HCMM Energy Budget Data as a Model Input for Assessing Regions of High Potential Groundwater Pollution

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15. Supplementary Notes

16. Abstract

The Fortran computer program for a finite-difference soil temperature simulation model is presented. Modification of the original model during this reporting period included programming for computation of thermal conductivity for each 1 cm increment of the 50 cm soil profile with inputs of soil bulk density, thermal conductivity of the dry soil, and soil moisture. Soil temperatures were monitored for both an irrigated and nonirrigated soil profile to evaluate the accuracy of the simulation model.

17. Key Words Suggested by Author	18. Distribution Statement
HCMM, Remote Sensing, Thermal Inertia, Soil Temperature, Water Table, Finite-difference Model.	

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A. Problems

None

B. Accomplishments

The finite-difference model was modified to allow for changes in thermal conductivity with depth caused by variation in soil moisture. Field measurements were used to modify the model.

Both U-2 and RB-57 flights are scheduled for mid-October. During the next reporting period, test fields for the aircraft flights will be selected. Temperature and soil moisture profiles in the fields will be measured at the time of overflight. Aircraft data and field measurements will be used to evaluate effects of vegetation, soil moisture, and water-table depth on soil-temperature profiles. Development of procedures for manipulation and reduction of HCMM data will begin.

C. Significant Results

In its original form the finite-difference model considered the top 50 cm of soil divided into layers 1 cm in thickness. The thermal conductivity of the soil was specified together with the solar radiation term of q_s and an initial temperature profile. The model then calculated the resulting heat flow between adjacent layers and the resulting change in temperature of each layer during each minute of time. Thus the model calculated temperature profiles as a function of time for the top 50 cm of soil.

The model was used to calculate the differences in surface temperature between two hypothetical sites which result from a temperature difference at 50 cm due to the presence of shallow groundwater at one of the sites. Although qualitative results of the model seemed consistant with experimental results, further evaluation showed a need for taking account of differences in thermal conductivity due to different moisture profiles at the two sites considered.

During this reporting period, the model has been modified to allow input of different thermal conductivities to each of the 50 layers on both sites. Using the method by DeVries (1963) the computer program calculates the thermal conductivity of each soil layer if bulk density, dry conductivity, and moisture content of the soil are known. Thus, a surface temperature difference for two sites with different soil moisture conditions can be related to temperature difference at 50 cm which may be due to the presence of shallow groundwater at one of the sites.

The model in its present form is shown in Appendix A. Schematically the model may now be represented as shown in Fig. 1. This form was chosen for use in evaluating the model. Modifications are planned which will change the model to the format shown in Fig. 2 to estimate depth to water tables.

DeVries, D.A. 1963. Thermal Properties of Soils. In W.R. Van Wijk (ed.). Physics of the Plant Environment. North-Holland Publishing Co., Amsterdam. p. 210-235.

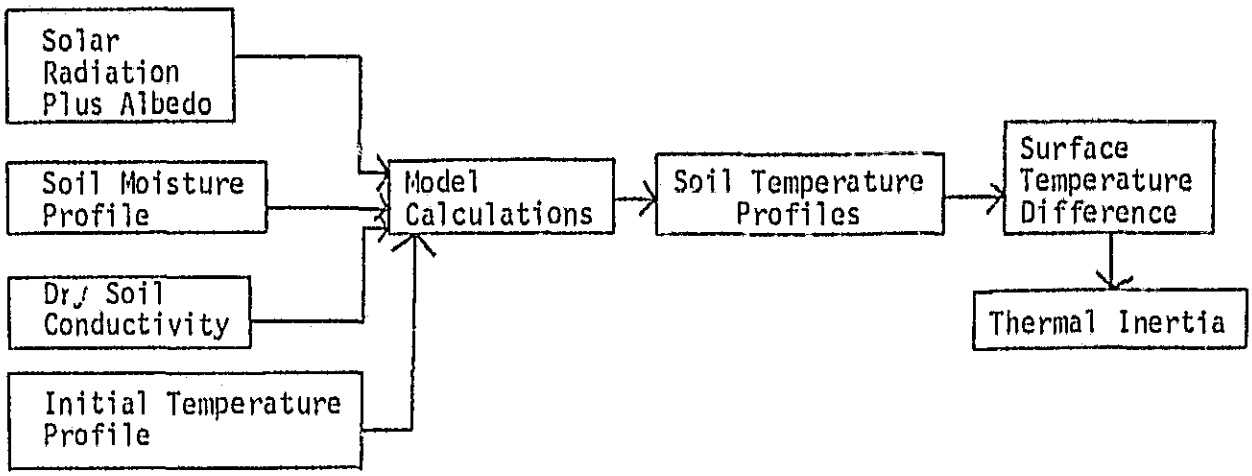

Fig. 1. Schematic representation of the finite-difference model in its present format.

