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Supporting Research

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AS-BUILT DOCUMENTATION OF PROGRAMS TO IMPLEMENT THE ROBERTSON AND DORAISWAMY/THOMPSON MODELS

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16. Abstract

This document describes the software which implements two spring wheat phenology models, the Robertson model and the Doraiswamy/Thompson model.

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AS-BUILT DOCUMENTATION OF PROGRAMS TO IMPLEMENT THE ROBERTSON AND DORAISWAMY/THOMPSON MODELS

Job Order 71-302

This report describes the activities of the Supporting Research project of the AgRISTARS program.

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PREFACE

The Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing is an 8-year program of research, development, evaluation, and application of aerospace remote sensing for agricultural resources, which began in fiscal year 1980. This program is a cooperative effort of the National Aeronautics and Space Administration, the U.S. Agency for International Development, and the U.S. Departments of Agriculture, Commerce, and the Interior.

The work which is the subject of this document was performed within the Earth Resources Research Division, Space and Life Sciences Directorate, at the Lyndon B. Johnson Space Center, National Aeronautics and Space Administration. Under Contract NAS 9-15800, personnel of Lockheed Engineering and Management Services Company, Inc., performed the tasks which contributed to the completion of this research.

CONTENTS

1. SCOPE

This report documents the software which has been developed under Job Order 73-315, Crop Stage Development Estimation Research. The software consists of programs which implement the basic Robertson crop phenology model and the Doraiswamy/Thompson crop phenology model.

2. SYSTEM OVERVIEW

The main program routines for the Doraiswamy/Thompson crop phenology model and the basic Robertson crop phenology model are DTMAIN and BRMAIN. The flow diagrams for these models are shown in figures 1 and 2. Routines DTMAIN and BRMAIN read meteorological data files and coefficient files, accept the planting date information and other information from the user, and initiate processing. Subroutines DTMOD and BRMOD serve as the driver routines for the processing and output segments of the programs. Daily processing for the basic Robertson program consists only of calculation of the basic Robertson increment of crop development. Additional processing in the Doraiswamy/Thompson program includes the calculation of a moisture stress index and correction of the basic increment of development. Output for both programs consists of listings of the daily results.

All of the routines in these two programs, with the exception of DTMAIN and BRMAIN, should be compatible with FORTRAN compilers on other computer systems. The main programs contain FORTRAN-IV plus "OPEN" and "CLOSE" statements.

The Doraiswamy/Thompson crop phenology program and the Robertson crop phenology program are described fully in sections 3 and 4, respectively. Refer to Appendix A for descriptions of terms used in this document. Appendix B consists of source listings for the entire Doraiswamy/Thompson program and Appendix C consists of source listings for two subroutines unique to the basic Robertson program.

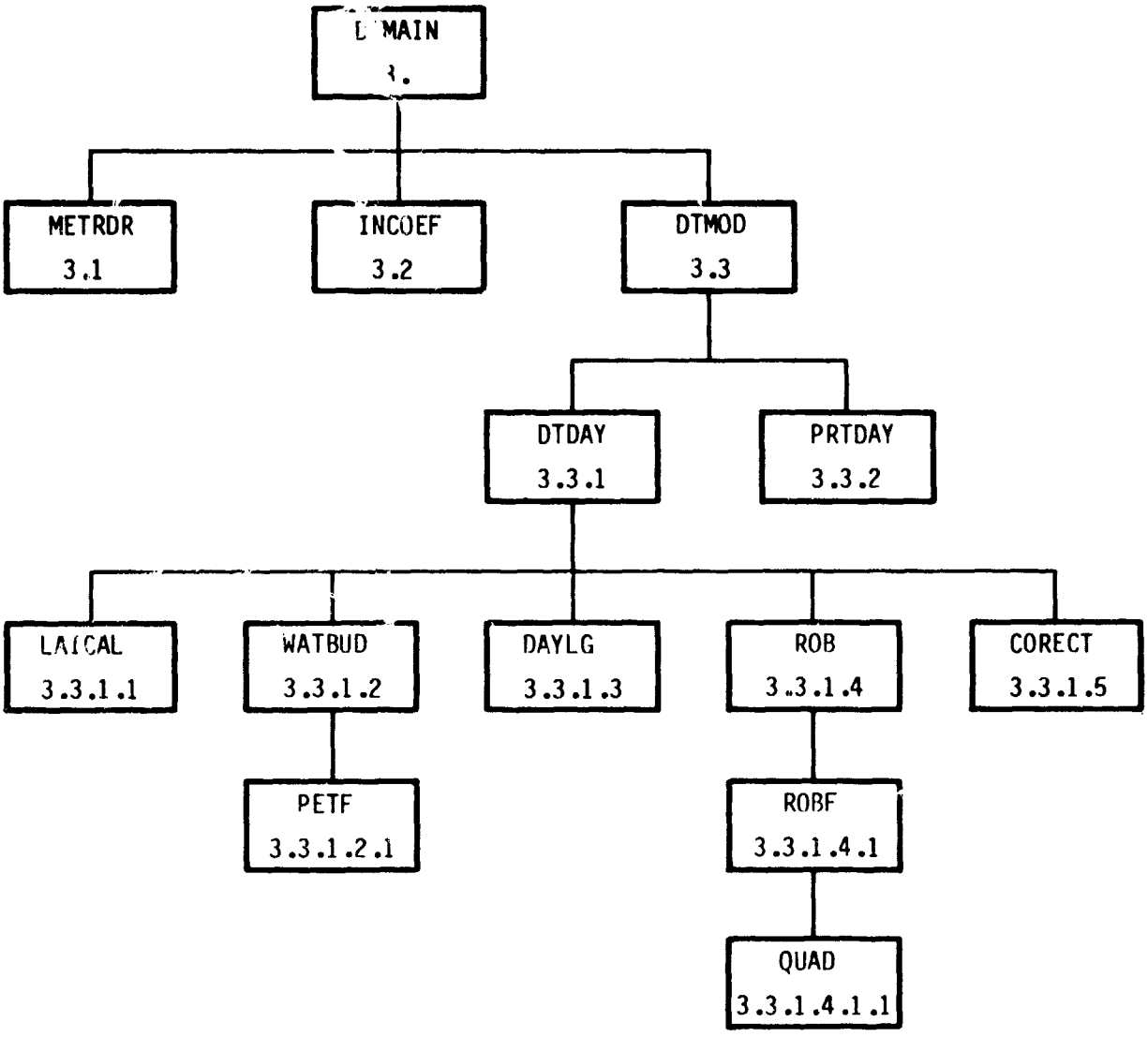

Figure 2-1.- Flow diagram of the Doraiswamy/Thompson program. The numbers shown below the subroutines refer to the section numbers in which the subroutines are described in this document.

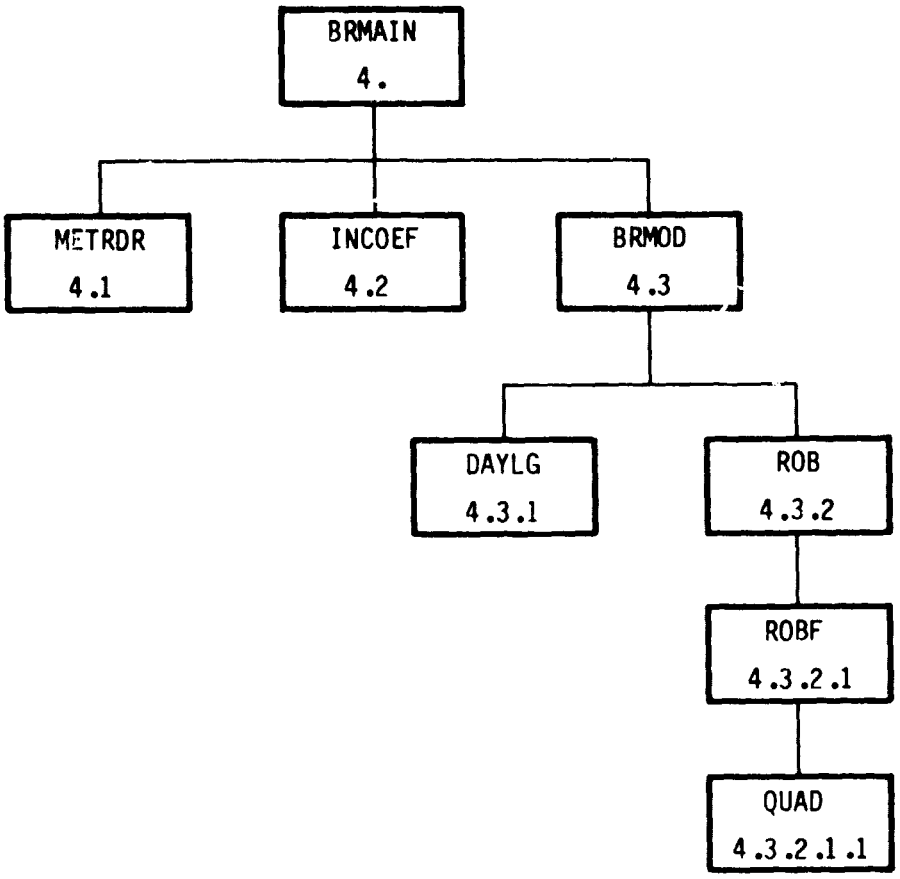

Figure 2-2.- Flow diagram of the Robertson Crop Phenology program. The numbers shown below the subroutines refer to the section numbers in which the subroutines are described in this document.

3. DTMAIN

The DTMAIN program is the driver routine of the Doraiswamy/Thompson crop phenology program.

CALLING SEQUENCE: PROGRAM DTMAIN

CALLING ARGUMENTS: Not applicable.

FILES: Not applicable.

COMMON BLOCKS: The following abbreviations are used in tables throughout this document.

I - integer

R - real

The common block for the DTMAIN routine is LUN(LUNCOE,LUNRES,LUNMET,LUNTRM, LUNRPT).

Name	Type	Definition
LUNCOE	I	Logical unit number of coefficient file.
LUNRES	I	Logical unit number of result files.
LUNMET	I	Logical unit number of weather data file.
LUNTRM	I	Logical unit number of user terminal.
LUNRPT	I	Logical unit number of result report file.

SUBROUTINES CALLED:

Name	Definition	Reference (section)
METRDR	Input weather data	3.1
INCOEF	Input coefficients	3.2
DTMOD	Doraiswamy/Thompson model	3.3

CALLED BY: Not applicable.

LOCAL VARIABLES:

Name	Definition
COEF	Coefficients; COEF(I,J,K), where I equals crop transition period, J equals function (V1,V2,V3), and K equals position of coefficient in function; COEF(*,3,1) is not used.
CRIT	Critical levels; CRIT(I,J), where I equals crop transition period and J equals function.
WD	Weather data; WD(I,J), where I equals maximum temperature (°F), minimum temperature (°F), and precipitation (cm), and J equals Julian day of year.
OUT	Result array; OUT(I,J), where I equals Julian day of year and J equals data field, for example temperature or precipitation.
NAME	File name.
SM	Maximum second layer moisture content.
PLOTFL	Result save flag; if flag equals Y, save; if flag equals N, do not save.
PRTFLG	Print flag; if flag equals Y, print daily results; if flag equals N, do not print.
PLT	Julian planting date.
SEG	Segment number.
LAT	Segment latitude.
AL	Constant.
KOUNT	Number of days in result array.

3.1 METRDR

The METRDR subroutine inputs meteorological data for the current segment.

CALLING SEQUENCE: SUBROUTINE METRDR(WD,LAT,SEG)

CALLING ARGUMENTS:

Name	Usage	Type	Definition
WD	Output	R	Weather data; (1) maximum temperature, °F, (2) minimum temperature, °F, (3) precipitation.
LAT	Output	R	Segment latitude.
SEG	Output	R	Segment number.

FILES:

File	Usage	Record format
Weather data file	Input	Variable

COMMON BLOCKS: Refer to program DTMAIN (section 3) for the description of common block LUN.

SUBROUTINES CALLED: Not applicable.

CALLED BY: The METRDR routine is called by subroutine DTMAIN (section 3).

LOCAL VARIABLES: Local variables for subroutine METRDR are as follows.

Name	Definition
M	DO loop index.
N	DO loop index.
YR	Year.
IDA	Flag.
J	DO loop index.

Name	Definition
JD	Julian date.
ND	Julian date.
K	DO loop index.

3.2 INCOEF

The INCOEF subroutine inputs coefficients and calculates critical levels.

CALLING SEQUENCE: SUBROUTINE INCOEF(COEF,CRIT)

CALLING ARGUMENTS:

Name	Usage	Type	Definition
COEF	Output	R	Coefficients.
CRIT	Output	R	Critical levels.

FILES:

File	Usage	Record format
Coefficient	Input	8E10.4

COMMON BLOCKS: Refer to the DTMAIN routine (section 3) for the description of common block LUN.

SUBROUTINES CALLED: Not applicable.

CALLED BY: The INCOEF subroutine is called by subroutine DTMAIN (section 3).

LOCAL VARIABLES: Local variables for the INCOEF subroutine are as follows.

Name	Definition
JS	DO loop index; crop stage.
K	DO loop index.
L	DO loop index.

3.3 DTMOD

The DTMOD subroutine is a driver routine for the Doraiswamy/Thompson crop phenology model. Beginning on January 1 and ending when the crop reaches its final stage of development, the following actions are performed daily.

1. Water budget and increment of development calculations
2. Output of daily results if flag is set
3. Storage of daily results if flag is set

CALLING SEQUENCE: SUBROUTINE DTMOD(COEF,CRIT,WD,PLT,LAT,AL,SM,PLOTFL,PRTFLG, OUT,KOUNT)

CALLING ARGUMENTS:

Name	Usage	Type	Definition
COEF	Input	R	Coefficients.
CRIT	Input	R	Critical levels.
WD	Input	R	Weather data.
PLT	Input	I	Julian planting date.
LAT	Input	R	Latitude.
AL	Input	R	Constant required in transpiration calculations.
SM	Input	R	Maximum second-layer moisture content.
PLOTFL	Input	R	Result save flag; if flag equals Y, save; if flag equals N, do not save.
PRTFLG	Input	R	Result print flag; if equals Y, print; if equals N, do not print.
OUT	Output	R	Result storage array.
KOUNT	Output	I	Number of days in result storage array.

FILES: Not applicable.

COMMON BLOCKS: Refer to main routine DTMAIN (section 3) for the description of common block LUN.

Results for potential (nonlimiting moisture) conditions and observed (limiting moisture) conditions are kept separate. Variables holding these results begin or end in P (potential) or O (observed) and are contained in the unnamed common block.

Name	Type	Definition
JD	I	Current Julian date.
TMIN	R	Minimum temperature, °F.
TMAX	R	Maximum temperature, °F
PRECIP	R	Precipitation.
FLB	R	(P and O); first-layer budget.
SLB	R	(P and O); second-layer budget.
DAYS	R	(P and O); days after stage 1 evaporation.
K	R	(P and O); transition period.
CUM	R	(P and O); cumulative increment of development.
LAI	R	(P and O); leaf area index.
SUMEO	R	(P and O); cumulative bare soil evaporation.
SUMTR	R	(P and O); cumulative transpiration.
SUMP	R	(P and O); cumulative precipitation.
R	R	(P and O); stress ratio.

SUBROUTINES CALLED:

Name	Definition	Reference (section)
DTDAY	Calculations for current day	3.3.1
PRTDAY	Print results for current day	3.3.2

CALLED BY: The DTMOD subroutine is called by the DTMAIN driver routine (section 3).

