SIMULATION MODEL OF

NITROGEN TILLAGE RESIDUE MANAGEMENT

SYSTEM 3

NTRM - S3

Guide for the Preparation of Input Data Files
and Execution of NTRM-S3

J. A. E. Molina and K. Richard
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Agricultural Experiment Station
University of Minnesota

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GUIDE FOR THE PREPARATION OF INPUT DATA FILES AND EXECUTION OF NTRM-S3

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00754
00761    NTRM-S3 IS A SIMULATION MODEL OF SOIL-CROP-MANAGEMENT DYNAMICS.
00771    AT PRESENT, NTRM-S3 IS A RESEARCH MODEL STILL UNDERGOING MODIFICATIONS.
00781    IT WILL REQUIRE MORE VALIDATIONS AND INPUT-OUTPUT STREAMLINING
00791    BEFORE IT CAN BE CODIFIED IN A FINAL FORM AND BECOME AN EXTENSION PROGRAM.
00801
00811    THIS GUIDE IS FOR USERS WHO WOULD LIKE TO PARTICIPATE IN THE VALIDATION PROCESS.
00821    THE FILES USER1S3 AND USER2S3 ARE FOR USERS WHO PROVIDE THE INPUT DATA
00831    TO THE PROGRAMMER AND INTERPRET THE OUTPUT DATA AND GRAPHICS.
00841    THE REMAINING FILES ARE FOR THE USERS WHO ALSO CREATE THE INPUT DATA FILES
00851    AND EXECUTE NTRM-S3. THE INSTRUCTIONS CONTAINED IN FILES USER3S3 TO USE10S3
00861    ARE NOT SUFFICIENT TO BECOME FLUENT WITH NTRM-S3. RATHER, THEY ARE TO BE CONSIDERED
00871    AS MEMORANDA TO BE USED DURING AND AFTER DEMONSTRATION SESSIONS.
00881
00891    EACH LINE OF THIS GUIDE IS NUMBERED. FUTURE REVISIONS WILL BE LOCALIZED
00901    BY REFERENCE TO LINE NUMBERS. FUTURE VERSIONS WILL BE IDENTIFIED AS NTRM-S4, NTRM-S5, etc.
00902
00903    THE INPUT-OUTPUT FORMAT OF NTRM-S3 IS DESCRIBED IN THIS PUBLICATION.
00904    SOME OPERATIONAL CONCEPTS USED IN NTRM-S3 HAVE ALREADY BEEN PUBLISHED:
00905   .WATER INFILTRATION IN THE SOIL PROFILE, PROGRAM "INFIL" (LINDEN, D. R.1979.
00906    A MODEL TO PREDICT SOIL WATER STORAGE AS AFFECTED BY TILLAGE PRACTICES.
00907    PH.D. THESIS, UNIVERSITY OF MINNESOTA);
00908   .CARBON AND NITROGEN TRANSFORMATIONS IN SOIL, PROGRAM "NCSOIL" (MOLINA, J.A.E., C.E. CLAPP,
00909    M.J. SHAFFER, F.W. CHICHESTER, AND W.E. LARSON.1983. SOIL SCI. SOC. AM. J. 47:85-91);
00911   .SOIL TEMPERATURE (GUPTA, S.C., J.K. RADKE, W.E. LARSON, AND M.J. SHAFFER.1982.
00912    SOIL SCI. SOC. AM. J. 46: 372-376);
00913   .SEVERAL NUMERICAL ANALYSIS PROGRAMS FROM THE COMPUTER LIBRARY OF THE UNIVERSITY OF MINNESOTA.
00915    PLANT GROWTH AND INTERACTION WITH THE SOIL NITROGEN AND SOIL WATER,
00917    SPATIAL AND TIME STRUCTURES WILL BE PUBLISHED AS VALIDATION CASES BECOME AVAILABLE.
00919
00921    SIMULATION OF NITROGEN TILLAGE RESIDUE MANAGEMENT ALSO CAN BE FOUND IN OTHER
00923    VERSIONS OF NTRM (SHAFFER,M.J., AND W.E. LARSON (EDS).1982. NITROGEN-TILLAGE
00925    RESIDUE MANAGEMENT (NTRM) MODEL. TECHNICAL DOCUMENTATION, USDA-ARS, ST. PAUL, MINNESOTA).
00927
00929    ------------------------------------------------------------------------------
```