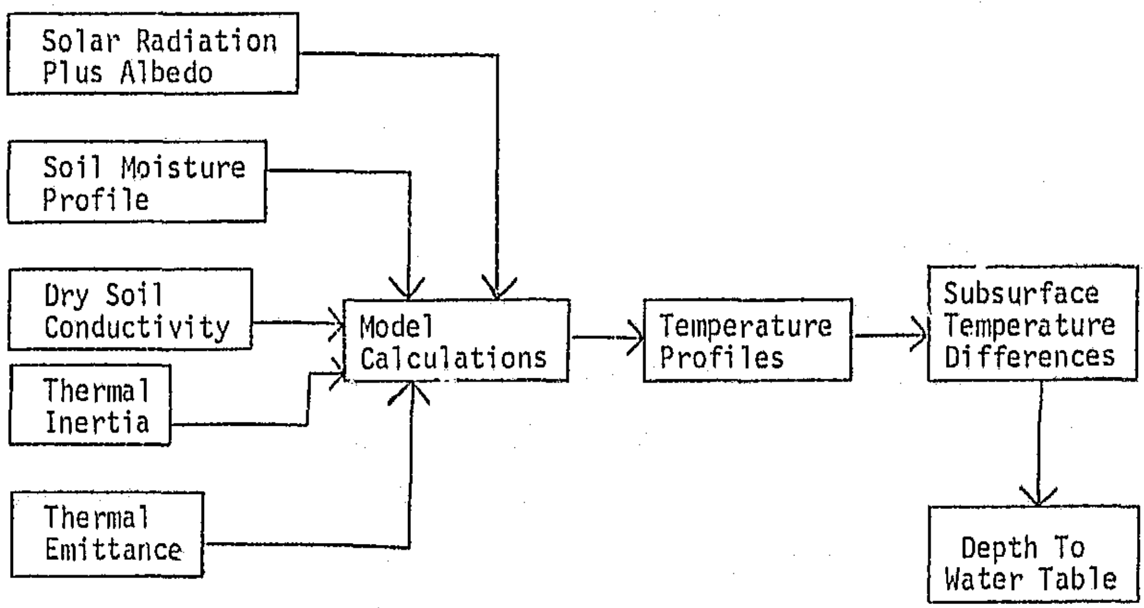

Fig. 2. Future format of the finite-difference model.

The model was modified using field measurements from two fallow plots at the South Dakota State University irrigation farm near Redfield, South Dakota. One plot was irrigated to increase its soil moisture while the other one was left as a dryland plot. Thermocouples were buried on these sites and temperature measurements were taken at depths of 1 cm, 5 cm, 10 cm, 25 cm, and 50 cm. Thermal emittance was measured for both plots using a Barnes PRT-5 mounted on a scanning apparatus. Net radiation and incoming solar radiation and other selected data such as cloud cover and wind velocity were also measured.

Measured and calculated temperature profiles are presently being used to calculate dry thermal conductivity for the soil to allow the model to be used to evaluate the conductivities at each site from measured temperature profiles.

D. Publications

None at this time.

E. Recommendations

None at this time.

F. Funds Expended

Total funds expended for the July→September period were $5,850.09.

G. Data Utility

At this time no spacecraft data have been acquired for examination.