LOCAL VARIABLES:

Name	Definition
JDO	Julian day when crop reaches final transition period.
SWITCH	Flag used in computing JDO.

3.3.1 DTDAY

The DTDAY subroutine calculates the water budget and the increments of development for the current day. In addition, cumulative increments of development and other running totals are updated.

CALLING SEQUENCE: SUBROUTINE DTDAY(COEF,CRIT,PLT,LAT,AL,SM)

CALLING ARGUMENTS:

Name	Usage	Type	Definition
COEF	Input	R	Coefficients.
CRIT	Input	R	Critical levels.
PLT	Input	I	Julian planting date.
LAT	Input	R	Latitude.
AL	Input	R	Constant required in transpiration calculations.
SM	Input	R	Maximum second-layer moisture content.

FILES: Not applicable.

COMMON BLOCKS: Refer to the DTMOD subroutine (section 3.3) for the description of the common blocks.

SUBROUTINES CALLED:

Name	Definition	Reference (section)
CORECT	Adjust daily increment of development for water stress	3.3.1.5
DAYLG	Computes day length	3.3.1.3
LAICAL	Computes leaf area index	3.3.1.1
ROB	Computes basic Robertson increment of development	3.3.1.4
WATBUD	Performs water budget calculations	3.3.1.2

CALLED BY: The DTDAY subroutine is called by the DTMOD subroutine (section 3.3).

LOCAL VARIABLES:

Name	Definition
DUM1	Dummy argument.
DUM2	Dummy argument.
DUM3	Dummy argument.
RD	Difference between water-limiting and nonlimiting water budget ratios; stress index.
DIDO	Uncorrected daily increment of development; old stage.
DIDN	Uncorrected daily increment of development; new stage.
DIDC1	Corrected daily increment; old stage.
DIDC2	Corrected daily increment; new stage.
DIDI	Daily increment interpolated from variables DIDC1 and DIDC2.
DIFF	The portion of DIDC1 contributing to DIDI when stage crossover occurs.
RPCT	Percentage of DIDC2 contributing to DIDI when stage crossover occurs.
TMPCUM	Temporary cumulative increment of development used to determine if DIDC1 carries crop to next transition period.
DL	Day length.
ITEMP	Temporary transition period variable.
IFLAG	Flag used for signaling when subroutine WATBUD should update running totals; if equals 0, update; if equals 1, do not update.
KS	Soil-moisture-limiting factor.

3.3.1.1 LAICAL

The LAICAL subroutine calculates the leaf area index.

CALLING SEQUENCE: SUBROUTINE LAICAL(CUM,AL,LAI)

CALLING ARGUMENTS:

Name	Usage	Type	Definition
CUM	Input	R	Cumulative increment of development.
AL	Input	R	Maximum leaf area index; constant for a particular crop.
LAI	Output	R	Calculated leaf area index.

FILES: Not applicable.

COMMON BLOCKS: Not applicable.

SUBROUTINES CALLED: Not applicable.

CALLED BY: The LAICAL subroutine is called by subroutine DTDAY (section 3.3.1).

LOCAL VARIABLES:

Name	Definition
BL	Constant which is a function of AL (see calling arguments).
DEV	Amount of development since last stage crossover.
CL	Constant which is a function of AL (see calling arguments).

3.3.1.2 WATBUD

The WATBUD subroutine performs water budget calculations. On each entry, the following actions are performed:

a. calculation of bare soil evaporation
b. update of first-layer budget
c. update of second-layer budget
d. update of cumulative precipitation
e. update of cumulative bare soil evaporation

The following actions are performed only after the crop has been planted:

a. calculation of transpiration
b. calculation of stress ratio
c. update of cumulative transpiration

CALLING SEQUENCE: SUBROUTINE WATBUD(JD,PLT,TMIN,TMAX,PRECIP,IFLAG,LAI,AL,SM, KS,FLB,SLB,TJ,SUMEO,SUMTR,SUMP,RATIO)

CALLING ARGUMENTS:

Name	Usage	Type	Definition
JD	Input	I	Current Julian date.
PLT	Input	I	Julian planting date.
TMIN	Input	R	Minimum temperature, °F.
TMAX	Input	R	Maximum temperature, °F.
PRECIP	Input	R	Precipitation.
IFLAG	Input	I	If = 1, do not update cumulative totals; if = 0, update cumulative totals.
LAI	Input	R	Leaf area index.
AL	Input	R	Constant required in transpiration calculation.
SM	Input	R	Maximum second-layer moisture content.
KS	Input/output	R	Soil-moisture-limiting factor (0.0 - 1.0).

Name	Usage	Type	Definition
FLB	Input/output	R	First-layer budget.
SLB	Input/output	R	Second-layer budget.
TJ	Input/output	R	Number of days since stage 1 evaporation.
SUMEO	Input/output	R	Cumulative bare soil evaporation.
SUMTR	Input/output	R	Cumulative transpiration.
SUMP	Input/output	R	Cumulative precipitation.
RATIO	Output	R	Stress ratio.

FILES:

File	Usage	Record format
Daily results	Output	Intermediate results for debugging purposes.

COMMON BLOCKS: Refer to driver routine DTMAIN (section 3) for a description of the common block LUN.

SUBROUTINES CALLED:

Name	Definition	Reference (section)
PETF	Computes potential evaporation	3.3.1.2.1

CALLED BY: The WATBUD subroutine is called by the DTDAY subroutine (section 3.3.1).

LOCAL VARIABLES:

Name	Definition
BLK	Leaf area index corresponding to 50 percent of the crop cover. A function of AL (see calling arguments).
ALFA	Constant for a particular crop and climatic condition.
C	Constant dependent on soil hydraulic properties.

Name	Definition
FLBT	First-layer budget for today. This is an estimate of today's first-layer moisture content. It is used to determine which second-layer budget equation applies. Variable FLBT = FLBY - EO + PRECIP.
FLBY	First-layer budget for yesterday. This is an estimate of yesterday's first-layer moisture content. It is used in the calculation of the FLBT. FLBY is not allowed to drop below zero.
TAU	Temporary variable in bare soil evaporation and transpiration calculations.
TR	Transpiration.
ALFAV	Constant for a particular crop.
ETB	Available second-layer moisture; independent variable in the calculation of KS.
PET	Potential evaporation.
TI	Temporary variable in stage-2 bare soil evaporation calculation.
EOP	Temporary variable in stage-2 bare soil evaporation calculation.
AU	Maximum first-layer moisture content.
EO	Bare soil evaporation.
BL	Function of AL (see calling arguments); used in transpiration calculation.

3.3.1.2.1 PETF

The PETF function computes potential evaporation.

CALLING SEQUENCE: FUNCTION PETF(TMIN,TMAX)

CALLING ARGUMENTS:

Name	Usage	Type	Definition
TMIN	Input	R	Minimum temperature, °F.
TMAX	Input	R	Maximum temperature, °F.

FILES: Not applicable.

COMMON BLOCKS: Not applicable.

SUBROUTINES CALLED: Not applicable.

CALLED BY: The PETF function is called by the WATBUD subroutine (section 3.3.1.2).

LOCAL VARIABLES:

Name	Definition
ES	Saturation vapor pressure derived from daily minimum temperature.
E	Actual vapor pressure derived from daily maximum temperature.
PANEV	Pan evaporation.

3.3.1.3 DAYLG

The DAYLG function computes day length.

CALLING SEQUENCE: FUNCTION DAYLG(W,J)

CALLING ARGUMENTS:

Name	Usage	Type	Definition
W	Input	R	Latitude.
J	Input	I	Julian date.

FILES: Not applicable.

COMMON BLOCKS: Not applicable.

SUBROUTINES CALLED: Not applicable.

CALLED BY: The DAYLG function is called by subroutine DTDAY (section 3.3.1).

LOCAL VARIABLES: Not applicable.

3.3.1.4 ROB

The ROB subroutine performs the daily increment of development calculations for the basic Robertson model.

CALLING SEQUENCE: SUBROUTINE ROB(TMIN,TMAX,DL,COEF,CRIT,JS,DIDO,DIDN,DIDI,CUM)

CALLING ARGUMENTS:

Name	Usage	Type	Definition
TMIN	Input	R	Minimum temperature, °F.
TMAX	Input	R	Maximum temperature, °F.
DL	Input	R	Day length.
COEF	Input	R	Coefficients.
CRIT	Input	R	Critical levels.
JS	Input/output	I	Transition period. Incremented in this subroutine if development for today moves crop to next transition period.
DIDO	Output	R	Daily increment of development using coefficients and critical levels from old transition period.
DIDN	Output	R	Daily increment of development using coefficients and critical levels from new transition period.
DIDI	Output	R	Daily increment of development that is interpolated from variables DIDO and DIDN.
CUM	Input/output	R	Cumulative increment of development. Variable DIDO or DIDI (if stage crossover occurs) is added to CUM in this subroutine.

FILES: Not applicable.

COMMON BLOCKS: Not applicable.

SUBROUTINES CALLED:

Name	Definition	Reference (section)
ROBF	Computes basic Robertson daily increment of development.	3.3.1.4.1

CALLED BY: The ROBF subroutine is called by subroutine DTDAY (section 3.3.1).

LOCAL VARIABLES:

Name	Definition
TMPCUM	Temporary cumulative increment of development. Used to check if DIDO carries crop to new transition period.
DIFF	The portion of DIDO contributing to DIDI when stage crossover occurs.
RPCT	Percentage of DIDN contributing to DIDI when stage crossover occurs.

3.3.1.4.1 ROBF

The ROBF function computes the basic Robertson daily increment of development.

CALLING SEQUENCE: FUNCTION ROBF(DL,TMIN,TMAX,COEF,CRIT,JS)

CALLING ARGUMENTS:

Name	Usage	Type	Definition
DL	Input	R	Day length.
TMIN	Input	R	Minimum temperature, °F.
TMAX	Input	R	Maximum temperature, °F.
COEF	Input	R	Coefficients.
CRIT	Input	R	Critical levels.
JS	Input	I	Current transition period.

FILES: Not applicable.

COMMON BLOCKS: Not applicable.

SUBROUTINES CALLED:

Name	Definition	Reference (section)
QUAD	Evaluates quadratic.	3.3.1.4.1.1

CALLED BY: The ROBF function is called by the LAICAL subroutine (section 3.3.1.1).

LOCAL VARIABLES:

Name	Definition
V1	Value of quadratic in day length.
V2	Value of quadratic in maximum temperature.
V3	Value of quadratic in minimum temperature.

3.3.1.4.1.1 QUAD

The QUAD function evaluates a quadratic.

CALLING SEQUENCE: FUNCTION QUAD(X,AD,A1,A2,C)

CALLING ARGUMENTS:

Name	Usage	Type	Definition
X	Input	R	Day length or temperature.
A0	Input	R	Coefficient.
A1	Input	R	Coefficient.
A2	Input	R	Leading coefficient.
C	Input	R	Critical level.

FILES: Not applicable.

COMMON BLOCKS: Not applicable.

SUBROUTINES CALLED: Not applicable.

CALLED BY: The QUAD function is called by subroutine ROBF (section 3.3.1.4.1).

LOCAL VARIABLES: Not applicable.

3.3.1.5 CORECT

The CORECT subroutine makes an adjustment to the basic Robertson daily increment of development. The corrected daily increment of development is a function of the current transition period and the moisture stress index, as follows.

Transition period	DIDC
1	DID
2	DID
3	DID*EXP(-R)
4	DID*EXP(R)
5	DID*F(R) if R ≤ 0.8, or DID*1.9 if R > 0.8

where

R = stress ratio

DID = daily increment of development before correction

DIDC = corrected daily increment of development

F = quadratic function (see source listing)

CALLING SEQUENCE: SUBROUTINE CORECT(DID,RD,CUM,DIDC)

CALLING ARGUMENTS:

Name	Usage	Type	Definition
DID	Input	R	Uncorrected daily increment of development.
RD	Input	R	Stress ratio.
CUM	Input	R	Cumulative increment of development.
DIDC	Output	R	Corrected daily increment of development.

FILES: Not applicable.

COMMON BLOCKS: Not applicable.

SUBROUTINES CALLED: Not applicable.

CALLED BY: The CORECT subroutine is called by the DTDAY subroutine (section 3.3.1).

LOCAL VARIABLES:

Name	Definition
A1	Constant.
A2	Constant.
A4	Temporary variable.

3.3.2 PRTDAY

The PRTDAY subroutine outputs the current day's results for both limiting and nonlimiting moisture conditions.

CALLING SEQUENCE: SUBROUTINE PRTDAY

CALLING ARGUMENTS: Not applicable.

FILES:

File	Usage	Record format
Daily results	Output	Two records per day are printed. Record 1 consists of Julian date and meteorological data followed by results for nonlimiting moisture conditions. Record 2 consists only of results for limiting moisture conditions.

COMMON BLOCKS: Refer to the DTMOD subroutine (section 3.3) for the description of common blocks, and refer to the main routine DTMAIN (section 3) for a description of common block LUN.

SUBROUTINES CALLED: Not applicable.

CALLED BY: The PRTDAY subroutine is called by subroutine DTMOD (section 3.3).

LOCAL VARIABLES: Not applicable.

4. BRMAIN

The BRMAIN routine is the main program of the basic Robertson crop phenology model. The BRMAIN program inputs meteorological data (METRDR), coefficients (INCOEF), and crop planting dates.

CALLING SEQUENCE: PROGRAM BRMAIN

CALLING ARGUMENTS: Not applicable.

FILES:

File	Usage	Record format
Meteorological data	Input	Refer to METRDR source listing
Coefficient	Input	8E10.4.

COMMON BLOCKS: Refer to the DTMAIN (section 3) for the description of common block LUN.

SUBROUTINES CALLED:

Name	Definition	Reference (section)
METRDR	Input meteorological data	4.1
INCOEF	Input coefficients	4.2
BRMOD	Basic Robertson model driver	4.3

CALLED BY: Not applicable.

LOCAL VARIABLES:

Variable	Definition
COEF	Coefficients; COEF(I,J,K), where I equals crop transition period, J equals function (V1,V2,V3), and K equals position of coefficient in function; COEF(*,3,1) is not used.
CRIT	Critical levels; CRIT(I,J), where I equals crop transition period and J equals function.
WD	Weather data; WD(I,J), where I equals maximum temperature (°F), minimum temperature (°F), and precipitation (cm), and J equals Julian day of year.
NAME	File name.
PLT	Julian planting date.
SEG	Segment number.
LAT	Segment latitude.

4.1 METRDR

The METRDR subroutine is described in section 3.1 of this document.

4.2 INCOEF

The INCOEF subroutine is described in section 3.2 of this document.

4.3 BRMOD

The BRMOD subroutine is the driver routine for the basic Robertson crop phenology model.

CALLING SEQUENCE: SUBROUTINE BRMOD(COEF,CRIT,WD,PLT,LAT)

CALLING ARGUMENTS:

Name	Usage	Type	Definition
COEF	Input	R	Coefficients.
CRIT	Input	R	Critical levels.
WD	Input	R	Weather data.
PLT	Input	I	Julian planting date.
LAT	Input	R	Latitude.

FILES:

File	Usage	Record format
Report of results	Output	Each record consists of Julian date, minimum and maximum temperature, day length, transition period, daily increments of development (old stage, new stage, and interpolated), and cumulative increment of development.

COMMON BLOCKS: Refer to the DTMAIN subroutine (section 3) for a description of common block LUN.

SUBROUTINES CALLED:

Name	Definition	Reference (section)
DAYLG	Computes day length.	3.3.1.3
ROB	Computes the basic Robertson daily increment of development.	3.3.1.4

CALLED BY: The BRMOD subroutine is called by driver routine BRMAIN (section 4).