```
01131   ------------------------------------------------------------------------
01151   [File: USER1S3]
01161
01171
01181    ENVIRONMENTAL INPUT DATA NEEDED FOR NTRM-S3
01191   ------------------------------------------
01192
01193
01194   ------------------------------------------------------------------------
01201
01202   Two types of input variables, environmental and process, are considered.
01211   Environmental input variables are divided into five categories: time-frame; crop; soil;
01221   meteorology; and management. Process variables include specific rates of transformations,
01254   reduction factor functions,etc. Model tuning is used as a research
01255   tool to obtain information about those process variables for which experimental data
01255   are either not available or have been obtained for environmental conditions outside
01256   the range specified by the environmental input data. An exhaustive list
01261   of the environmental and process input variables with their definitions and units
01271   is given in USER9S3. Refer also to USER2S3, where a resume of the initial conditions can be found.
01285
01291   ________________________________________________________________________
01301
01311
01321   TIME-FRAME
01331   __________
01341
01351
01361   Each simulation (a growing season) may cover up to 250 days.
01362   On the last day, final conditions are presented in a way that
01363   facilitates their use as input data for successive runs.
01371
01381        Time-frame input:
01391      -----------------
01401        Starting (initial) and stopping dates of the run.
01411   ________________________________________________________________________
```

CROP

NTRM-S3 computes the actual crop yield from a reference yield which is modified to account for the influence of water, nitrogen, and temperature (figure 1).

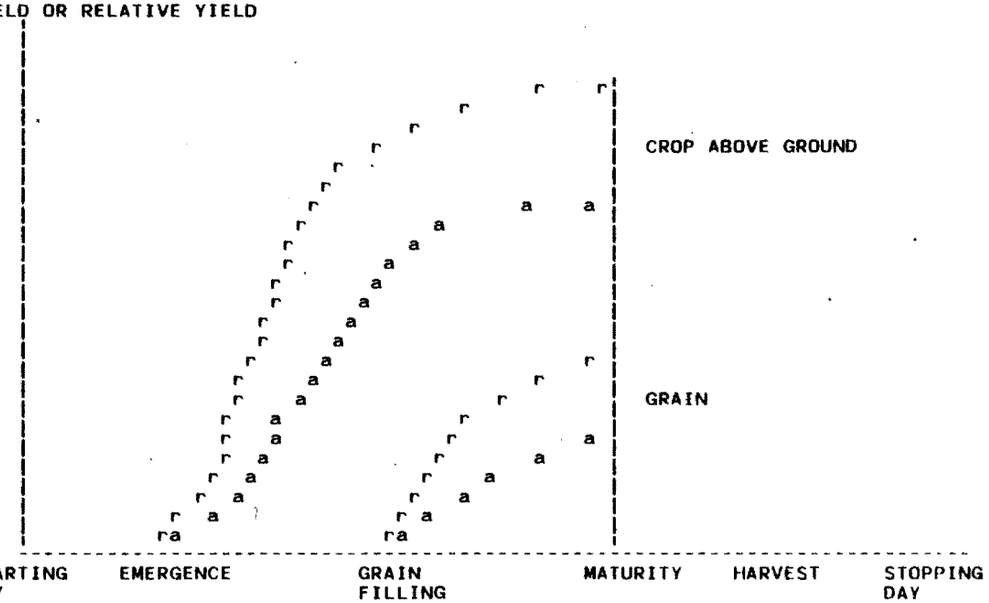


FIGURE 1. ABOVE GROUND AND GRAIN GROWTH CURVES. (r) REFERENCE AND (a) ACTUAL (COMPUTED)

The reference crop yield is defined for a particular field site and a reference set of air temperatures, and assumes neither water nor nitrogen limitations. K, P, and oligoelement limitations inherent to the field can be built into the reference yield. Losses from pests and weed competition are not considered.

NTRM-S3 is not limited to any particular crop.

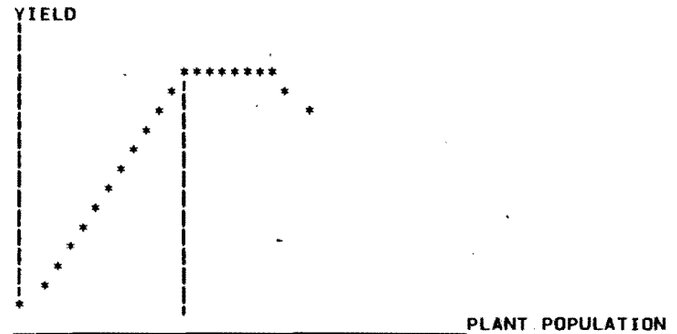
Crop inputs:

1. Type of crop (corn, alfalfa...).
2. Average daily reference air temperature in degrees Celsius (the area 10-year daily average provides an adequate reference temperature).
3. Water content of the crop above ground at harvest (for example W = 15.6% on a dry basis).
4. Nitrogen content of the reference crop assuming no nitrogen limitation, expressed as the ratio of the crop-above-ground N content to dry mass (0% water content) for various growth stages. Up to 10 growth stages (days after emergence) can be defined. For example:

growth stage	N/crop dry mass (g/g)
0 - 15	.020
16 - 30	.019
31 - 45	.018
46 - maturity	.017

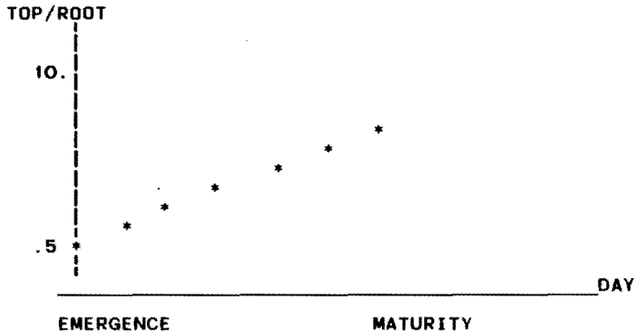
5. Maturity (days or degree days after emergence); if possible, the formula used to estimate the degree days should be given.
6. Beginning of grain filling (days or degree days after emergence or before maturity).
7. Date of emergence.
8. Total crop-above-ground reference yield, (kg/ha at W% water content).
9. Grain reference yield (kg/ha, at W% water content).
10. Reference crop growth curves; at least 4 points for each curve (crop-above-ground and grain) expressed in terms of relative weights (current weight/final weight) vs. days or degree days after emergence (refer to file USER5S3).

11. Optimum plant population (plants/ha): Point beyond which an increase in plant population will not result in yield increase, even for unlimited nutrient and water supply. For crops with tillers, the optimum plant population is expressed in terms of seeds/ha.



12. Actual plant population (plants or germinated seeds/ha, at emergence). It is assumed that the plant population will remain constant until harvest.

13. Ratio of top to root mass for various growth stages. For example:



14. Maximum root depth penetration observed for this crop under optimum soil and climatic conditions. Rooting depth at emergence.

15. If this crop fixes atmospheric nitrogen, number of days after emergence when fixation starts, and number of days or degree days after the beginning of grain filling when fixation stops under optimum conditions.

SOIL

A soil horizon is that layer of the soil profile which is considered homogeneous with respect to input values other than soil temperatures.

Soil temperature can be either computed by a temperature model or directly introduced. In the latter case, soil temperatures are homogeneous within soil "temperature horizons".

Soil inputs:

1. Depth of profile (cm).
2. Depth of plow layer, if any (cm).
3. Number of horizons.
4. For each horizon:
   a. Horizon's depth, from surface to lower boundary (cm).
   b. Initial NH4-N (ppm N).
   c. Initial NO3-N (ppm N).
   d. Initial residual material (residues, roots...) from preceding years (kg/ha).
   e. Ratio of soluble to adsorbed NH4 at equilibrium.
   f. Potentially mineralizable nitrogen (No) of Stanford and Smith (ppm N). If No is not available, give the total nitrogen content of at least the top horizon; if not available, describe the last two growing seasons for that field, in terms of the crop type, organic plus inorganic fertilization, tillage, and residue practices.
   g. Bulk density (g.cm-3).
   h. Initial gravimetric water content (ml.g-1).
   i. Gravimetric water content at field capacity (ml.g-1), or expressed as a percentage of the water content at saturation.
   j. Gravimetric water content (ml.g-1) when plants start to show symptoms of water stress (higher than the "wilting point").
   k. Gravimetric water content (ml.g-1) at saturation (optional).
   l. Saturated hydraulic conductivity (cm.day-1).
   m. Texture; at least indicate if wet soil forms a long, flexible, smooth ribbon when pinched (as opposed to no or rough ribbon).
5. If the soil temperature is directly introduced in NTRM-S3 instead of being computed by the temperature model, the number of soil temperature horizons. For each temperature horizon:
   a. Temperature horizon depth, from surface to lower boundary (cm).
   b. For each temperature horizon, the weekly average temperature (degrees Celsius).

6. Surface conditions:
   a. Slope (%).
   b. Water depression storage (cm, height of potentially ponded water).
7. Bottom conditions:
   a. open profile; or
   b. presence of a water table: depth from surface and NO3-N concentration in water table (the water table level is assumed not to fluctuate during a growing season); or
   c. sealed profile (impermeable clay layer; plastic lining, non-perforated container, etc.).
   d. If drained, depth of drain.
8. Drainage class of the soil profile: Is the profile very poorly to poorly drained (class 0,1); somewhat poorly drained (class 2); or moderately well to excessively well drained (class 3 to 6).
9. If N15 is used, ratio of N15 to total N for the components concerned (NH4, NO3, No, residues from the preceding years).

METEOROLOGY

Water applications are assumed to start at the beginning of the day and to be continuous and regular.

Air temperature can be used as input to the temperature model to compute the soil temperature, or it can be directly introduced in NTRM-S3.

Meteorological inputs:

1. Number of water applications during the growing season (only one application per day: rain, irrigation, snow melt, etc.).
2. For each day of water application:
   a. Date.
   b. Amount applied (cm).
   c. Duration of the application (hours).
   d. NH4-N in water (ppm N).
   e. NO3-N in water (ppm N).
3. Semi-monthly pan evaporation (cm per half month).
4. Air temperature (degrees Celsius).
   a. Input for temperature model: daily minimum and maximum.
   b. Input for NTRM-S3: daily average or daily minimum and maximum and daily reference temperature (long term average).

MANAGEMENT

Management inputs:

1. Choice of the crop (refer to CROP: input number 1,4,5,6,7 8,9,10,11,12 and 13).
2. Irrigation (refer to METEOROLOGY: input number 1 and 2).
3. Number of inorganic nitrogen applications (only one per day).
4. For each day of inorganic nitrogen application:
   a. Date.
   b. NH4-N or urea-N applied (kg N/ha).
   c. NO3-N applied (kg N/ha).
   d. Depth of application: upper and lower limits of application band (cm). For example, 0 cm - 0 cm for surface applied.
5. Number of organic applications (only one per day).
6. For each day of organic application and for the day of harvest:
   a. Date (organic applications or harvest).
   b. Nature of organics (corn stover, manure, etc); if possible, the C/N ratio of the material should be given.
   c. Depth of incorporation: upper and lower limits of application band (cm). See also next question.
   d. If surface applied, the percentage of surface coverage, and the percentage of the material which can be considered in the soil (as opposed to on the soil) should be given.
7. Number of tillages (only one per day).
8. For each tillage:
   a. Date.
   b. Depth of tillage, from surface to lower limit (cm).
   c. Minimum and maximum bulk density of the soil affected by tillage.
   d. If at the time of tillage the soil was covered with residue: percentage surface cover after tillage; percentage of residue cover incorporated in soil.
   e. New saturated hydraulic conductivity of tillage-affected layer (cm.day-1).
   f. New surface depression water storage (ponded water) after tillage.
9. Nitrification inhibitors applied: dates and depth of application; type used.
10. If N15 is used, ratio of N15 to total N for the components concerned (inorganic and organic applications).

```
04911    ------------------------------------------------------------------------------
04921    [File: USER3S3]
04931
04941
04951    EXECUTION OF NTRM-S3 : DEMONSTRATION PACKAGE
04961    ------------------------------------------
04971
04981
04991    ------------------------------------------------------------------------------
05001
05011
05021  The demonstration package requires the following:
05041
05051  .A 1200- or 300-baud, 132-column hard copy terminal with modem
05061
05071  .User number and password to access the CYBER computer
05081      with its corresponding CRAY computer password.
05091      It is recommended that the user become familiar with the
05101      University of Minnesota Computer Center (UCC) system by
05111      reading:'"A Guide to Interactive Computing" and "Guide to
05121      Batch Computing",  which can be obtained from:
05131
05141                University Computer Center
05151                227 Experimental Engineering Bldg.
05161                208 Union St. SE
05181                Minneapolis, MN 55455
05191                (612) 373-4360
05201
05202         The output can be routed to one of the UCC bins (refer
05203      to control statement ROUTE), and, if needed, mailed. It can also
05204      be received on the terminal used to initiate the job;
05211      however, at 1200 bps, noises may develop in the long distance telephone
05221      communication system (Telenet, etc.). Those noises may be avoided
05231      by using a 300 bps link. At 300 bps, the output would
05241      be too long to be printed. Instead, it should be scanned
05251      with the "Xedit" system. At 1200 bps, the demonstration printout time is
05261      about 25 minutes.
```

.Programs and input data files (the names of files in the demonstration package contain the symbol "S3"):

a. BNTRMS3, the relocatable binary code of NTRM-S3
b. GRAS3, the relocatable version of the graphic source code
c. SUBCRS3, the "submit" file of NOS control statements which
   allows user to execute BNTRMS3 as a batch mode from an interactive terminal
d. SUGRAS3, the submit file for GRAS3
e. TOPRES3, the non-linear regression model to obtain the crop coefficients (input file: INPRES3);
f. the source code, NTRMS3; the files SUCRS3 and SUCYBS3, for submitting the source
   code to the CRAY or CYBER computer respectively; and the soil temperature
   model of Dr. S. Gupta are not included in the demonstration package
g. five input data files:

   . 1 data file named INP1S3, assigned to TAPE55, which is the input file (TAPE55=INPUT)
   . 1 data file named TREFS3, assigned to TAPE13, which contains the reference air temperature
   . 1 data file named ACTS3, assigned to TAPE14, which contains the actual air temperature
   . 1 data file named TMDSOS3, assigned to TAPE20, which contains the soil temp generated by the temp model
   . 1 data file named TMDAIS3, assigned to TAPE21, which contains the actual air temp for the temp model

These data files are for demonstration only: They should not be modified.
The user will be shown later how to create new files (refer to USER4S3).

One example of NTRM-S3 execution is presented with the demonstration package; in it,
the temperature model and the regression program are not used.
It is suggested that the user try this example before attempting to create and use new data files.

Combination and names of the data files used in the demonstration package

assigned TAPE	actual air temp.	ref. temp.	soil temp.	other data
TAPE55=INPUT	-	-	INP1S3	INP1S3
TAPE13	-	TREFS3	-	-
TAPE14	ACTS3	-	-	-
TAPE20	-	-	-	-
TAPE21	-	-	-	-

The above combination of data files is made possible by setting in INP1S3 (refer USER9S3):
ITEMP=0; JTEMP=2; and IREFTEM=2.