Appendix A

Fortran program for the finite-difference

heat flow simulation model.

```
//*            R LUND CALC OF SOIL PROFILES FOR MUCH AUG 77
// EXEC  FORTHCLG
//FORT.SYSIN  DD  *
C
C    *******************************************************************
C    *     DX IS THE DISTANCE INTERVAL BETWEEN NODAL POINTS IN          *
C    *           CENTIMETERS                                             *
C    *     DT IS THE TIME INTERVAL BETWEEN CALCULATIONS IN SECONDS       *
C    *     M IS THE NUMBER OF EQUALLY SPACED NODAL POINTS                *
C    *     IJ IS THE NUMBER OF PROBLEMS TO BE SOLVED                     *
C    *     IK=1 IF CONDUCTIVITY AND DIFFUSIVITY VALUES ARE TO BE READ IN *
C    *          2 IF CONDUCTIVITY AND DIFFUSIVITY VALUES ARE TO BE       *
C    *          CALCULATED                                               *
C    *     PIT IS THE TIME INTERVAL BETWEEN PRINTOUTS IN SECONDS         *
C    *     CHR IS THE INITIAL STARTING HOUR                              *
C    *     CMIN IS THE INITIAL STARTING MINUTE                           *
C    *     EDAY IS THE NUMBER OF DAYS AFTER THE INITIAL DAY WHEN THE     *
C    *           CALCULATION IS TO STOP                                  *
C    *     EHR IS THE HOUR WHEN THE CALCULATION IS TO END                *
C    *     EMIN IS THE MINUTE WHEN THE CALCULATION IS TO END             *
C    *     TAI IS THE AIR TEMPERATURE  AAA=DELTATEMP                     *
C    *******************************************************************
C
      REAL K1(51),K2(51),KW,KS,KA
      DOUBLE PRECISION AAI,SA(51),SB(51),TA(51),TB(51),ST,HC1(51),
     1HC2(51),CC,DD,FK1,FK2,X21(50),X22(50)
      DIMENSION TDA(400),TDB(400),TDC(400),TDD(400),HOUR(400),
     4JSP(1420),PCTDA(400),DEPTH(400),AI1(400),AI2(400),
     1XO1(400),XO2(400),TDAA(400),PTA(51),PTB(51)
      KKK = 1
    2 READ(5,1000) DX,DT,M,IJ,IK,PIT,CHR,CMIN,EDAY,EHR,EMIN
      READ(5,1001) TAI,AAA
      DEPTH(1)=-1.
      DO 220 L=2,50
  220 DEPTH(L)=DEPTH(L-1)-1.
      J = 0
      NN = 0
      NAC = 0
      MIN=CHR*60 + CMIN
      N = M - 1
      DAY = 0.0
      TIME = 0.0
      CC = 0.0
      DD = 0.0
      IST=1
C
C     SPECIFICATION OF INITIAL TEMPERATURE PROFILE
C     TA(1) CORRESPONDS TO THE SURFACE TEMP, TA(2) CORRESPONDS TO 1 CM ETC.
C
      READ(5,1002)TA(1),TA(2),TA(6),TA(11),TA(26),TA(51),TB(1),TB(2),