LOCAL VARIABLES:

Name	Definition
JS	Transition period.
TMAX	Maximum temperature, °F.
TMIN	Minimum temperature, °F.
DL	Day length.
DIDO	Daily increment of development; old stage.
DIDN	Daily increment of development; new stage.
DIDI	Daily increment of development; interpolated from old stage and new stage.
CUM	Cumulative increment of development.

4.3.1 DAYLG

The DAYLG subroutine is described in section 3.3.1.3 of this document.

4.3.2 ROB

The ROB subroutine is described in section 3.3.1.4 of this document.

4.3.2.1 ROBF

The ROBF subroutine is described in section 3.3.1.4.1 of this document.

4.3.2.1.1 QUAD

The QUAD subroutine is described in section 3.3.1.4.1.1 of this document.

APPENDIX A

DESCRIPTION OF TERMS USED IN DOCUMENT

APPENDIX A

DESCRIPTION OF TERMS USED IN DOCUMENT

a. Daily Increment of Development (DID) — a numeric representation of a crop's development. The DID ranges from 1. at planting to 6. at ripening.

b. Cumulative Increment of Development (CUM) — the sum of the DID's from planting day to current day.

c. Crop Stage — a point in the crop's development which is identified by one of the following events:

Planting (P)	(CUM = 1.0)
Emergence (E)	(CUM = 2.0)
Jointing (J)	(CUM = 3.0)
Heading (H)	(CUM = 4.0)
Soft dough (S)	(CUM = 5.0)
Ripening (R)	(CUM = 6.0)

e. Transition period — one of the five intervals between each crop stage, as follows.

P to E	(1. < CUM < 2.)
E to J	(2. < CUM < 3.)
J to H	(3. < CUM < 4.)
H to S	(4. < CUM < 5.)
S to R	(5. < CUM < 6.)

f. Stage crossover — the advancement of a crop to a new transition period.

APPENDIX B

SOURCE LISTINGS OF THE DORAISWAMY/THOMPSON PROGRAM

```
C
C       MAIN PROGRAM
C
C       THIS PROGRAM IS A DRIVER FOR THE DORAISWAMY/THOMPSON
C       CROP PHENOLOGY MODEL.
C
C
C       COMMON BLOCK LUN:
C
C               NAME            MEANING
C
C               LUNCOE  LOGICAL UNIT NO. OF COEFFICIENT FILE
C               LUNRES  LOGICAL UNIT NO. OF RESULT  FILES
C               LUNMET  LOGICAL UNIT NO. OF WEATHER DATA FILE
C               LUNTRM  LOGICAL UNIT NO. OF USER TERMINAL
C               LUNRPT  LOGICAL UNIT NO. OF RESULT REPORT FILE
C
C
C       SUBROUTINES CALLED: METRDR,INCOEF,DTMOD
C
C
C       LOCAL VARIABLES:
C
C               NAME            MEANING
C
C               COEF    COEFFICIENTS; COEF(I,J,K)
C                          I - CROP TRANSITION PERIOD
C                          J - FUNCTION
C                          K - POSITION OF COEFFICIENT IN FUNCTION;
C                              COEF(*,3,1) IS NOT USED.
C               CRIT    CRITICAL LEVELS; CRIT(I,J)
C                          I - CROP TRANSITION PERIOD
C                          J - FUNCTION
C               WD      WEATHER DATA; WD(I,J)
C                          I - FIELD
C                               1. MAXIMUM TEMPERATURE, DEG. F
C                               2. MINIMUM TEMPERATURE, DEG. F
C                               3. PRECIPITATION
C                          J - JULIAN DAY OF YEAR
C               OUT     RESULT ARRAY; OUT(I,J)
C                          I - JULIAN DAY OF YEAR
C                          J - FIELD
C               NAME    FILE NAME
C               SM      MAXIMUM SECOND LAYER MOISTURE CONTENT
C               PLOTFL  RESULT SAVE FLAG; IF='Y',SAVE; IF='N',DO NOT SAVE.
C               PRTFLG  PRINT FLAG; IF='Y',PRINT DAILY RESULTS;
C                       IF='N', DO NOT PRINT.
C               PLT     JULIAN PLANTING DATE
C               SEG     SEGMENT NUMBER
C               LAT     SEGMENT LATITUDE
C               AL      CONSTANT
C               KOUNT   NUMBER OF DAYS IN RESULT ARRAY
C
C
C
0001            COMMON /LUN/ LUNCOE,LUNRES,LUNMET,LUNTRM,LUNRPT
```

```
        C
0002            DIMENSION COEF(5,3,3),CRIT(5,3),WD(3,366),NAME(30),
                1       OUT(200,14)
        C
0003            INTEGER PLT,SEG
0004            REAL LAT
        C
        C               INITIALIZATION
        C
0005            LUNCOE = 1
0006            LUNRES = 2
0007            LUNMET = 3
0008            LUNRPT = 4
0009            LUNTRM = 5
0010            AL = 3.5
0011            NAME(30) = 0
        C
        C          INPUT WEATHER DATA
        C
0012    10      WRITE (LUNTRM,20)
0013    20      FORMAT ('$TYPE NAME OF WEATHER DATA FILE >')
0014            READ (LUNTRM,40) (NAME(I),I=1,29)
0015    40      FORMAT (29A1)
0016            OPEN (UNIT=LUNMET,NAME=NAME,TYPE='OLD',ERR=1000)
0017            CALL METRDR (WD,LAT,SEG)
0018            CLOSE (UNIT=LUNMET)
        C
        C          INPUT PLANTING DAY
        C
0019    50      WRITE (LUNTRM,60)
0020    60      FORMAT ('$TYPE PLANTING DAY (JULIAN) >')
0021            READ (LUNTRM,80) PLT
0022    80      FORMAT (I4)
0023            IF (PLT.LT.1 .OR. PLT.GT.366) GO TO 50
        C
        C
        C          INPUT COEFFICIENTS, CALCULATE CRITICAL LEVELS
        C
0024            WRITE (LUNTRM,100)
0025    100     FORMAT ('$TYPE NAME OF DORAISWAMY/THOMPSON COEFFICIENT FILE >')
0026            READ (LUNTRM,40) (NAME(I),I=1,29)
0027            OPEN (UNIT=LUNCOE,NAME=NAME,TYPE='OLD',ERR=1000)
0028            CALL INCOEF (COEF,CRIT)
0029            CLOSE (UNIT=LUNCOE)
        C
        C          INPUT RESULT FILE INSTRUCTIONS
        C
0030    200      WRITE (LUNTRM,210)
0031    210      FORMAT ('$GENERATE RESULT FILE ? (Y OR N) >')
0032              READ (LUNTRM,220) PLOTFL
0033    220      FORMAT (A1)
0034             IF (PLOTFL.NE.'Y' .AND. PLOTFL.NE.'N') GO TO 200
        C
        C               INPUT PRINTING INSTRUCTIONS
        C
0035    225     WRITE (LUNTRM,230)
```

```
0036    230    FORMAT ('$PRINT DAILY RESULTS ? (Y OR N) >')
0037           READ (LUNTRM,220) PRTFLG
0038           IF (PRTFLG.NE.'Y' .AND. PRTFLG.NE.'N') GO TO 225
       C
       C
       C          INPUT NAME OF PRINT FILE
       C
0039           IF (PRTFLG.EQ.'N') GO TO 450
0040             WRITE (LUNTRM,400)
0041    400    FORMAT ('$TYPE NAME OF PRINT FILE >')
0042           READ (LUNTRM,40) (NAME(I),I=1,29)
0043           OPEN (UNIT=LUNRPT,NAME=NAME,TYPE='NEW',RECORDSIZE=133,ERR=1000)
0044    450    CONTINUE
       C
       C             INPUT SECOND LAYER CAPACITY
       C
0045           WRITE (LUNTRM,460)
0046    460    FORMAT ('$TYPE SECOND LAYER CAPACITY >')
0047             READ (LUNTRM,480) SM
0048    480    FORMAT (F10.1)
       C
       C
       C
       C
0049           CALL DTMOD (COEF,CRIT,WD,PLT,LAT,AL,SM,PLOTFL,PRTFLG,
                 1        OUT,KOUNT)
       C
       C
       C
       C
0050           IF (PRTFLG.EQ.'Y') CLOSE (UNIT=LUNRPT)
       C
0051             IF (PLOTFL.EQ.'N') GO TO 499
       C
       C                  CREATE FILE OF RESULTS
       C
0052             DO 490 J=2,14
0053             OPEN (UNIT=LUNRES,NAME='DTPLOT.DAT',TYPE='NEW')
0054             WRITE (LUNRES,485) (OUT(I,1),I=1,KOUNT)
0055             WRITE (LUNRES,485) (OUT(I,J),I=1,KOUNT)
0056    485      FORMAT (F10.2)
0057             CLOSE (UNIT=LUNRES)
0058    490      CONTINUE
       C
0059             KOUNT = KOUNT * 2
0060             WRITE (LUNTRM,491) KOUNT
0061    491      FORMAT ('0',I3,' RECORDS IN EACH RESULT FILE.')
       C
       C
       C
0062    499    WRITE (LUNTRM,500)
0063    500    FORMAT ('$CONTINUE ? (Y OR N) >')
0064             READ (LUNTRM,220) FLAG
0065           IF (FLAG.NE.'Y' .AND. FLAG.NE.'N') GO TO 499
0066           IF (FLAG.EQ.'Y') GO TO 10
0067           STOP
```

```
        C
        C
        C
0068    1000  CONTINUE
0069            WRITE (LUNTRM,1020)
0070    1020  FORMAT ('0ERROR IN OPENING FILE')
0071          STOP
0072          END
```

PROGRAM SECTIONS

NUMBER	NAME	SIZE		ATTRIBUTES
1	SCODE1	001656	471	RW,I,CON,LCL
2	SPDATA	000024	10	RW,D,CON,LCL
3	SIDATA	000766	251	RW,D,CON,LCL
4	SVARS	037056	7963	RW,D,CON,LCL
6	LUN	000012	5	RW,D,OVR,GBL

VARIABLES

NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS
AL	R*4	4-037034	FLAG	R*4	4-037062	I	I*2	4-037043	J	I*2	4-037060	KOUNT	I*2	4-037056
LAT	R*4	4-037030	LUNCOE	I*2	6-000000	LUNMET	I*2	6-000004	LUNPES	I*2	6-000002	LUNRPT	I*2	6-000010
LUNTRM	I*2	6-000006	PLOTFL	R*4	4-037042	PLT	I*2	4-037024	PRTFLG	R*4	4-037046	SEG	I*2	4-037052
SM	R*4	4-037052												

ARRAYS

NAME	TYPE	ADDRESS	SIZE		DIMENSIONS
COEF	R*4	4-000000	000264	90	(5,3,3)
CRIT	R*4	4-000264	000074	30	(5,3)
NAME	I*2	4-011030	000074	30	(30)
OUT	R*4	4-011124	025700	5600	(200,14)
WD	R*4	4-000360	010450	2196	(3,366)

LABELS

LABEL	ADDRESS	LABEL	ADDRESS	LABEL	ADDRESS	LABEL	ADDRESS	LABEL	ADDRESS
10	1-000102	20'	1-000200	30'	1-000344	50	1-000244	60'	3-000350
80'	3-000110	100	1-000314	200	1-000500	210'	3-000204	220'	3-000252
225	1-000510	230'	3-000226	400	3-000322	450	1-000100	460'	3-000360
480'	3-000420	485	3-000434	490	[illegible]	495'	3-000430	499	1-001470
500'	3-000474	1000	1-001622	1020	3-001526				