```
05931     In the following example, large captions are used to represent statements issued from
05941     the computer; small captions are those entered from the terminal.
05951
05961
05971
05981   After the user logs in, prompts the computer by pressing the control return key,
05991   and connects to the CA machine, the computer will ask for a user number:
06001
06011    82/08/09. 08.21.17. TERMINAL:  44, P 40
06021   UOFM CYBER 730 NOS 1.3 (06/13-CW).
06031   FAMILY : ca
06041   USER NUMBER: youruse                                  CYBER user number.
06051   PASSWORD
06061   yourpwd                                               CYBER password.
06071   TERMINAL:   44, P 40/TTY
06081   RECOVER /SYSTEM: batch
06091   $RFL,0.
06101   /acquire,subcrs3                                      Obtain a local copy of the SUBMIT file.
06111   /submit(subcrs3)                                      Execute BNTRMS3 on the CRAY computer.
06112   PASSWORD(ABC1234)
06113   yourpwd                                               CYBER password.
06121   PASSWORD (ABC1234        )
06131   yorcrpw                                               CRAY password.
06141    08.21.18.  SUBMIT COMPLETE.  JOBNAME IS CYBEAWS      When the job is complete, the output will be stored
06151   /catlist                                                as a permanent file on the user's catalog under the
06161      BNTRMS3                                              name CYBEAWS, which appears on the catalog following
06171   /catlist                                                a CATLIST command. A new plot file PLOTS3 containing the
06181      BNTRMS3  CYBEAWS   PLOTS3                           graphic output data will have been generated. CYBEAWS may
06191                                                           be acquired and examined, and the graphs executed.
06192                                                           The operating system report is on CYBEAWS.
06201   /acquire,sugras3                                      Obtain the submit file for the graphic package.
06211   /submit(sugras3)                                      Execute GRAS3 on the CYBER computer.
06221   PASSWORD(ABC1234)
06231   yourpw                                                CYBER password.
06241   08.21.19. SUBMIT COMPLETE. JOBNAME IS AOFIRWJ
06251   /catlist
06261      BNTRMS3   CYBEAWS    PLOTS3   PLOUTS3
06271   /acquire,cybeaws                                      The OUTPUT files from BNTRMS3 (i.e. CYBEAWS) can be
06281                                                           printed at the terminal using the ACQUIRE
06291   /copyei,cybeaws                                         and COPYEI commands. (COPYEI copies one file to
06301                                                           another file; here, the OUTPUT file is the
06311                                                           default file onto which the information is copied and
06321                                                           immediately printed at the terminal).
06331   /acquire,plouts3                                        The graphic file PLOUTS3 generated by GRAS3 is printed.
06341   /copyei,plouts3
06351
06361
06371   /bye                                                  Log off of the computer when this terminal session is over.
06381
06391   ABC1234   LOG OFF    08.35.23.
06401   EFGH044   SRU      1.253 UNTS.
06411
06421
06431
```

Other combinations of data files are possible: For example with
ITEMP=0; JTEMP=2; and IREFTEM=0 the files used would be:

assigned TAPE	actual air temp.	ref. temp.	soil temp.	other data
TAPE55=INPUT	-	-	INP2S3	INP2S3
TAPE13	-	-	-	-
TAPE14	ACTS3	-	-	-
TAPE20	-	-	-	-
TAPE21	-	-	-	-

In this case, reference temperature data are not needed, for they are set equal
to the actual air temperature by the variable IREFTEM=0 in the input file.

```
06831    ------------------------------------------------------------------------------
06841    [File: USER4S3]
06851
06861
06871    USE OF NTRM-S3
06881    ---------------
06891
06901
06911    ------------------------------------------------------------------------------
06921
06931    The use of NTRM-S3 requires 4 steps:
06941         1. If needed, use of the regression program, TOPRES3, to generate
06951            the crop regression coefficients (refer to file USER5S3).
06961         2. Creation of user data files (eventually, use of the temp model: not considered here).
06971         3. Adjustment of the submit file, SUBCRS3, to the conditions of the run.
06981         4. Actual run of NTRM-S3 with user files (refer to file USER3S3).
06991
07011
07021    CREATION OF DATA FILES
07031    ______________________
07041
07051
07061
07071    A data file is created by copying and editing an existing file.
07081    After logging in, the user enters from the terminal:
07091
07101
07111    /acquire,inp1s3                          Retrieve existing file (the input file in this case).
07121    /copyei,inp1s3=yournam                   Create a copy of INP1S3 which will be named YOURNAM.
07131    /xedit,yournam                           Access the text editor to make changes within YOURNAM.
07141
07151
07161
07171     A NOTE ABOUT XEDIT:
07181         XEDIT is a text editor which assists the user in making changes to the user's files.  Familiarity with
07191    XEDIT is very helpful in many operations on the UCC system.  An XEDIT manual, entitled "XEDIT U",
07201    is available from :
07211              University Computer Center
07221              227 Experimental Engineering Bldg.
07231              208 Union Street SE
07241              Minneapolis, Minnesota 55455
07251         For assistance with the use of XEDIT while editing a file, the user may enter the HELP command.
07271    Entering 'HELP,command' will retrieve information about the specified command.
07281    XEDIT commands which are commonly used are: BOTTOM,CHANGE,DELETE,HELP,INSERT,LOCATE,MODIFY,NEXT,PRINT,QUIT, and TOP.
07291
07301
07311    Information about the input file structure is found in the following files:
07321    USER6S3, USER7S3, USER8S3, USER9S3.
07331    Information about the structure of the temperature files is found in file USE10S3.
07341
07351    Files can also be directly created by using either the TEXT, ctrl C, NOSORT, PACK commands,
07361    or the XEDIT system in the INPUT mode.
07371
07381
07391    ____________________________________________________________________________
```

ADJUSTMENT OF THE SUBMIT FILE

The submit file is specific for:

1. The user number.
2. The password.
3. The name of NTRM-S3 binary code file and the names of the five data input files; the job will abort if those five files are not available (not present in the catalog of permanent files, or present but with a name which does not correspond to the one called by the submit file). This requirement applies even if the data in the called file are not used (for example, the air reference temperature file when IREFTEM=0). When the data are not used, the content of the file is not important: an empty file is appropriate.
4. The name of the two output files: CYBEAWS and PLOTS3. PLOTS3 should correspond to the name called by SUGRAS3 (alternately, SUGRAS3 could be edited).

By using the text editor and the "CHANGE" command (abbreviated by"C"), the submit file can be adjusted.

Example:

```
/acquire,subcrs3                                  Acquire the already made submit file SUBCRS3.
/copyei,subcrs3=yoursub                           Create a copy of SUBCRS3; name this copy YOURSUB.
 xedit,yoursub                                    Access the text editor to make changes within YOURSUB.
 XEDIT 3.1
?? t                                              Locate the XEDIT pointer at the top of the file.
?? c/abc1234/youruse/*                            Change all entries of user number ABC1234 to YOURUSE.
?? t
?? c/passwor/yourpwd/*                            Change all occurrences of password PASSWOR to YOURPWD.
.....
.....
?? quit                                           Exit XEDIT.
YOURSUB IS A LOCAL FILE.
/retain,yoursub                                   Save YOURSUB as a permanent file.
```

The SUBCRS3 file

