WRITE(1,*)
200        CONTINUE
           CLOSE(1)
           RETURN
900        WRITE(*,13) SAVE
13         FORMAT(' ERROR Opening file: ',A20)
           RETURN
           END
C-------------------------------------------------------------------------------
      SUBROUTINE COMPUTE(LOOP)
C*****************************************************************
C  THIS SUBROUTINE COMPUTES THE ATTENUATION & DISPERSIVE DELAY RATES
C*****************************************************************
      COMMON /ANS1/ D(12,501,10),ATT(501,10),DISP(501,10)
      COMMON /ANS/ FREQA(501),No(10),Bo(10),EV(10)
      COMMON /AIR/ NCASE,PBt(10),TCt(10),RHt(10),Wt(10),R(10)
      COMMON /RAIN/ RR(10),WA(10)
      COMMON /FREQS/ FMIN,FMAX,STEP,NF
      REAL No,Bo
      DIMENSION AD(12)
C
      NF=(FMAX-FMIN)/STEP +1.5
C   NUMBER OF FREQUENCIES
      DO 800 LP=1,LOOP
C*********************************
      Pbi=PBt(LP)
      Tci=TCt(LP)
      Rhi=RHt(LP)
      Wi=Wt(LP)
      RRi=RR(LP)
C*********************************
C
      DO 55 IF=1,NF
      DO 55 I=1,8
55    D(I,IF,LP)=0.
      WRITE(*,56) LP,LOOP
56    FORMAT(' Computing for  ***** Case',I3,' of',I3,' *****')
C
60    DO 100 IF=1,NF
C   FREQUENCY LOOP
      F=FMIN + (IF-1)*STEP
      FREQA(IF)=F
        IF(F.EQ.0.)F=1.E-6
C   SAVE FREQUENCY
      CALL Gas1(F,IF,Ad,Pbi,Rhi,Tci,Wi,RRi,V,Es,E,P,Tau,Nwv,Eps,fr)
        EV(LP)=E
85    DO 95 I=1,12
      D(I,IF,LP)=Ad(I)
95      CONTINUE
D         WRITE(*,*)'D(12)= ',D(12,IF,LP)
```

```
100   CONTINUE
C
        R(LP)=7.223*E*V
C  NONDISPERSIVE REFRACTIVITY No in ppm and DELAY Bo in ps/km [1].
        No(LP)=(2.588*P+(41.6*V+2.39)*E)*V+Nwv
        Bo(LP)=3.336*No(LP)
C    COMPUTE No,Bo
        DO 510 IF=1,NF
C  ADD TOTAL ATTENUATION AND DISPERSION
        ATT(IF,LP)=D(1,IF,LP)+D(2,IF,LP)+D(3,IF,LP)+D(4,IF,LP)+
     +              D(5,IF,LP)+D(11,IF,LP)
        DISP(IF,LP)=D(6,IF,LP)+D(7,IF,LP)+D(8,IF,LP)+
     +              D(9,IF,LP)+D(10,IF,LP)+D(12,IF,LP)
510     CONTINUE
800   CONTINUE
      RETURN
      END
C-------------------------------------------------------------------------------
      SUBROUTINE Gas1(F,Mt,Ad,Pb,Rh,Tc,W,RR,V,Es,E,P,Tau,Nwv,Eps,fr)
C*****************************************************************
C       COMPUTES SPECIFIC ATTENUATION & DISPERSIVE DELAY RATES
C       USING LINE DATA
C*****************************************************************
      COMMON /O2line/ FOO2(48),A(6,48)
C   OXYGEN LINES
      COMMON /H2O/ FOwater(30),B(3,30)
C   WATER VAPOR LINES
      DIMENSION AD(12),GAMD2(30)
        DIMENSION S(48),GAMMA(48),DELTA(48),SH(30),GAMH(30),DELH(30)
      REAL NIPP,NDPP,NOXPP,NVPP,NWPP,Noxp,Ndp,Nip,Nrp,NS,NU
C
      IF(Mt.GT.1) GO TO 40
C   ONLY CALC THESE FOR 1st FREQUENCY
C
      V=300./(Tc+273.15)
C   RELATIVE INVERSE TEMPERATURE
C          COMPUTE WATER VAPOR PARTIAL PRESSURE E in kPa
C   Eqn. (1)  [1] -- CORRECTED!
C     Es=2.409*V**5*10**(10.-9.834*V)
         Es=0.61078*(EXP(((18.61-Tc/240.7)*Tc)/(256.1+Tc)))
C   New Es [9] -- either version may be used.
        E=Es*Rh/100.
          P=Pb-E
          IF(P.LT.0)THEN
           P=0.
           Pb=E
          ENDIF
C
C            COMPUTE LINE FACTORS S,Gamma,Delta
        DO 10 I=1,48
C   For OXYGEN
        S(I)=A(1,I)*P*V**3*EXP(A(2,I)*(1.-V))*1.E-6
        GAMMA(I)=A(3,I)*(P*V**(.8-A(4,I)) + 1.1*E*V)*1.E-3
          IF(Pb.LT.0.7)THEN
          GAMMA(I)=(GAMMA(I)**2+(25*0.6E-4)**2)**0.5
C   Zeeman approximation for .6 Gauss, [10]
          ENDIF
10      DELTA(I)=A(5,I)*P*V**A(6,I)*1.E-3
        DO 20 I=1,30
C   For WATER VAPOR
```