FUNCTIONS AND SUBROUTINES REFERENCED

CLOSS DTMOD INCOEF METRDR OPENS

TOTAL SPACE ALLOCATED = 041770 8700

.CL:=SY0:[320,7]DTMAIN

```
0001            SUBROUTINE METRDR(WD,LAT,SEG)                                   ROB01580
                C
                C
                C       THIS SUBROUTINE INPUTS METEOROLOGICAL DATA FOR CURRENT
                C       SEGMENT.
                C
                C
                C       CALLING ARGUMENTS:
                C
                C               NAME    I/O     MEANING
                C
                C               WD       O      WEATHER DATA
                C                                 1. MAXIMUM TEMPERATURE
                C                                 2. MINIMUM TEMPERATURE
                C                                 3. PRECIPITATION
                C               LAT      O      SEGMENT LATITUDE
                C               SEG      O      SEGMENT NUMBER
                C
                C
                C       CALLED BY: DTMAIN,BRMAIN
                C
                C
                C       LOCAL VARIABLES:
                C
                C               NAME            MEANING
                C
                C               M       DO LOOP INDEX
                C               N       DO LOOP INDEX
                C               J       DO LOOP INDEX
                C               K       DO LOOP INDEX
                C               YR      YEAR
                C               IDA     FLAG
                C               JD      JULIAN DATE
                C               ND      JULIAN DATE
                C
                C
                C
0002            COMMON /LUN/ LUNCOE,LUNRES,LUNMET,LUNTRM,LUNRPT
                C
0003            DIMENSION WD(3,366),MET(16)                                     ROB01590
0004            INTEGER T(2,19),SEG,YR                                          ROB01600
0005            REAL LAT                                                        ROB01610
0006            DO 1 N = 1,366                                                  ROB01620
0007            DO 1 M = 1,3                                                    ROB01630
0008            WD(M,N) = 9999.                                                 ROB01640
0009       1    CONTINUE                                                        ROB01650
0010            READ(LUNMET,9) SEG,LAT
0011       9    FORMAT(I4,11X,F5.2)                                             ROB01670
0012            I = 1                                                           ROB01680
                C
                C**         INPUT PRECIPITATION
                C           INPUT IN HUNDRETHS OF AN INCH, CONVERT TO CENTIMETERS
                C
0013       5    READ(LUNMET,90,END=100) JD,MET,YR
0014      90    FORMAT(6X,I3,1X,16I4,4X,I2)                                     ROB01700
0015            IF(JD.EQ.-99)GO TO 20                                           ROB01710
```

```
0016            DO 10 J = 1,16                                          ROB01720
0017            ND = JD + J - 1                                         ROB01730
0018            IF(ND.GT.366)GO TO 15                                   ROB01740
0019            WD(3,ND) = FLOAT(MET(J)) * .0255                          01750
0020      10    CONTINUE                                                ROB01760
0021            GO TO 5                                                 ROB01770
0022      15    READ(LUNMET,90,END=169) IDA
0023            IF(IDA.EQ.-99)GO TO 20                                  ROB01790
0024            GO TO 15                                                ROB01800
        C
        C**       INPUT TEMPERATURE IN DEGREES F.
        C
0025      20    READ(LUNMET,91,END=80) JD,((T(K,J),K=1,2),J=1,10),YR
0026      91    FORMAT(6X,I3,20I3,1X,I2)                                ROB01820
0027            IF(JD.LT.0)GO TO 30                                     ROB01830
0028            DO 25 J = 1,10                                          ROB01840
0029            ND = JD + J - 1                                         ROB01850
0030            IF(ND.GT.366)GO TO 29                                   ROB01860
0031            IF(ND.LT.1)GO TO 25                                     ROB01870
0032            WD(1,ND) = T(1,J)                                       ROB01880
0033            WD(2,ND) = T(2,J)                                       ROB01890
0034      25    CONTINUE                                                ROB01920
0035            GO TO 20                                                ROB01930
0036      29    READ(LUNMET,91,END=30) JD
0037            IF(JD.LT.0)GO TO 30                                     ROB01950
0038            GO TO 29                                                ROB01960
0039      30    RETURN                                                  ROB01970
0040      80    IF(ND.LT.365)GO TO 100                                  ROB01980
0041            RETURN                                                  ROB01990
0042      100   WRITE(LUNTRM,95)
0043      95    FORMAT(' PREMATURE END OF FILE ENCOUNTERED ON MET FILE')
0044            RETURN                                                  ROB02020
0045            END                                                     ROB02030
```

```
ETRDR.FTN       /TR:BLOCKS/WR

PROGRAM SECTIONS

NUMBER    NAME        SIZE                 ATTRIBUTES

  1       $CODE1   000156    311           RW,I,CON,LCL
  2       $PDATA   000010      4           RW,D,CON,LCL
  3       $IDATA   000146     51           RW,D,CON,LCL
  4       $VARS    000176     63           RW,D,CON,LCL
  6       LUN      000012      5           RW,D,OVR,GBL

ENTRY POINTS

 NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS

 METRDR        1-000000

VARIABLES

 NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS

 I       I*2   4-000162    IDA     I*2   4-000172    J       I*2   4-000166    JD      I*2   4-000164    K       I*2   4-000174
 LAT     R*4   F-000004*   LUNCOE  I*2   6-000000    LUNMET  I*2   6-000002    LUNRES  I*2   6-000002    LUNRPT  I*2   6-000010
 LUNTRM  I*2   6-000006    M       I*2   4-000160    N       I*2   4-000156    ND      I*2   4-000170    SEG     I*2   6-000056*
 WR      I*2   4-000154

ARRAYS

 NAME    TYPE  ADDRESS        SIZE        DIMENSIONS

 MET     I*2   4-000000   000040    16    (16)
 T       I*2   4-000040   000114    38    (2,19)
 WD      R*4   F-000002*  010450  2196    (3,366)

LABELS

 LABEL   ADDRESS          LABEL   ADDRESS          LABEL   ADDRESS          LABEL   ADDRESS          LABEL   ADDRESS

 1          **            5       1-000216         9       3-000000         10         **            15      1-000120
 20      1-000506         25      1-001004         29      1-001030         30      1-001104         60      1-001126
 90      3-000010         91      3-000026         95      3-000042         100     1-001126

TOTAL SPACE ALLOCATED = 001544   434

.CL:=SY0:[320,70]METRDR
```

```
0001            SUBROUTINE INCOEF (COEF,CRIT)
      C
      C
      C       THIS SUBROUTINE INPUTS COEFFICIENTS AND CALCULATES
      C       CRITICAL LEVELS.
      C
      C
      C       CALLING ARGUMENTS:
      C
      C               NAME    I/O     MEANING
      C
      C               COEF     O      COEFFICIENTS
      C               CRIT     O      CRITICAL LEVELS
      C
      C
      C       CALLED BY: DTMAIN
      C
      C
      C       LOCAL VARIABLES:
      C
      C               NAME            MEANING
      C
      C               JS      DO LOOP INDEX; CROP STAGE
      C               K       DO LOOP INDEX
      C               L       DO LOOP INDEX
      C
      C
      C
0002            COMMON /LUN/ LUNCOE,LUNRES,LUNMET,LUNTRM,LUNRPT
      C
0003            DIMENSION COEF(5,3,3),CRIT(5,3)
      C
0004            DO 100 JS=1,5
0005            DO  50 K =1,3
0006    50      CRIT(JS,K) = 99999.9
      C
0007            READ (LUNCOE,75) ((COEF(JS,K,L),L=1,3),K=1,2), COEF(JS,3,2),
     +                        COEF(JS,3,3)
0008    75      FORMAT (8E10.4)
      C
      C
0009            IF (COEF(JS,1,3).NE.0.0) CRIT(JS,1) =
     +       -(COEF(JS,1,2)-2.0*COEF(JS,1,3)*COEF(JS,1,1))
     +       /(2.0*COEF(JS,1,3))
0010            IF (COEF(JS,2,3).NE.0.0) CRIT(JS,2) =
     +       -(COEF(JS,2,2)-2.0*COEF(JS,2,3)*COEF(JS,2,1))
     +       /(2.0*COEF(JS,2,3))
0011            IF (COEF(JS,3,3).NE.0.0) CRIT(JS,3) =
     +       -(COEF(JS,3,2)-2.0*COEF(JS,3,3)*COEF(JS,2,1))
     +       /(2.0*COEF(JS,3,3))
0012    100     CONTINUE
0013            RETURN
0014            END
```

```
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INCOEF.FTN       /TR:BLOCKS/WR

PROGRAM SECTIONS

NUMBER    NAME        SIZE                 ATTRIBUTES

  1       $CODE1    000544    178          RW,I,CON,LCL
  2       $PDATA    000004      2          RW,D,CON,LCL
  3       $IDATA    000032     13          RW,D,CON,LCL
  4       $VARS     000006      3          RW,D,CON,LCL
  6       LUN       000012      5          RW,D,OVR,GBL

ENTRY POINTS

 NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS

 INCOEF        1-000000

VARIABLES

 NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS

 JS      I*2   4-000000    K       I*2   4-000002    L       I*2   4-000004    LUNCOE  I*2   6-000000    LUNMET  I*2   6-000004
 LUNRES  I*2   6-000002    LUNRPT  I*2   6-000010    LUNTRM  I*2   6-000006

ARRAYS

 NAME    TYPE  ADDRESS        SIZE        DIMENSIONS

 COEF    R*4   F-000002*  000264     90    (5,3,3)
 CRIT    R*4   F-000004*  000074     30    (5,3)

LABELS

 LABEL   ADDRESS          LABEL   ADDRESS          LABEL   ADDRESS          LABEL   ADDRESS          LABEL   ADDRESS

 50        **             75      3-000000         100       **

TOTAL SPACE ALLOCATED = 000622   201

.CL:=SY0:[320,70]INCOEF
```

```
FORTRAN IV-PLUS V02-51E          10:34:55     02-JUN-81          PAGE 1
DTMOD.FTN       /TR:BLOCKS/WR

0001            SUBROUTINE DTMOD (COEF,CRIT,WD,PLT,LAT,AL,SM,PLOTFL,PRTFLG,
                1                 OUT,KOUNT)
      C
      C
      C       THIS SUBROUTINE IS A DRIVER FOR THE DORAISWAMY / THOMPSON
      C       CROP PHENOLOGY MODEL.  STARTING ON JANUARY 1, AND ENDING WHEN
      C       THE CROP REACHES ITS FINAL STAGE OF DEVELOPMENT, THE FOLLOWING
      C       ACTIONS ARE PERFORMED DAILY:
      C
      C               1.  WATER BUDGET AND INCR. OF DEVELOPMENT CALCULATIONS
      C               2.  OUTPUT OF DAILY RESULTS, IF FLAG SET
      C               3.  STORAGE OF DAILY RESULTS, IF FLAG SET
      C
      C
      C       CALLING ARGUMENTS:
      C
      C               NAME    I/O     MEANING
      C
      C               COEF     I      COEFFICIENTS
      C               CRIT     I      CRITICAL LEVELS
      C               WD       I      WEATHER DATA
      C               PLT      I      JULIAN PLANTING DATE
      C               LAT      I      LATITUDE
      C               AL       I      CONSTANT REQUIRED IN TRANSPIRATION
      C                               CALCULATIONS
      C               SM       I      MAXIMUM SECOND LAYER MOISTURE CONTENT
      C               PLOTFL   I      RESULT SAVE FLAG. IF='Y', SAVE; IF='N',
      C                               DO NOT SAVE.
      C               PRTFLG   I      RESULT PRINT FLAG. IF='Y',PRINT; IF='N',
      C                               DO NOT PRINT.
      C               OUT      O      RESULT STORAGE ARRAY
      C               KOUNT    O      NUMBER OF DAYS IN RESULT ARRAY
      C
      C
      C
      C       DESCRIPTION OF UN-NAMED COMMON BLOCK:
      C
      C       NOTE:  RESULTS FOR POTENTIAL (NON-LIMITING MOISTURE) CONDITIONS
      C       AND OBSERVED (LIMITING MOISTURE) CONDITIONS ARE KEPT SEPARATE.
      C       VARIABLES HOLDING THESE RESULTS BEGIN OR END IN P (POTENTIAL)
      C       OR O (OBSERVED).
      C
      C               NAME            MEANING
      C
      C               JD      CURRENT JULIAN DATE
      C               TMIN    MINIMUM TEMPERATURE, DEG. F
      C               TMAX    MAXIMUM TEMPERATURE, DEG. F
      C               PRECIP  PRECIPITATION
      C               FLB     (P AND O); FIRST LAYER BUDGET
      C               SLB     (P AND O); SECOND LAYER BUDGET
      C               DAYS    (P AND O); DAYS AFTER STAGE 1 EVAPORATION
      C               K       (P AND O); TRANSITION PERIOD
      C               CUM     (P AND O); CUMULATIVE INCR. OF DEVELOPMENT
      C               LAI     (P AND O); LEAF AREA INDEX
      C               SUME0   (P AND O); CUMULATIVE BARE SOIL EVAPORATION
      C               SUMTR   (P AND O); CUMULATIVE TRANSPIRATION
```

```
C                R       (P AND O); STRESS RATIO
C
C
C       SUBROUTINES CALLED: DTDAY,PRTDAY
C
C
C       CALLED BY: DTMAIN
C
C
C       LOCAL VARIABLES:
C
C                NAME            MEANING
C
C                JDO     JULIAN DAY WHEN CROP REACHES FINAL TRANSITION
C                        PERIOD
C                SWITCH  FLAG USED IN COMPUTING JDO
C
C
C
0002            COMMON /LUN/ LUNCOE,LUNRES,LUNMET,LUNTRM,LUNRPT
      C
0003            COMMON JD,TMIN,TMAX,PRECIP,PFLB,OFLB,PSLB,OSLB,
     +               PDAYS,ODAYS,KP,KO,PCUM,OCUM,PLAI,OLAI,
     +               PSUME0,OSUME0,PSUMTR,OSUMTR,PSUMP,OSUMP,RP,RO
      C
0004            INTEGER PLT
0005            REAL LAT
0006            INTEGER SWITCH
      C
0007            DIMENSION COEF(5,3,3),CRIT(5,3),WD(3,366),OUT(200,14)
      C
      C               PERFORM INITILIZATIONS AT BEGINNING OF YEAR
      C
0008            SWITCH = 0
0009            KOUNT = 0
0010            PFLB = 20.0
0011            OFLB = 20.0
0012            PSLB = SM
0013            OSLB = SM
0014            PDAYS = 1.0
0015            ODAYS = 1.0
0016            PSUMP = 0.0
0017            OSUMP = 0.0
0018            KP = 1
0019            KO = 1
0020            PCUM = 1.0
0021            OCUM = 1.0
0022            PSUME0 = 0.0
0023            OSUME0 = 0.0
0024            PSUMTR = 0.0
0025            OSUMTR = 0.0
      C
0026            DO 500 JD=1,366
0027            TMAX = WD(1,JD)
0028            TMIN = WD(2,JD)
0029            PRECIP = WD(3,JD)
```

```
                C
                C
0030                    CALL DTDAY (COEF,CRIT,PLT,LAT,AL,SM)
                C
                C
                C            PRINT CURRENT DAY'S RESULTS
                C
0031                    IF (JD.GE.PLT .AND. PRTFLG.EQ.'Y') CALL PRTDAY
                C
                C          STORE RESULTS FOR CURRENT DAY
                C
0032                    IF (PLOTFL.EQ.'N' .OR. JD.LT.PLT) GO TO 400
0033                    KOUNT = KOUNT + 1
0034                    IF (KOUNT.LE.200) GO TO 300
0035                    WRITE (5,280)
0036    280             FORMAT (' ','SUBSCRIPT OF ARRAY, OUT, EXCEEDS LIMIT')
0037                    STOP
0038    300             CONTINUE
0039                    OUT(KOUNT,1)  = FLOAT(JD)
0040                    OUT(KOUNT,2)  = PLAI
0041                    OUT(KOUNT,3)  = OLAI
0042                    OUT(KOUNT,4)  = PCUM
0043                    OUT(KOUNT,5)  = OCUM
0044                    OUT(KOUNT,6)  = PSUMP
0045                    OUT(KOUNT,7)  = OFLB
0046                    OUT(KOUNT,8)  = OSLB
0047                    OUT(KOUNT,9)  = OSUME0
0048                    OUT(KOUNT,10) = OSUMTR
0049                    OUT(KOUNT,11) = PSUME0
0050                    OUT(KOUNT,12) = PSUMTR
0051                    OUT(KOUNT,13) = RP
0052                    IF (OCUM.GE.6.0) RO = 0.0
0053                    OUT(KOUNT,14) = RO
0054    400             CONTINUE
                C
0055                    IF (SWITCH.EQ.1 .OR. OCUM.LT.6.0) GO TO 450
0056                    SWITCH = 1
0057                    JDO = JD
0058    450             CONTINUE
                C
                C
0059                    IF (PCUM.GE.6.0 .AND. OCUM.GE.6.0) GO TO 600
0060    500             CONTINUE
                C
                C
0061    600             CONTINUE
                C
0062                    WRITE (LUNTRM,800) JDO,JD
0063    800             FORMAT (///'0','CUM. INCR. OF DEVEL. REACHES 6.0 ON DAY ',
                +                    I3,' UNDER STRESS CONDITIONS.'
                +               /'0','CUM. INCR. OF DEVEL. REACHES 6.0 ON DAY ',
                +                    I3,' UNDER NON-STRESS CONDITIONS.'
                +               /// )
                C
                C
0064                    RETURN
```

```
0065            END
```

PROGRAM SECTIONS

NUMBER	NAME	SIZE		ATTRIBUTES
1	$CODE1	001434	398	RW,I,CON,LCL
2	$PDATA	000010	4	RW,D,CON,LCL
3	$IDATA	000402	129	RW,D,CON,LCL
4	$VARS	000004	2	RW,D,CON,LCL
6	LUN	000012	5	RW,D,OVR,GBL
7	.$$$$.	000132	45	RW,D,OVR,GBL

ENTRY POINTS

NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS
DTMOD		1-000000												

VARIABLES

NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS
AL	R*4	F-000014*	JD	I*2	7-000000	JDO	I*2	4-000002	KO	I*2	7-000050	KOUNT	I*2	F-000026*
KP	I*2	7-000046	LAT	R*4	F-000012*	LUNCOE	I*2	6-000000	LUNMET	I*2	6-000004	LUNRES	I*2	6-000002
LUNRPT	I*2	6-000010	LUNTRM	I*2	6-000006	OCUM	R*4	7-000056	ODAYS	R*4	7-000042	OFLB	R*4	7-000022
OLAI	R*4	7-000066	OSLB	R*4	7-000032	OSUME0	R*4	7-000076	OSUMP	R*4	7-000116	OSUMTR	R*4	7-000106
PCUM	R*4	7-000052	PDAYS	R*4	7-000036	PFLB	R*4	7-000016	PLAI	R*4	7-000062	PLOTFL	R*4	1-000000*
PLT	I*2	F-000010*	PRECIP	R*4	7-000012	PRTFLG	R*4	F-000022*	PSLB	R*4	7-000026	PSUME0	R*4	7-000072
PSUMP	R*4	7-000112	PSUMTR	R*4	7-000102	RO	R*4	7-000126	RP	R*4	7-000122	SH	R*4	F-000016*
SWITCH	I*2	4-000000	TMAX	R*4	7-000006	TMIN	R*4	7-000002						