```
/JOB
JAM,STMCR.
/USER
JOB,T=12.
/ACCOUNT
ACQUIRE,DN=BNTRMS3,ID=GVB6O62,UQ,TEXT=^
'A,BNTRMS3.CTASK.',DF=TR.
ACQUIRE,DN=ATRMSIN,ID=GVB6O62,UQ,TEXT=^
'A,ATRMSIN=INP1S3.CTASK.',DF=CB.
ACQUIRE,DN=SOILTEM,ID=GVB6O62,UQ,TEXT=^
'A,SOILTEM=TMDSOS3.CTASK.',DF=CB.
ACQUIRE,DN=AIRTEM,ID=GVB6O62,UQ,TEXT=^
'A,AIRTEM=TMDAIS3.CTASK.',DF=CB.
ACQUIRE,DN=AIRTEM2,ID=GVB6O62,UQ,TEXT=^
'A,AIRTEM2=ACTS3.CTASK.',DF=CB.
ACQUIRE,DN=REFTEM,ID=GVB6O62,UQ,TEXT=^
'A,REFTEM=TREFS3.CTASK.',DF=CB.
DELETE,DN=BNTRMS3,NA.
DELETE,DN=ATRMSIN,NA.
DELETE,DN=SOILTEM,NA.
DELETE,DN=AIRTEM,NA.
DELETE,DN=AIRTEM2,NA.
DELETE,DN=REFTEM,NA.
ASSIGN,DN=ATRMSIN,A=FT55.
ASSIGN,DN=SOILTEM,A=FT2O.
ASSIGN,DN=AIRTEM,A=FT21.
ASSIGN,DN=REFTEM,A=FT13.
ASSIGN,DN=AIRTEM2,A=FT14.
ASSIGN,DN=STEMINT,A=FTO8.
ASSIGN,DN=FERTINT,A=FTO9.
ASSIGN,DN=ORGINT,A=FT1O.
ASSIGN,DN=ATEMINT,A=FT11.
ASSIGN,DN=RTEMINT,A=FT12.
ASSIGN,DN=WASECA,A=FT23.
ASSIGN,DN=PLOTBIN,A=FT33,DC=ST.
LDR,LIB=$FTLIB:MINNLIB,DN=BNTRMS3,USA,SET=ZERO.
DISPOSE,DN=PLOTBIN,DC=ST,DF=CB,WAIT^
TEXT='CTASK.RETAIN,PLOTBIN=PLOTS3.'.
EXIT.
DISPOSE,DN=PLOTBIN,DC=ST,DF=CB,WAIT^
TEXT='CTASK.RETAIN,PLOTBIN=PLOTS3.'.
DUMPJOB.
DEBUG.
/EOF
```

```
08651   ------------------------------------------------------------------------------
08661   [File: USER5S3]
08671
08681
08691   DETERMINATION OF THE CROP REGRESSION COEFFICIENTS
08701   ------------------------------------------------
08711
08721
08731   ------------------------------------------------------------------------------
08741
08751   The program TOPRES3 computes the coefficients which define the
08761   growth curve equations for the relative weight of the crop top or of the grain.
08781
08791   In the following, an example is presented with the data which
08801   were used to compute B0, B1, B2, B3, and B4 (grain coefficients) in the demonstration package.
08811   The independent variable was expressed in terms of degree days.
08821
08831   TOPRES3 contains both the submit NOS control commands, and
08841   the FORTRAN source code for the non-linear regression program (as a CALL to UCC library program).
08851
08861   TOPRES3 calls an input file named INPRES3, and gives the
08871   results in a file named OUTRES3: The name of the input
08881   file should correspond to the name called by TOPRES3.
08891
08911
08921   Structure of the input file INPRES3
08931   ___________________________________
08941
08951
08961   9                                   Integer number of (x,y) data points (a minimum of 8 data points needed).
08971   1.,.002                             Degree-days,relative weight; real data must be used.
08981   25.,.05
08991   50.,.12
09003   200.,.44
09005   300.,.62
09007   400.,.76
09009   500.,.88
91001   600.,1.                             The relative weight "1.0" should correspond to
09011   700.,1.08                           degree days to maturity. The user should extrapolate the curve
09021                                       beyond the maturity point to force the regression curve to pass by "1.0".
09031
09041   ____________________________________________________________________________
```

```
09191   Structure of the output file OUTRES3
09201   ____________________________________
09211
09241
09311
09321
09331            FINAL PARAMETER ESTIMATES:
09341
09351                 A(0) OR B(0) =    .109069E+01
09361                 A(1) OR B(1) =    .335027E-01
09371                 A(2) OR B(2) =   -.236616E+00
09373                 A(3) OR B(3) =    .534318E-4
09375                 A(4) OR B(4) =   -.503921E-7
09381
09391
09393
09395
09401
09411   ____________________________________________________________________________
09421
09431   Execution of TOPRES3
09441   ____________________
09451
09461   a,topres3                              Acquire TOPRES3.
09471   submit(topres3)
09481   PASSWORD (GVB6062)
09491   yourpwd                                Enter your CYBER password.
09501   a,outres3                              Acquire the file which contains the coefficients.
09511   cbf,outres3.
09521
09531   ____________________________________________________________________________
```

```
09571    ------------------------------------------------------------------------------
09581    [File: USER6S3]
09591
09601
09611    EXAMPLE OF INPUT FILE
09621    ---------------------
09631
09641
09651    ------------------------------------------------------------------------------
09661
09671
09681
09691    This data file represents the input file, INP1S3, which was used to produce the
09701    output shown in File USER2S3 with the demonstration package.
09711
09721
09731    Inputs are free formatted; input values are separated by a comma. Integer data are needed for
09741    integer variables, but real variables can receive integer data which will be automatically
09751    adjusted to real data by the system. If in doubt as to the nature of the variable (real or
09761    integer) it is therefore safer to input whole numbers as integers. The meaning and units
09762    of the data can be found in files USER7S3, USER8S3, and USER9S3.
09771
09781    ------------------------------------------------------------------------------
09791    DEMONSTRATION;CORN
09801    0,2,2,1,1,0,1,1,1,1,0,0,1,1,1,3,0,0,0,0
09811    500,500,0
09821    1,1,91,272,79
09831    1.,.1,.05
09841    6,5,0,18
09851    6,18,60,120,144
09861    4
09871    6,24,84,144
09881    26
09891    5.4,6.5,8.2,9.0
09901    8.9,8.0,7.7,8.5
09911    9.4,8.9,8.6,8.7
09921    13.0,12.1,10.1,9.2
09931    10.7,10.4,10.2,9.8
09941    18.4,15.4,11.5,10.2
09951    14.7,13.9,12.7,11.3
09961    11.8,12.7,12.5,11.7
09971    16.4,14.3,12.2,11.6
09981    21.1,18.3,14.2,12.3
09991    18.4,17.4,15.3,13.4
10001    17.9,17.6,15.7,13.9
10011    17.5,16.7,15.4,14.1
10021    16.5,16.1,15.4,14.3
10031    21.8,19.2,15.9,14.4
10041    20.7,19.6,17.2,15.2
10051    21.6,20.2,17.6,15.7
10061    21.7,20.3,18.0,16.1
10071    21.4,20.7,18.4,16.5
10081    16.8,17.2,17.6,16.7
10091    19.9,19.0,17.4,16.3
10101    21.3,19.8,17.8,16.4
10111    19.6,19.7,18.4,16.8
10121    17.7,17.7,17.6,16.3
10131    15.2,16.0,16.7,16.7
10141    16.0,15.5,15.7,15.7
```

```
10281     1.4,1,'SIL',' '
10291     .2,.13,0,12,20,.65
10301     7.4,15
10311     2,10,0,2,36,6,0,105,6,.1,15,15,15,15
10321     1,1,1,1
10331     1.4,1,'SIL',' '
10341     .2,.13,0,12,20,.65
10351     7.4,15
10361     2,10,0,1,8,6,0,52.5,6,.1,15,15,15,15
10371     1,1,1,1
10381     1.4,1,'SILCL',' '
10391     .2,.13,0,5,20,.65
10401     7.4,15
10411     1,2,0,.5,1,6,0,2,6,.1,15,15,15,15
10421     1,1,1,1
10431     1.5,1,'SILCL',' '
10441     .25,.13,0,5,20,.65
10451     7.4,15
10461     1,2,0,.5,1,6,0,2,6,.1,15,15,15,15
10471     1,1,1,1
10481     1.5,1,'SILCL',' '
10491     .25,.13,0,5,20,.65
10501     7.4,15
10511     1,2,0,.5,1,6,0,2,6,.1,15,15,15,15
10521     1,1,1,1
10531     150,160,170,1,10,0,1
10541     .8,.1,.9,6,0
10551     20
10561     10,10
10571     110
10581     1,1,273,0.5,20
10591     1,109
10601     1,91
10611     1
10621     110,18,1.1,1.4,1,0,60,5
10631     0,6,15,15,0,1,1
10641     0,6,1,40,0,.045,.001,50,200,550,1000,.8,'CORN RES','IDUE'
```