```
      SH(I)=B(1,I)*E*V**3.5*EXP(B(2,I)*(1.-V))
c  Slightly different temperature dependence for width, following [6].
      GAMH(I)=B(3,I)*(P*V**.6 + 4.8*E*V**1.1)*1.E-3
        IF(Pb.LT.0.7)THEN
        GAMD2(I)=(2.14*F0water(I)**2)*1E-12/V
        GAMH(I)=(GAMH(I)**2+GAMD2(I))**0.5
C  Doppler approximation [10]
        ENDIF
20    DELH(I)=0.
C
C       WATER VAPOR CONTINUUM
C       Eqn. (14)  [1]; was revised in [2], Eqn. (10)
40    Bf=1.13E-6
      Bs=3.57E-5
      Nipp=(Bf*E*P*V**3.0 + Bs*E**2*V**10.8)*F
      Bo=6.47E-6
      Nip=E*Bo*F**2.05*V**2.4
C
C        DRY AIR CONTINUUM
C        Eqn. (13)  [1] -- CORRECTED!
      Ao=6.14E-4
      An=1.40E-10 *(1.-1.2E-5*F**1.5)
      GAMMAo=4.8E-3*(P+1.1*E)*V**.8
C     FAC=1./(1.+F**2/3600.)
C    Nonresonant rolloff FAC taken out.
        FAC=1.
      Ndpp=(Ao*P*V**2*GAMMAo*FAC/(F*F + GAMMAo**2) + An*P*P*V**3.5)*F
      Ndp =P*Ao/2.*V**2*(1./(1.+(F/GAMMAo)**2)-1.)
C
C            MOLECULAR OXYGEN LINES
      S1=0
      S2=0
      DO 60 I=1,48
      CALL FPPFP(F,FOO2(I),GAMMA(I),DELTA(I),FPP,FP,0)
      S1=S1+S(I)*Fpp
60    S2=S2+S(I)*Fp
      Noxpp=S1
C   N'' FROM OXYGEN
      Dox=S2 + Ndp
        Ad(6)=3.336*S2
        Ad(7)=3.336*Ndp
C   D FROM OXYGEN
C
C            WATER VAPOR LINES
      S1=0
      S2=0
      DO 70 I=1,30
      CALL FPPFP(F,FOWATER(I),GAMH(I),DELH(I),FPP,FP,1)
      S1=S1+SH(I)*Fpp
70    S2=S2+SH(I)*Fp
      Nvpp=S1
C    N'' FROM WATER VAPOR
      Dv=S2 + Nip
        Ad(8)=3.336*S2
        Ad(9)=3.336*Nip
C    D FROM WATER VAPOR
C
C            LIQUID WATER DIELECTRIC CONSTANT AND
C            FOG/CLOUD RAYLEIGH TERMS [3]
        fD=20.09-142*(V-1)+294*(V-1)**2
        NU=(F/fD)
        fS=590.-1500*(V-1)
        NS=F/fS
        Epinf=5.48
        Eopt=3.51
C   EPSILON SUB INFINITY
        Eps=103.3*(V-1)+77.66
C   EPSILON SUB S
        Epp=Eopt+(Eps-Epinf)/(1+NU**2)+(Epinf-Eopt)/(1+NS**2)
C EPSILON'
        Eppp=((Eps-Epinf)*NU)/(1+NU**2)+((Epinf-Eopt)*NS)/(1+NS**2)
C EPSILON''
        Ep=(2.+Epp)/Eppp
C   SUSPENDED WATER DROPLET EXTINCTION
        Nwpp=(4.50*W/(Eppp*(1.+Ep**2)))
C N'' FROM WATER DROPLETS
        Dw=-4.5*W*(Ep/(Eppp*(1+Ep*Ep)))+4.5*W/(Eps+2.)
        Nwv=1.5*W*(1.-(3./(Eps+2.)))
C
C ATTENUATION DUE TO RAIN [4]
C
        ARAIN=0.
        BRAIN=0.
        ATRAN=0.
        Nrp=0.
        IF (RR.EQ.0.) GOTO 501
C    ALPHA CALCULATION
        IF(F.GE.2.9) GOTO 300
          GA=6.39E-5
          EA=2.03
          GOTO 330
300     CONTINUE
        IF(F.GE.54.) GOTO 310
          GA=4.21E-5
          EA=2.42
          GOTO 330
310     IF(F.GE.180.) GOTO 320
          GA=4.09E-2
          EA=0.699
          GOTO 330
320     GA=3.38
        EA=-0.151
330     ARAIN=GA*(F**(EA))
C
C      BETA CALCULATION
        IF(F.GE.8.5) GOTO 340
          GB=0.851
          EB=0.158
          GOTO 370
340     IF(F.GE.25.) GOTO 350
          GB=1.41
          EB= -0.0779
          GOTO 370
350     IF(F.GE.164.)GOTO 360
          GB=2.63
          EB= -0.272
          GOTO 370
360     GB=0.616
        EB=0.0126
370     BRAIN=GB*(F**(EB))
```