ARRAYS

NAME	TYPE	ADDRESS	SIZE		DIMENSIONS
COEF	R*4	F-000002*	000264	90	(5,3,3)
CRIT	R*4	F-000004*	000074	30	(5,3)
OUT	R*4	F-000024*	025700	5600	(200,14)
WD	R*4	F-000006*	010450	2196	(3,366)

LABELS

LABEL	ADDRESS	LABEL	ADDRESS	LABEL	ADDRESS	LABEL	ADDRESS	LABEL	ADDRESS
280'	3-000000	300	1-000554	400	1-001236	450	1-001310	500	**
600	1-001364	800'	3-000054						

FUNCTIONS AND SUBROUTINES REFERENCED

DTDAY PRTDAY

```
FORTRAN IV-PLUS V02-51E          10:34:55     02-JUN-81          PAGE 6
DTMOD.FTN        /TR:BLOCKS/WR

TOTAL SPACE ALLOCATED = 002216   583

,CL:=SY0:[320,70]DTMOD
```

```
0001            SUBROUTINE DTDAY (COEF,CRIT,PLT,LAT,AL,SM)
                C
                C
                C       THIS SUBROUTINE PERFORMS WATER BUDGET AND DAILY INCREMENT OF
                C       DEVELOPMENT CALCULATIONS FOR THE CURRENT DAY.  IN ADDITION,
                C       CUMULATIVE INCREMENTS OF DEVELOPMENT AND OTHER RUNNING TOTALS
                C       ARE UPDATED.
                C
                C       BEFORE PLANTING DATE, WATER BUDGET CALCULATIONS ARE THE SAME
                C       UNDER BOTH WATER-LIMITING AND NON-LIMITING CONDITIONS.
                C       THEREFORE, THE WATER BUDGET IS CALCULATED ONLY UNDER
                C       NON-LIMITING CONDITIONS UNTIL PLANTING DAY IS REACHED,
                C       AT WHICH TIME BOTH BUDGETS ARE EQUATED.  ON DAYS AFTER THE
                C       PLANTING DAY, BUDGETS FOR BOTH CONDITIONS ARE PROCESSED
                C       SEPARATELY.
                C
                C       ON ALL DAYS AFTER THE PLANTING DAY, TWO INCREMENTS OF
                C       DEVELOPMENT ARE COMPUTED.  THE FIRST IS THE BASIC
                C       ROBERTSON INCREMENT.  THE SECOND IS DERIVED FROM THE FIRST
                C       BY MAKING ADJUSTMENTS FOR THE EFFECTS OF WATER STRESS.
                C
                C
                C       CALLING ARGUMENTS:
                C
                C               NAME    USAGE   MEANING
                C
                C               COEF      I     COEFFICIENTS
                C               CRIT      I     CRITICAL LEVELS
                C               PLT       I     JULIAN PLANTING DATE
                C               LAT       I     LATITUDE
                C               AL        I     CONSTANT REQUIRED IN TRANSPIRATION
                C                               CALCULATION
                C               SM        I     MAXIMUM SECOND LAYER MOISTURE CONTENT
                C
                C
                C       SUBROUTINES CALLED: LAICAL,WATBUD,DAYLG,ROB,CORECT
                C
                C
                C       LOCAL VARIABLES:
                C
                C               NAME            MEANING
                C
                C               DUM1    DUMMY VARIABLE
                C               DUM2    DUMMY VARIABLE
                C               DUM3    DUMMY VARIABLE
                C               RD      DIFFERENCE BETWEEN WATER-LIMITING AND
                C                       NON-LIMITING WATER BUDGET RATIOS; STRESS INDEX
                C               DIDO    UNCORRECTED DAILY INCR. OF DEVEL.; OLD STAGE
                C               DIDN    UNCORRECTED DAILY INCR. OF DEVEL.; NEW STAGE
                C               DIDC1   CORRECTED   DAILY INCR. OF DEVEL.; OLD STAGE
                C               DIDC2   CORRECTED   DAILY INCR. OF DEVEL.; NEW STAGE
                C               DIDI    DAILY INCREMENT INTERPOLATED FROM DIDC1
                C                       AND DIDC2
                C               DIFF    PORTION OF DIDC1 CONTRIBUTING TO DIDI WHEN
                C                       STAGE CROSSOVER OCCURS
                C               RPCT    PERCENT OF DIDC2 CONTRIBUTING TO DIDI WHEN
```

```
C                       STAGE CROSSOVER OCCURS
C                 TMPCUM  TEMPORARY CUMULATIVE INCREMENT OF DEVELOPMENT
C                       USED TO CHECK IF DIDC1 CARRIES CROP TO NEXT
C                       TRANSITION PERIOD
C                 DL    DAY LENGTH
C                 ITEMP TEMPORARY TRANSITION PERIOD VARIABLE
C                 IFLAG FLAG TO SIGNAL WHEN SUBROUTINE WATBUD SHOULD
C                       UPDATE RUNNING TOTALS; IF=0, UPDATE AND IF=1,
C                       DO NOT UPDATE
C                 KS    SOIL MOISTURE LIMITING FACTOR
C
C
C
0002            INTEGER PLT
0003            REAL LAT,KS
0004            DIMENSION COEF(5,3,3),CRIT(5,3)
0005          COMMON JD,TMIN,TMAX,PRECIP,PFLB,OFLB,PSLB,OSLB,
              +       PDAYS,ODAYS,KP,KO,PCUM,OCUM,PLAI,OLAI,
              +       PSUME0,OSUME0,PSUMTR,OSUMTR,PSUMP,OSUMP,RP,RO
C
C
C
C******          BEFORE AND ON PLANTING DAY - WATER BUDGET FOR BOTH LIMITING
C                   AND NON-LIMITING CONDITIONS
C                 AFTER PLANTING DAY - WATER BUDGET FOR ONLY NON-LIMITING
C                   CONDITIONS
C
0006            CALL LAICAL (PCUM,AL,PLAI)
0007            KS = 1.0
0008            IFLAG = 0
0009            CALL WATBUD (JD,PLT,TMIN,TMAX,PRECIP,IFLAG,PLAI,AL,SM,KS,PFLB,
              +             PSLB,PDAYS,PSUME0,PSUMTR,PSUMP,RP)
C
C
0010            IF (JD-PLT) 600,200,400
C
C******          ON PLANTING DAY, EQUATE RUNNING TOTALS
C
0011    200     OSLB = PSLB
0012            OFLB = PFLB
0013            ODAYS = PDAYS
0014            OSUME0 = PSUME0
0015            OSUMTR = PSUMTR
0016            OSUMP = PSUMP
0017            GO TO 600
C
C******          AFTER PLANTING DAY, COMPUTE DAILY INCREMENT OF DEVELOPMENT
C
0018    400     CONTINUE
0019            DL = DAYLG(LAT,JD)
C
C***            MODEL UNDER NON-LIMITING MOISTURE CONDITIONS
C               (WATER BUDGET PROCESSED ABOVE)
C               STAGE ESTIMATE
0020            CALL ROB (TMIN,TMAX,DL,COEF,CRIT,KP,DUM1,DUM2,DUM3,PCUM)
C
```

```
        C***            MODEL UNDER LIMITING MOISTURE CONDITIONS
        C
0021            IF (OCUM.GE.6.0) GO TO 600
        C
        C               WATER BUDGET
0022            CALL LAICAL (OCUM,AL,OLAI)
0023            KS = 0.0
0024            IFLAG = 0
0025            CALL WATBUD (JD,PLT,TMIN,TMAX,PRECIP,IFLAG,OLAI,AL,SM,KS,
     +                  OFLB,OSLB,ODAYS,OSUME0,OSUMTR,OSUMP,RO)
        C
        C               STAGE ESTIMATE
0026            ITEMP = KO
0027            TMPCUM = OCUM
0028            CALL ROB (TMIN,TMAX,DL,COEF,CRIT,ITEMP,DIDO,DIDN,DIDI,TMPCUM)
        C
        C***          STRESS CORRECTION, OLD STAGE
0029            RD = RP - RO
0030          CALL CORECT (DIDO,RD,OCUM,DIDC1)
        C
0031          IF (OCUM+DIDC1 .GE. FLOAT(KO+1)) GO TO 500
        C
        C***            UPDATE CUMULATIVE D.I.D.
        C
        C               CURRENT D.I.D. DOES NOT CARRY CROP TO NEW STAGE
0032          OCUM = OCUM + DIDC1
0033            GO TO 600
        C
        C               NEW STAGE ENTERED
0034    500   KO = KO + 1
0035          TMPCUM = OCUM + DIDI
0036            CALL LAICAL (TMPCUM,AL,OLAI)
0037          KS = 0.0
0038          IFLAG = 1
0039          CALL WATBUD (JD,PLT,TMIN,TMAX,PRECIP,IFLAG,OLAI,AL,SM,KS,
     +                  OFLB,OSLB,ODAYS,DUM1,DUM2,DUM3,RO)
        C
        C               STRESS CORRECTION
0040          RD = RP - RO
0041          CALL CORECT (DIDN,RD,TMPCUM,DIDC2)
        C
        C               INTERPOLATE
0042          DIFF = FLOAT(KO) - OCUM
0043          RPCT = 1. - DIFF/DIDC1
0044          OCUM = OCUM + (DIFF + RPCT*DIDC2)
        C
0045    600   RETURN
0046          END
```

PROGRAM SECTIONS

NUMBER	NAME	SIZE		ATTRIBUTES
1	$CODE1	001070	284	RW,I,CON,LCL
3	$IDATA	000336	111	RW,D,CON,LCL
4	$VARS	000074	30	RW,D,CON,LCL
6	.$$$$.	000132	45	RW,D,OVR,GBL

ENTRY POINTS

NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS
DTDAY		1-000000												

VARIABLES

NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS
AL	R*4	F-000012*	DIDC1	R*4	4-000054	DIDC2	R*4	4-000060	DIDI	R*4	4-000044	DIDN	R*4	4-000070
DIDO	R*4	4-000034	DIFF	R*4	4-000064	DL	R*4	4-000006	DUM1	R*4	4-000012	DUM2	R*4	4-000116
DUM3	R*4	4-000022	IFLAG	I*2	4-000J04	ITEMP	I*2	4-000926	JD	I*2	6-000000	KO	I*2	4-000000
KP	I*2	6-000046	KS	R*4	4-000000	LAT	R*4	F-000010*	OCUM	R*4	6-000056	ODAYS	R*4	4-000000
OFLB	R*4	6-000922	OLAI	R*4	6-000066	OSLB	R*4	6-000032	OSUME0	R*4	6-000076	OSUMP	R*4	4-000000
OSUMTR	R*4	6-000106	PCUM	R*4	6-000052	PDAYS	R*4	6-000026	PFLB	R*4	6-000016	PLAI	R*4	6-000000
PLT	I*2	F-000006*	PRECIP	R*4	6-000012	PSLB	R*4	6-000036	PSUME0	R*4	6-000072	PSUMP	R*4	4-000000
PSUMTR	R*4	6-000102	RD	R*4	4-000050	RO	R*4	6-000126	RP	R*4	6-000122	RPCT	R*4	4-000000
SM	R*4	F-000014*	TMAX	R*4	6-000000	TMIN	R*4	6-000002	TMPCUM	R*4	4-000030			

ARRAYS

NAME	TYPE	ADDRESS	SIZE		DIMENSIONS
COEF	R*4	F-000002*	000264	90	(5,3,3)
CRIT	R*4	F-000004*	000074	30	(5,3)

LABELS

LABEL	ADDRESS	LABEL	ADDRESS	LABEL	ADDRESS	LABEL	ADDRESS	LABEL	ADDRESS
200	**	400	1-000264	500	1-000636	600	1-001066		

FUNCTIONS AND SUBROUTINES REFERENCED

CORECT DAYLG LAICAL ROB WATBUD

TOTAL SPACE ALLOCATED = 001654 470

.CL:=SY0:[320,700]DTDAY

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FORTRAN IV-PLUS V02-51E          10:35:13     02-JUN-81          PAGE 2
PRTDAY.FTN       /TR:BLOCKS/WR

PROGRAM SECTIONS

NUMBER    NAME        SIZE                 ATTRIBUTES

  1       $CODE1   000364    122          RW,I,CON,LCL
  3       $IDATA   000040     16          RW,D,CON,LCL
  6       .$$$$.   000132     45          RW,D,OVR,GBL
  7       LUN      000012      5          RW,D,OVR,GBL

ENTRY POINTS

 NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS

 PRTDAY        1-000000

VARIABLES

 NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS

 JD      I*2   6-000300    KO      I*2   6-000050    KP      I*2   6-000046    LUNCOE  I*2   7-000000    LUNMET  I*2   7-000004
 LUNRES  I*2   7-000002    LUNRPT  I*2   7-000010    LUNTRM  I*2   7-000006    OCUM    R*4   6-000056    ODAYS   R*4   6-000042
 OFLB    R*4   6-000022    OLAI    R*4   6-000066    OSLB    R*4   6-000032    OSUME0  R*4   6-000076    OSUMP   R*4   6-000112
 OSUMTR  R*4   6-000106    PCUM    R*4   6-000052    PDAYS   R*4   6-000036    PFLB    R*4   6-000016    PLAI    R*4   6-000062
 PRECIP  R*4   6-000012    PSLB    R*4   6-000026    PSUME0  R*4   6-000072    PSUMP   R*4   6-000112    PSUMTR  R*4   6-000102
 RO      R*4   6-000126    RP      R*4   6-000122    TMAX    R*4   6-000006    TMIN    R*4   6-000002

LABELS

 LABEL   ADDRESS          LABEL   ADDRESS          LABEL   ADDRESS          LABEL   ADDRESS          LABEL   ADDRESS

 20'     3-000000         30'     3-000020

TOTAL SPACE ALLOCATED = 000570   188

NO FPP INSTRUCTIONS GENERATED

.CL:=SY0:[320,70]PRTDAY
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FORTRAN IV-PLUS V02-51E          10:35:19    02-JUN-81          PAGE 1
LAICAL.FTN       /TR:BLOCKS/WR