```
10741     30
10751     92,2.26,1,0,0
10761     94,1.63,1,0,0
10771     97,10,10,0,0
10781     98,1.57,1,0,0
10791     101,20,2,0,0
10801     103,1.63,1,0,0
10811     104,.51,1,0,0
10821     116,1.42,1,0,0
10831     124,.6,1,0,0
10841     134,.8,1,0,0
10851     149,.1,1,0,0
10861     151,.1,1,0,0
10871     152,.6,1,0,0
10881     157,.3,1,0,0
10891     159,.6,1,0,0
10901     162,.6,1,0,0
10911     163,.1,1,0,0
10921     207,.2,1,0,0
10931     209,.1,1,0,0
10941     211,.4,1,0,0
10951     214,1.5,1,0,0
10961     234,.6,1,0,0
10971     235,1.0,1,0,0
10981     236,.8,1,0,0
10991     239,1.0,1,0,0
11001     241,2.5,1,0,0
11011     250,.6,1,0,0
11021     256,8.15,12,0,0
11031     257,8.15,12,0,0
11041     258,.1,1,0,0
11051     0,0,0,0,0,0,1.96,4.85,6.73,5.51,7.80,8.33
11061     6.76,8.03,7.49,4.90,5.97,4.45,2.13,3.81,0,0,0,0
11071     65000,550,1050,100,150
11081     15000,1.027,4.5377,-.016926,.2227E-4,-.1275E-7
11091     8000,1.0901,3.3502,-.0266,.5243E-4,-.5039E-7,.155,.4,60000
11101     15,.5,.1357,65,.12
11111     50,2.,.22
11121     4,3
11131     10,20,40,60
11141     .55,.5,.45,.4
11151     0,150,.15
11161     9
11171     30,40,45,50,55,65,75,90,110
11181     .03,.0294,.027,.023,.021,.018,.016,.014,.012
11191     ------------------------------------------------------------------------------
```

```
11341  ------------------------------------------------------------------------------
11351  [File: USER7S3]
11361
11371
11381  READ STATEMENTS CALLING THE DATA IN THE INPUT FILE
11391  ------------------------------------------------
11401
11411
11421  ------------------------------------------------------------------------------
11431
11441
11451  List of the READ(55,*) statements (input file declared as TAPE55) in their order of appearance,in NTRM-S3.
11461
11471  ------------------------------------------------------------------------------
11491        READ(55,88) TITLE
11501        READ(55,*) ITEMP,JTEMP,IREFTEM,IDEMD,IPOPT,JSET,N15,NTRANS,
11511       1           ICROP,IFLOW,IGROUP,IENVDAT,NLIMIT,IREDISW,IRED&SN,
11521       2           LBOUND,IREDIS,IDRAIN,NUPLIM,SYMBTI
11531        READ(55,*) IPRINT,IMASS,IFIRSTP
11541        READ(55,*) START,SMONTH,IDYSTR,IDYSTP,IYEAR
11551        READ(55,*) DLTMAX,DLTMIN,DLFLOW
11561        READ(55,*) DELXS,O,QD,PLOTDEP
11571        READ(55,*) (HOR(J),J=1,O)
11581        READ(55,*) (DI(I),I=1,QD)
11591        READ(55,*) JDEP,JCON
11601        READ(55,*) TO
11611        READ(55,*) (THOR(J),J=1,TO)
11621        READ(55,*) NT
11631        READ(55,*) (TT(I),I=1,TO)
11641        READ(55,*) BDH(L),PLASTI(L),TEXTURE(L),TEXTURE(L+O)
11651        READ(55,*) THI(L),TD(L),TS(L),KSAT(L),SLH(L),FCSAT(L)
11661        READ(55,*) BEMP(IX2),AIRENT(IX2)
11671        READ(55,*) ANH3(1),AN03(1),UREA(1),CONC1(1),CONC14(1),CN1(1),
11681       1           CONC6(1),CONC2(1),CN2(1),SERATIO(1),
11691       2           CFNIT(1,1),CFNIT(1,2),CFNIT(1,3),CFNIT(1,4)
11701        READ(55,*) PERN15S(1),PERN15N(1),PER1,PER2
11711        READ(55,*) NIT(1),NIT(2),NIT(3),IDDAY,DAYSYBF,STPSYMB,ENRICN2
11721        READ(55,*) DNITSAT,AERNI,AERDN,CSTDEN,IDRAGE
```

```
      READ(55,*) BBCG
      READ(55,*) ANH3(QS),ANO3(QS)
      READ(55,*) DRAIND
      READ(55,*) BARE,NSEGEVP,LEVAP,DPSTOR,SOIX
      READ(55,*) ITOT,(IADD(K),K=1,ITOT)
      READ(55,*) JTOT,(IORNAP(K),K=1,JTOT)
      READ(55,*) ITIL
      READ(55,*) ITILL(K),TILLD(K),TILBDMN(K),TILBDMX(K),
     1           TILINC(K),TILCOVR(K),TILKSAT(K),TILDSTR(K)
      READ(55,*) (FERT(J),J=1,7)
      READ(55,*) (OFERT(J),J=1,12),IOFERT(I),IOFERT(I+JTOT)
      READ(55,*) IRTOT
      READ(55,*) IRR(I),AMT(I),APPDUR(I),AIRNH3(I),AIRNO3(I)
      READ(55,*) (PAN(I),I=1,12)
      READ(55,*) (PAN(I),I=13,24)
      READ(55,*) PPOP,DDT,DDM,SENESC,SDATE
      READ(55,*) DWMHA,AO,A1,A2,A3,A4
      READ(55,*) YMHA,BO,B1,B2,B3,B4,PERH2O,CPER,PPOPMIN
      READ(55,*) NAIR
      READ(55,*) TMAX,TMIN
      READ(55,*) NREFTEM
      READ(55,*) TMAX,TMIN
      READ(55,*) RTDEPTH,SREMERG,SRSLOPE,ISTSRGR,SLOUGH
      READ(55,*) IRTSLOW,SRGR1,SRGR2
      READ(55,*) NRSTAGE,NRTSEG
      READ(55,*) (NRTPER2(I),I=1,NRSTAGE)
      READ(55,*) (RTPER2(I),I=1,NRSTAGE)
      READ(55,*) DMFCAN,IFCDAY,PEREVAP
      READ(55,*) NSTAGE
      READ(55,*) (NANPER(I),I=1,NSTAGE)
      READ(55,*) (ANPER(I),I=1,NSTAGE)
C-----------------------------------------------------------------------
```

[File: USER8S3]

VARIABLES IN THE INPUT FILE

Inputs are free formatted; input values are separated by a comma. Integer data are needed for integer variables but real variables can receive integer data which will be automatically adjusted to real data by the system. If in doubt as to the nature of a variable (real or integer), it is therefore safer to input whole numbers as integers.

The definition of each variable is found in file USER9S3: Definition of the Variables in the Input File.

. title	TITLE	
. option variables	ITEMP, JTEMP, IREFTEM, IDEMD, IPOPT, JSET, N15, NTRANS,	1 input data record
. option variables	ICROP, IFLOW, IGROUP, IENVDAT, NLIMIT, IREDISW, IREDISN,	
. option variables	LBOUND, IREDIS, IDRAIN, NUPLIM, SYMBTI	
. print variables	IPRINT, IMASS, IFIRSTP	
. time variables	START, SMONTH, IDYSTR, IDYSTP, IYEAR	
. time variables	DLTMAX, DLTMIN, OLFLOW	
. horizon geometry	DELXS, O, QD, PLOTDEP	
. horizon depths	(HOR(J), J=L,O)	
if QD = 1. (skipped if QD=O)		
. hydraulic layer thicknesses	(DI(I), I=1,QD)	
if IGROUP = 1 (skipped if IGROUP=O)		
. segment grouping	JDEP, JCON	
if ITEMP = O soil temperature from input file; skipped if from TAPE2O generated by temp. model (ITEMP=1)		
. # temperature horizons	TO	
. temp. horizon depths	(THOR(J), J=1,TO)	
. # weekly soil temperatures	NT	
. weekly soil temperatures	(TT(I), I=1,TO)	total of
. weekly soil temperatures (more weeks:	one line of temp data per week)	NT lines (weeks)

```
12951    ***************************
12961    **initial properties, horizon 1
12971    *    . texture, bulk density              BDH(L), PLASTI(L), TEXTURE(L), TEXTURE(L+O)
12981    *    . hydraulic properties               THI(L), TD(L), TS(L), KSAT(L), SLH(L), FCSAT(L)
12991    *    . Campbell parameters                BEMP(IX2), AIRENT(IX2)
13001    *                                         ------------------------------------------------------------
13011    *    . chemical, biochemical              ANH3(1), ANO3(1), UREA(1), CONC1(L), CONC14(L), CN1(1)   |
13021    *    . chemical, biochemical              CONC6(1), CONC2(1), CN2(1), SERATIO(1)                   | 1 input data record
13031    *    . chemical, biochemical              CFNIT(1,1), CFNIT(1,2), CFNIT(1,3), CFNIT(1,4)           |
13041    *                                         ------------------------------------------------------------
13051    *    . chemical, biochemical              PERN15S(1), PERN15N(1), PER1, PER2
13061    ***************************
13071    **initial properties, horizon 2,3...
13081    *    .
13091    *    .
13101    *    .
13111    *    .
13121    *    .
13131    *    .
13141    *    .
13151    ***************************
13161         . biochemical                       NIT(1), NIT(2), NIT(3), IDDAY, DAYSYBF, STPSYMB, ENRICN2
13171         . biochemical                       DNITSAT, AERNI, AERDN, CSTDEN, IDRAGE
13181         . water content at lower boundary   BBCG
13191         . nitrogen content at lower boundary ANH3(QS), ANO3(QS)
13201         . drain depth                       DRAIND
13211         . surface properties                BARE, NSEGEVP, LEVAP, DPSTOR, SOIX
13221         . # inorganic applications, dates   ITOT, (IAOD(K), K=1,ITOT)
13231         . # organic applications, dates     JTOT, (IORNAP(K), K=1,JTOT)
```