     1TB(6),TB(11),TB(26),TB(51)
      DO 105 I=3,5
      TA(I)=((TA(6)-TA(2))/4)*(I-2)+TA(2)
  105 TB(I)=((TB(6)-TB(2))/4)*(I-2)+TB(2)
      DO 106 I=7,10
      TA(I)=((TA(11)-TA(6))/5)*(I-6)+TA(6)
  106 TB(I)=((TB(11)-TB(6))/5)*(I-6)+TB(6)
      DO 107 I=12,25
      TA(I)=((TA(26)-TA(11))/15)*(I-11)+TA(11)
  107 TB(I)=((TB(26)-TB(11))/15)*(I-11)+TB(11)
```

```
      DO 100 I=27,50
      TA(I)=((TA(51)-TA(26))/25)*(I-26)+TA(26)
  100 TB(I)=((TB(51)-TB(26))/25)*(I-26)+TB(26)
      ST = TA(1) - TB(1)
    5 J=J+1
C
C         TESTING IF CONDUCTIVITY AND SPECIFIC HEAT ARE TO BE READ
C         OR TO BE CALCULATED
C
      IF(J.GT.1)GO TO 30
      IF(K.NE.1)GO TO 10
C
C     READ VALUES FOR CONDUCTIVITY AND SPECIFIC HEAT
C
C     READ IN VALUES FOR SPECIFIC HEAT AND COND.
      READ(5,1003)K1(8),K1(25),K1(42),K2(8),K2(25),K2(42),
     1HC1(8),HC1(25),HC1(42),HC2(8),HC2(25),HC2(42)
      GO TO 11
   10 CONTINUE
C
C     IF CONDUCTIVITY AND SPECIFIC HEAT ARE TIME DEPENDENT,
C     CALCULATION SUBROUTINE GOES HERE
C
C          X01,2(X)=PERCENT OF H2O
C          X1=PERCENT OF SOIL
C         HC X S=HEAT CAP
C         CS=(HEAT CAP OF SOIL)
C         CW=(HEAT CAP OF H2O)
C         K1,2(X)=CONDUCTIVITY
      READ(5,1003)X01(8),X01(25),X01(42),X02(8),X02(25),X02(42),X1
      READ(5,1004)KW,KS,KA,GA,CW,CS
      X21(8)=1.-X01(8)-X1
      X22(8)=1.-X02(8)-X1
      X21(25)=1.-X01(25)-X1
      X22(25)=1.-X02(25)-X1
      X21(42)=1.-X01(42)-X1
      X22(42)=1.-X02(42)-X1
      FK1=(2.0/(1+(KS/KW-1.0)*GA)+1.0/(1.0+(KS/KW-1.0)*(1-2*GA)))/3.0
      FK2=(2.0/(1+(KA/KW-1.0)*GA)+1.0/(1.0+(KA/KW-1.0)*(1-2*GA)))/3.0
      K1(8)=(X01(8)*KW+FK1*X1*KS+FK2*X21(8)*KA)/(X01(8)+FK1*X1+FK2*X21(8
     C))
      K2(8)=(X02(8)*KW+FK1*X1*KS+FK2*X22(8)*KA)/(X02(8)+FK1*X1+FK2*X21(8
     C))
      K1(25)=(X01(25)*KW+FK1*X1*KS+FK2*X21(25)*KA)/(X01(25)+FK1*X1+FK2
     C*X21(25))
      K2(25)=(X02(25)*KW+FK1*X1*KS+FK2*X22(25)*KA)/(X02(25)+FK1*X1+FK2
     C*X22(25))
      K1(42)=(X01(42)*KW+FK1*X1*KS+FK2*X21(42)*KA)/(X01(42)+FK1*X1+FK2
     C*X21(42))
      K2(42)=(X02(42)*KW+FK1*X1*KS+FK2*X22(42)*KA)/(X02(42)+FK1*X1+FK2
     C*X22(42))
      HC1(8)=X1*CS+X01(8)*CW
      HC2(8)=X1*CS+X02(8)*CW
      HC1(25)=X1*CS+X01(25)*CW
      HC2(25)=X1*CS+X02(25)*CW
      HC1(42)=X1*CS+X01(42)*CW
      HC2(42)=X1*CS+X02(42)*CW
   11 CONTINUE
      DO 6 I=1,24
      K1(I)=K1(8)-((K1(25)-K1(8))/17.)*(8-I)
```