```
      ATRAN=ARAIN*RR**(BRAIN)
C
C    RAIN DELAY approximated after ZUFFEREY [5] who
C    used MARSHALL-PALMER drop size spectra and 20 deg. C
      fr=53.-0.37*RR+1.5E-3*RR**2
      Nro=(RR*(3.68-0.012*RR))/fr
      X=F/fr
      Nrp=-Nro*(X**2.5/(1+X**2.5))
501   CONTINUE
C
C CALC ABSORPTION
     Ad(1)=.182*F*Noxpp
C OXYGEN LINE ABSORPTION
     IF(Ad(1).LT.0.) Ad(1)=0.
C   Cannot be less than 0.
     Ad(2)=.182*F*Ndpp
C NONRESONAT DRY AIR ABSORPTION
     Ad(3)=.182*F*Nvpp
C WATER VAPOR LINE ABSORPTION
     Ad(4)=.182*F*Nipp
C WATER VAPOR CONTINUUM ABSORPTION
     Ad(5)=.182*F*Nwpp
C SUSPENDED WATER DROPLET EXTINCTION
C    Ad(6)=3.336*S2
C OXYGEN LINE DISPERSIVE DELAY (SEE ABOVE)
C    Ad(7)=3.336*Ndp
C OXYGEN NON-RESONANT DISP. DELAY (SEE ABOVE)
C    Ad(8)=3.336*S2
C WATER VAPOR CONTIUUM DISPERSIVE DELAY (SEE ABOVE)
C    Ad(9)=3.336*Nip
C WATER VAPOR LINE DISPERSIVE DELAY (SEE ABOVE)
     Ad(10)=3.336*Dw
C WATER DROPLET DISPERSIVE DELAY
     Ad(11)=ATRAN
C ATTENUATION DUE TO RAIN
       Ad(12)=3.336*Nrp
D        WRITE(*,*)'Ad(12)= ',Ad(12)
C RAIN DELAY
      RETURN
      END
C-----------------------------------------------------------------
      SUBROUTINE FPPFP(F,Vo,GAMMA,DELTA,Fpp,Fp,FLAG)
C*****************************************************************
C   CALC Fpp & Fp -- VW line shape functions
C*****************************************************************
      G2=GAMMA*GAMMA
      VMF=Vo-F
      VPF=Vo+F
        CUTOFF=40.
      Fpp=F/Vo*((GAMMA-VMF*DELTA)/(VMF**2+G2) +
     +          (GAMMA-VPF*DELTA)/(VPF**2+G2))
        IF(FLAG.EQ.1)THEN
        IF(F.GT.(Vo+CUTOFF*GAMMA)) Fpp=0.
C  SET ABSORPTION TO ZERO IF F IS > NU+40*GAMMA
C  High-frequency wing problem of VW shape function for H2O lines [7]!
C  Intensities <(approx. 7.5 E-4 Fpp) are neglected.
        ENDIF
      Fp=(VMF + GAMMA*(GAMMA+F*DELTA)/Vo)/(VMF**2+G2) +
     +   (VPF + GAMMA*(GAMMA-F*DELTA)/Vo)/(VPF**2+G2) - 2./Vo
      RETURN
      END
C-----------------------------------------------------------------
      SUBROUTINE Oxyda1
      COMMON /O2line/ FOO2(48),A(6,48)
C   PUT MOLECULAR OXYGEN LINE DATA OF [1] IN A(1:6,1:48)
      OPEN (2,FILE='OXYGEN.DAT',ERR=900)
C  DUMMY READ TO ALLOW FOR COMMEMTS.
        READ(2,*)
        READ(2,*)
      READ (2,*,ERR=910) (FOO2(I),(A(J,I),J=1,6),I=1,48)