```
13311       . # tillage                          ITIL
13321                                            ------------------------------------------------------
13331       . tillage data                       ITILL(K), TILLD(K), TILBDMN(K), TILBDMX(K),          | 1 input data | total
13341       . tillage data                       TILINC(k), TILCOVR(K), TILKSAT(k), TILDSTR(k)        | record line  | of
13351                                            ------------------------------------------------------            | ITIL
13361       . tillage data  | more tillage | 1 input data                                                        | record
13371       . tillage data  | data         | record line                                                         | lines
13381       . inorganic fertilizer composition     (FERT(J), J=1,7)  | total of ITOT
13391       . inorganic fertilizer composition, (more applications)  | record lines (applications)
13401       . organic composition                  (OFERT(J), J=1,12), IOFERT(I), IOFERT(I+JTOT) | total of JTOT
13411       . organic composition, (more applications)                                           | record lines (applications)
13421       . # water applications                 IRTOT
13431       . water dates, composition             IRR(I), AMT(I), APPDUR(I), AIRNH3(I), AIRNO3(I)| total of IRTOT
13441       . water dates, composition, (more applications)                                      | record lines (applications)
13451       . semimonthly pan evaporation          (PAN(I), I=1,12)
13461       . semimonthly pan evaporation          (PAN(I), I=13,24)
13471       . crop data                            PPOP, DDT, DDM, SENESC, SDATE
13481       . crop data                            DWMHA, AO, A1, A2, A3, A4
13483       . crop data                            YMHA, BO, B1, B2, B3, B4, PERH2O, CPER, PPOPMIN
13491    ------------------------------------------------
13501    |if JTEMP = 0  air temp. from input file; skipped if from TAPE14 (JTEMP=2); or from TAPE21 generated by temp. model (JTEMP=1)
13511    |   . # daily air temperatures           NAIR
13521    |   . daily max. and min. air temp.      TMAX, TMIN  | total of NAIR
13531    |   . daily max. and min. air temp. (more days)      | record lines
13561    ------------------------------------------------
13571    |if IREFTEM=1 ref. temp. from input file; skipped if from TAPE13 (IREFTEM=2); or if IREFTEM=0 (ref.equal actual temp.)
13581    |   . # daily reference temperatures     NREFTREM
13591    |   . daily max. and min. reference temp.  TMAX, TMIN  | total of NREFTEM
13601    |   . daily max. and min. reference temp. (more days)  | record lines
13611    ------------------------------------------------
13621       . root data                            RTDEPTH, SREMERG, SRSLOPE, ISTPRGR, SLOUGH
13631       . root data                            IRTSLOW, SRGR1, SRGR2
13641       . root data                            NTRSTAGE, NRTSEG
13651       . root data                            (NTRTPER2(I), I=1,NRSTAGE)
13661       . root data                            (RTPER2(I), I=1,NRSTAGE)
13671       . evapotranspiration data              DMFCAN, IFCDAY, PEREVAP
13681       . # growth stages                      NSTAGE
13691       . last day of each stage               (NANPER(I), I=1,NSTAGE)
13701       . N/dry mass ratios                    (ANPER(I), I=1,NSTAGE)
13711     ------------------------------------------------------------------------
```

```
13861    ------------------------------------------------------------------------------
13871    [File:USER9S3]
13881
13891     DEFINITION OF THE VARIABLES IN THE INPUT FILE
13901    ------------------------------------------------
13911
13921
13931    ------------------------------------------------------------------------------
13941
13951     Variables are listed in their order of appearance in NTRM-S3.
13961
13971     Stars (*****) mark end of records.
13981
13991
14001
14011    TITLE        title of job, up to 80 characters
14021   *****
14031    ITEMP     =0 soil temperatures must be included in the input data file
14041              =1 soil temperatures obtained from tape 20, as generated by the temperature model
14051    JTEMP     =0 daily maximum and minimum air temperatures must be included in the input data file
14061              =1 air temperatures obtained from TAPE 21, as generated by the temperature model
14071              =2 air temperature obtained from TAPE14
14073    IREFTEM   =0 reference temperature equal actual air temperature
14075              =1 reference temperature read from INPUT file
14077              =2 average daily reference temperature read from TAPE13
14081    IDEMD     =1 nitrogen crop uptake is interactive with the availability of nitrogen in the soil
14091              =0 unlimited supply of nitrogen available
14101    IPOPT     =0 conductivity and diffusivity are computed by user supplied functions
14111              =1 conductivity and diffusivity computed by Campbell's method.
14121    JSET      =0 actual root growth is equal to potential root growth
14131              =1 root growth interactive with soil water content, bulk density, and temperature
14141    N15       =0 N15 data are not considered
14151              =1 N15 data are considered
14161    NTRANS    =0 biological nitrogen and carbon transformations in soil are not considered
14171              =1 biological nitrogen and carbon transformations in soil are considered
14181    ICROP     =0 plant model not called
14191              =1 plant model activated
14201    IFLOW     =0 mass flow transport of soluble inorganic nitrogen is not activated
14211              =1 mass flow transport of soluble inorganic nitrogen is activated
14221    IGROUP    =0 biological nitrogen transformations are considered separately for each segment
14231              =1 several segments are homogenized and considered as a unit with respect to
14241                 biological soil transformations
14251    IENVDAT   =0 set to zero unless WASECA data are considered
14261              =1 daily maximum and minimum air temperatures, precipitation,
14271                 and pan evaporation are obtained from TAPE23  (WASECA data)
```

```
14411    NLIMIT   =0 nitrogen stress affecting crop growth is defined by the ratio
14421                of actual N uptake to N demand
14431             =1 nitrogen limitation of crop growth is defined by the deviation of
14441                N percentage in actual crop from the N percentage of the reference crop
14451    IREDISW  =0 water uptake is restricted by root distribution
14461             =1 crop may obtain needed water from anywhere within
14471                root zone, unrestricted by root distribution
14481    IREDISN  =0 nitrogen uptake is restricted by root distribution
14491             =1 crop may obtain required nitrogen from any segment within
14501                root zone, limited by nitrogen availability but not by root distribution
14511    LBOUND   =1 lower boundary is sealed                                  | profile with many saturated segments (large water
14521             =2 water table: lower boundary is maintained at saturation  | input, IDRAIN=0, LBOUND=1 or 2) will cause high cost
14531                                                                         | of run or time limit which can be avoided by
14541                                                                         | the use of IGROUP=1
14551             =3 water content of the lower boundary is maintained at a   |
14561                constant value less than saturation
14571    IREDIS   =0 water redistribution via water field capacity
14581             =1 water redistribution via finite differences (high cost of run, time limit are likely)
14591    IDRAIN   =0 no drain is present
14601             =1 a drain is considered
14611    NUPLIM   =0 nitrogen uptake is limited by available water above the
14621                water stress point and the current N concentration
14631             =1 nitrogen uptake is limited by evapotranspiration (crop
14641                water uptake) and current N concentration
14651    SYMBTI   =0 no symbiotic nitrogen fixation
14661             =1 symbiotic nitrogen fixation
14671    *****
14681     IPRINT      (day) number of days between output; e.g. for IPRINT = 2
14691                 output printed every other day beginning with the first day of run; if IPRINT=500, only one
14701                 output given on the last day of run
14711     IMASS       (day) number of days between water and nitrogen mass balance output,
14721                 beginning with the first day of the run.
14731                 if IMASS=500, only one mass balance given on the last day of run
14741     IFIRSTP     (day) number of days past first day of run for which an output
14751                 will be printed ( independent of IPRINT).
14761    *****
14771     START       reference day   | for START=1 and SMONTH=1,
14781     SMONTH      reference month | Julian days are considered
14791     IDYSTR      (day) first day of run, relative to the reference day-month
14801     IDYSTP      (day) last day of run relative to the reference day-month (Julian days if START=1 and SMONTH=1)
14811     IYEAR       (year) last  two digits of the year being considered
14821    *****
```