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```
      K2(I)=K2(8)-((K2(25)-K2(8))/17.)*(8-I)
      HC1(I)=HC1(8)-((HC1(25)-HC1(8))/17.)*(8-I)
    6 HC2(I)=HC2(8)-((HC2(25)-HC2(8))/17.)*(8-I)
      DO 8 I=26,51
      K1(I)=K1(25)+((K1(42)-K1(25))/17.)*(I-25)
      K2(I)=K2(25)+((K2(42)-K2(25))/17.)*(I-25)
      HC1(I)=HC1(25)+((HC1(42)-HC1(25))/17.)*(I-25)
    8 HC2(I)=HC2(25)+((HC2(42)-HC2(25))/17.)*(I-25)
      WRITE(6,2990)X01(8),X01(25),X01(42),X02(8),X02(25),X02(42),
     CHC1(8),HC1(25),HC1(42),HC2(8),HC2(25),HC2(42),K1(8),K1(25),
     CK1(42),K2(8),K2(25),K2(42)
 2990 FORMAT('0X01(8)=',F10.4//' X01(25)=',F10.4//' X01(42)=',F10.4//
     C' X02(8)=',F10.4//' X02(25)=',F10.4//' X02(42)=',F10.4//
     C' HC1(8)=',F10.4//' HC1(25)=',F10.4//' HC1(42)=',F10.4//
     C' HC2(8)=',F10.4//' HC2(25)=',F10.4//' HC2(42)=',F10.4//' K1(8)
     C=',F10.4//' K1(25)=',F10.4//' K1(42)=',F10.4//' K2(8)=',F10.4//
     C' K2(25)=',F10.4//' K2(42)=',F10.4)
      DO 31 I=1,51
      WRITE(6,3000)I,K1(I),I,K2(I),I,HC1(I),I,HC2(I)
 3000 FORMAT('0K1(',I2,')=',F9.5,3X,'K2(',I2,')=',F9.5,3X,'HC1(',I2,')='
     C,F8.5,3X,'HC2(',I2,')=',F8.5)
   31 CONTINUE
   24 AA1=DT/(2*DX*DX)
   26 DO 28 I=1,M
      AI1(I)=AA1/HC1(I)
   28 AI2(I)=AA1/HC2(I)
      GO TO 45
   30 CONTINUE
C
C     CALL SUBROUTINE TO CALCULATE THE SURFACE HEAT FLUX
C
C
      CALL QHEAT(QC,QD,DT,DX,TA,TB,M,CHR,CMIN,TAI)
C     CALCULATION OF INTERNAL NODAL TEMPERATURES
      DO 35 I=2,N
      SA(I)=AI1(I)*((K1(I-1)+K1(I))*TA(I-1)+(1/AI1(I)-K1(I-1)-2*K1(I)-
     1K1(I+1))*TA(I)+(K1(I)+K1(I+1))*TA(I+1))
   35 SB(I)=AI2(I)*((K2(I-1)+K2(I))*TB(I-1)+(1/AI2(I)-K2(I-1)-2*K2(I)-
     1K2(I+1))*TB(I)+(K2(I)+K2(I+1))*TB(I+1))
C
C     CALCULATION OF SURFACE NODAL TEMPERATURES
C
      SA(1)=AI1(1)*(4*DX*QC+(1/AI1(1)-2*K1(1)-2*K1(2))*TA(1)+(2*K1(1)+
     12*K1(2))*TA(2))
      SB(1)=AI2(1)*(4*DX*QD+(1/AI2(1)-2*K2(1)-2*K2(2))*TB(1)+(2*K2(1)+
     12*K2(2))*TB(2))
C
C     CALCULATION OF LOWER BOUNDARY TEMPERATURES
C
      SA(M)=TA(M)
      SB(M)=TB(M)
C
C     REASSIGNMENT OF NODAL TEMPERATURES FOR NEXT ITERATION
C
      DO 40 I=1,M
      TA(I)=SA(I)
   40 TB(I)=SB(I)
C
      IF(TIME.LT.PIT)GO TO 91
      ST = TA(1)-TB(1)
```