0001                SUBROUTINE LAICAL(CUM,AL,LAI)
                C
                C   THIS SUBROUTINE CALCULATES LEAF AREA INDEX.
                C
                C
                C   CALLING ARGUMENTS:
                C
                C           NAME    I/O     MEANING
                C
                C           CUM     I       CUMULATIVE INCREMENT OF DEVELOPMENT
                C           AL      I       MAXIMUM LEAF AREA INDEX; CONSTANT
                C           LAI     O       CALCULATED LEAF AREA INDEX
                C
                C
                C   CALLED BY: DTDAY
                C
                C
                C   LOCAL VARIABLES:
                C
                C           NAME            MEANING
                C
                C           BL      - CONSTANT WHICH IS A FUNCTION OF AL(SEE CALLING
                C                     ARGUMENTS)
                C           CL      - CONSTANT WHICH IS A FUNCTION OF AL
                C           DEV     - AMOUNT OF DEVELOPMENT SINCE LAST STAGE
                C                     CROSSOVER
                C
                C
                C
0002                REAL LAI
0003                LAI = 0.0
0004                BL  = AL / 3.0
0005                IF (CUM.LT.2.0) GO TO 500
0006                IF (CUM.LT.3.0) GO TO 100
0007                IF (CUM.LT.4.0) GO TO 200
0008                IF (CUM.LT.5.0) GO TO 300
0009                IF (CUM.LT.6.0) GO TO 400
0010                GO TO 500
0011    100         DEV = CUM - 2.0
0012                LAI = 0.85*BL*DEV
0013                GO TO 500
0014    200         DEV = CUM - 3.0
0015                LAI = 0.85*BL+2.15*BL*DEV
0016                GO TO 500
0017    300         DEV = CUM - 4.0
0018                LAI = AL-0.6*BL*DEV
0019                GO TO 500
0020    400         DEV = CUM - 5.0
0021                CL = AL-BL*0.6
0022                LAI = CL-CL*DEV
0023    500         CONTINUE
0024                RETURN
0025                END
```

PROGRAM SECTIONS

NUMBER	NAME	SIZE		ATTRIBUTES
1	$CODE1	000404	130	RW,I,CON,LCL
2	$PDATA	000014	6	RW,D,CON,LCL
4	$VARS	000014	6	RW,D,CON,LCL

ENTRY POINTS

NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS
LAICAL		1-000000												

VARIABLES

NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS
AL	R*4	F-000004*	BL	R*4	4-000000	CL	R*4	4-000010	CUM	R*4	F-000002*	DEV	R*4	4-000024
LAI	R*4	F-000006*												

LABELS

LABEL	ADDRESS	LABEL	ADDRESS	LABEL	ADDRESS	LABEL	ADDRESS	LABEL	ADDRESS
100	1-000132	200	1-000176	300	1-000252	400	1-000324	500	1-000432

TOTAL SPACE ALLOCATED = 000434 142

,CL:=SY0:[320,70]LAICAL

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FORTRAN IV-PLUS V02-51E          10:35:24     02-JUN-81          PAGE 1
WATBUD.FTN       /TR:BLOCKS/WR

0001              SUBROUTINE WATBUD (JD,PLT,TMIN,TMAX,PRECIP,IFLAG,LAI,AL,SM,
                 +                   KS,FLB,SLB,TJ,SUME0,SUMTR,SUMP,RATIO)
                C
                C       THIS SUBROUTINE PERFORMS WATER BUDGET CALCULATIONS.
                C       ON EACH ENTRY, THE FOLLOWING ACTIONS ARE PERFORMED:
                C
                C               1. CALCULATION OF BARE SOIL EVAPORATION
                C               2. UPDATE OF FIRST LAYER BUDGET
                C               3. UPDATE OF SECOND LAYER BUDGET
                C               4. UPDATE OF CUMULATIVE PRECIPITATION
                C               5. UPDATE OF CUMULATIVE BARE SOIL EVAPORATION
                C
                C       THE FOLLOWING ACTIONS ARE PERFORMED ONLY AFTER THE
                C       CROP HAS BEEN PLANTED:
                C
                C               1. CALCULATION OF TRANSPIRATION
                C               2. CALCULATION OF STRESS RATIO
                C               3. UPDATE OF CUMULATIVE TRANSPIRATION
                C
                C
                C       CALLING ARGUMENTS:
                C
                C               NAME    I/O     MEANING
                C
                C               JD      I       CURRENT JULIAN DATE
                C               PLT     I       JULIAN PLANTING DATE
                C               TMIN    I       MINIMUM TEMPERATURE, DEG. F
                C               TMAX    I       MAXIMUM TEMPERATURE, DEG. F
                C               PRECIP  I       PRECIPITATION
                C               IFLAG   I       IF=1, DO NOT UPDATE SUB-TOTALS;
                C                               IF=0, UPDATE SUB-TOTALS
                C               LAI     I       LEAF AREA INDEX
                C               AL      I       CONSTANT IN TRANSPIRATION CALCULATION
                C               SM      I       MAXIMUM SECOND LAYER MOISTURE CONTENT
                C               KS      I       SOIL MOISTURE LIMITING FACTOR
                C               FLB     I/O     FIRST LAYER BUDGET
                C               SLB     I/O     SECOND LAYER BUDGET
                C               TJ      I/O     DAYS SINCE STAGE 1 EVAPORATION
                C               SUME0   I/O     CUMULATIVE BARE SOIL EVAPORATION
                C               SUMTR   I/O     CUMULATIVE TRANSPIRATION
                C               SUMP    I/O     CUMULATIVE PRECIPITATION
                C               RATIO   O       STRESS RATIO
                C
                C
                C       SUBROUTINES CALLED: PETF
                C
                C
                C       CALLED BY: DTDAY
                C
                C
                C       LOCAL VARIABLES:
                C
                C               NAME            MEANING
                C
                C               BLK     LEAF AREA INDEX CORRESPONDING TO 50. PERCENT
                C                       CROP COVER. A FUNCTION OF AL (SEE CALLING ARGU.)
```

```
C                ALFA    CONSTANT FOR A PARTICULAR CROP AND CLIMACTIC
C                        CONDITION
C                C       CONSTANT DEFENDENT ON SOIL HYDRAULIC PROPERTIES
C                FLBT    FIRST LAYER BUDGET FOR TODAY. THIS IS AN
C                        ESTIMATE OF TODAY'S FIRST LAYER MOISTURE CONTENT.
C                        IT IS USED TO DECIDE WHICH SECOND LAYER BUDGET
C                        EQUATION APPLIES.
C                TAU     TEMPORARY VARIABLE IN BARE SOIL EVAPORATION AND
C                        TRANSPIRATION CALCULATIONS.
C                TR      TRANSPIRATION
C                ALFAV   CONSTANT FOR A PARTICULAR CROP
C                ETB     AVAILABLE SECOND LAYER MOISTURE; INDEPENDENT
C                        VARIABLE IN CALCULATION OF KS.
C                PET     POTENTIAL EVAPORATION
C                TI      TEMPORARY VARIABLE IN STAGE TWO BARE SOIL
C                        EVAPORATION CALCULATION.
C                EØP     EØ PRIME; TEMPORARY VARIABLE IN STAGE TWO
C                        BARE SOIL EVAPORATION CALCULATION.
C                AU      MAXIMUM FIRST LAYER MOISTURE CONTENT
C                EØ      BARE SOIL EVAPORATION
C                BL      FUNCTION OF AL (SEE CALLING ARGUMENTS);
C                        USED IN TRANSPIRATION CALCULATION.
C
C
C
0002            COMMON /LUN/ LUNCOE,LUNRES,LUNMET,LUNTRM,LUNRPT
C
0003            REAL KS,LAI
0004            INTEGER PLT
0005            DATA ALFA,ALFAV/1.15,1.26/
0006            DATA C,AU/3.Ø,2Ø.Ø/
C
0007            BL = AL/3.Ø
0008            TR = Ø.Ø
C
C***                    COMPUTE POTENTIAL EVAPORATION
C
0009            PET = PETF(TMIN,TMAX)
C
C***            COMPUTE TRANSPIRATION IF AFTER PLANTING DAY
C
0010            TAU = EXP(-Ø.537*LAI)
0011            IF (JD.LT.PLT+1) GO TO 2ØØ
C                       IF PROCESSING WATER BUDGET UNDER NON-LIMITING WATER CONDITIONS,
C                       THEN KS = 1.Ø ON ENTRY.  COMPUTE KS ONLY WHEN PROCESSING UNDER
C                       LIMITING WATER CONDITIONS (KS=Ø.Ø ON ENTRY)
0012            IF (KS.EQ.1.Ø) GO TO 6Ø
0013            ETB = (SLB/SM)*1ØØ.Ø
0014            KS = 1.Ø
0015            IF (ETB.GT.6Ø.Ø) GO TO 6Ø
0016            KS = -Ø.ØØ549764 -Ø.ØØØ49547*(ETB) +Ø.ØØ123765*((ETB)**2)
               1-Ø.ØØØØ2211*((ETB)**3) + Ø.ØØØØØØ11*((ETB)**4)
0017             IF (KS.GT.1.Ø) KS = 1.Ø
0018    6Ø      CONTINUE
0019            BLK = BL*2.Ø
0020            IF (LAI.GT.BLK) GO TO 1ØØ
```

```
        C                CROP COVER LESS THAN OR EQUAL TO 50 PERCENT
0021            TR = ALFAV*(1.-TAU)*PET*KS
0022            GO TO 150
        C                CROP COVER GREATER THAN 50 PERCENT
0023    100     TR = (1.35-TAU)*PET*KS
0024    150     IF (TR.GT.PET) TR=PET
0025    200     CONTINUE
        C
        C***             COMPUTE BARE SOIL EVAPORATION
        C
0026            FLBY = FLB
0027            IF (FLBY.LT.0.0) FLBY = 0.0
0028            FLBT = FLBY + PRECIP
0029            IF (FLBT.GT.AU) GO TO 300
        C
        C                STAGE 2 EQUATION
        C
0030            IF (PRECIP.NE.0.0) GO TO 280
0031            TI = TJ - 1.0
0032            IF (TI.LT.0.0) TI = 0.0
0033            GO TO 290
0034    280     E0P = SUME0 - PRECIP
0035            IF (E0P.LT.0.0) E0P = 0.0
0036            TI = (E0P/C)**2
0037    290     CONTINUE
0038            E0 = C*TJ**0.5 - C*TI**0.5
0039            IF (E0.LT.0.0) E0 = 0.0
0040            TJ = TJ + 1.0
0041            GO TO 350
        C
        C                STAGE 1 EQUATION
        C
0042    300     CONTINUE
0043            E0 = TAU*PET*(1.0/ALFA)
0044            TJ = 1.0
        C
        C
0045    350     CONTINUE
        C
        C
        C***                     UPDATE RUNNING TOTALS
        C
        C                NOTE: PRECIP WHICH IS IN UNITS OF CM ARE ADDED TO
        C                BUDGETS WHICH ARE IN UNITS OF MM.  HOWEVER, THIS
        C                DISCREPANCY IS ACCOUNTED FOR IN WATER BUDGET EQUATIONS.
0046            IF (IFLAG.NE.0) GO TO 900
        C
        C                SAVE YESTERDAY'S FIRST LAYER BUDGET
0047            FLBY = FLB
        C                FIRST LAYER BUDGET - CUMULATIVE
0048            FLB = FLB - E0 + PRECIP
        C                FIRST LAYER BUDGET - ACTUAL
        C                (FIRST LAYER BUDGET CAN NOT PHYSICALLY BE LESS THAN 0.0)
0049            IF (FLBY.LT.0.0) FLBY = 0.0
0050            FLBT = FLBY - E0 + PRECIP
        C                SECOND LAYER BUDGET
```

```
0051            IF (FLBT.GT.AU) GO TO 400
0052            IF (FLBT.LT.0.0) GO TO 450
      C
0053            IF (FLBT.GE.0.0 .AND. FLBT.LE.AU) GO TO 500
      C                 FIRST LAYER BEYOND MAXIMUM WATER HOLDING CAPACITY.
      C                 EXCESS WATER ADDED TO SECOND LAYER BUDGET.
0054    400     SLB = SLB - TR + (FLB-AU)
0055            FLB = AU
0056            GO TO 600
      C                 NOT ENOUGH WATER IN TOP LAYER TO SATISFY BARE SOIL EVAPORATION.
      C                 REQUIRED WATER IS TAKEN FROM SECOND LAYER.
0057    450     SLB = SLB - TR - E0
0058            GO TO 600
      C                 NO EXCHANGE BETWEEN FIRST AND SECOND LAYERS.
      C                 THE ONLY SECOND LAYER LOSS IS TRANSPIRATION.
0059    500     SLB = SLB - TR
      C
0060    600     CONTINUE
      C
      C               WATER BEYOND MAX. HOLDING CAPACITY IS LOST AS DRAINAGE
0061            IF (SLB.GT.SM) SLB = SM
      C
      C                 UPDATE EVAPORATION, TRANSPIRATION, AND PRECIPITATION TOTALS
0062            SUMTR = SUMTR + TR
0063            SUME0 = SUME0 + E0
0064            SUMP  = SUMP  + PRECIP
      C
0065            IF (JD.LT.PLT+1) GO TO 1000
      C
      C***              COMPUTE RATIO
      C
0066    900     CONTINUE
0067            IF (PET.EQ.0.0) PET = 0.00000001
0068            RATIO = (TR + E0) / PET
0069            IF (RATIO.LT.0.0) RATIO = 0.0
0070            IF (RATIO.GT.1.0) RATIO = 1.0
      C
0071    1000    CONTINUE
      C
      C                 WRITE STATEMENTS FOR DEBUGGING
      C
      D       WRITE (LUNRPT,1005) PET,TAU,ETB,KS,BLK,TR,E0,TI
      D1005 FORMAT (' ','PET = ',F6.2,2X,
      D     +             'TAU = ',F6.2,2X,
      D     +             'ETB = ',F6.2,2X,
      D     +             'KS  = ',F6.2,2X,
      D     +             'BLK = ',F6.2,2X,
      D     +             'TR  = ',F6.2,2X,
      D     +             'E0  = ',F6.2,2X,
      D     +             'TI  = ',F6.2  )
0072            RETURN
0073            END
```

```
FORTRAN IV-PLUS V02-51E          10:35:24     02-JUN-81          PAGE 5
WATBUD.FTN       /IR:BLOCKS/WD

PROGRAM SECTIONS

NUMBER    NAME        SIZE                 ATTRIBUTES

  1       $CODE1   001524    426           RW,I,CON,LCL
  2       $PDATA   000040     16           RW,D,CON,LCL
  3       $IDATA   000006      3           RW,D,CON,LCL
  4       $VARS    000074     30           RW,D,CON,LCL
  6       LUN      000012      5           RW,D,OVR,GBL

ENTRY POINTS

 NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS

 WATBUD        1-000000

VARIABLES

 NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS

 AL      R*4   F-000020*   ALFA    R*4   4-000000    ALFAV   R*4   4-000004    AU      R*4   4-000014    BL      R*4   [illegible]
 BLK     R*4   4-000044    C       R*4   4-000010    ET3     R*4   4-000040    E0      R*4   4-000070    E0P     R*4   4-000064
 FLB     R*4   F-000026*   FLBT    R*4   4-000054    FLBY    R*4   4-000050    IFLAG   I*2   F-000014*   JD      I*2   [illegible]
 KS      R*4   F-000024*   LAI     R*4   F-000016*   LUNCOE  I*2   6-000000    LUNMET  I*2   6-000004    LUNRES  [illegible]
 LUNRPT  I*2   6-000010    LUNTRM  I*2   6-000006    PET     R*4   4-000030    PLT     I*2   F-000004*   PRECIP  R*4   [illegible]
 RATIO   R*4   F-000042*   SLB     R*4   F-000030*   SM      R*4   F-000022*   SUME0   R*4   F-000034*   SUMP    R*4   [illegible]
 SUMTR   R*4   F-000036*   TAU     R*4   4-000034    TI      R*4   4-000060    TJ      R*4   F-000032*   TMAX    R*4   [illegible]
 TMIN    R*4   F-000006*   TR      R*4   4-000024

LABELS

 LABEL   ADDRESS          LABEL   ADDRESS          LABEL   ADDRESS          LABEL   ADDRESS          LABEL   ADDRESS

 60      1-000346         100     1-000432         150     1-000466         200     1-000516         280     1-000624
 290     1-000672         300     1-000772         350     1-001040         400     1-001164         450     1-001234
 500     1-001266         600     1-001312         900     1-001422         1000    1-001522

FUNCTIONS AND SUBROUTINES REFERENCED

 PETF     $EXP

TOTAL SPACE ALLOCATED = 001700   480

.CL:=SY0:[320,70]WATBUD
```

```
FORTRAN IV-PLUS V02-51E          10:35:34     02-JUN-81          PAGE 1
DAYLG.FTN        /TR:BLOCKS/WR

0001            FUNCTION DAYLG(W,J)                                          ROB02100
                C
                C       THIS FUNCTION COMPUTES DAY LENGTH.
                C
                C
                C       CALLING ARGUMENTS:
                C
                C               NAME    I/O     MEANING
                C
                C               W        I      LATITUDE
                C               J        I      JULIAN DATE
                C
                C
0002             DAYLG = 12.25+(1.6164+1.7643*(TAN(3.1416*W/180.))**2)*      ROB02110
                +COS(0.0172*J-2.94)                                          ROB02120
0003             IF(W.GT.40.)RETURN                                          ROB02130
0004             DAYLG=12.14+(3.37*TAN(3.1416*W/180.))*COS(0.0172*J-2.94)    ROB02140
0005             RETURN                                                      ROB02150
0006             END                                                         ROB02160
```

```
FORTRAN IV-PLUS V02-51E          10:35:34     02-JUN-81          PAGE 2
DAYLG.FTN        /TR:BLOCKS/WR

PROGRAM SECTIONS

NUMBER    NAME        SIZE                ATTRIBUTES

  1       $CODE1    000204     66          RW,I,CON,LCL
  2       $PDATA    000034     14          RW,D,CON,LCL
  3       $IDATA    000004      2          RW,D,CON,LCL
  5       $TEMPS    000004      2          RW,D,CON,LCL

ENTRY POINTS

 NAME   TYPE  ADDRESS    NAME   TYPE  ADDRESS    NAME   TYPE  ADDRESS    NAME   TYPE  ADDRESS    NAME   TYPE  ADDRESS

 DAYLG  R*4   1-000000

VARIABLES

 NAME   TYPE  ADDRESS    NAME   TYPE  ADDRESS    NAME   TYPE  ADDRESS    NAME   TYPE  ADDRESS    NAME   TYPE  ADDRESS

 J      I*2   F-000004*  W      R*4   F-000002*

FUNCTIONS AND SUBROUTINES REFERENCED

 $COS    $TAN

TOTAL SPACE ALLOCATED = 000250     84

,CL:=SY0:[320,70]DAYLG
```

```
FORTRAN IV-PLUS V02-51E          10:35:39    02-JUN-81          PAGE 1
ROB.FTN          /TR:BLOCKS/WR

0001              SUBROUTINE ROB (TMIN,TMAX,DL,COEF,CRIT,JS,DIDO,DIDN,DIDI,CUM)
                C
                C       THIS SUBROUTINE PERFORMS DAILY INCREMENT OF DEVELOPMENT
                C       CALCULATIONS FOR BASIC ROBERTSON MODEL.
                C
                C
                C       CALLING ARGUMENTS:
                C
                C               NAME    I/O     MEANING
                C
                C               TMIN    I       MINIMUM TEMPERATURE, DEG. F
                C               TMAX    I       MAXIMUM TEMPERATURE, DEG. F
                C               DL      I       DAY LENGTH
                C               COEF    I       COEFFICIENTS
                C               CRIT    I       CRITICAL LEVELS
                C               JS      I/O     TRANSITION PERIOD.  INCREMENTED IF
                C                               TODAY'S DEVELOPMENT MOVES CROP TO
                C                               NEXT TRANSITION PERIOD.
                C               DIDO    O       DAILY INCREMENT OF DEVELOPMENT USING
                C                               COEFFICIENTS AND CRITICAL LEVELS FROM
                C                               OLD TRANSITION PERIOD
                C               DIDN    O       DAILY INCREMENT OF DEVELOPMENT USING
                C                               COEFFICIENTS AND CRITICAL LEVELS FROM
                C                               NEW TRANSITION PERIOD
                C               DIDI    O       DAILY INCREMENT OF DEVELOPMENT
                C                               INTERPOLATED FROM DIDO AND DIDN
                C               CUM     I/O     CUMULATIVE INCREMENT OF DEVELOPMENT.
                C                               DIDO OR DIDI(IF STAGE CROSSOVER OCCURS)
                C                               IS ADDED TO CUM.
                C
                C
                C       SUBROUTINES CALLED: ROBF
                C
                C
                C       CALLED BY: DTDAY
                C
                C
                C       LOCAL VARIABLES:
                C
                C               NAME            MEANING
                C
                C               TMPCUM - TEMPORARY CUMULATIVE INCREMENT OF DEVELOPMENT.
                C                        USED TO CHECK IF DIDO CARRIES CROP TO NEW
                C                        TRANSITION PERIOD.
                C               DIFF   - THE PORTION OF DIDO CONTRIBUTING TO DIDI WHEN
                C                        STAGE CROSSOVER OCCURS.
                C               RPCT   - PERCENT OF DIDN CONTRIBUTING TO DIDI WHEN
                C                        STAGE CROSSOVER OCCURS
                C
                C
0002              DIMENSION COEF(5,3,3),CRIT(5,3)
                C
                C               D.I.D. FOR CURRENT STAGE
0003              DIDO = ROBF(DL,TMIN,TMAX,COEF,CRIT,JS)
0004              TMPCUM = CUM + DIDO
                C
```

```
0005            IF (TMPCUM.LE.6.0) GO TO 150
0006            CUM = 6.0
0007            JS = JS + 1
0008            RETURN
        C
        C
0009    150     CONTINUE
        C
0010            IF (TMPCUM.GE.FLOAT(JS+1)) GO TO 200
        C
        C               TODAY'S DEVELOPMENT DOES NOT MOVE CROP TO NEXT STAGE
0011            CUM = CUM + DIDO
0012            RETURN
        C
        C
0013    200     CONTINUE
        C
        C               TODAY'S DEVELOPMENT CARRIES CROP TO NEXT STAGE.
        C               COMPUTE DAILY INCREMENT OF DEVELOPMENT USING NEXT STAGE
        C               COEFFICIENTS, THEN INTERPOLATE.
        C
0014            JS = JS + 1
0015            DIDN = ROBF(DL,TMIN,TMAX,COEF,CRIT,JS)
0016            DIFF = FLOAT(JS) - CUM
0017            RPCT = 1.0 - DIFF/DIDO
0018            DIDI = DIFF + RPCT*DIDN
0019            CUM  = CUM + DIDI
0020            RETURN
0021            END
```

```
FORTRAN IV-PLUS V02-51E          10:35:39     02-JUN-81          PAGE 3
ROB.FTN          /TR:BLOCKS/WR

PROGRAM SECTIONS

NUMBER    NAME        SIZE                ATTRIBUTES

  1       $CODE1   000450    148           RW,I,CON,LCL
  3       $IDATA   000042     17           RW,D,CON,LCL
  4       $VARS    000014      6           RW,D,CON,LCL

ENTRY POINTS

 NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS

 ROB           1-000000

VARIABLES

 NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS

 CUM     R*4   F-00 [4*    DIDI    R*4   F-000022*   DIDN    R*4   F-000020*   DIDO    R*4   F-000016*   DIFF    R*4   4-[3[0[24
 DL      R*4   F-000026*   JS      I*2   F-000014*   RPCT    R*4   4-000010    TMAX    R*4   F-000004*   TMIN    R*4   F-[0E[82*
 TMPCUM  R*4   4-000000

ARRAYS

 NAME    TYPE  ADDRESS       SIZE        DIMENSIONS

 COEF    R*4   F-000010*  000264    90    (5,3,3)
 CRIT    R*4   F-000012*  000074    30    (5,3)

LABELS

 LABEL   ADDRESS         LABEL   ADDRESS         LABEL   ADDRESS         LABEL   ADDRESS         LABEL   ADDRESS

 150     1-000212        200     1-000262

FUNCTIONS AND SUBROUTINES REFERENCED

 ROBF

TOTAL SPACE ALLOCATED = 000526   171

.CL:=SY0:[320,700]ROB
```

```
FORTRAN IV-PLUS V02-51E          10:35:46     02-JUN-81          PAGE 1
CORECT.FTN       /TR:BLOCKS/WR

0001            SUBROUTINE CORECT (DID,RD,CUM,DIDC)
          C
          C
          C       THIS SUBROUTINE MAKES AN ADJUSTMENT TO THE BASIC ROBERTSON
          C       DAILY INCREMENT OF DEVELOPMENT.  THE CORRECTED DAILY
          C       INCREMENT OF DEVELOPMENT IS A FUNCTION OF THE TRANSITION
          C       PERIOD IN WHICH THE CROP IS CURRENTLY IN, AS WELL AS THE
          C       STRESS RATIO.
          C
          C               TRANSITION PERIOD       DIDC
          C
          C                       1               DID
          C                       2               DID
          C                       3               DID*EXP(-RD)
          C                       4               DID*EXP(RD)
          C                       5               DID*C
          C
          C               WHERE:
          C
          C                 C = F(R) IF R.LE.0.8 AND 1.9 IF R.GT.0.8
          C                 F = QUADRATIC FUNCTION (SEE BELOW)
          C
          C
          C
          C       CALLING ARGUMENTS:
          C
          C               NAME    USAGE   MEANING
          C
          C               DID       I     UNCORRECTED DAILY INCREMENT OF DEV.
          C               RD        I     STRESS RATIO
          C               CUM       I     CUMULATIVE INCREMENT OF DEVELOPMENT
          C               DIDC      O     CORRECTED DAILY INCREMENT OF DEV.
          C
          C
          C       CALLED BY: DTDAY
          C
          C
          C       LOCAL VARIABLES:
          C
          C               NAME            MEANING
          C
          C               A1          CONSTANT
          C               A2          CONSTANT
          C               A4          TEMPORARY VARIABLE
          C
          C
          C
0002            DATA A1,A2 /1.0,1.0/
0003            DIDC = DID
0004            IF (RD.LE.0.0) GO TO 1000
0005            IF (CUM.LT.2.0) GO TO 1000
          C
0006            IF (CUM.GE.3.0) GO TO 50
0007            IF (RD.GT.0.25) A1 = A1*0.95
0008            DIDC = DID * (A1*EXP(-RD))
0009            GO TO 1000
```

```
        C
0010    50      CONTINUE
0011            IF (CUM.GE.4.0) GO TO 100
0012            DIDC = DID * (A2*EXP(RD))
0013            GO TO 1000
        C
0014    100     CONTINUE
0015            IF (CUM.GE.6.0) GO TO 1000
0016            A4 = (0.990143 + 0.1869047*RD + 0.726190*5*(RD**2)) * 1.16
0017            IF (RD.GT.0.8) A4 = 1.9
0018            DIDC = DID * A4
        C
        C       IF(DSTI.LT.0.1)A4=1.                                          PAU02920
        C       IF(DSTI.GE.0.0.AND.DSTI.LT.0.2)A4=1.0                         PAU02930
        C       IF(DSTI.GE.0.2.AND.DSTI.LT.0.3)A4=1.05                        PAU02940
        C       IF(DSTI.GE.0.3.AND.DSTI.LT.0.4)A4=1.1                         PAU02950
        C       IF(DSTI.GE.0.4.AND.DSTI.LT.0.5)A4=1.15                        PAU02960
        C       IF(DSTI.GE.0.5.AND.DSTI.LT.0.6)A4=1.2                         PAU02970
        C       IF(DSTI.GE.0.6.AND.DSTI.LT.0.7)A4=1.35                        PAU02980
        C       IF(DSTI.GE.0.7.AND.DSTI.LT.0.8)A4=1.45                        PAU02990
        C       IF(DSTI.GE.0.8)A4=1.6                                         PAU03000
        C
0019    1000    RETURN
0020            END
```