```
14841    DLTMAX      (day <1) maximum computational time step (used when there is no
14851                water infiltration)
14861    DLTMIN      (day <DLTMAX) minimum computational time step (used when there
14871                is water infiltration)
14881    DLFLOW      (day <DLTMIN) maximum computational time step when water redistribution  by finite differences is considered
14891    *****
14901    DELXS       (cm) segments' thickness
14911    O           number of horizons
14921    QD          number of hydraulic layers (if QD = O, the profile geometry
14931                for hydraulic processes will be set internally using default values)
14941    PLOTDEP     (cm) depth  at which the profile is divided for summarizing data
14951                which will be plotted.
14961    *****
14971    HOR(J)      (cm) depth from surface to lower boundary of horizon J
14981                HOR(lowest horizon)/DELXS should be an integer .LE. 25
14991    *****-------------------------------------------------------
15001    DI(I)       (cm) thickness of hydraulic layer I, I = 1 to QD  ¦ present only if QD=1, skipped if QD=O. (internally set)
15011    *****-------------------------------------------------------------------------------------------------------------
15021    JDEP        segment at which segment grouping (JDEP included) begins for biological transformations  ¦ present only if IGROUP=1
15031    JCON        number of segments incuded within each group                                             ¦ skipped if IGROUP=O
15041    *****-------------------------------------------------------------------------------------------------
15051    TO          number of temperature horizon ( up to 4)                                 ¦ from input file
15061    *****                                                                                ¦
15071    THOR(J)     (cm) depth from surface to lower boundary of temperature horizon J;      ¦ if ITEMP=O;
15081                depth of lowest boundary must be equal to depth of                       ¦ skipped
15091                lower boundary of horizon O.  THOR(J) .GT .DELXS.                        ¦ (generated by the temp model)
15101    *****                                                                                ¦
15111    NT          number of weekly soil temperatures to span from IDYSTP to IDYSTR         ¦ if
15121    *****                                                                                ¦
15131    TT(I)       (oC) weekly temperature of temperature horizon I                         ¦ ITEMP=1
15141    *****-------------------------------------------------------------------------
15151    BDH         (gm.cm-3) volumetric mass of the soil, assimilated to the bulk density
15161    PLASTI   =1 for clay, silty clay, silty clay loam, clay loam, and sandy loam horizons
15171            =O for any other textural class
15181    TEXTURE     texture (8 alphanumeric characters available)
15191    TEXTURE     texture (8 alphanumeric characters available)
15201    *****
15211    THI         (cm3.gm-1) gravimetric initial water content
15221    TD          (cm3.gm-1) gravimetric water content at water stress point
15231    TS          (cm3.gm-1) gravimetric water content at saturation; if TS=O. the saturation value is computed
15241    KSAT        (cm.day-1) saturated hydraulic conductivity
15251    SLH         (cm) suction at the wetting front
15261    FCSAT       ratio of soil water field capacity to water content at saturation
15271    *****
```

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15331    BEMP          empirical constant          |required for calculation of conductivities and diffusivities by Campbell's
15341    AIRENT        (cm) air-entry potential    |method; dummy data needed even if IPOPT=0
15351    *****
15361    ANH3          (ug.gm-1) NH4-N initial concentration
15371    ANO3          (ug.gm-1) NO3-N initial concentration
15381    UREA          (ug.gm-1) urea-N initial concentration
15391    CONC1         (ug.gm-1) labile nitrogen pool I
15401    CON14         (ug.gm-1) recalcitrant nitrogen pool I
15411    CN1           C/N ratio pool I
15421    CONC6         (ug.gm-1) till pool II nitrogen
15431    CONC2         (ug.gm-1) pool II, nitrogen
15441    CN2           C/N ratio pool II
15451    SERATIO       ratio of soluble to total NH4-N; must be .LE. 1
15461    CFNIT(j,4)    (ug.gm-1.day-1) rate of NH4-N oxidation (nitrification)
15471                  possibility of 4 different rates of nitrification per growing season
15481    *****
15491    RERN15S       ratio N15 to total N in NH4                | =0
15501    PERN15N       ratio N15 to total N in NO3                | if
15511    PER1          ratio N15 to total N in pool I             | N15=0
15521    PER2          ratio N15 to total N in pool II            |
15531    *****
15541    NIT(3)        (day) last day of the time intervals corresponding to
15551                  the 4 nitrification rates  (CFNIT(I))
15561    IDDAY     =0  crop growth independent variable: days
15571              =1  crop growth independent variable: degree days
15581    DAYSYBF       (day) number of days after emergence when symbiotic        | dummy data
15591                  nitrogen fixation starts                                   | needed
15601    STPSYMB       symbiotic nitrogen fixation stops, days or degree days     | even if
15611                  after beginning of grain filling; use days or degree days  | SYMBTI=0
15621                  consistently with IDDAY                                    |
15631    ENRICN2       ratio N15 to total N in N2 atmospheric (=0 if N15=0)
15641    *****
15651    DNITSAT       fraction of water saturation corresponding to AERNI and
15661                  AERDN. Must be .GT. FCSAT, and .LT.1.
15671    AERNI         reduction factor for the nitrification rate at DNITSAT*100
15681    AERDN         reduction factor for the denitrification rate at DNITSAT*100
15691    CSTDEN        (ppmC,ppmN -1) denitrification's constant at soil water saturation
15701    IDRAGE    =1  very to somewhat poorly drained profile (class 0, 1, or 2)
15711              =0  moderately well- to excessively well-drained profile (class 3 to 6)
15721    *****
15731    BBCG          (cm3,gm-1) gravimetric water content in the bottom hydraulic layer (segment QS);
15741                  time invariant; .GE.TD(0); relevant only if IREDIS=1 and LBOUND=3;
15751                  dummy datum .GT.0 needed in other cases: LBOUND=1, or 2 ; internally set to saturation if LBOUND=2
15761    *****
15771    ANH3(QS)      (ug.gm-1) soluble NH4-N in bottom segment (QS)   | relevant only if LBOUND=2;
15781    ANO3(QS)      (ug.gm-1)  NO3-N in bottom segment (QS)          | dummy data needed in other cases (LBOUND=1,or 3)
15791    *****
15801    DRAIND        (cm) depth of drain; relevant only if IDRAIN = 1; dummy datum needed if IDRAIN=0
15811    *****
15821    BARE          fraction of surface that is not covered by residue on day IDYSTR.
15822                  BARE will be changed by TILCOVR or OFERT(12).
15831                  The reduction in evaporation due to residues is (1.-BARE).
15841    NSEGEVP       number of upper segments from which water may be evaporated
15851    LEVAP         (day) number of days after IDYSTR when evapotranspiration ceases and evaporation resumes;
15852                  a linear decrease in transpiration is assumed between SENESC and LEVAP
15861    DPSTOR        (cm) depression storage
15871    SOIX          microporous soil stability factor
15881    *****
```