```
C
C     THIS PORTION OF THE PROGRAM WRITES OUT THE PERTINENT DATA
C
   45 NHR=OHR
      NMIN=OMIN
      IF(M.GT.92)GO TO 50
      NN=NN+1
      NAN=NN/2
      NAB=NAN*2
      IF(NAB.EQ.NN)GO TO 52
   50 WRITE(6,2000)
C
C          THE FOLLOWING SEQUENCE IS NECESSARY SO ONE MAY PRINT
C          0200 HOURS INSTEAD OF  200 HOURS
C
   52 IF(NHR.GE.9)GO TO 56
      IF(NMIN.GE.9)GO TO 54
      WRITE(6,2001) NAC,NHR,NAC,NMIN
      GO TO 60
   54 WRITE(6,2002)NAC,NHR,NMIN
      GO TO 60
   56 IF(NMIN.GE.9)GO TO 58
      WRITE(6,2003) NHR,NAC,NMIN
      GO TO 60
   58 WRITE(6,2004)NHR,NMIN
   60 WRITE(6,2005)DT
      WRITE(6,2006) TA(1),CC
      WRITE(6,2007) TB(1),CD
      WRITE(6,2008) ST
      WRITE(6,2009)
      WRITE(6,2010)
      WRITE(6,2011)
C
C          THIS WILL PUT THE TABLE OF DATA IN 4 EQUAL COLUMN GROUPINGS
C
      MAN = M/4
      MAD=MAN*4
      KA=M-MAD
      DO 70 NIN=1,MAN
      MOA = NIN
      MMA = MOA
      IF(KA.GE.1) MMA = MMA + 1
      MOB = MMA + MAN
      MMB = MOB
      IF(KA.GE.2) MMB = MMB + 1
      MOC = MMB + MAN
      MMC = MOC
      IF(KA.GE.3) MMC = MMC + 1
      MOD = MMC + MAN
   70 WRITE(6,2012)MOA,TA(MOA),TB(MOA),MOB,TA(MOB),TB(MOB),
     1MOC,TA(MOC),TB(MOC),MOD,TA(MOD),TB(MOD)
      WRITE(6,2011)
      MOA = MOA + 1
      MOB = MOB+ 1
      MOC = MOC + 1
      IF(KA.GE.3)GO TO 72
      IF(KA.GE.2)GO TO 74
      IF(KA.GE.1)GO TO 76
      GO TO 80
   72 WRITE(6,2013)MOC,TA(MOC),TB(MOC),
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```
   74 WRITE(6,2014)MDB,TA(MDB),TB(MDB)
   76 WRITE(6,2015)MDA,TA(MDA),TB(MDA)
      WRITE(6,2007)
      WRITE(6,2009)
C
C     END OF PRINTOUT ROUTINE
C
   80 CONTINUE
      TIME = 0.0
      IF(NAB.NE.AN)GO TO 81
C
C     CONVERTING TEMP FROM DOUBLE PRESISION TO SINGLE FOR PLOT PROGRAM
C
      DO 250 I=1,51
      PTA(I)=TA(I)
  250 PTB(I)=TB(I)
       CALL PLOT A(JSP,10.,35.,-50.,0.,1)
      CALL PLOT B(PTA,DEPTH,'*',50)
      CALL PLOT C('SOIL TEMPERATURE PROFILE FOR SITE A',35,'LEVEL IN CM'
     A,11,'TEMPERATURE',11)
      CALL PLOT A(JSP,10.,35.,-50.,0.,1)
      CALL PLOT B(PTB,DEPTH,'*',50)
      CALL PLOT C('SOIL TEMPERATURE PROFILE FOR SITE B',35,'LEVEL IN CM'
     A,11,'TEMPERATURE',11)
   81 CONTINUE
C
C         TESTING IF CALCULATIONS HAVE RUN FOR DESIRED TIME LENGTH
C
      IF(CMIN.LT.EMIN)GO TO 84
      IF(CHR.LT.EHR) GO TO 84
      IF(DAY.LT.EDAY)GO TO 84
      GO TO 90
   84 CONTINUE
C
C     CAL TO PLOT TEMP DIFFERENCE EVERY 15 MINUTES
  201 MIN=MIN+1
      IF(MIN/(IST*15).GE.1)GO TO 203
      GO TO 210
  203 IST=IST+1
      TDAA(MIN/15)=TA(1)-TB(1)
      TDA(MIN/15)=TA(2)-TB(2)
      TDB(MIN/15)=TA(6)-TB(6)
      TDC(MIN/15)=TA(26)-TB(26)
      TDD(MIN/15)=TA(51)-TB(51)
      HOUR(MIN/15)=TIME/3600.+CHR+CDAY*24.
  210 CONTINUE
C
C     CALCULATION OF NEW TIME
C
      TIME = TIME + DT
      CMIN = CMIN + DT/60.
      IF(CMIN.LT.60)GO TO 88
      CMIN = CMIN - 60.
      CHR = CHR + 1.
      IF(CHR.LT.24)GO TO 88
      CHR = CHR - 24
      DAY = DAY + 1
   88 CONTINUE
      GO TO 5
   90 CONTINUE
```