FORTRAN IV-PLUS V02-51E 10:35:46 02-JUN-81 PAGE 3
CORECT.FTN /TR:BLOCKS/WR

PROGRAM SECTIONS

NUMBER	NAME	SIZE		ATTRIBUTES
1	$CODE1	000336	111	RW,I,CON,LCL
2	$PDATA	000034	14	RW,D,CON,LCL
4	$VARS	000014	6	RW,D,CON,LCL

ENTRY POINTS

NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS
CORECT		1-000000												

VARIABLES

NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS
A1	R*4	4-000000	A2	R*4	4-000004	A4	R*4	4-000010	CUM	R*4	F-000006*	DID	R*4	F-000002*
DIDC	R*4	F-000010*	RD	R*4	F-000004*									

LABELS

LABEL	ADDRESS	LABEL	ADDRESS	LABEL	ADDRESS	LABEL	ADDRESS	LABEL	ADDRESS
50	1-000146	100	1-000220	1000	1-000334				

FUNCTIONS AND SUBROUTINES REFERENCED

$EXP

TOTAL SPACE ALLOCATED = 000496 131

.CL:=SY0:[320,70]CORECT

```
FORTRAN IV-PLUS V02-51E          10:35:51    02-JUN-81          PAGE 1
PETF.FTN         /TR:BLOCKS/WR

0001              FUNCTION PETF (TMIN,TMAX)
                C
                C       THIS FUNCTION COMPUTES POTENTIAL EVAPORATION.
                C
                C
                C       CALLING ARGUMENTS:
                C
                C               NAME    I/O     MEANING
                C
                C               TMIN    I       MINIMUM TEMPERATURE, DEG. F
                C               TMAX    I       MAXIMUM TEMPERATURE, DEG. F
                C
                C
                C       CALLED BY: WATBUD
                C
                C
                C       LOCAL VARIABLES:
                C
                C               NAME            MEANING
                C
                C               ES      - SATURATION VAPOR PRESSURE DERIVED FROM
                C                         DAILY MINIMUM TEMPERATURE
                C               E       - ACTUAL VAPOR PRESSURE DERIVED FROM
                C                         DAILY MAXIMUM TEMPERATURE
                C               PANEV   - PAN EVAPORATION
                C
                C
                C
                C
                C
0002             PETF = 0.0
0003             IF (TMIN.LT.0.0 .OR. TMAX.LE.32.0) RETURN
                C
                C               ACTUAL VAPOR PRESSURE (E)
0004               E =6.11*EXP((-1.7620(2621E05 + 5.59760791SE03*TMAX-
                  12.850972636*TMAX**2)/(1.254162E05 + 273.0*TMAX))
                C               SATURATION VAPOR PRESSURE (ES)
0005               ES = 6.11*EXP((-1.7620426 21E05 +5.59760791SE03*TMIN-
                  12.850972636*TMIN**2)/(1.254162E05 + 273.0*TMIN))
                C               PAN EVAPORATION (PANEV)
0006               PANEV = (0.2163 + 0.3473*E - 0.2644*ES)*(24.55/31.0)
                C               POTENTIAL EVAPORATION (PETF)
0007               PETF = PANEV * .85
0008               RETURN
0009               END
```

PROGRAM SECTIONS

NUMBER	NAME	SIZE		ATTRIBUTES
1	$CODE1	000302	97	RW,I,CON,LCL
2	$PDATA	000054	22	RW,D,CON,LCL
3	$IDATA	000004	2	RW,D,CON,LCL
4	$VARS	000014	6	RW,D,CON,LCL

ENTRY POINTS

NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS
PETF	R*4	1-000												

VARIABLES

NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS
E	R*4	4-000000	ES	R*4	4-000004	PANEV	R*4	4-000010	TMAX	R*4	F-002004*	TMIN	R*4	F-002012*