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15941    ITOT        number of inorganic nitrogen applications (including urea); enter 0 if no application
15951    IADD        (day) number of days after IDYSTR corresponding to dates of inorganic
15961                nitrogen applications; skipped if ITOT=0
15971    *****
15981    JTOT        number of organic applications; enter 0 if no application
15991    IORNAP      (day) number of days after IDYSTR corresponding to dates of organic applications (skipped if JTOT=0)
16001    *****
16011    ITIL        number of tillage events; enter 0 if no tillage
16021    *****
16031                skip the whole record if ITIL=0
16041    ITILL       (day) number of days after IDYSTR corresponding to dates of till events.
16042                If fertilizer or residue applications and incorporation by tillage are done on the same day,
16043                the tillage is assumed to occur one day after the application (refer TILCOVR and OFERT(12)).
16051    TILLD       (cm) depth of tillage
16061    TILBDMN     (gm.cm-3) bulk density of affected segments, following tillage
16071    TILBDMX     (gm.cm-3) final bulk density to which tilled segments will settle
16081    TILINC      fraction of material in segment 1 (soil surface) incorporated after till
16091    TILCOVR     fraction of soil surface still covered by residue after tillage.
16092                OFERT(12) will be changed to TILCOVR if ITILL.GT.IORNAP.
16101    TILKSAT     (cm.day-1) saturated hydraulic conductivity in top horizon following tillage
16111    TILDSTR     (cm) depression storage after tillage
16121    *****
16131                skip the whole record if ITOT=0
16141    FERT(1)     (cm) depth from surface to upper portion of N fertilizer band | for surface application, set FERT(1)=FERT(2)=0
16151    FERT(2)     (cm) depth from surface to lower portion of N fertilizer band | application will be incorporated in segment 2
16161    FERT(3)     (kg.ha-1) fertilizer NH4-N added
16171    FERT(4)     (kg.ha-1) fertilizer NO3-N added
16181    FERT(5)     (kg.ha-1) fertilizer urea-N added
16191    FERT(6)     ratio N15 to total N in NH4 fertilizer  | =0 if
16201    FERT(7)     ratio N15 to total N in NO3 fertilier   | N15=0
16211    *****
16221                skip the whole record if JTOT=0
16231    OFERT(1)    (cm) depth from surface to upper portion of organic fertilier band   | for OFERT(1)=OFERT(2)=0. the carbon amount
16241    OFERT(2)    (cm) depth from surface to lower portion of organic application band | indicated by OFERT(8) and OFERT(9) will be
16251                                                                                    | incorporated in segment 2. For the same
16261                                                                                    | application, whatever values given to
16271                                                                                    | OFERT(1) and OFERT(2), the carbon
16281                                                                                    | amount indicated by
16291                                                                                    | OFERT(10) and OFERT(11) will be stored
16301                                                                                    | on the surface (segment 1), to be
16311                                                                                    | incorporated in the soil by subsequent
16321                                                                                    | tillages
16331    OFERT(3)    ratio N15 to total N in organic application band; =0 if N15=0
16341    OFERT(4)    carbon nitrogen ratio of the organic applied; if the organic
16351                compound does not contain nitrogen, set C/N ratio .GE. 10.000
16361    OFERT(5)    .EQ.1 if C/N ratio .GE.10000
16371                .NE.1 if C/N ratio .LT.10000
16381    OFERT(6)    (day-1) specific rate of decomposition for the labile fraction
16391    OFERT(7)    (day-1) specific rate of decomposition for the recalcitrant fraction
16401    OFERT(8)    (kg.ha-1) organic-C applied and incorporated in soil, labile portion
16411    OFERT(9)    (kg.ha-1) organic-C applied and incorporated in soil, recalcitrant portion
16421    OFERT(10)   (kg.ha-1) organic C applied on surface (segment 1), labile portion
16431    OFERT(11)   (kg.ha-1) organic C applied on surface (segment 1), recalcitrant portion
16441    OFERT(12)   fraction of surface coverage after organic application. If this application is used to directly input
16451                organic matter in the soil on day IDYSTR (for example, roots from the preceding years), the fraction
16461                of surface coverage should be equal to (1.-BARE).
16462                TILCOVR will be changed to OFERT(12) if IORNAP.GT.ITILL.
16471    IOFERT      | alphanumeric identifier for organic application I,
16481    IOFERT      | 2 strings with .LT.8 characters per string
16491    *****
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16551    IRTOT       number of water applications; enter 0 if no application
16561    *****
16571                skip the whole record if IRTOT=0
16581    IRR         (day) number of days after IDYSTR corresponding to the dates of water applications
16591    AMT         (cm) amount of water applied
16601    APPDUR      (hr) duration of water application; should be .LE. 24 hours
16611    AIRNH3      (ug.cm-3) NH4-N concentration in the water
16621    AIRNO3      (ug.cm-3) NO3-N concentration in the water
16631    *****
16641    PAN         (cm.half month-1) pan evaporation
16651    *****       2 records: first record to cover January to June (12 data);
16661    PAN         second record to cover July to December
16671    *****
16681    PPOP        (plant.ha-1) actual plant population
16691    DDT         (day or degree day) after emergence to beginning of grain filling       | use days or degree days
16701    DDM         (day or degree day) after emergence to maturity                         | consistently
16711    SENESC      onset of senescence, days or degree days before maturity (see LEVAP)    | with IDDAY
16721    SDATE       (day) after IDYSTR to emergence
16731    *****
16741    DWMHA       (kg.ha-1) potential yield of reference crop (crop-above-ground; PERH2O water content)
16751    AO          | regression coefficients of the growth curve equation for relative total weight;
16761    A1          | for their determination, use days or degree days consistently
16771    A2          | with IDDAY
16773    A3          |
16775    A4          |
16777    *****
16781    YMHA        (kg.ha-1) potential grain yield of reference crop (PERH2O water content)
16791    BO          | regression coefficients of the growth curve for the relative grain weight;
16801    B1          | for their determination, use days or degree days consistently
16811    B2          | with IDDAY
16813    B3          |
16815    B4          |
16821    PERH2O      water content of crop (expressed as a ratio: .15 for example)
16831    CPER        carbon content of crop on a dry basis (expressed as a ratio: .43 for example)
16841    PPOPMIN     (plant,ha-1) optimum plant population of reference crop
16851    *****-------------------------------------------
16861    NAIR        number of daily air temperatures          | first data pair corresponds to day IDYSTR, daily
16871    *****                                                 | thereafter up to IDYSTP; NAIR=IDYSTP-IDYSTR
16881    TMAX        (oC) maximum air temperature              | from input file if ITEMP=0;
16891    TMIN        (oC) minimum air temperature              | skipped if ITEMP=1, or 2
16951    *****-----------------------------------------------------------
16961    NREFTEM     number of daily max-min reference temp. data pair   | first data pair corresponds to day IDYSTR, daily
16971    *****                                                           |
16981    TMAX        (oC) daily maximum reference air temp.              | thereafter up to IDYSTP; from input file if IREFTEM=1;
16991    TMIN        (oC) daily minimum reference air temp.              | skipped if IREFTEM=0, or 2
17001    *****-----------------------------------------------------------
17003    RTDEPTH     (cm) rooting depth at emergence
17011    SREMERG     shoot to root ratio at emergence
17021    SRSLOPE     slope of linear relationship defining shoot to root ratio as a
17031                function of days past emergence
17040    ISTPRGR     number of days past emergence when roots mass does not increase
17041    SLOUGH      fraction of root growth that is sloughed off
17051    *****
17061    IRTSLOW     number of days past emergence when root penetration rates change
17071    SRGR1       (cm.day-1) first root penetration rate
17081    SRGR2       (cm.day-1) second root penetration rate
17091    *****
17101    NRSTAGE     number of root stages; must be .LE. 10
17111    NRTSEG      number of upper segments which contain RTPER2 root fraction
17121    *****
```

```
17191    NRTPER2     (day) number of days after emergence, corresponding to the last day of each
17201                growth stage for root fraction distribution
17211    *****
17221    RTPER2      fraction of total root mass increase found in the NRTSEG top segments
17241    *****
17251    DMFCAN      (kg.ha-1) crop-above-ground yield when full canopy first reached| either DMFCAN or IFCDAY should
17261    IFCDAY      number (integer) of days or degree days past emergence         | be zero
17271                when full canopy is first reached. (consistency with IDDAY)    | on the input file
17281    PEREVAP     constant fraction of total evapotranspiration that remains evaporation
17291                following full canopy
17301    *****
17311    NSTAGE      number of growth stages for which different plant nitrogen
17321                percentages are considered; must be .LE. 10
17331    *****
17341    NANPER      (day) number of days after emergence, corresponding to the last day of each
17351                growth stage for nitrogen percentages; last day of last growth stage must
17361                be equal or close to the number of days after emergence to maturity (even if DDM
17362                is expressed in degree days)
17371    *****
17381    ANPER       nitrogen to dry mass ratio in crop-above-ground for each growth stage
17391    ------------------------------------------------------------------------------
17401
```

```
17471   ------------------------------------------------------------------------------
17481   [File : USE1OS3]
17491
17501
17511   EXAMPLE OF AIR TEMP DATA FILES
17521   ------------------------------
17531
17541
17551   ------------------------------------------------------------------------------
17561
17571   There are two types of air temperature data files: the actual temperature,and the reference temperature.
17631
17641   The actual temperature data file is read by the statement : READ(14,*,END=520) ITDAY,TMAX,TMIN
17651   The structure of the actual air temperature file is as follows:
17661   ITDAY: day (from first to last day of run); TMAX and TMIN: maximum and minimum daily temperature.
17671
17681   91,15.7,5.8
17691   92,7.2,.7
17701   93,7.7,.8
17711   94,8.2,.9
17721   ........
17731
17741
17751
17771
17781   The reference temperature data file is read by the statement : READ(13,*,END=926) ITDAY,TAVE
17791   The structure of the reference air temperature data file is as follows:
17801   (TAVE= average daily temperature)
17811
17821   91,6.0
17831   92,6.0
17841   93,5.5
17851   94,6.2
17861   ......
17871
17881  ------------------------------------------------------------------------------
```

```
17891  ------------------------------------------------------------------------------
17901  [FILE USER2S3]
17911
17921
17931  EXAMPLE OF NTRM-S3 OUTPUT
17941  -------------------------
17951
17961
17971
17981
17991  ------------------------------------------------------------------------------
18001
18011  THE OUTPUT IS DIVIDED INTO TWO FILES:
18013
18021    1. ONE DATA FILE WHICH CONTAINS:
18031         a.  A RESUME OF THE INPUT DATA (INITIAL CONDITIONS)
18041             b.  OUTPUT DATA. FOR FREQUENCY OF OUTPUT
18051                 REFER TO VARIABLES; IPRINT, IMASS, IFIRST (FILE USER9S3)
18061             c.  FINAL CONDITIONS PER SOIL HORIZON
18071             d.  OPERATING SYSTEM REPORT
18081    2. GRAPHS: ONLY THOSE OUTPUT DATA WHICH ALLOW FOR A RAPID DIAGNOSIS OF THE SOIL-CROP-
18083               MANAGEMENT BEHAVIOR HAVE BEEN GRAPHED.
18091
18101
18111  THE SAMPLE OUTPUT, OBTAINED WITH THE DEMONSTRATION PACKAGE, CAN BE FOUND IN THE FOLDER POCKETS.
18121
18131  THE PRINTOUT TIME FOR THIS OUTPUT (DATA PLUS GRAPHS) AT 1200 BAUD IS 25 MINUTES
18141
18151  ------------------------------------------------------------------------------
```