```
      CALL PLOT A(JSP,0.,25.,-2.,3.,1)
      CALL PLOT B(HOUR,TDAA,'*',96)
      CALL PLOT C('SURFACE TEMPERATURE DIFFERENCE VERSUS TIME',42,
     1'TEMP DIFFERENCE',15,'HOUR',4)
      CALL PLOT A(JSP,0.,25.,-2.,3.,1)
      CALL PLOT B(HOUR,TDA,'*',96)
      CALL PLOT C(' 1CM TEMPERATURE DIFFERENCE VERSUS TIME',39,
     1'TEMP DIFFERENCE',15,'HOUR',4)
      CALL PLOT A(JSP,0.,25.,-2.,3.,1)
      CALL PLOT B(HOUR,TDB,'*',96)
      CALL PLOT C(' 5CM TEMPERATURE DIFFERENCE VERSUS TIME',39,
     1'TEMP DIFFERENCE',15,'HOUR',4)
      CALL PLOT A(JSP,0.,25.,-2.,3.,1)
      CALL PLOT B(HOUR,TDC,'*',96)
      CALL PLOT C('25CM TEMPERATURE DIFFERENCE VERSUS TIME',39,
     1'TEMP DIFFERENCE',15,'HOUR',4)
      CALL PLOT A(JSP,0.,25.,-2.,3.,1)
      CALL PLOT B(HOUR,TDD,'*',96)
      CALL PLOT C('50CM TEMPERATURE DIFFERENCE VERSUS TIME',39,
     1'TEMP DIFFERENCE',15,'HOUR',4)
      KKK = KKK + 1
      IF(KKK.LE.IJ)GO TO 2
 1000 FORMAT(2(F5.0),3(I5),5X,6(F5.0))
 1001 FORMAT(F4.2,F2.1)
 1002 FORMAT(I3F).1)
 1003 FORMAT(6F10.0/6F3.3)
 2005 FORMAT(6F7.4)
 1007 FORMAT(7F4.3)
 2000 FORMAT('1')
 2001 FORMAT(' ','TEMPERATURE PROFILE AT ',4(I1),' HOURS')
 2002 FORMAT(' ','TEMPERATURE PROFILE AT ',2(I1),I2,' HOURS')
 2003 FORMAT(' ','TEMPERATURE PROFILE AT ',I2,I1,I1,' HOURS')
 2004 FORMAT(' ','TEMPERATURE PROFILE AT ',2(I2),' HOURS')
 2005 FORMAT('0','ITERATION INTERVAL IS ',F4.0,' SECONDS')
 2006 FORMAT('0','SURFACE TEMPERATURE TA = ',F6.3,10X,'SURFACE HEAT ',
     1'FLOW IN PROFILE A IS ',F15.10)
 2007 FORMAT(' ',20X,'TB = ',F6.3,10X,'SURFACE HEAT FLOW IN PROFILE',
     1' B IS ',F15.10)
 2008 FORMAT('0','SURFACE TEMPERATURE DIFFERENCE = ',F6.3)
 2009 FORMAT('0')
 2010 FORMAT('0',4(4X,'DEPTH',4X,'TEMP A',5X,'TEMP B'))
 2011 FORMAT(' ')
 2012 FORMAT(' ',4(2X,'*',2X,I3,5X,F6.3,5X,F6.3),2X,'*')
 2013 FORMAT('+',62X,'*',2X,I3,2(5X,F6.3))
 2014 FORMAT('+',32X,'*',2X,I3,2(5X,F6.3))
 2015 FORMAT('+',2X,'*',2X,I3,2(5X,F6.3))
      STOP
      END
      SUBROUTINE OHEAT(CC,CD,DT,DX,TA,TB,M,CHR,CMIN,TAI)
      DOUBLE PRECISION TA(51),TB(51),CC,CD,TTC,TTD,TAU,TTR,TTE
C
C        SIG IS THE STEFAN-BOLTZMANN CONSTANT USED TO CALCULATE THE
C        RADIATION TERM
C
      SIG = 0.000136
      AMIN = CMIN/60.
      AHR = CHR + AMIN
      TAU=AHR-6.75
C
C     CONVERSION OF TEMPERATURES IN DEGREES CENTIGRADE TO
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```
C       DEGREES KELVIN
C
   61 TTE=(TA1+273.16)/100
      TTC = (TA(1) + 273.16)/100.
      TTD = (TB(1) + 273.16)/100.
      TTR = SIG*TTE**4
C
C       CALCULATION OF SURFACE HEAT LOSS TERM
C
      QC=-(SIG*TTC**4-TTR)
      QD = -(SIG*TTD**4-TTR)
C
C       CALCULATION OF SURFACE HEAT FLUX
C          THIS TESTS TO DETERMINE WHETHER THE TIME IS AT NIGHT OR
C          DURING THE DAY (0600 TO 1800 IS DAY)
C
      IF(TAU.LE.0.)GO TO 100
      IF(TAU.GE.13.)GO TO 100
      QC = 0.0094*DSIN(TAU*3.14159/13) + QC
      QD = 0.0094*DSIN(TAU*3.14159/13) + QD
  100 CONTINUE
      RETURN
      END
/*
//GO.FT06F001  DD  SYSOUT=A,DCB=(RECFM=FA),OUTLIM=6000
//GO.SYSIN  DD  *
   1.  60.   31    1    2     3600.   1.          1.   7.   0.
00000050
121134177192205193120137148170204201
0200025004000275025004500549
000142000165000000060012500150000000400000
/*
```