FUNCTIONS AND SUBROUTINES REFERENCED

$EXP

TOTAL SPACE ALLOCATED = 000376 127

,CL:=SY0:[320,70]PETF

```
FORTRAN IV-PLUS V02-51E          10:35:57    02-JUN-81          PAGE 1
ROBF.FTN         /TR:BLOCKS/WR

0001             FUNCTION ROBF (DL,TMIN,TMAX,COEF,CRIT,JS)
          C
          C      THIS FUNCTION COMPUTES THE BASIC ROBERTSON DAILY INCREMENT
          C      OF DEVELOPMENT.
          C
          C
          C      CALLING ARGUMENT:
          C
          C              NAME     I/O      MEANING
          C
          C              DL       I        DAY LENGTH
          C              TMIN     I        MINIMUM TEMPERATURE, DEG. F
          C              TMAX     I        MAXIMUM TEMPERATURE, DEG. F
          C              COEF     I        COEFFICIENTS
          C              CRIT     I        CRITICAL LEVELS
          C              JS       I        CURRENT TRANSITION PERIOD
          C
          C
          C      SUBROUTINES CALLED: QUAD
          C
          C
          C      CALLED BY: ROB
          C
          C
          C      LOCAL VARIABLES:
          C
          C              NAME             MEANING
          C
          C              V1      - VALUE OF QUADRATIC IN DAY LENGTH
          C              V2      - VALUE OF QUADRATIC IN MAX. TEMPERATURE
          C              V3      - VALUE OF QUADRATIC IN MIN. TEMPERATURE
          C
          C
          C
0002             DIMENSION COEF(5,3,3),CRIT(5,3)
          C
0003             IF (COEF(JS,1,1).NE.999.) GO TO 20
0004             V1 = 1.0
0005             GO TO 50
          C
0006        20   V1 = QUAD (DL,COEF(JS,1,1),COEF(JS,1,2),COEF(JS,1,3),CRIT(JS,1))
0007        50   V2 =QUAD(TMAX,COEF(JS,2,1),COEF(JS,2,2),COEF(JS,2,3),CRIT(JS,2))
0008             V3 =QUAD(TMIN,COEF(JS,2,1),COEF(JS,3,2),COEF(JS,3,3),CRIT(JS,3))
          C
0009             ROBF = V1 * (V2 + V3)
          C
0010             RETURN
0011             END
```

PROGRAM SECTIONS

NUMBER	NAME	SIZE		ATTRIBUTES
1	$CODE1	00055Ø	18Ø	RW,I,CON,LCL
2	$PDATA	000004	2	RW,D,CON,LCL
3	$IDATA	000044	18	RW,D,CON,LCL
4	$VARS	000014	6	RW,D,CON,LCL

ENTRY POINTS

NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS
ROBF	R*4	1-000000												

VARIABLES

NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS
DL	R*4	F-000002*	JS	I*2	F-000014*	TMAX	R*4	F-000006*	TMIN	R*4	F-000004*	V1	R*4	[illegible]
V2	R*4	4-003004	V3	R*4	4-000010									

ARRAYS

NAME	TYPE	ADDRESS	SIZE		DIMENSIONS
COEF	R*4	F-000010*	000264	90	(5,3,3)
CRIT	R*4	F-000312*	000074	30	(5,3)

LABELS

LABEL	ADDRESS	LABEL	ADDRESS	LABEL	ADDRESS	LABEL	ADDRESS	LABEL	ADDRESS
20	1-000126	50	1-000254						

FUNCTIONS AND SUBROUTINES REFERENCED

QUAD

TOTAL SPACE ALLOCATED = 000634 206

.CL:=SY0:[320,700]ROBF

```
FORTRAN IV-PLUS V02-51E          10:36:03     02-JUN-81          PAGE 1
QUAD.FTN         /TR:BLOCKS/WR

0001            FUNCTION QUAD(X,A0,A1,A2,C)                          ROB02040
                C
                C       THIS FUNCTION EVALUATES A QUADRATIC.
                C
                C
                C       CALLING ARGUMENTS:
                C
                C               NAME    I/O     MEANING
                C
                C               X       I       DAY LENGTH OR TEMPERATURE
                C               A0      I       COEFFICIENT
                C               A1      I       COEFFICIENT
                C               A2      I       LEADING COEFFICIENT
                C               C       I       CRITICAL LEVEL
                C
                C
                C       CALLED BY: ROBF
                C
                C
                C
0002            QUAD = A1*(X-A0)+A2*(X-A0)*(X-A0)                    ROB02050
0003            IF(A2.GT.0.AND.X.LT.C)QUAD=0.                        ROB02060
0004            IF(QUAD.LT.0.)QUAD=0.                                ROB02070
0005            RETURN                                               ROB02080
0006            END                                                  ROB02090
```

```
FORTRAN IV-PLUS V02-51E          10:36:03     02-JUN-81          PAGE 2
QUAD.FTN         /TR:BLOCKS/WR

PROGRAM SECTIONS

NUMBER    NAME        SIZE                ATTRIBUTES

  1       $CODE1   000130     44          RW,I,CON,LCL
  3       $IDATA   000004      2          RW,D,CON,LCL


ENTRY POINTS

 NAME   TYPE  ADDRESS     NAME   TYPE  ADDRESS     NAME   TYPE  ADDRESS     NAME   TYPE  ADDRESS     NAME   TYPE  ADDRESS

 QUAD   R*4   1-000000


VARIABLES

 NAME   TYPE  ADDRESS     NAME   TYPE  ADDRESS     NAME   TYPE  ADDRESS     NAME   TYPE  ADDRESS     NAME   TYPE  ADDRESS

 A0     R*4   F-000004*   A1     R*4   F-000006*   A2     R*4   F-000010*   C      R*4   F-000012*   X      R*4   F-000014*


TOTAL SPACE ALLOCATED = 000134     46

,CL:=SY0:[320,701]QUAD
```

APPENDIX C

SOURCE LISTINGS OF THE BASIC ROBERTSON PROGRAM

```
C
C       THIS ROUTINE IS THE MAIN PROGRAM OF THE BASIC
C       ROBERTSON CROP PHENOLOGY MODEL.  BRMAIN INPUTS
C       METEOROLOGICAL DATA (METRDR), COEFFICIENTS (INCOEF),
C       AND CROP PLANTING DATE, AND THEN RUNS THE MODEL (BRMOD).
C
C
C       SUBROUTINES CALLED:  METRDR,INCOEF,BRMOD
C
C
C       COMMON BLOCK LUN:
C
C               NAME            MEANING
C
C               LUNCOE  LOGICAL UNIT NO. OF COEFFICIENT FILE
C               LUNRES  LOGICAL UNIT NO. OF RESULT  FILES
C               LUNMET  LOGICAL UNIT NO. OF WEATHER DATA FILE
C               LUNTRM  LOGICAL UNIT NO. OF USER TERMINAL
C               LUNRPT  LOGICAL UNIT NO. OF RESULT REPORT FILE
C
C
C       LOCAL VARIABLES:
C
C               NAME            MEANING
C
C               COEF    COEFFICIENTS; COEF(I,J,K)
C                          I - CROP TRANSITION PERIOD
C                          J - FUNCTION
C                          K - POSITION OF COEFFICIENT IN FUNCTION;
C                              COEF(*,3,1) IS NOT USED.
C               CRIT    CRITICAL LEVELS; CRIT(I,J)
C                          I - CROP TRANSITION PERIOD
C                          J - FUNCTION
C               WD      WEATHER DATA; WD(I,J)
C                          I - FIELD
C                               1. MAXIMUM TEMPERATURE, DEG. F
C                               2. MINIMUM TEMPERATURE, DEG. F
C                               3. PRECIPITATION
C                          J - JULIAN DAY OF YEAR
C               NAME    FILE NAME
C               PLT     JULIAN PLANTING DATE
C               SEG     SEGMENT NUMBER
C               LAT     SEGMENT LATITUDE
C
C
C
0001            COMMON /LUN/ LUNCOE,LUNRES,LUNMET,LUNTRM,LUNRPT
C
0002            DIMENSION COEF(5,3,3),CRIT(5,3),WD(3,366),NAME(30)
0003            INTEGER PLT,SEG
0004            REAL LAT
C
C               INITIALIZE
C
0005            LUNCOE = 1
0006            LUNMET = 3
```

```
0007            LUNRPT = 4
0008            LUNTRM = 5
      C
      C            INPUT WEATHER DATA
      C
0009            WRITE (LUNTRM,20)
0010     20     FORMAT ('$TYPE NAME OF WEATHER DATA FILE >')
0011            READ (LUNTRM,40) NAME
0012     40     FORMAT (30A1)
0013            OPEN (UNIT=LUNMET,NAME=NAME,TYPE='OLD',ERR=1000)
0014            CALL METRDR (WD,LAT,SEG)
0015            CLOSE (UNIT=LUNMET)
      C
      C          INPUT PLANTING DAY
      C
0016            WRITE (LUNTRM,60)
0017     60     FORMAT ('$TYPE PLANTING DAY (JULIAN) >')
0018              READ (LUNTRM,80) PLT
0019     80     FORMAT (I4)
      C
      C            BASIC ROBERTSON MODEL
      C
0020            WRITE (LUNTRM,100)
0021     100    FORMAT ('$TYPE NAME OF BASIC ROBERTSON COEFFICIENT FILE >')
0022            READ (LUNTRM,40) NAME
0023            OPEN (UNIT=LUNCOE,NAME=NAME,TYPE='OLD',ERR=1000)
0024            CALL INCOEF (COEF,CRIT)
0025            CLOSE (UNIT=LUNCOEF)
      C
0026              WRITE (LUNTRM,120)
0027     120    FORMAT ('$TYPE NAME OF DAILY OUTPUT FILE >')
0028            READ (LUNTRM,40) NAME
0029            OPEN (UNIT=LUNRPT,NAME=NAME,TYPE='NEW',RECORDSIZE=133,ERR=1000)
0030            CALL BRMOD (COEF,CRIT,WD,PLT,LAT)
0031            CLOSE (UNIT=LUNRPT)
      C
0032            STOP
      C
0033     1000   CONTINUE
0034            WRITE (LUNTRM,1020)
0035     1020   FORMAT ('0ERROR IN OPENING FILE')
0036            STOP
0037            END
```

```
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BRMAIN.FTN       /TR:BLOCKS/WR

PROGRAM SECTIONS

NUMBER    NAME        SIZE                 ATTRIBUTES

  1       $CODE1    000478    156          RW,I,CON,LCL
  3       $IDATA    000454    150          RW,D,CON,LCL
  4       $VARS     011134   2350          RW,D,CON,LCL
  6       LUN       000012      5          RW,D,OVR,GBL

VARIABLES

 NAME   TYPE  ADDRESS     NAME   TYPE  ADDRESS     NAME   TYPE  ADDRESS     NAME   TYPE  ADDRESS     NAME   TYPE  ADDRESS

 LAT    R*4   4-011130    LUNCOE I*2   6-000000    LUNMET I*2   6-000004    LUNRES I*2   6-000002    LUNRPT I*2   6-000010
 LUNTRM I*2   6-000006    PLT    I*2   4-011124    SEG    I*2   4-011126

ARRAYS

 NAME   TYPE  ADDRESS       SIZE        DIMENSIONS

 COEF   R*4   4-000000    000264    90    (5,3,3)
 CRIT   R*4   4-000264    000074    30    (5,3)
 NAME   I*2   4-011030    000074    30    (30)
 WD     R*4   4-000360    010450  2190    (3,366)

LABELS

 LABEL   ADDRESS          LABEL   ADDRESS          LABEL   ADDRESS          LABEL   ADDRESS          LABEL   ADDRESS

 20'     3-000000         40'     3-000044         60'     3-000050         80'     3-000110         100'    3-000114
 120'    3-000200         1000    1-000434         1020'   3-000244

FUNCTIONS AND SUBROUTINES REFERENCED

 BRMOD   CLOSS   INCOEF  METRDR  OPENS

TOTAL SPACE ALLOCATED = 012312  2661

NO FPP INSTRUCTIONS GENERATED

,CL:=SY0:[320,70]BRMAIN
```

```
0001            SUBROUTINE BRMOD (COEF,CRIT,WD,PLT,LAT)
                C
                C
                C       SUBROUTINE BRMOD IS THE DRIVER FOR THE BASIC ROBERTSON
                C       CROP PHENOLOGY MODEL.
                C
                C
                C       CALLING ARGUMENTS:
                C
                C               NAME    I/O     MEANING
                C
                C               COEF    I       COEFFICIENTS
                C               CRIT    I       CRITICAL LEVELS
                C               WD      I       WEATHER DATA
                C               PLT     I       JULIAN PLANTING DATE
                C               LAT     I       LATITUDE
                C
                C
                C       SUBROUTINES CALLED:  DAYLG,ROB
                C
                C
                C       CALLED BY:  BRMAIN
                C
                C
                C       LOCAL VARIABLES:
                C
                C               NAME            MEANING
                C
                C               JS      TRANSITION PERIOD
                C               TMAX    MAXIMUM TEMPERATUR_, DEG. F
                C               TMIN    MINIMUM TEMPERATURE, DEG. F
                C               PRECIP  PRECIPITATION
                C               DL      DAY LENGTH
                C               DIDO    DAILY INCREMENT OF DEVEL.; OLD STAGE
                C               DIDN    DAILY INCREMENT OF DEVEL.; NEW STAGE
                C               DIDI    DAILY INCREMTNT OF DEVEL.; INTERPOLATED
                C                       FROM OLD AND NEW STAGE
                C               CUM     CUMULATIVE INCREMENT OF DEVELOPMENT
                C
                C
                C
0002              COMMON /LUN/ LUNCOE,LUNRES,LUNMET,LUNTRM,LUNRPT
                C
0003            INTEGER PLT
0004            REAL LAT
0005            DIMENSION COEF(5,3,3),CRIT(5,3),WD(3,366)
0006            JS = 1
0007            CUM = 1.0
                C
                C
0008            DO 100 JD=PLT,366
0009            TMAX = WD(1,JD)
0010            TMIN = WD(2,JD)
0011            PRECIP = WD(3,JD)
0012            DL = DAYLG(LAT,JD)
0013            CALL ROB (TMIN,TMAX,DL,COEF,CRIT,JS,DIDO,DIDN,DIDI,CUM)
```

```
0014            WRITE (LUNRPT,50) JD,TMIN,TMAX,DL,JS,DIDO,DIDN,DIDI,CUM
0015      50    FORMAT (' ',I5,3F12.4,I6,4F12.4)
0016            IF (CUM.GE.6.0) RETURN
0017      100   CONTINUE
          C
          C
0018            RETURN
0019            END
```

```
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BRMOD.FTN       /TR:BLOCKS/WR

PROGRAM SECTIONS

NUMBER    NAME        SIZE                  ATTRIBUTES

  1       $CODE1   000452    149           RW,I,CON,LCL
  3       $IDATA   000112     37           RW,D,CON,LCL
  4       $VARS    000044     18           RW,D,CON,LCL
  6       LUN      000012      5           RW,D,OVR,GBL

ENTRY POINTS

 NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS

 BRMOD         1-000000

VARIABLES

 NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS     NAME    TYPE  ADDRESS

 CUM     R*4   4-000002    DIDI    R*4   4-000040    DIDN    R*4   4-000034    DIDO    R*4   4-000038    DL      R*4   4-
 JD      I*2   4-000006    JS      I*2   4-000000    LAT     R*4   F-000012*   LUNCOE  I*2   6-000000    LUNMET  I*2   6-
 LUNRES  I*2   6-000002    LUNRPT  I*2   6-000010    LUNTRM  I*2   6-000006    PLT     I*2   F-000018*   PRECIP  R*4   4-
 TMAX    R*4   4-000010    TMIN    R*4   4-000014

ARRAYS

 NAME    TYPE  ADDRESS       SIZE        DIMENSIONS

 COEF    R*4   F-000082*  000264    90    (5,3,3)
 CRIT    R*4   F-000004*  000074    30    (5,3)
 WD      R*4   F-000006*  010450  2196    (3,366)

LABELS

 LABEL   ADDRESS         LABEL   ADDRESS         LABEL   ADDRESS         LABEL   ADDRESS         LABEL   ADDRESS

 5000    3-000000        100     **

FUNCTIONS AND SUBROUTINES REFERENCED

 DAYLG   ROR

TOTAL SPACE ALLOCATED = 000642   209

.CL:=SY0:[320,700]BRMOD
```