      CLOSE (2)
      RETURN
900   WRITE(*,901) IOS
901   FORMAT('Could not OPEN OXYGEN.DAT file, error=',I6)
        WRITE(*,*)'Check that OXYGEN.DAT is in the current directory.'
      STOP 'Could not OPEN OXYGEN file.'
910   STOP 'ERROR READing OXYGEN file.'
      END
C-----------------------------------------------------------------
      SUBROUTINE Vapda1
      COMMON /H2O/ FOwater(30),B(3,30)
C       PUTS WATER VAPOR LINE DATA OF [1] IN B(1:3,1:30)
      OPEN (2,FILE='WATER.DAT',ERR=900)
C   DUMMY READ TO ALLOW FOR COMMENTS.
        READ(2,*)
        READ(2,*)
      READ (2,*,ERR=910) (FOwater(I),(B(J,I),J=1,3),I=1,30)
      CLOSE (2)
      RETURN
900   WRITE(1,901) IOS
901   FORMAT('Could not OPEN WATER file, error=',I6)
        WRITE(*,*)'Check that WATER.DAT is in the current directory.'
      STOP 'Could not OPEN WATER file.'
910   STOP 'ERROR READing WATER file.'
      END
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15. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

Laboratory measurements have been performed at 138 GHz of water vapor attenuation α_x for pure vapor (H_2O) and its mixtures with air, nitrogen (N_2), oxygen (O_2), and Argon(Ar). A computer-controlled resonance spectrometer was employed. The results are interpreted in terms of underlying absorption mechanisms. A substantial amount of the self-broadening term proportional to the square of vapor pressure is left unaccounted. The negative temperature coefficient of the excess absorption is consistent with a dimer (H_2O_2) model. An empirical formulation of the experimental findings is incorporated into the parametric propagation model MPM that utilizes a local (30x H_2O, 48x O_2) line base to address frequencies up to 1000 GHz. Details of MPM are given in two Appendices. Predictions of moist air attenuation and delay by means of the revised MPM program generally compare favorably with reported (10 - 430GHz) data from both field and laboratory measurements.

16. Key Words *(Alphabetical order, separated by semicolons)*

atmospheric attenuation and delay; laboratory studies of moist air attenuation; millimeter/submillimeter-wave spectral range; propagation program MPM; terrestrial radio path data

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